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UNITED STATES RBDS STANDARD

JANUARY 8, 1993

Descriptors: **Broadcasting, sound broadcasting,** data transmission, **frequency modulation, message,** specification

Specification of the radio broadcast data system (RBDS)

Sponsored by the Electronic Industries Association and the National Association of Broadcasters

FOREWORD

The United States Radio Broadcast Data System Standard was produced by the RBDS subgroup of the National Radio Systems Committee (NRSC) sponsored by the Electronics Industry Association (EIA) and the National Association of Broadcasters (NAB). The Committee began its work in February of 1990.

The United States RBDS Standard reflects the input from broadcasters, receiver manufacturers, users and potential users of RDS services. Every attempt was made to keep the United States Standard compatible with the EBU and Cenelec Standard EN50067, where possible. Clearly, differences in the broadcasting environment, federal regulations, and other considerations influenced the final text of this Standard.

The United States RBDS Standard encompasses several data broadcast and data technologies. Among these technologies are Radio Data System (RDS), MBS and MMBS, and In-Receiver Database System (I-RDS).

> The RDS technology was developed for FM by the European Broadcasting Union and its member countries. The European RDS specifications were originally published in 1984 and revised in 1986, 1990, 1991 and 1992.
>
> MBS refers to the Swedish Telecommunications Administration (Televerket) Specification for the Swedish Public Radio Paging System (see reference [18]). MMBS refers to MBS modified for multiplexing with RDS. See Note 2.
>
> The I-RDS system is based on a in-receiver ROM database that is updated via the RDS data stream. See Note 3.

While this United States RBDS Standard is a voluntary Standard, it is hoped that broadcasters and receiver manufacturers will comply with the spirit and the letter of this Standard.

Recommended Standards and Publications are adopted by NRSC in accordance with the American National Standards Institute (ANSI) patent policy. By such action, NRSC does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the Recommended Standard or Publication. Parties considering adoption of the Recommended Standard or Publication may wish to investigate the existence of relevant patents and patent applications.

The Committee would especially like to thank Mr. Tom Mock of the Electronics Industry Association, Mr. John Marino of the National Association of Broadcasters, Mr. Almon Clegg consultant to Denon, Mr. Terrance Beale of Delco Electronics and Mr. Gregg Skall of Pepper & Corazzini for their dedication and hard work in producing this Standard. The Committee would also like to publicly thank Mr. Dietmar Kopitz of the EBU for his guidance.

NOTE 1: This standard contains numerous references to appendices. The reader should be advised that these appendices form part of the standard.

NOTE 2: Radio systems designers should also note that many broadcasters in the United States are currently transmitting MBS formatted data and paging services. Design criteria to accommodate MMBS is included in Appendix K of this standard and references to MMBS are highlighted within the body of the standard.

NOTE 3: To incorporate the RDS features of Program Service name (PS) and Program Type (PTY) it is possible to use an in-receiver station database which can be updated and corrected by the RDS data stream. This will allow for immediate implementation of call letter display and PTY scanning in both the FM and AM bands. See Section 4, page 55, and notes 1 and 2 on 5A groups, page 24.

CONTENTS

APPENDICES

O. Scope

The Radio Data System (RDS) is intended for application to FM sound broadcasts in the range 87.5 MHz to 108.0 MHz which may carry either stereophonic (pilot-tone system) or monophonic programs.

1. Modulation characteristics of the data channel (physical layer)

The Radio Data System (RDS) is intended for application to FM sound broadcasting transmitters in the range 87.5-108.0 MHz, which carry stereophonic (pilot-tone system) or monophonic sound broadcasts (see CCIR Recommendation 450).

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

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 FM transmitter. Block diagrams of the data source equipment at the transmitter and a typical receiver arrangement are shown in figures 1 and 2, respectively.

For European applications, ARI compatibility is required. Please see Cenelec EN50067 [15] (sections 1, 1.2, 1.3, 1.7, and Appendix H) for specifics to ARI compatibility. Receivers that do not implement ARI compatibility will not function properly for European applications.

