Tech. 3244-E

Specifications of the radio data system RDS for VHF/FM sound broadcasting

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SPECIFICATIONS OF THE RADIO DATA SYSTEM RDS FOR VHF/FM SOUND BROADCASTING

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CONTENTS

Introduction

In the following, the main characteristics of the Radio-Data System "RDS" for VHF/FM sound broadcasting are given. These characteristics are the result of extensive work carried out under the auspices of the EBU, using the PI system developed by the Swedish Telecommunications Administration as a basis. This system is free of patents and it is hoped that the publication of this document will stimulate the development of radio-data receivers by industry and open the way for the provision of equipment satisfying the requirements of broadcasting organisations and listeners.

The system specified permits the inaudible insertion of auxiliary tuning and programme information into a monophonic or stereophonic VHF/FM broadcast using the frequency range 87.5-108 MHz. The specification is elaborated to be in conformity with CCIR Recommendation 450-1, and relates in the case of stereophony to the pilot-tone system only. Additionally, the proposed system is designed to achieve full compatibility with the ARI* system for the identification of VHF/FM broadcasts for motorists. This latter system was agreed within the EBU Technical Committee in 1974 (see Appendix 9). However the system described here is designed to have a much wider range of applications and it includes the ARI features as well.

The main objective of the system is to permit the realisation of automatic tuning features in new receivers which would primarily evaluate programme identification and alternative frequencies. In addition a programme service name, which can be shown on a small display in new receivers, is intended to inform the listener about the programme to which a given receiver is tuned. Other applications of the system are optional, so that a particular broadcasting organisation has the choice of realising features suiting its own requirements.

* Autofahrer Rundfunk Information (Broadcast information for motorists).

The information given in this specification is structured in the following manner:

Chapter 1 gives a description of the modulation characteristics of the system, while Chapter 2 deals with the baseband coding structure of the data to be transmitted. The transmission of these data is organised in a structure consisting of groups and blocks. The method of synchronisation to the structure is explained in some greater detail in Appendices 1, 2 and 3.

Chapter 3 explains the detailed codes chosen for the various applications listed in the glossary given in Chapter 4. Additional information relevant to the programme-identification codes, the character sets for the programme service name and radiotext and programme-type codes are given in Appendices 4, 5 and 6, respectively. Appendix 7 gives some information on the conversion between the date and time conventions adopted for coding, and the information to be displayed to the listener. The system also provides for ample flexibility for introducing additional undefined applications which are yet to be defined (see also Appendix 8).

The glossary of the terms in Chapter 4 is used for describing the various applications to be realised in the system in the most flexible manner, which means that no transmission capacity would be wasted if only a few of the numerous listed options were chosen in a particular case, and that additionally it would be feasible to add later any of the options which were not initially introduced, without creating a problem to a receiver respecting the specification. The glossary briefly reviews the various applications and is essential for understanding the terms used in describing the system.

The characteristics of the system are presented in this document according to the general principles of the ISO layer model [1].

CHAPTER 1

Modulation characteristics of the data channel (physical layer)

The radio-data system is intended for application to VHF/FM radio-broadcast transmitters in the range 87.5-108 MHz, which carry pilot-tone stereo or monophonic broadcasts (see CCIR Recommendation 450-1).

It is important that radio-data receivers are not affected by signals in the multiplex spectrum outside the data channel.

The system can be used simultaneously with the ARI system (see Appendix 9 and CCIR Report 463-3, § 4.3), even when both systems are broadcast from the same transmitter. However, certain constraints on the phase and injection levels of the radio-data and ARI signals must be observed in this case (see §§ 2 and 3).

The data signals are carried on a subcarrier which is added to the stereo multiplex signal (or monophonic signal as appropriate) at the input to the VHF/FM transmitter. Block diagrams of the data source equipment at the transmitter and a typical receiver arrangement are shown in Figs. 1 and 2, respectively.

1. Subcarrier frequency

During stereo broadcasts the subcarrier frequency (57 kHz) will be locked to the third harmonic of the pilot tone. Since the tolerance on the frequency of the 19-kHz pilot-tone is ± 2 Hz (see CCIR Recommendation 450-1), the tolerance on the frequency of the subcarrier during stereo broadcasts is ± 6 Hz.

During monophonic broadcasts the frequency of the subcarrier will be 57 kHz ± 6 Hz.

2. Subcarrier phase

During stereo broadcasts the subcarrier will be locked either in phase or in quadrature to the third harmonic of the 19-kHz pilot-tone, i.e. 57 kHz. The tolerance on this phase angle is ± 10°, measured at the modulation input to the FM transmitter.

In the case when ARI and radio-data signals are transmitted simultaneously, the recommended phase angle between the two subcarriers is 90° ± 10°.

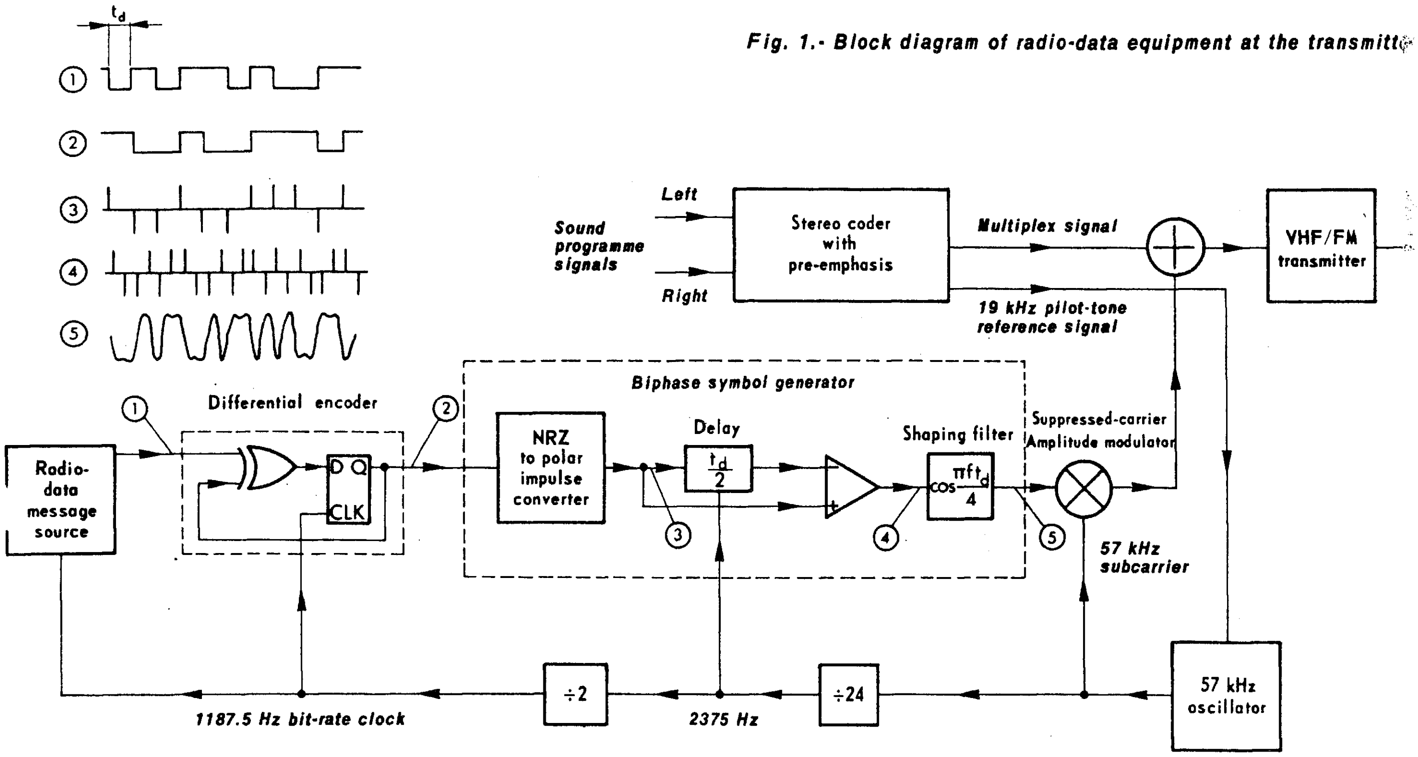

Fig. 1.- Block diagram of radio-data equipment at the transmitter

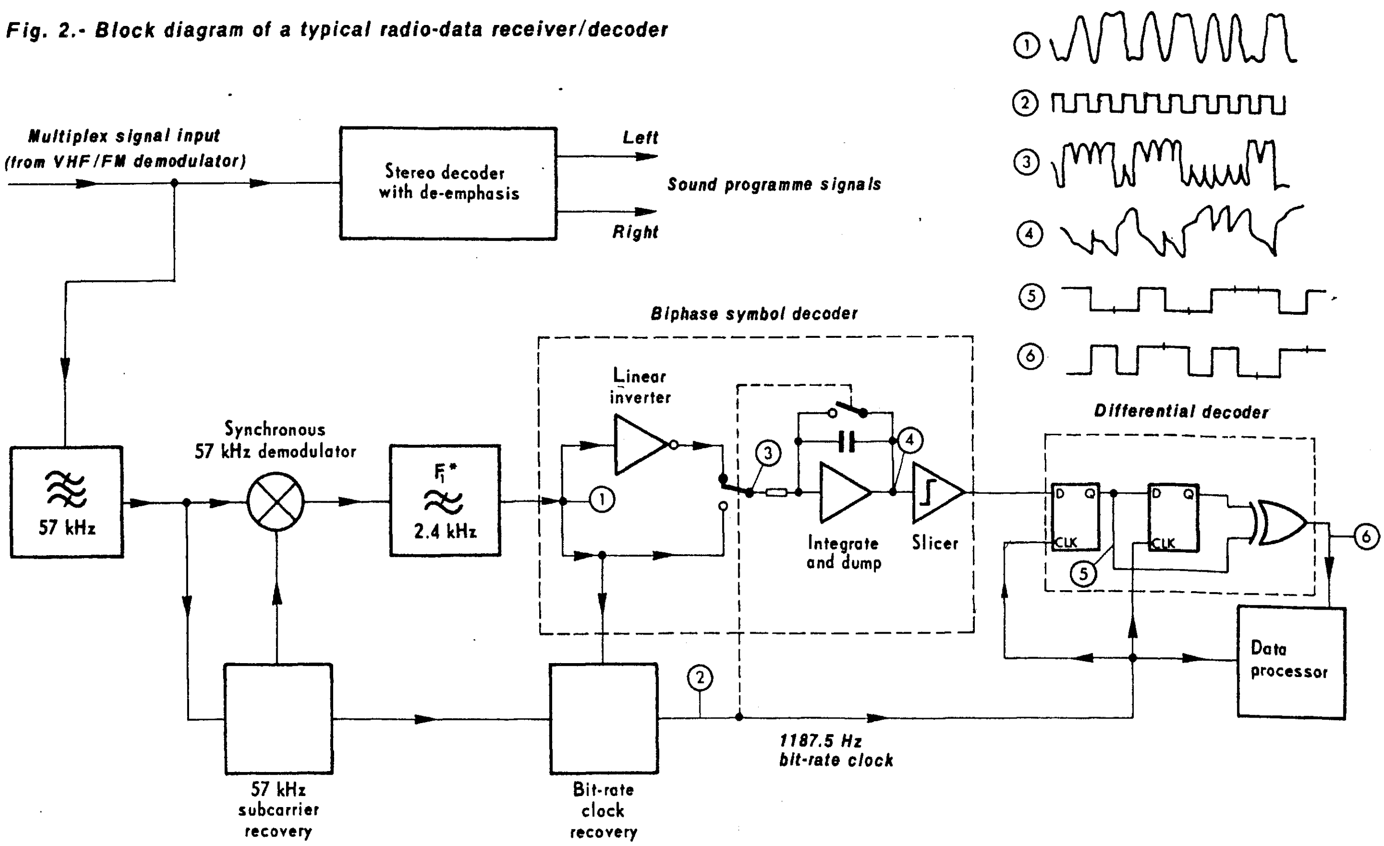

Fig. 2.- Block diagram of a typical radio-data receiver/decoder

* The overall data-shaping in this decoder comprises the filter F_1 and the data-shaping inherent in the biphase symbol decoder. The amplitude/frequency characteristic of filter F_1 is, therefore, not the same at that given in Fig. 3a.

3. Subcarrier level

The present recommended nominal deviation of the main FM carrier due to the unmodulated subcarrier is ± 2.0 kHz*. Headroom should be allowed in the decoder/demodulator for the full ± 7.5 kHz deviation permitted by the CCIR provisions for supplementary subcarriers. Allowance should also be made in the decoder/demodulator for possible operation with a reduced level of subcarrier such that the nominal deviation of the main FM carrier due to the unmodulated subcarrier is not less than ± 1 kHz. The decoder/demodulator should also operate properly when the deviation of the subcarrier is varied within these limits during periods not less than 10 ms.

In the case when ARI and radio-data signals are transmitted simultaneously, the recommended maximum deviation due to the radio-data subcarrier is ± 2 kHz. It is also recommended that in these cases the deviation due to the unmodulated ARI subcarrier should be reduced to ± 3.2 kHz.

The maximum permitted deviation due to the composite multiplex signal is ± 75 kHz.

4. Method of modulation

The subcarrier is amplitude-modulated by the shaped and biphase-coded data signal (see § 7). The subcarrier is suppressed. This method of modulation may alternatively be thought of as a form of two-phase phase-shift-keying (psk) with a phase deviation of ± 90°.

5. Data-rate and clock-frequency

The basic data-rate of the system (see Fig. 1) is 1187.5 bit/s ± 0.125 bit/s. This clock frequency is obtained by dividing the transmitted subcarrier frequency by 48.

6. Differential coding

The source data at the transmitter are differentially encoded according to the following rules:

Previous output (at time t_{i-1})	New input (at time t_i)	New output (at time t_i)
0	0	0
0	1	1
1	0	1
1	1	0

where t_i is some arbitrary time and t_{i-1} is the time one message-data clock-period earlier, and where the message-data clock-rate is equal to 1187.5 Hz.

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* With this level of subcarrier, the level of each sideband of the subcarrier corresponds to half the nominal peak deviation level of ± 2.0 kHz, i.e. ± 1.0 kHz for an "all-zeroes" message data stream (i.e. a continuous bit-rate sine-wave after biphase encoding).

Thus, when the input-data level is 0, the output remains unchanged from the previous output bit and when an input 1 occurs, the new output bit is the complement of the previous output bit.

In the receiver, the data may be decoded by the inverse process:

Previous input (at time t_{i-1})	New input (at time t_i)	New output (at time t_i)
0	0	0
0	1	1
1	0	1
1	1	0

The data is thus correctly decoded whether or not the demodulated data signal is inverted.

7. Data-channel spectrum shaping

The power of the data signal at and close to the 57-kHz centre frequency of the subcarrier is minimised by coding each source data bit as a biphase symbol.

This is done to avoid data-modulated cross-talk in phase-locked-loop stereo decoders, and to achieve compatibility with the ARI system. The principle of the process of generation of the shaped biphase symbols is shown schematically in Fig. 1. In concept each source bit gives rise to an odd impulse-pair, e(t), such that a logic 1 at source gives:

$$e(t) = \delta(t) - \delta(t + t_d/2) \qquad (1)$$

and a logic 0 at source gives:

$$e(t) = -\delta(t) + \delta(t + t_d/2) \qquad (2)$$

These impulse-pairs are than shaped by a filter, $H_T(f)$, to give the required band-limited spectrum where:

$$H_T(f) = \begin{cases} \cos \dfrac{\pi f t_d}{4} & \text{if } 0 \leqslant f \leqslant 2/t_d \\ 0 & \text{if } f > 2/t_d \end{cases} \qquad (3)$$

and here

$$t_d = \frac{1}{1187.5} \text{ s}$$

The data-spectrum shaping filtering has been split equally between the transmitter and receiver (to give optimum performance in the presence of random noise) so that, ideally, the data filtering at the receiver should be identical to that of the transmitter, i.e. as given above in Equation (3). The overall data-channel spectrum shaping $H_o(f)$ would then be 100% cosine roll-off.

The specified transmitter and receiver low-pass filter responses, as defined in Equation (3) are illustrated in Fig. 3a, and the overall data-channel spectrum shaping is shown in Fig. 3b.

The spectrum of the transmitted biphase-coded radio-data signal is shown in Fig. 4a and the time-function of a single biphase symbol (as transmitted) in Fig. 4b.

The 57 kHz radio-data signal waveform at the output of the radio-data source equipment may be seen in the photograph of Fig. 4c.

