ROHDE & SCHWARZ

SOUND and TV BROADCASTING

rigs and recipes

how to measure and monitor...

Info **N 4-023** E-2

Measurements on transmitting systems

LIST OF CONTENTS

(detailed list of contents on page 220)

MEASURING/MONITORING OF FM SOUND AND TV TRANSMITTER SYSTEMS

introduction

Measuring/monitoring Faults can occur in the operation of transmitters, transposers and broadband communication equipment (e.g. as a result of tube aging or component failures) which may not necessarily cause the complete shutdown of a transmitter but can nevertheless impair the quality of the broadcast. Such faults can be detected by measurements or continuous monitoring (visual or acoustic as well as automatic).

The systems to be measured or monitored have different designs and transmitted powers. Common to all systems is that the information to be transmitted (sound or TV programs) is modulated upon an RF carrier frequency and then sent to the viewers/listeners. In the case of transmitters and transposers, the program is sent by means of emission via an antenna, in the case of broadband communication systems via cable networks. Several programs (from several transmitters, transposers or broadband communication modulators) can also be transmitted simultaneously in all cases.

Sound and TV transmitters are usually used as basic network transmitters for the coverage of larger service areas. They are usually located at positions with favourable propagation conditions.

Transposers are used for areas (e.g. valleys) which cannot be reached by basic network transmitters. Whereas transmitters are provided with AF or VF input signals at a "constant" level (however changing in step with the information), transposers (sometimes also the broadband communication systems) receive the emission from a master transmitter (in the VHF or UHF range) with a strongly fluctuating level. They contain a receiver section in addition to the transmitter section which, compared to transmitters, places completely different demands on the measuring equipment.

Broadband communication systems are connected to subscribers via cable networks. Designed for much lower powers, the associated transmitter unit is similar to that of transmitters and must satisfy very high demands with respect to spurious suppression because of the large number of programs transmitted in the cable. Almost all types of input signals are possible: AF or VF signals as with transmitters, VHF/UHF signals as with transposers and also input signals from satellites in the SHF range. The receiver and transmitter units (modulators) are designed as separate units because of the large variety possible. The transmitter unit is fed with AF and VF signals (also IF signals in certain cases) and is therefore a transmitter with a very low power. The table below shows the most important differences between the various types of transmitting equipment.

	Input signal Frequency range	Level	Output signal Frequency range	Power range	Emission
Transmitter	AF, video	"constant"	VHF, UHF	kW	via antenna (also several programs simultaneously)
Transposer	VHF, UHF	large variation	VHF, UHF	W	as transmitter
Broadband communication systems	AF, video VHF, UHF, SHF (satellites)	"constant" large variation	VHF	mW, pW	cable network (many programs simultaneously)

The various groups are treated in separate sections because of the highly different measurements involved.

Measurements outside program times Real measurements (application of a test signal to the input and evaluation at the output) are only possible outside program times in the case of a sound broadcast and with fullfield measurements (where the test signal appears on the screen). These measurements are described starting on page 4.

Equipment racks The instrumentation required for measuring and monitoring FM sound and TV transmitter systems must be suitably interconnected and connected to the test items. An obvious solution is to combine the instrumentation in racks. The equipment racks available from Rohde & Schwarz and specially created for measuring and/or monitoring sound and TV transmitters are described from page 172 onwards.

Measurements during transmission A real measurement is possible during transmission of a TV program. Test signals, the so-called **test lines,** are inserted into the lines which do not appear on the screen. These are evaluated at the transmitter output and provide information on the condition of the transmitter.

The **Audiodat technique** is a method for measuring sound broadcasts during program transmission. The modulation at the beginning and end of a broadcast link is analyzed and provides information on the condition of the system. Measurements during program times are described starting on page 176.

Monitoring procedures Constant monitoring of broadcasts is of course much safer than occasional or routine measurements. **Visual** and **audible monitoring** require the constant presence of personnel, however, and are limited if several programs are to be monitored and are also subject to errors on the part of the operator. **Automatic monitoring procedures** offer the greatest safety because they immediately signal faults of every kind ranging from impairments in the broadcast quality to transmitter failure.

Insertion-signal testing and the Audiodat technique use limit-value monitors to signal deviations from prescribed nominal values and are ideal in monitoring systems for transmitters, transmission links and entire broadcast networks (page 186 onwards). The major area of application for both methods is in monitoring. Insertion signals are also used in pure measurement systems, however.

Computer-controlled measurements require instruments which are fitted with an IEC/IEEE-bus connection. Together with a controller and possibly a printer, they provide great simplification and fast documentation, especially with comprehensive test programs. The IEC/IEEE-bus and computer-controlled measurements are described in the appendix starting on page 210.

The TV Digital Oscilloscope ODF is a highly accurate instrument specially designed for measurements on TV equipment and provides completely new facilities as a result of the comprehensive storage functions and autorun control with a 16-bit microprocessor. It is described in the appendix from page 214 onwards.

GROUPING OF MEASUREMENTS

Grouping of measurement, standards specifications
The demands placed on sound and television transmitters are set down in standard specifications. The measurements that are necessary for checking the stipulated values can be divided into:

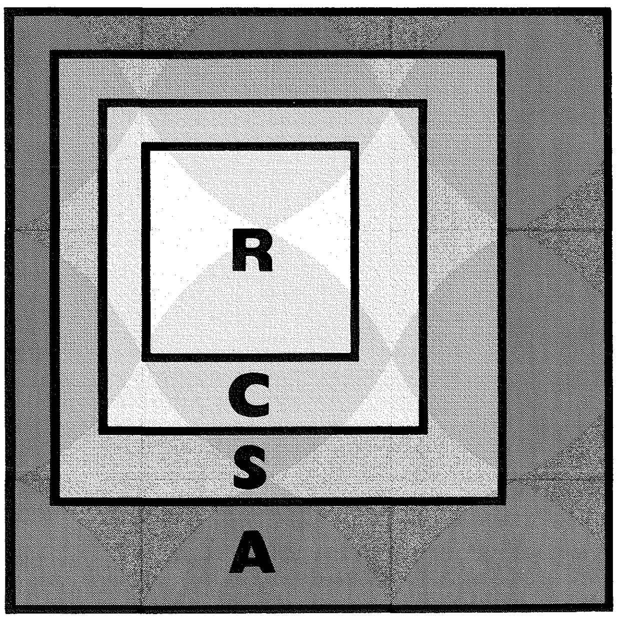
- **simple routine measurements** with small instrumentation requirements,
- **control and status measurements** with larger instrumentation requirements and of greater complexity,
- **acceptance measurements** which generally only have to be performed when a transmitter is handed over to the user.

The diagram below symbolizes the nesting of the different types of measurement. For example, the routine measurements are included in the control measurements, and the latter are included in turn in the status measurements etc.

Routine measurements quickly indicate the condition of a transmitter. They are therefore performed at shorter intervals than control measurements, which are more informative. Status measurements are necessary after major repairs or alterations or if the preceding measurements exhibit irregularities.

The intervals between the measurements as well as the individual measurements to be performed in each case can differ according to operational aspects. For example, an older transmitter should be measured more often than a modern one, and a television transmitter more often than a sound transmitter. In the case of modern, unattended stations, extensive status measurements are carried out in many cases at certain intervals instead of routine measurements. In all cases it is advisable to record the measurements so that trends can readily be recognized. The table opposite shows a possible grouping of the different measurements.

Nesting of the different measurements within one another (**R** routine, **C** control, **S** status and **A** acceptance measurements)



General measurements on transmitters

Power	S
Frequency stability	A
Spurious emissions (without modulation)	S
Enclosure leakage (RF tightness)	(A)

Transmission characteristics of FM sound and TV sound transmitters

Frequency response, preemphasis	R
Harmonic distortion	R
Intermodulation distortion	S
Spurious modulation	C
Deviation and phase stability	R
Crosstalk	C

Transmission characteristics of vision transmitters

Level stability (0.25 Hz, 50 Hz)	R
Linear distortions	
RF sideband characteristic	C
Video amplitude characteristic	C
Group delay	C
Transient response	
15 kHz	R
250 kHz	R
2T pulse	R
20T pulse	R
Nonlinear distortions	
Nonlinearity, line-time (staircase)	R
chrominance (1 MHz, 4.43 MHz superimposed)	S
Differential phase, differential gain	R
Spurious emissions (with modulation)	S
Intermodulation products	S
Spurious modulation	C

Measurements on vision/sound diplexers

Passband attenuation, return loss	S
Vision/sound isolation	S

Measurements on TV modulators

Nonlinearity, frequency response	S
Group delay	S

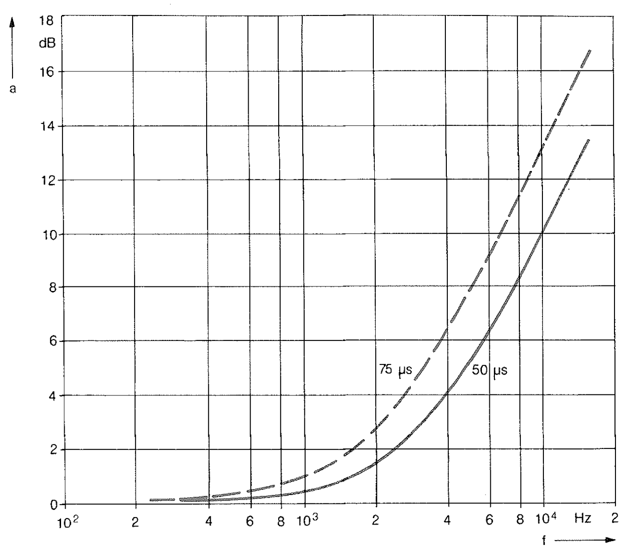
MEASUREMENTS ON FM SOUND TRANSMITTERS

The majority of FM sound transmitters nowadays is equipped for stereo broadcasting. A transmitter of this kind consists of a stereocoder, which converts the L (left) and R (right) channel information, each with a bandwidth of 15 kHz, into the coded MPX (multiplex) signal with a bandwidth of 53 kHz, and the actual transmitter, which must be able to transmit this wide frequency band. Without the stereocoder, the transmitters can generally be used as mono transmitters, with just one channel with a bandwidth of 15 kHz. A purely mono transmitter must not therefore be designed for a wider bandwidth.

Because of the very slight differences in the measurement procedures, mono and stereo transmitters are dealt with here together. In the case of stereo transmitters, a stereodecoder is required in addition, and the characteristics of two channels have to be measured, compared to one with mono transmitters. A special measurement where stereo transmitters are concerned is that for determining the crosstalk between the two channels. A procedure is also detailed that enables a mono transmitter to be tested for stereo capability.

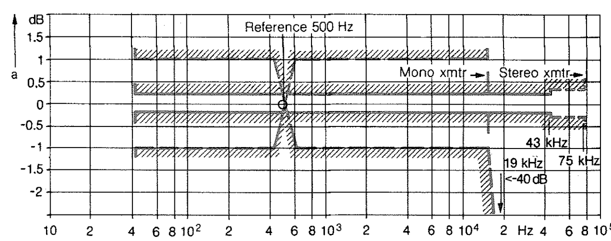
FREQUENCY RESPONSE OF AMPLITUDE, PREEMPHASIS

Preemphasis is used in a transmitter for FM broadcasting to improve the signal/noise ratio, and this is then compensated by deemphasis in the receiver. The preemphasis network accentuates the high frequencies with a time constant of 50 µs — in some countries 75 µs — (diagram opposite) and is connected in the transmitter with a lowpass filter for limiting the bandwidth of the modulation signal to 15 kHz. In a mono transmitter the preemphasis network and the lowpass filter can be jointly cut out so that a coded signal can be transmitted in stereo operation. In the stereocoder each channel is provided with disconnectible preemphasis. The band limiting is not disconnectible, however. The diagram bottom right shows the tolerances for FM sound transmitters with and without preemphasis.



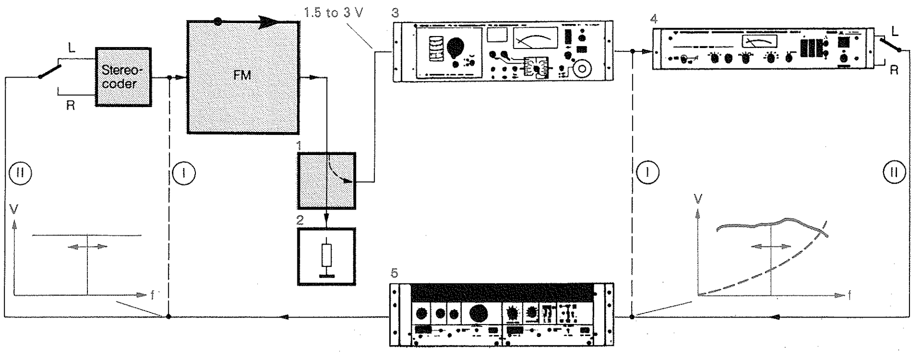
Preemphasis with time constants 50 µs and 75 µs in FM sound transmitters

With mono and stereo transmitters the frequency response of the amplitude is first determined alone. In the case of mono transmitters the preemphasis and the band limiting can then be measured with the same setup. For stereo transmitters these measurements are performed individually for each channel with the stereocoder and stereodecoder. The tolerances are the same as for a mono channel.



Tolerances for frequency response of amplitude in FM sound transmitters; solid lines without, broken lines with preemphasis and deemphasis

For these measurements Rohde & Schwarz offers, in addition to the FM/AM Demodulator FAB (and the Precision Stereodecoder MSDC 2 for stereo), the AF Transmission Measuring Set SUN 2, which consists of an AF generator (10 Hz to 100 kHz) and a level meter (−84 to +32 dBm). Measurements are considerably simplified by the possibility of being able to take any measured value as the reference value (0 dB) in the case of the level meter. The instrumentation mentioned here is illustrated on pages 12 (FAB), 13 (MSDC 2) and 18 (SUN 2).



1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 FM/AM Demodulator FAB (photo p. 12)
4 Precision Stereodecoder MSDC 2 (photo p. 13) (only for stereo transmitter)
5 AF Transmission Measuring Set SUN 2 (photo p. 18)

Measurement Procedure

I. Transmitter without stereocoder or mono transmitter

A. Basic settings

1. Make connections (I); separate internal connection stereocoder/transmitter and connection demodulator/stereodecoder.
2. On AF generator, with reference frequency 500 Hz, set level to +6 dBm (with mono transmitters set prescribed level).
3. Tune demodulator to transmitter frequency, calibrate as prescribed and measure frequency deviation in FM setting.
4. Set prescribed frequency deviation in transmitter (= reference deviation, e.g. 40 kHz). Do not alter setting any more.

II. Stereo transmitter

The L and R channels are to be measured separately. The measurements described apply to one channel.

1.a Perform settings as in I. A.
1.b Connect stereocoder to transmitter, and demodulator to stereodecoder. Make connections (II).
2. Set stereocoder as prescribed (pilot tone −9.5 dBm).
3. Set stereodecoder with LEVEL controls so that in PILOT setting of testpoint selector a level of −9.5 dBm is indicated. Do not alter setting any more.

These basic settings apply to all further measurements on mono or stereo transmitters.

B. Measurement of frequency response of amplitude without preemphasis and deemphasis

If a coded stereo signal, which has a relatively large bandwidth, is to be transmitted, the transmitter must have an appropriate bandwidth. This can only be checked with the basic settings I. A. because the stereocoder contains lowpass filters for limiting the passband to 15 kHz that are not disconnectible. The measurement procedure is the same in all cases, except that with a stereo transmitter alone (without a stereocoder) a wider frequency band is examined.

1. Disconnect preemphasis or deemphasis in all units.
2. Set required deviation (e.g. 40 kHz) on AF generator at 500 Hz.
3. Set level meter to 10 Hz to 100 kHz (MODE 1) and NORMal (dBm), following which the output level of demodulator or stereodecoder is indicated (e.g. +6 dBm).
4. Switch level meter to REF (0 dB).
5. Vary frequency on AF generator over required range (e.g. 30 Hz to 20 kHz for mono transmitter and individual stereo channels, 30 Hz to 53 (75) kHz for stereo transmitter alone). Difference from reference value is indicated.

C. Measurement of preemphasis

I. 1. Turn on preemphasis only in transmitter.

II. 1. Turn on preemphasis only in stereocoder.

2.[1]) Reduce level on AF generator (at 500 Hz) by 14 (17) dB (e.g. to −8 dBm/−11 dBm).
3.[1]) As for B.3. (indication, e.g. −8 dBm/−11 dBm).
4. As for B.4.
5. Vary frequency on AF generator in range 30 Hz to 20 kHz (to detect effect of 15-kHz lowpass filter). Difference from reference value is indicated.

[1]) In points 2. and 3. the first value applies to a preemphasis time constant of 50 μs (usual value) and the second value to a time constant of 75 μs.

D. Measurement of frequency response of amplitude with preemphasis and deemphasis

I. 1. Turn on preemphasis in transmitter and deemphasis in demodulator.
2. As for C.2. through C.5.

II. 1. Turn on preemphasis only in stereocoder and deemphasis only in stereodecoder.
2. As for C.2. through C.5.

HARMONIC DISTORTION

to DIN 45403, sheet 2

measurements outside

As a result of the nonlinearity of transfer characteristics when a sound is transmitted, harmonics of its frequency are produced. The rms value of the sum of all harmonics, referred to the overall signal, is the **total harmonic distortion THD** in percent. The exact value is:

$$\mathrm{THD} = \frac{\sqrt{V_2^2 + V_3^2 + \dots V_n^2}}{V_a}$$

where:

- V_2 voltage of 2nd harmonic
- V_3 voltage of 3rd harmonic
- V_n voltage of nth harmonic
- V_a voltage of overall signal

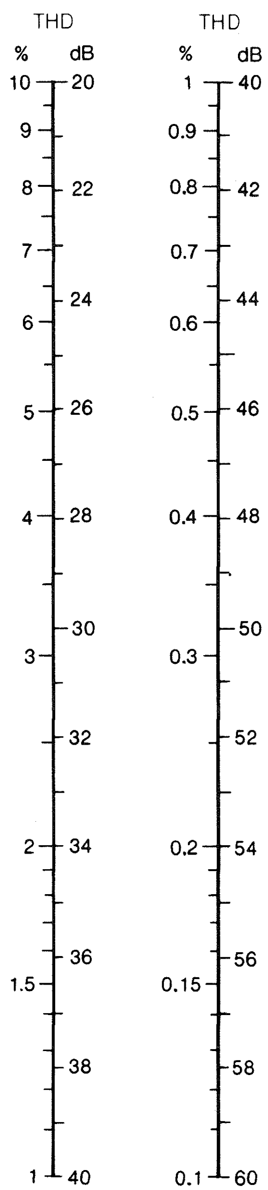
In addition to the total harmonic distortion, the **nth-order distortion factors** are also defined:

$D_2 = \frac{V_2}{V_a}$, 2nd-order distortion factor

$D_3 = \frac{V_3}{V_a}$, 3rd-order distortion factor

etc.

$$\mathrm{THD} = \sqrt{\left(\frac{V_2}{V_a}\right)^2 + \left(\frac{V_3}{V_a}\right)^2 + \dots \left(\frac{V_n}{V_a}\right)^2} = \sqrt{D_2^2 + D_3^2 + \dots D_n^2}$$



The total harmonic distortion THD in dB is also very much used:

$$\mathrm{THD} = 20 \log \frac{1}{\mathrm{THD}\ \%}$$

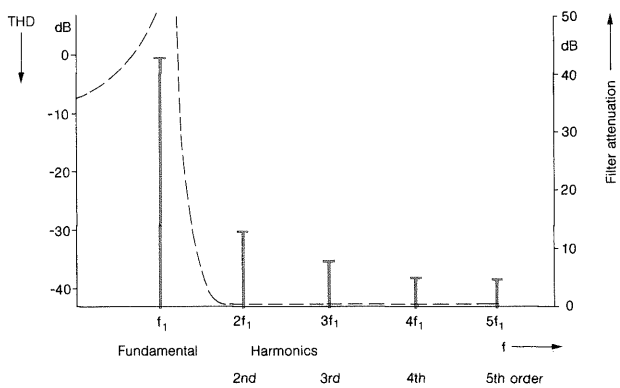
The diagram on the left simplifies the conversion of THD in dB into THD in percent.

Conversion of THD in dB into THD in %

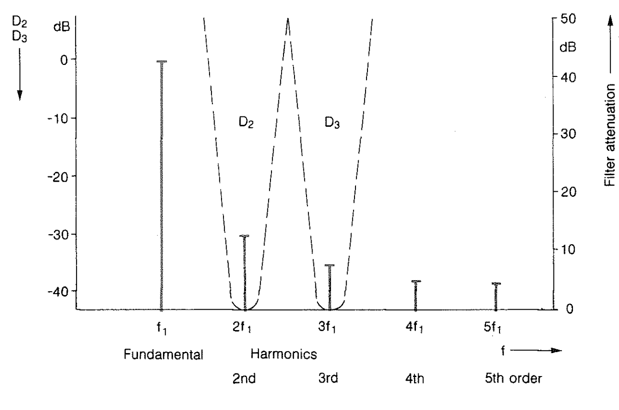
For measuring harmonic distortion the level meter of Rohde & Schwarz's AF Transmission Measuring Set SUN 2 is recommended, which has built-in highpass filters. In the three DISTortion settings 4 to 6 of the MODE switch, the unit will first automatically measure the level of the overall signal and store the value. Then a highpass filter is cut in to suppress the fundamental, and the level of the remaining harmonic mixture is measured (first diagram below). The level meter indicates the difference between this and the previously stored value, in other words the **total harmonic distortion** directly **in dB.** For measuring the **individual distortion factors D_2 and D_3** in dB, bandpass filters are cut in (MODE 7 and 8) that filter out the 2nd and 3rd harmonics (second diagram below). With these filters incorporated in the SUN 2 (180 Hz and 1.6 kHz), it is possible to measure distortion at the following frequencies:

distortion	**fundamental**
THD	40 Hz, 1 kHz, 4.7 kHz
2nd order D_2	90 Hz, 800 Hz
3rd order D_3	60 Hz, 533 Hz

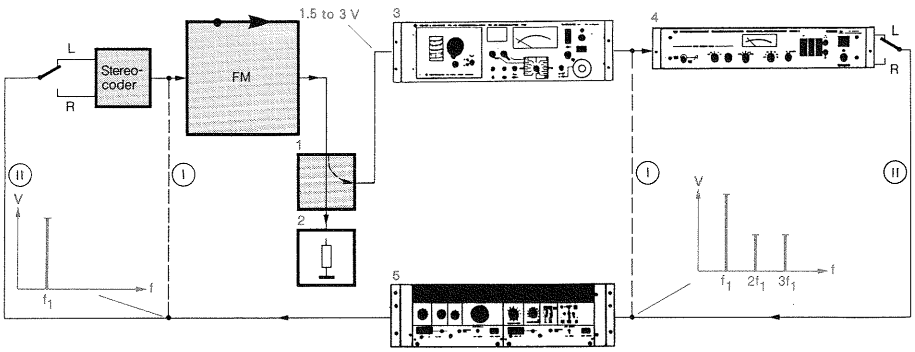
For measuring distortion at other frequencies, the level meter of the SUN 2 will have to be replaced by a selective level meter or AF analyzer.



Measuring THD in dB: highpass filter suppresses fundamental, and rms value of sum of all harmonics is taken (level values, fundamental 0 dB)



Measuring nth-order distortion: bandpass filters extract particular harmonic (level values, fundamental 0 dB)



1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 FM/AM Demodulator FAB (photo p. 12)
4 Precision Stereodecoder MSDC 2 (photo p. 13) (only for stereo transmitter)
5 AF Transmitter Measuring Set SUN 2 (photo p. 18)

Measurement Procedure

I. Mono transmitter

II. Stereo transmitter

The L and R channels are to be measured separately. The measurements described apply to one channel.

A. Basic settings

I: As on p. 5, section I.A.

II: As on p. 5, section II.A.

B. Measurement of total harmonic distortion in dB

1. Cut out preemphasis or deemphasis in all units.
2. Set test frequency (40 Hz, 1 kHz or 4.7 kHz) and frequency deviation on AF generator.
3. On level meter set DISTortion (MODE 4, 5 or 6) for corresponding frequency. THD is then indicated directly (with negative sign).

C. Measurement of 2nd- and 3rd-order distortion in dB

1. As for B.1.
2. Set frequency (see table below) and required frequency deviation on AF generator.
3. On level meter set FILTER (MODE 7 or 8). Display of level meter indicates — according to selected frequency and filter — 2nd- or 3rd-order distortion (D_2 or D_3) with negative sign (see table).

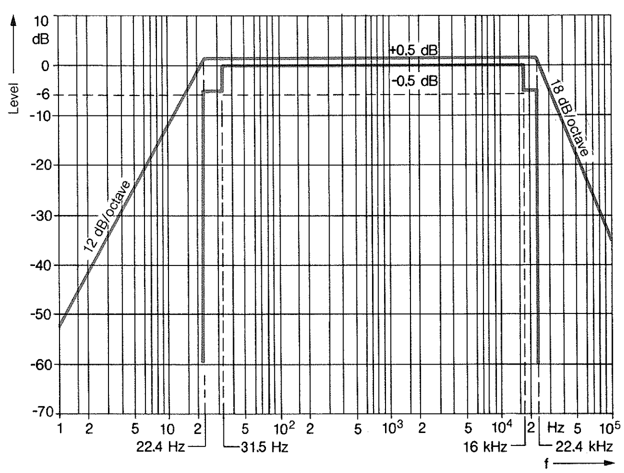
AF generator	**Level meter**		
Frequency	Filter	Mode	Indication
90 Hz	180 Hz	7	D_2
60 Hz	180 Hz	7	D_3
800 Hz	1.6 kHz	8	D_2
533 Hz	1.6 kHz	8	D_3

SPURIOUS MODULATION

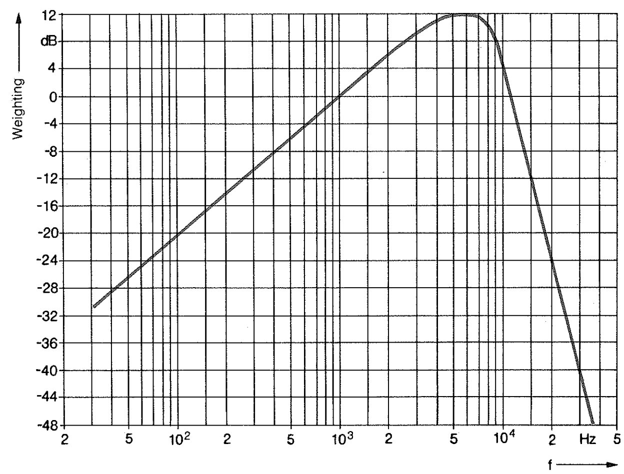
The noise voltages that appear in a transmitter when no modulation is applied are measured according to CCIR Recommendation 468-3 (Geneva 1982) or DIN 45405 (Nov. 83). A distinction is made between **unweighted** and **weighted noise levels.** The latter is measured by means of a special filter, the psophometer filter. According to the requirements mentioned above, the measurement is performed in both cases with quasi-peak-responding rectification so that the disturbing effect of pulses can be detected. The filter incorporated in the level meter of the AF Transmission Measuring Set SUN 2 (photo p. 18) and the rectifier circuit (in the PEAK setting) are in line with these requirements (see diagrams below). The filter is designed so that at a frequency of 1 kHz the weighting is 0 dB. With a sinusoidal voltage the quasi-peak-responding rectifier indicates the rms value (not the peak value).

With frequency-modulated transmitters, a distinction is made between the **FM noise level** (weighted and unweighted) and the **AM noise level**, which indicates undesired amplitude modulation of the frequency-modulated signal. The residual AM noise level (hum, noise) is independent of the modulation, the incidental AM noise level results from the modulation on narrowband resonant circuits and steep filter edges in the transmitter. Both are referred to amplitude modulation of 100% and are measured unweighted. They are of less significance because of the limiter circuits in receivers and are only dependent on the characteristics of the transmitter. Therefore they can only be measured in a mono mode (without stereo units).

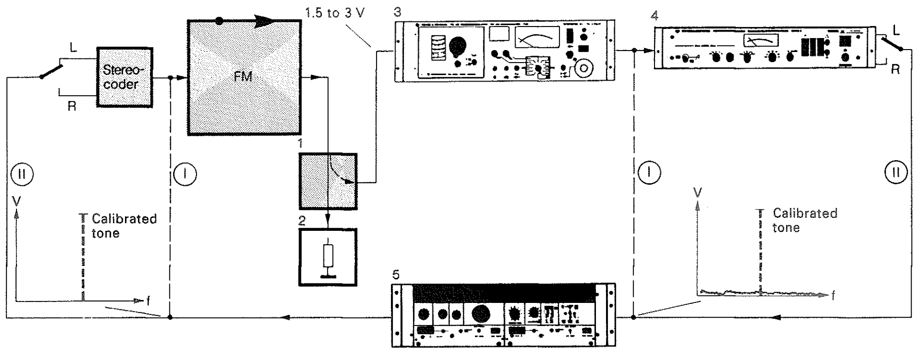
What are generally of interest are the noise levels referred to the useful or signal levels, i. e. the **signal/noise ratios.** These can be directly measured with the level meter of the AF Transmission Measuring Set SUN 2 after entering the signal level.



Tolerances for unweighted noise levels according to CCIR Rec. 468-3 and DIN 45405



Weighting curve for measuring weighted noise level according to CCIR Rec. 468-3 and DIN 45405



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Measurement Procedure

I. Mono transmitter

II. Stereo transmitter
The L and R channels are to be measured separately. The measurements described apply to one channel.

A. Basic settings

I: As on p. 5, section I.A.

II: As on p. 5, section II.A.

B. Measurement of unweighted FM signal/noise ratio

I:
1. Turn on preemphasis in transmitter and deemphasis in demodulator.

II:
1. Turn on preemphasis only in stereocoder, deemphasis only in stereodecoder.

2. Set reference deviation (e.g. 40 kHz) on AF generator with modulation frequency of 1 kHz.
3. Switch level meter to UNWEIGHTED (MODE 2), NORMal (dBm) and PEAK, following which the output voltage of demodulator or stereodecoder (e.g. +6 dBm) is indicated.
4. Switch level meter to REF (0 dB).
5. Separate AF generator from transmitter, short transmitter input. Unweighted signal/noise ratio is then indicated (with negative sign).

C. Measurement of weighted FM signal/noise ratio

1. As for B.1.
2. As for B.2.
3. Switch level meter to WEIGHTED (MODE 3), NORMal (dBm) and PEAK, following which the output voltage of demodulator or stereodecoder is indicated.
4. As for B.4.
5. Separate AF generator from transmitter, short transmitter input. Weighted signal/noise ratio is then indicated (with negative sign).

D. Measurement of residual AM signal/noise ratio

Basic settings I.A. also for stereo transmitters.
1. Separate AF generator from transmitter, short transmitter input.
2. Switch demodulator to AM, calibrate as prescribed and measure spurious AM modulation (in percent).
Conversion to dB levels as shown on page 6.

E. Measurement of incidental AM signal/noise ratio

Basic settings I.A. also for stereo transmitters.
1. Turn on preemphasis in transmitter and deemphasis in modulator.
2. Set reference deviation (e.g. 40 kHz) on AF generator with modulation frequency of 500 Hz.
3. Switch demodulator to AM, calibrate as prescribed and measure spurious AM modulation (in percent).
Conversion to dB levels as shown on page 6.

INTERMODULATION DISTORTION

to DIN 45403, sheet 3

General If several frequencies are fed into a transmission system, the nonlinearities can give rise to additional sum and difference frequencies besides the harmonics. The intermodulation distortion is the ratio of the sum of the particular difference tones to the peak value of the voltage mixture. With the intermodulation method two frequencies f_1 and f_2 of the same amplitude are used, these having a frequency interval of Δf (acc. to DIN 45403: 80 Hz). The even-order difference tones are removed from the frequency zero by multiples of Δf. The odd-order difference tones are removed from the frequencies f_1 and f_2 by multiples of Δf (see diagrams below). The 2nd- and 3rd-order difference tones that are of interest here have the following frequencies:

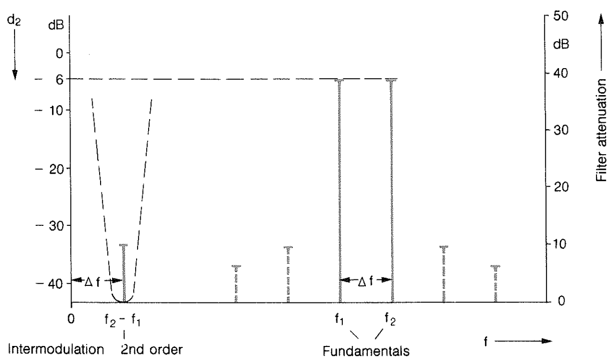
2nd order $f_2 - f_1$
3rd order $2f_1 - f_2$ and $2f_2 - f_1$

The corresponding intermodulation distortion is:

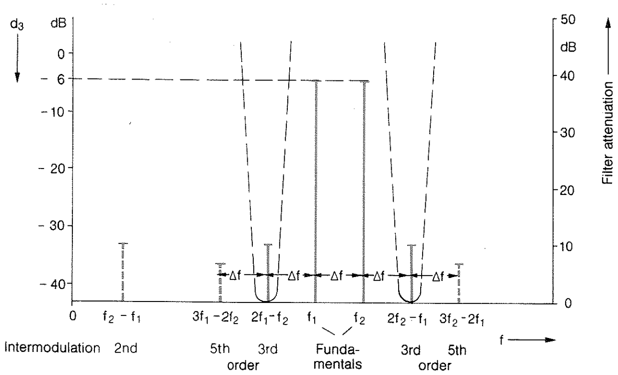
$$d_2 = \frac{V_{(f_2 - f_1)}}{V_a \sqrt{2}}$$

$$d_3 = \frac{V_{(2f_2 - f_1)} + V_{(2f_1 - f_2)}}{V_a \sqrt{2}}$$

V_a rms value of mixture



Measuring 2nd-order intermodulation distortion d_2 (level values, 0 dB: sum level)



Measuring 3rd-order intermodulation distortion d_3; amplitudes of two difference tones must be added (level values, 0 dB: sum level)

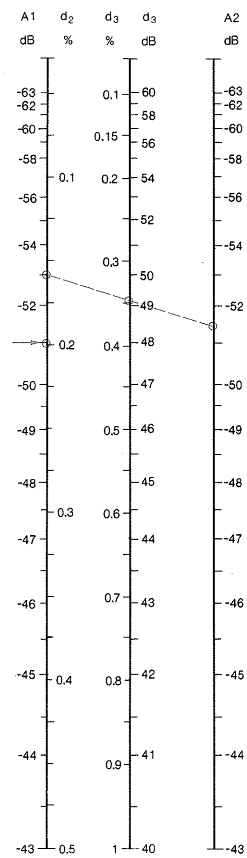
Determination of intermodulation distortion with the AF Transmission Measuring Set SUN 2 With the 180-Hz and 1.6-kHz bandpass filters in the level meter of the AF Transmission Measuring Set SUN 2 from Rohde & Schwarz (photo p. 18), it is possible to determine the 2nd-order intermodulation distortion if the two measurement frequencies have a spacing of 180 Hz. The 3rd-order intermodulation distortion can be determined for the measurement frequencies 653 Hz and 1127 Hz because at these frequencies the two difference tones fall within the passbands of the filters. Unlike in the recommendations of DIN 45403 (80 Hz) and of the DBP/ARD standard specifications (1000 Hz), the spacing between the two measurement frequencies is in this case 474 Hz. This is of no importance, however, because the frequency response of transmitters is highly linear in most cases. Due to the fact that the intermodulation distortion is referred to the peak value of the voltage mixture ($V_a \sqrt{2}$), and that the level meter measures the rms value (V_a), there is a difference of 3 dB between the indicated value and the actual intermodulation distortion.

The circuit illustrated below enables simple combination of two AF Generators SUN 2/S for these measurements.

Conversion With 3rd-order intermodulation distortion in particular, calculation can be rather involved, and this is simplified by the straight-line chart on the right, from which the intermodulation distortion d_2 and d_3 can be read off in percent and dB (A1 and A2 are the values read on the SUN 2, d_2 and d_3 are results).

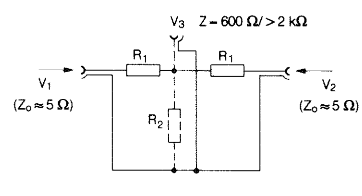
2nd order
(only lefthand scale)
d_2 [dB] = $|A1|$ +3;
d_2 [%] read off at A1;
example:
A1 reads −51 dB,
therefore d_2 = 54 dB or 0.2%.

3rd order (all scales)
values read A1 and A2, result d_3 in dB and %;
example:
A1 = −53 dB,
A2 = −51.4 dB,
therefore d_3 = 49.2 dB or 0.35%.

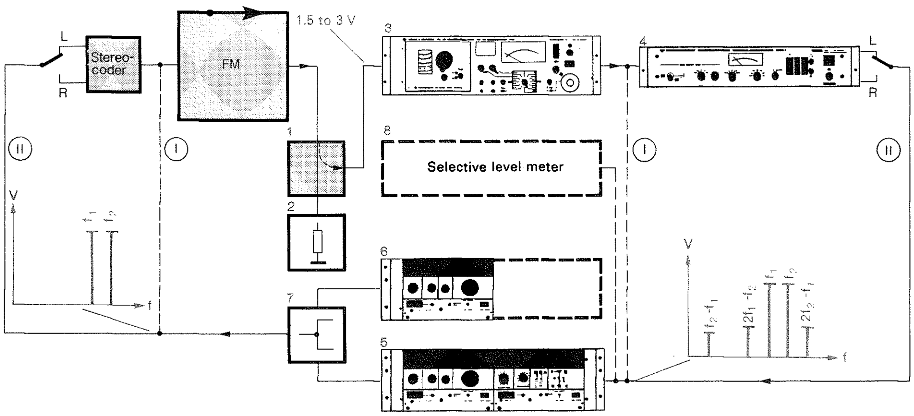


Straight-line chart for calculating intermodulation distortion d_2 and d_3 in dB and %

Branching circuit for two AF Generators SUN 2/S.
R_1 = 390 Ω ±2%,
R_2 = ∞ for R = 600 Ω,
820 Ω for R > 2 kΩ;
attenuation
$\frac{V_3}{V_1} = \frac{V_3}{V_2}$ approx. 8 dB,
isolation
$\frac{V_2}{V_1}$ approx. 45 dB



transmission times



1 Directional coupler (incorporated in transmitter)

2 Dummy antenna (according to transmitter power)

3 FM/AM Demodulator FAB (photo p. 12)

4 Precision Stereodecoder MSDC 2 (photo p. 13) (only for stereo transmitter)

5 AF Transmission Measuring Set SUN 2 (photo p. 18)

6 AF Generator SUN 2/S (photo p. 18)

7 Branching circuit (600 Ω, diagram opposite)

8 Selective level meter or AF analyzer

Measurement Procedure

I. Mono transmitter

II. Stereo transmitter

The L and R channels are to be measured separately. The measurements described apply to one channel.

A. Basic settings

1. Connect one AF generator directly to transmitter input or (with stereo transmitter) to one input of stereocoder. Then carry out basic settings:

as on p. 5, section I.A. — as on p. 5, section II.A.

2. Connect both AF generators via branching circuit to transmitter input or (with stereo transmitter) to one input of stereocoder. Turn on both AF generators.
3. Set one AF generator for minimal output level and other for half test deviation (e.g. 20 kHz) and note level indication (with stereo transmitter cut out pilot tone only for this).
4. Set second AF generator to same level as other.

B. Measurement of 2nd-order intermodulation distortion

1. Cut out preemphasis or deemphasis in all units.
2. Set AF generators to 1000 Hz and 1180 Hz.
3. Switch level meter to FILTER 180 Hz (MODE 7). It then indicates 2nd-order intermodulation distortion, reduced by 3 dB, with negative sign (see straight-line chart opposite for conversion into intermodulation distortion as percentage).
4. Measurements can be performed at any frequencies above 500 Hz (with $\Delta f = 180$ Hz), preferably at 1/1.18 kHz, 5/5.18 kHz, 14/14.18 kHz. Conversion as under 3.

C. Measurement of 3rd-order intermodulation distortion

1. As for B.1.
2. Set AF generators to 653 Hz and 1127 Hz.
3. Switch level meter to FILTER 180 Hz (MODE 7). It then indicates attenuation of lower difference tone, reduced by 3 dB, with negative sign.
4. Switch level meter to FILTER 1.6 kHz (MODE 8). It then indicates attenuation of higher difference tone, reduced by 3 dB, with negative sign.
5. Calculate 3rd-order intermodulation distortion in dB and % from **indicated** values according to points 3. and 4. using straight-line chart opposite.

Measurement with the Level Meter SUN 2/U is only possible at the frequencies given above. If measurements are to be performed at other frequencies, a selective level meter or AF analyzer will be required.

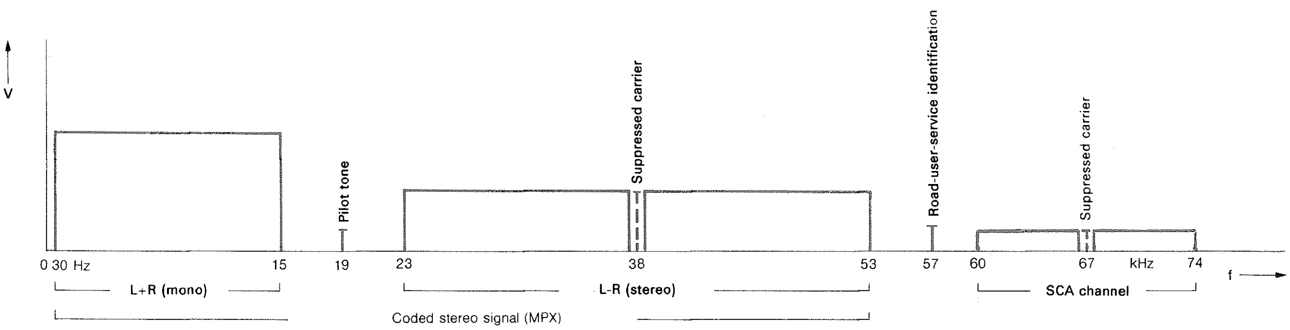
STEREO CROSSTALK

General The stereo signals in FM sound broadcasting are transmitted by the pilot-tone method defined in CCIR Recommendation 450, section 2. The sum of the left and right information channels L and R produces the mono signal M (middle), which is transmitted normally and provides for monophonic reproduction in mono receivers. The additional signal for stereo, L − R = S (side), is transmitted as amplitude modulation on a subcarrier of 38 kHz. The bandwidth of the individual signals L and R is 30 Hz to 15 kHz, and so the mono signal L + R is also in this region; the additional signal for stereo L − R covers the band 23 to 53 kHz. In the gap between the M and S signals is the pilot tone (19 kHz), which serves for synchronizing the 38-kHz subcarrier in demodulation and is at the same time the identification for stereo broadcasts. The diagram below illustrates the channel occupancy with FM sound transmitters.

In some countries the band above 53 kHz is used for other signals. In the Federal Republic of Germany, for instance, the identification for the road-users' information service is at 57 kHz, this identifying stations that broadcast traffic information and their regional coverage by means of different modulation frequencies. Above this frequency, in what is called the SCA channel (60 to 74 kHz), there is room for still more information, e.g. music broadcasts (of lower quality). These will not be dealt with here, however.

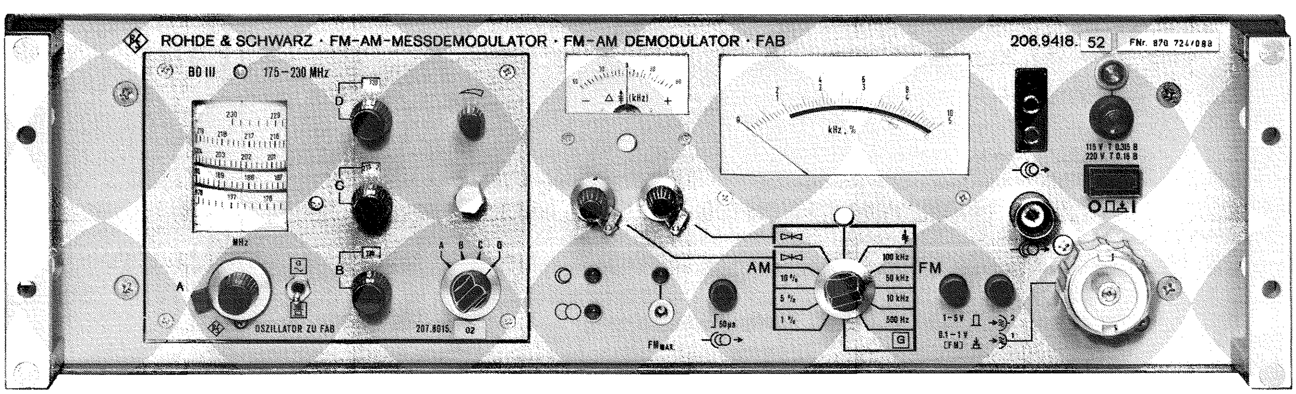
Measurement of crosstalk between L and R channels In stereo operations and reception, the crosstalk between the two channels L and R, or rather its rejection, is a factor of importance. The minimum values called for in the standard specifications of the Federal-German association of broadcasters (ARD) and the Federal-German post and telecommunications authority (DBP) are relatively low. Modern transmitters can achieve considerably better figures, especially at the band limits.

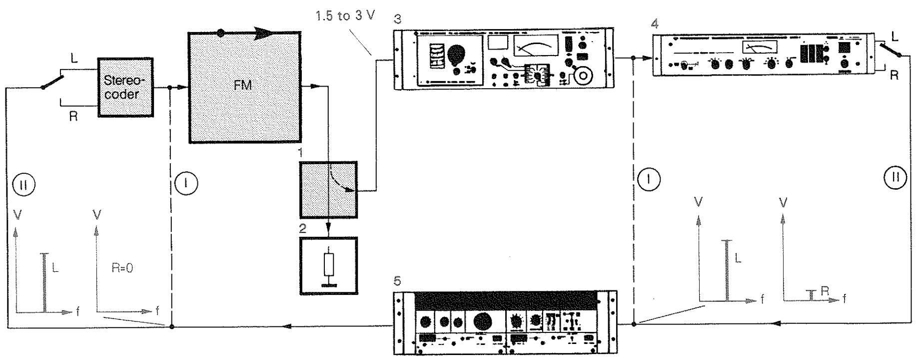
The measurement itself is simple to carry out: one just has to measure the voltage at the decoder output for the channel that is not fed with a signal. What is important is low crosstalk at the medium to high frequencies (directional information).



Channel occupancy of FM sound transmitters

FM/AM Demodulator FAB





1 Directional coupler (incorporated in transmitter)

2 Dummy antenna (according to transmitter power)

3 FM/AM Demodulator FAB (photo opposite)

4 Precision Stereodecoder MSDC 2 (photo below)

5 AF Transmission Measuring Set SUN 2 (photo p. 18)

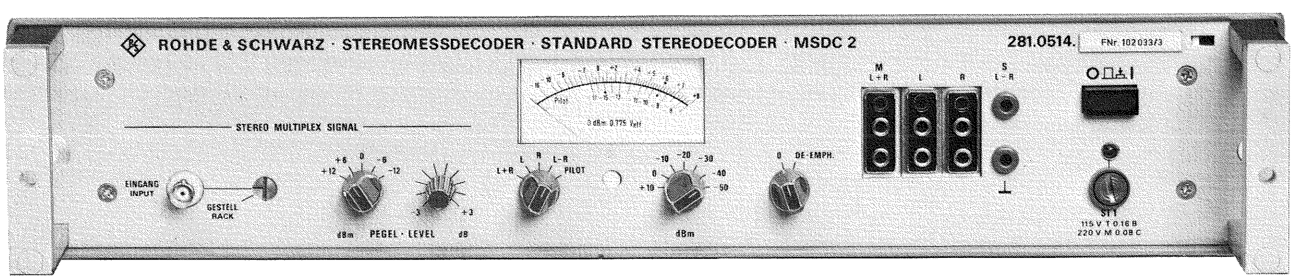
Measurement Procedure

A. Basic settings
As on p. 5, section II.A.

B. Measurement of crosstalk attenuation between L and R channels

1. Cut out preemphasis and deemphasis in all units.
2. Feed channel L of stereocoder with frequency of 500 Hz at level of +6 dBm.
3. Switch level meter to 10 Hz to 100 kHz (MODE 1) and NORMal (dBm) and connect to L output of stereodecoder. Output level +6 dBm is indicated.
4. Switch level meter to REF (0 dB) and connect to R output of stereodecoder.
5. Vary frequency on AF generator over required range (e.g. 40 Hz to 15 kHz). Crosstalk attenuation between L and R is then indicated directly (with negative sign).
6. Repeat measurement in analogous manner for R channel.

Precision Stereodecoder MSDC 2



OUTPUT POWER

Principle An exact measurement of the output power of a transmitter is elaborate and calls for considerable care. An equipment producer generally performs such a measurement with a high level or precision because — particularly in the case of vision transmitters — the quality depends on accurate setting of the power.

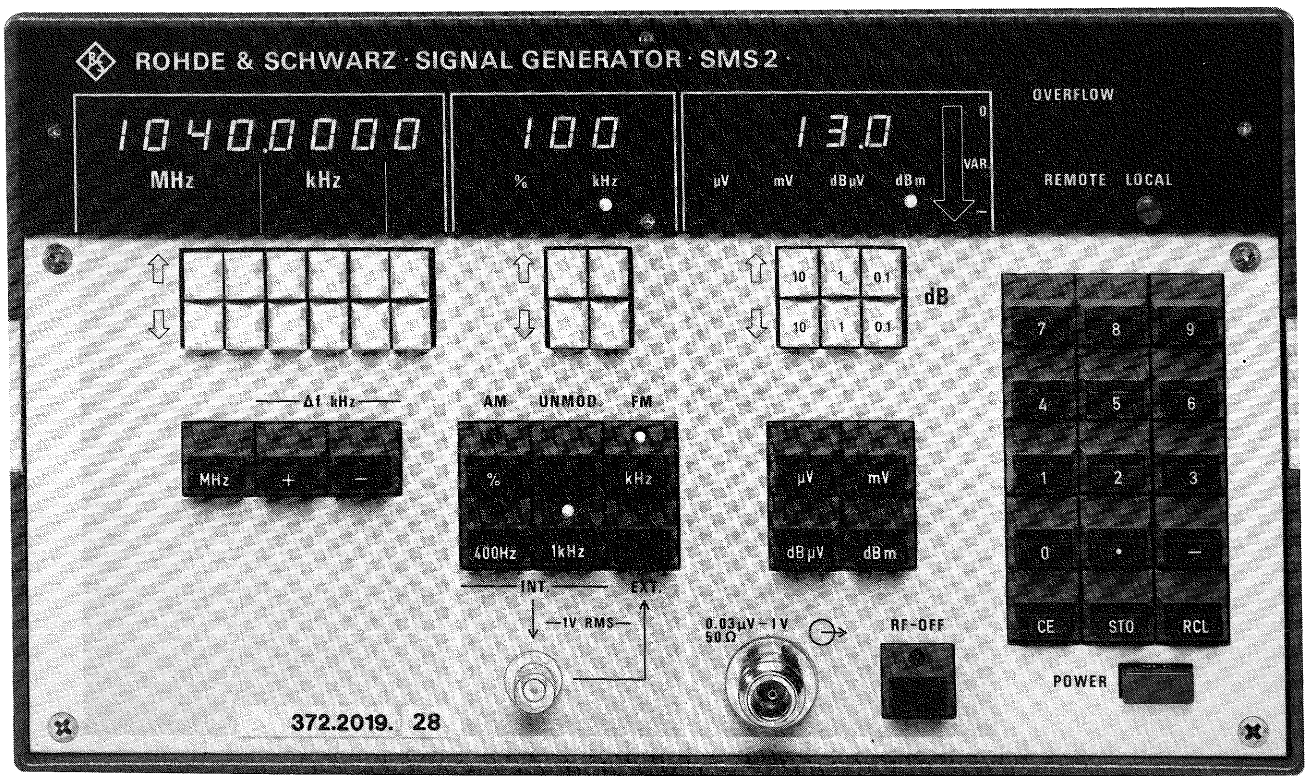
Power is measured in two stages. The coupling of the test point is first measured, and then the secondary power. The actual power can be calculated from these two values. A set of exactly dimensioned high-power attenuators is required to determine the coupling (between 35 and 60 dB depending on the output power of the transmitter). The attenuation can be measured easily using the Signal Generator SMS 2 and the Power Meter NRV from Rohde & Schwarz. The NRV is also used to measure the secondary power. It can also calculate the actual power after entering the value of the coupling.

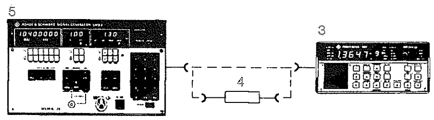
Measurement of high-power attenuators High-power attenuators are measured with a power meter and a signal generator. A maximum attenuation of only 20 dB (possibly 30 dB) should be measured at one time to ensure that the accuracy of the power meter is adequate. Higher attenuations can be achieved by using several attenuators.

Determination of coupling The coupling at a test output is best determined with a simulation formed of attenuators (measured beforehand) instead of a dummy antenna and with a very accurate power meter of high sensitivity (this should be calibrated in dB). The required setting of the transmitter to an appropriately low power (e.g. 100 W maximum with a 10-kW transmitter) calls for steps that have to be decided on in each individual case (such as the bypassing of intermediate stages and the like). Under no circumstances may the RF air-line system of the output stage with the test point be altered (mechanical tensioning could alter the coupling for instance). The high-power attenuators must be capable of handling the power applied. The RBU series from Rohde & Schwarz is suitable for this purpose, with models for up to 100 W (see photo on p. 16).

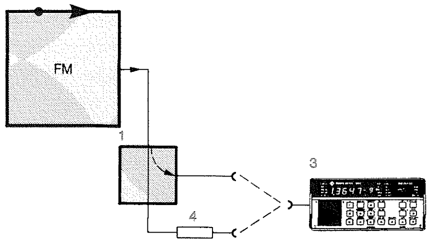
Measurement of secondary power and output power The secondary power at the test output of a transmitter is determined using a power meter, which is also required for measuring the high-power attenuators. After entering the values of the coupling, it indicates the actual power at the transmitter output.

Signal Generator SMS 2

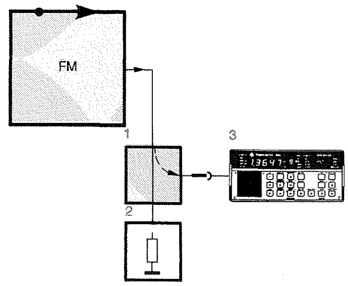




Measurement of attenuators



Determination of coupling



Measurement of secondary power at test output

1 Directional coupler (incorporated in transmitter)

2 Dummy antenna (according to transmitter power)

3 Power Meter NRV (photo p. 31) with Sensor NRV-Z2

4 High-power Attenuators RBU, 3, 10, 20, 30 dB; max. 100 W (photo p. 16)

5 Signal Generator SMS 2 (photo opposite), 0.1 to 1040 MHz

(**6** Directional Power Meter NAUS 4, see section C.)

Measurement Procedure

A. Basic settings
As on p. 5, section I.A. or II.A. Short modulation inputs.

B. Measurement of attenuators (top left)
1. Set signal generator to transmitter frequency and maximum output level (no modulation).
2. Connect sensor of Power Meter NRV directly to signal generator output; the power is indicated in Watt.
3. Press the SEL DIM (select dimension) key on the NRV until dBm is indicated in the display. The signal generator power is now indicated in dB referred to 1 mW into 50 Ω.
4. Press the SHIFT and STO (store) keys (the measured value is then stored as the reference value).
5. Press ΔINT and then SEL REL until ΔdB is indicated in the display. The difference between the measured power and the stored value is indicated in dB (0 dB in this example).
6. Disconnect the sensor from the signal generator and screw the attenuator to be measured directly onto the signal generator output. Connect the sensor to the output of the attenuator. Do not change the SMS 2 and NRV settings.
7. The NRV indicates the attenuation in dB (negative sign). All attenuators can be measured in succession with the same setting so that a set of exactly dimensioned attenuators is then available.

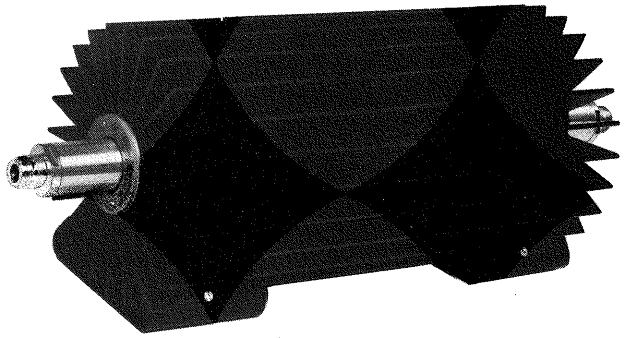
C. Determination of coupling (top centre)
1. For this measurement the power at the transmitter output may be 50 W maximum so that attenuators are not overloaded. This calls for modifications of the internal connections (bypassing of intermediate stages or the like) to ensure that the transmitter under no circumstances outputs more power. If required, connect directional power meter, e.g. NAUS 4 from Rohde & Schwarz, in line to dummy antenna (adapters necessary).
2. Combine measured attenuators to approximately achieve expected coupling (connect directly, no intermediate cables) and connect directly to transmitter output (instead of dummy antenna).
3. Connect sensor of NRV to directional coupler output of transmitter.
4. Turn on transmitter. Press the ABSOLUTE key on the NRV; the power is indicated in Watt. Select the unit dBm using SEL DIM. The display is now in dB referred to 1 mW.
5. As for B.4.
6. As for B.5.
7. Separate sensor from test output and connect directly to output of attenuators.
8. Power meter then shows difference between attenuation of directional coupler and attenuators.
9. The coupling is thus:
   $a_c = a_a + a_p$
   a_c coupling (dB)
   a_a total attenuation of attenuators (dB)
   a_p value indicated on power meter (dB)

D. Calculation of true power (top right)
1. Connect transmitter to the dummy antenna again and remove modified connections set up under C. Connect sensor of NRV to test output of transmitter.
2. Press SHIFT and mark ATT/dB (attenuation) in display using INP key. Enter the coupling value determined in C.9. using the numeric keypad and press STO.
3. Press ABSOLUTE. The secondary power is displayed in Watt.
4. After pressing ATT CORR, the NRV displays the actual output power of the transmitter.

SPURIOUS EMISSIONS

Harmonics of the transmitter frequency must be limited to very low values according to the standard specifications to prevent interference with other services. This also applies to mixture signals which may occur with certain transmitters depending on the type of frequency generation. Either a receiver of high sensitivity and adequate selectivity, e. g. the Test Receiver ESV (photo below) or a frequency analyzer, e. g. the TV Transcope MUF 2 (photo on p. 104), both from Rohde & Schwarz, is recommended for the measurement. Measurement using a frequency analyzer has the advantage that the frequency spectrum of interest can be displayed with all occurring frequencies, whereas with the receiver measurement all frequencies have to be searched for individually.

When attenuating harmonics of more than 60 dB — as required in the standard specifications for transmitter powers above 1 kW — it is advantageous to suppress the carrier to prevent the formation of harmonics in the analyzer. Either a rejector circuit tuned to the carrier can be used or a highpass which only allows the harmonics to pass. The carrier suppression can be determined using the analyzer.



Power
Attenuator RBU for 100 W

Measurement Procedure

I. Measurement with the TV Transcope MUF 2

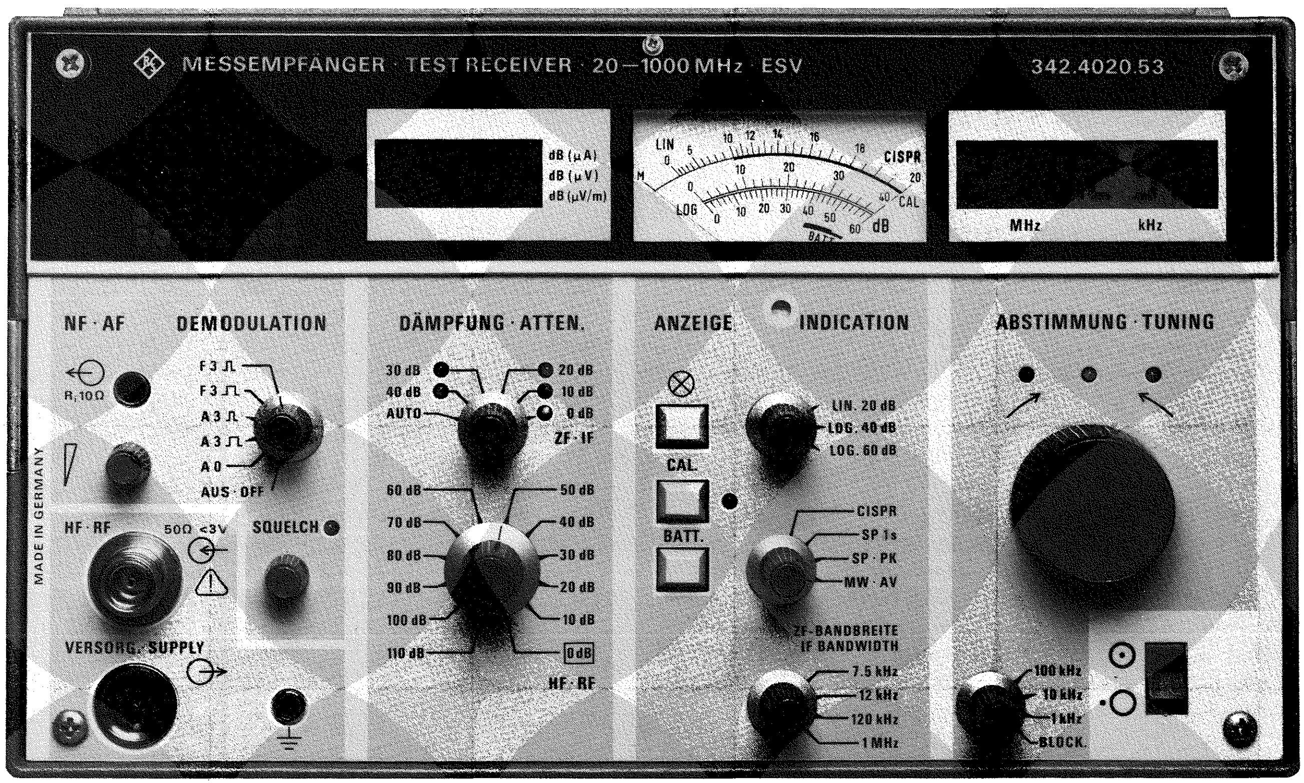
A. Basic settings

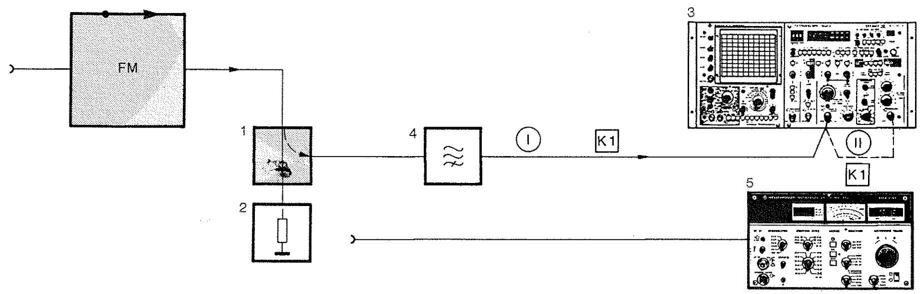
1. As on p. 5, section II. A.
2. Connect directional coupler to input of selective demodulator in MUF 2 (①).
3. Short modulation input of transmitter.

B. Calibration of test equipment

1. Calibrate Transcope in setting LOG of selective demodulator (p. 98).
2. Set curve to readily evaluatable value using ATTEN RF (do not set below 0 dB), with control ↕ fully clockwise. Set curve to centre of display using TUNING FINE.
3. Position peak of curve to highest graticule line using ↕.
4. Press LEVEL key and set level line to peak of curve. Press ΔdB key, output on display becomes 0 dB.

Test Receiver ESV





1 Directional coupler (incorporated in transmitter)

2 Dummy antenna (according to transmitter power)

3 TV Transcope MUF 2 (photo p. 104) for display of spectrum

4 Highpass $f_{lim} \approx 150$ MHz/50 Ω for display of spectrum (e.g. NHP 200 from Mini Circuits)[1])

5 Test Receiver ESV for selective measurement (photo p. 16)

K1 Precision test cable used for the calibration of the MUF 2

Measurement Procedure (continued)

C. Determination of spurious emissions
Determine from the circuit diagram whether spurious is to be expected, and at what frequencies. If yes, proceed as follows:

1. Increase sweep to 5 MHz/DIV and switch on FREQ MARK 10/1. Increase the attenuation further using ATTEN RF until spurious, if any, becomes visible.
2. Adjust level line to peak of spurious emissions. The display indicates the offset from the carrier.

D. Determination of harmonics of transmitter frequency

1. Increase sweep to 50 MHz/DIV, switch on FREQ MARK 100/10. Shift the carrier to approximately the second grid line from the left using TUNING COARSE and FINE.
2. Disconnect the precision test cable K1 to the selective demodulator input from the directional coupler output and connect to the generator output of the MUF 2 (connection (II)). Adjust the generator level such that the resulting line cuts the level line (set to 0 dB on the display) at the transmitter frequency. For more exact determination, switch to FREQ MARK 10/1 again if necessary.
3. Determine the level deviation at the expected frequencies of the harmonics using the level line and note (e.g. at $2f_p$: −1.5 dB).
4. Reestablish original connection to directional coupler ((I)). The peak of the carrier must be at 0 dB. Switch on highpass; the reduction in carrier can be measured using the level line.
5. Increase the gain in the selective demodulator until the harmonics are visible. Measure the level referred to the fundamental using the level line.
6. Correct the level values using the values determined in 3. The actual value is the displayed value minus the correction value, e.g.
   −62 dB — (−1.5 dB) = −60.5 dB,
   i.e. the attenuation (or offset) of the harmonics is 60.5 dB.

II. Measurement with Test Receiver ESV
Note A highpass is not required because test receivers have a much higher overload capacity than spectrum analyzers. The harmonics of the transmitter frequency and the spurious emissions can be measured in the same manner as with an analyzer and also at greater accuracy.

A. Basic settings

1. As for I.A.1.
2. Connect receiver input to output of power attenuator.
3. Test receiver setting: ATTEN IF 0 dB, ATTEN RF 70 ... 80 dB, IF BANDWIDTH 120 kHz, operating mode SP, DISPLAY LOG 60 dB, DEMODULATION OFF.
4. Prior to measurement, press CAL briefly.

B. Calibration of equipment

1. Tune receiver to transmitter frequency and tune to maximum on meter (centre LED above rotary knob should light up). Reduce RF ATTEN until meter shows approx. full-deflection.
2. Note measured value. Add the value displayed on the left and the meter value.

C. Determination of harmonics of transmitter frequency and of spurious emissions

1. Tune receiver to frequency of harmonics and spurious emissions which may have been determined in I.C.1. Reduce RF ATTEN by approx. 60 dB to this end.
2. The attenuation of the harmonics or spurious emissions is the difference between the measured value at the transmitter frequency and the respective measured value.
   Example:

Measured value at transmitter frequency	70 + 57 dB
− Measured value at a harmonic	−(10 + 54 dB)
Offset of harmonics	60 + 3 dB

[1]) German agent:
Industrial Electronics GmbH
D-6000 Frankfurt/Main
Telephone: 069/724752

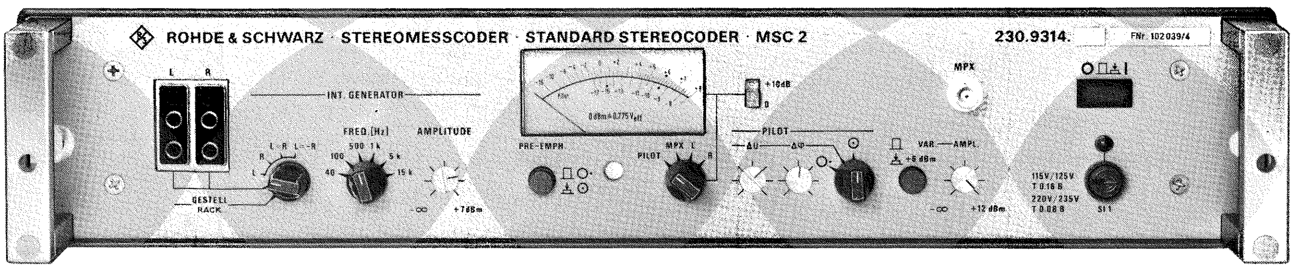
FM

STEREO CAPABILITY OF MONO TRANSMITTERS

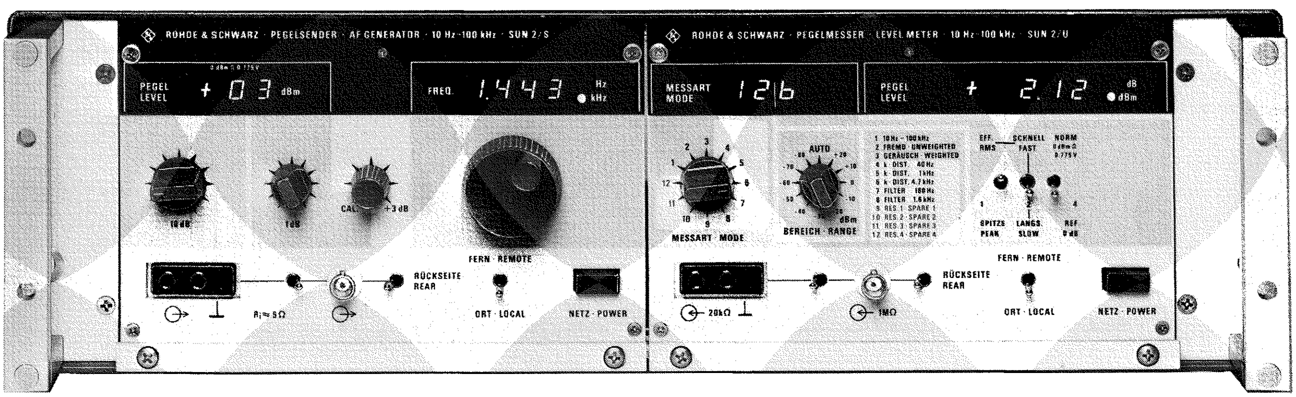
If a mono transmitter is to be converted for stereo operation, the frequency response of the amplitude and the phase must satisfy certain conditions. The frequency response of the amplitude can be determined directly, that of the phase indirectly by way of the crosstalk values.

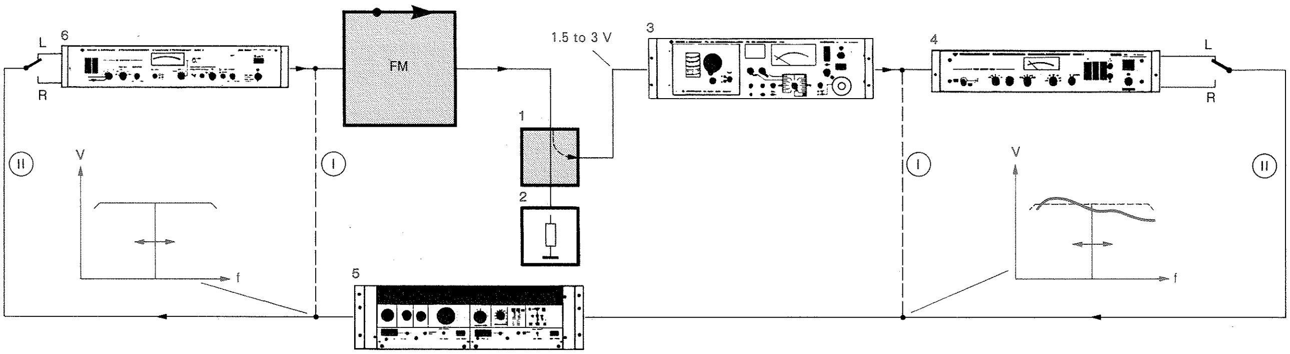
The measurements are best performed in the following order: first the frequency response of the amplitude is determined; if the results of this measurement are satisfactory, the crosstalk values can then be determined with the Precision Stereocoder MSC 2. The built-in AF generator in the MSC 2 with six fixed frequencies simplifies and speeds up the measurements. If the results meet the requirements, the frequency response, harmonic distortion, noise level etc. of the individual channels can be measured.

Precision Stereocoder MSC 2



AF Transmission Measuring Set SUN 2





1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 FM/AM Demodulator FAB (photo p. 12)
4 Precision Stereodecoder MSDC 2 (photo p. 13)
5 AF Transmission Measuring Set SUN 2 (photo opposite)
6 Precision Stereocoder MSC 2 (photo opposite)

Measurement Procedure

I. Measurements on transmitter alone
(without stereocoder)

A. Basic settings
As on p. 5, section I.A. (level +6 dBm).

B. Measurement of frequency response
As on p. 5, section B. (frequency band 30 Hz to 53 (75) kHz).

II. Measurements on transmitter with connected Precision Stereocoder MSC 2

A. Basic settings
As on p. 5, section II.A.

B. Measurement of crosstalk between L and R channels
In analogous manner to p. 13, section B. Instead of AF generator of SUN 2, built-in generator of stereocoder can be used. Following settings are then necessary:

1. Set input selector to L, turn off PILOT, meter selector on MPX, PREEMPHasis off.
2. Set meter to +6 dBm with AMPLITUDE, then switch on PILOT (PILOT indication must be −9.5 dBm).
3. through 6.
   As on p. 13, B.3. through B.6. Switch frequency on stereocoder to 40, 100, 500 Hz, 1, 5 and 15 kHz. Any intermediate values required can be set with AF generator of SUN 2.

C. Measurement of frequency response in individual channels
As on p. 5, section II.B. through II.D.

D. Measurement of harmonic distortion
As on p. 7, sections B. and C.

E. Measurement of spurious modulation
As on p. 9, section II.B. through II.E.

F. Measurement of intermodulation distortion
As on p. 11, section A. through C.

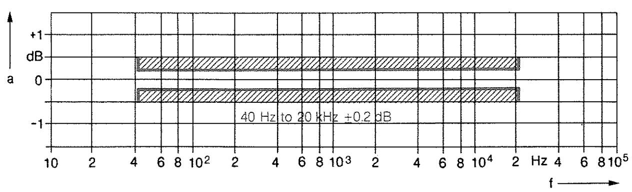
MEASUREMENTS ON TV SOUND TRANSMITTERS (single sound)

Only in the case of TV transmitters with *separate* vision and sound amplification is separate sound transmitter provided which also has to be measured independently. With *combined* vision/sound amplification the vision and sound signals are combined at low power and amplified together in the power stages. If the vision power is disconnected (so that the "sound transmitter" can be measured alone), the driving of the power-output stages is very much altered, and the measured values are then no longer realistic. The following measurements are therefore based on simultaneous operation of the vision and sound transmitter. It is assumed that the vision transmitter, without modulation, will deliver a continuous wave. If this is not the case, a video-test-signal generator has to be connected, which for some measurements is necessary anyway. Because the vision and sound signals are present simultaneously, an instrument is required which can clearly separate them. This is not the case in the FM/AM Demodulator FAB which has been designed for sound broadcasting transmitters. The new TV Dual-Sound Demodulator FATF is used instead and also enables measurements on TV dual-sound transmitters. These are dealt with separately because of the special measurement procedure (dual-sound measurements from p. 28 onwards).

FREQUENCY RESPONSE OF AMPLITUDE, PREEMPHASIS

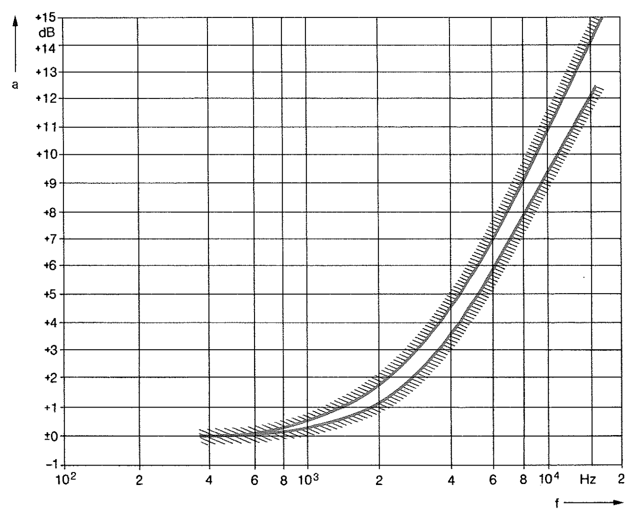
The sound transmitters with frequency modulation that are looked at here are very similar to monophonic sound-broadcasting transmitters and, like them, contain a disconnectible preemphasis that accentuates the high frequencies with a time constant of 50 µs (diagram right). This can be included in the measurement of the frequency response. The tolerances for the frequency response of the amplitude in the case of TV sound transmitters broadcasting single sound are shown in the diagram below.

For these measurements Rohde & Schwarz offers, in addition to the AF Transmission Measuring Set SUN 2 used for measurements on sound broadcasting transmitters, the TV Dual-Sound Demodulator FATF. This enables measurements on TV sound transmitters with one or two sound channels without interference from the vision carrier.

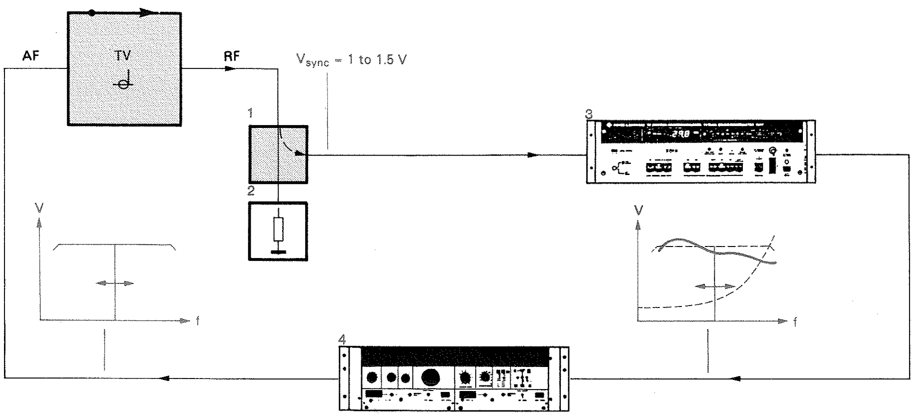


Tolerances for frequency response of amplitude (without preemphasis) of TV sound transmitters (single sound) according to standard specifications of DBP/ARD

The FATF is available with an RF or an IF input. The model with the IF input must be used together with the TV Demodulator AMF 2 which is required for all measurements on TV vision transmitters.



Tolerances for preemphasis (50 µs ±5 µs) of TV sound transmitters (single sound)



1 Directional coupler (incorporated in transmitter)

2 Dummy antenna (according to transmitter power)

3 TV Dual Sound Demodulator FATF (photo p. 22)

4 AF Transmission Measuring Set SUN 2 (photo p. 18)

Measurement Procedure

A. Basic settings
(TV Dual Sound Demodulator FATF with RF input)[1])

1. Connect directional coupler output to RF input of FATF (rear panel), set level range II (rear panel).
2. Connect AF output of FATF to level meter input of SUN 2.
3. Insert crystal for the vision carrier frequency into the FATF and tune oscillator according to manual. Press RF, FM and K1 keys.
4. Set prescribed level (e.g. 0 dBm) on AF generator of SUN 2 at 500 Hz (reference frequency).
5. Set prescribed frequency deviation in transmitter (reference deviation, e.g. 30 kHz). Do not alter setting any more.

The basic settings apply to all further measurements on TV sound transmitters (mono and dual sound).

B. Measurement of frequency response of amplitude without preemphasis and deemphasis

1. Disconnect preemphasis in transmitter and deemphasis in demodulator.
2. Set required measurement deviation (e.g. 30 kHz) on AF generator at 500 Hz (displayed on FATF).
3. Set level meter to 10 Hz to 100 kHz (MODE 1) and NORMal (dBm), following which output level of demodulator is indicated (e.g. +6 dBm).
4. Switch level meter to REF (0 dB).
5. Vary frequency on AF generator over required range (e.g. 30 Hz to 15 kHz). Difference from reference value is indicated.

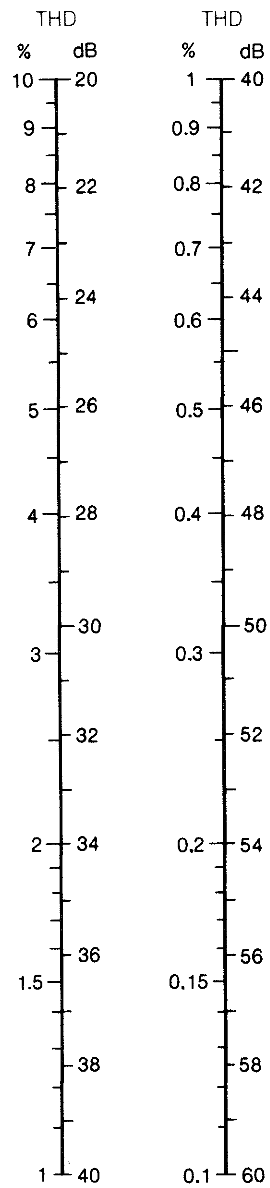
C. Measurement of preemphasis

1. Turn on preemphasis in transmitter and disconnect deemphasis in demodulator.
2. On AF generator, at 500 Hz, set $^1/_5$th (−14 dB) of test deviation (e.g. 6 kHz).
3. As for B. 3. (indication e.g. −8 dBm).
4. As for B. 4.
5. As for B. 5.

[1]) A TV Demodulator AMF 2 must be connected ahead in case of dual-sound demodulators without RF input and must be tuned when equipped with the corresponding crystal for the vision carrier frequency. The FATF must be connected to the IF output of the AMF 2 and switched to IF 1. All further settings as above.

HARMONIC DISTORTION

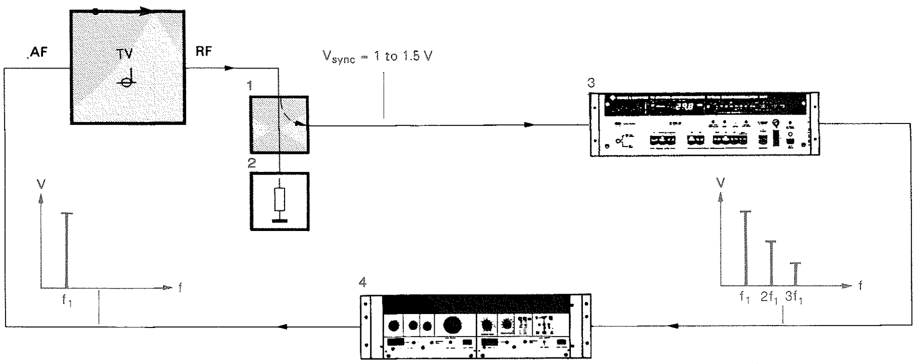
Harmonic distortion is measured in a similar fashion with TV sound transmitters as with monophonic sound-broadcasting transmitters. The distortion factors are defined on page 6. The only difference is that a different demodulator is used.



Conversion of THD in dB into THD in %

TV Dual Sound Demodulator FATF

HARMONIC DISTORTION



1 Directional coupler (incorporated in transmitter)

2 Dummy antenna (according to transmitter power)

3 TV Dual Sound Demodulator FATF (photo p.22)

4 AF Transmission Measuring Set SUN 2 (photo p.18)

Measurement Procedure

A. Basic settings

As on p.21.

B. Measurement of total harmonic distortion in dB

1. Disconnect preemphasis in transmitter and deemphasis in demodulator.
2. Set required test frequency (40 Hz, 1 kHz or 4.7 kHz) and frequency deviation on AF generator.
3. On level meter set DISTortion (MODE 4, 5 or 6) for corresponding frequency. THD is then indicated directly (with negative sign).

C. Measurement of 2nd- and 3rd-order distortion in dB

1. As for B.1.
2. Set frequency (see table right) and required frequency deviation on AF generator.
3. On level meter set FILTER (MODE 7 or 8, see table right). Display of level meter indicates — according to selected frequency and filter — 2nd- or 3rd-order distortion (D_2 or D_3) with negative sign.

AF generator	**Level meter**		
Frequency	Filter	Mode	Indication
90 Hz	180 Hz	7	D_2
60 Hz	180 Hz	7	D_3
800 Hz	1.6 kHz	8	D_2
533 Hz	1.6 kHz	8	D_3

SPURIOUS MODULATION

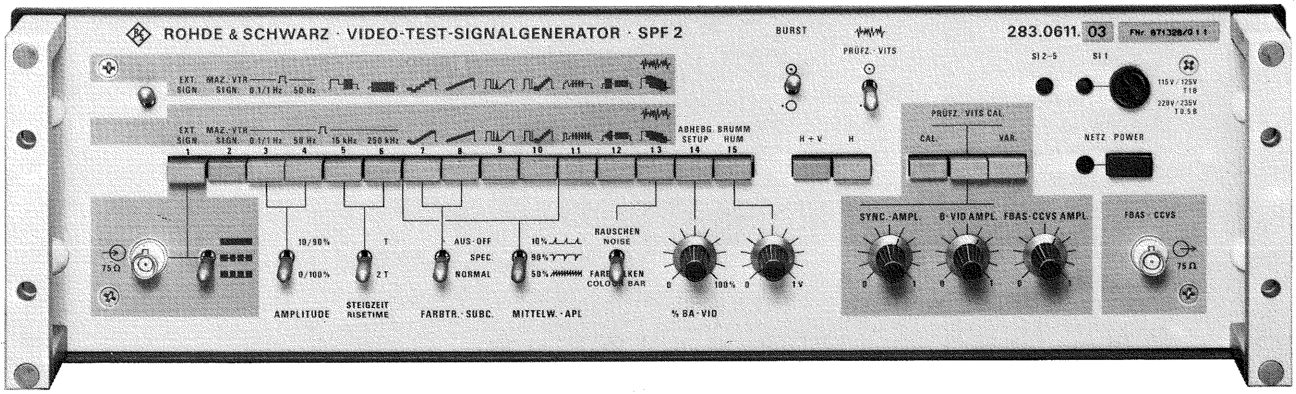
With a TV sound transmitter noise levels can be produced not only by the sound transmitter itself but also by the associated vision transmitter. Measurements of the spurious modulation must consequently be performed with the vision transmitter modulated and unmodulated.

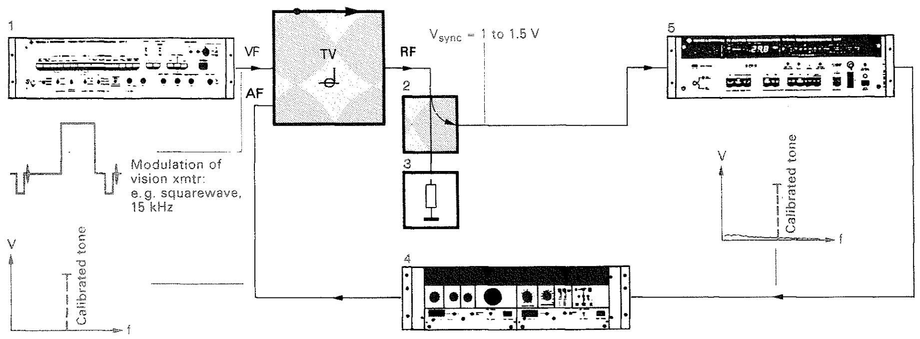
This double measurement procedure and the other demodulator in the test setup are the differences from the same measurement performed on a sound broadcasting transmitter.

The various noise signals and the requirements for measuring them are described on page 8.

The dual-sound demodulator measures the AM and FM noise levels separately. It indicates the spurious AM modulation in % and the spurious FM in Hz or kHz. The level meter indicates the values in dB. Since the FATF demodulates the sound signals independent of the vision signals, the true S/N ratios of the sound signals are measured without interference from the intercarrier signal/noise ratio (see p. 62).

Video Test Signal Generator SPF 2





1 Video Test Signal Generator SPF 2 (photo opposite) or Insertion Signal Generator SPZF (photo below)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 AF Transmission Measuring Set SUN 2 (photo p. 18)

5 TV Dual Sound Demodulator FATF (photo p. 22)

Measurement Procedure

A. Basic settings
As on p. 21.

B. Measurement of unweighted FM signal/noise ratio
1. Turn on preemphasis in transmitter and deemphasis in demodulator.
2. Set reference deviation (e.g. 30 kHz) on AF generator with modulation frequency of 1 kHz.
3. Switch level meter to UNWEIGHTED (MODE 2), NORMal (dBm) and PEAK, following which output voltage of demodulator (e.g. +6 dBm) is indicated.
4. Switch level meter to REF (0 dB).
5. Separate AF generator from transmitter, short transmitter input. Unweighted signal/noise ratio is then indicated (with negative sign).

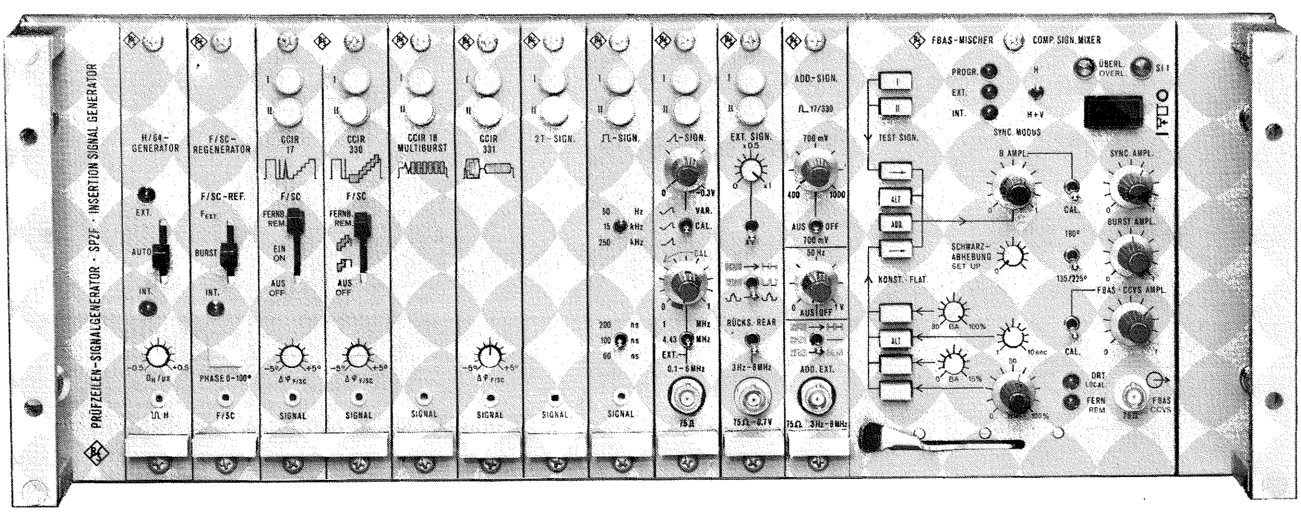
C. Measurement of weighted FM signal/noise ratio
1. As for B.1.
2. As for B.2.
3. Switch level meter to WEIGHTED (MODE 3), NORMal (dBm) and PEAK, following which output voltage of demodulator is indicated.
4. As for B.4.
5. As for B.5. Weighted signal/noise ratio it then indicated (with negative sign).

D. Measurement of residual AM noise level
1. to 4. As for B.1. to B.4.
5. Disconnect AF generator from transmitter, short transmitter input.
6. The FATF indicates the spurious modulation in % when switched to AM, the level meter indicates the noise level (negative sign).

E. Measurement of incidental AM noise level
As for D., but without D.5.

Note Perform the measurements with the vision transmitter unmodulated and then with any modulation (connect the SPF 2 to the video input of the transmitter. Basic settings as on p. 41).

Insertion Signal Generator SPZF



INTERMODULATION DISTORTION

General Intermodulation distortion and its measurement is described on page 10. The measurement procedure here is virtually the same as with monophonic sound-broadcasting transmitters, only a different demodulator is required for measurements on TV sound transmitters. The circuit illustrated below enables simple combination of two AF Generators SUN 2/S for this measurement.

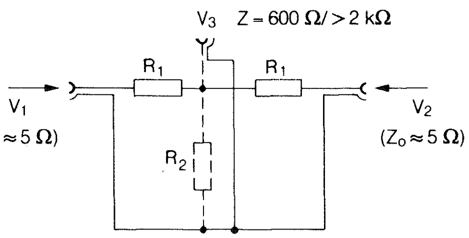
Conversion With 3rd-order intermodulation distortion in particular, calculation can be rather involved, and this is simplified by the straight-line chart on the right, from which the intermodulation distortion d_2 and d_3 can be read off in percent and dB (A1 and A2 are the values read on the SUN 2, d_2 and d_3 are results).

2nd order (only lefthand scale) d_2 [dB] = $|A1| + 3$;
d_2 [%] read off at A1;

example: A1 reads −51 dB,
therefore d_2 = 54 dB or 0.2%.

3rd order (all scales) values read A1 and A2, result d_3 in dB and %;

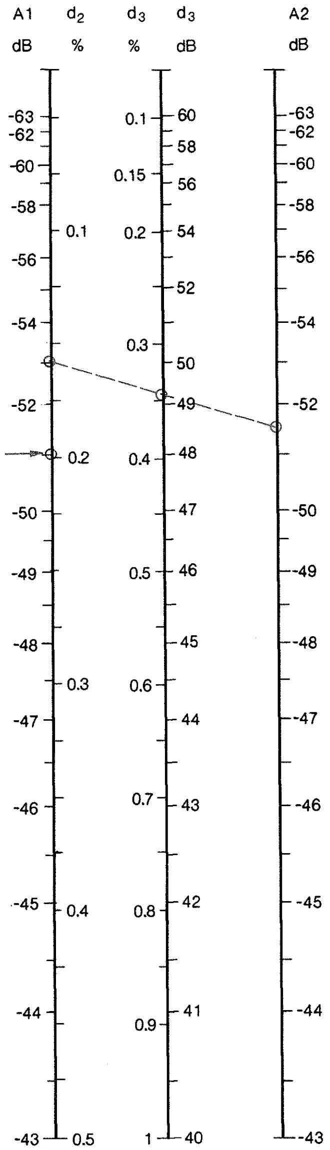
example: A1 = −53 dB, A2 = −51.4 dB;
therefore d_3 = 49.2 dB or 0.35%.



T-circuit for two AF Generators SUN 2/S.
R_1 = 390 Ω ±2%, R_2 = ∞ for R = 600 Ω,
820 Ω for R > 2 kΩ;

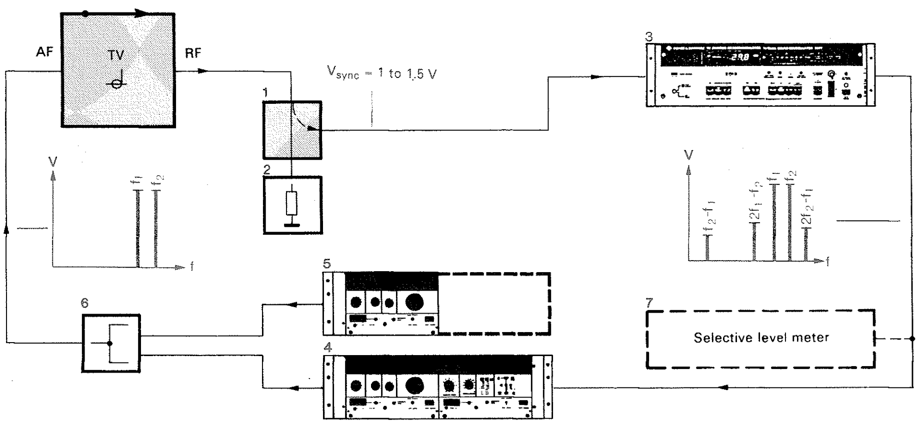
attenuation $\frac{V_3}{V_1} = \frac{V_3}{V_2}$ approx. 8 dB,

isolation $\frac{V_2}{V_1}$ approx. 45 dB



Straight-line chart for calculating intermodulation distortion d_2 and d_3 in dB and %

INTERMODULATION DISTORTION



1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 TV Dual Sound Demodulator FATF (photo p. 22)
4 AF Transmission Measuring Set SUN 2 (photo p. 18)
5 AF Generator SUN 2/S (photo p. 18)
6 T-circuit (600 Ω, diagram opposite)
7 Selective level meter or AF analyzer

Measurement Procedure

A. Basic settings
1. Connect one AF generator directly to transmitter input and carry out basic settings (p. 21).
2. Connect both AF generators via T-circuit to transmitter and turn on.
3. Set one AF generator for minimal output level, and other for half test deviation (e.g. 15 kHz) and note level indication.
4. Set second AF generator to same level as other.

B. Measurement of 2nd-order intermodulation distortion
1. Cut out preemphasis in transmitter and deemphasis in demodulator.
2. Set AF generators to 1000 Hz and 1180 Hz.
3. Switch level meter to FILTER 180 Hz (MODE 7). It then indicates 2nd-order intermodulation distortion, reduced by 3 dB, with negative sign (see straight-line chart opposite for conversion into intermodulation distortion as percentage).
4. Measurements can be performed at any frequencies above 500 Hz (with Δf = 180 Hz), preferably at 1/1.18 kHz, 5/5.18 kHz, 14/14.18 kHz. Conversion as under 3.

C. Measurement of 3rd-order intermodulation distortion
1. As for B.1.
2. Set AF generators to 653 Hz and 1127 Hz.
3. Switch level meter to FILTER 180 Hz (MODE 7). It then indicates attenuation of lower difference tone, reduced by 3 dB, with negative sign.
4. Switch level meter to FILTER 1.6 kHz (MODE 8). It then indicates attenuation of higher difference tone, reduced by 3 dB, with negative sign.
5. Calculate 3rd-order intermodulation distortion in dB and % from indicated values according to points 3. and 4. using straight-line chart opposite.

Note Measurement with the Level Meter SUN 2/U is only possible at the frequencies given above. If measurements are to be performed at other frequencies, a selective level meter or AF analyzer will be required.

MEASUREMENT ON TV SOUND TRANSMITTERS (dual sound)

With dual-sound television, in addition to the first sound carrier, which has the same specifications as the sound carrier in single-sound television, a second sound carrier is transmitted, also frequency-modulated, and at a spacing of approximately 242 kHz from the first. The power of the first sound carrier is $\frac{1}{20}$th (−13 dB) and that of the second sound carrier $\frac{1}{100}$th (−20 dB) of the sync vision power. Because of the small frequency spacing, conventional FM/AM demodulators cannot separate the two sound carriers. In addition, the vision carrier interferes with the measurement if special precautions are not taken.

A complete measurement of both sound channels with the vision carrier switched on can be made using the TV Dual Sound Demodulator FATF from Rohde & Schwarz. The channels are measured separately. The amplitude and modulation of the pilot tone are determined in addition.

For dual-sound operation the TV Dual-Sound Coder STCF is required at the transmitter end. This codes the AF signals and adds the pilot tone that produces the mono/stereo/dual-sound switchover in a receiver. Although the STCF is not necessary for all measurements, it is generally advantageous to use it — as a part of the transmission path — so that the characteristics of the overall system can be determined.

FREQUENCY RESPONSE OF AMPLITUDE, PREEMPHASIS

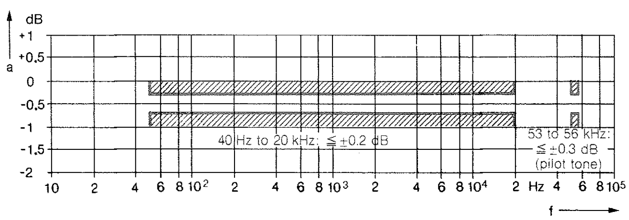
The frequency deviation is set for each sound carrier with the TV Dual Sound Demodulator FATF in the same manner as with single-sound operation. Mutual influencing of the channels does not occur because of the high selectivity of the device. The selected channel (KI or KII) is demodulated, and the frequency deviation, spurious AM and spurious FM are output on the digital display. The demodulated signal is also available at two outputs for further processing.

The frequency response of a transmitter can also be simply checked with the test oscillator incorporated in the TV Dual-Sound Coder STCF, which offers six fixed frequencies (40/100/500 Hz/1/5/15 kHz). The diagram at the bottom right shows the tolerances for the frequency response of the amplitude of TV sound transmitters (dual sound).

The pilot tone for switching over the receiver is generated in the STCF and transmitted in channel 2 (see p. 30). It has a frequency of 54.6875 kHz and is amplitude-modulated as follows for mono/stereo/dual-sound modes with various frequencies:

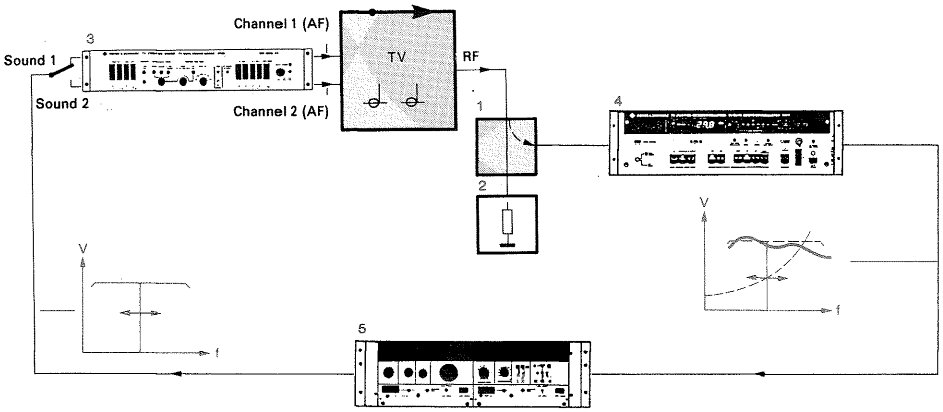
Operating mode	Carrier frequency (kHz)	Average frequency deviation (kHz)	Modulation frequency (Hz)	Modulation depth (%)
Mono	54.6875	±2.5	—	0
Stereo	54.6875	±2.5	117.5	approx. 50
Dual-sound	54.6875	±2.5	274.1	approx. 50

When in PILOT setting, the TV Dual Sound Demodulator FATF can be used to measure the average frequency deviation and the modulation depth. The mode corresponding to the modulation frequency is displayed on LEDs. The demodulated signal is available at the signal outputs.



Tolerances for frequency response of amplitude of TV sound transmitters (dual sound)

FREQUENCY RESPONSE OF AMPLITUDE PREEMPHASIS



1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 TV Dual-Sound Coder STCF (photo p. 30)
4 TV Dual Sound Demodulator FATF (photo p. 22)
5 AF Transmission Measuring Set SUN 2 (photo p. 18)

Measurement Procedure

A. Basic settings

1. Connect AF generator to input AF 1 of TV Dual-Sound Coder. Switch coder to 2 SOUND.
2. Basic setting as on p. 21, but adjust AF generator to +6 dBm (standard level).
3. Set frequency deviation of 30 kHz on transmitter. Do not alter setting any more.
4. Connect AF generator to input AF 2 of TV Dual-Sound Coder STCF. Switch TV Dual Sound Demodulator FATF to K2.
5. Perform same basic settings as for channel 1.

These basic settings apply to all further measurements on TV sound transmitters (dual sound).

B. Measurement of frequency response of amplitude without preemphasis and deemphasis

1. Disconnect preemphasis in coder and transmitter and deemphasis in demodulator.
2. Set required deviation (e.g. 30 kHz) in sound channel 1 on AF generator at 500 Hz. Set dual-sound demodulator to K1.
3. Set level meter to 10 Hz to 100 kHz (MODE 1) and NORMal (dBm), following which the output level of the TV Dual Sound Demodulator FATF is indicated (e.g. +6 dBm).
4. Switch level meter to REF (0 dB).
5. Vary frequency on AF generator over required range (e.g. 30 Hz to 15 kHz). Difference from reference value is indicated.
6. Measure sound channel 2 in same manner on TV Dual-Sound Demodulator FATF after switching to K2.

C. Measurement of preemphasis

1. Turn on preemphasis in coder, disconnect preemphasis in transmitter and deemphasis in TV Dual Sound Demodulator FATF.
2. Set AF generator to level of −8 dBm at 500 Hz.
3. As for B.3. (indication −8 dBm).
4. As for B.4.
5. As for B.5.
6. As for B.6.

D. Measurement of frequency response with test oscillator in TV Dual-Sound Coder STCF

1. Disconnect preemphasis in transmitter and deemphasis in TV demodulator.
2. Switch STCF to TEST TONE 1/1 and FREQ 500 Hz.
3. Set level meter to 10 Hz to 100 kHz (MODE 1) and NORMal (dBm), following which output level of TV Dual-Sound Demodulator FATF (setting K1) is indicated (e.g. +6 dBm).
4. Switch level meter to REF (0 dB).
5. Select different frequencies on coder, level meter indicates differences from reference value.
6. Measure second sound channel in setting K2 of TV Dual Sound Demodulator FATF in same manner.

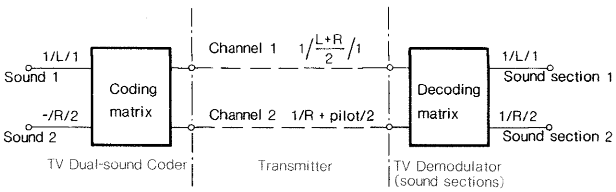
The setup described under D enables measurements at frequencies of 40/100/500 Hz and 1/5/15 kHz with a deviation of 30 kHz, which covers most requirements.

E. Measurement of pilot tone

1. Switch FATF to PILOT and FM.
2. The average frequency deviation of the pilot tone is indicated (e.g. 2.5 kHz).
3. Switch FATF to PILOT and AM.
4. The modulation depth of the pilot tone is indicated (in mono mode: zero indication).
5. The LEDs always indicate the mode (set on STCF).

AMPLITUDE AND PHASE DIFFERENCE OF CHANNELS

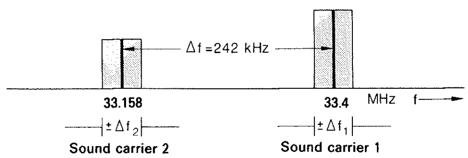
In stereo operation the two information signals L (sound 1) and R (sound 2) are coded and distributed on the two sound channels of the transmitter so that the mono signal $\frac{L+R}{2}$ is transmitted in channel 1 (corresponding to the sound channel in mono operation) and the R signal with the pilot tone for the automatic receiver switching in channel 2. The following diagram illustrates the channel occupancy of the dual-sound coder, the transmitter and the demodulator in mono, stereo and dual-sound operation.



Channel occupancy of TV dual-sound coder, transmitter and TV demodulator in mono/stereo/dual-sound modes
1 Signal 1
2 Signal 2
L Left stereo signal
R Right stereo signal

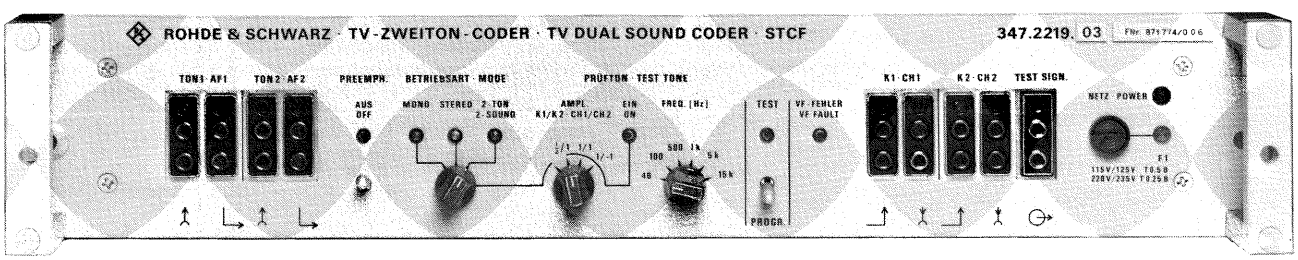
The amplitude and phase difference of the channels can be measured with the TV Dual-Sound Demodulator FATF by means of the difference in deviation. Both channels are driven with the same signal (test switch setting 1/1 on dual-sound coder, see p. 32). A frequency difference of 242 kHz is produced in the FATF with simultaneous amplitude demodulation of both channels and is constant if the frequency deviations are identical (Fig. below). If differences in the amplitude (frequency deviation) or phase of the modulation signal occur, these result in a frequency modulation of the frequency difference which is indicated by the FATF. The magnitude of this frequency deviation is a measure of the asymmetry of the channels but not necessarily of the stereo crosstalk since additional errors may occur in the demodulation and amplification in the receiver.

In transmitters with **separate vision and sound amplification,** the vision/sound diplexer, because of the transfer characteristic of the sound section, influences the phase response and thus the phase difference and crosstalk between the sound channels (see also pages 32 and 33). This influence of the vision/sound diplexer can be determined by measuring the sound transmitter alone operating into the dummy antenna. A measurement of this kind, however, since there is no vision carrier present, is only possible with the FATF.

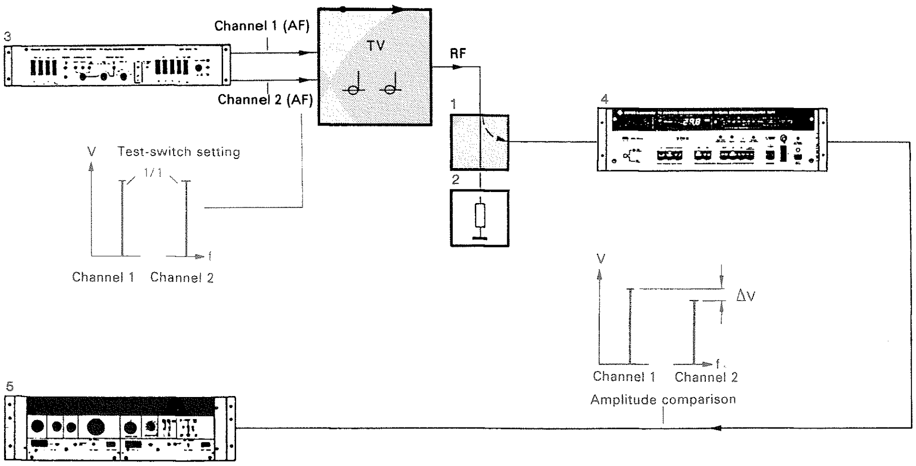


Measurement of difference in deviation

TV Dual-Sound Coder STCF



AMPLITUDE AND PHASE DIFFERENCE OF CHANNELS



1 Directional coupler (incorporated in transmitter)

2 Dummy antenna (according to transmitter power)

3 TV Dual-Sound Coder STCF (photo opposite)

4 TV Dual Sound Demodulator FATF (photo p. 22)

5 AF Transmission Measuring Set SUN 2 (photo p. 18)

Measurement Procedure

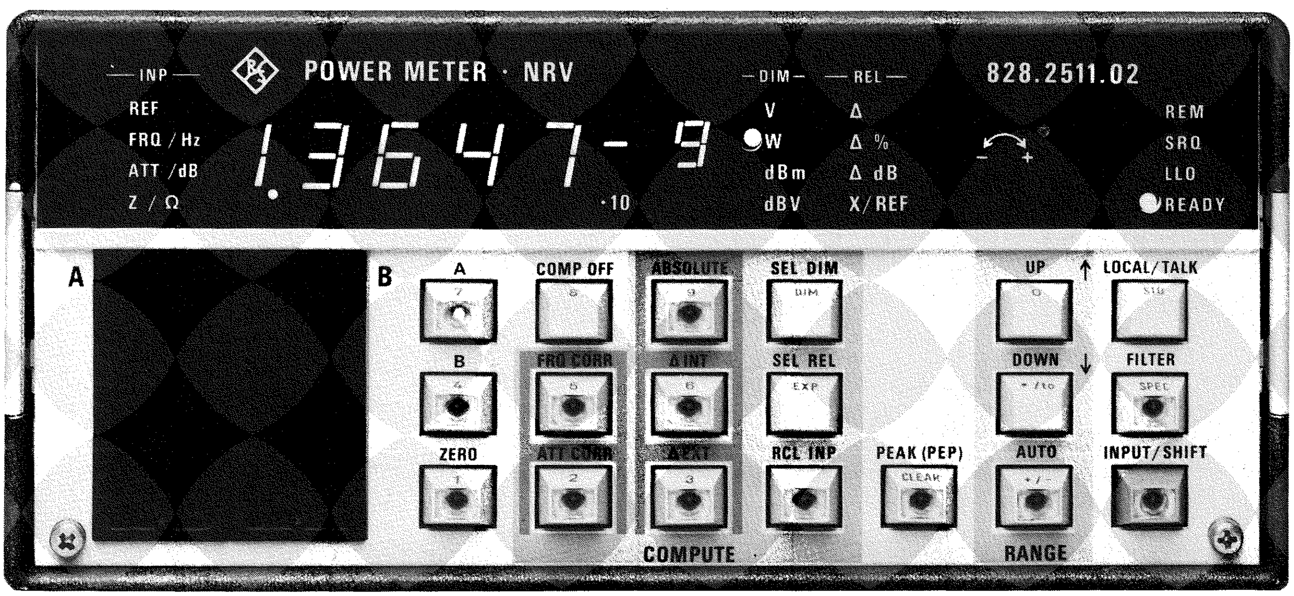
A. Basic settings

As basic settings on p. 29.

B. Measurement of difference in deviation

1. Disconnect preemphasis in transmitter and deemphasis in dual-sound demodulator.
2. Set test switch on dual-sound coder to 1/1.
3. Settings on FATF: RF, FM, deviation measurement of channels in positions K1 and K2.
4. The difference in deviation of the channels is displayed in setting ΔDEVIATION and is a measure of the amplitude and phase difference of the transmission channels.
5. Measure the difference in deviation at the test frequencies possible with the STCF.

