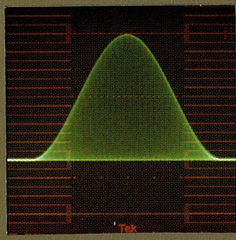
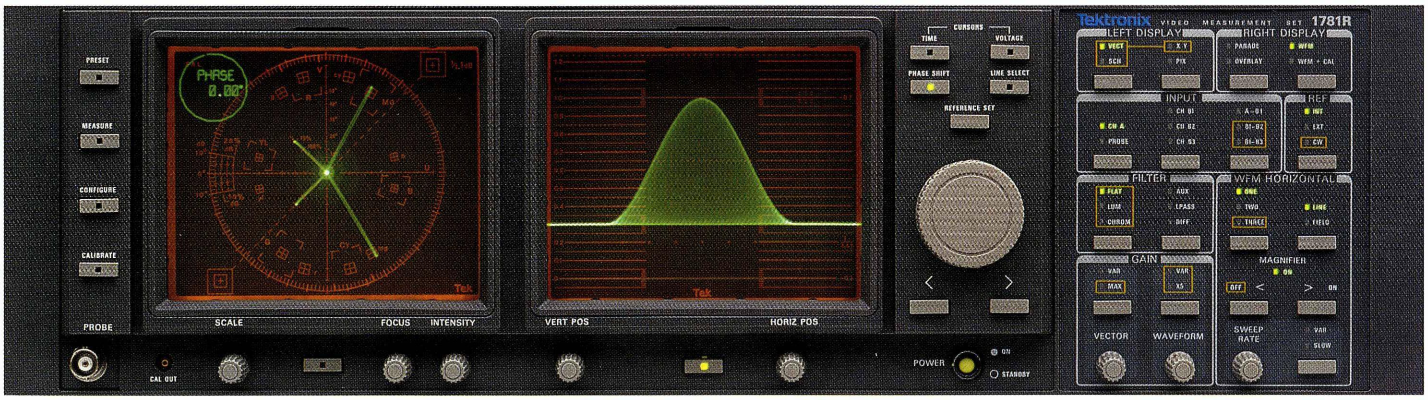


TELEVISION MEASUREMENTS
PAL SYSTEMS

Tektronix®

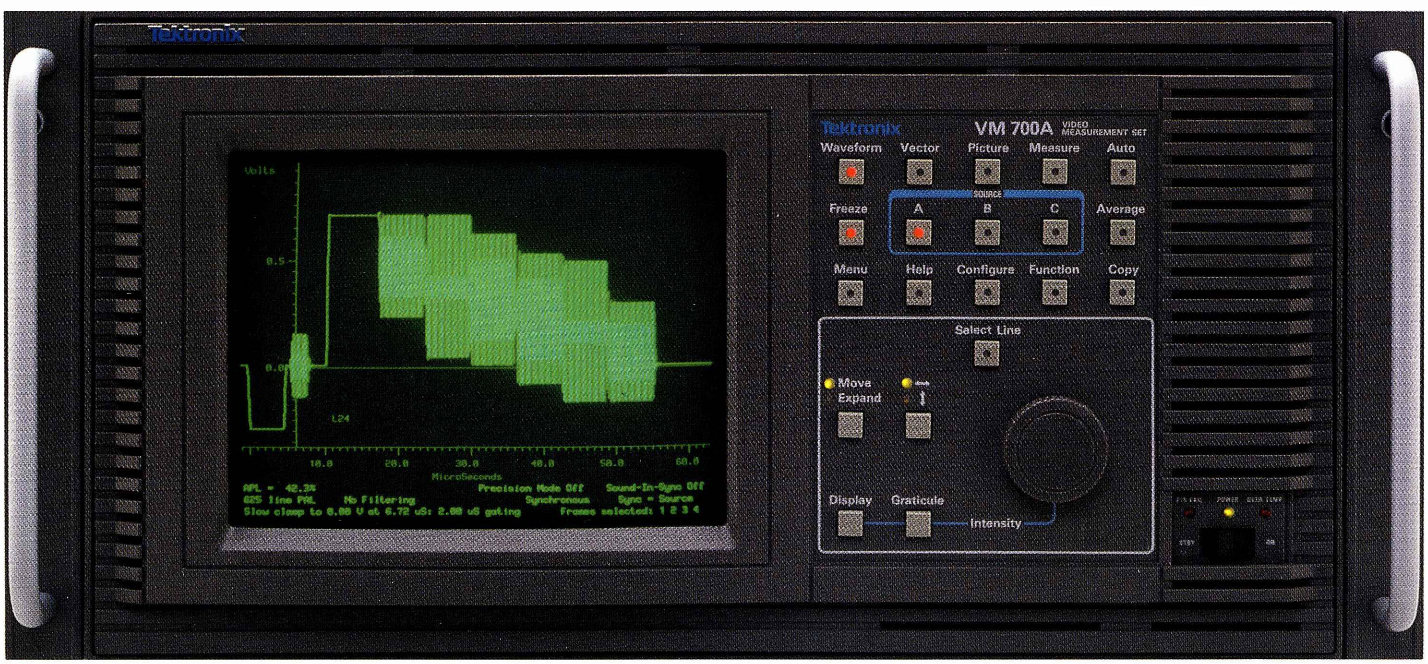
1781R Video Measurement Set

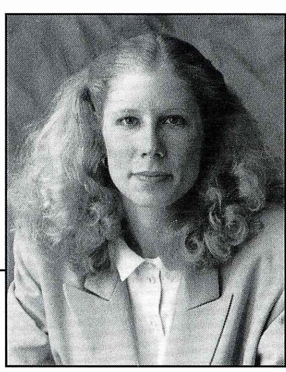
The 1781R is a wide bandwidth, multi-input analogue instrument which provides both waveform monitor and vectorscope functions. Precision measurements are facilitated by features such as cursors, a polar SCH phase display, and special differential phase and gain modes.



VM700A Video Measurement Set

The VM700A automatically monitors and measures the video signal, and provides digital waveform and vector displays for manual measurements. Spectrum displays and complete noise measurement capabilities are also available, as well as user programmable functions and hardcopy output.





About the Author

Margaret Craig is an engineering manager in the Tektronix Television Division. Her experience includes circuit design for analogue waveform monitors and vectorscopes, as well as project leadership responsibilities. She holds a BSEE from Iowa State University.

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Preface

To characterise television system performance, you need an understanding of signal distortions and measurement methods as well as proper instrumentation. This booklet will familiarise you with television test and measurement practices, and serve as a comprehensive reference on methods of quantifying signal distortions. It can help you learn to figure out if something is wrong with the signal, but does not offer any assistance in correcting a distortion once you have identified it. In order to adjust the system for optimum performance, you will need an in-depth understanding of all the equipment in your signal path.

New instruments, test signals, and measurement procedures continue to be introduced as television test and measurement technology evolves. This booklet encompasses both traditional measurement techniques and newer methods. After a discussion of good measurement practices, five general categories of television measurements are addressed:

I. Amplitude and Timing Measurements
II. Linear Distortions
III. Non-linear Distortions
IV. Noise Measurements
V. Transmitter Measurements

This publication deals with PAL composite analogue signals — component, digital, and HDTV measurements are outside its scope. A basic knowledge of video is assumed, but a glossary of commonly used terms is included to refresh your memory and introduce newer concepts. It is also assumed that you know the basics of waveform monitor and vectorscope operation, and that you know how to use the various controls on your instruments. Consult your instrument manuals for specific operating instructions.

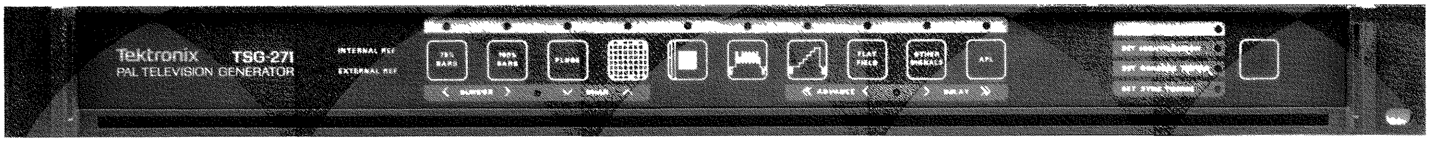


Figure 1. Tektronix TSG-271 PAL Test Signal Generator.

■ EQUIPMENT REQUIREMENTS

Television system performance is evaluated by sending test signals with known characteristics through the signal path. The signals are then observed at the output (or at intermediate points) to determine whether or not they are being accurately transferred through the system. You need two basic types of television test and measurement equipment to perform these tasks: test signal generators provide the stimulus, and specialised oscilloscopes known as waveform monitors and vectorscopes provide displays for evaluating the response.

Test Signal Generators

Television signal generators typically provide a variety of test signals and synchronisation signals, ranging from colour black to more complex signals designed for evaluation of specific distortions. Each generator model offers a different selection of signals, so be sure to choose one that provides all the signals you need for characterising your system. It is also important to take a close look at the output signal specifications — generator performance is critical to accurate system testing. You need to be confident that any distortions you observe are introduced by the system under test and not by the generator itself.

Analogue generators, such as the Tektronix 1411 PAL Test Signal Generator, have traditionally provided highly accurate, flexible signal generation. While analogue generators are still widely used today, digital generators are increasingly being chosen for modern facilities. Digital generators are very stable, and tend to be less expensive than their analogue counterparts. The Tektronix TSG-271 PAL Television Generator is an example of a general-purpose digital test signal generator.

Most generators provide test signals which occur on every active line of the video field. These signals, known as **full-field** signals, can be used only for out-of-service testing: the system cannot simultaneously pass programme material and full-field test signals. In-service tests can be performed if the test signals appear only in the vertical interval of the programme signal. Several blank lines are available in the vertical interval for this purpose, and generators such as the VITS 201 PAL Insertion Generator perform the insertion function.

Waveform Monitors and Vectorscopes

The instruments used to evaluate a system's response to test signals make up the second major category of television test and measurement equipment. Although some measurements can be performed with a general purpose oscilloscope, a waveform monitor is generally preferred in television facilities. Waveform monitors automatically trigger on the television synchronising pulses, and provide a voltage-versus-time display of the video signal. These instruments are equipped with specialised video clamps and filters which allow you to separately evaluate the chrominance and luminance portions of the signal. Most models also have a line selector for looking at signals in the vertical interval.

A vectorscope, which is designed for accurate evaluation of the chrominance portion of the signal, is another important test and measurement tool. This instrument demodulates the PAL signal and displays the V (R-Y) colour difference component on the vertical axis and the U (B-Y) colour difference component on the horizontal axis.

When you select waveform monitors and vectorscopes, carefully evaluate their feature sets and specifications to make sure they will meet your measurement needs. This is particularly true if you want to be able to make accurate measurements of all the signal parameters and distortions described in this booklet. Many varieties of waveform monitors and vectorscopes are on the market today, but the majority of them are not intended for precision measurement applications. Most vectorscopes, for example, do not have precision differential phase and gain measurement capabilities.

For many years, the television industry has relied on the Tektronix 1481 Waveform Monitor and 521A Vectorscope for accurate measurements. Many of the procedures we use today were developed with these instruments. While the 1481 and 521A still perform most of the required functions, the Tektronix 1781R is now recommended for precision analogue measurements. The 1781R is a microprocessor-controlled instrument which has both waveform monitor and vectorscope functions. Many of the measurement procedures in this booklet are based on 1781R features and operation.

Another option for measuring waveform distortions is the Tektronix VM700A, which digitises the incoming video signal and automatically analyses it in the digital domain. The VM700A has four basic modes of operation: WAVEFORM, VECTOR, MEASURE and AUTO. The WAVEFORM and VECTOR displays can be used in much the same way as analogue waveform monitors or vectorscopes operating in the "line select" mode. Because of the similarity, these modes are not discussed in any detail in this booklet.

The VM700A's MEASURE mode provides unique displays of measurement results, many of which are presented on the following pages. Numeric measurement results are also available for most parameters in the AUTO mode.

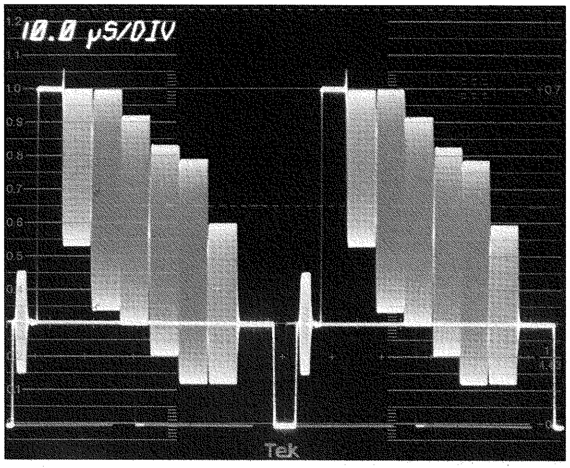


Figure 2. A waveform monitor display of Colour Bars; 2-line display.

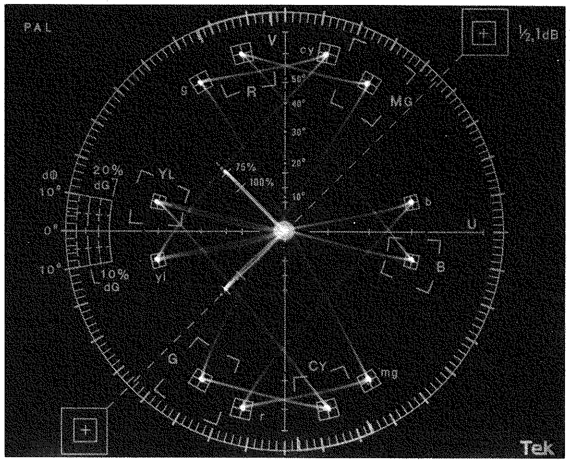


Figure 3. A vectorscope display of Colour Bars.

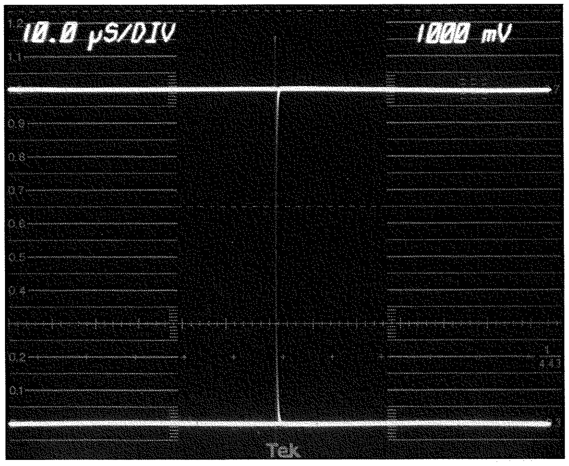


Figure 4. The 1781R waveform calibrator.

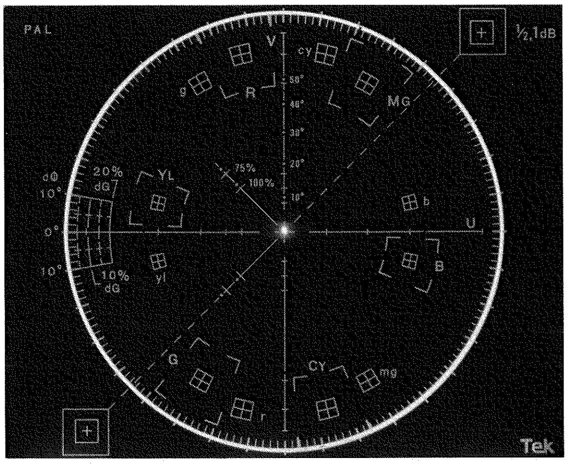


Figure 5. The 1781R vectorscope calibration oscillator.

■ CALIBRATION

Most instruments are quite stable over time, but it is good practice to verify the calibration of your waveform monitor and vectorscope prior to every measurement session. Many instruments have internally-generated calibration signals which facilitate this process. In the absence of a calibrator, or as an additional check, a test signal directly out of a high-quality generator makes a good substitute. Calibration procedures vary from instrument to instrument, so check your manual for detailed instructions.

Analogue CRT-based instruments such as the 1781R have a specified warm-up time, typically 20 or 30 minutes. Turn the instrument on and allow it to operate for at least that long before you check the calibration and begin to make measurements. Otherwise, gain drifts during the warm-up time may prevent you from getting accurate readings.

Computer-based instruments such as the VM700A also specify a warm-up time, but the operator does not need to verify or adjust the calibration settings. The VM700A will automatically calibrate itself when it is turned on, and will continue to do so periodically during operation. To ensure accurate results, wait 20 or 30 minutes before making any measurements.

■ INSTRUMENT CONFIGURATION

Most of the functions on waveform monitor and vectorscope front panels are fairly straightforward and have obvious applications in measurement procedures. A few controls, however, might need a bit more explanation.

DC Restorer

The basic function of the DC restorer in a waveform monitor is to clamp one point in the video waveform to a fixed DC level. This ensures that the display will not move vertically with changes in signal amplitude or Average Picture Level (APL).

Some instruments offer a choice of SLOW and FAST DC restorer speeds. Use the SLOW setting to measure hum or other low frequency distortions. The FAST setting removes hum from the display so it will not interfere with other measurements. BACK PORCH is the most commonly used clamp point, but SYNC TIP clamping has some applications at the transmitter.

Automatic Frequency Control (AFC) versus Direct Triggering

The AFC/DIRECT selection, which is in the 1781's CONFIGURE menu, allows you to choose between two methods of triggering the waveform monitor's horizontal sweep. The ramp which produces the horizontal sweep is always synchronous with the H (line) or V (field) pulses of the reference video, but can be started either by the pulses themselves (DIRECT) or by their average (AFC).

In the DIRECT mode, the video sync pulses directly trigger the waveform monitor's horizontal sweep. The DIRECT setting should be used when you want to remove the effects of time base jitter from the display in order to evaluate other parameters. Since a new trigger point is established for each sweep, the line-to-line jitter is not very visible in this mode.

In AFC (Automatic Frequency Control) mode, a phase-locked loop generates pulses that represent the average timing of the sync pulses. These averaged pulses are used to trigger the sweep. The AFC mode is useful for making measurements in the presence of noise, because the effects of noise-induced horizontal jitter are removed from the display.

The AFC mode is also useful for evaluating the amount of time base jitter in a signal. The leading edge of sync will appear wide (blurred) if much time base jitter is present. This method is very useful for comparing signals or for indicating the presence of jitter, but be cautious about actually trying to measure it. The bandwidth of the AFC phase-locked loop also affects the display.

Vectorscope Gain: 75%/100% Bars

Several different kinds of colour bars are used in PAL systems, and many generators produce at least two types. In order to accommodate the various types of colour bars, some vectorscopes have a 75%/100% selection on the front panel which changes the calibration of the vectorscope's chrominance gain. It is very important to know which kind of bars you are using, and to select the corresponding setting on your vectorscope. Otherwise it's easy to misadjust your chrominance gain.

The 75% setting corresponds to 100.0.75.0 Colour Bars, often referred to as EBU bars. The 100% setting corresponds to 100.0.100.0 Colour Bars. (The 75%/100% distinction refers to **chrominance amplitude**, not to saturation or white bar level.) Colour bar parameters and nomenclature are discussed in detail in Appendix A.

■ DEMODULATED RF SIGNALS

All of the baseband measurements discussed in this booklet can also be made on demodulated RF signals. It is important, however, to eliminate the demodulator itself as a possible source of distortion. With a measurement-quality demodulator such as the Tektronix 1450, you can be confident that problems are not being introduced by the demodulator. The synchronous detection mode should be used for most measurements to ensure that quadrature distortion does not affect your results.

■ TERMINATION

Improper termination is a very common source of operator error and frustration. If you put two terminators in the signal path, or leave it unterminated, the signal amplitude will be seriously affected. It is therefore essential that you terminate each video signal in your facility in **one** location, using a 75 Ohm terminator. When the signal is looped through several pieces of equipment, it is generally best to terminate at the final piece of equipment in the signal path.

The quality of the terminator is also important, particularly if you are trying to measure very small distortions. Be sure to select a terminator with the tightest practical tolerance, because incorrect termination impedance can cause amplitude errors as well as frequency response problems and pulse distortions. Terminators in the ½% to ¼% tolerance range are widely available, and are generally adequate for routine testing. For precision amplitude measurements, a 0.025% terminator (Tektronix part number 011-0102-01 or equivalent) will ensure accurate results.

■ DEFINITION OF THE PAL TELEVISION STANDARD

The most widely used definition of the PAL standard is probably Report 624 of the CCIR (International Radio Consultative Committee), which specifies amplitude, timing and colour encoding parameters for all of the major television standards. This report was last reviewed in 1986, making version 624-3 the most current at this time.

There are a number of variations of PAL (M, N, B, G, H, I, D, etc.). With the exception of PAL-M, which is a 525-line system, the differences between the standards are fairly minor at baseband and usually involve only a bandwidth change. The default standard for this publication is PAL-B/G, which has a 5-MHz bandwidth and is used in much of Europe.

Governments of the various countries which use the PAL standard, as well as broadcasting organisations (such as the EBU, BBC, IBA, etc.), also publish standards documents. You may find discrepancies between the various standards — these can be difficult to resolve since there is no absolutely ''correct'' answer. In general, documents from your local broadcasting authority should take precedence when there are conflicts.

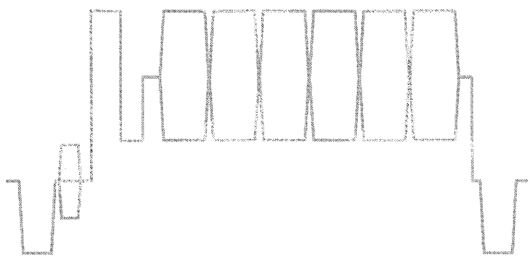
■ PERFORMANCE GOALS

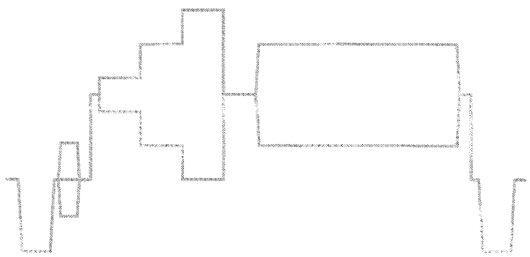
Acceptable levels of distortion are usually determined subjectively, but a number of broadcasting organisations publish documents which provide recommended limits. These documents can be very useful as performance guidelines, and in some cases government regulations may require that certain published criteria be met. However, each facility ultimately needs to determine its own performance goals. Only experience can tell you what is practical with the equipment and personnel at your own facility.

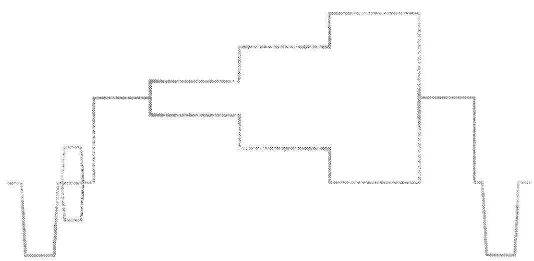
While there is usually agreement about the nature of each distortion, definitions for expressing the magnitude of the distortion may vary considerably from standard to standard. A number of questions should be kept in mind. Is the measurement absolute or relative? If it is relative, what is the reference? Under what conditions is the reference established? Is the peak-to-peak variation or the largest peak deviation to be quoted as the amount of distortion?

A misunderstanding about one of these issues can seriously affect your measurement results, so it is important to become familiar with the definitions in whatever standards you use. Make sure everyone involved in measuring your system agrees on how to express the amount of distortion. It is good practice to record this information along with measurement results.

Waveform Distortions & Measurement Methods







I. VIDEO AMPLITUDE & TIME MEASUREMENTS

This section deals with two fundamental properties of the signal: amplitude and time. In these two dimensions, problems are more frequently caused by operator error than by malfunctioning equipment. Correction of amplitude and pulse width problems often simply involves proper adjustment of the equipment the signal passes through.

Two kinds of amplitude measurements are important in television systems. Absolute levels, such as peak-to-peak amplitude, need to be properly adjusted. The relationships between the parts of the signal are also important. The ratio of sync to the rest of the signal, for example, must be accurately maintained.

When setting video amplitudes, it is not sufficient to simply adjust the output level of the final piece of equipment in the signal path. Every piece of equipment should be adjusted to appropriately transfer the signal from input to output, since television equipment is generally not designed to handle signals which deviate much from the nominal 1-volt peak-to-peak amplitude. Signals which are too large can be clipped or distorted, and signals which are too small will suffer from degraded signal-to-noise performance.

Video amplitudes are monitored and adjusted on a daily basis in most television facilities, but sync pulse widths tend to be checked less often. It is still important, however, to understand time measurement methods. You should periodically verify that all pulse widths and rise times are within the recommended limits, and adjust them if necessary.

This booklet does not address system timing issues, which deal with relative time relationships between the many signals in a television facility. Although system timing is critical to production quality, it is outside the scope of this publication. On the following pages, only those timing measurements which relate to a single signal are addressed.

■ DEFINITION

PAL composite video signals are nominally 1 volt peak-to-peak. Amplitude measurement techniques are used to verify that the signals conform to this nominal value, and to make the appropriate gain adjustments if they do not. Similar methods of evaluating the waveform are used for both measurement and adjustment of signal levels.

Measurements of the peak-to-peak amplitude of the video signal are sometimes called ''insertion gain'' measurements.

■ PICTURE EFFECTS

Insertion gain errors cause the picture to appear too light or too dark. Because of the effects of ambient light, apparent colour saturation is also affected.

■ TEST SIGNAL

Insertion gain can be measured with any signal that contains a 700 mV white portion. Colour Bars and Pulse & Bar signals are most frequently used. (See Figures 6 and 7.) Many of the standard ITS signals also contain a 700 mV bar, and can be used to measure or adjust video gain.

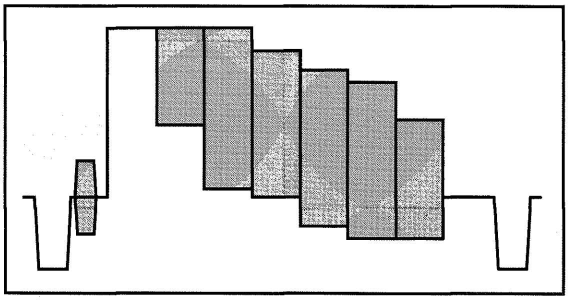


Figure 6. 100.0.75.0 Colour Bars.

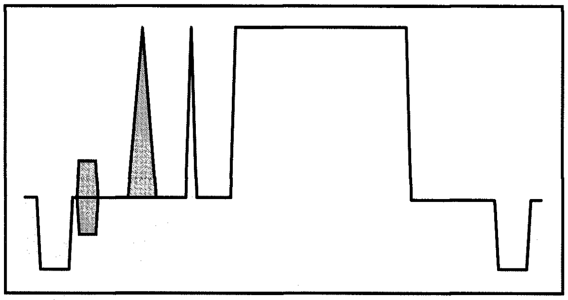


Figure 7. Pulse & Bar test signal.

■ MEASUREMENT METHODS

Waveform Monitor Graticule

Signal amplitude can be measured with a waveform monitor by comparing the waveform to the vertical scale on the graticule. With the waveform monitor vertical gain in the calibrated setting (1 volt full scale), the signal should be 1 volt from sync tip to peak white, as shown in Figure 8. The graticule in the VM700A WAVEFORM mode can be used in a similar manner.

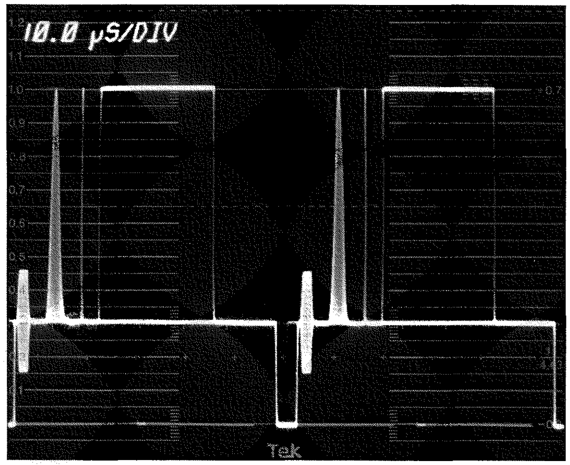


Figure 8. A 1-volt signal properly positioned with respect to the 1781R graticule.

Added Calibrator Method

Some waveform monitors have a feature which allows the internal calibrator signal to be used as a reference for amplitude measurements. This feature is known as WFM + CAL in the 1781R. In the 1481 it is accessed by depressing both the CAL button and the OPER button.

The WFM + CAL display consists of two video traces vertically offset by the calibrator amplitude. This display is obtained by adding the incoming signal to a calibrated square wave of known amplitude. Signal amplitude is equal to the calibrator amplitude when the bottom of the upper trace and the top of the lower trace coincide.

The WFM + CAL mode is most commonly used to set insertion gain, which requires a 1-volt calibrator signal. If you are using a 1781R, select a calibrator amplitude of 1000 mV. In the 1481R, the DC RESTORER setting determines which of two calibrator amplitudes is currently selected. The calibrator amplitude is 1 volt when SYNC TIP is selected, and 700 mV when BACK PORCH is selected.