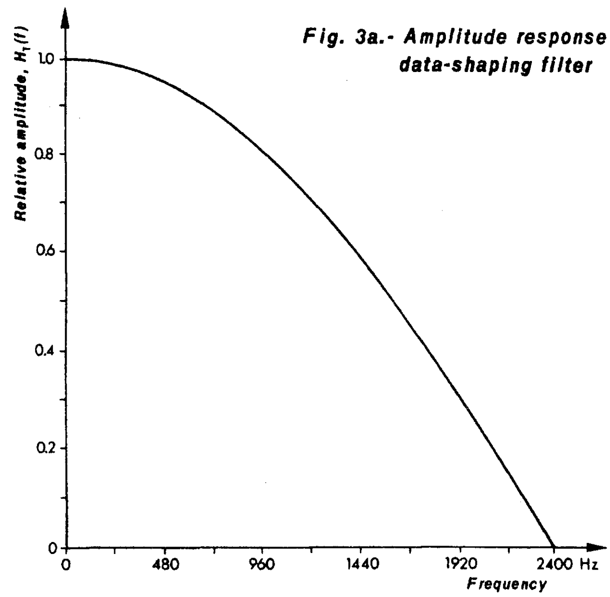


Fig. 3a.- Amplitude response of the specified transmitter or receiver data-shaping filter

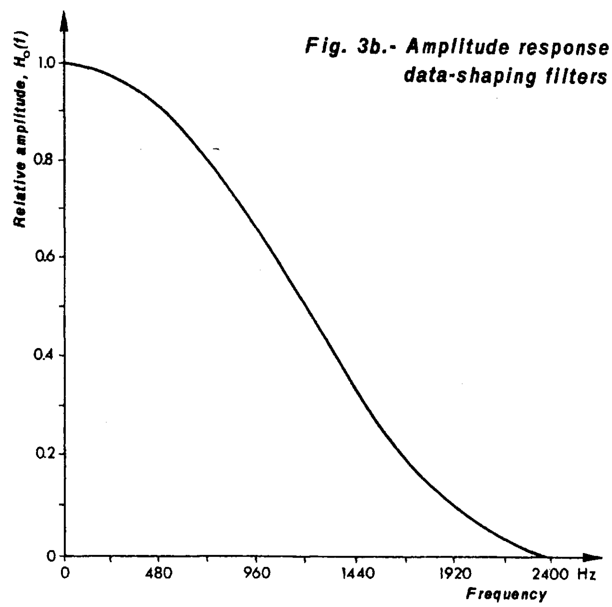


Fig. 3b.- Amplitude response of the combined transmitter and receiver data-shaping filters

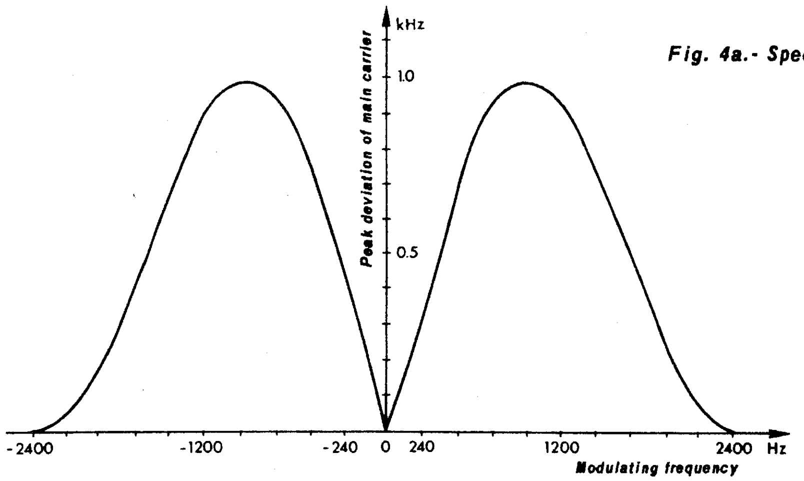
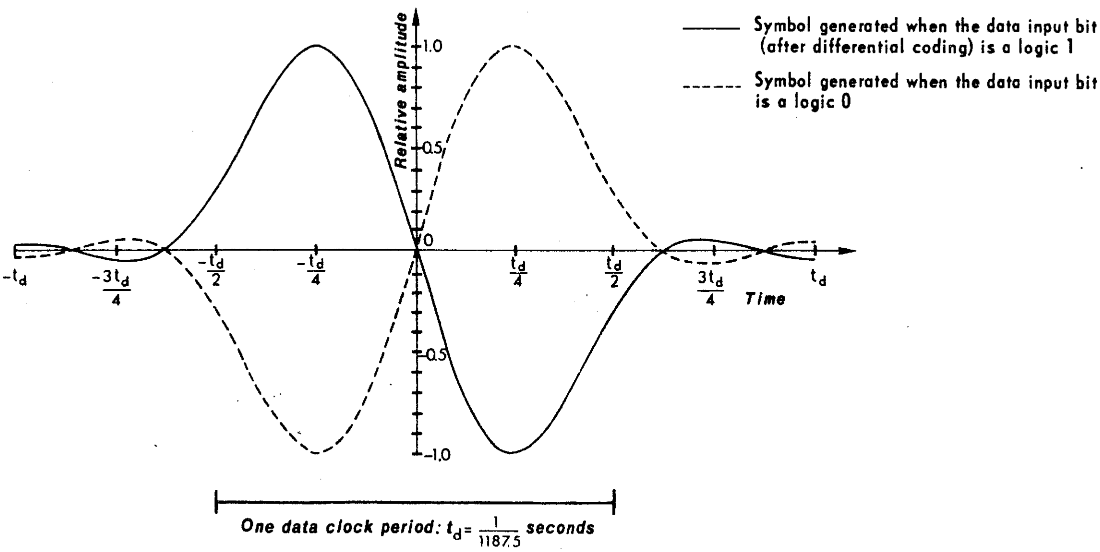


Fig. 4a.- Spectrum of biphase coded radio-data signals

Fig. 4b.- Time-function of a single biphase symbol



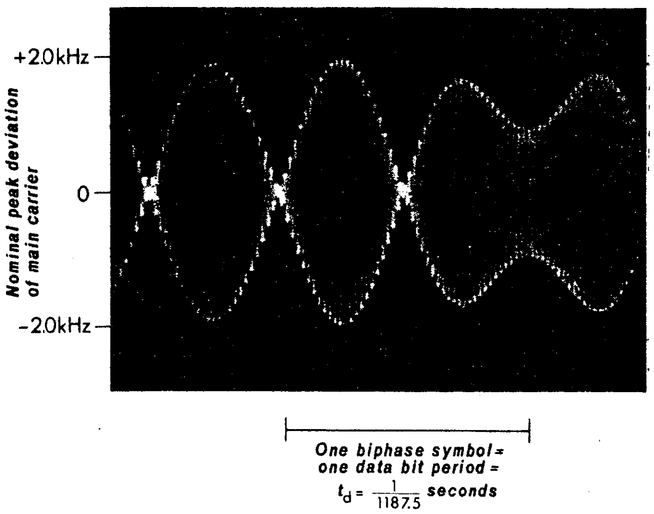


Fig. 4c.- 57 kHz radio-data signals

CHAPTER 2

Baseband coding (data-link layer)

1. Baseband coding structure

Fig. 5 shows the structure of the baseband coding. The largest element in the structure is called a "group" of 104 bits each. Each group comprises 4 blocks of 26 bits each. Each block comprises an information word and a checkword. Each information word comprises 16 bits. Each checkword comprises 10 bits (see § 3).

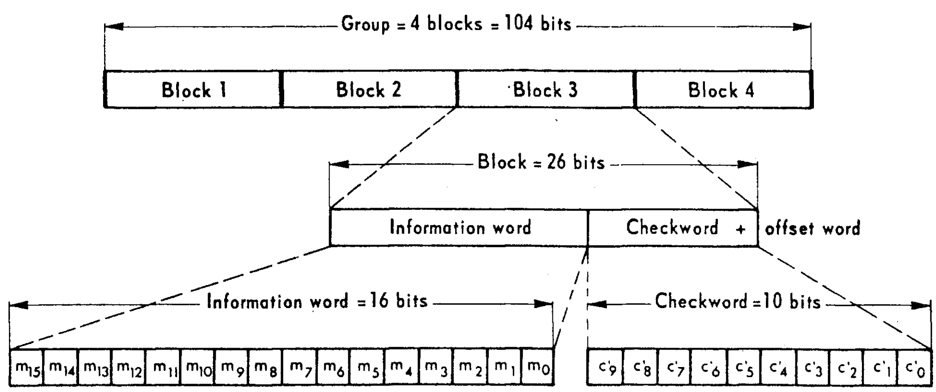


Fig. 5 - Structure of the baseband coding

2. Order of bit transmission

All information words, checkwords, binary numbers or binary address values have their most significant bit (m.s.b.) transmitted first (see Fig. 6). Thus the last bit transmitted in a binary number or address has weight 2^0.

The data transmission is fully synchronous and there are no gaps between the groups or blocks.

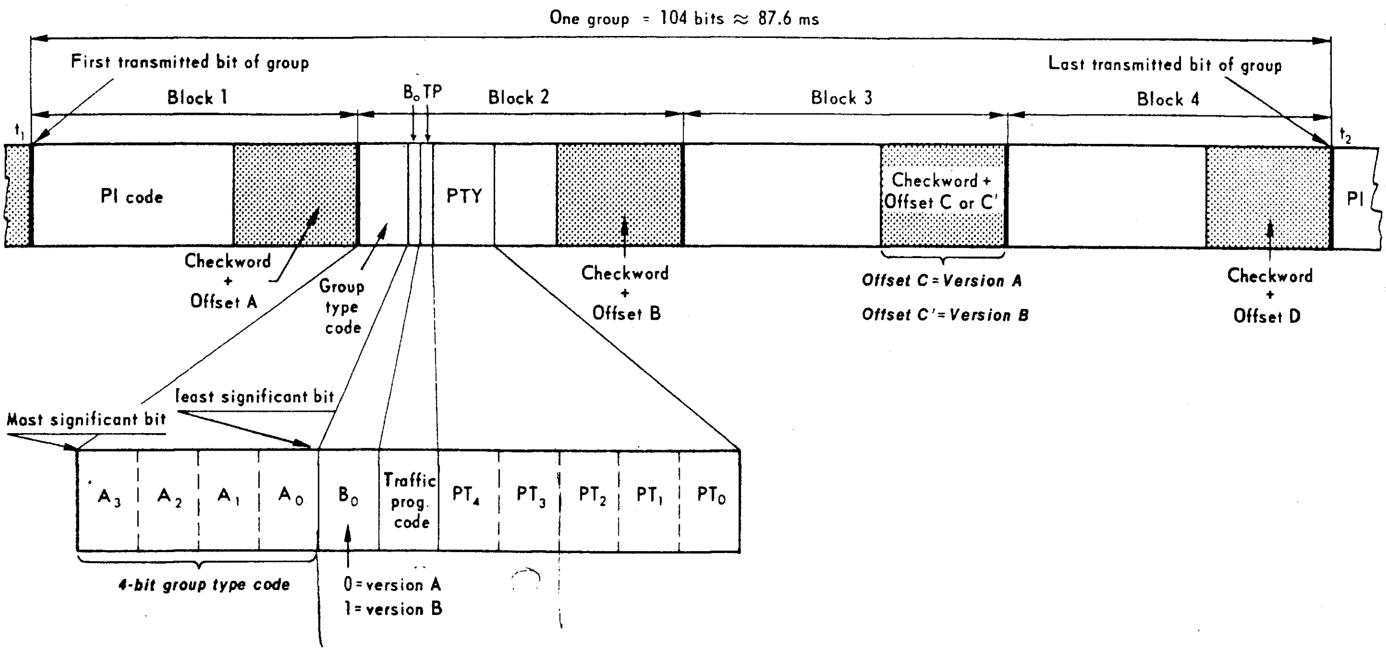


Fig. 6.- Message format and addressing

Notes:

1. Group type code = 4 bits (see Chap. 3, § 1).
2. B_0 = version code = 1 bit (see Chap. 3, § 1).
3. PI code = programme identification code = 16 bits (see Chap. 3, § 2.1.1 and Appendix 4).
4. TP = traffic programme identification code = 1 bit (see Chap. 3, § 2.1.3).
5. PTY = programme type code = 5 bits (see Chap. 3, § 2.1.2 and Appendix 6).
6. Checkwork + offset "N" = 10 bits added to provide error protection and block and group synchronisation information (see §§ 3 and 4 and Appendices 1, 2 and 3).
7. $t_1 < t_2$: block 1 of any particular group is transmitted first and block 4 last.

3. Error protection

Each transmitted 26-bit block contains a 10-bit checkword which is primarily intended to enable the receiver/decoder to detect and correct errors which occur in transmission. This checkword (i.e. c'_9, c'_8, ... c'_0 in Fig. 5) is the sum (modulo 2) of:

a) the remainder after multiplication by x^{10} and then division (modulo 2) by the generator polynomial g(x), of the 16-bit information word

and

b) a 10-bit binary string d(x), called the "offset word",

where the generator polynomial, g(x) is given by:

$$g(x) = x^{10} + x^8 + x^7 + x^5 + x^4 + x^3 + 1$$

and where the offset values, d(x), which are different for each block within a group (see the next Section), are given in Appendix 1.

The purpose of adding the offset word is to provide a group and block synchronisation system in the receiver/decoder (see the next Section). Because the addition of the offset is reversible in the decoder the normal additive error-correcting and detecting properties of the basic code are unaffected.

The checkword thus generated is transmitted m.s.b. (i.e. the coefficient of c'_9 in the checkword) first and is transmitted at the end of the block which it protects.

The above description of the error protection may be regarded as definitive, but further explanatory notes on the generation and theory of the code are given in Appendices 2 and 3.

The error-protecting code has the following error-checking capabilities [3, 4]:

a) Detects all single and double bit errors in a block.
b) Detects any single error burst spanning 10 bits or less.
c) Detects about 99.8% of bursts spanning 11 bits and about 99.9% of all longer bursts.

The code is also an optimal burst error-correcting code [5] and is capable of correcting any single burst of span 5 bits or less. It is left as an option for receiver manufacturers whether or not the error-correcting capabilities of the code are used. However, it should be noted that the use of the full error-correcting capability of the code greatly increases the undetected error rate beyond the values quoted above. This is because many uncorrectable error patterns are deemed correctable and thus pass undetected.

It is therefore recommended that where error-correction is used the decoder should only correct cases of bursts spanning one or two bits and attempt to detect (and then discard) blocks with longer bursts. With this restricted error-correction, about 90% of bursts spanning 11 bits and about 95% of all longer bursts will be detected. The other error-checking capabilities of the code listed above will be unaffected by the use of error-correction.

It would also be possible to implement a decoder in which error- correction was used on certain blocks and error-detection (alone) on others.

4. Synchronisation of blocks and groups

The blocks within each group are identified by the offset words A, B, C or C' and D added to blocks 1, 2, 3, and 4 respectively in each group (see Appendix 1).

The beginnings and ends of the data blocks may be recognised in the receiver decoder by using the fact that the error-checking decoder will, with a high level of confidence, detect block synchronisation slip as well as additive errors. This system of block synchronisation is made reliable by the addition of the offset words (which also serve to identify the blocks within the group). These offset words destroy the cyclic property of the basic code so that in the modified code cyclic shifts of codewords do not give rise to other codewords [6, 7].

Further explanation of a technique for extracting the block synchronisation information at the receiver is given in Appendix 3.

CHAPTER 3

Message format (session and presentation layers)

1. Addressing

1.1. Design principles

The basic design principles underlying the message format and addressing structure are as follows:

a) The messages which are to be repeated most frequently, and for which a short acquisition time is required e.g. Programme Identification (PI) codes , in general occupy the same fixed positions within every group. They can therefore be decoded without reference to any block outside the one which contains the information.

b) There is no fixed rhythm of repetition of the various types of group, i.e. there is ample flexibility to interleave the various kinds of message to suit the needs of the users at any given time and to allow for future developments.

c) This requires addressing to identify the information content of those blocks which are not dedicated to the high-repetition-rate information.

d) Each group is, so far as possible, fully addressed to identify the information content of the various blocks.

e) The mixture of different kinds of message within any one group is minimised, e.g. one group type is reserved for basic tuning information, another for radiotext, etc. This is important so that broadcasters who do not wish to transmit messages of certain kinds are not forced to waste channel capacity by transmitting groups with unused blocks. Instead, they are able to repeat more frequently those group types which contain the messages they want to transmit.

f) To allow for future applications the data-formatting has been made flexible. For example, one of the eight spare group types (see § 1.3) may be assigned to future applications. Another possibility is to use the spare offset words. An example is given in Appendix 8.

1.2. Principal features

The main features of the message structure have been illustrated in Fig. 6. These may be seen to be:

1) The first block in every group always contains a Programme Identification (PI) code.

2) The first four bits of the second block of every group are allocated to a four-bit code which specifies the application of the group. Groups will be referred to as types 0 to 15 according to the binary weighting $A_3 = 8$,

$A_2 = 4$, $A_1 = 2$, $A_0 = 1$ (see Fig. 6). For each type (0 to 15) two "versions" can be defined. The "version" is specified by the fifth bit (B_0) of block 2 as follows:

a) $B_0 = 0$: the PI code is inserted in block 1 only. We shall refer to this as version A, e.g. 0A, 1A, etc.

b) $B_0 = 1$: the PI code is inserted in block 1 and block 3 of all block types. We shall refer to this as version B, e.g. 0B, 1B, etc.

In general, any mixture of versions A and B of groups may be sent.

3) The Programme Type Code (PTY) and Traffic Programme Identification (TP) occupy fixed locations in block 2 of every group.

The PI, PTY and TP codes can be decoded without reference to any block outside the one that contains the information. This is essential to minimise acquisition time for these kinds of message and to retain the advantages of the short (26-bit) block length. To permit this to be done for the PI codes in block 3 of version B groups, a special offset word (which we shall call C') is used in block 3 of version B groups. The occurrence of offset C' in block 3 of any group can then be used to indicate directly that block 3 is a PI code without reference to the value of B_0 in block 2.

1.3. Group types

It was described above (see also Fig. 6) that the first five bits of the second block of every group are allocated to a five-bit code which specifies the application of the group and its version.

At present eight group types have been specified and all except two (types 4 and 15) are defined in version A and version B. The remaining group types will be specified at a later date when possible applications have been defined.