Power Meter NRV



CHANNEL AND STEREO CROSSTALK

measurements outside

When signals are transmitted in two separate sound channels, it is important to determine their mutual influence. A differentiation must be made between channel crosstalk (sound 1 to sound 2 and vice versa) and stereo crosstalk (R to L; only this direction is possible because R is transmitted directly).

Channel crosstalk is a purely low-frequency process and is therefore far smaller than stereo crosstalk which requires good amplitude and phase symmetry because of the coding and decoding.

Measurement of the difference in deviation (p. 31) using the TV Dual-Sound Coder STCF provides a measure of the channel symmetry.

The effects of differences in amplitude and phase in the two channels on the crosstalk in stereo mode can be checked easily using the STCF. Its tone generator with six selectable frequencies (40/100/500 Hz/1/5/15 kHz) can be directly connected to the sound channels according to the following scheme:

TV Dual-Sound Coder STCF					TV Demodulator AMF 2			
Test-switch setting (channel occupation)	Corresponds to inputs (stereo) Sound 1 (L)	Sound 2 (R)	Output level Channel 1 (dBm)	Channel 2 (dBm)	Output level (dBm) Sound section 1 Dual-sound	stereo (L)	Sound section 2 Dual-sound	stereo (R)
½/1	0	1	0	+6	0	≤ −30	+6	+6
1/1	1	1	+6	+6	+6	+6	+6	+6
1/−1[1]	–	–	+6	+6 (opposite phase)	+6	–	+6 (opposite phase)	–

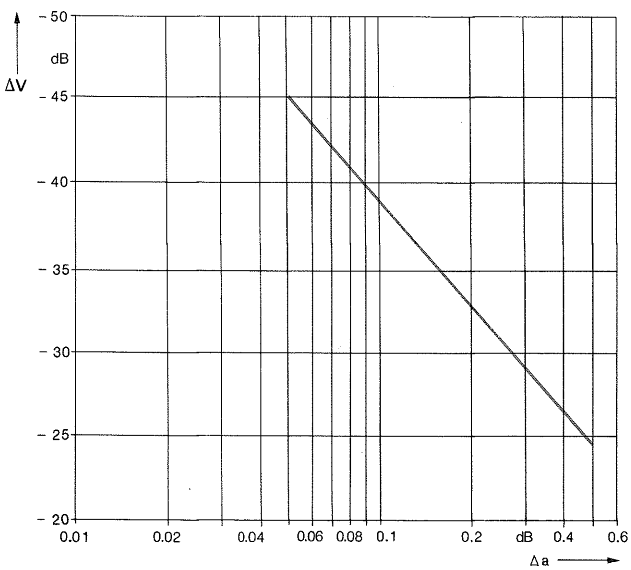
[1]) The third test switch position of the STCF is of no significance to stereo mode.

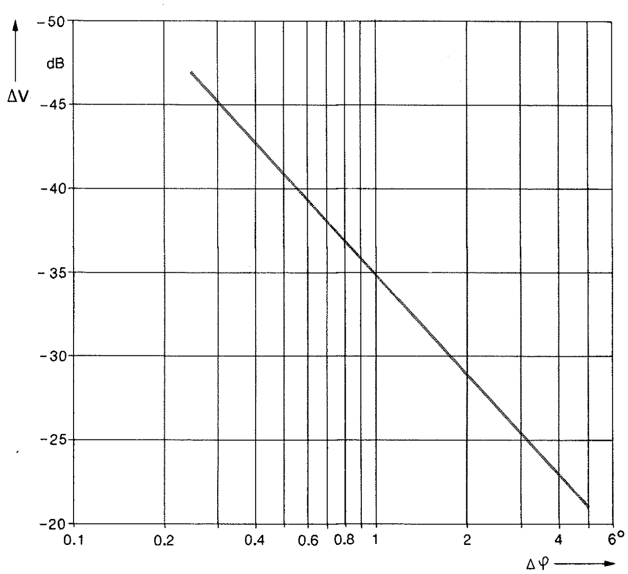
The position ½/1 of the STCF test switch corresponds to sound 1 not present. The signals of the TV demodulator should therefore compensate each other if the MODE DEMATRIX switch on the AMF 2 is at STEREO. The output level of sound section 1 is therefore very low, and zero if the amplitudes and phases of the signals are exactly identical. The channel symmetry can be tested by switching the tone generator to six different frequencies. The influence of amplitude and phase errors on the output level in channel 1 is shown in the diagrams below. The influence of the input and matrixing circuit of the coder are not taken into consideration, however. The measurement in the method described here therefore starts at the input of the coder, i.e. it is for the complete transmission path.

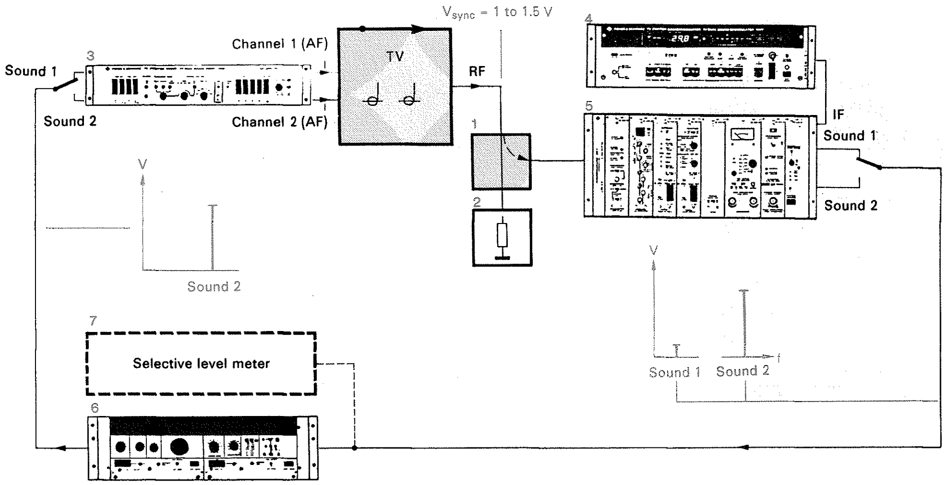
See p. 30 for the influence of the vision/sound diplexer in transmitters with separate vision and sound amplification.

Channel crosstalk in dual-sound operation is caused primarily in the AF band. It is therefore very low, meaning that the crosstalk tone that is to be measured can be submerged in noise if the measurement is broadband, and especially with a high sound-carrier frequency. Cases like this call for a selective level meter.

Influence of amplitude difference (left) and phase difference (right) of transmitter sound channels on the level spacing in sound channel 1 of the TV demodulator (test switch position in STCF ½/1, MODE DEMATRIX switch on TV demodulator to STEREO)







1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 TV Dual-Sound Coder STCF (photo p. 30)
4 TV Dual Sound Demodulator FATF (photo p. 22)
5 TV Demodulator AMF 2 with dual-sound option (photo p. 36)
6 AF Transmission Measuring Set SUN 2 (photo p. 18)
7 Selective level meter or AF analyzer

Measurement Procedure

A. Basic settings
As on p. 29.

B. Measurement of stereo crosstalk (only R to L)
1. Disconnect preemphasis in coder and transmitter and deemphasis in demodulator.
2. Connect AF generator to input AF 2 of STCF.
3. Tune TV demodulator (crystal for vision-carrier frequency available?). On sound section 1 of AMF 2 set MODE DEMATRIX switch to STEREO and connect level meter to AUDIO OUTPut 1 of sound section 2. Connect TV Dual Sound Demodulator FATF to the IF output of the AMF 2. Set FATF to position IF 1.
4. With a modulation frequency of 500 Hz, set the desired deviation (e.g. 30 kHz) on the AF generator in sound channel 2 (read deviation on FATF in setting K2).
5. Set level meter to 10 Hz to 100 kHz (MODE 1) and NORMal (dBm), following which the output level of the TV demodulator is indicated (e.g. +6 dBm).
6. Switch level meter to REF (0 dB).
7. Switch level meter to AUDIO OUTPut 1 of sound section 1 of AMF 2 and short input AF 1 on coder. The stereo crosstalk of R (sound section 2) to L (sound section 1) is indicated with a negative sign.
8. Repeat measurement at different frequencies in transmission band.

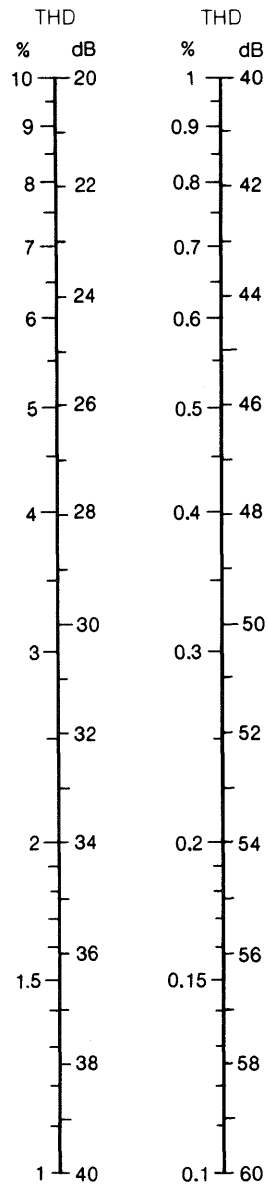
C. Measurement of channel crosstalk
1. As for B.1.
2. Connect AF generator to AF 2 of STCF and switch this to 2-SOUND.
3. As for B.3., but set MODE DEMATRIX to DUAL SOUND.
4. As for B.4.
5. As for B.5.
6. As for B.6.
7. As for B.7., the channel crosstalk from sound 2 to sound 1 is indicated.
8. As for B.8.
9. Repeat measurement in analogous manner for crosstalk from sound 1 to sound 2.

If applicable, use a selective level meter instead of the level meter in the SUN 2.

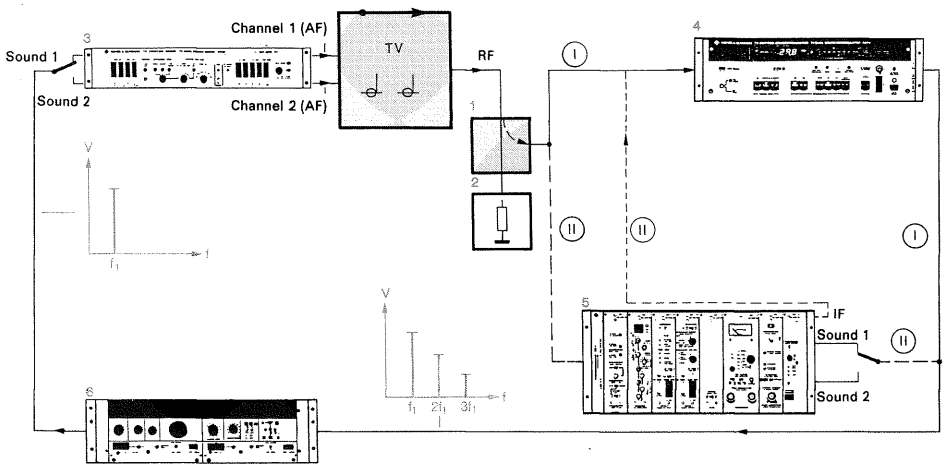
HARMONIC DISTORTION

Harmonic distortion (definition on p.6) is measured in a similar fashion as with TV transmitters for mono sound and for each channel. The TV Dual-Sound Demodulator FATF is used to set the deviation. The harmonic distortions of the individual channels are measured in DUAL SOUND mode of the TV Dual-Sound Coder STCF via the FATF. These largely correspond to the values in stereo mode because the decoding switch does not contain any non-linear elements.

Direct measurement of the harmonic distortion in stereo mode is not possible with the FATF because it does not contain a decoder circuit. The TV Demodulator AMF 2 is suitable for direct measurement and also for the measurement of individual channels.



Conversion of THD in dB into THD in %



1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 TV Dual-Sound Coder STCF (photo p. 30)
4 TV Dual-Sound Demodulator FATF (photo p. 22)
5 TV Demodulator AMF 2 with dual-sound option (photo p. 36)
6 AF Transmission Measuring Set SUN 2 (photo p. 18)

Measurement Procedure

A. Basic settings
As on p. 29.

I. Measurement with the TV Dual-Sound Demodulator FATF
(connections Ⓘ)

B. Measurement of total harmonic distortion in dB in DUAL SOUND mode

1. Disconnect preemphasis in coder and transmitter and deemphasis in TV Dual-Sound Demodulator FATF.
2. Connect AF generator to input AF 1 of coder. Set coder to position 2-SOUND.
3. Set required test frequency (40 Hz, 1 kHz or 4.7 kHz) and frequency deviation on the AF generator (read off deviation on FATF in position K1).
4. Set DIStortion on the level meter for the corresponding frequency (MODE 4, 5 or 6). The total harmonic distortion is then indicated with a negative sign.
5. Repeat measurement in analogous manner for sound channel 2.

C. Measurement of 2nd- and 3rd-order distortion in dB in DUAL SOUND mode

1. As for B.1.
2. As for B.2.
3. Set frequency (see table below) and required frequency deviation on AF generator.
4. Set filter (MODE 7 or 8) on level meter according to table. The display indicates the 2nd or 3rd order distortion (D_2 or D_3) with a negative sign depending on the selected frequency and filter.
5. As for B.5.

AF generator	Level meter		
Frequency	Filter	Mode	Indication
90 Hz	180 Hz	7	D_2
60 Hz	180 Hz	7	D_3
800 Hz	1.6 kHz	8	D_2
533 Hz	1.6 kHz	8	D_3

II. Measurement of the TV Demodulator AFM 2
(connections Ⓘ̲Ⓘ)

B. Measurement of total harmonic distortion in dB in STEREO mode

1. Disconnect preemphasis in coder and transmitter and deemphasis in FATF and AMF 2.
2. Connect AF generator to input AF 1 of coder. Coder in position STEREO.
3. Tune TV demodulator (crystal for vision-carrier frequency available?). Set MODE DEMATRIX switch on sound section 1 to STEREO and connect level meter to AUDIO OUTPut 1 of sound section 1. Connect TV Dual-Sound Demodulator FATF to IF output of AMF 2. FATF in position IF 1.
4. As for I.B.3.
5. As for I.B.4.
6. As for I.B.5.

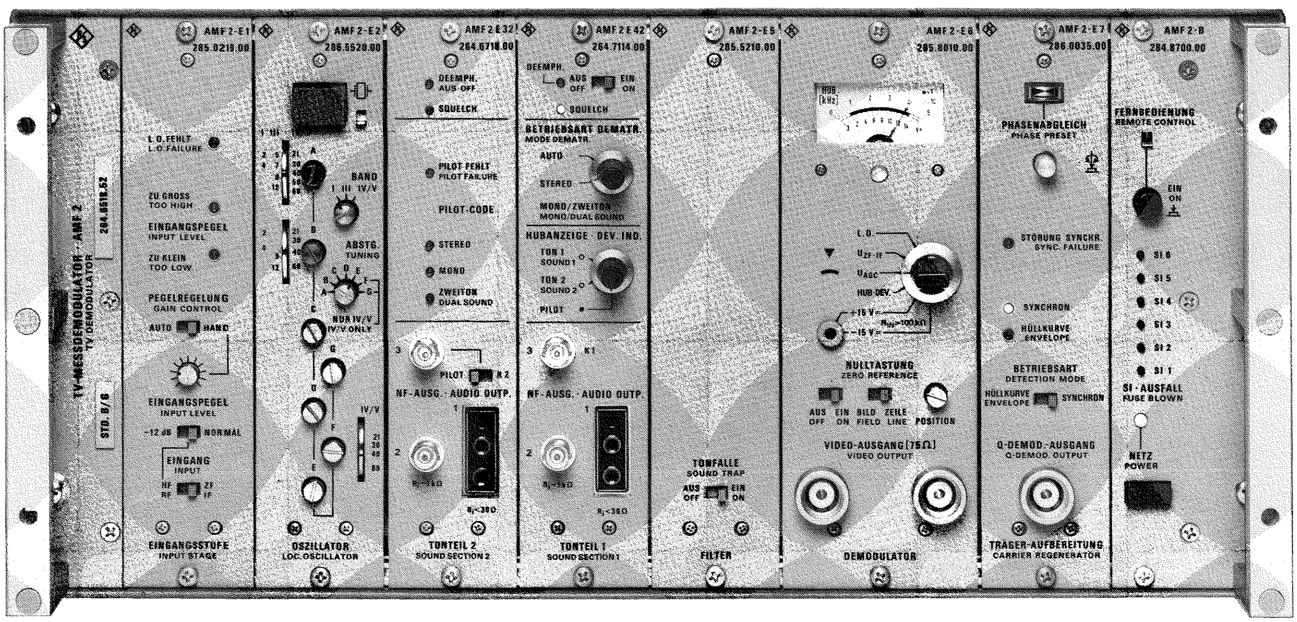
C. Measurement of 2nd- and 3rd-order distortion in dB in STEREO mode

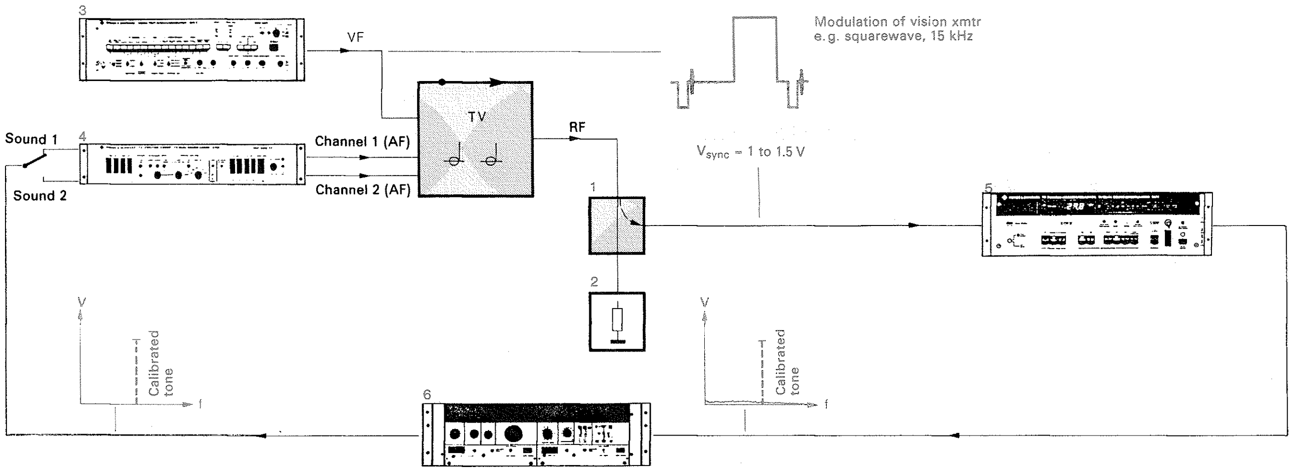
1. As for II.B.1.
2. As for II.B.2.
3. As for II.B.3.
4. As for I.C.3.
5. As for I.C.4.
6. As for I.B.5.

Note With this test setup, the values for dual-sound mode can be also measured in setting 2-SOUND on the STCF and DUAL SOUND on the AMF 2.

The weighted and unweighted noise levels (definition on p. 8) are measured individually for each channel in the same manner as with TV transmitters for mono sound. The TV Dual-Sound Demodulator FATF can measure the true AM and FM S/N ratios without interference occurring as a result of the intercarrier interference ratio being too small (p. 62) (this occurs with the TV Demodulator AMF 2 as a result of the intercarrier principle used to generate the sound signal). Although this principle is used in the majority of domestic receivers, the real noise levels of the sound transmitters cannot be measured. In the measurements described here, the noise levels referred to the useful signal level, i.e. the S/N ratios, are determined.

TV Demodulator AMF 2





1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)
4 TV Dual-Sound Coder STCF (photo p. 30)
5 TV Dual-Sound Demodulator FATF (photo p. 22)
6 AF Transmission Measuring Set SUN 2 (photo p. 18)

Measurement Procedure

A. Basic settings
As on p. 29.

B. Measurement of unweighted FM S/N ratio in DUAL SOUND mode
1. Turn on preemphasis in coder and disconnect in transmitter. Turn on deemphasis in TV Dual-Sound Demodulator FATF.
2. Connect AF generator to input AF 1 of coder; set coder to 2-SOUND.
3. Set required reference deviation (e.g. 30 kHz) on AF generator with a modulation frequency of 1 kHz. Read off deviation on FATF set to K1.
4. Switch level meter to UNWEIGHTED (MODE 2), NORMal (dBm) and PEAK, following which the output voltage of the TV demodulator (e.g. +6 dBm) is indicated.
5. Switch level meter to REF (0 dB).
6. Separate AF generator from coder, short coder input AF 1. The unweighted signal/noise ratio in channel 1 is then indicated with a negative sign.
7. Repeat measurement in analogous manner for sound channel 2.

C. Measurement of weighted FM S/N ratio in DUAL SOUND mode
1. As for B.1.
2. As for B.2.
3. As for B.3.
4. Switch level meter to WEIGHTED (MODE 3), NORMal (dBm) and PEAK. Indication as for B.4.
5. As for B.5.
6. As for B.6. Weighted S/N ratio is then indicated with negative sign.
8. As for B.7.

D. Measurement of residual AM S/N ratio
1. to 5. As for B.1. to B.5.
6. Separate AF generator from coder, short coder input AF 1.
7. The FATF switched to AM indicates the spurious modulation in %, the level meter indicates the S/N ratio (negative sign).
8. As for B.7.

E. Measurement of residual AM S/N ratio
Measurement as for D., but without D.6.

Note Perform the measurements with the vision transmitter unmodulated and then with modulation of any value.

INTERMODULATION DISTORTION

General Intermodulation distortion (definition on p. 10) is measured in basically the same manner as with TV transmitters for mono sound, but for each channel. The TV Dual-Sound Demodulator FATF is used to set the deviation. The actual measurement is performed by the TV Demodulator AMF 2. For determining the values of intermodulation distortion see p. 10. The aids for conversion are repeated here for convenience.

The T-circuit illustrated below enables simple combination of two AF Generators SUN 2/S for these measurements.

The FATF can be used in setting 2-SOUND to measure the intermodulation distortion of the channels. The TV Demodulator AMF 2 is required in addition in stereo mode. Since stereo mode is the normal operating mode, it would appear correct to also use the AMF 2 to measure in dual-sound operation (see also p. 34).

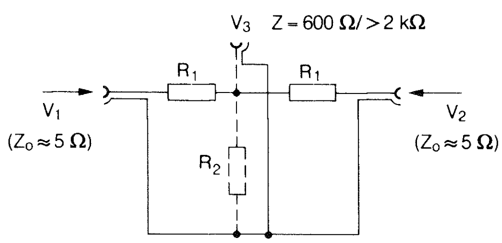
Conversion With 3rd-order intermodulation distortion in particular, calculation can be rather involved, and this is simplified by the straight-line chart on the right, from which the intermodulation distortion d_2 and d_3 can be read off in percent and dB (A1 and A2 are the values read on the SUN 2, d_2 and d_3 are results).

2nd order (only lefthand scale) d_2 [dB] = $|A1| + 3$;
d_2 [%] read off at A1;

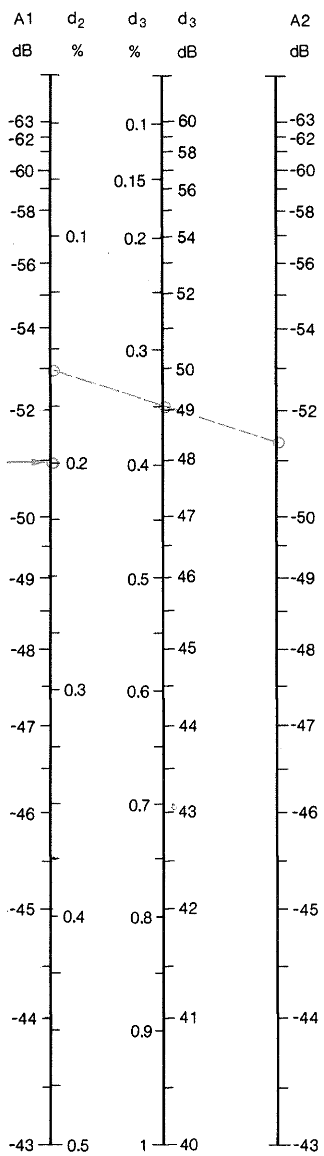
example: A1 reads −51 dB,
therefore d_2 = 54 dB or 0.2 %.

3rd order (all scales) values read A1 and A2, result d_3 in dB and %;

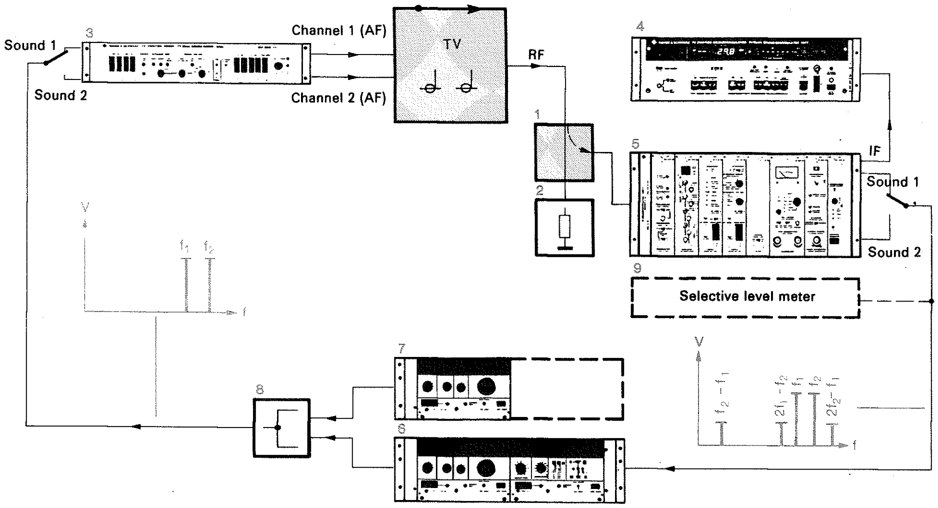
example: A1 = −53 dB, A2 = −51.4 dB;
therefore: d_3 = 49.2 dB or 0.35 %.



T-circuit for two AF Generators SUN 2/S.
R_1 = 390 Ω ±2 %, R_2 = ∞ for R = 600 Ω,
820 Ω for R > 2 kΩ;
attenuation $\frac{V_3}{V_1}$ approx. 8 dB,
isolation $\frac{V_2}{V_1}$ approx. 45 dB



Straight-line chart for calculating intermodulation distortion d_2 and d_3 in dB and %



1 Directional coupler (incorporated in transmitter)
2 Dummy antenna (according to transmitter power)
3 TV Dual-Sound Coder STCF (photo p.30)
4 TV Dual-Sound Demodulator FATF (photo p.22)
5 TV Demodulator AMF 2 with dual-sound option (photo p.36)
6 AF Transmission Measuring Set SUN 2 (photo p.18)
7 AF Generator SUN 2/S (photo p.18)
8 T-circuit (diagram opposite)
9 Selective level meter or AF analyzer

Measurement Procedure

A. Basic settings

1. Connect one AF generator to input AF 1 of coder. Perform basic settings according to p.29.
2. Connect the two AF generators via T-circuit to input AF 1 of coder and turn on.
3. Tune TV demodulator (crystal for vision-carrier frequency available?). On sound section 1 set MODE DEMATRIX switch to DUAL SOUND and connect level meter to AUDIO OUTPut 1 of sound section 1. Connect dual-sound demodulator to IF output of AMF 2. Set FATF to position IF 1.
4. Set one AF generator for minimal output level, and other for half test deviation (e.g. 15 kHz) and note level indication (read deviation on FATF in position K1).
5. Set second AF generator to same level as other.

B. Measurement of 2nd-order intermodulation distortion in DUAL SOUND mode

1. Disconnect preemphasis in coder and transmitter, deemphasis in TV demodulator.
2. Set AF generator to 1000 Hz and 1180 Hz.
3. Switch level meter to FILTER 180 Hz (MODE 7). It then indicates the 2nd-order intermodulation distortion, reduced by 3 dB, with a negative sign (see straight-line chart opposite for conversion into intermodulation distortion as percentage).
4. Measurements can be performed at any frequencies above 500 Hz (with $\Delta f = 180$ Hz), preferably at 1/1.18 kHz, 5/5.18 kHz and 14/14.18 kHz. For conversion into 2nd-order intermodulation distortion as percentage, see straight-line chart opposite.
5. Repeat measurement in analogous manner for sound channel 2.

C. Measurement of 3rd-order intermodulation distortion in DUAL SOUND mode

1. As for B.1.
2. Set AF generators to 653 Hz and 1127 Hz.
3. Switch level meter to FILTER 180 Hz (MODE 7). It then indicates the attenuation of lower difference tone, reduced by 3 dB, with a negative sign.
4. Switch level meter to FILTER 1.6 kHz (MODE 8). It then indicates the attenuation of higher difference tone, reduced by 3 dB, with a negative sign.
5. Calculate 3rd-order intermodulation distortion in dB and % from indicated values according to points 3. and 4. using straight-line chart opposite.
6. Repeat measurement in analogous manner for sound channel 2.

D. Measurement of intermodulation distortion in STEREO mode

The measurement procedures are the same as in B. and C., but the coder and the TV demodulator are set to STEREO mode.

Note The measurement is possible with the Level Meter SUN 2/U only at the specified frequencies. A selective level meter or an AF frequency analyzer is required for measurements at other frequencies.

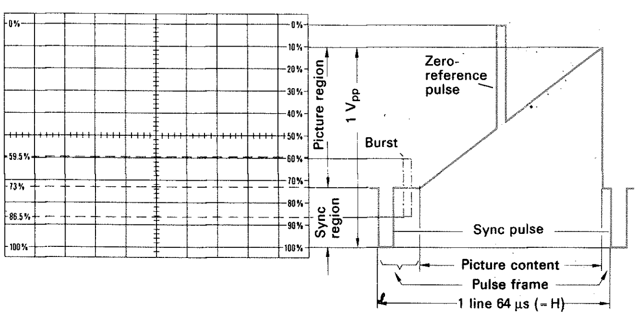
MEASUREMENTS ON VISION TRANSMITTERS

The modulation signals for vision transmitters are considerably more complicated than the modulation signals for sound broadcasting or TV sound transmitters: on the one hand, the bandwidth of the signal to be transmitted is very large (approx. 0 Hz to 5 MHz), and then, in addition to the picture information, i.e. the luminance and chrominance signals, other pulses are transmitted for field and line synchronization. All these signals have to be transmitted with very exact timing. They must satisfy very high demands as regards quality and must not influence one another. The inspection of vision transmitters consequently calls for a considerably larger number of measurements than in the case of sound broadcasting or TV sound transmitters.

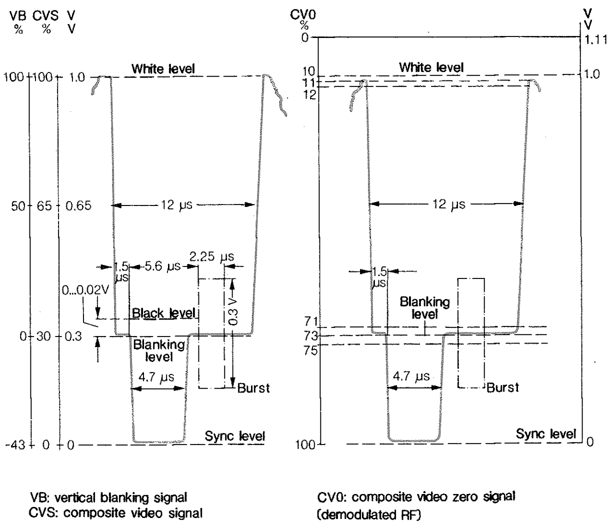
LEVEL STABILITY

With television pictures the actual vision content is embedded in a pulse frame that serves for field and line synchronization (V and H pulses) and which also contains a reference signal for the colour subcarrier (burst). This pulse frame, which also determines the maximal amplitudes of the vision content, is exactly defined as regards time and amplitude at the input and output of a TV transmitter. It is particularly important that the prescribed levels be maintained. For testing, a test-signal generator is connected to the input of the transmitter to supply a standard signal. A TV demodulator at the output of the transmitter demodulates the RF signal into a video signal. This can then be compared with the transmitter input signal on a TV oscilloscope. With the TV Oscilloscope OPF from Rohde & Schwarz, various tolerance masks are available which can be fitted over the screen of the instrument to simplify judgement of the signals that are measured. In the diagram below, a tolerance mask is illustrated on the left for comparing transmitter input and output signals, and on the right of this an oscillogram of the output signal is shown.

It would be quite correct to show the transmitted signal with the sync pulse on top because it represents a major portion of the RF amplitude. Generally, however, the output signals are shown with the sync pulse below to make it easier to compare them with the input signal. For the same reason, the output signal with the composite video component is approximated to the corresponding input-signal value of 1 V_{pp}. The following diagram illustrates the relationships between the input signal and the output signal.



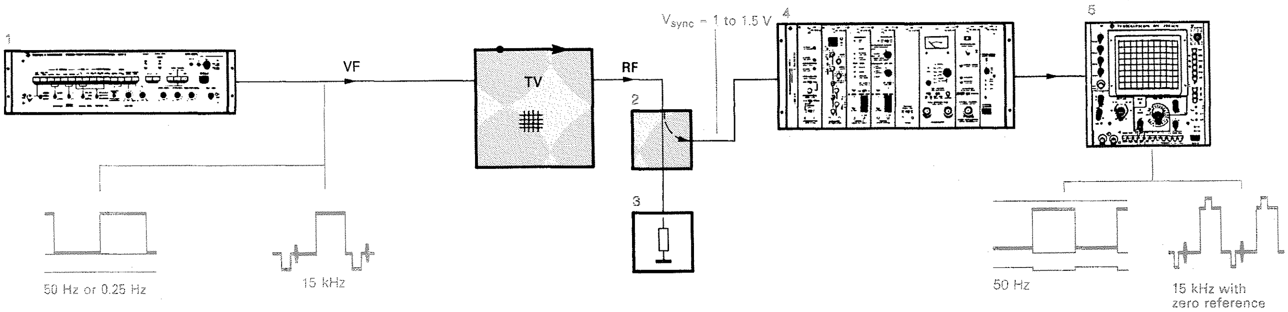
Tolerance mask for TV Oscilloscope OPF and line oscillogram of output signal



Amplitudes and timing for input and output signals of vision transmitters

Almost all TV standards work with what is called negative modulation in the vision transmitter. This means that the maximal value of the RF amplitude corresponds to the zero value of the modulation signal that is fed in (sync level). The minimum value (what is called the residual carrier) of the RF amplitude corresponds to the maximal value of the modulation signal (white level) and, depending on the TV standard, is 10% or 20% of the maximal RF amplitude.

Low-frequency transients in power supplies and control circuits can produce fluctuations in the output power of the transmitter, and these can be recognized in the oscillogram. The levels are consequently first set up with average loading of the power supply (15-kHz pulse) and then examined at 50 Hz and 0.25 Hz (video signal changes every 4 s between black and white). Thus faults in the power supply can be detected.



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF

5 TV Oscilloscope OPF (photo p. 49) with CCVSO level mask

Measurement Procedure

A. Basic settings

1. Connect video input of transmitter to Video Test Signal Generator SPF 2, and the signal output (directional coupler) to the RF input of the TV Demodulator AMF 2.
2. Set level control on TV demodulator to AUTO and tune to vision-carrier frequency (crystal available?) and set ZERO REFERENCE to positions ON and LINE.
3. Set up line-frequency squarewave (15 kHz, rise time 2T) with H pulses and burst on test-signal generator.
4. Connect input of OPF (on left of front panel) to video input of AMF 2.
5. Set 0.1 V/DIV. on oscilloscope, ⊿ to end position so that UNCAL LED does not light up. Set TIME/DIV to 10 µs/DIV, UNCAL LED must still not light up. Press 75 Ω and H in the bottom row of keys.
6. Set oscillogram on oscilloscope using ↕ so that the sync-pulse base is at 100% and the tip of the zero-reference pulse is at 0% in the tolerance mask (slight adjustment of ⊿ if necessary).
7. Determine levels for blanking, white and black levels and burst amplitude, correct setting on transmitter if necessary.

These basic settings apply to all further measurements on vision transmitters.

B. Measurement of level stability

1. Switch test-signal generator to H+V and squarewave 50 Hz, press 50 Hz and = keys on oscilloscope.
2. Check on oscilloscope how 50-Hz test signal affects level values[1]).
3. Switch test-signal generator to 0.1/1 Hz (video signal changes every 4 s between black and white).
4. Examine again as for B.2. (comparison with standard specifications).

[1]) On the scale of the CCVSO mask, 0.2 div (smallest division) corresponds to an amplitude of 2.8% of the video signal. If the oscilloscope sensitivity is changed from 0.1 V/div to 50 mV/div, 0.2 div corresponds to an amplitude of 1.4% (37 dB).

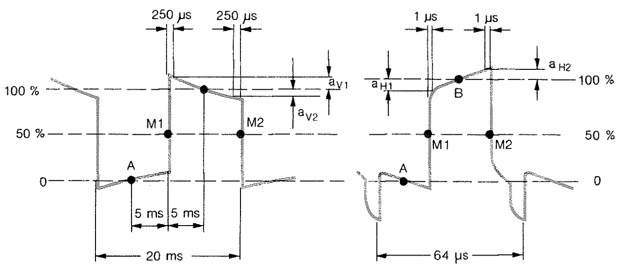
TILT AND ROUNDING (50 Hz/15 kHz)

measurements outside

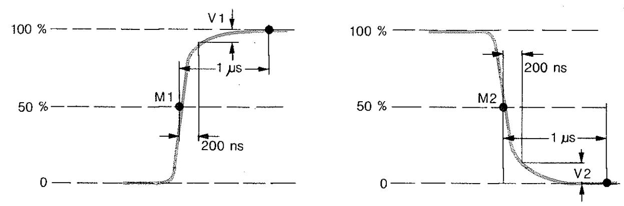
For examining the characteristics of vision transmitters in the low to middle frequency region, squarewaves are used with rise times that cannot cause any overshoots in transmission (see also page 44). Tilt or rounding of the squarewaves at the transmitter output beyond a tolerable degree point to impaired frequency response.

The 50-Hz squarewave signal detects errors in the frequency range below approx. 15 kHz, and the 15-kHz signal detects faults from 15 kHz up to several hundred kHz. To determine the tilt, the demodulated squarewave is lined up on the X and Y axes of the internal graticule of the OPF screen according to the diagram below. The fixed points A, B, MV, M1 and M2 are not defined in this graticule. It is advisable to ignore the top and bottom lines so that 10 height units are available for the range 0 to 100%. Measurements are made 250 µs or 1 µs from the edges and the result referred to the step amplitude. It is recommendable to set the pulse widths as large as possible so that the distances of the test points from the centre of the edge are not smaller than 0.2 div. (smallest marking on screen). The tilts of the top and bottom of the pulses should therefore be measured separately.

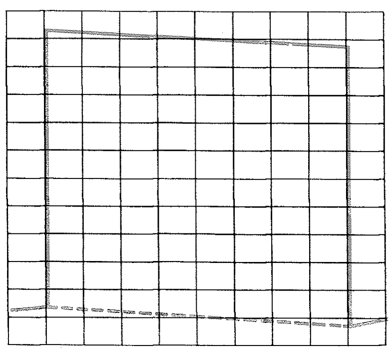
Rounding is only determined with the 15-kHz signal. Measurement is made 0.2 µs after 50% value, referred to the step amplitude 1 µs after the centre of the edge. The following diagrams illustrate the measurement of tilt and rounding according to ARD standard specifications 8/1.1, section 1.2.3., pp. 3/7.



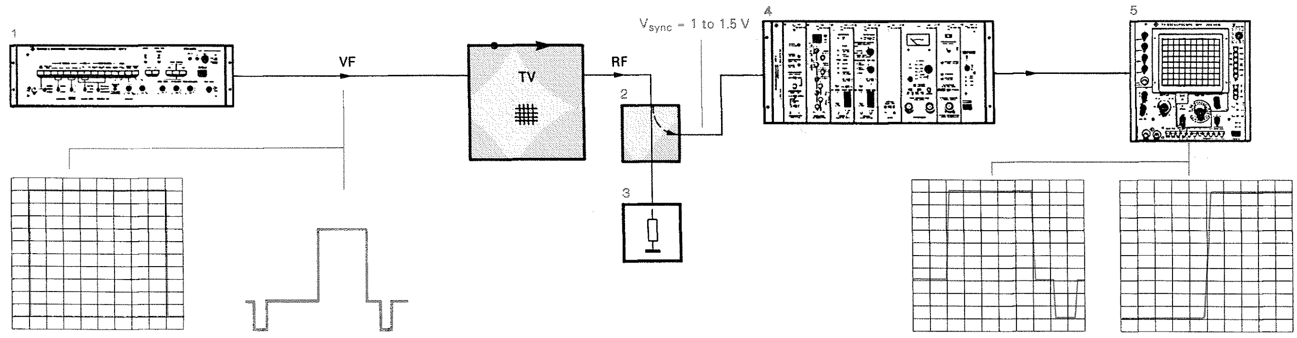
Determining tilt: left squarewave signal 50 Hz, right squarewave signal 15 kHz:
maximum distortion: largest a,
tilt: $a_1 + a_2$



Determining rounding: rounding to white V1 (left), rounding to black V2 (right)



Lining up of 50-Hz squarewave in OPF mask



50 Hz, sweep 10 ms/DIV x10, trigger NORM

15 kHz, sweep 10 µs/DIV

15 kHz, sweep 5 µs/DIV, trigger H

15 kHz, rising edge, sweep 5 µs/DIV x10, trigger H

1 Video Test Signal Generator SPF 2 (photo p.24) or Insertion Signal Generator SPZF (photo p.25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p.36) or AMF

5 TV Oscilloscope OPF (photo p.49) without tolerance mask, use internal graticule

Measurement Procedure

A. Basic settings

As on p.41.

B. Measurement of tilt (50 Hz)

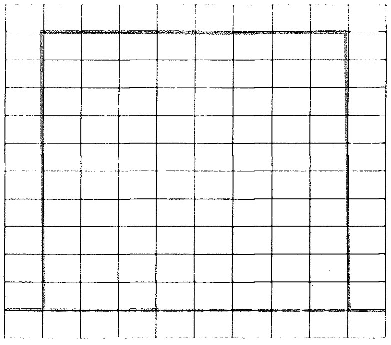
1. Set 50-Hz squarewave on test signal generator. Set oscilloscope to 0.1 V/DIV and 10 ms/DIV; press 75 Ω, x10 and NORM keys.
2. Switch to 50 mV/DIV; set oscillogram amplitude to 10 DIV using ⊲ (left) and set to position corresponding to example at bottom on opposite page using ↕.
3. Adjust the width of the pulse top to 8 DIV using ⊲ and ↔ (centre) so that the screen display is as shown below (10 ms = 8 DIV, 250 µs = 0.2 DIV).
4. Evaluate as illustrated in diagrams on opposite page at top.
5. Set pulse base to centre of screen using ↔.
6. Evaluate as illustrated in diagrams on opposite page at top.

C. Measurement of tilt (15 kHz)

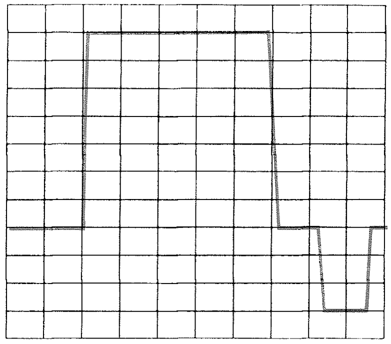
1. Set 15-kHz squarewave on test-signal generator and rise time 2T. Set oscilloscope to 0.1 V/DIV and 5 µs/DIV, press 75 Ω and H.
2. Set pulse top to centre of screen using ↔ (spacing of edge centres 25 µs = 5 DIV, 1 µs = 0.2 DIV).
3. The pulse width between the centres of the edges must be 5 DIV (25 µs).
4. As for B.4.
5. As for B.5.
6. As for B.6.

D. Measurement of rounding (15 kHz)

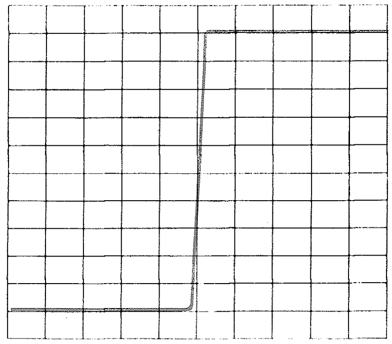
1. As for C.1.
2. Press x10 key on oscilloscope. Set centre of rising pulse edge to centre of screen using ↔.
3. As for B.2. (example bottom right).
4. Evaluate as illustrated in diagrams on opposite page (1 µs = 2 DIV, 200 ns = 0.4 DIV).



50 Hz, sweep 10 ms/DIV x10, trigger NORM



15 kHz, sweep 5 µs/DIV, trigger H

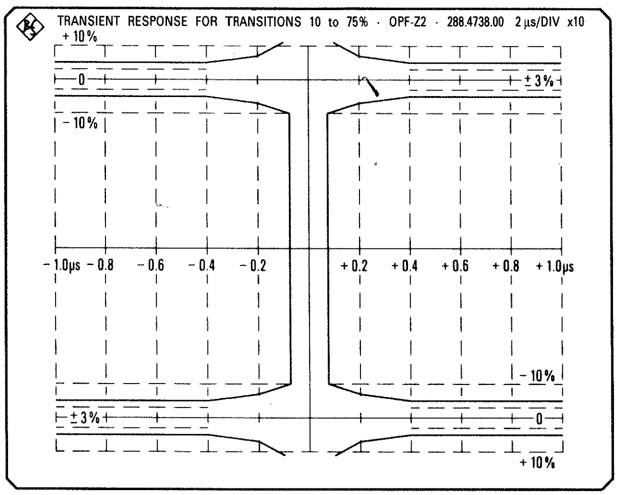


15 kHz, rising edge, sweep 5 µs/DIV x10, trigger H

TRANSIENT RESPONSE (15 kHz/250 kHz) with OPF

In addition to its fundamental, a squarewave includes a harmonic spectrum, whose width depends on the rise time of the pulse edges. In TV measurement engineering squarewaves with rise times of 100 ns (T) and 200 ns (2T) are used. The spectrum of the 200-ns pulse ranges up to approx. 5 MHz, that of the 100-ns pulse up to about 10 MHz. A TV system represents a 5-MHz (or 6-MHz) lowpass system, so 200-ns pulses can still be properly transmitted, but not 100-ns pulses. Here overshoots occur because of the nature of the system. By adjustment of the group delay it is possible to balance these overshoots on the rising and falling edges of the squarewave.

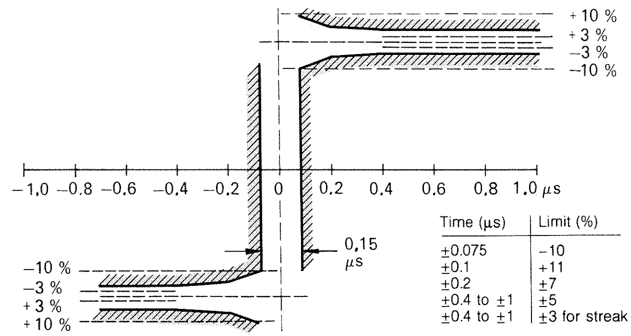
Oscillations with a rise time of 100 ns are thus mainly used for a rough appraisal of group delay. The complete oscillation is first displayed on the screen for the measurement and the time base is subsequently expanded. The signal edges are then shifted in succession into the tolerance mask.



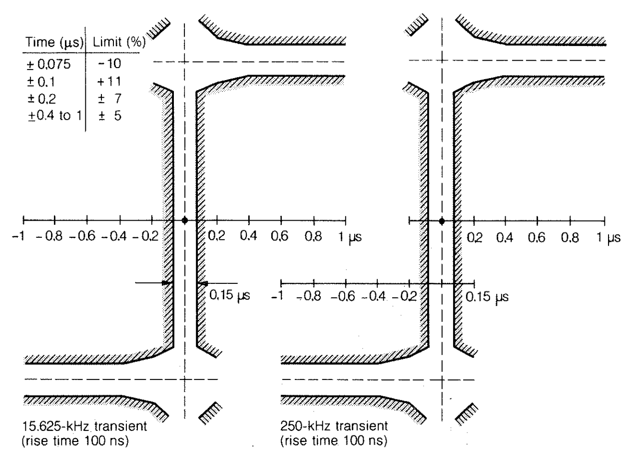
Tolerance mask of TV Oscilloscope OPF for measuring transient response of vision transmitters

Because of the vestigial-sideband transmission, system-conditioned quadrature errors occur in envelope detection at high transient amplitude. These appear as a shift in the overshoot towards higher levels of modulation. Thus, with envelope detection, one only measures with small transient amplitudes (e.g. 55/75% in the standard specifications of the Swiss PTT). If a test demodulator with synchronous detection is used however (e.g. AMF 2 from Rohde & Schwarz), it is possible to measure with full modulation (10/75%, standard specifications of the Federal-German DBP).

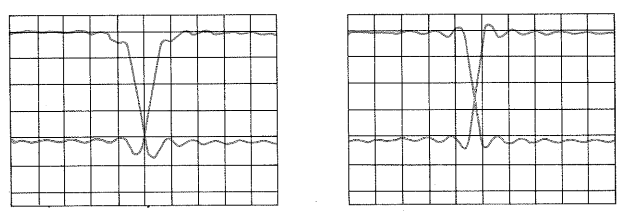
The diagrams on the right show tolerance schematics for transient response according to the standard specifications of the Federal-German DBP/ARD and the Swiss PTT, and an illustration of a transient with envelope and synchronous detection.



Tolerance schematic for transient response with transitions from 10 to 75% of peak voltage and vice versa with synchronous detection; 250-kHz squarewave, rise time 100 ns (according to standard specifications of DBP/ARD)

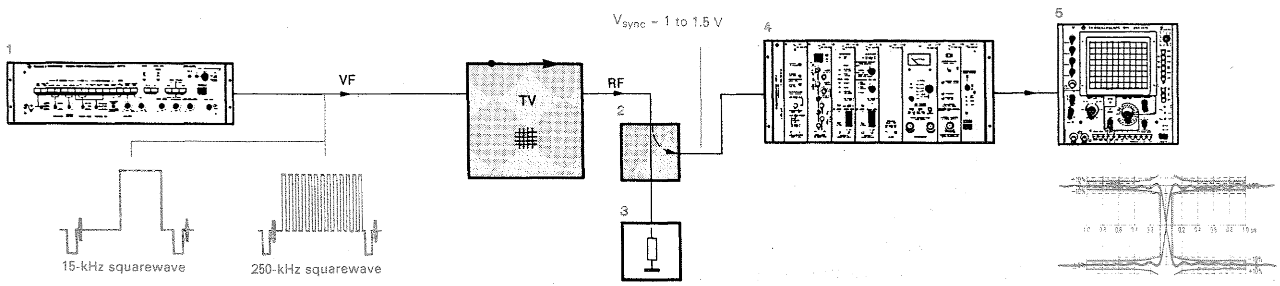


Tolerance schematic for transient response with transitions from 55 to 75% of peak voltage and vice versa; 15.625-kHz squarewave left, 250-kHz squarewave right, rise time 100 ns in each case (according to standard specifications of Swiss PTT; no details on detection)



Transient from 10 to 75% of peak voltage with envelope detection (left) and synchronous detection (right)

TRANSIENT RESPONSE
with OPF (15 kHz/250 kHz)



Sweep 10 µs/DIV

Sweep 2 µs/DIV x10, recorded with double exposure

1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF

5 TV Oscilloscope OPF (photo p. 49) with tolerance mask for measurement of transient response

Measurement Procedure

A. Basic settings
As on p. 41.

B. Measurement of transient response with 15-kHz squarewave

1. For modulation 10/75% set 15-kHz squarewave, RISE-TIME T and mode H on test-signal generator.
2. For other modulation additionally press SETUP and VITS CALibration and set prescribed amplitude of picture content on screen (e. g. 55/75%) with VIDeo AMPLitude and % VIDeo.
3. Switch TV demodulator to SYNCHRONous DETECTION with step amplitude 10/75%.
4. Switch to 50 mV/DIV and adjust amplitude of squarewave into tolerance frame using ⊏ (left) and ↕.
5. Set TIME/DIV to 2 µs/DIV, press x10 key (bottom) and then set the rising edge into the tolerance frame using ↔. At 15 kHz, only this edge is tolerated in the standard specifications.
6. Adjust gain and TIME/DIV again if necessary so that the pulse edge is exactly symmetrical in the tolerance frame.
7. The overshoots must not cross the tolerance lines at any point.

C. Measurement of transient response with 250-kHz squarewave

1. to 4. As for B.1. to B.4. (but 250-kHz squarewave).
5. As for B.5., but first set one edge into the tolerance frame using ↔, and then the other edge.
6. As for B.6., both edges should be exactly symmetrical in the tolerance frame.
7. As for B. 7.

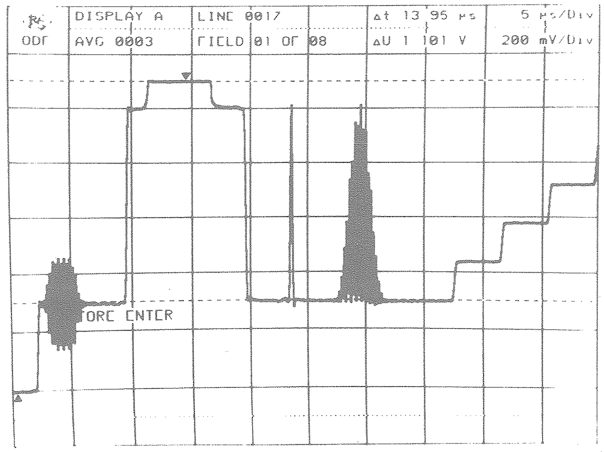
Note Since the squarewaves have the same rise times, the same sweep speed is used to measure the overshoot despite different frequencies. The overshoot is only dependent on the rise time (and the system bandwidth), see opposite page.

TRANSIENT RESPONSE (15 kHz/250 kHz) with ODF

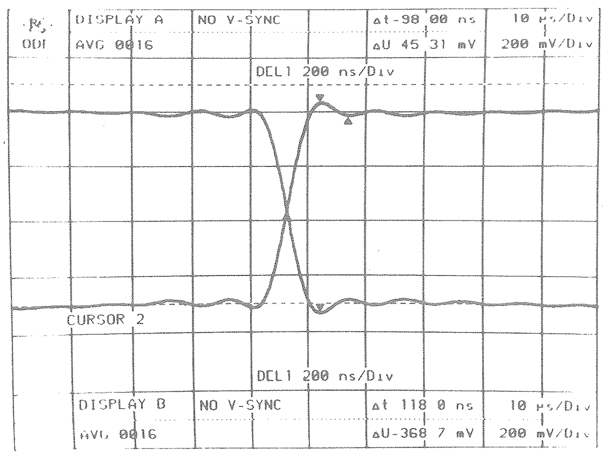
Note A detailed description of the TV Digital Oscilloscope ODF is included in the appendix from p. 214 onwards.

Storage of the measured values in the ODF results in a uniform and flicker-free display even with long sweep times and thus guarantees higher accuracy than with conventional analog oscilloscopes. The electronic generation of the graticule or the tolerance masks also contributes towards higher accuracy (no geometric and parallax errors), as does the facility of accessing each point on the curve with the cursor and displaying the Y value with great accuracy as a number on the screen (10-bit resolution = 1024 steps).

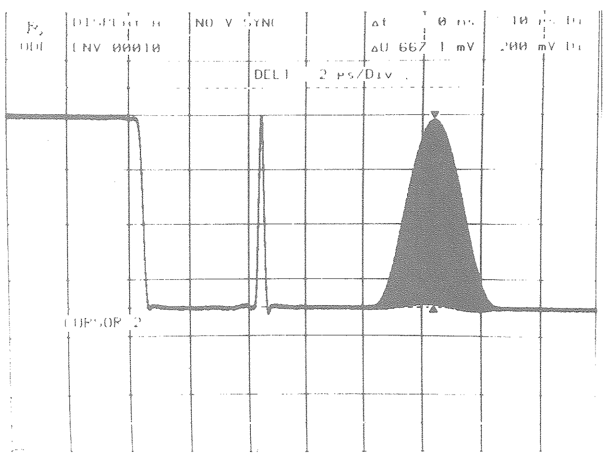
When measuring the transient response of 15-kHz and 250-kHz squarewaves (see p. 44), it is advantageous to display both edges of the step function in the tolerance mask at the same time. The TV Digital Oscilloscope ODF is provided for this purpose with two independently adjustable units for delaying the start of the sweep. Two parts of a curve in DUAL DELAY mode can then be displayed simultaneously in a tolerance mask called from the SCALE memory. The cursors for measured points enable time (absolute) and amplitude (absolute or relative) differences to be displayed as numeric values on the screen for comparison with freely selectable reference values (cursor function). Thus comparisons between the overshoot of the 15-kHz and 250-kHz squarewaves can easily be made with amplitudes without overshoot, or comparisons between the amplitudes of the 2T and 20T pulses with the black-white transition. The last three signals mentioned are contained in test line 17.



Test line 17 (section) with zero reference pulse
Average-value formation (AVG), N = 3;
no envelope function (ENV);
voltage measurement with cursor function:
(zero reference pulse — sync pulse = 1.101 V)



Transient response of a 250-kHz signal (10/75%), displays A and B used with two cursors each;
rising edge (display A): overshoot amplitude 45.3 mV = 5.9%;
falling edge (display B): one cursor is located at the point where the curves cross, the other at the lowest overshoot. ΔV = 368.7 mV, overshoot referred to 350 mV: 18.7 mV = 2.7%



Test line 17 (section)
Envelope curve formation (ENV), N = 10;
cursor measurement on 20T pulse, ΔV = 667 mV, referred to 700 mV results in ΔA = 33 mV = 4.7% drop at 4.43 MHz compared to low frequencies

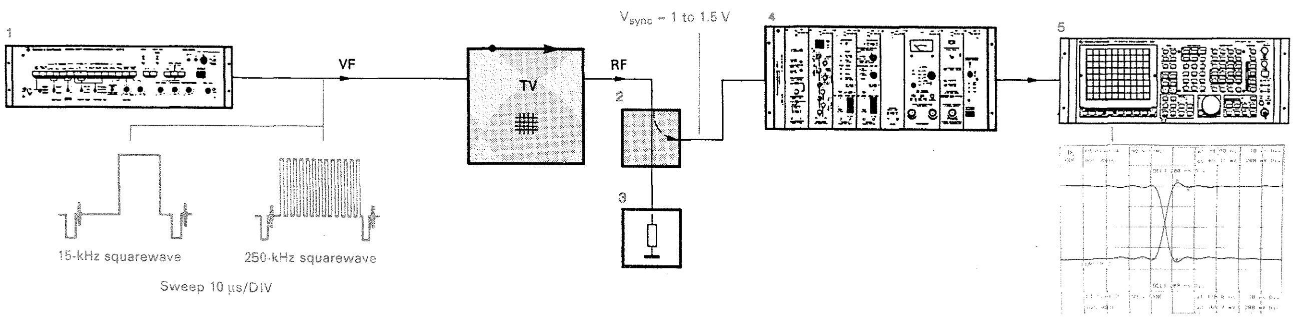
Measurement Procedure

A. Basic settings

1. As on p. 41 (15-kHz squarewave, rise time 2T), but connect front input of TV Digital Oscilloscope ODF to video output 2 of AMF 2 (note: no overshoots because of rise time 2T).
2. Press following keys on ODF:
   DISPLAY: A, DOT JOIN,
   MODE: SCOPE,
   ANALOG INPUT MODE: FRONT 75 Ω, TV DC RESTORER ⏚,
   TRIGGER SELECT: INT, –, DIRECT, ◆ and LINE, ALL,
   TIME-VOLT/DIV: 200 (green), mV and 10 (green), μs,
   RESPONSE: FLAT;

These settings apply to use of the ODF as a TV digital oscilloscope. It is recommendable to store this setting (keys STORE, STAT, 1 (red), ENTER).

TRANSIENT RESPONSE
with ODF (15 kHz/250 kHz)



See opposite page for explanations

1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF

5 TV Digital Oscilloscope ODF (photo p. 56)

Measurement Procedure (continued)

B. Measurement of transient response with 15-kHz squarewave (10/75 %)

1. Press ↕Y on oscilloscope and adjust oscillogram to correct height using spinwheel VARY.
2. Switch TV demodulator to SYNCHRONous (demodulation).
3. Settings on ODF: DEL 1, 200 (green), ns, DEL 1. Position the bar in the oscillogram above the rising edge using VARY.
4. Press DEL 2, 200 (green), ns, DEL 2. Position the bar in the oscillogram below the falling edge using VARY.
5. Press START. Both edges appear on the screen. Adjust falling edge to centre of screen using VARY (slowly).
6. Press DEL 1. Position the rising edge on the falling edge using VARY such that the point of intersection is at half the pulse amplitude.
7. Press RCL, SCALE, X (red) and ENTER. The tolerance mask called from the memory appears on the screen (obtain X from the table which is called using RCL, SCALE, 0 (red) and ENTER).
8. Position curves into the tolerance mask exactly using the keys DIGITAL WINDOW ↕ and ↔ and with VARY. The horizontal adjustment ↔ always acts on the curve whose associated delay key (DEL 1, DEL 2) was pressed last.
9. If necessary, use Y ⊽ (top right) to adjust height of oscillogram into the tolerance mask.
10. Press CURSOR 1; triangle appears above curve; shift to top line using VARY.
11. Press CURSOR 2; triangle appears below curve; shift to bottom line (black value) using VARY.
12. Press % and ENTER. Output on display: 100 %.
13. Set 15-kHz squarewave, RISETIME T and MODE H.
14. The overshoots can be recognized on the screen or measured using the cursor function (see F).

C. Measurement of transient response with 250-kHz squarewave

1. For modulation 10/75 %, set 250-kHz squarewave on SPF 2 and initially RISETIME 2T with H pulses.
2. As for B.1. to B.14.

D. Measurement of transient response with other modulation (15 kHz or 250 kHz)

1. On test-signal generator, first press 15 kHz, RISETIME 2T, MODE H, SETUP and VITS CALibration.
2. As for B.1.; set the prescribed amplitude of picture content on screen (e.g. 55/75 %) using VIDeo AMPLitude and % VIDeo on the SPF 2.
3. Press 100 (green) and mV keys on ODF and adjust transient amplitude to 3.5 DIV using control Y ⊽ (top right).
4. As for B.3. to B.14.
5. For measurements on the 250-kHz pulse, set SPF 2 to 250 kHz; the other settings remain unchanged; same procedure as 1. to 4.

E. Measurement of transient response with 15-kHz squarewave in test line 17

1. Press LINE, 1 (red), 7 (red) and ENTER on ODF.
2. As for B.1. to B.12.
3. As for B.14.

F. Measurement with cursor function of ODF

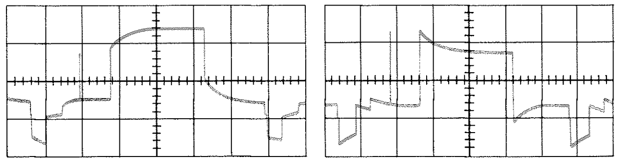
1. The step amplitude has already been calibrated to 100 % in sections B and D according to B.10. to B.12.
2. Use CURSOR 2 key and spinwheel VARY to set the bottom triangle exactly to the point of intersection of the two edges (centre of tolerance mask).
3. Press CURSOR 1. Use VARY to move the top triangle along the curves. The display outputs the difference in time with respect to CURSOR 2 (abscissa of tolerance mask) and the difference in amplitude compared to the average value 50 %. The amplitude of the overshoots in % is
   $\Delta V_{\%} - 50$ ($\Delta V_{\%}$ = indicated value).
4. The values of the overshoots can be conveniently measured at the times required in the standard specifications by means of VARY.
5. Proceed in exactly the same manner to measure the lower part of the curves, but interchange CURSOR 1 and CURSOR 2.

2T PULSE AND SQUAREWAVE SIGNAL

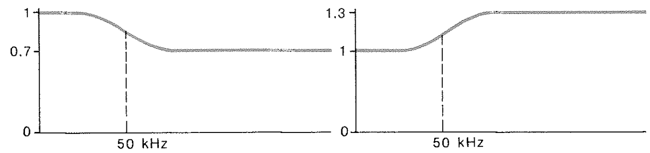
The line-frequency squarewave signal with a rise time of 200 ns determines frequency-response errors of the vision transmitter in the range from 15 kHz to several hundred kHz (see diagram opposite). The tilt and rounding that occur are dealt with on pages 42 and 43.

The 2T pulse is a sine² pulse with a half-amplitude duration of 200 ns. Its name is derived from the transient time constant $T = 1/2\,f_c$ of television systems. At a limit frequency of 5 MHz, it is 100 ns. The shape and size of the 2T pulse are particularly affected by frequency-response errors in the middle of the vision-transmitter band. Its distortions are rated with k factors for pulse height ($k_{2T/B}$, see diagram opposite) and for pulse shape (k_{2T}). The 2T-pulse k-rating mask (below) for baseline distortions shows distortion produced by group-delay errors. Because of the quadrature errors with full modulation (10/75%), it is only possible to work with synchronous detection. With envelope detection, lower modulation (50/70%) must be applied.

The 2T pulse and the squarewave signal do not cover the colour-subcarrier region, so they are chiefly used for examining the luminance response of TV transmitters. Both are contained together with the modulated 20T pulse (page 50) and a five-riser staircase in test line 17 (see oscillogram in diagram of setup on next page).

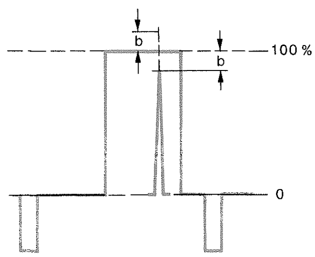


2T pulse and squarewave signal

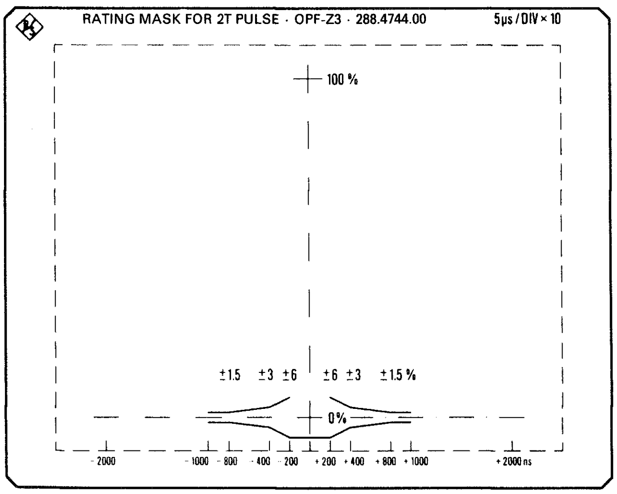


Frequency response of amplitude

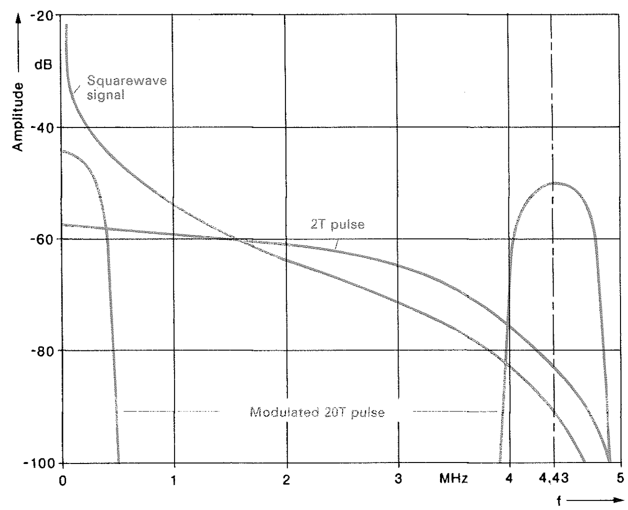
Influence of errors in frequency response of amplitude in vision transmitters on 2T pulse and squarewave signal



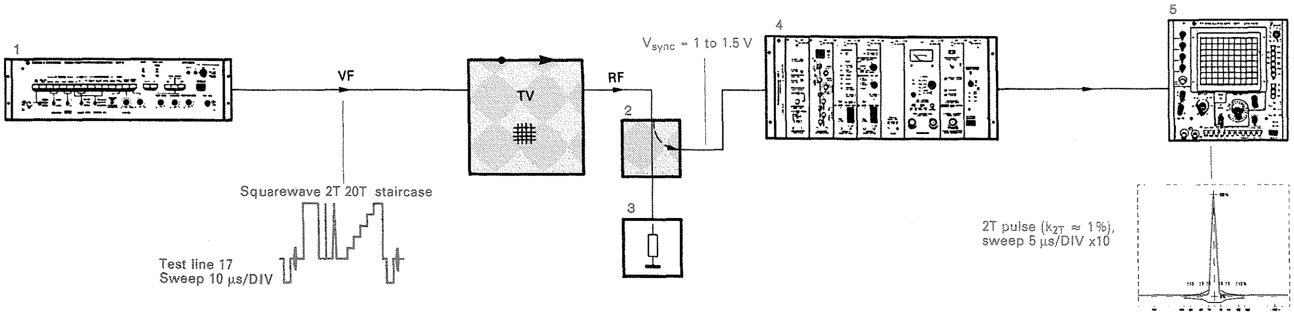
Determining $k_{2T/B}$ factor of 2T pulses:
$k_{2T/B} = 25 \cdot \frac{b}{h}$ [%];
(h = pulse height = 100%)



2T-pulse k-rating mask of TV Oscilloscope OPF for determining baseline distortions of 2T pulses (factor k_{2T})



Frequency spectra of 2T pulse, squarewave signal and modulated 20T pulse (amplitude 0 dB corresponds to peak value of signals)



1 Video Test Signal Generator SPF 2 (photo p.24) or Insertion Signal Generator SPZF (photo p.25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p.36) or AMF

5 TV Oscilloscope OPF (photo below) with 2T-pulse rating mask

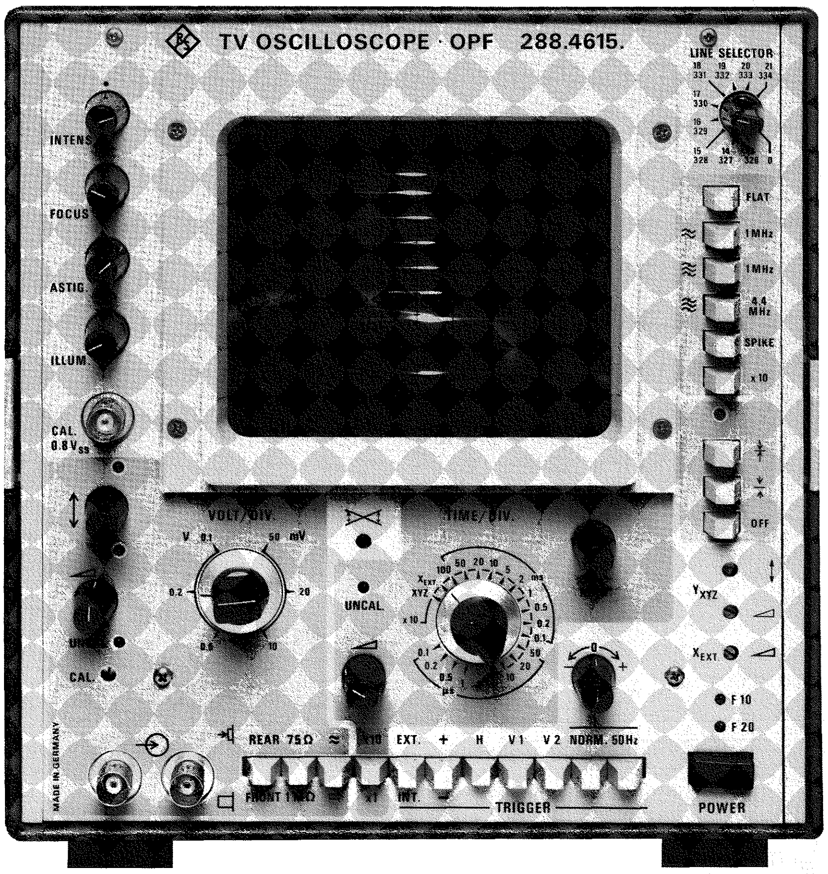
Measurement Procedure

A. Basic settings

As on p.41 (set TIME/DIV to 5 µs/DIV).

B. Measurement of pulse height and overshoot of 2T pulse

1. Set mode H and test line 17 on test-signal generator.
2. Switch TV demodulator to SYNCHRONous DETECTION.
3. Adjust gain on oscilloscope so that top of squarewave signal is at 100%.
4. Adjust 2T pulse to centre of screen using ↔, then press x10 key (bottom) and set pulse to centre of tolerance mask.
5. Measure deviation of pulse height from 100% line and calculate factor $k_{2T/B}$.
6. Set pulse height to 100% with Y gain of oscilloscope.
7. Calculate factor k_{2T} from 2T-pulse rating mask.



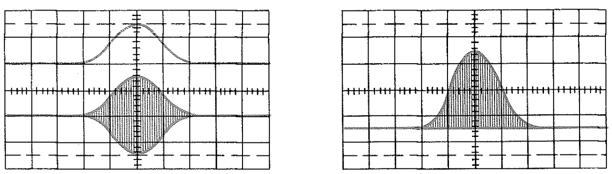
TV Oscilloscope OPF

MODULATED 20T PULSE

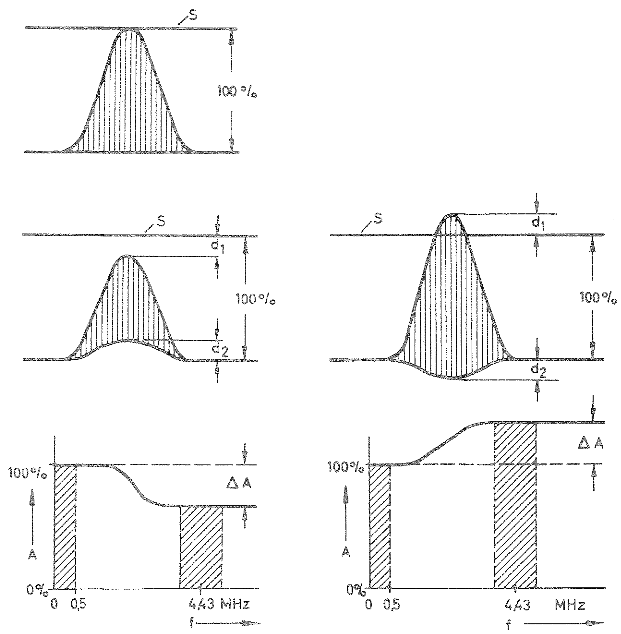
The 20T pulse has a half-amplitude duration of 2 µs. It is produced by modulation of a colour-subcarrier signal with a sine² pulse, the modulation signal subsequently being added to the subcarrier again (diagram below). It contains two spectral regions of the same bandwidth and amplitude in luminance and chrominance (see p. 48). Because of its pulse spectrum it is particularly suitable for examining colour-television systems. Its baseline distortion points to amplitude and group-delay errors in the colour-subcarrier region. Purely amplitude errors produce symmetrical baseline distortion and alteration of the pulse amplitude, whereas purely group-delay errors appear as unsymmetrical baseline distortion without alteration of the pulse amplitude.

Because of the quadrate errors with full modulation (10/75%), it is only possible to work with synchronous detection. With envelope detection lower modulation (50/70%) must be applied.

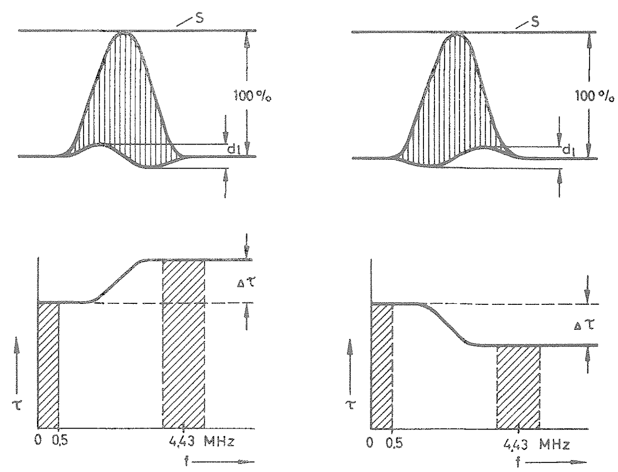
The following diagrams show typical pulse distortion for amplitude and group-delay errors and the error quantities that can be determined.



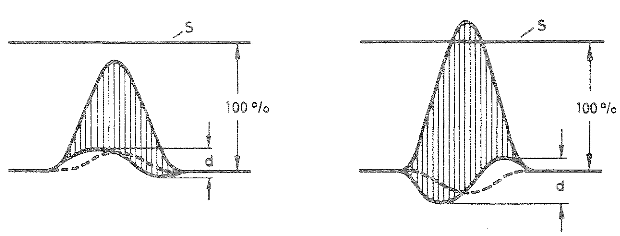
Modulated 20T pulse obtained through phase and amplitude addition of low frequency and colour-subcarrier pulse;
left: low-frequency component and colour-subcarrier pulse;
right: 20T pulse



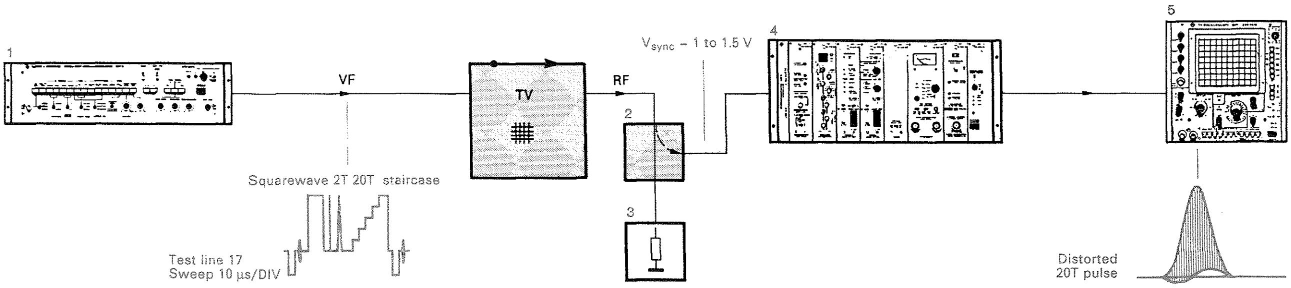
Distortion of modulated 20T pulse with purely amplitude errors;
above: undistorted 20T pulse
(S = top of squarewave signal)
centre: pulse shapes ($d_1 = d_2 = d_a$)
below: frequency response of amplitude $\Delta A = 2 \cdot d_a$ [%]



Distortion of modulated 20T pulse with purely group-delay errors;
above: pulse shapes
below: frequency response of group delay $\Delta\tau_g = 12.7 \cdot d_1$ [ns]



Simultaneous amplitude and group-delay errors;
dashed lines are amplitude errors alone (d is not a linear addition of d_a and d_1)



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF (only for low level of modulation)

5 TV Oscilloscope OPF (photo p. 49)

Measurement Procedure

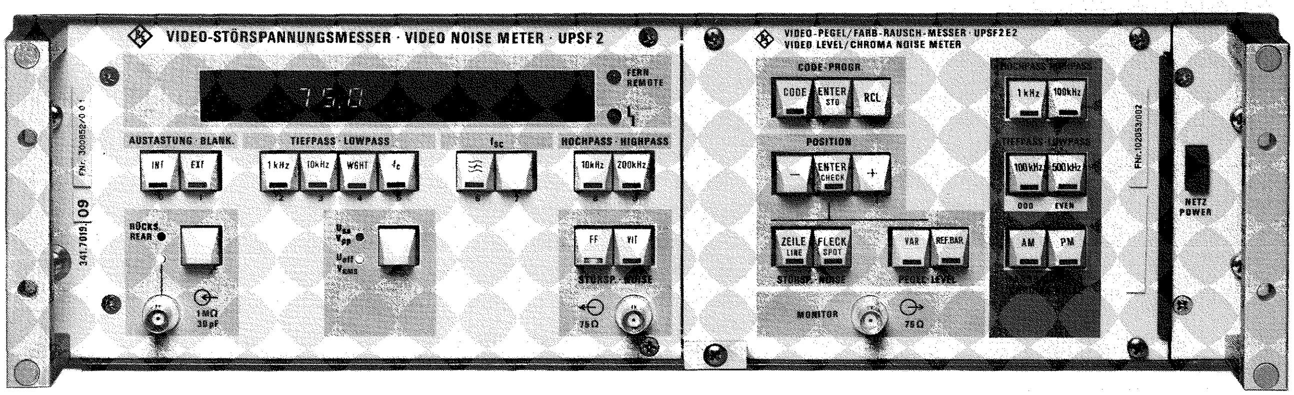
A. Basic settings

As on p. 41, TIME/DIV to 5 µs/DIV.

B. Measurement of amplitude and group-delay errors in colour-subcarrier region

1. Select mode H and test line 17 on test-signal generator.
2. Switch TV demodulator to SYNCHRONous DETECTION.
3. Adjust gain on oscilloscope so that squarewave signal has amplitude of 10 DIV (= 100%).
4. Press x10 in the bottom row of keys and set pulse to centre of display.
5. Measure distortion of 20T pulse and determine distortion values according to details opposite.

Video Noise Meter UPSF 2



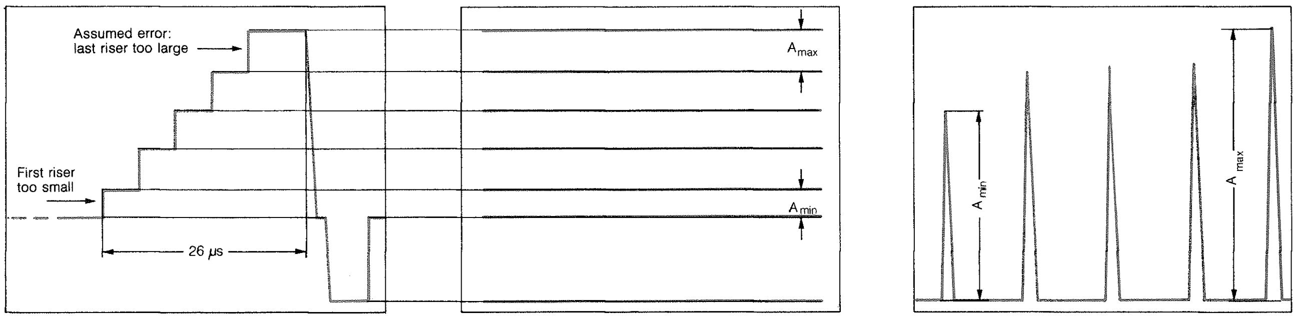
LINE-TIME NONLINEARITY

with OPF

Note Measurement of line-time nonlinearity using the TV Digital Oscilloscope ODF is described on pages 56 and 57.

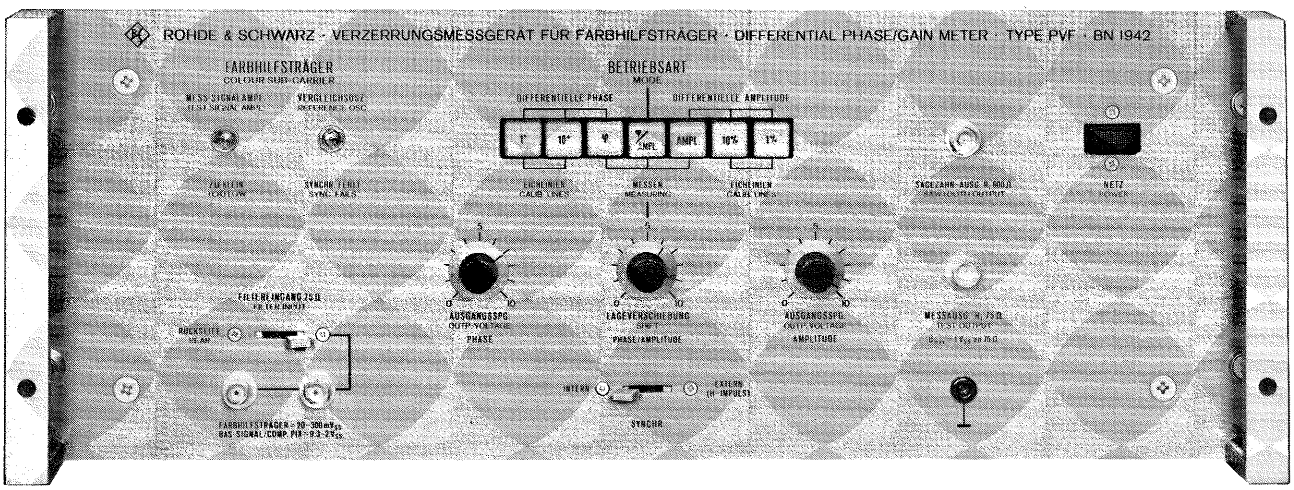
Measuring principle A particularly important factor to be determined in the testing and measuring of vision transmitters is the alteration of the gain with differing modulation. This is defined by the figure of linearity (minimum to maximum slope of the modulation characteristic) and is measured in different frequency regions. Nonlinearity in the low-frequency region, or what is known as line-time nonlinearity, is best investigated with a staircase signal. The difference in height of the risers in the output signal — in the original input signal they are all of the same height — is a measure of the line-time nonlinearity. This can be measured with the oscilloscope unsynchronized. Another method is to differentiate the output signal. Voltage peaks appear at each of the riser transitions that are a measure of the riser height and can therefore be used to determine the line-time nonlinearity (diagram below).

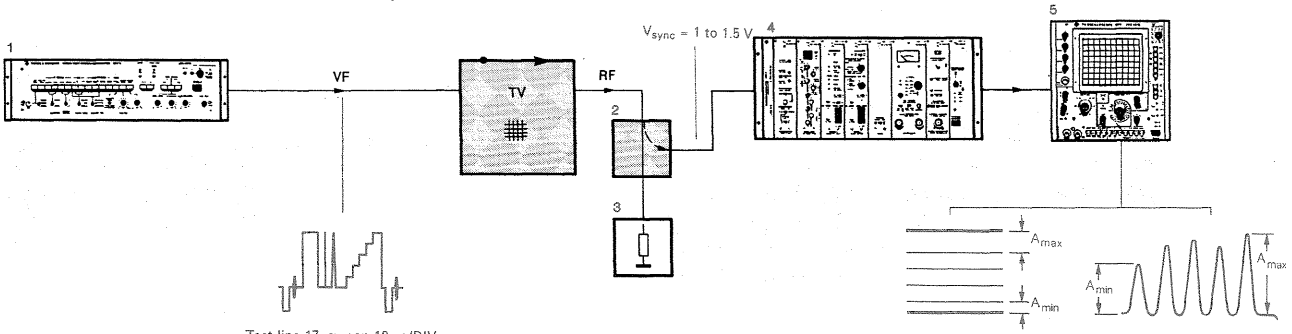
The **TV Oscilloscope OPF** from Rohde & Schwarz possesses a differentiating network for simply determining line-timing nonlinearity. The **Video Test Signal Generator SPF 2** produces test line 17, which contains a five-riser staircase and the 2T and 20T pulse and bar signals.



Measuring line-time nonlinearity: the staircase signal (left) appears as stripes (centre) when the oscilloscope is unsynchronized. The spacing between the stripes yields $\frac{A_{min}}{A_{max}}$ the line-time nonlinearity. The diagram on the right shows the staircase signal after differentiation. A_{min} and A_{max} can easily be read off.

Differential Phase/Gain Meter PVF





Test line 17, sweep 10 µs/DIV

1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF

5 TV Oscilloscope OPF (photo p. 49), without tolerance mask, use internal graticule

Measurement Procedure

A. Basic settings
As on p. 41.

B. Determination of line-time nonlinearity with free-running staircase (oscilloscope unsynchronized)

1. Select mode H and signals for test line 17 on test-signal generator.
2. Set TIME/DIV on TV Oscilloscope OPF to 5 µs/DIV and TRIGGER to V1 or V2 so that the display is free-running.
3. Measure largest and smallest spacing (A_{max} and A_{min}) between lines (use graticule for ease of reading).
   Measuring accuracy can be improved by increasing gain so that largest spacing between lines is 1 or 2 DIV for example. Centre the "steps" with ↕ (left) and measure them individually.
4. Line-time nonlinearity is:
   $\frac{A_{min}}{A_{max}}$

C. Determination of line-time nonlinearity with differentiated staircase

1. Select mode H and test line 17 on test-signal generator.
2. Set TIME/DIV on oscilloscope to 5 µs/DIV and TRIGGER to H. Centre the staircase using ↔.
3. Press SPIKE key, set base of spikes to second graticule line from bottom using ↕. Determine the largest and smallest amplitudes of the spikes.
4. Line-time nonlinearity is:
   $\frac{A_{min}}{A_{max}}$

CHROMINANCE NONLINEARITY

with OPF

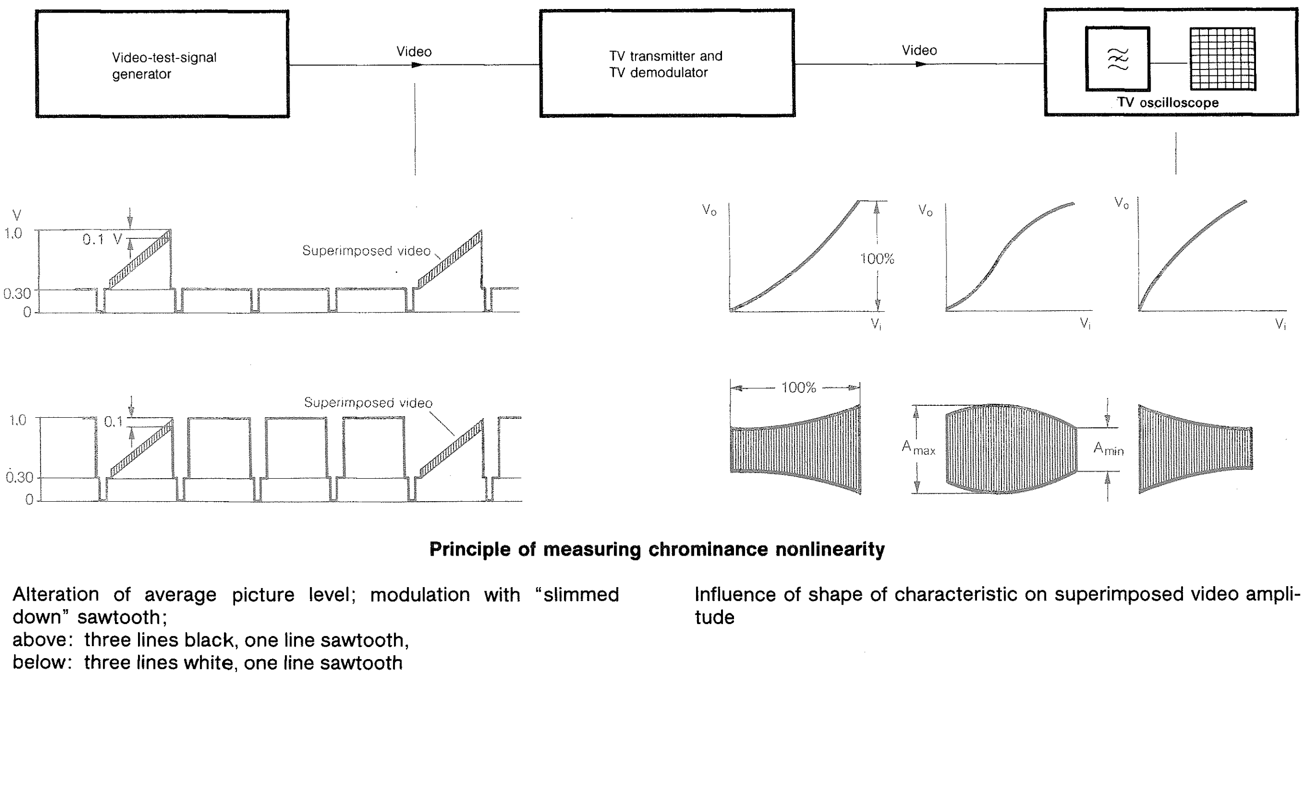
measurements outside

Note Measurement of line-time nonlinearity using the TV Digital Oscilloscope ODF is described on pages 56 and 57.

Measuring principle In contrast to line-time nonlinearity, which is measured at low frequencies, chrominance nonlinearity is measured at frequencies in the MHz region. For this a sawtooth signal is used, superimposed with a signal of small amplitude. For evaluation, only the amplitude of this superimposed signal is examined, as a function of modulation. The chrominance nonlinearity is the ratio of the smallest to the highest amplitude. The use of a "slimmed down" sawtooth (one line sawtooth, three lines black or white) provides information pointing to the dependence of chrominance nonlinearity on average picture level. The principle of this is illustrated in the diagram below. Any frequency within the video band is suitable for the superimposed signal. In practice 1 MHz is adequate and the colour-subcarrier frequency.

What is of advantage here is the fact that the Video Test Signal Generator SPF 2 supplies sawtooth signals directly with a superimposed colour subcarrier, i.e. without the need for an additional level generator. The frequency of 1 MHz can be derived from any video signal generator. The TV Oscilloscope OPF has bandpass filters of 1 MHz and 4.43 MHz especially for these measurements.

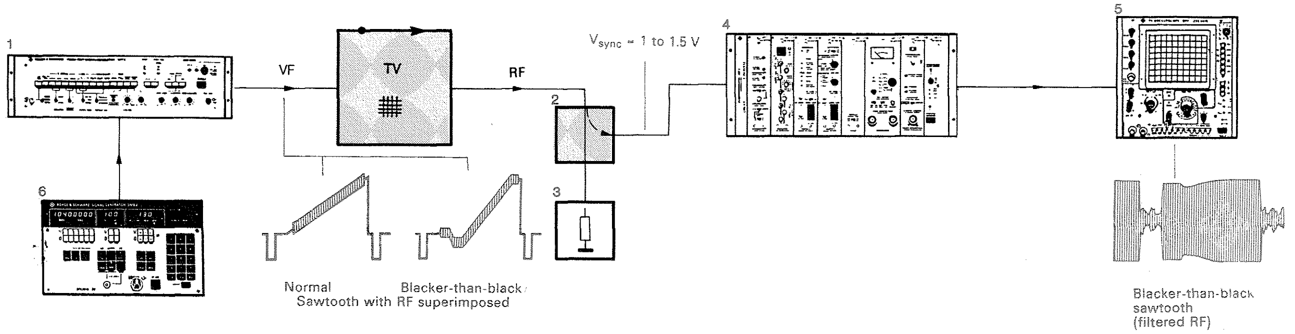
The **chrominance nonlinearity at the colour-subcarrier frequency** can also — in addition to the method described here — be determined with the **Differential Phase/Gain Meter PVF** from Rohde & Schwarz (see pages 66 and 67). In this case it should be noted that another sawtooth signal (a blacker-than-black sawtooth) is generally used for the colour-subcarrier frequency, and that the Differential Phase/Gain Meter shows the differential gain as the difference from 100% linearity.



Principle of measuring chrominance nonlinearity

Alteration of average picture level; modulation with "slimmed down" sawtooth;
above: three lines black, one line sawtooth,
below: three lines white, one line sawtooth

Influence of shape of characteristic on superimposed video amplitude



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)
2 Directional coupler (incorporated in transmitter)
3 Dummy antenna (according to transmitter power)
4 TV Demodulator AMF 2 (photo p. 36) or AMF
5 TV Oscilloscope OPF (photo p. 49)
6 Signal Generator SMS 2, 0.1 to 1040 MHz (photo p. 14) or any RF signal generator up to max. 10 MHz

Measurement Procedure

A. Basic settings

1. As on p. 41.
2. Connect output of Signal Generator SMS 2 to input EXT. SIGNAL of SPF 2. Frequency setting 1 MHz, $Z_s = 50\ \Omega$, output voltage 35.5 mV.
3. On Video Test Signal Generator SPF 2, select EXTernal SIGNal, APL clamping with blanking, sawtooth signal, APL 50%, SUBCarrier OFF and mode H.
4. Check output signal on OPF. Superimposed amplitude should be approx. 10% CVS (V_{pp}). Correct output voltage on SMS 2 if necessary.

B. Measurement of chrominance nonlinearity at 1 MHz

1. Set oscilloscope to 0.1 V/DIV, 10 μs/DIV and TRIGGER H, then press 1 MHz key (top right). Adjust gain if necessary so that display is easy to evaluate (e.g. amplitude 10 DIV).
2. Determine maximum (A_{max}) and minimum (A_{min}) amplitude.

Chrominance nonlinearity: $S_{1\ MHz} = \frac{A_{min}}{A_{max}}$

C. Measurement of chrominance nonlinearity at 4.43 MHz (differential gain)

1. Select blacker-than-black sawtooth on SPF 2, set SMS 2 to 4.43 MHz.
2. As for B.1., but press 4.4 MHz key (top right).
3. Determine maximum (A_{max}) and minimum (A_{min}) amplitude.

Chrominance nonlinearity: $S_{4.43\ MHz} = \frac{A_{min}}{A_{max}}$

Differential gain: $1 - \frac{A_{min}}{A_{max}}$

D. Measurement of chrominance nonlinearity at 4.43 MHz (differential gain) without additional generator

1. Set SPF 2 to blacker-than-black sawtooth, SUBCarrier NORMAL, EXTernal SIGNal off, APL 50%.
2. Set oscilloscope to 0.1 V/DIV and TRIGGER H. Press 4.4 MHz key. Adjust gain if necessary so that display is easy to evaluate (e.g. amplitude 10 DIV).
3. Determine maximum amplitude (A_{max}) and minimum (A_{min}) amplitude.

Chrominance nonlinearity: $S_{4.43\ MHz} = \frac{A_{min}}{A_{max}}$

Differential gain: $1 - \frac{A_{min}}{A_{max}}$

E. Measurement with "slimmed down" sawtooth

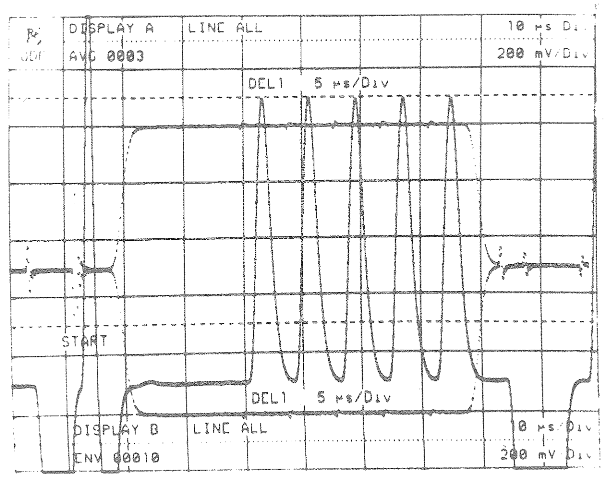
The measurements under B, C and D can also be performed with a "slimmed down" sawtooth (black and white). For this purpose set switch APL on video-test-signal generator to 10% (black) or 90% (white). Set TIME/DIV on oscilloscope to 50 μs/DIV. Evaluate as above.

NONLINEARITY (LINE-TIME/CHROMINANCE) with ODF

Note The measuring principle is explained on pages 52 (line-time linearity with OPF) and 54 (chrominance non-linearity with OPF). A detailed description of the TV Digital Oscilloscope ODF is included in the appendix from p. 214 onwards.

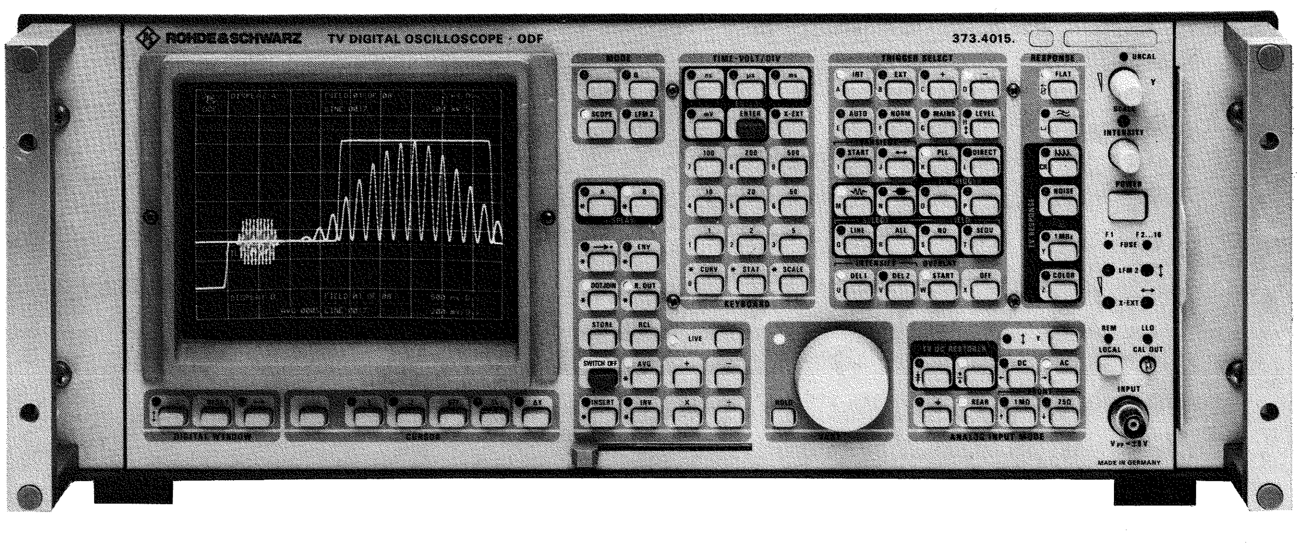
The TV Digital Oscilloscope ODF simultaneous displays two different traces (displays A and B) on the screen which are obtained from **one** test curve by different treatments. The line-time and chrominance non-linearity result from a staircase signal with superimposed RF signal by differentiating or filtering out the RF signal. The two curves can be displayed simultaneously following appropriate expansion and offset (the delay timebase can be set separately for each curve); see diagram on right. Since the nonlinearity measurement requires the same sections of the test curve to be displayed in the two traces, the settings for sensitivity, delay and timebase are identical. Only the differential filter or bandpass and the amplitude offset need be entered separately for each display.

The staircase signal with superimposed RF signal can be obtained from a video-test-signal generator. It is also contained in the test line signal 330.

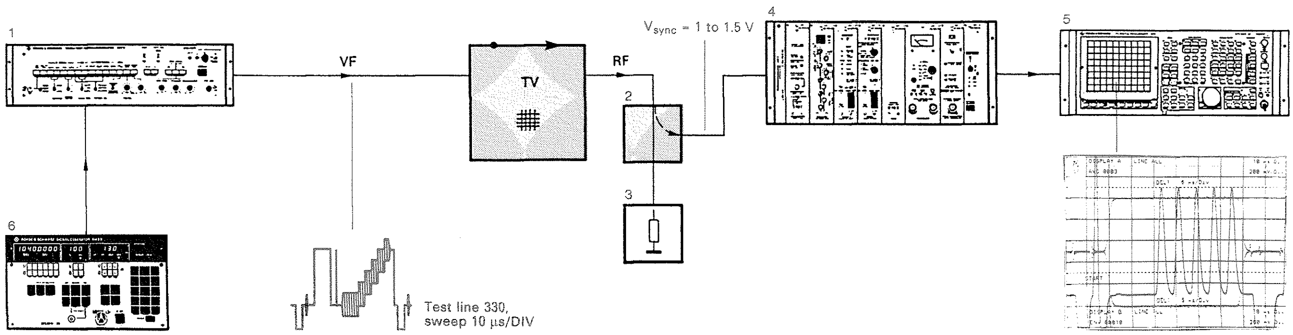


Test line signal CCIR 330
DUAL DISPLAY MODE
DISPLAY A: line-time nonlinearity with spike filter
DISPLAY B: chrominance nonlinearity
Single-point display with envelope function

TV Digital Oscilloscope ODF



NONLINEARITY with ODF (LINE-TIME/CHROMINANCE)



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)
2 Directional coupler (incorporated in transmitter)
3 Dummy antenna (according to transmitter power)
4 TV Demodulator AMF 2 (photo p. 36) or AMF
5 TV Digital Oscilloscope ODF (photo on left)
6 Signal Generator SMS 2, 0.1 to 1040 MHz (photo p. 14) or any RF signal generator up to max. 10 MHz

Measurement Procedure

A. Basic settings

1. Oscilloscope settings as on p. 46, A.2. (if necessary, recall stored setting using RCL, STAT, 1 (red) and ENTER).
2. Connect output of Signal Generator SMS 2 to input EXT. SIGNAL of SPF 2. Frequency setting 4.43 MHz, $Z_0 = 50\ \Omega$, output voltage 35.5 mV.
3. Switch SPF 2 to blacker-than-black staircase signal (toggle switch up). For internal colour-subcarrier: SUBCarrier NORMAL, for colour-subcarrier from SMS 2: EXTernal SIGNal, APL clamping with blanking, SUBCarrier OFF.
4. Check output signal on ODF. Superimposed amplitude should be 10% CVS (peak-to-peak). Correct output voltage of SMS 2 if necessary (adjust oscillogram to correct amplitude using ↕Y and VARY).

B. Measurement of nonlinearity at 4.43 MHz

1. On ODF press keys DEL 1, 5 (green), µs and DEL 1.
2. Mark the staircase with the bar using VARY, then press START. The staircase is now expanded on the screen.
3. Press TV RESPONSE ⩘⩘⩘ ; the spikes appear on the screen. Using ↕Y and VARY set the highest peak to 1.5 DIV from the top (dashed line).
4. The curve disappears when SWITCH OFF and DISPLAY A are pressed.
5. Press DISPLAY B and then same setting as in 1. and 2. The magnified staircase (as in B.2.) appears on the screen.
6. Press TV RESPONSE COLOR, ENV, ENTER, SWITCH OFF and DOT JOIN. The filtered-out colour-subcarrier burst appears on the screen. Using ↕Y and VARY set the top edge to the second graticule line from the top.
7. Press DISPLAY A; the spikes appear in addition.
8. Determine the maximum (A_{max}) and minimum (A_{min}) amplitude in each case. The spikes refer to the line-time nonlinearity, the RF amplitudes to the chrominance nonlinearity:

   $$S = \frac{A_{min}}{A_{max}}$$

   See E. for evaluation with cursor function.

C. Measurement of nonlinearity at 1 MHz

1. Set SMS 2 to 1 MHz. Set EXTernal SIGNal, APL clamping with blanking and SUBCarrier OFF on SPF 2.
2. Press DISPLAY B and TV RESPONSE 1 MHz on ODF. The same display appears as in B.6., but for 1 MHz.
3. Evaluate as in B.8.

D. Determination of nonlinearity with test line 330

1. Press LINE, 3 (red), 3 (red), 0 (red) and ENTER on ODF.
2. As for B.1. to B.8.

E. Evaluation with cursor function

1. Press SWITCH OFF and DISPLAY A on ODF. Only the display as in B.6. for measuring the chrominance nonlinearity appears on the screen.
2. To smoothen the curves, press ENV, 5 (red) and ENTER.
3. Press CURSOR 1. Use VARY to set the top triangle to the highest point of the area. Press CURSOR 2 and set bottom triangle to lowest point of the area. The x value must be the same as with CURSOR 1. (Output on display: $\Delta t = 0$).
4. Press % and ENTER. Output on display: 100%.
5. Set triangles to the lowest peak of the area using VARY (same x value, $\Delta t = 0$). The display indicates nonlinearity:

   $S = \frac{A_{min}}{A_{max}} \times 100\,\%$ (A: height of area).
6. Carry out same measurement with sideband frequency 1 MHz. Set SMS 2 to 1 MHz and press TV RESPONSE 1 MHz on ODF.
7. Press DISPLAY A, SWITCH OFF and DISPLAY B. Only the display according to B.3. appears on the screen for measurement of the line-time nonlinearity.
8. Press CURSOR 1 and set triangle to highest peak using VARY.
9. Press CURSOR 2 and set triangle to baseline using VARY.
10. Press % and ENTER. Output on display: 100%.
11. Press CURSOR 1. Set triangle to lowest peak using VARY.
12. Display indicates line-time nonlinearity in %.

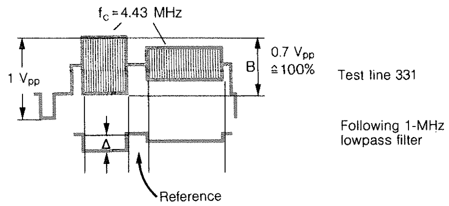
TV

CHROMINANCE/LUMINANCE INTERMODULATION

The measurement of chrominance/luminance intermodulation shows to what extent the colour information (chrominance signal) affects the brightness information (luminance signal).

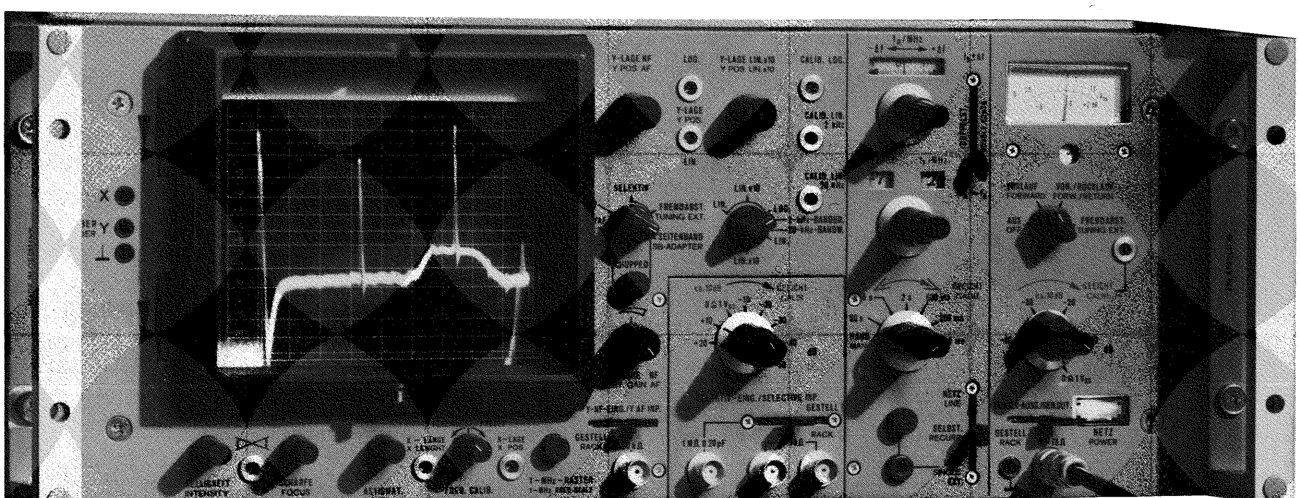
The test line 331 considerably simplifies this measurement. It consists of two different colour-subcarrier bursts with an average grey pedestal. If the colour-subcarrier frequency is suppressed for evaluation (there is a 1-MHz lowpass filter in the TV Oscilloscope OPF for this purpose), the screen of the oscilloscope will only show the luminance information (DC average value of colour-subcarrier bursts). The shift in this average value as a result of the colour-subcarrier amplitudes enables the intermodulation to be determined (diagram on the right).

For this measurement a TV demodulator with synchronous detection should be used (e.g. AMF 2 from Rohde & Schwarz). With envelope detection the single-sideband transmission of the chrominance signal leads to an additional, system-dependent basic error, which will have to be deducted.

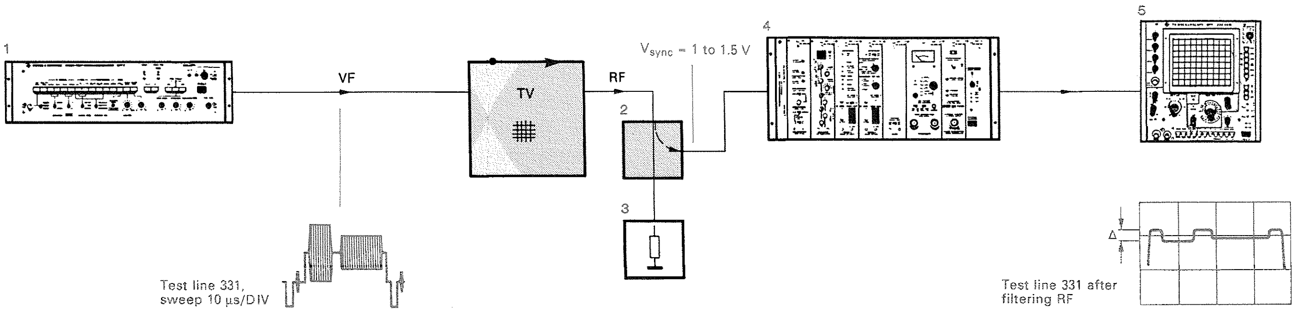


$$\text{Chrominance/luminance intermodulation} = \frac{\Delta}{B} \cdot 100\ [\%]$$

Videoscope SWOF 3



CHROMINANCE/LUMINANCE INTERMODULATION



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36)

5 TV Oscilloscope OPF (photo p. 49)

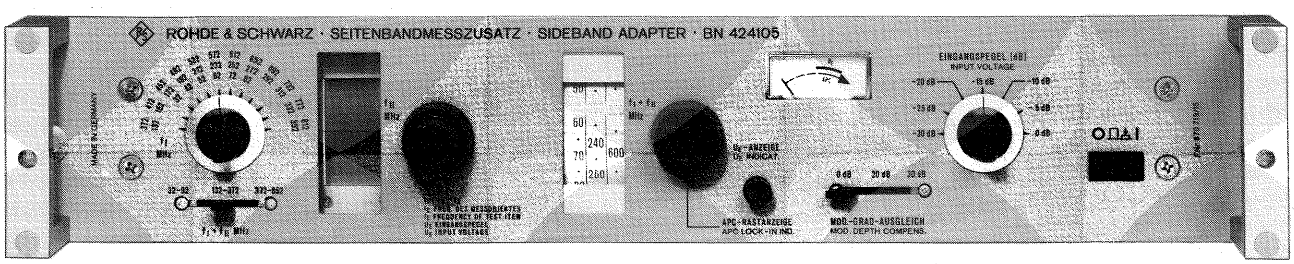
Measurement Procedure

A. Basic settings
As on p. 41.

B. Measurement of chrominance/luminance intermodulation

1. Switch test-signal generator to mode H and test line 331.
2. Switch TV demodulator to SYNCHRONous DETECTION.
3. On oscilloscope set largest vision content B (= 1st colour-subcarrier burst) to obtain an acceptable display height, e.g. 10 DIV (100%).
4. Cut in 1-MHz lowpass filter on oscilloscope (key at top right).
5. Measure shift of centre line (Δ) and refer to full vision amplitude (100%).
6. Intermodulation = $\frac{\Delta}{B} \times 100\%$.