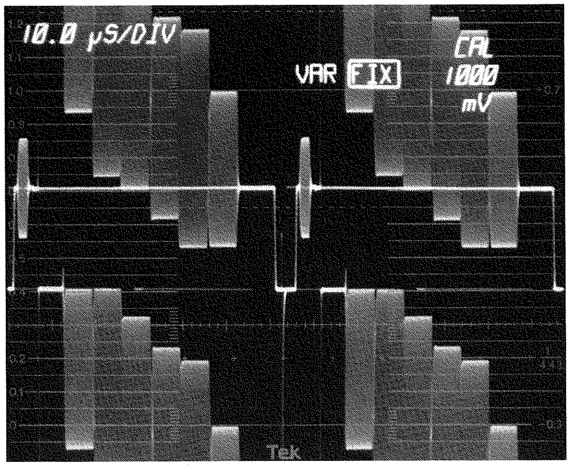


Figure 9. The WFM + CAL mode in the 1781R indicates that insertion gain is properly adjusted.

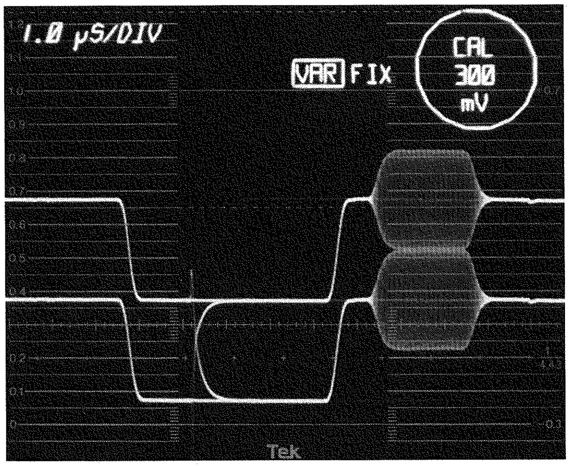


Figure 10. The WFM + CAL mode can also be used to measure sync amplitude.

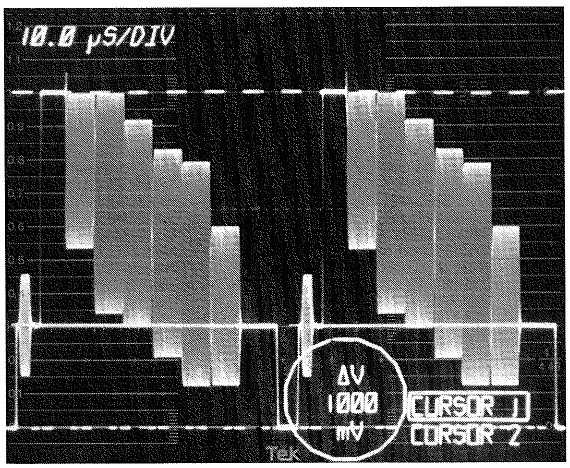


Figure 11. 1781R voltage cursors positioned to measure peak-to-peak amplitude.

Once you have obtained a 1-volt calibrator signal, set insertion gain by externally adjusting the signal amplitude until sync tip of the upper trace and peak white of the lower trace coincide. Figure 9 shows a properly adjusted signal. Since the waveform monitor vertical gain need not be calibrated in this mode, the gain can be increased for greater resolution.

The 1781R has a variable-amplitude calibrator, so the WFM + CAL mode can be used to measure signal amplitudes other than 1 volt. Measurements are made by adjusting the calibrator amplitude with the large front panel knob until the bottom of the upper trace and the top of the lower trace coincide. At this point the calibrator amplitude (which now equals the signal amplitude) can be read from the screen. The example in Figure 10 shows the WFM + CAL mode being used to measure sync amplitude.

Voltage Cursors (1781R)

Some waveform monitors, such as the 1781R, are equipped with on-screen voltage cursors for making accurate amplitude measurements. Peak-to-peak amplitude can be measured by positioning one cursor on sync tip and the other on peak white, as shown in Figure 11. The waveform monitor vertical gain control in the 1781R affects the cursors and the waveform in the same way, so vertical gain can be increased to allow for more accurate positioning of the cursors.

When setting insertion gain, it may be convenient to first set the cursor separation for 1000 mV. You can then externally adjust the signal amplitude until it reaches the cursors.

Cursors (VM700A)

Manual amplitude measurements can be made with the VM700A by selecting CURSORS in the WAVEFORM mode. The horizontal baseline in the middle of the screen is used as a reference. To measure peak-to-peak amplitude, first position sync tip on the baseline. Touch the RESET DIFFS selection on the screen to reset the voltage difference to zero. Now move the waveform down until the white bar is on the baseline, and read the voltage difference from the screen.

■ NOTES

1. Sync to Picture Ratio

If the signal amplitude is wrong, it is a good idea to verify that the problem is really a simple gain error rather than a distortion. This can be accomplished by checking the ratio of sync to the picture signal (the part of the signal above blanking), which should be 3:7. If the ratio is correct, go ahead and adjust the gain. If it is not, there could be a problem somewhere that demands further investigation. The signal could be suffering from a distortion, or a piece of equipment which re-inserts sync and burst may not be functioning properly.

2. Sync & Burst Measurements

Sync and burst should each measure 30% of the composite video amplitude (300 millivolts for a 1-volt signal). Most of the methods discussed in this section can be used to measure sync and burst amplitudes. If you are using the 1781R voltage cursors, the TRACK mode is a convenient tool for comparing sync and burst amplitudes. In this mode, the separation between the two cursors remains fixed and they can be moved together with respect to the waveform.

3. Measurement Accuracy

In general, the added calibrator and voltage cursor methods are more accurate than the graticule technique. However, some cursor implementations have far more resolution than accuracy, creating an impression of measurements more precise than they really are. Familiarity with the specifications of your waveform monitor and an understanding of the accuracy and resolution available in the various modes will allow you to make an appropriate choice.

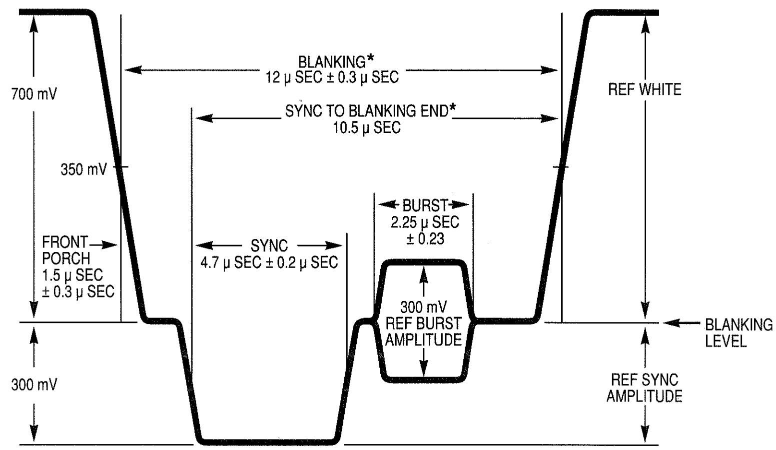
4. Using the Luminance Filter

It may be useful to enable the LUMINANCE or LOWPASS filter on your waveform monitor if you must set insertion gain with a live signal rather than a test signal with a white bar. These filters remove the chrominance information, allowing easier use of the luminance levels for setting gain.

■ DEFINITION

Horizontal and vertical synchronisation pulse widths are measured in order to verify that they fall within the limits specified in a standard or required by a broadcasting authority. These parameters can be adjusted in some types of equipment to bring them within the specified limits. Other synchronisation parameters such as rise times, fall times, and the position and number of cycles in burst are also specified, and should occasionally be measured to verify that they are correct.

CCIR Report 624 is a widely accepted standard for PAL timing values and tolerances. The CCIR timing information for PAL systems is reproduced in Figure 12.



* NOTE: BLANKING INTERVALS ARE MEASURED BETWEEN THE HALF AMPLITUDE POINTS OF APPROPRIATE ACTIVE AREA TRANSITIONS, WHICH MAY NOT ALWAYS BE 700 mV.

Figure 12. CCIR horizontal pulse width requirements.

■ PICTURE EFFECTS

Small errors in pulse widths will not affect picture quality. If the errors become so large that the pulses cannot be properly processed by equipment, picture breakup may occur.

■ TEST SIGNAL

Pulse width measurements can be made on any composite signal which contains horizontal, vertical and subcarrier (burst) synchronisation information.

■ MEASUREMENT METHODS

Waveform Monitor Graticule

Time intervals can be measured by comparing the waveform to the marks along the horizontal baseline of a waveform monitor graticule. In order to get adequate resolution, it is usually necessary to magnify the waveform display horizontally: select the setting that provides as much magnification as possible while still keeping the interval of interest entirely on-screen. The scale factor, typically microseconds per major division, changes with horizontal magnification. The 1781R displays the microseconds per division setting on the screen; for the 1481 it is obtained from the switch setting.

Most PAL pulse width measurements are specified between the 50% points of the rising and falling edges. Such measurements can usually be made with the vertical gain in the calibrated position. To measure horizontal sync width, for example, position the waveform so that the sync pulse is centred around the graticule baseline (blanking level at 150 mV above the baseline and sync tip at 150 mV below the baseline). The time scale is now at the 50% level, and the pulse width can be read directly from it as shown in Figure 13.

Time Cursors (1781R)

Some waveform monitors and oscilloscopes are equipped with cursors to facilitate the measurement of time intervals. The time cursors in the 1781R appear as bright dots on the waveform, an implementation which allows for very accurate positioning on waveform transitions.

To make a pulse width measurement, position the cursors on the 50% points of the transitions, and read the cursor separation directly from the screen. An example of a horizontal sync width measurement is shown in Figure 14. If necessary, use the vertical graticule scale to help locate the 50% points. Alternatively, the voltage cursors in the RELATIVE mode can be used to locate the 50% points.

Cursors (VM700A)

The cursors in the VM700A WAVEFORM mode can be used to make pulse width measurements. After establishing the 100% and 0% points of sync, the cursors can be moved to the 50% point to obtain a time measurement, as shown in Figure 15. Consult your manual for detailed instructions on how to use the cursors.

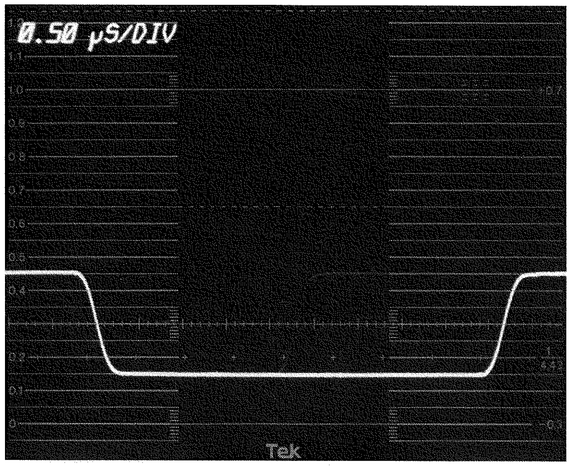


Figure 13. Horizontal sync width measurement at the 50% amplitude points.

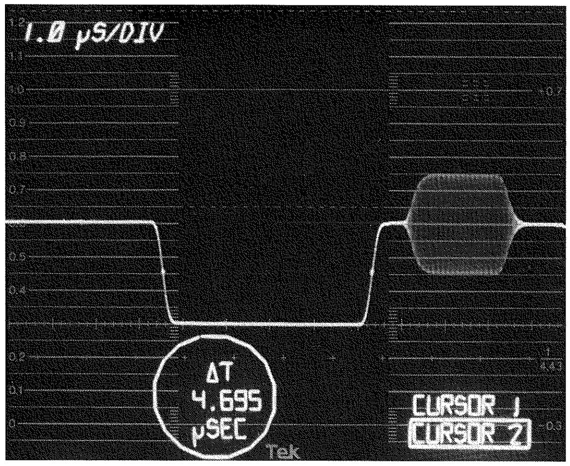


Figure 14. The 1781R time cursors positioned to measure horizontal sync width at the 50% amplitude points.

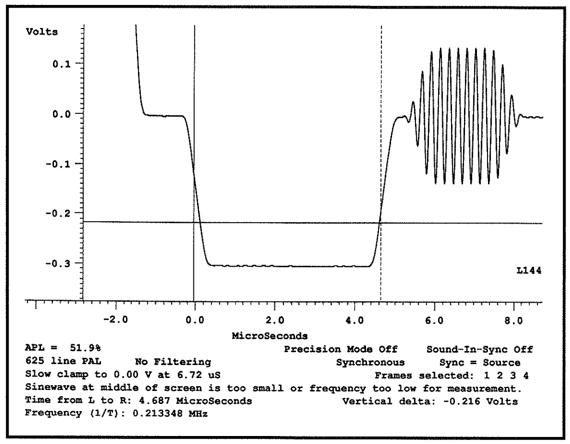


Figure 15. The VM700A cursors can be used to make horizontal sync width measurements.

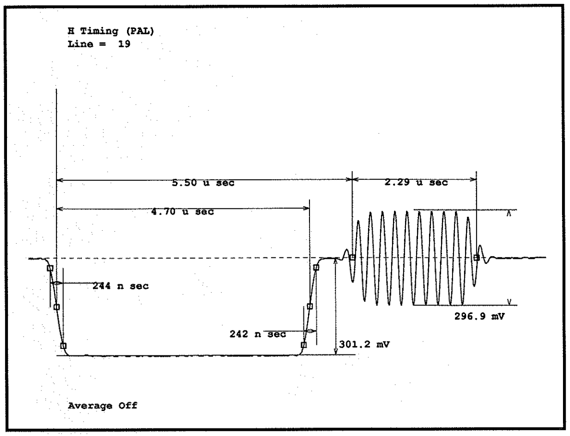


Figure 16. The H Timing selection in the VM700A MEASURE mode.

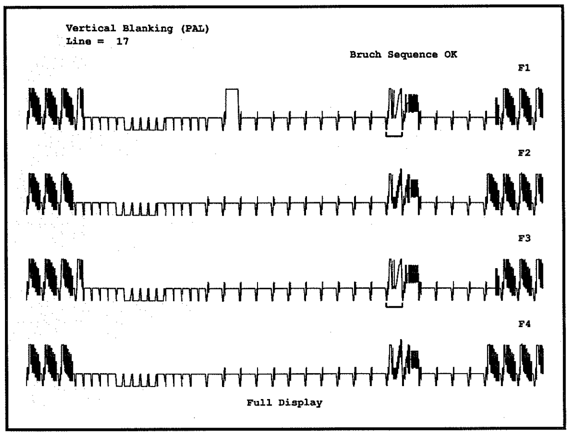


Figure 17. The VM700A V Blank display.

VM700A Automatic Measurement

The **H Timing** selection in the VM700A MEASURE menu displays all of the horizontal blanking interval timing measurements, as shown in Figure 16. The AUTO mode also provides measurements of the individual parameters.

■ NOTES

5. Rise and Fall Time Measurements

Many standards include specifications for the rise time and fall time of the sync pulse, also sometimes referred to as the build-up time. These measurements are indicators of how fast the transitions occur. They are typically made between the 10% and 90% points of the signal.

The methods used for measuring pulse widths can generally be applied to rise and fall times. However, for 10%-to-90% measurements it is generally most convenient to use the waveform monitor's variable gain control to normalise the pulse height to 500 or 1000 mV. The 10% and 90% points can then easily be located with the graticule. The 1781R's voltage cursors in the RELATIVE mode can also be used to locate the appropriate levels.

6. Checking the Vertical Interval

The number of pulses in the vertical interval, as well as the widths of the equalising pulses and vertical serrations, are also specified. CCIR nominal values and tolerances are shown in Figure 18.

It is a good idea to occasionally verify that all of these parameters are correct. The **V Blank** selection in the VM700A's MEASURE mode provides a convenient means of checking the format of the vertical interval and the timing of the individual pulses. This display is shown in Figure 17.

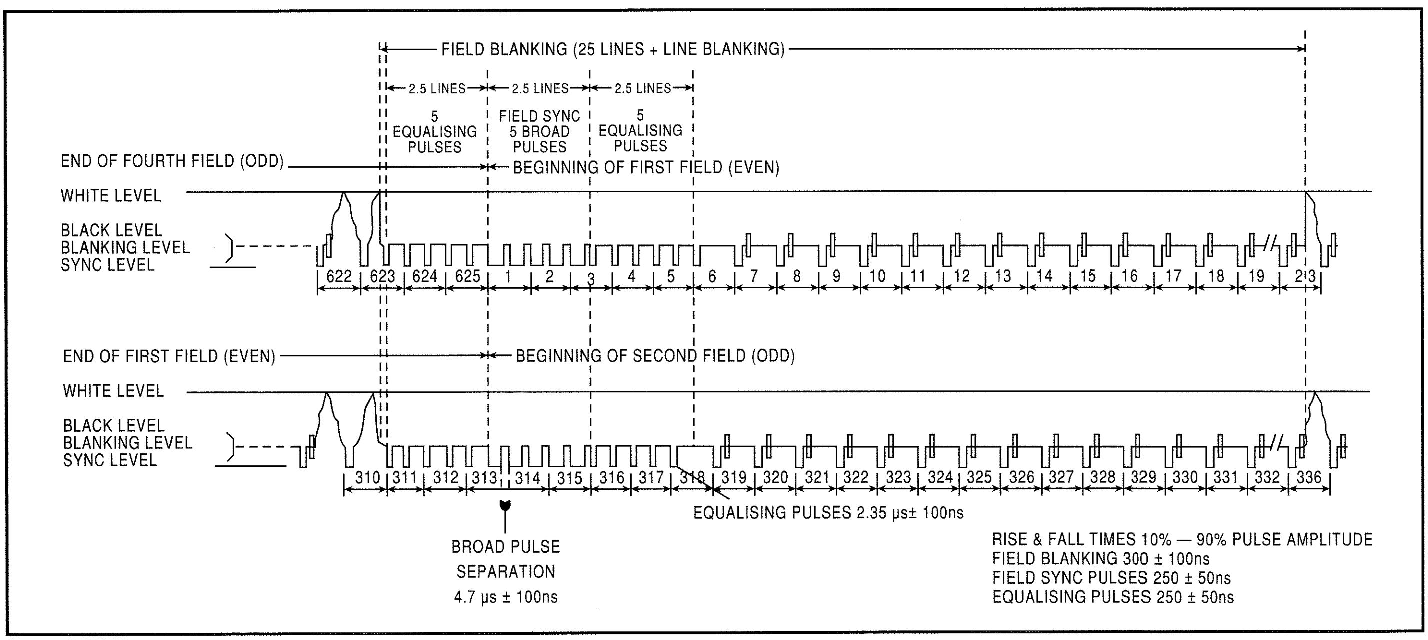


Figure 18. CCIR vertical interval specifications.

■ DEFINITION

SCH (SubCarrier to Horizontal) Phase refers to the timing relationship between the 50% point of the leading edge of sync and the zero crossings of the reference subcarrier. Errors are expressed as degrees of subcarrier phase. The official EBU definition, taken from EBU Technical Statement D 23-1984 (E), is as follows: "The subcarrier-to-line sync (Sc-H) phase is defined as the phase of the $+E'_U$ component of the colour burst extrapolated to the half-amplitude point of the leading edge of the synchronising pulse of line 1 of field 1."

Since there is no burst on line 1, measurement of SCH phase on line 7 of field 1 has become the generally accepted convention. Target tolerances of ±20 degrees have been established, although in practice much tighter tolerances are generally maintained. Modern facilities often try to ensure that SCH phase errors do not exceed a few degrees.

■ PICTURE EFFECTS

SCH phase becomes important only when television signals from two or more sources are combined or sequentially switched. In order to ensure that horizontal jumps do not occur when a switch is made, the sync edges of the two signals must be accurately timed **and** the phases of burst must be matched. Since both sync and subcarrier are continuous signals with a fixed relationship to one another, it is possible to simultaneously achieve both timing conditions only if the two signals have the same SCH phase relationship.

Because of the complex relationship between the sync and subcarrier frequencies, an eight-field sequence exists for PAL signals — the exact SCH phase relationship for a given line repeats itself only once every eight fields (see Note 7). In order to achieve the sync and burst timing conditions required for a clean switch between two signals, the eight-field sequences of the signals must be properly lined up (i.e. Field 1 of Signal A and Field 1 of Signal B must occur at the same time). When this condition is achieved, the two signals are said to be "colour framed". It is important to remember that colour framing is inextricably tied to your other system timing parameters — it is by no means an independent variable. Only if your two signals have the same SCH phase relationship and are properly colour framed can the sync timing and burst phase matching conditions be achieved.

Since signals must have the same SCH phase relationship in order to be cleanly combined, standardisation on one value of SCH phase will clearly facilitate the transfer of programme material. This is one reason for trying to maintain 0 degrees of SCH phase error. Another motivation for keeping SCH phase within reasonable limits is that various pieces of equipment need to be able to distinguish between the colour frames in order to process the signal properly. This cannot be done accurately if the SCH phase is allowed to approach 90 degrees.

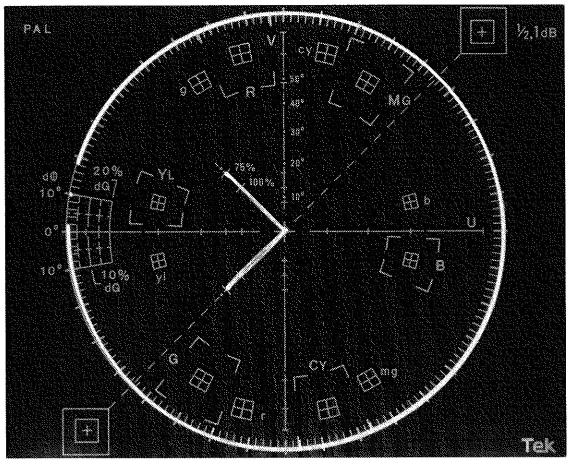


Figure 19. The 1781R's polar SCH phase display, showing a 10 degree error.

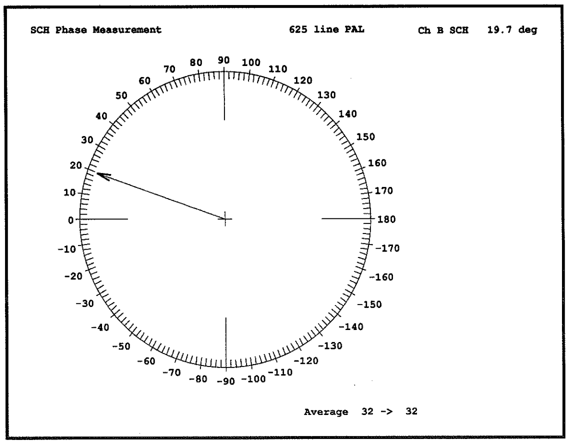


Figure 20. The VM700A SCH Phase display.

■ TEST SIGNALS

SCH phase measurements can be made on any signal with both sync and burst.

■ MEASUREMENT METHODS

Polar Display

Some instruments, such as the 1781R, are equipped with a polar SCH display which consists of the two burst vectors and a dot representing the phase of sync. The dot is in the centre of a ''window'' in the large circle which appears as part of the display, as shown in Figure 19. This circle is a result of the 25 Hertz offset (see Note 7), which changes the SCH phase from line to line — the circle contains no relevant information.

The SCH phase is 0 degrees when the dot is at an angle midway between the two bursts. If there is an SCH phase error, its magnitude can be determined by measuring the angle between the sync dot and the midway point of the two bursts. The graticule can be used for this purpose when the bursts are properly positioned on their +135° and −135° points. The precision phase shifter in the 1781R can also be used to quantify the error.

The instrument must be **internally** referenced to measure the SCH phase of a single signal. Sync and burst of the selected signal are compared to each other in this mode. When external reference is selected, both burst and sync of the selected signal are displayed relative to burst of the external reference signal. This display allows you to determine whether or not two signals are colour framed. Assuming that both the reference signal and the selected signal have no SCH phase error, the sync dot will be between the burst vectors if the signals are colour framed, and 180° away when they are not.

VM700A Automatic Measurement

Select **SCH Phase** in the VM700A MEASURE menu to obtain a polar display of SCH phase. As shown in Figure 20, the vector in this display directly represents SCH phase; there are not separate vector representations of sync and burst. The dual SCH display allows you to simultaneously view the SCH vectors for two signals. You can also select Full Field from the menu to obtain a field-rate display which plots the SCH phase of each line in the field.

■ NOTES

7. The PAL Eight-Field Sequence

The eight-field sequence exists in PAL because of the relationships between the line, field and subcarrier frequencies. Remember that subcarrier and H sync can be thought of as two continuous signals with a fixed relationship to one another. This relationship is defined mathematically as:

$$F_{sc} = (1135/4 \times F_h) + 25$$

which yields a subcarrier frequency (F_{sc}) of 4,433,618.75 Hz for a line frequency (F_h) of 15,625 Hz. We can see from the equation that there are an odd number of subcarrier quarter-cycles in a line, which implies that SCH phase changes by 90 degrees every line. Since there are also an odd number of lines in a frame, the exact phase relationship between sync and burst for a given line repeats itself only every eight fields (four frames).

Due to the 25 Hz offset which is added to interleave chrominance dot patterns in the picture, the line-to-line change in SCH phase is actually somewhat more than 90 degrees. Keep this in mind when you're making measurements — this is why SCH phase is defined on a given line in PAL. It is important to remember, however, that the existence of the eight-field sequence is determined only by the sync-to-subcarrier relationship and is **independent** of the 25 Hertz offset, the Bruch blanking sequence, and the alternate-line V-axis inversion.

8. For More Information

For a comprehensive discussion of SCH phase and colour framing issues, see Tektronix Application Note #37 (20W-5614), *Measuring and Monitoring SCH Phase with the 1751 Waveform/Vector Monitor.*

II. LINEAR DISTORTIONS

Waveform distortions which are **independent** of signal amplitude are referred to as linear distortions. These distortions occur as a result of a system's inability to uniformly transfer amplitude and phase characteristics at all frequencies.

When fast signal components such as transitions and high-frequency chrominance are affected differently than slower line-rate or field-rate information, linear distortions are probably present. These distortions are most commonly caused by imperfect transfer characteristics in the equipment in the signal path. However, linear distortions can also be externally introduced. Signals such as power line hum can couple into the video signal and manifest themselves as distortions.

One method of classifying linear distortions involves grouping them according to the duration of the signal components which are affected by the distortion. Four categories, each of which corresponds to a familiar television time interval, have been identified. (The range of time intervals for each category may vary somewhat from definition to definition.) These categories are:

SHORT TIME (100 nanoseconds to 1 microsecond)
LINE TIME (1 microsecond to 64 microseconds)
FIELD TIME (64 microseconds to 20 milliseconds)
LONG TIME (greater than 20 milliseconds)

This classification is convenient because it allows you to easily correlate the distortions with what you see in the picture or in a waveform display. A single measurement for each category takes into account both amplitude and phase distortions within that time range.

While the combination of these four categories covers the entire video spectrum, it is also useful to have methods of simultaneously evaluating response at all frequencies of interest. **Frequency response** measurements look at the system's amplitude versus frequency characteristics, and **group delay** measurements examine the phase versus frequency characteristics. Unlike the measurements classified by time interval, frequency response and group delay measurements enable you to separate amplitude distortions from delay distortions.

In addition to all of these measurements, there is one specific case that needs to be examined in detail. The phase and amplitude relationships between the chrominance and luminance information in a signal are critical. Chrominance-to-luminance gain and delay are therefore measured in order to quantify the system's ability to process chrominance and luminance in correct proportion and without relative time delays.

Sine-squared pulses and rise times are used extensively in the measurement of linear waveform distortions. You may find it helpful to review the information in Appendix B, which discusses the use of sine-squared pulses in television testing.

Chrominance-to-Luminance Gain & Delay Inequalities

■ DEFINITION

Chrominance-to-luminance gain inequality (relative chrominance level) is the difference between the gain of the chrominance components and the gain of the luminance components as they pass through a system. The difference is expressed in percent or dB, and the number is negative for low chrominance and positive for high chrominance.

Chrominance-to-luminance delay inequality (relative chrominance time) is the difference between the time it takes for the chrominance portion of the signal to pass through a system and the time it takes for the luminance portion to pass through. The amount of distortion is expressed in units of time, typically nanoseconds. The number is positive for delayed chrominance and negative for advanced chrominance.

■ PICTURE EFFECTS

Gain errors most commonly appear as attenuation or peaking of the chrominance information, which shows up in the picture as incorrect colour saturation.

Delay distortion will cause colour smearing or bleeding, particularly at the edges of objects in the picture. It may also cause poor reproduction of sharp luminance transitions.

■ TEST SIGNALS

Chrominance-to-luminance gain and delay inequalities are measured with a 10T or 20T modulated sine-squared pulse, sometimes called a composite pulse. Many combination ITS signals include such a pulse.

The frequency spectrum of a composite pulse includes energy at low frequencies and energy centred around the subcarrier frequency. Selection of an appropriate pulse width is a tradeoff between occupying the PAL chrominance bandwidth as fully as possible, and obtaining a pulse with sufficient sensitivity to delay errors. (The 10T pulse is more sensitive to delay errors than the 20T pulse, but does not occupy as much of the chrominance bandwidth.) CCIR specifications generally recommend the use of 20T pulses, while 10T pulses are commonly used in the U.K.