The applications of the eight group types defined so far are as follows:

Group type						Applications
Decimal value	Binary code A_3	A_2	A_1	A_0	B_0	
0	0	0	0	0	X	Basic tuning and switching information (§ 1.3.1)
1	0	0	0	1	X	Programme item number (§ 1.3.2)
2	0	0	1	0	X	Radiotext (§ 1.3.3)
3	0	0	1	1	X	Information about other networks (§ 1.3.4)
4	0	1	0	0	0	Clock-time and date (§ 1.3.5)
5	0	1	0	1	X	Transparent channels for text or other graphics (32 channels) (§ 1.3.6)
6	0	1	1	0	X	In-house applications (§ 1.3.7)
7 - 14						Applications not yet defined
15	1	1	1	1	1	Fast basic tuning and switching information (§ 1.3.8)

X indicates that value may be "0" (version A) or "1" (version B).

The recommended minimum repetition rates for some of the main applications are indicated in the table below:

Applications	Group types which contain this information	Recommended minimum repetition rate per second
Programme identification (PI) code	all	11*
Programme service (PS) name	0A, 0B	1*
Programme type (PTY) code	all	11
Traffic programme (TP) identification code	all	11
Alternative frequency (AF) code	0A	4**
Traffic announcement (TA) code	0A, 0B, 15B	4
Decoder identification (DI) code	0A, 0B, 15B	1
Music/speech (M/S) code	0A, 0B, 15B	4
Programme item number (PIN) code	1A, 1B	1
Radiotext (RT) message	2A, 2B	0.2

* Valid codes for these two items will be transmitted with at least these recommended minimum repetition rates whenever the transmitter carries a normal broadcast programme.

** The alternative frequencies (if any) for transmitters carrying the same programme signal will be transmitted cyclically from a list of up to 25. When no alternative frequencies are transmitted, type 0B groups (which do not contain the alternative frequency information) should be used instead of type 0A.

In order to satisfy the above recommended minimum repetition rates, the following mixture of groups might be used:

Group type	Applications	Typical proportion of groups of this type transmitted
0A or 0B	PI, PS, PTY, TP, AF*, TA, DI, M/S	40%
1A or 1B	PI, PTY, TP, PIN	10%
2A or 2B	PI, PTY, TP, RT	15%**
3A or 3B	PI, PTY, TP, ON	10%
Any	Optional applications	25%

* Group type 0A only.

** Assuming that type 2A groups are used to transmit a 32-character radiotext message. A mixture of type 2A and 2B groups in any given message should be avoided (see § 1.3.3).

1.3.1. Type 0 groups : Basic tuning and switching information

Fig. 7a shows the format of type 0A groups and Fig. 7b the format of type 0B groups.

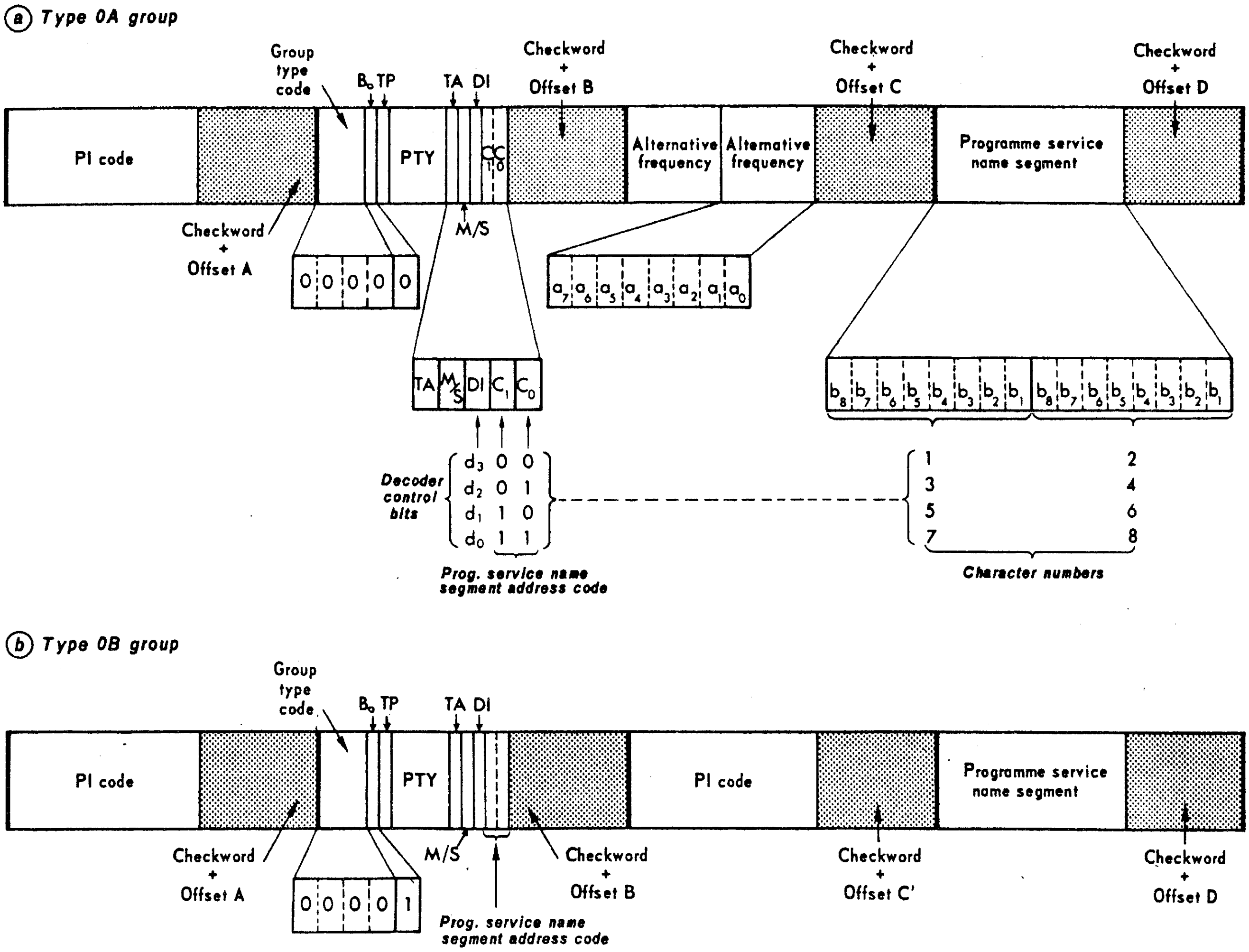


Fig. 7.- Basic tuning and switching information

Type 0B groups will be transmitted if there are no alternative frequencies for the transmitted main programme signal. Otherwise type 0A groups will be transmitted. At least four type 0A or 0B groups per second will be transmitted whenever the transmitter carries a normal broadcast programme.

The alternative frequencies (from a list of up to twenty-five) will be transmitted cyclically.

Notes on Type 0 groups:

1. Version B differs from version A only in the contents of block 3, the offset word in block 3, and, of course, the version code B_0.
2. For details of Programme identification (PI), Programme type (PTY) and traffic programme (TP) code, see Fig. 6, § 2.1 and Appendices 4 and 6.

3. TA = Traffic announcement code (1 bit) (see § 2.1.3).

4. M/S = Music-speech switch code (1 bit) (see § 2.1.4).

5. DI = Decoder-identification control code (4 bits) (see § 2.1.5). This code is transmitted as 1 bit in each type 0 group. The Programme service name segment address code (C_1 and C_0) also serves to locate these bits in the DI codeword. Thus in a group with $C_1 C_0$ = "00" the DI bit in that group is d_3. These code bits are transmitted m.s.b. (d_3) first.

6. Alternative frequency codes (2 x 8 bits) (see § 2.1.6).

7. Programme service name (for display) is transmitted as 8-bit characters as defined in the 8-bit code-tables in Appendix 5. Eight characters (including spaces) are allowed for each network and are transmitted as a 2-character segment in each type 0 group. These segments are located in the displayed name by the code bits C_1 and C_0 in block 2. The addresses of the characters increase from left to right in the display. The m.s.b. (b_8) of each character is transmitted first.

1.3.2. Type 1 groups : Programme-item number

Fig. 8a shows the format of type 1A groups and Fig. 8b the format of type 1B groups.

It is expected that when this application is used, at least one type 1A or 1B group per second will be transmitted. The unused bits in blocks 2 and 3 (type 1A only) are reserved for undefined applications.

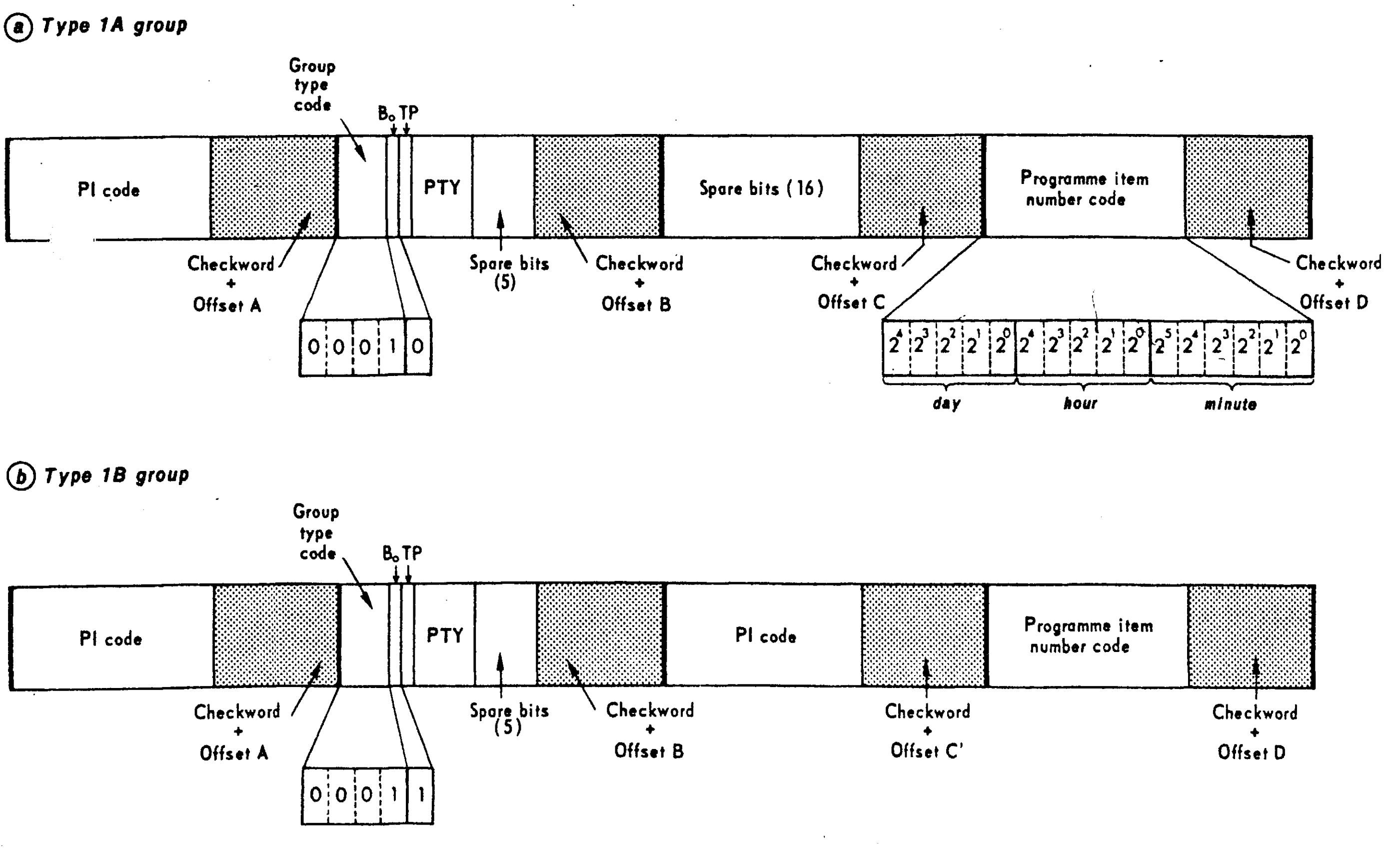


Fig. 8.- Programme item number

Notes on Type 1 groups:

1. Version B differs from version A only in the contents of block 3, the offset word in block 3, and, of course, the version code B_0.
2. The programme item number is its scheduled broadcast start time and day of month as published by the broadcaster. The day of month is transmitted as a five-bit binary number in the range 1-31. Hours are transmitted as a five-bit binary number in the range 0-23. The spare codes are not used. Minutes are transmitted as a six-bit binary number in the range 0-59. The spare codes are not used.

1.3.3. Type 2 groups : Radiotext

Fig. 9a shows the format of type 2A groups and Fig. 9b the format of type 2B groups.

The 4-bit address-code in the last four bits of the second block serves to locate in the displayed message the segment of text contained in the third (version A only) and fourth blocks. Since each text segment in version 2A groups comprises four characters, messages of up to 64 characters in length can be sent using

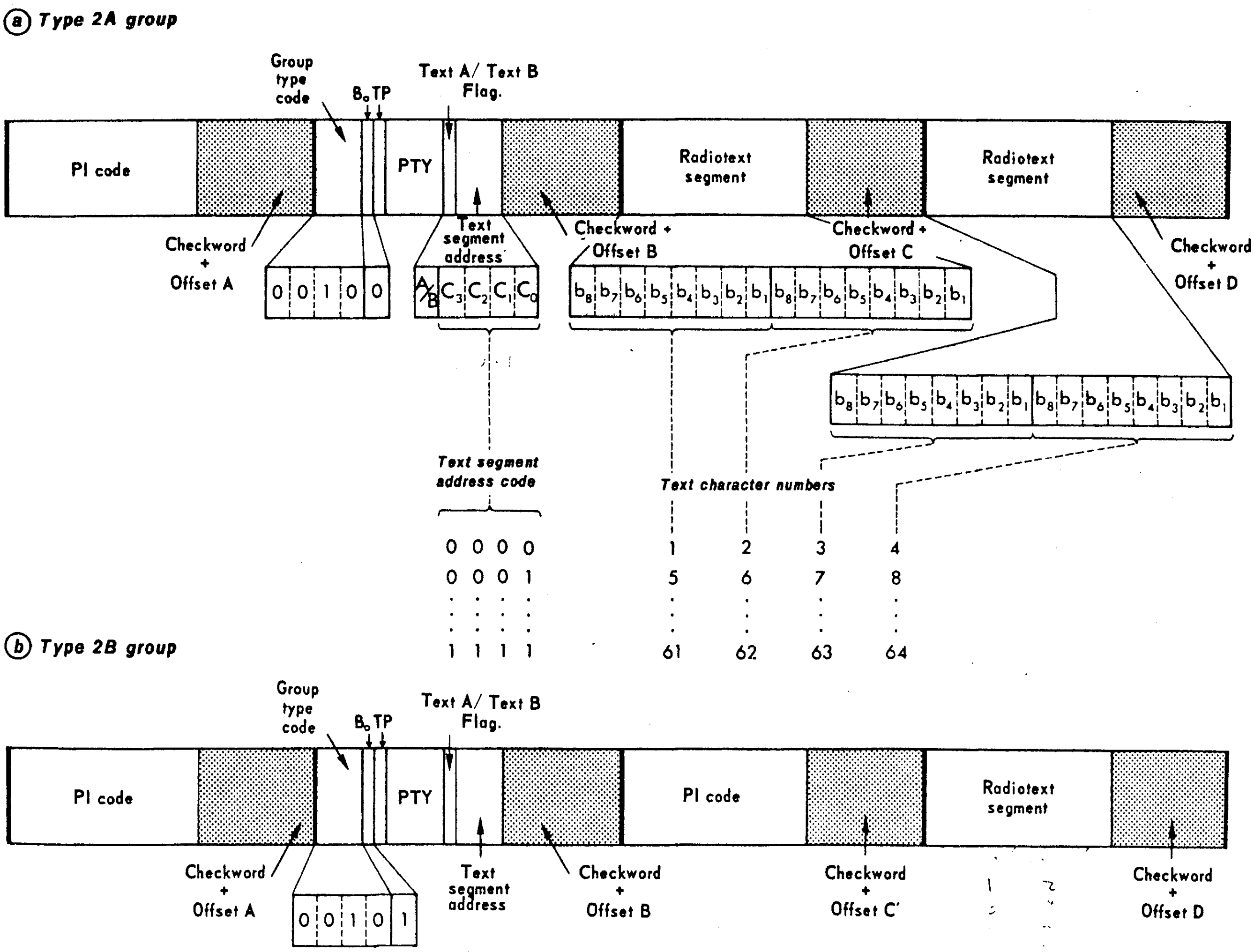


Fig. 9.- Radiotext

this version. In version 2B groups, each text segment comprises only two characters and therefore when using this version the maximum message length is 32 characters.

If a display which has fewer than 64 characters is used to display the radiotext message then memory should be provided in the receiver/decoder so that elements of the message can be displayed sequentially. This may, for example, be done by displaying elements of text (of length to fit the available display) one at a time in sequence, or, alternatively by scrolling the displayed characters of the message from right to left.

It should be noted that because of the above considerations there is possible ambiguity between the addresses contained in version A and those contained in version B. For this reason it is recommended to avoid a mixture of version 2A and 2B groups when transmitting any one given message.

An important feature of type 2 groups is the Text A/Text B flag contained in the second block. Two cases occur:

- If the receiver detects a change in the flag for a given segment (from binary "0" to binary "1" or vice-versa), then the whole radiotext display should be cleared and the newly received radiotext message segments should be written into the display with blanks left for those segments or characters for which no update is received.

- If the receiver detects no change in the flag, then the received text segments or characters should be written into the existing displayed message and those segments or characters for which no update is received should be left unchanged.