Sideband Adapter SWOF 3-Z



PHASE MODULATION OF VISION CARRIER

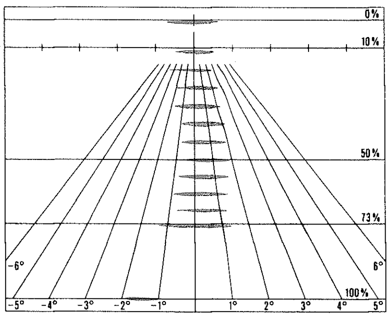
The modulation-dependent change in the phase of the vision carrier occurs in particular with overloaded amplifier stages and poor modulator balance. This phase deviation in the vision carrier is responsible for the intercarrier S/N ratio (see p. 62) which is of great importance because of the stringent demands placed on stereo and dual-sound transmissions.

The phase deviation can be measured directly using a combination of the TV Demodulator AMF 2 and TV Oscilloscope OPF. The AMF 2 outputs a signal in SYNCHRONous (demodulation) mode which is used to track the phase of the switching carrier frequency and is directly proportional to the signal amplitude and the phase deviation of the vision carrier. This so-called quadrature signal (Q signal) is used in the OPF for X deflection, and the signal amplitude for Y deflection. In the normal case (phase deviation zero), all signal values are located on a vertical straight line. A phase deviation can be recognized by a deviation from this line. The zero amplitude value is generated by blanking in the AMF 2. When measuring in test line 17 — during an ongoing program — line 15 is additionally unblanked in the OPF. Line 15 contains the blanking pulse in the AMF 2 (see top line in oscillograms, the measurements have been carried out with a 10-riser staircase signal).

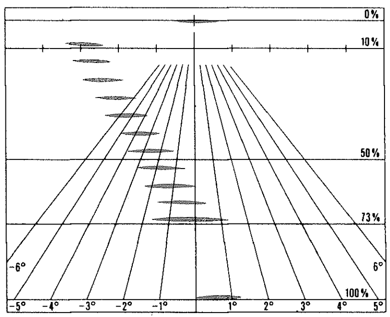
A mask is provided with the OPF for evaluation. The relationship between phase deviation and intercarrier S/N ratio cannot be displayed simply because it depends on the picture contents. According to work performed by the IRT[1]), the following relationship exists between the required intercarrier S/N ratios and the associated permissible phase errors:

	Requirement in standard specifications for TV transmitters	**Permissible phase error**
Black picture	54 dB	2° in synchronous range
FuBK colour test pattern	50 dB	1° in picture range

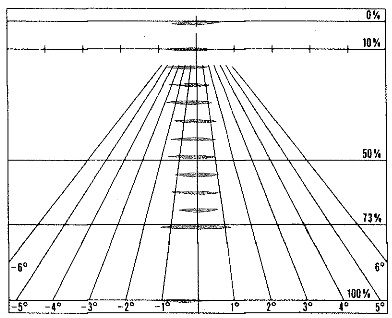
[1]) IRT: Institut for Rundfunktechnik: Schneeberger, G., Rundfunktechnische Mitteilungen 27 (1983), pp. 272—276.



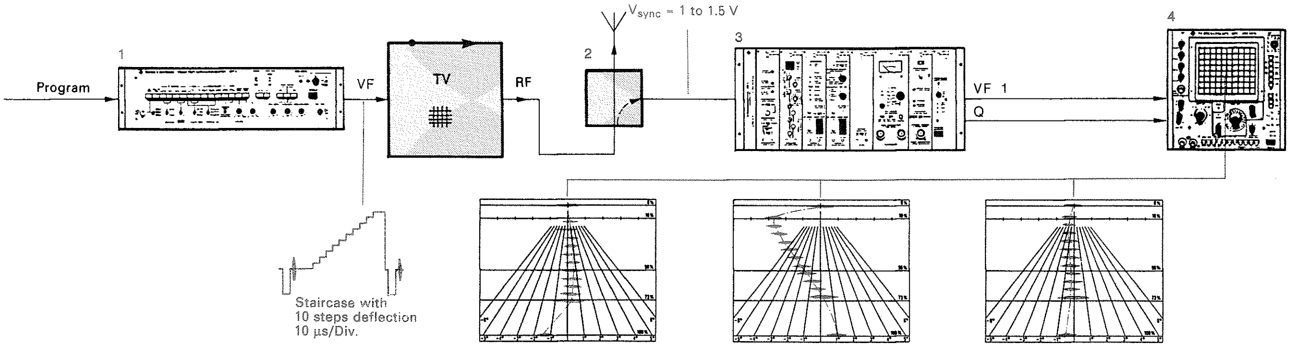
Phase angle of an overloaded amplifier: phase error in synchronous range



Phase angle of vision modulator: balance incorrectly set



Exactly set vision modulator



1 Video Test Signal Generator SPF 2 (photo p. 24) (only required if the program does not contain any test lines)

2 Directional coupler (incorporated in transmitter)

3 TV Demodulator AMF 2 (photo p. 36)

4 TV Oscilloscope OPF (photo p. 49) with mask for phase angle measurement

Measurement Procedure

A. Basic settings

1. As on p. 41.
2. Connect Q DEMOD output of AMF 2 to input X_{EXT} (on rear) of OPF. Set TIME/DIV on OPF to X_{EXT}.
3. Press PHASE PRESET control on AMF 2 and adjust the resulting line on the OPF until it is horizontal by turning the control. Then set the line to 5 DIV (internal graticule) on the OPF using X_{EXT}, keeping PHASE PRESET on the AMF 2 pressed during the process; ZERO REFERENCE must be switched off.
4. Subsequently readjust phase preset on AMF 2 to minimum according to the meter.

B. Measurements in the full-field

(without application of program; use dummy antenna if necessary)

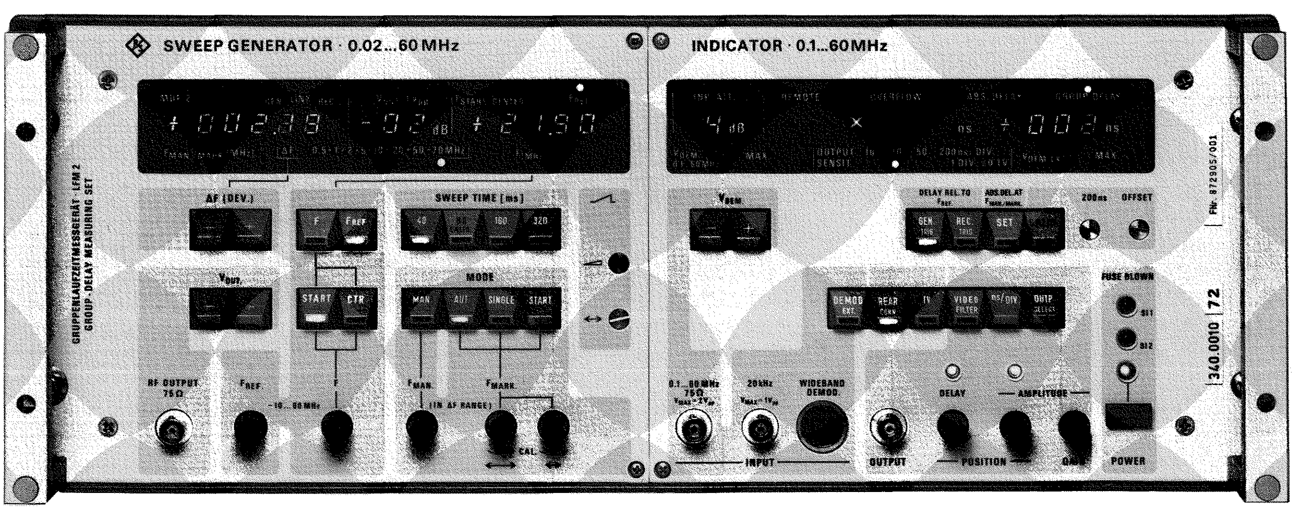
1. On the SPF 2, select 10-riser staircase signal, SUBCarrier OFF (or test line 17) and H. Switch on ZERO REFERENCE on AMF 2.
2. Press H and x10 keys in the bottom row on the OPF. Line up the top point with the mask zero using ↕ (left) and ↔.
3. Read phase angle on mask.

C. Measurements in test line 17

(transmitter connected to antenna)

1. The Video Test Signal Generator SPF 2 is not required if the applied program contains test lines.
2. If no test lines are present, use the SPF 2 (use connectors PROGRAM INPUT and OUTPUT [rear panel]).
3. Switch on ZERO REFERENCE LINE on AMF 2, press TRIGGER V1 and x10 key in bottom row of keys on OPF. Set LINE SELECTOR (top right) to 17/330.
4. Read phase angle on mask.

Group-delay Measuring Set LFM 2



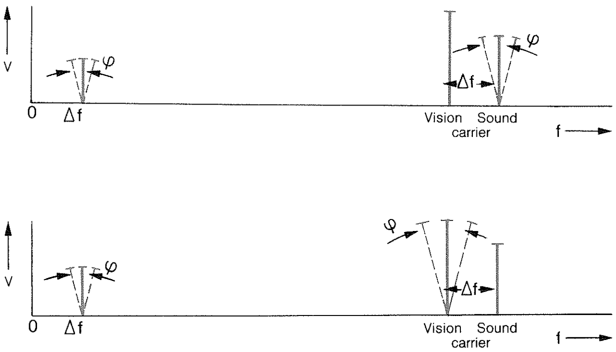
INTERCARRIER INTERFERENCE RATIO

measurements outside

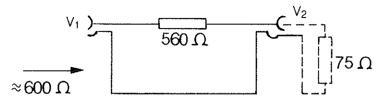
In the modulation of a vision transmitter, it is possible for phase modulation of the vision carrier to occur. With intercarrier demodulation — where the spacing between the vision-carrier and sound-carrier frequencies is used to produce the sound signal — this can result in phase modulation of the difference frequency and phase modulation of the sound carrier (diagram below). The effect can be measured as interference in the sound channel.

For measurement purposes the vision transmitter (with the sound transmitter unmodulated) is fully modulated with sinusoidal signals up to 100 kHz (10/75 %), and the interference voltage that appears is measured at the AF output of the TV demodulator (with deemphasis and weighting).

The TV Demodulators AMF and AMF 2 from Rohde & Schwarz, just like the majority of domestic TV receivers, work with intercarrier demodulation and are thus particularly suitable for this kind of measurement. The AF generator of the AF Transmission Measuring Set SUN 2 serves as the AF source for modulating the vision transmitter, and the level meter contained in this measuring set is used with its weighting filter switched on to measure the interference.

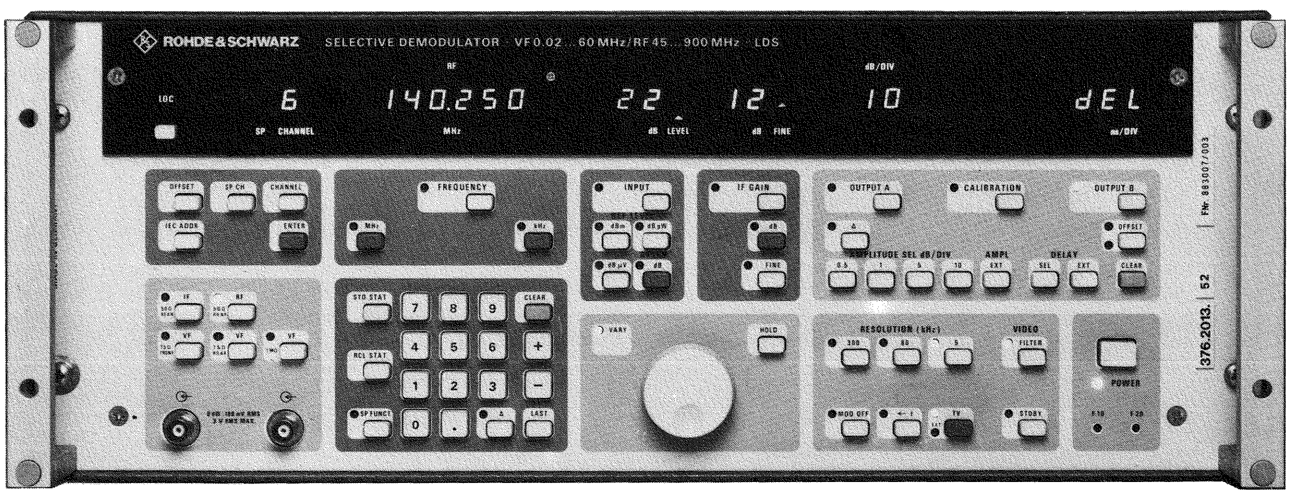


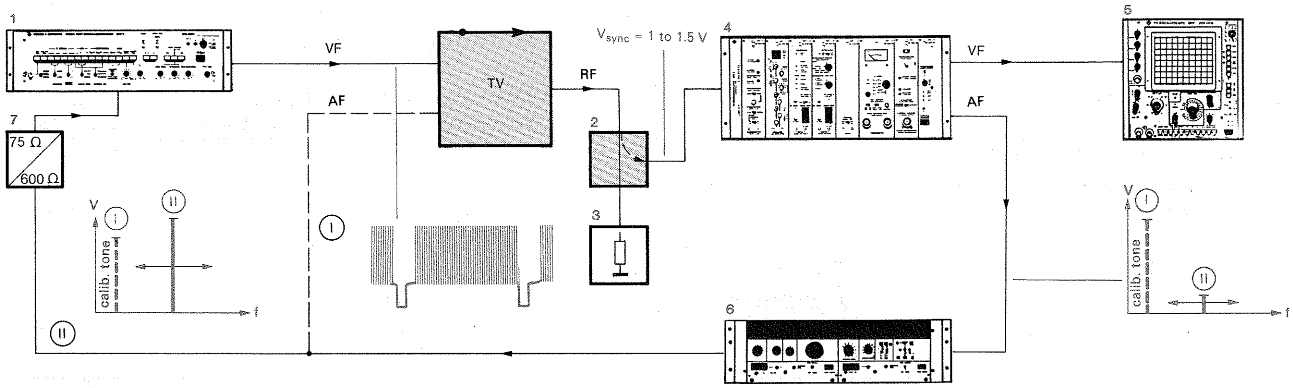
Occurrence of intercarrier interference; phase modulation of sound carrier (above) and of vision carrier (below)



Circuit (600/75 Ω) for matching AF generator of SUN 2 to Video Test Signal Generator SPF 2 (attenuation $\frac{V_1}{V_2} \approx 18$ dB)

Selective Demodulator LDS





1 Video Test Signal Generator SPF 2 (photo p.24) or Insertion Signal Generator SPZF (photo p.25)
2 Directional coupler (incorporated in transmitter)
3 Dummy antenna (according to transmitter power)
4 TV Demodulator AMF 2 (photo p.36) or AMF
5 TV Oscilloscope OPF (photo p.49)
6 AF Transmission Measuring Set SUN 2 (photo p.18)
7 Matching circuit 600/75 Ω (diagram opposite)

Measurement Procedure

A. Basic settings

1. Vision transmitter and oscilloscope as on p.41. Sound transmitter as on p.21.
2. Connect output of AF generator to input of sound transmitter, i.e. connection (I). Switch on preemphasis of sound transmitter.
3. With AF generator on 500 Hz (reference frequency) set prescribed level (e.g. 0 dBm).
4. Set level meter to 10 Hz to 100 kHz (MODE 1) and NORMal (dBm). Output level of TV demodulator is then indicated (e.g. +6 dBm). Switch level meter to REF (0 dB).

B. Measurement of intercarrier S/N ratio

1. Separate connection (I) and short input of sound transmitter. Connect output of AF generator via matching circuit to input EXTernal SIGNal of SPF 2, i.e. connection (II). Set output level of approx. 8.8 dBm.
2. On test-signal generator select EXTernal SIGNal, APL clamping with blanking, SETUP and mode H + V. Set % VIDeo to 50.
3. Check signal from transmitter on TV Oscilloscope OPF. Modulation should be 10/75%. Readjust on AF generator if necessary.
4. Switch level meter to WEIGHTED (MODE 3) and PEAK.
5. On AF generator alter frequency through range 30 Hz to 100 kHz. Weighted S/N ratio (with negative sign) is indicated directly on level meter for each frequency.

Division into frequency bands The noise voltages that occur in a vision transmitter are divided into different bands because of the large modulation-frequency range and measured separately. In the instruments used for these measurements, there are filters to select the various frequency bands. They also incorporate a weighting filter to simulate the response of the human eye to noise of different frequencies. The following frequency bands and modes of weighting are customary (e.g. according to the standard specifications of the DBP/ARD in the Federal Republic of Germany and of broadcasters and postal authorities in many other countries):

Noise voltage	Frequency	Weighting
Hum	<1 kHz	peak
Periodic interference	0.8 to 100 kHz	peak
	1 kHz to 5 MHz	peak
Pulse interference		peak
Random noise	100 kHz[1]) to 5 MHz	rms
	100 kHz[1]) to 5 MHz	rms with weighting filter

[1]) 200 kHz for measurement in test lines.

Measurements should be made over the entire range of modulation. In most cases, however, a measurement at black and white level is sufficient. The values given in the standard specifications should also be maintained if the sound transmitter is modulated up to maximum deviation with any modulation frequency.

The **Video Noise Meters UPSF and UPSF 2 from Rohde & Schwarz** are specially designed for this kind of measurement. They incorporate the required filters and devices for rms and peak measurement and can also handle signals with line and field pulses because of their blanking circuits for H and V pulses. The UPSF indicates noise voltages on a meter, while the UPSF 2 has a digital display. They have an oscilloscope output to enable analysis of the detected noise.

The filters for separating the frequency bands are contained in a separate filter plug-in in the case of the UPSF, there being various plug-ins for easy adaptation to different TV standards.

In the UPSF 2 the filters are built-in and are automatically switched according to the applied signal (625-line or 525-line standard). The level-reference value (625-line systems: 0 dB corr. to 700 mV, 525-line systems: 0 dB corr. to 714 mV) is likewise automatically switched.

The following filters are included:

1. A video lowpass filter for limiting measurement to the video band (cutoff frequencies of 5.0 and 4.2 MHz, diagram on the right).

2. A noise-weighting filter for simulating the response of the eye to noise (diagram above).

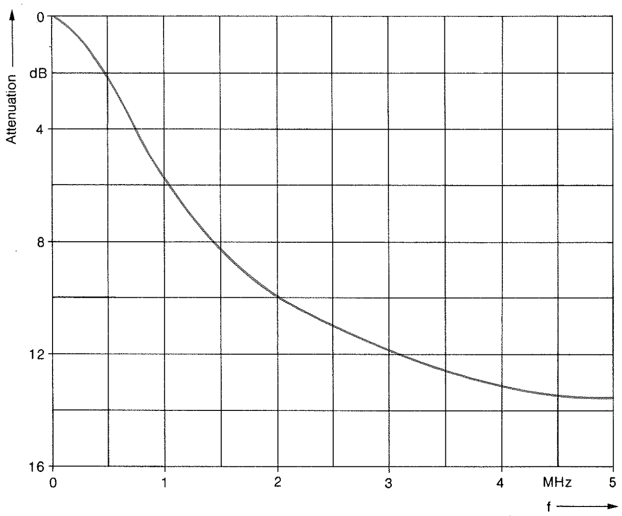
3. A 1-kHz lowpass filter to enable the measurement of hum voltages but reject line-repetitive components (the UPSF 2 additionally has a 10-kHz lowpass filter).

4. A 10-kHz highpass filter for detecting noise voltages without hum components.

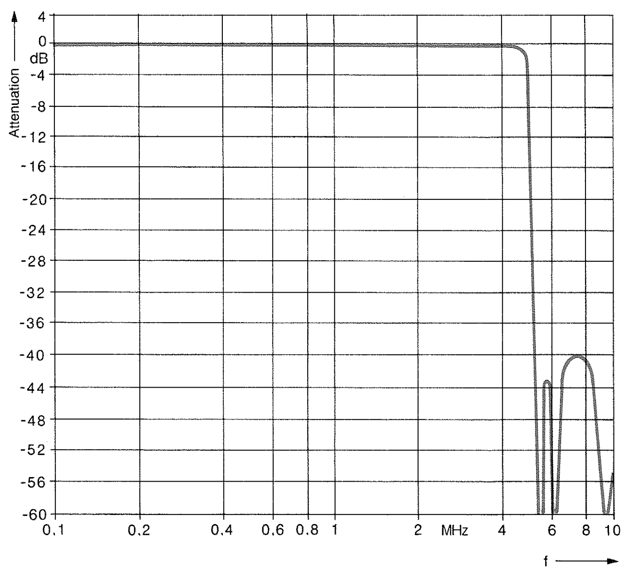
5. A 100-kHz or 200-kHz highpass filter for measuring noise voltages without hum and line-repetitive components.

6. A wave trap for rejecting residual colour-subcarrier components (cutoff frequency 4.43 or 3.58 MHz).

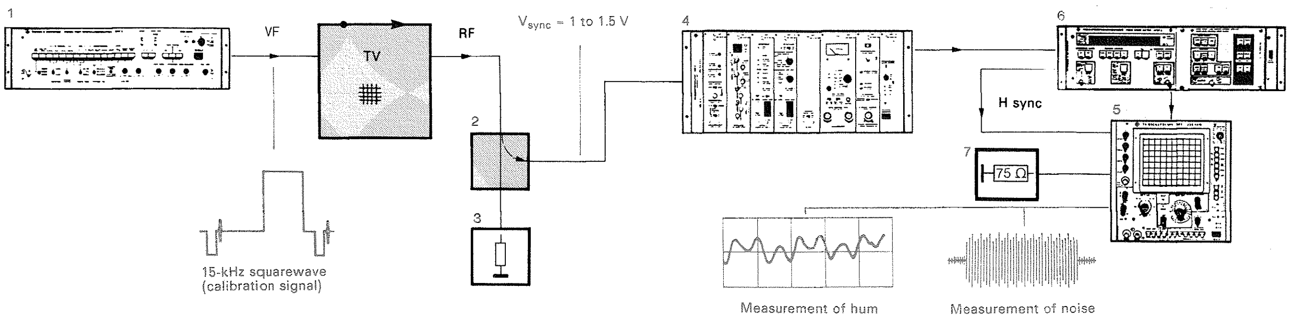
The UPSF has adjustable sag and tilt compensation for oscilloscope display to prevent these effects from being rated as noise voltage. The UPSF 2 can measure in test lines, i.e. during an ongoing program, in addition to the full field like the UPSF.



Noise-weighting curve according to CCIR Rec. 567



Passband of video lowpass filter (bandwidth 5 MHz, standards B, C, G, H, I)



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF

5 TV Oscilloscope OPF (photo p. 49)

6 Video Noise Meter UPSF 2 (photo p. 51) or UPSF

7 Precision Termination RMF 2, 75 Ω (photo p. 86)

Measurement Procedure

A. Basic settings

1. As on p. 41.
2. Separate connection between TV demodulator and oscilloscope. Connect TV demodulator to input of loop-through filter of video noise meter (on rear) and filter output to input S_{EXT} of oscilloscope (loop-through filter, on rear). Terminate filter output with 75 Ω. Press EXT in the bottom row of keys on the oscilloscope.
3. Connect 75 Ω output of video noise meter to input of oscilloscope. Press 75 Ω key on OPF.
4. Select 15-kHz squarewave, RISE TIME 2T and MODE H on SPF 2.
5. Calibrate Video Noise Meter UPSF according to manual (not necessary with UPSF 2) and switch to REAR, FILTER 75 Ω and BLANKING INTernal.

B. Measurement of noise voltage (for black level)

1. **Calibration of UPSF and UPSF 2:**
   Cut out HIGHPASS and LOWPASS filters, select mode V_{pp} (meter or display shows 0 dB). On test-signal generator select SETUP and switch % VIDeo to 0 (black level).
2. **Measurement of hum**
   With UPSF:
   Switch off BLANKING. On filter plug-in switch on LOWPASS FILTER 1 kHz and set practical indication range with range switch (peak). Noise voltage is indicated directly.
   With UPSF 2:
   Switch on LOWPASS 1 kHz, NOISE FF and V_{pp}. Noise voltage is displayed directly.
3. **Measurement of periodic interference**
   With UPSF or UPSF 2:
   Switch on BLANKing and LOWPASS video f_c. Different bands are detected by switching on HIGHPASS filters (peak measurement):

Off:	entire video band (including hum)
10 kHz:	video band without hum but with line-frequency components
100 kHz or 200 kHz on UPSF 2:	remaining video band without hum and line-frequency components

   The type of interference can be judged on the oscilloscope.
4. **Measurement of random noise**
   With UPSF or UPSF 2:
   Switch on HIGHPASS 100 or 200 kHz and select V_{RMS} measurement. With LOWPASS video f_c measurement is unweighted, with setting WEIGHTING or WGHT noise-weighting filter is cut in.

In measurements 3. and 4. it is possible to determine whether residual colour-subcarrier components cause a higher noise voltage by cutting in the wave trap for f_{SC}.

C. Measurement of noise voltage (for white level)

1. Calibration: as for B.1., but after calibration set % VIDeo on test-signal generator to 100 (white level).
2. As for B.2.
3. As for B.3.
4. As for B.4.

Check measurements with modulation of sound transmitter switched on and off (frequencies up to 15 kHz, deviation up to 50 kHz). Basic settings on transmitter as on p. 21 or 29.

D. Measurement in test lines during ongoing program (only with UPSF 2)

1. On Video Test Signal Generator SPF 2 press button H+V.
2. Press button NOISE VIT on UPSF 2, line number is then indicated. Change line number by briefly and repeatedly pressing button. Check vision content on oscilloscope.
3. Remainder of measurement as in B. and C.

DIFFERENTIAL PHASE AND GAIN

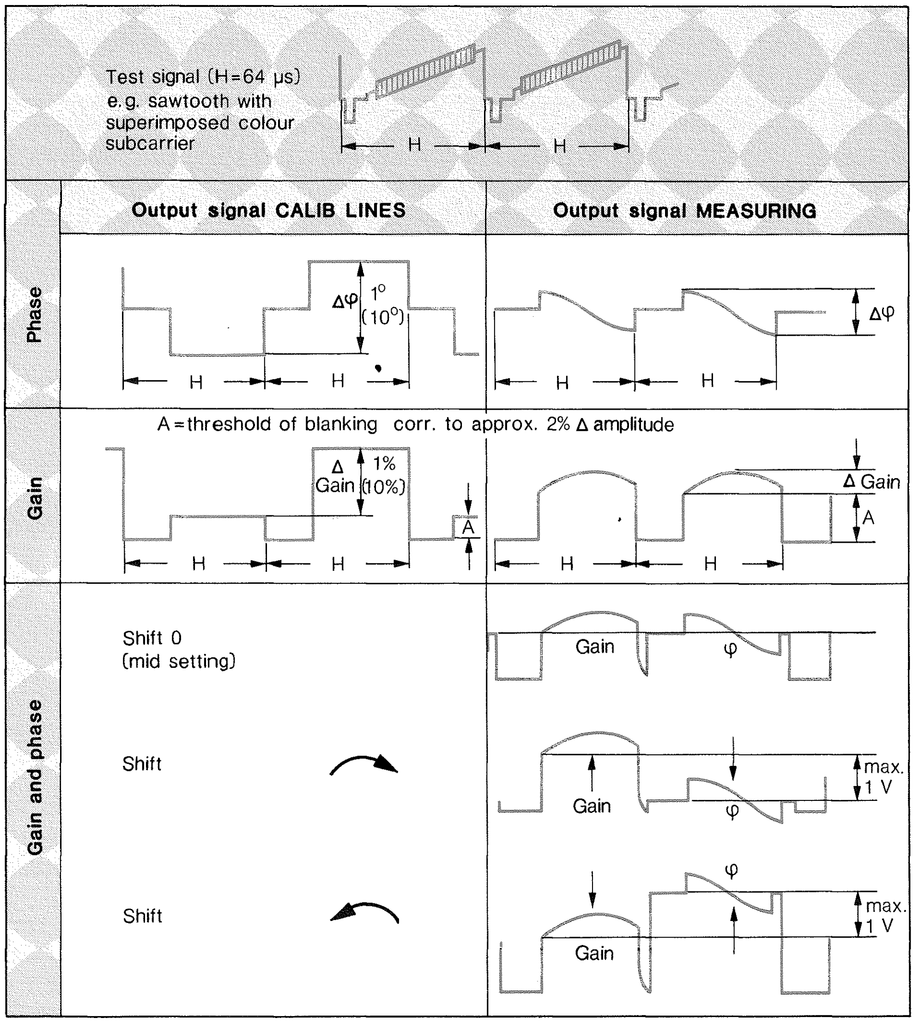
With colour-television transmitters it is particularly important that the colour-subcarrier signal be correctly transmitted. Alteration of the gain affects colour saturation, alteration of the phase affects the hue. The dependence of these quantities on modulation is usually expressed in the following terms:

The **differential phase** is the alteration in the phase of the colour subcarrier as a function of modulation.

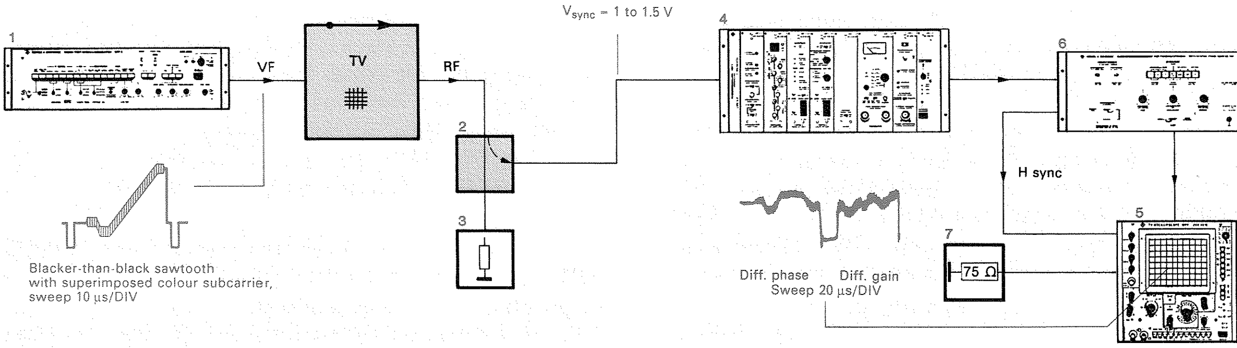
The **differential gain** is the alteration in the gain of the colour subcarrier as a function of modulation. This is nothing other than a measurement of the chrominance nonlinearity with the colour-subcarrier frequency as on pages 54 and 55. In that particular case, however, the difference from 100% is not measured; linearity of 0.95 thus corresponds to a measured value of 5% for differential gain.

The test signal is a sawtooth with a superimposed colour subcarrier. The oscillations of the colour subcarrier extend into the sync region, so a blacker-than-black sawtooth is generally used, resulting in transmitter modulation up to 86.5% of sync-pulse amplitude.

Measurement of differential phase and gain is possible with the Differential Phase/Gain Meter PVF from Rohde & Schwarz. This enables the display of phase, gain or both together as a function of modulation in conjunction with a normal oscilloscope. The simultaneous display of phase and gain considerably simplifies adjustments. An internal calibration voltage permits straight-forward calibration of the display.



Output signals of PVF (assumed characteristics of gain and phase). Test signal is simple sawtooth with superimposed colour subcarrier



1 Video Test Signal Generator SPF 2 (photo p.24) or Insertion Signal Generator SPZF (photo p.25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p.36) or AMF

5 TV Oscilloscope OPF (photo p.49)

6 Differential Phase/Gain Meter PVF (photo p.52)

7 Precision Termination RMF 2, 75 Ω (photo p.86)

Measurement Procedure

A. Basic settings

1. As on p.41.
2. Separate connection between TV demodulator and oscilloscope. Connect TV demodulator to input of PVF (loop-through filter) and filter output to S_{EXT} (loop-through filter, on rear) of oscilloscope. Terminate filter output with 75 Ω.
3. Connect output of differential phase/gain meter to input of oscilloscope, press 75 Ω key.
4. Press EXT in the bottom row of keys on the oscilloscope.

B. Calibration of display

1. Phase calibration:
   On PVF press one of buttons CALIBration LINES DIFFERENTIAL PHASE (1° or 10°) and set practical scale on screen with control OUTPUT VOLTAGE PHASE (e.g. 10° corr. to 5 cm). Display can be adjusted on Y axis with SHIFT control.
2. Gain calibration:
   On PVF press one of buttons CALIBration LINES DIFFERENTIAL AMPLITUDE (1% or 10%) and set practical scale on screen with control OUTPUT VOLTAGE AMPLITUDE.

C. Measurement of differential phase and gain

1. On test-signal generator select H, CALibration and blacker-than-black sawtooth. SUBCarrier is set to NORMAL, APL (average picture level) to 50%.
2. Press φ on PVF. Curve of phase alteration appears on oscilloscope, magnitude of which can be determined from previous calibration.
3. Press AMPLitude on PVF. Curve of gain alteration appears on oscilloscope. Linearity of 0.95 corresponds to differential gain of 5% for example.
4. If φ/AMPLitude is pressed on PVF and with 10 µs/DIV, both curves appear one above the other (they can be separated with SHIFT control). With 20 µs/DIV, they are next to one another (see oscillogram in diagram of setup above).

VIDEO AMPLITUDE CHARACTERISTIC

selective with SWOF 3

Note Broadband measurement of the video amplitude characteristic using the Group-delay Measuring Set LFM 2 is described on pages 72 and 73.

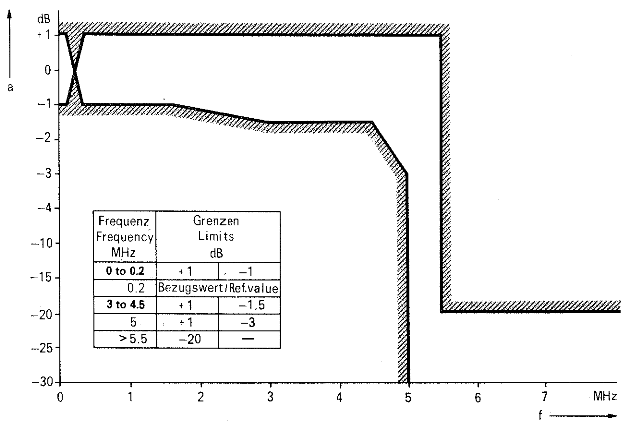
The video amplitude characteristic is the frequency response of the amplitude of the overall transmitter/receiver system. The TV demodulator is a high-quality receiver that demodulates the RF signal from the transmitter into video (and AF). For measurement purposes, a video-test-signal generator supplies a constant television signal (black or white), upon which the test frequency (video, 0 to 6 MHz) is superimposed with low amplitude (10%) (see oscillogram in diagram of setup opposite). The amplitude of this frequency can be measured with an oscilloscope and the transmission characteristic thus determined as a function of frequency.

The use of a video sweeper makes the measurement a great deal easier. The Videoscope SWOF 3 from Rohde & Schwarz incorporates a video generator whose frequency can be swept from approx. −2 to +6 MHz in such a measurement. The receiver of the unit is kept tuned to the transmitted frequency by the same sweep voltage so that the amplitude can be displayed as a function of frequency on a built-in oscilloscope. The video amplitude characteristic of the entire transmission system thus appears directly on the screen. This characteristic is generally a function of amplitude and is therefore measured at black level and at white level. A simultaneous display of the amplitude frequency response at black and white level can be obtained by chopping the test signal. The reference frequency when measuring video amplitude characteristic is usually 1.5 MHz. In the latest standard specifications of the Federal-German DBP/ARD, the only amendment concerns an alteration of the reference frequency to 0.2 MHz.

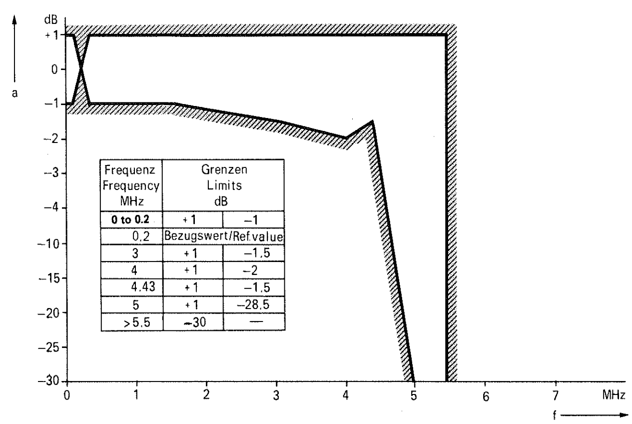
It is usual to perform the measurement for **two different equipment settings:** with and without preemphasis in the transmitter or sound trap in the demodulator. In the measurement without preemphasis and sound trap, the video amplitude characteristic of the transmitter is checked. The second measurement with the other settings is more of an operational check, because the TV demodulator corresponds to a domestic receiver in this condition.

In the diagram of the setup on the opposite page, two screen displays from the SWOF 3 are shown (tolerance masks with reference of 1.5 MHz): left without, right with sound trap and preemphasis, the upper curve for white level, the lower curve for black level.

There are tolerance schematics for both measurements. The latest curves from the DBP/ARD standard specifications are illustrated below. There are tolerance masks available for the SWOF 3 with reference points of 0.2 MHz or 1.5 MHz.

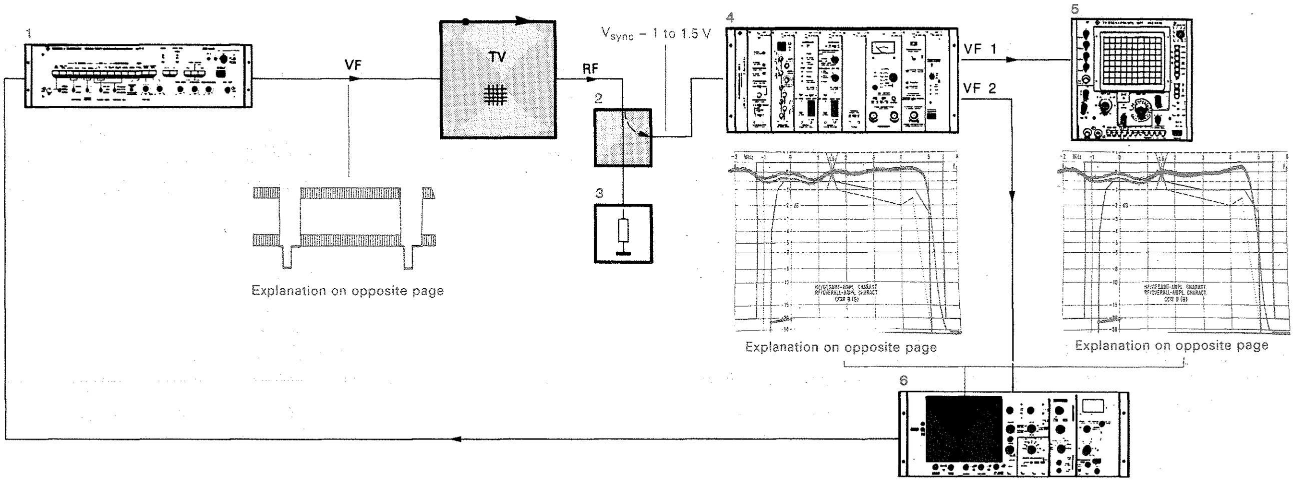


Frequenz Frequency MHz	Grenzen Limits dB	
0 to 0.2	+1	−1
0.2	Bezugswert/Ref.value	
3 to 4.5	+1	−1.5
5	+1	−3
>5.5	−20	—



Frequenz Frequency MHz	Grenzen Limits dB	
0 to 0.2	+1	−1
0.2	Bezugswert/Ref.value	
3	+1	−1.5
4	+1	−2
4.43	+1	−1.5
5	+1	−28.5
>5.5	−30	—

Tolerance schematics for video amplitude characteristic of signal from transmission system vision transmitter/TV demodulator: left without, right with sound trap and preemphasis (reference frequency 0.2 MHz in each case)



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF

5 TV Oscilloscope OPF (photo p. 49)

6 Videoscope SWOF 3 (photo p. 58) with tolerance mask for RF overall amplitude characteristic

Measurement Procedure

A. Basic settings

1. As on p. 41.
2. Connect GENerator OUTput of videoscope to input EXTernal SIGNal of Video Test Signal Generator SPF 2. Set output attenuator on videoscope to −20 dB and sweep range of −2 to +6 MHz. On test-signal generator switch to EXTernal SIGNal, APL clamping with blanking, 50-Hz squarewave, 10/90 % AMPLITUDE and mode H.
3. Connect SELECTIVE INPut of videoscope to 2nd VIDEO OUTPUT of TV demodulator. Set input attenuator on videoscope to −20 dB.
4. Switch TV demodulator to SYNCHRONous DETECTION.
5. Check modulation of transmitter on TV oscilloscope. Nominal values 10/20 % and 65/75 %. If necessary, correct superimposed signal with output attenuator of videoscope.

B. Measurement of video amplitude characteristic

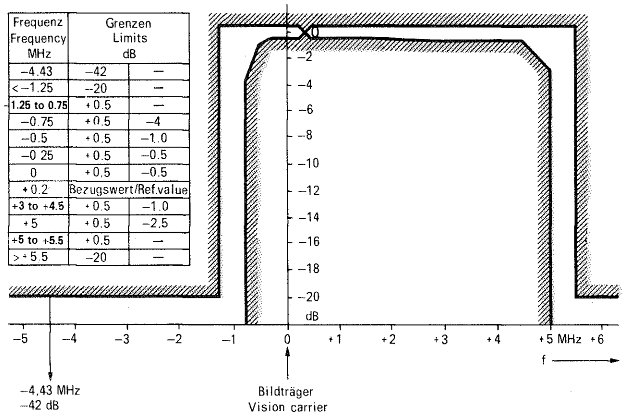
1. On videoscope set sweep time to 200 ms, mode switch on receiver unit to SELECTIVE, display to LIN x 10.2-kHz BANDWidth.
2. With Y POSition LIN x 10 adjust trace on screen to pass through reference point (0.2 or 1.5 MHz).
3. To check X deflection press button 1-MHz FREQuency SCALE and set calibration lines to coincide with lines of tolerance mask using X POSition and X LENGTH.
4. Screen shows frequency response for white and black level simultaneously. Press button 0.1/1 Hz on test-signal generator and display will switch from black to white and vice versa every four seconds to simplify observation of curves.

RF SIDEBAND CHARACTERISTIC

selective with SWOF 3/SWOF 3-Z

Note Selective measurement of the RF sideband characteristic with the Group-delay Measuring Set LFM 2 and the Selective Demodulator LDS is described on pages 74 and 75.

Principle Because of the large bandwidth of the picture content, television pictures are transmitted by the vestigial-sideband method. Only the upper sideband of the RF signal is fully formed, the frequency of the lower one being considerably narrower in bandwidth (vestigial sideband). Tolerances are set down for the frequency response of the amplitude at the transmitter output which differ according to the TV standard (video bandwidth, width of vestigial sideband, slope of the left edge, interval between vision-carrier and sound-carrier frequencies). The following diagram shows the tolerances of the latest DBP/ARD standard specifications (with reference point of 0.2 MHz).



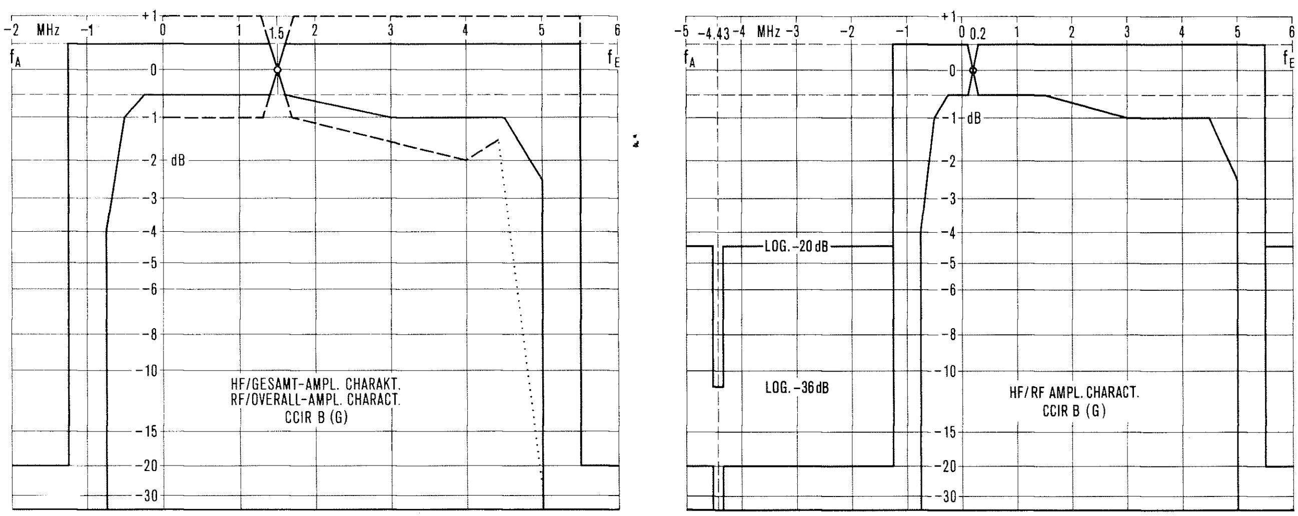
Frequenz Frequency MHz	Grenzen Limits dB	
−4.43	−42	—
< −1.25	−20	—
−1.25 to 0.75	+0.5	—
−0.75	+0.5	−4
−0.5	+0.5	−1.0
−0.25	+0.5	−0.5
0	+0.5	−0.5
+0.2	Bezugswert/Ref.value	
+3 to +4.5	+0.5	−1.0
+5	+0.5	−2.5
+5 to +5.5	+0.5	—
> +5.5	−20	—

Tolerance schematic for RF sideband spectrum of vision transmitter (standard specifications of DBP/ARD)

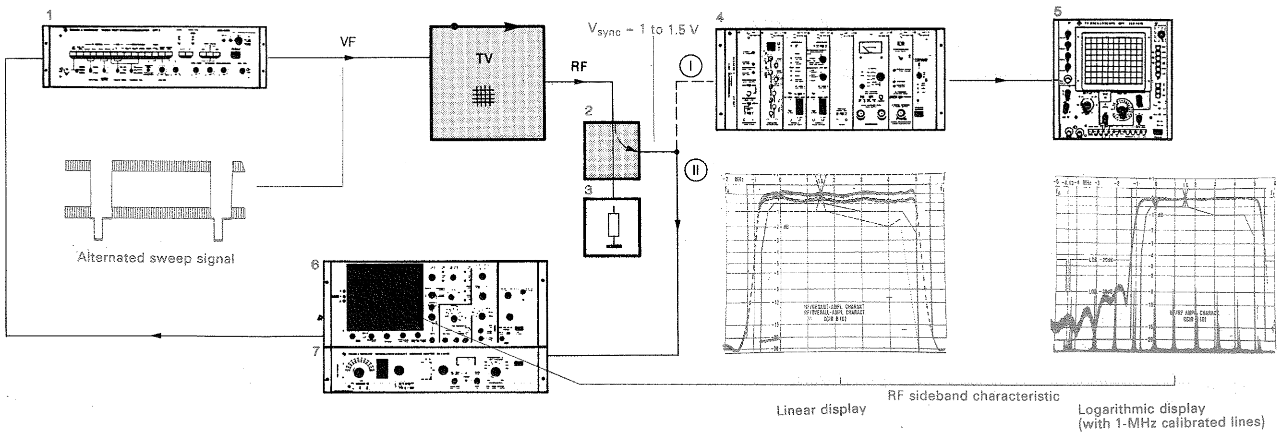
For measurements of this kind in the RF, the Videoscope SWOF 3 from Rohde & Schwarz is used together with its Sideband Adapter SWOF 3-Z. They thus form a tracking receiver which is maintained at the frequency of the generator unit by the sweep voltage and can therefore be accurately tuned to the sideband frequency of a transmitter. The RF sideband spectrum can accordingly be displayed directly on the screen.

With the tolerance masks for the Videoscope SWOF 3, the tolerances for the video amplitude characteristic and the RF sideband characteristic are found together (see diagrams below). The linear mask (with dB scale) is suitable for displaying the RF spectrum in the transmission band, whereas the logarithmic mask is used to examine the spectrum in the left sideband; the latter has a much larger dynamic range.

In the measurement described opposite, the input is an alternated sweep signal (as on page 68) to enable simultaneous display of the curves for white and black level. The screen displays illustrated in the diagram of the setup show the RF sideband characteristic in linear (left) and logarithmic form (right).



Tolerance masks for Videoscope SWOF 3 for measuring video amplitude characteristic and RF sideband characteristic of vision transmitters (each is available with reference of 0.2 MHz or 1.5 MHz);
left: linear display with dB scale, reference point 1.5 MHz;
right: logarithmic display, reference point 0.2 MHz (righthand dB scale is invalid)



1 Video Test Signal Generator SPF 2 (photo p.24) or Insertion Signal Generator SPZF (photo p.25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p.36) or AMF

5 TV Oscilloscope OPF (photo p.49)

6 Videoscope SWOF 3 (photo p.58) with tolerance masks for RF sideband characteristic

7 Sideband Adapter SWOF 3-Z (photo p.59)

Measurement Procedure

A. Basic settings

1. As on p.41.
2. Hook up videoscope and sideband adapter as prescribed in manual.
3. Connect GENerator OUTput of videoscope to input EXTernal SIGNal of test-signal generator. Set output attenuator on videoscope to −20 dB and sweep range of −2 to +6 MHz or −5 to +6 MHz (according to mask used). On test-signal generator switch to EXTernal SIGNal, APL clamping with blanking, 50-Hz squarewave, 10/90% AMPLITUDE and mode H.
4. Check modulation of transmitter on TV oscilloscope. Nominal values 10/20% and 65/75%. If necessary, correct measurement signal using output attenuator on videoscope.
5. Separate connection (I) to TV demodulator. Connect output of directional coupler to RF input of sideband adapter (II). Set MODulation-DEPTH COMPENSation to 20 dB.

B. Measurement of RF sideband characteristic

1. On videoscope set sweep time to 200 ms, mode switch on receiver unit to ADAPTER, display to LIN/2-kHz BANDWidth or LOG/2-kHz BANDWidth.
2. On test-signal generator (only for this step) disconnect EXTernal SIGNal, switch on SETUP and set control % VIDeo to 0 (= black level).

   On sideband adapter set input level within black region of meter with INPUT ATTENUATOR (press button U_E INDICATion). Re-establish original settings on test-signal generator.
3. On sideband adapter set receive frequency (= vision-carrier frequency) $f_E = f_I + f_{II}$ with range switch, crystal selector f_I and according to indication on scale f_{II}. Then set receive frequency on drum scale so that meter deflects to maximum.
4. Sideband curves then appear on screen of videoscope. Tune finely on scale f_{II} of sideband adapter until largest sideband curve appears.
5. With Y POSition LIN or Y POSition LOG adjust trace on screen to pass through reference point (0.2 or 1.5 MHz). Reduce sweep time to point where curve shape no longer alters.
6. To check X deflection press button 1-MHz FREQuency SCALE and set calibration lines to coincide with lines of tolerance mask using X POSition and X LENGTH.
7. Screen of videoscope then shows sideband characteristics for black level (lower curve) and white level (upper curve) (see illustrations of screen displays above). On logarithmic display relatively small amplitudes of left sideband can be better recognized. Righthand dB scale of tolerance mask is then invalid. Press button 0.1/1 Hz on test-signal generator and display will switch from white to black and vice versa every four seconds to simplify observation of curves.

TV

GROUP DELAY
VIDEO AMPLITUDE CHAR. broadband with LFM 2 **measurements outside**

Note Selective measurement of the group delay is described on pages 74 and 75, selective measurement of the video amplitude characteristic on pages 68 and 69.

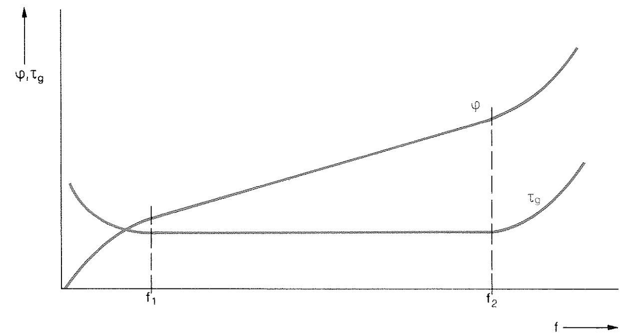
General For the distortion-free transmission of complex signals like those for television, the group delay, in addition to the amplitude frequency response, must maintain certain tolerances within the transmission band. A constant group delay ensures that the individual frequencies of a TV picture (consisting of many harmonic signals that are constantly changing in amplitude) will be transmitted at the same speed and again form the original signal at the end of the transmission path. This is particularly important in vision transmission because the human eye is considerably more sensitive to delay errors than the human ear.

Definition The group delay τ_g is the differential quotient of the phase angle with frequency: $\tau_g = \frac{d\varphi}{d\omega}$. This demonstrates that a constant group delay calls for a phase angle that increases linearly with frequency (diagram above on the right). In a transmission system that is fed with an amplitude-modulated signal (carrier frequency with two sideband components) for the purpose of group-delay measurement, the group delay is the difference between the phase angles of the two sideband components, referred to their frequency spacing. By alteration of the carrier frequency at a constant modulation frequency, and thus with a constant interval between the sidebands, the phase difference produces a measure for the group delay at the carrier frequency.

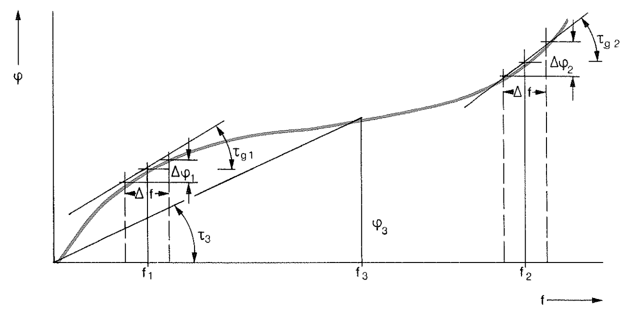
Group-delay meters use a carrier signal that can be altered within the transmission band and which is modulated with a constant frequency. This modulation frequency, or probe frequency, is shifted through the transmission band by the, generally, swept carrier signal. By way of a compromise between measurement accuracy and technical feasibility, this frequency is 20 kHz (for determining a delay change of one nanosecond, a phase deviation of approx. 1/100th of one degree has to be measured!).

Group-delay Measuring Set LFM 2 The LFM 2 from Rohde & Schwarz (photo p. 61) consists of a generator, whose swept carrier is modulated with 20 kHz, and an indicator plus phase meter. By means of buttons it is possible to set the start or centre frequency of the sweep range and its sweep width, plus a marker frequency at which the absolute delay or group delay, referred to a reference frequency, is indicated. By varying the marker frequency, one can measure the group delay point by point in the transmission band. It is common, however, to display the group delay on an oscilloscope, the marker frequency then appearing as a bright spot.

Simultaneous measurement of the video amplitude characteristic is possible with the LFM 2 (see next page, C.4.).



Relationship between phase φ and group delay τ_g: with a linear increase in phase angle (between f_1 and f_2), group delay is constant



Group-delay measurement by probe-frequency method

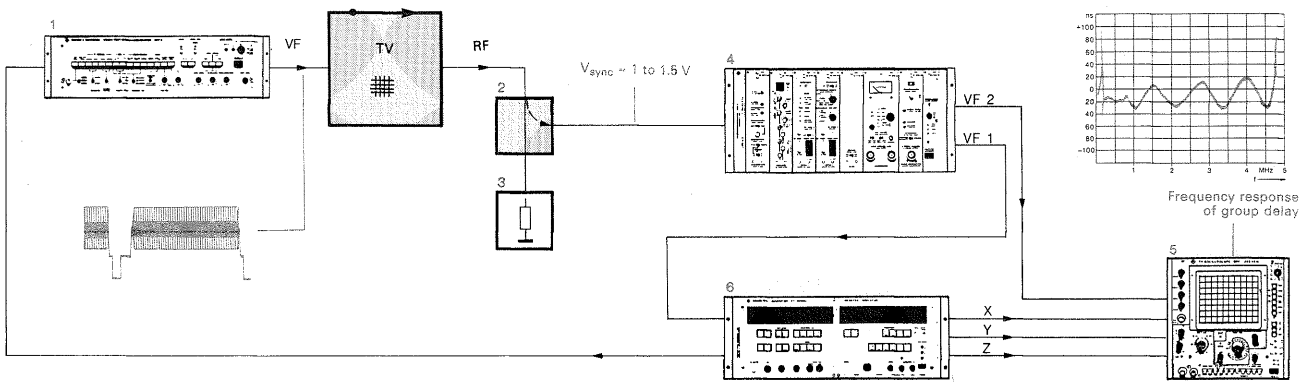
Group delay: $\tau_g = \frac{\Delta\varphi}{2\pi\Delta f}$; because Δf is constant (2×20 kHz), group delay is proportional to $\Delta\varphi$. LFM 2 shows difference in group-delay values between marker frequency f_2 and reference frequency f_1.

Absolute delay: $\tau_A = \frac{\varphi}{2\pi f}$; LFM 2 shows delay at selected marker frequency (here f_3)

Measurement Procedure

A. Basic settings

1. As on p. 41.
2. Connect RF OUTPUT of LFM 2 to input EXT. SIGNAL of Video Test Signal Generator SPF 2. Set latter to EXTernal SIGNal, APL clamping with blanking, SETUP and mode H. Set % VIDeo to 50 (grey level).
   Connect INPUT 0.1 to 60 MHz of Group-delay Measuring Set LFM 2 to VIDEO OUTPUT 1 of TV demodulator. Switch off ZERO REFERENCE in demodulator.
3. Set TIME/DIV to XYZ on oscilloscope, connect rear connectors X.15/.2/.3 and /.4 to rear connectors X4.2, X5.3 and X5.1 of LFM 2. Press REAR CONN. on LFM 2. Connect VIDEO OUTPUT 2 of AMF 2 to front input of OPF, press key 75 Ω.



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)
2 Directional coupler (incorporated in transmitter)
3 Dummy antenna (according to transmitter power)
4 TV Demodulator AMF 2 (photo p. 36) or AMF
5 TV Oscilloscope OPF (photo p. 49)
6 Group-delay Measuring Set LFM 2 (photo p. 61)

Measurement Procedure (continued)

B. Calibration of setup

1. Enter following frequencies on generator of LFM 2:
   a) Reference frequency
   Press key F_{REF} (display on right F_{REF}), setting with F_{REF} (e.g. 2 MHz). The reference frequency should not be too low because of the particularly strong spectrum of the line pulses close to the carrier.
   b) Start frequency
   Press key F_{START} (display on right, $F_{START/CENTRE}$), setting with F (e.g. −2 MHz).
   c) Marker frequency (must be in band investigated)
   Press key MODE AUTomatic (display on left, $F_{MAN/MARK}$), setting with F_{MARK}.
   d) Sweep width
   Set required sweep width (e.g. 10 MHz) with the two keys ΔF (DEV.) +/−. Indication in bottom line of display.
2. Connect RF OUTPUT and INPUT 0.1 to 60 MHz on LFM 2 using cable, set SWEEP TIME to 80 ms/DIV, display V_{OUT} to 0 dB (keys V_{OUT} +/−), press GENerator TRIGger. Use keys V_{DEM} +/− to cancel the LED V_{DEM} > MAX. Press OUTPut SELECTion until the LEDs AMPLITUDE and DELAY light up.
3. The display should be 0 ns, otherwise correct using control OFFSET.
4. Press CALIBration, display should be 200 ms; correct if necessary using control 200 ns. If 0 ns is displayed, adjust F_{MARK} slightly.
5. Adjust X deflection of oscilloscope to exactly 10 DIV using ⟋, ⟹ and ↔ on LFM 2 (frequency check possible using marker frequency).
6. Adjust the squarewave signal to an amplitude of 10 DIV (1 DIV = 20 ns) on the OPF using Y_{XYZ}, ⟹ and ↕ (right). Subsequently connect as in A.2. again.
7. Adjust output voltage of LFM 2 to −4 dB using keys V_{OUT} +/− (corresponds to 0.63 V_{pp} and results in a transmitter modulation of 13/70% with a video level of 50% [on the SPF 2]).
   Check using OPF: TIME/DIV to 10 µs/DIV, VOLT/DIV to 0.1 V/DIV, trigger H.
8. Press key TV on LFM 2.
9. Set input attenuation on indicator using keys V_{DEM} +/− such that display V_{DEM} > MAX. is extinguished.

C. Measurement of group delay

1. Press key OUTPut SELECTion (several times if necessary) until LED DELAY illuminates. With key ns/DIV set required measurement range.
2. Display of indicator then shows group delay at marker frequency, referred to reference frequency.
   (Check of zero indication: set marker frequency to same frequency as reference frequency. Indication must be 0 ns.)
3. By shifting marker frequency, group delay can then be accurately measured at any frequency within sweep width. Oscilloscope shows response of group delay over entire frequency band. Scale can be altered with control ns/DIV on indicator, and position of curve with control POSITION.
4. **The amplitude response can also be displayed by pressing OUTPut SELECTion** (controls AMPLITUDE, POSITION and GAIN). Simultaneous display of amplitude and group delay is also possible. This can be very important for adjustments on group-delay equalizers.

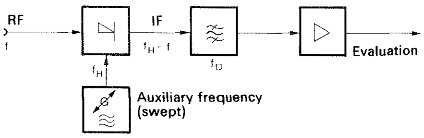
D. Measurement of absolute delay

1. Press SET.
2. Absolute delay between input and output of twoport can be calculated at set marker frequency from values shown on display of indicator, e.g.
   Measurement with test item:
   13 × 250 ns + 87 ns = 3337 ns
   − Short-circuit measurement:
   2 × 250 ns + 22 ns = −522 ns
   Absolute delay: 2815 ns

GROUP DELAY RF SIDEBAND CHAR. selective with LFM 2/LDS **measurements outside**

Note Broadband measurement of the group delay using the Group-delay Measuring Set LFM 2 is described on pages 72 and 73, selective measurement of the RF sideband characteristic using the Videoskop SWOF 3 and the Sideband Adapter SWOF 3-Z on pages 70 and 71.

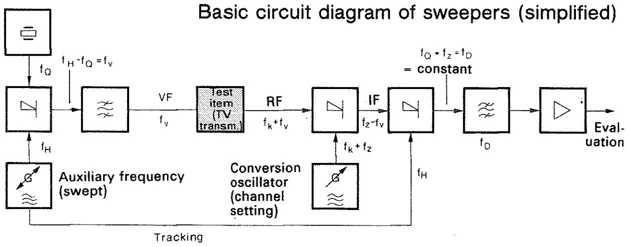
Advantages of selective measuring equipment Swept-frequency measurements where selective receivers are used are far less sensitive to interference (fixed frequencies, harmonics, noise) than those with a broadband receiver and provide a much larger dynamic range with amplitude measurements. Selective equipment use highly selective bandpass filters (usually with adjustable bandwidth). The frequency f to be examined is transposed to the passband f_D of the filter by mixing with an auxiliary frequency f_H and subsequently evaluated further. With a swept auxiliary frequency, the frequencies of a band corresponding to the frequency sweep of the oscillator are transposed in succession to the passband of the filter and evaluated. This procedure can be compared with a "receiver window" which the sweep oscillator "shifts" through the frequency band. This is the **frequency analysis** method which is used in an extended form (with additional frequency conversions) in all frequency analyzers.



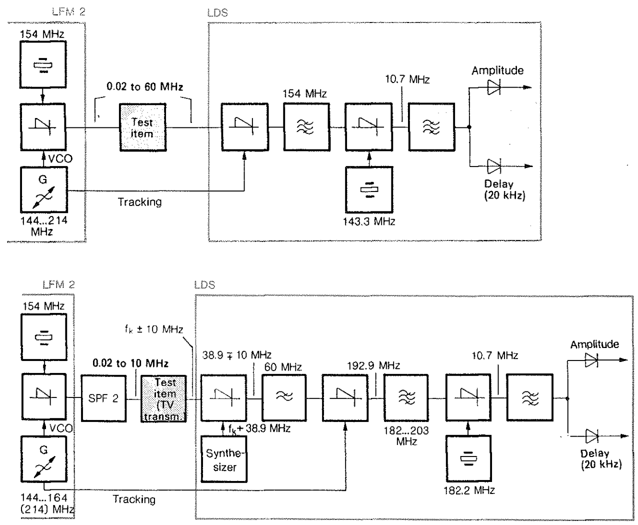
Principle of frequency analysis

In order to display the frequency response of a TV transmitter, for example, the video frequency (VF) must be applied to the transmitter input. To ensure that the associated RF falls within the receiver window, the video frequency must be swept in the same manner as the auxiliary frequency. It is therefore expedient to derive the former from the latter by mixing with the fixed frequency f_Q of a crystal oscillator (see basic circuit diagram below). If the frequency f_H of the sweep oscillator is higher than the crystal frequency, the receiver frequency is above the carrier frequency (channel frequency f_K) of the transmitter (i.e. at the frequency corresponding to the modulating VF). The same VF is produced if the sweep frequency is lower than the crystal frequency, but the receiver window is now below the carrier frequency. The vestigial sideband is then detected and the complete RF sideband characteristic thus displayed. The same circuit is used for a selective group-delay measurement, only the evaluation is different. This principle provides the advantage, especially when adjusting group-delay equalizers, that measurements can also be made below the vision carrier frequency, which is not possible with a broadband measurement.

Basic circuit diagram of sweepers (simplified)



Instruments for selective group-delay measurements from Rohde & Schwarz The **Group-delay Measuring Set LFM 2** and the **Selective Demodulator LDS** constitute a test assembly for selective group-delay and amplitude measurements in the RF/IF/VF range. The highly selective filters used guarantee a large dynamic range for amplitude measurements and enable measurements close to the carrier.



Test assembly comprising Group-delay Measuring Set LFM 2 and Selective Demodulator LDS (frequency values for standard B/G, f_K is channel frequency of transmitter);
top: VF mode, bottom: IF/RF mode

The **TV Transcope MUF 2** (selective sweeper in IF and RF bands), **Videoskop SWOF 3** (selective sweeper in VR band) and SWOF 3 with **Sideband Adapter SWOF 3-Z** (analyzer in RF band, sweeper in VF band) operate in a similar manner, but without the possibility for group-delay measurements.

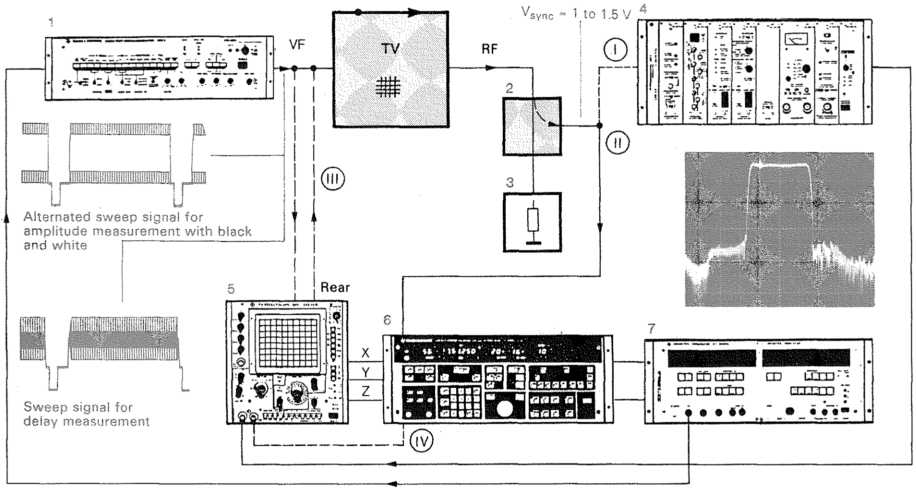
Measurement Procedure

A. Basic settings

1. As on p. 41 (connection ①).
2. Connect RF OUTPUT of LFM 2 to input EXTernal SIGNAL of Video Test Signal Generator SPF 2. Set latter to EXTernal SIGNal, APL clamping with blanking, SETUP and mode H. Set % VIDeo to 50 (grey level).
3. Connect LDS to LFM 2 using system cable LDS-Z1 (accessory supplied with LDS); connect X2.2 on LDS to X5.4 on LFM 2.
4. Set TIME/DIV on oscilloscope to XYZ, connect rear connectors X15.2, .3 and .4 to rear connectors X3.3, .2 and .1 of LDS and front Y input to video output of AMF 2. Press key 75 Ω.

B. Calibration of setup

1. Calibrate LFM 2 as on p. 73, B.1. to B.5. (only setting of X deflection of oscilloscope).
   Note When using a combination of LFM 2 and LDS, the setting must be carried out again as in B.5.
2. Press CALIBRATION on LDS; adjust the two calibration lines on the oscilloscope (50% and 100% reference levels) using Y_{XYZ} and ↕ (right) on the OPF until they line up with the graticule (centre and second line from top are most appropriate).



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)
2 Directional coupler (incorporated in transmitter)
3 Dummy antenna (according to transmitter power)
4 TV Demodulator AMF 2 (photo p. 36) or AMF
5 TV Oscilloscope OPF (photo p. 49)
6 Selective Demodulator LDS (photo p. 62)
7 Group-delay Measuring Set LFM 2 (photo p. 61)

Measurement Procedure (continued)

3. Press one of the keys dB/DIV (e.g. 1 dB/DIV) on the LDS. Set sweep on LFM 2 to 10 MHz. Adjust the peak of the curve on the oscilloscope to the reference line 100% using the spinwheel VARY on the LDS.
   Note In the case of measurements with the LDS in the video band, the frequency 38.9 MHz of the calibration oscillator must be covered (only for this setting, setting F_{START} on LFM 2).
4. Set LFM 2 to position CALIBration, press DELAY EXTernal on LDS. Adjust squarewave signal on oscilloscope to amplitude of 10 DIV using VARY.
5. Adjust output voltage of LFM 2 to −4 dB using keys V_{OUT} +/− (corresponds to 0.63 V_{pp} and results in a transmitter modulation of 13/70% with a video level of 50% [on SPF 2]). Check using OPF, connection (I), set TIME/DIV on OPF to 10 µs/DIV, TRIGGER H[1]).
6. For simultaneous display of the amplitude curves with black and white, adjust output voltage on LFM 2 to −20 dB (corresponds to heterodyne amplitude of 10%); set SPF 2 to squarewave 50 Hz and 10/90%. Check using OPF as in 5.
   Black/white can be differentiated using setting 0.1/1 Hz on SPF 2.
7. Connection (II) to rear connectors of LDS:
   X2.1 for the video band (0.02 to 60 MHz),
   X4 for the IF band (38.9 MHz in standard B/G) and RF band (45 to 900 MHz).
   Press respective key VF/IF/RF on LDS.
8. Press TV on LDS.

C. Measurement of amplitude frequency response in RF band (RF sideband characteristic)

1. The vision carrier frequency can be entered on the LDS either as a value or a channel number.
   Frequency display (MHz) on second field in display.
   Frequency input using numeric keypad: press FREQUENCY, then enter value (with decimal point) and press MHz.
   Input as channel number: press CHANNEL, enter channel number and press ENTER.
   Frequency offset input via CHANNEL or SP CH: press OFFSET (left), enter value (in 1/12 of line frequency), press + or − and ENTER (e.g. 8M means: −8/12 of line frequency, approx. 10 kHz).
2. Press INPUT, SPecial FUNCTion, 3 and ENTER. The instrument then automatically sets the input attenuation (output on display above INPUT) and the IF gain (output on display above IF GAIN).
3. Select OUTPUT A (or B) and scale dB/DIV (output above OUTPUT A). Curve appears on screen. Set input signal according to B.6. for simultaneous display of black and white.
4. In order to measure the differences in attenuation of the curve, set the marker frequency (bright point in oscillogram) on the LFM 2 to any reference frequency and press the key Δ (below OUTPUT A on LDS).
5. The scale displayed above OUTPUT A is now transferred to the display above OUTPUT B (the curve of OUTPUT B is deleted). The display above OUTPUT A becomes 0 dB, and the set marker frequency is thus defined as the reference frequency. If the marker frequency is changed (the bright point moves on the curve), the display above OUTPUT A indicates the deviation compared to the value at the reference frequency in dB.

D. Measurement of frequency response of group delay in RF band

1. Settings as for C.1. and C.2.
2. Input signal as in B.5., press OUTPUT B (or A) and DELAY SELect. The scale is output in the display above OUTPUT B (ns/DIV, setting on LFM 2). The delay curve appears on the screen, possibly at the same time with the curve from OUTPUT A.
3. Measurement of the curve with the Δkey is possible in the same manner as with the amplitude measurement (C.4. and C.5.) if the delay curve is measured via OUTPUT A.

E. Measurement of frequency response of amplitude and group delay in video band

1. Establish connection (I). Connect front left input of LDS (key VF 75 Ω, FRONT) to second input of OPF (loop-through filter, release key 75 Ω) ((IV)).
2. Settings on LDS for amplitude measurement as for C.2. to C.5.
3. Settings on LDS for group-delay measurements as for C.2., D.2. and D.3.

Note The RF and VF settings on the LDS are stored and automatically recalled by the keys RF and VF respectively.

[1]) If the output of the SPF 2 is connected to the transmitter input (connections (III)) via the rear loop-through filter in the OPF (X14.1 and .2), the transmitter input signal can also be measured with the key REAR pressed.
The measurement via the AMF 2 may then be superfluous.

Note Measurement of intermodulation using the Group-delay Measuring Set LFM 2 and the Selective Demodulator LDS is described on pages 78 and 79.

Definition Television transmitters emit several frequencies at the same time: vision-carrier frequency, colour-subcarrier frequency and sideband frequency (vision content) as well as one or two sound-carrier frequencies. If the vision and sound signals are amplified together, intermodulation between the individual frequencies produces additional sum and difference frequencies. Although these interfering frequencies have the same origins, the intermodulation products within the useful channel are covered by the term intermodulation and those outside it are called spurious emissions. Intermodulation products only occur when there is joint amplification of the vision and sound signals.

Measurement For determining intermodulation products, the vision transmitter is fully modulated (10/75%) with a sinusoidal signal (in addition to the sync pulses). The frequency of this signal can be varied within the video band. The sound transmitter is left unmodulated. For the colour subcarrier frequency, standard specifications prescribe different levels of modulation. The modulation with 10/75% results in the following values for the various frequencies (sync level = 0 dB):

vision carrier:	− 8 dB,
sideband:	−16 dB,
one sound carrier:	−10 (or −13) dB[1]),
two sound carriers:	−13 and −20 dB.

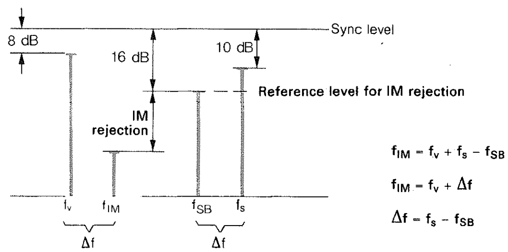
[1]) Standard value is −10 dB, but in the FR −13 dB has been used for some time.

This spectrum can be displayed on a spectrum analyzer, the intermodulation products then also becoming visible. The diagrams on the right show the weighting and the minimum spacing of the intermodulation products according to DBP/ARD standard specifications. The two oscillograms on the MUF 2 (in diagram of setup opposite) show on the left the intermodulation products for joint vision/sound amplification and on the right for separate vision/sound amplification (VC = vision carrier, SC = sound carrier, SB = sideband frequency, Sp = spurious emissions, IM = intermodulation). With joint amplification, there is intermodulation between all three frequencies (VC, SC, SB), with separate amplification only between the jointly amplified frequencies VC and SB.

To detect the high amplitudes that occur with the colour red, measurements are prescribed at other modulation levels. The diagram below shows values from the standard specifications of the Federal-German DBP/ARD and the Swiss PTT.

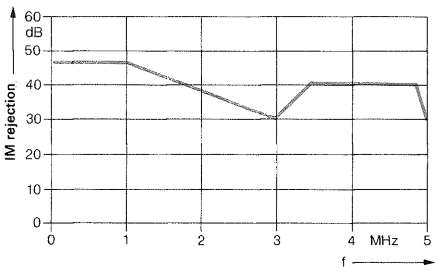
The measurement of spurious emissions differs from that of intermodulation only in the frequency scale (larger sweep width) and — in some specifications — in the weighting.

The sideband frequency is generated by the Signal Generator SMS 2. The TV Transcope MUF 2 is used as the spectrum analyzer. This enables exact measurement of the intermodulation products with a calibrated level line.



f_v vision-carrier frequency
f_s sound-carrier frequency
f_{SB} sideband frequency
f_{IM} intermodulation frequency
RF

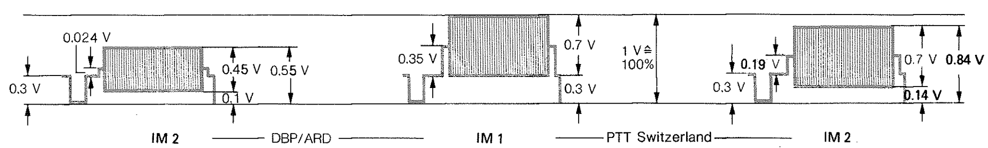
Occurrence and weighting of intermodulation products in transmitter (modulation 10/75%, VC/SC power ratio 10:1, pulse spectrum not shown)



Frequency MHz	IM rejection dB
0 to 1	46
3	30
3.6 to 4.9	40
5	30

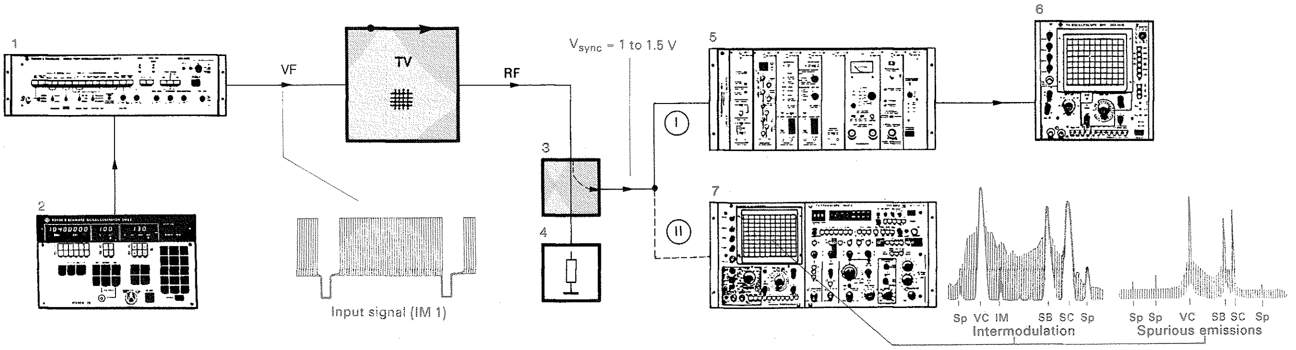
Minimum intermodulation rejection in transmitter according to standard specifications of DBP/ARD

Different modulation according to standard specifications of DBP/ARD and Swiss PTT (video signals)



Video			
VB amplitude (V_{pp})	0.45 V/64%	0.7 V/100%	0.7 V/100%
Setup	0.024 V/3.5%	0.35 V/50%	0.19 V/27%
RF			
Transmitter modulation	51/91%	10/73%	24/87%
Vision carrier	−3 dB	−8 dB	−5 dB
Sideband	−20 dB	−16 dB	−16 dB

transmission times



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Signal Generator SMS 2 (photo p. 14) or any RF generator up to 10 MHz

3 Directional coupler (incorporated in transmitter)

4 Dummy antenna (according to transmitter power)

5 TV Demodulator AMF 2 (photo p. 36) or AMF

6 TV Oscilloscope OPF (photo p. 49) with CCVSO level mask

7 TV Transcope MUF 2 (photo p. 104)

Measurement Procedure

A. Basic settings

1. As on p. 41.
2. Press key H+V on Video Test Signal Generator SPF 2 (for better display of 0-dB value with TV Transcope MUF 2).
3. Check output signal (15-kHz squarewave, 10/75%) on oscilloscope.
4. Separate connection (I), connect output of directional coupler to RF input of MUF 2 selective demodulator (II). Calibrate MUF 2 beforehand according to manual.

B. Calibration of setup

1. On sweep section of MUF 2 press keys SWEEP and → plus MHz below the decade switches. Set vision-carrier frequency of +2.5 MHz using TUNING COARSE and FINE. Select sweep width 1 MHz/DIV.
2. Press key LOG on MUF 2 selective demodulator (IF bandwidth 300 kHz) and set SWEEP speed to 5 ms/DIV. Centre curves on screen using TUNING FINE if necessary. Set control ↕ fully clockwise, select display height using RF ATTENuator and use ↕ to set tip of vision carrier (continuous bright point) to a graticule line below the upper screen edge.
3. Press LEVEL. Set level line with associated control to tip of vision carrier and press ΔdB. Display shows 0 dB.

C. Measurement of intermodulation

1. Connect output of Signal Generator SMS 2 to input EXTernal SIGNal of SPF 2; frequency setting 2.5 MHz, Z = 50 Ω, output voltage 0.25 V_{pp}.
2. Switch SPF 2 to EXTernal SIGNal, APL clamping with blanking, SETUP and mode H+V. Set % VIDeo to 50 (grey level).
3. Check modulation on TV Oscilloscope OPF (should be 10/73%). Make connection (I), switch OPF to 0.1 V/DIV and 10 µs/DIV, trigger H.
   Correction: output voltage on SMS 2. Subsequently establish connection (II) again.
4. The sideband frequency is now approx. in centre of screen of MUF 2 (correct using TUNING FINE).
   The amplitudes of the three frequencies should be as follows:
   vision carrier: – 8 dB,
   sideband: –16 dB,
   sound carrier: –10 (or –13) dB.
   Measure with aid of level line and displayed indication.
   Correction: vision carrier: % VIDeo on SPF 2,
   sideband: output voltage on SMS 2,
   sound carrier: on transmitter.
5. To determine intermodulation rejection, set level line on MUF 2 to tip of sideband amplitude, press key ΔdB and measure difference in level between intermodulation products and sideband amplitude with aid of level line.
6. Shift sideband frequency over entire video band and measure intermodulation products (the permissible values are contained in standard specifications). To suppress the pulse spectrum, reduce the IF bandwidth on the MUF 2 and the sweep time until the levels **just do not** change.
7. Choose other modulation for colour-subcarrier frequency if necessary (see opposite page). Make appropriate settings on SPF 2 and SMS 2 and proceed according to C.4. to C.6.

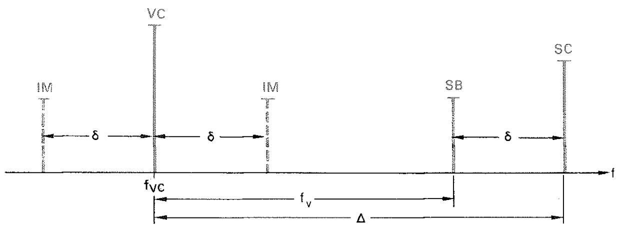
D. Measurement of spurious emissions

1. Set sweep width on MUF 2 to 2 MHz/DIV.
2. Measure intermodulation products outside of useful channel in same manner as in C. (observe reference value, see standard specifications).
3. For accurate determination of frequency, internal calibration markers can be used (key 10/1).

Note Details on intermodulation and its measurement using the TV Transcope MUF 2 can be found on pages 76 and 77.

Advantages of this instrument combination The frequency spectrum can be displayed using any frequency analyzer. The combination of Group-delay Measuring Set LFM 2 and Selective Demodulator LDS together with a monitor is particularly suitable since, in addition to display of the frequency spectrum (measurement method I), the intermodulation products can also be displayed as a continuous curve (measurement method II).

Occurrence of intermodulation products The amplitudes of the intermodulation products depend on the amplitudes of the frequencies causing them, i.e. on the interaction between vision carrier, sideband frequency (colour subcarrier) and sound carrier I. The following relationship exists:



		Frequency
VC	vision carrier	f_{VC}
SC	sound carrier	$f_{VC} + \Delta$
SB	sideband	$f_{VC} + f_v$
IM	intermodulation products	f_{IM}
f_v	video frequency	
Δ	frequency spacing vision/sound carrier	

$$f_{IM} = f_{VC} \pm (\Delta - f_v) = f_{VC} \pm \delta$$

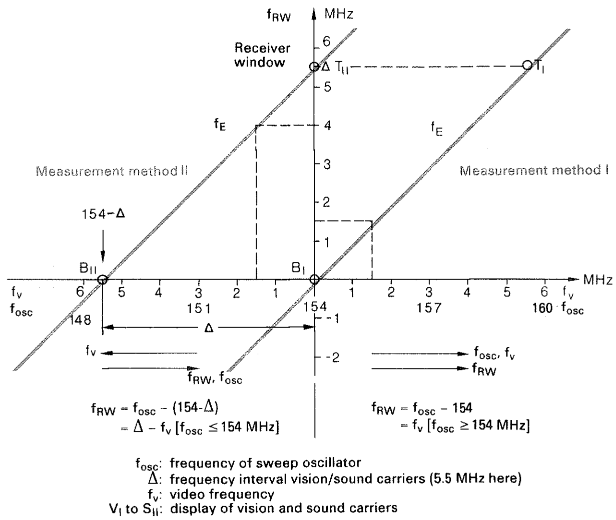
corresponding to $\Delta - f_v = \delta$ **in the video band**

With **measurement method I**, a constant, adjustable (sideband) frequency is applied to the transmitter from a separate generator. The IM products occur as discrete frequencies. In the analysis method used for the evaluation, the receiver window passes over these. The response time of the bandpass filters prevents correct display of changes in amplitude if the bandwidth is too small. Therefore do not select a bandwidth which is too small as this will affect the accuracy of the measurement. In addition, the spectrum of the line pulses cannot be suppressed in this case.

The right-hand side of the diagram shows the frequencies of the sweep oscillator in the LFM 2 (see p. 74) and the resulting video frequency (which is not used in this method, however). The position of the receiver window is linearly dependent on the frequency of the sweep oscillator. In this method, setting of the conversion oscillator (synthesizer) in the LDS to the vision carrier frequency results in coincidence of the video frequency zero and the frequency zero of the receiver window (vision-carrier frequency, point V_I in right-hand diagram).

With **measurement method II**, the LDS is tuned to the sound carrier. The conversion oscillator is then higher than in measurement method I by the interval Δ. The sweep oscillator must therefore be set lower by the same amount in order to meet the pass frequency of the receiver bandpass filter (the start frequency on the LFM 2 is correspondingly below $-\Delta$, see left-hand side in diagram. Thus the video frequency — which is applied to the transmitter in this measurement (sweep method) — is in the opposite direction to the frequency of the sweep oscillator, the receiver window is in the correct direction according to the equation $f_{RW} = \Delta - f_v$.

Since this equation corresponds to that for intermodulation products, only the associated intermodulation product is displayed in each case and not the applied video frequency. Since the amplitudes are approximately the same, no transient problems occur which means that the bandwidth can be reduced until the line pulse spectrum is suppressed (only once the amplitude of the sideband frequency and vision/sound carrier have been correctly set with a large bandwidth; these are no longer correctly displayed with a small bandwidth, as shown in the oscillograms in the setup on the next page). The result is a continuous curve of the intermodulation products, although the sideband amplitude is displayed in the centre of the video band and coincides in this case with the intermodulation product. The vision and sound carriers appear at the usual positions, except at lower frequencies of the sweep oscillator (points V_I, S_I or V_{II}, S_{II}).

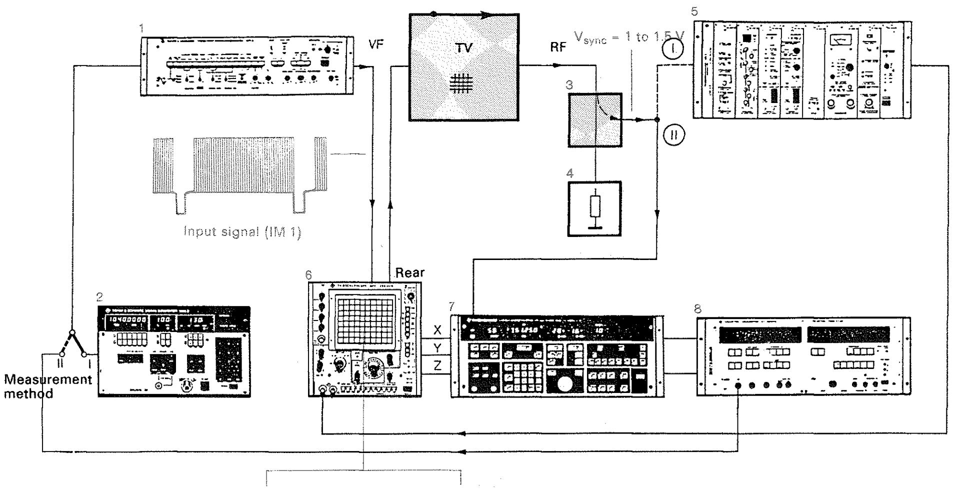


Position of receiver window f_{RW} with measurement methods I and II

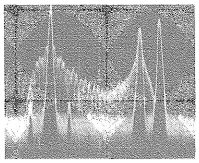
Measurement Procedure

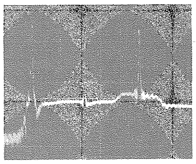
A. Basic settings

1. As on p. 41 (connection ①).
2. Connect output of SPF 2 to transmitter input via loop-through filter on rear of OPF (X14.1 and .2).
3. Switch SPF 2 to EXTernal SIGNal, APL clamping with blanking, SETUP and mode H+V. Set % VIDeo to 50 (grey level). Connect input EXTernal SIGNal to signal generator (method I, see B.I.) or to RF OUTPUT of LFM 2 (method II, see B.II).
4. Connect LDS to LFM 2 using system cable LDS-Z1 (accessory provided with LDS); connect X2.2 on LDS to X5.4 on LFM 2.



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)
2 Signal Generator SMS 2, 0.1 to 1040 MHz (photo p. 14), or any RF signal generator up to 10 MHz
3 Directional coupler (incorporated in transmitter)
4 Dummy antenna (according to transmitter power)
5 TV Demodulator AMF 2 (photo p. 36) or AMF
6 TV Oscilloscope OPF (photo p. 49)
7 Selective Demodulator LDS (photo p. 62)
8 Group-delay Measuring Set LFM 2 (photo p. 61)


Measurement method I


Measurement method II

Measurement Procedure (continued)

5. Set TIME/DIV on oscilloscope to XYZ, connect X15.2, .3 and .4 on rear to X3.3, .2 and .1 on rear of LDS, and front Y input to video output of AFM 2. Press 75 Ω.
6. Connect directional coupler output to IF/RF input of LDS (X4., rear) (II). Press RF REAR.

Measurement method I: spectrum display
I.B. Calibration of setup

1. Calibrate LFM 2 and LDS as on p. 74, B.1. to B.3. (only amplitude calibration).
2. Set frequency on signal generator to video band (e.g. 2.5 MHz, and output level to 0.25 V_{rms} (= 0.7 V_{pp}) (for IM 1 according to German DBP).
3. Check transmitter input signal on OPF with key REAR pressed, 10 µs/DIV and 0.1 V/DIV and TRIGGER H. The transmitter output signal appears with the key REAR released (establish connection (I)).
4. Set the prescribed level values for the various measurements using the signal generator output voltage and the % VIDeo control on the SPF 2 (see p. 76).

I.C. Measurement of intermodulation (connection (II))

1. Proceed as for amplitude measurement on p. 75, C.1. to C.3.
2. The curve on the screen represents the vision carrier, sound carrier and sideband frequency including the spectrum of the line pulses.
3. Press RESOLUTION 300 kHz and IF GAIN and set the peak of the carrier curve to the 100% reference line using VARY (scale 5 dB/DIV).
   Note To enable better reading, it may be necessary to set the bright point of the curve (blanking interval) to sweep slowly by slightly adjusting the frequency (control F on LFM 2).
4. For measurements according to IM 1 of the German DBP/ARD, the three frequencies should have the following levels:

		Correction
Vision carrier:	− 8 dB,	Control % VIDeo on SPF 2
Sideband:	−16 dB,	Output voltage on SMS 2
Sound carrier:	−10 (or −13 dB)	On transmitter

(scale on screen).

5. The spacing of the intermodulation products must also be measured on the screen (scale 10 dB/DIV).
6. Shift the sideband frequency over the complete video band and measure the intermodulation products (the permissible values are defined in the standard specifications).
   Select, if required, another modulation for the vision-carrier frequency (see p. 76). Carry out the corresponding settings on the signal generator and test-signal generator and proceed as in 3. to 5.

Measurement method II: continuous display of IM products
II.B. Calibration of setup

1. As for I.B.1. The start frequency on the LFM 2 must be below −Δ (e.g. −10 MHz).
2. Press MOD OFF on LDS (switching off of probe frequency modulation).
3. For the measurement according to IM 1 of the German DBP/ARD, set output voltage of LFM 2 to −2 dB (corresponds to 0.79 V_{pp}) using the keys V_{out} +/−. Since the output voltage of the LFM 2 can only be adjusted in 2-dB steps, the fine adjustment must be made on the SPF 2 (press VAR and set desired modulation using VIDeo AMPLitude. Set CCVS AMPLitude and SYNC AMPLitude to zero).
4. As for I.B.3.
5. Set the prescribed values for the various measurements using the keys V_{out} +/− on the LFM 2 and the two controllers % VIDeo (SETUP) and VIDeo AMPLitude on the SPF 2.

II.C. Measurement of intermodulation

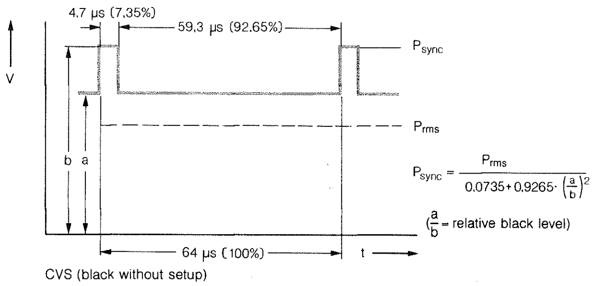
1. Enter vision-carrier frequency as on p. 75, C.1.
2. Press FREQUENCY and + (on right of numeric keypad) on LDS and then enter the Δ value (e.g. 5.5 MHz) on the numeric keypad. Press MHz. The **sound**-carrier frequeny is output in the display.
3. As on p. 75, C.2.
4. As on p. 75, C.3.
5. The curve on the screen represents the vision carrier, sound carrier and the sideband frequency Δ/2 in between (Δ frequency spacing vision/sound carrier).
6. As for I.C.3.
7. Level setting as for II.B.5., then press RESOLUTION 5 kHz, TV and VIDEO FILTER on the LDS (suppression of pulse spectrum).
8. The line between the vision/sound carrier and the sideband frequency indicates the level of the IM products. These can be measured on the screen (scale 10 dB/DIV).

OUTPUT POWER

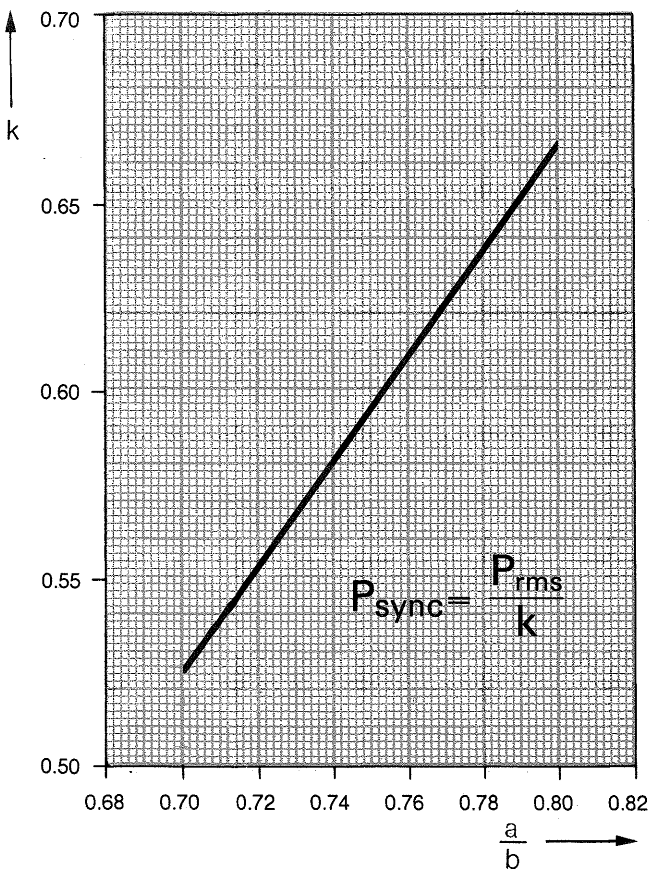
Accurately measuring the output power of transmitters is an involved task that calls for a great deal of care. An equipment producer will generally perform such a measurement with a high degree of precision because — particularly in the case of the vision transmitters for TV — the quality is affected by the accuracy of the power setting.

Determining sync peak power

The nominal power of a vision transmitter — the sync peak power — is only present for a relatively short time. Using conventional methods therefore (e.g. thermocouple), it can only be measured by determining the rms value and then converting. The conversion factor necessary for this can only be derived if the form and amplitude of the transmitter modulation are known. The following diagrams illustrate the conversion from rms power to sync peak power for a composite video signal with black level and no setup, and show the conversion factor as a function of the relative black level.



Conversion of rms to sync peak power



Conversion factor for rms to sync peak power ($\frac{a}{b}$ = relative black level)

With the TV Transcope MUF 2 from Rohde & Schwarz it is possible to measure the (secondary) sync peak power directly.

Indirect power measurement

Principle Indirect power measurement, which can be used with transmitters of any power, is performed in two steps. The coupling of the test point is first determined (between 35 and 60 dB depending on the output power of the transmitter), and then the secondary power at the test output of the transmitter (a few milliwatts). From these two values it is then possible to calculate the actual output power.

Measuring high-power attenuators A set of exactly measured attenuators is necessary to determine the coupling. The attenuations can be determined simply using the Signal Generator SMS 2 and the Power Meter NRV. A maximum attenuation of 20 dB (possibly 30 dB) should be measured at one time to ensure that the accuracy of the power meter is adequate. Higher attenuations can be achieved using several attenuators.

Determining coupling The coupling of a test output is determined with attenuators (measured beforehand) instead of a dummy antenna and with a very accurate power meter of high sensitivity. The required setting of the transmitter to an appropriately low level of power (e.g. 75 W maximum with a 10-kW transmitter) calls for steps that have to be decided on in each individual case (such as the bypassing of intermediate stages and the like). Under no circumstances may the RF air-line system of the output stage with the testpoint be altered (mechanical tensioning could alter the output for instance). The high-power attenuators must be capable of carrying the load imposed on them. The RBU series from Rohde & Schwarz is suitable for this purpose, with models for up to 100 W.

Measuring secondary power The secondary power can be measured by two different methods. On the one hand there is the possibility of **measurement with the Power Meter NRV.** This produces the rms power value, which is converted to sync peak power with the aid of the conversion factor.

Much simpler, however, is **measurement with the TV Transcope MUF 2.** A calibrated level line is set to the transmitter frequencies displayed on the screen, and the power of the vision transmitter (sync peak power) or sound transmitter is immediately indicated. It is advisable to use both methods to gain an impression of the measuring accuracy. The two oscillograms from the screen of the MUF 2 in the diagram of the setup for measuring secondary peak power (page 83) show the vision carrier (black with H and V pulses). The lefthand display is with a sweep of approx. 0.1 MHz/div. Here it is difficult to synchronize and, because of the spots that run backwards and forwards (field blanking interval), not too easy to read off. With setting AFC on the MUF 2, as in the righthand display, the matter becomes easier. In both cases, the level line has been set higher than usual for the sake of clarity, for measurements it would be exactly on the points.

The secondary sound-transmitter power is measured on transmitters with separate vision/sound amplification (and **only** on these) after shutting down the vision transmitter. With all other transmitters it is deduced from the increase in rms power when the sound transmitter is cut in, or it can be measured directly with the MUF 2.

After entering the coupling, the Power Meter NRV indicates the rms value of the output power which must be converted to the sync peak power using the factor k. The MUF 2 indicates the secondary sync peak power which must be converted to the output power using the coupling value.

Direct power measurement

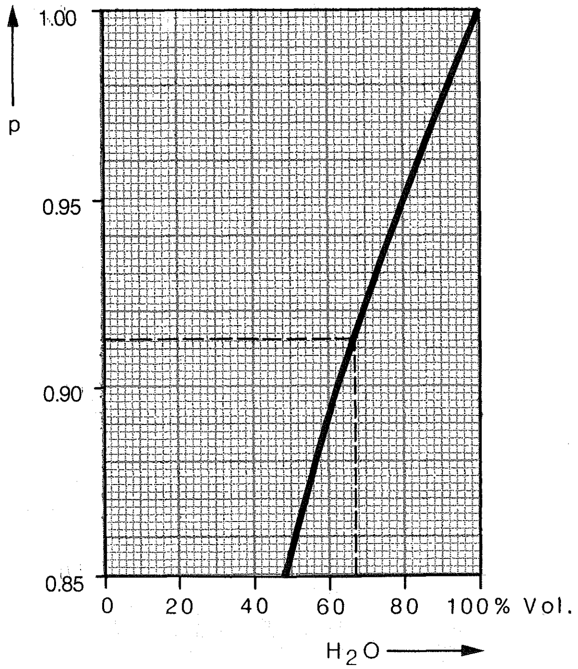
In the case of transmitters with nominal power above 10 kW, it is also possible to determine the rms power by a direct calorimetric method using a liquid-cooled dummy antenna. For measuring the power the antenna must be fitted with precision thermometers to detect the input and output temperature. They must be located as close as possible to the actual load resistor to avoid heat losses, and all lines for cooling liquid in their vicinity have to be properly insulated. The cooling liquid often consists of a mixture of distilled water and glycol to prevent freezing. The flowmeter must consequently be calibrated for the cooling means in use. The diagram on the right illustrates the influence of the mixture ratios of glycol and water on the specific heat capacity.

For power measurement with a liquid-cooled dummy antenna the following applies:

$P_{rms} = 0.07 \cdot q \cdot \Delta t \cdot p$

P_{rms}	power [kW]
q	flow volume [l/min]
Δt	temperature difference output/input [°C]
p	correction factor for specific heat capacity of cooling liquid

In calorimetric measurements the sound-transmitter power is deduced from the increase in rms power when the sound transmitter is cut in.



Correction factor p for specific heat capacity of cooling liquid (for the usual mixture of 1/3 glycol and 2/3 water p = 0.913)

The measurement procedure is described on the following two pages.

Measurement Procedure

A. Basic settings (for all methods used to measure secondary power)

1. Transmitter settings as on p. 41.
2. Set up equipment as on opposite page. Use a short, precision cable to connect the directional coupler output to the TV Transcope MUF 2 (connect to input of selective demodulator).
3. On Video Test Signal Generator SPF 2 select SETUP, CALibrated and mode H+V. Set % VIDeo to 0 (black level).

B. Measurement of attenuators
(diagram opposite, top right)

1. Set signal generator to transmitter frequency and maximum output level (no modulation).
2. Connect sensor of Power Meter NRV directly to output of signal generator; the power is indicated in Watt.
3. Press SELect DIMension on NRV until dBm is marked in display. The power of the signal generator is now indicated in dB (referred to 1 mW) into 50 Ω.
4. Press SHIFT and STOre. The measured value is then stored as the reference value.
5. Press ΔINT and then SELect RELative until ΔdB is marked in the display. The deviation of the measured power from the stored value is then indicated in dB (0 dB in this example).
6. Disconnect the sensor from the signal generator and directly screw the attenuator to be measured onto the signal generator output. Connect the sensor to the output of the attenuator. Do not change settings on SMS 2 and NRV.
7. The NRV indicates the attenuation in dB (negative sign). All attenuators can be measured in succession with the same setting so that a set is available with exactly measured values.

C. Determination of coupling
(diagram opposite, bottom left)

1. For this measurement the power at the transmitter output must not be more than 75 W, otherwise the attenuators could be overloaded. This calls for internal measures (bypassing of intermediate stages, etc.) to ensure that the transmitter under no circumstances gives off more power. If required, connect a directional power meter, e.g. NAUS 4 from Rohde & Schwarz, into the line to the dummy antenna (adapters necessary).
2. Combine measured attenuators to approximately achieve expected coupling (connect directly, no intermediate cables) and connect directly to transmitter output (instead of dummy antenna).
3. Connect sensor of NRV to directional coupler output of transmitter.
4. Switch on transmitter. Press ABSOLUTE on NRV; the power is indicated in Watt. Select the unit dBm using SELect DIMension. The indication is now in dB (above 1 mW).
5. As for B.4.
6. As for B.5.
7. Separate sensor from test output and connect directly to output of attenuators.
8. Power meter then shows difference between attenuation of directional coupler and attenuators.
9. Coupling is thus:
   $a_c = a_a + a_p$
   a_c coupling (dB)
   a_a total attenuation of attenuators (dB)
   a_p value indicated on power meter (dB)
10. Connect transmitter to dummy antenna again; reconnect internal wiring.

D. Calibration of setup (for all methods used to measure secondary power)

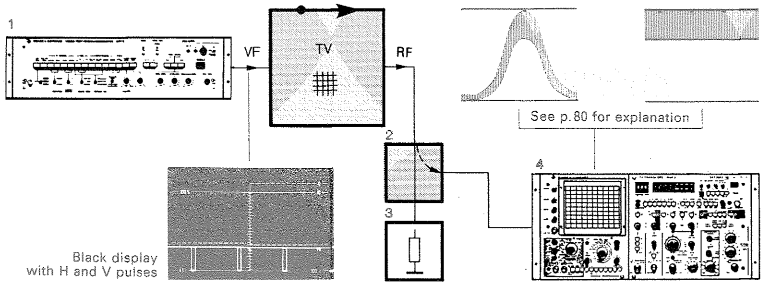
1. On TV Transcope MUF 2 press keys SWEEP, → and MHz. Select IF bandwidth 300 kHz. Set TUNING COARSE and FINE to vision-carrier frequency and sweep width MHz/DIV to 1. SWEEP time 10 ms/DIV and control ↕ fully CW.
2. Press key LOG on selective demodulator. With TUNING FINE centre vision carrier and then select MHz/DIV of 0.1. Adjust for display height and position with RF ATTENuator and control ↕.
3. Disconnect precision test cable from directional coupler and connect to GENERATOR output of MUF 2.
4. Press button LEVEL, set RF ATTENuator to CALibrated (release lock) and with setting screw under ↕ adjust both level lines to coincide. Then release LOG key, press LIN and perform same calibration.
5. Reconnect precision test cable to test output (directional coupler) on transmitter.

E.I. Measurement of secondary power with TV Transcope MUF 2

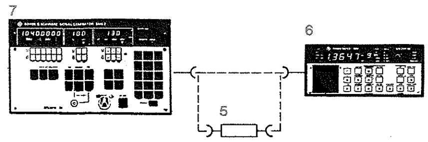
1. Reset RF ATTENuator on TV transcope to previous position. Set suitable display height with TUNING FINE on selective demodulator.
2. For easier reading set sweep switch MHz/DIV to AFC and adjust SWEEP time so that display runs slowly. Upper points on screen correspond to sync peak amplitude (see diagram of setup above).
3. Press Watt key and adjust level line with associated control to cover upper points on screen. Vision-carrier sync peak power $P_{sync\,I}$ is indicated directly in mW.
4. To measure sound-carrier power set sweep switch MHz/DIV to 1 and centre sound-carrier curve with TUNING FINE.
5. Reduce RF ATTENuator by 10 dB and set practical display height with IF ATTENuator.
6. Set level line to peak of curve; secondary sound-transmitter power is indicated directly.

E.II. Measurement of secondary power with Power Meter NRV

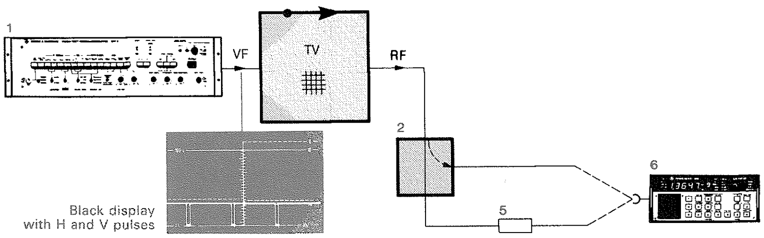
1. As for E.I.1. and 2., but switch off sound transmitter.
2. Press Volt button on MUF 2 and adjust level line to upper points on screen. Note indicated value V_{sync}.
3. Adjust level line to continuous line at bottom (black level) and note indicated value V_b. Calculate V_b/V_{sync} (= relative black level a/b).
4. From diagram on p. 80 calculate factor k for V_b/V_{sync}.
5. On SPF 2 press key H (instead of H+V).



Measurement of secondary peak power



Measurement of attenuators



Determination of coupling

1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Transcope MUF 2 (photo p. 104)

5 High-power Attenuators RBU (photo p. 16), 3, 10, 20, 30 dB; max. 100 W

6 Power Meter NRV (photo p. 31) with Precision Power Sensor NRV-Z2 (50 Ω)

7 Signal Generator SMS 2 (photo p. 14), 0.1 to 1040 MHz

(8 Directional Power Meter NAUS 4, see section C.)

Measurement Procedure (continued)

6. Disconnect cable to MUF 2 from output of directional coupler and directly connect the sensor of the NRV there.
7. The power P_{rms} is indicated.
8. Sync peak power is calculated acc. to $P_{sync\ II} = P_{rms}/k$. It is advisable to compare with vision-carrier sync peak power $P_{sync\ I}$ obtained in E.I.3.
9. Sound-transmitter power is deduced from increase in rms power when sound transmitter is cut in.

F. Calculation of true power from secondary power

Power at transmitter output:

$P_1 = P_2 \cdot 10^{0.1a_c}$

P_1 power at transmitter output

P_2 measured secondary power

a_c measured coupling

F.I. The power $P_{sync\ I}$ measured according to E.I. must be converted according to the above equation and results in the output sync peak power.

F.II. The Power Meter NRV indicates the rms output power after entering the coupling value.

1. Press SHIFT and mark in display field ATT/dB (attenuation) using key INP. Enter the value of the coupling attenuation determined in C.9. on the numeric keypad and press STOre.
2. Press ABSOLUTE. The secondary power is indicated in Watt.
3. After pressing ATTenuation CORRection, the NRV indicates the rms output power (same value as according to G.9.).
4. Calculate the sync peak power from this value and the factor k.

G. Direct measurement of power on liquid-cooled dummy antenna (only for transmitters with nominal power above 10 kW)

1. to 5. As for E.II.1 to E.II.5.
6. Read off flow volume q of cooling means (flowmeter must be calibrated for cooling means used).
7. Measure input and output temperature and form temperature difference Δt.
8. Derive correction factor p for specific heat capacity from diagram on p. 81.
9. Calculate rms power $P_{rms} = 0.07 \cdot q \cdot \Delta t \cdot p$
10. Sync peak power is then $P_{sync} = P_{rms}/k$ (factor k from E.II.4.).
11. Sound-transmitter power is deduced from increase in rms power when sound transmitter is cut in.

MEASUREMENTS ON VISION/SOUND DIPLEXERS

When vision and sound are amplified separately in a television transmitter, the two separately produced vision and sound power components are combined by a vision/sound diplexer before they are applied to the transmitting antenna. Such diplexers handle the entire transmitter power and must exhibit as little passband attenuation as possible so that the power losses remain small and components are not overheated. What is more, the matching — especially on the vision-transmitter side — must be very good to prevent the occurrence of reflections. And to avoid mutual interference between the vision and sound transmitters, their isolation must also be adequate. If the circuits used in these diplexers are not properly tuned, passband attenuation, matching and isolation can all suffer. It is therefore advisable to check vision/sound diplexers from time to time.