A modulated bar is also sometimes used to measure chrominance-to-luminance gain inequalities.

■ MEASUREMENT METHODS

Conventional chrominance-to-luminance gain and delay measurements are based on analysis of the baseline of a modulated sine-squared pulse. (See Appendix B for a definition of the time interval T.) This pulse is made up of a sine-squared luminance pulse and a chrominance packet with a sine-squared envelope, as shown in Figure 22.

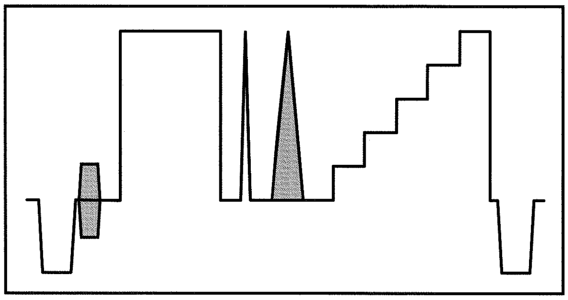


Figure 21. A combination signal which includes a 20T modulated pulse (CCIR Line 17).

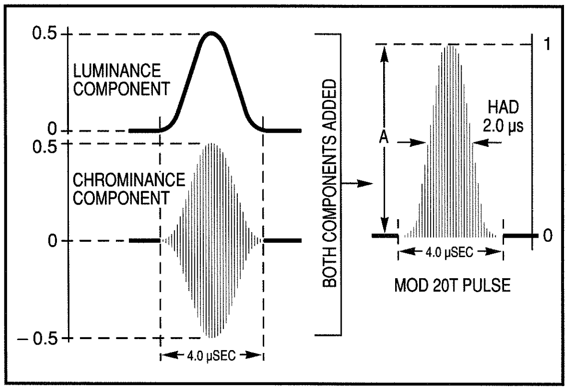


Figure 22. The chrominance and luminance components of a modulated sine-squared pulse.

Modulated sine-squared pulses offer several advantages. First of all, they allow you to evaluate both gain and delay differences with a single signal. A further advantage is that modulated sine-squared pulses eliminate the need to separately establish a low-frequency amplitude reference with a white bar. Since a low-frequency reference pulse is present along with the high-frequency information, the amplitude of the pulse itself can be normalised.

The baseline of the modulated pulse is flat if no chrominance-to-luminance gain or delay errors exist. Various types of gain and delay distortion affect the baseline in different ways. A single peak in the baseline indicates the presence of gain errors only, and symmetrical positive and negative peaks indicate the presence of delay errors only. When both types of errors are present, the positive and negative peaks will have different amplitudes and the zero crossing will not be at the centre of the pulse. Figure 23 shows the effects of various types of distortion.

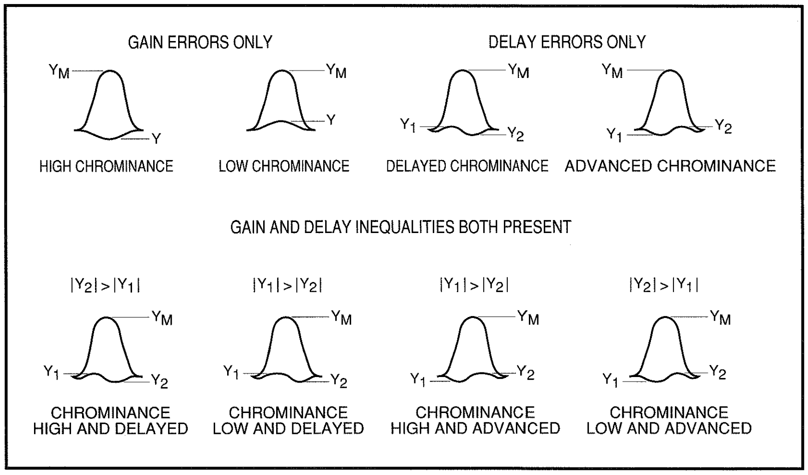


Figure 23. Effects of gain and delay inequalities on the modulated sine-squared pulse.

Waveform Monitor & Nomograph

One method of quantifying chrominance-to-luminance inequalities involves measuring the peaks of the modulated pulse's baseline distortion and applying these numbers to a nomograph. The nomograph converts the baseline measurements into gain and delay numbers.

To make a measurement, first normalise the pulse height to 100% (500 mV or 1000 mV is generally most convenient). The baseline distortion can be measured either by comparing the waveform to a graticule or by using voltage cursors. Using a nomograph such as the one shown in Figure 24, find the locations on the horizontal and vertical axes which correspond to the two measured distortion peaks. At the point in the nomograph where perpendicular lines drawn from those two points intersect, the gain and delay numbers can be obtained.

Chrominance-to-Luminance Gain & Delay Inequalities

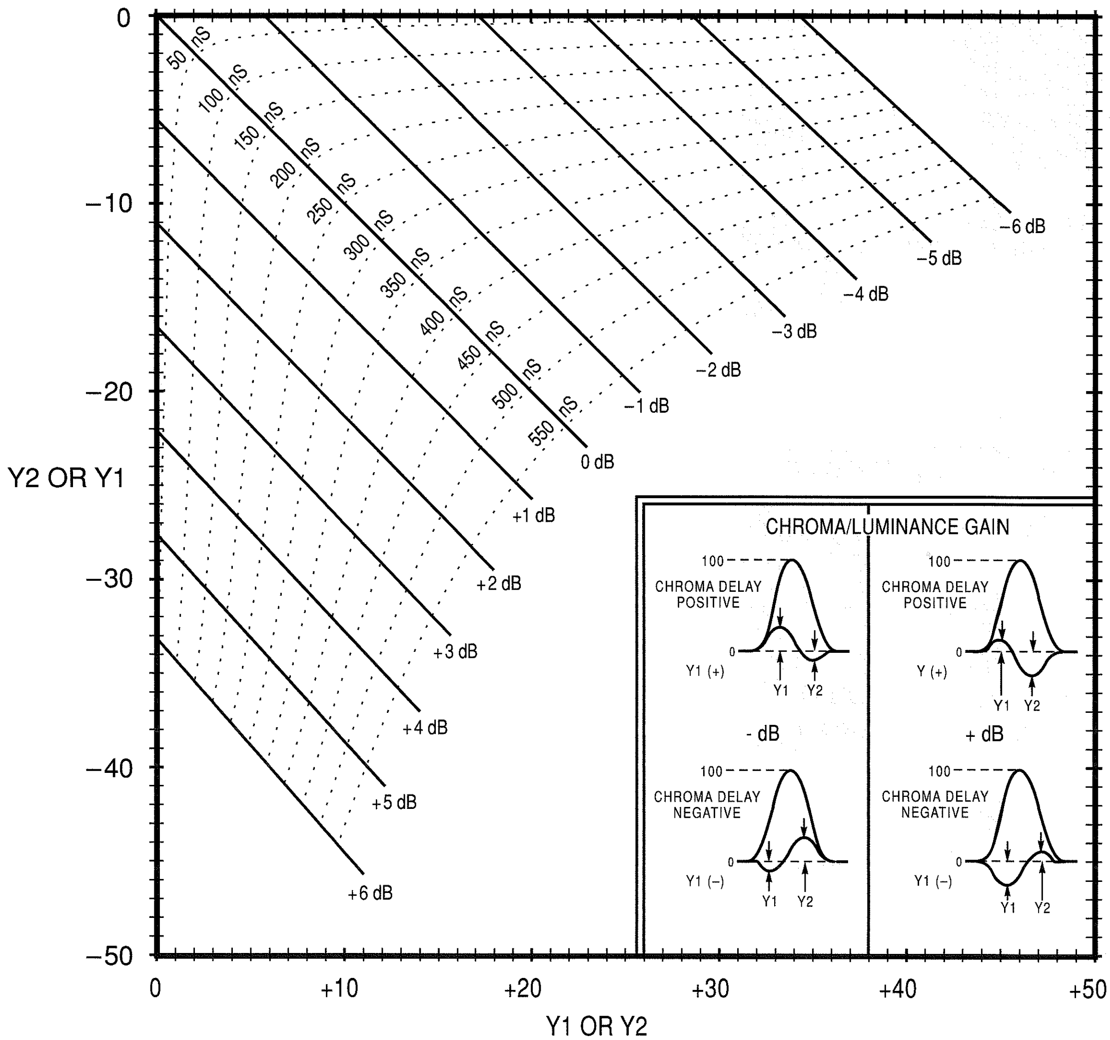


Figure 24. Chrominance-to-luminance gain and delay nomograph for a 20T pulse.

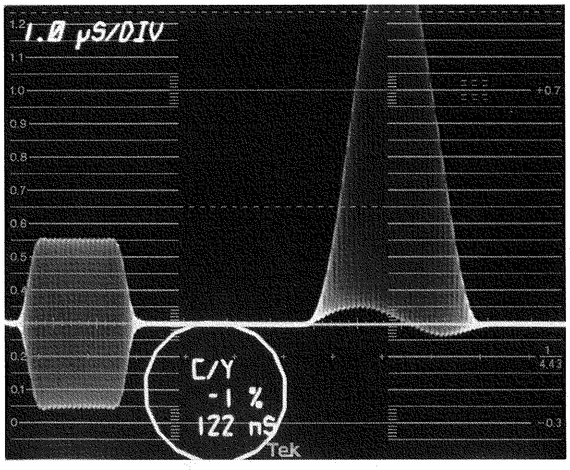


Figure 25. Results obtained with the CHROMA/LUMA selection in the 1781R's MEASURE mode.

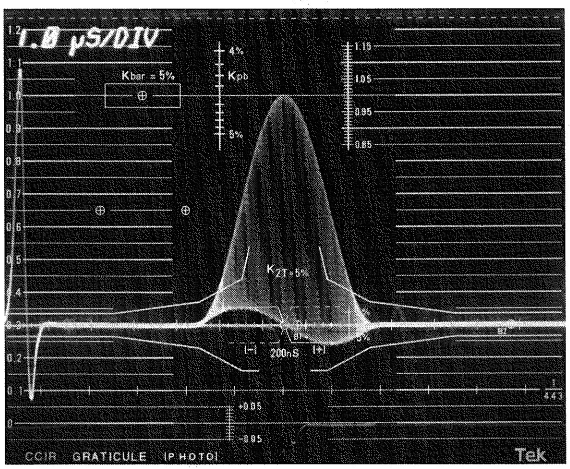


Figure 26. The 1781R graticule indicates that this signal has approximately 200 nanoseconds of chrominance-to-luminance delay.

When making measurements in this manner, it is important to know whether your signal contains a 10T or a 20T pulse. The same nomograph can be used for both, but a correction factor must be applied. The nomograph on the following page is for 20T pulses; divide the delay result by two if you are working with 10T pulses.

1781R Semi-Automatic Procedure

The CHROMA/LUMA selection in the 1781R MEASURE menu eliminates the need for a nomograph. The on-screen readout guides the user through cursor measurements of the various parameters required to obtain a number from a nomograph. After all of the parameters have been entered, the instrument calculates the results. See Figure 25. The accuracy and resolution of this method are roughly equivalent to using the graticule and a nomograph.

Waveform Monitor Graticule Approximations

When there are no non-linearities in the system and delay distortion is within certain limits, chrominance-to-luminance gain inequalities can be measured directly by comparing the height of the modulated pulse to the white bar. This method and the nomograph will yield identical results when there is no delay distortion. It is generally considered a valid approximation for signals with delay distortion in the 100 to 200 nanosecond range, and is accurate to within a few percent for signals with several hundred nanoseconds of delay.

This measurement is made by normalising the white bar amplitude to 100%, and then measuring the amplitude difference between the 10T or 20T pulse top and the white bar. This difference number, **times two**, is the amount of chrominance-to-luminance gain distortion in percent. (Note that when the pulse top is higher or lower than the bar, the bottom of the pulse is displaced from the baseline by the same amount. Thus the peak-to-peak difference between the modulated pulse and the bar is actually twice the difference between their peak values — hence the factor of two.)

The lines at the center of the baseline on the 1781R/1481 external graticule can be used to estimate chrominance-to-luminance delay errors. This method yields valid results only if gain errors are negligible — the baseline distortion should appear symmetrical. To use these graticule marks, first use the variable gain to normalise the modulated pulse height to 100%. Then centre the pulse on the two graticule lines which cross in the centre of the baseline, as shown in Figure 26. The graticule lines indicate 200 nanoseconds of delay for a 20T pulse, and 100 nanoseconds for a 10T pulse. If you select X5 vertical gain in addition to the variable gain required to normalise the pulse, the lines indicate 40 nanoseconds of delay for the 20T pulse and 20 nanoseconds for the 10T pulse.

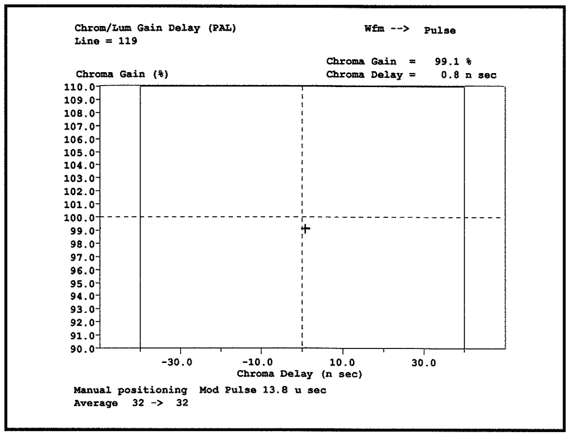


Figure 27. The ChromLum GainDelay display in the VM700A MEASURE mode.

VM700A Automatic Measurement

Chrominance-to-luminance gain and delay errors can be measured by selecting **ChromLum GainDelay** in the VM700A MEASURE mode. Numeric results are given in this mode, and both parameters are simultaneously plotted on the graph. As shown in Figure 27, delay is plotted on the X axis and gain inequality is plotted on the Y axis. These measurements are also available in the VM700A AUTO mode.

Calibrated Delay Fixture

Another method of measuring these distortions involves use of a calibrated delay fixture. The fixture allows you to incrementally adjust the delay until there is only one peak in the baseline, indicating that all delay errors have been nulled out. The delay value can then be read from the fixture, and gain measured from the graticule. This method can be highly accurate, but requires the use of specialised equipment.

■ NOTES

9. Harmonic Distortion

If harmonic distortion is present, there may be multiple aberrations in the baseline rather than one or two clearly distinguishable peaks. In this case, nomograph measurement techniques are indeterminate. The VM700A, however, is capable of removing the effects of harmonic distortion and will yield valid results in this case. Minor discrepancies between the results of the two methods may be attributable to the presence of small amounts of harmonic distortion, as well as to the higher inherent resolution of the VM700A method.

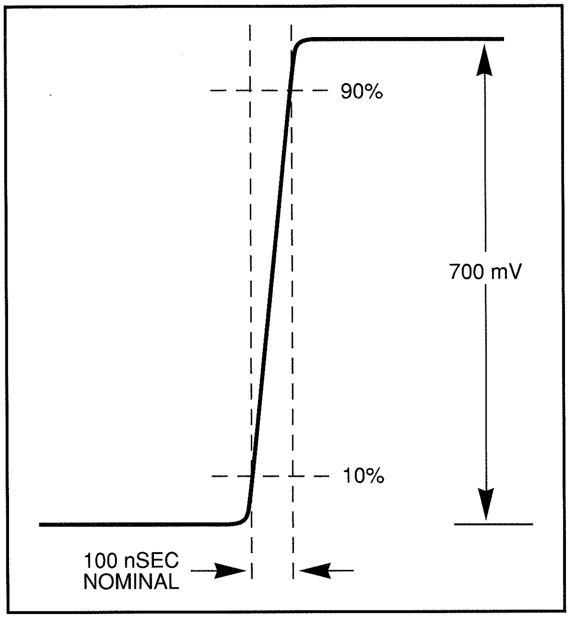


Figure 28. A T rise time bar has a 10% to 90% rise time of nominally 100 nanoseconds.

■ DEFINITION

Short time distortions cause amplitude changes, ringing, overshoot and undershoot in fast rise times and 2T pulses. The affected signal components range in duration from 0.100 microsecond to 1.0 microsecond.

For PAL systems, distortions in the short time domain are most often characterised by measuring K_{2T} or $K_{pulse/bar}$. These measurements are described in the K Factor section of this booklet (page 44). Alternatively, the aberrations in a T rise time bar can be described in terms of the ''percent SD'' method described in this section.

■ PICTURE EFFECTS

Short time distortions produce fuzzy vertical edges. Ringing can sometimes be interpreted as chrominance information (cross colour), causing colour artifacts near vertical edges.

■ TEST SIGNALS

2T pulses are generally specified when K Factor and pulse-to-bar methods are used to characterise short time distortion. In order to use the ''percent SD'' method, however, a signal with a T rise time white bar is required. As shown in Figure 28, a T rise time bar has a 10%-to-90% rise time of nominally 100 nanoseconds. (See Appendix B for a discussion of the time interval T.)

It is very important to make sure you are using a T rise time bar with the short time distortion graticule. Many common test signals have 2T rather that T rise times, and 2T bars are not suitable for this measurement. It should also be noted that T rise times cannot survive transmission, because they contain fast components which do not pass through the 5 or 6 MHz lowpass filter. Short time distortion measurements made on transmitted signals will therefore evaluate only those components in approximately the 200 nanosecond to 1 microsecond range.

■ MEASUREMENT METHODS

Measurements of the undershoot, overshoot and ringing at the edge of a T rise bar are not generally quoted directly as a percent of the transition amplitude, but rather are expressed in terms of an amplitude-weighting system that yields results in ''percent SD''. This weighting is necessary because the amount of distortion depends not only on the distortion amplitude, but also on the time the distortion occurs with respect to the transition. Although results can be calculated from the time and amplitude of the measured ringing lobes, special graticules, conversion tables or nomographs are used in practice.

Waveform Monitor Graticule

Graticules for measurement of short time distortion are not included in the 1781R. However, some organisations use custom graticules which indicate, for example, 2% and 5% SD limits. The measurement procedure involves normalising the gain and positioning the rising or falling edge of the bar in the graticule. The largest graticule limit touched by the waveform indicates the amount of distortion, and other values can be interpolated.

VM700 Automatic Measurement

Select **Short Time Distortion** in the VM700A's MEASURE mode to obtain an SD result and a tracking graticule (CCIR 421). The user can also define custom graticules in this mode.

■ NOTES

10. Non-Linearities

If there are no non-linear distortions present in the system, the rising and falling transitions will have symmetrical distortions. In the presence of non-linearities, however, the transitions may be affected differently. It is a good idea to measure, or at least look at, both positive and negative transitions.

11. Pulse-to-Bar Ratios

The amplitude ratio between a 2T pulse and a line bar is sometimes used as an indication of short time distortion. To make a pulse-to-bar measurement with a waveform monitor, first normalise the bar amplitude to 100%. Now measure the pulse amplitude, in percent, to obtain pulse-to-bar ratio reading. The 1781R's voltage cursors can be used in the RELATIVE mode to make measurements of this type.

A pulse-to-bar measurement can be obtained from the VM700A by selecting K Factor in the MEASURE mode. Both pulse-to-bar ratio and $K_{pulse/bar}$ results (see Note 17 on page 46) are provided in this mode.

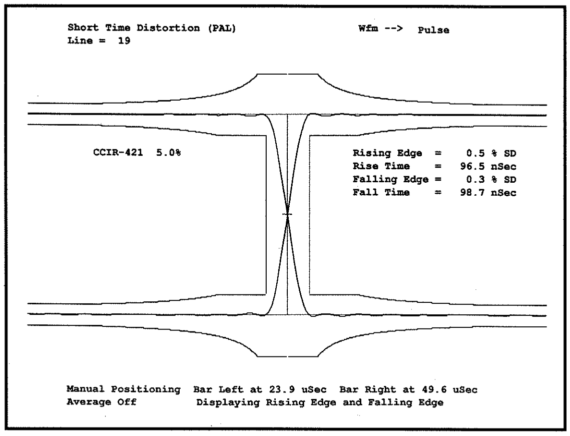


Figure 29. The VM700A Short Time Distortion display.

Line Time Distortion

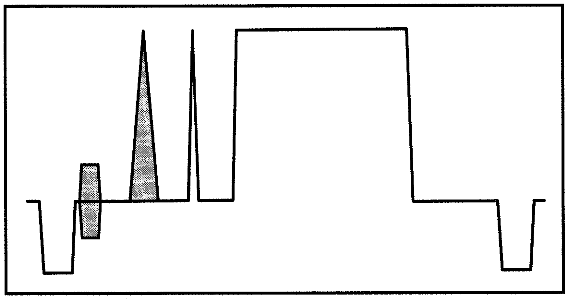


Figure 30. Pulse & Bar signal.

■ DEFINITION

Line time distortion causes tilt in line-rate signal components such as white bars. The affected signal components range in duration from 1.0 microsecond to 64 microseconds. The amount of distortion is expressed as a percentage of the amplitude at the centre of the line bar amplitude.

Distortions in the line time domain can also be quantified by measuring K_{bar} as discussed in the K FACTOR section of this booklet.

■ PICTURE EFFECTS

In large picture details, this distortion produces brightness variations between the left and right sides of the screen. Horizontal streaking and smearing may also be apparent.

■ TEST SIGNAL

Line time distortion is measured with a signal which contains a 10 microsecond or 25 microsecond white bar. Rise time of the bar is not critical for this measurement.

■ MEASUREMENT METHODS

Line time distortion is quantified by measuring the amount of tilt in the top of the line bar. For PAL systems, the maximum departure of the bar top from the level at the centre of the line bar is most often quoted as the amount of distortion. In some cases the peak-to-peak level variation is given, particularly when 10 micro-second bars are used. The measurement methods in this section are described in terms of peak results, but can readily be adapted for peak-to-peak measurements.

In either case, the tilt is expressed as a percentage of the level at the centre of the bar. The first and last microsecond of the bar should be ignored, because errors near the transition are in the short time domain.

Waveform Monitor Graticule

The graticule on a waveform monitor can be used to quantify this distortion. Measure the maximum deviation from the centre of the bar, and express that number as a percentage of the level at bar centre. It is generally most convenient to use the variable gain to normalise the centre of the bar to 500 or 1000 mV. Deviations in the top of the bar can then be read directly off the graticule in percent. Remember to ignore the first and last microsecond.

1781R Voltage Cursors

Waveform monitor voltage cursors in the RELATIVE mode can be used to measure line time distortion. Define the amplitude difference between blanking level and the bar centre as 100%. Leave one cursor at the bar centre, and move the other cursor to measure the peak positive and peak negative deviations in the top of the bar. The largest of these numbers (ignore the sign) is the amount of line time distortion.

The 1781R time cursors are convenient for locating the appropriate time interval in the centre of the bar. Set the time separation to the bar time (usually 10 or 25 microseconds) **minus** 2 microseconds. Put the time cursors in the TRACK mode, and move the two cursors together until they are centred on the bar. See Figure 31.

VM700A Automatic Measurement

Select **Bar LineTime** in the VM700A's MEASURE menu to obtain a line time distortion result. This display is shown in Figure 32. Line time distortion can also be measured in the AUTO mode.

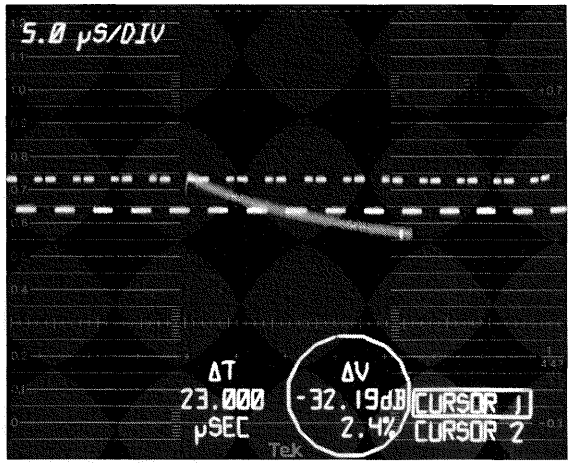


Figure 31. The 1781R voltage and time cursors can facilitate line time distortion measurements.

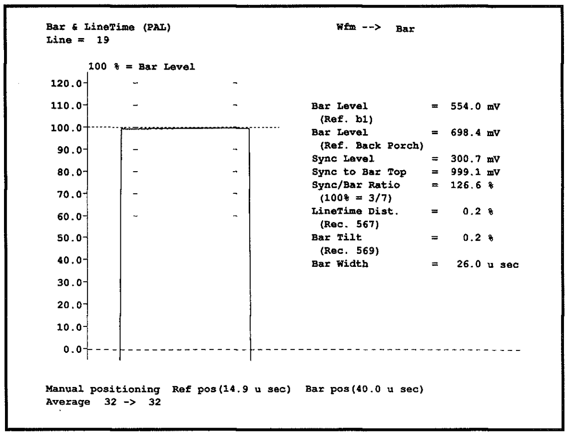


Figure 32. The VM700A Bar LineTime display.

Field Time Distortion

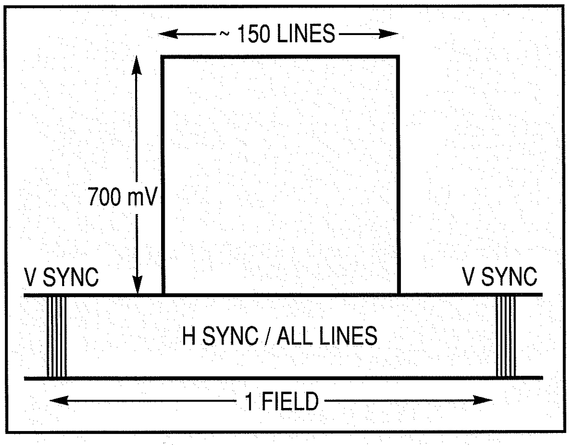


Figure 33. The Field Square Wave test signal.

■ DEFINITION

Field time distortion causes field-rate tilt in video signals. The affected signal components range in duration from 64 microseconds to 20 milliseconds. The amount of distortion is generally expressed as a percentage of the amplitude at the centre of the line bar.

$K_{50\ Hz}$ measurements, which are discussed in the K FACTOR section of this booklet, provide another method of describing field time distortions.

■ PICTURE EFFECTS

Field time linear distortion will cause top-to-bottom brightness inaccuracies in large picture details.

■ TEST SIGNALS

Field time distortion is measured with a Field Square Wave. In this signal, each line in one half of the field is a 0-volt pedestal, while each line in the other half is a 700-millivolt pedestal. The signal usually includes normal horizontal and vertical synchronisation information.

■ MEASUREMENT METHODS

Field time distortions are quantified by measuring the amount of tilt in the top of the field bar (the 700 mV part of the field square wave signal). The maximum departure of the field bar top from the level at the centre of the field bar is generally quoted as the amount of distortion, although peak-to-peak results are sometimes given. (The measurement methods in this section are described in terms of peak results, but can readily be adapted for peak-to-peak measurements.) The centre of the **line** bar is usually used as the reference amplitude, and the first and last 250 microseconds (about 4 lines) of the field bar should be ignored. Distortions in that region are not in the field time domain.

Waveform Monitor Graticule

The first step in making a field time distortion measurement is to normalise the gain. With the waveform monitor in a line-rate sweep mode, use the variable gain control to set the centre of the line bar to 100% (1000 mV or 500 mV). You can do this most accurately if you turn on the waveform monitor's FAST DC restorer. The DC restorer will remove the effects of field time distortion from the waveform monitor display, and therefore reduce the vertical blurring you see in the line rate display. Now select a field-rate sweep, and select either the SLOW or OFF setting for the DC restorer. Examine the top of the field bar, and measure the peak positive and peak negative level change from the center, excluding the first and last 4 lines. The largest of these two numbers, expressed as a percentage of the line bar amplitude, is the amount of field time distortion. See Figure 34.

1781R Voltage Cursors

The 1781R voltage cursors can be used in the RELATIVE mode to measure field time distortion. Select a one-line or two-line sweep, and define the centre of the line bar (relative to blanking) as 100%. Remember to select the FAST DC restorer setting. Then select a field-rate sweep and set the DC restorer to SLOW or OFF. Place one cursor so that it intersects the top of the field bar in the middle. Use the other cursor to measure the peak positive and peak negative level deviation in the top of the bar, ignoring the first and last 4 lines. The largest of the two numbers is the amount of field time distortion in percent.

VM700A Automatic Measurement

The VM700A provides a field time distortion result in the AUTO mode, and field time distortion results are also available in the Two Field MEASURE display.

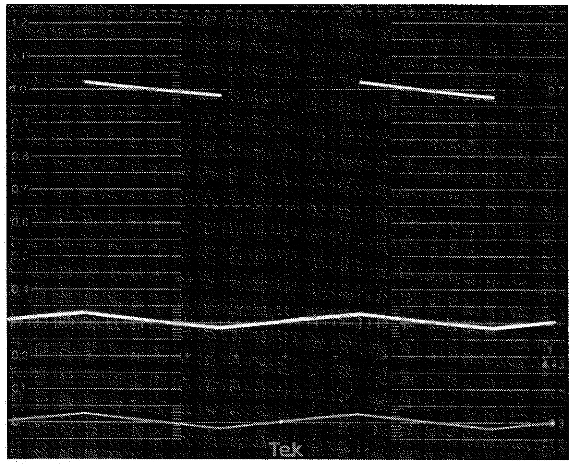


Figure 34. A 2-field waveform monitor display showing field time distortion.