It is expected that when this application is used to transmit a 32-character message, at least three type 2A groups or at least six type 2B groups should be transmitted in every two seconds.

It may be found from experience that all radiotext messages should be transmitted at least twice to improve reception reliability.

Notes on Type 2 groups:

1. Radiotext is transmitted as 8-bit characters as defined in the 8-bit code-tables in Appendix 5. The m.s.b. (b_8) of each character is transmitted first.
2. The addresses of the characters increase from left to right in the display.
3. The text of up to 64 characters is transmitted in four (version A) or two (version B) character segments. These segments are located by the text segment address code.

1.3.4. Type 3 groups : Information about other networks

Fig. 10a shows the format of type 3A groups and Fig. 10b the format of type 3B groups.

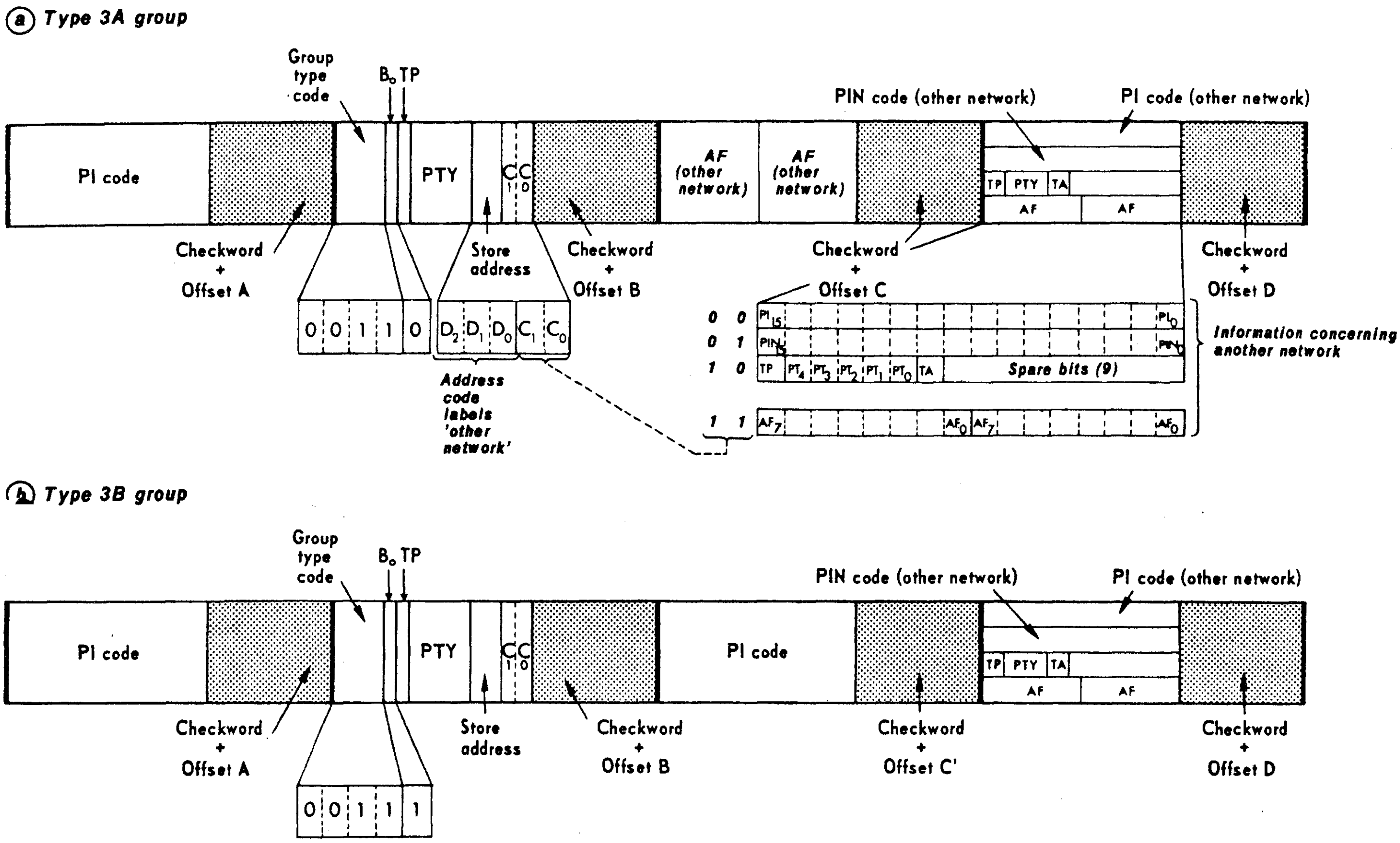


Fig. 10.- Information about other networks

The 2-bit address-code in the last two bits of the second block identifies the contents of the fourth block as follows:

Binary address code C_1	C_0	Applications of block 4
0	0	Programme identification (other network)
0	1	Programme item number (other network)
1	0	Traffic programme code, programme type code, traffic announcement code, the unused bits are reserved for undefined applications
1	1	Alternative frequencies (only to be used for longer AF lists)

Information concerning up to eight other networks may be transmitted. The 3-bit store address code D_2, D_1, D_0 contained in block 2 is used to distinguish information concerning each of these other networks. (These 3-bit address codes shall be assigned to the networks concerned. They serve only to avoid false linking of the PI, PIN, and other elements of the information concerning other networks.) A list of up to 25 alternative frequencies may be transmitted for each of the other networks.

It is expected that when this application is used, at least one type 3A or 3B group will be transmitted every two seconds.

1.3.5. Type 4A groups : Clock-time and date

Fig. 11 shows the format of type 4A groups. Type 4B groups are not yet defined.

It is expected that when this application is used, one type 4A group will be transmitted every minute.

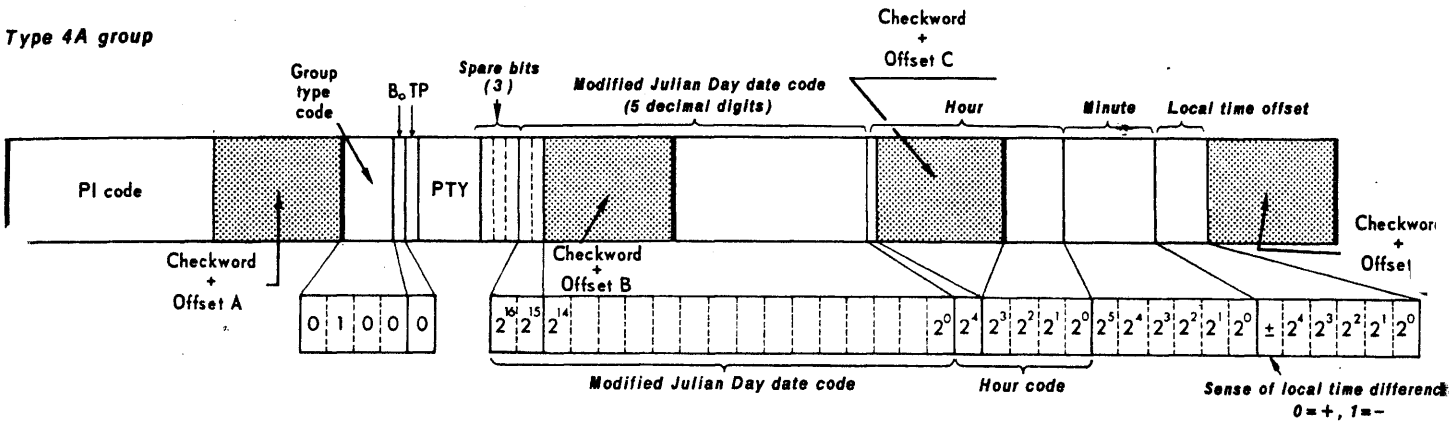


Fig. 11.- Clock time and date transmission

Notes on Type 4A groups:

1. Time of day is expressed in terms of Coordinated Universal Time (UTC).
2. The information relates to the epoch immediately following the start of the next group.
3. The clock-time group is inserted so that the minute edge will occur within 0.1 seconds of the end of the clock-time group.
4. Minutes are coded as a six-bit binary number in the range 0-59. The spare codes are not used.
5. Hours are coded as a five-bit binary number in the range 0-23. The spare codes are not used.
6. The date is expressed in terms of Modified Julian Day and coded as a 17-bit binary number in the range 0-99999. Simple conversion formulas to month and day, or to week number and day of week are given in Appendix 7. Note that the Modified Julian Day date changes at UTC midnight *not* local midnight.
7. The local time difference is *expressed in multiples of half hours* with the range -12 to +12 h and is coded as a six-bit binary number. "0" = positive offset, and "1" = negative offset (e.g. USA).

1.3.6. Type 5 groups : Transparent data channels

Fig. 12a shows the format of type 5A groups and Fig. 12b the format of type 5B groups.

The 5-bit address-code in the second b
(out of 32) to which the data contained in block
dressed. Unlike the fixed-format radiotext o
and format can be sent using these channels.
line-feed and carriage-return) will, of cour

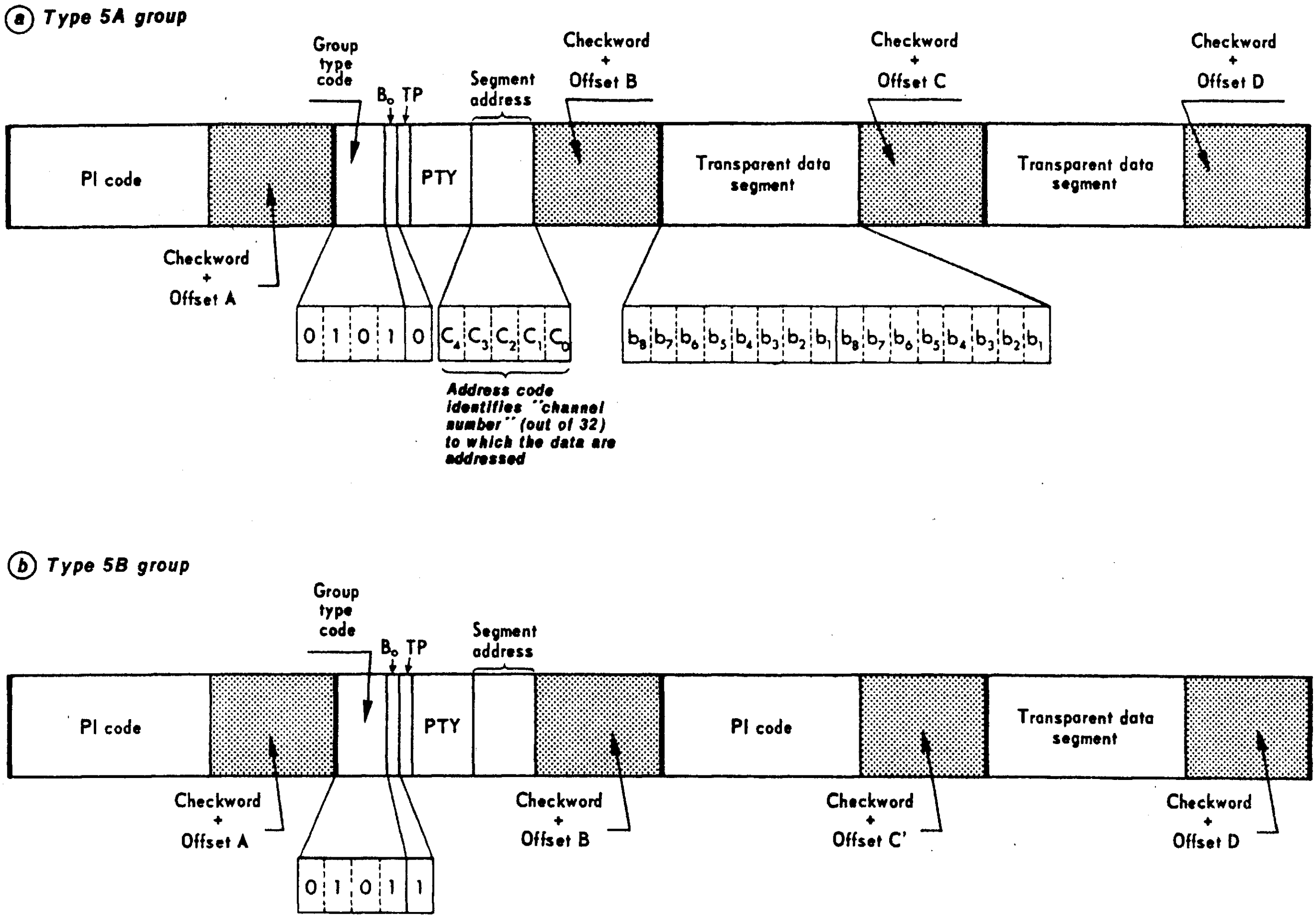


Fig. 12.- Transparent data channels

These channels may be used to send alphanumeric characters, or other text (including mosaic graphics), or for transmission of computer programmes and similar data not for display. Details of implementation of these last options are to be specified later.

The repetition rate of these group types may be chosen to suit the application and the available channel capacity at the time.

1.3.7. Type 6 groups : In-house applications

Fig. 13a shows the format of type 6A groups and Fig. 13b the format of type 6B groups.

The contents of the unreserved bits in these groups may be defined unilaterally by the broadcasters.

Broadcasting receivers should ignore the "in-house" information coded in these groups.

The repetition rate of these group types may be chosen to suit the application and the available channel capacity at the time.

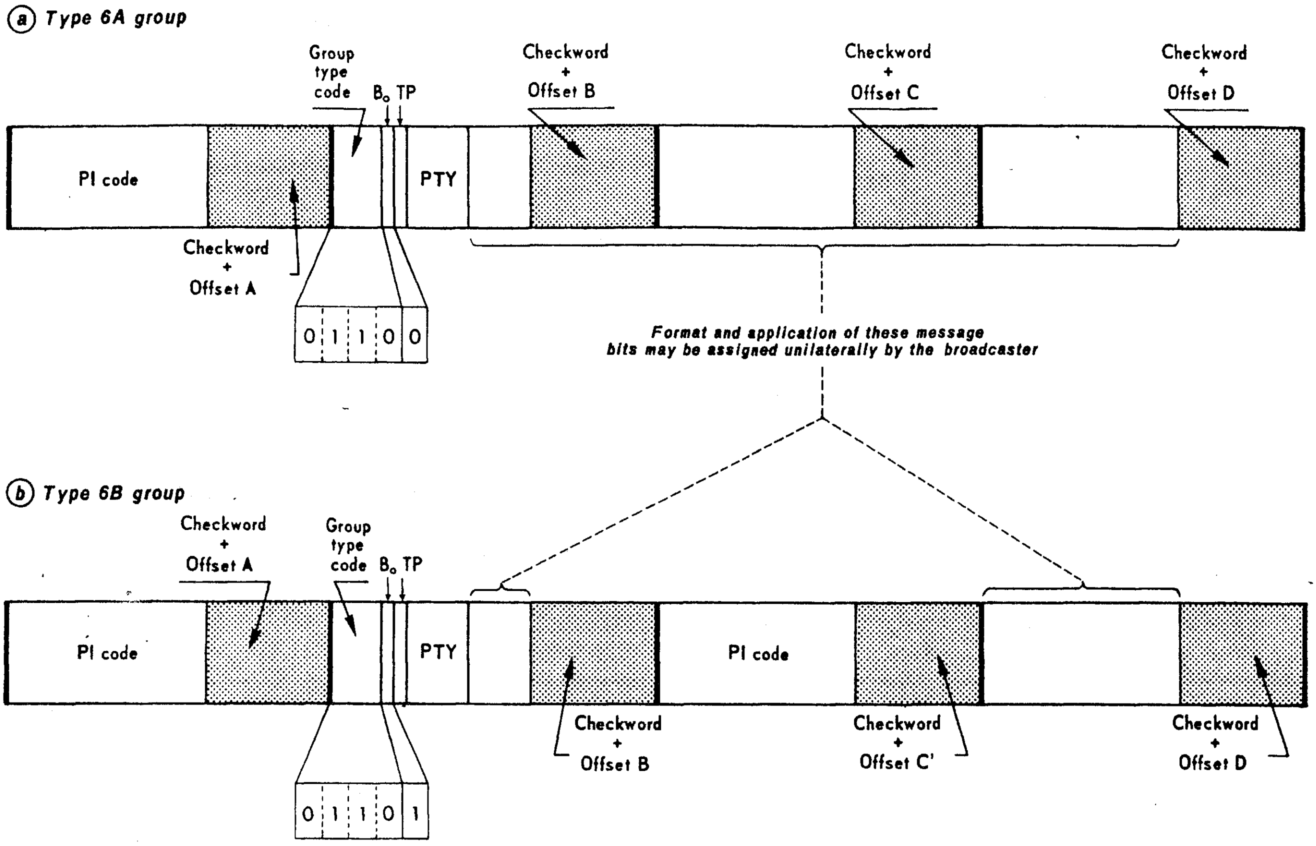


Fig. 13.- In-house applications

1.3.8. Type 15B groups : Fast basic tuning and switching information

Fig. 14 shows the format of type 15B groups.

It is intended that groups of this type should be inserted where it is desired to increase the repetition rate of the switching information contained in type 0 blocks without increasing the repetition rate of the other information contained in these blocks. No alternative-frequency information or programme-service name is included in groups of this type, and these groups will be used to supplement rather than to replace type 0A or 0B groups.