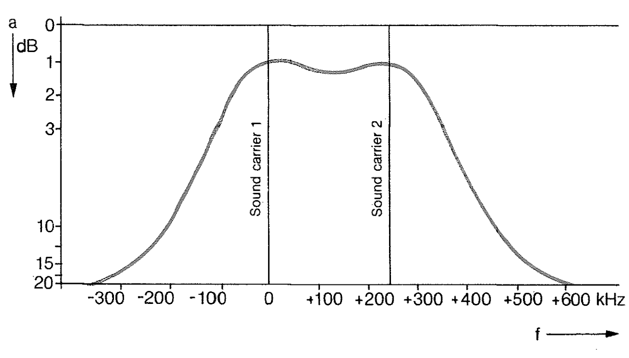
PASSBAND ATTENUATION AND RETURN LOSS

(see also p. 100)

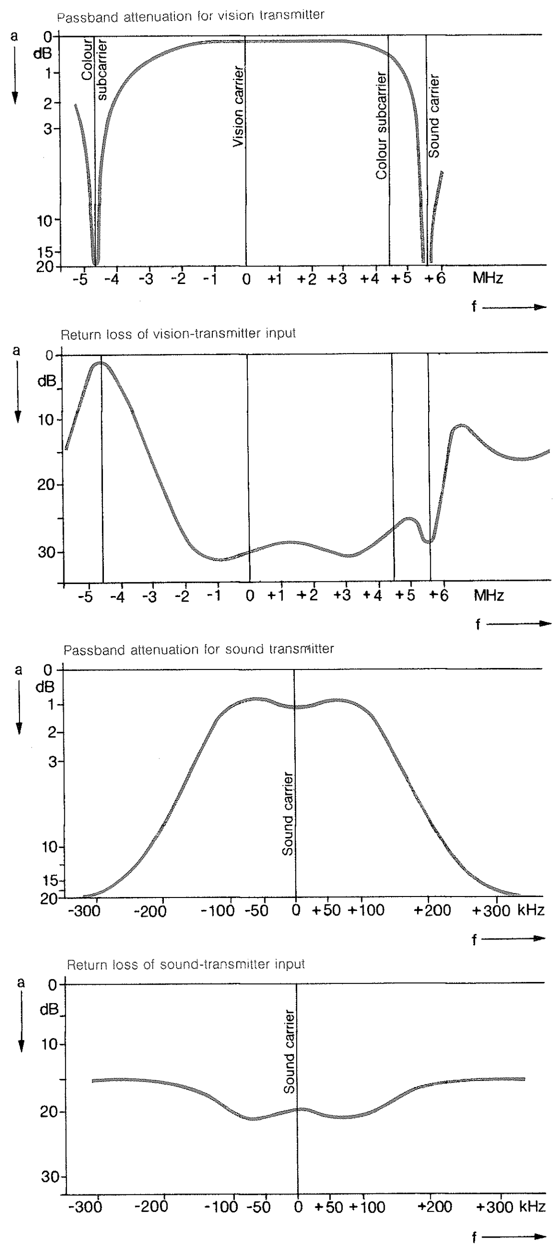
Vision/sound diplexers are generally dual-bridge diplexers with 3-dB couplers as the bridge networks. In the block diagram (bottom of page opposite) it can be seen that the 3-dB coupler DCP 2 divides the sound-transmitter frequency f_s into two equal power components, which are passed by the two filter circuits tuned to the frequency f_s and fed by way of the 3-dB coupler DCP 1 to the antenna output. DCP 1 also splits the vision-transmitter frequency f_v into two equal power components, which are reflected by the filter circuits however and fed back again by way of DCP 1 to the antenna output. The diagrams on this page show some typical curves measured on such diplexers.

With TV transmitters that broadcast dual sound, it should be noted that the passband on the sound side is sufficiently wide to ensure virtually the same amplitude and phase conditions for both sound-transmitter frequencies. Otherwise the crosstalk ratings for stereo operation would be degraded (see page 30).

The TV Transcope MUF 2 from Rohde & Schwarz is highly suitable in conjunction with a matching bridge for measurements of this kind. And what is of particular advantage is the fact that the curves for passband attenuation and return loss (i.e. matching) can be displayed simultaneously on the screen of the MUF 2.

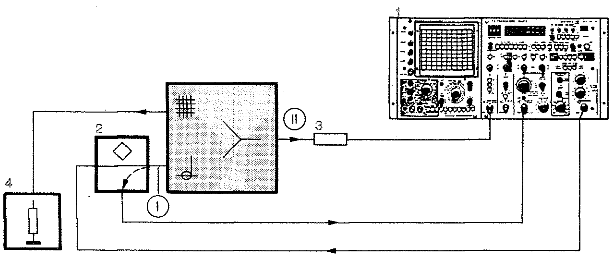


Passband attenuation for sound transmitter with diplexer for dual-sound broadcasting



Typical curves measured on vision/sound diplexers for mono sound broadcasting

PASSBAND ATTENUATION AND RETURN LOSS



1 TV Transcope MUF 2 (photo p. 104)
2 VSWR Bridge ZRB 2 (photo p. 86)
3 Attenuator DNF (photo p. 86), 20 dB, 50 Ω
4 Precision Termination RNA (photo p. 86), 50 Ω

Measurement Procedure

A. Basic settings

1. Fit vision/sound diplexer with test adapters. Connect VSWR bridge directly to sound input of diplexer (I). Connect termination directly to vision input, and attenuator to output of diplexer (II).
2. Connect GENERATOR output of MUF 2 to input of VSWR bridge. Connect output of bridge to input of selective demodulator of MUF 2, and output of attenuator to BROADBAND input of MUF 2.
3. Settings on MUF 2: press LOG and Y × 2 on selective demodulator, set RF ATTENuator to 0 dB, press LOG and 1 dB/DIV on broadband demodulator; on generator: press SWEEP, →, FREQuency MARKer 10/1, set RF LEVEL to −6 dB and sweep width MHz/DIV to 1.
4. Press MHz and set sound-carrier frequency on digital display with TUNING COARSE and FINE.
5. Calibrate MUF 2 as prescribed in manual.

B. Calibration of setup

1. Centre curves with TUNING FINE, reduce sweep width to 0.1 MHz/DIV (roughly adjust position of displayed curves with ↕ if necessary).
2. Separate connections (I) and (II) (with attenuator) from diplexer and connect them directly to one another.
3. With ↕ on broadband demodulator move line to 2nd graticule line from top (zero-reference line for passband attenuation).
4. Reconnect line (II) to diplexer, line (I) remains open-circuit.
5. With RF ATTENuator on selective demodulator set size of display, and with ↕ also move line to 2nd graticule line from top (zero-reference line for return loss).
6. Reconnect (I).

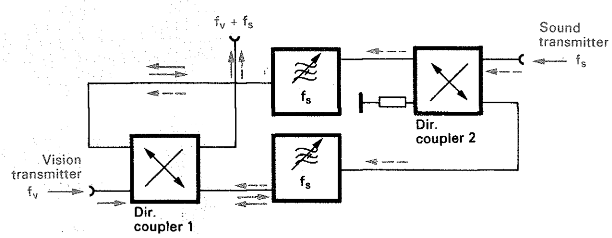
C. Determination of passband attenuation and return loss at sound-transmitter input

1. Read results from curves on screen with aid of graticule scale.
   Scales: 0.5 dB/DIV for passband attenuation
   5 dB/DIV for return loss
2. Admissible values can be taken from relevant standard specifications or acceptance records.

D. Determination of passband attenuation and return loss at vision-transmitter input

1. Connect VSWR bridge with line (I) to vision-transmitter input, connect termination to sound-transmitter input.
2. Reset sweep width to 1 MHz/DIV, centre display with TUNING FINE. 1-MHz calibrated markers enable frequency to be accurately determined.
3. As for C. 1.
4. As for C. 2.

Note The passband attenuation at the input of the vision transmitter is normally very small (approx. 0.1 dB), so this measurement can only be used as an indicator.



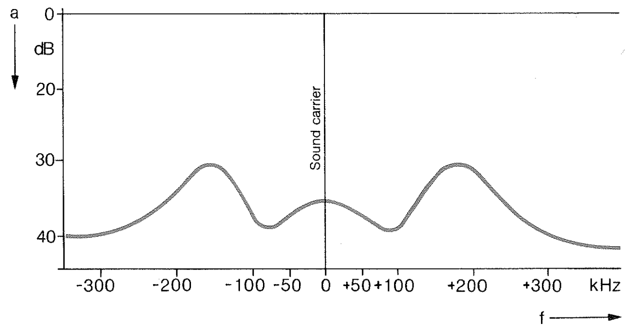
Block diagram of vision/sound diplexer

VISION/SOUND ISOLATION

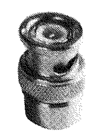
The degree of the isolation between the inputs for vision and sound on a vision/sound diplexer determines to what extent the two transmitters influence one another. The frequencies of the two transmitters are different, so there is no direct influence between them. As a result of intermodulation however, it is possible for additional frequencies to appear within or outside of the frequency band of a transmitter, these disturbing either the transmitter's own emissions or those of another transmitter. Furthermore, if the isolation is inadequate, there can be mutual interference of the input impedances.

The vision transmitter, because of its large bandwidth, is particularly susceptible to other frequencies and to mismatch. It is therefore especially important to examine the isolation from the sound to the vision side. From the block diagram of a vision/sound diplexer on page 85 it can be seen that the isolation for the sound-transmitter frequency depends only on the isolation of the directional coupler DCP 1, because the filter circuits allow this frequency to pass. For the vision-transmitter frequencies, there is, in addition to the coupler attenuation, the attenuation of the filter circuits, meaning that the isolation here is greater than for the sound-transmitter frequency. It is consequently sufficient to measure the isolation in the region of the sound-transmitter frequency.

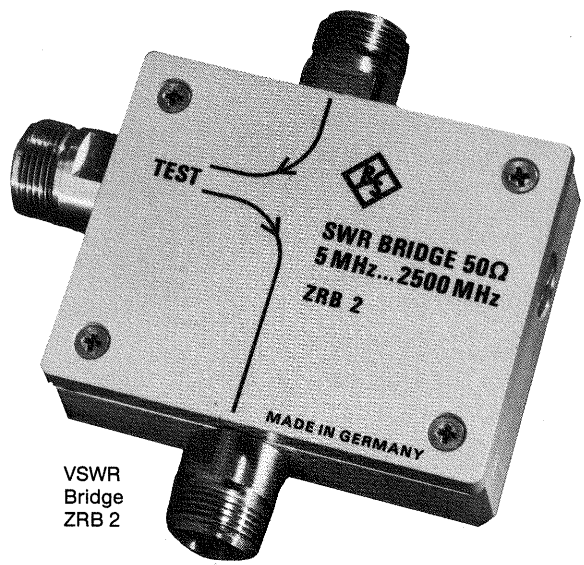
With the TV Transcope MUF 2 it is possible to measure the isolation simply and speedily in the entire range as well as in the critical region of the sound-transmitter frequency.



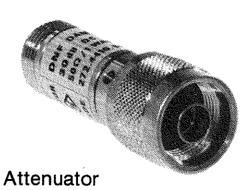
Example of isolation from sound-transmitter input to vision-transmitter input of vision/sound diplexer for mono sound (only in region of sound-transmitter frequency)



Termination
RMF 2

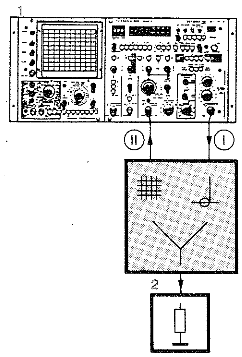


VSWR
Bridge
ZRB 2



Attenuator
DNF

Precision
Termination
RNA



1 TV Transcope MUF 2 (photo p. 104)

2 Precision Termination RNA (photo opposite), 50 Ω

Measurement Procedure

A. Basic settings

1. Fit vision/sound diplexer with test adapters. Connect termination directly to output of diplexer. Connect sound input to GENERATOR output and vision input to RF input of selective demodulator on MUF 2.
2. Settings on MUF 2: press LOG and Y × 2 on selective demodulator, SWEEP, → and FREQuency MARKer 10/1 on generator. Set RF LEVEL to −6 dB and sweep width to 1 MHz/DIV.
3. Press button MHz and set vision-carrier frequency +2.5 MHz acc. to display with TUNING COARSE and FINE. Check frequency with calibrated markers, correcting if necessary with TUNING FINE.

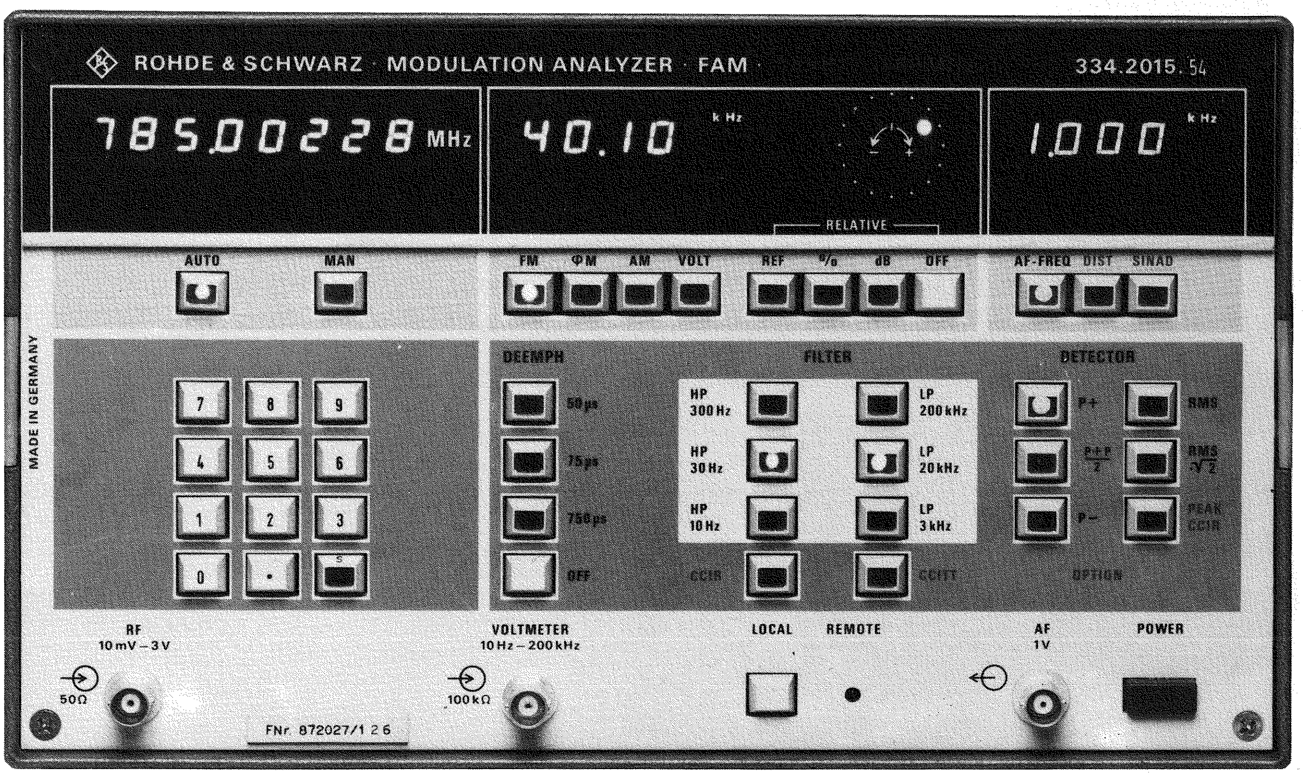
B. Calibration of setup

1. Separate connections (I) and (II) from diplexer and connect them directly to one another.
2. With RF ATTENuator and ↕ on selective demodulator move line to 2nd graticule line from top (zero-reference line). Press keys LEVEL and dBm and with associated control set level line to coincide with other line. Press key ΔdB.

C. Determination of vision/sound isolation

1. Re-establish connections (I) and (II) on diplexer.
2. Curve on screen shows vision/sound isolation over entire transmission band.
3. Determine measured values either with graticule lines (scale 5 dB/DIV) or level line. For this, set level line to coincide with points of interest using associated control. Isolation is then indicated directly on digital display.

Modulation Analyzer FAM



CHECKING OF TV DEMODULATOR

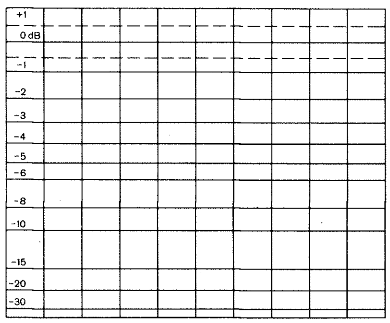
A TV demodulator is required for virtually all measurements on vision transmitters. This recovers the modulation signals from the RF issued by the transmitter so that they can be compared with the original signals fed to the transmitter. Such an instrument has to be unusually accurate, because its errors will appear in the measured results. It is therefore advisable from time to time to check important characteristics of a TV demodulator, such as nonlinearity, video amplitude characteristic and group delay.

CHROMINANCE NONLINEARITY – VIDEO AMPLITUDE CHARACTERISTIC

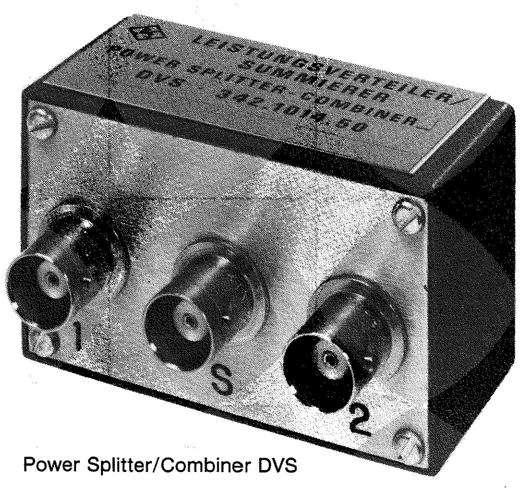
Note Selective measurement of chrominance nonlinearity, video amplitude characteristic and group-delay with the LFM 2/LDS/ODF is described on pages 92 and 93, the same selective measurement with LFM 2/LDS/ODF is described on pages 94 and 95.

It is best to measure the (chrominance) nonlinearity at the sideband frequencies of 1 MHz and 4.43 MHz. For this purpose the vision-carrier frequency produced by the TV Test Transmitter SBUF is modulated with the blacker-than-black sawtooth with H pulses from the Video Test Signal Generator SPF 2. This signal runs through the characteristic of the tested item from 10% to 86.5%. The Signal Generator SMS 2 is set to a frequency of 1 MHz or 4.43 MHz above the vision-carrier frequency. Both frequencies are mixed non-reactively in the Power Splitter/Combiner DVS in order to eliminate the error of previous modulation. The amplitude of the superimposed signal should be about 10% (V_{pp}). By means of the bandpass filters incorporated in the TV Oscilloscope OPF, it is possible to filter out the superimposed signal and display it on the screen. The procedure thus corresponds to that for measuring the chrominance nonlinearity of vision transmitters, as described on page 54.

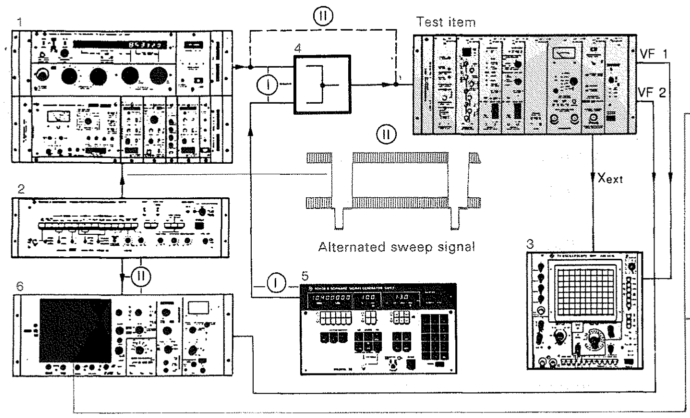
For measuring the video amplitude characteristic, the TV Test Transmitter SBUF and the Video Test Signal Generator SPF 2 are used again. Also necessary is the Videoskop SWOF 3, with which a level mask is available especially for this measurement (diagram). The Signal Generator SMS 2 is not required for this measurement. As a result of the extremely small frequency-response error of the SBUF, the frequency-response curve of the TV demodulator is produced directly without any additional measures. The measurement procedure is largely the same as that for vision transmitters (see page 68). Different frequency responses for white or black level can only be discerned for very large nonlinearities.

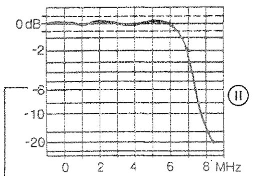


Level mask for measuring video amplitude characteristic with Videoskop SWOF 3

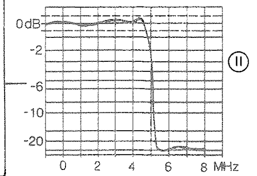


Power Splitter/Combiner DVS





Frequency response of amplitude (sound trap OFF)



Frequency response of amplitude (sound trap ON)

1 TV Test Transmitter SBUF (photo p. 92)
2 Video Test Signal Generator SPF 2 (photo p. 24)
3 TV Oscilloscope OPF (photo p. 49)
4 Power Splitter/Combiner (only for measuring nonlinearity) 0.1 to 400 MHz: DVS (photo opposite) 10 to 1000 MHz: model H-8-4 from Anzac[1])
5 Signal Generator SMS 2 (photo p. 14), 0.1 to 1040 MHz (only for measuring nonlinearity)
6 Videoskop SWOF 3 (photo p. 58) with tolerance mask video frequency response (only for measuring video amplitude characteristic)

[1]) German agent: Omecon Electronic GmbH, Jaegerweg 8, D-8012 Ottobrunn, Telephone: 089/6094084

Measurement Procedure

I. Measurement of nonlinearity

A. Basic settings

1. In setup produce condition corresponding to (I).
2. Tune TV test transmitter to vision-carrier frequency: MODE LOCKED, with PICTURE-CARRIER TUNING I (right) preset frequency from 1-kHz to 10-MHz place. Then with PICTURE-CARRIER TUNING II (left) set frequency with lefthand display. After illumination of LED SYNChronized, set APC indication to centre. Lefthand display extinguishes, 100-MHz place is transferred to righthand display. Set OUTPUT LEVEL at gain 0 dB to 106 dBμV (= 200 mV_{pp}).
3. Set up vision modulator as prescribed in manual. Then switch DC RESTORATION to CLAMPED, VSB FILTER and PRECORRection to OFF. Connect output of Video Test Signal Generator SPF 2 to INPUT VIDEO on SBUF, switch on 75 Ω. Press key DYNamic PROGRam on program module SBUF-E4.
4. On test-signal generator press keys H, CALibrated and blacker-than-black sawtooth. Set SUBCarrier to OFF, APL to 50%.
5. On TV demodulator (i.e. test item) select INPUT RF, INPUT LEVEL −12 dB, GAIN CONTROL HAND and ZERO REFERENCE ON.
6. Connect TV Oscilloscope OPF to TV Demodulator AMF 2: Y input to VIDEO OUTPUT 1, X_{EXT} (rear panel, X15.1) to Q OUTPUT. Settings on OPF as on p. 41 (0.1 V/DIV, 10 μs/DIV, 75 Ω, H).
7. Check the modulator balance in position X_{EXT} of the oscilloscope (setting as on p. 61). Correct if necessary using MOD BALANCE on modulator unit of SBUF.
8. On Signal Generator SMS 2 select vision-carrier frequency +1 MHz and output level approx. 10 mV_{rms}.

B. Measurement of nonlinearity

1. Set manual control HAND on TV demodulator so that output signal is 1.1 V_{pp} (compare with internal calibration voltage of OPF).
2. Check superimposed signal (nominal value 10% V_{pp}). Correct on signal generator if necessary. Note position of sync pulse.
3. On AMF 2 switch ZERO REFERENCE to OFF.
4. On OPF select 1-MHz bandpass filter. Set gain so that display is easy to evaluate (e.g. 10 DIV in height).
5. Determine maximum amplitude A_{max} and minimum amplitude A_{min}.
   Nonlinearity $s = \frac{A_{min}}{A_{max}}$

Note In this measurement, the sync pulse also has a signal superimposed. One may only evaluate the range of amplitude from white (10%) to blacker-than-black (86.5%).

6. Perform same measurement at sideband frequency 4.43 MHz. For this set Signal Generator SMS 2 to vision-carrier frequency +4.43 MHz, select bandpass 4.43 MHz on OPF.

II. Measurement of video amplitude characteristic

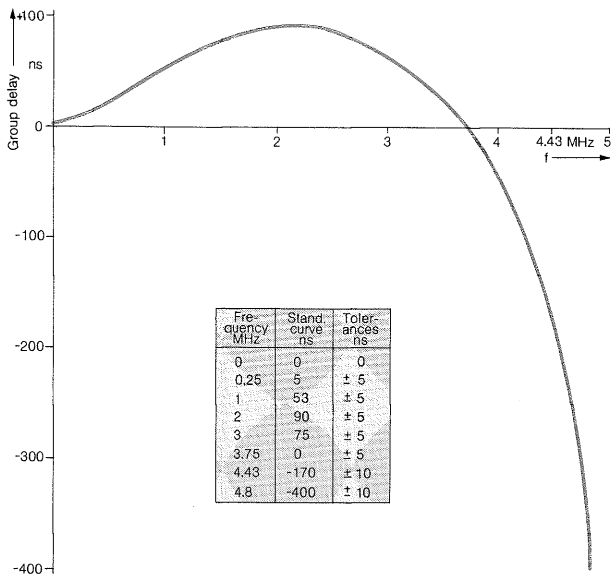
1. Separate connections and equipment (I) and hook up as (II).
2. Connect GENerator OUTput of Videoskop SWOF 3 to input EXTernal SIGNal of Video Test Signal Generator SPF 2. Set output attenuator on videoscope to −20 dB and sweep range of −2 to +6 MHz. On SPF 2 switch to EXTernal SIGNal, APL clamping with blanking, 50-Hz squarewave, 10/90% AMPLITUDE and mode H.
3. Connect SELECTIVE INPut of videoscope to 2nd VIDEO OUTPUT of TV demodulator. Set input attenuator on videoscope to −20 dB.
4. Switch TV demodulator to SYNCHRONous DETECTION, SOUND TRAP OFF and ZERO REFERENCE ON.
5. Check modulation of test transmitter on oscilloscope (0.1 V/DIV, 10 μs/DIV, 75 Ω, mode H). Nominal values 10/20% and 65/75%. If necessary, correct superimposed signal with output attenuator of videoscope.
6. On AMF 2 switch ZERO REFERENCE to OFF.

B. Measurement of video amplitude characteristic

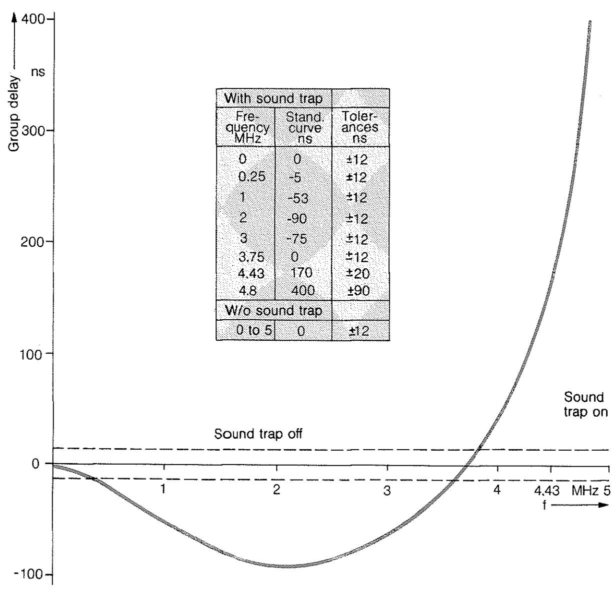
1. On Videoskop SWOF 3 set sweep time to 200 ms, mode switch on receiver unit to SELECTIVE, display to LIN × 10 and 2-kHz BANDWIDTH.
2. With Y POSition LIN × 10 adjust trace on screen so that it is on 0-dB line at 1.5 MHz.
3. To check X deflection press 1-MHz FREQuency SCALE and with X POSition and X LENGTH adjust calibrated lines to coincide with lines of tolerance mask.
4. Display on screen shows video amplitude characteristic for white and black levels simultaneously. Differentiation is possible by switching SPF 2 to 0.1/1 Hz.
5. Repeat measurement with PRECORRection of vision modulator of SBUF ON and SOUND TRAP of TV demodulator ON.

GROUP DELAY (IF, RF)

The transmission system TV transmitter/TV receiver is provided with **correction of group delay** to ensure correct transmission of the modulation signals. The group delay may not exceed certain limits in the entire transmission band. The correction differs from TV standard to TV standard. Either the correction circuits are only in the transmitter (full correction, e.g. standards I, K and M) or they are distributed between the transmitter and the receiver (half correction, e.g. standards B, D, G and K, see following diagrams). In the latter case the TV demodulator — which is supposed to represent an ideal domestic receiver — must have delay correction, which, together with the receiver precorrection in the transmitter, ensures the prescribed frequency-response flatness of the group delay.



Frequency MHz	Stand. curve ns	Tolerances ns
0	0	0
0.25	5	± 5
1	53	± 5
2	90	± 5
3	75	± 5
3.75	0	± 5
4.43	-170	± 10
4.8	-400	± 10



Frequency MHz	Stand. curve ns	Tolerances ns
With sound trap		
0	0	±12
0.25	-5	±12
1	-53	±12
2	-90	±12
3	-75	±12
3.75	0	±12
4.43	170	±20
4.8	400	±90
W/o sound trap		
0 to 5	0	±12

Response of group delay for half correction according to standard specifications of Federal-German DBP/ARD, standards B and G;
top: precorrection in transmitter (curve of test modulator)
bottom: sound trap in TV demodulator

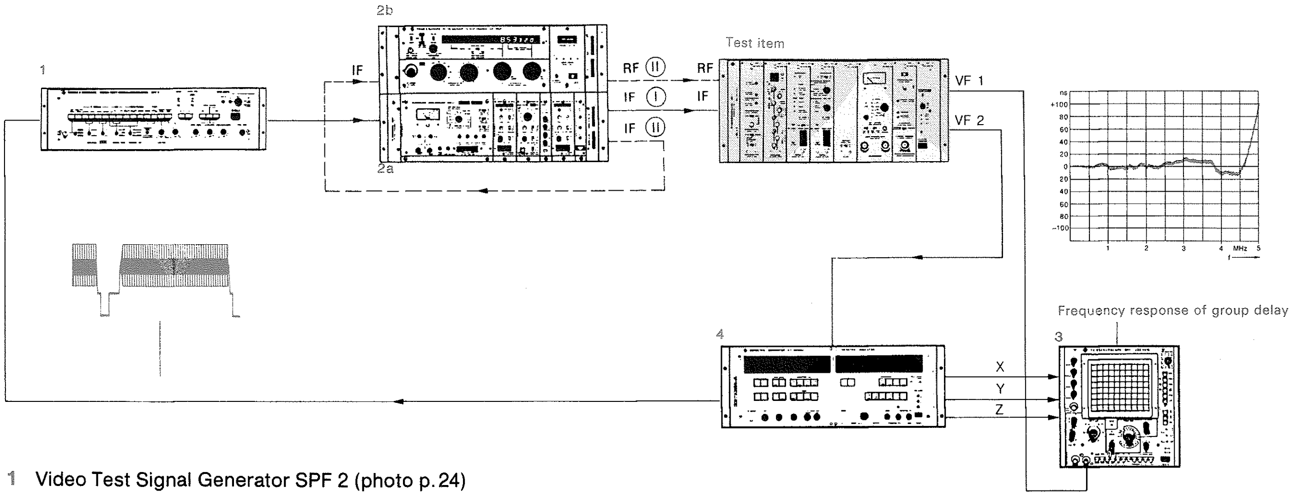
The group-delay frequency response flatness can be examined using the TV Test Transmitter SBUF, either via the IF input with the modulator unit on its own or also via the RF unit with the modulator and converter units. With the vestigial sideband filter cut out, the modulator unit delivers an IF double sideband signal which enables the shape of the passband characteristic (especially the Nyquist slope) of the demodulator to be tested. Errors in the shape, just like errors in the correction circuit, appear in the frequency response of the group delay.

When a **TV demodulator is examined via its RF input** — which is normally the case — the TV Test Transmitter SBUF is used including the transposer unit. The Group-delay Measuring Set LFM 2 shows the group delay digitally to within ±1000 ns and the absolute delay down to 12 µs with a resolution of ±1 ns. The Video Test Signal Generator SPF 2 supplies the necessary pulses. The very slight group-delay error that this produces can be determined by a shorted measurement.

Measurement Procedure

A.I. Basic settings (IF measurement)

1. Connect Video Test Signal Generator SPF 2 to VIDEO INPUT of modulator unit of SBUF, IF OUTPUT to IF OUTPUT of AMF 2 (①). Connect 1st VIDEO OUTPUT of AMF 2 to input of OPF and 2nd VIDEO OUTPUT to INPUT 0.1 to 60 MHz of Group-delay Measuring Set LFM 2. Connect RF OUTPUT of LFM 2 to input EXTernal SIGNal of SPF 2.
   On oscilloscope connect TIME/DIV to XYZ, rear connectors X15.2, .3 and .4 to rear connectors X4.2, X5.3 and X5.1 of LFM 2. Press REAR CONNectors on LFM 2.
2. Set Video Test Signal Generator SPF 2 to 15-kHz squarewave and RISE TIME 2T.
3. Adjust modulator unit of SBUF according to manual, then switch on 75 Ω, DC RESTORATION CLAMPED, VSB FILTER OFF, PRECORRection ON. Press DYNamic PROGRam on Program Selector SBUF-E4.
4. On TV Test Demodulator AMF 2: INPUT on IF, GAIN CONTROL on AUTOmatic, SOUND TRAP ON.
5. On modulator unit set signal to 10% residual carrier using LEVEL. Check on OPF, set TIME/DIV to 10 µs/DIV with ZERO REFERENCE on AMF 2 ON. Then switch ZERO REFERENCE to OFF.
6. Switch Video Test Signal Generator SPF 2 to EXTernal SIGNal, APL clamping with blanking, SETUP and mode H. Set % VIDeo to 50% (grey level).



1 Video Test Signal Generator SPF 2 (photo p.24)

2a For IF measurement: TV Test Transmitter SBUF (photo p.92), modulator unit only

2b For RF measurement: transposer unit of SBUF in addition

3 TV Oscilloscope OPF (photo p.49) with CCVSO mask

4 Group-delay Measuring Set LFM 2 (photo p.61)

Measurement Procedure (continued)

A.II. Basic settings (RF measurement)

1. Same connections as for A.I.1., but connect IF OUTPUT of modulator unit to IF INPUT of SBUF transposer unit. Connect RF OUTPUT of transposer unit to RF INPUT of TV demodulator ((II)).
2. Set Video Test Signal Generator SPF 2 to 15-kHz squarewave and RISE TIME 2T.
3. Tune TV test transmitter to vision-carrier frequency, see p.89, A.2.
4. Set up SBUF modulator unit as described in manual, then set 75 Ω ON, DC RESTAURATION CLAMPED, VSB FILTER OFF, PRECORRection ON. Press DYNamic PROGRam on Program Selector SBUF-E4.
5. On TV Demodulator AMF 2 (test item): INPUT on RF, INPUT LEVEL −12 dB, GAIN CONTROL on AUTOmatic, SOUND TRAP ON.
6. Set signal to 10% residual carrier on modulator unit using LEVEL. Check on OPF, set TIME/DIV to 10 µs/DIV with ZERO REFERENCE on AMF 2 ON. Then switch ZERO REFERENCE to OFF.
7. As for A.I.6.

B. Calibration of setup (for basic settings according to A.I. or A.II.)

1. Remove mask from oscilloscope and use internal graticule. Enter the following frequencies on the generator of the LFM 2:
   a) Reference frequency
      Press key F_{REF} (indication on right F_{REF}), set using F_{REF} (e.g. 2 MHz). The reference frequency should not be too low because of the strong line pulses close to the carrier.
   b) Start frequency
      Press key F_{START} (display on right $F_{START/CENTRE}$), set using F (e.g. −2 MHz).
   c) Marker frequency (must be in band to be investigated)
      Press key MODE AUTomatic (display on left $F_{MAN/MARK}$) set using F_{MARK}.
   d) Sweep width
      Set required sweep width (e.g. 10 MHz) using the two keys ΔF(DEV)+/−. Indication in bottom line of display.
2. Connect RF OUTPUT and INPUT 0.1 to 60 MHz on LFM 2 using cable, set SWEEP TIME to 80 ms/DIV, display V_{OUT} to 0 dB (keys V_{OUT}), press GENerator TRIGger. Extinguish the LED V_{DEM} > MAX using the keys V_{DEM}. Press OUTPut SELECTion until the LEDs AMPLITUDE and DELAY light up.
3. The indication should be 0 ns, correct if necessary using OFFSET.
4. Press CALIBration, indication should be 200 ns; correct if necessary using control 200 ns. If 0 ns is indicated, slightly adjust F_{MARK}.
5. On OPF set TIME/DIV to XYZ. Exactly set X deflection of oscilloscope to 10 DIV using ⟋, ⊏ and ↔ on LFM 2 (frequency can be checked using marker frequency).
6. Adjust squarewave signal to amplitude of 10 DIV (1 DIV = 20 ns) on OPF using Y_{XYZ}, ⊏ and ↕ (right).
   Subsequently establish connections again as in A.1.
7. Set output voltage of LFM 2 to −4 dB using keys V_{OUT}+/− (corresponds to 0.63 V_{pp} and produces a modulation of the SBUF of 13/70% with a % VIDeo setting of 50% [on SPF 2]).
   Check on OPF: set TIME/DIV to 10 µs/DIV, VOLT/DIV to 0.1 V/DIV, trigger H.
8. Press key TV on LFM 2.
9. Set input attenuation on indicator with keys V_{DEM} +/− so that indication V_{DEM} > MAX is extinguished.

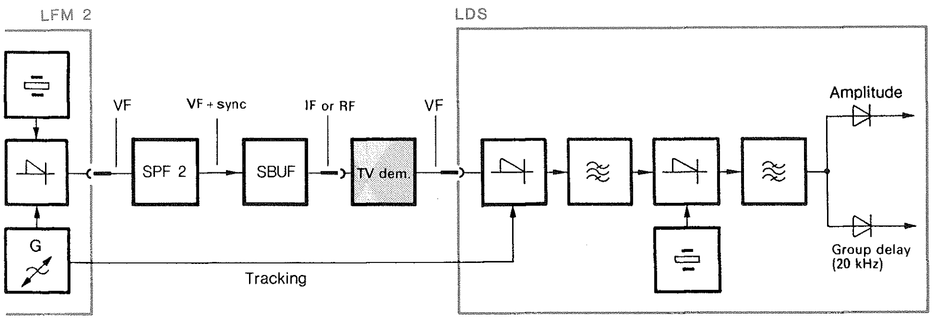
C. Measurement of group delay

1. Press key OUTPut SELECTion (several times if necessary) until LED DELAY illuminates. With key ns/DIV set required measurement range.
2. Display of indicator then shows group delay at marker frequency, referred to reference frequency.
   (Possibility for checking: set marker frequency to same frequency as reference frequency. Indication must be 0 ns.)
3. By shifting marker frequency, group delay can then be accurately measured at any frequency within sweep width. TV oscilloscope shows response of group delay over entire frequency band. Scale can be altered with key ns/DIV on indicator, and position of curve with knob POSITION.

Note The same measurements, but using the TV Digital Oscilloscope ODF instead of the TV Oscilloscope OPF, are described on pages 94 and 95.

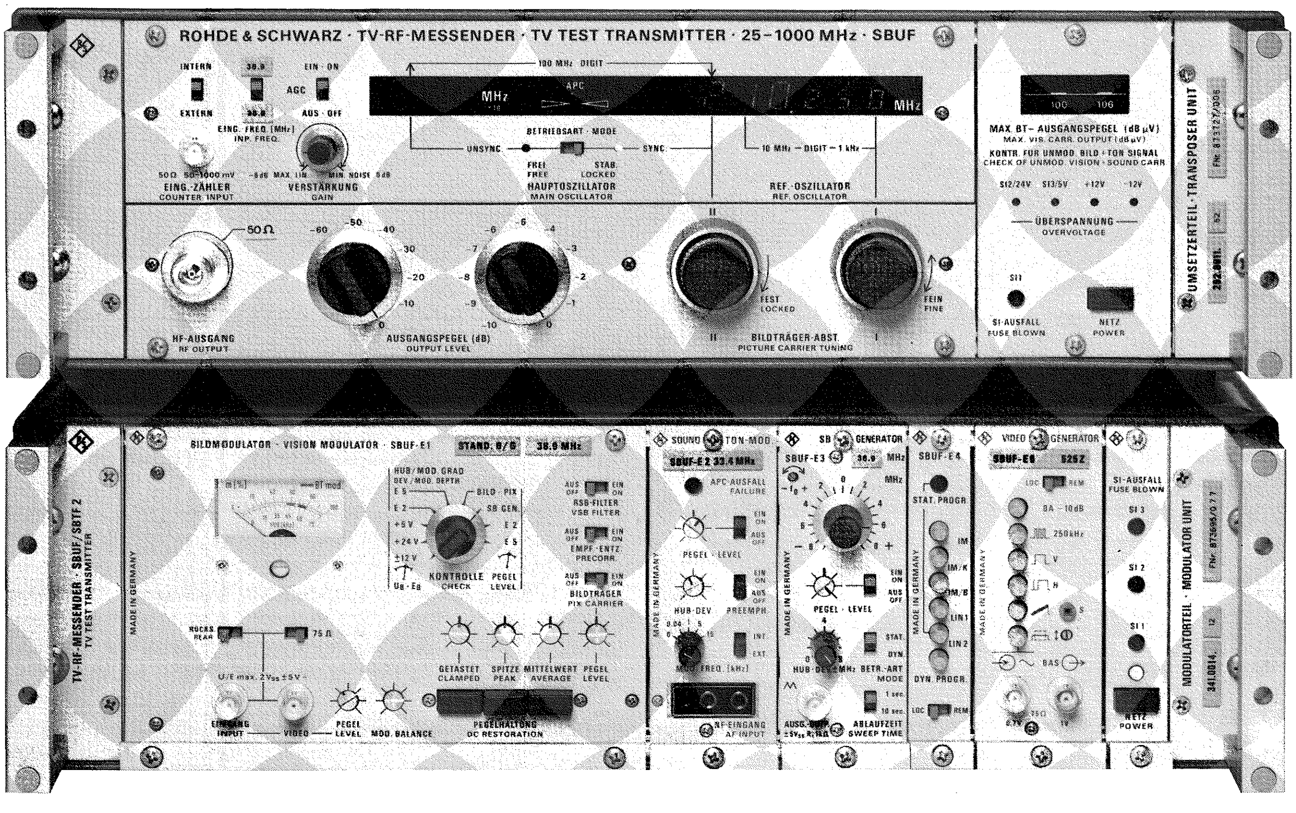
As already mentioned on p. 74, measurements with a selective input unit are far less sensitive to interference (e.g. fixed frequencies, harmonics, noise) than broadband measurements. Because of the associated increased accuracy, it is advantageous to use this method for group-delay measurements on TV demodulators where accuracy is particularly important. Measurement of the video amplitude characteristic can be carried out selectively using the Videoskop SWOF 3 (see pages 88 and 89), but the combination of instruments LFM 2/LDS enables both measurements with the same setup. The amplitude frequency response can also be displayed better because of the greater sensitivity of the LDS (max. 0.5 dB/DIV).
The nonlinearity is measured using the Signal Generator SMS 2 in the same manner as described on p. 89.

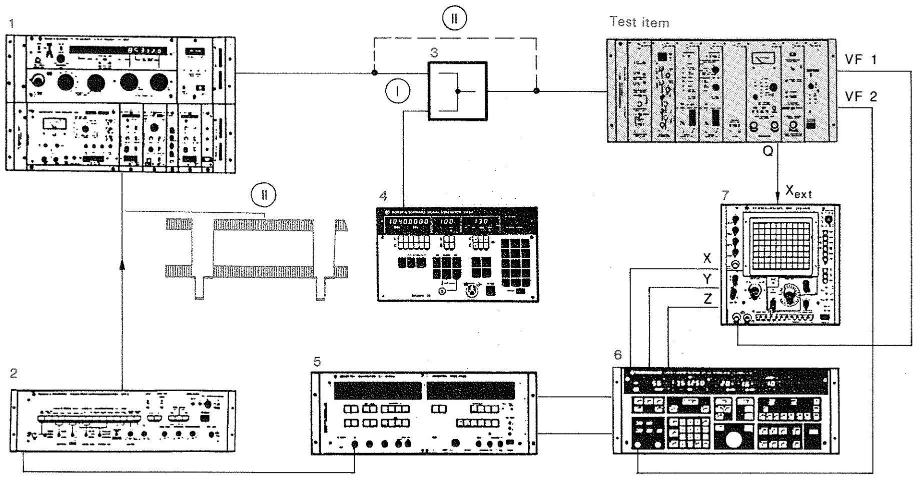
Since the test modulator to be examined has an RF or IF input and a video output, the setup is somewhat different from that on p. 75. The measurement is made with the LFM 2 and LDS in the video setting. The video signal is applied to the TV Test Transmitter SBUF (via the Video Test Signal Generator SPF 2 for generation of the pulse frame), modulated on the RF or IF and then demodulated again to the video frequency in the TV demodulator.



Principle of selective measurement of TV demodulators with LFM 2 and LDS
(video amplitude characteristic and group-delay frequency response)

TV Test Transmitter SBUF





1 TV Test Transmitter SBUF (photo p. 92)
2 Video Test Signal Generator SPF 2 (photo p. 24)
3 Power Splitter/Combiner (only for measuring nonlinearity) 0.1 to 400 MHz: DVS (photo p. 88) 10 to 1000 MHz: model H-8-4 from Anzac[1])
4 Signal Generator SMS 2 (photo p. 14), 0.1 to 1040 MHz (only for measuring nonlinearity)
5 Group-delay Measuring Set LFM 2 (photo p. 61)
6 Selective Demodulator LDS (photo p. 62)
7 TV Oscilloscope OPF (photo p. 49)

[1]) German agent:
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Jaegerweg 8
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Telephone: 089/6094084

Measurement Procedure

I. Measurement of nonlinearity
Same procedure as on p. 89.

II. Measurement of video amplitude characteristic and group delay (connections (II))

A. Basic settings

1. As on p. 41.
2. Connect RF OUTPUT of LFM 2 to input EXTernal SIGNal of Video Test Signal Generator SPF 2. Set latter to EXTernal SIGNal, APL clamping with blanking, SETUP and H. Set % VIDeo 50% (grey level).
3. Connect LDS to LFM 2 using system cable LDS-Z1 (accessory provided with LDS); connect X2.2 on LDS to X5.4 on LFM 2.
4. Set TIME/DIV on oscilloscope to XYZ, connect X15.2, .3 and .4 at rear to X3.3, .2 and .1 on rear of LDS and front Y input to VIDEO OUTPUT of AMF 2. Press 75 Ω.
5. The SBUF and modulator settings have already been carried out in I.
6. Connect VIDEO OUTPUT of AMF 2 to front left-hand input of LDS, press VIDEO, 75 Ω and FRONT.
7. Swith TV Demodulator AMF 2 (test item) to INPUT RF, INPUT LEVEL −12 dB, GAIN CONTROL AUTO, SYNCHRONous and SOUND TRAP OFF.

B. Calibration of setup

1. Calibration LFM 2 as on p. 91, B.1. to B.5. (only adjustment of X deflection of oscilloscope).
   Note When using the instrument combination LFM 2 and LDS, the setting must be carried out again according to B.5.
2. Press CALIBRATION on LDS; adjust the two calibration lines on the oscilloscope (50% and 100% reference levels) using the controls Y_{XYZ} and ↕ (right) on OPF until they coincide with the graticule (centre line and second line from top are suitable).
3. Press one of the keys dB/DIV (e.g. 1 dB/DIV) on the LDS. Set sweep on LFM 2 to 10 MHz/DIV. Adjust the peak of the curve on the oscilloscope to the reference line 100% using the spinwheel VARY on the LDS.
   Note In the case of measurements in the video range using the LDS (only for above settings), the frequency 38.9 MHz of the calibration oscillator must be covered (setting F_{START} on LFM 2).
4. Set LFM 2 to position CALIBration, press DELAY EXTernal on LDS. Adjust height of squarewave signal on oscilloscope to 10 DIV using VARY.
5. Adjust output voltage of LFM 2 to −4 dB using V_{out}+/− (corresponds to 0.63 V_{pp} and results in a modulation of 13/70% with a VIDeo of 50% [on SPF 2]). Check using OPF (0.1 V/DIV, 10 μs/DIV, TRIGGER H).
6. For simultaneous display of the amplitude curves with black and white, adjust output voltage on LFM 2 to −20 dB (corresponds to 10% superimposed amplitude), switch to 50 Hz and 10/90% on SPF 2. Check if black and white can be distinguished using the OPF as in 5. and with the setting 0.1/1 Hz on the SPF 2.
7. Press TV on LDS.

C. Measurement of frequency response of amplitude and of group delay

1. Settings for amplitude measurements as on p. 75, C.2. to C.5.
2. Settings for group-delay measurements as on p. 75, C.2., D.2. and D.3.

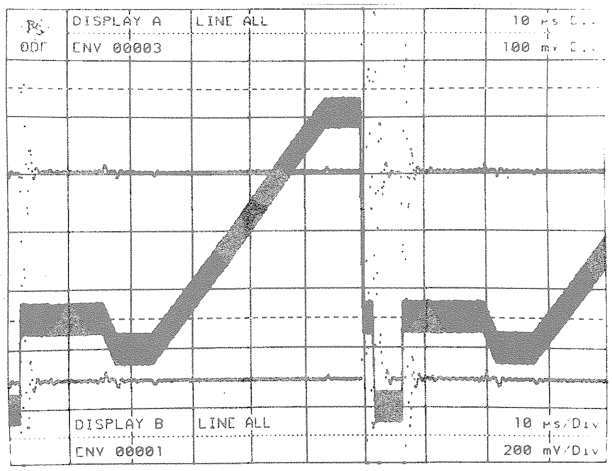
TV

CHROMINANCE NONLINEARITY, VIDEO AMPLITUDE CHAR., GROUP DELAY

selective with LFM 2/LDS/ODF **measurements outside**

Note The same measurements, but using the TV Oscilloscope OPF instead of the TV Digital Oscilloscope ODF, are described on pages 92 and 93.

TV Digital Oscilloscope ODF Because of the high accuracy required when testing TV demodulators, a precision oscillator should be used for the evaluation. The TV Digital Oscilloscope ODF (detailed description in appendix on p. 214) is highly suitable as a result of the flickerfree and non-parallax display even with low sweep speeds and as a result of the ability to display differences in amplitude at great accuracy as numbers on the display (10 bit = 1024 amplitude steps). Use together with the LFM 2/LDS enables highly accurate measurement of TV demodulators. The TV Digital Oscilloscope ODF is fitted with suitable facility to enable operation together with these two instruments. A special multiple cable is used for connecting the units.



Measurement of nonlinearity of TV Demodulator AMF with superimposed video signal. The sync range, which must not be used for the evaluation, can be clearly recognized in the display of the filtered video signal (between the two horizontal lines)

Measurement Procedure

I. Measurement of chrominance nonlinearity (connection 1)

A. Basic settings

1. As on p. 89, I.A.1. to I.A.5.
2. Connect front input of ODF to 1st VIDEO OUTPUT of AMF 2.
3. On Signal Generator SMS 2, set video-carrier frequency to +4.43 MHz and output level to approx. 10 mV_{rms}.
4. Oscilloscope settings as on p. 46, A.2., if necessary recall the stored setting using RCL, STAT, 1 (red) and ENTER.

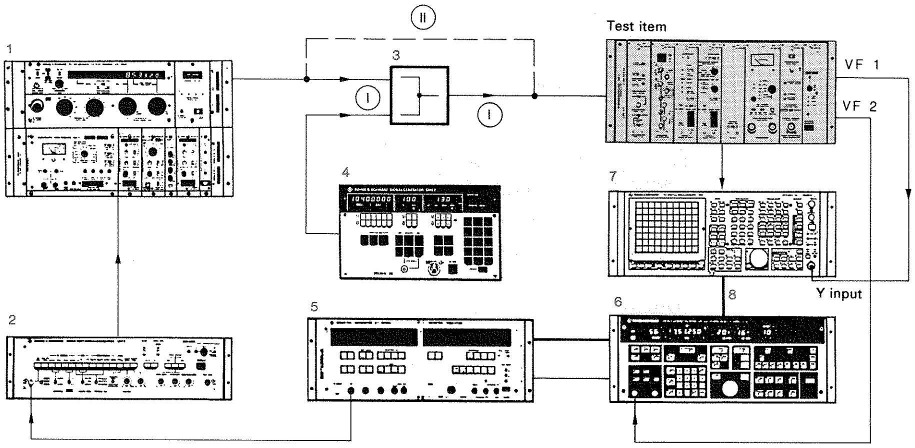
B. Calibration of setup

1. Switch SMS 2 to RF OFF.
2. Adjust oscillogram to correct height on ODF using ↕Y and the spinwheel VARY (black value on dashed line, 2.5 units from bottom line (see Fig. on left).
3. Adjust manual control on AMF 2 such that the zero reference is on the top dashed line (corresponding to 1.1 V_{pp} for CCVSO).
4. To smoothen the curves on the ODF, press AVG, 3 (red) and ENTER.
5. Press CURSOR 1 on ODF. Adjust triangle to peak of the zero reference using VARY. Then press CURSOR 2 and ΔY and adjust bottom triangle to black value using VARY.
6. The difference ΔV indicated on the display should be 800 mV, correct on AMF 2 if necessary. Then switch off zero reference.

C. Measurement of chrominance nonlinearity

1. Switch on RF voltage of SMS 2 again. Check magnitude of superimposed signal (nominal value 10% CVS [V_{pp}]). Correct on SMS 2 if necessary. Note time range of video signal (10 to 86.5%).
2. Press RESPONSE COLOR, 100 (green), mV, ENVelope and ENTER on the ODF. A bright area appears on the screen: the filtered video signal. After pressing SWITCH OFF and DOT JOIN, only the border remains as in the Fig. opposite.
3. Press CURSOR 1. Adjust the triangle to the highest point of the area using VARY. Do not take into account the sync range, see note opposite. Then press CURSOR 2 and adjust bottom triangle to lowest value of area. The X value must be the same as with CURSOR 1 ($\Delta t = 0$ on display).
4. Press % and ENTER. Output on display: 100%.
5. Adjust triangles to smallest height of area using VARY (same X value, $\Delta t = 0$). The display provides direct indication of the nonlinearity:

$$S = \frac{A_{min}}{A_{max}} \cdot 100\% \quad \text{(A is height of area).}$$



1 TV Test Transmitter SBUF (photo p. 92)
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4 Signal Generator SMS 2 (photo p. 14), 0.1 to 1040 MHz (only for measuring nonlinearity)
5 Group-delay Measuring Set LFM 2 (photo p. 61)
6 Selective Demodulator LDS (photo p. 62)
7 TV Digital Oscilloscope ODF (photo p. 56)
8 System cable ODF — LDS — LFM 2 (Order No. 373.8956.00)

[1]) German agent:
Omecon Electronic GmbH
Jaegerweg 8
D-8012 Ottobrunn
Telephone: 089/6094084

Measurement Procedure (continued)

6. Carry out same measurement with sideband frequency 1 MHz. Adjust signal generator to vision-carrier frequency of +1 MHz. Press key TV RESPONSE 1 MHz on ODF. **Note** In these measurements, the sync pulse also has a signal superimposed on it. Only the amplitude range from white (10%) to blacker-than-black (86.5%) must be evaluated (has already been determined in 1.). The permissible values are listed in the corresponding standard specifications.

II. Measurement of video amplitude characteristic and group delay (connection II)

A. Basic settings
1. As on p. 74, A.2. and A.3.
2. Connect 2nd VIDEO OUTPUT of AMF 2 to front lefthand input of LDS and press VF 75 Ω FRONT on LDS.
3. Connect ODF and LDS using system cable (Order No. 373.8956.00).
4. Press key MODE LFM 2 on ODF. A graticule appears with 12 lines along Y axis (8 lines in position SCOPE).

B. Calibration of setup
1. Calibration LFM 2 as on p. 73, B.1. to B.5. (only setting of X axis of oscilloscope).
2. Press CALIBRATION on LDS, two calibration lines appear on the screen (50% and 100% reference levels). On ODF set 50% line to centre using control LFM 2 ↕, and 100% line to 2nd graticule line from the top (10 DIV amplitude = 100%) using control LFM 2 ⇃.
3. Set the start frequency to 34 MHz on the LFM 2 (only for the calibration) and the sweep width to 10 MHz. Press one of the keys dB/DIV (e.g. 1 dB/DIV) on the LDS. Adjust the peak of the curve on the screen to the 100% reference line using the spinwheel VARY.
4. Set LFM 2 to CALIBration, press DELAY EXTernal on LDS. Adjust squarewave signal on screen to 10 height units (= 200 ns) using VARY on the LDS.
5. Adjust output voltage on LFM 2 to −4 dB (keys V_{out}+/−, corresponds to 0.6 V_{pp}), results with a VIDeo value of 50% on the SPF 2 in a modulation of 13/70%. Check on the ODF by pressing SCOPE, ENVelope and ENTER.
6. Press TV on LDS.

C. Measurement of amplitude frequency response
1. As on p. 75, C.2. and C.3.
2. Measure the difference in attenuation using the Δ function of the LDS as in C.4. and C.5.

D. Measurement of group-delay frequency response
1. Settings as on p. 75, C.2. and D.2.
2. Measure with the Δ function of the LDS as in D.3.

E. Measurement of curves with the cursor function
In the LFM 2 mode of the ODF, the cursor triangles can no longer be adjusted using VARY, they are located at the LFM 2 marker frequency. The scale (dB or ns) is transferred from the LFM 2 or LDS, as is the display switchover.
1. Adjust desired reference frequency on LFM 2 (F_{MARK}).
2. Press CURSOR 1, CURSOR 2 and ΔY on the ODF. The two triangles appear at the same point on the curve, cursor 1 above, cursor 2 below. Display 0 dB (with amplitude measurement), 0 ns (with delay measurement). This setting is possible with every display (four cursor triangles are available).
3. Offset marker frequency on LFM 2. Cursor 2 moves along the bottom of the curve accordingly. The deviation from the reference value (cursor 1) is displayed on the screen.

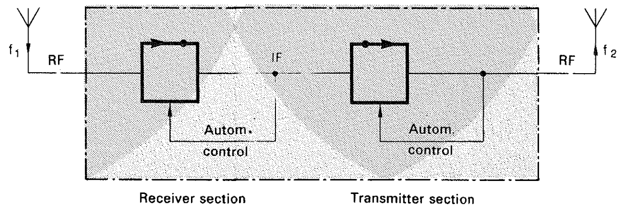
INTRODUCTION TO MEASUREMENTS ON TRANSPOSERS

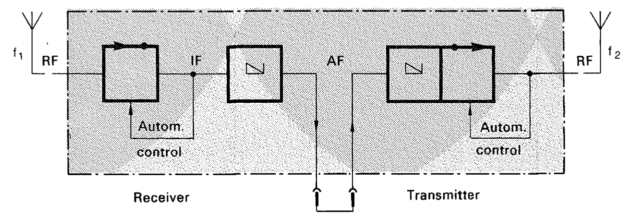
Characteristics Transposers for sound broadcasting and TV are used for areas where the basic network transmitters cannot be received, or to an unsatisfactory extent. Low powers of approx. 1 to 10 W are usually sufficient, TV transposers can however be rated with several kW of power. Transposers do not have a modulation line like a transmitter, but receive the signal from a master transmitter, convert it to another frequency and then emit at this frequency. The conversion can be to almost any other channel of the band (sound broadcasting) or also into other bands (TV).

Repair and maintenance philosophy Because of the large number of different transposers, the units should be of simple design to enable efficient servicing. They must also be of high quality since in areas with unfavourable topology it is necessary to connect several transposers in series (transposer sets). They are located for favourable reception of the master transmitter, i.e. often at the top of mountains with difficult access. They are accommodated in simple buildings, sometimes even in weather-proof housings directly on the antenna mast. This explains why the repair and maintenance philosophy is different compared to transmitters which are normally accommodated in stable buildings with good access. Whereas on-site measurements and repairs can be carried out, the work is limited to replacing modules in the case of transposers (the modular design facilitates this). The faulty modules are then repaired later in a service centre.

Measuring instruments To determine the fault on site, measuring instruments are necessary which must provide detailed information on the transposer condition but must also be as compact as possible because of the poor access. These limitations do not apply to the service centre and larger transposer stations. In this case, measurements at the transposer output are made using the same instruments as for the measurements on transmitters, only the input signals are generated differently.

Design Transposers basically comprise a receiver section and a transmitter section. These are not always fully equipped. In the case of the TV transposers and direct transposers for FM sound, signal is transferred at the IF. In FM sound transposers with conversion via the AF, signal transfer is at the AF. This corresponds to reception via a demodulator repeater, where a transmitter is modulated with the signal provided by a relay receiver. The standard specifications for relay receivers are applicable in an analogous manner for the receiver unit in this case.





Transposer designs:
top: TV and sound broadcasting direct transposers
bottom: Conversion via AF (sound broadcasting)

A complete transposer measurement requires the high-quality simulation of the high-frequency input signal which may be subject to strong fluctuations during operation because of the changing propagation conditions. To compensate these variations, transposers are equipped with automatic control equipment which ensures a constant IF amplitude. Frequency-modulated sound broadcasting signals are controlled to a constant amplitude of the IF carrier, the amplitude-modulated TV signals to a constant amplitude of the sync pulse. The constant IF is used either directly or following demodulation to modulate the RF output signal. It is also possible to have a further control circuit for a constant RF output power.

CLASSIFICATION OF MEASUREMENTS

General comments on measurements In the following recommended measurements, the sound or TV transposer as the test item is always considered as a device with an RF input and an RF output. Measurements which require modifications in the equipment itself have been included — because of the different characteristics of the various products — only if specifically defined in the standard specifications of the German DBP/ARD.

For measurement of the transmission characteristics, a precision RF test generator with AF or video signal is required at the input and a precision test demodulator with evaluation facilities at the output. The Rohde & Schwarz range includes the **Signal Generator SMK** and the **FM/AM Demodulator FAB** for FM sound broadcasting and the **TV Test Transmitter SBUF** and the **TV Demodulator AMF 2** for TV broadcasting.

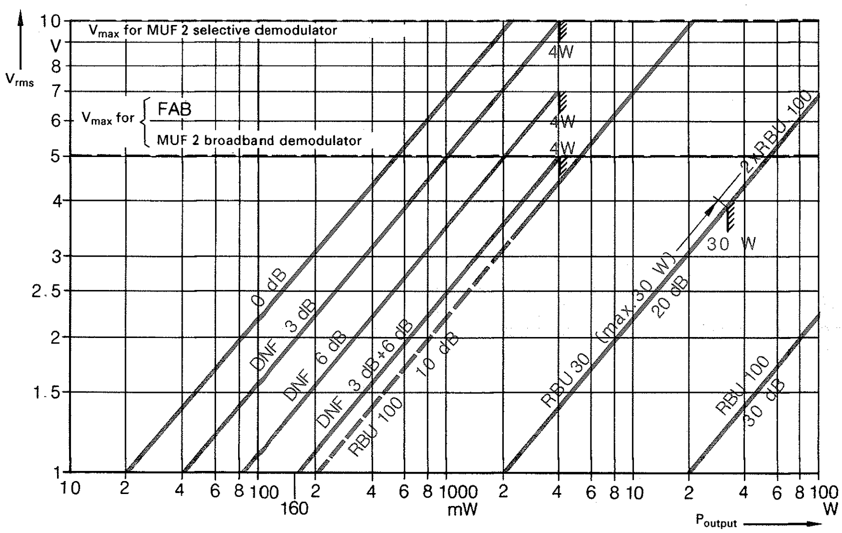
High-power attenuators can be used to advantage for connection of the measuring instruments in the case of the usually low output powers of the transposers. The diagram below shows the Rohde & Schwarz attenuators required depending on the output power and the measuring instruments used. With the TV transposers, a 1-V test point is usually provided for the TV Demodulators AMF/AMF 2.

The measurements are arranged according to increasing instrument requirements. On-site control measurements are therefore listed first, for which the universal **TV Transcope MUF 2** is highly suitable. The other measurements require more instruments which are usually only available in the service centre. The transmission characteristics are largely determined using methods common to transmitter measurements.

In addition to the actual transposer measurements, measurements are also listed which cover the complete system, i.e. also the antennas with associated cables.

		Sound broadcasting transposers (FM)	TV transposers (AM)
General measurements			
Frequency stability		A	A
Spurious emissions (without mod.)		(S) A	S
Enclosure leakage (RF tightness)		(A)	(A)
Measurements on receiver section			
Input matching		C	C
Antenna matching		C	C
Antenna voltage		C	C
Reradiation at antenna input		(C) A	(C) A
Input filter		--	S X
Dynamic selection		A	--
Noise		(A) XX	S
Input voltage/AGC		S	S
Measurements on complete transposer			
RF frequency response		(A) XX	C
Frequency response per stage		--	S X
RF power		C	C
RF power (black/white dependence)		--	S
Frequency response AF/video		S	S
Harmonic distortion	TV sound section	S	(S)
Spurious modulation	TV sound section	S	(S)
Stereo crosstalk	TV sound section	S	(S)
Intermodulation distortion	TV sound section	S	(S)
Nonlinearity	TV vision section	--	S
Group delay	TV vision section	--	S
Crossmodulation	TV vision section	--	S
Spurious modulation	TV vision section	--	S

C Control measurement on site
S Measurement in service centre for exact testing and following repairs
A Acceptance measurements
X Modifications required in equipment
XX Measurements only possible in laboratory because of system used (FM); extensive modifications required in equipment



Selection diagram for high-power attenuators from Rohde & Schwarz

MEASUREMENTS ON FM SOUND TRANSPOSERS

The two types of FM sound transposers — conversion via IF (direct transposers) or conversion via AF (see p. 96) — have greatly different functions and are therefore also measured differently. Direct transposers are no longer as significant as in the past because conversion via AF provides a better quality in stereo mode (corrections possible at the AF) and a far better spurious suppression. Furthermore, units with conversion via AF can also be used as autonomous transmitters for special purposes (e.g. outside broadcasting).

In both designs, the IF amplitude is controlled and limited at a constant value. The amplitude limitation required in FM systems means that measurement of the RF passband characteristic (statistic selectivity) and measurement of noise figure are not possible without extensive modifications in the device.

With the direct transposers, the RF output amplitude is proportional to the IF amplitude (without output control). It only reaches its nominal value if the RF input voltage is sufficient. In the conversion via NF, on the other hand, the RF output amplitude is independent of the IF amplitude (apart from the automatic pause facility which switches off the transmitter unit if the input signal is missing). In this case the frequency deviation of the output signal only reaches its nominal value when the RF input voltage is sufficient (onset of limitation). With both types of transposers, the S/N ratio of the output signal rises with an increasing (frequency-modulated) input voltage, however, so that the required input voltage and control response can be determined in this manner.

ANTENNA VOLTAGE — RFI VOLTAGE AT INPUT

The magnitude of the voltage fed by the antenna is of great importance for correct functioning of the transposer system (see also p. 106). This measurement can be carried out easily using the TV Transcope MUF 2.

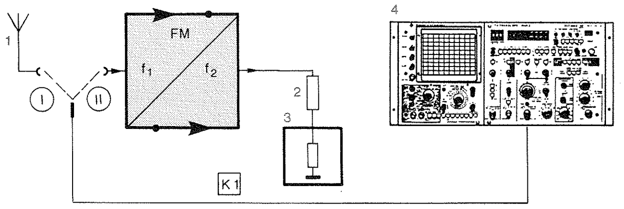
The RFI voltage at the input (oscillator reradiation), which the transposer outputs to the antenna, can be measured in a similar manner. This is an acceptance (possible service) measurement and not a control measurement, but can still be carried out simply using the setup shown.

Note The TV Transcope MUF 2 must be calibrated as described in the adjacent column prior to the measurement. This always applies to absolute measurements of voltage, level and power.

Calibration of the TV Transcope MUF 2 for absolute level measurements

1. Connect output of generator unit to input of selective demodulator via a precision cable (K1). This cable must also be used again for the measurements.
2. Press MHz and select → and sweep 0.1 MHz/DIV on the generator unit. Adjust the respective test frequency on the display using TUNING COARSE and FINE.
3. On the selective demodulator, press LIN (for measurements in V, mV, µV or W) or LOG (for measurement in dBµV, dBm or ΔdB) and also LEVEL. Set ATTENuator RF to CALibrate (release lock) and use the controls CALibrate until the two lines coincide in settings LIN and LOG.

ANTENNA VOLTAGE
RFI VOLTAGE AT INPUT



1 Receiver antenna including cable
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
3 Termination RNB (photo p. 110), 1 W
4 TV Transcope MUF 2 (photo p. 104)

Measurement Procedure

A. Basic settings

Calibrate the MUF 2 at the transposer receive frequency in setting LIN of the selective demodulator (see opposite page).

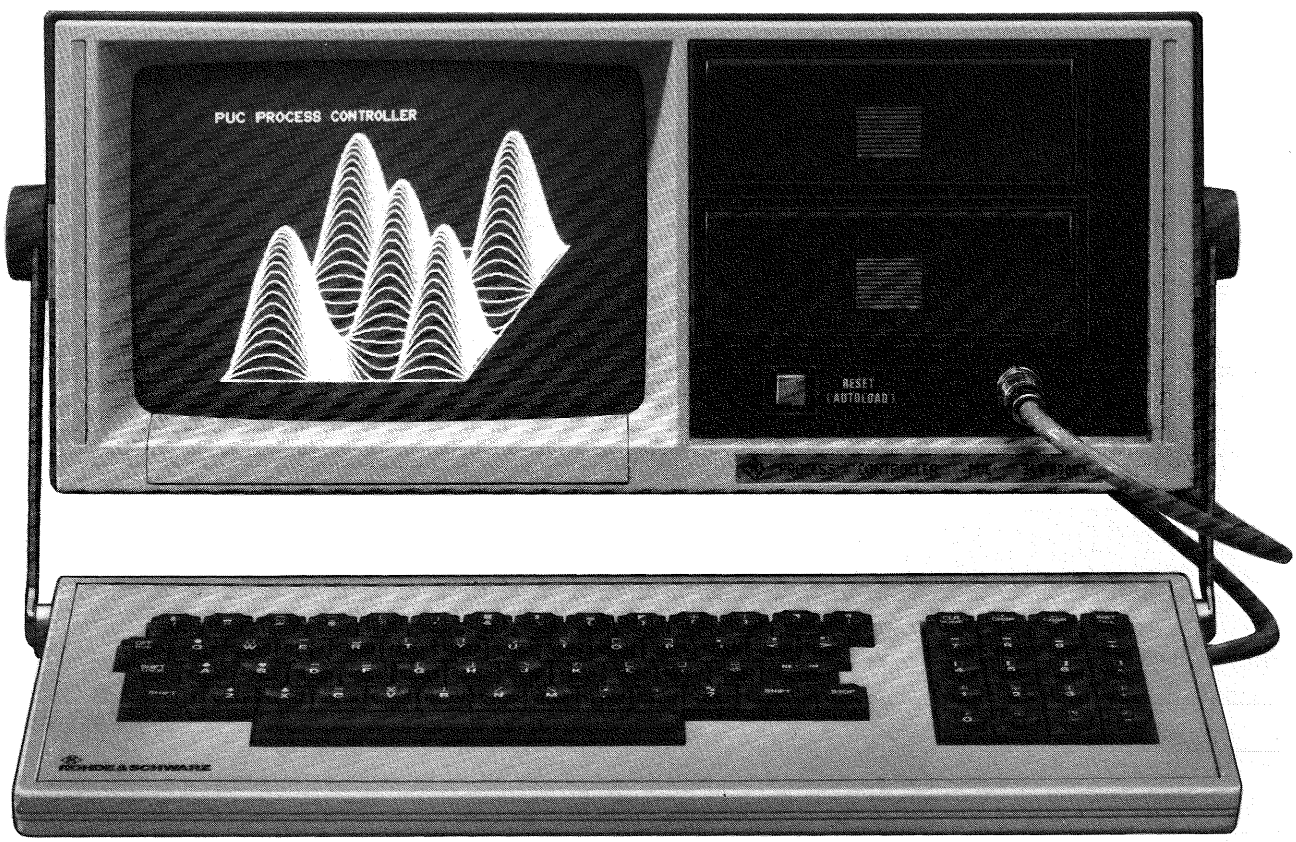
B. Measurement of antenna voltage at receive frequency

1. Connect input of MUF 2 selective demodulator to antenna cable using precision cable K1 (connection Ⓘ).
2. Switch on FREQuency MARKer 10/1 on the generator unit. Set sweep to 1 MHz/DIV and ATTENuator RF on selective demodulator to 0 dB. Reduce the attenuation using ATTENuator IF COARSE and FINE until the curve on the screen has a magnitude which can be evaluated.
3. Exactly determine the frequency using the frequency markers. Centre the display using TUNING FINE, then reduce sweep to 0.1 MHz/DIV.
4. Press LEVEL and V and set level line to peak of curve. The antenna voltage is displayed directly in mV.

C. Measurement of RFI voltage at transposer input

1. Adjust generator unit of MUF 2 to frequency of receive oscillator (= receiver frequency + or − IF, depending on equipment) and check calibration.
2. Connect precision cable K1 to transposer input (connection Ⓘⓘ).
3. As for B.2.
4. As for B.3.
5. As for B.4. The oscillator voltage is displayed directly in µV.

Process Controller PUC



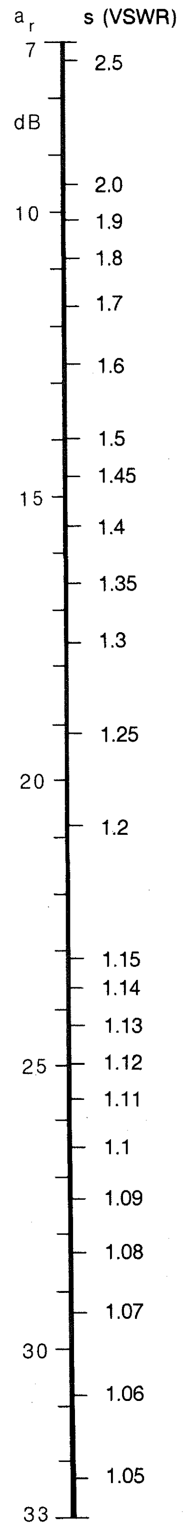
INPUT MATCHING
ANTENNA MATCHING

The **mismatch of the transposer input and the antenna** must not exceed specific values since reflections would occur which — particularly with longer antenna cables — could reduce the transmission quality. These measurements can be carried out simply using the TV Transcope MUF 2 and the VSWR Bridge ZRB 2.

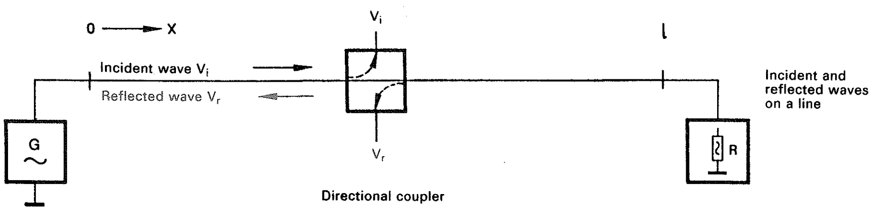
The result is the return loss a_r in dB. The diagram on the right shows the associated voltage standing-wave ratio s (VSWR).

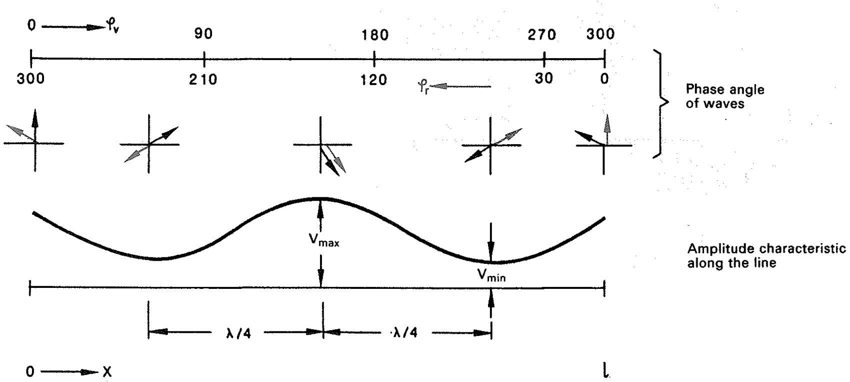
Conditions on a mismatched line A reflected wave always occurs if the terminating resistance R is not equal to the ohmic value of the line impedance. Superposition of the outgoing and reflected waves results in voltage maxima and minima on the line which were previously frequently used to determine the VSWR (test line).

A directional coupler provides an output voltage which — depending on the connection — is proportional to the incident or reflected wave. The voltage corresponding to the reflected wave is coupled out in the VSWR bridge and connected to an RF voltmeter for evaluation. The reference value (0 dB) for the reflection coefficient or the return loss results if the output of the bridge is open-circuited or short-circuited since the incident and reflected waves are then the same. The return loss can be read directly on an instrument calibrated in dB, in this case the MUF 2.



Relationship between return loss a_r and voltage standing-wave ratio s (VSWR)

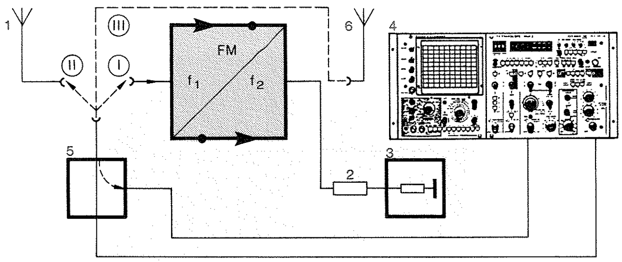




Conditions on a mismatched line

Reflection coefficient $r = \frac{V_r}{V_i}$; Return loss $a_r = 20 \log \frac{1}{r}$

Voltage standing-wave ratio s (VSWR) $= \frac{(1+r)}{(1-r)} = \frac{V_{max}}{V_{min}}$



1 Receiving antenna including cable

2 High-power Attenuator RBU (photo p. 16) or similar (from diagram p. 97)

3 Termination RNB (photo p. 110), 1 W

4 TV Transcope MUF 2 (photo p. 104)

5 VSWR Bridge ZRB 2 (photo p. 86), transmission loss 6 dB

6 Transmitting antenna including cable

Measurement Procedure

I. Measurements on the receiver section

A. Basic settings

1. Connect generator output of MUF 2 to input of VSWR Bridge ZRB 2, and signal output of ZRB 2 to input of MUF 2 selective demodulator. Connect output of ZRB 2 directly to transposer input.
2. Settings on MUF 2
   Selective demodulator: press LOG and Yx2;
   generator unit: select SWEEP, → and FREQuency MARKer 10/1, RF level −26 dB (results in 5 mV at transposer input), sweep 1 MHz/DIV.
3. Press MHz and adjust receiver frequency of transposer on the display using TUNING COARSE and FINE.

B. Calibration of setup

1. Determine frequency accurately using the frequency markers, position the interesting range of the curve to the centre of the screen using TUNING FINE, reduce sweep to 0.1 MHz/DIV.
2. Disconnect bridge from transposer.
3. Adjust ATTENuator RF on selective modulator to −10 dB and adjust to second graticule line from the top using ↕ (zero line for return loss).
4. Press LEVEL and adjust level line to coincide with the line on the screen.
5. Press ΔdB: display 0 dB.

C. Determination of return loss of transposer input

1. Connect bridge to transposer input again (connection (I)).
2. Adjust level line to coincide with curve at receive frequency.
3. The return loss a_r is output directly on the display in dB.
4. The voltage standing-wave ratio s (VSWR) can be determined using the scale on the opposite page.

D. Determination of return loss of receiving antenna

1. Connect bridge to antenna cable (connection (II)). MUF 2 settings as for A.2. Adjust RF LEVEL on MUF 2 generator unit to −10 dB (results in approx. 30 mV on the antenna, see diagram on page 120).
2. Calibrate setup as in B.1. to B.5.
3. As for C.2.
4. As for C.3.
5. As for C.4.

II. Measurements on the transmitter section

A. Basic settings

1. Establish connections as in I.A.1., but connect bridge to antenna cable of transmitting antenna (connection (III)).
2. Settings on MUF 2 as in I.D.1.
3. Press MHz and adjust transmitter frequency of transposer on display using TUNING COARSE and FINE.

B. Calibration of setup

As for I.B.

C. Determination of return loss of transmitting antenna

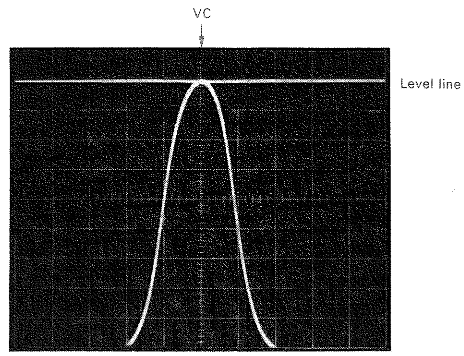
1. Connect bridge to antenna cable again.
2. Adjust level line to coincide with curve at transmitter frequency.
3. The return loss a_r is output directly in dB on the display.
4. As for I.C.4.

RF OUTPUT POWER

The output power could be measured in the same manner as with the sound transmitters. It is simpler and just as accurate, however, to carry out the measurement using the (previously calibrated) TV Transcope MUF 2 (p. 98).

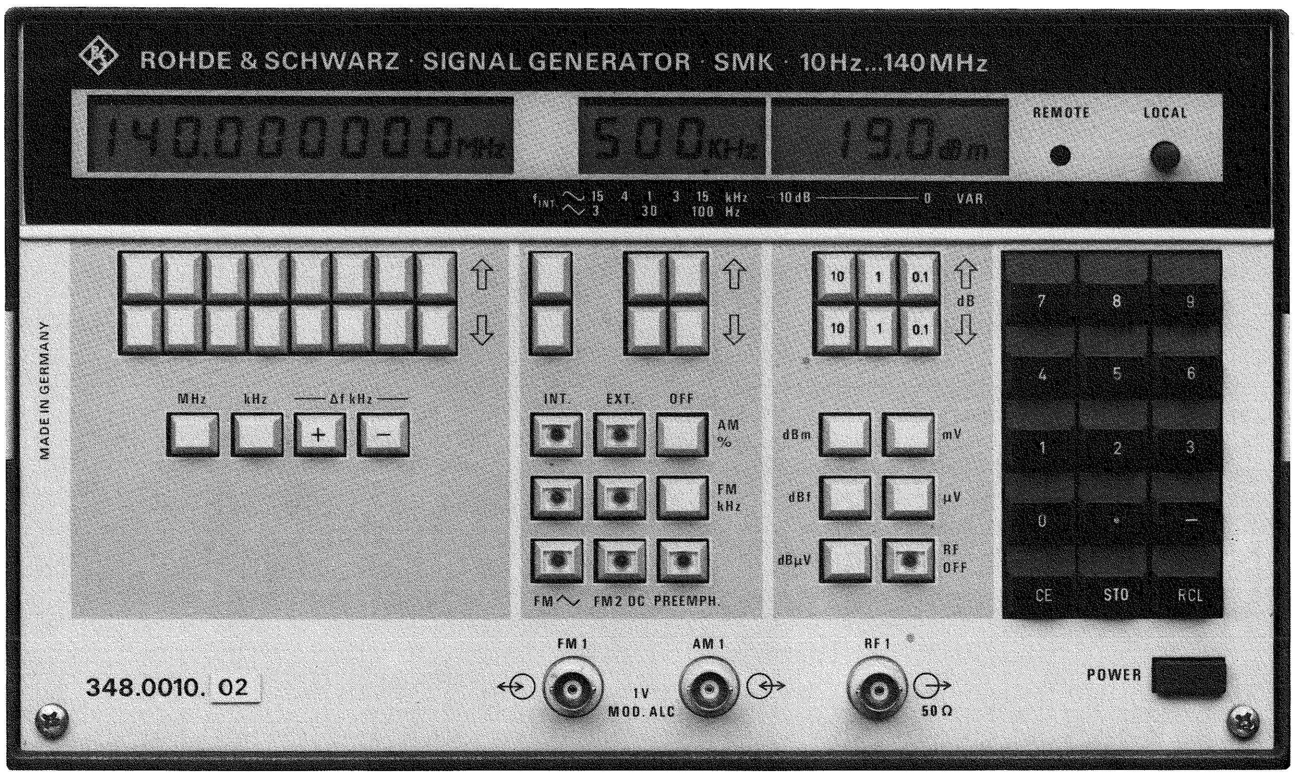
Because the powers are usually smaller, it is possible to measure directly at the transposer output via a high-power attenuator (from diagram on p. 97). The attenuator should be measured prior to exact measurements (p. 14). The attenuation can be entered into the TV Transcope MUF 2. The output power is displayed directly in Watt if the measurement is carried out using the level line.

Either the signal of the master transmitter (with measurement on site) or that of a signal generator can be used at the input side.

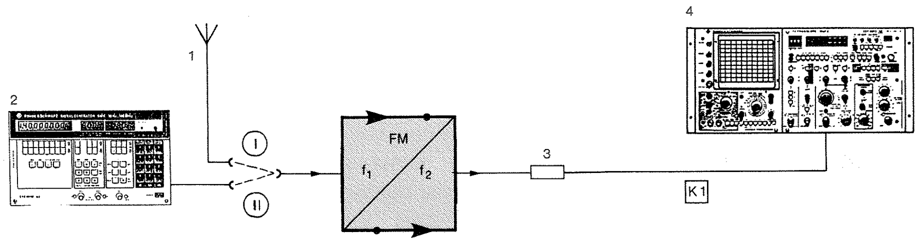


Measurement of output power of a TV transposer: adjust level line to highest point of curve and read power on display;
X: 10 ms/DIV (Δf = 0.1 MHz/DIV)

Signal Generator SMK



RF OUTPUT POWER



1 Receiving antenna including cable
2 Signal Generator SMK (photo p. 102)
3 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
4 TV Transcope MUF 2 (photo p. 104)
For measurement of high-power attenuator:
Power Meter NRV (photo p. 31)

Measurement Procedure

A. Basic settings

1. Calibrate MUF 2 at transmit frequency of transposer with selective demodulator in setting LIN (p. 98).
2. Connect transposer input to antenna (I) or to an RF signal generator (II). Adjust signal generator to receive frequency of transposer, output voltage 2 mV, no modulation.

B. Measurement of RF output power

1. Connect output of high-power attenuator to selective demodulator input of MUF 2 using precision cable K1.
2. Measure accurately the attenuation of the high-power attenuator (p. 14). Set this value on the decade switches dB EXTernal.
3. Press SWEEP and → on generator unit, adjust sweep to 1 MHz/DIV.
   Adjust transmit frequency on display using TUNING COARSE and FINE (press MHz).
4. Centre curve using TUNING FINE, reduce sweep to 0.1 MHz/DIV. Adjust the display height to a value which can be easily evaluated using the RF attenuator, and then with the IF attenuators COARSE and FINE.
5. Press LEVEL and W and adjust level line to peak of curve.
6. The output power of the transposer is read out directly in Watt. The set attenuation of the high-power attenuator is automatically taken into consideration.

SPURIOUS EMISSIONS

With a sound broadcasting transposer (as with sound broadcasting transmitters), the auxiliary frequencies used for the conversion may appear in the output signal in addition to the harmonics of the transmit frequency. These emissions must be limited to very small values according to the standard specifications so that other services are not interfered with.

The measurement can be carried out using a highly sensitive receiver — e.g. the ESV from Rohde & Schwarz — or a frequency analyzer — the TV Transcope MUF 2 is highly suitable, for example. Measurement using a frequency analyzer has the advantage that the frequency spectrum of interest can be displayed with all occurring frequencies, whereas with the receiver measurement, all frequencies have to be searched for individually.

Measurement Procedure

I. Measurement with the TV Transcope MUF 2

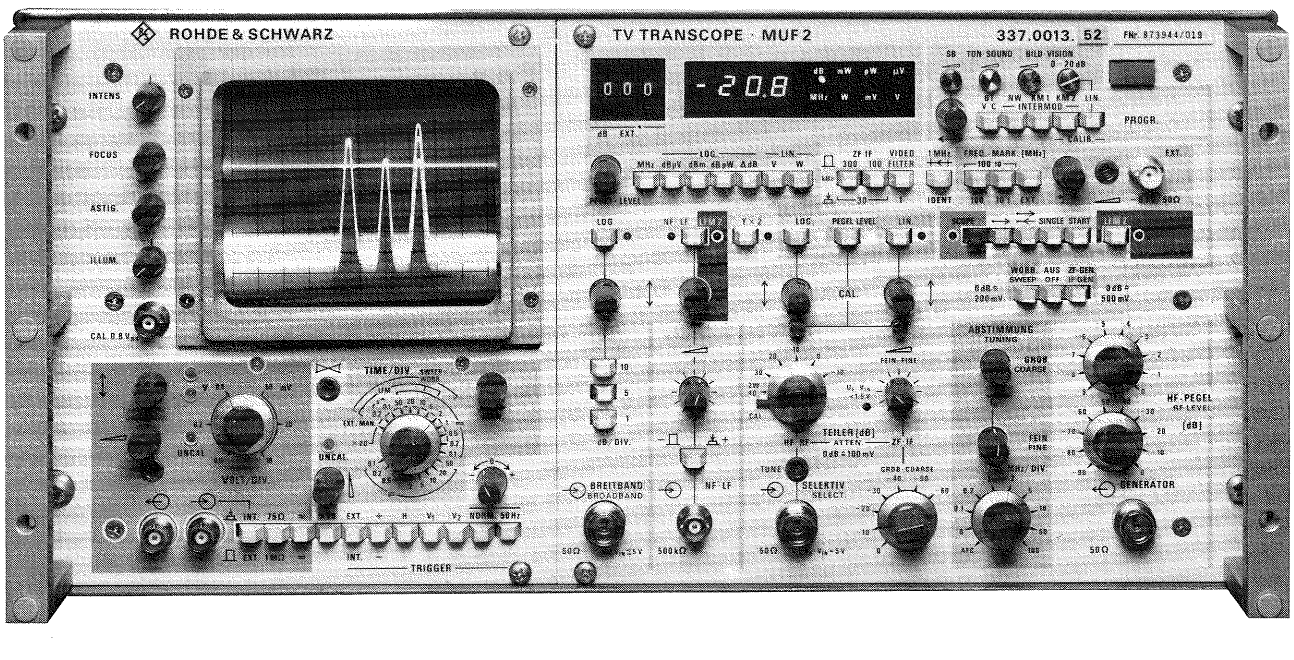
A. Basic settings

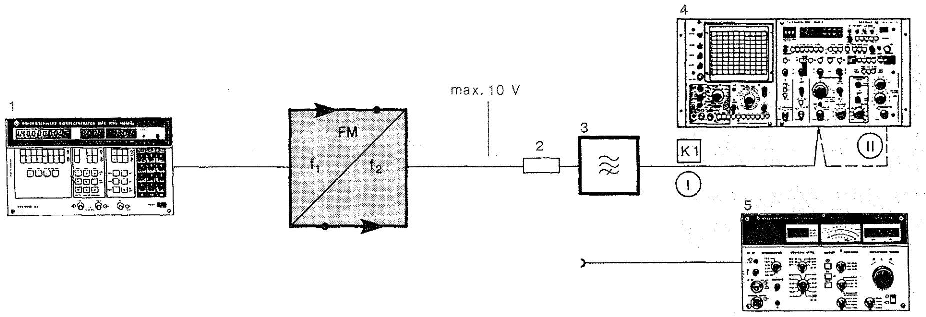
1. Connect signal generator to transposer input (receive frequency, output voltage 2 mV, without modulation).
2. Connect selective demodulator input of MUF 2 to output of high-power attenuator (connection ①).
3. Press SWEEP, → and MHz on generator unit of MUF 2. Adjust the transmit frequency of the transposer using TUNING COARSE and FINE. Sweep 1 MHz/DIV.

B. Calibration of setup

1. Calibrate MUF 2 in setting LOG of selective demodulator (p. 98).
2. Centre curve on MUF 2 selective demodulator using TUNING FINE. With ↕ fully clockwise, adjust suitable display height using ATTENuator RF and position peak of curve to highest graticule line using ↕.
3. Press LEVEL and set level line to peak of curve. Press ΔdB. Output on display: 0 dB.

TV Transcope MUF 2





1 Signal Generator SMK (photo p. 102)
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram p. 97)
3 Highpass for display of spectrum, f_l approx. 150 MHz/50 Ω (e. g. NHP 200 from Mini Circuits)[1]
4 TV Transcope MUF 2 (photo p. 104) for display of spectrum
5 Test Receiver ESV (photo p. 16) for selective measurement

[1] German agent: Industrial Electronics GmbH D-6000 Frankfurt/Main Telephone: 069/724752

Measurement Procedure (continued)

C. Determination of spurious emissions

1. Determine from the circuit diagram of the transposer whether spurious is to be expected (and at what frequencies) in addition to the harmonics. If yes, proceed as follows:
2. Increase sweep to 5 MHz/DIV and switch on FREQuency MARKer 10/1. Increase the gain further until spurious emissions become visible (possibly frequency of transmitter oscillator).
3. Adjust level line to peak of spurious emissions. The display indicates the spacing of spurious from the carrier.

D. Determination of harmonics of transmit frequency

1. Increase sweep 50 MHz/DIV, switch on FREQuency MARKer 100/10. Shift the carrier curve to approximately the second graticule line from the left using TUNING COARSE and FINE.
2. Disconnect the cable to the selective demodulator input from the directional coupler output and connect to the generator output of the MUF 2 (connection (II)). Adjust the generator level such that the resulting line cuts the level line (set to 0 dB on the display) at the transmit frequency. For more exact determination, switch to FREQuency MARKer 10/1 again if necessary.
3. Determine the level deviations at the expected frequencies of the harmonics using the level line and note (e. g. at $2f_p$: −1.5 dB).
4. Reestablish original connection to directional coupler ((I)). The peak of the carrier must be at 0 dB. Switch on highpass; the reduction in carrier can be measured using the level line.
5. Increase the gain on the selective demodulator until the harmonics are visible. Measure the level referred to the fundamental using the level line.
6. Correct the level values using the values determined in 3. The actual level is the displayed value minus the correction value, e. g.
   −62 dB − (−1.5 dB) = −60.5 dB,
   i. e. the harmonics suppression is 60.5 dB.

II. Measurement with Test Receiver ESV

Note A highpass is not required because test receivers have a much higher overload capacity than spectrum analyzers. The harmonics of the transmit frequency and the spurious emissions can be measured in the same manner as with an analyzer and also at greater accuracy.

A. Basic settings

1. As for I.A.1.
2. Connect receiver input to output of power attenuator.
3. Test receiver setting: ATTENuation IF 0 dB, ATTENuation RF 70 to 80 dB, IF BANDWIDTH 120 kHz, operation mode SP, DISPLAY LOG 60 dB, DEMODULATION OFF.
4. Prior to measurement, press CAL briefly.

B. Calibration of setup

1. Tune receiver to transmit frequency and tune to maximum on meter (centre LED above spinwheel should light up). Reduce RF ATTENuation until meter shows approx. full-deflection.
2. Note measured value. Add the value displayed on the left and the meter value.

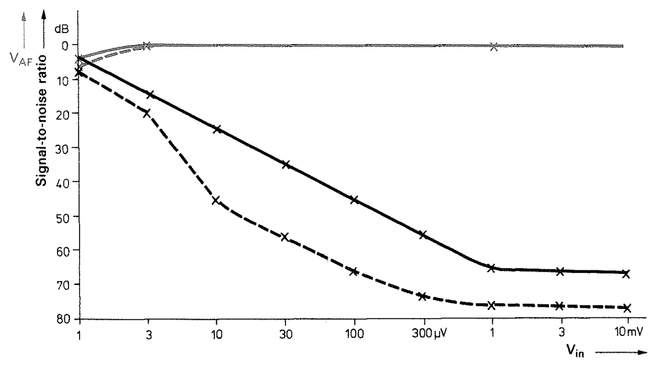
C. Determination of harmonics of transmit frequency and of spurious emissions

1. Tune receiver to frequency of harmonics and spurious emissions which may have been determined in I.C.1. Reduce RF ATTENuation by approx. 60 dB to this end.
2. The suppression of the harmonics or spurious emissions is the difference between the measured value at the transmit frequency and the respective measured value.
   Example:

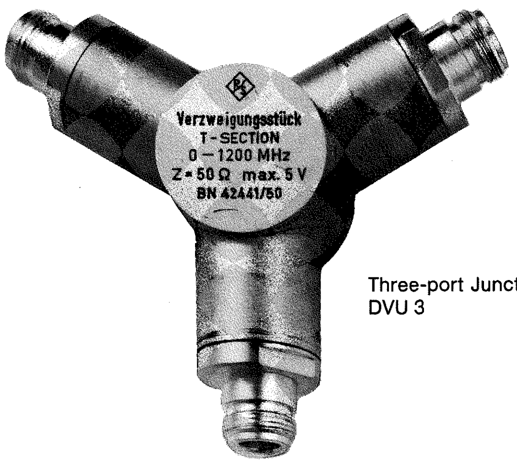
Measured value at transmit frequency	70 + 57 dB
− Measured value at a harmonic	− (10 + 54 dB)
Harmonics	60 + 3 dB

As already mentioned on p. 98, the two types of FM sound transposers have different responses depending on the input voltage: in the case of direct transposers, the output amplitude only reaches its nominal value above a particular input voltage, in the case of conversion via AF, this applies to the frequency deviation of the output signal (or to the AF voltage from the receiver section). The signal-to-noise ratio of the output signal is dependent on the input voltage in both cases, however, and allows the minimum input voltage required for a satisfactory transmission quality to be determined. Because of the system design, this value is approx. 20 dB higher in stereo mode than in mono mode.

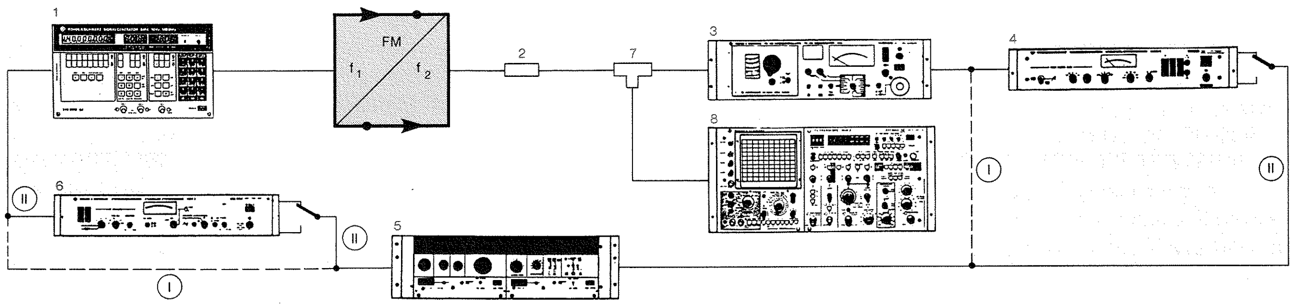
For the measurement, a frequency-modulated RF signal of variable magnitude is applied to the transposer from the Signal Generator SMK. The AF Transmission Measuring Set SUN 2 measures the AF amplitude of the output signal and — after switching off the modulation — the signal-to-noise ratio depending on the RF input voltage. As a check, the output power can be read on the MUF 2 and the frequency deviation on the FM/AM Demodulator FAB.



Example of measurement of an FM transposer with conversion via AF;
blue: AF amplitude or frequency deviation (0 dB = +6 dBm),
black: weighted signal-to-noise ratio (continuous line: stereo mode, dashed line: mono mode)



Three-port Junction Box DVU 3



1 Signal Generator SMK (photo p. 102)
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
3 FM/AM Demodulator FAB (photo p. 12)
4 Precision Stereodecoder MSDC 2 (photo p. 13)
5 AF Transmission Measuring Set SUN 2 (photo p. 18)
6 Precision Stereocoder MSC 2 (photo p. 18)

In addition for checking the output power:

7 Three-port Junction Box DVU 3 (photo opposite), attenuation 6 dB
8 TV Transcope MUF 2 (photo p. 104)

Measurement Procedure

I. Mono mode
Transposer mode mono

II. Stereo mode
Channels L and R must be measured separately. The procedure applies to one channel.
Transposer mode stereo.

A. Basic settings

1. Establish connections (I).
2. Set signal generator to receive frequency of transposer. Output voltage 2 mV, modulation FM EXTernal AC.
3. Adjust AF generator to 500 Hz and frequency deviation on SMK to 40 kHz.
4. Tune demodulator to transmit frequency of transposer, calibrate according to specifications and measure the frequency deviation in setting FM.

1.1. Settings as in I.A.
1.2. Connect stereocoder to signal generator and AF generator, connect stereodecoder to the demodulator and the level meter ((II)).
2. Adjust stereocoder according to specifications (pilot tone −9.5 dBm).
3. Adjust stereodecoder using LEVEL such that a level of −9.5 dBm is indicated with the test-point selector in setting PILOT.
4. Do not change the settings any more.

5. To check the output power (p. 103) depending on the input voltage, connect the TV Transcope MUF 2 via the Three-port Junction Box DVU 3; enter the 6-dB attenuation of the latter in addition to that of the attenuator on the decade switches dB EXTernal of the MUF 2.

B. Calibration of setup

1. Switch on deemphasis in FM/AM Demodulator FAB.

1. Switch off deemphasis in FAB and switch on in Precision Stereodecoder MSDC 2.

2. Set level meter to 10 Hz — 100 kHz (mode 1) and NORMal (dBm); the output level of the decoder is indicated (e.g. +6 dBm).
3. Switch level meter to REFerence (0 dB). The indication is now 0 dB (= reference value for noise voltage measurement).
4. Switch level meter to WEIGHTED (mode 3).
5. Switch modulation off on signal generator. The level meter indicates the weighted signal-to-noise ratio (negative sign).

C. Determination of spurious modulation as a function of input voltage

1. Reduce the input voltage in steps and measure the S/N ratio in each case. Widely different values are obtained in mono and stereo modes. The smallest permissible input voltage is reached when the S/N ratio falls below a value defined in the standard specifications or in the data sheet.
2. The output power with direct transposers, or the frequency deviation with converters via AF, should drop at far smaller input voltages at an inadmissible S/N ratio.

DYNAMIC SELECTIVITY

Definition Because of the amplitude limitation required in FM receivers and transposers, the RF passband characteristic cannot be measured directly (as static selectivity) but must be determined indirectly (as dynamic selectivity). The voltage of an interfering transmitter is then determined which reduces the S/N ratio of the wanted signal at the receiver or transposer input down to a value defined in the standard specifications. The ratio of the interfering to wanted voltages $V_{Int.}/V_W$ would then be the determining factor for selectivity. With good selectivity, a large interfering voltage is acceptable, but only a very low voltage when the selectivity is poor in the passband. Representation of this ratio as a function of the frequency yields an inverted passband curve. It is therefore usual to specify the logarithmic reciprocal value (the selectivity value S) because of the large range of values:

$$S = 20 \log V_W/V_{Int.}$$

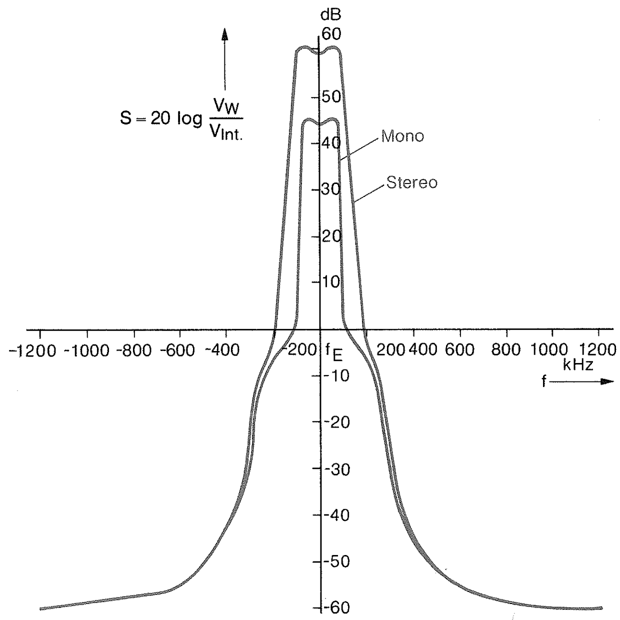
This results in the passband characteristic shown on the right. Good selectivity (strong interfering signal) results in a lower value according to this definition, poor selectivity (weak interfering signal). Differentiation is made between **co-channel selectivity** (interfering transmitter frequency in passband of selectivity curve), **nearby selectivity** (frequency interval between interfering transmitter and useful transmitter $\leq \pm 600$ kHz) and **far-off selectivity** (frequency interval $> \pm 1.2$ MHz).

Since the channel width of a stereo signal (and thus also the passband of the receiver section) is far greater than with a mono signal, the nearby selectivity values in stereo mode are far greater than in mono mode (the permissible voltage of interfering transmitter is lower). The far-off selectivity values are approximately the same in both modes.

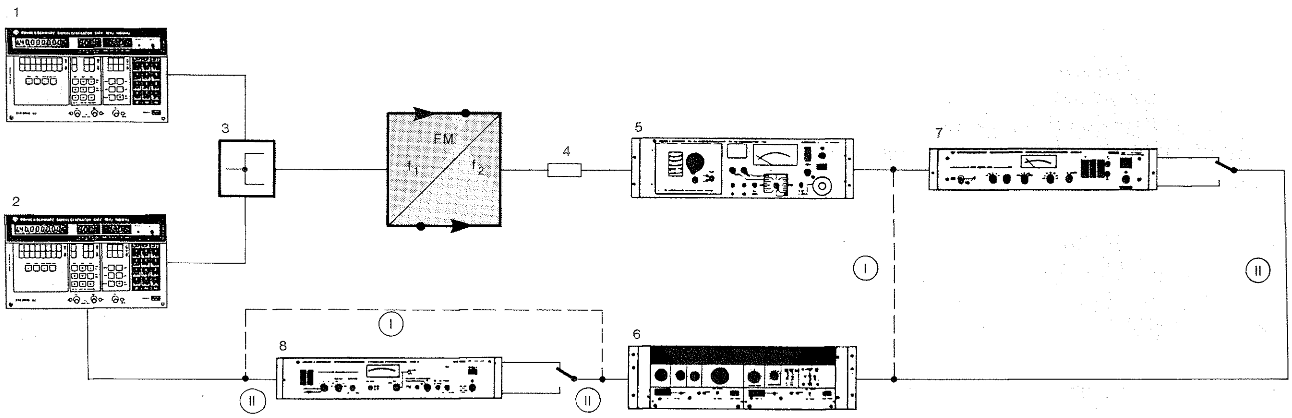
The selectivity properties also include the **image-frequency rejection** ($f_{Int.} = f_W \pm f_{IF}$) and the **IF noise immunity** ($f_{Int.} = f_{IF}$). These two are usually defined as absolute voltage values.

Measurement principle The unmodulated wanted signal is adjusted to a voltage in the normal operating range or to a value defined in the standard specifications and applied together with the modulated frequency of the interfering source to the transposer input. The S/N ratio of the wanted signal is measured at the output — initially without the interfering signal — following a demodulator (and possibly a stereodecoder). The modulated interfering source is then adjusted to the desired S/N ratio with respect to the wanted transmitter and its level increased until the permissible (weighted) S/N ratio of the output signal is achieved. The ratio $V_W/V_{Int.}$ (in dB) is determined at various frequencies and, if a switchover feature is present, in mono and stereo modes as well.

If the levels of wanted and interfering source are given in dBm, the required selectivity value is the difference of the two.



Dynamic selectivity S of an FM transposer with mono/stereo switchover (reference variables: weighted S/N ratio 54 dB referred to the frequency deviation ±40 kHz of the wanted transmitter)



1 Signal Generator SMK (photo p. 102) as wanted transmitter
2 Signal Generator SMK as interfering transmitter
3 Power Splitter/Combiner DVS (photo p. 88), insertion loss approx. 3 dB
4 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
5 FM/AM Demodulator FAB (photo p. 12)
6 AF Transmission Measuring Set SUN 2 (photo p. 18)
7 Precision Stereodecoder MSDC 2 (photo p. 13)
8 Precision Stereocoder MSC 2 (photo p. 18)

Measurement Procedure

I. Mono mode
Transposer mode mono

II. Stereo mode
Channels L and R must be measured separately. The procedure applies to one channel. Transposer mode stereo.

A. Basic settings

1. Switch off interfering source.
2. Carry out basic settings as on p. 107, I.A.1. to 4. and II.A.1. to 4. Adjust output voltage of wanted source to 2.8 mV, however (results in 2 mV at transposer input).

Connections (I). | Connections (II).

B. Calibration of setup

1. Switch on deemphasis in FAB. | 1. Switch off deemphasis in FAB and on in MSDC 2.
2. Switch level meter to 10 Hz to 100 kHz (mode 1) and NORMal (dBm). The output level of the demodulator or the decoder is displayed (e.g. +6 dBm).
3. Switch level meter to REFerence (0 dB), the display becomes 0 dB (= reference value for noise voltage measurement).
4. Switch level meter to WEIGHTED (mode 3).
5. Switch off modulation on wanted source. The level meter now indicates the weighted S/N ratio (negative sign).

C. Determination of dynamic selectivity

1. Change output display of wanted source to dBm.
2. Switch on interfering source, adjust frequency to desired offset from frequency of wanted signal (e.g. ±100/200/300/600 kHz/1.2 MHz). Switch output display to dBm, set output level −130 dBm, modulation FM INTernal 500 Hz and frequency deviation 75 kHz.
3. Increase output level of interfering source until the permissible weighted S/N ratio (e.g. 54 dB) is obtained on the level meter (negative display).
4. The selectivity value results from the difference in level of the wanted and interfering signal:
   $S = a_W - a_{Int.}$ a_W Wanted signal level e.g. $a_W = -38$ dBm (= 2.82 mV)
   $a_{Int.}$ Interfering signal level e.g. $a_{Int.} = -20$ dBm (= 22.3 mV)
   S Selectivity value e.g. $S = -38 - (-20) = -18$ dB
5. The measurements should be carried out for different input voltages of the wanted source defined in the standard specifications for mono and stereo mode, and also at various frequency spacing between wanted and interfering signals.

D. Determination of the image-frequency rejection

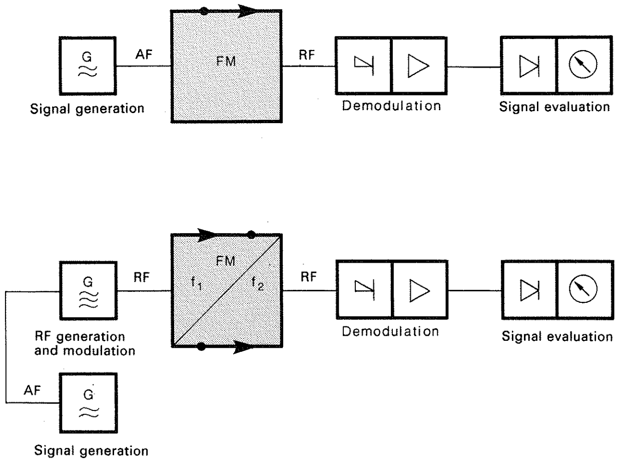
1. Arrangement as in C.1. and C.2. Adjust the interfering source to the image frequency (usually the receive frequency − or + IF, depending on equipment). The output voltage is displayed in Volt.
2. Increase the output level of the interfering source (not above 2 V) until the permissible S/N ratio is obtained. Then change the frequency of the interfering signal by ±6 kHz.
3. Carry out the measurements for various input voltages of the wanted source defined in the standard specifications.

E. Determination of IF rejection

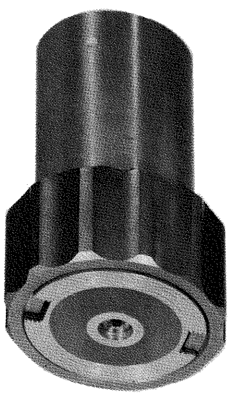
1. As for D.1., but tune interfering source to IF (change by ±6 kHz).
2. As for D.2.
3. As for D.3.

Measurement of the transmission characteristics (AF frequency response, harmonic distortion, spurious modulation, stereo crosstalk, intermodulation distortion) is the same at the output end of the transposer (transmitter section) as for FM sound transmitters (pages 4 to 13). Because the powers involved are usually lower, the instruments are connected via a high-power attenuator. A signal generator with stereo modulation facility, e.g. the SMK, is connected at the input and provides the modulated RF signal. The excellent characteristics of the SMK guarantee exact determination of the transmission characteristics of the transposers.

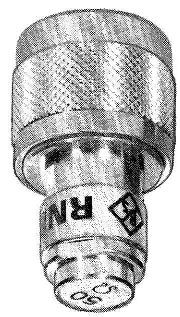
The RF input voltages of the transposers are different in mono and stereo modes (see also pages 106 and 107).



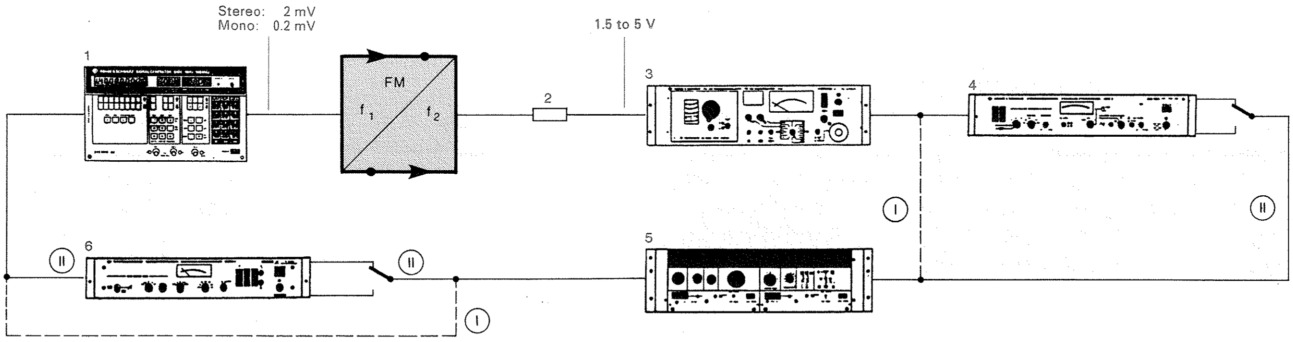
Basic circuitry for measurement of transmission characteristics of FM sound transmitters (top) and transposers (bottom).