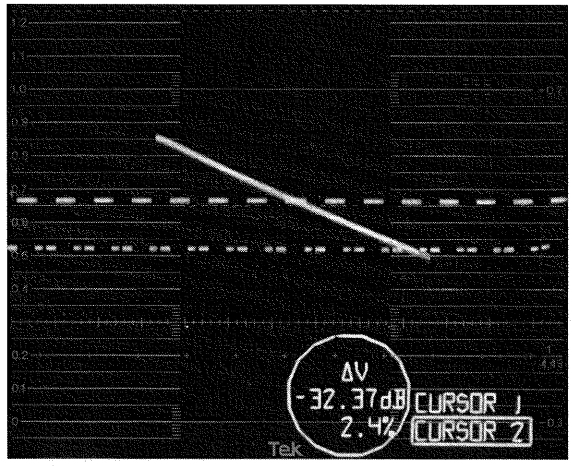


Figure 35. The 1781R voltage cursors can be used to measure field time distortion.

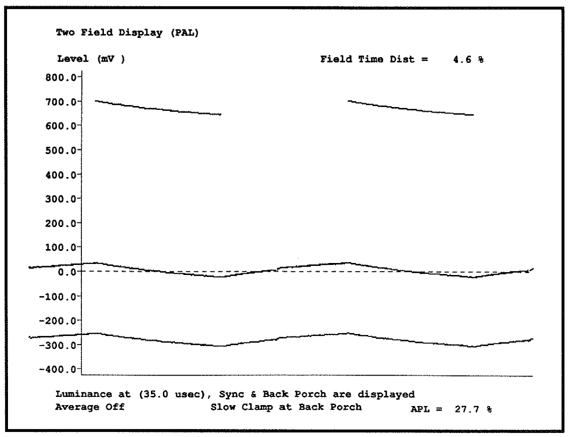


Figure 36. The VM700A TwoField display.

■ NOTES

12. Externally Introduced Distortions

Externally introduced distortions such as mains hum are also considered field rate distortions. Be sure to turn the DC restorer OFF or select the SLOW clamp speed if you want to measure hum.

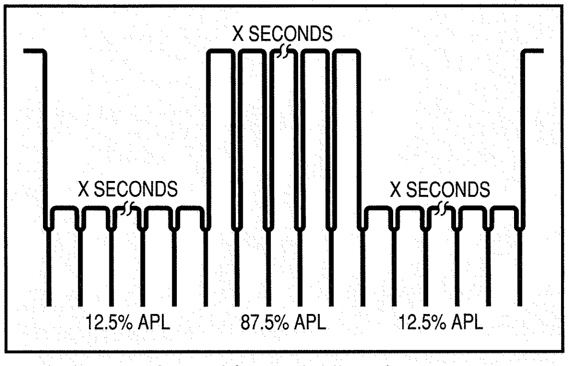


Figure 37. A Flat Field Bounce signal.

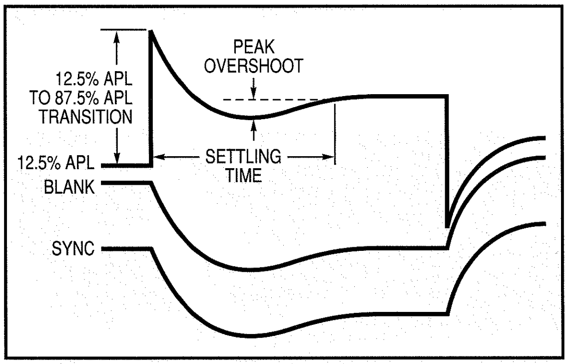


Figure 38. Long time distortion measurement parameters.

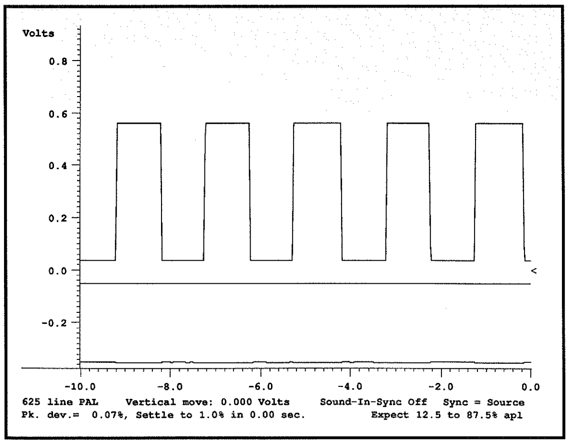


Figure 39. The VM700A Bounce display.

■ DEFINITION

Long time distortions affect slowly varying aspects of the signal, such as APL changes which occur at one second intervals. The distortion usually appears as a very low frequency damped oscillation. The affected signal components range in duration from 20 milliseconds to 10s of seconds.

The peak overshoot which occurs as a result of an APL change, expressed as a percentage of the nominal luminance amplitude, is generally quoted as the amount of distortion. Settling time is also sometimes given, and occasionally the slope at the beginning of the phenomenon, in % per second.

■ PICTURE EFFECTS

Long time distortions are slow enough that they are often perceived as flicker in the picture.

■ TEST SIGNALS

A flat field test signal with normal sync signals and variable APL is used to measure long time distortion. The signal should be "bounced", or switched between 10% and 90% APL, at intervals no shorter than five times the settling time. See Figure 37.

■ MEASUREMENT METHODS

Long time distortions are measured by examining the damped low-frequency oscillation resulting from a change in APL. The peak overshoot and settling time are generally measured, as shown in Figure 38.

Waveform Monitor

It is usually necessary to use a storage oscilloscope or a waveform monitor in the SLOW SWEEP mode to measure long time distortion. A waveform photograph can be helpful in quantifying the distortion. Once you have obtained a stable display or a photograph, measure overshoot and settling time as shown in Figure 38.

VM700A Automatic Measurement

Select **Bounce** in the VM700A MEASURE mode to obtain a display of long time distortion. This display is shown in Figure 39. Peak deviation and settling time are given at the bottom of the screen.

■ DEFINITION

Frequency response measurements evaluate a system's ability to uniformly transfer signal components of different frequencies without affecting their amplitudes. This parameter, which is also known as gain/frequency distortion or amplitude versus frequency response, evaluates the system's amplitude response over the entire video spectrum.

The amplitude variation may be expressed in dB or percent. The reference amplitude (0 dB, 100%) is typically the white bar or some low frequency. Frequency response numbers are only meaningful if they contain three pieces of information: the measured amplitude, the frequency at which the measurement was made, and the reference frequency.

■ PICTURE EFFECTS

Frequency response problems can cause a wide variety of aberrations in the picture, including all of the effects discussed in the sections on short time, line time, field time and long time distortions.

■ TEST SIGNALS

There are a number of test signals which can be used to measure amplitude versus frequency response. Since there are significant differences between these signals, each one is discussed in some detail in this section.

Some test signals are available either as full-amplitude or reduced-amplitude signals. The reduced amplitude signal should be used if you know there are amplitude non-linearities in your system. Since the smaller signal will be less sensitive to these kinds of distortions, you can separate the non-linearity effects from your frequency response measurements.

Multiburst

Multiburst typically includes six packets of discrete frequencies which fall within the TV passband. The packet frequencies usually range from 0.5 MHz to 5.8 MHz, with frequency increasing toward the right side of each line. See Figure 40. This signal is useful for quick approximation of the system's frequency response, and can be used on an in-service basis as a vertical interval test signal

Multipulse

Multipulse is made up of modulated 20T and 10T sine-squared pulses with high-frequency components at various frequencies of interest, generally from 0.5 MHz to 5.8 MHz. This signal, which is shown in Figure 41, can be inserted in the vertical interval.

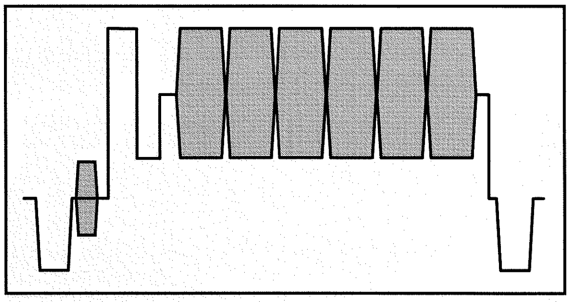


Figure 40. A Multiburst test signal.

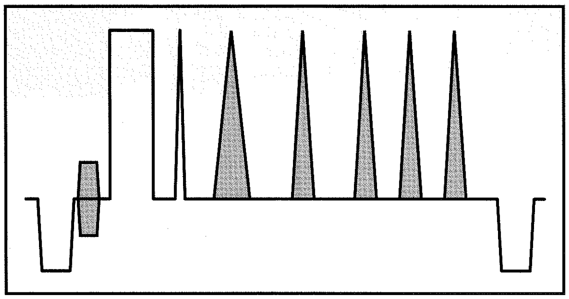


Figure 41. The Multipulse test signal.

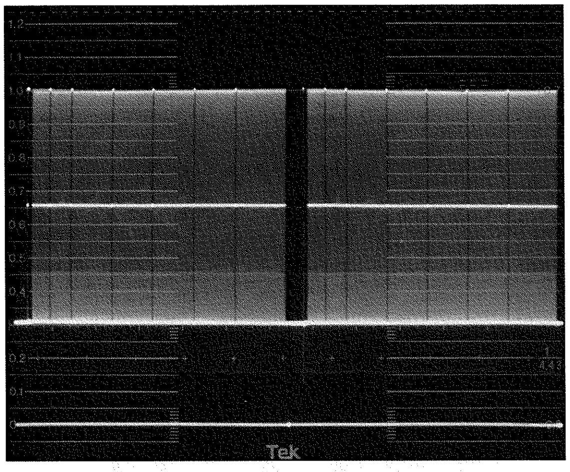


Figure 42. 6 MHz field-rate sweep signal with markers (2-field display).

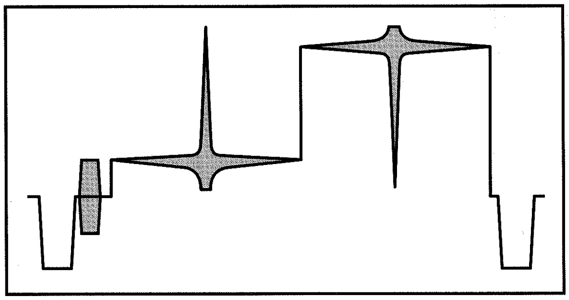


Figure 43. Time domain display of Sin X/X.

Modulated sine-squared pulses, which are also used to measure chrominance-to-luminance gain and delay errors, are discussed on page 25. Although different high-frequency components are used in Multipulse, the same principles apply. Bowing of the baseline indicates an amplitude error between the low-frequency and high-frequency components of that pulse. Unlike Multiburst, Multipulse allows you to evaluate group delay errors as well as amplitude errors.

Sweep Signal

It is sometimes recommended that line-rate or field-rate sweep signals be used for measuring frequency response. In a sweep signal, the frequency of the signal sine wave is continuously increased over the interval of a line or field. An example of a sweep signal is shown in Figure 42. The markers indicate 1 MHz frequency intervals.

A sweep signal allows you to examine frequency response continuously over the interval of interest rather than only at the discrete frequencies of Multiburst or Multipulse. This can be important for detailed characterisation of a system, but does not offer any significant advantages in routine testing. While the other signals discussed here can be used in the vertical interval and therefore permit in-service testing, field-rate sweep signals can only be used on an out-of-service basis.

Sin X/X

Sin X/X is a signal which has equal energy present at all harmonics of the horizontal scan frequency up to a cutoff point (usually 6 MHz). In other words, it produces a flat spectral display when viewed on a spectrum analyser. Sin X/X is primarily designed for use with a spectrum analyser or an automatic measurement set such as the VM700A. Very little information is discernible in a time domain display.

■ MEASUREMENT METHODS

Since each signal requires a different measurement method, separate discussions for the various test signals are presented in this section. The first three signals (Multiburst, Multipulse, and Sweep) can all be measured with a waveform monitor, using either the graticule or the voltage cursors to quantify the distortion. Ratios may be expressed in dB either by calculation or by using a dB conversion chart.

Waveform Monitor — Multiburst

Frequency response measurements are made with Multiburst by measuring the peak-to-peak amplitudes of the packets. The low-frequency square wave at the beginning of the line should be used as the amplitude reference.

Figures 44 and 45 show the 1781R voltage cursors being used to measure a frequency response distortion of −3.59 dB at 5.8 MHz. The error in dB is calculated as follows:

$$20 \log_{10} \left(\frac{274}{414}\right) = -3.59 \text{ dB}$$

In the RELATIVE mode, the 1781R's voltage cursors will provide results directly in dB.

Waveform Monitor — Multipulse

Frequency response distortion shows up as bowing of the pulse baselines, as shown in Figure 46. Distortions are quantified by measuring the amount of baseline displacement in the pulse(s) of interest. It is often easy to see which pulse exhibits the largest gain inequality, so you can obtain an overall result by measuring only that pulse.

This measurement can be made by using a waveform monitor graticule to measure the baseline distortion, and then transferring the numbers for each pulse to a nomograph. The nomograph for chrominance-to-luminance gain and delay measurements, which is shown on page 27 of this booklet, can also be used for Multipulse measurements. Be sure to normalise each pulse height to 100%, and remember that the nomograph is for 20T pulses, so delay results must be divided by two for 10T pulses.

If only gain distortion is present, you will see a single peak in each baseline. (A value of zero is therefore applied to one axis of the nomograph.) If group delay distortion is also present, you will see sinusoidal baseline distortion rather than a single peak. In this case you need to measure both lobes and apply the two numbers to the nomograph, which will yield correct frequency response results as well as a group delay measurement.

The CHROMA/LUMA selection in the 1781R MEASURE menu can be used to make frequency response measurements with Multipulse. Repeat the cursor measurement procedure for the pulse corresponding to each frequency of interest.

If there are no significant non-linearities in your system, it is also possible to estimate the amplitude error without using a nomograph. Normalise the white bar to 100%, and then measure either the amount of baseline bowing or the displacement of the pulse top from the white bar. (The two numbers will be equal in a linear system.) The amplitude error, in percent, is approximately equal to **two times** either value. This method yields valid results even in the presence of some delay error, which is indicated by asymmetrical baseline distortion. When delay errors of more than about 150 nanoseconds are present, however, this method does not provide a useful approximation.

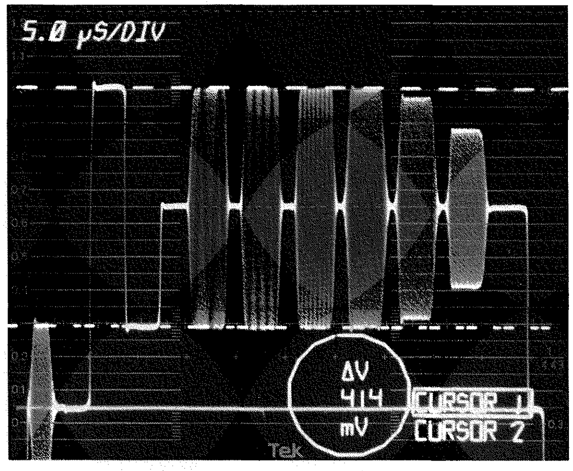


Figure 44. The low-frequency square wave is defined as the reference.

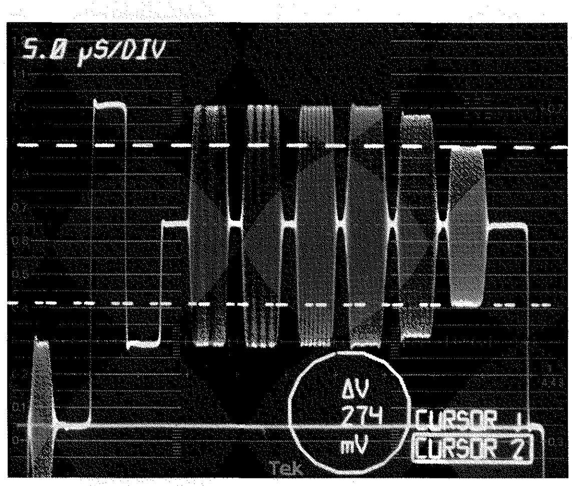


Figure 45. The peak-to-peak amplitude of the smallest packet is then measured.

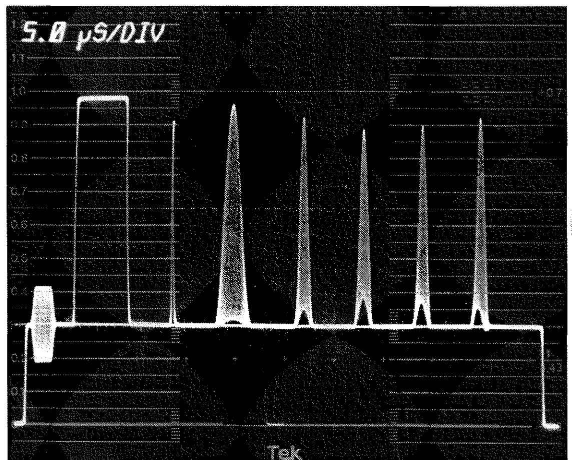


Figure 46. Multipulse exhibiting frequency response distortion.

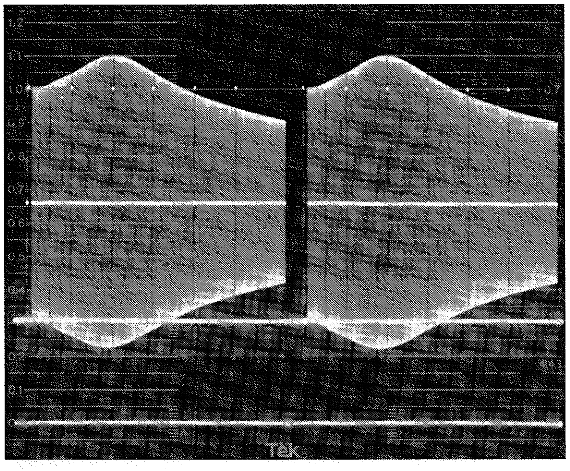


Figure 47. A sweep signal showing frequency response distortion.

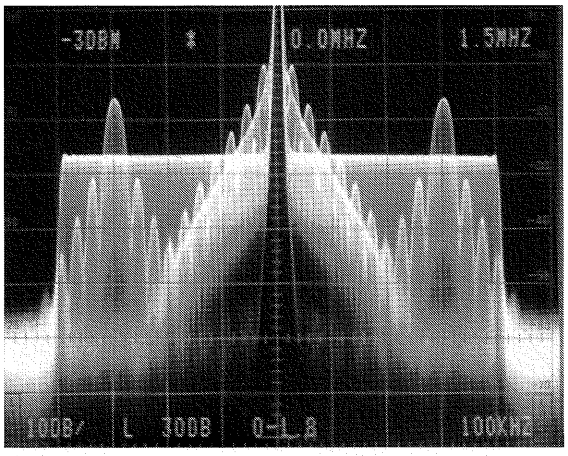


Figure 48. A spectrum analyser display of the Sin X/X signal.

Waveform Monitor — Sweep Signal

Amplitude variations can be measured directly from a time-domain display when a sweep signal is used. Be sure to select a field-rate display on your waveform monitor if you are using a field sweep. Establish a reference at some low frequency, and measure the peak-to-peak amplitude at other frequencies of interest. See Figure 47.

Spectrum Analyser — Sin X/X

Frequency response testing with the Sin X/X signal is done with a spectrum analyser. Attenuation or peaking of the flat portion of the spectral display (the Sin X/X part of the signal) can be read directly from the analyser display in dB. See Figure 48.

In the time domain display, the pulse amplitudes and the amplitudes of the lobes at the bottom of the pulses are reduced in the case of high-frequency roll-off. It is difficult, however, to quantify the error. In the time domain it is possible to note the presence of non-linearities in the system — the positive and negative Sin X/X pulses are not symmetrically distorted in this case.

VM700A Automatic Measurement

The VM700A provides amplitude versus frequency response information for either the Multiburst signal or the Sin X/X signal. Select **Multiburst** or **Group Delay Sin X/X** in the MEASURE mode. Multiburst measurements are also available in the AUTO mode.

■ NOTES

13. Multipulse and Non-Linear Distortions

Your system must be reasonably free of non-linear distortions such as differential phase and gain if you plan to use the Multipulse signal. Large non-linear distortions can cause erroneous readings of both frequency response and group delay.

14. More Information

Two Tektronix application notes are available for more information on frequency response testing. See No. 30, *The Multipulse Waveform* (20AX-4759) and No. 31, *Frequency Response Testing Using the SIN X/X Test Signal* (20W-5055).

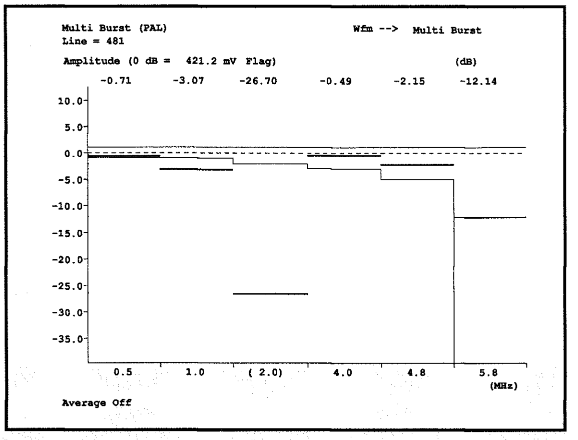


Figure 49. VM700A Multiburst measurement.

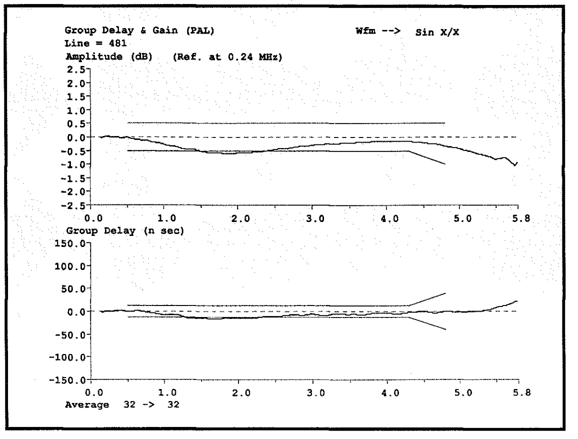


Figure 50. VM700A Group Delay Sin X/X measurement.

Group Delay

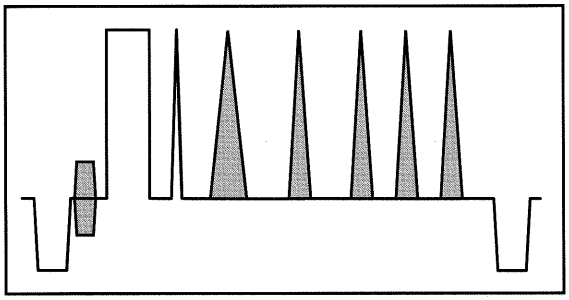


Figure 51. The Multipulse test signal.

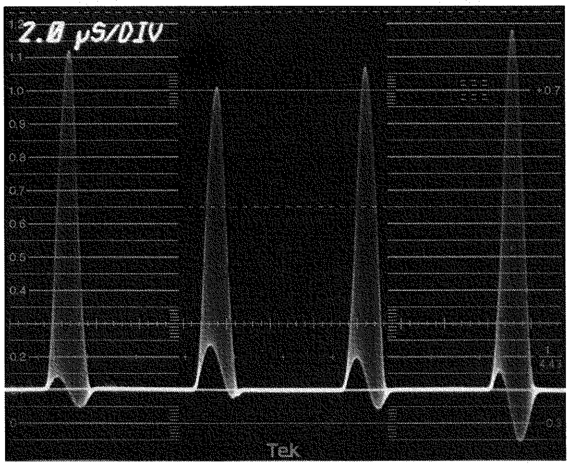


Figure 52. Multipulse exhibiting group delay distortion. Group delay differences between the high-frequency and low-frequency components of the pulse appear as sinusoidal distortion of the baseline.

■ DEFINITION

Group delay distortion is present when signal components of different frequencies experience different delays as they pass through a system. Distortions are expressed in units of time. The difference in delay between a reference low frequency and the highest frequency tested is typically quoted as the group delay error.

■ PICTURE EFFECTS

Group delay problems can cause a lack of vertical line sharpness due to luminance pulse ringing, overshoot, or undershoot.

■ TEST SIGNAL

The Multipulse test signal, which is described on page 37, is used to measure group delay. It is also possible to obtain a group delay measurement from the Sin X/X signal, but only with an automatic measurement set such as the VM700A.

■ MEASUREMENT METHODS

Group delay is measured by analysing the baseline distortion of the modulated sine-squared pulses in the Multipulse signal. As discussed on page 26, delay errors between the low-frequency and high-frequency components of the pulse appear as sinusoidal distortion of the baseline. See Figure 52. The measurement methods for group delay are very similar to those used for chrominance-to-luminance delay, but in this case it is necessary to examine the delay at a number of different frequencies within the video passband.

Waveform Monitor & Nomograph

The baseline distortion of each pulse must be individually measured and applied to a nomograph when group delay measurements are made with Multipulse. Normalise each pulse height to 100%, and measure the positive & negative peaks of the baseline distortion. Voltage cursors in the RELATIVE mode can also be used for these measurements. Apply the numbers to the nomograph on page 27 to obtain the delay number. The largest delay measured in this way is typically quoted as the group delay error.

The first pulse in a Multipulse signal is generally a 20T, and the others are 10T pulses. The nomograph works for any modulated 20T pulse, regardless of the modulation frequency. For 10T pulses, however, you will need to divide the delay number from the nomograph by two. In practice, it is often easy to see which of the pulses exhibits the most delay. If you are just interested in the largest delay error, measure only that pulse.

1781R Semi-Automatic Procedure

Group delay can be measured with the CHROMA/LUMA selection in the 1781R MEASURE menu. Go through the measurement procedure for the pulse which exhibits the most delay, or for each pulse if you wish.

Automatic Measurement — Sin X/X

The VM700A uses the Sin X/X signal to make group delay measurements. This method offers the advantage of providing delay information for a large number of frequencies, rather than just at the six discrete frequencies included in Multipulse.

The lower graph in the **Group Delay Sin X/X** selection in the VM700A MEASURE mode shows group delay errors.

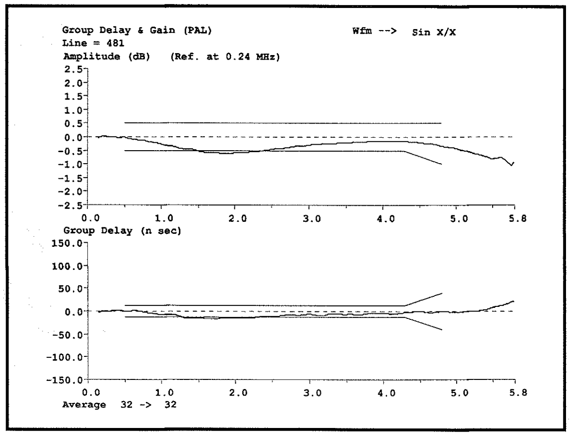


Figure 53. VM700A Group Delay Sin X/X display.

■ NOTES

15. Group Delay Definition

In mathematical terms, group delay is defined as the derivative of phase with respect to frequency ($d\phi/d\omega$). In a distortionless system, the phase versus frequency response is a linear slope, and the derivative is therefore a constant. See Figure 54.

If the phase versus frequency response is not linear, then the derivative is not a constant and group delay distortion is present. As shown in Figure 55, the largest difference in $d\phi/d\omega$ which occurs over the frequency interval of interest is the amount of group delay.

16. Envelope Delay

The term "envelope delay" is often used interchangeably with group delay in television applications. Strictly speaking, envelope delay is measured by passing an amplitude modulated signal through the system and observing the modulation envelope. Group delay, on the other hand, is measured directly by observing phase shift in the signal itself. Since the two methods yield very nearly the same results in practice, it is safe to assume the two terms are synonymous.

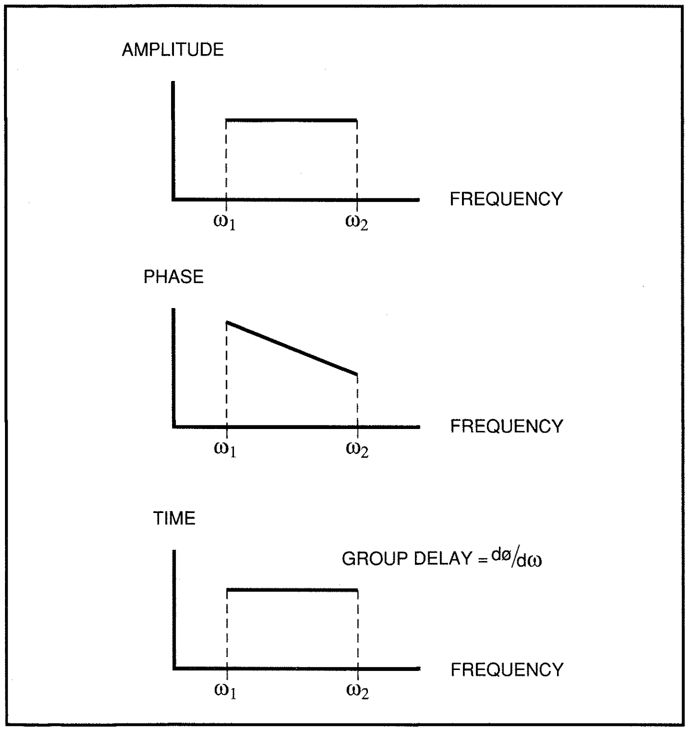


Figure 54. Response of a distortionless system.