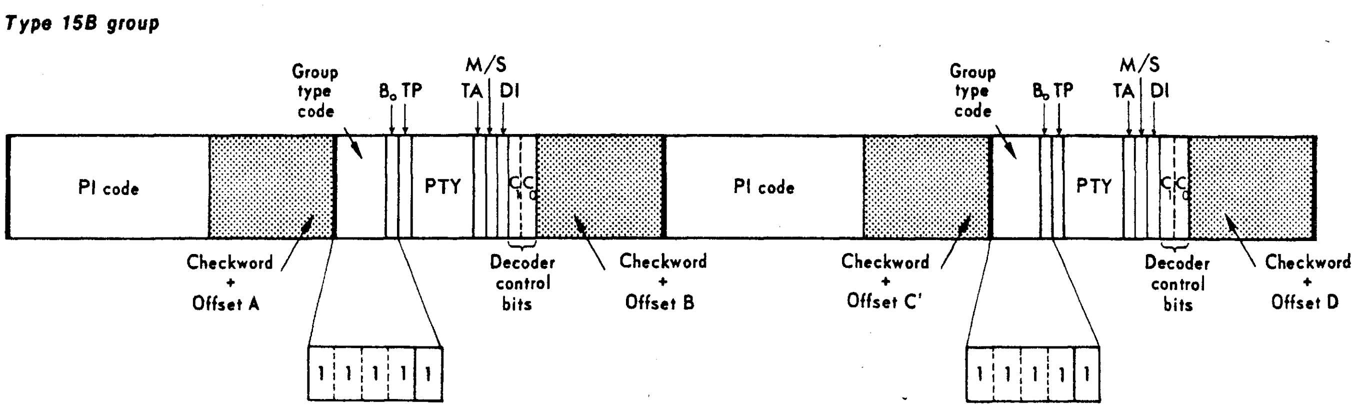


Fig. 14.- Fast basic tuning and switching information

When groups of this type are transmitted, the repetition rate may be chosen to suit the application and the available channel capacity at the time.

Type 15A groups are not yet defined.

Note on Type 15B groups:

For explanation of symbols, see notes on type 0 groups and Fig. 7.

2. Coding of information

A glossary of terms used in radio-data applications is given in Chapter 4 of this document which also explains the expected responses of the receiver to the various codes.

2.1. Coding of information for control

2.1.1. Programme-identification (PI) codes

A proposed EBU coding model for programme-identification information in radio-data transmissions is given in Appendix 4.

2.1.2. Programme-type (PTY) codes

The applications of the 5-bit programme type codes are specified in Appendix 6. The last number in the table in Appendix 6 is reserved for an alarm indication (code No. 31).

2.1.3. Traffic-programme (TP) and traffic-announcement (TA) codes

These codes correspond to similar features in the ARI system. The coding to be used is as follows:

Traffic programme code (TP)	Traffic announcement code (TA)	Applications
1	0	This station carries traffic announcements but none are being broadcast at present
1	1	A traffic annoucement is being broadcast on this station at present
0	0	This station does not carry traffic annoucements
0	1	Not yet defined

2.1.4. Music/speech (M/S) switch code

This is a 1-bit code. A "0" indicates that speech is at present being broadcast and a "1" indicates that music is at present being broadcast. When the broadcaster is not using this facility the bit value will be set at "1".

2.1.5. Decoder-identification (DI) codes

This 4-bit code can be used to identify 16 different operating modes, i.e. to switch individual decoders (or combinations of decoders) on or off.

Decoder identification code d_3	d_2	d_1	d_0	Decimal value	Operating mode*
0	0	0	0	0	Monophonic transmission
0	0	0	1	1	Stereophonic transmission
0	0	1	0	2	Not yet assigned
0	0	1	1	3	Stereo, artificial head
0	1	0	0	4	Mono, compressed**
0	1	0	1	5	Stereo, compressed**
0	1	1	0	6	Not yet assigned
0	1	1	1	7	Stereo, compressed**, artificial head
1	0	0	0	8	Not yet defined
.	.	.	.	.	
.	.	.	.	.	
.	.	.	.	.	
1	1	1	1	15	

* These specified operating modes exclude each other. However, it should be noted that operating modes may be specified which are transmitted successively, but which should be used simultaneously.

** See CCIR Study Programme 46A/10 (Geneva, 1982).

2.1.6. Alternative frequency (AF) codes

Two AF codes are normally transmitted in block 3 of group 0A. The 8-bit codes normally indicate VHF channels at 100 kHz intervals:

Number	Binary code	Carrier frequency
0	00000000	87.5 MHz
1	00000001	87.6 MHz
.	.	.
.	.	.
.	.	.
.	.	.
204	11001100	107.9 MHz
205	11001101	Filler code*

* Used where the list of AF codes does not completely fill the available space.

Number 224 and upwards for the first AF code in the block do not indicate channels but indicate special cases thus:

Numbers from 224 to 249 show how many different frequencies excluding filler words are included in the list. This number precedes the list of AF codes:

Number	Binary code	Meaning
224	11100000	No AF exists
225	11100001	1 AF code follows
.	.	.
.	.	.
.	.	.
249	11111001	25 AF codes follow

Numbers 253, 254 and 255 indicate that the second AF code in this block has a frequency offset:

Number	Binary code	Offset
253	11111101	+ 25 kHz
254	11111110	+ 50 kHz
255	11111111	+ 75 kHz

The number 250 (binary code 11111010) indicates that the second AF code in this block applies to an LF or MF channel.

For applications in ITU Regions 1 and 3 the following numbers then apply for LF and MF.

	Number	Binary code	Carrier frequency	
LF	1	00000001	(153 kHz*	155 kHz
	.	.	.	.
	.	.	.	.
	15	00001111	279 kHz)	281 kHz
MF	16	00010000	531 kHz	
	.	.	.	
	.	.	.	
	.	.	.	
	.	.	.	
	135	10000111	1602 kHz	

If the AF feature is not used then group type 0B should be applied.

2.1.7. Programme-item number (PIN) codes

The transmitted programme item number code will be the scheduled broadcast start time and day of month as published by the broadcaster.

* These LF frequencies do not all come into use until 1990.

2.1.8. Information about other networks (ON)

The information about other networks consists of programme identification code (PI) (see § 2.1.1), programme item number code (PIN) (see § 2.1.7), traffic programme code (TP) (see § 2.1.3), programme type code (PTY) (see § 2.1.2), traffic announcement code (TA) (see § 2.1.3) and alternative frequency code (AF).

The 8-bit AF code (bits AF_0 to AF_7; see Fig. 10) indicates channel numbers as described in § 2.1.6. However, the AF codes can be transmitted in block 3 (group 3A only) and in block 4 (indicated by bits C_1 and C_0), as well. The list of AF codes should be transmitted in the same order as that of the network to which the receiver is tuned. If necessary, filler codes should be used. If the AF feature is not used the group 3B should be applied and the code $C_1 C_0$ = "11" should be avoided.

2.2. Coding of information for display

Code tables for the displayed 8-bit text characters relating to the programme service name and radiotext are given in Appendix 5.

2.3. Coding of clock-time and date

In order to avoid ambiguity when radio-data broadcasts from various sources are processed at one point (e.g. reception from multiple time zones), and to allow calculations of time intervals to be made independent of time zones and summer-time discontinuities, it is proposed that the broadcast time and date codes should use Coordinated Universal Time (UTC) and Modified Julian Day (MJD) in accordance with CCIR Recommendations 457-1 and 460-3. A coded local time-difference, expressed in multiples of half-hours is appended to the time and date codes.

Conversion between the Modified Julian Day date and UTC time codes and the various calendar systems (e.g. year, month, day, or year, week number, day of week) can be accomplished quite simply by processing in the receiver decoder (see Appendix 7).

2.4. Coding of information for transparent data channels

The coding of this information may be decided unilaterally by the broadcaster to suit the application. Radio-data receivers may provide an output of it (e.g. as a serial data stream) for an external device (e.g. a home computer).

2.5. Coding of information for in-house applications

The coding of this information may be decided unilaterally by the broadcaster to suit the application. Radio-data receivers should entirely ignore this information.

CHAPTER 4

Glossary of terms for the applications

1. Programme identification (PI)

This information consists of a code enabling the receiver to distinguish between countries, areas* in which the same programme is transmitted, and the identification of the programme itself. The code is not intended for direct display and is assigned to each individual radio programme, to enable it to be distinguished from all other programmes. One important application of this information would be to enable the receiver to search automatically for an alternative frequency in case of bad reception of the programme to which the receiver is tuned; the criteria for the change-over to the new frequency would be the presence of a better signal having the same programme-identification code.

Three kinds of receiver could be designed for this search tuning:

a) A "scanning" receiver (with or without a memory for alternative frequencies having the same programme identification) which is muted during the search process or which would switch inaudibly to an alternative frequency.

b) A "learning" receiver equipped with a memory to store alternative frequencies. Such a receiver would remain in the data-reception mode and scan the band even if the audio output is switched off.

c) A receiver equipped with two RF front-ends, one of which would feed the AF output while the other would search for the same programme on an alternative frequency, with inaudible switch-over to the better signal.

In the "scanning" receiver, the time for finding the alternative frequency is critical and should not be longer than 8 seconds. In practice this means that the code must be repeated frequently (see Chap. 3, § 1.3). Details concerning application of the code on a European scale are given in Appendix 4.

2. Programme service (PS) name

This is a text consisting of not more than eight alphanumeric characters coded in accordance with Appendix 5, which could be displayed by future receivers in order to inform the listener what programme service is being broadcast by the station to which the receiver is tuned (see Chap. 3, § 1.3.1). An example for a name could be "SRG BERN". In the case of a local programme, the broadcaster may use any designation (up to 8 characters). The length of this name has to be limited for economic reasons, i.e. to keep the receiver cheap. The programme service name is not intended to be used for automatic search tuning.

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* For traffic broadcasts, the area code may correspond to the respective ARI Code.

3. Programme type (PTY)

This is an identification number to be transmitted with each programme item, which is intended to specify the programme type within 31 possibilities (see Appendix 6). This code could also be used for search tuning. The code will, moreover, enable suitable receivers and recorders to be pre-set to respond only to programme items of the desired type. The last number, i.e. 31, is reserved for an alarm identification which is intended to switch on the audio signal when a receiver is operated in a waiting reception mode.

4. Traffic-programme identification* (TP)

This is an on/off switching signal to indicate, by means of a special lamp (or a similar device) on the receiver, that this is a programme on which announcements are usually made for motorists. The signal could be taken into account during automatic search tuning.

5. List of alternative frequencies (AF)

It would be desirable to transmit a list of up to 25 frequency-channel numbers. This would give information on the various transmitters broadcasting the same programme in the same or adjacent reception areas, and would enable receivers equipped with a memory to store that list in order to reduce the time for switching to another transmitter. This facility is particularly useful in the case of car and portable radios.

6. Traffic-announcement identification* (TA)

This is an on/off switching signal to indicate whether an announcement for motorists is on the air. The signal could be used in receivers to:

a) switch automatically from the cassette listening mode to the traffic announcement;

b) switch on the traffic announcement automatically when the receiver is in a waiting reception mode and the audio signal is muted;

c) switch from a programme carrying no traffic information to one carrying a traffic announcement, according to those possibilities which are given in Chap. 3, §§ 1.3.4 or 2.1.3.

After the end of the traffic announcement the initial operating mode will be restored.

7. Decoder identification (DI)

This is a switching signal indicating which of 16 possible operating modes (or combinations thereof) is appropriate for use with the broadcast signals.

8. Music/speech switch (M/S)

This is a two-state signal to provide information on whether music or speech is being broadcast. The signal would permit receivers to be equipped with two separate volume controls, one for music and one for speech, so that the listener could adjust the balance between them to suit his individual listening habits.

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* This feature corresponds to that of the ARI system.

9. Programme-item number (PIN)

The code should enable receivers and recorders designed to make use of this feature to respond to the particular programme item(s) that the user has pre-selected. Use is made of the scheduled programme time, to which is added the day of the month in order to avoid ambiguity (see Chap. 3, § 2.1.7).

10. Radiotext (RT)

This refers to text transmissions coded in accordance with Appendix 5, primarily addressed to new home receivers, which would be equipped with suitable display facilities (see Chap. 3, § 2.2). In car receivers where a text display is undesirable for safety reasons, the radiotext transmission could be used to control a speech synthesizer; details of operation in this mode require further study.

11. Information concerning other networks (ON)

This feature can be used in conjunction with a list of up to 25 alternative frequencies for each of up to 8 other networks. Traffic-programme and announcement identification as well as programme-type and programme item number information can be transmitted for each other network. The relation to the corresponding programme is established by means of the relevant programme identification (see Chap. 3, § 1.3.4).

12. Transparent data channel (TDC)

As well as for the application described above, radiotext could also be sent in a form suitable for presenting a display on a television receiver similar to that obtained with teletext. These channels may be used to send alphanumeric characters, or other text (including mosaic graphics), or for transmission of computer programs and similar data not for display.

13. In-house application (IH)

This refers to data to be decoded only within the broadcasting organisation. Some examples noted are identification of transmission origin, remote switching of networks and paging of staff. The applications of coding may be decided by each broadcasting organisation itself.

14. Clock-time and date (CT)

In application of the relevant CCIR Recommendations, broadcast time and date codes should use Coordinated Universal Time (UTC) and Modified Julian Day (MJD). Details of using these codes are given in Chap. 3, § 2.3 and Appendix 7. The listener, however, will not use this information directly and the conversion to local time and date will be made in the receiver's circuitry.

APPENDIX 1

Offset words to be used for group and block synchronisation

The offset words are chosen in such a way that the content in the syndrome register will not be interpreted as a burst of errors equal to or shorter than five bits when rotated in the polynomial shift register (see Appendix 2).

Only eight bits (i.e. d_9 to d_2) are used for identifying the offset words. The remaining two bits (i.e. d_1 and d_0) are set to logical level zero.

The first five offset words (A, B, C, C', D) of the table below are used for the applications so far identified (see Chap. 3, § 1.3).

Offset word	Binary value									
	d_9	d_8	d_7	d_6	d_5	d_4	d_3	d_2	d_1	d_0
A	0	0	1	1	1	1	1	1	0	0
B	0	1	1	0	0	1	1	0	0	0
C	0	1	0	1	1	0	1	0	0	0
C'	1	1	0	1	0	1	0	0	0	0
D	0	1	1	0	1	1	0	1	0	0
E*	0	0	0	0	0	0	0	0	0	0
F*	0	1	1	0	0	1	0	1	0	0

* Reserved for future applications (see Appendix 8).

The offset words are added (modulo-two) to the checkword $c_9 - c_0$ to generate the modified check-bits $c'_9 - c'_0$ (see Chap. 2, § 3, Error protection).

Normally, offset words A, B, C (or C') and D will be used and added to blocks 1, 2, 3 and 4, respectively. When offset words E or F are used, the 4-block group structure described in this document need not be used. Decoders designed to meet this present specification should entirely ignore the information in any blocks found to have offset words E or F, but may use the syndromes resulting from these offsets to maintain block synchronisation. However, when using these syndromes, in order to avoid an increased rate of false synchronisation pulses, it is important that this block synchronisation information is used only if four or more consecutive blocks are found, all with offset word E or all with offset word F.

APPENDIX 2

Theory and implementation of the modified shortened cyclic code

The data format described in this document uses a shortened cyclic block code, which is given the capability of detecting block-synchronisation-slip by the addition (modulo-two) of chosen binary sequences (offset words, see Appendix 1) to the check bits of each codeword [4, 6, 7].

1. Encoding procedure

1.1. Theory

A definitive description of the encoding of the information is given in Chap. 3, § 2.

The code used is an optimum burst-error-correcting shortened cyclic code [5] and has the generator polynomial:

$$g(x) = x^{10} + x^8 + x^7 + x^5 + x^4 + x^3 + 1$$

Each block consists of 16 information bits and 10 check bits. Thus the block length is 26 bits.

The 10-bit checkword of the basic shortened cyclic code may be formed in the usual way, i.e. it is the remainder after multiplication by x^{n-k} (where n-k is the number of check bits, 10 here), and then division (modulo-two) by the generator polynomial g(x), of the message vector.

Thus if the polynomial $m(x) = m_{15} x^{15} + m_{14} x^{14} + \ldots + m_1 x + m_0$ (where the coefficients m_n are 0 or 1), represents the 16-bit message vector, the basic code vector v(x) is given by:

$$v(x) = m(x)x^{10} + \left.\frac{m(x)x^{10}}{g(x)}\right| \bmod g(x)$$

The transmitted code vector is then formed by the addition (modulo-two) of the 10-bit offset word, d(x) (see Appendix 1) to the basic code vector v(x).

Thus the transmitted code vector, c(x), is given by:

$$c(x) = d(x) + v(x)$$

$$= d(x) + m(x)x^{10} + \left.\frac{m(x)x^{10}}{g(x)}\right| \bmod g(x)$$

The code vector is transmitted m.s.b. first, i.e. information bits $c_{25} x^{25}$ to $c_{10} x^{10}$, followed by modified check bits $c'_9 x^9$ to $c'_0 x^0$.