Termination RMC



Termination RNB



1 Signal Generator SMK (photo p. 102)
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
3 FM/AM Demodulator FAB (photo p. 12)
4 Precision Stereodecoder MSDC 2 (photo p. 13)
5 AF Transmission Measuring Set SUN 2 (photo p. 18)
6 Precision Stereocoder MSC 2 (photo p. 18)

Measurement Procedure

I. Mono mode
Transposer mode mono.

II. Stereo mode
Channels L and R must be measured separately.
The procedure applies to one channel.
Transposer mode stereo.

A. Basic settings
As on p. 107, I.A.1. to 4. and II.A.1. to 4.
Test transmitter output voltage: 0.2 mV for mono mode,
2 mV for stereo mode.

B. Measurement of frequency response of amplitude
As on pages 4 and 5 (B. and D.).

C. Measurement of harmonic distortion
As on pages 6 and 7 (B. and C.).

D. Measurement of spurious modulation
As on pages 8 and 9 (measure B., D. and E. with connections (I)).

E. Measurement of crosstalk in stereo mode
As on pages 12 and 13 (B.).

F. Measurement of intermodulation distortion
Basic settings as for A. (above), then as for A.2. to 4. on p. 11. Measurement as on pages 10 and 11 (B. and C.).

TV TRANSPOSERS

In contrast to FM sound-broadcasting transposers, which convert amplitude-constant FM signals, TV transposers operate with amplitude-modulated signals. The output amplitude of the transposer must remain proportional to the input amplitude to prevent distortions to be generated. Thus amplitude limitation must not occur in the transmission path as is necessary with FM sound-broadcasting transposers. Because the input voltage varies with the transmission conditions, automatic control to a constant output power is required (slow compared to the modulation frequencies) which must not influence the modulation content.

MEASUREMENTS ON TV TRANSPOSERS

General Signal transfer with TV transposers is always at the IF. The IF signal (which is then converted to the output frequency) must be held at a constant value. This is carried out by a control circuit which evaluates the modulation-independent sync pulse in the vision signal. If correction circuits are present (e.g. for amplitude, group delay, differential phase and gain) for the IF — as with most transposers — this control circuit must hold the IF amplitude constant very accurately to ensure exact operation of the corrector. A separate control circuit for compensating variations in the gain of the transposer and the following amplifier stages ensures a constant output power. In the case of transposers without a corrector at the IF, the output control circuit can be linked to the IF control (see Figs. opposite).

A high-precision signal generator is required as the signal source for testing transposers and must supply a standardized TV signal. The TV Test Transmitter SBUF available from Rohde & Schwarz is highly suitable for measurements on transposers with any power — even for intermodulation measurements (p. 128).

Three-source method Since signal generators with a sufficiently high precision were in the past not available, standard specifications usually define the three-source method (measurement with equivalent signals) for determining the intermodulation characteristics. Three separate RF signals are applied to the transposer input (vision carrier, sound carrier and a sideband signal with variable frequency). The amplitudes correspond to the transmitter level to be simulated in each case (see also p. 76). The automatic control can no longer operate because the sync pulse is missing in the equivalent signal (normally used to define the 0-dB point [sync peak power]). The standard specifications therefore include a unit for switching from automatic control to manual control where the output power of the transposer must be set via a DC voltage. This manual control must be used for all measurements with equivalent signals and several other types of measurements.

Operation using equivalent signals results in a number of special features:

1. In order to define the 0-dB point, the output power must first be determined using a standardized TV signal (with H and V pulses) and with automatic control. The equivalent signals are then selected and the same output power is set at the maximum vision carrier (0 dB) and with manual control. It is then possible to switch, for example, to the levels (e.g. VC/SC/SB −8/−10/−16 dB) required for intermodulation measurements.

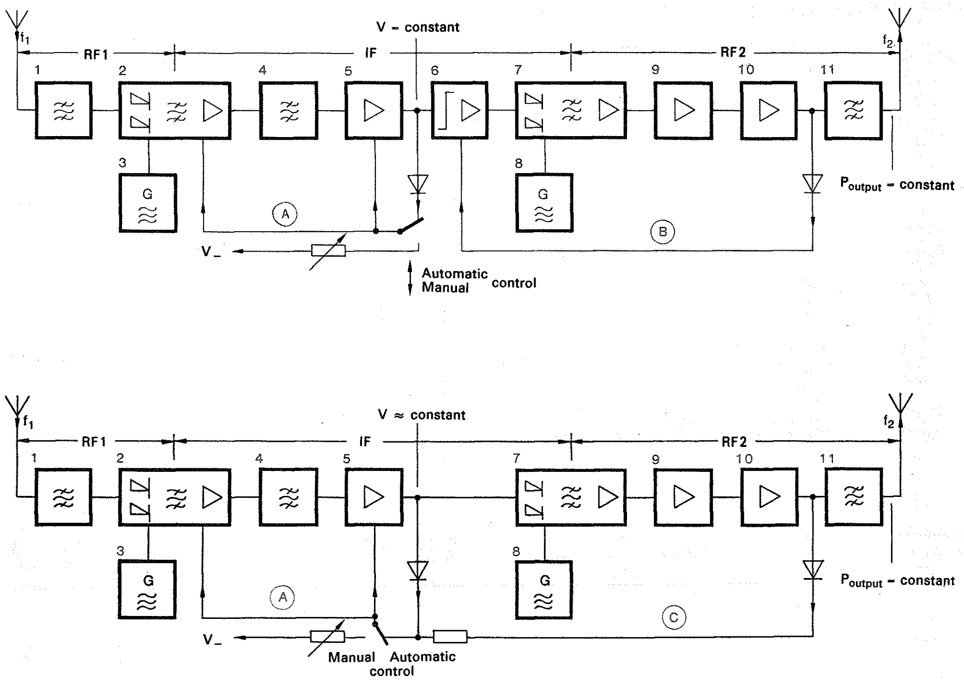
2. The constantly present peak level of the vision carrier present during the settings increases the effective power (compared to the maximum value of continuous black during operation) and the average DC current value of the transposer. This may lead to a higher temperature of the components and, especially with semiconductors, to a change in the characteristics. The original characteristics are restored with subsequent measurements with a normal modulation and the associated cooling down to normal temperatures. The output power, which is particularly important for intermodulation measurements for example, could change and lead to incorrect results.

3. The spectrum of the V and H pulses is missing on the screen during intermodulation measurements. This greatly facilitates evaluation. When measuring with normal TV signals (with H and V pulses), the influence of the spectrum can only be reduced by selecting a video filter and a very long sweep time.

4. The three-source method is highly suitable for low-power transposers, but not for high-power transposers (valves) because the associated increase in the effective power would overload the valves and components and cause the protective circuits to switch off the transposer. In this case, it is only possible to measure using real TV signals (with sync pulses).

Measuring instruments Instead of individual signal generators, state-of-the-art instruments such as the TV Transcope MUF 2 or the TV Test Transmitter SBUF generate all three frequencies. The SBUF also delivers a standardized RF input signal with sync pulses, sound signal (mono or dual sound) and sideband for measurements under real operating conditions. Thus all transmission characteristics, even of transposers with larger powers, can be measured in the same manner as with a transmitter (pages 136 and 137).

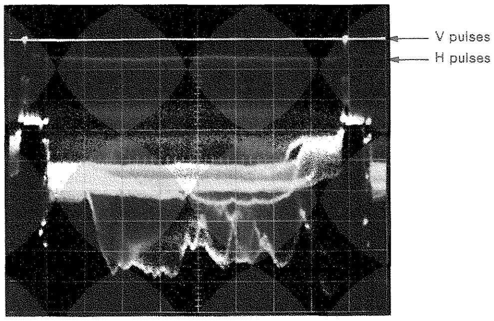
The TV Transcope MUF 2 enables the measurements defined in standard specifications to be carried out easily. In addition to the intermodulation and nonlinearity measurements, for which special equipment is provided, the measurements include matching to the transposer input and to the antennas, voltage and power as well as, with TV transposers, the measurement of the amplitude frequency response of the complete transposer, individual amplifier stages and filters.



Functional principle of TV transposers: top with IF corrector, bottom without IF corrector
1 Input filter
2 Receiver section
3 Receiver oscillator
4 IF filter
5 IF amplifier
6 IF corrector
7 Transmitter transposer
8 Transmitter oscillator
9 + 10 Amplifier stages
11 Transmitter filter
Ⓐ IF control, control range >40 dB
Ⓑ Output control, separate from IF control — Control range approx. 2 to 3 dB
Ⓒ Output control, linked to IF control — Control range approx. 2 to 3 dB

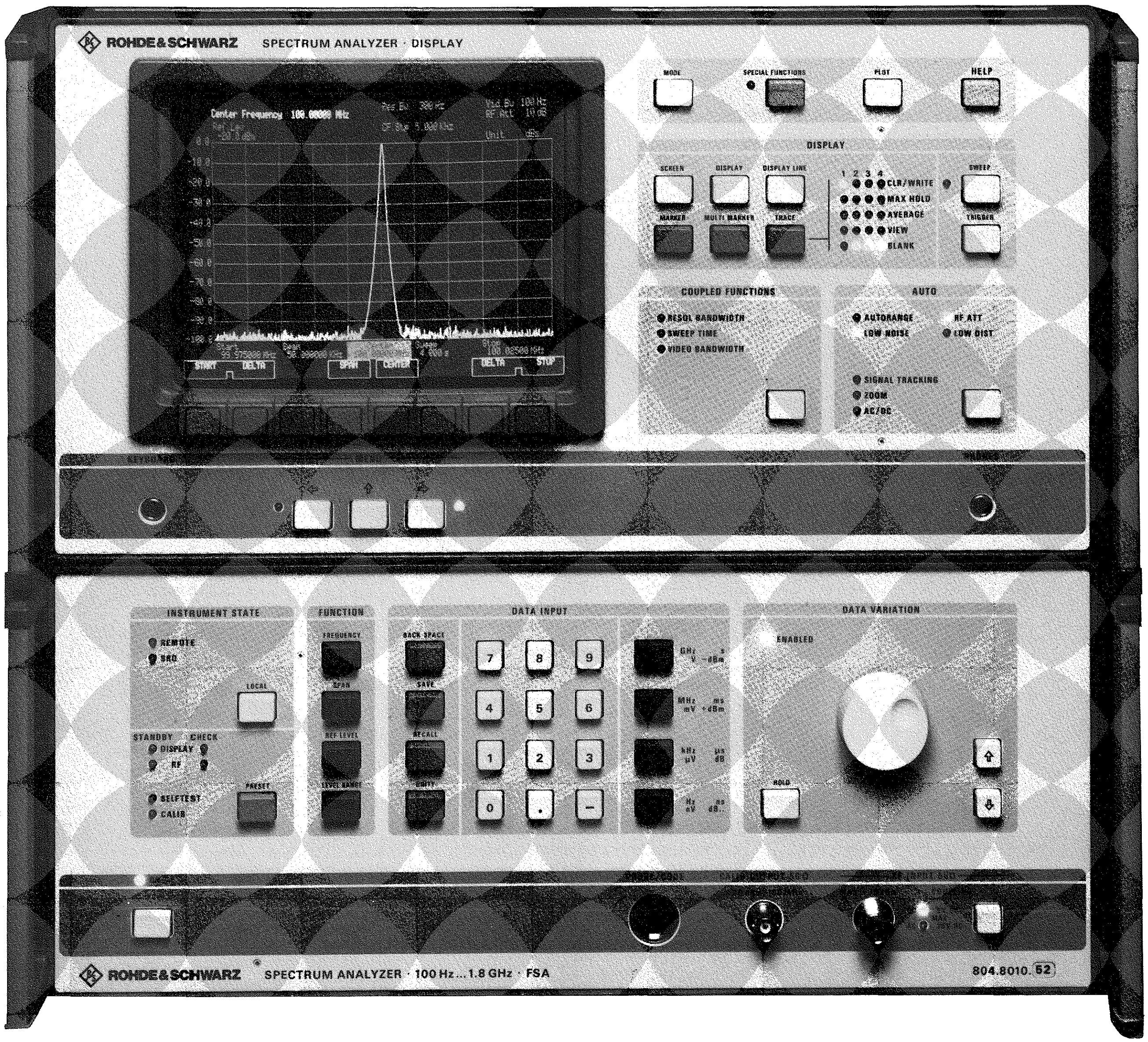
ANTENNA VOLTAGE
RFI VOLTAGE AT INPUT

Voltage measurements on the receiving antenna and the input of TV transposers (oscillator reradiation) can be performed using the TV Transcope MUF 2 in a similar manner as with FM sound transposers (p. 98). However, the measurement of the antenna voltage requires different settings for determination of the sync peak power compared to measurement of the continuous-wave power in the case of FM sound transposers.



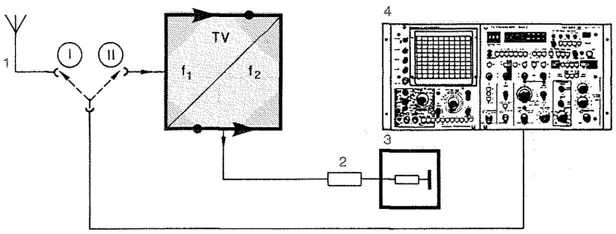
Measurement of antenna voltage (X-deflection 2 ms/DIV), determination of voltage with level line

Spectrum Analyzer FSA



transmission times

ANTENNA VOLTAGE
RFI VOLTAGE AT INPUT



1 Receiving antenna including cable
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
3 Termination RMC, 1 Watt (photo p. 110)
4 TV Transcope MUF 2 (photo p. 104)

Measurement Procedure

I. Measurement of antenna voltage

A. Basic settings

1. Calibrate TV Transcope MUF 2 at the receive frequency (vision-carrier frequency) in position LIN of the selective demodulator (p. 98).
2. Connect precision cable K1 to input of selective demodulator and to antenna cable (connection I).

B. Measurement of voltage supplied by receiving antenna

1. Select FREQuency MARKer 10/1 and sweep 1 MHz/DIV on the generator unit of the MUF 2. Set RF ATTENuator on selective demodulator to 0 dB. Reduce the attenuation using ATTENuator IF COARSE and FINE until the curve has a magnitude which can be evaluated.
2. Exactly determine the vision-carrier frequency using the frequency markers and centre the curve on the screen using TUNING FINE.
3. With a sweep of 2 ms/DIV, make the display on the screen stationary using the fine control ⊲ for the X sweep (the blanking intervals must be on the left and right).
4. Press LEVEL and V and set level line to V pulses (over the blanking intervals). The antenna voltage is displayed directly in mV.

II. Measurement of oscillator noise voltage

A. Basic settings

1. Calibrate the MUF 2 at the frequency of the receiver oscillator (receiver frequency + IF) in position LIN of the selective demodulator (p. 98).
2. Connect precision cable K1 to transposer input and to selective demodulator input of MUF 2 (connection II).

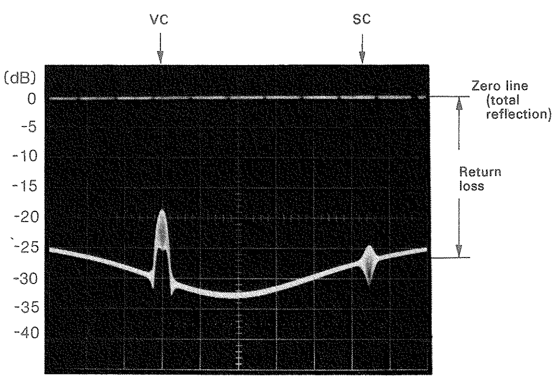
B. Determination of oscillator noise voltage at transposer input

1. As for I.B.1., sweep 0.1 MHz/DIV.
2. Determine the oscillator frequency exactly using the frequency markers and centre the curve on the screen using TUNING FINE. Switch bandwidth to 30 kHz.
3. Press LEVEL and V and set level line to peak of curve. The oscillator noise voltage is displayed in μV.

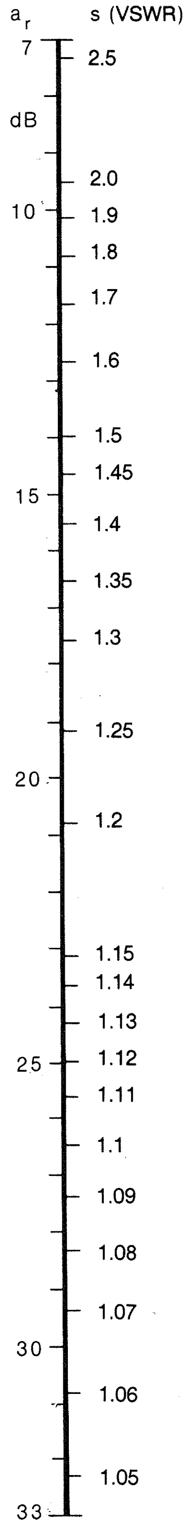
ANTENNA MATCHING

Matching of the transposer input to the antenna is particularly important for TV signals. Reflections caused by poor matching, resulting from the delay time of the antenna cable, generate ghost images. The matching requirements are therefore greater than with sound broadcasting transposers.

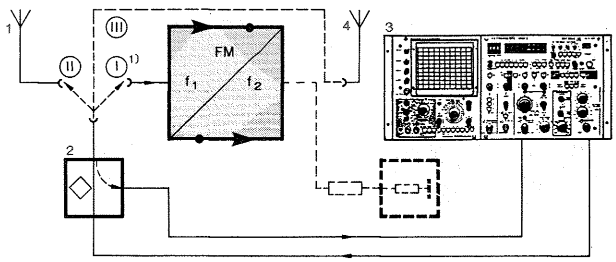
Return loss measurements at the receiving and transmitting antennas can be carried out using the TV Transcope MUF 2 in almost the same manner as with the FM sound transposers (p. 100). The same also applies to the measurement at the transposer input. It is advantageous to combine this measurement with measurement of the amplitude frequency response of the complete transposer. Since a different setting is required in this case (manual control), this combined measurement is carried out with the frequency response measurements (p. 118).



Return loss of an antenna as function of frequency; the vision and sound carriers of the reference transmitter are evident;
X: 10 ms/DIV (Δf = 1 MHz/DIV)
Y: 5 dB/DIV



Relationship between return loss a_r and voltage standing-wave ratio s (VSWR)



1 Receiving antenna including cable
2 VSWR Bridge ZRB 2 (photo p. 86), transmission loss 6 dB
3 TV Transcope MUF 2 (photo p. 104)
4 Transmitting antenna including cable

[1)] Return loss measurement at transposer input (p. 118)

Measurement Procedure

(Measurement of input matching of transposer, see p. 118)

I. Measurement of receiving antenna

A. Basic settings

1. Switch off transposer. Connect generator output of MUF 2 to input of VSWR bridge, and signal output of bridge to input of MUF 2 selective demodulator. Disconnect the receiving antenna from the transposer input and connect to the bridge (connection (II)).
2. Settings on MUF 2:
   Selective demodulator: press LOG and Y×2, set ATTENuator RF to 0 dB.
   On generator unit: press SWEEP, →, FREQuency MARKer 10/1, set RF LEVEL to −10 dB (results in approx. 30 mV on antenna, see diagram on p. 120), sweep to 1 MHz/DIV.
3. Press MHz and set receive frequency (vision-carrier frequency) to +2.5 MHz on the display using TUNING COARSE and FINE.

B. Calibration of setup

1. A curve with frequency markers at the vision and sound frequencies is now present on the screen (exact determination possible using frequency markers). Set the curve approximately symmetrical to the centre of the screen using TUNING FINE.
2. Disconnect bridge from antenna.
3. Adjust line to second graticule line from top using ↕ (zero line for return loss).
4. Press LEVEL and adjust level line to coincide with line on the screen.
5. Press ΔdB: display 0 dB.

C. Determination of return loss of receiving antenna

1. Connect bridge to antenna cable again.
2. Adjust the level line to coincide with the curve at the frequency values of interest.
3. The return loss a_r is displayed directly in dB.
4. The voltage standing-wave ratio s (VSWR) can be determined from the diagram opposite.

II. Measurement of transmitting antenna

A. Basic settings

1. As for I.A.1. Connect bridge to transmitting antenna cable.
2. As for I.A.2.
3. As for I.A.3. Set to transmit frequency +2.5 MHz.

B. Calibration of setup

1. Adjust curve on screen using frequency markers and TUNING FINE such that the vision and sound carrier frequencies are symmetrical around the centre of the screen.
2. to 5. As for I.B.2. to 5.

C. Determination of return loss of transmitting antenna

1. to 4. As for I.C.1. to 4.

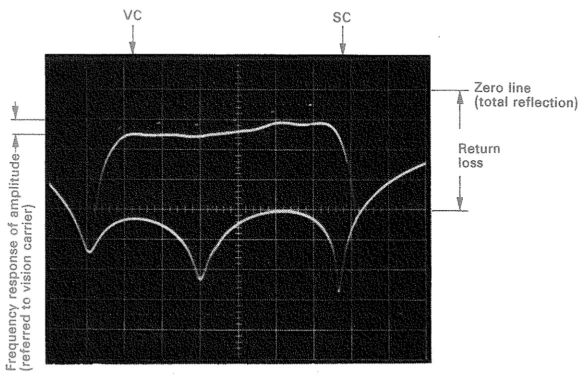
RF AMPLITUDE FREQUENCY RESPONSE, INPUT MATCHING, FILTER MEASUREMENTS

measurements outside

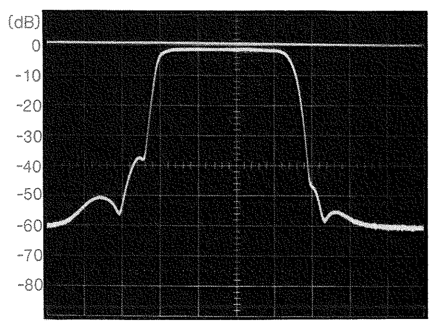
The TV Transcope MUF 2 contains a **sweep generator** and two receivers: the **broadband demodulator** (5 mV to 5 V) and the far more sensitive **selective demodulator** (10 µV to 10 V). These units enable measurement of the amplitude frequency response and the matching of active two-ports if they have defined input and output impedances. The voltages occurring and the required dynamic range are decisive for use of the respective demodulator. It is possible to use the unused demodulator for simultaneous measurement of the return loss (VSWR).

If frequency conversion takes place in the two-port network, the broadband demodulator must be used to measure the amplitude frequency response. The selective demodulator is then available for measurement of return loss. This is the case with the measurement of transposers. A sufficiently large voltage is available at the output for the broadband demodulator. Because of the low input voltage of transposers, the selective demodulator is required to measure the reflected voltage at the input. Expansion of the measuring range in the broadband demodulator (10/5/1 dB/DIV) enables exact measurement of the passband (up to 0.5 dB/DIV with Y×2).

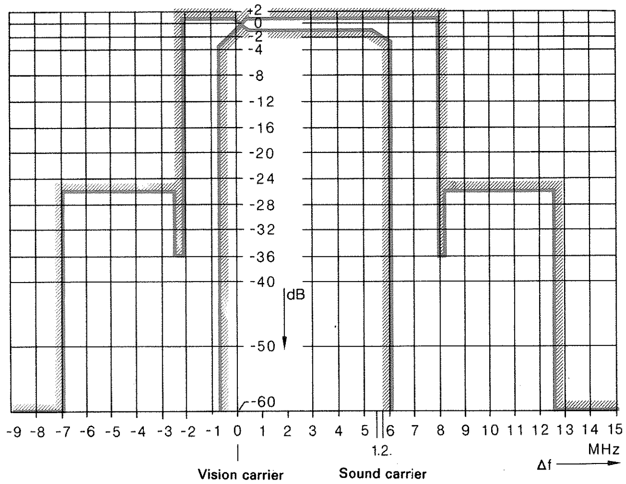
On the other hand, the selective demodulator is required for frequency response measurements with filters with a large stopband attenuation. The return loss can still be determined using the broadband demodulator with a corresponding input voltage. This type of measurement also enables exact determination of the passband (see p. 120).



Return loss (bottom) and frequency response of amplitude of a TV transposer (vision carrier is reference value);
X: 10 ms/DIV (Δf = 1 MHz/DIV)
Y: 0.5 dB/DIV (amplitude response), 5 dB/DIV (return loss)



Amplitude response of a TV transposer into the adjacent channels;
X: 10 ms/DIV (Δf = 2 MHz/DIV)
Y: 10 dB/DIV



Tolerance schematic of passband curve of a transposer (amplitude frequency response) with input channels in band IV/V (standard specifications of German DBP/ARD)

Measurement Procedure

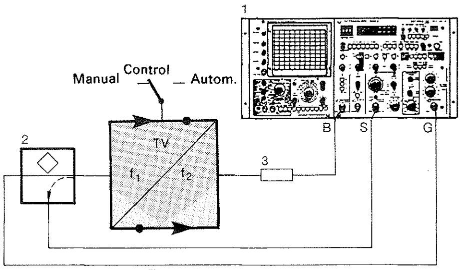
I. Measurements on transposers

A. Basic settings

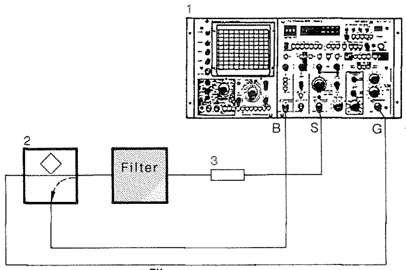
1. Connect VSWR bridge directly to transposer input, and transposer output via high-power attenuator to input of broadband demodulator.
2. Connect generator output of MUF 2 to input of bridge, and test output of bridge to input of selective demodulator.
3. Settings on MUF 2
   Generator unit: press RF LEVEL −30 dB, →, SWEEP and FREQuency MARKer 10/1. Adjust tuning on display to receive frequency of transposer (press MHz), adjust sweep to 1 MHz/DIV.
   Selective demodulator: press LOG and Y×2, set RF ATTENuator to −10 dB.
   Broadband demodulator: press LOG and 1 dB/DIV.

B. Calibration of measuring equipment

1. Adjust vision-carrier frequency to centre of screen using frequency markers and TUNING FINE, then switch sweep to 0.
2. Adjust curve to second graticule line from top using ↕ on broadband demodulator, switch transposer to manual control and set curve to same position.
3. Set RF LEVEL on generator unit to −34 dB (results in 2 mV at transposer input, see diagram on p. 120) and adjust curve to same position again using ↕ (= reference point for amplitude frequency response).
4. Disconnect VSWR bridge from transposer input. Adjust curve to second graticule line from top using IF control and ↕ on selective demodulator (= zero line for return loss).
5. Connect VSWR bridge to transposer input again.
6. Set sweep to 1 MHz/DIV again. Adjust curves to centre of screen using TUNING FINE if necessary. The top curve is the amplitude frequency response, the bottom curve the return loss of the transposer input.



Transposer measurement



Filter measurement

1 TV Transcope MUF 2 (photo p. 104):
G Generator output
B Broadband demodulator
S Selective demodulator

2 VSWR Bridge ZRB 2 (photo p. 86), insertion loss 6 dB

3 High-power Attenuator (from diagram on p. 97)

Measurement Procedure (continued)

C. Measurement of amplitude frequency response in passband (broadband demodulator)

1. The frequency response curve can be evaluated using the graticule (scale 0.5 dB/DIV).
2. In order to evaluate with the level line, press LOG, LEVEL and dBm (the bottom curve disappears).
3. Set level line to second graticule line from top and press ΔdB. The curve can now be measured using the level line.

D. Measurement of return loss (selective demodulator)

1. If C.2. has not been carried out, both curves are still present. Otherwise press LOG. Evaluation according to graticule, scale 5 dB/DIV.
2. In order to evaluate with the level line, press LOG, LEVEL and dBm (the top curve disappears).
3. As for C.3.
4. See p. 116 to convert the return loss into the voltage standing-wave ratio s (VSWR).

E. Measurement of amplitude frequency response including adjacent channels (broadband demodulator)

1. Set frequency sweep to 2 MHz/DIV, possibly to 5 MHz/DIV. Press LOG, LEVEL and dBm (the bottom curve disappears). Adjust the level line to coincide with the curve at the reference frequency (0.2 MHz or 1.5 MHz), press ΔdB.
2. Press 10 dB/DIV on broadband demodulator and release Y×2. Adjust the curve to the level line at the reference frequency again using ↕.
3. Switch on video filter and reduce sweep speed until the waveform is not changed.
4. The curve can now be measured by means of the graticule (scale 10 dB/DIV) or with the level line.
5. If the above measurement with the broadband demodulator does not produce satisfactory results, repeat with the selective demodulator (in position LOG).

II. Measurement of input or output filter

A. Basic settings

1. Connect VSWR bridge directly to filter input, and filter output to the input of the selective demodulator via an attenuator ≥ 10 dB (use high-power attenuator if necessary).
2. Connect generator output of MUF 2 to input of bridge, and signal output to input of broadband demodulator.
3. Settings on MUF 2
   Generator unit: press RF LEVEL −6 dB, →, SWEEP and FREQuency MARKer 10/1. Set tuning on display to receive frequency (or transmit frequency) of transposer (press MHz). Set sweep to 1 MHz/DIV.
   Selective demodulator: press LOG or LIN depending on desired display.
   Broadband demodulator: press LOG and 5 dB/DIV.

B. Calibration of measuring equipment

1. Disconnect filter from circuit and connect bridge output to attenuator.
2. Adjust curve to highest graticule line (= reference line for amplitude measurement) using ATTENuator RF and IF on selective demodulator (only in position LIN).
3. Disconnect bridge output from attenuator and leave open. Adjust curve to second graticule line from top (= zero line for return loss) using ↕ on broadband demodulator.
4. Refit filter into circuit.

C. Measurement of amplitude frequency response (selective demodulator, top curve)

1. Adjust curves to centre of screen using TUNING FINE, define positions of vision and sound carriers using frequency markers.
2. Press LIN and LEVEL (bottom curve disappears). Linear display of the frequency response curve is now shown on the screen.
   Scale, if ↕ (LIN) fully clockwise:
   total screen height 10 DIV = 100%, 9 DIV = 90% (approx. −1 dB).
3. Both displays appear on the screen with the keys LOG and LIN pressed (level line disappears). They can be shifted together using ↕ (LOG).
   Scale: LOG: 10 dB/DIV, LIN as for 2.

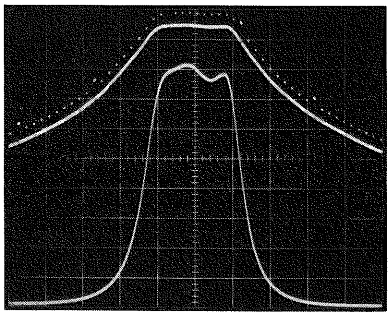
D. Measurement of return loss (broadband demodulator, bottom curve)

1. Press LOG and LEVEL (top curve disappears).
2. The curve indicates the return loss.
   Scale: 5 dB/DIV.
   Evaluate using graticule or level line.

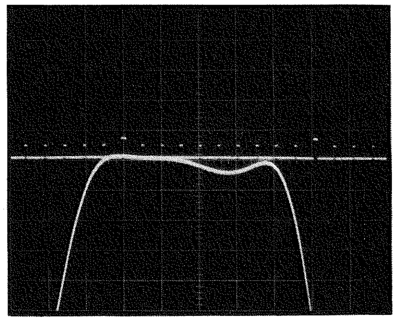
STAGE GAIN

Amplifier stages, which are equipped with 50-Ω inputs and outputs and which can be disconnected from the circuit, can be measured using the TV Transcope MUF 2 in the same manner as the complete transposer (see previous page). This also applies if they contain frequency-converting elements.

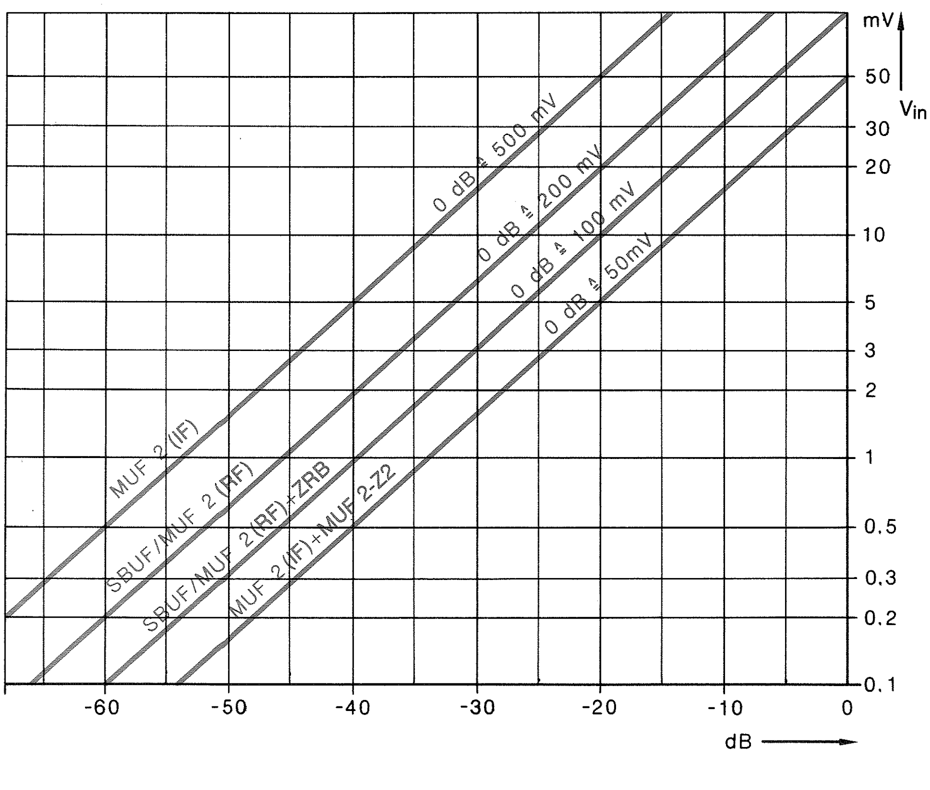
If the broadband demodulator is used to measure the output voltage, the return loss can be measured at the same time using the selective demodulator. The stage gain cannot take place at the nominal output voltage of the amplifier with this measurement, however. This is only possible when measuring with the selective demodulator. In this case, the gain can be read in dB even in setting LIN using the decade switch dB EXT.



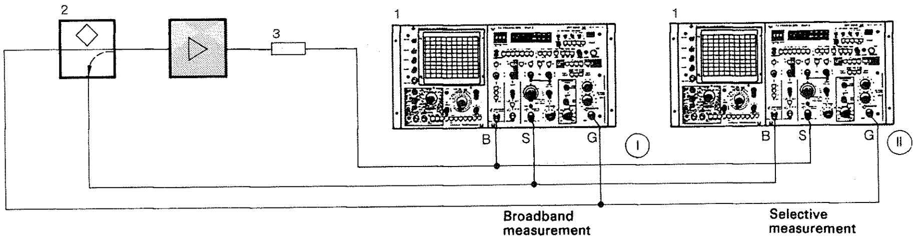
RF amplifier of a TV transposer with output filter:
logarithmic (top) and linear display of amplitude frequency response;
X: 10 ms/DIV (Δf = 5 MHz/DIV)
Y: linear display 10 DIV = 100% amplitude,
90% amplitude = approx. −1 dB
logarithmic display: 10 dB/DIV



Measurement of stage gain:
level line (top) is used following calibration as auxiliary line for gain 0 dB;
X: Δf = 2 MHz/DIV
Y: 0.5 dB/DIV with Y×2



Transposer input voltages as function of the position of controls RF LEVEL (MUF 2) or OUTPUT LEVEL (SBUF); with the SBUF, the position of the gain controller (0 or −6 dB) is taken into account [e.g. −34 dB + (−6 dB) = −40 dB]



1 TV Transcope MUF 2
B Broadband demodulator
G Generator
S Selective demodulator

2 VSWR Bridge ZRB 2 (photo p.86), insertion loss 6 dB

3 High-power attenuator (from diagram on p.97)

Measurement Procedure

I. Broadband measurement (connections (I)).

A. Basic settings

1. Analogous to p.118, I.A.1.
2. Analogous to p.118, I.A.2.
3. Settings on MUF 2

   Generator unit: press →, SWEEP and FREQuency MARKer 10/1. Adjust tuning on display (press MHz) to centre of working range (sweep 1 MHz/DIV) and RF level to operating input level of amplifier, taking into account 6 dB insertion loss of VSWR bridge (see diagram opposite).

   Selective demodulator: press LOG and Y×2, set RF ATTENuator to −10 dB.

   Broadband demodulator: press LOG and 1 dB/DIV.

B. Calibration of measuring equipment

1. Remove amplifier from circuit and connect bridge output directly to attenuator.
2. Adjust curve to second graticule line from top using ↕ on broadband demodulator. Press LOG and LEVEL and adjust level line to coincide with curve (= reference line for gain measurements). Do not change any of the settings.
3. Disconnect bridge output from attenuator and leave open. Press LOG on selective demodulator and adjust line to second graticule line from bottom using ↕.
4. Refit amplifier into circuit.

C. Measurement of return loss (selective demodulator, bottom curve)

1. Press LEVEL. Do not change level line.
2. The curve indicates the return loss of the amplifier input. Scale 5 dB/DIV. Determine the voltage standing-wave ratio s (VSWR) from the return loss using the diagram on p.116.

D. Measurement of gain (broadband demodulator, top curve)

1. Press LOG and LEVEL; the bottom curve disappears.
2. Note position of RF LEVEL on generator unit (value a).
3. Reduce level until curve reaches the level line (value b).
4. The gain is the difference between the two values:

   $v = a - b$ — a Generator level from A.3. or D.2.; b Generator level from D.3.; v Gain

   Example: $a = -20$ dB, $b = -34$ dB

   $v = -20 - (-34) = +14$ dB.

II. Selective measurement (connections (II))

Note With this type of connection it may be that a simultaneous measurement of return loss is no longer possible at small amplifier input voltages.

A. Basic settings

1. Analogous to p.119, II.A.1.
2. Analogous to p.119, II.A.2.
3. Analogous to I.A.3.

B. Calibration of measuring equipment

1. Disconnect bridge output from amplifier input and leave open.
2. Adjust curve to second graticule line from top using ↕ on broadband demodulator (10 dB/DIV), then press LOG and LEVEL and adjust level line to coincide with curve. Press ΔdB; display 0 dB (= level line for return loss).
3. Connect bridge output to amplifier input again.

C. Measurement of return loss (broadband demodulator, bottom curve)

1. Centre curve on screen using TUNING FINE and determine frequencies using the frequency markers. The curve represents the return loss of the amplifier input.
2. Evaluate using the graticule or level line. Determine the voltage standing-wave ratio s (VSWR) using the conversion diagram on p.116.

D. Measurement of gain (selective demodulator, top curve)

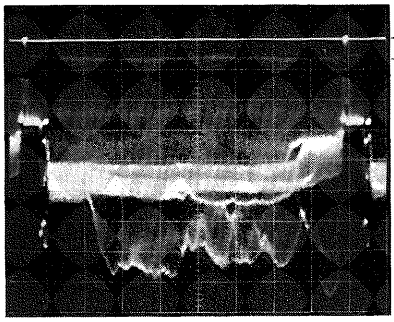
1. Press LIN, LEVEL and V.
2. Set curve to top part of screen using ATTENuator RF and IF and adjust level line to coincide with curve at frequency of interest; do not change settings.
3. Set decade switch dB EXT to 00.0, read voltage on display and note.
4. Now connect bridge output directly to attenuator.
5. Adjust curve to top part of screen again using ATTENuator RF and IF so that it intersects the level line at the same frequency as in 2.
6. Adjust the attenuation using the decade switches dB EXT until the same voltage is displayed as in 3.
7. The gain in dB is the same as the attenuation set on the decade switches.

OUTPUT POWER
BLACK/WHITE DEPENDENCE

The output power of the transposer can be determined in a similar manner to the antenna voltage. The standardized modulated RF signal of the master transmitter is present at the input of the transposer during operation. In this case the output power can be determined by a voltage measurement across a precision termination. The TV Transcope MUF 2 indicates the power directly in Watt with the use of the level line if the value of the high-power attenuator is set accurately on the decade switches dB EXT. Exact simulation of operation is possible with the TV Test Transmitter SBUF which provides a standardized TV signal with V and H pulses if the Video Generator SBUF-E6 module is fitted.

If only the vision-carrier frequency is applied to the transposer as a continuous-wave signal (i.e. without V and H pulses), the output power depends on the characteristics of the control circuits. These may be different depending on the transposer design. It is therefore not advisable to determine the output power of the transposer in this manner. Exact determination is only possible with a standardized TV signal.

The black/white dependence can also be determined with the SBUF. The TV Transcope MUF 2 is used as an oscilloscope to exactly set the modulation signals. This not only applies to setting of the black and white signals, of course, but to all modulation signals in general.



Measurement of output power of TV transposers with antenna signal fed: adjust level line to height of V pulses and read power on display;
X: 2 ms/DIV
Y: 10 DIV = 100%, 90% = approx. −1 dB

Measurement Procedure

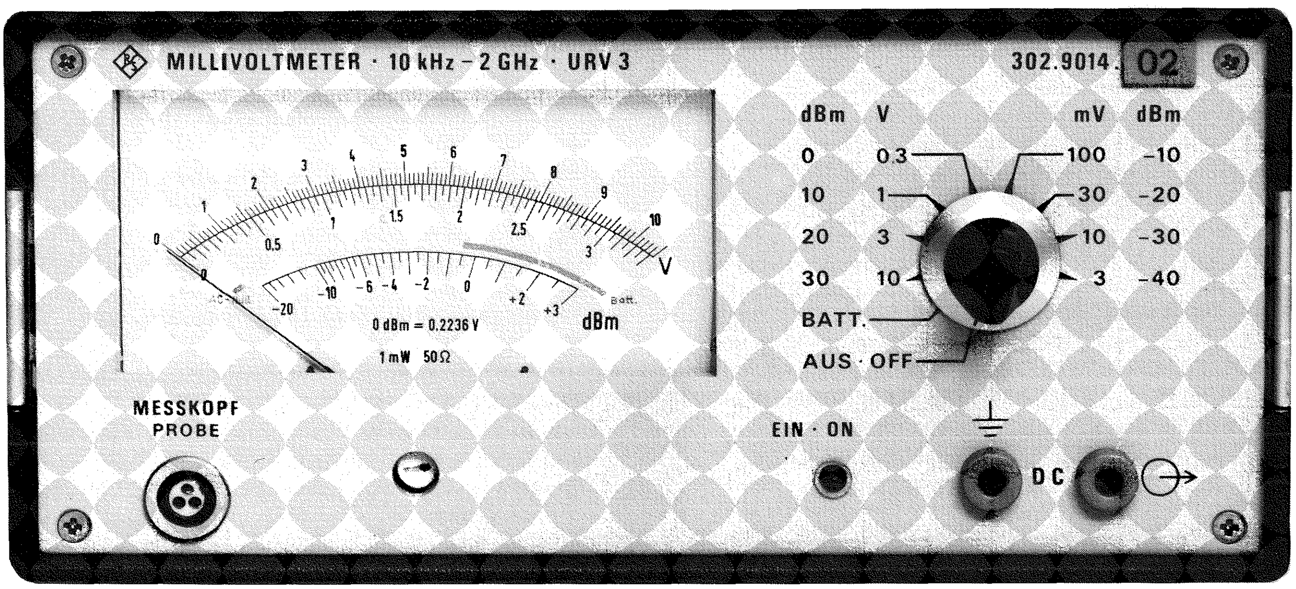
Note The power measurement according to I. or II. is necessary for all measurements using manual control.

I. Power measurement with antenna signal (connection ①)

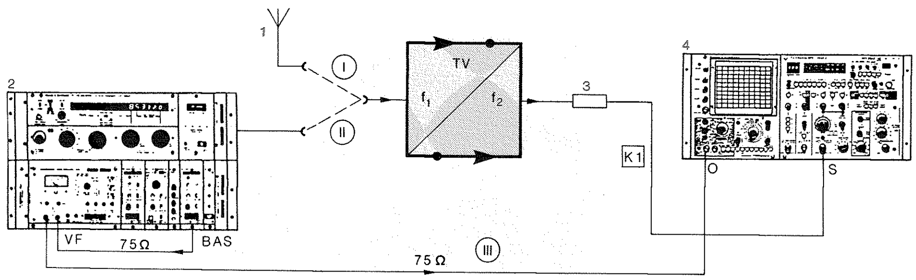
A. Basic settings (output side)

1. Calibrate MUF 2 at transmit frequency of transposer with selective demodulator in setting LIN (p. 98).
2. Connect transposer output to selective demodulator input of MUF 2 via a high-power attenuator. Use the precision cable K1 already used for the calibration.
3. Set selective demodulator to LIN, ATTENuator RF to 40 dB (2 Watt), sweep 1 MHz/DIV, sweep speed to 2 ms/DIV.

Millivoltmeter URV 3



OUTPUT POWER BLACK/WHITE DEPENDENCE



1 Receiving antenna including cable
2 TV Test Transmitter SBUF (photo p. 92) with Video Generator Module SBUF-E6
3 High-power attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
4 TV Transcope MUF 2 (photo p. 104)
S Selective demodulator
O Oscilloscope input

Measurement Procedure (continued)

B. Determination of output power

1. Centre curve using TUNING FINE and adjust to suitable height with ATTENuator RF (possibly also with ATTENuator RF). Reduce sweep to 0.1 MHz/DIV. If necessary, correct centering of curve and then switch to AFC.
2. Make display stationary on screen using fine control for X sweep so that both V blanking intervals are visible.
3. Set the attenuation of the high-power attenuator on the decade switches dB EXT (must first be measured, see p. 82).
4. Press LEVEL and W and adjust level line to V pulses (above blanking intervals).
5. The sync peak power is now output directly in Watt on the display.

II. Power measurement with TV Test Transmitter SBUF (connection (II))

A. Basic settings

1. Set TV Test Transmitter SBUF to receive frequency of transposer: in mode LOCKED, set the 1-kHz to 10-MHz digits of the frequency using PICTURE CARRIER TUNING I. Then set the frequency on the left display using PICTURE CARRIER TUNING II. Once SYNC lights up, set the APC display to the centre. The left display goes out, the 100-MHz digit is transferred to the right display.
2. Select output voltage 2 mV (−34 dB in −6 dB setting of gain control on transposer unit, see diagram on p. 120).
3. Connect output BAS (CVS) of video generator to input VIDEO of vision modulator on SBUF modulator unit using a 75-Ω cable. Switch on 75 Ω on vision modulator.
4. Adjust SBUF vision modulator according to manual, set DC RESTORATION to CLAMPED, VSB FILTER to ON and PRECORRection to ON. Switch on sound modulator, select modulation INTernal and MODulation FREQuency 1 kHz.
5. The sideband generator delivers a standardized TV signal with V and H pulses. The modulation can be selected using keys:
   — 15-kHz and 2T pulse,
   — squarewave 50 Hz or 250 kHz,
   — sawtooth signal with superimposed signal,
   — adjustable grey level for superposition with external frequency (up to approx. 6 MHz).
6. To check the modulation signals, connect an additional 75-Ω cable from the second input of the vision modulator to the input of the MUF 2 monitor (connection (III)). Switch off 75 Ω on vision modulator, press 75 Ω, = and H on monitor. Adjust gain to 0.2 V/DIV (sweep time for these measurements 10 μs/DIV). If the red key SCOPE is pressed, the modulation signal appears on the screen.

This basic setting — with the video generator but also with direct connection of a Video Test Signal Generator SPF 2 to the video input of the vision modulator — applies to all other transposer measurements with exact RF TV signals as they occur during transmission.

B. Determination of output power

In analogous manner as in I.A. and I.B.

C. Determination of black/white dependence of output power

1. Select adjustable grey level on Video Generator SBUF-E6. Press SCOPE on MUF 2, adjust sweep time to 10 μs/DIV on monitor. Adjust base of sync pulse to second graticule line from bottom using ↕.
2. Adjust grey level to white on video generator. The display must now be 5 units in height (= 1 V_{pp}) (fully clockwise).
3. Press → on generator unit (SCOPE is then released). Set sweep time to 2 ms/DIV again.
4. Measure the power as in II.B. and note the value.
5. Adjust the video generator to black. Check on the oscilloscope as in 1., display amplitude same as sync pulse amplitude (1.5 units = 0.3 V_{pp}).
6. Power measurement as for 3. and 4.
7. The reduction in power can be calculated from the two measured values or determined in dB if an additional attenuation is set by the decade switches until the display indicates the same power as for white. This additional attenuation is the power reduction with black in dB.

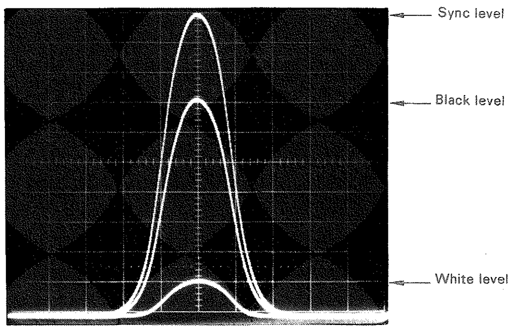
Note To correctly determine the power, set the (measured) value of the high-power attenuator on the decade switches again.

NONLINEARITY

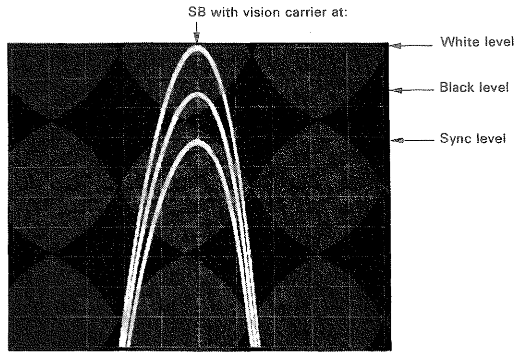
Measurement principle A special program is provided in the TV Transcope MUF 2 for the determination of the non-linearity error (key PROGR. LIN.). The vision carrier is then set cyclically to three different amplitude levels: −3 dB (black level), −20 dB (white level) and a level adjustable between 0 dB (sync value) and −20 dB.

It is therefore possible to display the sync, black and white levels simultaneously. The sideband amplitude (−20 dB) and the sound-carrier amplitude (−10 dB) remain unchanged. The change in sideband amplitude at the transposer output when the vision-carrier amplitude is changed provides information on the magnitude of the nonlinearity. By setting the selective demodulator accordingly, the change in sideband amplitude can be displayed with 5 %/DIV so that the nonlinearity error can be determined with adequate accuracy.

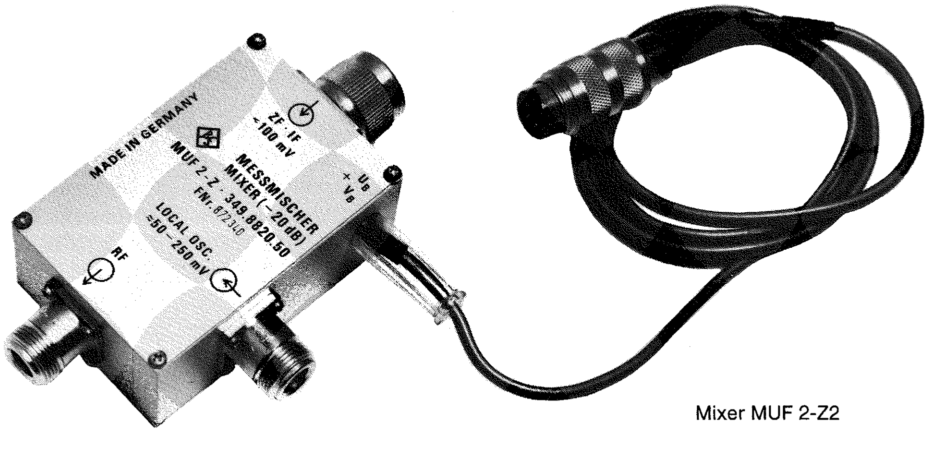
It is necessary to use the Mixer MUF 2-Z2 because the MUF 2 outputs the signals at the IF. The transposer is required to have a 50-Ω output at which the frequency of the receiver oscillator is applied. The transposer must be operated in manual control. The output power must therefore first be determined with automatic control and the manual control then set accordingly.



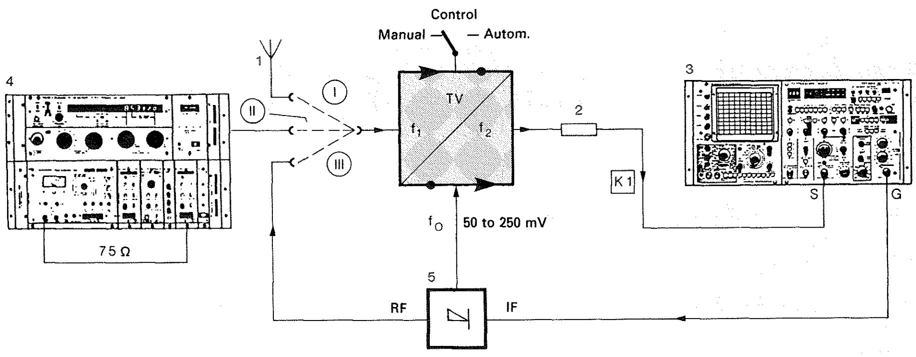
Vision carrier with alternated levels 100/70/10 % for nonlinearity measurements;
X: 2 ms/DIV (Δf = 0.2 MHz/DIV)
Y: linear display, 10 %/DIV



Associated sideband amplitude at various values of vision carrier;
X: 2 ms/DIV (Δf = 0.2 MHz/DIV)
Y: linear display, 5 %/DIV (Y×2)



Mixer MUF 2-Z2



1 Receiving antenna including cable
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
3 TV Transcope MUF 2 (photo p. 104)
S Selective demodulator
G Generator
4 TV Test Transmitter SBUF (photo p. 92) with Video Generator SBUF-E6
5 Mixer MUF 2-Z2 (photo opposite), conversion loss 20 dB

Measurement Procedure

A. Basic settings

Note The transposer must be equipped with a 50-Ω output for this measurement at which the frequency of the receiver oscillator is applied (50 to 250 mV).

1. Connect generator output of MUF 2 to IF input of Mixer MUF 2-Z2, and oscillator input of mixer to output for receiver oscillator frequency on transposer. Connect RF output of mixer to transposer input (connection (III)). The power supply is connected to the mixer from the MUF 2 (Tuchel-type socket on rear panel).
2. Connect transposer output to selective demodulator input via the attenuator and the precision cable K1.
3. Settings on MUF 2
   Generator unit: press → and IF GENerator, set RF LEVEL to −28 dB (results in 2 mV at transposer input, see p. 120), tune frequency to transposer output frequency, select sweep 1 MHz/DIV.
   Selective demodulator: press LIN, LEVEL and W. Set ↕ fully clockwise.

B. Calibration of measuring equipment

1. First connect transposer input to receiver antenna (I) or to TV Test Transmitter SBUF (II). Adjust test transmitter as on p. 123, II.A.1. to 5.
2. Determine output power using MUF 2 (see I.A. and I.B. on pages 122/123).
3. Connect transposer input to output of mixer again ((III)). Calibrate IF level on generator unit of MUF 2 according to manual, and then press NW (vision carrier 0 dB, sound carrier −10 dB).
4. Switch transposer to manual control and adjust to same power of vision carrier as in 2. (use level line).
5. Press PROGRam LINear and adjust highest vision carrier value to level line using control 0 to 20 dB. The frequency of the sideband can be changed using the control on the right next to the display.
6. Adjust the highest vision carrier curve to the top graticule line using the IF control on the selective demodulator (= 10 DIV = 100 %, bottom graticule line is zero line). The cyclically sampled values of the vision carrier must now be at 10 DIV (100 % = 0 dB, sync value), 7 DIV (70 % = −3 dB, black level) and 1 DIV (10 % = −20 dB, white level).

C. Measurement of nonlinearity

1. Reduce sweep to 0.2 MHz/DIV, centre sideband curve on screen using TUNING FINE, adjust the highest curve peak to the top graticule line on the selective demodulator using the RF ATTENuator. Press Y×2 and adjust highest curve peak to top graticule line again using ↕.
2. The highest curve corresponds to the sideband amplitude at white, the lowest at the sync value (the assignment can be checked according to the setting B.6.). The nonlinearity error in the vision range is the difference between the two top curves. One graticule unit corresponds to a deviation of 5 %.

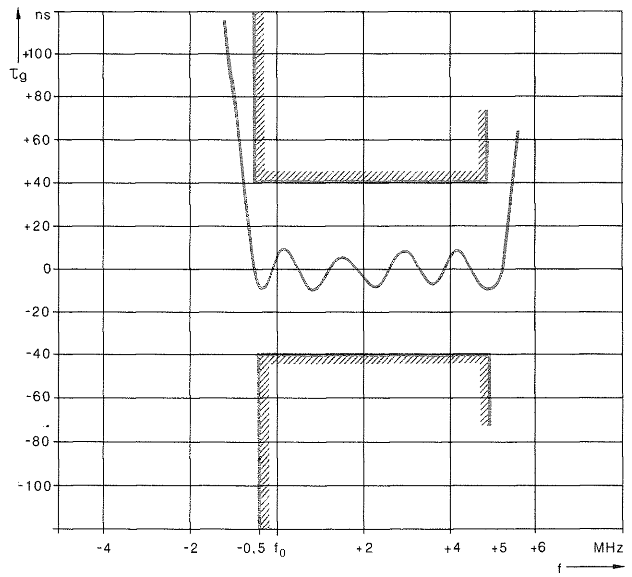
FREQUENCY RESPONSE OF GROUP DELAY

The group delay τ_G is an important variable for TV vision transmissions. This physical variable is defined on p.72, and this page also includes an explanation of the functions of the Group-delay Measuring Set LFM 2.

The TV Transcope MUF 2 extends the frequency range of the LFM 2 (0.1 to 60 MHz) up to 1000 MHz and is specially designed for operation with the LFM 2. All connections required are contained in one cable. The connections are made using two keys on the MUF 2, and the TV transcope is set to the LFM 2 mode. The LFM 2 then operates differently compared to its use on its own: the sweep frequency is now generated by the MUF 2, and therefore no frequency settings are required on the LFM 2. The delay can only be read on the graticule during sweep mode (corresponds to the ns/DIV value set on the LFM 2) because the LFM 2 does not display anything. The reference frequency for this measurement is the centre frequency on the screen so that the curve is always present there at the same point of the screen. (The curve is therefore shifted horizontally and vertically when the frequency is changed.) The frequency responses of group delay and amplitude can be displayed simultaneously, thus greatly facilitating adjustments.

A display on the LFM 2 is only possible with manual adjustment of the frequency (on the MUF 2). Only one or two spots then appear on the screen (group delay and amplitude) and move across the screen when the frequency is changed. It is advisable to first define the frequency limits in sweep mode. The LFM 2 displays the group delay referred to the frequency at the screen centre as the reference frequency.

In setting ABSolute DELay, the LFM 2 indicates the total delay at the set frequency. There is no reference frequency in this case, every frequency of the range to be examined can be defined as such. The group delay is the difference between the displayed value at the test frequency and the reference value. If a change is made to the frequency and/or sweep (the frequency limits on the screen should be defined in sweep mode again), very accurate measurements can be carried out, even of subranges of the curve. The reference value is the same, even if its frequency is no longer in the examined range.



Example of group-delay frequency response of a transposer

Measurement Procedure

A. Basic settings

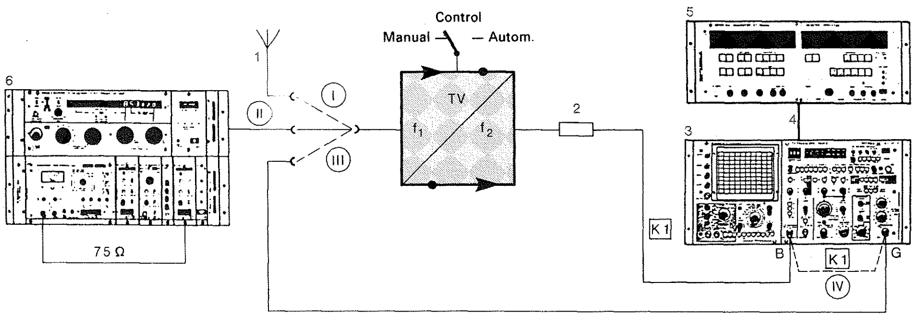
1. Connect Group-delay Measuring Set LFM 2 to the TV Transcope MUF 2 via cable MUF 2-Z4 (or -Z1, see setup opposite). Connect transposer input to generate output of MUF 2 (connection Ⓘ), and transposer output to input of broadband demodulator via attenuator and precision cable K1.
2. Settings on MUF 2
   Generator unit: press →, SWEEP, FREQuency MARKer 10/1 and LFM 2. Set RF LEVEL to −40 dB and sweep 1 MHz/DIV. Tune to receive frequency of transposer.
   Broadband demodulator: press LFM 2, LOG and 1 dB/DIV (to display the amplitude curve). On the rear panel, set the switch DEMODulator to BRoadband. Set sweep on monitor to 5 or 10 ms/DIV.
3. Settings on LFM 2
   Press DEMODulator EXTernal, REAR CONNector and GENerator TRIGger. Select desired scale using ns/DIV.

B. Calibration of measuring equipment

1. Disconnect cable from LFM 2, release keys DEMODulator EXTernal and REAR CONNector. Connect RF OUTPUT to INPUT 0.1 to 60 MHz using 75-Ω cable. Adjust the group-delay display on the right-hand display to 0 ns using OFFSET. Press CALIBrate and adjust display to 200 ns using control "200 ns" (if 0 ns is then displayed, offset F_{MARKer} slightly).
2. Reconnect cable and press DEMODulator EXTernal as well as REAR CONNector and CALIBrate on the LFM 2. Disconnect the precision cable K1 from the high-power attenuator and connect to the generator output of the MUF 2 (connection Ⓥ).
3. The calibration squarewave on the MUF 2 monitor must be 10 graticule units high (corresponding to 200 ns with 20 ns/DIV on the LFM 2). Corrections can be made using centre controls on the MUF 2 front panel.
   Release CALIBrate on the LFM 2 and press GENerator TRIGger (setting corresponds to A.3. again). Connect cable K1 to attenuator again.

transmission times

FREQUENCY RESPONSE OF GROUP DELAY



1 Receiving antenna including cable
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
3 TV Transcope MUF 2 (photo p. 104)
B Broadband demodulator
G Generator
4 Cable MUF 2-Z4 (or -Z1)[1]
5 Group-delay Measuring Set LFM 2 (photo p. 61)
6 TV Test Transmitter SBUF (photo p. 92) with Video Generator SBUF-E6

[1]) MUF 2-Z1 for equipment with serial numbers 871.739/... and 300.974/...

Measurement Procedure (continued)

4. Connect transposer input to receiving antenna or SBUF (connection I or II). Test transmitter settings as on p. 123, II.A.1. to 5.
5. Release key LFM 2 on MUF 2 and disconnect cable. Connect cable K1 to the MUF 2 selective demodulator, adjust the generator frequency to the output frequency of the transposer and determine the output power (see I.A. and I.B. or II.A. and II.B. on pages 122/123).
6. Set transposer to manual control and adjust to the same power according to the level line.
7. Set MUF 2 to basic settings again as in A.2. (connections III, connect cable K1 to broadband demodulator, tune generator frequency to receive frequency of transposer).

C. Display of frequency response curves in swept-frequency operation
(usually sufficient for transposer measurement)

1. Check that the overload display $V_{DEM.EXT.} >$ MAX. on the LFM 2 is off. Otherwise reduce the RF level on the generator unit of the MUF 2.
2. The curves for the group delay (from the AF unit of the broadband demodulator) and the amplitude (from the logarithmic unit of the broadband demodulator) now appear on the screen. Their vertical positions can be shifted using the controls ↕.
3. Adjust the scale of the group-delay curve using the key ns/DIV on the LFM 2. The value is output on the display. Evaluate using the graticule.
4. First define frequency on display (press MHz) and then determine exactly using the frequency markers (FREQuency MARKer 10/1). The markers appear on the curve selected last. They can be shifted horizontally using TUNING FINE. Next determine the frequency values of the graticule lines.
5. The level line can also be used to determine the frequency of the graticule lines. Press LFM 2 and LEVEL on the MUF 2. The frequency markers appear on the level line and the amplitude curve disappears.
6. To display both curves again, press LOG and LFM 2 on the broadband demodulator.

D. Measurement of group delay in manual mode

1. Determine the frequency of graticule lines as in C.5.
2. Set sweep speed on MUF 2 monitor to EXTernal/MANual. Only two spots are now visible from the curve and level line and can be shifted horizontally using MANual (on monitor unit of MUF 2).
3. The group-delay display, referred to the frequency at the screen centre, is now output on the right-hand display of the LFM 2.
4. This mode cannot be used for more exact measurement of a part of the curve by means of expansion because the reference frequency is always the frequency at the centre of the screen. In this case, proceed as in E.

E. Measurement of total delay in manual mode

1. As for D.1.
   The set frequency range must always be in the passband of the test item, otherwise no display is obtained.
2. As for D.2.
3. Press SET on LFM 2 and fetch curve onto screen again using control DELAY on LFM 2. The LFM 2 now displays the **absolute delay** at the currently set frequency.
4. Any frequency can be defined as the reference frequency.
5. The group delay is the difference between the absolute delays at the set frequency and the values at the reference frequency.
6. The curve can now be shifted (TUNING COARSE and FINE) or expanded (sweep) as required. First set the sweep speed to 5 or 10 ms/DIV again (delay indication disappears). Then select the section of the curve required and determine the frequency of the graticule lines according to C.5.
7. Switch to EXTernal/MANual again on the monitor unit of the MUF 2. The absolute delay is now displayed on the LFM 2 at the set frequencies. Evaluate as in 4., above.

INTERMODULATION

standard input signals

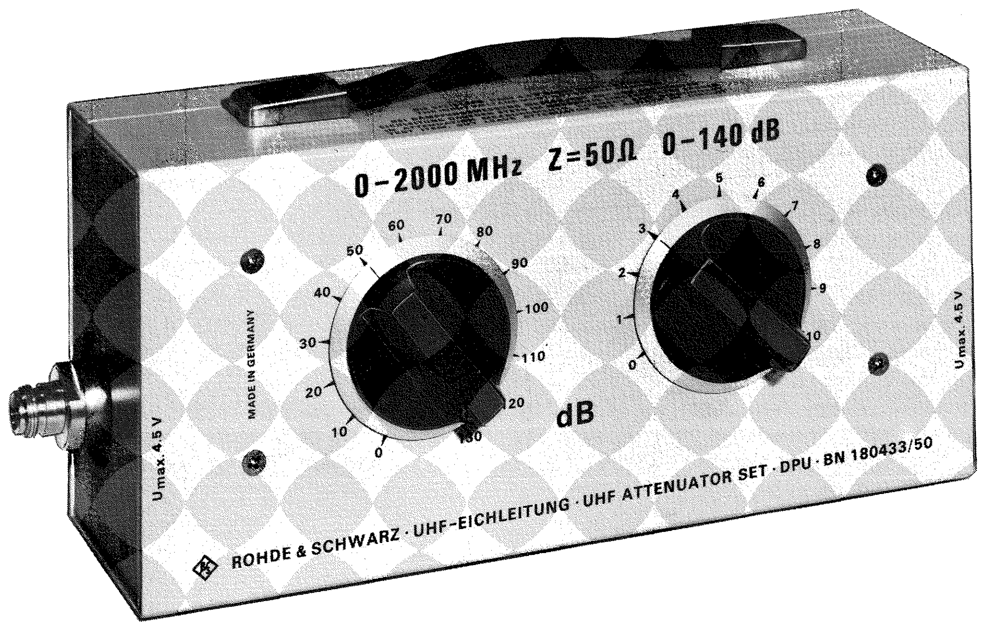
measurements outside

Principle As a result of the simultaneous amplification of several high-frequency signals (vision carrier, sideband signal and one or more sound carriers), additional signals are produced because of nonlinearities of the amplifier characteristics and may lie within or outside the transmission channel. Signals within the transmission channel are identified as intermodulation products, those outside the transmission channel as spurious emissions. An exact definition of the intermodulation products and the signals used for transmitter measurements can be found on p. 76.

Measurement Transposers can be measured like transmitters if the TV Test Transmitter SBUF is used for the input and if corresponding signals are used for modulation. The measurement then corresponds completely to the standard operation of the transposer and requires no switching whatsoever. Use of the TV Transcope MUF 2 as an oscilloscope enables with this measurement exact checking of the modulation signals used on the video side.

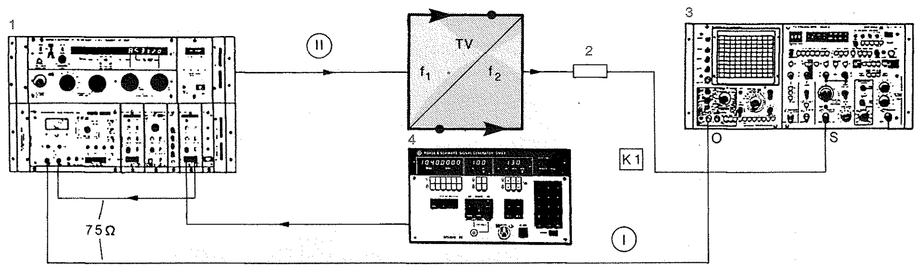
When evaluating the measurements, note the reference point defined for the intermodulation products (sync or sideband level). The reference points for transposers and transmitters are different in some standard specifications.

Measurements with equivalent signals In addition to measurements with standard input signals, methods are also common which use equivalent signals without sync pulses. These require different measurements and cannot be used for transposers of all power ranges. These are described on pages 130 and 131.



UHF Attenuator Set DPU

transmission times



1 TV Test Transmitter SBUF (photo p. 92) with Video Generator SBUF-E6; additional modules required for dual-sound measurements:
— FM Sound Modulator SBUF-E5
— TV Dual-Sound Coder SBUF-E7

2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)

3 TV Transcope MUF 2 (photo p. 104)
O Oscilloscope input
S Selective demodulator

4 Signal Generator SMS 2 (photo p. 14), 0.1 to 1040 MHz, or Signal Generator SMK (photo p. 102), 10 Hz to 140 MHz

(I) Cable to check the input signals of the test transmitter

Measurement Procedure

A. Basic settings

1. Setup and settings as on p. 123, I.A. and II. (connections (I) and (II)).
2. Connect input of SBUF video generator to output of SMS 2. The SMS 2 provides the sideband signal with the video generator set at the grey level. Check the value (level p. 76) according to p. 123, II.A.6.
   Settings
   Setup: grey level on video generator
   Video signal amplitude: output voltage on SMS 2.

B. Determination of intermodulation

1. Switch video generator to grey level and set desired value according to A.2. Switch on sound modulator on SBUF. Modulation INTernal, MODulation FREQuency 1 kHz.
2. Determine power as on p. 123, II.A. and II.B.
3. Press LOG on selective demodulator, LEVEL and dBm; adjust level line to amplitude of V pulses again, then press ΔdB. The display indicates 0 dB.
4. Switch sweep to 1 MHz/DIV, centre display using TUNING FINE. The levels of the vision and sound carriers, the sideband and the intermodulation products can now be measured using the level line.
5. It may be necessary to press VIDEO FILTER on the MUF 2 to suppress the pulse spectrum. Reduce the sweep speed until the levels of the signals are not changed.
6. Change the sideband frequency on the SMS 2 within the band and measure the intermodulation products in each case.

C. Determination of spurious emissions

1. Increase sweep to 2 MHz/DIV, possibly to 5 MHz/DIV. Switch off sideband signal on SMS 2 (RF OFF).
2. Measure the spurious emissions lying outside the channel (intermodulation products of vision and sound carriers) in an analogous manner to B.4. using the level line.
3. In the case of transposers for dual-sound mode, measure the combination signals of the two sound carriers in the same manner (see above for test transmitter equipment required).

In the case of **measurements with equivalent signals,** the three frequencies (vision carrier, sideband and sound carrier) are generated separately, mixed non-reactively and then applied to the transposer. This method is also called the **three-source method.**

Adjustment of transposer power The mixture of the three frequencies does not contain any sync pulses. These are required, however, for correct operation of the automatic control circuit. Therefore the transposer output power must first be determined using a standard RF signal and with automatic control (p. 122). Manual control must then be selected and the same output power set with the sync value of the vision carrier as a continuous-wave signal (0 dB). (A different power setting — for example with automatic control and the sync value of the vision carrier as the continuous-wave signal — is not advisable since the response of the transposer control circuit is not known under the new conditions.)

The measurements must be carried out with the determined setting of the manual control. It should be noted that switching off of the automatic control means that changes in gain (e.g. resulting from thermal influences) can no longer be compensated. The measurement should therefore be carried out after a certain warm-up time with the levels for the intermodulation measurement and should not take unduly long. It is advisable to check the output power before and after the measurement with a vision-carrier level of 0 dB.

The missing sync pulses and the power setting with a 0-dB vision carrier means that the transposer loading with respect to the average DC value, peak value and effective power may well be different from the standard operating case with sync pulses. The table indicates the percentage deviations compared to the normal case with sync pulses for 0-dB vision carrier and for IM 1, IM 2 and IM 2 (PTT) (according to p. 76).

Level	VC (dB)	SB (dB)	SC (dB)	I_{mean} (Δ%)	I_{max} (Δ%)	P_{rms} (Δ%)
Vision carrier (with ref. to black)	0	–	(−10)	+33 (+23)	0 (0)	+75 (+64)
IM 1	−8	−16	(−10)	−15 (−10)	−27 (−21)	−29 (−12)
IM 2 (DBP/ARD)	−3	−20	(−10)	−3 (−2)	−9 (−7)	−7 (−6)
IM 2 (PTT)	−5	−16	(−10)	−8 (−5)	−12 (−9)	−16 (−13)

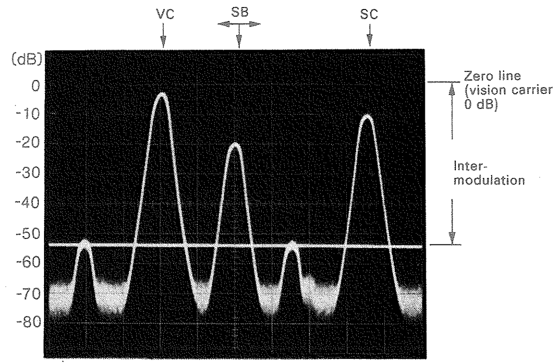
VC Vision carrier
SB Sideband
SC Sound carrier
dB values referred to the sync peak value
Values in brackets: with sound carrier −10 dB

These deviations may well have an influence on the intermodulation products, especially if the working point of the amplifiers is controlled as a function of the average DC value, as is frequently the case with advanced transposers.

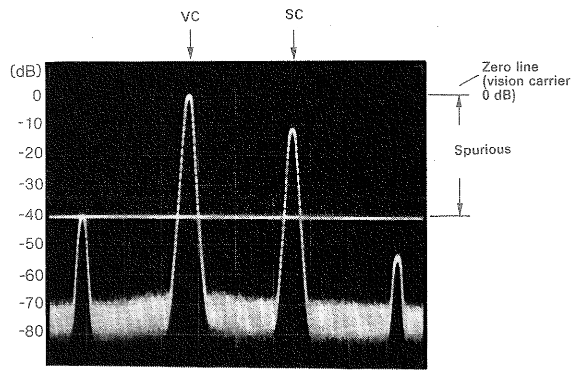
In the case of larger transposers, increasing the average DC value and the effective power with a vision carrier setting of 0 dB may lead to switching-off, thus making measurement with equivalent signals no longer applicable.

The 0-dB setting always results in a change in the thermal conditions, and should therefore only be switched on briefly because the automatic control is switched off.

Measuring instruments Both the TV Test Transmitter SBUF (with the Sideband Generator SBUF-E3 and Program Selector SBUF-E4) and the TV Transcope MUF 2 (with Mixer MUF 2-Z2) incorporate facilities for measurements according to the three-source method. The SBUF enables measurements according to both methods, thus enabling comparison of the results.



Measurement of intermodulation of a TV transposer with program IM 1 (increased level, VC/SC/SB = −3/−10/−20 dB), IF bandwidth 300 kHz;
X: 5 ms/DIV (Δf = 1 MHz/DIV)
Y: 10 dB/DIV



Determination of spurious: shift level line of vision carrier (0 dB, reference) to spurious and read result on display;
X: 10 ms/DIV (Δf = 2 MHz/DIV)
Y: 10 dB/DIV

Measurement Procedure

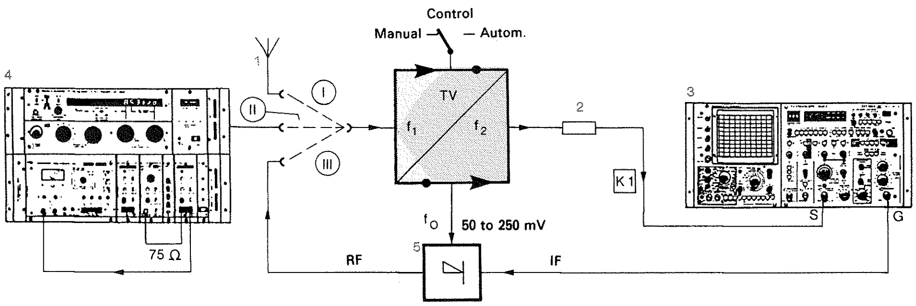
I. Using TV Test Transmitter SBUF (connection II)

A. Basic settings

1. Setup and settings as on p. 123, I.A. and II.A.1. to 5.
2. Connect output of sideband generator to input of video generator.
3. Switch on DYNamic PROGRam on Program Selector SBUF-E4 and 15-kHz wave and 2T pulse on video generator.

B. Calibration of measuring equipment

1. Connect transposer input to receiver antenna I or to SBUF II.
2. Determine the output power using the MUF 2 (see p. 123, II.A. and II.B.).
3. Switch transposer to manual control and adjust same power according to level line.



1 Receiving antenna including cable
2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
3 TV Transcope MUF 2 (photo p. 104)
S Selective demodulator
G Generator
4 TV Test Transmitter SBUF with modules
— Sideband Generator SBUF-E3
— Program Selector SBUF-E4
— Video Generator SBUF-E6
5 Mixer MUF 2-Z2 (photo p. 124), conversion loss 20 dB

Measurement Procedure (continued)

C. Determination of intermodulation

1. Connect transposer input to SBUF again (connection II). Press IM key on SBUF program module (vision carrier 0 dB, sound carrier −10 dB).
2. Switch MUF 2 selective demodulator to LOG and LEVEL and select sweep 1 MHz/DIV. Centre display using TUNING FINE, set level line to peak of vision carrier and press ΔdB. Indication 0 dB.
   Note After pressing DYNamic PROGRam on the SBUF program module, the V pulses must reach the level line at the peak of the vision carrier.
3. Press IM/K on the program module. The values (VC −8 dB/SB −16 dB/SC −10 dB) corresponds to the setting IM 1 on p. 76. The levels of the individual frequencies and the intermodulation products can now be measured with the level line on the MUF 2 screen.
4. It may be necessary to press VIDEO FILTER on the MUF 2 to suppress the pulse spectrum. Reduce the sweep speed until the levels of the signals are no longer changed.
5. The sideband frequency can be varied on the sideband generator within the video band.
6. The program IM/B (VC −5.5 dB/SB −11.5 dB/SC −11.5 dB) is provided for broadband communication equipment and cannot be used for transposer measurements.

D. Determination of spurious

1. Select IM (VC 0 dB/SC −10 dB) on the SBUF program module. Set sweep on MUF 2 to 2 MHz/DIV, possibly to 5 MHz/DIV.
2. The spurious emissions lying outside the channel can be measured using the level line analogous to C.3.
3. The combination signals of the two sound carriers in transposers for dual-sound mode are to be measured using the equipment according to p. 129, C.3.

II. Using TV Transcope MUF 2 and Mixer MUF 2-Z2

Note In this measurement, the transposer must be equipped with a 50-Ω output at which the frequency of the receiver oscillator is present (50 to 250 mV).

A. Basic settings

1. Connect generator output of MUF 2 to IF input of Mixer MUF-Z2, and oscillator input of mixer to output for receiver oscillator frequency on transposer. Connect RF output of mixer to transposer input (connection III). The power supply to the mixer is from the MUF 2 (Tuchel-type socket at rear).
2. Connect transposer output to selective demodulator input via attenuator and precision cable K1.
3. Settings on MUF 2
   Generator unit: press → and IF GENerator, adjust RF LEVEL to −28 dB (results in 2 mV at transposer input), tune frequency to transposer output frequency, select sweep 1 MHz/DIV.
   Selective demodulator: press LIN, LEVEL and W.

B. Calibration of measuring equipment

1. First connect transposer input to receiver antenna I or to TV Test Transmitter SBUF II. Adjust transmitter as on p. 123, II.A.1. to 5.
2. Determine output power using MUF 2 (see II.A. and II.B. on p. 123).
3. Connect transposer input to output of mixer again (III). Calibrate IF level on generator unit of MUF 2 according to manual, then press NW (vision carrier 0 dB, sound carrier −10 dB).
4. Switch transposer to manual control and adjust to same power of vision carrier as in 2. (use level line).

C. Determination of intermodulation

1. Press LOG, LEVEL and dBm on selective demodulator, set sweep to 1 MHz/DIV. Adjust level line to peak of vision carrier and press ΔdB. Indication becomes 0 dB.
2. Press IM 2 on MUF 2 program panel (corresponds to IM 1 on p. 76: VC −8 dB/SB −16 dB/SC −10 dB). The sideband frequency can be varied on the MUF 2 using the control SB to the right of the display. The intermodulation products can now be measured using the level line.
3. The key IM 1 results in a higher level, corresponding to IM 2 of the German DBP/ARD on p. 76 (VC −3 dB/SB −20 dB/SC −10 dB).
   The evaluation is the same as in 2.

D. Determination of spurious

1. Press NW on MUF 2 program panel (VC 0 dB, SC −10 dB), adjust sweep to 2 MHz/DIV, possibly to 5 MHz/DIV.
2. The spurious emissions lying outside the channel can be measured using the level line analogous to C.2.

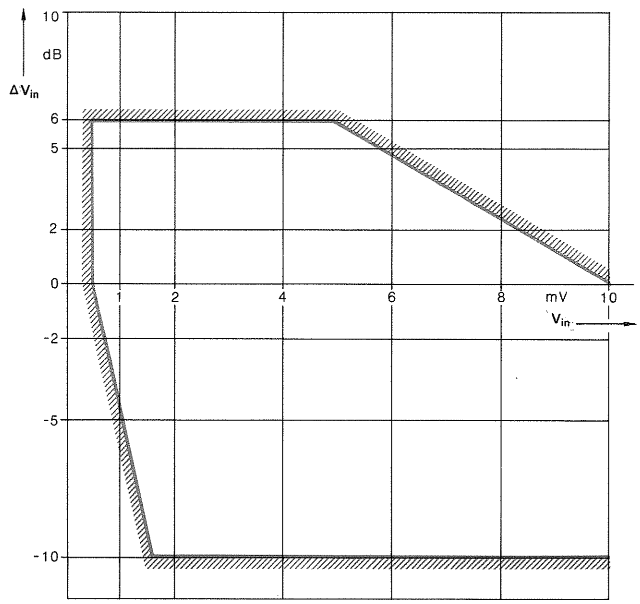
Note Measurements in dual-sound mode are not possible with this arrangement.

AGC RESPONSE

Because of the changing transmission conditions, the voltage applied from the receiving antenna to the transposer can vary within wide limits. The transposer must therefore be equipped with an automatic gain control which ensures a constant output power. The voltage of the sync pulse serves as the control criterion.

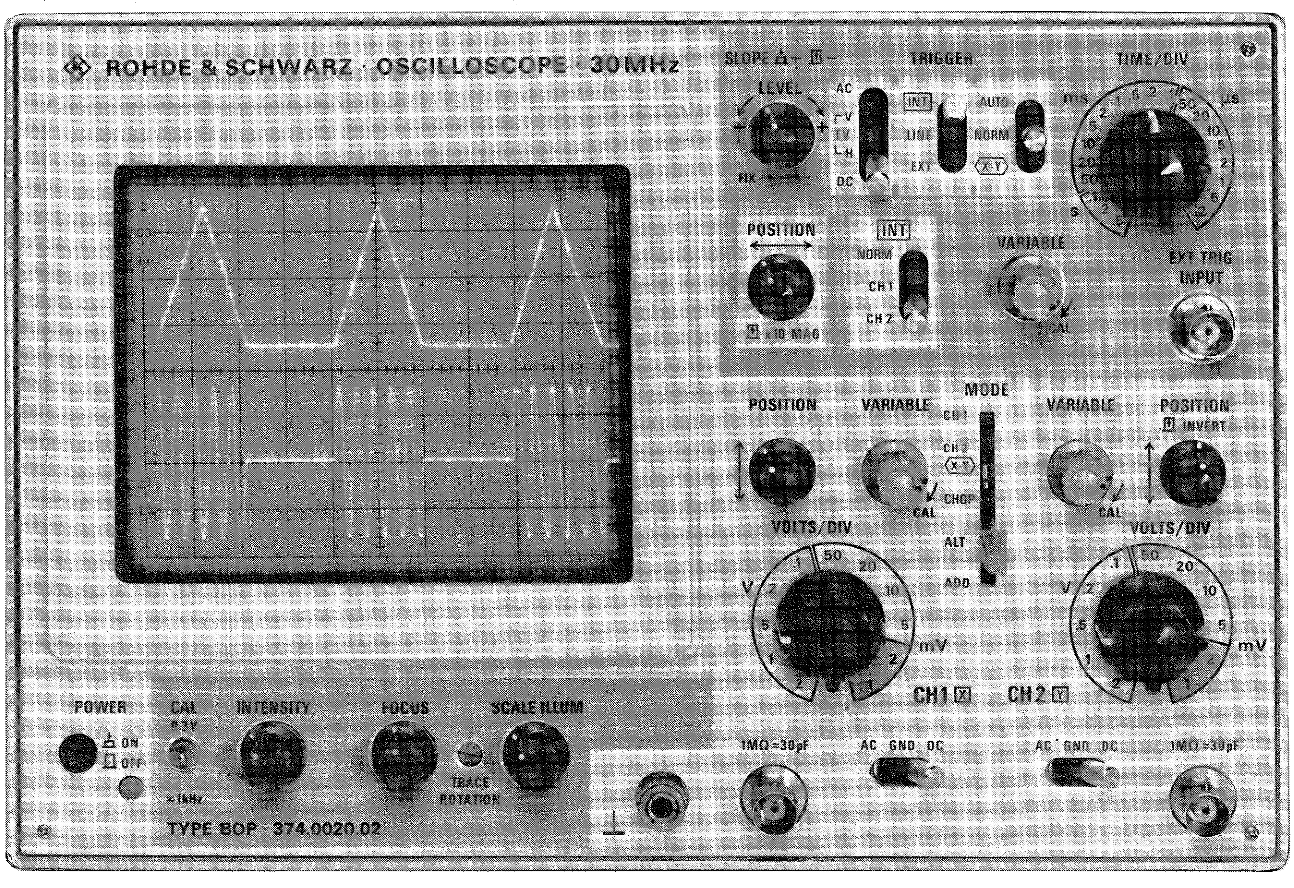
The standard specifications include detailed information on the permissible range of the input voltage, the control accuracy and the control speed.

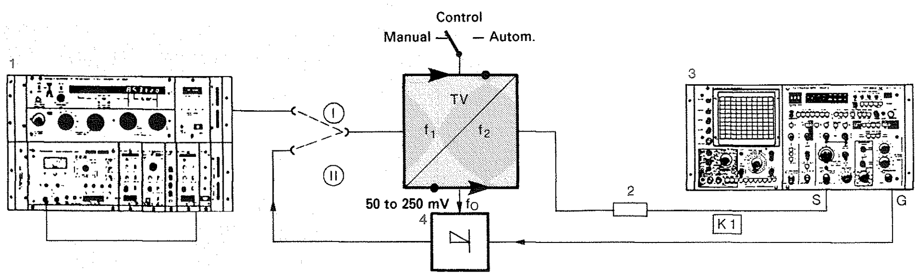
The measurement can be carried out either with the TV Test Transmitter SBUF and standard TV signals (thus corresponding to operating conditions) or with the TV Transcope MUF 2 and the vision-carrier frequency as the continuous signal. However, the same restrictions apply as with all measurements with equivalent signals: firstly, the response of the control circuits — which are designed for the vision carrier sampled at the line frequency — with a continuous-wave signal is unknown. Furthermore, the vision carrier as a continuous-wave signal results in a far larger effective power and a higher average DC value than normal. This is impermissible for larger transposers.



Input voltage range of TV transposers according to standard specifications of German DBP/ARD;
the maximum deviation of the output power with a change in input voltage within the level limits must be less than ±1 dB after 1 second

Oscilloscope BOP





1 TV Test Transmitter SBUF (photo p. 92) with Video Generator SBUF-E6

2 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)

3 TV Transcope MUF 2 (photo p. 104)
S Selective demodulator
G Generator

4 Mixer MUF 2-Z2 (photo p. 124), conversion loss 20 dB

Measurement Procedure

I. Measurement with TV Test Transmitter SBUF

A. Basic settings

1. Connect transposer input to output of SBUF (connection Ⓘ), and transposer output to input of MUF 2 selective demodulator via the high-power attenuator and the precision cable K1.
2. SBUF settings as on p. 123, II.A.1. to 5.
3. Measure output power (as on p. 123, II.A. and B.). Note value.

B. Measurement of AGC response

1. Vary output voltage of SBUF in steps (between 0.1 and 20 mV, corresponding to a total attenuation in the transposer unit of −66 dB and −20 dB), refer to diagram on p. 120. Measure the output power in each case.
2. The change in power in dB can be determined if the decade switches dB EXTernal are adjusted for each new setting until the power noted for A.3. is displayed again. The change in power is the same as the change in attenuation on the decade switches but with the opposite sign: an increase in attenuation means a reduction in power and vice versa.
   Note After the measurement, set the original value on the decade switches again.

II. Measurement with TV Transcope MUF 2

A. Basic settings

Note For this measurement, the transposer must be fitted with a 50-Ω output at which the frequency of the receiver oscillator is present (50 to 250 mV).

1. Connect generator output of MUF 2 to IF input of Mixer MUF 2-Z2, and oscillator input of mixer to output for receiver oscillator frequency on transposer. Connect RF output of mixer to transposer input (connection Ⓘⓘ). The power supply to the mixer is from the MUF 2 (Tuchel-type socket on rear panel).
2. Connect transposer output to the selective demodulator input via the attenuator and the precision cable K1.
3. Settings on MUF 2
   Generator unit: press → and IF GENerator, set RF LEVEL to −28 dB (results in 2 mV at transposer input), tune frequency to transposer output frequency, select sweep 1 MHz/DIV.
   Selective demodulator: press LIN, LEVEL and W.
4. Press key NW on MUF 2 program panel (VC 0 dB, SC −10 dB).
5. Measure output power of transposer (as on pages 122/123, I.A. and B.). Note value.

B. Measurement of AGC response

1. Vary output voltage of MUF 2 generator unit in steps (between 0.1 and 20 mV, corresponding to a total attenuation in the transposer unit of −54 dB and −8 dB), refer to diagram on p. 120. Measure the output power in each case.
2. The change in power in dB can be determined if the decade switches dB EXTernal are adjusted for each new setting until the power noted for A.5. is displayed again. The change in power is the same as the change in attenuation on the decade switches but with the opposite sign: an increase in attenuation means a reduction in power and vice versa.
   Note After the measurement, set the original value on the decade switches again.

III. Measurement of AGC speed

1. Rapidly change the input level of the transposer on the test transmitter (measurement as in I.) or on the TV Transcope MUF 2 by the amount defined in the standard specifications (e.g. +6 or −10 dB).
2. Determine the time required to attain the original value and the deviation of the output power from this value. Determine change in power as in B.2.

Definition Noise is the variation of current and voltage caused by the flow of electrons which occurs statistically across the complete frequency range in virtually all components. The noise power resulting from these variations depends on the measured bandwidth in the case of white noise (constant amplitude throughout complete frequency range).

The unit of noise power is the power P_n output by a matched resistor. It is:

$P_n = k\,T\,\Delta f = 4 \times 10^{-21}$ W per Hz bandwidth at $T_0 = 290$ K
- k 1.38×10^{-23} W/K (Boltzmann's constant)
- T Absolute temperature [K]
- T_0 Standard temperature (290 K or 17 °C)
- Δf Bandwidth [Hz]

Amplifier noise The noise power P_2 at the output of an amplifier or transposer is a combination of the values of the individual stages. These values depend on the ratio of the incoming noise power (amplified noise power of previous stages) and the inherent noise power. This means that the first stages have the largest influence on the total noise power.

An equivalent noise power P_1 is defined at the input which generates the noise power P_2 generated at the output. The former is referred to the noise power of a resistor and is therefore:

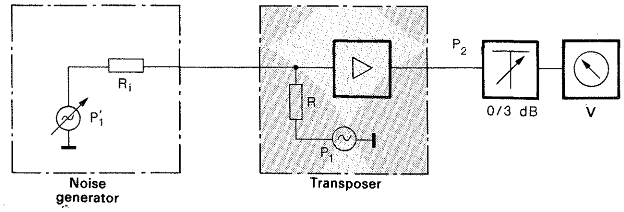
$P_1 = F\;k\,T_0\,\Delta f = P_2/g$
- F Required noise factor
- g Total power gain from input to output

Since only the noise power P_2 at the output can be measured, the result for the noise factor is

$$F = \frac{P_2}{g\,k\,T_0\,\Delta f}$$

F is therefore inversely proportional to the gain and the measured bandwidth. (With a defined output noise power, a smaller input noise power is associated with a larger gain — which is set by the automatic control of the transposer at a smaller input voltage.) An average input voltage is therefore defined in the standard specifications for the measurement. Since the measurement must be carried out without a signal voltage, the automatic control must be switched off and the amplifier set to the defined input voltage under manual control.

Determination of noise factor The noise factor F can be determined simply by using a substitution procedure with a calibrated noise generator. A noise power of zero (i.e. no signal power) is first applied to the amplifier input and the noise voltage measured at the output using an RF voltmeter which is only used for the relative display. An attenuator connected to the output, which is then set to 3 dB, reduces the noise power by half. The noise power applied by the noise generator is not increased until the original display is reached again by the output. The applied noise power $P_1' = F\,k\,T_0\,\Delta f$ then corresponds to the inherent noise power P_1 of the transposer, where F is the noise factor. Since both P_1' and P_1 concern the same amplification path, the bandwidth is the same for both and the factor F is therefore independent of the bandwidth.

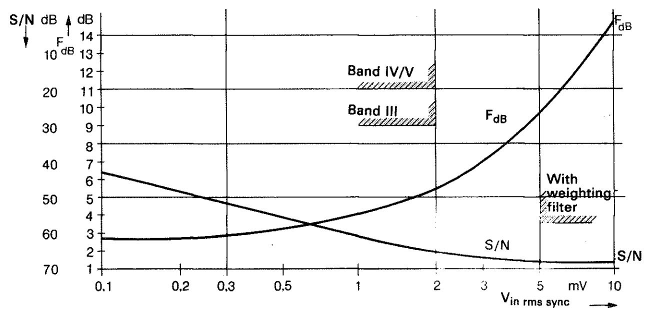


Principle of noise factor measurement
The equivalent noise power P_1 at the input of the transposer generates the noise voltage V at the output. If a noise power P_1' is applied to the transposer input which causes doubling of the output noise power (same noise voltage V with 3-dB attenuator connected ahead), P_1' is then equal to the required equivalent noise power P_1 at the input of the transposer

In addition to the dimensionless noise factor F, it is also common to use the logarithmic noise figure $F_{dB} = 10\log F$.

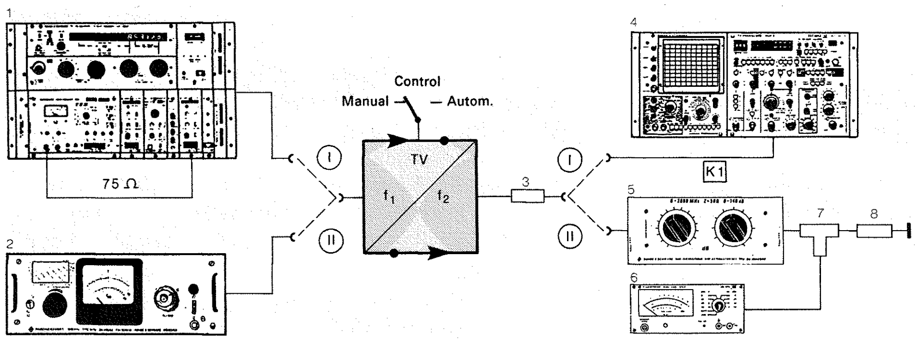
In order to determine the noise factor as a function of the input voltage, the desired voltage is first applied to the transposer input from the test transmitter and the same gain (same output power) then set with manual control. The noise factor can then be determined in the specified manner.

The signal-to-noise ratio S/N is inversely proportional to the input voltage. With a small input (signal) voltage, the ratio to the noise voltage at the input is small, and large with a large signal voltage. Since both voltages or powers are amplified in the same manner in accordance with the definition, this ratio is retained up to the output independent of the gain.



Example of the response of the noise figure F_{dB} and S/N ratio of a transposer as a function of the input voltage

NOISE FACTOR



1 TV Test Transmitter SBUF (photo p. 92) with Video Generator SBUF-E6
2 Noise Generator SKTU
3 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
4 TV Transcope MUF 2 (photo p. 104)
5 UHF Attenuator Set DPU (photo p. 128), 50 Ω
6 Millivoltmeter URV 3 (photo p. 122)
7 10-V insertion unit for URV 3
8 Termination RNB (photo p. 119), 50 Ω

Measurement Procedure

A. Basic settings

1. Connect transposer input to output of SBUF, and transposer output to input of MUF 2 selective demodulator via high-power attenuator and precision cable K1 (connections (I)).
2. Settings on SBUF as on p. 123, II.A.1. to 5.

B. Calibration of measuring equipment

1. Determine the output power using the MUF 2 (p. 123, II.A. and B.).
2. Switch transposer to manual control and adjust to same power according to level line.

C. Determination of noise factor

1. Disconnect test transmitter from transposer input and connect Noise Generator SKTU instead. Disconnect cable K1 from input of selective demodulator and connect to Attenuator Set DPU (connections (II)). Connect output of DPU to 10-V insertion unit of Millivoltmeter URV 3. Terminate insertion unit by 50 Ω.
2. Set noise generator to a noise power of zero and attenuator set to 0 dB. Read voltage on URV 3 and note.
3. Adjust attenuator set to 3 dB and increase the noise power on the noise generator until the URV 3 indicates the same voltage as in 2.
4. The noise factor F and the noise figure F_{dB} can be read directly on the SKTU.

D. Dependence of noise factor on input voltage

1. To measure the noise factor at a different input voltage, adjust the output voltage of the SBUF to the desired value according to A.2. (see diagram on p. 120).
2. Proceed in the same manner as in B. and C.

TRANSMISSION CHARACTERISTICS

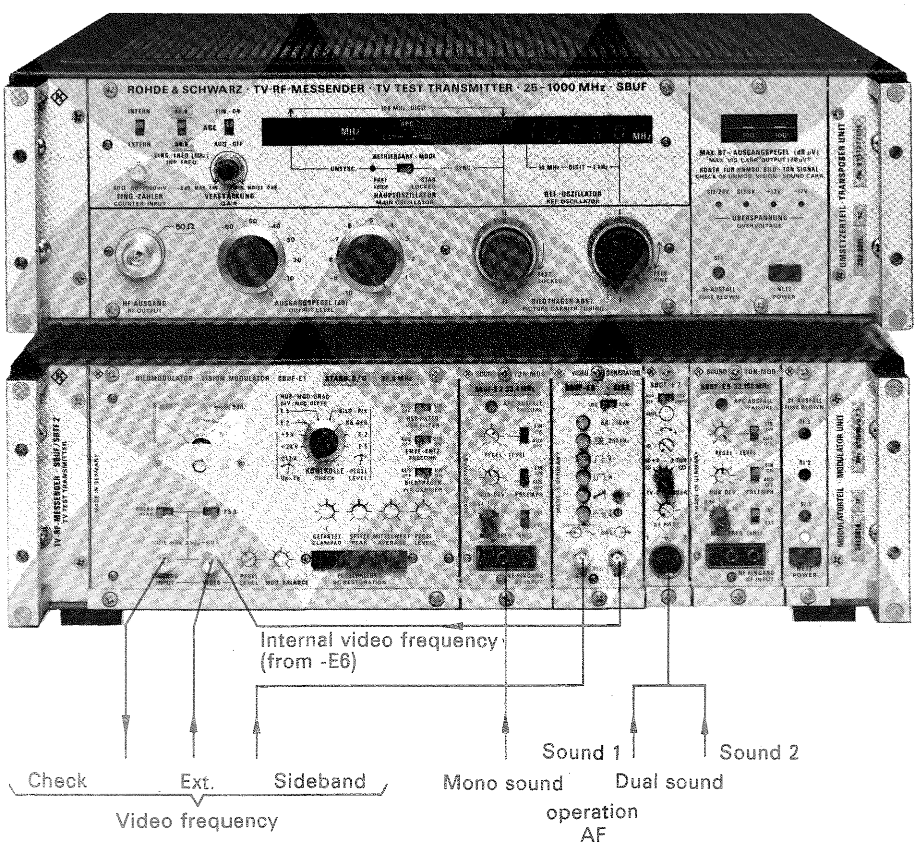
measurements outside

Measurement principle Measurement of the transmission characteristics with transposers cannot be carried out as with transmitters (comparison of demodulated RF signal with applied modulation signal) because a modulated RF signal is already applied to them. If the standard modulated RF signal required for these measurements is generated by a high-precision test transmitter whose inherent errors are negligibly small (e.g. the TV Test Transmitter SBUF from Rohde & Schwarz), the transmission errors caused by the transposer can be determined by comparing the modulation signals with the demodulated signals from the output of the transposer.

The advantage of this method is that the transposer operates under normal conditions (standard input signals) and the quality values occurring during operation are measured. Thus the transmission characteristics can be examined in the sound channel (mono or dual sound) in addition to those in the vision channel. The measurements in the sound channel are not as significant as those in the vision channel, however, because frequency-modulated signals are far less sensitive than amplitude-modulated signals.

Setup The measurement procedure at the transposer output is almost the same as for transmitter measurements (except for the high-power attenuator) which are described on pages 20 to 83. The TV Test Transmitter SBUF is used on the input side and is equipped with the Video Generator SBUF-E6 (only for dual-sound measurements), the second FM Sound Modulator SBUF-E5 and the TV Dual-Sound Coder SBUF-E7. The inputs of the vision modulator (if the video generator is not used) and those of the sound modulators correspond to the modulation inputs of the transmitter or the TV Dual-Sound Coder STCF for transmitter measurements.

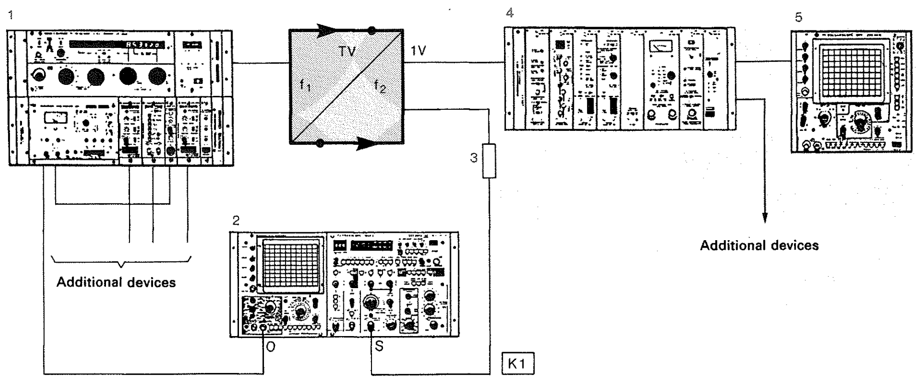
The TV Transcope MUF 2 in mode SCOPE is highly suitable for checking the modulation signals on the input side. It can be simultaneously used to determine the output power of the transposer.



Modulation inputs on TV Test Transmitter SBUF
Configuration of modulator unit (bottom) from left to right:

Vision Modulator	SBUF-E1	
FM Sound Modulator 1	SBUF-E2	
Video Generator	SBUF-E6	
TV Dual-Sound Coder	SBUF-E7	Only required for dual-sound operation
FM Sound Modulator 2	SBUF-E5	

transmission times



1 TV Test Transmitter SBUF
See opposite page for configuration and connections
2 TV Transcope MUF 2 (photo p. 104)
S Selective demodulator
O Oscilloscope input
3 High-power Attenuator RBU (photo p. 16) or similar (from diagram on p. 97)
4 TV Demodulator AMF 2 with dual-sound module (photo p. 36)
5 TV Oscilloscope OPF (photo p. 49)

Measurement Procedure

A. Basic settings

1. Basic settings of SBUF and MUF 2 for power measurement and modulation check as on p. 123, I.A. and II.A.
2. Connect TV Demodulator AMF 2 to the 1-V signal output of the transposer. Tune to output frequency of transposer (crystal present?).
3. Connect TV Oscilloscope OPF to demodulator output.
4. The additional units required on the input side for the various measurements are listed below. The additional units on the output side are listed with the respective transmitter measurements and must be connected according to the diagrams shown there.

B. Measurements in the vision channel

The following measurements can be carried out using the Video Generator SBUF-B6 in the TV Test Transmitter SBUF:

		Page
Level stability		41
Tilt and rounding (50 Hz/15 kHz)		43
Transient response (15 kHz/250 kHz)	with OPF	45
	with ODF	47
2T pulse and bar signal		49
Chrominance nonlinearity (4.43 MHz)	with OPF	55
	with ODF	57
Spurious modulation		65
Differential phase and gain		67
Video amplitude characteristic	with SWOF 3	69
	with LFM 2	73
RF sideband characteristic	with SWOF 3 and SWOF 3-Z	71
	with LFM 2 and LDS	75
Group delay	with LFM 2	73
	with LFM 2 and LDS	75

The Video Test Signal Generator SPF 2 is required in addition for the following measurements:

Modulated 20T pulse		51
Line-time nonlinearity	with OPF	53
Chrominance-luminance intermodulation		59

Plus SMS 2

Chrominance nonlinearity (1 MHz)	with OPF	55
	with ODF	57
Intermodulation	with MUF 2	77
	with LFM 2 and LDS	79

C. Measurements in sound channel (mono sound)

The following measurements can be carried out with the AM Sound Modulator SBUF-E2 in the SBUF:

	Page
Frequency response of amplitude	21
Harmonic distortion	23
Spurious modulation	25
Intermodulation distortion	27

D. Measurements in sound channel (dual sound)

The Sound Modulators SBUF-E2 and -E5 and the TV Dual-Sound Coder SBUF-E7 are required in the SBUF for these measurements. The following measurements can then be carried out:

Frequency response of amplitude	29
Amplitude and phase difference of channels in stereo operation	31
Channel and stereo crosstalk	33
Harmonic distortion	35
Spurious modulation	37
Intermodulation distortion	39

MEASUREMENTS ON BROADBAND COMMUNICATION SYSTEMS

Broadband communication systems These systems are able to transmit a multitude of sound and TV programs simultaneously via broadband cables to the receivers. These systems (previously designated as cable TV) receive the programs by a headend located at a site offering favourable conditions for reception, modulate them and feed them into cable networks (local programs transmitted via cable can also be fed in). The received programs can be transferred to local transmitters, remote terrestrial transmitters and also to satellites (satellite receiving system).

Broadband communication frequency bands The frequency range between 40 and 300 MHz is made available for the transmission of radio and TV programs in broadband communication systems as follows (illustration below):

Sound broadcasting:
- band II (87.5 to 108 MHz) 55 channels with 300-kHz bandwidth or 165 channels with 100-kHz bandwidth
- channels S2 and S3 (111 to 125 MHz) are intended for digital transmission of 16 high-quality stereo programs; programs from other broadcasting bands (medium frequency) can also be converted into the broadband communication channels.

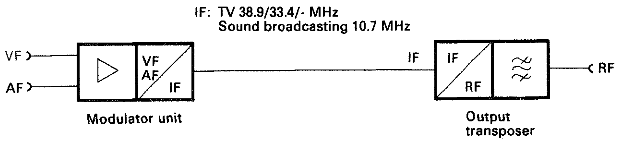
TV broadcasting: 30 (28) channels with 7-MHz bandwidth
- band I (47 to 68 MHz), channels 2 to 4
- CATV lower band (108 [125] to 174 MHz), channels S2 (S4) to S10
- band III (174 to 230 MHz), channels 5 to 12
- CATV upper band (230 to 300 MHz), channels S11 to S20
- band extension up to 440 MHz is intended.

Programs from bands IV/V are converted into the regular channels or into the special channels below or above band III. This can be performed by demodulation down to the baseband (as required for satellite signal reception because of the frequency modulation) or by conversion via the IF (TV transposer) for reception from terrestrial transmitters.

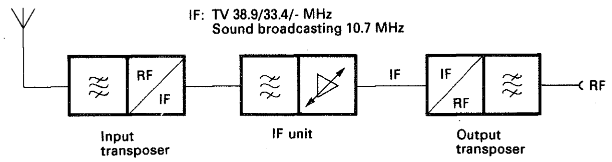
Selectivity requirements Due to the dense channel occupancy in broadband communication systems, the selectivity requirements for the transmitting (and also receiving) equipment are far more stringent — in particular in the TV channels — than with the conventional television, since the adjacent channel is as a rule occupied (whereas with TV transmitters and transposers this is the exception). This leads to special requirements for the high-frequency output spectrum and the noise immunity of frequency-converting units because the units are also used for conversions within the broadband communication systems.

Transmitting and receiving equipment Because of the direct application of the RF signals to the receivers, only very low transmitter powers (fractions of a milliwatt) are required at the inputs. There are three basically different designs of modulators:

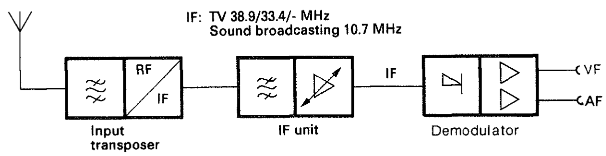
1. **Application of signals in the baseband range and conversion to RF** Used for directly applied programs (e.g. from local transmitters) and for satellite programs (which must be demodulated down to the baseband because of the different modulation method).
   These units are low-power **transmitters.**



2. **Application of signals at RF and conversion to a different RF** Used to receive distant transmitters and to feed in from radio links. (Usually with conversion via IF, sound transposers operate under difficult reception conditions also with conversion via the baseband.)
   These devices are low-power **transposers.**

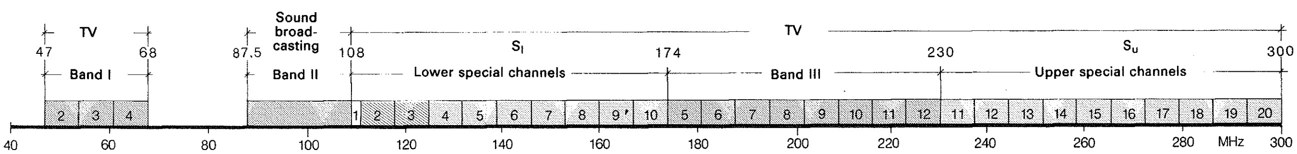


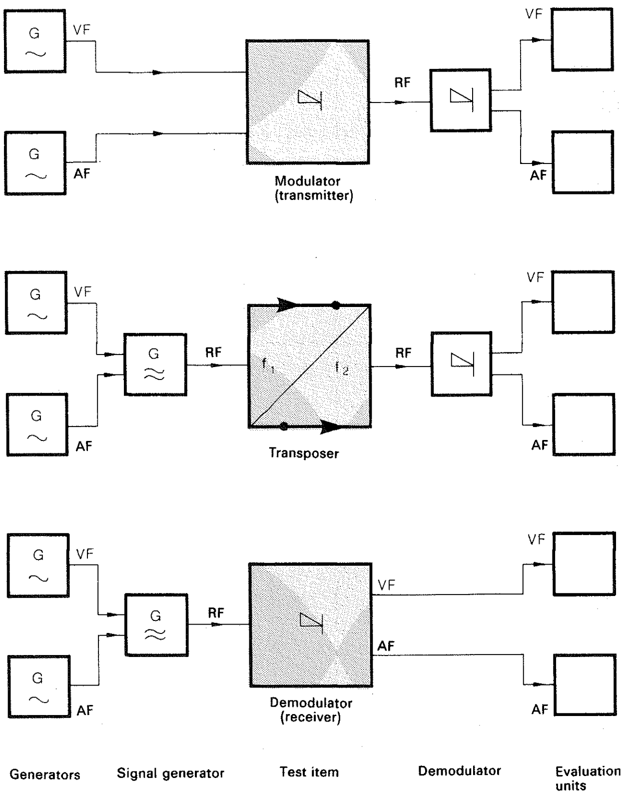
3. **Application of signals at RF and demodulation down to baseband** Used if RF signals from distant transmitters or from radio links are to be converted into a different RF range via the baseband.
   These devices are **receivers.**



The **output powers** of the transmitting and receiving equipment are defined in the standard specifications in dBpW (decibel referred to one picowatt [1×10^{-12} W]). The diagram on the opposite page shows the associated voltages in mV (rms values with sync value) and the levels in dBm (decibels referred to one milliwatt).