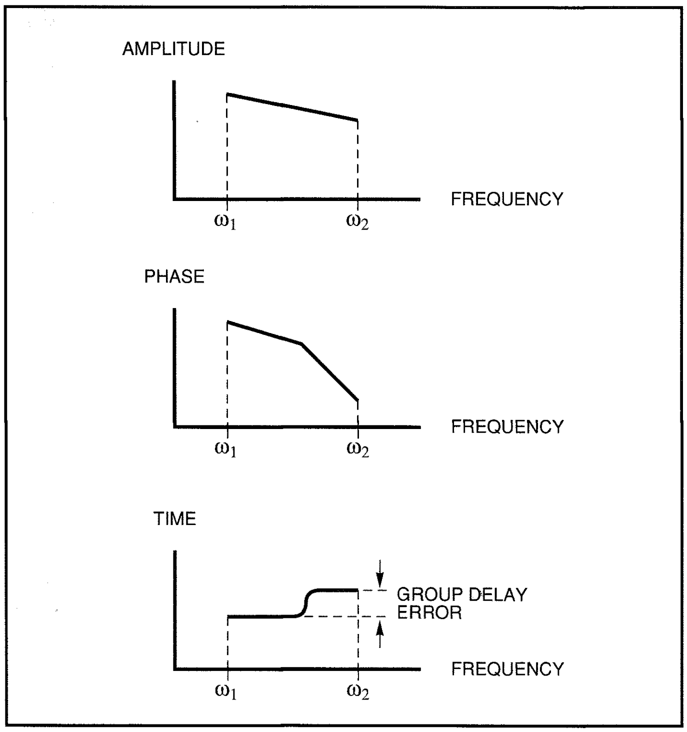


Figure 55. Response of a system with amplitude and phase distortion.

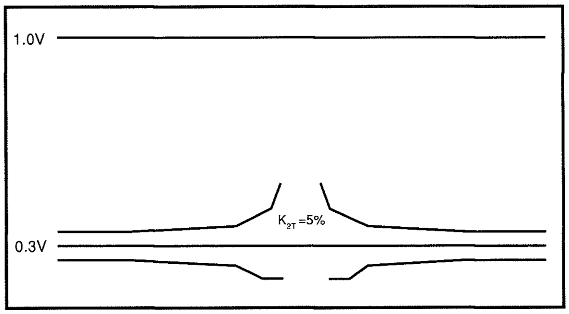


Figure 56. The 1781R's external graticule includes a 5% K_{2T} limit.

DEFINITION

The K Factor rating system maps linear distortions of 2T pulses and line bars onto subjectively determined scales of picture quality. The various distortions are weighted in terms of impairment to the picture.

The usual K Factor measurements are $K_{pulse/bar}$, K_{2T}, K_{bar}, and sometimes $K_{50\ Hz}$. The overall K Factor rating is the largest value obtained from all of these measurements. Special graticules can be used to obtain the K factor number, or it can be calculated from the appropriate formula. Definitions of the four K factor parameters are as follows:

K_{2T}

K_{2T} is a weighted function of the amplitude and time of the distortions occurring before and after the 2T pulse. In practice, a graticule is almost always used to quantify this distortion. Different countries and standards use slightly different amplitude weighting factors. An example is shown in Figure 56.

$K_{pulse/bar}$

Calculation of this parameter requires that you measure the pulse amplitude and the bar amplitude. Kpulse/bar is equal to:

$$1/4\,|(\text{bar-pulse})/\text{pulse}| \times 100\%.$$

It should be noted that some documents, including CCIR 567-2, recommend that the (bar-pulse) quantity be divided by the bar amplitude rather than the pulse amplitude. The two definitions will yield very nearly the same answer for practical levels of distortion, but be sure to check which definition is recommended by your broadcast authority.

K_{bar}

A line bar (10 or 25 microseconds) is used to measure K_{bar}. Locate the centre of the bar time, normalise that point to 100%, and measure the maximum amplitude deviation for each half. Ignore the first and last 2.5% of the bar. The largest deviation of the two, expressed in percent, is generally taken as the K_{bar} rating. The peak-to-peak deviation is sometimes quoted, however, particularly if a 10 microsecond bar is used. This is another case where you will want to carefully read the measurement standard used by your facility. It is usually a good idea to record the bar width with your measurement result.

$K_{50\ Hz}$

A field-rate square wave is used to measure this parameter. Locate the centre of the field bar time, normalise that point to 100%, and measure the maximum amplitude deviation for each half. Ignore the first and last 2.5%. The largest of the two tilt measurements, **divided by two**, is the $K_{50\ Hz}$ rating.

PICTURE EFFECTS

All types of linear distortions affect K Factor rating. Picture effects may include any of the aberrations discussed in the sections on short time, line time, field time and long time distortions. Since overall K factor rating is the maximum value obtained in the four measurements, the picture effects corresponding to a given K Factor rating may vary widely.

TEST SIGNAL

Any test signal containing a 2T pulse and a white bar can be used to measure K_{2T}, $K_{pulse/bar}$, and K_{bar}. A 50 Hz square wave is required for measurement of $K_{50\ Hz}$.

MEASUREMENT METHODS

Waveform Monitor

The external graticule provided with 1781R and 1481 waveform monitors includes special marks for making K Factor measurements. To make a K_{2T} measurement, use the vertical position control to set the black level to coincide with the 0.3 volt graticule mark. Then use the variable gain control to set the top of the 2T pulse to the 1 volt graticule line, as shown in Figure 58. Set the horizontal magnification to 0.20 microseconds per division. Under these conditions, the K_{2T} graticule indicates a 5% limit. If you enable the X5 vertical gain in addition to the variable gain required to normalise the pulse height, the graticule indicates a 1% limit.

The 1781R is also equipped with an electronic K_{2T} graticule. Select K FACTOR in the MEASURE menu, and make sure that the horizontal magnification is set to 0.20 microseconds per division. Set the black level of the signal to overlay the dotted electronic graticule line, and adjust the pulse amplitude until it reaches the small cross drawn electronically near the top of the screen. Use the large front panel knob to adjust the graticule size until it just touches the waveform at the point of greatest distortion. The readout will now indicate the K_{2T} distortion in percent.

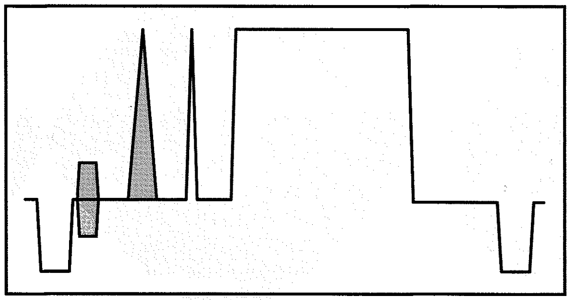


Figure 57. This signal contains the pulse and bar signal elements required for K Factor measurements.

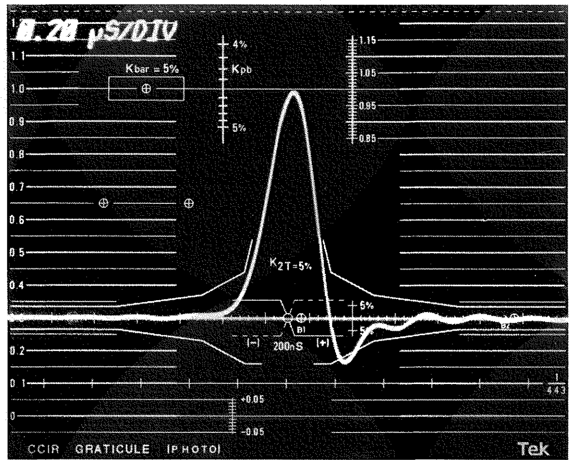


Figure 58. A 2T pulse properly positioned for a K_{2T} measurement. This signal has a K_{2T} distortion of slightly more than 5%.

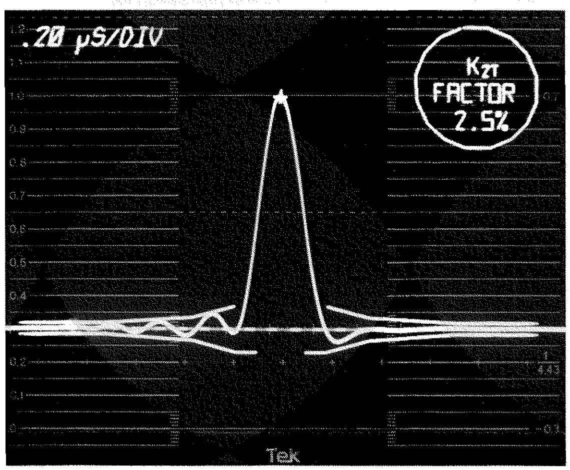


Figure 59. The 1781R electronic K Factor graticule measures a 2.5% K_{2T} distortion for this signal.

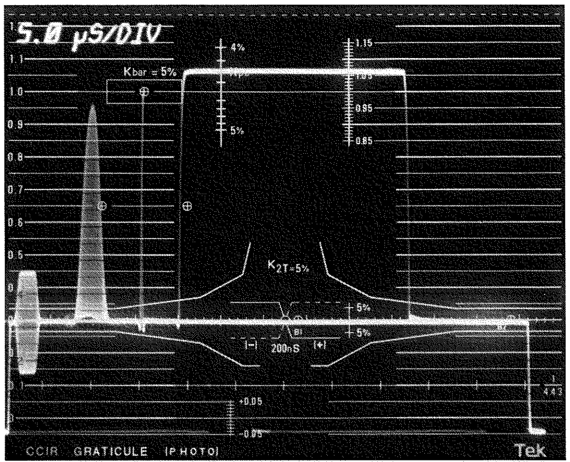


Figure 60. With the pulse taken as the reference, the 1781R graticule indicates that this signal has a $K_{pulse/bar}$ distortion of 2%.

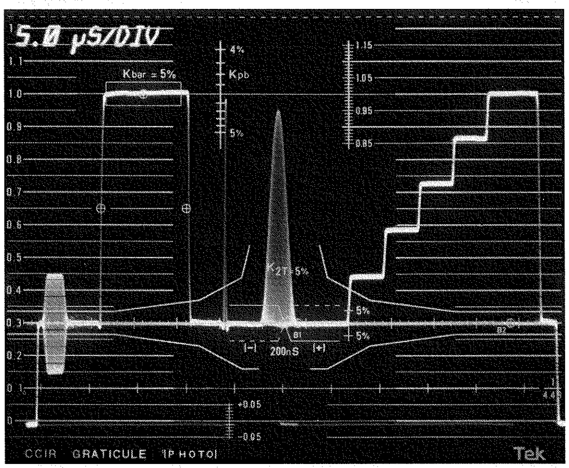


Figure 61. This signal is properly positioned for a K_{bar} measurement with the 1781R graticule.

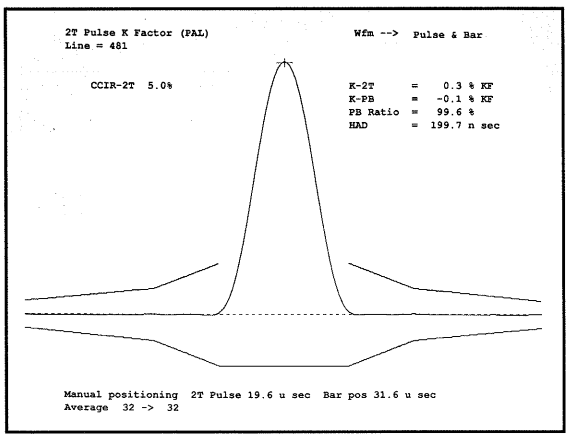


Figure 62. The VM700A K Factor measurement.

The external 1481/1781R graticule includes $K_{pulse/bar}$ marks in the centre near the top. To use this graticule, normalise the pulse amplitude (or the bar amplitude, depending on which definition you're using) to extend from 0.3 to 1.0 volts. Then compare the other signal element to the $K_{pulse/bar}$ scale, and obtain a K Factor reading in percent.

There is also a 5% K_{bar} limit near the upper left-hand corner of the 1481/1781R graticule. This limit is designed for use with a 10 microsecond bar when a 1H sweep is selected. Position the waveform horizontally so that the rising and falling edges of the bar pass through the graticule circles on the 0.65 volt line, as shown in Figure 61. The waveform vertical gain should be adjusted so that the black level coincides with the 0.3 volt line and the centre of the bar passes through the cross in the centre of the K_{bar} box.

VM700A Automatic Measurement

Select **K Factor** in the VM700A MEASURE mode to obtain a measurement of K_{2T}. The graticule can automatically track the waveform, or you can manually shrink and expand the graticule with the knob. As shown in Figure 62, this display also provides numeric K_{2T} and $K_{pulse/bar}$ results. Measurements of these parameters are also available in the VM700A AUTO mode.

■ NOTES

17. Pulse-to-Bar Definitions

There are several different methods of expressing the relationship between pulse amplitude and bar amplitude. Be sure to understand the difference and make it clear which you are specifying. Three of the most common definitions are given below.

PULSE-TO-BAR RATIO = (pulse/bar) × 100%
PULSE-BAR INEQUALITY = (pulse-bar) × 100%
K PULSE-TO-BAR = 1/4 |(pulse-bar)/pulse| × 100%

III. NON-LINEAR DISTORTIONS

Amplitude-dependent waveform distortions are often referred to as non-linear distortions. This classification includes distortions which are dependent on Average Picture Level (APL) changes and/or instantaneous signal level changes.

Since amplifiers and other electronic circuits are linear over only a limited range, they may tend to compress or clip large signals. The result is non-linear distortion of one type or another. Non-linear distortions may also manifest themselves as crosstalk and intermodulation effects between the luminance and chrominance portions of the signal.

The first three distortions discussed in this section are differential phase, differential gain, and luminance non-linearity. These are by far the most familiar and most frequently measured non-linear distortions. These parameters are included in the performance specifications of most video equipment, and are regularly evaluated in television facilities. The other distortions are not as routinely tested, but most measurement standards and performance checks include them.

It is generally recommended that non-linear distortions be measured at different APLs. Some test signal generators provide variable-APL signals by combining the test signal with a variable-level pedestal. In the TSG-271, this is accomplished by alternating between six lines of the test signal and eighteen lines of the pedestal. Since in-service measurements cannot be made with these test signals, APL dependency checks are sometimes eliminated from routine testing.

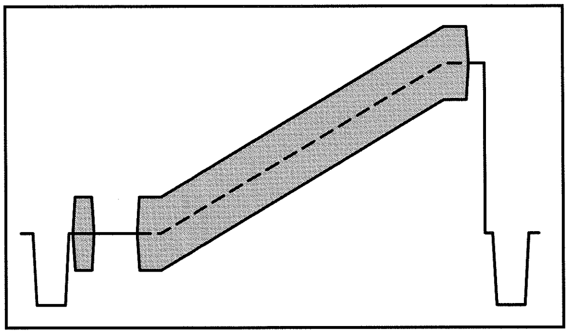


Figure 63. Modulated Ramp test signal.

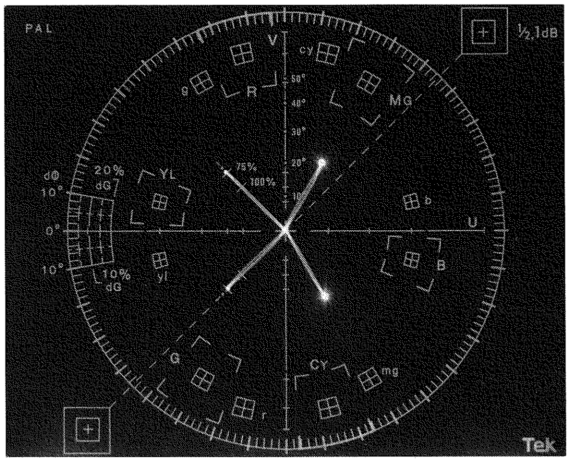


Figure 64. Vector display of TSG-271 phase-alternate Modulated Ramp.

■ DEFINITION

Differential phase distortion, sometimes referred to as "diff phase", "dP" or "dϕ", is present if a signal's chrominance phase is affected by luminance level. This phase distortion is a result of a system's inability to uniformly process the high-frequency chrominance information at all luminance levels.

The amount of differential phase distortion is expressed in degrees of subcarrier phase. Since both positive and negative (lead and lag) phase errors may occur in the same signal, it is important to specify whether the peak-to-peak phase error or peak deviation from the blanking level phase is being quoted.

PAL measurement standards most frequently refer to peak deviation differential phase measurements. Two numbers are typically given to describe the distortion: the peak positive phase deviation and the peak negative phase deviation from the subcarrier phase at blanking level. Sometimes the larger of these two values is given as a single peak result.

This distortion should be measured at different APLs, and the worst error should be quoted.

■ PICTURE EFFECTS

Since virtually all PAL receivers now employ delay-line decoders, reasonable amounts of differential phase distortion cannot be readily detected in the picture. A delay-line decoder averages each two successive lines in the field, and the resultant information is displayed. Chrominance phase shifts are therefore canceled out, and do not result in a hue shift in the picture. (Differential phase is actually converted to differential gain in the resultant, but gain errors are much less objectionable in the picture.)

■ TEST SIGNALS

This distortion is measured with a test signal which consists of uniform-phase chrominance superimposed on different luminance levels. A Modulated Staircase (5 or 10 step) or a Modulated Ramp (See Figure 63) is typically used. A ramp is normally used when the signal is passing through digital systems.

Some generators, such as the Tektronix TSG-271, offer a phase-alternate Modulated Ramp test signal. A vector display of this signal is shown in Figure 64. This signal can help you detect distortions which have affected the U and V components differently, which is most likely to occur if the signal has been demodulated and the U and V components passed through separate processing channels. If this signal is available, you may wish to repeat the measurement procedures outlined below for both signal vectors.

■ MEASUREMENT METHODS

If differential phase is present, the chrominance phase will be different on the different luminance levels of the test signal. This phase information can be conveniently displayed after the chrominance has been demodulated, so differential phase is measured with a vectorscope. Although a standard vector display can indicate the presence of large amounts of distortion, a vectorscope equipped with a special DIFF PHASE mode or an automatic measurement set such as the VM700A is required for precision measurements.

Vectorscope Display

In a vectorscope display, the dots corresponding to the various subcarrier packets will spread out along the circumference of the graticule circle when differential phase is present. (If you are using a ramp signal, the dot will become elongated along the circumference.) To make a measurement, first set the phase of the signal vector to the reference 9 o'clock phase position. Use the vectorscope variable gain control to bring the signal vector out to the graticule circle.

Vectorscope graticules generally have special dϕ and dG marks on the left-hand side to help quantify the distortion, so you can read the peak-to-peak phase deviation directly from the graticule. Obtaining peak positive and peak negative results from the vector display is less straightforward, but it is possible when the signal vector lies along the 0 degree or 180 degree axis. In this case you can align the bursts with the +135 and −135 degree graticule marks, and obtain an approximate peak reading by noting how far positive or negative the dots extend from the 0/180 degree axis.

Demodulated R-Y Sweep

Although distortions show up in the vectorscope display, there are some advantages to be gained by examining the demodulated R-Y (V) signal in a voltage versus time display. (Recall that the weighted R-Y signal drives the vertical axis of a vectorscope, as shown in Figure 66.) First of all, more gain and therefore more measurement resolution are possible in waveform displays. Secondly, the sweep display lets you correlate the demodulated R-Y signal with the original test signal in the time dimension. You can see exactly how the effects of differential phase vary with luminance level, or how they vary over a field.

Precise measurements of differential phase are therefore made by examining a voltage versus time display of the demodulated R-Y information. Distortions manifest themselves as tilt or level changes across the line.

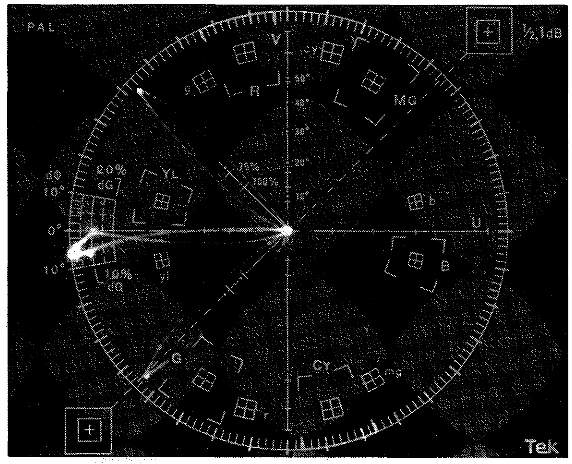


Figure 65. A vectorscope display showing a peak-to-peak differential phase distortion of about 7 degrees. (Differential gain distortion is also present.)

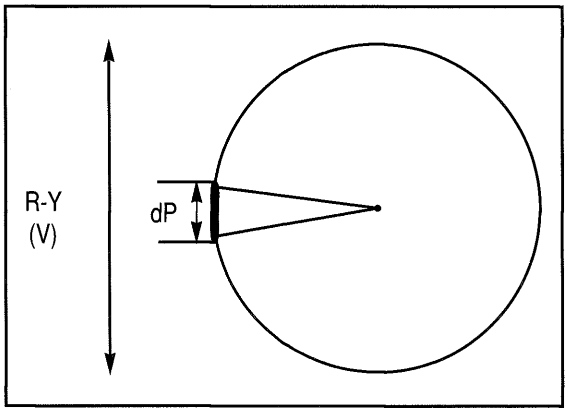


Figure 66. Differential phase distortion affects the R-Y (V) signal.

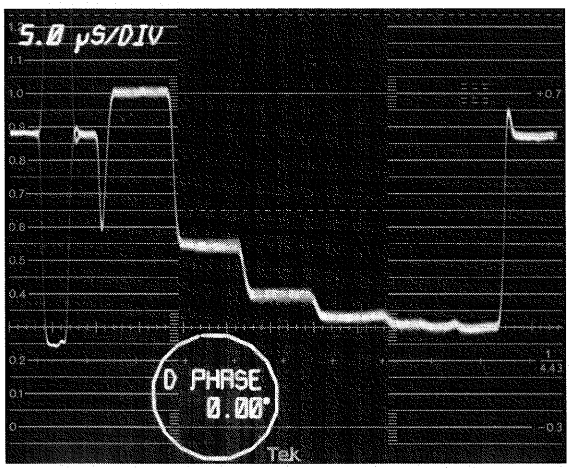


Figure 67. A single trace display indicating about 7 degrees of differential phase distortion.

Two different types of demodulated R-Y displays, known as ''single trace'' and ''double trace'' displays, can be used to make this measurement. As described below, different measurement techniques are used with the two displays. In the 1781R, these modes are both accessed by selecting DIFF PHASE in the MEASURE menu. The SINGLE/DOUBLE touchscreen selection determines which of the two displays will appear.

Single Trace Method

In the single trace mode, distortions are quantified by comparing the R-Y waveform to a vertical graticule scale. To make a measurement, first use the vectorscope display to set the signal vector to the reference 9 o'clock phase position. Use the vectorscope variable gain control to bring the signal vector out to the edge of the vectorscope graticule circle. In addition, make sure the 1781R's waveform monitor gain is in the calibrated (1 volt full scale) setting.

The R-Y display appears on the waveform (right-hand) screen in the 1781R. Each major division (100 mV) on the vertical graticule scale corresponds to one degree when the R-Y waveform is being displayed. As shown in Figure 67, you can determine the amount of peak-to-peak differential phase by measuring the largest vertical deviation between any two parts of the signal. To obtain peak results, measure how far positive and how far negative the signal extends from the level that corresponds to blanking level subcarrier.

Double Trace Method

The double trace method provides a more accurate way of measuring the tilt in a one-line sweep of the R-Y information. Instead of comparing the waveform to a graticule, you use the vectorscope's calibrated phase shifter to quantify the amount of distortion.

The double trace display, which also appears on the waveform screen in the 1781R, is produced by displaying the single trace R-Y information non-inverted for half the lines and inverted for the other half. Since phase changes affect the amplitude of the R-Y signal, the inverted and non-inverted traces can be moved vertically with respect to each other by shifting phase. Measurements can therefore be made by introducing calibrated amounts of phase shift with the vectorscope's phase control. The basic technique involves nulling the blanking level part of the signal by bringing the inverted and non-inverted traces together at that point. The amount of phase shift that is then required to overlay the two traces at the point of maximum level shift is the amount of differential phase.

Select DOUBLE in the 1781R DIFF PHASE mode to make this measurement. First look at the vectorscope screen and use the phase shifter to set the signal vector to the reference 9 o'clock phase position. Neither vectorscope nor waveform monitor gain is critical in this mode (see Note 18), but setting the vector to the graticule circle is a good starting point. Now refer to the waveform monitor (right-hand) screen, and use the phase shifter to overlay the blanking level portions of the two waveforms. Press REFerence SET to set the phase readout to 0.00 degree, as shown in Figure 68.

The next step is to use the phase shifter to overlay the point in the R-Y waveforms that deviates most from blanking level. As shown in Figure 69, the phase readout now indicates the amount of differential phase distortion. In this example the phase error is all in one direction so peak and peak-to-peak results will be the same. If the signal has both positive and negative phase errors (the R-Y signal extends both positive and negative from blanking), repeat the process for the largest positive and largest negative signal excursions.

The double trace technique is similar if you are using a 521A Vectorscope. Start by setting the ''calibrated phase'' dial to zero. Use the Aϕ or Bϕ goniometer to null the blanking level, and then use the **calibrated** phase shifter to null the largest excursion. The number above the calibrated phase dial will now give the amount of differential phase distortion.

VM700A Automatic Measurement

To make an automatic measurement of differential phase with the VM700A, select **DGDP** in the MEASURE mode. Both differential phase and differential gain are shown on the same display; the lower graph is differential phase. Measurement results are also available in the AUTO mode.

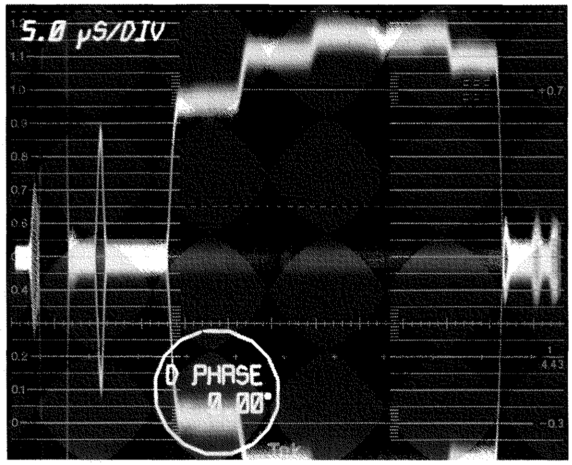


Figure 68. The 1781R double trace DIFF PHASE display; phase readout zeroed.

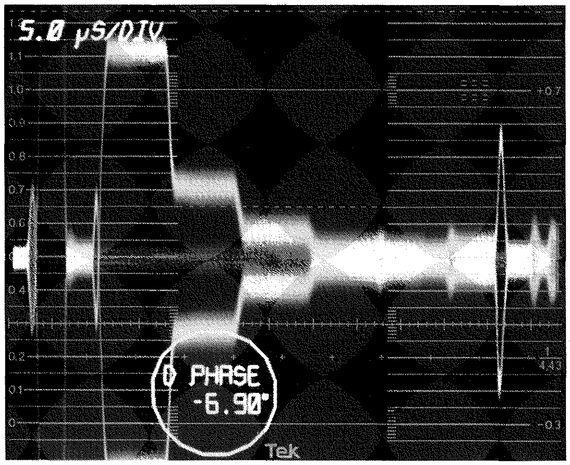


Figure 69. The double trace DIFF PHASE display showing results.

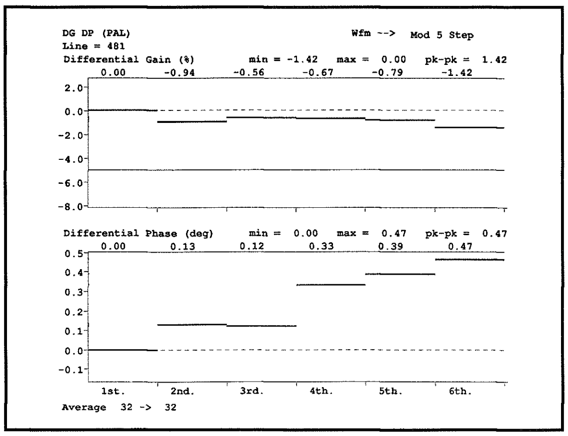


Figure 70. The VM700A DGDP display.