The encoding process may alternatively be considered in terms of its generator matrix G which is derived from the generator polynomial. The 16 information bits are expressed as a 16 × 1 row matrix and multiplied by the generator matrix to give the information bits and check bits. The complete transmitted code vector is then formed by the addition of the offset word, d(x).

$$G = \left(\begin{array}{cccccccccccccccccccccccccc}
1&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&1&1&0&1&1&1\\
0&1&&&&&&&&&&&&&&0&1&0&1&1&1&0&0&1&1&1\\
0&&1&&&&&&&&&&&&&0&1&1&1&0&1&0&1&1&1&1\\
0&&&1&&&&&&&&&&&&0&1&1&0&0&0&0&1&0&1&1\\
0&&&&1&&&&&&&&&&&0&1&1&0&1&0&1&1&0&0&1\\
0&&&&&1&&&&&&&&&&0&1&1&0&1&1&1&0&0&0&0\\
0&&&&&&1&&&&&&&&&0&0&1&1&0&1&1&1&0&0&0\\
0&&&&&&&1&&&&&&&&0&0&0&1&1&0&1&1&1&0&0\\
0&&&&&&&&1&&&&&&&0&0&0&0&1&1&0&1&1&1&0\\
0&&&&&&&&&1&&&&&&0&0&0&0&0&1&1&0&1&1&1\\
0&&&&&&&&&&1&&&&&0&1&0&1&1&0&0&0&1&1&1\\
0&&&&&&&&&&&1&&&&0&1&1&1&0&1&1&1&1&1&1\\
0&&&&&&&&&&&&1&&&0&1&1&0&0&0&0&0&0&1&1\\
0&&&&&&&&&&&&&1&&0&1&1&0&1&0&1&1&1&0&1\\
0&&&&&&&&&&&&&&1&0&1&1&0&1&1&1&0&0&1&0\\
0&0&0&0&0&0&0&0&0&0&0&0&0&0&0&1&0&1&1&0&1&1&1&0&0&1
\end{array}\right)$$

Fig. 15.- Generator matrix of the basic shortened cyclic code in binary notation

Thus:

$$(m_{15}\,x^{15} + m_{14}\,x^{14} + \ldots + m_0)\,G = m_{15}\,x^{25} + m_{14}\,x^{24} + \ldots + m_0x^{10} + c_9x^9 + c_8x^8 + \ldots + c_0x^0$$

where:

$$c_9 = (m_{15} \times 0) \oplus (m_{14} \times 1) \oplus (m_{13} \times 1) \oplus \ldots \oplus (m_1 \times 1) \oplus (m_0 \times 0)$$

$$c_8 = (m_{15} \times 0) \oplus (m_{14} \times 0) \oplus (m_{13} \times 1) \oplus \ldots \oplus (m_1 \times 1) \oplus (m_0 \times 1), \text{ etc.}$$

($\oplus$ indicates modulo-two addition).

The check bits of the code vector are thus readily calculated by the modulo-two addition of all the rows of the generator matrix for which the corresponding coefficient in the message vector is "1".

Thus for the message vector:

m(x) = 0000000000000001

The corresponding code vector is:

v(x) = 00000000000000010110111001

which may be seen to be the bottom row of the generator matrix.

After adding the offset word say d(x) = 0110011000 the transmitted code vector is:

c(x) = 00000000000000010000100001

Similarly for the all "1"s message vector:

m(x) = 1111111111111111

it follows that:

v(x) = 11111111111111110011001101

which on adding an offset word d(x) = 0110011000 becomes:

c(x) = 11111111111111110101010101

1.2. Shift-register implementation of the encoder

Fig. 16 shows a shift-register arrangement for encoding the transmitted 26-bit blocks. The encoding procedure is as follows:

a) At the beginning of each block clear the 10-bit encoder shift-register to the "all-zeroes" state.

b) With gates A and B open (i.e. data passes through) and gate C closed (data does not pass through) clock the 16-bit message string serially into the encoder and simultaneously out to the data channel.

c) After all the 16 message bits for a block have been entered, gates A and B are closed and gate C opened.

d) The encoder shift-register is then clocked a further 10 times to shift the checkword out to the data channel through a modulo-two adder where the offset word, d(x), appropriate to the block is added serially bit-by-bit to form the transmitted checkword.

e) The cycle then repeats with the next block.

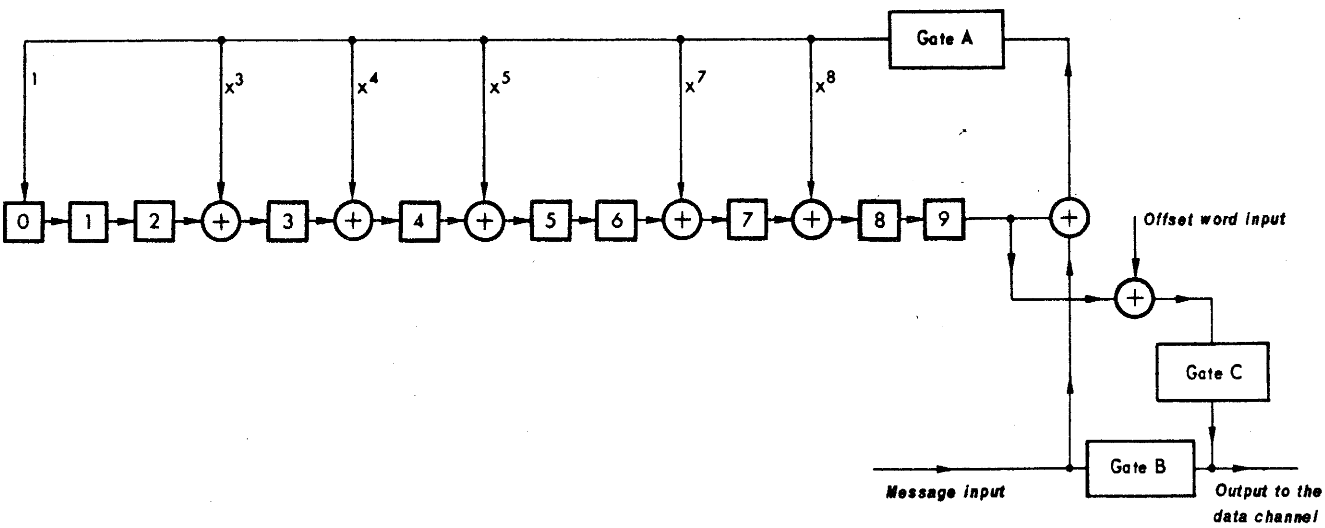


Fig. 16.- Shift-register implementation of the encoder

2. Decoding procedure

2.1. Theory

For a received binary sequence, $\bar{y}$, the syndrome $\bar{s}$ can be calculated as $\bar{s} = \bar{y}H$, where H is a parity-check matrix such as that given in Fig. 17. If $\bar{x}$ is the transmitted binary sequence and $\bar{y}$ is the received sequence, then $\bar{y} + \bar{x}$ is a sequence that contains a 1 in each position in which $\bar{y}$ and $\bar{x}$ differ. This sequence is called the error sequence $\bar{z}$. The definition of the parity-check matrix H is such that $\bar{x}H = 0$ if $\bar{x}$ is a codeword.

Thus, $\bar{z}H = (\bar{y} \oplus \bar{x})H = \bar{y}H \oplus \underbrace{\bar{x}H}_{=0} = \bar{y}H = \bar{s}$

i.e. $\bar{s} = \bar{z}H$

If the errors introduced on the channel are known then the syndrome is also known. This relation is used for synchronisation in the system.

If an offset word is added to each block, it is the same as an error added to each block, i.e. the offset word is equivalent to an error sequence $\bar{z}$, on the channel. If there are no other errors on the channel the offset word can be found in the received information by calculating the syndrome $\bar{s} = \bar{y}H$.

The calculation of the syndromes for the different offset words can easily be done by multiplying each word with the parity matrix H.

For example, with offset word A = 0011111100:

$$\bar{z} = 0000000000000000 \,|\, 0011111100 \,|$$

(arrows: m_{15} at the first bit, m_0 at the last bit of the first group; c_9 at the first bit of the second group; c_2, c_1, c_0 at its last three bits)

Now the parity-check matrix H is:

$$H = \begin{pmatrix} 1000000000 \\ 0100000000 \\ 0010000000 \\ 0001000000 \\ 0000100000 \\ 0000010000 \\ 0000001000 \\ 0000000100 \\ 0000000010 \\ 0000000001 \\ 1011011100 \\ 0101101110 \\ 0010110111 \\ 1010000111 \\ 1110011111 \\ 1100010011 \\ 1101010101 \\ 1101110110 \\ 0110111011 \\ 1000000001 \\ 1111011100 \\ 0111101110 \\ 0011110111 \\ 1010100111 \\ 1110001111 \\ 1100011011 \end{pmatrix}$$

Fig. 17.- Parity-check matrix of the basic shortened cyclic code

It is this matrix which is used in the decoder of Fig. 18

Thus $\bar{s} = \bar{z}H = 1111011000$

The other syndromes can be calculated in the same way. The syndromes corresponding to offset words A to F calculated using the matrix of Fig. 17, are shown in the Table below:

Offset	Offset word $d_9, d_8, d_7, \ldots d_0$	Syndrome $S_9, S_8, S_7, \ldots S_0$
A	0011111100	1111011000
B	0110011000	1111010100
C	0101101000	1001011100
C'	1101010000	1111001100
D	0110110100	1001011000
E	0000000000	0000000000
F	0110010100	0110000100

2.2. Implementation of the decoder

There are several methods using either hardware or software techniques for implementing the decoder. One possible method is described below.

Fig. 18 shows a shift-register arrangement for decoding the transmitted 26-bit blocks and performing error-correction and detection.

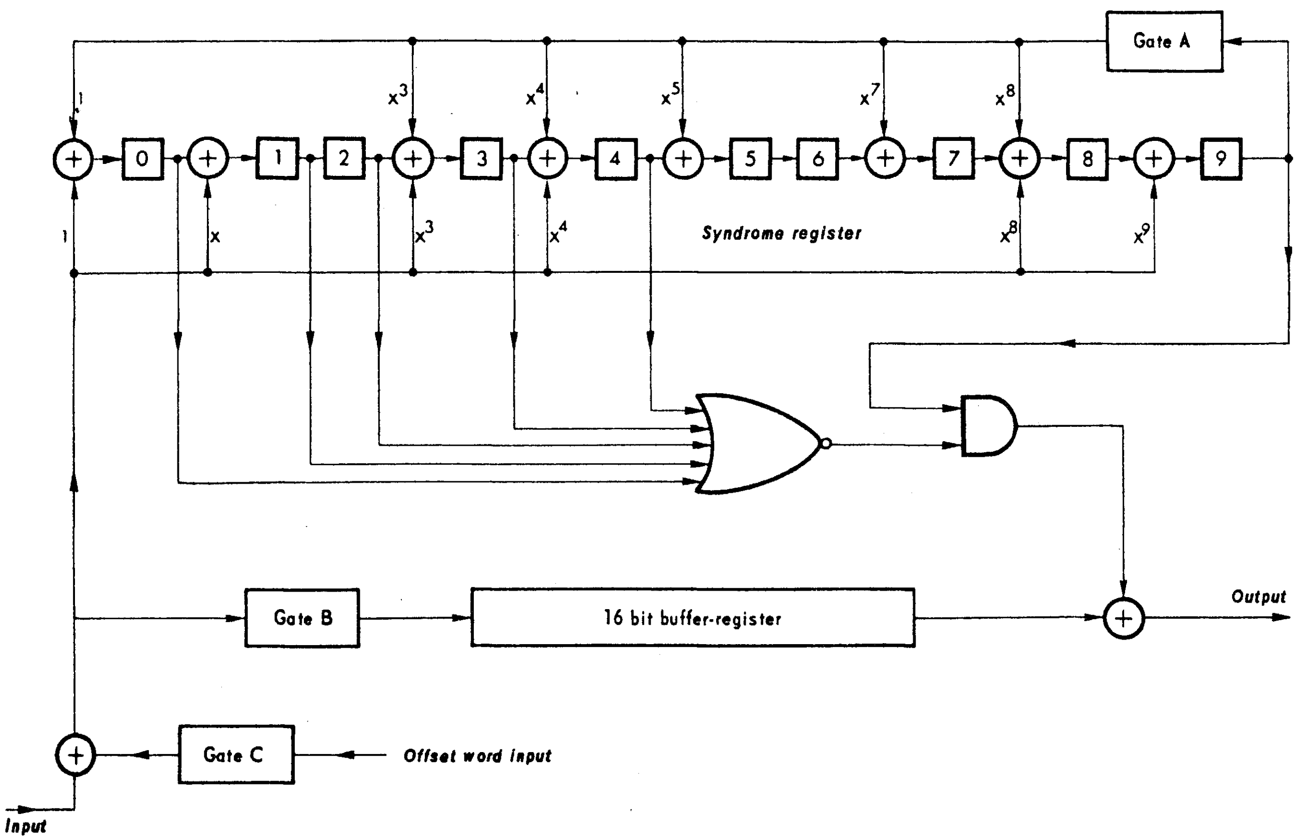


Fig. 18.- Shift-register implementation of the decoder

The decoding procedure is as follows, assuming that in this explanation group and block synchronisation have already been acquired (see Appendix 3):

a) At the beginning of each block the 10-bit syndrome-register and the 16-bit buffer-register are cleared to the "all-zeroes" state.

b) The 16 information bits are fed into the syndrome- and buffer-registers. Gates A and B are open (conducting), and Gate C is closed (not conducting).

c) With Gate B closed and Gate C open the 10 check-bits are fed into the syndrome-register. The offset word appropriate to the block is then subtracted from the checkword serially bit-by-bit at the modulo-two adder at the input to the decoder.

d) The 16 information bits in the buffer-register are clocked to the output and the contents of the syndrome-register are rotated with Gate A open.

e) When the five left-most stages in the syndrome-register are all zero a possible error burst with a maximum length of five bits must lie in the five right-hand stages of the register.

f) Gate A is closed and the contents of the syndrome register are added bit-by-bit to the bit-stream coming from the buffer-register. If the five left-most stages do not become all zero before the buffer-register is empty, either an uncorrectable error has occurred or the error is in the check-bits.

g) The cycle then repeats with the next block.

In this implementation of the decoder, in addition to the connections to the syndrome register corresponding to the coefficients of the generator polynomial, g(x), there is a second set of connections to perform automatic premultiplication of the received message by x^{325} modulo g(x). This is necessary because the code has been shortened from its natural cyclic length of 341 bits. The remainder of x^{325} modulo g(x) is $x^9 + x^8 + x^4 + x^3 + x + 1$, and the second set of connections to the syndrome register may be seen to correspond to the coefficients in this remainder.

Reference [4] gives a further explanation of this decoding technique.

APPENDIX 3

Implementation of group and block synchronisation using the modified shortened cyclic code

1. Theory

1.1. Acquisition of group and block synchronisation

To acquire group and block synchronisation at the receiver (for example when the receiver is first switched on, on tuning to a new station, or after a prolonged signal-fade) the syndrome $\bar{s}$ must be calculated for each received 26-bit sequence. That is, on every data-clock pulse the syndrome of the currently stored 26-bit sequence (with the most recently received data bit at one end and the bit received 26 clock pulses ago at the other) is calculated on every clock pulse.

This bit-by-bit check is done continuously until two syndromes corresponding to valid offset words, and in a valid sequence for a group i.e. [A, B, C (or C'), D] are found n x 26 bits apart (where n = 1, 2, 3 etc.). When this is achieved, the decoder is synchronised and the offset words which are added to the parity bits at the transmitter are subtracted at the receiver before the syndrome calculation for error correction/detection is done (see Appendix 2).

1.2. Detection of loss of synchronisation

It is very important to detect loss of synchronisation as soon as possible. One possibility is to check the syndrome continuously as for acquisition of synchronisation. However, errors in the channel will make it difficult to continuously receive the expected syndromes, and therefore the decision must be based on the information from several blocks, e.g. up to 50 blocks. Another possibility is to check the number of errors in each block and base the decision on the number of errors in 50 blocks.

One possibility for detecting block synchronisation slips of one bit is to use the PI code, which does not usually change on any given transmission. If the known PI code is received correctly, but is found to be shifted one bit to the right or to the left, then a one bit clock-slip is detected. The decoder can then immediately correct the clock-slip.