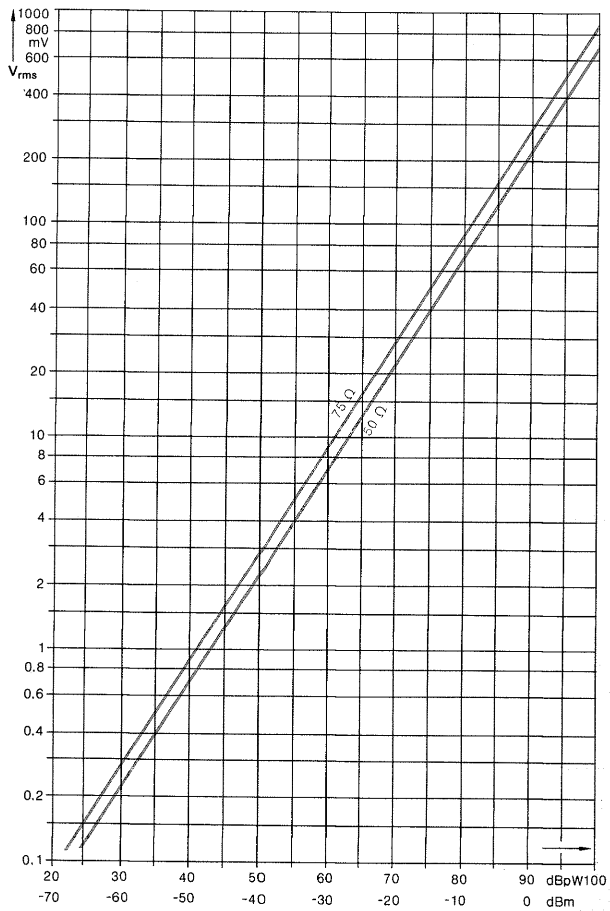
Channel allocation in broadband communication networks





Measurement of transmission characteristics of transmitting and receiving equipment (principle)

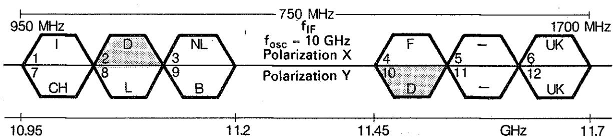
Power level and associated output voltage



Satellites At present the European communication satellites ECS 1, ECS 2 and Intelsat V are in use. These are distribution satellites for the international exchange of programs and operate with a relatively low transmit power. For the reception of frequency-modulated signals, large parabolic antennas with a diameter of approx. 3.7 m are required, so that mainly **commercial receiving stations** will be suitable (also for feeding the signals into broadband communication networks).

Launching of the satellites TV-Sat (FRG) and TDF-1 (France) with a higher transmit power is planned for 1987. A parabolic reflector with a diameter of 60 to 90 cm should be sufficient to enable **direct reception of TV programs.**

ECS and Intelsat V operate in the 11-GHz band, whereas TV-Sat and TDF-1 will operate in the 12-GHz band. Since many satellites are able to operate with two senses of polarization, frequency bands can be used twice. The ECS 1 has 12 channels (linear polarization) with 83-MHz spacing, two of which are provided for the Federal Republic of Germany. TV-Sat will have 5 channels with circular polarization in the band from 11.7 to 12.5 GHz with a channel spacing of 38 MHz and a channel width of ±13.5 MHz. The odd channels have right-handed polarization, the even channels left-handed polarization.



Downlink (transmission channels) of ECS 1 satellite, channel spacing 83 MHz

B Belgium	D Germany[1])	I Italy	UK Great Britain
CH Switzerland	F France	NL Netherlands	L Luxembourg

Satellite signal receiving systems These systems demodulate the received signal down to the baseband. They are measured like receivers. Modulators with a baseband input are used for feeding the satellite signals into broadband communication networks. The complete system can then be measured like a transposer. The design and the measurement of satellite signal receiving systems are described starting on p. 154.

[1]) The Federal Republic of Germany currently uses channel 3 (NL) because channel 2 does not transmit.

MEASUREMENTS ON TRANSMITTING AND RECEIVING EQUIPMENT FOR SOUND BROADCASTING SIGNALS

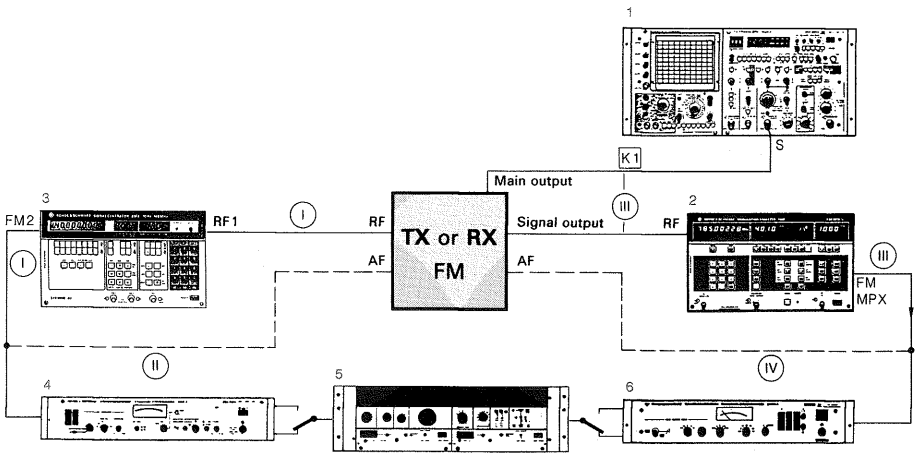
The characteristic of the transmitted sound signals (which determine the transmission quality) defined in the standard specifications are the same for all equipment. They are determined by comparing the sound signals at the input and output of the test item. A direct comparison of these signals is not possible with any of the various designs of equipment (transmitter, transposer, receiver) since the inputs and outputs have different frequency bands. It may be necessary to connect a signal generator with a modulating feature to the input which modulates the RF with the AF signals. It may be necessary to connect a demodulator to the output side which demodulates the AF signals from the RF. The adjacent table lists the requirements, the associated function diagram is on the previous page.

Equipment type	Input Frequency band	Additional device	Output Frequency band	Additional device
Transmitter	AF	—	RF	Demodulator
Transposer	RF	RF signal generator	RF	Demodulator
Receiver	RF	RF signal generator	AF	—

The additional devices may only have a very small inherent error since this error is transferred to the result. The measurements themselves largely correspond to those for transmitters and transposers. The high-quality devices available from Rohde & Schwarz are the stereo-compatible Signal Generator SMK (10 Hz to 140 MHz) and the Modulation Analyzer FAM (55 kHz to 120 MHz).

TRANSMISSION CHARACTERISTICS

The transmission characteristics of transmitting and receiving equipment for sound broadcasting signals are relatively easy to measure. The AF devices used are the AF Transmission Measuring Set SUN 2, the Precision Stereocoder MSC 2 and the Precision Stereodecoder MSDC 2. The Signal Generator SMK modulates the RF with the AF signals, the Modulation Analyzer FAM demodulates. Its broadband input only enables one frequency for measurement at a time. Therefore measurement following the output summing panel of a broadband communication system (many programs are already present simultaneously in this case) is not possible with the FAM. Measurement of the power at this point is possible using the TV Transcope MUF 2.



for	transmitter	transposer	receiver
1 TV Transcope MUF 2 (photo p. 104) S Selective demodulator	x	x	
2 Modulation Analyzer FAM (photo p. 87)	x	x	
3 Signal Generator SMK (photo p. 102)		x	x
4 Precision Stereo-coder MSC 2 (photo p. 18)	x	x	x
5 AF Transmission Measuring Set SUN 2 (photo p. 18)	x	x	x
6 Precision Stereo-decoder MSDC 2 (photo p. 13)	x	x	x

Measurement Procedure

A. Basic settings

Transmitter
(connections (II) and (III))
—

Transposer
(connections (I) and (III))

Receiver
(connections (I) and (IV))

1. Adjust SMK to receiver frequency of test item and set the voltage corresponding to the desired input power (from diagram on p. 139).
2. Modulation connection FM 2 (rear panel); press modulation EXTernal and FM kHz.
3. Connect FAM to signal output of test item. Press AUTO, FM, DEEMPHasis OFF and AF FREQuency. Connect output FM MPX to input of MSDC 2. —
4. MUF 2: calibrate selective demodulator using the precision cable K1 (p. 98) then connect to main output of test item. —

B. Calibration of measuring equipment

1. Initially connect SUN 2 AF generator directly (without stereocoder) to the modulation input of the test item or of the SMK. Settings on SUN 2: 500 Hz (reference frequency), level according to standard specifications (6 or 9 dBm).
2. Set a deviation of ±40 kHz on the test item (read deviation on dBm) or on the SMK; do not change this setting.
3. Connect stereocoder to circuit again and adjust to level as in B.1. without a pilot tone, then connect pilot tone. Do not change this setting. Adjust SUN 2 output level to 6 dBm.
4. Adjust stereodecoder using controls LEVEL such that a level of −9.5 dBm is displayed with the measurement-point selector in position PILOT. Do not change this setting.
   All further measurements must be carried out with these settings.

C. Measurement of power and transmission characteristics

	Page
1. Output power	103 (only transmitter and transposer)
2. Frequency response of amplitude, preemphasis	5
3. Harmonic distortion	7
4. Intermodulation distortion	11
5. Stereo crosstalk	13
6. Spurious modulation	9

On the pages listed, only Sections B. and C. apply in an analogous manner to receivers. To measure the AM spurious modulation with transmitters and transposers (p. 9, Sections D. and E.): switch FAM to AM and use AM output on rear panel. Carry out other measurements again in setting FM.

The following measurements can only be carried out with transposers and receivers.

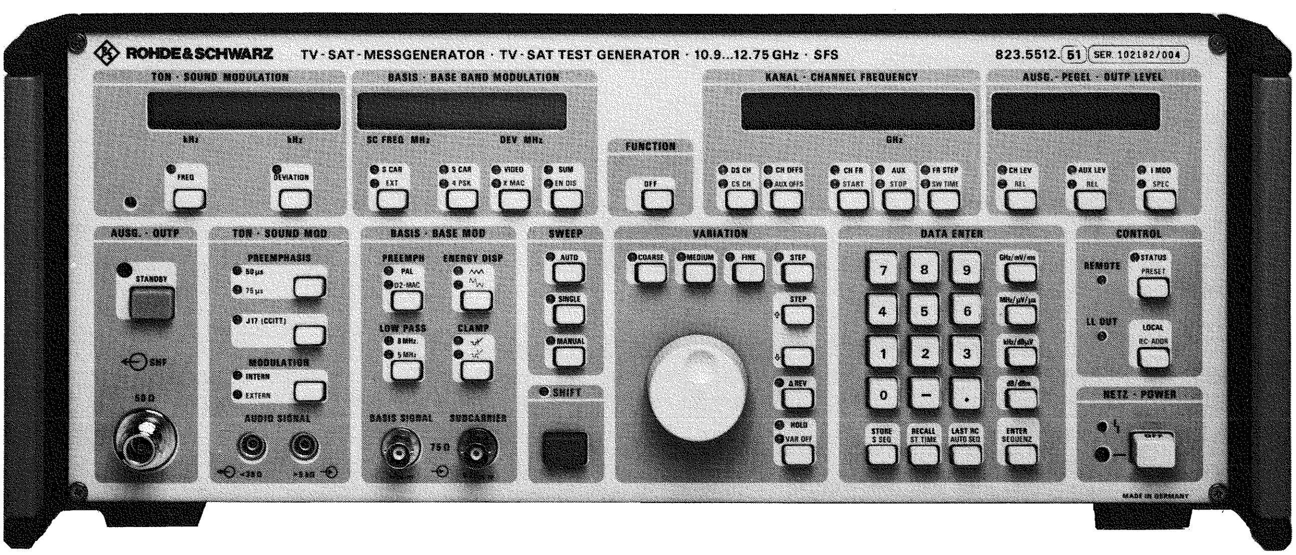
7. AM/FM conversion
   Press INTernal and AM% on SMK in addition and set to 1 kHz and 30%. FAM in position FM. Measurements as in 6. Subsequently set SMK again as previously (A.2.).
8. AGC response — 107
   Obtain the voltage (setting on SMK) corresponding to the desired input power from the diagram on p. 139.
9. RF noise voltage at input — 99
10. Antenna voltage — 99

RF REJECTION

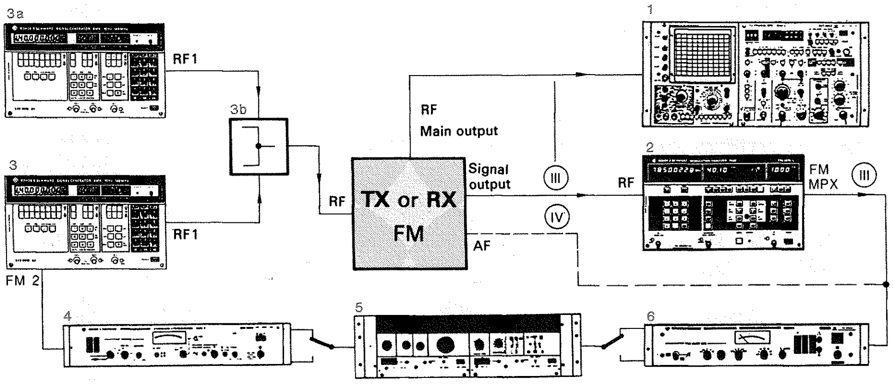
The dense occupation of the broadband communication frequency range means that transposers and receivers which process these frequencies must have a large RF rejection. The standard specifications define comprehensive measurements. The modulated signal of an interfering transmitter is added to the high-frequency signal of the useful transmitter and the influence of the former signal on the spurious modulation determined at the output of the test item.

This measurement largely corresponds to measurement of the dynamic selectivity with sound broadcasting transposers (p. 108).

TV Sat Test Generator SFS



RF REJECTION



1 TV Transcope MUF 2 (photo p. 104) — Only for transposer

2 Modulation Analyzer FAM (photo p. 87) — Only for transposer

3 Signal Generator SMK (photo p. 102), useful transmitter

3a Signal Generator SMK, interfering transmitter

3b Power Splitter/Combiner DVS (photo p. 88), (insertion loss approx. 3 dB)

4 Precision Stereocoder MSC 2 (photo p. 18)

5 AF Transmission Measuring Set SUN 2 (photo p. 18)

6 Precision Stereodecoder MSDC 2 (photo p. 13)

Measurement Procedure

A. Basic settings

Transposer (connection III) — Receiver (connection IV)

1. Adjust SMK (3, useful transmitter) as on p. 141, A.1. and 2. Take the insertion loss of the DVS into account with the voltage setting (in the diagram on p. 139, read a power increased by 3 dB).
2. Adjust SMK (3a, interfering transmitter) to a frequency which is 1 MHz away from the receiver frequency of the test item. Modulation: FM, INT, modulation frequency 1 kHz, deviation 75 kHz, output voltage approx. 10 mV. Then press RF OFF.
3. Connect FAM to signal output of test item. Press AUTO, FM, DEEMPHasis OFF and AF FREQuency. Connect output FM MPX to input of MSDC 2.
4. MUF 2: calibrate selective demodulator using precision cable K1 (p. 98), then connect to main output of test item.

B. Calibration of measuring equipment

1. Initially connect SUN 2 AF generator directly (without stereocoder) to modulation input of SMK. Settings on SUN 2: 500 Hz (reference frequency), level 6 dBm.
2. Adjust a deviation of ± 40 kHz on the SMK; do not change this setting.
3. Connect stereocoder to circuit again and adjust to 6 dBm (key) and pilot tone (-9.5 dBm). Do not change this setting.
4. Adjust stereocoder using controls LEVEL such that a level of -9.5 dBm is indicated with the measurement-point selector in setting PILOT. Do not change this setting.

C. Determination of RF rejection

1. With the interfering transmitter switched off, adjust the useful transmitter to the input power of the test item defined in the standard specifications. **(Caution:** take into account 3-dB insertion loss of DVS.)
2. Measure spurious FM as on p. 141, C.6. and note.
3. Adjust interfering transmitter to frequency and level values defined in the standard specifications and release RF OFF.
4. Measure spurious FM values and note.
5. Carry out measurement with all frequency and level values defined in the standard specifications.

MEASUREMENTS ON TRANSMITTING AND RECEIVING EQUIPMENT FOR TV SIGNALS

The characteristics of the sound and video signals defined in the standard specifications (which determine the transmission quality) are the same for all transmitting and receiving equipment. As with equipment for sound broadcasting signals, they are also determined in this case by comparing the signals, which may be demodulated, with the modulating signals (in this case AF and video frequency signals). Additional, special measurements are also required for the video signals. The basic measurement method is the same as for sound broadcasting signals. The fundamental considerations, the basic circuit diagram on p. 139 and the table on p. 140 also apply here.

TRANSMISSION CHARACTERISTICS

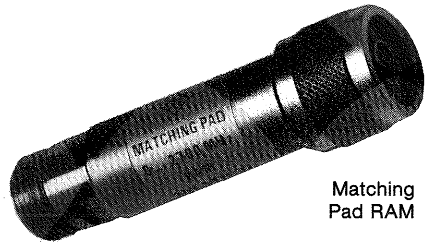
In the case of measurements on equipment for TV signals, the transmitter, transposer and receiver can be treated together as is also the case for equipment for sound broadcasting signals.

The TV Test Transmitter SBUF is used as the source which is equipped for measurement of the transmission characteristics in the dual-sound design with the following additional modules: FM Sound Modulator SBUF-E5, TV Dual-Sound Coder SBUF-E7 and the Video Generator SBUF-E6. The attenuation setting required on the SBUF for an output level in dBpW is shown in the diagram below.

The TV Transcope MUF 2 can be used to conveniently determine the output power of transmitters and transposers. The TV Oscilloscope OPF with its two loop-through filter inputs enables fast comparison of video input and output signals.

The CATV model of the TV Demodulator AMF 2 has a highly selective input with a synthesizer frequency setting. This also enables measurements on the output lines of broadband communication headends to which all programs are already fed.

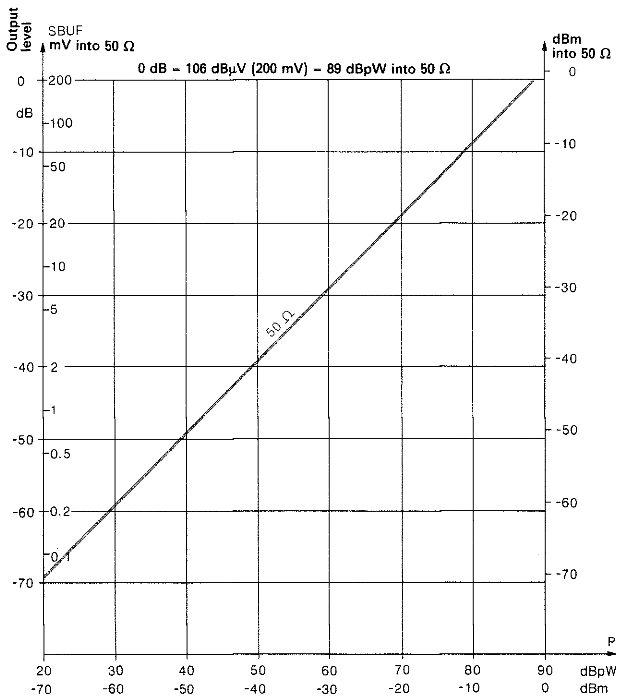
The TV Dual-Sound Demodulator FATF is used for exact examination of the sound channels and enables AM, FM and pilot tone measurements even with the vision carrier present.



Matching Pad RAM

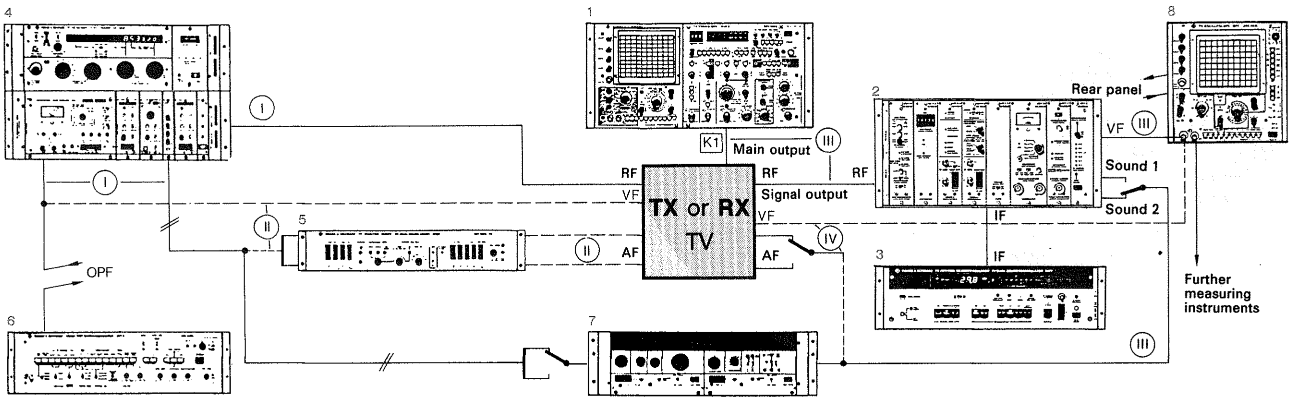
Legend for test setup on opposite page

	for transmitter	for transposer	for receiver
1 TV Transcope MUF 2 (photo p. 104)	x	x	
2 TV Demodulator AMF 2 (CATV)	x	x	
3 TV Dual-Sound Demodulator FATF (photo p. 22)	x	x	
4 TV Test Transmitter SBUF (photo p. 92) Dual-sound design with FM Sound Modulator SBUF-E5 Video Generator SBUF-E6 TV Dual-Sound Coder SBUF-E7		x	x
5 TV Dual-Sound Coder STCF (photo p. 30)	x	x	x
6 Video Test Signal Generator SPF 2 (photo p. 24)	x	x	x
7 AF Transmission Measuring Set SUN 2 (photo p. 18)	x	x	x
8 TV Oscilloscope OPF (photo p. 49)	x	x	x



Output power of SBUF as function of **total attenuation** (including the control GAIN 0 to −6 dB)

transmission times



Measurement Procedure

A. Basic settings

Transmitter	Transposer	Receiver
(connections Ⓘ and Ⓘ)	(connections Ⓘ and Ⓘ)	(connections Ⓘ and Ⓘ)

Transmitter (connections Ⓘ and Ⓘ)
—

Transposer / Receiver

1. Adjust SBUF to receiver frequency of test item (see p. 123) and adjust attenuation according to desired input power (see diagram opposite).
2. Modulation connections as on p. 137.

3. Connect input of AMF 2 to signal output of test item and adjust to its output frequency. Set RF input 50 Ω, INPut ATTENUATOR 6 dB and AUTO. Connect IF output of AMF 2 to IF input of FATF.
4. Connect video output of AMF 2 to OPF; set TRIGGER H, 75 Ω, 0.2 V/DIV and 10 μs/DIV on latter. To connect further devices to the front loop-through filter of the OPF, release the key 75 Ω.
5. MUF 2: calibrate selective demodulator using the precision cable K1 (p. 98), then connect to main output of test item.
6. Connect output of SPF 2 via the rear loop-through filter of the OPF to the test item or the vision modulator input of the SBUF. Switch on 75 Ω.
7. Adjust SUN 2 AF generator to 500 Hz and +6 dBm and connect to input of SBUF or STCF. Connect level meter to sound output of AMF 2 or of test item.

B. Calibration of measuring equipment

1. Select 15-kHz squarewave and H+V on the Video Test Signal Generator SPF 2.
2. Determine output power using MUF 2 (see p. 123).

2. Connect AMF 2 input directly to SBUF output (only for this calibration). Tune to SBUF frequency.

3. Connect SUN 2 AF generator to the sound channel inputs of the STCF (setting 2-sound) or SBUF and adjust test item or SBUF to a deviation of 30 kHz. Read on FATF.
Carry out all further measurements with this setting.

C. Measurement of transmission characteristics

Sound channels		**Mono sound**	**Dual sound**
1. Frequency response of amplitude/preemphasis	**Page**	21	29
2. Harmonic distortion		23	35
3. Intermodulation distortion (SUN/2S in addition)		27	39
4. Spurious modulation		25	37
5. Channel and stereo crosstalk			33

Vision channel

The switchover facility between FRONT and REAR on the OPF enables direct comparison of the input and output signals.

		Further devices
6. Level stability and sync pulse reduction	41	
7. Tilt and rounding	43	
8. Transient response (15/250 kHz)	45	
9. 2T pulse and bar signal	49	
10. Spurious modulation	65	UPSF 2
11. Intercarrier interference ratio	63	
12. Differential gain/phase	67	PVF
13. Video amplitude characteristic/frequency response of group delay	73	LFM 2

The following measurements can only be carried out with transposers and receivers.

14. AGC response — 133
The attenuation corresponding to the desired input power can be obtained from the diagram opposite.
15. RF noise voltage at input/antenna voltage — 115

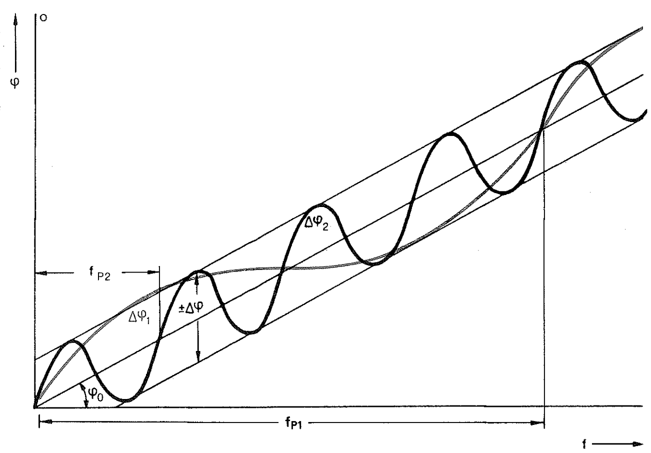
FREQUENCY RESPONSE OF GROUP DELAY (equipment with surface wave filters)

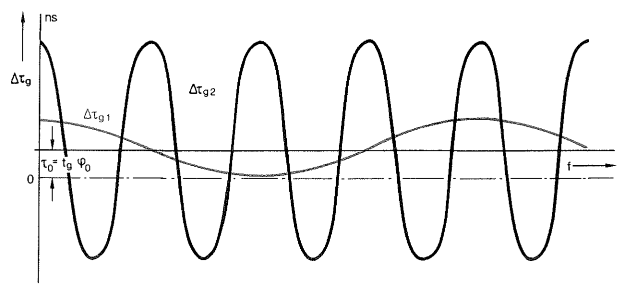
Because of the high selectivity requirements in demodulators for broadband communication systems, **surface acoustic wave** (SAW) filters are used instead of common vestigial sideband filters made of discrete components as used with transmitters. The group delay response of these filters is greatly different from conventional filters, and it is therefore advisable to critically consider the previous method of measurement.

Theory of group delay measurements As explained on p.72, group delay is defined as the differential ratio of phase angle to frequency:

$$\tau_g = \frac{d\varphi}{d\omega}.$$

The delay correctors used together with the filters made of discrete components cause periodic oscillations of the phase angle around the ideal response (straight line through zero) in the transmission band. The SAW filters also generate such oscillations and in far larger numbers. The period of these oscillations has a great influence on the group delay. The following diagram shows that the group delay — which is subject to tight tolerances as the most important transmission variable — also depends on the frequency f_p of the phase oscillations.

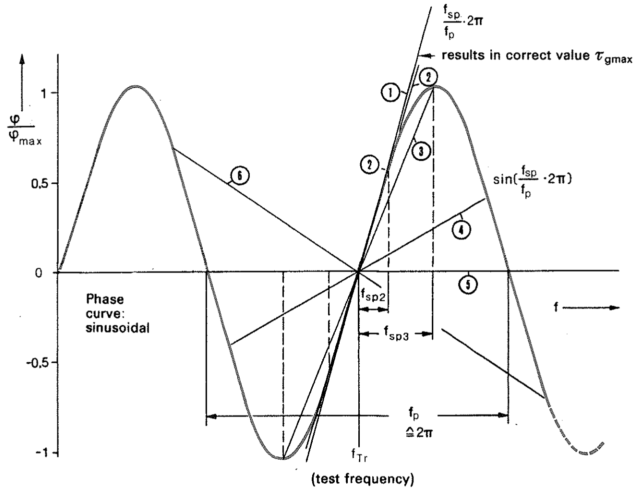




Phase (top) and group delay frequency response (bottom) with same magnitude of phase oscillation but with different periods (f_p is oscillation frequency)

Thus a SAW filter with a low frequency f_p and a correspondingly large number of oscillation periods in the transmission band would also exceed the permissible group delay limits even for small phase oscillations. It is the phase oscillation, and not the group delay, which is the important factor in the perception of noise.

The group delay is therefore determined because its measurement is simpler than a direct phase measurement. The difference ratio of the probe frequency f_{sp} is determined (p.72) and not the differential ratio. This must be significantly smaller than the oscillation frequency f_p of the phase oscillations so that the group delay can still be measured sufficiently accurately (see following diagram).



Relationship between probe frequency f_{sp}, oscillation frequency f_p and displayed group delay τ'_{gmax} (maximum group delay)

f_{Tr} carrier frequency of measuring equipment

$$\frac{\tau'_{gmax}}{\tau_{gm}} = \frac{\sin((f_{sp}/f_p) \cdot 2\pi)}{(f_{sp}/f_p) \cdot 2\pi}$$

$\frac{f_{sp}}{f_p}$: ① = 0, ② = 0.1, ③ = 0.28, ④ = 0.44, ⑤ = 0.5, ⑥ = 0.6

With a sinusoidal phase oscillation — as is the case with SAW filters — the probe frequency should not be more than 10% of the oscillation frequency (f_{sp2}). Larger values (③ to ⑥) yield completely nonrealistic results (incorrect gradient of straight lines).

The **Group-delay Measuring Set LFM 2** from Rohde & Schwarz with a probe frequency of 20 kHz satisfies this condition (the oscillation frequency of commercial SAW filters is approx. 200 kHz). The frequency response of the group delay can therefore be measured reliably using this set.

Tolerance scheme for phase oscillations[1] The frequency response of the group delay may exceed the permissible tolerance limits with the fast phase oscillations of SAW filters even though the phase oscillations important for noise perception are sufficiently small. Rohde & Schwarz has therefore developed a tolerance scheme for phase oscillations. The phase curve is then obtained from the group-delay curve by integration and rotated appropriately (frequency-proportional subtraction) such that it passes through zero with a video frequency of zero and a colour-subcarrier frequency of 4.43 MHz (or in the RF band at the vision-subcarrier frequency and a frequency higher by 4.43 MHz). It is thus matched to a tolerance scheme which is shown opposite.

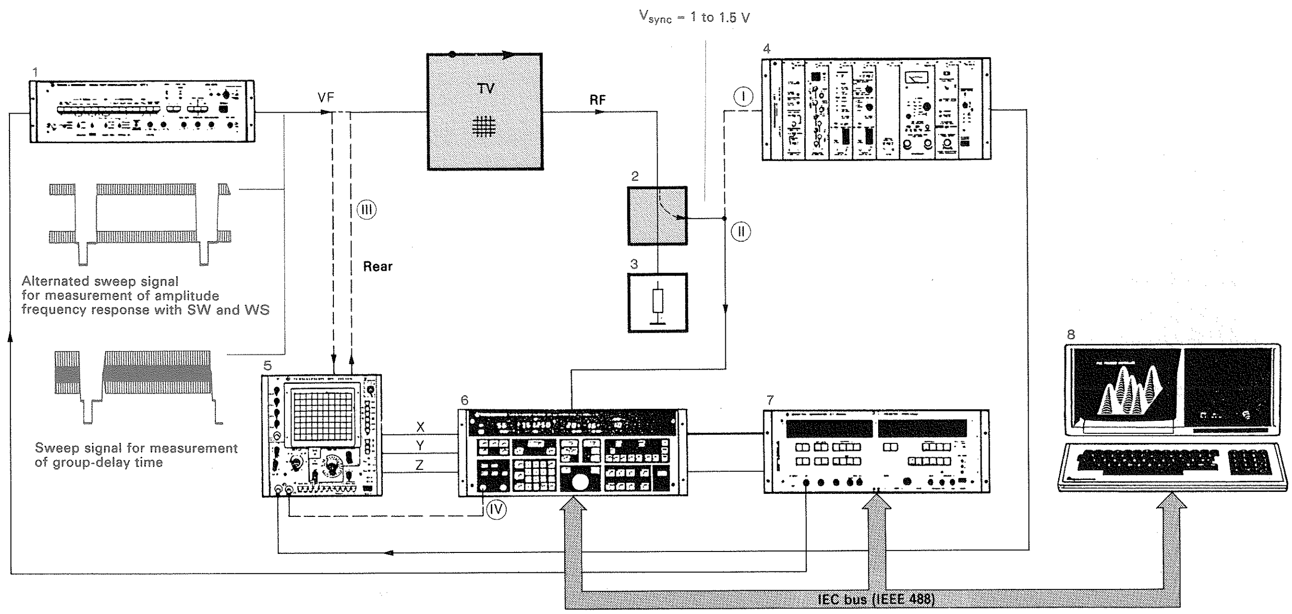
Computer-controlled measurement The operations described above are contained in a program produced by Rohde & Schwarz for the **Process Controller PUC.** Because the LFM 2 and the Selective Demodulator LDS required for this measurement have IEC-bus connectors, the associated phase curve can be immediately calculated for group-delay measurements and output.

The setup required is shown opposite. The diagrams below show the frequency response, delay and phase curves of units with conventional VSB filters and, as a comparison, those with SAW filters. In addition to the TV Oscilloscope OPF (used in the setup opposite according to the description on p.75), the TV Digital Oscilloscope ODF is also suitable for the measurement because of its high accuracy. The setup and operation are then analogous to p.95.

[1]) Ebersberger, G., Strössenreuther, W.
TV signal distortions resulting from SAW filters ...
RTM 31 (1987), Vol. 1.

FREQUENCY RESPONSE OF GROUP DELAY

(equipment with surface wave filters)



1 Video Test Signal Generator SPF 2 (photo p. 24) or Insertion Signal Generator SPZF (photo p. 25)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36) or AMF

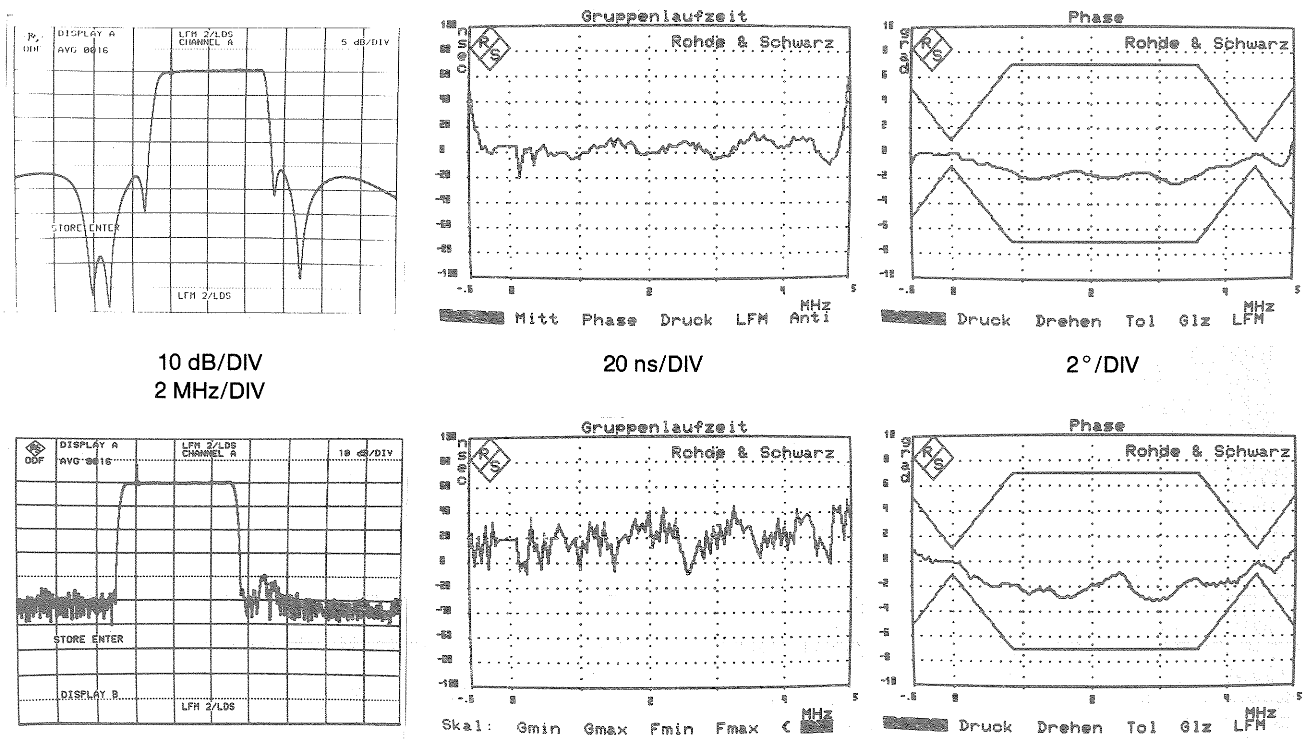
5 TV Oscilloscope OPF (photo p. 49) or TV Digital Oscilloscope ODF (photo p. 56) (with connection cable ODF — LDS, Order No. 373.8956.00)

6 Selective Demodulator LDS (photo p. 62)

7 Group-delay Measuring Set LFM 2 (photo p. 61)

8 Process Controller PUC (photo p. 99)

IF equipment with conventional VSB filter (top row) and broadband communication equipment with SAW filter (all curves recorded using TV Digital Oscilloscope ODF)



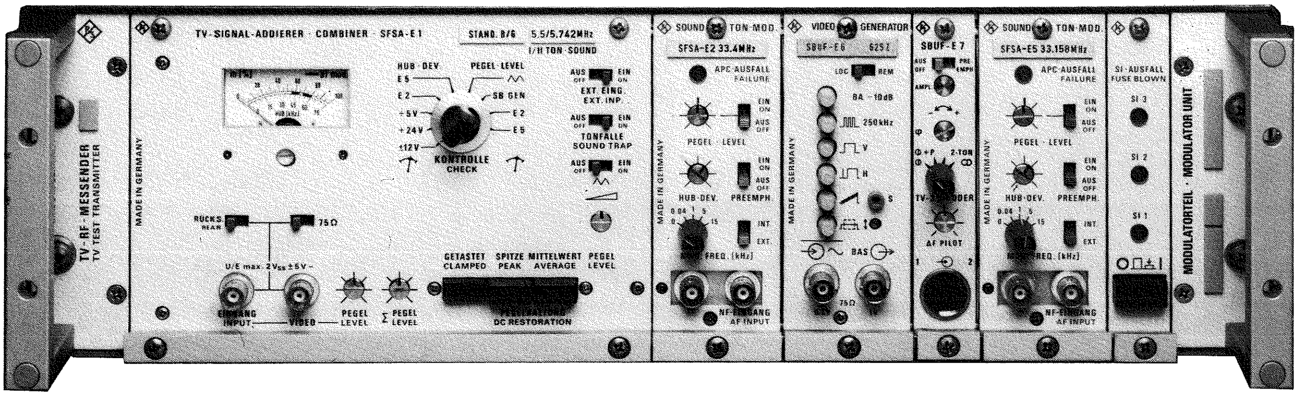
INTERMODULATION

(transmitter, transposer, receiver)

Intermodulation is determined most suitably for broadband communication transmitters, transposers and receivers using the **three-source method.** The method is easily applicable because of the low power of broadband communication equipment and is essential for the required large intermodulation. With the use of standard signals, the spectrum of the line pulses would otherwise make the measurement extremely difficult. The levels of the vision and sound carriers required for the measurement as well as the sideband can be directly selected on the TV Test Transmitter SBUF with the Sideband Generator SBUF-E3 and Program Selector SBUF-E4. The program IM/K with −8/−16/−10 dB is provided for measurements on TV transposers and transmitters and also for level of the interfering transmitter when measuring the RF rejection of broadband communication equipment (p. 150). The program IM/B with −3/−20/−10 dB is used for intermodulation measurements on broadband communication equipment.

In the case of transmitters and transposers, the levels of the individual frequencies (VC, SB, SC) must be set following a measurement at the RF output; they can be determined using the **TV Transcope MUF 2** which is also used for the evaluation. It is appropriate to apply the input signals with transmitters at the IF (from the modulator unit of the SBUF). Input of the signals at video frequencies is usually only possible with line pulses. The measurement is made at the output of the IF unit in the case of broadband receivers and the levels of the three frequencies at this point are therefore decisive for the setting.

TV-Sat Base Signal Combiner SFSA

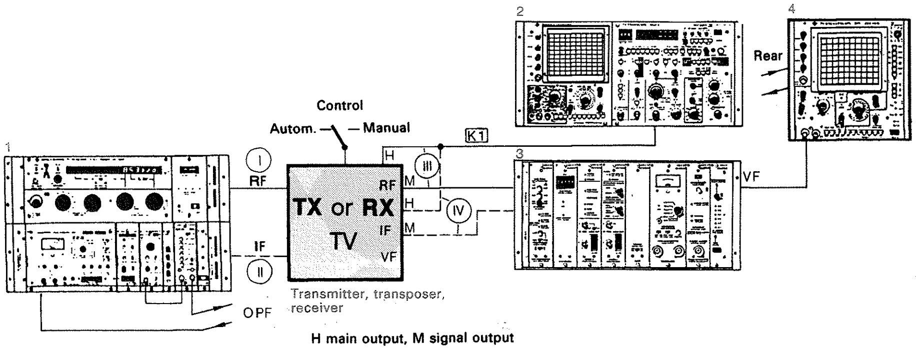


INTERMODULATION

TX or RX TV

transmission times

(transmitter, transposer, receiver)



1 TV Test Transmitter SBUF (photo p. 92) with modules:
— S Sideband Generator SBUF-E3
— P Program Selector SBUF-E4
— V Video Generator SBUF-E6

2 TV Transcope MUF 2 (photo p. 104)

3 TV Demodulator AMF 2 (CATV model)

4 TV Oscilloscope OPF (photo p. 49)

K1 Precision test cable

Measurement Procedure

A. Basic settings

Transmitter (connections (II) and (III))

1. Connect IF output of SBUF modulator unit to IF input of test item ((II)).

Transposer (connections (I) and (III))

1. Connect RF output of SBUF to RF input of test item ((I)). Set attenuation according to desired input power (see diagram on p. 144). Adjust SBUF to receive frequency of test item (p. 123).

Receiver (connections (I) and (IV))

Transmitter and transposer:

2. Connect RF main output of test item to selective demodulator input of MUF 2 via precision cable K1 ((III)).

Receiver:

2. Connect IF main output of test item to selective demodulator input of MUF 2 via precision cable K1 ((IV)).

All:

3. Connect right-hand video generator output of SBUF to the vision modulator input of the SBUF via the loop-through filter at the rear of the OPF. Switch on 75 Ω. Connect output of sideband generator to video generator input.

Transmitter and transposer:

4. AMF 2: connect RF input to RF signal output of test item ((III)). Adjust output frequency of test item and set RF, AUTO and INPut ATTENUATOR 6 dB.

Receiver:

4. AMF 2: connect IF input to IF signal output of test item ((IV)). Set IF, AUTO and INPut ATTENUATOR 6 dB.

All:

5. Connect front input of OPF to video output of AMF 2. Adjust 0.1 V/DIV and 10 μs/DIV on OPF.

B. Calibration of measuring equipment

1. Press key DYNamic PROGRam on SBUF program selector and press 15 kHz on SBUF video generator.
2. The modulator input signal appears on the OPF (press H and REAR) or the output signal of the test item (press 75 Ω and H, release REAR).
3. Measure output power using MUF 2 (p. 123).

   Receiver: 3. Measure IF output power using MUF 2 (p. 123).
4. Switch test item to manual control and adjust same power — or possibly the power defined for this measurement in the standard specifications — according to the level line.

C. Determination of intermodulation

1. Press program key IM on SBUF program selector (vision carrier 0 dB, sound carrier −10 dB).
2. Switch selective demodulator of MUF 2 to SWEEP, →, LOG and LEVEL. Set sweep to 1 MHz/DIV, bandwidth to 30 kHz and long sweep time. Centre display using TUNING FINE. Set level line to peak of vision carrier and press ΔdB. The display becomes 0 dB.

   Note After pressing DYNamic PROGRam on the SBUF program selector, the V pulses must reach the level line at the peak of the vision carrier.
3. Select IM/B on the SBUF program selector. The level values (VC −3 dB, SB −20 dB, SC −10 dB) should correspond to the setting IM2 (DBP) on p. 76. Correct if necessary using the level controls on the modulator unit of the SBUF.
4. The levels of the various frequencies and the various intermodulation products can now be measured using the level line on the screen of the MUF 2.
5. The sideband frequency can be varied within the video band using the sideband generator.

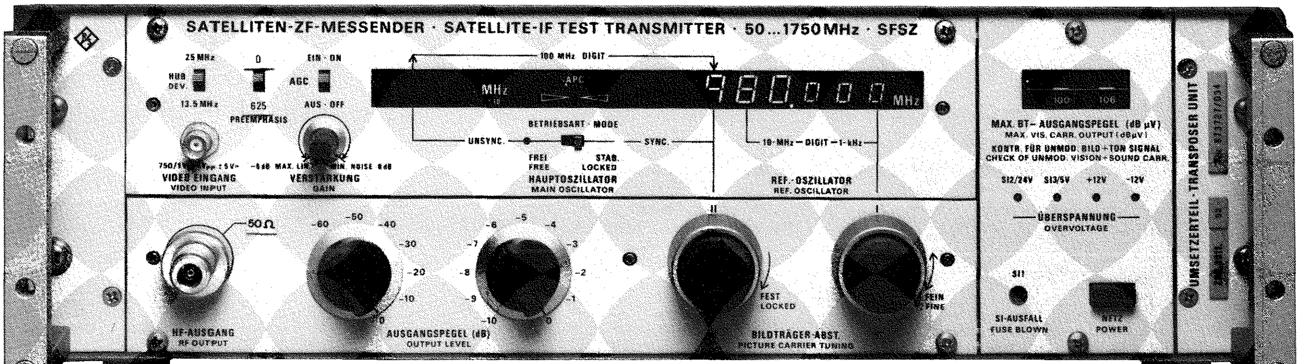
RF REJECTION

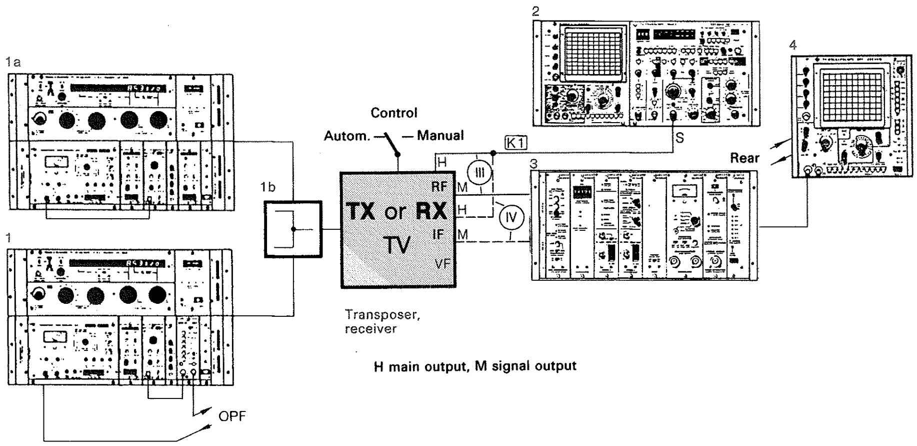
(transposer, receiver)

Measurement principle Units which operate with RF input signals (transposers and receivers) are subject to a large variety of standard specifications because of the dense occupation of channels in broadband communication systems. A modulated or unmodulated TV signal is applied to the test item in the adjacent channel in addition to the useful signal in the operating channel. The signal levels are defined in the standard specifications. The resulting combination frequencies in transposers should be measured using a frequency analyzer. Because of the large level ratios required, only equivalent signals without sync pulses can be used just as in the case of intermodulation measurements. Receivers are measured at the IF, as for intermodulation measurements.

The **TV Test Transmitter SBUF** with the Sideband Generator SBUF-E3 and Program Selector SBUF-E4 is highly suitable as the transmitter for useful and interfering signals.

Satellite IF Test Transmitter SFSZ (model without sweep facility)





1 TV Test Transmitter SBUF (photo p. 92) as useful transmitter with modules:
— S Sideband Generator SBUF-E3
— P Program Selector SBUF-E4
— V Video Generator SBUF-E6

1a As 1 (SBUF-E6 not required), as interfering transmitter

1b Power Splitter/Combiner
0.1 to 400 MHz: DVS (photo p. 88)
10 to 1000 MHz: model H-8-4 from Anzac[1])

2 TV Transcope MUF 2 (photo p. 104)

3 TV Demodulator AMF 2 CATV design

4 TV Oscilloscope OPF (photo p. 49)

K1 Precision test cable

Measurement Procedure

A. Basic settings

Transposer (connections Ⓘⅈⅈ) — **Receiver** (connections Ⓥ)

Transposer (connections III) | Receiver (connections IV)

1. Connect SBUF outputs to RF input of test item via the power splitter/combiner (take into account insertion loss of 3 dB. Enter attenuation into SBUF reduced by 3 dB compared to result from diagram on p. 144). Adjust useful transmitter to receive frequency of test item (p. 123).
2. Connect video generator output of useful source to the vision modulator input via the rear loop-through filter of the OPF.

Transposer:

3. MUF 2: connect selective demodulator input to RF main output of test item via the precision cable K1 (III).
4. Connect RF input of AMF 2 to RF signal output of test item (III). Set RF, AUTO and INPut ATTENUATOR 6 dB.

Receiver:

3. MUF 2: connect selective demodulator input to IF main output of test item via precision cable K1 (IV).
4. Connect IF input of AMF 2 to IF signal output of test item (IV). Set IF, AUTO and INPut ATTENUATOR 6 dB.

5. Connect front input of OPF to video frequency output of AMF 2.

B. Calibration of measuring equipment

Switch off interfering source and proceed as on p. 149, B.1. to 4.

C. Determination of RF rejection

1. Set useful source as on p. 149, C.1. and 2.
2. Switch on interfering source again and adjust to frequency defined in the standard specifications.
3. Adjust the levels (IM, IM/K or IM/B) and the input level of the test item (take into account insertion loss of 3 dB) specified in the standard specifications on both test transmitters.
4. Use the MUF 2 to measure the useful signals and the interfering frequencies caused by the interfering transmitter according to the demands in the standard specifications. Bandwidth 30 kHz, long sweep time.

[1]) German agent:
Omecon Electronic GmbH
Jaegerweg 8
D-8012 Ottobrunn
Telephone: 089/6094084

RF S/N RATIO (transposer)

Measurement principle In contrast to measurement of the noise figure F_{dB} or the noise factor required for transposers (p. 134), the standard specifications define measurement of the **RF S/N ratio** for broadband communication transposers. It is defined as the logarithmic ratio of the useful power to the noise power at the transposer output:

$$a_{nRF} = 10\log\frac{P_2}{P_{2n}}\ .$$

This measurement can be carried out using a frequency analyzer, e.g. the TV Transcope MUF 2 from Rohde & Schwarz. The value obtained must be converted because the analyzer bandwidth is different to the noise bandwidth of the transposer. It is additionally necessary to take the detector characteristics of the analyzer into consideration. The following applies to the MUF 2:

Noise bandwidth on transposer	$\Delta f_c = 8$ MHz
Analyzer bandwidth of MUF 2	$\Delta f_A = 300$ kHz
Conversion factor	$k = \dfrac{8 \times 10^6}{3 \times 10^5} = 26.67 = 14.2$ dB.

The RF S/N ratio is reduced by this factor because of the larger noise bandwidth of the transposer and the resulting increased noise power. A further reduction also results because the detector circuit of the analyzer does not fully evaluate the noise peaks. This factor is 3 dB for the MUF 2. The conversion is therefore:

$$a_{nRF} = a - 17.2\ [\text{dB}]$$

where a is the S/N ratio measured using the MUF 2.

Determination from noise factor The RF S/N ratio can also be determined from the noise factor whose measurement is described on p. 134. The equivalent noise power at the input is:

$$R_{1n} = F\,k\,T_0 \cdot \Delta f.$$

Referred to the noise bandwidth $\Delta f = 8$ MHz and the absolute temperature $T_0 = 290$ K (17 °C) results in:

$$P_{1n} = F \times 3.2 \times 10^{-14}\,\text{W}\ (= F \times 3.2 \times 10^{-2}\,\text{pW}).$$

Since both the noise power P_{1n} and the signal power P_1 pass through the same amplifier (same gain, same bandwidth), the following also applies:

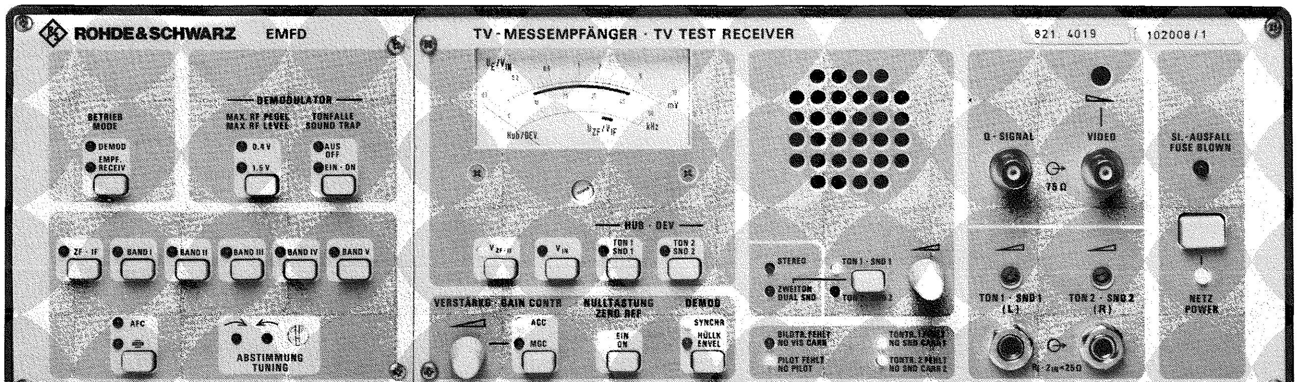
$$\frac{P_1}{P_2} = \frac{P_2}{P_{2n}} = \frac{P_1}{F \times 3.2 \times 10^{-14}\,\text{W}}\ .$$

When the logarithm is taken and referred to one picowatt (according to the broadband communication standard specifications), the following is obtained:

$$a_{nRF} = P_{1[dBpW]} + 15 - F_{dB}.$$

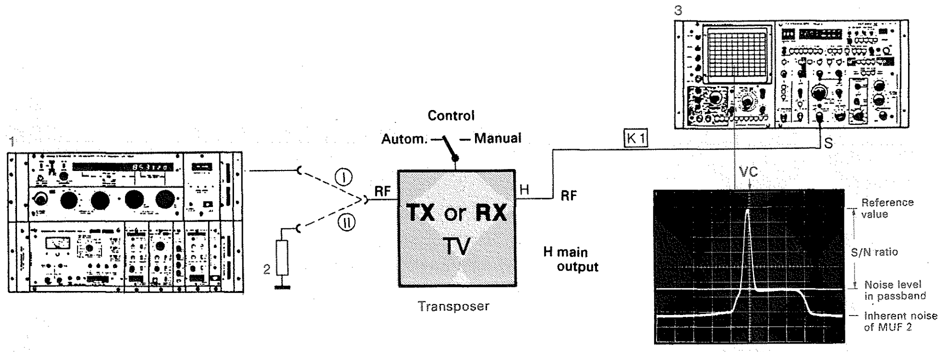
The video-frequency S/N ratio is 4.1 dB below the RF S/N ratio.

TV Test Receiver EMFD



RF S/N RATIO

(transposer)



RF S/N ratio of a TV transposer

1 TV Test Transmitter SBUF (photo p. 92) with modules:
- — S Sideband Generator SBUF-E3
- — P Program Selector SBUF-E4
- — V Video Generator SBUF-E6

2 Termination RNB (photo p. 110), 50 Ω

3 TV Transcope MUF 2 (photo p. 104)

K1 Precision test cable

Measurement Procedure

A. Basic settings

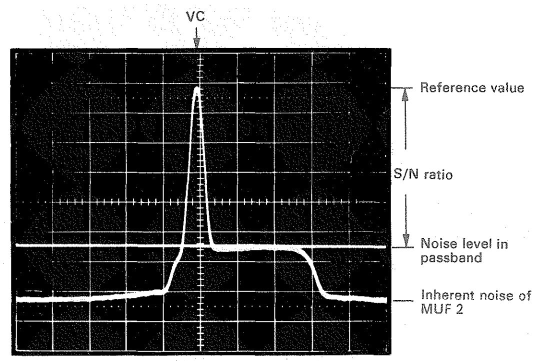
1. Connect SBUF to RF input of test item (Ⓘ).
2. Connect MUF 2 selective demodulator to main output of test item via precision cable K1.

B. Calibration of measuring equipment

1. Calibrate MUF 2 (p. 98).
2. SBUF: set receive frequency of test item (p. 123). Switch on attenuation according to desired output power (diagram on p. 144).
3. Press key IM on SBUF program selector. Switch off sound modulator.
4. Tune MUF 2 in analyzer mode to output frequency of test item and measure output power (p. 123).

C. Determination of RF S/N ratio

1. MUF 2: select bandwidth 300 kHz; set selective demodulator to LOG and sweep to 2 MHz/DIV. Switch on VIDEO FILTER.
2. Set peak of vision carrier to second graticule line from top and adjust level line to peak. Press ΔdB (display: 0 dB).
3. Switch test item to manual control and adjust same output power according to level line.
4. Disconnect input of test item from SBUF and terminate with 50 Ω (Ⓘ).
5. Adjust level line to noise base. Convert the value output on the display according to the following equation:
   $a_{nRF} = a - 17.2$ [dB] (see opposite page)
   where a output on display,
   a_{nRF} RF S/N ratio.
6. Repeat measurement at input powers defined in standard specifications.



RF S/N ratio of a TV transposer

MEASUREMENTS ON SATELLITE SIGNAL RECEIVING SYSTEMS[1])

Design Satellite signal receiving systems comprise an outdoor unit (parabolic antenna, orthogonal-mode transducer and receiver converter) and an indoor unit (IF distributor and receiver unit). An additional cable amplifier is used in the case of long cable runs between the outdoor and indoor units (see basic circuit diagram below).

The outdoor unit converts the received signals in the low-noise converter (LNC) into the first IF (950 to 1750 MHz). The orthogonal-mode transducer separates the programs which are transmitted with different polarizations. The first IF is broadband amplified in the IF distributors of the indoor unit and distributed to 4 outputs (and an equivalent test output). The receiver units filter out the required receiver channel, amplify it and demodulate it to the baseband which contains the video frequency and the frequency-modulated sound carriers. The latter are demodulated in special sound demodulators down to AF. Modulators with video frequency and AF inputs (transmitter) are used to feed broadband communication distribution networks.

Measurements on these systems can be made with the receiver energy applied at different points:

1. In the SHF band using a small transmitting antenna directly into the parabolic antenna of the receiving system
2. In the SHF band into the input of the receiver converter
3. In the UHF band into the input of the IF distributor or the IF receiver units.

The first two methods are difficult to carry out with existing installed systems and are therefore used only seldomly. With the measurement as in 1., the positions of the parabolic antenna would have to be changed to avoid the influence of the satellite. The IF receiver unit would have to be mistuned if the measurement were made at a different frequency.

A measurement as in 2. is important for test departments and laboratories, especially for examining the LNC converter for which standard specifications are available. Since the outdoor unit is fed during operation from the IF distributors of the indoor unit via the IF cable, additional equipment is required to apply the operating voltages when measuring the LNC and cable amplifier as individual units.

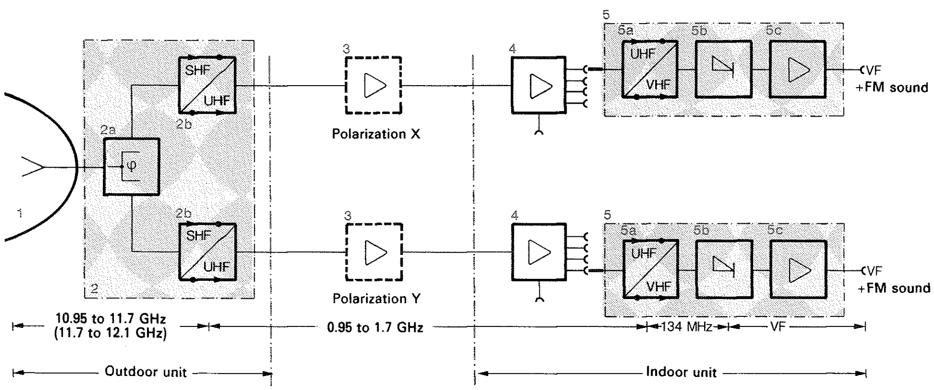
Measurement as in 3. enables simple testing of the indoor unit of the receiving system which is mainly responsible for the quality.

[1]) The characteristics of the satellites to be received have already been described on p. 139. A list of the currently used transmitting channels of ECS and Intelsat V is on p. 156, a list of the methods used for sound transmission is on p. 166.

FREQUENCY RESPONSE OF AMPLITUDE (low-noise converter)

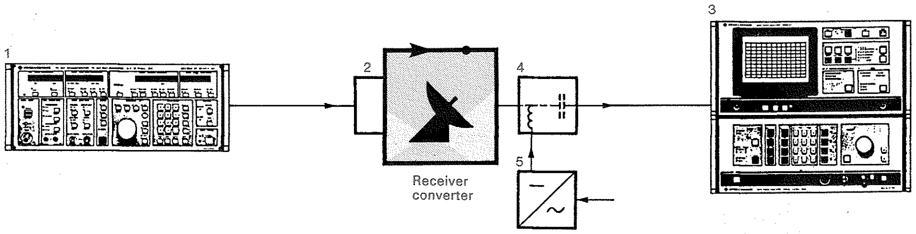
Rohde & Schwarz provides the TV-Sat Test Generator SFS for measurements in the SHF band, and the Satellite IF Test Transmitter SFSZ in the UHF band (both can be swept). The TV-Sat Base Signal Combiner SFSA combines the video frequency channel and the sound channels (e.g. mono signal, left and right information) and provides them to the SFSZ for modulation.

In order to examine the LNC, the SFS — which has special equipment for intermodulation measurements — is used together with the Spectrum Analyzer FSA (100 Hz to 2 GHz). These instruments can be used to measure the frequency response of the amplitude in the total range and in the receiver channels of interest.



Basic circuit diagram of a satellite signal receiving system The design is shown for reception of the ECS using two polarization directions (only the design for one polarization direction is required for reception of Intelsat V)

1 Parabolic antenna
2 LNC (fixed to antenna) with
 2a Orthogonal-mode transducer
 2b SHF/UHF transposer (1× per polarization direction)
3 Equalized cable amplifiers (only if required)
4 IF distributors with 4 (5) equivalent outputs
5 IF receiver unit for one receiver channel (4 or 5 per polarization direction) with
 5a UHF/VHF transposer
 5b FM demodulator
 5c Output amplifier



1 TV-Sat Test Generator SFS (photo p. 142) with N-to-SMA adapter
2 SMA-to-R120 adapter
3 Spectrum Analyzer FSA (photo p. 114), 100 Hz to 2 GHz
4 Separating filter (Order No. 670.8887.02)
5 Power supply unit 5 to 15 V (e.g. NGM 15 from Rohde & Schwarz or similar)

Measurement Procedure

A. Basic settings

1. Connect SHF input of LNC with adapters to the TV-Sat Test Generator SFS. Connect IF output of converter to Spectrum Analyzer FSA via a separating filter. Apply the operating voltage to the converter via this separating filter.
2. Settings on FS:
   Note The keys at the bottom edge of the screen are softkeys whose functions are displayed on the screen via menus and which are adjusted using the hardkeys (fixed functions). A coloured marker over a softkey indicates that the associated value must be entered.
3. Press FREQUENCY. The associated menu appears on the screen. Press softkey START MANUAL and enter start frequency (e.g. 900 MHz) on the keyboard. The value is displayed on the screen. (With an oscillator frequency of 10.0 GHz in the converter, this value corresponds to an SHF of 10.9 GHz.)
4. Press softkey STOP MANUAL and enter stop frequency (e.g. 1900 MHz corresponding to an SHF of 11.9 GHz). This frequency, the span, centre and sweep are displayed on the screen.
5. Press TRACE and softkey MAX HOLD.
6. Press REF LEVEL, softkey REF LEV is marked. Enter the reference level (e.g. −10 dBm) on the keyboard. The value appears at the top left above the grid.
7. Press LEVEL RANGE and the softkeys LOG RANGE 20 dB and GRID ABS. The grid on the screen is now scaled from −10 to −30 dBm (for an average converter gain of 50 dB; see 13. with an input level of −70 dBm).

Settings on SFS:

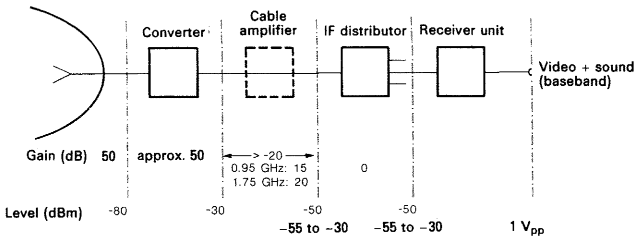
8. Press S CAR (subcarrier) and OFF.
9. Enter start frequency: press SHIFT and START. Enter value on keyboard (e.g. 10.9 GHz, see remark for 3.). The start frequency is output on the display.
10. Enter stop frequency: press SHIFT and STOP. Enter value (e.g. 11.9 GHz). The stop frequency is output on the display.
11. Enter step size: press RF STEP and enter value (e.g. 2 (10) MHz). The step size is output on the display.
    Note The generator does not sweep continuously, but in steps (synthesizer) of approx. 50 ms. The entered data result in 500 (100) steps, and it therefore takes approx. 25 (5) s until the curve has been completely produced.
12. Press SWEEP AUTO.
13. Press CH LEV (channel level). Enter value (with minus sign, decimal point and unit) on keyboard (e.g. −70 dBm yields a good S/N ratio). The output appears on the display.

B. Measurement of frequency response of amplitude

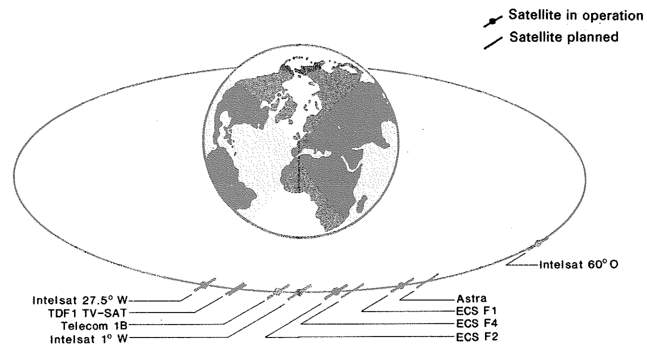
1. The output voltage is enabled after pressing STANDBY and OFF on the SFS.
2. The curve of the amplitude frequency response is produced on the FSA screen.
   Note The gain curve measured using the noise gain analyzer (p. 159) corresponds to the curve measured above.

Measurement principle An important quality characteristic of receiver converters, cable amplifiers and IF distributors is the level of the intermodulation products. The actual input levels with these devices are extremely low (e.g. in the picowatt and nanowatt range) which means that intermodulation levels can no longer be measured. The standard specifications therefore define that the measurement be made at a peak output power of 1 mW (two frequencies spaced by 5 MHz with levels of −6 dBm each). The stipulated levels which do not normally occur should ensure that the received signals do not deteriorate if directional radio signals enter the satellite antenna, even if these signals are located in the satellite frequency band and therefore reach the converter input unhindered.

The **TV Sat Test Generator SFS** has special equipment for these measurements which means that a second SHF generator is superfluous. Two frequencies in the SHF band with an adjustable spacing (up to 100 MHz) and at the same level can be transmitted simultaneously.



Level diagram of a satellite signal receiver system



Currently operating and planned TV satellites

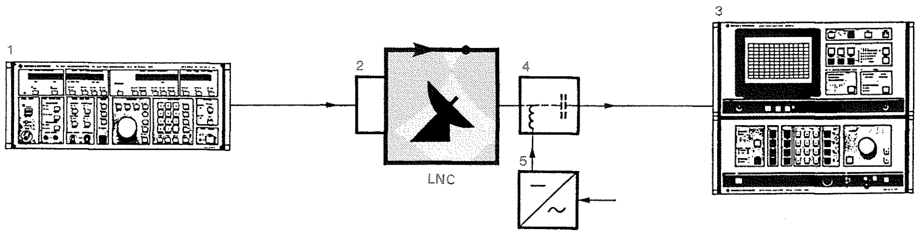
Channel designation	Country of origin	Satellite	Position	Transponder polarization		Frequency [GHz]	Standard	
							Sound [MHz]	Picture
RAI Uno	Italy	ECS-F1	13° O	1	H	11.005	6.60	PAL
3 SAT	FRG	ECS-F1	13° O	3	H[1])	11.171	6.60	PAL
TV 5	France	ECS-F1	13° O	4	H	11.471	6.65	Secam
World Net	France	ECS-F1	13° O	4	H	11.508	6.65	PAL
Sky Channel	Great Britain	ECS-F1	13° O	6	H	11.650	6.65	PAL
Teleclub	Switzerland	ECS-F1	13° O	7	V	10.986	6.50	PAL
RTL Plus	Luxembourg	ECS-F1	13° O	8	V	11.091	6.65	PAL
Film Net	Belgium	ECS-F1	13° O	9	V	11.140	6.60	PAL
SAT 1	FRG	ECS-F1	13° O	10	V	11.507	6.65	PAL
Super Channel	Great Britain	ECS-F1	13° O	12	V	11.674	6.65	PAL
Musik Box	Great Britain	ECS-F1	13° O	12	V	11.674	6.65	PAL
NRK	Norway	ECS-F2	7° O			11.644	Digital	C-MAC
Premiere	Great Britain	Intelsat	27.5° W			11.015	6.60	PAL
Childrens Chan.	Great Britain	Intelsat	27.5° W			11.015	6.60	PAL
Arts Channel	Great Britain	Intelsat	27.5° W			11.135	6.60	PAL
Life Style	Great Britain	Intelsat	27.5° W			11.135	6.60	PAL
Screen Sport	Great Britain	Intelsat	27.5° W			11.135	6.60	PAL
CNN	Canada	Intelsat	27.5° W			11.155	6.60	PAL
3 SAT	FRG	Intelsat	60° O			10.971	6.65	PAL
WDR 3	FRG	Intelsat	60° O			11.010	6.60	PAL
KMP Musicbox	Netherlands	Intelsat	60° O			11.137	6.65	PAL
BR 3	FRG	Intelsat	60° O			11.173	6.60	PAL
Eins Plus		Intelsat	60° O			11.560	6.65	PAL
Eureka		Intelsat	60° O			11.598	6.60	PAL
SVT 1	Sweden	Intelsat	1° W			11.133	Digital	C-MAC
SVT 2	Sweden	Intelsat	1° W			11.178	Digital	C-MAC
Canal 7		Telecom 1B	5° W			12.564	5.80	PAL
La 5	France	Telecom 1B	5° W			12.606	5.80	Secam
TV 6	France	Telecom 1B	5° W			12.648	5.80	Secam
World Net	France	Telecom 1B	5° W			12.690	5.80	NTSC

Satellite channels currently used for feeding into public broadband communication networks (source: Cable and Satellite Europe, 03/87).
[1]) 3 SAT currently transmits via transponder No. 3 (Netherlands) since transponder No. 2 does not transmit.

INTERMODULATION

(SHF/UHF low-noise converter)

transmission times



1 TV-Sat Test Generator SFS (photo p. 142) with N-to-SMA adapter
2 SMA-to-R120 adapter
3 Spectrum Analyzer FSA (photo p. 114), 100 Hz to 2 GHz
4 Separating filter (Order No. 670.8887.02)
5 Power supply unit (e.g. NGM 15 from Rohde & Schwarz or similar)

Measurement Procedure

A. Basic settings

1. Connect SHF input of receiver converter with adapters to the TV-Sat Test Generator SFS. Connect IF output of converter to Spectrum Analyzer FSA via a separating filter. Apply the operating voltage to the converter via this separating filter.
2. Setting on FSA:
   Note The keys at the bottom edge of the screen are softkeys whose functions are displayed on the screen via menus and which are adjusted using the hardkeys (fixed functions). A coloured mark over a softkey indicates that the associated value must be entered.
3. Press FREQUENCY, softkey CENTRE MANUAL is marked. Enter frequency on keyboard (e.g. 1170 MHz, this corresponds to channel 3X of ECS 1 with a vision-carrier frequency of 11.1710 GHz and an oscillator frequency of the receiver converter of 10.0 GHz).
4. Press softkey SPAN MANUAL and enter value (e.g. 50 MHz). The values of the start, stop and centre frequencies and the span appear on the screen.
5. Press REF LEVEL; softkey REF LEV is marked. Enter value (e.g. 0 dBm).
6. Press LEVEL RANGE and then LOG RANGE 50 dB. The screen grid is now labelled from 0 to −50 dBm.
7. Press key COUPLED FUNCTIONS and softkey RESOLUTION BW MANUAL. Enter value on keyboard (e.g. 100 kHz).
   Settings on SFS:
8. Press S CAR (subcarrier) and OFF.
9. Press SWEEP AUTO and OFF.
10. The frequency can also be entered in this case as a channel No., either:
    — CH FR, number, GHz or
    — DS CH (direct satellite channel), channel number, ENTER or
    — SHIFT, CS CH (communication satellite channel), channel number, ENTER (e.g. CS CH 3X: 11.171 GHz according to setting in point 3.).
    The frequency is displayed in GHz in all cases.
11. To set the second frequency: press SHIFT and AUX OFFS. Enter value (e.g. 5 MHz).
12. Press CH LEV (channel level) and enter value (with minus sign) (e.g. −60 dBm). Output on display.

B. Determination of intermodulation

1. The output voltage is enabled after pressing STANDBY and OFF on the SFS. The two frequencies are displayed on the screen of the FSA.
2. Press CH LEV and MEDIUM (1-dB steps) on the SFS, then increase the output voltage using the spinwheel until a level of 0 dBm is obtained on the FSA. Switch to 0.1-dB steps using the key FINE if necessary.
3. Press I MOD (intermodulation) and ENTER. The level of the two frequencies is reduced by 6 dB compared to the level set in 2. The peak level corresponds to 0 dBm again.
4. The analyzer screen now indicates the two fundamentals and the 3rd and (possibly) 5th order intermodulation products to the left and right.
5. The levels of the intermodulation products with reference to the peak level (0 dBm) can be directly read on the screen grid.
6. The levels of the intermodulation products can also be determined using a level line. Press the key DISPLAY LINE and the softkey DISPLAY LINE 1 on the FSA. Use the spinwheel to set the level line to the peak of the intermodulation product. The value displayed on the screen directly indicates the spacing from the peak level (negative sign).
7. Carry out the measurements for all frequencies of interest (receive channels). Change the frequencies on the SFS and the centre frequencies on the FSA in the same manner (see example). Leave the other settings unchanged.

The **RFI voltage** supplied by the LNC to the antenna — mainly the frequency of the conversion oscillator, possibly its harmonics — can deteriorate the reception in other systems and must therefore not exceed the values defined in the standard specifications. The measurement is best carried out using a spectrum analyzer with a frequency range up to 12 GHz, or better up to 26 GHz. The measurement is made as described in the spectrum analyzer manual.

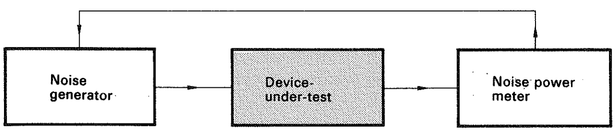
The **inherent noise** of the converter must be particularly low because of the extremely small receive energies, for this value determines the minimum input voltage for flawless reception.

The noise factor is measured using the same principle as with a TV transposer (p. 134). The different frequency range and the lower permissible noise factor necessitate a special noise generator and a special measuring instrument which can display the noise factor over the complete frequency range. The noise gain analyzer from Eaton covers a frequency range from 10 to 1900 MHz and is therefore well suited to direct measurements in the range of the satellite IF (950 to 1750 MHz).

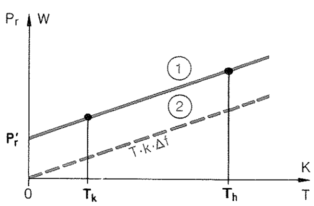
Noise factor measurement (principle) The method is different from the usual method for determining the noise factor. The noise power of a device is directly dependent on the absolute temperature (p. 134):

$P_r = k\,T\,\Delta f$ with
- P_r Noise power (W)
- k 1.38×10^{-23} W/K (Boltzmann's constant)
- T Absolute temperature (K)
- Δf Bandwidth (Hz)

This also applies to the noise generator which is connected in this method to the input of the device to be examined.



The noise power meter switches the noise generator to two different temperatures (T_c and T_h, cold and hot) and determines the noise power at the output of the test item in each case. As a result of the linear dependence of the applied noise power on temperature and the constant noise power of the test item (constant temperature), a curve results from which the noise power component of the test item can be calculated.



① Measured values of noise generator + test item

② Theoretical values for noise-free test item (calibration)

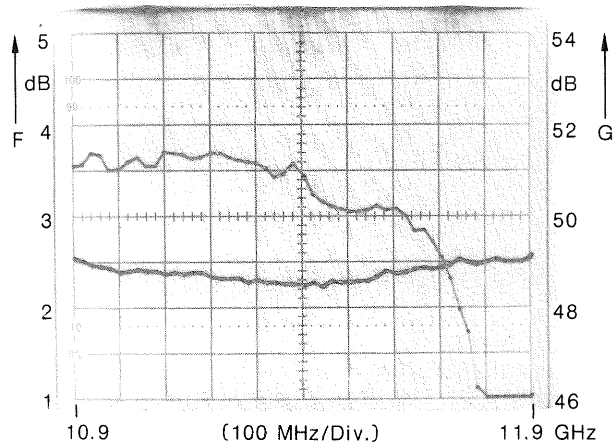
P_r' Noise power of test item

The noise factor is obtained from the measured values as the ratio of the values of curves ① and ② at the temperature T_c of the test item:

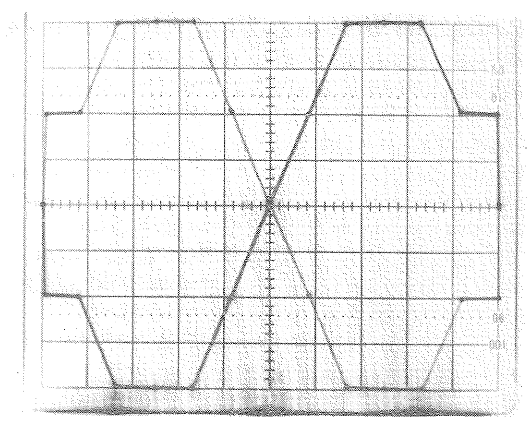
This is $P_r' + T_c \cdot k \cdot \Delta f = F \cdot T_c \cdot k \cdot \Delta f$ and therefore:

$$F = \frac{P_r' + T_c \cdot k \cdot \Delta f}{T_c \cdot k \cdot \Delta f} = \left(\frac{P_{r1}}{P_{r2}}\right)_{T_c}$$

This calculation is carried out by a microprocessor in the device and the noise factor is displayed directly. The noise power meter is designed as a tuned receiver with a constant bandwidth. The noise factor can therefore be measured at each frequency in the range and displayed in analyzer mode over the complete frequency range on an oscilloscope. It is also advantageous that the gain of the test item can be displayed at the same time in addition to the noise factor.



Measurement on a converter
Bottom curve: noise figure (dB)
Top curve: gain



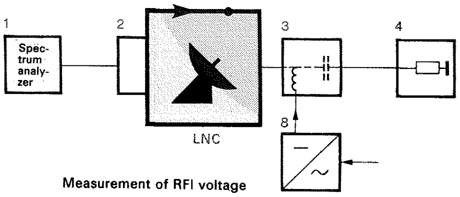
The noise gain analyzer delivers a calibration signal (special function 7.2) for setting the oscilloscope

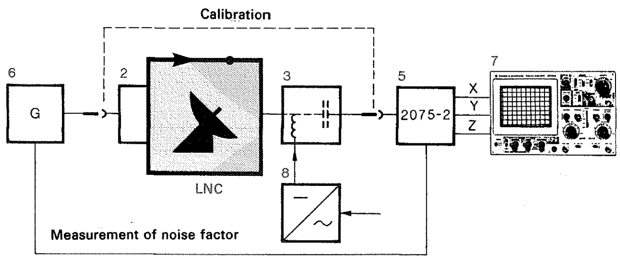
Measurement Procedure

A. Basic settings

1. Noise Gain Analyzer 2075-2: connect rear outputs X, Y, Z to Oscilloscope BOP (X and Y inputs on front, Z input at rear). Set MODE X-Y.
2. Connect converter to adapter R 120/SMA and on the IF side to the separating filter. Do not yet incorporate into the circuit.
3. Connect Noise Generator 7618 EL directly to input of 2075-2 and connect on the DC side (BNC) to the connection NOISE DRIVE of the 2075-2.

RFI VOLTAGE AT INPUT NOISE FACTOR (low-noise converter)





1 Spectrum analyzer, 40 GHz
(e. g. 640 C from Polarad or 85 .. from Hewlett Packard)
2 SMA-to-R120 adapter
3 Separating filter (Order No. 670.8887.02)
4 Termination 50 Ω
5 Noise/gain analyzer (e. g. 2075-2 from Eaton)[1]
6 Noise generator, 10 MHz to 18 GHz (e. g. 7618 EL from Eaton)
7 Oscilloscope BOP for X/Y operation (photo p. 132)
8 Power supply unit 5 to 15 V
(e. g. NGM 15 from Rohde & Schwarz or similar)

[1]) German agent: Brienner Straße 48, D-8000 München 2, Telephone: 0 89/5 23 30 23

Measurement Procedure (continued)

B. Calibration of measuring equipment

1. A calibration figure appears on the oscilloscope after switching on the 2075-2 and must be adjusted vertically and horizontally to be within the screen grid using the gain controls on the oscilloscope.
2. Press keys SPEC FUNCT 7.0 and ENTER. The calibration figure disappears.
3. Enter data of noise diode: press SPEC FUNCT 5.1, →, ENTER and ENR. ENTER flashes on display A (left). Enter the calibration values of the noise diode (table supplied with diode). Only the values in the IF band (actual measuring range) and the values in the lower frequency band are of interest, e. g. 0.3, 1, 2 and 10, 11, 12 GHz.
4. Enter the frequencies of the calibration table in MHz: e. g. 300, then press ENTER. ENTER now flashes on display B (centre). Now enter the calibration value of the noise diode in dB (e. g. 5.32), subsequently press ENTER. Then continue with the next frequency etc.
5. Terminate this function at the end of the table using key ENR. The analyzer now measures its own noise factor. A mean value should be selected for all noise measurements, also for the calibration procedures, to smooth the display by using the keys SMOOTHING (bottom right). The number of the bars on the scale above these indicates the exponent of the number 2, starting with 0 (4 bars = 2^3 = 8; experience has shown this value to be appropriate).
6. Measurement of the converter corresponds to the configuration 5 in the manual (fixed oscillator frequency, variable IF). Press SPEC FUNCT 1.5 and ENTER.
7. First enter all values required for the measurement (the message ERR may appear on display B until all values have been entered, but this has no significance):

START FREQ	e. g. 10900 →	ENTER
STOP FREQ	e. g. 11900 →	ENTER
STEP SIZE	e. g. 20 →	ENTER
SHIFT LO (loc. osc.)	e. g. 10000 →	ENTER

To measure the upper sideband:

SPEC FUNCT	2.2 →	ENTER

Then the limits for display of noise figure and gain:

UPPER LIMIT	e. g. 5 dB →	ENTER	for noise figure
LOWER LIMIT	e. g. 1 dB →	ENTER	
SHIFT UPPER LIMIT	e. g. 54 dB →	ENTER	for gain
SHIFT LOWER LIMIT	e. g. 46 dB →	ENTER	

The values for the noise figure appear on display C (right), those for the gain on display B. The following scales are produced on a screen with a height of 8 div.:

	Centre line	per div.	Frequency scale
Noise figure	3 dB	0.5 dB	100 MHz/div.
Gain	50 dB	1 dB	

8. Press key CALIB. The device carries out several calibrations automatically. FCAL → CAL0 → CAL3 appear in succession on display B. The key F + G (corrected measurement) lights up at the end of the procedure. The device measures at any frequency which can be modified using the keys below FIXED FREQ. Output on display A. Negative noise figures may also be displayed because the analyzer compares the values measured in the range from 10 to 1800 MHz with the stored values for 10 to 12 GHz.

C. Determination of noise figure and gain

1. Connect the converter into the circuit (connection according to A.2.). Switch on associated power supply.
2. Press SWEEP. The analyzer measures the gain (display B) and the noise figure (display C) starting at the start frequency (display A). The range of the analog meters under displays B and C corresponds to the entries in B.7.
3. The curves for noise figure and gain appear simultaneously on the oscilloscope screen. Each measured value is averaged according to the setting SMOOTHING (see B.5.).
4. The calibration figure can be called to check the oscilloscope input: first release SWEEP (the analyzer does not accept commands in this function). The calibration figure appears after pressing SPEC FUNCT 7.2 and ENTER. Check oscilloscope setting. The calibration figure disappears when the key SWEEP is pressed, and a new measurement starts with a new curve display.
5. The SWEEP function results in an automatic, continuous SWEEP of the curves. If only one sweep is to be made (e.g. for photographing), SHIFT and SWEEP must be pressed.

D. Storage of settings

1. The settings from B.6. and B.7. can be stored in 9 registers. Enter STORE, register number, e. g. 1 and ENTER.
2. The stored settings can be recalled using RECAL, register number and ENTER.
3. The calibration (without test item) as in B.8. must always be carried out before a measurement is started.

The gain of the devices in the IF path (cable amplifier and IF distributor) and the decoupling of the five outputs of the IF distributor can easily be determined using the swept-frequency Satellite IF Test Transmitter SFSZ and a spectrum analyzer.

Values for the return loss are defined in the standard specifications for matching the individual devices to one another. In principle this can be determined using the VSWR Bridge ZRB 2 and the equipment used for the gain measurement.

A special feature must be observed when measuring the UHF equipment, however: Since the LNC and the cable amplifier are normally supplied by the IF amplifier, it is necessary to use separating filters when measuring the individual units in order to apply the operating voltage as well as to protect the devices from this operating voltage. The power supply is always supplied to the (RF) output of the device-under-test. This does not present any problems with the gain measurement, but does for the return loss measurement. The separating filters, which are not used in normal operation, have a return loss that is approximately as large as the value in the standard specifications of the test item because of the large frequency band (900 to 1750 MHz). The measured value is thus falsified. An exact measurement is only possible if measurements are made without separating filters in which case the test item has to be modified internally. Therefore only the return loss measurement on the IF receiver unit can be described here, and not that on the LNC, cable amplifier and IF distributor.

The separating filters (SF) must be assigned as follows for the gain measurement:

Device	Input	Output
Cable amplifier	SF	SF
IF distributor	SF	—[1])

[1]) Terminate unused outputs with 50 Ω.

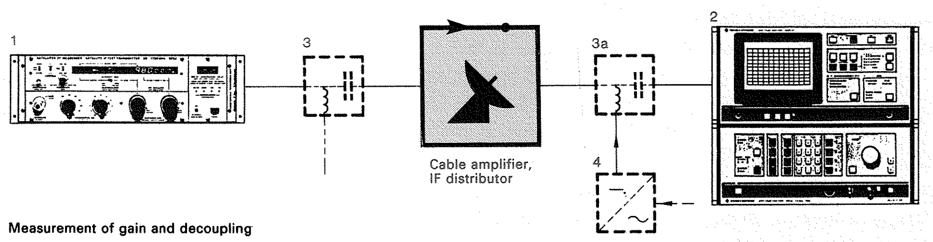
The measurement must be carried out over the complete range of the satellite IF.

Measurement Procedure

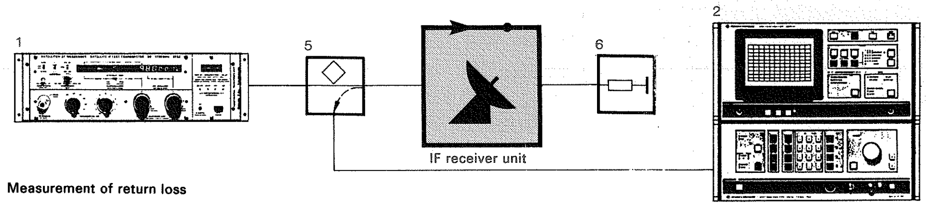
I. Measurement of gain and decoupling

A. Basic settings

1. Connect the input of the test item to the output of the SFSZ and the output of the test item to the analyzer input. Connect the separating filters according to the above table.
2. Settings on FSA (see preliminary remarks on p. 155, A.2.):
   Press FREQUENCY, the associated menu appears on the screen. The softkey CENTRE MANUAL is marked. Enter centre frequency (e.g. 1250 MHz) on keyboard, the value is displayed on the screen.
3. Press softkey SPAN MANUAL, enter span (e.g. 1 GHz for the complete satellite IF band). This frequency, as well as START, STOP and SWEEP, are displayed on the screen.
4. Press TRACE and then the softkey MAX HOLD.
5. Press REF LEVEL, softkey REF LEV is marked. Enter reference level (e.g. −10 dBm) on keyboard; the value appears at the top left above the grid.
6. Press LEVEL RANGE and then the softkeys LOG RANGE 50 dB and GRID ABS. The grid on the screen is now labelled from −10 to −60 dBm.
7. Press key DISPLAY LINE and then softkey DISPLAY LINE 1, enter −35 dBm on keyboard. A level line appears on the screen at −35 dBm which is used as the reference line for the gain (range 25 dB) and for decoupling and return loss (range 25 dB).
8. Settings on SFSZ:
   Set centre frequency of band to be examined (e.g. for complete satellite IF band of 1250 MHz):
   Preset the 1-kHz to 10-MHz digits of the frequency in mode LOCKED with TUNING I (right). Then adjust frequency according to left-hand display using TUNING II (left). Centre the APC display when the signal SYNC has lit up. The left-hand display is cleared and the digits are transferred to the right-hand display. Set output level −40 dB.



Measurement of gain and decoupling



Measurement of return loss

1 Satellite IF Test Transmitter SFSZ (photo p. 150)

2 Spectrum Analyzer FSA (photo p. 114), 100 Hz to 2 GHz

3 Separating filter (Order No. 670.8887.02)

3a Separating filter (Order No. 670.8887.02) — Only for measurement of cable amplifier

4 Power supply unit 5 to 12 V (e. g. NGM 15 from R & S or similar) — Only for measurement of cable amplifier

5 VSWR Bridge ZRB 2 (photo p. 86)

6 Termination 50 Ω, 4 off for decoupling measurement

Measurement Procedure (continued)

B. Calibration of measuring equipment

1. Connect output of SFSZ directly to analyzer.
2. Switch SFSZ to FREE (unsynchronized). Set SWEEP ON, time to I (5 s) and span to desired value (e.g. 100 MHz/DIV results in a span ±5 MHz, the SFSZ therefore sweeps from 750 to 1750 MHz; same values in FSA).
3. A horizontal line now appears on the analyzer. Set using the controls OUTPUT LEVEL on the SFSZ to the level line −35 dBm of the analyzer grid.

C. Determination of amplification and decoupling

1. Establish original circuit connection as in A.1.
2. The gain (amplitude from top to −35 dBm reference line) appears on the analyzer after inserting the cable amplifier.
3. The decoupling between the outputs on the IF distributor can be measured best using the defined settings. Terminate the input (via a separating filter) and unused outputs with 50 Ω.
4. Enter (SFSZ) into one output. Measure (FSA) at another. The attenuation (decoupling) is now displayed on the analyzer as a function of frequency (amplitude from below to reference line).
5. Carry out measurement at several outputs.
6. A different measuring range of the analyzer is usually selected for the gain measurement on the IF distributor (nominal value 0 ±1 dB). Set according to A.5. REF LEVEL −30 dBm and according to A.6. LOG RANGE 10 dB (the level line remains at −35 dBm). One unit of the grid then corresponds to 1 dB, which means that the gain curve can be easily evaluated.

II. Adaptation measurement (only IF receiver unit)

A. Basic settings

1. Connect output of SFSZ to test item via VSWR Bridge ZRB 2. Terminate test item outputs with 50 Ω.
2. Connect signal output of ZRB 2 to input of analyzer.
3. Setting and calibration of FSA and SFSZ as in I.A.2. to 8. and I.B.1. to 2.

B. Calibration of measuring equipment

1. Disconnect VSWR bridge from test item.
2. Using the controls OUTPUT LEVEL on the SFSZ, adjust the horizontal line on the analyzer screen to coincide with the level line (−35 dBm) (reference line for return loss).

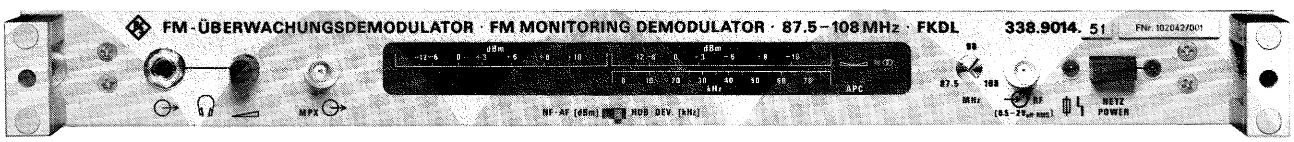
C. Determination of return loss

1. Connect VSWR bridge to test item again.
2. The curve on the analyzer now shows the return loss as a function of frequency. The attenuation value is the amplitude from the reference line.

Measurement principle The measurement of the intermodulation of broadband IF amplifiers (cable amplifiers and IF distributors) is just as important as with broadband converters. Intermodulation is measured in the same manner as with LNCs, but using IF signal generators. The level of the two signals (frequency spacing 5 MHz, level −6 dBm) with these measurements is also approx. 30 dB higher than the maximum level occurring. The required intermodulation of 30 dB ensures extremely high intermodulation suppression at the actual level values and prevents deterioration in the picture transmission even if directional radio signals are applied into the antenna (which are converted unattenuated into the IF by the LNC if they are in the satellite frequency band). Cable amplifiers and IF distributors are measured using the same setup. See p. 160 for connection of separating filters.

It is important when measuring intermodulation with two test generators that there is sufficient decoupling between them so that "own" intermodulation does not take place. At low levels with, for example, 20-dB attenuation in each test generator, a decoupling of 46 dB is sufficient even when using a resistance network for combining the generators (6-dB insertion loss). Similar values are obtained with cable amplifiers which have a gain of 15 to 20 dB depending on the frequency. On the other hand, IF distributors do not amplify, so that the required levels of −6 dBm are already necessary at the input. The attenuation would have to be set to 2 dB in each test generator when using a 3-dB coupler. However, sufficient decoupling is no longer guaranteed with the directivity of a standard 3-dB coupler of 25 dB (over a range of 1:2). A special (multiple) coupler must therefore be used where an inherent intermodulation suppression of 60 dB is achieved at the required levels so that accurate measurements are possible up to approx. 45 dB. This fully satisfies the standard specification requirements of 30 dB.

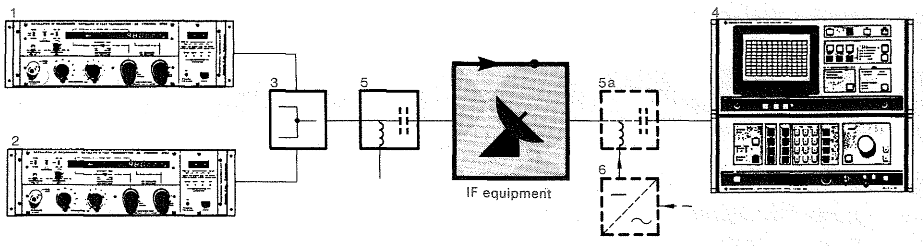
FM Monitoring Demodulator FKDL



transmission times

INTERMODULATION

(IF equipment)



1 Satellite IF Test Transmitter SFSZ (photo p. 150) for signal 1
2 Satellite IF Test Transmitter SFSZ for signal 2
3 Satellite IF Test Transmitter Coupler (Order No. 837.6200.03)
4 Spectrum Analyzer FSA (photo p. 114), 100 Hz to 2 GHz
5 Separating filter (Order No. 670.8887.02)

5a Separating filter (Order No. 670.8887.02) 6 Power supply unit 5 to 15 V (e. g. NGM 15 from R & S or similar)	Only required for measurement of cable amplifier

Measurement Procedure

A. Basic settings

1. Connect both test transmitters SFSZ via the decoupling network and a separating filter to the input of the test item whose output is connected to the analyzer. When measuring the cable amplifier, connect an additional separating filter.
2. Set test transmitter to desired frequency (IF of receive channel, e.g. 1171 MHz — channel 3X of ECS 1) according to p. 160 I.A.8. Set test transmitter 2 5 MHz higher than test transmitter 1. Both output levels initially −60 dB.
3. Settings on FSA (see preliminary remark on p. 155, A.2.):
4. Press FREQUENCY; softkey CENTRE MANUAL is marked. Enter frequency on keyboard (e.g. 1170 MHz).
5. Press softkey SPAN MANUAL and enter value (e.g. 50 MHz). The values of the start, stop and centre frequencies and for the span appear on the screen.
6. Press REF LEVEL; softkey REF LEV is marked. Enter value (e.g. 0 dBm).
7. Press LEVEL RANGE and then LOG RANGE 50 dB. The screen grid is now labelled 0 to −50 dBm.
8. Press key COUPLED FUNCTIONS and softkey RESOLUTION BW MANUAL. Enter value on keyboard (e.g. 100 kHz).
9. Press TRACE and then softkey MAX HOLD.

B. Calibration of measuring equipment

1. First incorporate cable amplifier into setup. Then increase output level of test transmitter 1 until the line 0 dBm is reached on the analyzer.
2. Reduce output level on test transmitter 1 by 6 dB and adjust same value on test transmitter 2. The peak value of the signal mixture is then 0 dBm.

C. Determination of intermodulation products

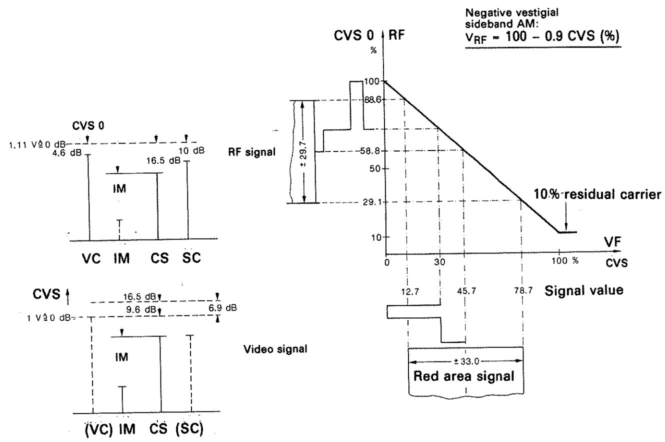
1. The two fundamentals are now visible on the analyzer screen with the 3rd and possibly 5th order intermodulation products on the left and right.
2. The levels of the intermodulation products referred to the peak value can be read directly using the screen grid.
3. The level of the intermodulation products can also be determined using a level line. Press the key DISPLAY LINE and the softkey DISPLAY LINE 1 on the FSA. Set the level line to the peak of the intermodulation product using the spinwheel. The value displayed on the screen directly indicates the intermodulation level with respect to the peak level (negative sign).
4. Carry out the measurements at all frequencies of interest (receive channels), possibly in the complete IF band. Modify the test transmitter frequencies and the analyzer centre frequency simultaneously in steps and determine the intermodulation products as above.

The **IF receiver unit** filters the desired receiver channel out of the IF frequency band and demodulates it following further frequency conversion. A clamping circuit suppresses the energy-dispersal signal which is superimposed additively on the modulation signals. This triangular voltage with a frequency of 50/25 Hz synchronized with the field frequency is to prevent concentration of the total energy of the FM carrier at one single frequency (power flux density too high within a particular bandwidth upon failure of modulation).

The 8-MHz wide baseband is available at the output of the IF receiver unit. In addition to the 5-MHz wide video band, it also contains a (mono) sound carrier at 6.5, 6.6 or 6.65 MHz as well as 2 (or more) sound carriers at 7.02 and 7.2 MHz (7.38, 7.56 MHz) for stereo or multi-sound transmission with currently used systems. The video channel is isolated from the sound channels in a separate demodulator. Further details on p. 166.

Signal processing The Satellite IF Test Transmitter SFSZ is a high-quality transmitter for the frequency range 50 to 1750 MHz which can be frequency-modulated with 10 Hz to 8 MHz. In order to measure the influence of the sound carriers on the VF transmission characteristics, the SFSZ is modulated by the TV-Sat Base Signal Combiner SFSA which generates the energy-dispersal signal and the sound carriers. A completely modulated satellite signal at the IF (UHF) is then available at the output of the SFSZ.

Intermodulation measurement The intermodulation products between vision carrier, colour subcarrier and the sound carriers is important in addition to the VF transmission characteristics. Especially the combination between colour subcarrier and sound carrier 1 (around 2.2 MHz) or sound carriers 2 and 3 (180 kHz) can lead to interferences in the picture. These measurements are always made at the RF for terrestrial TV transmitters and transposers which operate with an AM vestigial sideband. The peak value of the vision carrier is used as the reference value. This is not possible with satellite links operating with FM, however. A measurement is only possible at the VF in this case. Intermodulation levels are by nature different for the same interference effect at the RF and VF. The transmitter is therefore modulated with a sinewave signal with as large an amplitude as possible, and this value is defined as the reference value. The signal provides red areas, as generated by most TV signal generators (photo on page opposite). The voltage values with a video frequency voltage of 1 V_{pp} are:
carrier amplitude 0.457 V, colour subcarrier amplitude 0.33 V.
If this signal is transmitted in a transmitter with a negative vestigial sideband AM (e.g. in a broadband communication network), a relationship can be established between the RF and VF levels by measuring the resulting RF spectrum:



Level scheme for the red area VF signal at the VF and RF
The associated frequency spectra are shown on the left. Boosting of the 0-dB value is shown for the VF to achieve uniform measured values at the VF and RF.
VC Vision carrier SC Sound carrier CS Colour subcarrier
IM Intermodulation product

If the amplitudes are referred to the respective nominal value — 1.11 V = CVSO of the RF signal, 1.0 V = CVS of the VF signal — the result is as follows:

Measurement	Reference (V) = 0 dB	Carrier %	Carrier dB	CS amplitude %	CS amplitude dB
RF	1.11	58.8	–4.6	(±29.7) × 1/2[1])	–16.5
VF	1.0	—	—	±33	–9.6

[1]) Vestigial sideband transmission

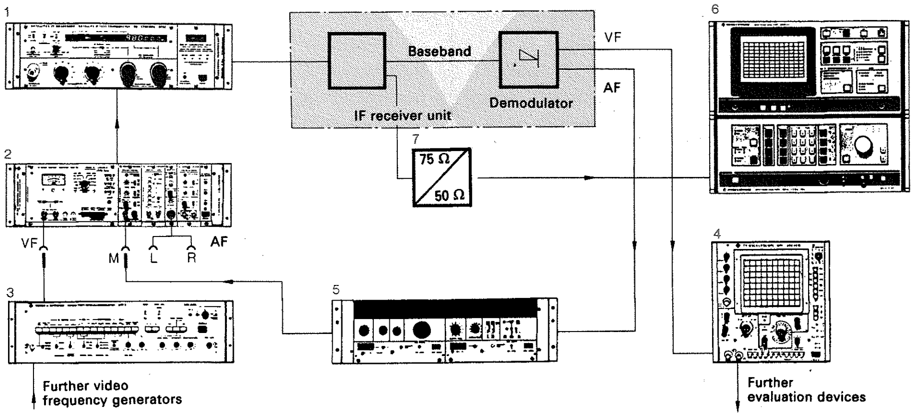
The level of the intermodulation products with reference to the sideband amplitude, which is decisive with transmitter measurements (see p. 76), is the same for both measurements. Reference to the peak amplitude — as is prescribed for broadband communication devices (transmitters) — cannot be carried out at the VF because the carrier is missing. Reference to the peak value 1 V into 75 Ω would be possible in this case.

In order to nevertheless enable simple comparison of results if satellite signals are applied to a broadband communication network — where the intermodulation products are tolerated compared to the peak carrier level — the (fictitious) peak level is applied using a frequency analyzer during the VF measurement such that the colour subcarrier amplitude has the same spacing (16.5 dB) from the peak level as when measuring at the RF. This merely means a shift of 6.9 dB upwards. The spacing of the intermodulation products to the subcarrier amplitude is not changed. Values comparable with the RF measurement are then obtained when referring to the corrected peak level.

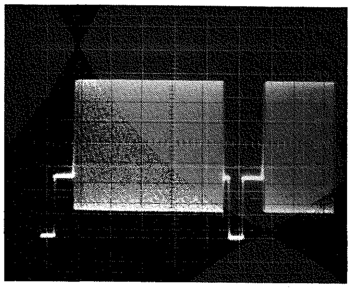
The sound carriers are also available at the output of the VF receiver unit. Their levels are also reduced by 6.9 dB compared to the reference level like the colour subcarrier signal. The following values apply to the commonly used Wegener's method:

Sound carrier	Frequency [MHz]	Amplitude Absolute [mV]	Referred to 1 V [dB]	Referred to ref. level [dB]
1 (Mono)	6.65	100	–20	–26.9
2 (Stereo L)	7.02	50	–26	–32.9
3 (Stereo R)	7.20	50	–26	–32.9

transmission times (IF receiver unit)



1 Satellite IF Test Transmitter SFSZ (photo p. 150)
2 TV-Sat Base Signal Combiner SFSA (photo p. 148)
3 Video Test Signal Generator SPF 2 (photo p. 24)
4 TV Oscilloscope OPF (photo p. 49)
5 AF Transmission Measuring Set SUN 2 (photo p. 18)
6 Spectrum Analyzer FSA (photo p. 114), 100 Hz to 2 GHz
7 Matching Pad RAM (photo p. 144), 75/50 Ω



Oscillogram of red area signal (burst switched off)

Measurement Procedure

A. Basic settings

1. Connect SPF 2 to video frequency input of TV-Sat Base Signal Combiner SFSA and the output of the latter to the base signal input of the Satellite IF Test Transmitter SFSZ. Connect output of SFSZ to input of IF receiver unit and one output of latter via a 75/50 Ω Matching Pad RAM to the Spectrum Analyzer FSA and the other output to the demodulator. Connect a TV Oscilloscope OPF to the video frequency output of the demodulator (0.1 V/DIV, 10 µs/DIV, trigger H).
2. Adjust SFSZ to vision-carrier frequency of receive channel (e.g. 1171 MHz, as on p. 163, A.2.) (p. 160, I.A.8.), span 13.5 MHz, output level −50 dB.
3. Settings on FSA (see remarks on p. 155, A.2.): Press FREQUENCY, softkey CENTRE MANUAL is marked, enter centre frequency of baseband (5 MHz), then press softkey SPAN MANUAL and enter span (10 MHz).
4. Press key REF LEVEL, softkey REF LEVEL is marked. Enter reference value +20 dBm on keyboard.
5. Press LEVEL RANGE and then softkeys LOG RANGE 100 dB and GRID ABS. The grid on the screen is now labelled from +20 to −80 dBm.
6. Press COUPLED FUNCTIONS and softkey RESOLUTION BW. Enter value of 5 kHz on keyboard.
7. Press TRACE and then softkey MAX HOLD.

B. Calibration of measuring equipment

1. Initially switch SPF 2 to 15 kHz squarewave, H and CAL.
2. Check value of output signal on OPF. Nominal value 1 V_{pp}, adjust on SFSA if necessary.
3. Switch SPF 2 to red area signal (burst off).
4. Press DISPLAY LINE on FSA and then softkey DISPLAY LINE 1. A horizontal level line appears on the screen and can be shifted using the spinwheel.
5. Set level line to peak of sideband line (at approx. −4 dBm). The exact level value is displayed at the top left on the screen.
6. Add 16.5 dB to the displayed value (approx. +12 dBm), and then enter this value as the reference value (as in A.4.) and press GRID REL. The screen grid is now labelled from 0 to −100 dB. 0 dB corresponds to the (fictitious) peak value. The colour subcarrier is at −16.5 dB.
7. Switch on sound carrier on SFSA, do not modulate. Set the frequencies according to the present conditions (see page opposite for the Wegener's stereo method).

C. Determination of intermodulation between vision and sound carriers

1. The main intermodulation products lie (with the defined frequencies) around 2.2 MHz (colour subcarrier/sound carrier) and between 180 and 550 kHz (sound carrier/sound carrier). These can be recognized on the screen and measured using the level line. The spacing from 0 dB is displayed on the screen.
2. In order to determine the frequency, press DISPLAY LINE and softkey FREQUENCY LINE 1. The vertical line can also be shifted using the spinwheel. The frequency is displayed on the screen.
3. The measurements should be carried out for all frequencies (receive channels) of interest. The same method can be used, only the frequency need be changed on the SFSZ.

D. Measurement of VF transmission characteristics

If the VF input of the SFSA is regarded as the VF input of a transmitter, and the VF output of the demodulator as the output of the TV modulator, the VF transmission characteristics can be measured exactly the same way and with the same instruments as described for the transmitter measurements on pages 41 to 79, but without measurement of the RF sideband characteristic.

AF TRANSMISSION CHARACTERISTICS (IF receiver unit)

The modulation methods for sound transmission are still in a state of flux. The table presents a list of the currently used methods (from Cable & Satellite Europe, 09/86).

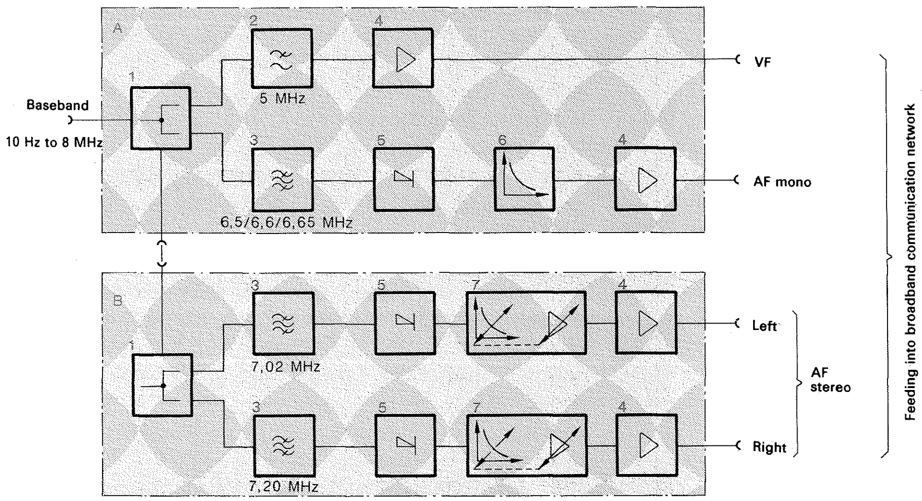
It was agreed in June 1986 to use the modulation method D2-MAC packet for the satellites TV-Sat (W. Germany) and TDF (France) (description on p. 168). The satellites are expected to start in 1987.

Program name	Sound carrier	Transmission type	Frequency span	Bandwidth	Preemphasis
Sky Channel	6.60 MHz	Mono	50 kHz	280 kHz	50 µs
Sky Channel	7.02 MHz	L Stereo	50 kHz	130 kHz	[1])
Sky Channel	7.20 MHz	R Stereo	50 kHz	130 kHz	[1])
Music Box	6.65 MHz	Mono	50 kHz	280 kHz	50 µs
Music Box	7.02 MHz	L Stereo	50 kHz	130 kHz	[1])
Music Box	7.20 MHz	R Stereo	50 kHz	130 kHz	[1])
Teleclub	6.50 MHz	Mono	50 kHz	280 kHz	75 µs
Teleclub	5.50 MHz	Switching signal	50 kHz	—	—
RAI Uno	6.60 MHz	Mono	75 kHz	400 kHz	50 µs
Filmnet	6.60 MHz	Mono	50 kHz	280 kHz	J17
Sat 1	6.65 MHz	Mono (TV)	50 kHz	280 kHz	50 µs
Sat 1[3])	7.02 MHz	Mono (Radio)	50 kHz	130 kHz	—
3 Sat	6.65 MHz	Mono	50 kHz	280 kHz	50 µs
TV 5	6.65 MHz	Mono	150 kHz	900 kHz	J17
RTL Plus	6.65 MHz	Mono	50 kHz	280 kHz	50 µs
World Net	6.65 MHz	Mono	75 kHz	400 kHz	J17
NRK	C-MAC digital audio				
Premiere[2])	6.60 MHz	Mono	50 kHz	280 kHz	50 µs
Premiere[2])	7.02 MHz	L Stereo	50 kHz	130 kHz	[1])
Premiere[2])	7.20 MHz	R Stereo	50 kHz	130 kHz	[1])
Screen Sport	6.65 MHz	Mono	50 kHz	280 kHz	50 µs
CNN	6.60 MHz	Mono	50 kHz	280 kHz	50 µs
CNN	7.56 MHz	96 kbit datastream			
Sveriges 1[4])	6.60 MHz	Mono	50 kHz	280 kHz	50 µs
Sveriges 2[4])	6.60 MHz	Mono	50 kHz	280 kHz	50 µs
Music Box	6.65 MHz	Mono	50 kHz	280 kHz	50 µs
BR 3	6.60 MHz	Mono	50 kHz	280 kHz	50 µs

[1]) Controlled preemphasis (Wegener's system).
[2]) Premiere will probably also transmit in stereo soon.
[3]) The sound channel on Sat 1 (Voa Europe) will probably transmit in stereo soon.
[4]) Sound information coded (Sat-Tel Save System).
Source: Cable & Satellite Europe, 09/86.