■ NOTES

18. 1781R Waveform & Vector Gains

In the single trace mode, the vector gain must be set so the signal vector extends to the graticule circle. The waveform gain must be in the calibrated (1 volt full scale) position. The graticule is calibrated to one degree per division only under these conditions.

With the double mode display, however, you can introduce more gain for greater resolution. Additional vectorscope gain and/or waveform vertical gain can be selected without affecting the results.

19. Noise Reduction Filter

A digital recursive filter is available in the 1781R to facilitate differential phase and gain measurements in the presence of noise. Select the NOISE REDUCTION ON touchscreen selection in the DIFF PHASE or DIFF GAIN menu to enable this filter. The filter removes about 15 dB of noise from the signal without any loss of bandwidth or horizontal resolution. This mode is particularly useful for VTR and transmitter measurements.

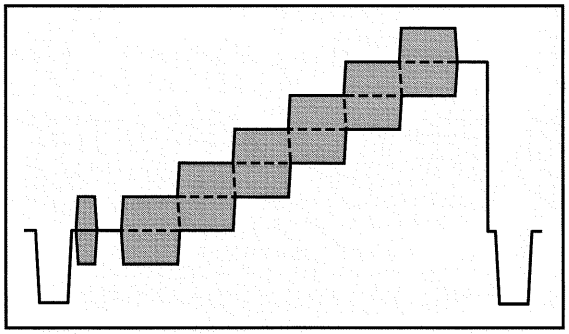


Figure 71. A Modulated 5-step Staircase test signal.

■ DEFINITION

Differential gain, which is often referred to as "diff gain" or "dG", is present if chrominance gain is dependent on luminance level. These amplitude errors are a result of the system's inability to uniformly process the high-frequency chrominance signal at all luminance levels.

Differential gain distortion is expressed in percent. Since both attenuation and peaking can occur in the same signal, it is important to specify whether the peak-to-peak amplitude difference or the peak deviation is being quoted. The reference for peak-to-peak results may be either the maximum chrominance amplitude or the amplitude of the chrominance packet at blanking level. Peak deviation measurements are generally referenced to the chrominance amplitude at blanking level.

PAL measurement standards generally refer to peak differential gain measurements. Two numbers are typically given to describe the amount of distortion: the peak positive deviation and the peak negative deviation in chrominance amplitude from the amplitude at blanking level. These numbers are expressed as a percentage of the blanking level chrominance amplitude. Sometimes the larger of the two values is given as a single peak result.

Differential gain should be measured at different APL levels; the worst distortion should be quoted.

■ PICTURE EFFECTS

When differential gain is present, colour saturation is not correctly reproduced. (Colour saturation is determined by the relationship between the amplitudes of the chrominance and luminance portions of the signal, so saturation is affected whenever this ratio is not correctly transferred through the system.) Differential gain is generally most noticeable in reds and yellows.

■ TEST SIGNALS

This distortion is measured with a test signal which consists of uniform-amplitude chrominance superimposed on different luminance levels. A Modulated Staircase (5 or 10 step) or a Modulated Ramp is typically used.

Some generators, such as the Tektronix TSG-271, offer a phase-alternate Modulated Ramp test signal. This signal can help you detect distortions which have affected the U and V components differently, which is most likely to occur if the signal has been demodulated and the U and V components passed through separate processing channels. If this signal is available, you may wish to repeat the measurement procedures outlined below for both signal vectors.

■ MEASUREMENT METHODS

Differential gain distortions can be quantified in a number of ways. Chrominance amplitudes can be measured directly with a waveform monitor, and large distortions can be seen on a vectorscope display. For precision measurements, however, a vectorscope with a special DIFF GAIN mode or an automatic measurement set such as the VM700A is required.

Vectorscope Display

In a vectorscope display, the dots corresponding to the various subcarrier packets will spread out in the radial direction when differential gain is present. (If you are using a ramp signal, the dot will become elongated in the horizontal direction.) To make a measurement, first set the phase of the signal vector to the reference position. Use the vectorscope variable gain control to bring the signal vector out to the graticule circle.

Vectorscope graticules generally have special dϕ and dG marks on the left-hand side to help quantify the distortion, so you can read the peak-to-peak gain deviation directly from the graticule. It is difficult to obtain a peak reading from this display since there is no convenient method of establishing which amplitude corresponds to the amplitude at blanking level.

Waveform Monitor/Chrominance Filter

Differential gain measurements can also be made with a waveform monitor. This process is facilitated by enabling the chrominance filter, which passes only the high-frequency chrominance portion of the signal. Peak-to-peak chrominance amplitudes can be easily compared in the resulting display.

To make a measurement, first normalise the peak-to-peak amplitude of the first chrominance packet (the one at blanking level) to 100 percent. Then measure the peak-to-peak amplitudes of the smallest and largest packets. The positive and negative peak differential gain results are the differences between these two measurements and the blanking level amplitude. Equations are given below.

$$\text{Peak dG (Negative)} = -100 \left| [V_{pp}\text{ (Blanking)} - V_{pp}\text{ (Smallest Packet)}] / V_{pp}\text{ (Blanking)} \right| \%$$
$$\text{Peak dG (Positive)} = +100 \left| [V_{pp}\text{ (Blanking)} - V_{pp}\text{ (Largest Packet)}] / V_{pp}\text{ (Blanking)} \right| \%$$

This measurement can also be made by using the 1781R's voltage cursors in the RELATIVE mode. Define the peak-to-peak amplitude of the blanking level packet as 100%, and then move the cursors to measure peak-to-peak amplitude of the smallest and largest packets. Use the equations above to calculate results.

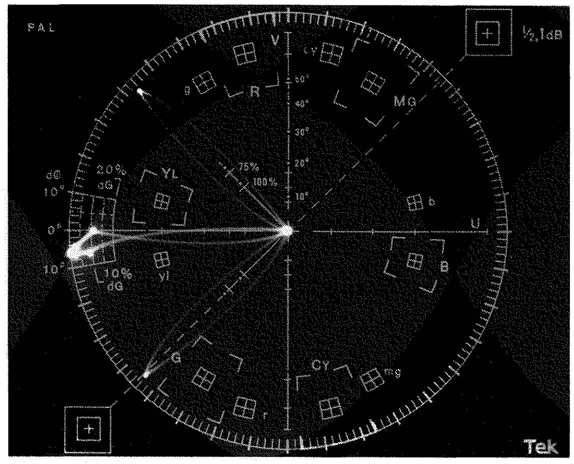


Figure 72. A vectorscope display of a signal with 10% peak-to-peak differential gain. (Differential phase distortion is also present.)

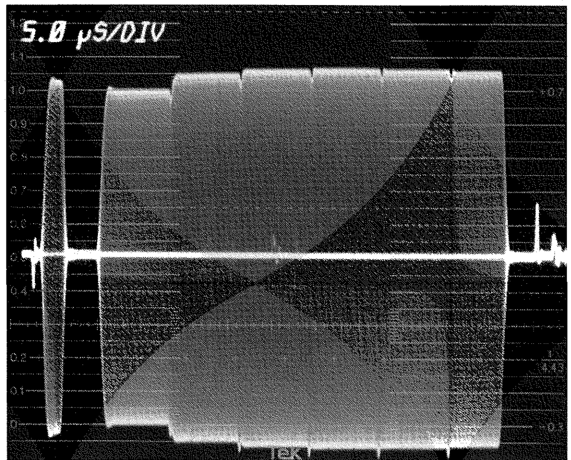


Figure 73. A chrominance filter display indicating about 6% differential gain.

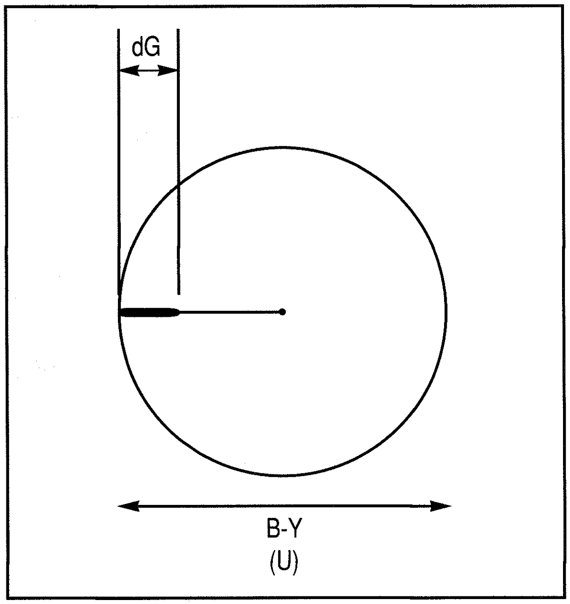


Figure 74. Differential gain distortion affects the B-Y (U) signal.

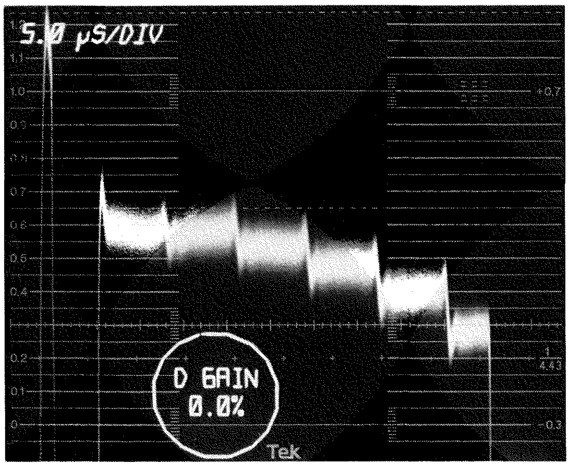


Figure 75. A single trace DIFF GAIN display, indicating a distortion of about 3%.

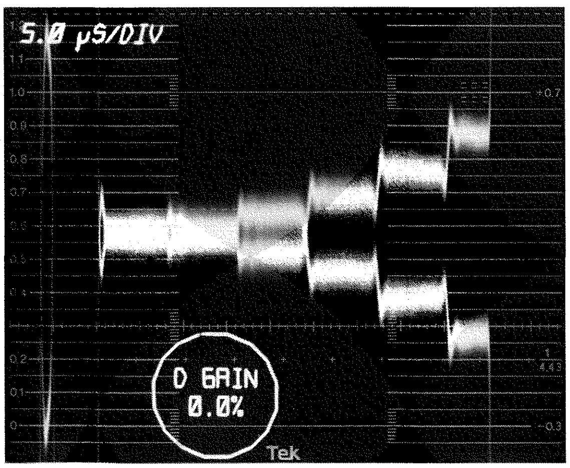


Figure 76. The 1781R double trace DIFF GAIN display; readout zeroed.

B-Y Sweep

Some vectorscopes are equipped with a special mode for making accurate differential gain measurements. Since differential gain affects the B-Y (U axis) signal (See Figure 74), a line-rate sweep of demodulated B-Y information can be used to measure the amount of distortion. Errors manifest themselves as tilt or level changes across the line. Like the R-Y display used to measure differential phase, this display provides greater resolution and lets you see how the distortion varies over a line. In the 1781R, both ''single trace'' and ''double trace'' versions of this display are available. Both are accessed by selecting DIFF GAIN in the MEASURE menu.

Single Trace Method

The single trace differential gain display is familiar to users of the 521A vectorscope, and it is also available in the 1781R by selecting SINGLE in the DIFF GAIN menu. The amount of distortion is quantified by comparing the demodulated waveform to a vertical graticule scale.

The phase shifter should be used to set the signal vector to the reference (9 o'clock) position prior to making this measurement. Adjust the vectorscope variable gain control so the signal vector extends to the edge of the graticule circle. In addition, make sure the 1781R's waveform gain is in the calibrated (1 volt full scale) setting.

In the 1781R, the differential gain display appears on the waveform screen. Compare the waveform to the vertical scale on the graticule, and measure the largest deviation between the part of the signal that corresponds to blanking-level chrominance and the largest and smallest packets. One major graticule division (100 mV) is equal to one percent.

Double Trace Method

The double trace method in the 1781R provides a highly accurate way of measuring the amount of tilt or level shift in a one-line sweep of the B-Y information. This method is very similar to the differential phase double trace method described on page 50, but a calibrated gain control rather than a calibrated phase control is used to null the traces.

Select DOUBLE in the 1781R DIFF GAIN menu to make this measurement. Use the phase shifter to set the signal vector to the reference phase position. The vectorscope variable gain must be adjusted so the signal vector reaches the graticule circle. The 1781R waveform monitor gain setting is not critical in this mode, as described in Note 21.

Now refer to the waveform (right-hand) display, and start the measurement procedure by using the large knob to overlay the blanking level portions of the inverted and non-inverted waveforms. Press REFerence SET to set the readout to 0.00 percent, as shown in Figure 76. Now use the large knob to bring together the largest positive and/or negative excursions. As shown in Figure 77, the readout now indicates the amount of differential gain distortion.

VM700A Automatic Measurement

To make an automatic measurement of differential gain with the VM700A, select **DGDP** in the MEASURE mode. Both differential phase and differential gain are shown on the same display; the upper graph is differential gain. Measurement results are also available in the AUTO mode.

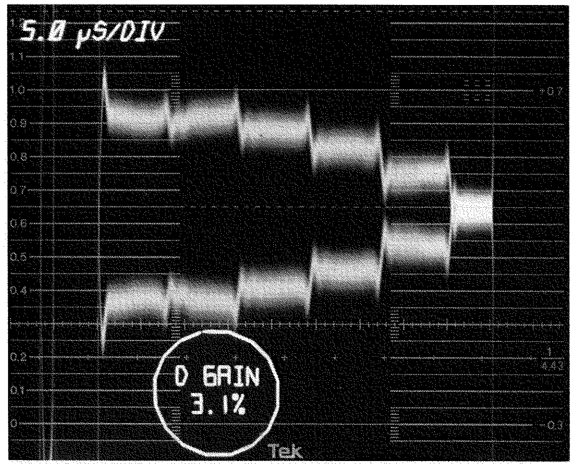


Figure 77. The 1781R double trace DIFF GAIN display showing results. (Attenuation only; peak and peak-to-peak results are the same.)

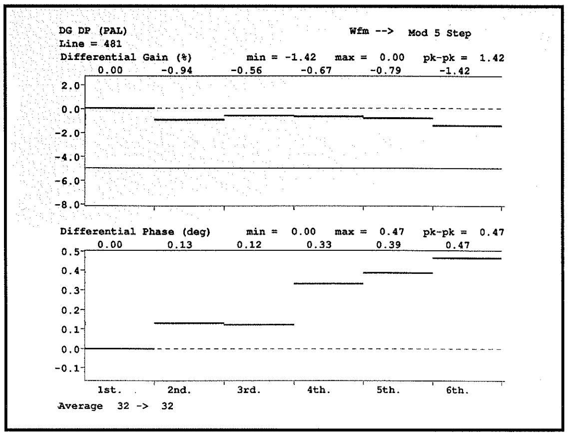


Figure 78. The VM700A DGDP display.

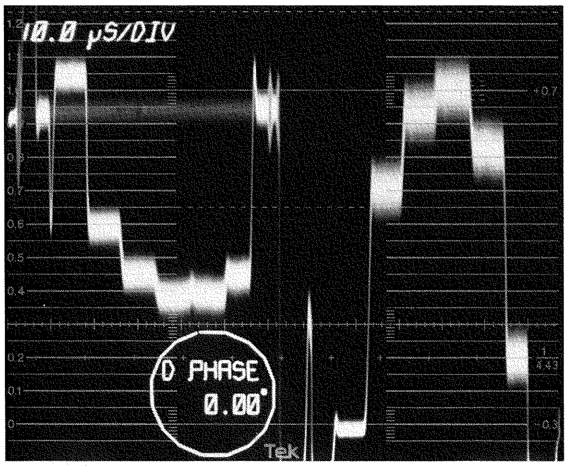


Figure 79. The 1781R DP & DG display.

■ NOTES

20. Demodulated "B-Y" Signal

It should be noted that in instruments such as the 521A Vectorscope and the 1781R, the displayed signal is not simply the B-Y demodulator output of the vectorscope. Rather, an envelope (square law) detector scheme is used. The demodulated signal is derived by multiplying the signal by itself rather than by a constant-phase CW subcarrier as in a synchronous demodulator. The primary advantage of this method is that in the presence of both differential phase and differential gain, synchronous detection yields a phase-dependent term, but square law detection does not. Thus the presence of differential phase does not affect the differential gain result.

21. 1781R Waveform & Vector Gains

If you are using the single trace mode, the vector gain must be set to the graticule circle and the waveform gain must be in the calibrated position. The graticule is only calibrated to 1 percent per division under these conditions.

In the double mode display, you can introduce more gain in the waveform vertical (X5 or VAR) for greater resolution. However, it is critical that the vectorscope gain be set to the graticule circle — you will not obtain correct results unless it is properly adjusted.

22. Simultaneous Display of DP and DG

It is sometimes useful to have a display which shows both differential phase and differential gain, particularly when you are trying to adjust a piece of equipment for minimum distortion. A display which shows a one-line sweep of differential phase on the left and a one-line sweep of differential gain on the right can be accessed by selecting DP & DG in the 1781R MEASURE menu. See Figure 79. As noted above, the VM700A DP DG display also shows both distortions simultaneously.

Luminance Non-Linearity

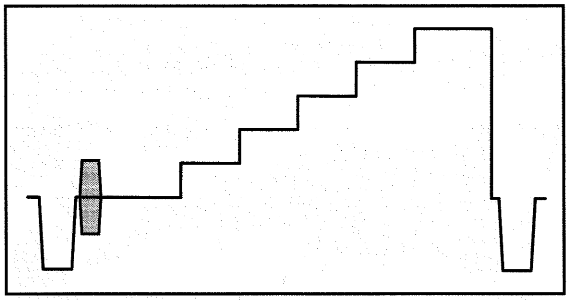


Figure 80. Unmodulated Staircase signal.

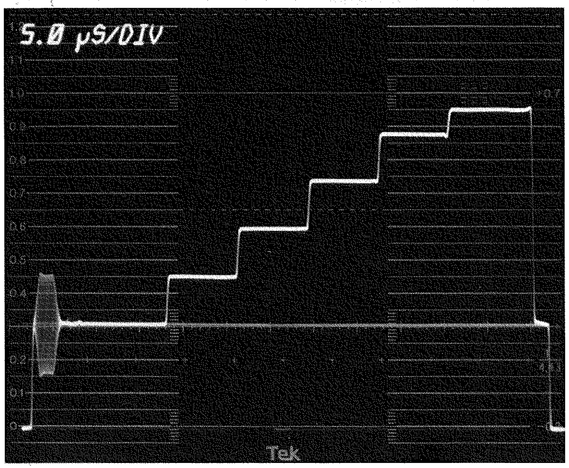


Figure 81. An example of luminance non-linearity distortion.

■ DEFINITION

Luminance non-linearity, or differential luminance, is present if luminance gain is affected by luminance level. In other words, there is a non-linear relationship between the input and output signals in the luminance channel. This amplitude distortion is a result of the system's inability to uniformly process luminance information over the entire amplitude range.

The amount of luminance non-linearity is expressed as a percentage. Measurements are made by comparing the amplitudes of the individual steps in a Staircase signal. The difference between the largest and smallest steps, expressed as a percentage of the largest step amplitude, is the amount of luminance non-linearity distortion. Measurements should be made at both low and high APL; the worst result should be quoted.

■ PICTURE EFFECTS

People are not particularly sensitive to luminance non-linearity in black and white pictures. If large amounts of distortion are present, however, you might notice loss of detail in the shadows and highlights. These effects correspond to crushing or clipping of the black and white.

In colour pictures, however, luminance non-linearity is often more noticeable. This is because colour saturation, to which the eye is more sensitive, is affected. (Colour saturation is affected whenever the ratio between chrominance and luminance amplitude is not accurately transferred through a system.)

■ TEST SIGNALS

Luminance non-linearity should be measured with a test signal which consists of uniform-amplitude luminance steps. Unmodulated 5 step or 10 step Staircase signals (without chrominance) are typically used.

If an unmodulated signal is not available, the measurement can also be made with a Modulated Staircase. This is generally not good practice, however, since both differential gain and luminance non-linearity can have the same net effect on the signal.

■ MEASUREMENT METHODS

Luminance non-linearities are quantified by comparing the step amplitudes of the test signal. Since the steps were initially all of uniform height, any differences are a result of this distortion. The waveform in Figure 81 exhibits luminance non-linearity distortion — note that the top step is shorter than the others.

Waveform Display

This measurement can be made with a waveform monitor by individually measuring each of the steps in the test signal. It is most convenient to use the variable gain to normalise the largest step to 100% (500 mV or 1 Volt) so percentage can be read directly from the graticule. Voltage cursors can also be used to measure the steps. Although this method can yield accurate results, it is very time-consuming and is therefore not frequently used in practice.

Waveform Monitor — Differentiated Step Filter

Some waveform monitors are equipped with a special filter, usually called a ''diff step'' filter, for measurement of luminance non-linearity. Since it provides an accurate and convenient method of evaluating this distortion, it is generally recommended practice to use such a filter for this measurement. External filters can be used if your waveform monitor is not equipped with the filter.

When the differentiated step filter is enabled, each step transition appears as a spike on the display. The amplitude of each spike is proportional to the corresponding step height, so the amount of distortion can be determined by comparing the spike amplitudes.

Either the waveform monitor graticule or the voltage cursors can be used to measure the spikes. Use the variable gain to normalise the largest spike amplitude to 100% if you are using the graticule. The difference between the largest and smallest spikes, expressed as a percentage of the largest, is the amount of luminance non-linearity.

The 1781R voltage cursors should be in the RELATIVE mode for this measurement. Define the largest spike amplitude as 100%. Leave one cursor at the top of the largest spike, and move the other cursor to the top of the smallest spike. The readout will indicate the amount of luminance non-linearity distortion, as shown in Figure 82.

VM700A Automatic Measurement

Select **Luminance NonLinearity** in the VM700A MEASURE menu to obtain a display of this distortion. Numeric results are also available in the AUTO mode. The VM700A uses an internal differentiated step filter to make this measurement.

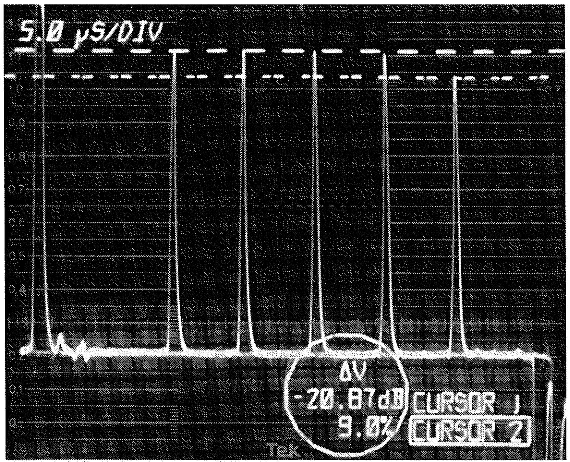


Figure 82. This photograph shows a 5 step Staircase after it has been passed through a differentiated step filter. The 1781R voltage cursors indicate 9% luminance non-linearity.

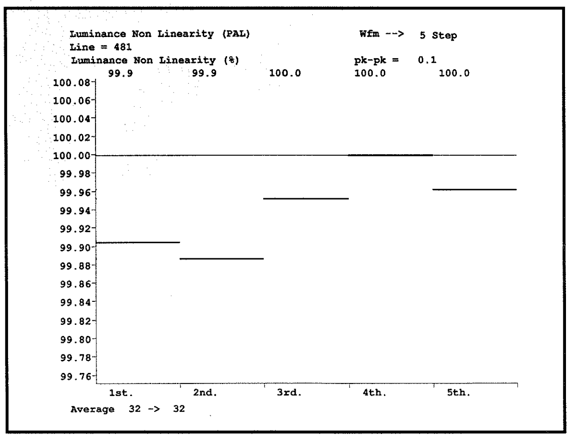


Figure 83. The VM700A Luminance NonLinearity display.

Chrominance Non-Linear Phase

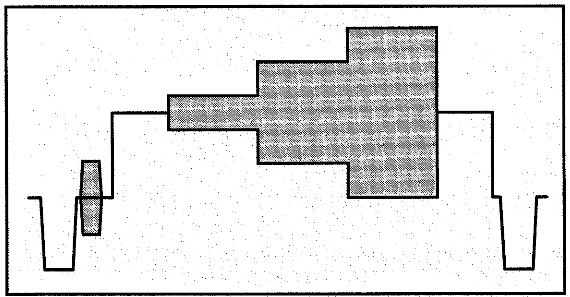


Figure 84. The Modulated Pedestal test signal.

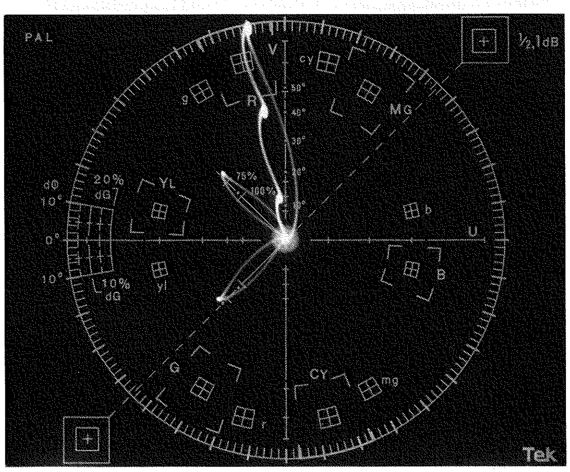


Figure 85. The 1781R vectorscope display showing a signal that suffers from chrominance non-linear phase distortion.

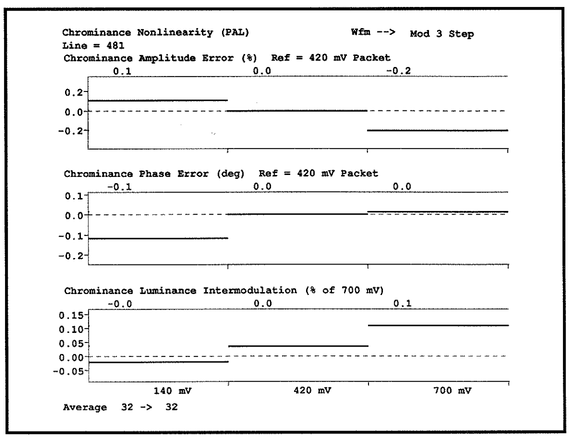


Figure 86. The VM700A Chrominance NonLinearity display.

■ DEFINITION

Chrominance non-linear phase distortion is present if a signal's chrominance phase is affected by chrominance amplitude. These phase errors are a result of the system's inability to uniformly process all amplitudes of high-frequency chrominance information.

Chrominance non-linear phase distortion is expressed in degrees of subcarrier phase. This parameter should be measured at different APL levels; the worst result is quoted as the amount of distortion.

■ PICTURE EFFECTS

Like differential phase, the effects of chrominance non-linear phase are averaged out in delay-line PAL decoders. Hue shifts therefore cannot be detected in the picture.

■ TEST SIGNAL

A Modulated Pedestal signal, sometimes called a three-level chrominance bar, is used to measure this distortion. This signal consists of three different chrominance packets with the same phase, on the same luminance level (350 mV above blanking), with different amplitudes (140, 420 and 700 mV peak-to-peak). This signal element is sometimes part of combination signals used as ITS.

■ MEASUREMENT METHODS

Chrominance non-linear phase is quantified by measuring the phase differences between the chrominance packets of the modulated pedestal signal.

Vectorscope

Since phase information is required, a vectorscope is used to measure chrominance non-linear phase. Examine the three dots (which correspond to the three chrominance packets) and measure the maximum phase difference between the three signal vectors. As shown in Figure 85, this is easiest if you use the vectorscope variable gain to bring the largest vector out to the graticule circle. If you are using a 1781R or a 521A Vectorscope, the calibrated phase shifter can be used to obtain a precise reading.

VM700A Automatic Measurement

Select **Chrominance NonLinearity** in the VM700A MEASURE mode to obtain a display of this distortion. The display also includes two other distortions; the middle display shows chrominance non-linear phase. See Figure 86. Numeric results are also available in the VM700A AUTO mode.

■ DEFINITION

Chrominance non-linear gain distortion is present if chrominance gain is dependent on chrominance amplitude. In other words, the proportionality between input and output chrominance amplitudes does not remain constant as the input amplitude is varied.

Chrominance non-linear gain distortion is expressed as a percentage. The amplitude of the middle packet is normalised to its nominal value. The other two packets are then measured, and the amount of distortion for each packet is the deviation from nominal amplitude, expressed as percentage of the nominal amplitude. The largest of the two resulting numbers is generally taken as the overall result.

This distortion should be measured at different APL levels, and the worst distortion should be quoted.

■ PICTURE EFFECTS

Chrominance non-linear gain is often seen as attenuation of relatively high amplitude chrominance signals. It will appear in the TV picture as incorrect colour saturation.

■ TEST SIGNAL

A Modulated Pedestal signal, sometimes called a three-level chrominance bar, is used to measure this distortion. This signal consists of three different chrominance packets with the same phase, on the same luminance level (350 mV above blanking), with different amplitudes (140, 420 and 700 mV peak-to-peak). This signal element is sometimes part of combination signals used as ITS.

■ MEASUREMENT METHODS

Chrominance non-linear gain distortion is quantified by measuring how much the amplitudes of the chrominance packets deviate from their nominal values.