2. Shift-register arrangement for deriving group and block synchronisation information

There are several methods using either hardware or software techniques for deriving group and block synchronisation information. One possible method is described below. Fig. 19 shows a block diagram of a shift-register arrangement for deriving group and block synchronisation information from the received data stream. It may be seen to comprise five main elements:

a) a 26-bit shift-register which may either act as a straight 26-bit delay (A/B input selector high) or as a recirculating shift-register (A/B input selector low);

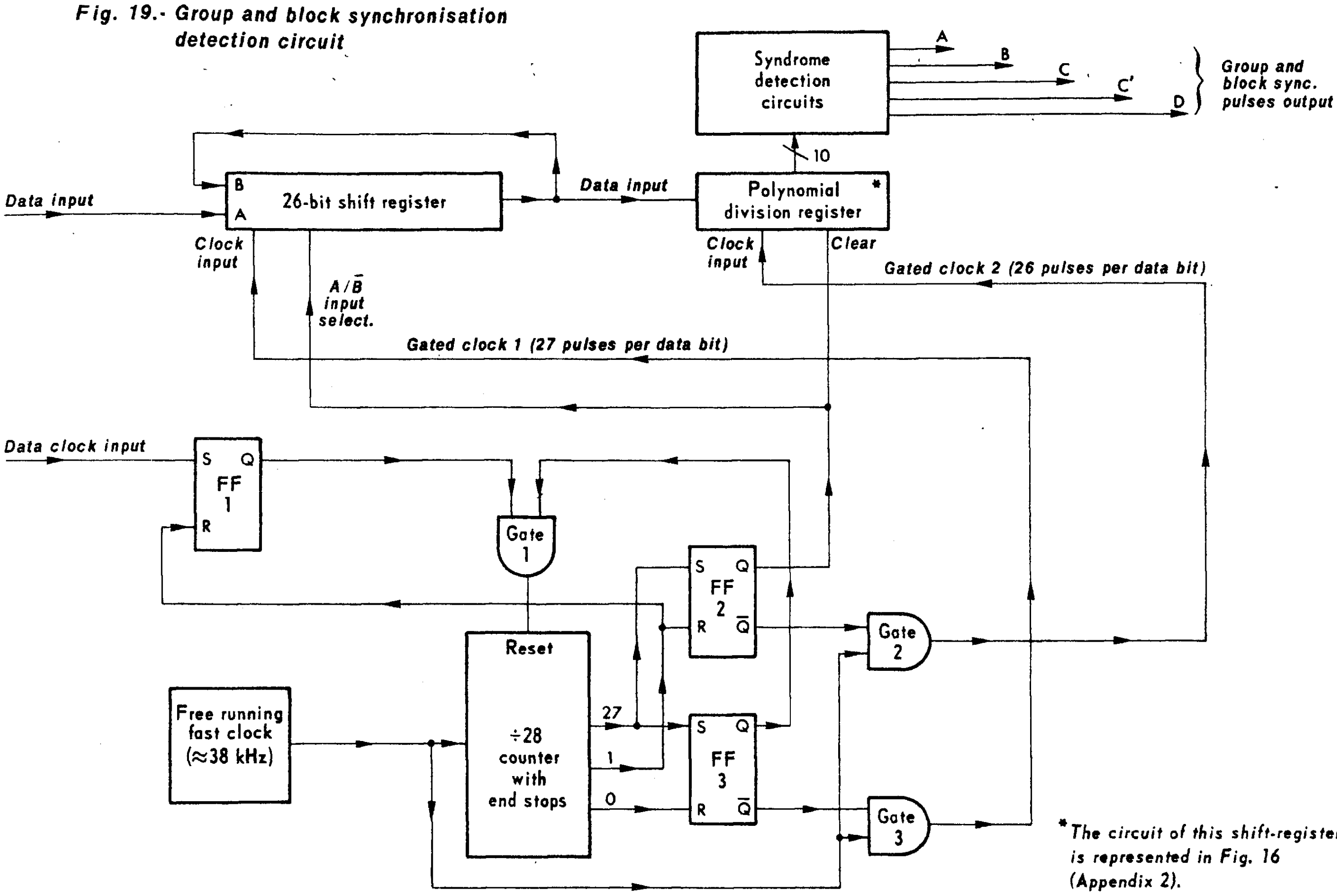
b) a polynomial division circuit comprising a 10-bit shift-register with feed-back taps appropriate to the generator polynomial, g(x), described in Chap. 2, § 3 and Appendix 2;

c) a combinational logic circuit with five ouputs indicating the presence of the "correct" syndromes resulting from the five offset words A, B, C, C' and D;

d) a fast-running clock operating at at least 33.5 kHz;

e) a modulo-28 counter with endstops, decoding for states 0, 1 and 27, and associated logic gates 1 to 3 and flip-flops 1 to 3 (FF1 to FF3).

Fig. 19.- Group and block synchronisation detection circuit



The circuit of this shift-register is represented in Fig. 16 (Appendix 2).

Assume that the modulo-28 counter is initially on its top endstop (state 27). Then FF2 and FF3 are set and FF1 is reset. The gated clocks to the 26-bit shift-register and the polynomial division circuit (gated clocks 1 and 2) are inhibited and the division circuit shift-register is cleared.

On the next data clock pulse FF1 is set, which in turn resets the modulo-28 counter to state 0. This resets FF3 which enables the fast clock (gated clock 1) to the 26-bit shift-register. This has its input A selected and thus the new data bit is entered into its left-hand end; the shift-register of the polynomial division circuit remains cleared and not clocked. On the next fast clock-pulse FF1 is reset ready for the next data clock-pulse.

Before then, however, the fast clock circulates the 26 bits currently stored in the shift-register around, and thus passes them serially into the polynomial division shift-register where the syndrome (i.e. the remainder of the polynomial division) is calculated. If these 26 bits happened to be a valid code-word then the syndrome would be $x^{10}d(x)$ modulo $g(x)$, e.g. if the offset word $d(x)$ = 0011111100 then the corresponding "correct" syndrome for that block would be 0101111111.

It should be noted that the syndromes obtained with this polynomial division register are different from that resulting from the matrix of Fig. 17 or the circuit of Fig. 18 (Appendix 2). The syndromes corresponding to offset words A to F are shown in the table below.

Offset	Offset word $d_9, d_8, d_7, \ldots d_0$	Syndrome $S_9, S_8, S_7, \ldots S_0$
A	0011111100	0101111111
B	0110011000	0000001110
C	0101101000	0100101111
C'	1101010000	1011101100
D	0110110100	1010010111
E	0000000000	0000000000
F	0110010100	0001010000

When the syndrome corresponding to one of the five offset words is found, a block synchronisation pulse is given out of the appropriate one of the five outputs of the combinational logic circuit.

With high probability (99.5%) this will only occur when the stored 26 bits are a complete error-free block.

This decoding process must all be achieved in under one data-bit period ($\simeq$842 μs).

On the next data-clock pulse the whole process repeats with the new data bit in the leftmost cell of the 26-bit shift-register and all the other bits shifted along one place to the right. Thus a block synchronisation pulse will usually be derived one every 26 bits and will mark the end of each received block.

Moreover, since the circuit identifies which offset word A, B, C, C' or D was added to the block, group synchronisation is also achieved.

These group and block synchronisation pulses cannot, however, be used directly because although with this system false synchronisation pulses due to data mimicking or errors will be infrequent, they will, on average (with random data), occur once every 5×2^{10} bits or approximately once every six seconds. Similarly, when errors occur, block synchronisation pulses will be missed because even with correct block synchronisation one of the "correct" syndromes corresponding to one of the five offset words will not result.

Thus it is necessary to have some sort of block sychronisation flywheel to eliminate spurious synchronisation pulses and fill in the missing ones. This could be achieved with any one of the standard strategies, but should take into account the fixed cyclic rhythm of occurrence of the offset words i.e. A, B, C (or C'), D, A, B ..., etc.

APPENDIX 4

Coding model for programme identification information in radio-data transmissions

1. EBU coding model

1				5				9				13			

Columns 1 to 4 : Country identification.
Codes are indicated on the map on page 44 and listed on page 45.

Columns 5 to 8 : Programme type, classified according to its area coverage.
Codes are given on page 46.

Columns 9 to 16: Programme reference number.
Codes are given on page 47.

General remark: All codes are binary-coded HEX numbers. Code assignments must be decided by each country individually.

* * *

Example 1: United Kingdom = C
Area coverage: N = 2
Programme BBC1 = 1

HEX-code: C201*

1				5				9				13			
1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	1

Example 2: Germany FR = D
Area coverage: traffic area B = B
Programme NDR2 = 33

HEX-code DB21*

1				5				9				13			
1	1	0	1	1	0	1	1	0	0	1	0	0	0	0	1

* A conversion table from HEX numbers to binary codes is showed on page 48.

2. Country identification

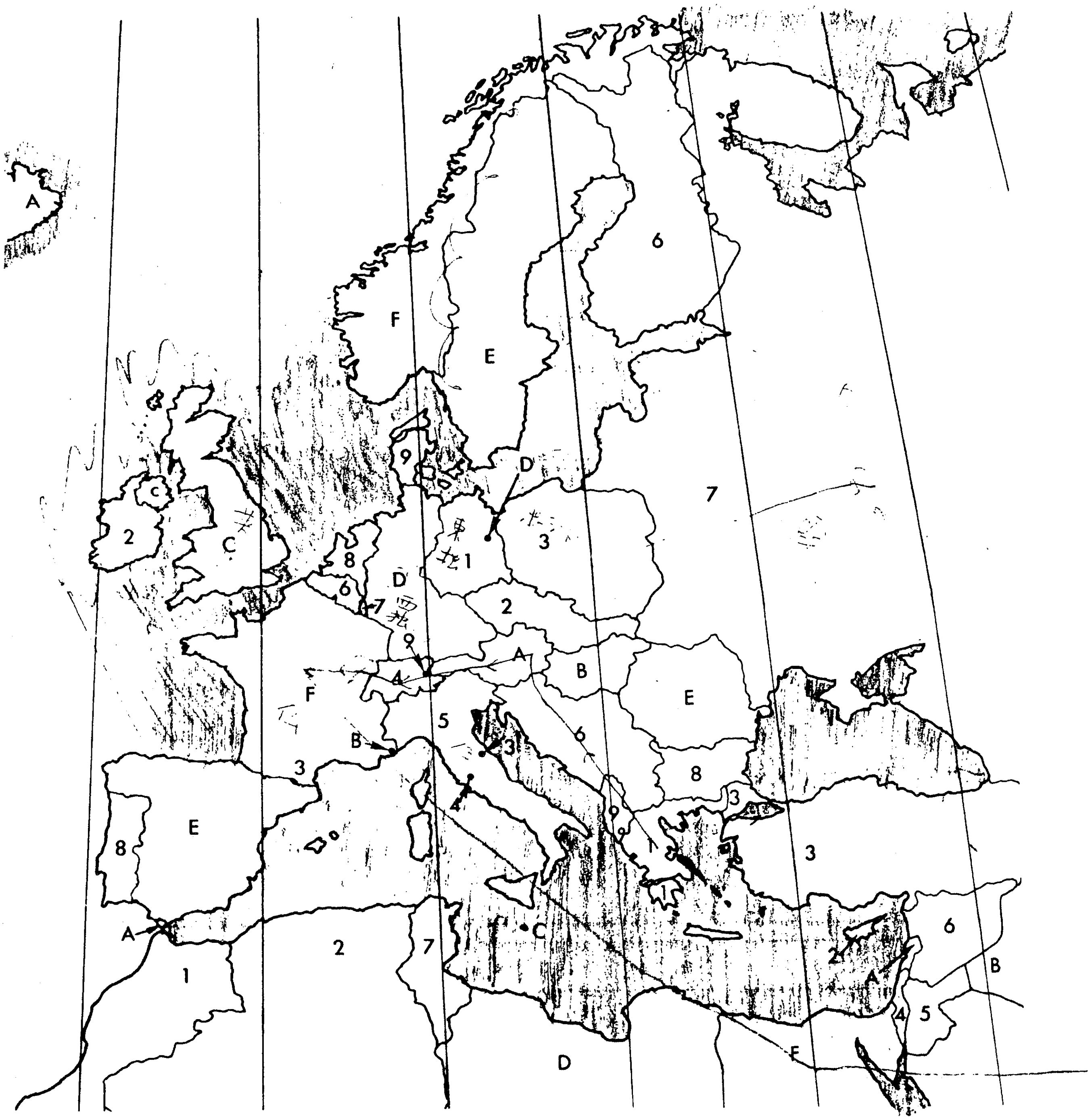


Fig. 20.- Geographical locations of the symbols used for the various countries

Note.- The representation of national frontiers in this map is of geographical significance only and does not imply their recognition by the EBU.

Symbols used for the countries in the European Broadcasting Area

Country	Symbol*
Albania (Socialist People's Republic of)	9
Algeria (Algerian Democratic and Popular Republic of)	2
Andorra	3
Austria	A
Azores (Portugal)	8
Belgium	6
Bielorussia (see USSR)	7
Bulgaria (People's Republic of)	8
Canary Islands (Spain)	E
Cyprus (Republic of)	2
Czechoslovak Socialist Republic	2
Denmark	9
Egypt (Arab Republic of)	F
Faroe (Denmark)	9
Finland	6
France	F
German Democratic Republic	1
Germany (Federal Republic of)	D
Gibraltar (United Kingdom)	A
Greece	1
Hungarian People's Republic	B
Iceland	A
Iraq (Republic of)	B
Ireland	2
Israel (State of)	4
Italy	5

Country	Symbol*
Jordan (Hashemite Kingdom of)	5
Libya (Socialist People's Libyan Arab Jamahirya)	D
Lebanon	A
Liechtenstein	9
Luxembourg	7
Madeira (Portugal)	8
Malta (Republic of)	C
Monaco	B
Morocco (Kingdom of)	1
Netherlands (Kingdom of the)	8
Norway	F
Poland (People's Republic of)	3
Portugal	8
Roumania (Socialist Republic of)	E
San Marino (Republic of)	3
Spain	E
Sweden	E
Switzerland (Confederation of)	4
Syrian Arab Republic	6
Tunisia	7
Turkey	3
Ukraine	7
Union of Soviet Socialist Republics	7
United Kingdom	C
Vatican City State	4
Yugoslavia (Socialist Federal Republic of)	6

* The corresponding binary coding (bits 1 to 4) is shown on page 48.

Correspondence between the symbols and the ITU country codes

1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
DDR	ALG	AND	ISR	I	BEL	BLR	AZR	ALB	AUT	HNG	MLT	D	CNR	EGY
GRC	CYP	SM	SUI	JOR	FNL	LUX	BUL	DNK	GIB	IRQ	G	LBY	ROU	F
MRC	TCH	POL	CVA		SYR	TUN	MAR	LIE	ISL	MCO			E	NOR
	IRL	TUR			YUG	UKR	HOL		LBN				S	
						URS	POR							

3. Programme type in terms of area coverage*

I: (International)	The same programme is also transmitted in other countries.
N: (National)	The same programme is transmitted throughout the country.
S: (Supra-regional)	The same programme is transmitted throughout a large part of the country.
R1 . . . R4: (Regional)	The programme is available only in one location or region and there exists no definition of its frontiers. These four codes for regions with undefined frontiers are available for distinguishing between adjacent regions.
R5 . . . R12: (Regional)	Area codes, including ARI traffic areas A to F.
L: (Local)	Local programme transmitted via single transmitter only.

Hexadecimal-coding rules*

Area coverage code	L	I	N	S	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12
ARI traffic area											A	B	C	D	E	F
HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F

* The corresponding binary coding (bits 5 to 8) is shown on page 48.

4. Programme reference number

Numbers*	Bits*	
00	9 to 16	Not assigned
01 to 255	9 to 16	Reserved for the *major programmes, in terms of area coverage* (mark in addition codes for I, N, S or R5 to R12 in bits 5 to 8)**
01 to 255	9 to 16	Reserved for *local programmes with only one transmitter* (mark in addition code for L in bits 5 to 8)**
01 to 255	9 to 16	Reserved for *local or regional programmes with more than one transmitter* (use regional codes R1 to R4 in bits 5 to 8)**

Note.- Codes must be assigned in such a way that automatic search tuning to other transmitters radiating the same programme can locate the same programme-identification code, i.e. all 16 bits must be identical. In cases where during a few programme hours a network is split to radiate different programmes, each of these programmes must carry a different programme-identification code, e.g. by using different coverage-area codes.

* The corresponding binary coding is shown on page 48.

** These codes are given on page 46.

5. Use of hexadecimal numbers

a) Conversion table from decimal to hexadecimal

The decimal number between 0 and 255 is found in the table, and the two figures of the corresponding hexadecimal number are read off from the first column and the top line.

D_1 ↓ / D_2 →	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
2	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
3	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
4	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
5	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
6	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
7	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127
8	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143
9	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159
A	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175
B	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191
C	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207
D	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223
E	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239
F	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255

D_1 : first digit } from hexadecimal number
D_2 : second digit

Example: decimal number 148 corresponds to hexadecimal-code 94.

b) Conversion table from hexadecimal to binary

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Binary	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111

APPENDIX 5

Character repertoires for use in radio-data transmissions

Three different alphanumeric character repertoires have been defined; they are reproduced in Figs. 21 to 23. Taken together, they permit the composition of texts indicating the name of the programme service and the constitution of radio-data messages, and they satisfy all the known requirements of the EBU Active Members as regards radio-data transmission. The three code-tables each contain almost all the characters in the international reference version of ISO Standard 646*. The same codes have been given to each of these characters in all three tables. Care has been taken in the design of the coding tables to ensure that it will be possible to satisfy all the requirements within large geographical areas with each repertoire, and it is therefore likely that some receivers will be equipped to display only the characters included in one of the three repertoires. Nonetheless, it will be necessary to provide information identifying the repertoire in use, in order to ensure that the display corresponds as closely as possible to the intentions of the broadcasting organisation when received on a receiver able to display characters from more than one repertoire.

In accordance with the practice in the videotex service, where more than one character repertoire is defined also, control codes have therefore been allocated to distinguish between the basic (G0) and two auxiliary (G1 and G2) code-tables. The selection of the required code-table is controlled in videotex by the transmission of the corresponding repertoire control characters; SI (0/15), SO (0/14) and LS2 (1/11 followed by 6/14)**. In radio-data, it is controlled by the transmission of one of the following pairs of repertoire control characters:

- 0/15, 0/15: code-table of Fig. 21
- 0/14, 0/14: code-table of Fig. 22
- 1/11, 6/14: code-table of Fig. 23.

These characters do not occupy a space in the display, but have effect on the displayable characters having the same address, and on all characters having numerically higher addresses up to, but not including, the address of another repertoire control character. In default of a repertoire control character, the display coding taking effect at address 0 should be assumed to be in accordance with Fig. 21. Receivers must not respond to any other characters of columns 0 or 1 of the code-tables which are reserved for possible future extensions of the system.

---

* Including the figures 0 to 9 and punctuation; nonetheless, in certain cases, codes have been re-allocated to characters taken from the EBU repertoires, in accordance with the provisions of ISO Standard 646.

** In accordance with CCIR practice, the notation A/B is used to designate the character appearing on line B of column A in the table.

For example, the name of the second Greek programme service could be transmitted in type 0 groups as follows:

Characters: ΔΕ ΥΤ ΕΡ Ο
Addresses : 0 1 2 3

Address	Codes	Characters	Function
0	0/14, 0/14	SO, SO	Selection of code-table
0	15/14, 4/5	Δ, E	First two letters
1	5/9, 5/4	Y, T	Second two letters
2	4/5, 5/0	E, P	Third two letters
3	4/15, 2/0	O, SP	Last letter and space

The code-tables of Figs. 21, 22 and 23 have also been adopted for the "service identification system" defined in the specifications of the C-MAC/packet system for satellite broadcasting in Europe.