1.1 Subcarrier frequency

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

1.2 Subcarrier phase

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

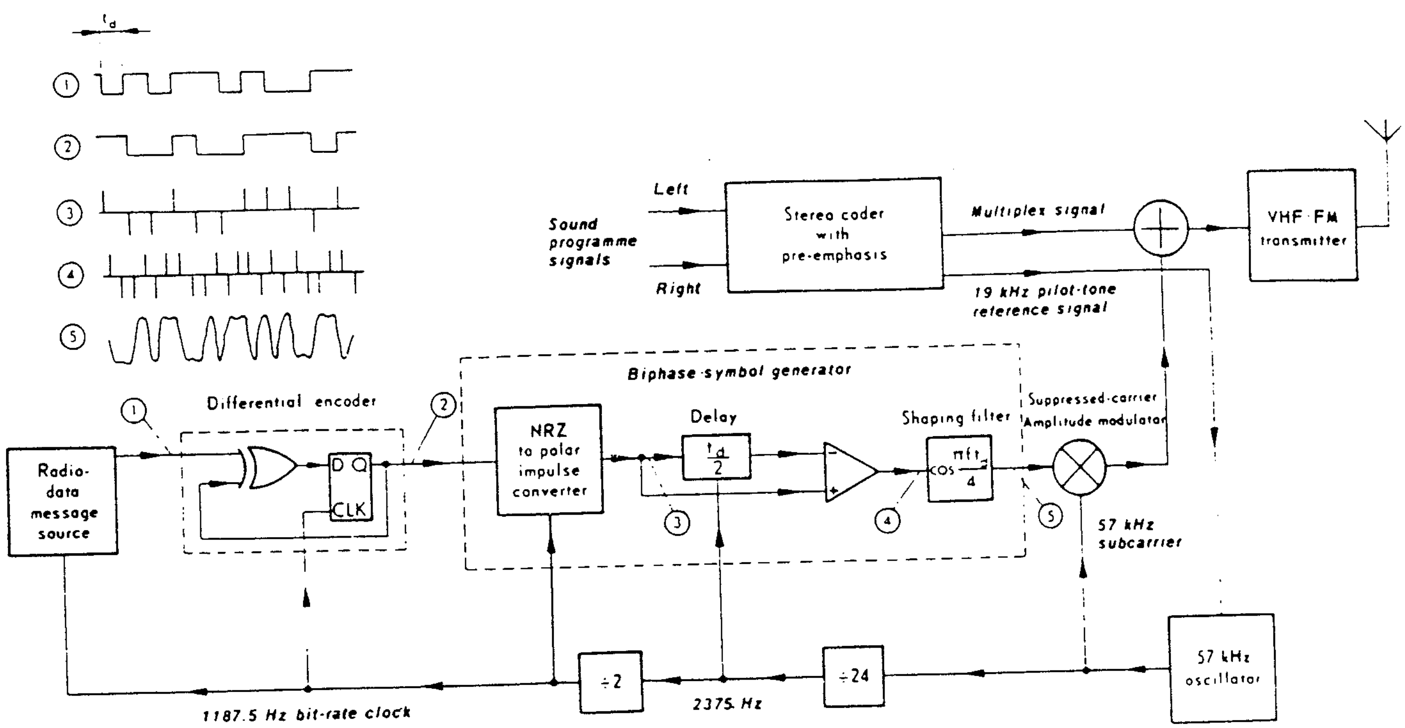
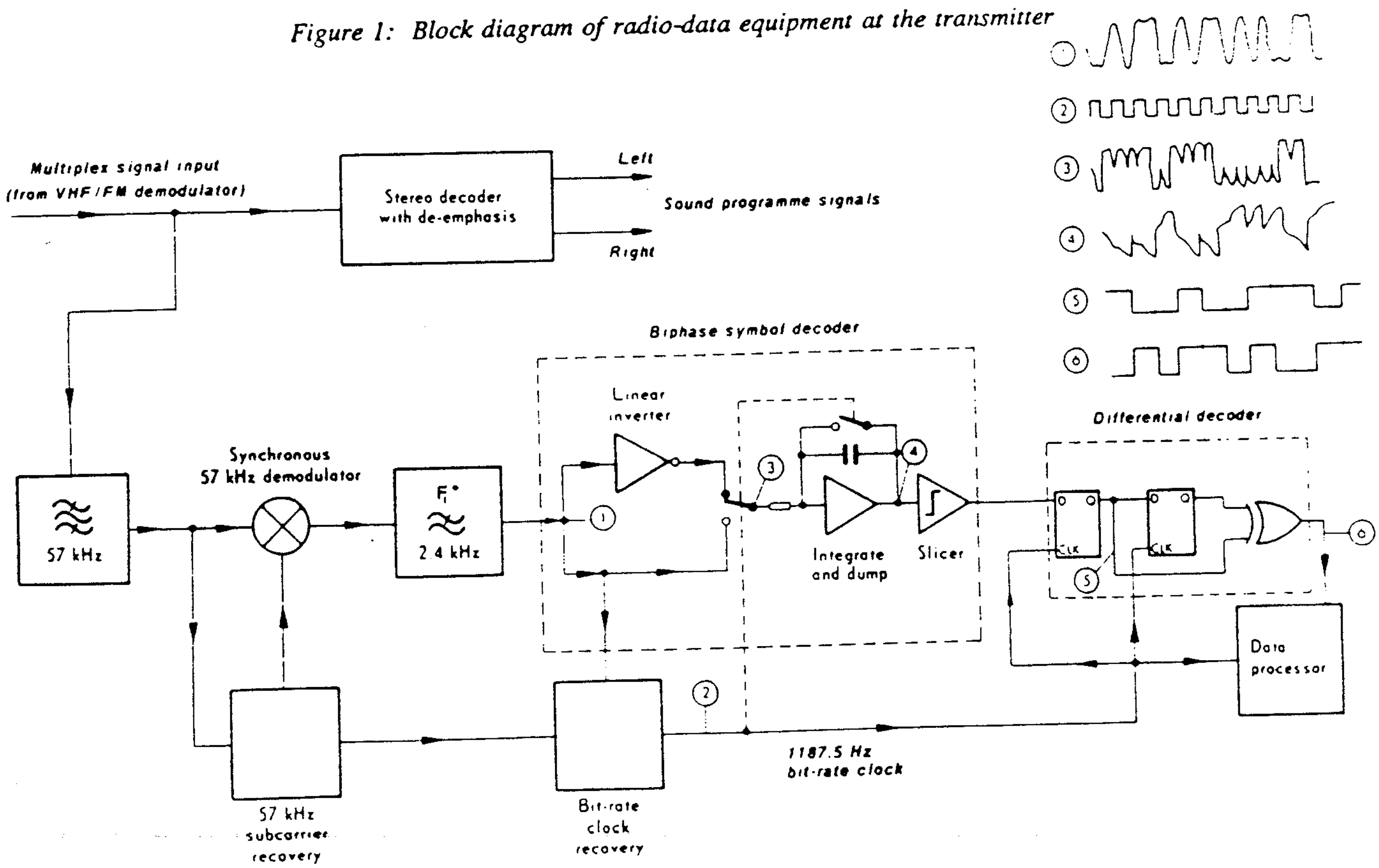


Figure 1: Block diagram of radio-data equipment at the transmitter



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 as that given in figure 3a.