Waveform Monitor

The waveform monitor graticule should be used for this measurement — the 1781R voltage cursors do not lend themselves to this procedure. First use the waveform monitor variable gain to normalise the middle subcarrier packet to its prescribed value of 420 mV. The amount of chrominance non-linear gain distortion is the largest deviation from nominal value for the other two packets, expressed as a percentage of the nominal amplitude of the affected packet.

VM700A Automatic Measurement

Select **Chrominance NonLinearity** in the VM700A MEASURE menu to make this measurement. Chrominance non-linear gain is shown on the upper graph. This parameter can also be measured in the VM700A AUTO mode.

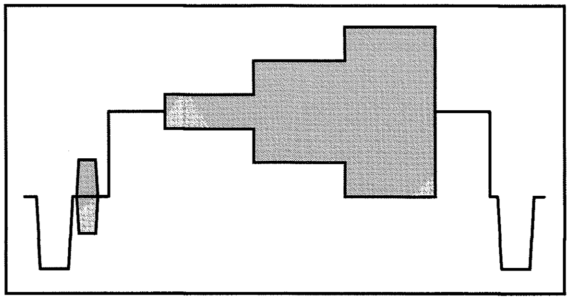


Figure 87. The Modulated Pedestal test signal.

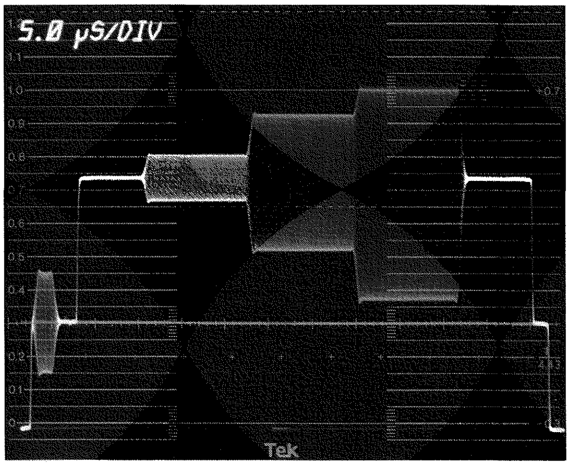


Figure 88. This signal exhibits chrominance non-linear gain distortion. Note that the amplitude of the largest packet is reduced.

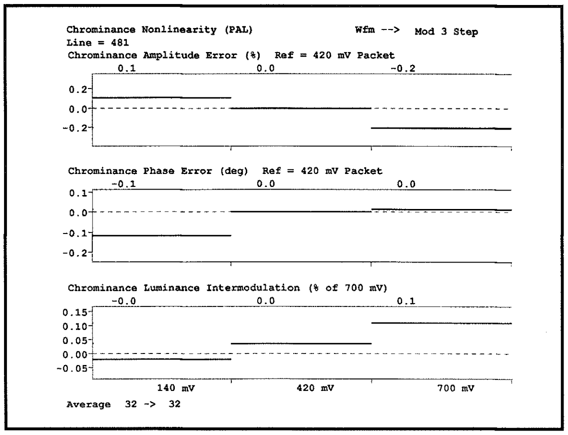


Figure 89. The VM700A Chrominance NonLinearity display.

■ NOTES

23. Chroma Filter

It is sometimes recommended that you enable the chroma filter on your waveform monitor when measuring chrominance non-linear gain. While the chroma filter will make the display more symmetrical, you should obtain the same results either way since you are measuring peak-to-peak amplitudes. A possible exception is a case where chrominance harmonic distortion is present. The chrominance filter can remove the effects of harmonic distortion, which are likely to be different for different packets.

■ DEFINITION

Chrominance-to-luminance intermodulation, also known as cross-talk or cross-modulation, is present when luminance amplitude is affected by superimposed chrominance. The luminance change may be caused by clipping of high-amplitude chrominance peaks, quadrature distortion, or various crosstalk and inter-modulation effects.

The deviation in the pedestal level may be expressed:

- As a percentage of the pedestal level
- As a percentage of the measured white bar amplitude
- As a percentage of 700 millivolts

These definitions will yield different measurement results under some conditions, so it is very important to standardize on a single method of making intermodulation measurements.

■ PICTURE EFFECTS

When intermodulation distortion is present, colour saturation will not be accurately represented in affected pictures.

■ TEST SIGNALS

A Modulated Pedestal signal, sometimes called a three-level chrominance bar, is used to measure this distortion. This signal consists of three different chrominance packets with the same phase, on the same luminance level (350 mV above blanking), with different amplitudes (140, 420 and 700 mV peak-to-peak). This signal element is sometimes part of combination signals used as ITS.

■ MEASUREMENT METHODS

Chrominance-to-luminance intermodulation is quantified by measuring the effects that chrominance packets of different amplitudes have on the luminance level which they are superimposed on. This process is facilitated by removing the chrominance information from the display with a waveform monitor filter.

Waveform Monitor

The chrominance information can be filtered off with either the LUMinance or LOWPASS filter in the 1781R. The Y display of the 521A Vectorscope also works well.

Details of the measurement method will depend on how you choose to express the amount of distortion. In general, you must first use the variable gain on your waveform monitor to normalise the appropriate part of the signal. Then measure the largest level shift in the top of the pedestal.

The 1781R voltage cursors can be used in the relative mode to make this measurement. In Figure 91, the level shift is 8.5% of the pedestal level.

VM700A Automatic Measurement

Select **Chrominance NonLinearity** in the VM700A MEASURE menu to measure chrominance-to-luminance intermodulation. This parameter is shown on the lower graph.

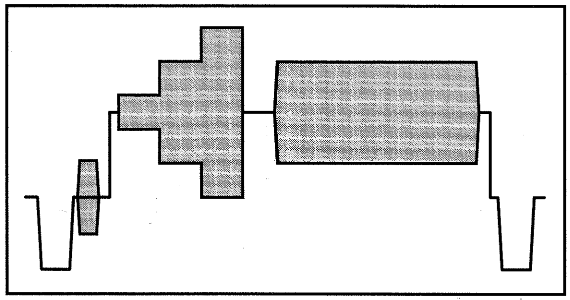


Figure 90. This combination ITS contains the Modulated Pedestal signal element (CCIR Line 331).

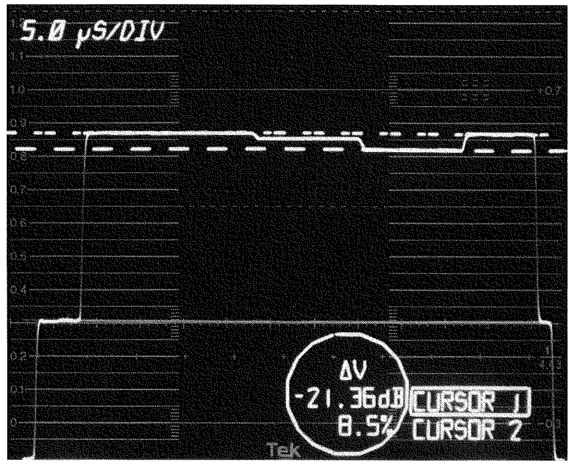


Figure 91. A chrominance-to-luminance intermodulation distortion of 8.5% referenced to the pedestal level.

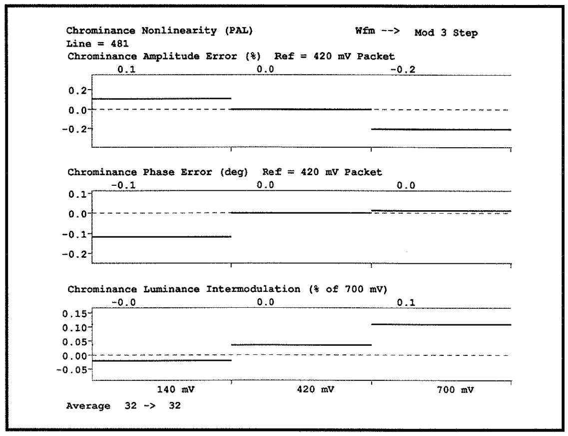


Figure 92. The VM700A Chrominance NonLinearity mode includes chrominance-to-luminance inter-modulation results.

Transient Sync Gain Distortion

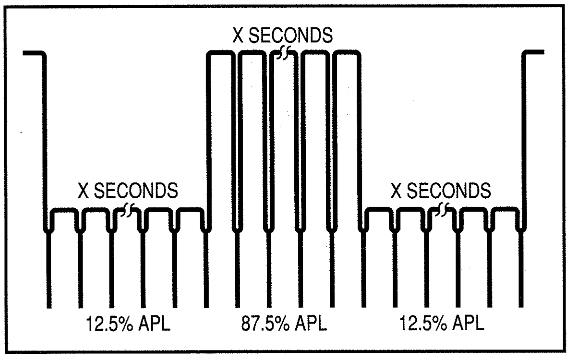


Figure 93. Flat Field Bounce test signal.

■ DEFINITION

Transient sync gain distortion, also referred to as transient non-linearity, is present when abrupt changes in APL temporarily affect sync amplitude. The amount of distortion is defined as the maximum transient departure in the amplitude of sync from the amplitude which existed before the change in APL. It is generally expressed as a percentage of the original amplitude, but some standards specify the distortion as a percentage of the largest amplitude.

Measurement of this distortion requires an out-of-service test. Both low-to-high APL changes and high-to-low APL changes should be evaluated.

■ PICTURE EFFECTS

Sudden switches between high APL and low APL pictures can cause transient brightness or saturation effects in the picture.

■ TEST SIGNAL

Use a Flat Field signal (black burst with pedestals) to make this measurement. A generator with a ''bounce'' feature can be used to make the APL switches, but be sure the time interval between switches is considerably longer than any transient effect.

■ MEASUREMENT METHODS

Transient gain changes are measured by abruptly changing APL and observing the transient effects on a waveform monitor.

Waveform Monitor

This distortion is easiest to evaluate if you look at the test signal on a waveform monitor with the differentiated step filter selected. (Recall that this filter produces spikes with amplitudes proportional to the step amplitudes.) Be sure the DC restorer is turned OFF for this measurement.

Depending on the nature of the distortion, you may be able to observe it when the waveform monitor is in the field sweep mode. Otherwise it will be necessary to use the 1781R's SLOW SWEEP mode. (Some 1481 Waveform Monitors are equipped with Option 7 SLOW SWEEP.) A waveform photograph may make the measurement easier.

Adjust the waveform monitor variable gain to set the amplitude of the positive spike which corresponds to the trailing edge of sync equal to 100%. Switch between extreme APL levels, typically 12.5% and 87.5%. The resulting envelope of the sync spikes represents the transient distortion. Measure the maximum departure from 100% to obtain the amount of transient sync non-linearity.

The 1781R voltage cursors can also be used to make this measurement. In the relative mode, define the positive sync spike as 100%. Then use the cursors to measure the largest deviation from that amplitude.

■ DEFINITION

Steady-state gain distortion of the sync signal is present when horizontal sync amplitude is dependent on APL. This parameter is evaluated by measuring sync amplitude at high and low APL (typically 12.5% and 87.5%). The amount of distortion may be expressed as a percentage of the amplitude at 50% APL, or as a percentage of the maximum amplitude. This is an out-of-service test.

Steady-state gain distortion of the picture signal is also sometimes measured. In this case APL dependencies of a 700 mV white bar are evaluated.

■ PICTURE EFFECTS

If only sync is affected, small amounts of static gain distortion will not be noticeable in the picture. Large amounts of distortion may affect the ability of some equipment to derive synchronisation information and/or to clamp the signal. If the picture signal is also affected, luminance levels will be APL-dependent if this type of distortion is present.

■ TEST SIGNAL

Any test signal with variable APL can be used to measure steady-state sync gain. A 700 mV signal element such as a white bar is required for steady-state picture gain measurements.

■ MEASUREMENT METHODS

Waveform Monitor

To make a measurement, first select 50% APL and use the waveform monitor variable gain to set the sync amplitude to 100%. Vary the APL of the signal to 12.5%, and then to 87.5%. At each APL level, record the amplitude of sync. The peak-to-peak variation for the three APLs, expressed in percent, is typically quoted as the steady-state sync gain distortion. This measurement can be made with the 1781R voltage cursors in the RELATIVE mode. Figures 95 and 96 illustrate the measurement procedure.

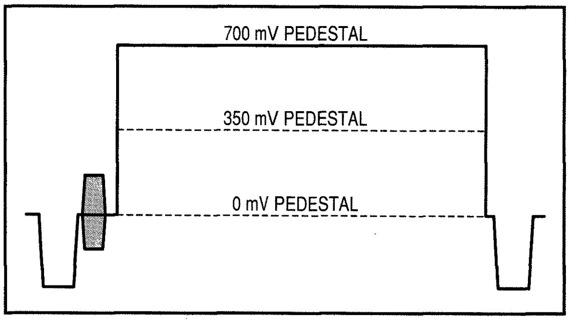


Figure 94. A Staircase signal with variable APL.

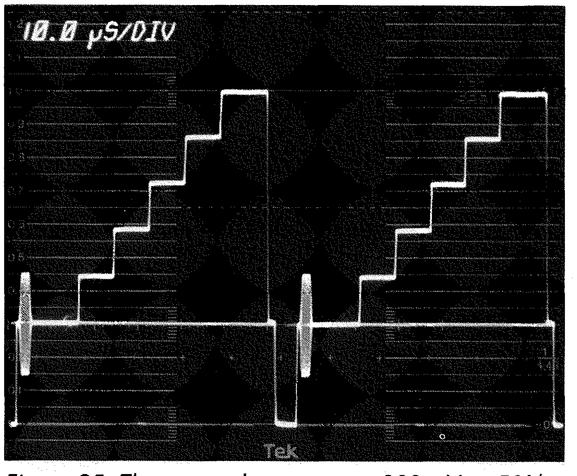


Figure 95. The sync pulse measures 300 mV at 50% APL.

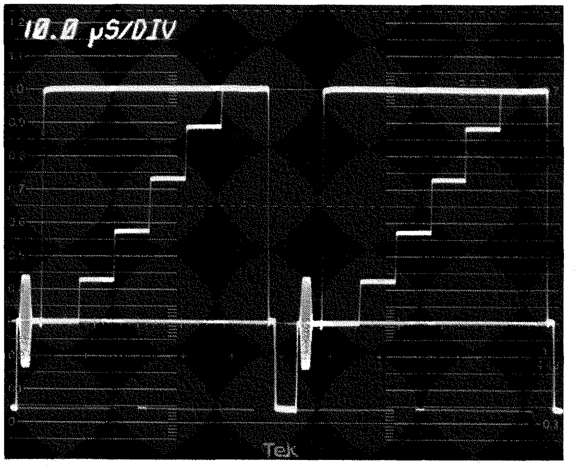


Figure 96. At 87.5% APL, the sync pulse measures 260 mV. This indicates a steady-state distortion of about 13%.

IV. NOISE MEASUREMENTS

The electrical fluctuations which we refer to as noise form a very complex signal, and this signal does not lend itself to straightforward amplitude measurements. A number of special techniques have therefore been developed for measuring noise. A comprehensive discussion of noise measurement is outside the scope of this publication, but some of the methods which apply to television systems are discussed in this section.

Special filters are generally required for noise measurements. These filters are used to separate the noise into its various frequency components for analysis. Each measurement standard typically calls for three or four measurements made with various combinations of the filters, but specifications for the filters vary from standard to standard.

The tangential method of noise measurement, which is useful for making operational measurements of random noise, is the only method discussed in detail in this publication. While not the most accurate technique, the tangential measurement can provide a quick way of keeping track of your system's noise performance over time. Tangential noise measurements are made with a specially equipped waveform monitor. This feature is standard in the 1781R and available as a field-installable option (1480F30) for the 1481 Waveform Monitor.

Specialised equipment is required if you wish to completely characterise the noise performance of your system. Until recently, these capabilities were available only in dedicated noise measurement instruments. The VM700A, however, makes them available as part of a package which addresses most other measurement needs. It can function as a complete, self-contained noise measurement set with filters implemented in software. The noise measurement features of the VM700A are briefly reviewed in this section.

■ DEFINITION

Noise refers to the fluctuations which are present in any electrical system. Noise can be either random or coherent, and comes from a variety of natural and man-made sources. Although there is always some noise present, an excessive amount is undesirable since it tends to degrade or obscure the signal of interest.

Signal amplitudes do not always remain constant as the video signal is processed and transmitted. An absolute measurement of noise is therefore not particularly relevant — a certain amount of noise will have very different effects on signals of different amplitudes.

Since it is the amount of noise relative to the signal amplitude rather than the absolute amount of noise that tends to cause problems, we typically work with signal-to-noise ratios, expressed in dB.

■ PICTURE EFFECTS

Noisy pictures often appear grainy or snowy, and sparkles of colour may be noticeable. Extremely noisy signals may be difficult for equipment to synchronise to, and the picture may suffer from blurriness and a general lack of resolution.

■ TEST SIGNALS

The tangential method can be used on any video signal which has a portion with a constant luminance level a few microseconds long with no superimposed chrominance. The measurement can be made on a single line in the vertical interval, although full-field measurements are somewhat easier to make and more accurate.

Any line with a constant pedestal level can be used to make VM700A **Noise Spectrum** measurements. A quiet line in the vertical interval is typically used.

The VM700A **Chrominance AMPM** noise measurement requires a Red Field test signal, which is shown in Figure 97.

■ MEASUREMENT METHODS

Tangential Method

Tangential noise measurements can be made with a 1781R, or with a 1481 with a 1480F30 kit installed. The method is accurate to about 1 or 2 dB, down to noise levels of about 60 dB. Filters can be inserted in the AUX OUT/AUX IN path to separate noise components of different frequencies.

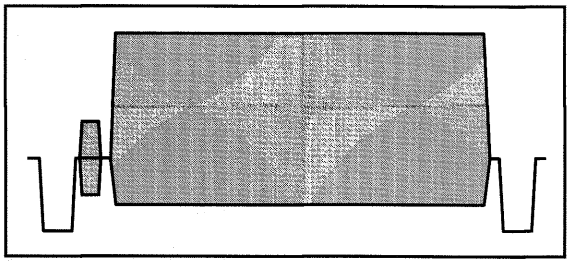


Figure 97. The Red Field test signal.

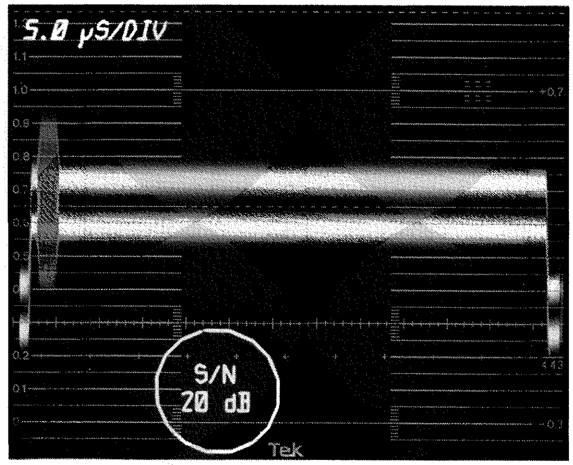


Figure 98. The 1781R tangential noise measurement mode, showing excessive trace separation.

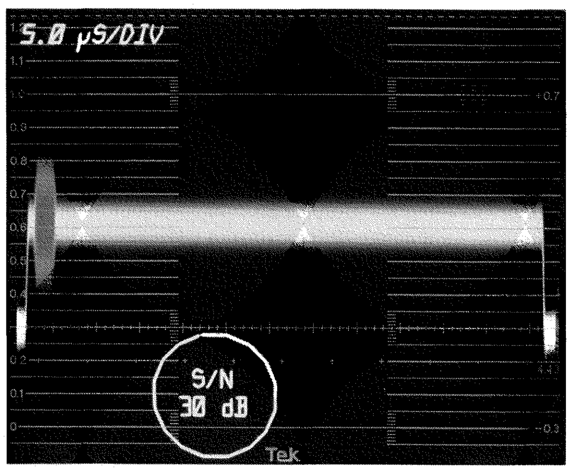


Figure 99. Properly adjusted separation; this signal has a signal-to-noise ratio of 30 dB.

Signal-to-Noise Ratio

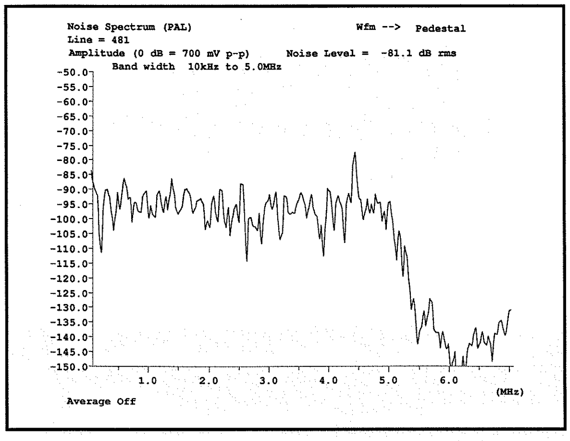


Figure 100. The VM700A Noise Spectrum display.

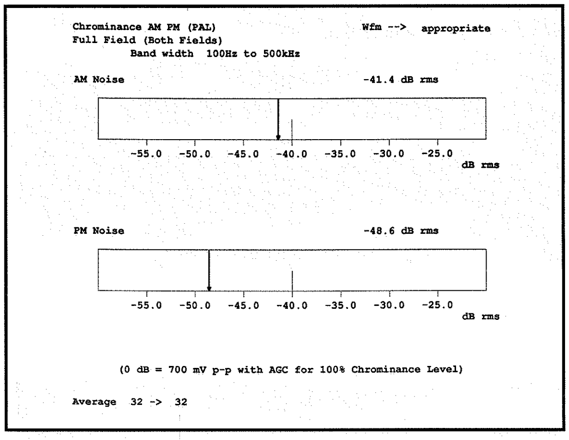


Figure 101. The VM700A Chrominance AMPM display.

To configure your waveform monitor for a measurement, make sure the FLAT filter is selected (unless you are using the AUXiliary filter capability). Set the DC restorer to OFF or FAST, and select NOISE in the 1781R MEASURE menu. If you are using a 1481, use the WAVEFORM COMPARISON mode to split the luminance level of interest in half and overlay the two parts. (This is not necessary if you are using a 1781R. Two complete waveforms will appear on the screen.)

The measurement is made by adjusting the separation between the two traces until the dark area between them just disappears. When there is no perceptible dip in brightness between the two traces, the calibrated offset level (in dB) is the amount of noise. In the 1781R, the large knob is used to control the offset and the onscreen readout provides the dB reading. In the 1481, the offset function is performed by the two dB NOISE controls in the lower right-hand corner. The dB reading is obtained from the knob settings.

VM700A Automatic Measurement

Select **Noise Spectrum** in the VM700A MEASURE menu to make signal-to-noise measurements. A spectral display as well as numeric results are provided in this mode, as shown in Figure 100.

Several lowpass, highpass and weighting filters are available in this mode. Measurement standards typically require three or four measurements made with various combinations of these filters.

The rms signal-to-noise ratio of the entire spectrum is always displayed in the upper right-hand corner of the display. A cursor can be used to select a certain frequency for a peak-to-peak noise measurement. The cursors can also be used to define a narrow range of frequencies for S/N measurements.

The **Chrominance AMPM** selection in the VM700A MEASURE mode, which requires a Red Field test signal, provides information about the noise that affects the chrominance portion of the signal. Since the chrominance signal is sensitive to both amplitude (AM) and phase (PM) components of noise, two separate measurements are provided. A selection of filters is available in this mode.

Noise measurements are also available in the VM700A AUTO mode.

■ NOTES

24. Quiet Lines

"Quiet lines" in the vertical interval are sometimes used to evaluate the amount of noise introduced in a certain part of the transmission path. A line is re-inserted (and is therefore relatively noise free) at the transmitting end of the path of interest. This ensures that any noise measured on that line at the receiving end was introduced in that part of the path.

V. TRANSMITTER MEASUREMENTS

In this section, we discuss two parameters which should be monitored and adjusted at the transmitter — depth of modulation and ICPM. These two measurements are commonly made with time domain instruments such as waveform monitors or oscilloscopes. Most of the other tests for characterising transmitter performance are made with a spectrum analyser, and are not addressed in this publication.

In order to make these measurements, you need a high-quality demodulator such as the Tektronix 1450. This instrument provides two kinds of demodulation — envelope and synchronous. Unlike envelope detectors, synchronous detectors are not affected by the quadrature distortion inherent in the vestigial sideband transmission system. For measurement purposes, the effects of quadrature distortion should be removed so they do not obscure distortions from other sources. A quadrature output is available when the instrument is operating in the synchronous detection mode. Envelope detection is most similar to the demodulation used in most home receivers, and is therefore available in instruments such as the 1450.

The 1450 produces a zero carrier reference pulse, which provides the reference level required for depth of modulation measurements. This pulse is created at the demodulator by briefly reducing the amplitude of the RF signal to the zero carrier level prior to demodulation.

For more information on the 1450, see Tektronix Application Note No. 28 (20W-4177-2), ***Testing and Using Synchronous Demodulators.***

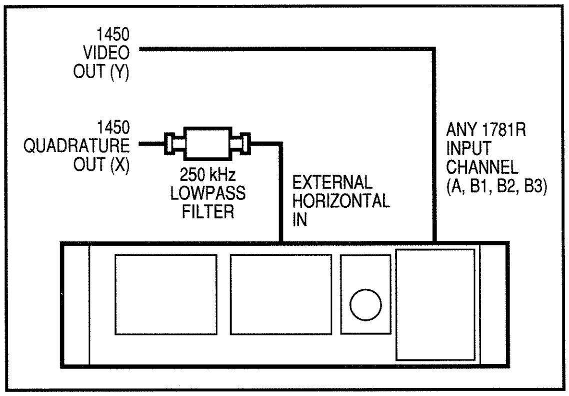


Figure 102. How to hook up the 1781R for ICPM measurements.

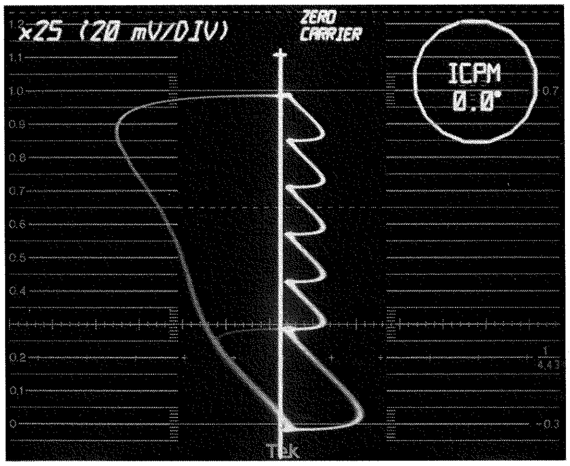


Figure 103. 1781R display; no ICPM distortion.

■ DEFINITION

ICPM (Incidental Carrier Phase Modulation) is present when picture carrier phase is affected by video signal level. ICPM distortion is expressed in degrees, using the following definition:

ICPM = arctan (quadrature amplitude/video amplitude)

■ PICTURE EFFECTS

The effects of ICPM will depend on the type of demodulation used to recover the baseband signal from the transmitted signal. ICPM shows up in synchronously demodulated signals as differential phase and many other types of distortions, but the baseband signal is generally not as seriously affected when envelope detection is used. The effects of ICPM are therefore rarely seen in the picture in home receivers, which use envelope detection.

However, ICPM may manifest itself as audio buzz at the home receiver. In the intercarrier sound system, the picture carrier is mixed with the FM sound carrier to form a sound IF. Audio rate phase modulation in the picture carrier can therefore be transferred into the audio system and heard as a buzzing noise.

■ TEST SIGNAL

An Unmodulated Staircase signal, either 5 or 10 steps, is used to measure ICPM. An Unmodulated Ramp signal can also be used.

■ MEASUREMENT METHODS

ICPM is measured by examining an XY plot of VIDEO OUT versus QUADRATURE OUT when the demodulator is operating in the synchronous mode. A phase error will produce an output from the quadrature detector. If this phase error varies with amplitude, the result is a tilted display. The 1450 must be properly configured for this measurement — make sure the zero carrier reference pulse is turned on, and select the synchronous detection mode. Select the SLOW time constant.

Waveform Monitor

To obtain an ICPM display with a waveform monitor, connect VIDEO OUT from the demodulator to one of the vertical channels of the waveform monitor, and QUADRATURE OUT to EXT HORIZ IN. Select EXT HORIZ on the 1481 front panel, or ICPM in the 1781R MEASURE menu.

Although it is not strictly necessary, it is generally recommended that the signals be lowpass-filtered to make the display easier to interpret. With either the 1781R or the 1481, this can be accomplished in the vertical channel by selecting the LOWPASS filter. Use an external 250 kHz lowpass filter for the horizontal. (Tektronix part number 015-0352-00 is available for this purpose.) Figure 102 shows a typical measurement setup.

The display resulting from this configuration, which appears on the right-hand screen in the 1781R, is shown in Figure 103. The amount of tilt (deviation from the vertical) is an indication of ICPM. There is no ICPM in the signal shown in Figure 103, while distortion is present in Figure 104. To adjust for minimum ICPM, make the line as nearly vertical as you can.