					Displayable characters from the code table of ISO Norm 646:						Additional displayable characters for: EBU common-core (7 languages)		Additional displayable characters for: Complete Latin-based repertoire (25 languages)					
				b8	0	0	0	0	0	0	1	1	1	1	1	1	1	1
				b7	0	0	1	1	1	1	0	0	0	0	1	1	1	1
				b6	1	1	0	0	1	1	0	0	1	1	0	0	1	1
				b5	0	1	0	1	0	1	0	1	0	1	0	1	0	1
b4	b3	b2	b1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0		0	@	P	‖	p	á	â	ª	º	Á	Â	Ã	ã
0	0	0	1	1	!	1	A	Q	a	q	à	ä	α	¹	À	Ä	Å	å
0	0	1	0	2	"	2	B	R	b	r	é	ê	©	²	É	Ê	Æ	æ
0	0	1	1	3	#	3	C	S	c	s	è	ë	‰	³	È	Ë	Œ	œ
0	1	0	0	4	¤	4	D	T	d	t	í	î	Ğ	±	Í	Î	Ŷ	ŵ
0	1	0	1	5	%	5	E	U	e	u	ì	ï	ě	İ	Ì	Ï	Ý	ý
0	1	1	0	6	&	6	F	V	f	v	ó	ô	ň	ń	Ó	Ô	Õ	õ
0	1	1	1	7	'	7	G	W	g	w	ò	ö	ő	ű	Ò	Ö	Ø	ø
1	0	0	0	8	(	8	H	X	h	x	ú	û	π	µ	Ú	Û	Þ	þ
1	0	0	1	9	)	9	I	Y	i	y	ù	ü	₠	¿	Ù	Ü	Ŋ	ŋ
1	0	1	0	10	*	:	J	Z	j	z	Ñ	ñ	£	÷	Ř	ř	Ŕ	ŕ
1	0	1	1	11	+	;	K	[(1)	k	{ (1)	Ç	ç	$	°	Č	č	Ć	ć
1	1	0	0	12	,	<	L	\	l	|	Ş	ş	←	¼	Š	š	Ś	ś
1	1	0	1	13	-	=	M	] (1)	m	} (1)	β	ğ	↑	½	Ž	ž	Ź	ź
1	1	1	0	14	.	>	N	―	n	‾	İ	ı	→	¾	Đ	đ	Ŧ	ŧ
1	1	1	1	15	/	?	O	_	o		Ĳ	ij	↓	§	Ŀ	ŀ	ð	

Fig. 21.- Code table for 218 displayable characters forming the complete EBU Latin-based repertoire.
The characters shown in positions marked (1) in the table are those of the "international reference version" of ISO 646 that do not appear in the "complete Latin-based repertoire" given in Appendix 2 of EBU document Tech. 3232 (2nd edition, 1982).

					Latin (ISO Norm 646)						EBU common-core		Part of the EBU complete Latin-based repertoire		Cyrillic etc.		Greek	
				b8	0	0	0	0	0	0	1	1	1	1	1	1	1	1
				b7	0	0	1	1	1	1	0	0	0	0	1	1	1	1
				b6	1	1	0	0	1	1	0	0	1	1	0	0	1	1
				b5	0	1	0	1	0	1	0	1	0	1	0	1	0	1
b4	b3	b2	b1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0		0	@	P	‖	p	á	â	ª	º	Є	ý	Π	π
0	0	0	1	1	!	1	A	Q	a	q	à	ä	ľ	¹	Я	Љ	α	Ω
0	0	1	0	2	"	2	B	R	b	r	é	ê	©	²	Б	ď	β	ρ
0	0	1	1	3	#	3	C	S	c	s	è	ë	‰	³	Ч	Ш	ψ	σ
0	1	0	0	4	¤	4	D	T	d	t	í	î	ă	±	Д	Ц	δ	τ
0	1	0	1	5	%	5	E	U	e	u	ì	ï	ě	İ	Э	Ю	ε	ξ
0	1	1	0	6	&	6	F	V	f	v	ó	ô	ň	ń	Ф	Щ	φ	Θ
0	1	1	1	7	'	7	G	W	g	w	ò	ö	ő	ű	Ѓ	Њ	γ	Γ
1	0	0	0	8	(	8	H	X	h	x	ú	û	ť	ţ	Ъ	Џ	η	Ξ
1	0	0	1	9	)	9	I	Y	i	y	ù	ü	Œ	¿	И	Й	ι	υ
1	0	1	0	10	*	:	J	Z	j	z	Ñ	ñ	£	÷	Ж	З	Σ	ζ
1	0	1	1	11	+	;	K	[(¹)	k	{ (¹)	Ç	ç	$	°	Ќ	č	χ	ς
1	1	0	0	12	,	<	L	\	l	|	Ş	ş	←	¼	Л	š	λ	Λ
1	1	0	1	13	-	=	M	] (¹)	m	} (¹)	β	ğ	↑	½	Ћ	ž	μ	Ψ
1	1	1	0	14	.	>	N	―	n	‾	¡	ı	→	¾	Ђ	đ	ν	Δ
1	1	1	1	15	/	?	O	_	o		Ĳ	ĳ	↓	§	Ы	ć	ω	

Fig. 22.- Code table for a combined repertoire consisting of the EBU Common-core, Greek and upper-case Cyrillic alphabets (together with certain characters from the EBU complete Latin-based repertoire, and the lower-case characters required for texts in Serbo-Croat, Slovenian, Slovakian, Hungarian and Romanian).

The characters shown in positions marked (¹) in the table are those of the "international reference version" of ISO 646 that do not appear in the "complete Latin-based repertoire" given in Appendix 2 of EBU document Tech. 3232 (2nd edition, 1982).

					Latin (ISO Norm 646)						Arabic		Hebrew		Cyrillic etc.		Greek	
				b8	0	0	0	0	0	0	1	1	1	1	1	1	1	1
				b7	0	0	1	1	1	1	0	0	0	0	1	1	1	1
				b6	1	1	0	0	1	1	0	0	1	1	0	0	1	1
				b5	0	1	0	1	0	1	0	1	0	1	0	1	0	1
b4	b3	b2	b1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0	0	0		0	@	P	‖	p	بـ	ظ	א	ן	Є	ý	Π	π
0	0	0	1	1	!	1	A	Q	a	q	تـ	عـ	ב	ס	Я	Љ	α	Ω
0	0	1	0	2	"	2	B	R	b	r	ة	غـ	ג	ע	Б	ď	β	ρ
0	0	1	1	3	#	3	C	S	c	s	ثـ	فـ	ד	פ	Ч	Ш	ψ	σ
0	1	0	0	4	¤	4	D	T	d	t	جـ	قـ	ה	ף	Д	Ц	δ	τ
0	1	0	1	5	%	5	E	U	e	u	حـ	كـ	ו	צ	Э	Ю	ε	ξ
0	1	1	0	6	&	6	F	V	f	v	خـ	لـ	ז	ץ	Ф	Щ	φ	Θ
0	1	1	1	7	'	7	G	W	g	w	د	مـ	ח	ק	Ѓ	Њ	γ	Γ
1	0	0	0	8	(	8	H	X	h	x	ذ	نـ	ט	ר	Ъ	Џ	η	Ξ
1	0	0	1	9	)	9	I	Y	i	y	ر	هـ	י	ש	И	Й	ι	υ
1	0	1	0	10	*	:	J	Z	j	z	ز	و	כ	ת	Ж	З	Σ	ζ
1	0	1	1	11	+	;	K	[(1)	k	{ (1)	سـ	يـ	ך	°	Ќ	č	χ	ς
1	1	0	0	12	,	<	L	\	l	|	شـ	←	ל	¼	Л	š	λ	Λ
1	1	0	1	13	-	=	M	] (1)	m	} (1)	صـ	↑	מ	½	Ћ	ž	μ	Ψ
1	1	1	0	14	.	>	N	—	n	ء	ضـ	→	ם	¾	Ђ	đ	ν	Δ
1	1	1	1	15	/	?	O	_	o	ا	ط	↓	נ	§	Ы	ć	ω	

Fig. 23.- Code table for a combined repertoire consisting of the ISO 646 Latin-based alphabet, Greek, upper-case Cyrillic and Hebrew and Arabic.

The characters shown in positions marked (1) in the table are those of the "international reference version" of ISO 646 that do not appear in the "complete Latin-based repertoire" given in Appendix 2 of EBU document Tech. 3232 (2nd edition, 1982).

APPENDIX 6

EBU proposals for programme-type codes

Number	Code	Programme type
0	00000	No programme type is indicated
1	00001	News
2	00010	Current affairs
3	00011	Magazine
4	00100	Sport
5	00101	Education
6	00110	For children
7	00111	For young people
8	01000	Religious
9	01001	Drama, literature and feature
10	01010	Pop and rock music
11	01011	Light music
12	01100	Serious music
13	01101	Jazz
14	01110	Folk music
15	01111	Variety
16	10000	As yet undefined (16–30)
.	.	
.	.	
.	.	
21	.	
22	.	
.	.	
.	.	
.	.	
30	11110	
31	11111	Alarm

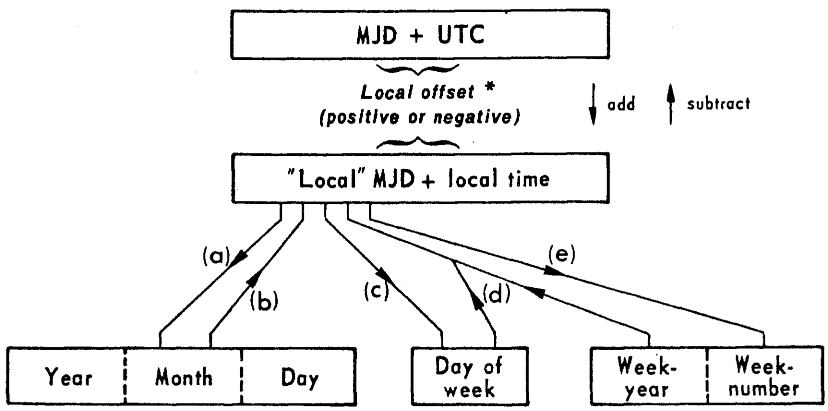
Definition of the terms used to denote programme type

1. *News*	Short, regular accounts of facts, events, and publicly expressed views.
2. *Current affairs*	Programme expanding or enlarging on the news, generally in different presentation or concept, including documentary.
3. *Magazine*	Programme comprising a mixture of informational and entertainment items, the latter usually musical.
4. *Sport*	Programmes concerned with any aspect of sport.
5. *Education*	Programmes intended primarily to educate, of which the pedagogical element is fundamental.
6. *For children*	Programmes other than educational, for children up to the age of about 12 years.
7. *For young people*	Programmes other than educational, for young people up to the age of about 19 years.
8. *Religious*	Programmes concerned with religion, including different forms of religious services.
9. *Drama, literature and feature*	Radio plays and serials, book and poetry readings, literary reviews, feature programmes.
10. *Pop and rock music*	Programmes of rock, beat and similar music.
11. *Light music*	Light entertainment music which cannot be classified as pop, rock or serious music.
12. *Serious music*	Any form of classical or modern music which cannot be classified as pop, rock or light music. It includes opera, symphonic, chamber, choral and church music.
13. *Jazz*	Music of an improvisational nature, generally recognised as jazz, traditional, contemporary and "avant-garde".
14. *Folk music*	Songs or dances, usually handed down in the oral tradition, both contemporary and traditional.
15. *Variety*	Quizzes, games, comedy shows.
16-30.	As yet undefined.
31. *Alarm*	Emergency announcement made under exceptional circumstances to give warning of events causing danger of a general nature.

APPENDIX 7

Conversion between time and date conventions

The types of conversion which may be required are summarised in the diagram below.



* Offsets are positive for longitudes east of Greenwich and negative for longitudes west of Greenwich.

The conversion between MJD + UTC and the "local" MJD + local time is simply a matter of adding or subtracting the local offset. This process may, of course, involve a "carry" or "borrow" from the UTC affecting the MJD. The other five conversion routes shown on the diagram are detailed in the formulas below.

Symbols used MJD:	Modified Julian Day
UTC:	Coordinated Universal Time
Y:	Year from 1900 (e.g. for 2003, Y = 103)
M:	Month from January (= 1) to December (= 12)
D:	Day of month from 1 to 31
WY:	"Week number" Year from 1900
WN:	Week number according to ISO 2015
WD:	Day of week from Monday (= 1) to Sunday (= 7)
K, L, M', W, Y':	Intermediate variables
* :	Multiplication
int:	Integer part, ignoring remainder
mod 7:	Remainder (0-6) after dividing integer by 7.

a) To find Y, M, D from MJD

$$Y' = \text{int}\ [(MJD - 15078.2)/365.25]$$

$$M' = \text{int}\ \{[MJD - 14956.1 - \text{int}(Y' * 365.25)]/30.6001\}$$

$$D = MJD - 14956 - \text{int}(Y' * 365.25) - \text{int}(M' * 30.6001)$$

If $M' = 14$ or $M' = 15$, then $K = 1$; else $K = 0$

$$Y = Y' + K$$

$$M = M' - 1 - K * 12.$$

b) To find MJD from Y, M, D

If $M = 1$ or $M = 2$, then $L = 1$; else $L = 0$

$$MJD = 14956 + D + \text{int}\ [(Y - L) * 365.25] + \text{int}\ [(M + 1 + L * 12) * 30.6001]$$

c) To find WD from MJD

$$WD = [(MJD + 2) \bmod 7] + 1$$

d) To find MJD from WY, WN, WD

$$MJD = 15012 + WD + 7 * \{WN + \text{int}\ [(WY * 1461/28) + 0.41]\}$$

e) To find WY, WN from MJD

$$W = \text{int}\ [(MJD/7) - 2144.64]$$

$$WY = \text{int}\ [(W * 28/1461) - 0.0079]$$

$$WN = W - \text{int}\ [(WY * 1461/28) + 0.41]$$

Example

MJD = 45218	W = 4315
Y = (19)82	WY = (19)82
M = 9 (September)	WN = 36
D = 6	WD = 1 (Monday)

Note.- These formulas are applicable between the inclusive dates 1900 March 1 to 2100 February 28.

APPENDIX 8

Other applications

One basic requirement throughout has been to make the formatting flexible, so that it will be possible to use this channel for future applications. One possibility is to select one of the spare group types to code each application. Another possibility is to use other offset words.

One example of future applications is given:

This example describes how the Swedish MBS system for paging can be integrated in the RDS system (see Specification No. 76 16560-2E, issued by Swedish Telecommunications Administration):

a) Integration with a special group type number.

Each paging call consists of 18 decimal digits.

PI		PAGING	PAGING
Block 1	Block 2	Block 3	Block 4

b) Integration with a special offset word.

Each block with paging information has an offset word E (see Appendix 1). The group synchronisation word is B5XX with X = 0...F_{HEX}. The maximum distance between two synchronisation words is 5 blocks. The maximum time interval where the offset word is equal to 0 is T = 32.707 s. If the RDS receiver starts to synchronise on one channel, and finds two offset words E then the channel is regarded as a RDS/MBS channel. To avoid false synchronisation caused by blocks with information equal to 0, which also gives the syndrome equal to 0, the receiver has to find the special synchronisation word B5XX (HEX) within 6 blocks. If the receiver is in the scanning mode, it has to mark (set a flag) that the channel is a RDS/MBS channel and then continue to scan the band. If the searched programme is detected, the receiver has to go back to the RDS/MBS channel and wait the time $T \leqslant 32.707$ s for RDS information.

APPENDIX 9

Specification of the ARI system

1. *Frequency of the subcarrier* : 57 kHz

   1.1. Nominal value: ± 57 kHz

   1.2. Tolerances:

   Mono: ± 6 Hz

   Stereo: The phase relationship between the pilot tone and the subcarrier is such that when both sine waves are crossing the time axis simultaneously, the slopes have to be the same. Since the tolerance of the pilot tone can be ± 2 Hz, the frequency of the subcarrier can deviate by ± 6 Hz.

2. *Frequency deviation* : ± 4.0 kHz ± 200 Hz

3. *Modulation* : AM

4. *Traffic announcement identification*

   4.1. Modulation frequency: 125 Hz (57 kHz divided by 456)

   4.2. Tolerance: derived from 57 kHz subcarrier

   4.3. Modulation depth: m = 0.3 ± 5%

5. *Traffic area identification*

   5.1. Modulation frequencies: derived from the subcarrier frequency.

Traffic area	Frequency (Hz)	Frequency division ratio
A	23.7500	2400
B	28.2738	2016
C	34.9265	1632
D	39.5833	1440
E	45.6731	1248
F	53.9773	1056

   5.2. Modulation depth: m = 0.6 ± 5%.

Index of abbreviations

The abbreviations which are commonly used in context with the radio-data system are listed below in alphabetical order. Most of these terms are explained in the glossary (see Chapter 4).

AF : List of alternative frequencies.

CT : Clock time and date.

DI : Decoder identification.

IH : In-house application.

M/S : Music/speech switch.

ON : Information concerning other networks.

PI : Programme identification.

PIN : Programme-item number.

PS : Programme service name.

PTY : Programme type.

RDS : Radio-data system.

RT : Radiotext.

TA : Traffic-announcement identification.

TDC : Transparent data channel.

TP : Traffic-programme identification.

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