1.3 Subcarrier level

For the US the peak deviation range of the FM carrier due to the unmodulated subcarrier is from ± 1.0 kHz to ± 7.5 kHz[1]). The recommended best compromise is ± 2.0 kHz[2]).

1.4 Method of modulation

The subcarrier is amplitude-modulated by the shaped and biphase coded data signal (see 1.7). The subcarrier is suppressed. This method of modulation may alternatively be thought of as a form of two-phase-shift-keying (psk) with a phase deviation of ± 90°.

1.5 Clock-frequency and data-rate

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

1.6 Differential coding

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

Table 1

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.

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.

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[1]) For Canada and Mexico see appropriate governmental regulation for maximum deviation of subcarriers.

[2]) 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 for an "all-zeroes" message data stream (i.e. a continuous bit-rate sine-wave after biphase encoding).

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

Table 2

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.

1.7 Data-channel spectrum shaping

The power of the data signal at and close to the 57 kHz subcarrier is minimized 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. The principle of the process of generation of the shaped biphase symbols is shown schematically in figure 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 then shaped by a filter $H_T(f)$, to give the required band-limited spectrum where:

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

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 figure 3a, and the overall data-channel spectrum shaping is shown in figure 3b.

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

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

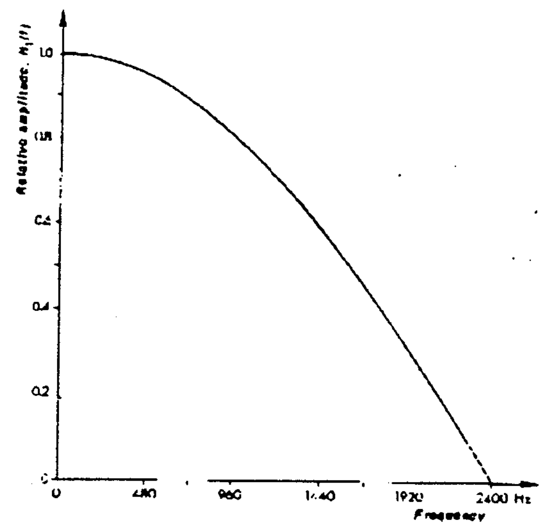


Fig. 3a - Amplitude response of the specified transmitter or receiver data-shaping filter

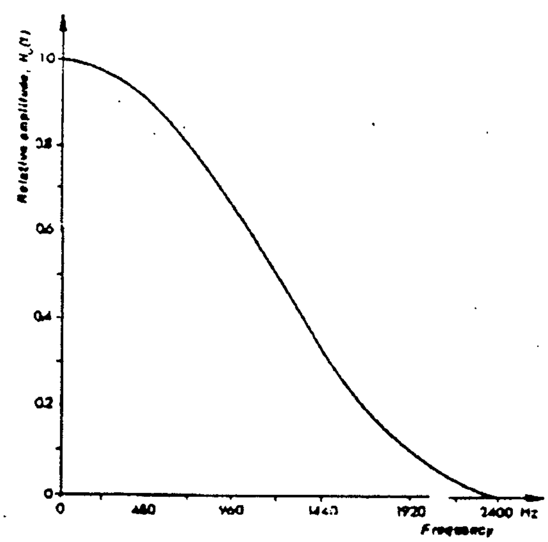


Fig. 3b - Amplitude response of the combined transmitter and receiver data-shaping filters