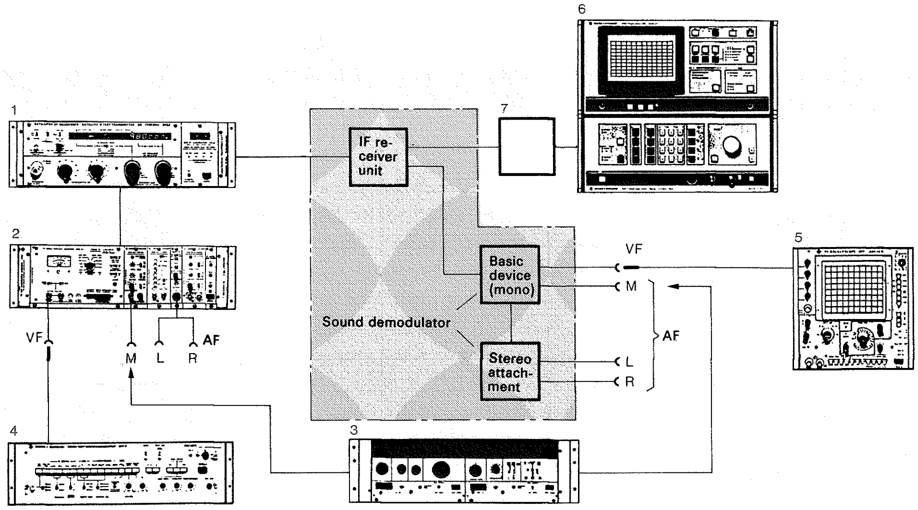
A compander system with three sound carriers and a controlled preemphasis (Wegener's or similar system) is currently used for stereo transmission. A dynamic compressor is used at the transmitter end, and a corresponding expander at the receiver end. Since the TV-Sat Base Signal Combiner SFSA is used at the transmitter end for the measurements and does not have a dynamic compressor, the expander must be switched off in the receiver unit.

The video channel is isolated from the mono-sound channel in the basic unit of a separate demodulator. An additional device is used to demodulate the stereo channels (basic circuit diagram below). Corresponding devices are used at the transmitter end. The AF transmission characteristics can be measured using almost the same test set-up as for the VF transmission characteristics. The stereo attachment of the sound demodulator is incorporated in stations receiving stereo or multi-sound transmissions so that the stereo channels must also be measured. The methods are analogous to those with TV sound transmitters. No additional crosstalk occurs in stereo transmissions compared to dual-sound operation since the channels are transmitted completely separately (no matrixing).



Demodulator for TV sound transmission with FM subcarriers via satellite links

A Basic device (mono)
B Stereo attachment
1 Splitter
2 Video frequency lowpass
3 Bandpass
4 Amplifier
5 FM demodulator
6 Deemphasis
7 Controlled deemphasis with expander (Wegener's or similar method)



1 Satellite IF Test Transmitter SFSZ (photo p. 150)
2 TV-Sat Base Signal Combiner SFSA (photo p. 148)
3 AF Transmission Measuring Set SUN 2 (photo p. 18)
4 Video-Test Signal Generator SPF 2 (photo p. 24)
5 TV Oscilloscope OPF (photo p. 49)
6 Spectrum Analyzer FSA (photo p. 114), 100 Hz to 2 GHz
7 Matching Pad RAM (photo p. 144), 75/50 Ω

Measurement Procedure

A. Basic settings
Same arrangement as on p. 165, A.1. to 7.

B. Calibration of measuring equipment
As on p. 165, B.1. to 7.

C. Measurement of AF transmission characteristics of mono channel
If the mono input of the SFSA is regarded as the modulation input of a transmitter, and the mono output of the demodulator as the AF output of the TV demodulator, the mono transmission characteristics can be measured exactly the same way as for the transmitter measurements on pages 21 to 27.

D. Measurement of AF transmission characteristics of stereo channels
1. Calibration as in B.
2. If the transmission operates with a compander system (e. g. Wegener's or similar system), the expander must be switched off in the demodulator.

The stereo channels L and R are transmitted completely separately by satellites (no compatibility is required as a result of the separate transmission of the mono channel). Therefore matrixing circuits are not required (see p. 30), and thus only the channel crosstalk need be measured.

The other transmission characteristics from the input of the stereo channels on the SFSA to the output of the stereo channels on the demodulator must be measured as for transmitter measurements on pages 29, 31 and 33 (analogous) and 35 to 39. Use of the TV Dual-Sound Demodulator FATF is not possible because of the different transmission method.

TV standards C-MAC and D2-MAC for TV satellites
The standards for terrestrial TV transmitters (PAL, Secam, NTSC) are not optimal for satellite transmissions. The following demands were placed on a special standard:

- low power consumption in satellite
- large coverage, all Europe if possible
- several sound channels of different quality
- higher picture resolution free from cross-colour (intermodulation interferences)
- transmission of data for various services and for automatic setting of TV receiver
- simple coding facility for pay-TV

The commission responsible defined the **C-MAC method (Combined Multiplexed Analogue Component).** The sound signal is transmitted in digital mode (2/4 PSK), the vision signal in FM, separated according to luminance and chrominance information. Transmission of the signals is in succession, firstly the sound data and then the chrominance and luminance signals. Since only one single sound carrier is present in each case (four with the PAL system), the power consumption of the satellite is far lower and intermodulation interferences are prevented. Since the line structure of the TV picture must remain the same (64 µs per line) although more information must be accommodated in each line, it is essential to compress the information (see diagram on right): the luminance signal in a ratio of 3:2, the colour difference signal (alternately red or blue minus luminance) in a ratio of 3:1.

This results in the following signal format per line (the times are slightly different for C-MAC and D2-MAC):

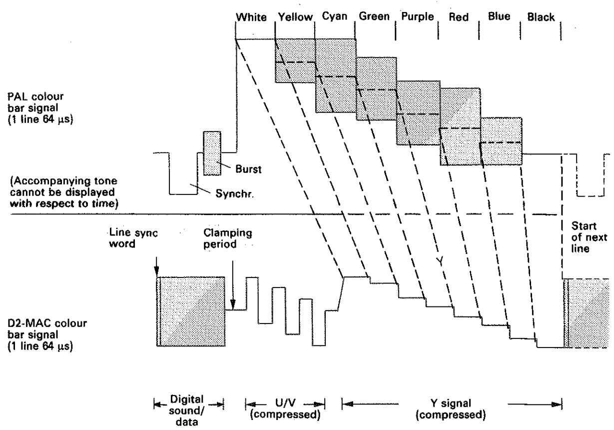
Sound and data bits	10.3 µs
Clamping	0.74 µs
Colour difference signal	17.2 µs
Luminance	34.2 µs
	62.44 µs

The remainder of 1.56 µs is provided for transients such as between different states.

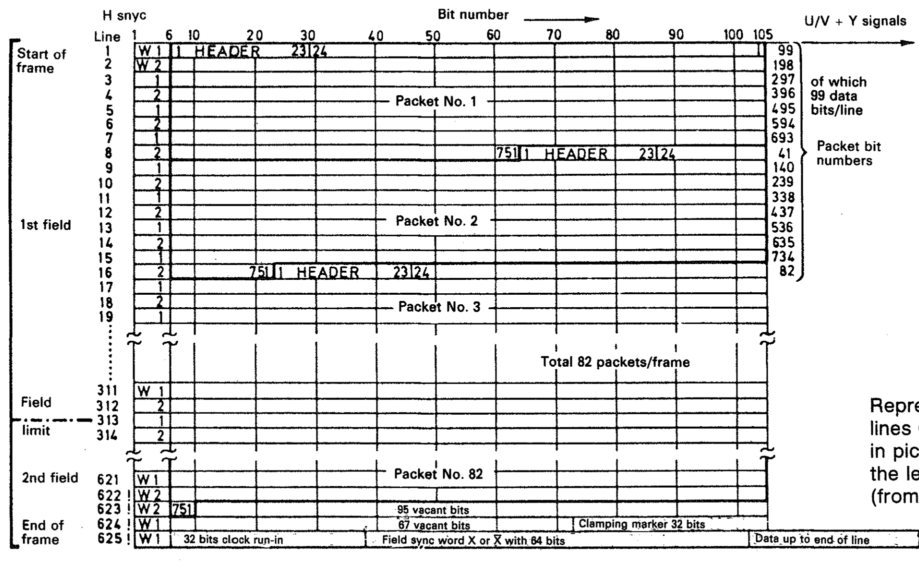
This method has the disadvantage that it cannot be distributed in normal cable systems because of its data transmission rate of 20.25 MHz (1296 clocks per line, 49.38 ns per clock).

The standard **D2-MAC packet** which is a further development of the C-MAC standard is to be used for the TDF (France) and TV-Sat satellites. The designation D2 means duo-binary modulation with half the bit rate compared to C-MAC. The half bit rate reduces the data bandwidth to 10.125 MHz, the duo-binary modulation further to approx. 5.5 MHz so that it is significantly below the required vision bandwidth of 8.5 MHz. Packet refers to the fact that the digital sound and data transmission is now in lines 1 to 623 in a total of 82 packets with 751 bits each (diagram below) which can additionally be used for a variety of purposes, e.g. for:

- identification of broadcasting station
- information on language
- TV program identification (sport, music etc.)
- Teletext
- VPS signals



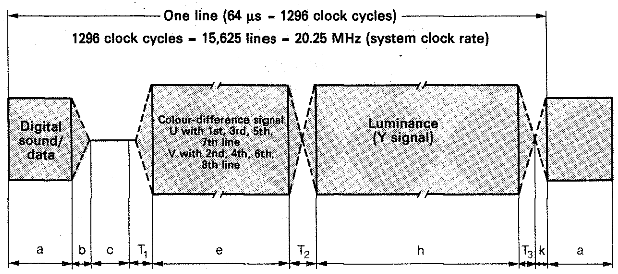
Comparison between PAL signal and corresponding D2-MAC packet signal;
compression: luminance signal (Y) 3:2
colour difference signal (U/V) 3:1



Representation of packets in data burst; lines 624 and 625 to identify the change in picture (signals X and $\overline{X}$) and to define the level (reference level);
(from: Pooch, Heinz (Hrsg.): Taschenbuch der Fernmeldepraxis 1987, Fachverlag Schiele & Schön GmbH, Berlin 1987)

transmission times

Four 15-kHz wide channels (HQ channels) are contained in the data packets as sound information, e.g. for one stereo transmission and two mono channels. Mixture with 7.5-kHz wide MQ channels (comment channels) is also possible.

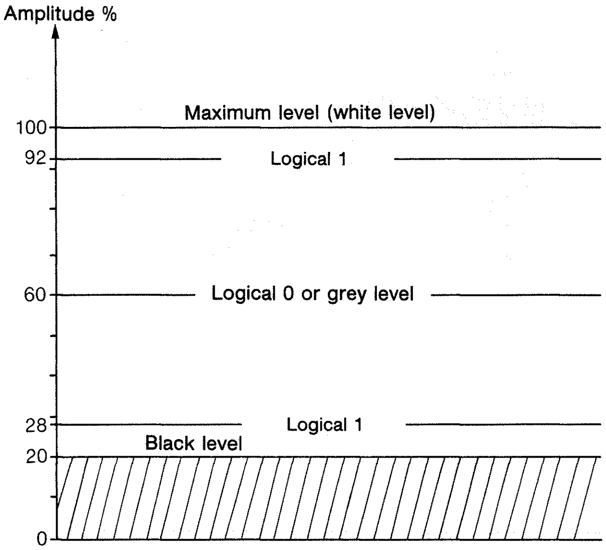


D2-MAC packet baseband signal
Colour-difference signals: U = B – Y
V = R – Y

B blue, R red, Y brightness

- a 209 clock cycles = approx. 10.32 µs, 105 bit for line synchronization, digital sound, data
- b 4 clock cycles = approx. 0.2 µs, transition at end of digital sound/data section
- c 15 clock cycles = approx. 0.74 µs, clamping period
- T1 10 clock cycles = approx. 0.49 µs, transition to colour-difference signal
- e 349 clock cycles = appprox. 17.23 µs, compressed colour-difference signal
- T2 5 clock cycles = approx. 0.25 µs, transition from colour-difference to luminance signal
- h 697 clock cycles = approx. 34.2 µs, compressed luminance signal
- T3 6 clock cycles = approx. 0.3 µs, transition from luminance signal
- k 1 clock cycle = approx. 0.05 µs, transition to digital sound/data section

A great advantage of this method is that the signals can be applied to broadband communication systems without recoding. Special receivers are required, of course, which are generally not yet available. Conversion to the previous standards will still be required for some time in headends. This results in a loss in definition, however. Furthermore, all information except two sound channels and the conventional teletext is suppressed.



Modulation level of D2-MAC packet signal
(positive modulation)

Advantages of the D2-MAC packet method
(without recoding)

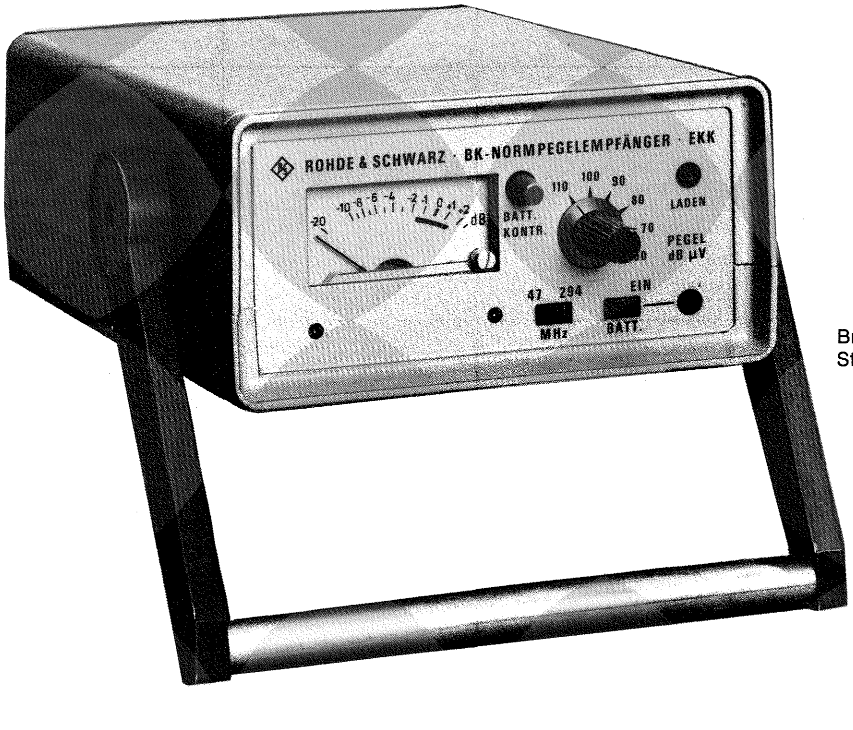
- better utilization of satellite power, thus smaller parabolic antenna at the receiver end
- uniform transmission method for the directly broadcasting satellites TV-Sat and TDF
- improved picture quality resulting from offset transmission of luminance and chrominance information to prevent mutual influencing (cross-colour)
- only one carrier (four with PAL), therefore no inherent intermodulation interferences, even when feeding broadband communication systems
- direct feed into broadband communication systems possible
- improved picture quality even with unfavourable receiving conditions
- four high-quality digital sound channels (two stereo channels or four mono channels)
- many additional information services possible (190 kbit/s for data)
- sound and video signals can be coded using simple means

MEASUREMENTS ON BROADBAND COMMUNICATION NETWORKS

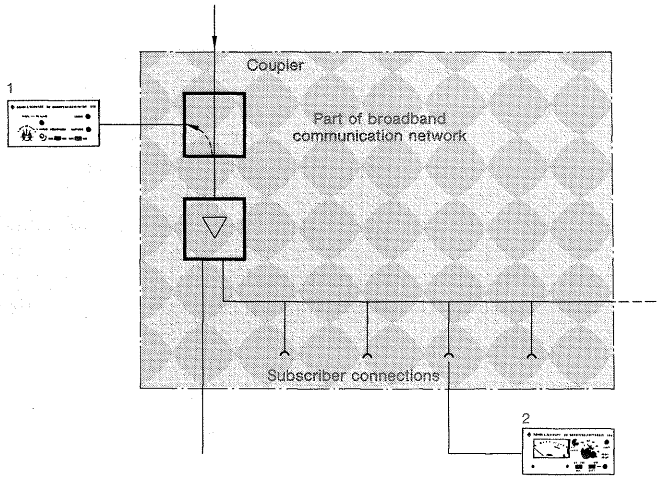
In broadband communication networks, the individual subscribers must be provided with sufficient signal levels. It is therefore necessary to determine the attenuation of the cable links from the point of feed or from a repeater station up to the subscriber. This can be carried out using a transmitter at the point of feed and a receiver at the subscriber.

ATTENUATION

Rohde & Schwarz provides two instruments especially for these measurements: the Standard Level Generator SKK and the Standard Level Receiver EKK (small, battery-operated units for servicing). The SKK simultaneously outputs signals with frequencies of 43 MHz and 294 MHz and levels of 98 dBμV each (approx. 80 mV). The EKK measures incoming levels in the range from 50 to 110 dBμV. Attenuation occurring in a broadband communication network can be determined simply and rapidly in this way. The simultaneous transmission of two signals with different frequencies enables monitoring of the frequency response of the network and thus immediate detection of any installation faults.



Broadband Communication
Standard Level Receiver EKK



1 Standard Level Generator SKK (photo below)
2 Standard Level Receiver EKK (photo opposite)

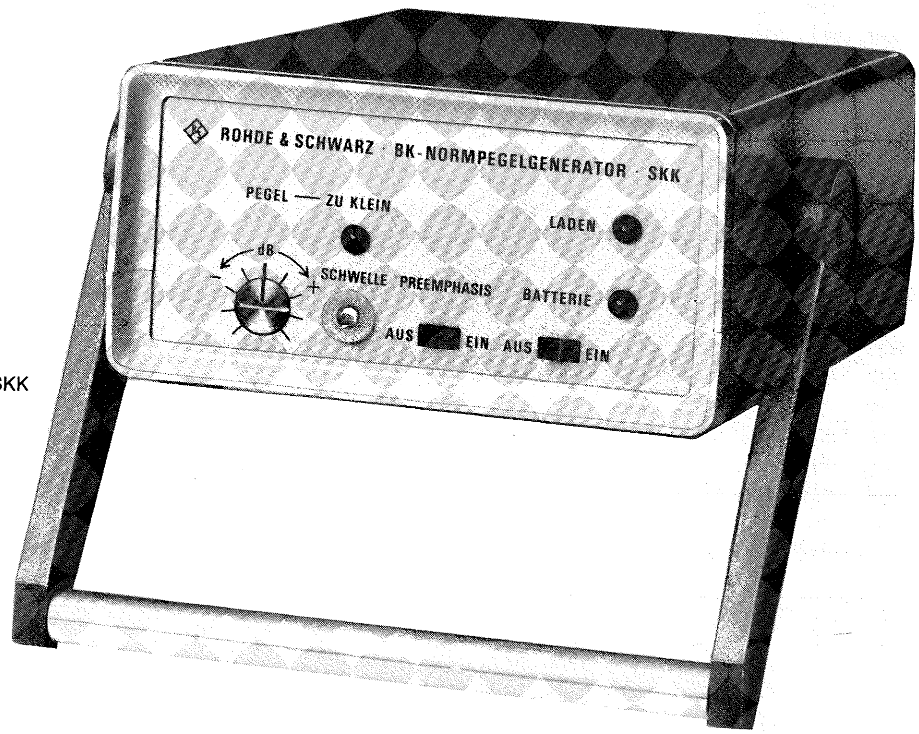
Measurement Procedure

A. Calibration of measuring equipment

1. Connect SKK and EKK together using short cable.
2. Set level on SKK to 98 dBμV. Read off on EKK.

B. Measurement of path attenuation

1. Connect output of SKK to feed point (coupler). Take attenuation (a_F) of feed point into account during evaluation.
2. Connect input of EKK to desired test point and note level display (a_M) at 43 and 294 MHz.
3. The attenuation a_{ST} of the measured path is:
   $a_{ST} = 98 - a_M - a_F$ [dB]
   a_M level display at test point
   a_F attenuation of feed point
4. The transmit level for 43 MHz is reduced by 6 dB on the SKK with the preemphasis switched on. The path attenuation for this frequency is then 6 dB lower than according to the above equation.



Broadband Communication
Standard Level Generator SKK

TEST ASSEMBLY RACKS FOR MONITORING/MEASURING

A great variety of instruments are required for the measurements described in the previous sections. These instruments must appropriately be connected together and to the device-under-test. It is advantageous to combine these instruments into an assembly where the connections required for the individual measurements are made via a central switching panel manually or by remote control. The time required for the measurements can thus be greatly reduced.

One distinguishes between test assemblies for monitoring (primarily of outgoing programs) and assemblies for measuring which contain all instruments required for the described measurements. This distinction is mainly common in the case of test assemblies for TV transmitters. Because less instrumentation is required for sound broadcasting, only one assembly is normally used which incorporates instruments for both monitoring and measuring.

Test assemblies for monitoring of TV transmitters and the corresponding assemblies for sound transmitters can be used — depending on their configuration — both for measuring and monitoring. They always contain demodulators for recovery of the modulation signal from the transmitted RF signal, e.g. the FM/AM Demodulator FAB for sound broadcasting, and the TV Demodulator AMF 2 and possibly the TV Dual Sound Demodulator FATF for TV broadcasting.

Test assemblies for acoustic monitoring of sound transmitters are obtained by extending the assemblies with amplifiers and loudspeakers (and also a Precision Stereodecoder MSDC 2 for stereo transmitters) and possibly an FM Monitoring Demodulator FKDL (photo on p. 162) or FKD.

An assembly for **visual and acoustic monitoring of TV transmitters** is produced in a similar manner from a TV Modulator AMF 2, a monitor and an amplifier with loudspeaker. A checkpoint selector is usually incorporated with which the various video frequency, IF and RF measurement points can be connected to the monitoring instruments.

Basic of test assemblies The configuration of test assemblies mainly depends on the operational needs and customer requirements. In the course of time, however, several basic versions have crystallized, as described below.

The FM Transmitter Input and Monitoring Assembly UEMT 2 from Rohde & Schwarz (photo opposite) is suitable for monitoring FM transmitters with up to four stereo programs. The program lines of the transmitter are also routed via the rack assembly. Limiting amplifiers can be used if required, and stereocoders are also provided (if not incorporated in transmitter). Incoming program lines can be connected to any transmitter via an input switching panel. In addition, test signals from the AF Transmission Measuring Set SUN 2 can be fed in here. All program lines can be monitored by two VU meters. The output modulation of the four transmitters is indicated on the four plug-ins of the FM Monitoring Demodulator FKD and can be monitored via a loudspeaker panel.

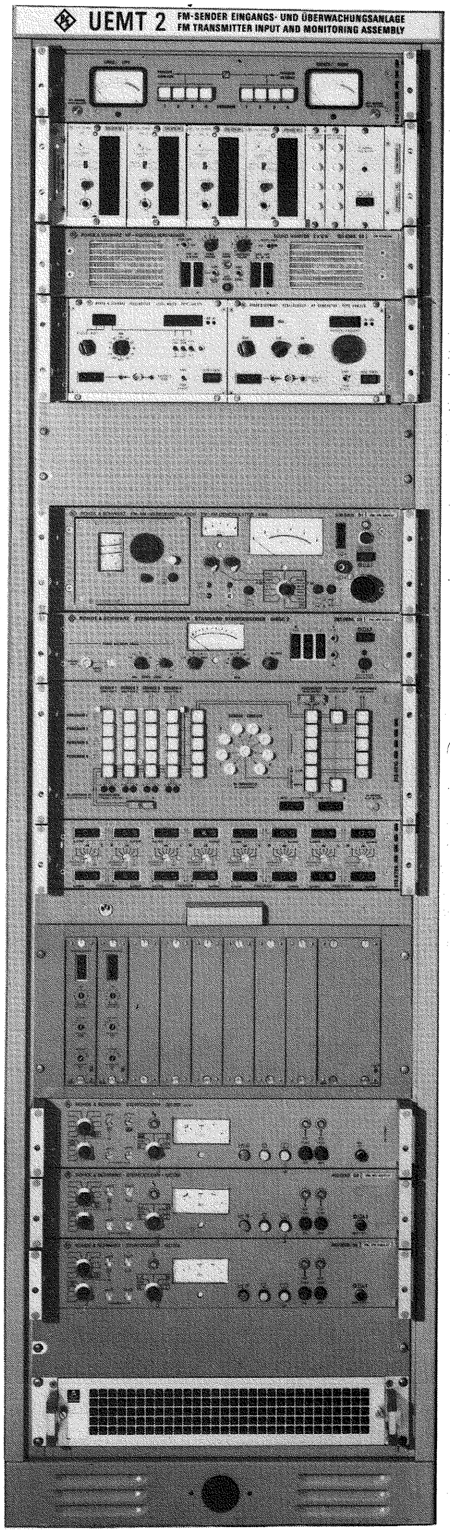
Picture Transmitter Monitoring Assemblies of type UKFZ (photo opposite) always contain a TV Demodulator AMF 2 for vision monitoring, a TV Dual Sound Demodulator FATF for sound monitoring and a checkpoint selector. A monitor and a loudspeaker panel are provided for monitoring purposes.

If the transmitter to be monitored is operated as a passive standby unit (dual transmitter), two TV demodulators and two checkpoint selectors are usually fitted: one set of equipment for monitoring the main transmitter and one set for measurements on the standby transmitter.

If there are several transmitters in a station, it is recommendable to assign a TV demodulator to each of the transmitters because of the different transmitting frequencies. All the input and output signals can then be compared directly at the video and audio frequencies as necessary for most measurements.

The Picture Transmitter Test Assembly UMVF 2 (p. 175) which is connected to the monitoring assembly via the **junction panel** (righthand side) is used for the measurements. The test signals are applied to the transmitter via the test line. The signals from the measurement points selected using the checkpoint selector and processed in the monitoring assembly are sent to the test assembly via the return signal line. The checkpoint selector can also be remote controlled by the test assembly via the junction panel.

FM Transmitter Input and Monitoring Assembly UEMT 2 for up to four FM stereo transmitters



2 VU meters

FM Monitoring Demodulators FKD

Loudspeaker panel

AF Transmission Measuring Set SUN 2

FM/AM Demodulator FAB

Precision Stereodecoder MSDC 2

AF switching panel

AF input panel

Table flap

Maximum of 8 limiters

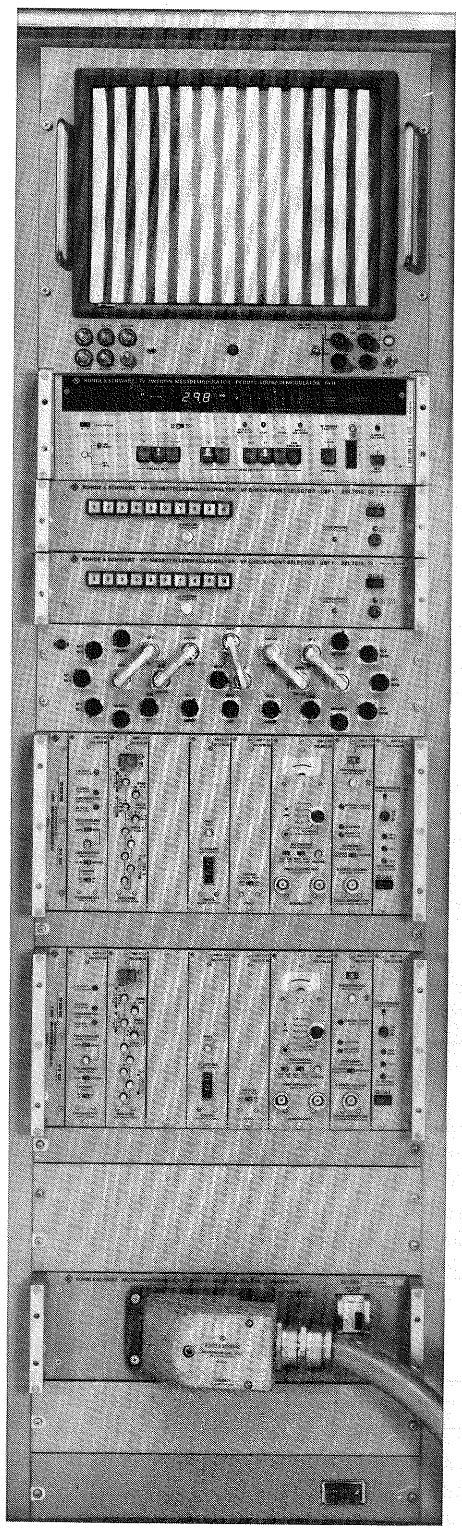
Stereocoder GC 001

Stereocoder GC 001

Stereocoder GC 001

(Stereocoder GC 001)

Picture Transmitter Monitoring Assembly UKFZ for TV dual transmitters



Monitor

TV Dual Sound Demodulator FATF

Checkpoint Selector USF 1

Checkpoint Selector USF 1

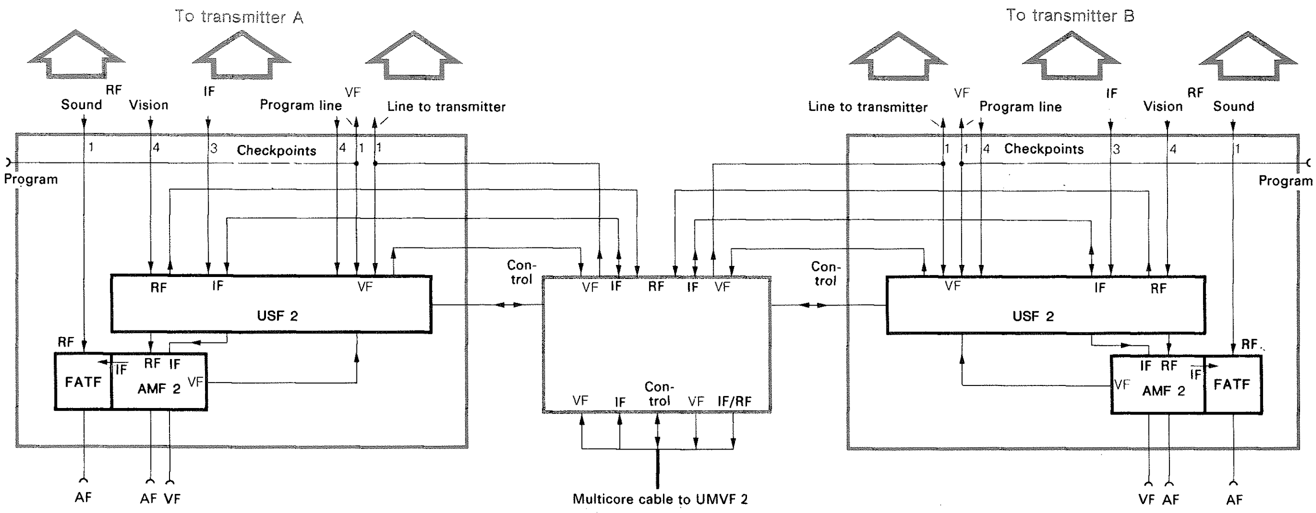
Monitoring panel

TV Demodulator AMF 2

TV Demodulator AMF 2

Junction panel to UMVF 2

test assembly racks



Basic connections between TV Transmitter Monitoring Assembly UKFZ 2, junction panel and Picture Transmitter Test Assembly UMVF 2; **USF 2** Checkpoint Selector, **AMF 2** TV Demodulator, **FATF** TV Dual Sound Demodulator, **4** Number of checkpoints

TV Transmitter Monitoring Assembly UKFZ 2 (photo below) The standard transmitters of the German DBP are designed as dual transmitters. They use a special monitoring assembly of type UKFZ 2 in each transmitter which is accommodated in the exciter rack. This monitoring assembly contains the TV Demodulator AMF 2 and the TV Dual Sound Demodulator FATF as well as a Checkpoint Selector USF 2 which establishes the connection to the desired checkpoints in the transmitter via corresponding RF/IF relays. The TV demodulator of the operating transmitter is always automatically connected to the antenna output of the transmitter since the assembly for automatic quality monitoring (p. 192 onwards) is fed by it.

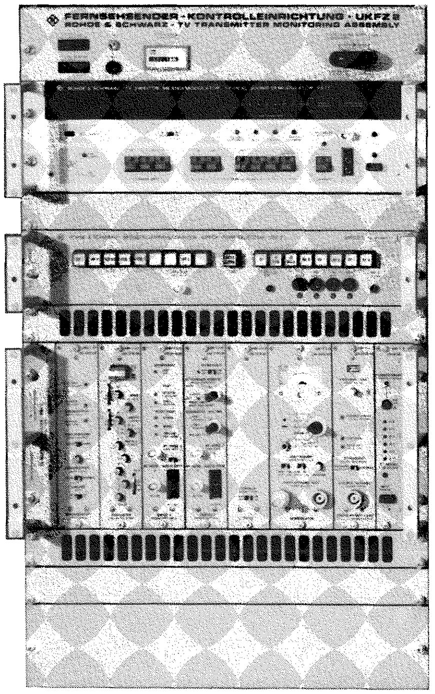
The two monitoring assemblies of a dual transmitter are connected to the mobile Picture Transmitter Test Assembly UMVF 2 via a common **junction panel.** The checkpoint selectors of the transmitters can also be remote controlled from this panel so that e.g. the standby transmitter can also be completely measured during program transmission.

Test assembly racks for measurements The mobile **Picture Transmitter Test Assembly UMVF 2** from Rohde & Schwarz (photo on opposite page) is designed for measurements on vision transmitters and is connected via a special cable to the junction panel in the monitoring rack (or in the transmitter). Since the test assembly is mobile, it can easily be moved to all transmitters in a large station. Remote control of the checkpoint selector enables all RF, IF and video measurements to be made at the corresponding checkpoints and at the transmitter input so that the quality parameters of the transmitter can be checked out practically fully. The UMVF 2 contains sources for generating insertion test signals and instruments for evaluation. The configuration is customer-specific. In the following example, it is equipped with the following instruments:

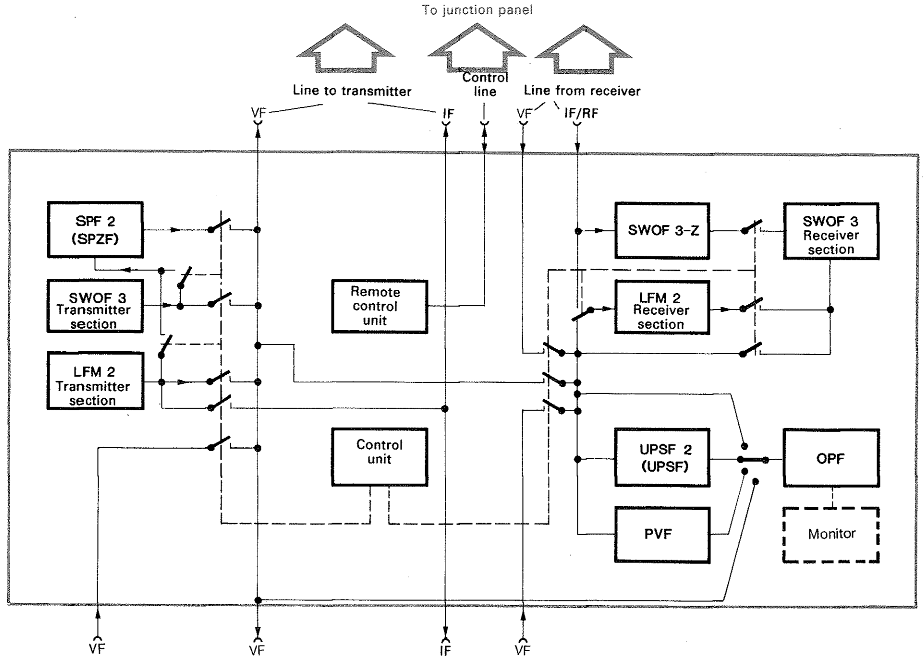
- Video Test Signal Generator SPF 2 or SPZF
- TV Oscilloscope OPF with monitor
- Videoskop SWOF 3
- Sideband Adapter SWOF 3-Z
- Group-delay Measuring Set LFM 2
- Video Noise Meter UPSF or UPSF 2
- Differential Phase/Gain Meter PVF.

There is also a control unit and a remote control unit (for the checkpoint selector) and the multiple cable for connection to the transmitter. The test assembly can also be used independent of the transmitter as a video IF test assembly.

TV Transmitter Monitoring Assembly UKFZ 2 for single transmitters



test assembly racks



Block diagram of Picture Transmitter Test Assembly UMVF 2 shown below (see text for configuration)

SWOF 3

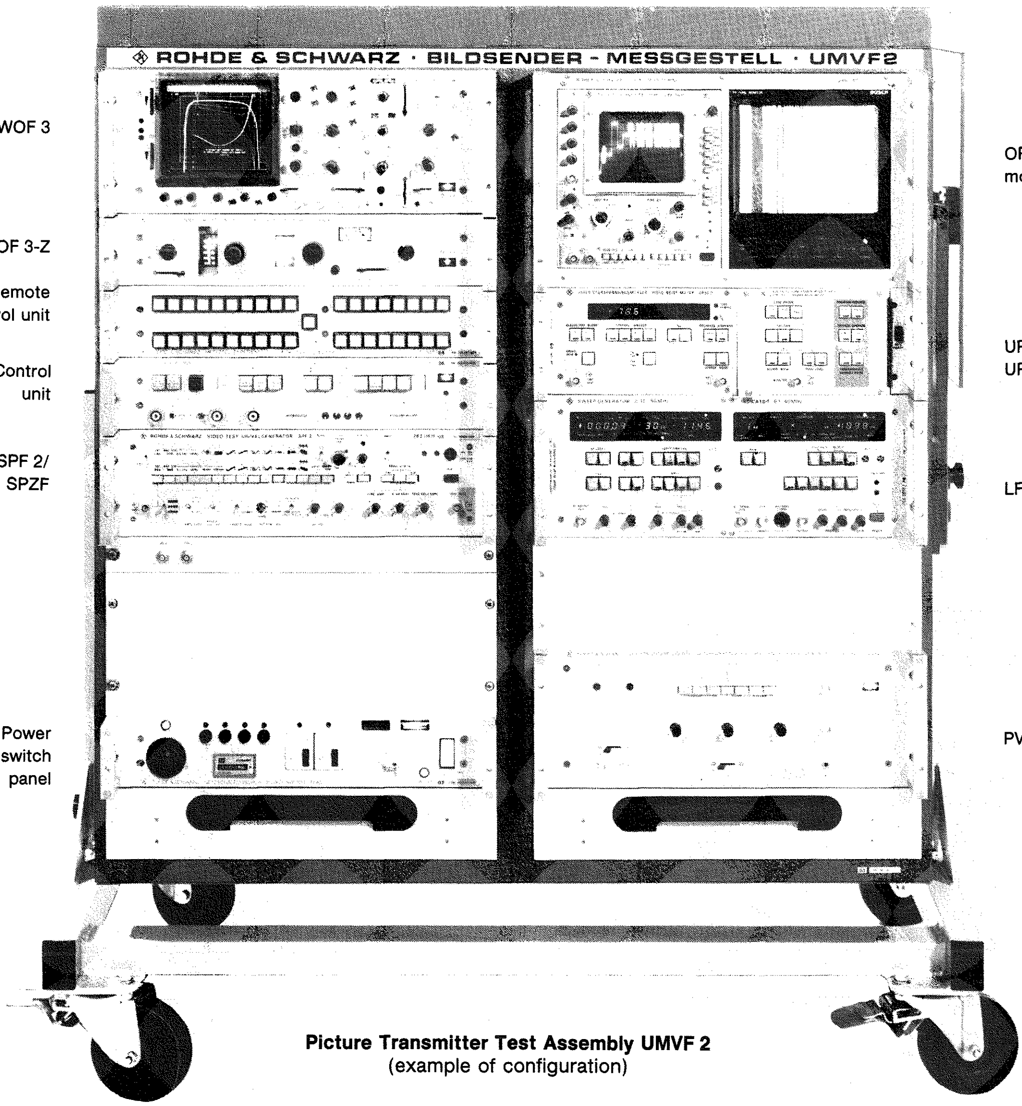
SWOF 3-Z

Remote control unit

Control unit

SPF 2/ SPZF

Power switch panel



OPF, monitor

UPSF/ UPSF 2

LFM 2

PVF

Picture Transmitter Test Assembly UMVF 2
(example of configuration)

MEASUREMENTS ON SOUND AND TV TRANSMISSION SYSTEMS DURING TRANSMISSION

Measurements that can only be performed outside transmission times have to be made at relatively inconvenient times if program pauses are of short duration, as is usually the case with sound broadcasting in particular. The remedy lies in techniques that enable measurements to be performed during the ongoing program.

There are lines in the TV picture that do not appear on the screen and into which test signals can be inserted. The evaluation of the signals inserted into these test lines at the transmitter output thus enables a genuine in-program measurement.

This is not possible with sound broadcasts, however, and the program contents are therefore analyzed at the beginning and end of a monitored link, thus providing information on the transmission characteristics of the examined equipment. A combination of both methods enables measurement of vision and sound transmissions during a program in the case of TV transmissions via a transmitter and transposer and in broadband communication and satellite systems.

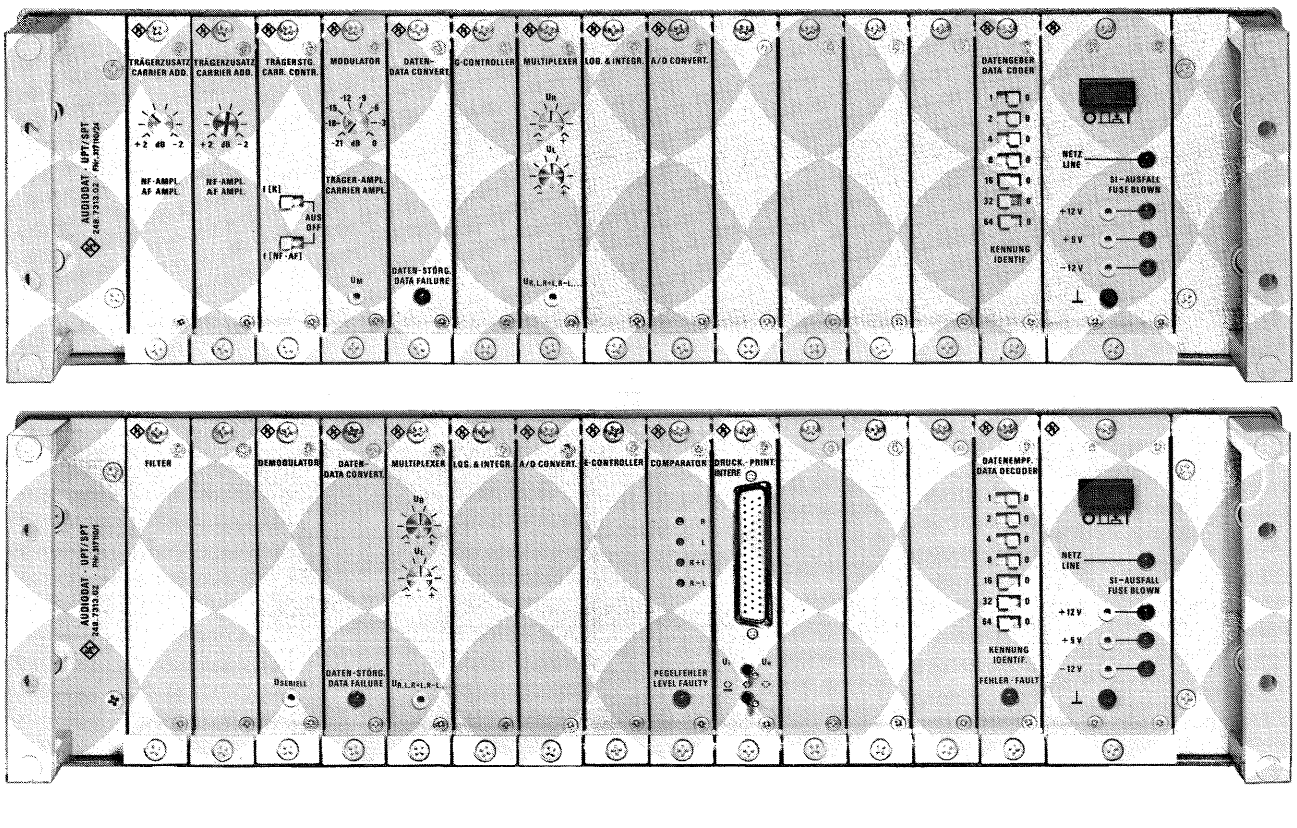
The main significance of this method is not the measurement during the ongoing program but the continuous monitoring of the transmission obtained by automatic evaluation of the results and the output of error messages (see monitoring procedures).

MEASUREMENTS ON SOUND TRANSMITTERS ON-SITE/VIA LINK

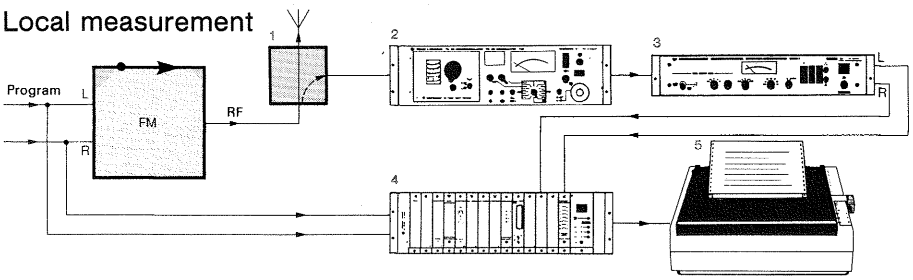
Measurements in the true sense — evaluation of a test signal applied to the test item — cannot be performed during an ongoing program in sound broadcasting because, in contrast to vision transmission, time gaps for the insertion of test signals are not present in transmission of sound. By comparative analysis of the program contents at the input and output of the equipment or link, however, it is nevertheless possible to gain information on the transmission characteristics, e.g. frequency response and signal/noise ratio.

The Audiodat system SPT/UPT from Rohde & Schwarz (photos below), which is mainly used for the automatic monitoring of sound-broadcast transmitters and networks, is described starting on p. 188.

Audiodat system with Transmitter SPT (top) and Receiver UPT (bottom)



Local measurement

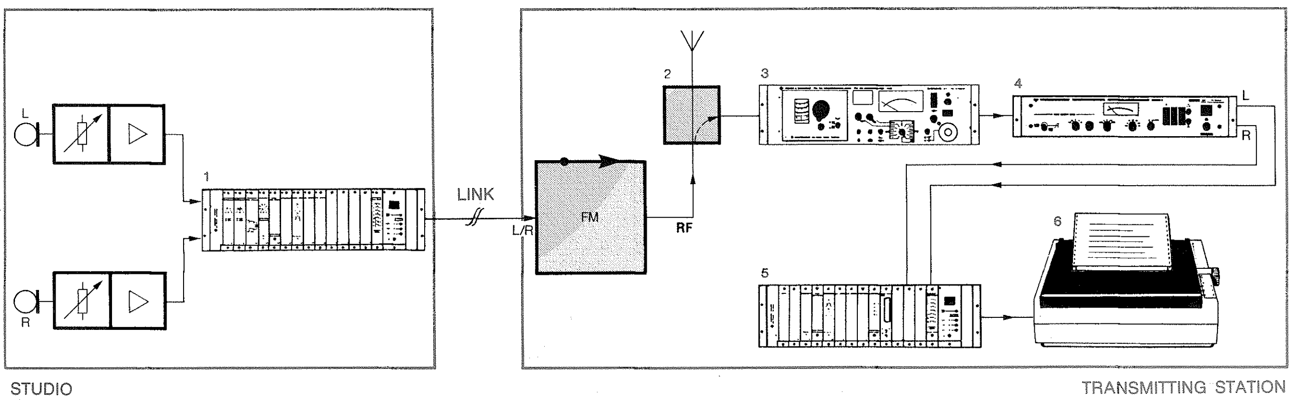


1 Directional coupler (incorporated in transmitter)
2 FM/AM Demodulator FAB (photo p. 12)
3 Precision Stereodecoder MSDC 2 (photo p. 13)
4 Audiodat Unit SPT/UPT for local operation
5 Printer (BCD)

Measurement Procedure

The arrangement above, through constant level analysis of the program contents (three frequency bands) at the input and output of a transmitter, can provide data concerning frequency response and signal/noise ratio. The results are logged by the printer. This arrangement only detects the characteristics of the transmitter.

Measurement over link



1 Audiodat Transmitter SPT (photo opposite)
2 Directional coupler (incorporated in transmitter)
3 FM/AM Demodulator FAB (photo p. 12)
4 Precision Stereodecoder MSDC 2 (photo p. 13)
5 Audiodat Receiver UPT (photo opposite)
6 Printer (BCD)

Measurement Procedure

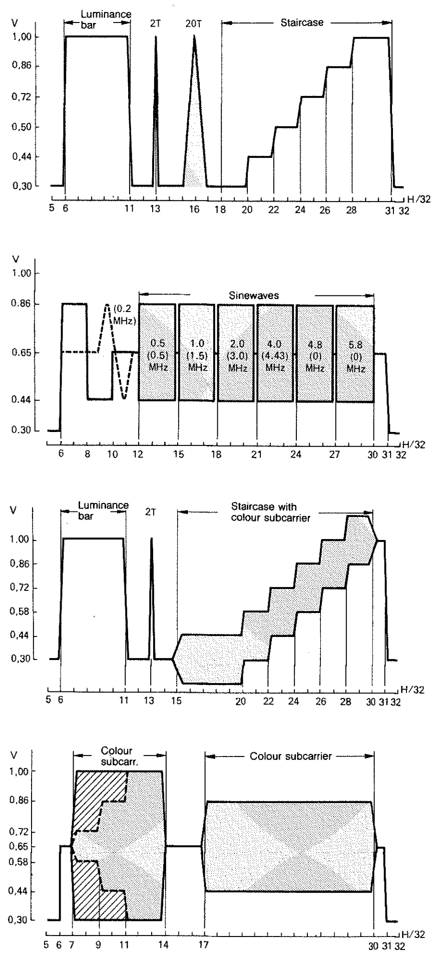
If a transmission link is also to be included in the measurement, an Audiodat Transmitter SPT is required at the input of the link — e.g. in the studio — and an Audiodat Receiver UPT at the transmitter instead of the SPT/UPT Audiodat unit. The transmitter sends the results of its analysis of the modulation as an inaudible code telegram. The receiver compares this with the result of its own analysis at the transmitter output and thus derives the characteristics of the transmission link. This is described more fully together with further possibilities on p. 188.

Measurements with test-line signals In the transmission of TV pictures, there are time gaps present — unlike with pure sound broadcasting or the transmission of TV sound — into which test signals can be inserted. These gaps are a result of the special construction of the TV picture: the first, third lines etc. of the picture are transmitted first, and then the second, fourth lines and so on. In the case of the system with 625 lines that is generally found in Europe, the lines 1 to 312.5 form the first field and the lines from 312.5 to 625 the second field.

Twentyfive of these lines are used up in each case by the field blanking interval of the field frequency, and these do not appear on the screen. The field frequency only requires some 7.5 lines however, so it is possible to accommodate signals in the remaining lines. By international agreement (CCIR Rec. 473-2), the lines 17 and 18 in the first field and 330 and 331 in the second field are reserved as test lines, in which the international insertion test signals in the diagrams on the right are transmitted. Other lines are vacant for additional test signals or other transmissions (data line, teletext). The constantly sent test-line signals offer an excellent possibility of performing measurements on transmitters and transmission links while programs are actually being transmitted.

The insertion test signals were already used in some of the full-field measurements described earlier, and this chapter follows up with full-field measurements. This chiefly concerns the lines 17 and 331. Lines 18 and 330, in a different manner to full-field measurements, permit the video amplitude characteristic and differential gain to be determined.

Note The average DC value constantly changes during measurements in an ongoing program. To what extent this affects the measurement can be judged by measuring the level stability.



CCIR test-line signals for (from top) lines 17 and 18 (in parentheses: frequencies of standard version of Video Test Signal Generator SPF 2 and Insertion Signal Generator SPZF) of first field and lines 330 and 331 (with and without staircase) of second field

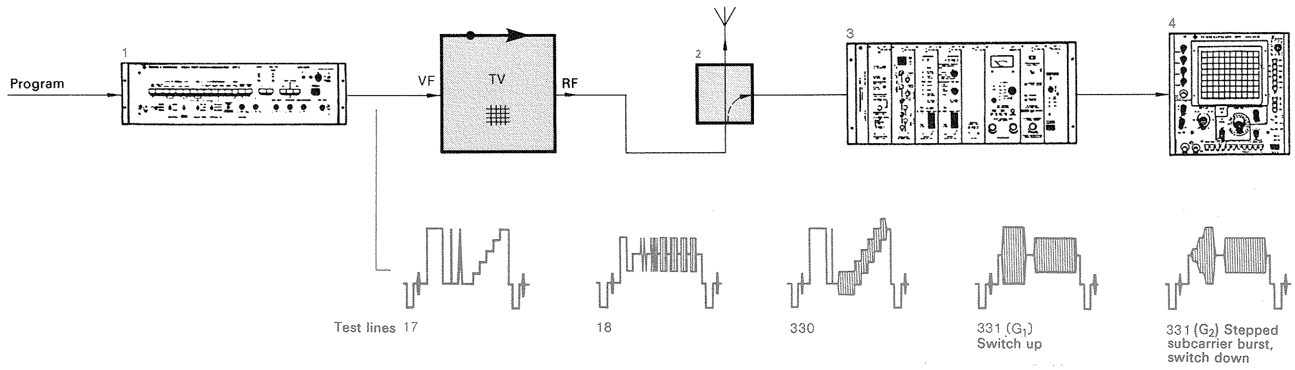
Measuring instruments The **TV Oscilloscope OPF** from Rohde & Schwarz is specially designed for these insertion-test-signal measurements. Its line selector enables the required test lines to be displayed individually or together.

Using the **Video Distortion Analyzer UPF** it is possible to automatically derive as many as 28 different measured values from insertion test signals. This instrument signals any non-adherence to fixed limits and indicates the called up measured values in digital form. This unit is mainly used for in-program monitoring of transmitter networks and links and is described more fully starting on p. 196.

Measurement Procedure

A. Basic settings

1. As on p. 41.
2. If the received program contains test lines, the Video Test Signal Generator SPF 2 is not required.
3. If no test lines are present in the program or if the transmitter is to be measured alone (without program line), use the SPF 2. Use the connectors PROGRAM INPUT AND OUTPUT (rear panel). Press CALibrated.
4. Tune TV Demodulator AMF 2 to vision-carrier frequency (crystal available?) and switch ZERO REFERENCE to ON.
5. Press key V1 on the OPF for test lines 17 and 18 and key V2 for test lines 330 and 331.
6. Select test line 17 (V1).
7. Set gain on oscilloscope according to level mask CCVSO such that the base of the sync pulse is at 100% and the zero-reference pulse at 0%.



1 Video Test Signal Generator SPF 2 (photo p. 24)

2 Directional coupler (incorporated in transmitter)

3 TV Demodulator AMF 2 (photo p. 36) or AMF

4 TV Oscilloscope OPF (photo p. 49) with appropriate level mask for measurement

Measurement Procedure (continued)

B. Measurement of level stability (see p. 41)

1. Press key = on OPF and set 5 µs/DIV. Switch ZERO REFERENCE on AMF 2 to OFF.
2. The top of the luminance bar must be at 10%, the base at 73% and the sync pulse base at 100%. Correct if necessary using ↕ (left).
3. Fluctuation of these values during the program point to alterations in gain caused by changes in transmitter load (average DC value of program). They should only be very slight.

C. Measurement of noise

1. Switch OPF to 50 mV/DIV. Adjust height of luminance bar to 10 DIV (= 100%) using ⊿ (left) and ↕. Release key =.
2. Select line without vision content (e.g. line 22 or 335).
3. Press key x10 (righthand side).
4. Using ↕ (left) adjust part of signal to be evaluated to screen area.
5. Measure noise amplitude or superimposed interference (without extreme peaks). 0.1 DIV corresponds to a signal/noise ratio of 60 dB (peak-to-peak, video reference amplitude 100 DIV).

D. Measurement of line-time nonlinearity

1. Select test line 17 on OPF (press V1).
2. Measure and evaluate as on p. 53.

E. Measurement of tilt of 15-kHz squarewave

Measure and evaluate as on p. 43.

F. Measurement of rounding of 15-kHz squarewave

Measure and evaluate as on p. 43.

G. Measurement with 2T pulse

Measure and evaluate as on p. 49.

H. Measurement with modulated 20T pulse

Measure and evaluate as on p. 51.

I. Measurement of video amplitude characteristic

1. Select line 18 on TV Oscilloscope OPF (press V1).
2. Set largest frequency burst between 0% and 100% using ⊿ (left) and ↕.
3. The magnitude of the other frequency bursts provides an overall assessment of the video amplitude characteristic.

J. Measurement of differential gain

1. Select line 330 on the OPF (press key V2 and 4.4 MHz). Centre the filtered subcarrier bursts using ↔.
2. Adjust the largest amplitude A_{max} between 0% and 100% of the mask using ⊿ (left) and ↕.
3. Determine the smallest amplitude (A_{min}) in percent from the mask.
4. The nonlinearity is:
$$m_{4.43} = \frac{A_{min}}{A_{max}} = A_{min}$$
5. The differential gain is:
$$\Delta A_{4.43} = \frac{1-A_{min}}{A_{max}} \quad (= 1-A_{min})$$

K. Measurement of chrominance nonlinearity

1. Select line 331 on OPF (press V2).
2. The subcarrier burst with staircase shows nonlinearities of the modulation characteristic at the colour-subcarrier frequency.
3. The exact values of the three amplitude risers are 1/5, 3/5 and 1. Switch OPF to 50 mV/DIV and set largest burst to 10 DIV (= 100%) using ⊿ (left) and ↕. The values of the other bursts can then be clearly read.
4. If the measured amplitudes are designated A1 (smallest) and A3 (largest), the nonlinearity in percent is the larger of the two values:
$$\left|\frac{A1 - 1/3\,A2}{1/3\,A2}\right| \cdot 100 \quad \text{and} \quad \left|\frac{A3 - 5/3\,A2}{5/3\,A2}\right| \cdot 100\ [\%]$$

L. Measurement of chrominance/luminance intermodulation

Measure and evaluate as on p. 59.

TV

AUTOMATIC INSERTION TEST SIGNAL EVALUATION with UVF

measurements during

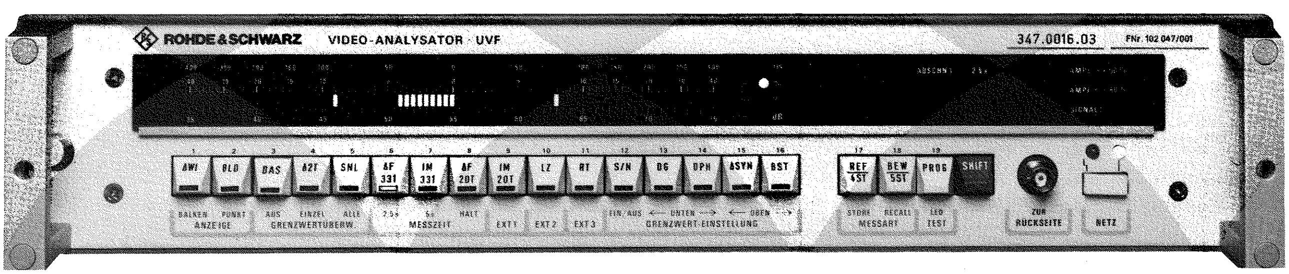
Video Analyzer UVF Evaluation of insertion test signals with an oscilloscope is laborious and tedious. The Video Analyzer UVF from Rohde & Schwarz enables much simpler and faster evaluation of a total of 16 insertion test signal parameters. The measured values can be called individually and are displayed on a quasi-analog bar indicator. The instrument can also be used for mobile applications as a result of its compact design and low weight. The UVF lists the insertion signal parameters listed on the right in accordance with the CCIR Recommendation 569-1 and the EBU Specifications D34-1982, D35-1982 and Tech 3216. Three inputs are also provided via which the external DC voltage can be measured and evaluated in a range of ±4 V.

Four test programs are stored in the instrument and can be key-selected. These determine in which line and at what time each of the 16 parameters is measured (e.g. evaluation of the source or sectional test lines).

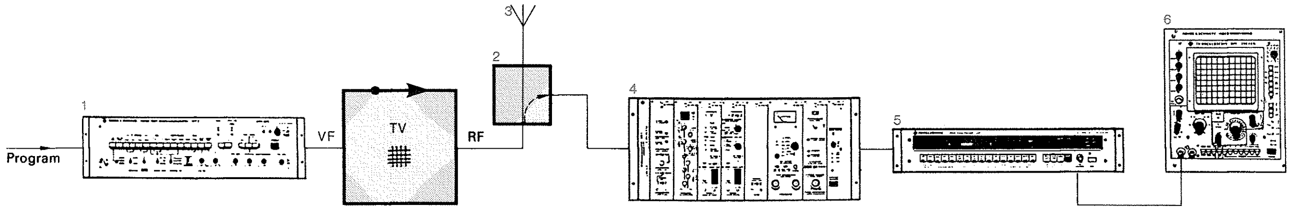
The 16 parameters are usually evaluated in 2.5 seconds (5 seconds can be selected). The measured values can be called individually using keys. The UVF is therefore a universal instrument which can very rapidly provide a large number of measured values during ongoing programs by evaluation of the insertion test signals which could otherwise be measured using conventional instruments only in a far more complex manner and outside the transmission times. A built-in limit monitoring facility in the UVF means that it is highly suitable for continuous monitoring of systems (see p. 193).

ΔWI	Luminance bar amplitude
BLD	Base line distortion
DAS	Tilt
Δ2T	2T amplitude
SNL	Line-time nonlinearity
ΔF 331	Colour subcarrier
IM 331	Intermodulation
ΔF 20T	Colour subcarrier on 20T pulse
IM 20T	Intermodulation on 20T pulse
LZ	Chrominance-luminance delay
RT	Residual picture carrier
S/N	Signal/noise ratio
DG	Differential gain
DPH	Differential phase
ΔSYN	Sync pulse amplitude
BST	Burst amplitude

Video Analyzer UVF



Measurement on TV vision transmitters during transmission times



1 Video Test Signal Generator SPF 2 (photo p. 24) or VITS Generator & Inserter SKF — Only required if the applied program does not contain insertion test signals

2 Directional coupler (incorporated in transmitter)

3 Transmitting antenna

4 TV Demodulator AMF 2 (photo p. 36)

5 Video Analyzer UVF (photo opposite)

6 TV Oscilloscope OPF (photo p. 49), only for monitoring insertion test signals

Measurement Procedure

A. Basic settings

1. Connect video signal without insertion test signals to program input connector of SPF 2 (at rear). Connect program output to transmitter input.
2. The TV Oscilloscope OPF is suitable for displaying insertion test signals. Loop through the monitoring output of the UVF to the front. Connect VIDEO and FRONT connectors on rear panel using short cable.
3. Connect front connector of UVF to front connector of TV Oscilloscope OPF and press key 75 Ω. Press key V1 for the test lines in the first field (e.g. 17 and 18) and press key V2 for those in the second field (e.g. 330 and 331) (line selection using switch at top right).

B. Measurement of insertion test signal parameters

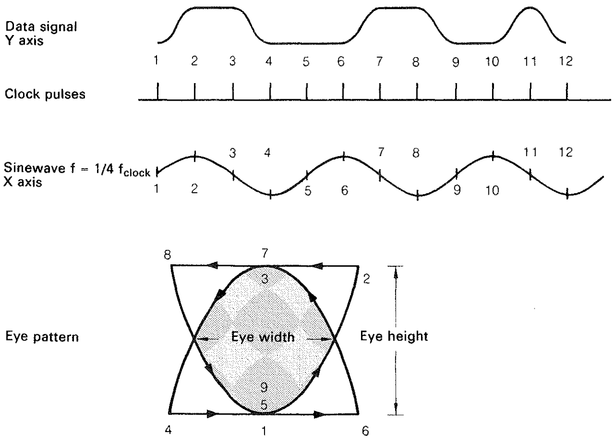
1. Select test program using key 19 (PROG). Indicated on display.
2. Set the measuring time (for evaluation of all 16 parameters) using keys SHIFT and 6 (2.5 s) or 7 (5 s). Standard setting: 2.5 s.
3. Select desired parameter using keys 1 to 16. Select external parameters (max. DC voltage ±4 V, connection on rear panel, EXTernal DC) to the keys SHIFT and 9 to 11 for EXT1 to EXT3 (EXT output on display and LED lights up in key).
4. The measured value is displayed on the bar scale (with dimension). No display of dimension for external parameters. Read on the % scale (10% = 1 V).
5. Output as bar or dotted display: press SHIFT and 1 or 2.
6. Evaluation of 4 or 5 risers of the staircase signal is possible for measurement of the differential gain (key 13) and phase (key 14) (setting using key 17 (4ST) or 18 (5ST), output on display).
7. When measuring the signal/noise ratio (S/N, key 12), sync pulse amplitude (ΔSYN, key 15) and burst amplitude (BST, key 16) the reference value can be switched between the nominal value (700 mV) and the actual signal level (luminance bar). Set using key 17, output on display (REFerence SIGnal or NOMinal, standard case: SIG). If a luminance bar is not present in the signal, reference to SIG is not possible (measurement with reference to NOM is still possible).
8. A weighting filter can be switched on using key 18 in the case of a signal/noise voltage measurement (S/N, key 12) (output on display: WGH ON or OFF).
9. SHIFT and 8 (HOLD) can be used to freeze the current state of all measured values. HOLD is output on the display (important for examination of brief signal disturbance. Return to normal setting as in 2.).

C. Storage of settings

1. Settings modified according to B.6. to 9. can be stored using the keys SHIFT and 17 (STORE) so that they are fixed for further measurements.
2. Settings modified during the measurements can be reset to their original values using SHIFT and 18 (RECALL).

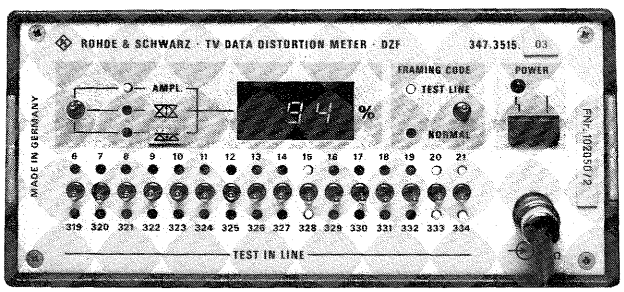
Transmission principle Teletext information[1]) is transmitted as pulsed binary signals in the lines which do not appear on the screen (currently 20, 21 and 333, 334). The NRZ code (**n**on-**r**eturn-to-**z**ero) and the band-limiting filters used guarantee that a data stream of 6.94 Mbit/s — corresponding to a half-amplitude width of 144 ns per single bit — can be accommodated in a 5-MHz wide TV channel. The levels of the teletext signals lie between 0% video (binary 0) and 66% video (binary 1). The complete signal of a line comprises a clock run-in of 16 bits for synchronization of the decoder oscillator and a subsequent framing code to identify the teletext information.

Eye pattern Various parameters can be used to assess the quality of a teletext transmission. Some of these can be determined on an oscilloscope from the so-called eye pattern and read directly on special teletext measuring instruments. The eye pattern is produced if the teletext data bits are overlaid such that the 1- and 0-bit values appear at the same position on the X axis. If the X axis is expanded, an eye is produced whose amplitude (difference between the lowest 1-bit value and the highest 0-bit value) represents a measure of the transmission reliability.



Generation of eye pattern

TV Data Distortion Meter DZF



Important variables (see also drawings on opposite page) The reference value for the measurements is the nominal teletext level of 66% video (= 462 mV). For certain instruments the video value is obtained from the bar amplitude of a test line (e. g. 17) which then represents the reference level for all teletext values.

The instruments evaluate the **eye height** (decoding margin) from the difference in voltage between the fourth lowest 1 bit and the fourth highest 0 bit. The reference voltage is the amplitude of the clock run-in or 66% of the bar amplitude. Additional measurement of half-eye height enables detection of limiting effects in the transmission channel. The eye height in the example on the left is the voltage difference between points 1 and 3, i. e. approximately comparable with the opening of the pupil of the eye. Distorted teletext signals can be easily adjusted to optimum waveform and eye height using this pattern and appropriate correction networks. The eye pattern is provided with cursors on state-of-the-art instruments which help detect the exact centre of the teletext data bit.

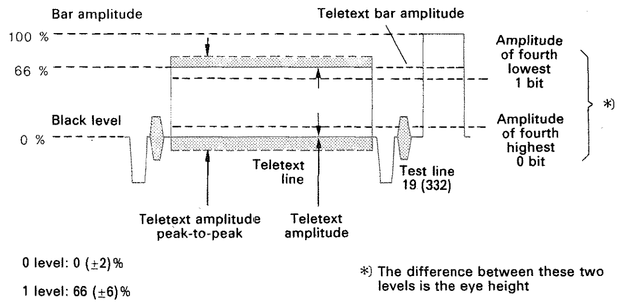
Double the difference in voltage between the average level of the run-in bit and the black level of the teletext line is referred to as the **amplitude** of the data stream with reference to the nominal amplitude (462 mV) or 66% of the bar amplitude.

Further variables of interest include:

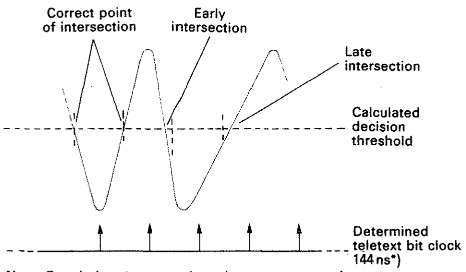
- **Peak-to-peak amplitude** Difference between fourth highest 1 value and fourth lowest 0 value
- **Eye width (timing margin)** Points of intersection of bit edges by mean-value line, referred to the teletext clock period
- **Number of run-in bits** (nominal value: 2 words = 16 bits)
- Time up to **start of data code (data timing)**
- **Bit error rate** of transmission (parity errors referred to the total number of transmitted bits)
- **Signal/noise ratio** which can be measured in a modulation-free line (e. g. 22).

[1]) The designations Fernsehtext or Videotext are used in the Federal Republic of Germany. This method corresponds to Teletext, Ceefax, Oracle in Great Britain. The instruments described are suitable for all these methods. Similar methods in France are Antiope and Didon.

Definition of teletext parameters



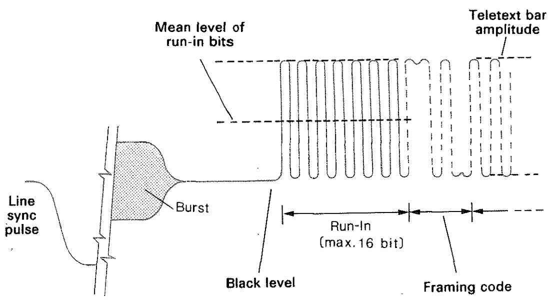
Teletext bar amplitude, eye height (decoding margin) and peak-to-peak amplitude



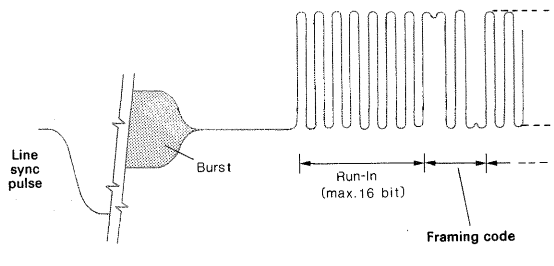
Note: For clarity, the errors have been exaggerated

*) The theoretical point of intersection of the decision threshold is exactly in between

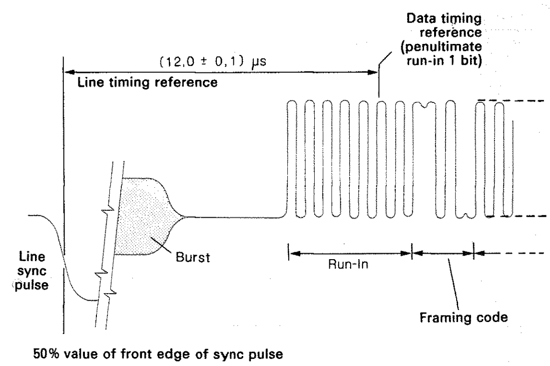
Eye width (timing margin) This is the difference between the fourth earliest and fourth latest points of intersection referred to the bit clock



Amplitude (basic amplitude) Double the average value of the clock run-in bits



Number of run-in bits



Start of data code (data timing)

Measuring instruments Rohde & Schwarz offers two different devices for teletext measurements: the low-priced **TV Data Distortion Meter DZF** and the advanced **Digital Teletext Analyzer ATF.**

The **DZF** is a pure measuring instrument and enables three types of measurement: amplitude, eye height and half-eye height in lines 6 to 21 and 319 to 334. In the selected line, the instrument set to FRAMING CODE NORMAL searches for the (internally selectable) start sequence for teletext lines which is a prerequisite for the measurement. If several lines are selected, these are measured in succession and the DZF indicates the worst value. If the teletext start sequence is missing in the selected line, the instrument outputs ERR. The framing code TEST LINE must be switched on for measurements in the teletext test line (currently 328). The instrument has corresponding outputs for monitoring the eye pattern on an oscilloscope.

The **ATF** (photo overleaf) has far more facilities. It measures all parameters mentioned above and indicates them in alphanumeric form. Its IEC/IEEE-bus connection and the RS-232-C interface means that it can be used in automatic test setups. It is not only a measuring instrument, but enables limits to be set for each parameter and is therefore highly suitable as a monitoring device for teletext parameters (see also p. 208). The operating mode SLOW VIDEO, where the display is read digitally from a line memory slowed down by a factor of 256, enables bright and flicker-free display of every individual line (not only the teletext lines) on a standard oscilloscope. The waveforms displayed can be transmitted on standard telephone lines to a second ATF and observed there on an oscilloscope.

The eye pattern can also be expanded in time by a factor of 256 in the operating mode EYE and displayed on an oscilloscope. The memory contents are usually refreshed each time a line has passed through, thus producing a continuous display. The operating mode FREEZE suppresses the refresh cycle, thus freezing the current state. This enables evaluation (photo) with constantly changing signal contents on an oscilloscope.

The RS-232-C interface enables problem-free remote control of one or more slave instruments via a telephone line. The connection to the slave instrument is first made via the public telephone network and the local instrument is then switched to MASTER. The slave instrument can then be controlled by the local instrument. The results (including the waveforms and eye patterns) can be displayed on the local instrument (and an oscilloscope). Because of the relatively low transmission rate (1200 Bd)[1]), the transmission of measured values takes 1 to 2 seconds and the transmission of the waveform of a line approx. 30 seconds.

Measurements using the ATF are described on p. 185, its use as a monitoring device is described on p. 208.

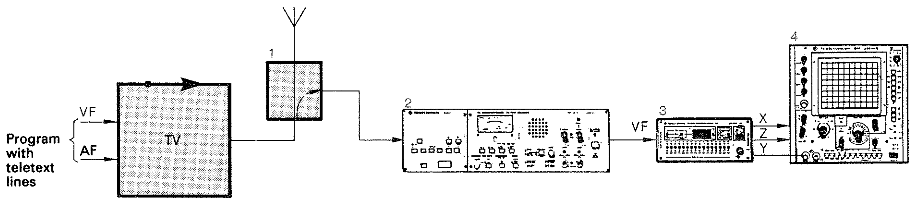
[1]) Applies to a 3-kHz telephone channel. The ATF can transmit at up to 9600 Bd (adjustable). The above transmission times are therefore reduced to one eighth on suitable transmission lines.

TV

TELETEXT MEASUREMENTS

with DZF

measurements during



1 Directional coupler (incorporated in transmitter)

2 TV Demodulator EMFD (photo p. 152) or TV Demodulator AMF 2 (photo p. 36)

3 TV Data Distortion Meter DZF (photo p. 182) for display of eye pattern

4 TV Oscilloscope OPF (photo p. 49)

Measurement Procedure

A. Basic settings

1. Connect TV demodulator to signal output of transmitter, DZF to video output of demodulator.
2. Adjust demodulator to vision-carrier frequency of transmitter.

B. Measurement of teletext parameters

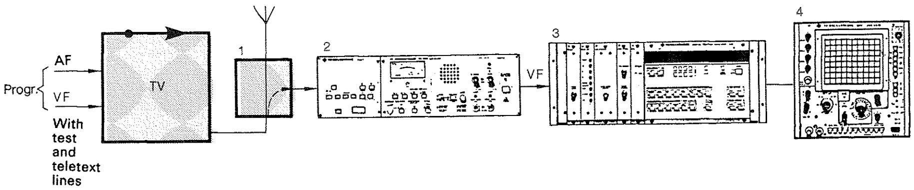
1. Switch on the teletext line(s) to be examined (shown by LED). Switch FRAMING CODE to NORMAL for normal teletext lines, and to TEST LINE for teletext test line (currently 328).
2. Select mode on left-hand switches: AMPLitude, eye height or half-eye height.
3. The respective value is displayed in percent referred to the nominal value (66% video = 462 mV). In position AMPLitude, the DZF displays the amplitude of the run-in bits of the selected line, in setting DECODING MARGIN (eye height) it indicates the difference between the lowest 1 level and the highest 0 level.
4. If several teletext lines are selected, the DZF measures them in succession and indicates the lowest value.
5. If the correct framing code (start sequence) is not present in the selected line, or if no code at all is present, or if the input voltage is too large or too small, the instrument indicates ERR.

C. Display of eye pattern

1. Connect TV Oscilloscope OPF to DZF. Connect Y output of DZF to front-panel connector of OPF, X and Z outputs to the rear connectors X15.1 and X.15.5 of the OPF. Press 75 Ω and TRIGGER EXTernal.
2. Set TIME/DIV to X_{EXT} and VOLT/DIV to 0.1 V/DIV.
3. The display width can be adjusted slightly using X_{EXT}.

Digital Teletext Analyzer ATF

transmission times



1 Directional coupler (incorporated in transmitter)
2 TV Demodulator EMFD (photo p. 152) or TV Demodulator AMF 2 (photo p. 36)
3 Digital Teletext Analyzer ATF (photo opposite)
4 TV Oscilloscope OPF (photo p. 49)

Measurement Procedure

A. Basic settings
1. Connect signal output of transmitter to demodulator input and the latter's output to input VIDEO INPUT of the ATF.
2. Connect output SLOW VIDEO OUTPUT of ATF to input of OPF and output SCOPE TRIGGER of ATF to rear connector S_{EXT} (X14.3) of the OPF.
3. Press 75 Ω and TRIGGER EXTernal on the OPF.
4. Tune demodulator to vision-carrier frequency of transmitter.

B. Measurement of teletext parameters
1. Switch on power on ATF. The display now indicates an LED test (all LEDs light up), the caption ATF-NEMESIS appears (**N**umerical **E**ye **M**easuring **E**quipment for **S**urveillance of **I**nsertion **S**ignals) and the set IEC-bus address is displayed. A parameter key then lights up (basic setting) and the associated line number and the result in percent for the displayed parameter[1]) now appear on the display.
2. The line number can be changed using the keys below the display. Switch from 1st to 2nd field using key FIELD. The display indicates the line number.
3. The ATF checks whether the selected line has the correct framing code. The teletext test line (328) has a special framing code which is stored in the instrument together with three further codes. The ATF checks the set line to see whether one of the four codes is present, otherwise the message NO TTXT LINE appears.
4. To measure further parameters, press the corresponding keys TELETEXT PARAMETER.

C. Measurement of S/N ratio
1. Press S/N. The instrument measures the S/N ratio in a non-modulated line (e.g. 22).
2. The line number is displayed as well as the S/N ratio in dB referred to the bar amplitude of the test line (nominal value 700 mV).

D. Changing the stored values in the ATF

The row of keys REFERENCE SETUP is used to change the line numbers and framing codes stored in the instrument.
1. The key TTXT LINE results in a display of the stored line number in which the measurement is immediately made following power-up (basic setting, see B.1.). It is possible to change the line number using the keys below the display. To store the new value as the TTXT line, press STORE.
2. The key ITS LINE displays the line from which the reference bar amplitude is obtained. Change as in 1.
3. The key S/N LINE displays the line for the S/N measurement. Change as in 1.
4. The key FRAMING CODE displays the codes stored in the device and the code found for the stored line. The four codes can be selected using the two left-hand keys in the group below the display, and changed using the four right-hand keys. Subsequently as in 1.

E. Display of lines on an oscilloscope
1. First press the key VIDEO OUTPUT CONTinuous. Switch oscilloscope to 2 ms/DIV and 0.1 V/DIV.
2. Testing of teletext-specific parameters is now suppressed; any line can now be set. The signal contents are stored in the ATF in a fast line memory and read out again slowed down by a factor of 256. The memory contents are continuously refreshed (25 Hz) so that a moving display appears on the oscilloscope.
3. The position FREEZE suppresses continuous refresh of the memory. The result is a stationary display (one-shot display).

F. Display of eye pattern on an oscilloscope
1. First press EYE OUTPUT CONTinuous. Switch oscilloscope to 5 µs/DIV and 0.1 V/DIV.
2. If the selected line contains teletext signals (framing code), the eye pattern appears on the screen. The display is slower than the original by a factor of 256 as in E.2. and thus bright and flicker-free.
3. The magnitude of the markers in the oscillogram for identifying the exact centre of the data bit can be changed using the control EYE MARKER AMPLITUDE.
4. The display can be frozen as in E.3. to enable exact evaluation of the diagram.

G. Master/slave mode

See p. 209.

[1]) Various reference values are possible with the percentage display for the parameters DECODING MARGIN, BASIC AMPLitude, P/P AMPLitude and S/N:

I ITS:	actual bar amplitude in test line
N Nominal:	nominal bar amplitude 700 mV
T Teletext:	basic amplitude of teletext (see manual for settings)

MONITORING PROCEDURES

The measurements on transmitters and systems described in the preceding sections — the majority of which can only be performed outside transmission times — are used to check that the transmission equipment is functioning correctly. Changes in quality can thus be detected. If failures or alterations in quality are to be detected during the ongoing program, however, broadcasts must be monitored continuously. This can be done either by the personnel of a transmitting station or, better still, by a monitoring centre. Most preferable is automatic monitoring with equipment specially designed for this purpose which can be located either in the stations or in a monitoring centre (see also introduction to measurements on sound and vision transmitting systems during programming times, p. 176).

MONITORING BY PERSONNEL

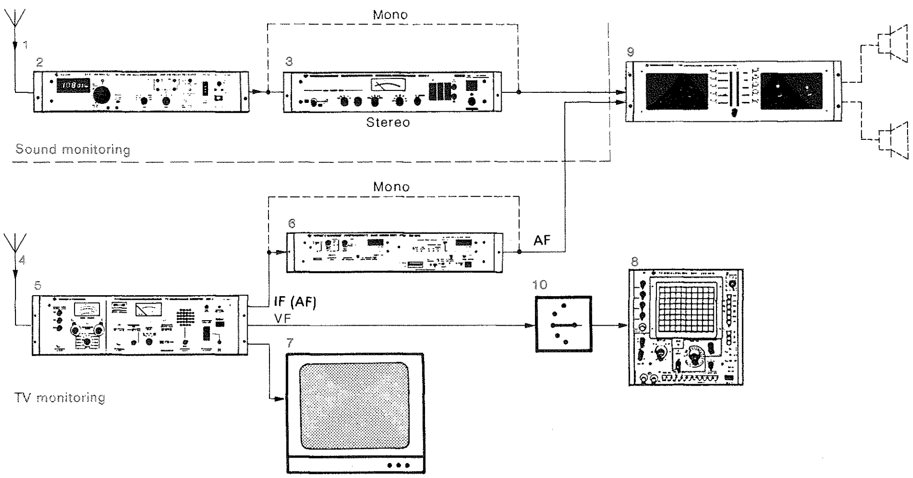
The simplest method of monitoring sound or TV transmitters is to listen to or watch the programs continuously while they are being broadcast.

If only one sound or TV channel is concerned, this can be handled in the transmitting station. The outlay is small: besides the usual demodulators, amplifiers with loudspeakers are required for monitoring sound and a monitor for the picture. If several channels are to be monitored, however, the pictures can be monitored simultaneously, but the sound channels can only be monitored in succession.

In large broadcasting networks, one often finds monitoring centres from which unattended transmitting stations can also be remotely controlled. Centres of this kind are located where they can easily receive from the transmitters to be monitored, for each of which they will have a receiver and (if necessary because of different reception directions or frequency bands) a separate directional antenna. There is a monitor for each TV channel and loudspeakers can be cut in as necessary (as with sound broadcasts). The diagram overleaf illustrates the principle of sound and TV monitoring by personnel.

The entire fault signals from the transmitters are sent to the control centre, from where the transmitters are also remotely controlled, so it is possible to manage a complete broadcasting network centrally and with less personnel. The fact should not be overlooked, however, that complete monitoring cannot be provided because of human inadequacies and due to the fact that the sound channels are not constantly switched to.

procedures



Necessary for each sound channel

1	Receiving antenna band II	
2	VHF FM Relay Receiver	EU 200 or EU 201
3	Precision Stereodecoder (only for stereo)	MSDC 2 (photo p. 13)

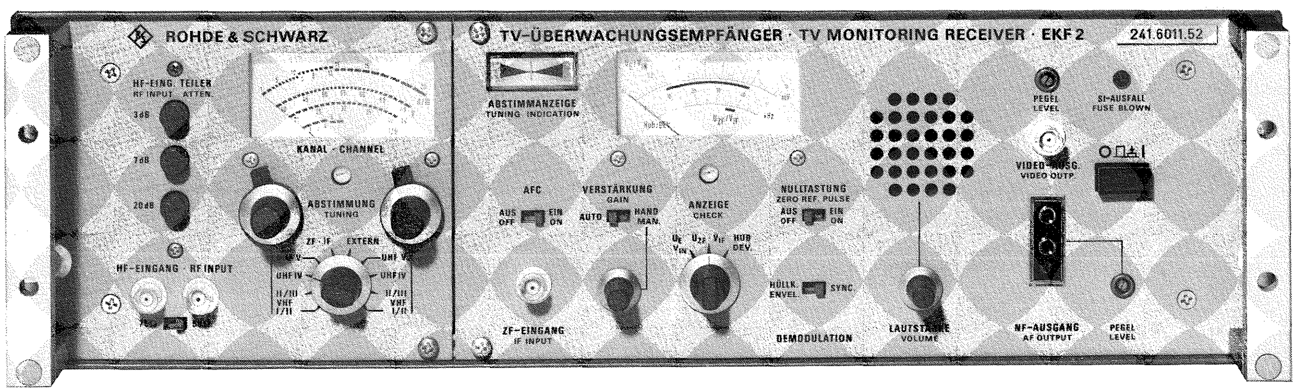
Necessary for each TV channel

4	Receiving antenna band III or IV/V	
5	TV Monitoring Receiver	EKF 2 (photo below)
6	Dual-sound Unit (only for dual sound)	FTDZ
7	Monitor	e.g. MC 37 BA 487 E from Bosch

Only required once (connected as necessary)

8	TV Oscilloscope	OPF (photo p. 49)
9	Audio Monitor	MTA-702
10	Selector	according to number of programs monitored

TV Monitoring Receiver EKF 2



AUTOMATIC MONITORING OF SOUND TRANSMITTERS

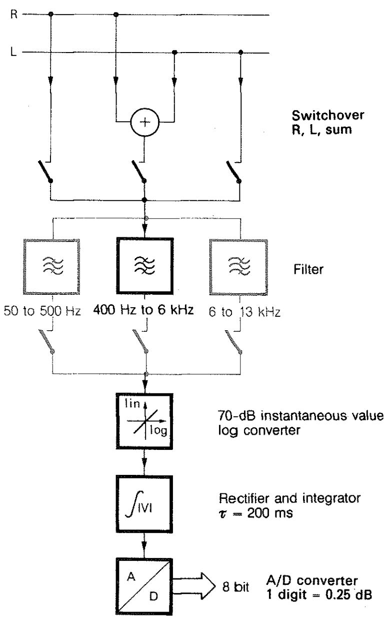
The Audiodat system (photo p. 176) for monitoring sound and TV sound transmitters and transmission links consists of the **Audiodat Transmitter SPT** and the **Audiodat Receiver UPT.** The transmitter is located at the beginning of the path to be monitored (in the studio or at the transmitter input), the receiver at the end of the path (at the transmitter input or output). At both points, the modulation is analyzed with respect to the levels in the two stereo channels. For the frequency response measurement, the modulation can be measured in three separate frequency bands (diagram below). By comparing the results from each end of the path, information is obtained on the levels, the S/N ratio and, possibly, the frequency response. Following evaluation of the individual levels L and R and the total level L+R of the two stereo channels, it is possible to detect channel changeover or polarity inversion on the transmission path.

Monitoring of transmitters If a transmitter alone is to be monitored, the Audiodat transmitter and receiver are sited together and the results of the analysis can be compared directly (the cassettes of the two units can be housed in one case). The result of the analysis (level difference between the various measurements) can be output on a printer or displayed on meters. The Audiodat system signals any non-adherence to the preselected tolerances.

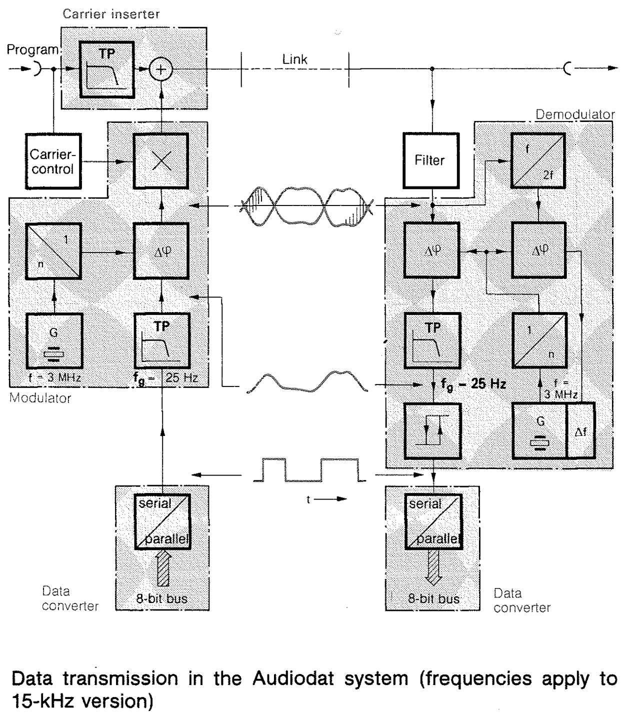
Monitoring of entire transmission path In most cases, however, the Audiodat system monitors the entire transmission path from studio to transmitter output. The result of the analysis must therefore be conveyed from the beginning of this path to its end. The transmission path required with sound broadcasts for the modulation (line or radio relay) can be used for this purpose. The result is converted into a code telegram and transferred on the modulation path by phase-shift keying (diagram below).

A data converter changes the nominal values derived from the level analysis at the beginning of the link into a serial code telegram. The modulation content of the program line is reduced by a lowpass at the Audiodat carrier frequency and the carrier, phase-shift-keyed with the code telegram, is added. Its amplitude, depending on the amplitude of the program, is regulated such that it is always below the audibility threshold. At the receiving end, the filtered-out carrier frequency is used to synchronize the receiver oscillator which is used to retrieve the code telegram. After reconversion to the nominal values entered at the beginning of the link, an automatic comparison is made with the actual values analyzed at the end of the link and the deviations are output.

There are **two versions of the Audiodat system:** one operates with a **carrier frequency of 15 kHz,** the other with **60 kHz.** In both cases, the signal level is too low to affect modulation.

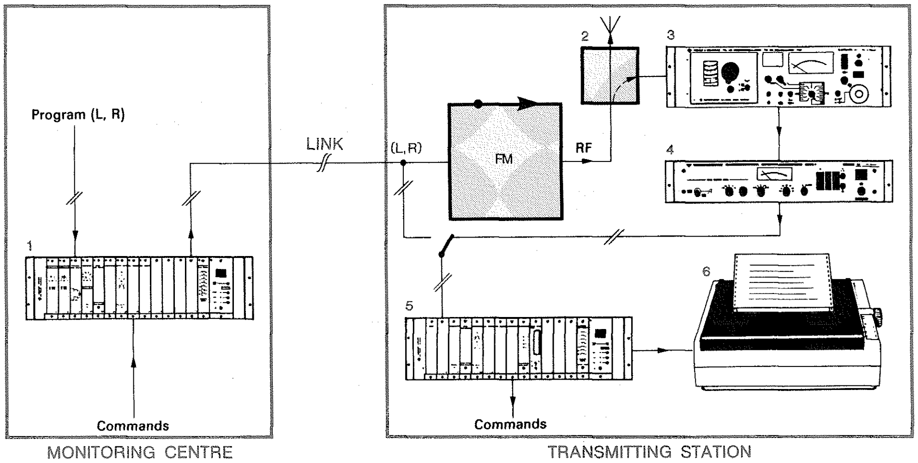


Principle of level measurements in Audiodat system for quality monitoring; blue: additional modules for frequency-response measurement



Data transmission in the Audiodat system (frequencies apply to 15-kHz version)

Automatic monitoring of sound transmitter without status signalling



Equipment required in monitoring centre

1 Audiodat Transmitter SPT (15 kHz, photo p. 176)

in transmitting station

2 Directional coupler (incorporated in transmitter)

3 FM/AM Demodulator FAB (photo p. 12) or FM Monitoring Demodulator FKDL

4 Precision Stereodecoder MSDC 2 (photo p. 13)

5 Audiodat Receiver UPT (15 kHz, photo p. 176)

6 Printer (BCD)

Remote control of sound broadcast networks In addition to the transmission of results, the Audiodat system can also be used to transfer remote-control commands. The 15-kHz system with a bit rate of 25 bit/s is primarily intended as a quality control system and to a limited extent for the transmission of data (e.g. mono/stereo switchover, road-user's report identification etc.). The 60-kHz version, with a bit rate of 200 bit/s, is a transmission system for control data and reporting in broadcast networks. However, this calls for transmission paths that can handle 60 kHz correctly, e.g. a stereo relay link or an appropriate carrier-frequency channel.

By combining 15-kHz systems for quality monitoring and 60-kHz systems for remote control and reporting, it is possible to remotely control and monitor entire sound broadcast networks. If there is a receiving link between a central monitoring station and its substations that can be used for reporting the execution of commands and for quality monitoring, central control and monitoring are possible without the need for any additional transmission channels.

Monitoring Procedure (for example above)

The Audiodat transmitter in the monitoring centre continuously measures the levels of the program in the sequence: left channel, sum of both channels, right channel and again sum of both channels. Each measurement present in digital form is termed a word, and the four measurements together are a record. The frequency range is divided into three bands by filters to enable measurement of the frequency response. The first three measurements of each record are performed at mid-band. Instead of the last sum measurement of the record, the left channel is measured in the lower frequency band and in the next record in the upper frequency band. The same is then carried out for the right channel. In this manner, the entire result including the frequency response measurement is obtained after four records (4 × 4.4 s).

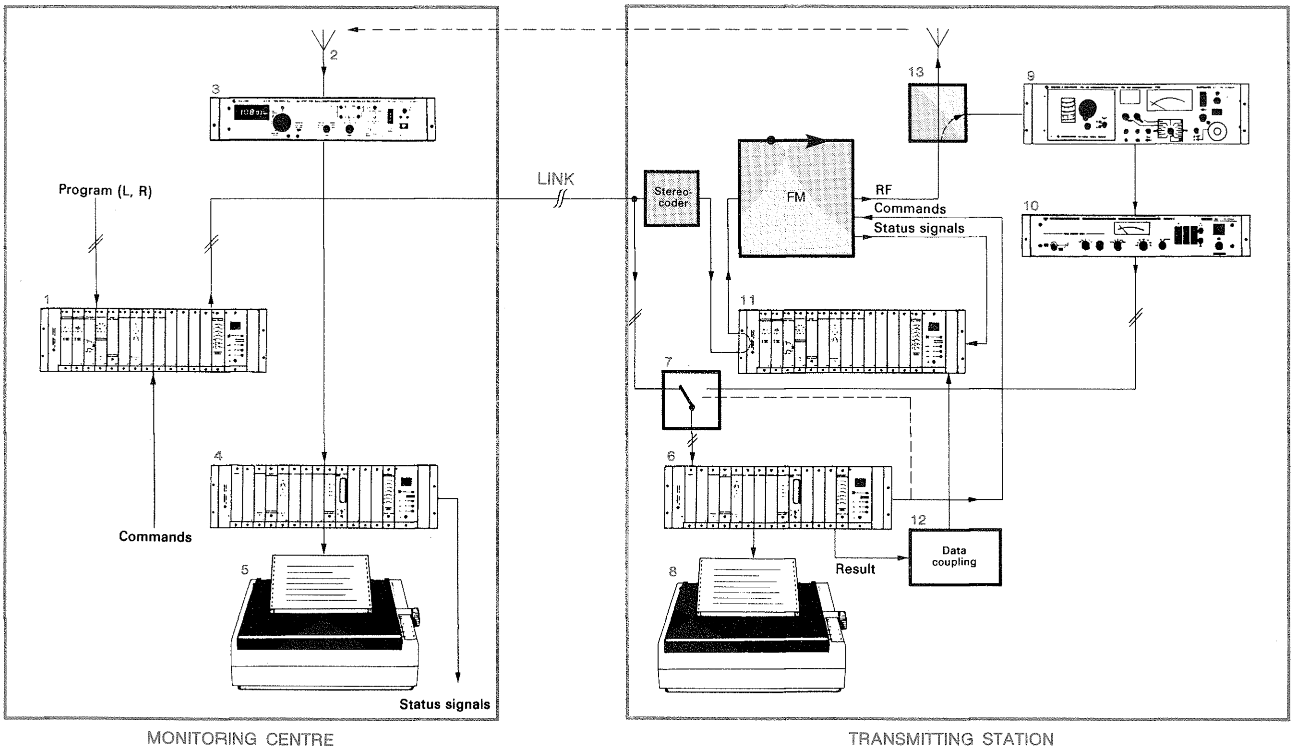
The results are added to the modulation as a code telegram, evaluated in the Audiodat receiver and compared with the results of its own analysis. The differences are output by the printer in the transmitting station. By switching over at the receiver input (see block diagram above), it is possible to determine whether faults originate in the transmission link or in the transmitter itself.

In addition to quality monitoring, simple remote-control tasks are also possible with the 15-kHz Audiodat system (e.g. program identification, mono/stereo switchover etc.). If the monitored station cannot be received at the monitoring centre, back-signalling of the executed commands is only possible via a special line.

AUTOMATIC MONITORING OF SOUND TRANSMITTERS

with SPT/UPT

Automatic monitoring of sound transmitter with status signalling



Equipment required in monitoring centre

1 Audiodat Transmitter (15 kHz)	SPT (photo p. 176)
2 Receiving antenna band II	
3 VHF/FM Relay Receiver	EU 200 or EU 201
4 Audiodat Receiver (60 kHz)	UPT (photo p. 176)
5 Printer (BCD)	

Equipment required in transmitting station

6 Audiodat Receiver (15 kHz)	UPT
7 Line switch	
8 Printer (BCD)	
9 FM/AM Demodulator	FAB (photo p. 12)
10 Precision Stereodecoder	MSDC 2 (photo p. 13)
11 Audiodat Transmitter (60 kHz)	SPT
12 Data coupler	
13 Directional coupler (incorporated in transmitter)	

Monitoring Procedure

If the transmitter can be received by the monitoring centre, it is possible to determine the quality of transmission and the performance of commands by way of this receiving path. A 60-kHz Audiodat system is the best solution for status signalling of the executed commands and for the transmission of quality data.

The 15-kHz Audiodat transmitter in the monitoring centre and the 15-kHz Audiodat receiver in the transmitting station monitor the quality of broadcasts in the manner described on p. 189. It is thus also possible to transmit remote-control commands, e.g. to activate the line switch 7 in the transmitting station (the switch must be thrown to the left if commands are to be transmitted when the transmitter is shut down). The results of the analysis are output by the printer and at the same time are fed via the data coupler (conversion of the parallel output data into a serial data stream) to the 60-kHz Audiodat transmitter, which adds the information as a code telegram — into which the status signalling of the transmitter is inserted as so-called external data — to the transmitter modulation.

The 60-kHz Audiodat receiver evaluates the telegram in the monitoring centre and outputs the result on the printer. Remote control of the line switch in the transmitting station means that it is possible to monitor the link from the centre to the transmitting station, or the entire route up to the transmitter output.

The transmission of quality data in the form of a code telegram offers the advantage that the quality of the receive path (receiver characteristics, interference, fading) cannot affect the results.

Automatic monitoring and management of sound network

The block diagrams below illustrate the possibilities of a combined system. In the centre (left), the program is first analyzed by a 15-kHz Audiodat transmitter and the result added to the program as a code telegram in the usual way. Transmission of the program to the substations in this case is via relay links. With a 60-kHz Audiodat transmitter, control commands can also be added to the program for the transmitters of the substations.

In the centre, there is also a relay receiver for each substation and a 60-kHz Audiodat receiver for transferring the messages from the substations to the computer.

In the substation, a relay receiver receives the program from the transmitter at the centre. First the 60-kHz Audiodat receiver filters out the control commands from the program signal, evaluates them and transfers them to the substation processor. The program is applied to the transmitter, analyzed at the transmitter output by a 15-kHz Audiodat receiver and compared with the 15-kHz code telegram from the Audiodat transmitter in the centre. The result is applied to the computer for evaluation and storage. The result of the comparison is also mixed with the program signal via a 60-kHz Audiodat transmitter and emitted by the transmitter so that it can be received in the centre and evaluated there.

The Audiodat receiver can also analyze the input signal to the transmitter. In this way, it is possible to determine whether errors originate in the transmitter or transmission link. This switchover can be performed automatically by the substation processor or by remote control from the centre. Status signals from the transmitter (and the substation) can thus also be conveyed to the centre. Consequently, a complete picture of the status of all stations in the network is available in the centre at all times.

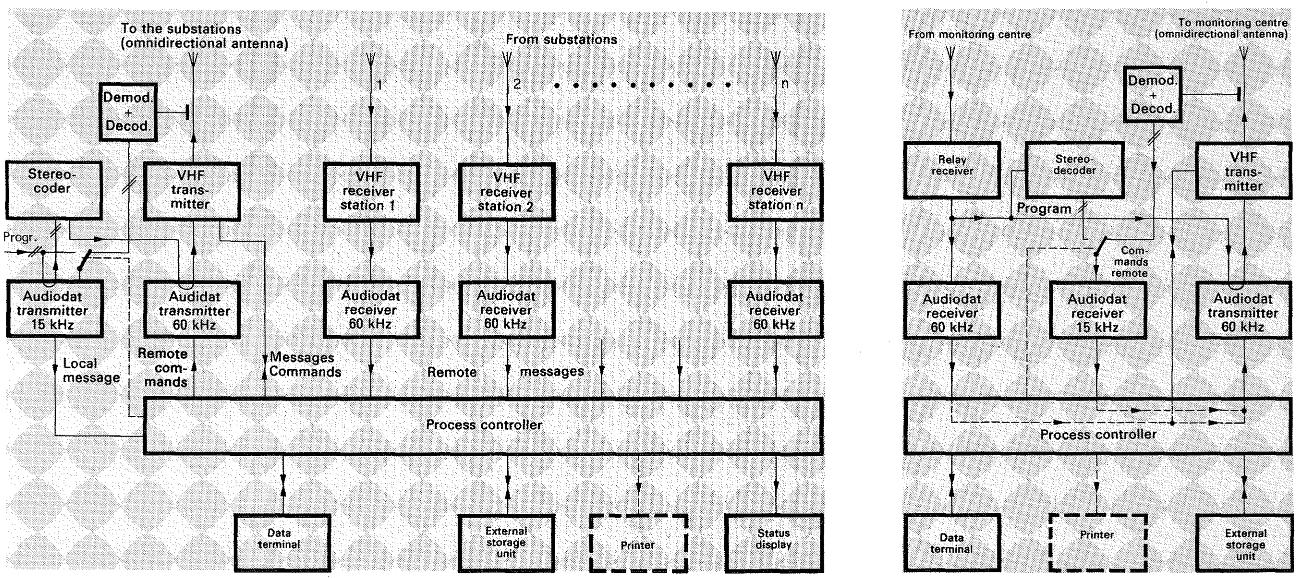
No further 60-kHz equipment is required when transmitting several programs in the centre and substations via the corresponding number of transmitters. The remote control commands to the substations as well as their returned status signals and quality data are only sent via one transmitter so that only one relay receiver is required per substation in the centre. The corresponding switchovers are controlled by the processor in the centre via the substation processors.

The great advantage of the system is that two independent links are produced without additional lines or radio channels: the 15-kHz link for quality monitoring and the 60-kHz link for remote control and status signalling. The considerable flexibility of the modular Audiodat system is also worth emphasizing which frequently enables the use of the same modules and their accommodation in the same subrack when two such links are operated together.

Control and quality monitoring of a sound-broadcast network with Audiodat devices

Monitoring centre

Substation



AUTOMATIC MONITORING OF TV TRANSMITTERS

Automatic vision monitoring As already described on p. 178 in detail, the TV picture contains lines which do not appear on the screen and can therefore be used for other purposes (data transmission, teletext and — of interest here — monitoring with insertion test signals). The internationally standardized test-line signals are generally fed in directly at the program source in lines 17, 18, 330 and 331. By evaluating these lines at the transmitter output, it is possible to check the entire transmission path from the studio to the transmitter output. Switching the analyzing unit from the output to the input of the transmitter enables errors to be detected in the transmission path separately from any which may be present in the transmitter.

In some cases, the standard test-line signals are also fed into other lines at a transmitter station (or at a video interconnection point). It is then possible, without switching over at the transmitter station, to evaluate the signals in the different lines and to measure both the values of the overall transmission path (from the studio up to and including the transmitter) and of the transmitter alone.

Evaluation of these test-line signals is an excellent means for automatic monitoring of the vision quality. Automatic evaluation of various test-line parameters enables detection of changes in transmission quality during an ongoing program.

Measuring instruments for test-line evaluation Rohde & Schwarz provides two different instruments for this purpose: the **Video Analyzer UVF** with a quasi-analog bar display so that it is also highly suitable as a measuring instrument (see p. 180). It is a low-priced, lightweight unit also suitable for mobile use and is programmed to evaluate 16 fixed test-line parameters thus enabling a large number of monitoring functions (see last paragraph).

The **Video Distortion Analyzer UPF** has established itself world-wide as the standard monitoring device for TV transmission systems (the complete TV transmitter network of the German DBP and ARD is monitored using these instruments). The UPF is a measuring and monitoring instrument and indicates up to 28 measured values in digital form. The modular design for each test-line parameter (and recently also for teletext parameters) enables extremely flexible adaptation to any measurement problem.

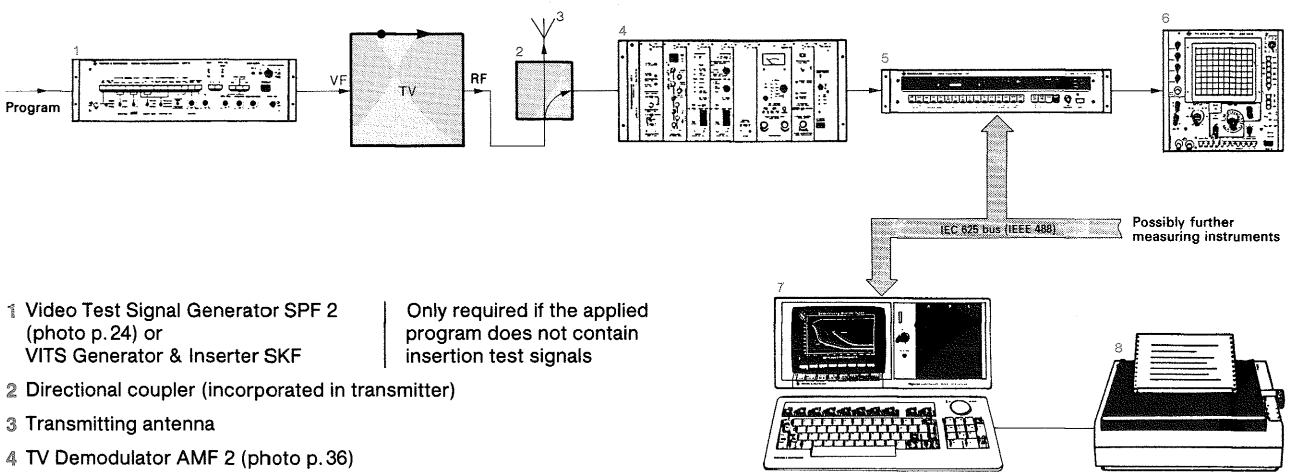
TV sound monitoring can be carried out with the Audiodat system as with sound broadcasts. The source data transmission in the data line of the TV signal is suitable for this purpose, and is also used for many control functions. Combination of the two instruments enables complete and automatic sound monitoring of TV transmitters.

Computer-controlled measurements Several transmitters are usually accommodated in a transmitting station, e. g. for several programs but also as dual transmitters with passive standby. It would seem advantageous to utilize the not inconsiderable expense of a monitoring system for all transmitters, i. e. to scan several measurement points cyclically.

The UVF can be controlled via its IEC-bus connection by a Process Controller, e. g. the PCA 5 from Rohde & Schwarz. The fixed-program TV Data Processor UPCF is available for the UPF and forms, together with the latter and a checkpoint selector, the **TV Test Equipment UPKF** (for vision transmitter monitoring). Complete vision and sound monitoring is possible using the **TOPAS sound and test-line evaluation system** which uses the Audiodat Receiver UPT (a model with display and IEC-bus connector) in addition to the Video Distortion Analyzer UPF for vision monitoring. The programmable Process Controller PCF is used for the autorun control. Like the TV Test Equipment UPKF, TOPAS can also be used just for vision monitoring without the equipment for sound monitoring.

UVF as monitoring instrument The Video Analyzer UVF with its built-in limit monitoring equipment is highly suitable as a monitoring unit for vision. Either the selected and displayed parameters or all parameters can be monitored for adherence to freely-selectable limits. The limits can be individually set for each parameter using the bar display and stored independently for all four test programs. A process controller connected to the IEC-bus interface of the UVF is required for the autorun control and for transfer of messages to a centre if required. The messages appear in plain text on the controller screen and can be logged on a printer. Pages 193 to 195 show a number of possible applications.

Automatic monitoring of TV transmitter during ongoing program



1 Video Test Signal Generator SPF 2 (photo p. 24) or VITS Generator & Inserter SKF — Only required if the applied program does not contain insertion test signals

2 Directional coupler (incorporated in transmitter)

3 Transmitting antenna

4 TV Demodulator AMF 2 (photo p. 36)

5 Video Analyzer UVF (photo p. 180)

6 TV Oscilloscope OPF (possible for observing the test lines)

7 Process Controller PCA 5 — Required to log the results during monitoring

8 Universal Printer PUD 2 — Required to log the results during monitoring

Measurement Procedure

A. Basic settings
As on p. 181, A.1. to 3.

B. Monitoring of a parameter
1. Setting of test program, time and type as well as storage of these settings as on p. 181, B. and C.
2. Using SHIFT and SELect PARameter (4) on UVF, switch on limit monitoring for the selected parameter.
3. In addition to the measured value, the limits defined in the program now appear on the bar scale.
4. Flashing signals on the bar display indicate out-of-tolerance conditions.

C. Monitoring of all parameters
1. Setting of test program, time and type as well as storage of these settings as on p. 181, B. and C.
2. Using SHIFT and ALL PARameters (5) switch on limit monitoring for all parameters. GRWUBW (limit monitoring) appears on the display. The 16 selectable parameters and the 3 external parameters are monitored.
3. The bar display indicates the measured values and the limits of the key-selected parameters.
4. A limit violation of the selected (and displayed) parameter is signalled as in the case of single monitoring (B.4.). In the case of the other parameters, the LED flashes in the associated key. The indicator EXT flashes on the display for the external parameters.

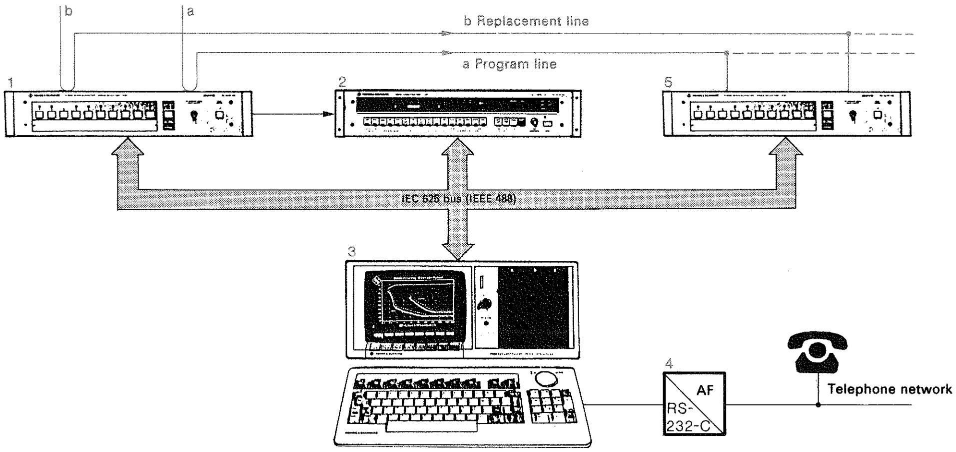
D. Changing the limits
1. The limits defined for each parameter in the test programs can be modified using keys 12 to 16. Press SHIFT and LOAD LIMIT ON/OFF (12). GRWLAD (load limit) appears on the display.
2. Select desired parameter and adjust lower and upper limit marks to the desired values using keys 13 to 16.
3. Store the newly set limits by moving on to the next parameter or by returning to the normal test mode using the keys SHIFT and ON/OFF (12).
4. The limit settings in the various programs are independent of one another and must therefore be carried out separately.