The 1781R has an electronic graticule which can be used to quantify the amount of tilt. The waveform should be positioned so the small dot corresponding to the zero carrier reference pulse is set on the cross at the top of the screen. The horizontal magnification will automatically be set to X25 when you select this mode; X50 can be used for greater resolution. Start with the two graticule lines widely separated, and use the large knob to move them together to the point where a graticule line first contacts one of the dots. (Disregard the ''loops'' — these correspond to the level transitions and are not indicative of distortion.) The amount of ICPM distortion is indicated on the screen, as shown in Figure 104.

An external ICPM graticule is available for the 1481. Position the zero carrier reference pulse, which shows up as a small dot, on the cross at the top of the graticule. The graticule is calibrated for 2 degrees per radial division when the horizontal magnifier is set to X25, or 1 degree per division with 50X horizontal magnification. Read the amount of ICPM from the graticule at the point of greatest distortion.

VM700A Automatic Measurement

The **ICPM** selection in the VM700A's MEASURE mode provides a display and numeric results, and an ICPM measurement is also provided in the AUTO mode. The quadrature output must be connected to Channel C of the VM700A to make ICPM measurements.

■ NOTES

25. Configuring the 1481

1481 instruments are shipped with unblanking disabled in the EXTERNAL HORIZONTAL mode to prevent damage to the CRT. ICPM measurements can be made in line select with the instrument in this mode, but for full-field measurements you must move a jumper as described in the OPERATING CHANGES section of the 1481 manual.

26. Other XY Displays

Any XY display can be used to measure ICPM. Connect QUADRATURE OUT to the horizontal and VIDEO OUT to the vertical, and use the formula given on page 68 to calculate the amount of distortion. For small errors, some amount of gain will be needed to improve the measurement resolution. Lowpass filters in both channels are recommended.

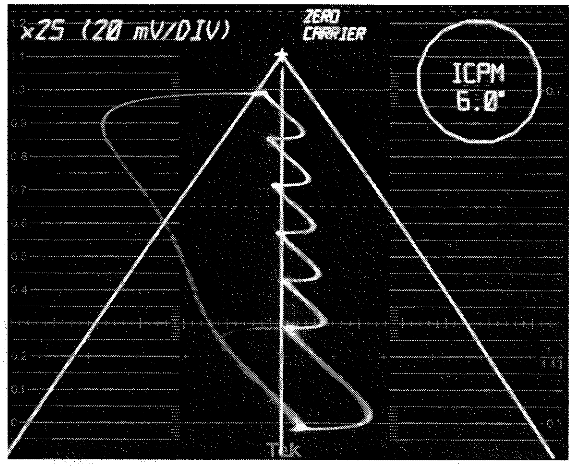


Figure 104. 1781R electronic graticule indicating an ICPM distortion of 6 degrees.

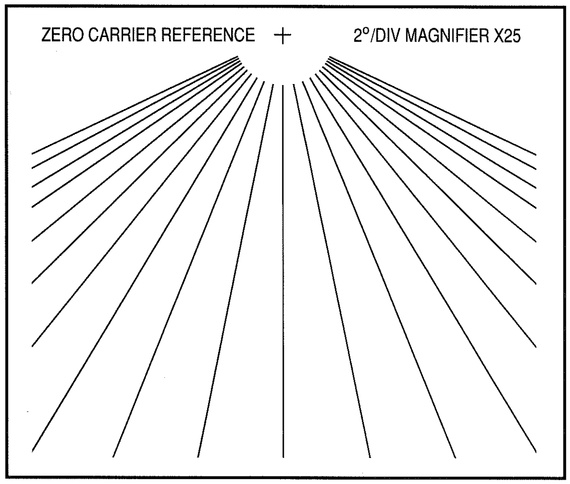


Figure 105. 1481 ICPM graticule.

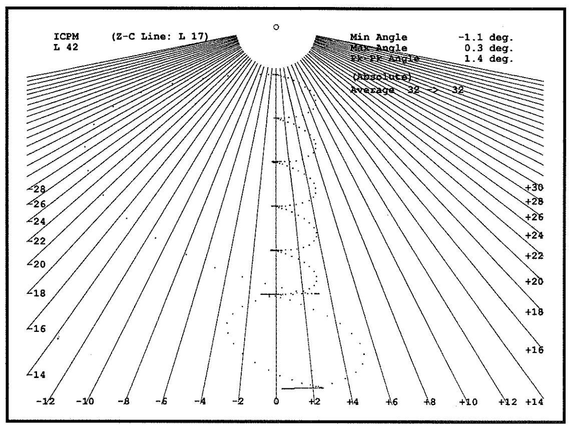


Figure 106. The VM700A ICPM display.

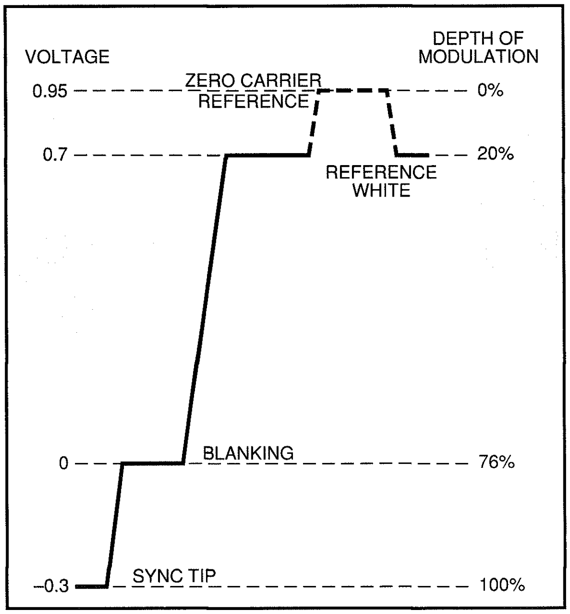


Figure 107. Depth of modulation levels.

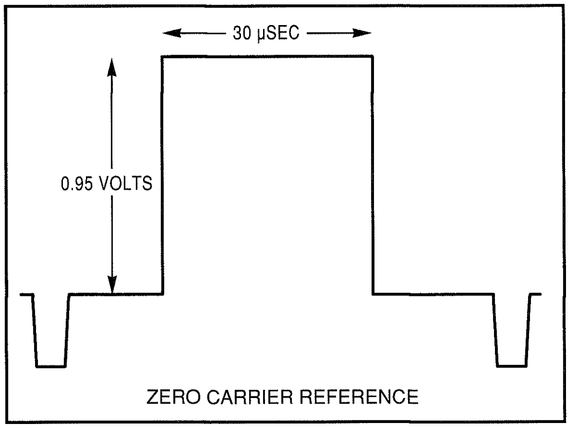


Figure 108. The zero carrier reference pulse as it appears in a baseband signal.

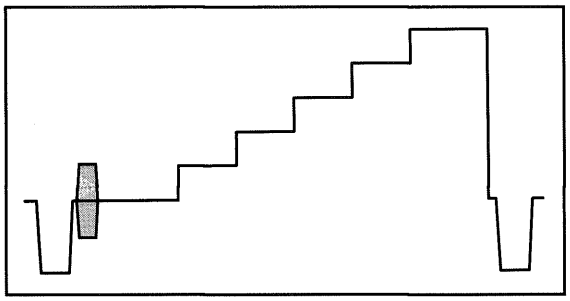


Figure 109. A signal which extends to 700 mV, such as this Staircase signal, is used in conjunction with the zero carrier pulse to verify modulation levels.

■ DEFINITION

Depth of modulation (percentage of modulation) measurements indicate whether or not video signal levels are properly represented in the RF signal.

The PAL modulation scheme yields an RF signal that reaches its maximum peak-to-peak amplitude at sync tip (100%). In a properly adjusted signal, blanking level corresponds to 76% and white to 20%. The zero carrier reference level corresponds to 0%, as shown in Figure 107.

■ PICTURE EFFECTS

Overmodulation often shows up as non-linear distortions such as differential phase and gain, and picture effects therefore correspond to those caused by the various distortions. ICPM or white clipping may also result. Undermodulation often results in degraded signal-to-noise performance.

■ TEST SIGNAL

A signal with black and white levels is required for depth of modulation measurements. This signal is used in conjunction with the zero carrier reference pulse, which the demodulator typically places on one line in the vertical interval. In the composite signal the zero carrier pulse appears as a 0.95 volt (above blanking) bar approximately 30 microseconds in duration. See Figure 108.

■ MEASUREMENT METHODS

Modulation depth is measured at the output of a precision demodulator by verifying that the ratios between the parts of the signal are correct. Overall amplitude is not critical, but it should be adjusted in the system to be approximately 1.25 volts from sync tip to zero carrier at 100% transmitter power. This will minimise the effects of non-linearities in the measurement system.

Waveform Monitor

Depth of modulation can be measured with a waveform monitor graticule. Use the variable gain if necessary, and position the zero carrier reference pulse at 1.25 volts and sync tip at 0 volts. Verify that blanking level and white level occur at the prescribed points (0.3 and 1.0 volts respectively). The voltage cursors can also be used for this measurement.

■ NOTES

27. Envelope Detection Mode

Depth of modulation measurements should be made with the 1450 in the envelope detection mode to minimise effects of ICPM. (Quadrature distortion will not affect modulation depth.)

AC-COUPLED A connection which removes the constant voltage (DC component) on which the signal (AC component) is riding. Implemented by passing the signal through a capacitor.

AM Amplitude Modulation (AM) is the process by which the amplitude of a high-frequency carrier is varied in proportion to the signal of interest. In the PAL television system, AM is used to encode the colour information and to transmit the picture.

Several different forms of AM are differentiated by various methods of sideband filtering and carrier suppression. Double sideband suppressed carrier is used to encode the PAL colour information, while the signal is transmitted with a large-carrier vestigial sideband scheme.

APL Average Picture Level. The average signal level (with respect to blanking) during active picture time, expressed as a percentage of the difference between the blanking and reference white levels.

BACK PORCH The portion of the video signal that lies between the trailing edge of the horizontal sync pulse and the start of the active picture time. Burst is located on back porch.

BANDWIDTH The range of frequencies over which signal amplitude remains constant (within some limit) as it is passed through a system.

BASEBAND Refers to the composite video signal as it exists before modulating the picture carrier. Composite video distributed through a studio and used for recording is at baseband.

BLACK BURST Also called "colour black", black burst is a composite video signal consisting of all horizontal and vertical synchronisation information and burst. Typically used as the house reference sychronisation signal in television facilities.

BLANKING LEVEL Refers to the 0.3 volt level (with respect to sync tip) which exists before and after horizontal sync and during the vertical interval.

BREEZEWAY The portion of the video signal that lies between the trailing edge of the horizontal sync pulse and the start of burst. Breezeway is part of back porch.

BROAD PULSES Another name for the vertical synchronising pulses in the center of the vertical interval. These pulses are long enough to be distinguished from all others, and are the part of the signal actually detected by vertical sync separators.

BRUCH BLANKING A 4-field burst blanking sequence employed in PAL signals to ensure that burst phase is the same at the end of each vertical interval.

BURST A small reference packet of the subcarrier sine wave sent during the horizontal blanking interval on every line of video. Since the carrier is suppressed, this phase and frequency reference is required for synchronous demodulation of the colour difference signals in the receiver.

B-Y One of the colour difference signals used in the PAL system, obtained by subtracting luminance (Y) from the blue camera signal (B).

CHROMINANCE Chrominance refers to the colour information in a television picture. Chrominance can be further broken down into two properties of colour, hue and saturation.

CHROMINANCE SIGNAL The high-frequency portion of the video signal, obtained by quadrature amplitude modulation of a 4.43 MHz subcarrier with R-Y and B-Y information.

COLOUR BLACK See Black Burst.

COLOUR DIFFERENCE SIGNALS Signals used by colour television systems to convey colour information in such a way that the signals go to zero when there is no colour in the picture. U and V are colour difference signals.

COMPONENT VIDEO Video which exists in the form of three separate signals, all of which are required in order to completely specify the colour picture. For example: R, G and B or Y, R-Y and B-Y.

COMPOSITE VIDEO A single video signal containing all of the necessary information to reproduce a colour picture. Created by adding quadrature amplitude modulated U and V to the luminance signal.

CW Continuous Wave. Refers to a separate subcarrier sine wave used for synchronisation of chrominance information.

dB (DECIBEL) A decibel is a logarithmic unit used to describe signal ratios. For voltages, $dB = 20 \log_{10} (V_1 / V_2)$.

DC-COUPLED A connection configured so that both the signal (AC component) and the constant voltage on which it is riding (DC component) are passed through.

DC RESTORER A circuit used in picture monitors and waveform monitors to clamp one point of the waveform to a fixed DC level.

DEMODULATOR In general, this term refers to any device which recovers the original signal after it has modulated a high frequency carrier. In television, it may refer to:

(1) An instrument, such as a Tektronix 1450, which takes video in its transmitted form (modulated onto the picture carrier) and converts it to baseband.

(2) The circuits that recover U and V from the composite signal.

EQUALISER The pulses that occur before and after the broad pulses in the vertical interval.

ENVELOPE DETECTION A demodulation process in which the shape of the RF envelope is sensed. This is the process used by a diode detector.

FIELD In interlaced scan systems, the information for one picture is divided up into two fields. Each field contains half of the lines required to produce the entire picture. Adjacent lines in the picture are in alternate fields.

FM Frequency Modulation (FM) is the process by which the frequency of a carrier signal is varied in proportion to the signal of interest. In the PAL television system, audio information is transmitted using FM.

FRAME A frame (sometimes called a ''picture'') contains all the information required for a complete picture. For interlaced scan systems, there are two fields in a frame.

FRONT PORCH The portion of the video signal between the end of active picture time and the leading edge of horizontal sync.

GAMMA Since picture monitors have a non-linear relationship between the input voltage and brightness, the signal must be correspondingly predistorted. Gamma correction is always done at the source (camera) in television systems: the R, G and B signals are converted to $R^{1/\gamma}$, $G^{1/\gamma}$ and $B^{1/\gamma}$. Values for gamma range from 2.2 to 2.8.

GENLOCK The process of locking both sync and burst of one signal to sync and burst of another, making the two signals completely synchronous.

HARMONIC DISTORTION If a sine wave of a single frequency is put into a system, and harmonic content at multiples of that frequency appears at the output, there is harmonic distortion present in the system. Harmonic distortion is caused by non-linearities in the system.

HORIZONTAL BLANKING Horizontal blanking is the entire time between the end of the active picture time of one line and the beginning of active picture time of the next line. It extends from the start of front porch to the end of back porch.

HORIZONTAL SYNC Horizontal sync is the −300 mV pulse occurring at the beginning of each line. This pulse tells the picture monitor to go back to the left side of the screen and trace another horizontal line of picture information.

HUE Hue is the property of colour that allows us to distinguish between colours such as red, yellow, purple, etc.

HUM Hum refers to the undesirable coupling of the 50 Hz power sine wave into other electrical circuits.

INTERCARRIER SOUND A method used to recover audio information in the PAL system. Sound is separated from video by beating the sound carrier against the video carrier, producing a 5.5 MHz IF that contains the sound information.

ITS Insertion Test Signal. A test signal which is inserted in one line of the vertical interval to facilitate in-service testing.

LINEAR DISTORTION Refers to distortions that are independent of signal amplitude.

LUMINANCE The signal which represents brightness, or the amount of light in the picture. This is the only signal required for black and white pictures, and for colour systems it is obtained as a weighted sum ($Y = 0.3R + 0.59G + 0.11B$) of the R, G and B signals.

MODULATED When referring to television test signals, this term implies that chrominance information is present. (For example, a modulated ramp has sub-carrier on each step.)

MODULATION A process which allows information to be moved around in the frequency domain in order to facilitate transmission or frequency-domain multiplexing. See AM and FM for details.

NON-LINEAR DISTORTION Refers to distortions that are amplitude-dependent.

NTSC National Television System Committee. The organisation that developed the television standard currently in use in the United States, Canada and Japan. Now generally used to refer to that standard.

PAL Phase Alternate Line. Refers to one of the television systems used in Europe and many other parts of the world. The phase of one of the colour difference signals alternates from line to line to help cancel out phase errors.

QUADRATURE AM A process which allows two signals to modulate a single carrier frequency. The two signals of interest Amplitude Modulate carrier signals which are the same frequency but differ in phase by 90 degrees (hence the Quadrature notation). The two resultant signals can be added together, and both signals recovered at the other end, if they are also demodulated 90 degrees apart.

QUADRATURE DISTORTION Distortion resulting from the asymmetry of sidebands used in vestigial sideband television transmission. Quadrature distortion appears when envelope detection is used, but can be eliminated by using a synchronous demodulator.

RF Radio Frequency. In television applications, RF generally refers to the television signal after the picture carrier modulation process.

RGB Red, Green and Blue. The three primary colours used in colour television's additive colour reproduction system. These are the three colour components generated by the camera and used by the picture monitor to produce a picture.

R-Y One of the colour difference signals used in the PAL system, obtained by subtracting luminance (Y) from the red camera signal (R).

SATURATION The property of colour which relates to the proportion of white light in the colour. Highly saturated colours are vivid, while less saturated colours have more white mixed in and therefore appear pastel. For example, red is highly saturated, while pink is the same hue but much less saturated.

In signal terms, saturation is determined by the ratio between luminance level and chrominance amplitude. It should be noted that a vectorscope does **not** display saturation: the length of the vectors represents chrominance amplitude. In order to verify that the saturation of the colours in a colour bar signal is correct, you must check luminance amplitudes with a waveform monitor in addition to observing the vectors.

SUBCARRIER Refers to the high-frequency signal used for quadrature amplitude modulation of the colour difference signals. For PAL, subcarrier frequency is 4,433,618.75 Hz.

SYNCHRONOUS DETECTION A demodulation process in which the original signal is recovered by multiplying the modulated signal with the output of a synchronous oscillator locked to the carrier.

TERMINATION In order to accurately send a signal through a transmission line, there must be an impedance at the end which matches the impedance of the source and of the line itself. Amplitude errors and reflections will otherwise result. Video is a 75 Ohm system, so a 75 Ohm terminator must be put at the end of the signal path.

U The B-Y signal after a weighting factor of 0.493 has been applied. The weighting is necessary to reduce peak modulation in the composite signal.

UNMODULATED When referring to television test signals, this term refers to pulses and pedestals which do not have high-frequency chrominance information added to them.

V The R-Y signal after a weighting factor of 0.877 has been applied. The weighting is necessary to reduce peak modulation in the composite signal.

VECTORSCOPE A specialised oscilloscope which demodulates the video signal and presents a display of V versus U. The angle and magnitude of the displayed vectors are respectively related to hue and saturation.

VERTICAL INTERVAL The synchronising information that appears between fields and tells the picture monitor to go back to the top of the screen to begin another vertical scan.

Y Abbreviation for luminance.

ZERO CARRIER REFERENCE A pulse in the vertical interval which is produced by the demodulator to provide a reference for evaluating depth of modulation.

APPENDIX A: PAL COLOUR BARS

There are several varieties of PAL colour bars, three of which are in common use. These three varieties, which are shown in Figure 110, are frequently referred to as 100% colour bars, 95% colour bars, and EBU colour bars. The 100% and 95% distinction refers to **saturation** in this case. However, this convention is not universal. The maximum amplitudes of the R, G and B signals are also sometimes used to describe the various types of bars. (Recall from page 9 that Tektronix vectorscopes use the 75%/100% designation to refer to amplitude.)

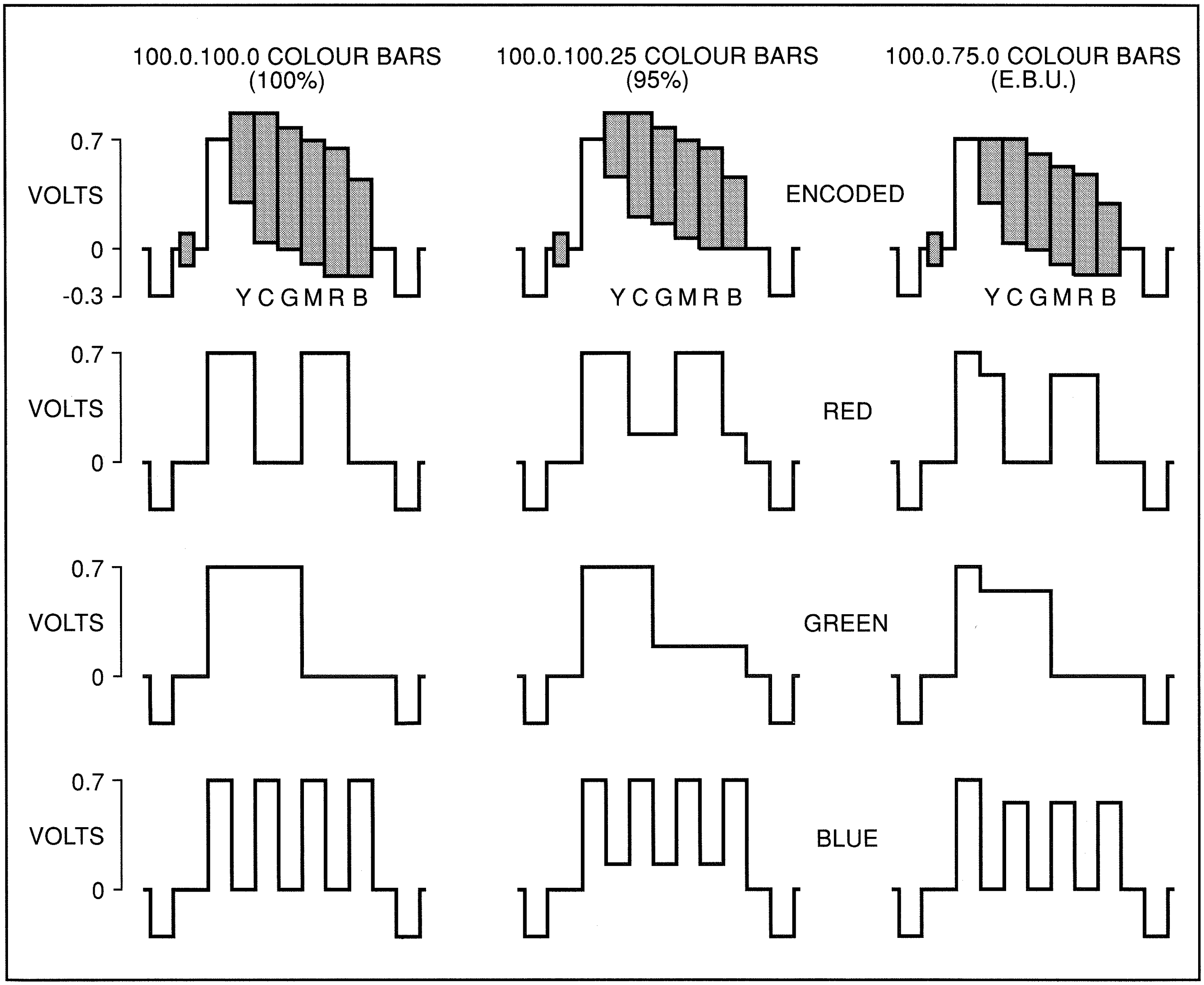


Figure 110. Waveforms and RGB voltages for three types of PAL colour bars.

Nomenclature

It is confusing to use a single number to distinguish between the various types of colour bars, particularly if it is not clear which parameter that number describes. Furthermore, a single number is inadequate to completely and uniquely define a given signal. For these reasons, a four-parameter system of colour bar specification has been developed. The following four parameters are used to describe the signal:

(a) Maximum value of E_R', E_G' or E_B' for an uncoloured bar.
(b) Minimum value of E_R', E_G' or E_B' for an uncoloured bar.
(c) Maximum value of E_R', E_G' or E_B' for a coloured bar.
(d) Minimum value of E_R', E_G' or E_B' for a coloured bar.

E_R', E_G' and E_B' are the three colour signals. Each parameter is specified as a percentage of the maximum voltage excursion allowable for PAL colour signals, which is 700 millivolts.

The three common types of bars can be uniquely described as 100.0.100.0 bars, 100.0.100.25 bars, and 100.0.75.0 bars with this system of nomenclature. These numbers can readily be correlated with the Red, Green and Blue signals corresponding to each type of colour bars. See Figure 110.

Saturation

Note that saturation is **not** included in this list of parameters. Saturation is a particularly difficult parameter to use for uniquely specifying a colour bar signal because it depends on the value of Gamma. Saturation is calculated as follows:

$$\text{Saturation}(\%) = [1-(E_{min}/E_{max})^{\gamma}] \times 100$$

Thus 100.0.100.25 colour bars have a saturation value of 95% if a value of 2.2 is used for Gamma. However, CCIR standards currently call for a Gamma value of 2.8, which yields a saturation value of 98% for 100.0.100.25 bars. Clearly, then, the saturation nomenclature is best avoided altogether.

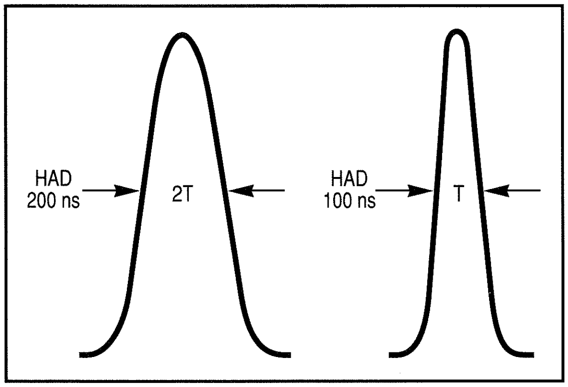


Figure 111. 2T pulse and 1T pulses for PAL systems.

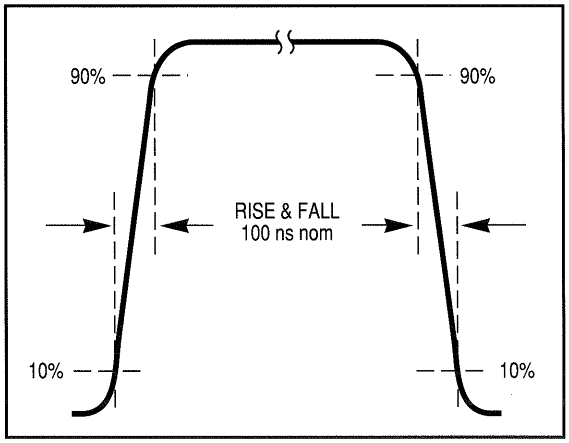


Figure 112. T rise time step.

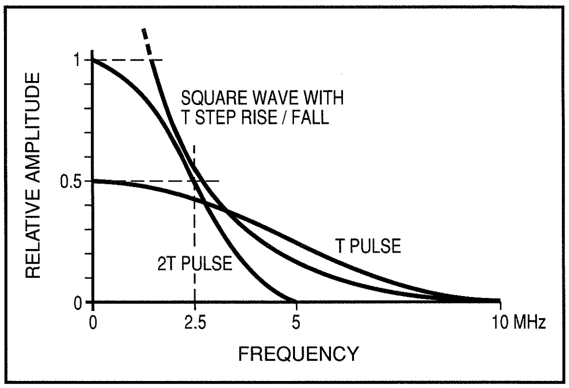


Figure 113. Frequency spectra of T pulse, 2T pulse, and T step.

Testing Bandlimited Systems

Fast rise time square waves cannot be used for testing bandlimited systems because attenuation and phase shift of out-of-band components cause ringing in the output pulse. These out-of-band distortions can obscure the inband distortions you are trying to measure. Sine-squared pulses are themselves bandwidth limited, and are thus useful for testing bandwidth limited systems.

Description of the Pulse

The sine-squared pulse looks like one cycle of a sine wave, as shown in Figure 111.

Mathematically, a sine-squared pulse is obtained by squaring a half-cycle of a sine wave. Physically, the pulse is generated by passing an impulse through a sine-squared shaping filter.

T Intervals

Sine-squared pulses are specified in terms of half amplitude duration (HAD), which is the pulse width measured at 50% of the pulse amplitude.

Pulses with HADs which are multiples of the time interval T are used to test bandwidth limited systems. T, 2T, 10T and 20T are common examples. T is the Nyquist interval, or $1/2f_c$, where f_c is the cutoff frequency of the system to be measured. For PAL systems, f_c is usually taken to be 5 MHz and T is therefore 100 nanoseconds. Most PAL test signals use this default value for T, even though the system under test may have a bandwidth of 5.5 or 6 MHz.

T Steps

The rise times of transitions to a constant luminance level (such as a white bar) are also specified in terms of T. A T step has a 10%-to-90% rise time of nominally 100 nanoseconds (see Figure 112), while a 2T step has a rise time of nominally 200 nanoseconds.

Mathematically, a T step is obtained by integrating a sine-squared pulse. (This is why the T step has a rise time that is only nominally equal to T. The integral actually yields a rise time of 0.964T for a T step.) Physically, it is produced by passing a step through a sine-squared shaping filter.

Energy Distribution

Sine-squared pulses possess negligible energy at frequencies above f = 1/HAD. The amplitude of the envelope of the frequency spectrum at 1/(2HAD) is one-half of the amplitude at zero frequency. Energy distributions for a T pulse, 2T pulse, and T step are shown in Figure 113.

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