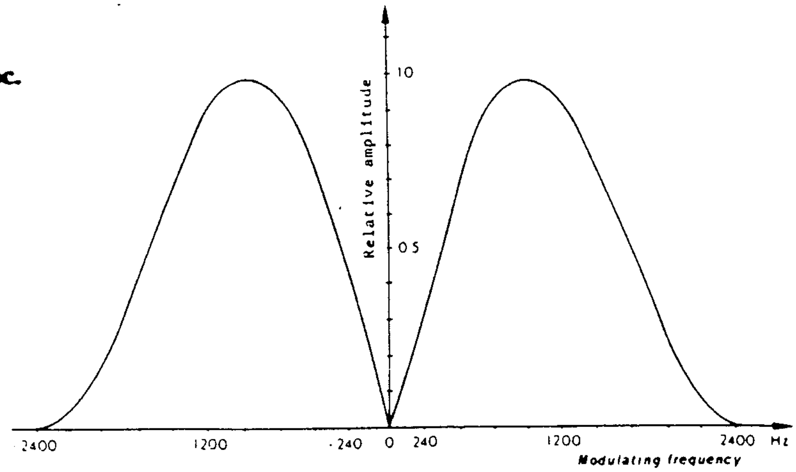


Figure 4a: Spectrum of biphase coded radio-data signals

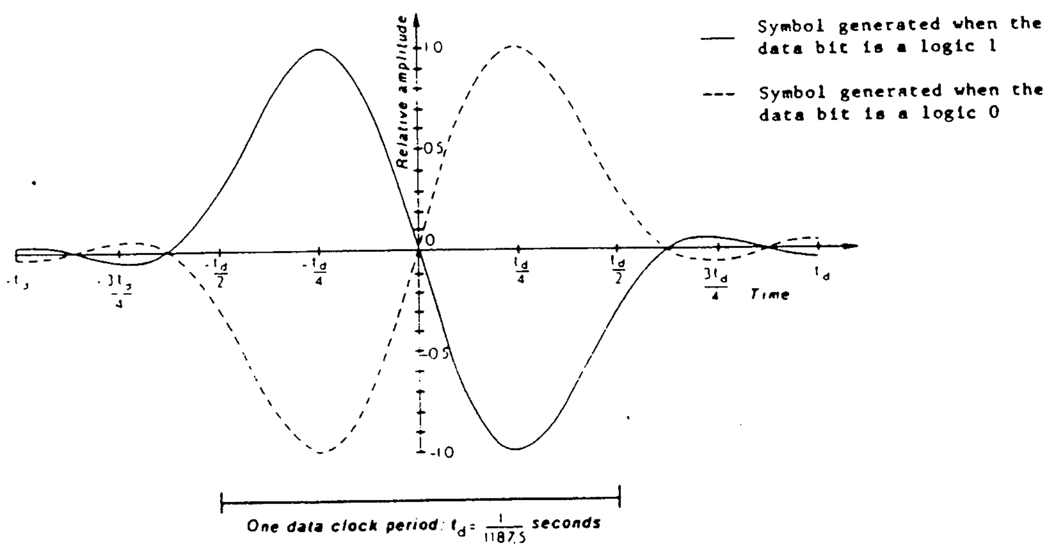


Figure 4b: Time-function of a single biphase symbol

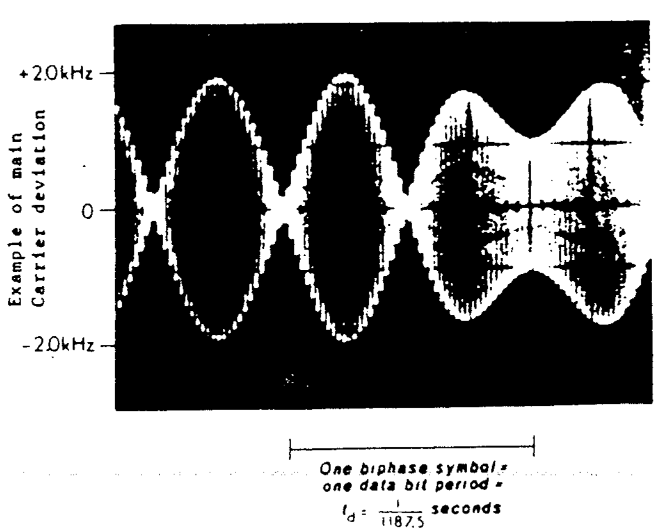


Figure 4c: 57 kHz radio-data signals

2. Baseband coding (data-link layer)

2.1 Baseband coding structure

Figure 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 2.3).

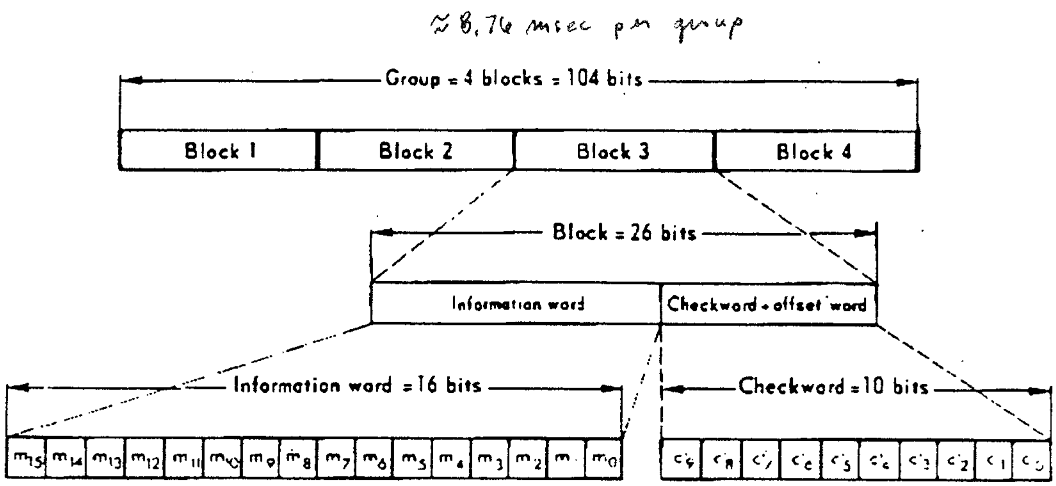


Figure 5: Structure of the baseband coding

For obtaining RDS information from an RDS/MMBS multiplex signal please reference appendix K.

2.2 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 figure 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.

<u>Notes to figure 6:</u>

1. *Group type code = 4 bits (see 3.1)*
2. *B_0 = version code = 1 bit (see 3.1)*
3. *PI code = Program Identification code = 16 bits (see 3.2.1.1 and appendix D)*
4. *TP = Traffic Program identification code = 1 bit (see 3.2.1.3)*
5. *PTY = Program Type code = 5 bits (see 3.2.1.2 and appendix F)*
6. *Checkword + offset "N" = 10 bits added to provide error protection and block and group synchronization information (see 2.3 and 2.4 and appendixes A,B and C)*
7. *$t_1 < t_2$: Block 1 of any particular group is transmitted first and block 4 last*