E. Data output
1. All results can be output via the IEC-bus interface. A process controller is required to display on its screen the results and any error messages. A printer can be connected to log the results.
2. The value displayed on the bar display is the result of a series of individual measurements. The measured values can also be output singly via the process controller, e.g. the amplitude of the individual risers when measuring line-time nonlinearity, the amplitude of the colour subcarrier on the individual risers when measuring the differential gain etc.
3. Special computer programs can be used to produce graphic displays of the test-line distortions (with nominal and actual values) and fault statistics on the screen from the values thus determined.
4. To enable incorporation into an automatic monitoring system, the UVF has an operating mode in which it only signals on the SRQ line of the IEC bus if a limit is violated. In this case, data are only output when required. A check on the data is possible at any time.

The two following pages show examples with the UVF used as a monitoring device. The Video Distortion Analyzer UPF should be used to monitor other or further test-line parameters with increased accuracy (see p. 196).

AUTOMATIC MONITORING OF TV PROGRAM LINES with UVF

Automatic monitoring of program lines (possibly with automatic line selection)

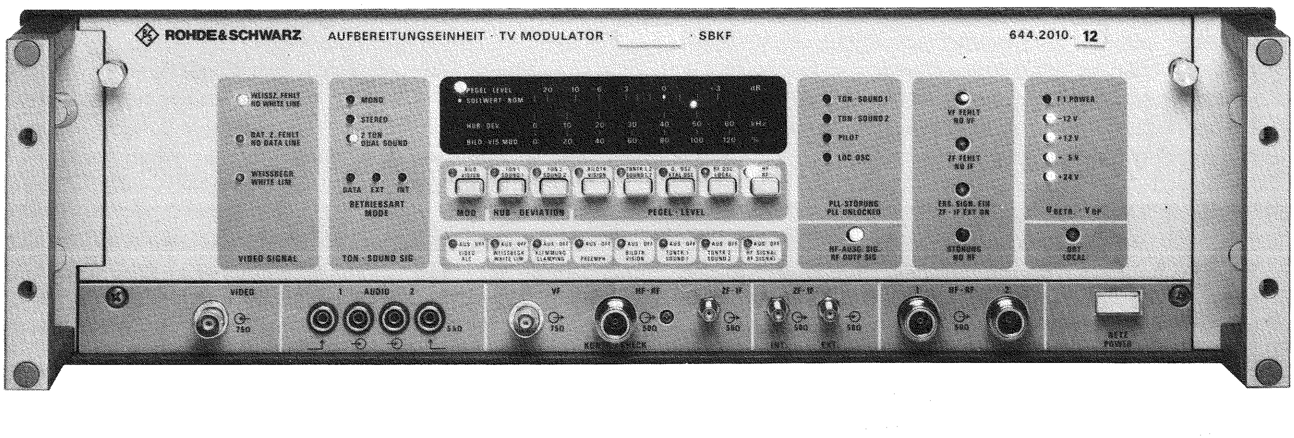


1 Video Selector VSF (for line monitoring)
2 Video Analyzer UVF (photo p. 180)
3 Process Controller PCF (photo p. 206)
4 Selector modem (for informing control station)
5 Video Selector VSF (possibly for automatic line selection)

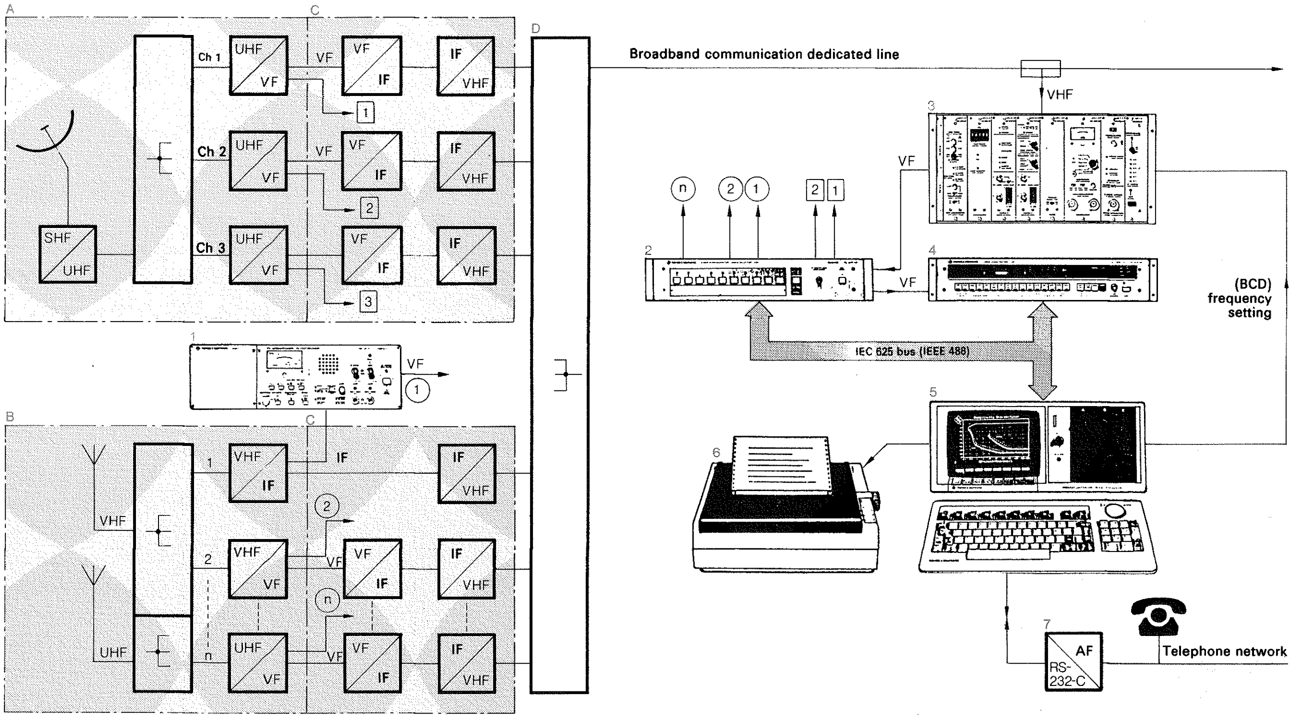
Monitoring Procedure

To automatically monitor a program line and the associated replacement line (e.g. from a remote studio), both lines are connected to the loop-through inputs of the Video Selector VSF and routed from there to the equipment to be fed. Controlled by the Process Controller PCF, the VSF cyclically connects the lines to the Video Analyzer UVF which evaluates the test lines. If a limit is violated, the selector modem calls the control station via the public telephone network and signals the fault. Automatic switchover to the replacement line — provided a test of it indicates a fault-free condition — is possible using the second video selector. The switchover is also signalled to the control station.

TV Modulator SBKF



Automatic vision monitoring of broadband communication headend for programs from terrestrial transmitters and satellites



Equipment of headend

A Satellite Communications Receiving System (e.g. RS 002 from Rohde & Schwarz)

B TV receiving equipment for terrestrial programs (e.g. Receiver EMFK from Rohde & Schwarz)

C TV Modulators (e.g. SBKF from Rohde & Schwarz, photo opposite)

D Combining network

Equipment for automatic monitoring

1 TV IF Demodulator EMFZF (only required for conversion via IF)

2 Video Selector VSF

3 TV Demodulator AMF 2, CATV version

4 Video Analyzer UVF (photo p. 180)

5 Process Controller PCF (photo p. 206)

6 Universal Printer PUD 2

7 Selector modem (only for connection to a remote control station via public telephone network)

$\boxed{1}$ Measurement points for satellite signal reception

(1) Measurement points for reception of terrestrial transmitters

Monitoring Procedure

The headend for broadband communication feeds the satellite programs (Ch1 to Ch3) and several programs from terrestrial TV transmitters into the broadband communication network. The satellite channels must be demodulated (video and audio frequencies) down to the baseband because of the FM. This is not necessary in all cases with terrestrial channels. If the input quality is satisfactory, the channels can also be directly converted via the IF. In such cases, an IF receiver (TV IF Demodulator EMFZF) is required for demodulation. In all other cases, the video signal is routed from a parallel output of the receiver units to the Video Selector VSF and from there to the Video Analyzer UVF. The Process Controller PCF controls cyclic scanning of all measurement points via the IEC bus as well as test-line evaluation and limit monitoring in the UVF. A printer logs the results.

If a limit is violated, it is also possible for the process controller to call the associated control station via the public telephone network using the selector modem and to then transfer the measured data to the station. The control station can communicate with the process controller of the headend via the established connection and request further data.

The CATV version of the TV Demodulator AMF 2 with synthesizer and remotely-adjustable frequency is provided for monitoring outgoing VHF programs. Its video output is also connected to the video selector. The frequency setting is controlled by the process controller. In this way, continuous and automatic monitoring is guaranteed from the input signal up to the outgoing signal.

AUTOMATIC VISION MONITORING with UPF

The Video Distortion Analyzer UPF (photo opposite) is used to evaluate many (selectable) parameters of insertion test signals. It is primarily designed as a monitoring device (with limit monitoring) and consists of the following main functional groups (see also block diagram below):
— Gain control and timing program
— Parameter cassettes | according to measure-
— Limit monitors | ments required
— Display unit with measured-value output

The **timing program** selects the lines to be examined and determines the corresponding sampling instant.

Parameter cassettes are available for more than 60 different parameters. These output the measured value as a DC voltage after an integration time of 10 s (versions with 5 s also possible).

The **limit monitors** compare the measured value with predetermined inner and outer tolerances (positive and negative) and signal out-of-tolerance conditions.

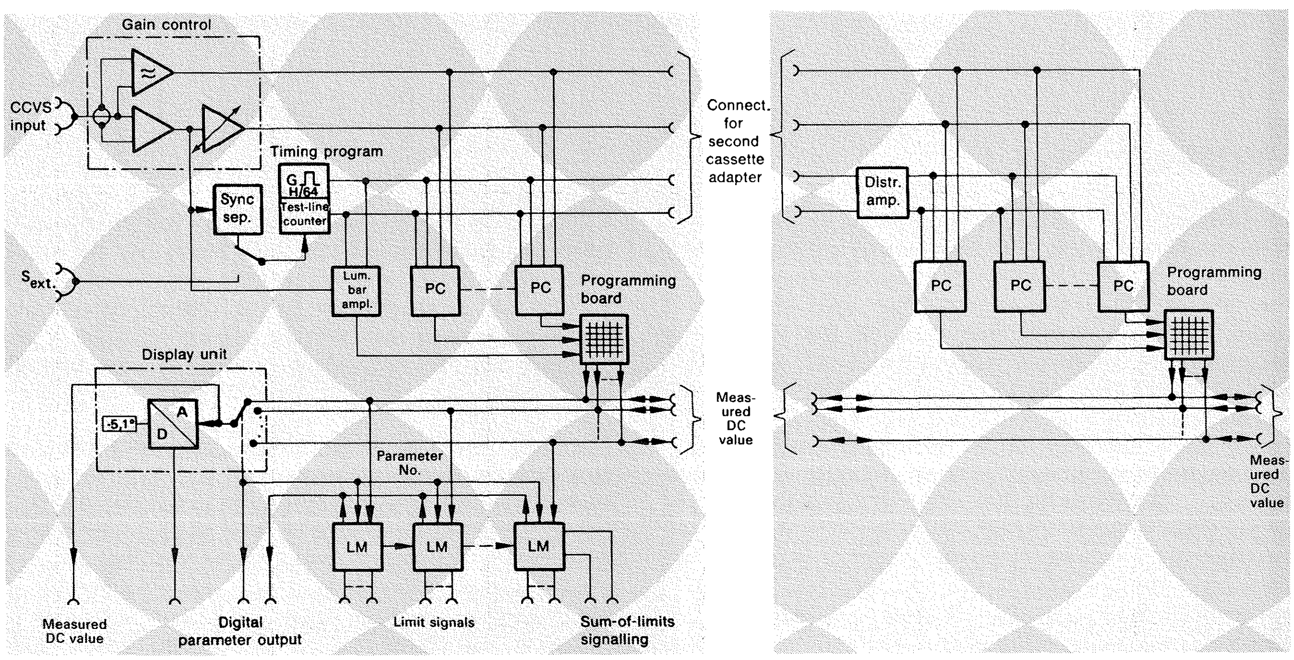
The **display unit** indicates the deviation of a selected parameter from the nominal value (level measurement) or the measured value itself. These values are also read out in analog and digital form (with parameter number) for transfer to high-speed printers, computers or teletypes when called or automatically when a measured value changes.

For measuring the same signals in different lines, it is possible to switch from "normal" (i.e. lines 17, 18, 330, 331) to "offset" (e.g. lines 19, 20, 332, 333). Externally applied measured values can also be processed by the limit monitors. Deviations from nominal values and tolerance violations are then output just as with the internally derived measured values.

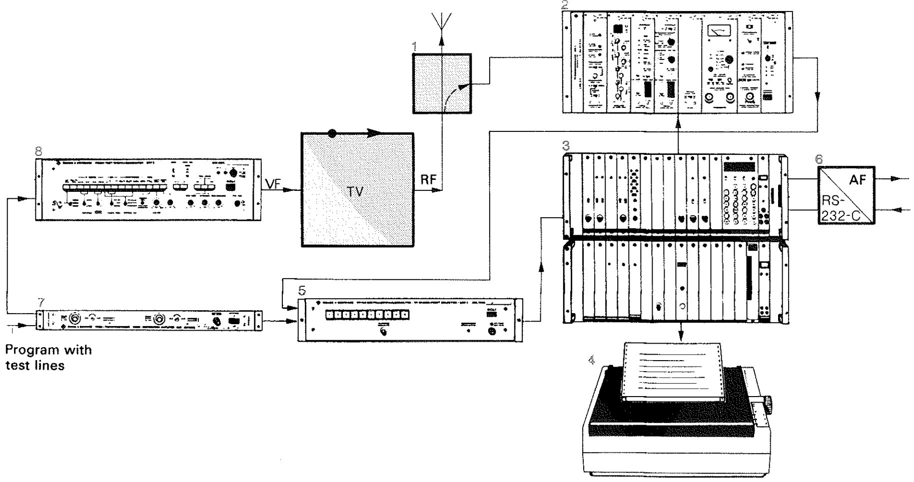
The instrument is of **cassette design** and can be fitted with the plug-ins required to adapt it to any particular measuring application. A **cassette adapter** is also available for housing extra plug-ins when the mainframe is full.

A TV transmitter or — if the input of the video distortion analyzer is switched cyclically — a complete transmitting station can be monitored with one UPF. The results can be transferred to a monitoring centre via a modem and a telephone line.

Principle of Video Distortion Analyzer UPF with basic plug-ins, parameter cassettes (PC), limit monitors (LM) and display unit. **Right:** adapter with distribution amplifier for up to 14 additional parameter cassettes



Automatic monitoring of a vision transmitter



1 Directional coupler (incorporated in transmitter)
2 TV Demodulator AMF 2 (photo p. 36)
3 Video Distortion Analyzer UPF (photo below)
4 Printer (BCD)
5 Checkpoint Selector USF 1
6 Modem (for transferring results)
7 Video Distribution Amplifier AVF

In addition for insertion own test signals:

8 Video Test Signal Generator SPF 2 (photo p. 24) or VITS Generator & Inserter SKF

Monitoring Procedure

The Video Distortion Analyzer UPF constantly measures the parameters of the test lines as determined by the fitted parameter cassettes. The measured values or deviations from nominal values are displayed in digital form after a parameter has been called up by a pushbutton. A connected line printer outputs the measured values together with their parameter numbers and denotes inner and outer tolerance errors. It is possible to print out all measured values in a very clear tabular form on a teletype, including information on out-of-tolerance conditions which are additionally output as a sum message. If the existing status alters, the analyzer automatically outputs a message for all monitored parameters.

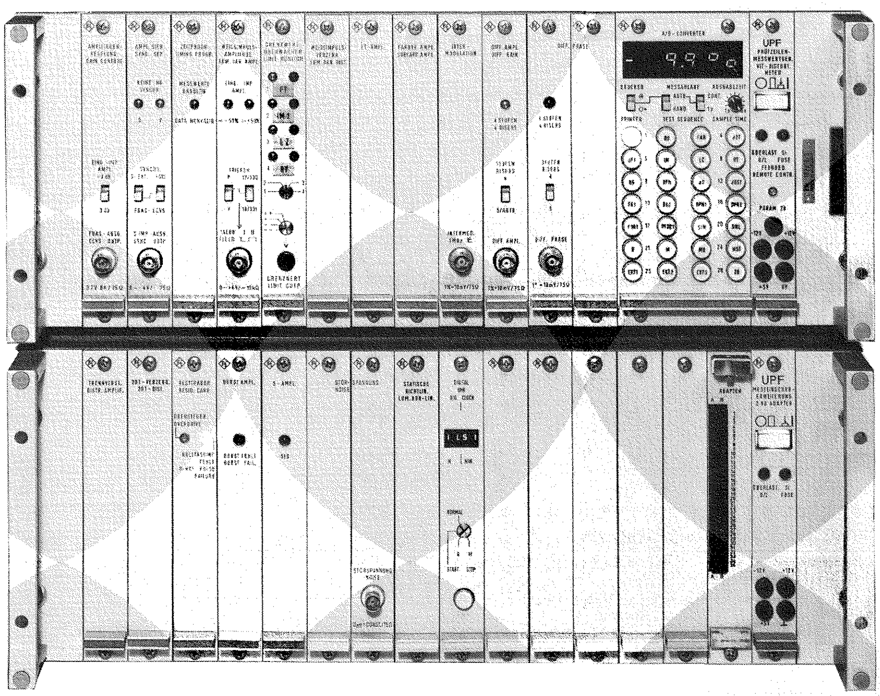
Faults can be located by switching between the transmitter input and output. The values of the transmitter alone can be measured if an additional test-line inserter is used in front of the transmitter input. The measured values can also be transmitted to another location (e.g. a monitoring centre) via a modem and telephone line.

The configuration of the Video Distortion Analyzer UPF depends on the parameters to be measured. The table (below left) lists the cassettes available for measurements on TV transmitters.

UPF parameter cassettes for measurements on TV transmitters

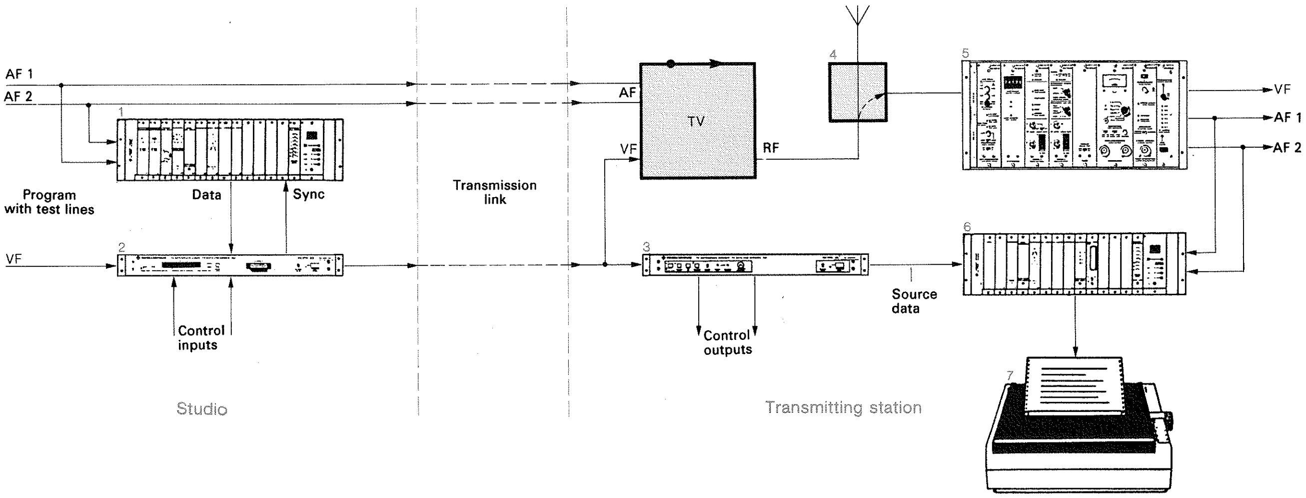
Luminance-bar amplitude
Luminance-bar distortions
2T amplitude
2T overshoot/undershoot
Subcarrier amplitude
Subcarrier intermodulation (luminance)
Subcarrier intermodulation (sound carrier)
20T pulse subcarrier
Intermodulation
Group delay
Differential gain
Differential phase
Residual carrier
Noise voltage
Hum
Luminance nonlinearity
50-Hz tilt
Sync amplitude
Burst amplitude
Frequency response 0.2 MHz
1 MHz
2 MHz
4 MHz
4.8 MHz
Vision-carrier phase
Teletext

Video Distortion Analyzer with cassette adapter



AUTOMATIC SOUND MONITORING OF TV TRANSMITTERS with SPT/UPT

TV sound monitoring with the Audiodat system



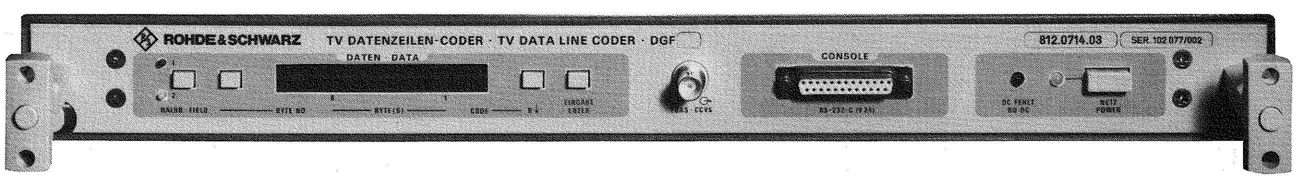
1 Audiodat Transmitter SPT (photo p. 176)
2 TV Data Line Coder DGF (photo below)
3 TV Data Line Decoder DEF (photo opposite)
4 Directional coupler (incorporated in transmitter)
5 TV Demodulator AMF 2 (photo p. 36)
6 Audiodat Receiver UPT (photo p. 176)
7 Universal Printer PUD 2

Monitoring Procedure

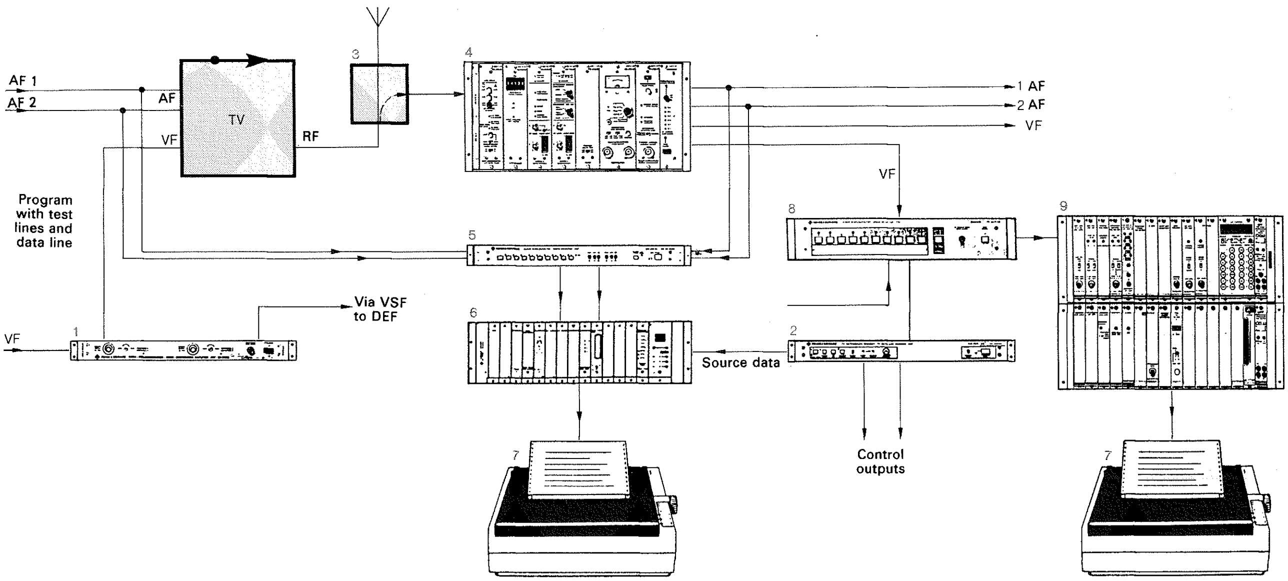
The Audiodat system (p. 188) can be used to advantage for sound monitoring with TV transmitters. Basically the same units are used as for sound broadcasting. However, the data line — one of the lines which does not appear on the screen and is used for many control functions — can be used to transmit the result of the analysis. It is also advantageous that part of the Audiodat equipment for data transmission (p. 188, bottom right) can be omitted. The transmission rate of 25 bit/s corresponds to that of the 15-kHz system but no modification to the modulation path is necessary (e.g. reduction with 15 kHz). The TV Data Line Coder DGF is used to insert the result in the form of a code telegram into the data line (line 329, word 5, bit 3). The DGF is provided for the (fast) transmission of other control data (including the VPS signal).

The TV Data Line Decoder DEF in the transmitting station decodes the data line and passes on the result to the Audiodat Receiver UPT which compares it with the analysis from the transmitter output and then outputs the result on the printer.

TV Data Line Coder DGF



Separate automatic vision and sound monitoring of TV transmitter



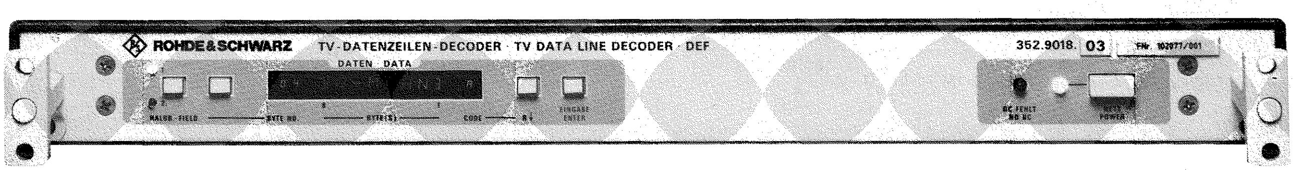
1 Video Distribution Amplifier AVF
2 TV Data Line Decoder DEF (photo below)
3 Directional coupler (incorporated in transmitter)
4 TV Demodulator AMF 2 (photo p. 36)
5 Audio Selector AST (photo p. 203)
6 Audiodat Receiver UPT (photo p. 176)
7 Universal Printer PUD 2
8 Checkpoint Selector USF 1 or VSF
9 Video Distortion Analyzer UPF (photo p. 197)

Monitoring Procedure

The above configuration is a combination of the arrangement for automatic vision monitoring (p. 197) and for sound monitoring with the Audiodat system (opposite). Both monitoring systems operate completely separately but are fed from the same TV demodulator. Combination of the outputs of the two systems — e.g. for data output on a common printer — is not possible. The systems operate with different clock times, data selection is not provided. Switching between the transmitter input and output must be made manually, the (separate) routing of data to a remote position is possible.

A system for combined vision and sound monitoring is described on p. 202.

TV Data Line Decoder DEF



AUTOMATIC VISION MONITORING OF TV TRANSMITTING STATIONS with UPKF

Automatic TV Test Equipment UPKF The Video Distortion Analyzer UPF can be used to monitor a large number of parameters of a TV transmitter during an ongoing program. In the case of large transmitting stations containing several TV transmitters (e.g. a primary transmitter and a standby transmitter each for two channels, i.e. a total of four transmitters), it would be possible to use a video distortion analyzer for each transmitter. Since the analyzer only requires ten seconds to produce all measured values (or only five seconds depending on version), it is sufficient to use one unit by switching it cyclically to the various checkpoints. The Automatic TV Test Equipment UPKF from Rohde & Schwarz (photo p. 204) which has been designed for this and similar applications consists of

- Video Distortion Analyzer UPF
- Checkpoint Selector USF 1 for ten checkpoints (with a second USF 1, the UPKF can sample up to 16 checkpoints)
- TV Data Processor UPCF
- status decoder

The latter indicates the status of the 10 or 16 checkpoints on coloured LEDs. The video signals are fed to the checkpoint selector from the checkpoints via adjustable cable equalizers.

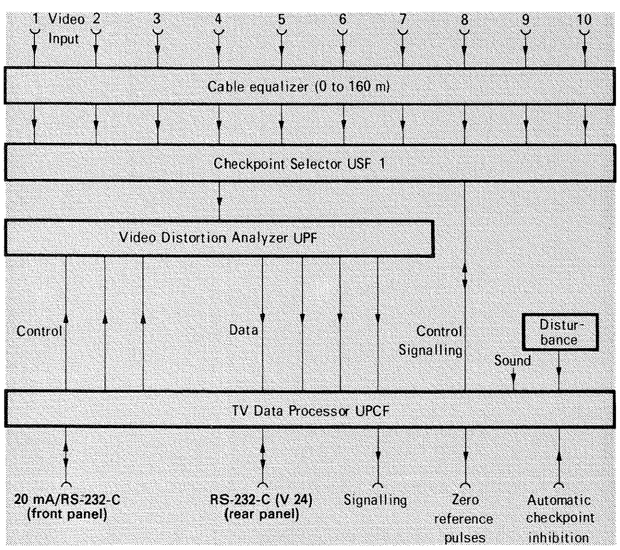
The **TV Data Processor UPCF** is a fixed-programmed process computer especially for such applications. Its microcomputer controls the entire monitoring cycle. It selects the next checkpoint in the cycle by means of the checkpoint selector and sets the Video Distortion Analyzer UPF for the different conditions of each checkpoint (e.g. for measurement of so-called sectional test lines, in contrast to test lines from the program source, or by switching the tolerance limits for measurements at the transmitter input or output). It also receives the test-line data, status reports (e.g. tolerances exceeded, checkpoint inhibited, measured value invalid, no program) and operating-status messages (e.g. no burst, no zero reference, slide on, tolerance group 1 or 2 etc.).

The tolerances of the individual measured values are defined in the **software of the Data Processor UPCF;** the limit monitors are therefore unnecessary. The measured values and messages are stored in tables for each checkpoint, and the checkpoints continue to be sampled cyclically. The processor outputs the overall status information and a data log for the checkpoint concerned only if there is an alteration in the status information or if requested.

The **status decoder in the UPKF** evaluates the sum message for out-of-tolerance conditions and indicates for each checkpoint the status "good" (green LED), "inner" tolerance exceeded (yellow LED) or "outer" tolerance exceeded (red LED). If the checkpoint has no signal, the red and yellow LEDs light up, if the checkpoint is excluded from the cycle (e.g. standby transmitter) no LED lights up. Local operation, fault and cycle stop are also indicated (see also p. 205).

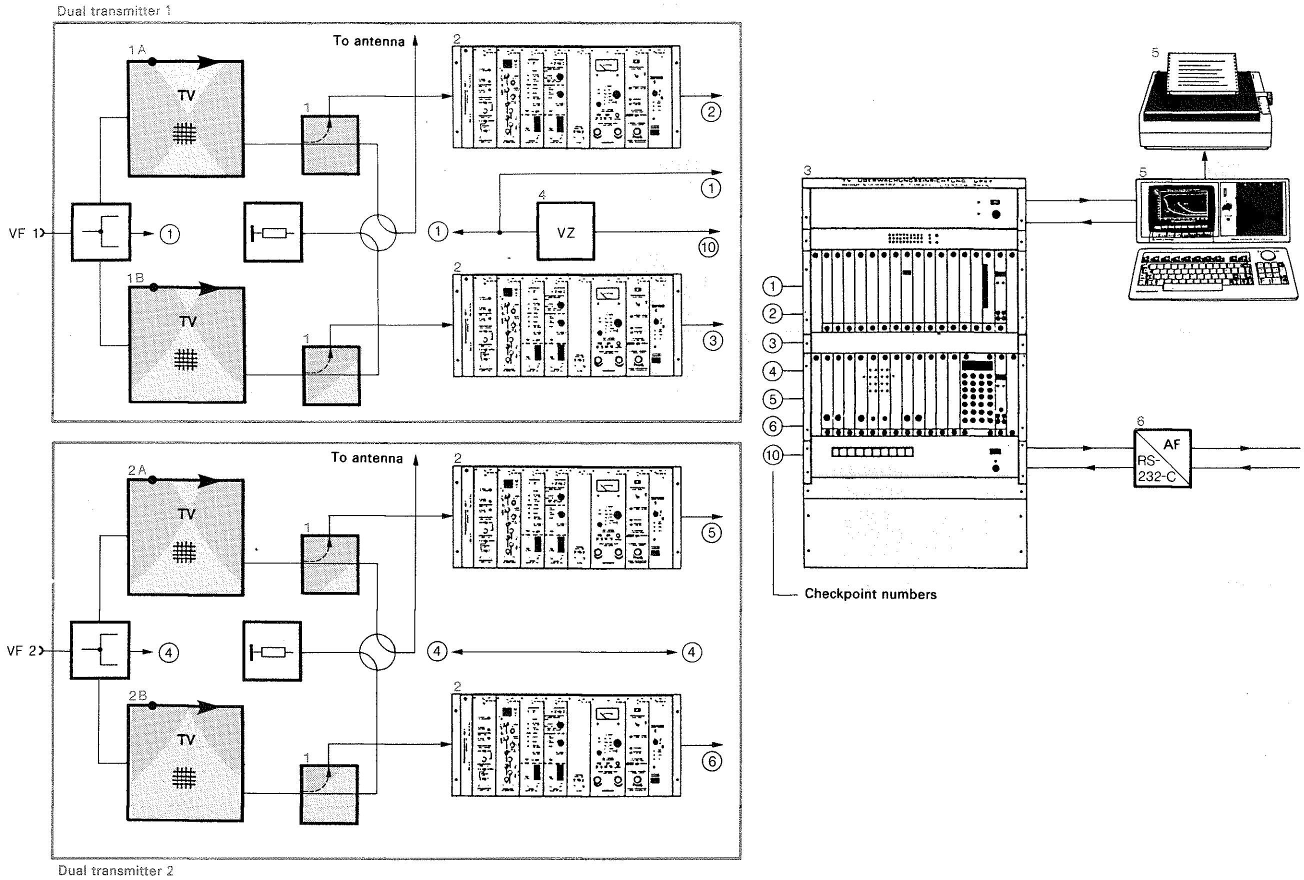
Normally the data processor operates with the automatic checkpoint cycle defined in the software, with data output when there is a change in status. It is also possible to enter special sets of commands via data terminal after the execution of which the system returns to its normal mode.

The test equipment can also be operated manually. Following appropriate entries, the parameters selected using the front-panel keys on the video distortion analyzer are displayed directly.



Principle of Automatic TV Test Equipment UPKF for monitoring vision quality

Automatic vision monitoring of TV transmitting station with two dual transmitters



1	Directional coupler (incorporated in transmitter)	
2	TV Demodulators (two for each dual transmitter)	AMF 2 (possibly included in transmitter)
3	Automatic TV Test Equipment consisting of:	UPKF (photo p. 204)
	— TV Data Processor	UPCF
	— Status Decoder	UPCF-Z5
	— Video Distortion Analyzer	UPF (photo p. 197)
	— Checkpoint Selector with cable equalizer	USF 1
4	Distortion Network UPF-Z	
5	Terminal and printer (for local use)	
6	Modem RS-232-C/AF (for link to centre)	

Monitoring Procedure

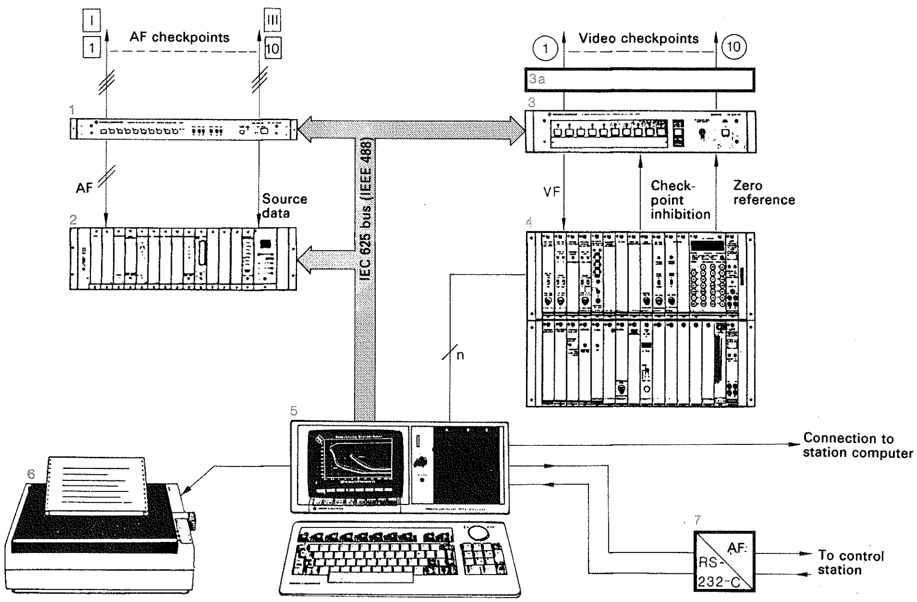
The example illustrates the use of automatic TV test equipment in a TV transmitting station with two dual transmitters in passive standby (transmitters A and B in each case) for two program channels. The checkpoints 1 and 4 of the Checkpoint Selector USF 1 carry the input signals of the two transmitters, and the checkpoints 2 and 3, 5 and 6 are assigned to the video outputs of the TV Demodulators AMF 2.

To enable a self-check of the test equipment, checkpoint 10 is connected via a distortion network to the video input of one transmitter, the system thus checking itself out on each measurement cycle. A terminal and a printer are connected to the UPKF to read out status messages and data logs, as well as to enter instructions.

A connection can be made to a distant control centre using the modem, as is required when monitoring complete broadcasting networks. Checkpoints 7 to 9 are vacant for further measurement points, e.g. for a third dual transmitter or for monitoring of the standby modulation lines.

AUTOMATIC VISION/SOUND MONITORING OF TV TRANSMITTING STATIONS with TOPAS

Block diagram of Sound and Insertion Signal Evaluation System TOPAS
(the checkpoint designations correspond to those in the examples on the opposite and previous pages)



1 Audio Selector AST (photo opposite)
2 Audiodat Receiver UPT (photo p. 176) with IEC bus interface
3 Video Selector VSF with
3a cable equalizer (0 to 160 m)
4 Video Distortion Analyzer UPF (photo p. 197) with second cassette adapter
5 Process Controller PCF (photo p. 206)
6 Universal Printer PUD 2 (possibly for documentation)
7 Modem RS-232-C/AF for link to control station

Sound and Insertion Signal Evaluation System TOPAS
Further development of the TV vision and sound monitoring equipment has resulted in the Sound and Insertion Signal Evaluation System TOPAS for automatic vision and sound monitoring of TV transmitters, stations and complete broadcasting networks (photo p. 206).

TOPAS contains the units proven in the UPKF (p. 200), but without the TV Data Processor UPCF, which is programmed for fixed vision monitoring functions, as well as the units for sound monitoring: Audio Selector AST and Audiodat Receiver UPT, in this case in a modified design with display and IEC-bus connection. The Video Distortion Analyzer UPF is provided with the teletext plug-in enabling these parameters to be checked as well.

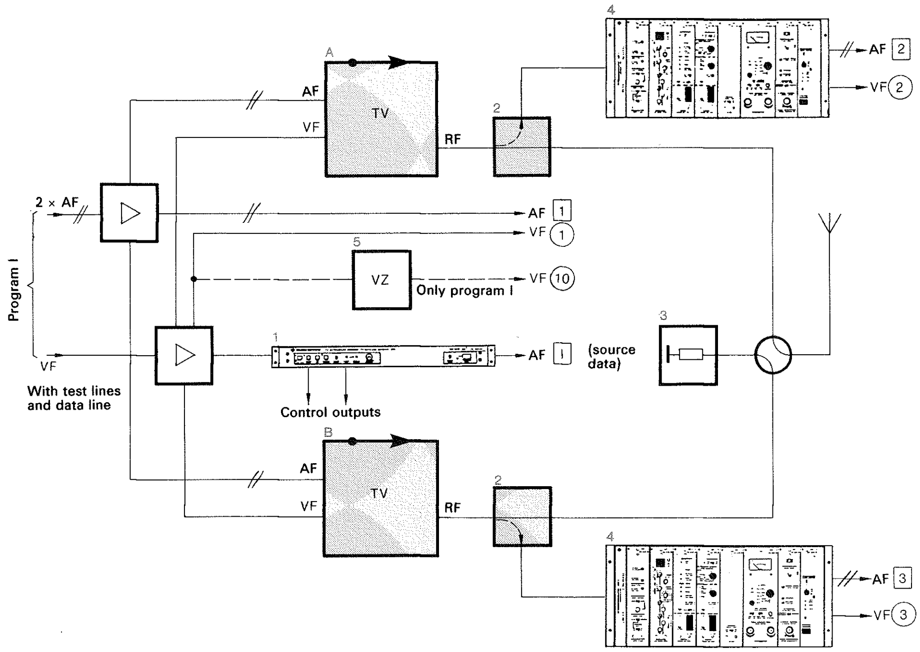
The programmable Process Controller PCF is used for the autorun control. Connection to the station computer is possible via a V.24/RS-232-C connection. The station computer can establish a connection to the control stations via the modem of the PCF.

As shown in the table, monitoring of a third dual transmitter is also possible using the built-in checkpoint selectors. (Further measurement points can still be monitored using additional audio and video selectors.)

Checkpoint No.		Audio Selector AST		Video Selector VSF
1	Progr. I Line	1 2 Sound lines (L, R)	I Source data progr. I	1 Video line I
2	Progr. I Transm. 1A	2 2 AF transm. 1A		2 Video transm. 1A
3	Progr. I Transm. 1B	3 2 AF transm. 1B		3 Video transm. 1B
4	Progr. II Line	4 2 Sound lines (L, R)	II Source data progr. II	4 Video line II
5	Progr. II Transm. 2A	5 2 AF transm. 1A		5 Video transm. 2A
6	Progr. II Transm. 2B	6 2 AF transm. 1B		6 Video transm. 2B
7, 8, 9	Vacant for standby lines, possibly 3rd program			
10	Selftest			10 Video line I via distortion network

Connection of checkpoints to monitoring system

Automatic vision and sound monitoring of TV dual transmitter



1 TV Data Line Decoder DEF (photo p. 199)

2 Directional coupler (incorporated in transmitter)

3 Dummy antenna (according to transmitter power)

4 TV Demodulator AMF 2 (photo p. 36), two for each dual transmitter

5 Distortion Network UPF-Z

(1) Measuring points for vision monitoring

[1] Measuring points for sound monitoring

[I] Measuring points for sound source data

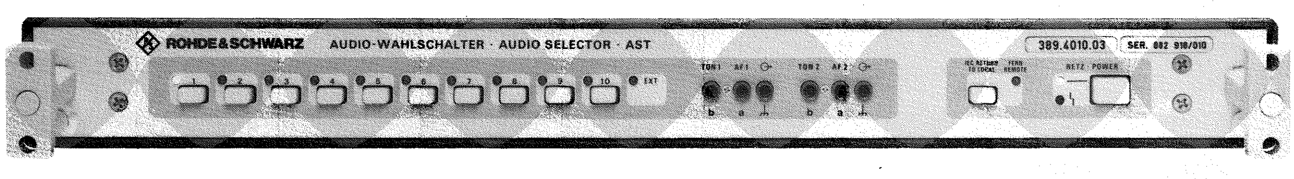
The digits correspond to program I in the table opposite

Monitoring Procedure

The example shows vision and sound monitoring of a transmitting station with two dual transmitters, analog to the automatic vision monitoring equipment on p. 201. It only differs from the vision monitoring set up by the data line decoder for the sound source data and the sound measurement points. The digits correspond to those in the table opposite, and are shown for program I.

Without the units for sound monitoring, the system can be used for purely vision monitoring (similar to the Automatic TV Test Equipment UPKF).

Audio Selector AST



AUTOMATIC VISION/SOUND MONITORING OF TV BROADCASTING NETWORKS central

Summary Automatic monitoring of transmitter **networks** is possible in two different ways. In the case of **central, reception-oriented automatic monitoring,** a central station is equipped with as many receivers as there are transmitters to be monitored. The video outputs of the receivers are connected to the Automatic TV Test Equipment UPKF which is also accommodated in the centre. This page and the following page contain an example and the description of this method.

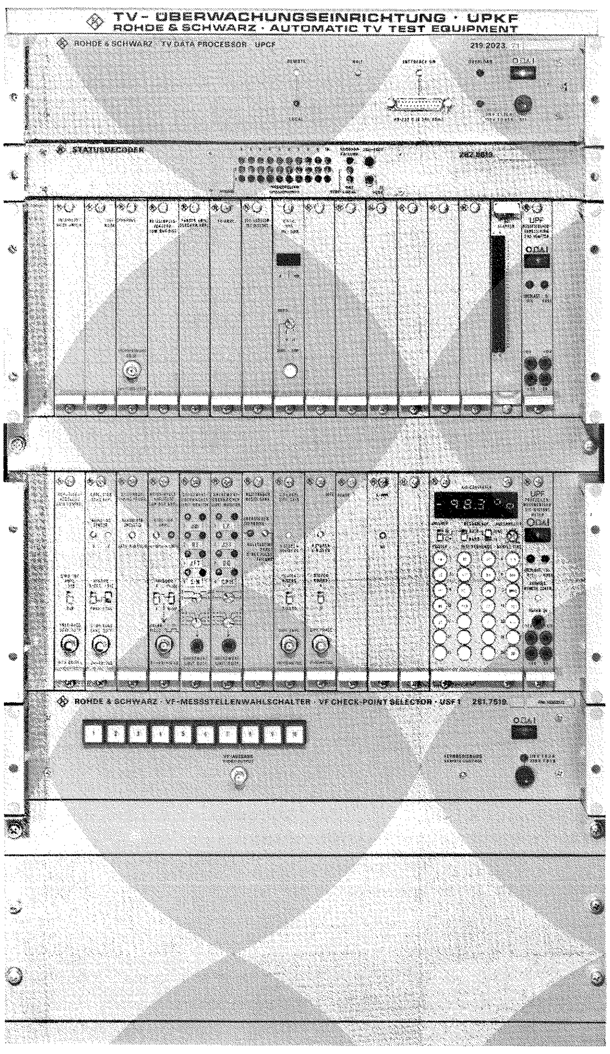
In the case of **decentralized automatic monitoring,** each transmitter station is assigned its own test equipment on site and the results are sent back to the centre via lines. This method is described on p. 206 with an example on p. 207.

Central, reception-oriented automatic monitoring This solution is characterized by relatively low equipment requirements. In its makeup, it corresponds to central visual and acoustic monitoring (p. 187).

The low equipment outlay brings about certain disadvantages. For example, changing propagation conditions and interferences can affect the values measured on the transmitters. In addition, it is only possible to assess the transmitter output signal. It is not possible to determine whether interferences originate in the transmitter or its modulation feeder. As a result of the cyclic scanning and the measurement period of the UPF (10 s for all checkpoints), the time elapsing before a fault is signalled may be up to approx. one minute.

This principle is nevertheless a decisive improvement over visual and acoustic monitoring because all transmitters in a network are monitored constantly and changes in quality are signalled immediately without the monitoring personnel being continuously on the alert.

Automatic TV Test Equipment UPKF



TV Data Processor UPCF

Status Decoder UPCF-Z5

Video Distortion Analyzer UPF

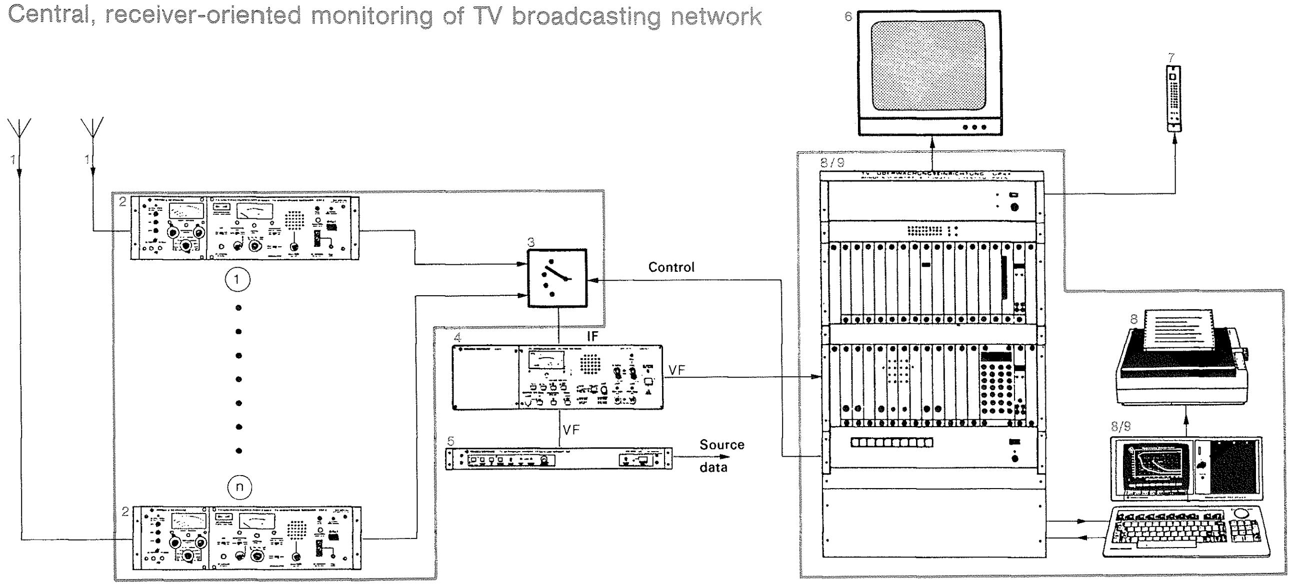
Video Distortion Analyzer UPF

Checkpoint Selector USF 1

Monitoring Procedure

The monitoring centre must have a favourable topographic location so that the different channels can be received well enough with the individual antennas and TV Channel Receivers EMFK. The receiver units are tuned to a fixed frequency and have an IF output. An IF switch cyclically links the outputs to a TV IF Demodulator EMFZF (with dual-sound facility) whose video output feeds the Automatic TV Test Equipment UPKF which is used for vision monitoring (description on p. 200, photo on left). The Sound and Insertion Signal Evaluation System TOPAS (description on p. 202, photo on p. 206) is used for simultaneous vision and sound monitoring; a TV Data Line Decoder DEF is required in addition and provides the source data for sound monitoring.

One of the advantages provided by receiver units with IF outputs is the low equipment requirement. They are also advantageous if the distance between the receiving antennas and the monitoring location is large. This is the case, Central, receiver-oriented monitoring of TV broadcasting network



Equipment required for each TV channel

1	Receiving antenna[1]) band I/III/IV/V, depending on receive frequency	
2	TV Channel Receiver	EMFK with crystal for the receiver channel
	or TV Measuring Receiver	EKF 2K

Only required once

3	IF Checkpoint Selector	
4	TV IF Demodulator	EMFZF
5	TV Data Line Decoder (only for Monitoring Equipment TOPAS)	DEF (photo p. 199)
6	Monitor	e. g. MC 37 BA 487 E from Bosch
7	LED Indicator Panel (not for Monitoring Equipment TOPAS)	UPCF-Z1

For TV vision monitoring

8	Automatic TV Test Equipment consisting of:	UPKF (photo opposite)
	— TV Data Processor	UPCF
	— Status Decoder	UPCF-Z5
	— Video Distortion Analyzer	UPF (photo p. 197)
	— Checkpoint Selector	USF 1
	— Terminal and printer	

For TV vision and sound monitoring

9	Sound and Insertion Signal Evaluation System consisting of:	TOPAS
	— Audio Selector	AST (photo p. 203)
	— Audiodat Receiver	UPT (photo p. 176)
	— Video Selector	VSF
	— Video Distortion Analyzer with second cassette adapter	UPF
	— Process Controller	PCF (photo p. 206)

[1]) Only one antenna with a distributor may be required for the same receiving direction and same frequency band.

Monitoring Procedure (continued)

for example, if the receiving antennas are located high on the mast for the transmitting antenna so that the received field strength is as large as possible, and the monitoring point is housed in the transmitting station. In order to prevent unnecessary RF losses, the receiver units and the IF selector should be housed as close as possible to the antennas. Using the IF prevents RF and cable losses and also prevents amplitude distortions which would occur at video frequency.

The status decoder incorporated in the Automatic TV Test Equipment UPKF or an additional LED Indicator Panel show the current status of all monitored checkpoints (10, extension possible up to 16):

- Green LED — Signal OK
- Yellow LED — Inner tolerance violated (B alarm)
- Red LED — Outer tolerance exceeded or test line missing (A alarm)
- Red and yellow LEDs — No signal at checkpoint
- No LED illuminated — Checkpoint excluded from cycle
- LOCAL — System used for manual measurements
- Cycle STOP — No automatic monitoring cycle, e. g. entered commands are being executed by TV Data Processor
- FAILURE — e. g. interruption of data transmission link or power failure in a unit of UPKF

Changes in status cause the LEDs for the old status and the new status to blink alternately, the new status being indicated by the longer on-time of the corresponding LED. After the acknowledgement button has been pressed, the new status is indicated by the associated LED being continuously on. The LED Indicator Panel thus provides complete information at a glance on the status of the entire network being monitored. Detailed data logs for the individual program channels can be called up on the terminal. The monitor shows the extent of picture quality impairment resulting from out-of tolerance conditions and whether it is necessary to switch over to the standby transmitter.

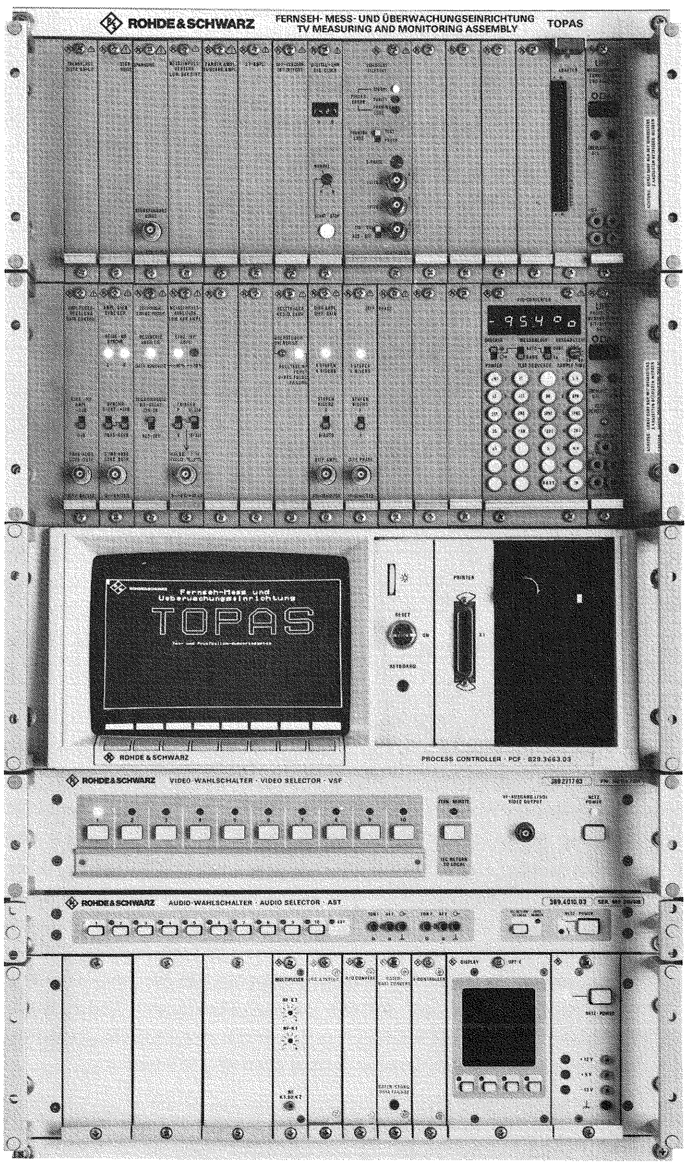
The TOPAS system signals faults on the screen of the Process Controller PCF.

AUTOMATIC VISION/SOUND MONITORING OF TV BROADCASTING NETWORKS decentralized

Decentralized automatic monitoring In the case of decentralized monitoring, the test equipment is located in the stations to be monitored (configuration as on pages 200 to 203). The status reports are transmitted from the stations to the monitoring point on dedicated lines. Modems convert the AF signals from the line back into digital signals.

The information flow with this decentralized procedure is considerably greater than with central monitoring because not only the emitted signal of the transmitter is measured but also its input signal. The standby transmitter can also be checked out remotely.

Sound and Insertion Signal Evaluation System TOPAS



Video Distortion Analyzer UPF

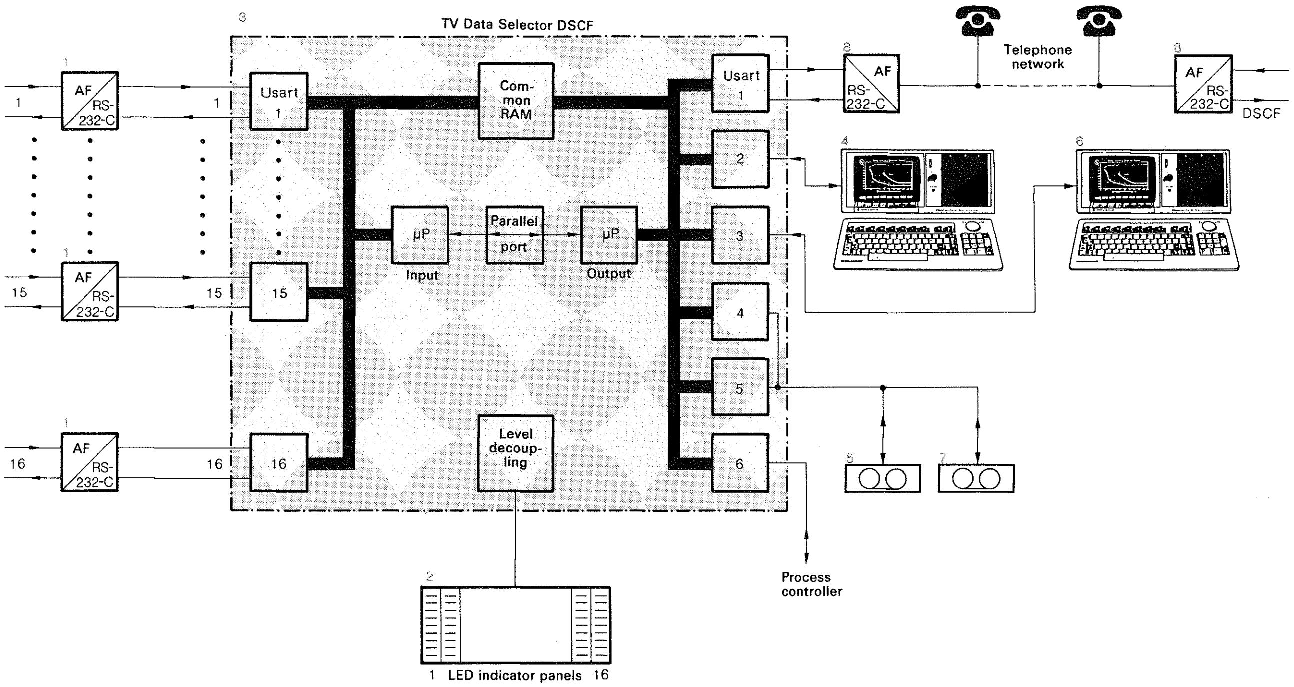
Process Controller PCF

Video Selector VSF

Audio Selector AST

Audiodat Receiver UPT

Decentralized, automatic monitoring of TV broadcasting network



Equipment required for each transmitting station monitored

1 Modem AF/RS-232-C

2 LED Indicator Panel UPCF-Z1 (up to 16 modules can be fitted in Cassette Adapter UPCF-Z0)

Usart Universal bidirectional data interface

Only required once

3 TV Data Selector DSCF

4 Main terminal

5 Associated data recorder

6 Additional terminal

7 Associated data recorder

8 Switching modem (for selecting a different control station via telephone line)

Monitoring Procedure

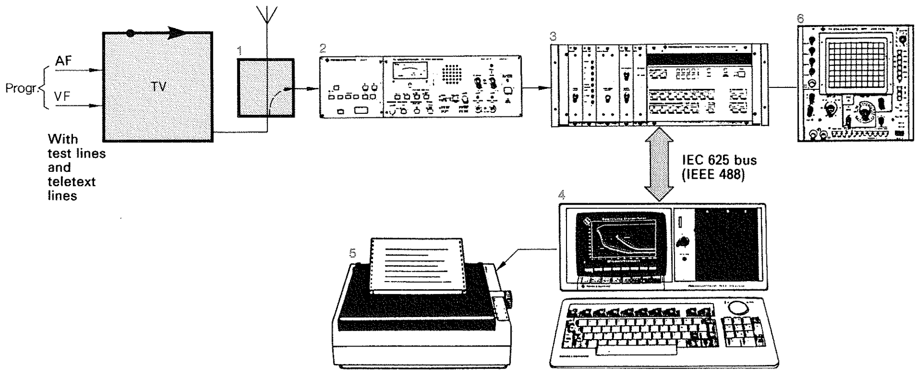
The link between the lines and the indicator and storage devices is the Data Selector DSCF. Up to 16 locations can be connected to this on the input side and two terminals with different priorities, two data recorders, a data modem and a process controller on the output side. All interfaces have an RS-232-C format. To decouple incoming data signals from the LED indicator panels, the latter are controlled at RS-232-C level via a 72-way connector.

There is a separate LED indicator panel for each transmitting station which indicates the status of all 10 checkpoints. The LEDs light up continuously as long as there is no change. If a change in status occurs at a station, the monitoring equipment automatically outputs a new status log which causes the LED of the checkpoint concerned to flash. Once this has been acknowledged by the monitoring personnel, the LEDs light up continuously to show the new status.

At the same time as the occurrence of a signal, the main terminal outputs the error message with station name and time in plain text and this is stored by the recorder. The station in question can now be called by the terminals and further signals requested. During interactive mode, the Data Selector DSCF switches off the automatic logging. All following entries up to the end of the interactive mode now only affect the DSCF or a connected location. The interactive mode is also logged on the recorder. The DSCF switches back to automatic logging approx. 1 minute after reception of the last character.

AUTOMATIC TELETEXT MONITORING

Decentralized, automatic teletext monitoring



1 Directional coupler (incorporated in transmitter)

2 TV Demodulator EMFD (photo p. 152) or TV Demodulator AMF 2 (photo p. 36)

3 Digital Teletext Analyzer ATF (photo p. 184)

4 Process Controller PCA 5

5 Universal Printer PUD 2

In addition for visual monitoring

6 TV Oscilloscope OPF (photo p. 49)

Monitoring Procedure

A. Basic settings

1. Connect demodulator input to test output of transmitter and the latter to VIDEO INPUT of ATF.
2. For visual evaluation:
   Connect SLOW VIDEO OUTPUT of ATF to OPF input, and output SCOPE TRIGGER of ATF to rear OPF connector X14.3.
3. Press 75 Ω and TRIGGER EXTernal on OPF. Set 0.1 V/DIV and 5 μs/DIV.
4. Tune demodulator to vision-carrier frequency of transmitter.
   With this arrangement, monitoring is possible manually or remotely controlled (opposite page). The instruments listed above are required in addition for the autorun control and for documentation.
5. Connect Process Controller to ATF via IEC-bus cable and connect printer to controller.
6. Program the Process Controller according to the ATF manual.

B. Monitoring a parameter

1. Press the key LIMITS CHECK and the key of the parameter to be monitored.
2. The LEDs of the pressed keys light up, the line number and measured value appear on the display. The line number can be changed using the keys below the display (as for the measurement).
3. The limits for the set parameter can be displayed using the keys LIMITS. If these values are exceeded, the LED of the parameter key flashes alternately with one of the keys LIMITS LOW or LIMITS HIGH. The meaured value appears on the display.

C. Monitoring of all parameters

1. Press key LIMITS CHECK. The associated LED lights up. LIMITS BUSY appears on the display.
2. The parameter keys are initially dark, the instrument checks all parameters in succession (approx. 20 s) and the LED in the key of a tested parameter lights up continuously if no limit is exceeded. It otherwise flashes alternately with one of the keys LIMITS LOW or LIMITS HIGH. The monitoring continues cyclically.
3. LIMITS O. K. or LIMITS FAIL appears on the display if the limits are exceeded for a parameter.

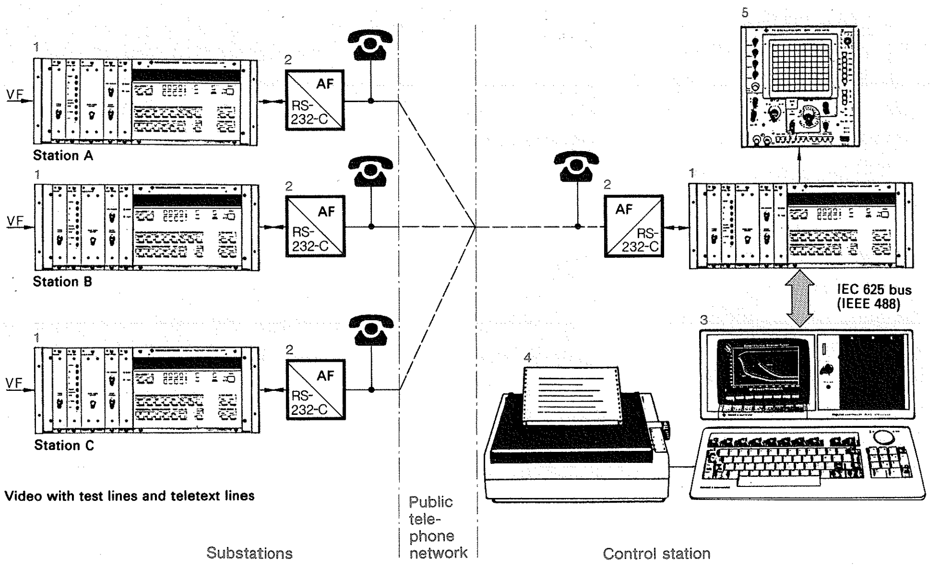
D. Checking and setting the limits

1. The limits of the individual parameters can be output on the display by pressing the respective parameter key with the keys LIMITS LOW or LIMITS HIGH.
2. The displayed limit can be modified using the keys below the display. If any other key is pressed (except LIMITS LOW or LIMITS HIGH), the set values are automatically stored power-failure-proof, and the limit setting mode is left.

E. Data output

1. The data generated during monitoring must either be logged locally or continuously sent to a remote control station.
2. A process controller together with printer connected to the IEC-bus connector of the ATF handles the autorun control and documentation when programmed appropriately.
3. A further possibility is use of the RS-232-C interface which enables the use of standard telephone lines via a modem for data transmission and remote control (see facing page).

Central, automatic teletext monitoring via public telephone network



Equipment per substation

1 Digital Teletext Analyzer ATF (photo p. 184)

2 Modem RS-232-C/AF

Possibly an additional TV demodulator (if not already present for other monitoring tasks)

Equipment in the control centre

1 Digital Teletext Analyzer ATF (photo p. 184)

2 Modem RS-232-C/AF (with switching facility)

3 Process Controller PCA 5

4 Universal Printer PUD 2

Add-on:

5 TV Oscilloscope OPF (photo p. 49), only for eye diagrams or TV lines

Monitoring Procedure

The Digital Teletext Analyzer ATF can be remote controlled by a second ATF via the RS-232-C interface and can transmit results to it. This is possible on standard telephone lines with a speed of 1200 Bd corresponding to the SLOW VIDEO display (p. 184). If the key LOCAL MASTER is pressed on the controlling device, the message MASTER appears on the display, and the remote device indicates REMOTE. The MASTER unit controls the REMOTE unit which transfers its results to the MASTER unit where they are then displayed.

Since only two-core lines are required to connect the two units, the connection can also be made via the public telephone network using modems with a switching facility. The results from several stations can then be polled and logged from a central control station. Depending on how the process controller is programmed, this can be carried out cyclically or only if a station signals irregularities.

In addition to the transfer of measured values, it is also possible to transmit a complete eye pattern or a complete TV line (in a correspondingly longer time, see p. 184).

Advantages of computer-controlled measurements In the case of measurements which are only carried out occasionally, it is usual to connect the individual units for the respective task or to combine them in racks. If the task is constantly repeated, however, such as in servicing, development or manufacturing, connection of the units to a computer may provide distinct advantages. These advantages include automatic control of the complete setup (which may well comprise a larger number of individual units) according to a program entered into the computer or also the immediate documentation of results in the form of tables (printer) or curves (plotter). Highly different tasks can be carried out depending on the number and type of units used in the setup, so that e.g. after entering the required parameters into the program, the complete measured values of an examined unit (or also several units) can be output as a table or as curves without further work involved.

The **IEC (IEEE) bus** is a worldwide standardized data bus for use in test systems which permits measuring instruments from different manufacturers to be combined at will with any computer via a multi-pole data line without requiring an instrument-specific interface or special driver software. The controllers send commands to the measuring instruments and receive data from them via the IEC bus. The instruments must be system-compatible, i.e. remote-controllable via the IEC bus. Instruments which can be remote controlled but do not satisfy the IEC-bus criteria can be connected to the bus via supplementary devices.

The IEC bus is designed such that combining the instruments into a system requires no special knowledge and is achieved by simply linking up the IEC-bus connectors of the individual units. All other functions, such as monitoring the usually different data transfer rates of the individual instruments, are performed automatically. The code used for transmitting information via the IEC bus is the ISO 7-bit code, which normally also provides the communication between computers and their peripherals and delivers characters which can be written and read directly. It is also known as the ASCII code according to the U.S. national standard.

Rohde & Schwarz measuring instruments with an IEC bus connection are generally designated as IEC-bus-compatible and marked by the symbol IEC625Bus Their function complies with the standard IEC 66.22. In the USA, the corresponding national standard is IEEE 488; the designation GPIB (general purpose interface bus) is also used. All these names identify the same bus system. The international standard IEC 625-1 applies all over the world; this results in the designation: IEC 625 Bus.

The 24-contact connector (Amphenol) fully complying with the latest IEC standard is used for all R&S instruments which are therefore compatible with all other equipment on the market.

Small computing systems such as desktop computers or process controllers featuring a favourable price/performance ratio are ideal for **controlling IEC-bus-compatible equipment.** Computers using standard programming languages such as BASIC are of special advantage since the speed of such computers is generally sufficient for analog test systems.

How is an IEC-bus test system set up? The most important criterion is the selection of suitable **measuring instruments.** These are selected according to their specifications to meet all the requirements involved. The necessary interconnections are then made. The user can check in **manual mode** whether the test assembly complies with his idea. All measuring functions and accuracy specifications are verified. In this respect, the configuration of an IEC-bus test assembly does not differ from that of a manually controlled setup.

The step towards **automation** is taken by linking up the IEC-bus connectors located on the rear of the instruments and by connecting them to a control computer. The interface standardization means that products from different manufacturers can be interconnected without problems. Criteria for selecting the computer are the programming language, storage capacity, computing speed and operating convenience, and for RF measurements a minimum of emitted RF.

The test assembly thus set up performs in fully automatic operation all test routines that are possible manually. The **first step** with the IEC-bus test system is therefore a configuration of instruments which are operated from a computer. Operator's errors are excluded and reproducible results obtained at high speed.

In the **second step,** efficient use of the computer capabilities permits optimization of the instrument characteristics. This can be achieved by suitable programs for error correction and self-calibration in accordance with reference curves. In this way, the accuracy can be considerably increased in most cases.

In the **third step,** evaluation of the measurements can be extended beyond simple logging of the results to error statistics, error diagnosis, nominal/actual value comparison and graphic display.

The assembly of IEC-bus systems is so easy in practice that the user himself can set up the system. Rohde & Schwarz naturally offers comprehensive system consultancy and assistance for any questions or problems that may arise. Finally, turnkey test systems are available on request.

The computer programming depends on the measurements required. Rohde & Schwarz provides basic software for many applications which considerably simplifies test program writing by using an interactive mode with the user. For special applications, programming is carried out using the associated computer and instrument manuals.

How does the IEC bus function? The IEC bus consists of three groups of lines: the **data lines** provided for the actual data transfer, the **interface management lines** controlling the system function and the **data-byte transfer control lines** for the timing.

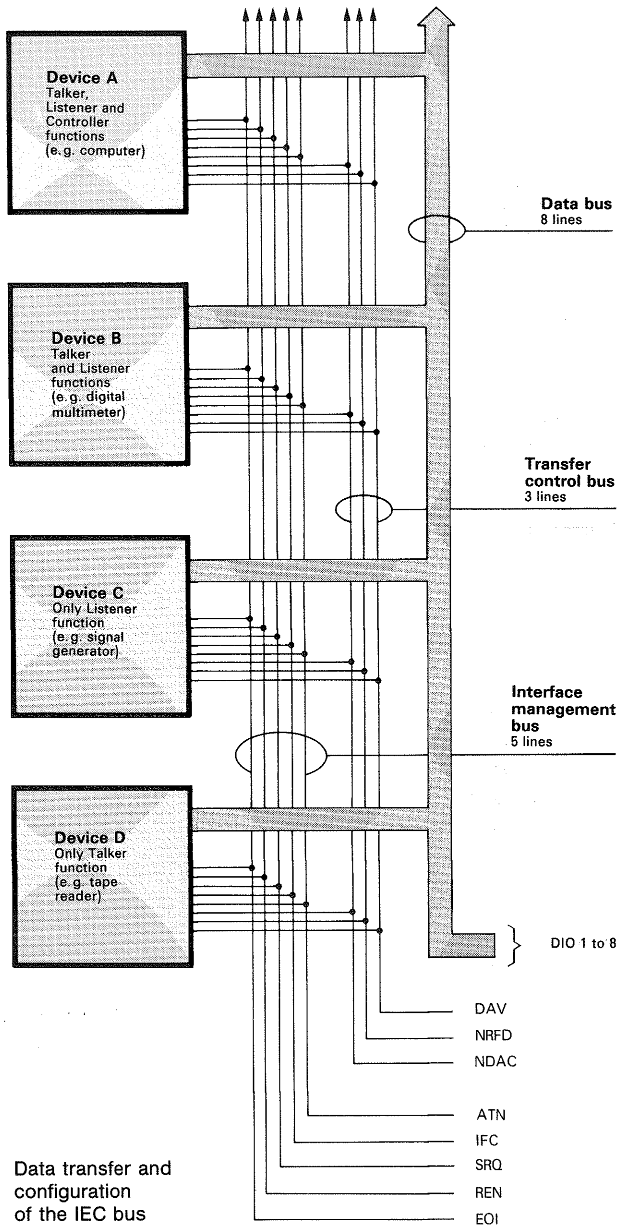
All information, data and also addresses are transferred on eight data lines **DIO** (data input/output). The data bus is bidirectional, i.e. data can flow in both directions.

As already mentioned, the characters are in ISO 7-bit code (ASCII code), one complete character per clock being transferred on the data bus.

The control line **ATN** (attention) serves to identify whether instrument addresses, commands or data are being transferred.

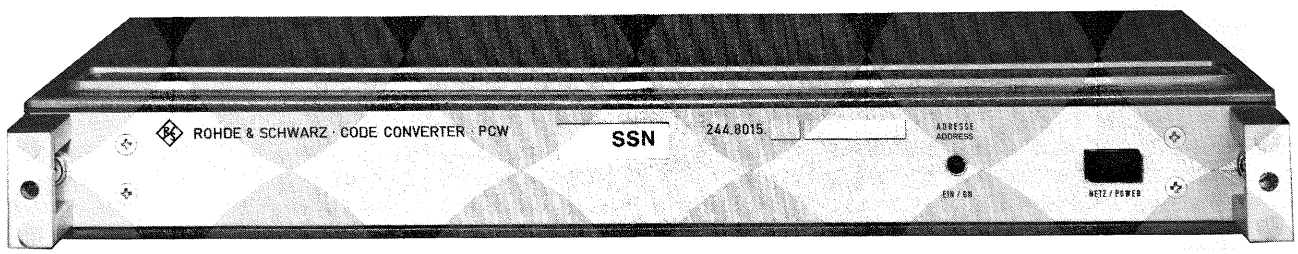
The other lines for system control are: **IFC** (interface clear) for resetting the system to a defined initial state, **SRQ** (service request) which enables the instrument to request the attention of the control computer for supplying a test result or signalling an error, **REN** (remote enable) for setting the devices in programmed operation and **EOI** (end or identify) for identifying the last character sent for other identification purposes (SRQ status signal).

The timing of data transfer is controlled via the lines **DAV** (data valid), **NDAC** (not data accepted) and **NRFD** (not ready for data) by the handshake process where the slowest device determines the speed of operation. Although this method is not the best from the point of view of speed, it has the advantage that the user does not have to concern himself about data transfer timing: any combination of IEC-bus-compatible devices can be assembled which then automatically controls the speed of data flow. The data rate of R&S units is high to the extent that normally no noticeable delay occurs in the speed of testing. Since analog instruments usually entail transients, it can be assumed that computer control does not reduce the physically feasible maximum test speed.



Data transfer and configuration of the IEC bus

Code Converter PCW



The following sound and TV measuring instruments from Rohde & Schwarz, most of which appear in this catalog, are provided with an IEC-bus connection:

Instrument	**Designation**	**Software available for:**
Video Test & Pattern Generator	SVDF	
Video Analyzer	UVF	PUC/PCA 5
Video Noise Meter	UPSF 2	PUC
Group-delay Measuring Set	LFM 2	PUC/PCA 5
Selective Demodulator (for LFM 2)	LDS	
Digital Teletext Analyzer	ATF	
TV Digital Oscilloscope	ODF	
Audiodat Receiver (new model)	UPT	
Noise Generator	SUF 2	
Audio Selector	AST	
Video Selector	VSF	PUC

With supplementary unit UPIF or PCW:

TV Demodulator	AMF 2 (CATV)	
Video Test Signal Generator	SPF 2	PUC
Video Distortion Analyzer	UPF	Tektronix 4051/4052
Checkpoint Selector	USF 1	HP 9826/ 9835/9836

Further instruments can be connected to the IEC bus via the Code Converter PCW (photo p. 211) provided they can be remotely controlled.

Instruments for general measuring applications with IEC-bus interface are contained in the Rohde & Schwarz measuring equipment catalog.

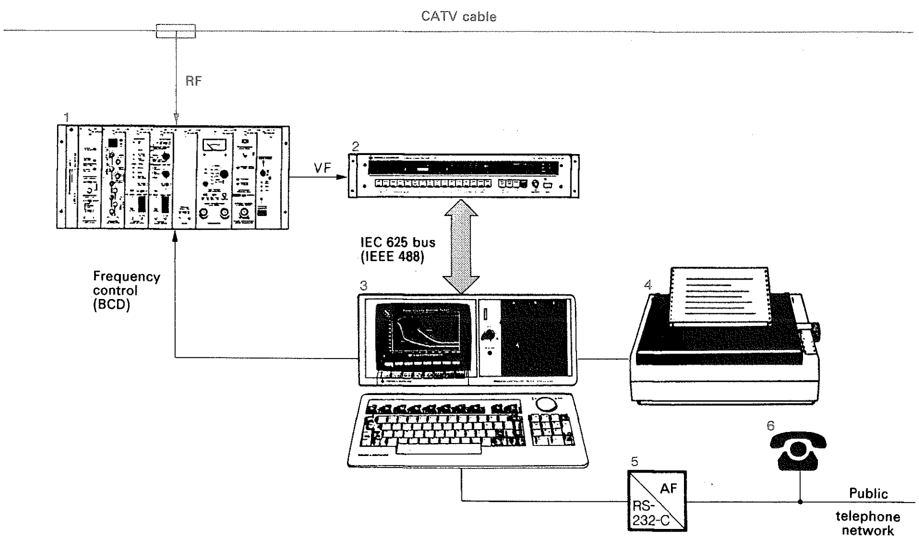
In addition to measuring instruments, IEC-bus setups also require various system devices for control and auxiliary functions, e. g.:

Controllers	Process Controller	PUC
	Process Controller	PCA 2, PCA 5,
	Process Controller	PCA 12, PCA 15,
	Process Controller	PCF
	Desktop computer	Tektronix 4051/4052
	Desktop computer	HP 9826/ 9835/9836
Printer	Universal Printer	PUD 2, PUD 3
Plotter	Plotter	DOP
Other devices	IEC Bus Interface	UPIF
	Code Converter	PCW

In addition to the above system devices, simpler equipment (e. g. from the personal computer environment) can also be used in many cases.

Examples of computer-controlled measurements

Automatic quality monitoring in a broadband communication headend

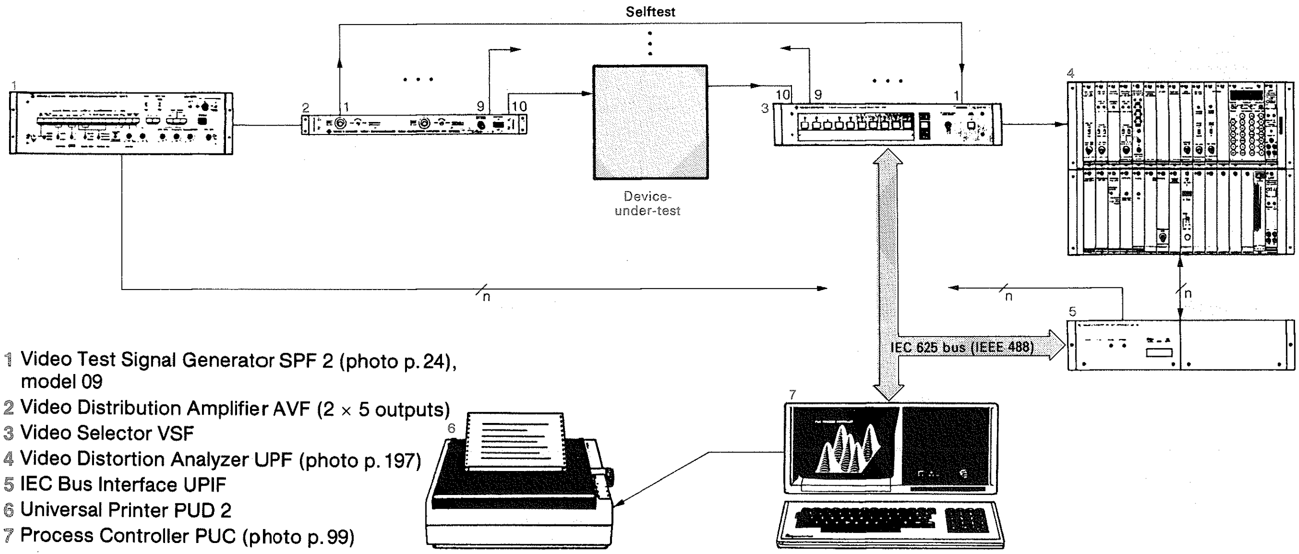


1 TV Demodulator AMF 2, CATV model
2 Video Analyzer UVF (photo p. 180)
3 Process Controller PCA 5
4 Universal Printer PUD 2
5 Switching modem | for automatic alarm signalling to a master station
6 Telephone |

Monitoring Procedure

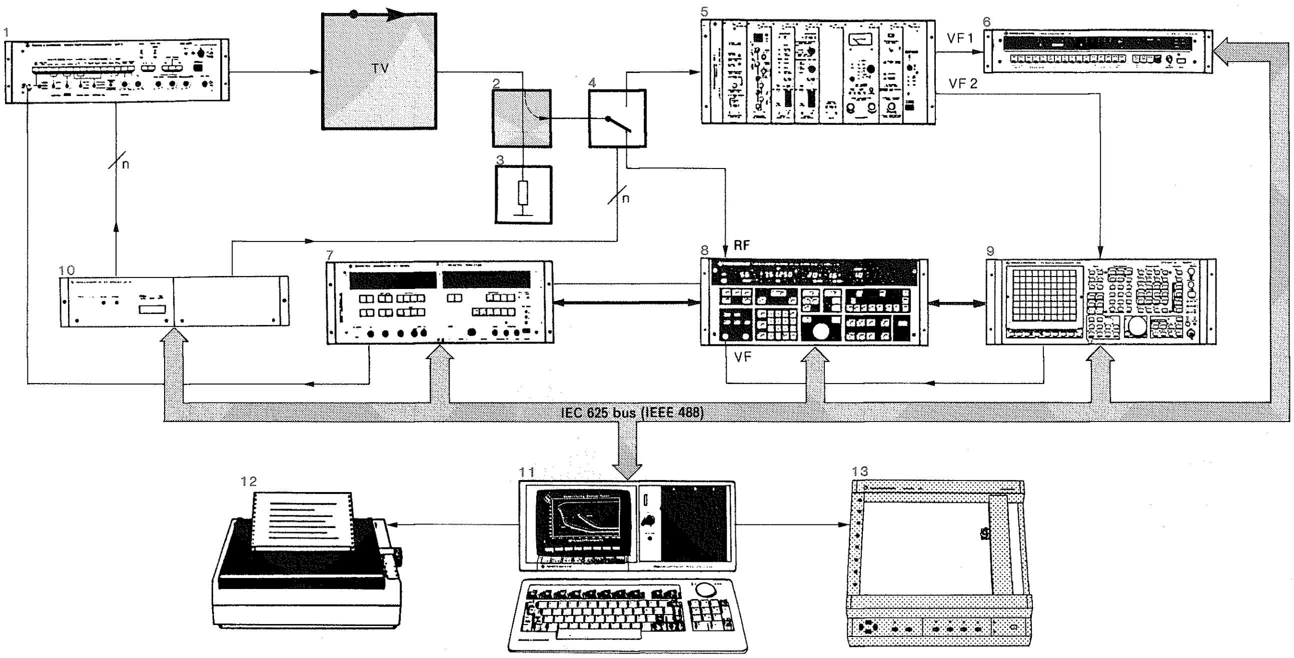
The transmission quality of any number of programs is continuously monitored by evaluating the insertion signals. The process controller sets the AMF 2 in succession to the frequencies of the channels to be monitored. An alarm is triggered if a limit stored in the UVF is violated. The various test programs in the UVF enable different limits to be set for particular TV programs (e. g. satellite and terrestrial programs). Cyclic monitoring of all programs ensures that faults are signalled within the shortest possible time. The measured values can then be automatically transferred to a master station via a switching modem. The master station can also scan the measured values at any time.

System for automatic testing and documentation of up to nine video devices (The values from the selftest of the test setup can be stored in the computer and used when the results are output)



1 Video Test Signal Generator SPF 2 (photo p. 24), model 09
2 Video Distribution Amplifier AVF (2 × 5 outputs)
3 Video Selector VSF
4 Video Distortion Analyzer UPF (photo p. 197)
5 IEC Bus Interface UPIF
6 Universal Printer PUD 2
7 Process Controller PUC (photo p. 99)

Automatic measurement of a TV transmitter (or broadband communication TV modulator)



1 Video Test Signal Generator SPF 2 (photo p. 24), model 09
2 Directional coupler (incorporated in transmitter)
3 Dummy antenna (according to transmitter power)
4 RF switching relay
5 TV Demodulator AMF 2 (photo p. 36)
6 Video Analyzer UVF (photo p. 180)
7 Group-delay Measuring Set LFM 2 (photo p. 61)
8 Selective Demodulator LDS (photo p. 62)
9 TV Digital Oscilloscope ODF (photo p. 56)
10 IEC Bus Interface UPIF
11 Process Controller PCA 5
12 Universal Printer PUD 2
13 Plotter DOP

The UVF measures a total of 16 insertion-signal parameters. The combination LFM 2/LDS/ODF selectively measures video frequency and RF responses (RF sideband characteristic, adjacent-channel rejection) and group-delay frequency responses (selective measurement at video frequency and RF). The results are output in tabular form and as curves (digital data output of ODF) on the printer or plotter.

Note A system of this complexity which enables completely automatic measurement of TV transmitters requires extensive programming to ensure correct functioning. It is therefore mainly used to advantage for routine measurements, e.g. in production or development, but certainly not for individual measurements.

appendix

Advantages of digital technology Digital technology enables analog signals (e.g. periodic or non-periodic) to be converted at great accuracy into digital values and to process these further. The successive values of a signal voltage, for example, are stored following conversion and are then available for further use, e.g. for processing or for display on a screen.

Modern digital oscilloscopes such as the TV Digital Oscilloscope ODF from Rohde & Schwarz have the following characteristics:

1. **The display of signals on the screen is independent of their refresh rate.** Thus single-shot signals or those occurring at long intervals of time (e.g. test lines of a TV signal) can also be displayed flicker-free and just as bright as periodic signals.
2. **Digitization of the measured values enables far more accurate evaluation** than with conventional analog oscilloscopes since all values of a curve displayed on the screen are available in memory in digital form. Two cursor functions (cursor 1 for the current value of the curve at an adjustable point, cursor 2 for the reference point) enable absolute (in mV) or relative (in %) measurement of the curve.
3. In addition to the current signal voltage, further values can be stored and displayed alternately with the signal voltage. **Thus a reference curve** (e.g. from a short-circuit measurement of the test setup) **or a tolerance mask can be displayed in addition to the test curve.** The purely electronic display on the same screen rules out geometric and parallax errors.
4. The **processing of measured values** made possible by the digitization enables e.g. the deviation from a stored reference curve to be displayed as a continuous curve or — by using the cursor — as a number on the screen. In addition to the elimination of parallax and geometric errors, this results in a far greater accuracy than with the attachable masks used with analog oscilloscopes.
5. Continuous evaluation and averaging of periodic signals enable **non-coherent components** (e.g. noise, "electric noise") to be **largely suppressed.** Thus even very noisy signals can be displayed correctly. Furthermore, the measured signal is not influenced because this method does not use any frequency-selective elements.
6. In the case of constantly changing signals, the **maximum and minimum values** occurring within a specific period can be displayed. This is also of interest for noisy signals, e.g. to determine the maximum amplitude of the noise.

The TV Digital Oscilloscope ODF is a precision instrument designed especially for measurements on TV equipment. Comprehensive storage capabilities and autorun control by a 16-bit microprocessor open up completely new possibilities with high operating convenience. The ODF is fitted as standard with an IEC-bus interface for use in automatic systems.

The oscilloscope has only one analog input but can display the applied signal voltage in two completely different ways on the screen (displays A and B): with different scales in the Y direction and different delays or sections in the X direction as well as with different treatment of the signal voltage (e.g. differentiation, selection of lowpass or bandpass filters).

Two cursor triangles are assigned to each display (A and B) and can be shifted separately along the curves using the spinwheel: cursor 1 moves along the top of the curve, cursor 2 along the bottom. The differences in the cursor positions in the X direction (absolute) and the Y direction (absolute or percentage) are output on the respective display and thus enable exact signal evaluation.

The digital sampling procedure enables a number of special features to improve the display on the screen. The mode DOT JOIN connects the sampling points by a straight line (vector display). Only a few points are present on steep edges, e.g. those of a squarewave pulse. DOT JOIN connects these into a continuous line on which the sampling points can still be recognized.

In the case of higher-frequency components of the signal voltage — e.g. the colour subcarrier packet of a TV signal — the display initially only comprises a number of points which do not provide exact information on the type and magnitude of the signal component. The mode ENV (envelope) only outputs the respective highest and lowest values sampled thus enclosing the colour-subcarrier packet on the screen. If DOT JOIN is additionally selected, the packet is displayed as a bright area.

The mode AVG (average) results in continuous generation of the average value from a (selectable) number of displays of the signal voltage. Components (e.g. noise) not correlated with the signal voltage can be adequately suppressed in this manner so that even very noisy signals can be displayed correctly.

Trigger facilities Triggering is particularly important with complex TV signals. Various possibilities are provided by the ODF:

- **Line all** Trigger at each video line, field blanking interval is eliminated
- **Line select** Trigger at a particular video line within a frame
- **Field number** Trigger at any video line in a selectable field 1 to 4
- **Field sequence** Trigger at any video line in a selectable field with a trigger sequence of 2, 4 or 8 fields

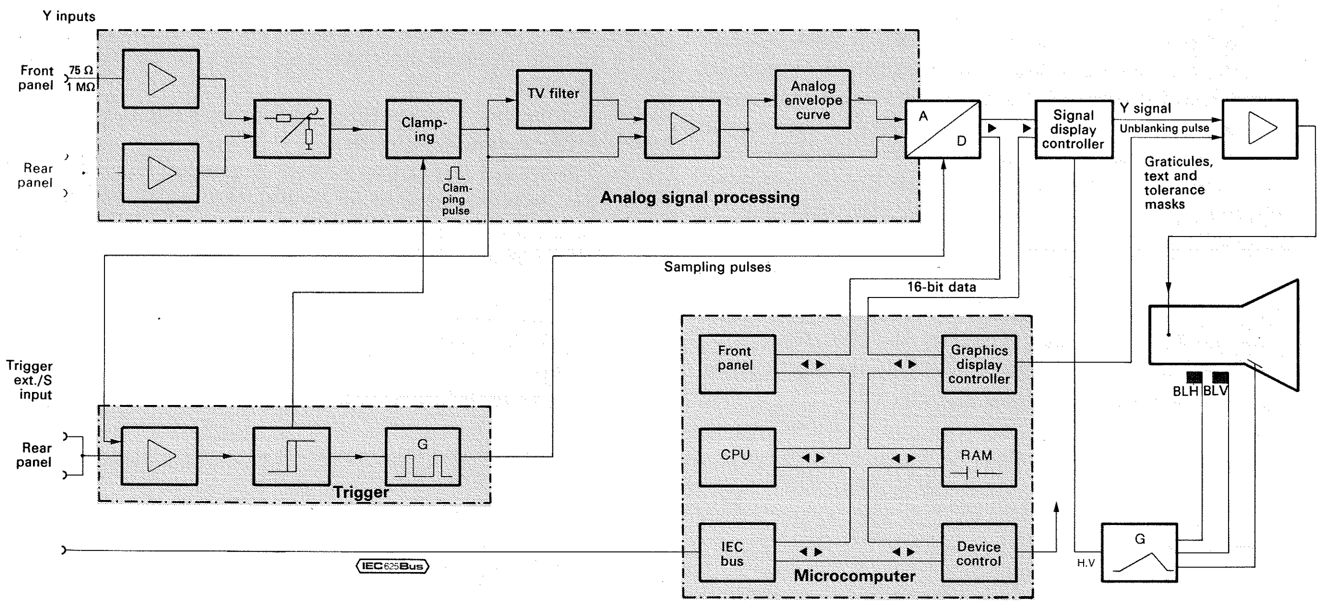
In **mode PLL,** an internal crystal generator which is synchronized by a (slow) control loop with the line frequency of the applied video signal determines the point of triggering. Thus a stable trigger is guaranteed even with very noisy TV signals which is an essential prerequisite for use of mode AVG.

Signal section display Two delay timebases are available to enable signal sections to be displayed in a simple way. In mode **DELAY INTENSIFY,** a bar is displayed for each time base, and its X position and length can be modified. The signal section desired can thus be defined. In mode **DELAY START,** the selected signal section is displayed. Using a time range defined via the basic timebase, up to two sections with different trigger delays and different delay timebases can be selected.

Long-term evaluation In the case of signal components which are not locked in-phase to the trigger, it is a statistical problem to measure all signal components with their maximum amplitude. This particularly applies to sporadic interference on the signal ("electric noise"). Such interferences frequently occur if TV signals are received in the vicinity of high-voltage lines or industrial plants. For such applications, the envelope curve evaluation of the signal with a maximum bandwidth can be expanded to a selectable number of sampled displays ranging from two to infinity. This means that noise signals can be measured which only occur at infrequent intervals.

Up to 10 oscilloscope settings used for various measurements, as well as up to 10 measured curves, can be **stored in non-volatile memories** and recalled at any time. This is a simplification in operation resulting from digital technology.

The following pages show a number of measurements with the TV Digital Oscilloscope ODF which clarify the characteristics and convenience of operation of the oscilloscope.



Principle of TV Digital Oscilloscope ODF

Noise superimposed on TV signals Non-correlating signals such as occur when weak signals are received (e.g. noise, superimposed signals or "electric noise") make evaluation with an oscilloscope more difficult. On the one hand, they extend the display in the Y direction so that exact evaluation with large noise amplitudes is not possible, on the other hand, they affect the point of triggering so that extension of the curve also takes place in the X direction (time jitter).

Reduction of noise in Y direction Noise in the Y direction can be greatly decreased using mode AVG (average). This forms the average value from an adjustable number (N) of sampling cycles where the last cycle influences the new result with the N-th part of its sampled value.

If the signals are not particularly noisy, a small averaging factor (N = 3 to 5) already greatly reduces the noise effect. The rate of change remains sufficiently high so that settings can be made on the device. Suppression of non-correlating noise does not increase linearly with N, but only with $\sqrt{N}$, i.e. increasing N from 4 to 16, for example, only halves the noise.

In the position TRIGGER SELECT -◆-, each selected line is triggered in conjunction with SELECT LINE. Since the phase of the burst signal changes from field to field and only attains the original value again after the eighth field, the subcarrier is recognized in the signal with this trigger mode as a non-coherent signal and is thus also suppressed in mode AVG.

TRIGGER SELECT -ww- must be switched on if the colour subcarrier is to be retained so that triggering is only made at each eighth field. The colour subcarrier then appears as a stable sinewave signal (mode DOT JOIN results in a continuous line).

Reduction of noise in X direction The mode PLL is also provided to stabilize the trigger point in the case of noisy TV signals. An internal crystal oscillator is synchronized with the line pulses of the measured voltage (with interference) via a narrowband PLL. The oscillator then sets itself to the mean frequency of the measured voltage. The spurious FM of the oscillator, which determines the trigger point, is far smaller than the spurious FM of the trigger signal in mode DIRECT because of the low cut-off frequency of the PLL. This means that the stability is also significantly improved in the X direction.

The mode PLL must not be used for signal voltages which already exhibit instabilities in the X direction (jitter) because it increases the instabilities even further. PLL is basically only useful with very noisy signals.

Selection of averaging factor N The measures described to reduce noise in the Y and X directions guarantee a suitable display even with very noisy signals. The elimination of noise is improved with each cycle until the set number (N) of cycles has been reached (N = 16 if no number is entered), and then no further noise reduction takes place. The display is continuously modified by the ratio 1/N of the subsequent sampling results. Suppression of the noise components increases with the square root of the averaging factor N, the time taken to obtain the final display increases with N. This is particularly important for insertion-test signals since these are only evaluated in $^1/_{625}$ of the time — or only in $^1/_4 \times {}^1/_{625}$ in mode TRIGGER SELECT -ww- . It is therefore advisable to select a small value for N when carrying out adjustments. N should have a larger value for logging.

Measurement Procedure

Note When measuring TV antenna signals with receivers, it is generally only possible to evaluate the insertion-test signals.

A. Basic settings

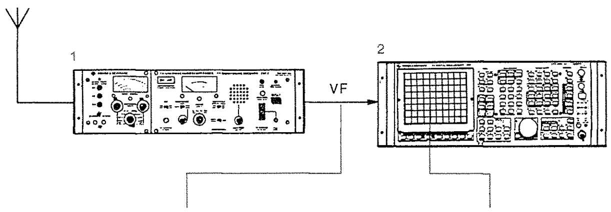
1. Oscilloscope setting as on p.46, A.2. Call stored setting using RCL, STAT, 1 (red), ENTER.

B. Measurement of insertion-test signals

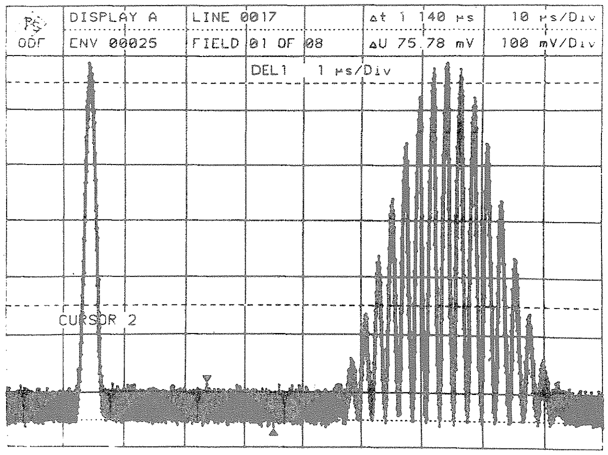
1. Press LINE, test line number (red) and ENTER. The selected test line appears on the screen.
2. In the case of signals with interference (white noise, "electric noise"), press AVG, ENTER and PLL. This setting results in averaging of 16 cycles.
3. To display colour subcarriers in the signal, switch to TRIGGER SELECT -ww- , otherwise the colour subcarriers are also suppressed.
   Note Since only every eighth field is evaluated, it takes several seconds until the final value of the averaging appears.
4. The number N of sampling cycles can be entered using AVG, N (red) and ENTER.
5. The display shows the number of evaluated cycles and the selected number of cycles. The signal display is continuously updated up to the value N, and then by the ratio 1/N in each case.

C. Measurement of frame signals

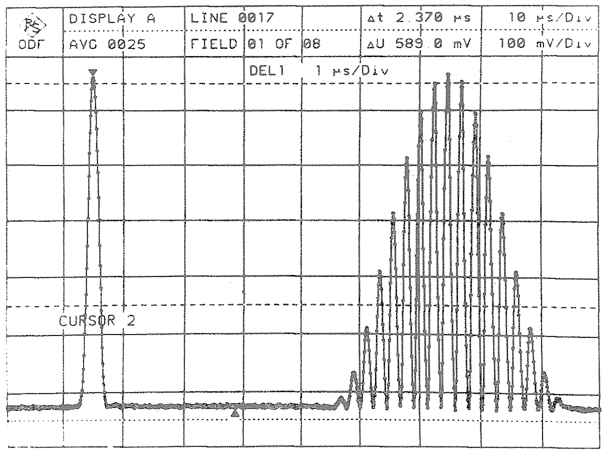
1. Press LINE and ALL. The frame signal appears on the screen.
2. to 5. As for B.2. to 5. (without note in 3.).



1 TV Monitoring Receiver EKF 2 (photo p. 187) or TV Test Receiver EMFT (photo p. 218)
2 TV Digital Oscilloscope ODF (photo p. 56)

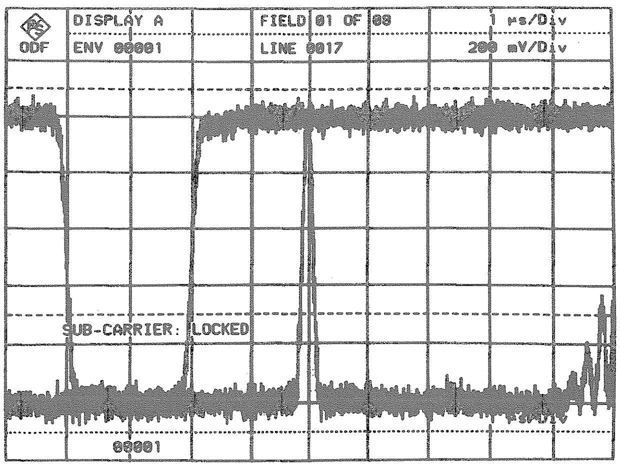


Insertion signal CCIR 17 with superimposed noise
(S/N = 34 dB_{rms})
Trigger mode: line 17 with delayed start (DEL 1)
Refresh rate: 8 fields

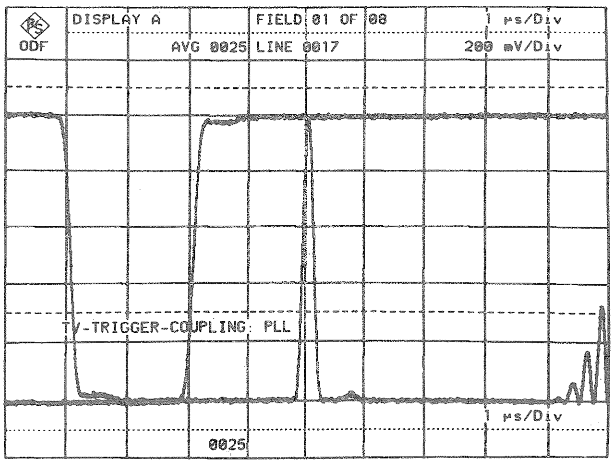


Insertion signal CCIR 17 with superimposed noise
Display of same signal as on left but with averaging (N = 25)

The cursor triangles on the left are set to the noise peaks. The amplitude (and time) differences are output in the display. The magnitude of the 2T pulse is evaluated in the same manner on the right.



Insertion signal CCIR 17 with superimposed noise
(S/N = 34 dB_{rms})
Trigger mode: line 17 with delayed start (DEL 1 and DEL 2)
Refresh rate: 8 fields
Vector display with envelope function (ENV 1)



Insertion signal CCIR 17 with superimposed noise
Display of same signal but with averaging (N = 25);
reflexion = 2%/800 ns. The reflection amplitude can only be detected in the display freed from noise.
Timing and percentage measurements using the cursor triangles are also possible but were not carried out here.

Detection of interfering voltage peaks The detection of the peak values of superimposed noise where the peaks appear very seldomly (e.g. "electric noise") may be of interest. This type of measurement cannot be carried out using a standard noise voltage meter or an analog oscilloscope and is made possible using a digital oscilloscope with storage facility.

In mode ENV (envelope), 20 staggered sampling cycles with 1000 points each are evaluated with **timebases of 10 μs/DIV** (i.e. 20,000 sampling points corresponding to an effective sampling frequency of 200 MHz). The microcomputer calculates the 1000 highest and 1000 lowest values and displays these on the screen.

In the case of **timebases of 20 μs/DIV and greater,** 1000 sampling points are used per cycle as well as analog envelope curve display with storage. This mode is more suitable for statistical purposes than the digital method. At 20 μs/DIV, three TV lines are displayed on the screen (see example on opposite page). The setting ENV, ENTER corresponds to one sweep (N = 1). The values are deleted following each sweep, and the values of the next cycle are output.

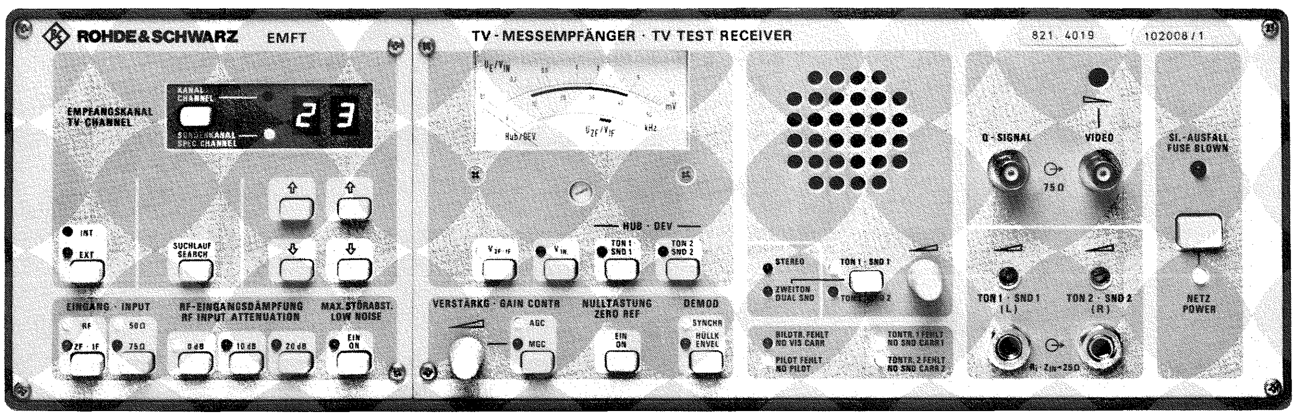
After entering ENV, N (red) and ENTER, the oscilloscope determines the highest and lowest values from a total of N cycles and displays these on the screen. The display is then "frozen" and not evaluated any further.

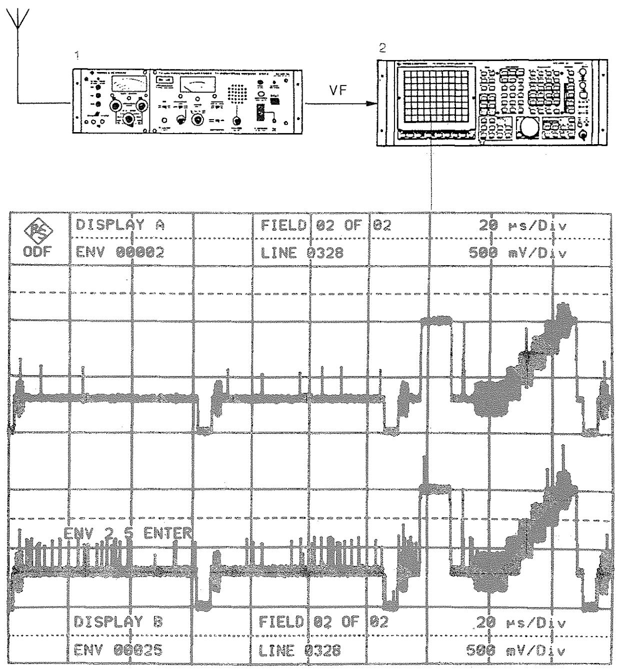
Evaluation over a longer period is possible by entering N = 1000. The display is then no longer frozen but updated continuously so that all maxima and minima during the complete measuring period appear on the screen.

If only mode ENV is selected, the values appear as dots on the screen. Additional entry of DOT JOIN joins the points by means of vertical lines, and the area between the rows of points appears bright on the screen.

In order to obtain a **reference value for the noise amplitudes,** the noise is first suppressed using the AVG function (see p. 216). The reference value is then set using the cursor function and the noise statistics then carried out using the ENV function. The noise signal amplitude is measured after the build-up of the display is completed.

TV Test Receiver EMFT





1 TV Monitoring Receiver EKF 2 (photo p. 187) or TV Test Receiver EMFT (photo opposite)

2 TV Digital Oscilloscope ODF (photo p. 56)

Insertion signal with superimposed noise
(S/N = 37 dB_{rms}) and statistically distributed, high-frequency noise peaks;
DISPLAY A: envelope curve of 2 displays
DISPLAY B: envelope curve of 25 displays

Measurement Procedure

Note When measuring TV antenna signals with receivers, only one evaluation of the insertion signals is usually possible.

A. Basic settings

1. Oscilloscope setting as on p. 46, A.2. Call stored setting using RCL, STAT, 1 (red) and ENTER.
2. Press key 20 (green) and µs.

B. Calibration of setup

1. Enter LINE, test line number (red) and ENTER. Select a test line with a luminance bar (e.g. line 17 or 330).
2. Noise suppression as on p. 216, B.
3. Press CURSOR 1. Adjust the triangle to the top of the luminance bar using VARY.
4. Press CURSOR 2. Adjust triangle to base of sync pulse. Press % and ENTER. The display indicates 100%. The CVS value is thus defined as the reference variable.

C. Measurement of test line signals

1. Enter LINE, test line number (red) and ENTER. A test line without modulation is most suitable for these measurements (line 328 or 329 in example, X timebase 20 µs/DIV).
2. There are several possibilities:

2a Press ENV and ENTER. The maxima and minima occurring during the cycle appear as points joined to the baseline by vertical lines. New values appear with each cycle, and the previous values disappear.

2b Press ENV, N (red) (N corresponds to the number of cycles required) and ENTER. The maxima and minima within the N cycles are displayed. The display then remains constant.

2c Press ENV 1, 0, 0, 0 (red) and ENTER. The maxima and minima are displayed continuously and evaluated for the complete measuring period.

3. The numbers of entered and respectively evaluated cycles are displayed on the screen. In the example, the same curves are output in displays A and B but with different numbers of cycles so that the influence of the measuring time is clearly evident.

D. Measurement of frame signals

1. Press LINE and ALL. The frame signal appears on the screen.
2. Analogous to C.2.

E. Evaluation with cursor function

1. Press CURSOR 1. Adjust triangle to peak of largest noise amplitude using VARY. Press CURSOR 2 and adjust triangle to base of same peak ($\Delta t = 0$).
2. The display indicates the largest noise amplitude in percent, referred to the CVS.

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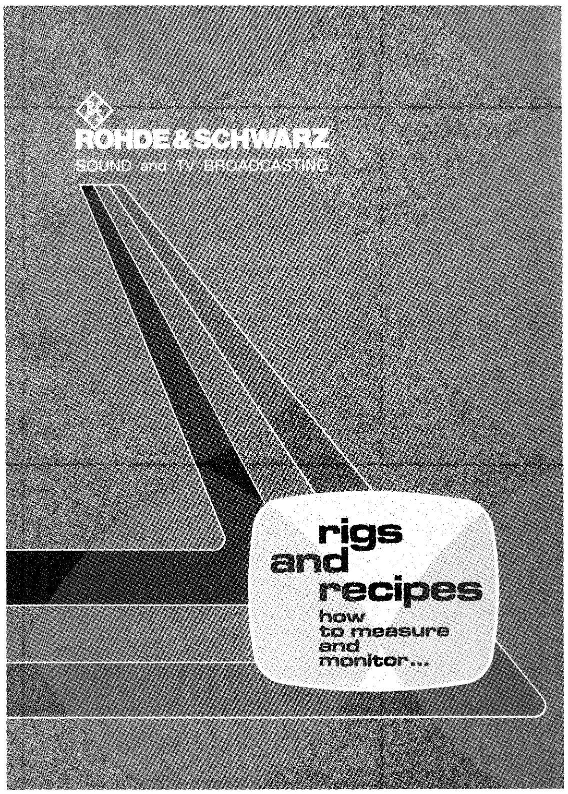

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