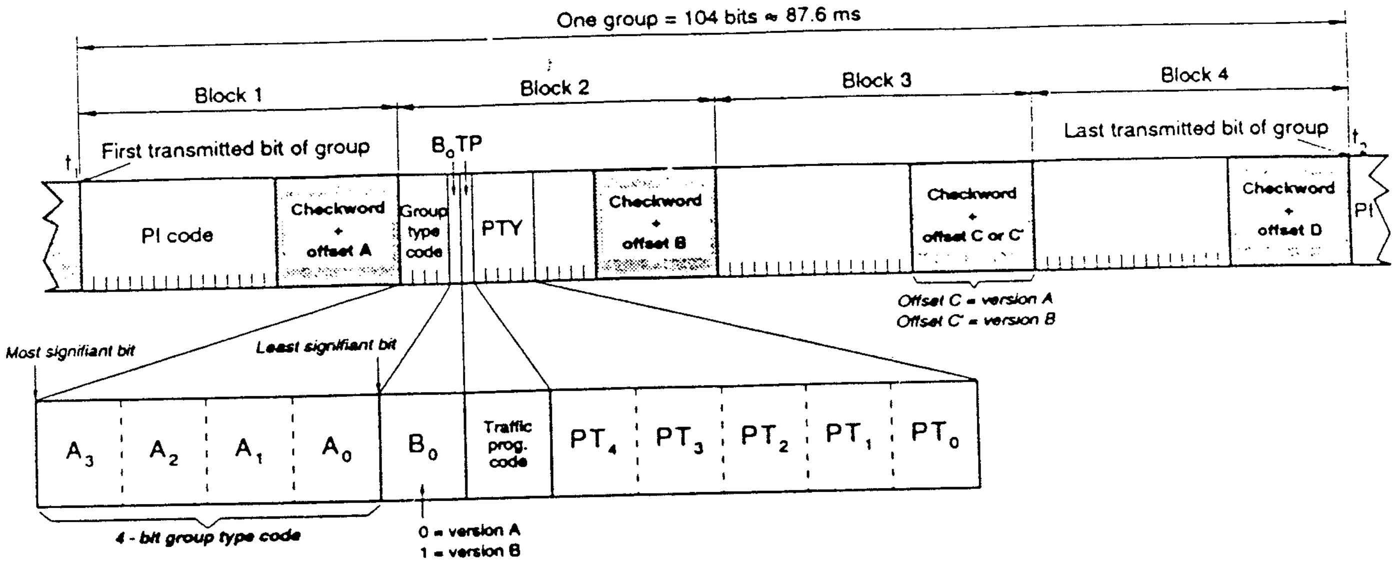


Figure 6: Message format and addressing

2.3 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 figure 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,

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 2.4) are given in appendix A.

The purpose of coding the offset word is to provide a group and block synchronization system in the receiver/decoder (see 2.4). 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 appendixes B and C .

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.

2.4 Synchronization 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 A).

The beginnings and ends of the data blocks may be recognized in the receiver decoder by using the fact that the error-checking decoder will, with a high level of confidence, detect block synchronization slip as well as additive errors. This system of block synchronization 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 synchronization information at the receiver is given in appendix C.

For obtaining RDS information from an RDS/MMBS multiplex signal the E offset word must be recognized. Please reference appendix K.

3. Message format (session and presentation layers)

3.1 Addressing

3.1.1 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. Program 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 messages within any one group is minimized, 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 four spare group types (see 3.1.3) may be assigned to future applications.

3.1.2 Principal features

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

1) The first block in every group always contains a Program 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 figure 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. This will be called version A, e.g. 0A, 1A, etc.

   b) $B_0 = 1$: the PI code is inserted in block 1 and block 3 of all group types. This will be called version B, e.g. 0B, 1B, etc.

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

3) The Program Type Code (PTY) and Traffic Program 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 minimize 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.

3.1.3 Group types

It was described above (see also figure 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 thirteen group types have been specified and all except six (types 3, 4, 7, 8, 9 and 10) 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 thirteen group types defined so far are as follows:

Table 3

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 (see 3.1.3.1)
1	0	0	0	1	X	Program item number and slow labelling codes (see 3.1.3.2)
2	0	0	1	0	X	Radiotext (see 3.1.3.3)
3	0	0	1	1	0	LN - Location and Navigation (see 3.1.3.4)
4	0	1	0	0	0	Clock-time and date (see 3.1.3.5)
5	0	1	0	1	X	Transparent data channels (32 channels) (see 3.1.3.6)
6	0	1	1	0	X	In-house applications (see 3.1.3.7)
7	0	1	1	1	0	Radio paging (see 3.1.3.8)
8	1	0	0	0	0	Reserved for TMC (see 6.18)
9	1	0	0	1	0	Emergency warning systems (see 3.1.3.9)
10	1	0	1	0	0	Program Type Name (see 3.1.3.10)
11-13						Undefined
14	1	1	1	0	X	Enhanced other networks information (see 3.1.3.11)
15	1	1	1	1	X	Fast basic tuning and switching information (see 3.1.3.12)
X indicates that value may be "0" (version A) or "1" (version B).						

Typical group repetition rates give the broadcasters a way to maximize their RDS data capacity while still maintaining proper RDS functions of all data being transmitted. The recommended RDS group sequencing can be seen in Table 4. The actual group sequencing will be up to the broadcaster's individual needs.

The group sequencing for a multiplex of RDS/MMBS groups is given in appendix K.4.

Table 4

												1 Second											2 Second
Skeleton structure w/ AF's	0A		0A	3A		0A		0A				1A	0A		0A	3A		0A		0A			1A
Skeleton structure w/o AF's	0B		15A	3A		0B		15A				1A	0B		15A	3A		0B		15A			1A
Normal Run w/ AF's		2A			0A		2A		0A	0A	2A			2A			0A		2A		0A	0A	
Normal Run w/o AF's		2A			15A		2A		15A	15A	2A			2A			15A		2A		15A	15A	
Normal Run w/ AF's w/ PTYN		10A			0A		10A		0A	0A	10A			10A			0A		10A		0A	0A	
Normal Run w/o AF's w/ PTYN		10A			15A		10A		15A	15A	10A			10A			15A		10A		15A	15A	
Every Minute																							4A
Every 12 hours		9A												9A									
Before and after Traffic Message		2A			15B		2A		15B	15B	2A			2A			15B		2A		15B	15B	
Emergency (EWS)		9A			9A		1A		9A	9A	9A			9A			9A		1A		9A	9A	
Paging		2A			7A		2A		7A	7A	7A			2A			7A		2A		7A	7A	
Paging (peak) - alt.		7A			7A		7A		7A	7A	7A			7A			7A		7A		7A	7A	
TMC (peak)		2A			8A		2A		8A	8A	8A			2A			8A		2A		8A	8A	
Inhouse applic.		2A			6A		2A		6A	6A	6A			2A			6A		2A		6A	6A	
Navigational		3A			0A		3A		0A	0A	0A			3A			0A		3A		0A	0A	
Navigat. (peak)		3A			0A		3A		3A	0A	3A			3A			3A		3A		3A	0A	15A
Transparent Data Channel		2A			5A		2A		5A	5A	5A			2A			5A		2A		5A	5A	
GROUP 1A BLOCK 3 VARIANT SEQUENCING *																							
TMC	0	1	1	1	1	1																	
EWS	0	7	7	7	7	7																	

* When Group 1A is transmitted, slow labeling codes (as defined in Section 3.1.3.2) located in block 3 will need to be sequenced by variants. These variants contain certain information relating to several RDS options. Thus, the sequencing of the block 3 variant of Group 1A given in the above table are to optimize the data transfer for the specific RDS operations: ECC (variant 0), TMC (variant 1), and EWS (variant 7).

3.1.3.1 Type 0 groups : Basic tuning and switching information

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

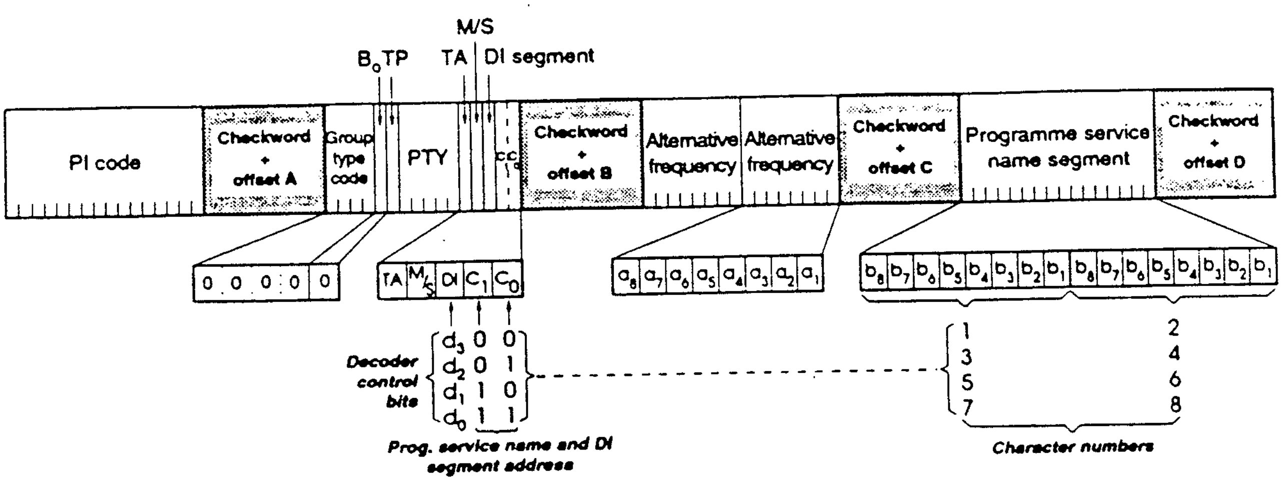


Figure 7a: Basic tuning and switching information - Group type 0A

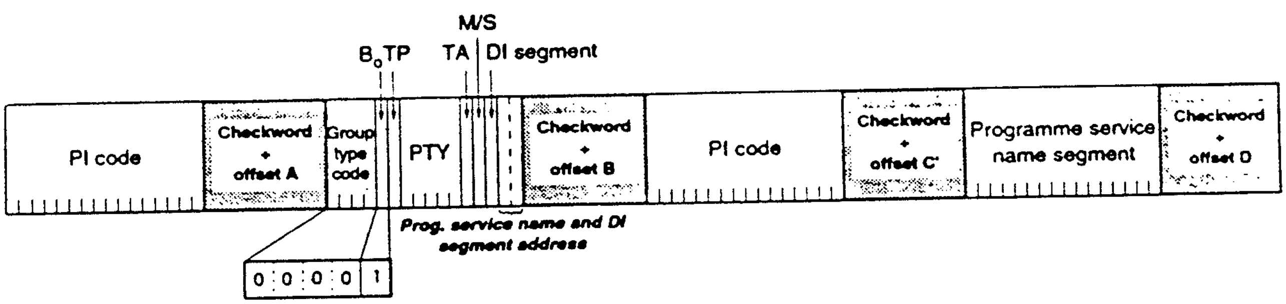


Figure 7b: Basic tuning and switching information - Group type 0B

Type 0A groups are usually transmitted whenever alternative frequencies exist. Type 0B and 15A groups without any type 0A groups may be transmitted only when no alternative frequencies exist.

The method for transmission of alternative frequencies is explained in 3.2.1.6.2.

<u>*Notes on Type 0 groups:*</u>

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 Program identification (PI), Program type (PTY) and traffic program (TP) code, see figure 6, 3.2.1 and appendixes D and F.*
3. *TA = Traffic announcement code (1 bit) (see 3.2.1.3).*
4. *M/S = Music-speech switch code (1 bit) (see 3.2.1.4).*

5. *DI = Decoder-identification control code (4 bits) (see 3.2.1.5). This code is transmitted as 1 bit in each type 0 group. The Program service name and DI segment address code (C_1 and C_0) also serves to locate these bits in the DI codeword. Thus in a group with C_1C_0 = "00" the DI bit in that group is d_3. These code bits are transmitted most significant bit (d_3) first.*
6. *Alternative frequency codes (2 x 8 bits) (see 3.2.1.6).*
7. *Program service name (for display) is transmitted as 8-bit characters as defined in the 8-bit code-tables in appendix E. 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 most significant bit (b_8) of each character is transmitted first.*

3.1.3.2 Type 1 groups : Program-item number and slow labelling codes

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

When a program item number is changed, Group 1 should be repeated four times with a separation of about 0.5 seconds. The unused bits in blocks 2 (type 1B only) are reserved for future applications.

Where Radio Paging is implemented with RDS, Group 1A will be transmitted in an invariable sequence, regularly once per second, except at each full minute, where it is replaced by one 4A Group.

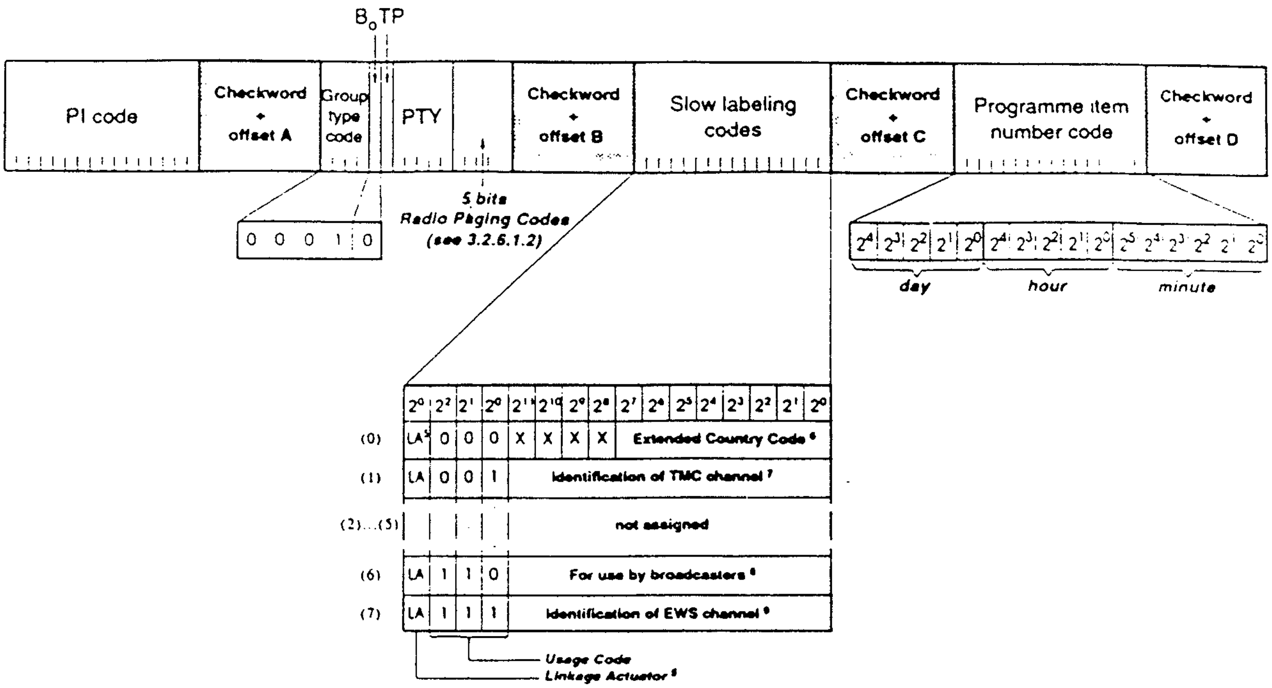


Figure 8a: Program item number and slow labelling codes - Group type 1A

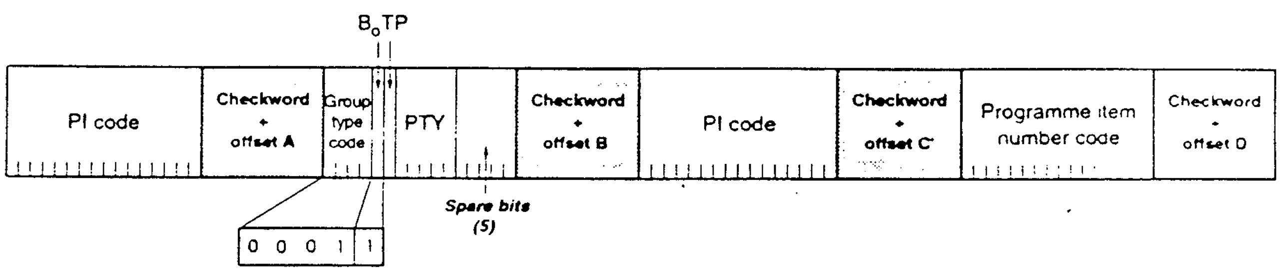


Figure 8b: Program item number - Group type 1B

<u>Notes on Type 1 groups:</u>

1. *Version B differs from version A in the contents of blocks 2 and 3, the offset word in block 3, and, of course, the version code B_0.*
2. *The program item number is the 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.*
3. *If Type 1 is transmitted without a valid PIN, the day of month shall be set to zero.*
4. *Bits 2, 3 and 4 of Block 3 of Version A form the usage code, which determines the application of data carried in bits 5 to 16. A broadcaster may use as many or as few of the usage codes as he wishes, in any proportion and order.*
5. *The Linkage Actuator is defined in the "Method for Linking RDS Program Services" (see 3.2.1.8.3).*

6. *Extended country codes are defined separately (see appendix D).*
7. *Under discussion.*
8. *The coding of this information may be decided unilaterally by the broadcaster to suit the application. Radio-data receivers should entirely ignore this information.*
9. *The Emergency Warning System (EWS) is defined separately (see 3.2.7).*
10. *Bits indicated by "X" are not assigned and may be in either state "1" or "0".*

3.1.3.3 Type 2 groups : Radiotext

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

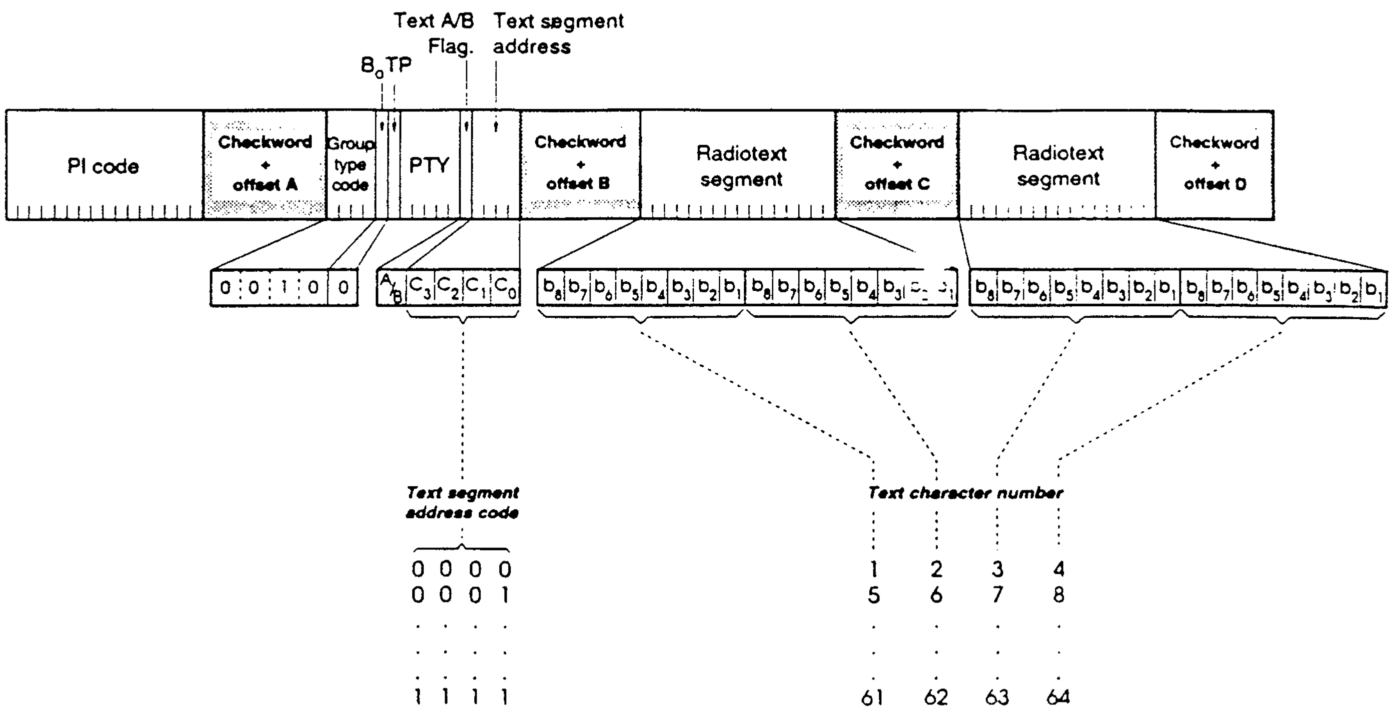


Figure 9a: Radiotext - Group type 2A

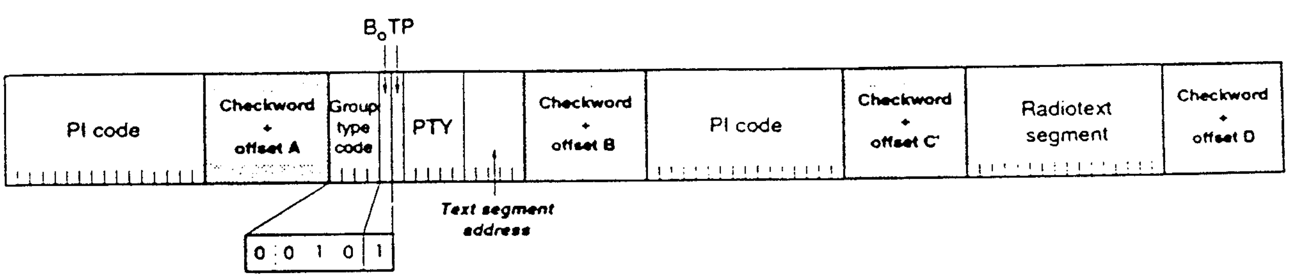


Figure 9b: Radiotext - Group type 2B

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 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.

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 <u>at least twice</u> to improve reception reliability.

<u>*Notes on Type 2 groups:*</u>

1. *Radiotext is transmitted as 8-bit characters as defined in the 8-bit code-tables in appendix E. The most significant bit (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.*

3.1.3.4 Type 3A groups: Location and navigational information

Figure 10 shows the format of type 3A groups. Type 3B groups are not yet defined.

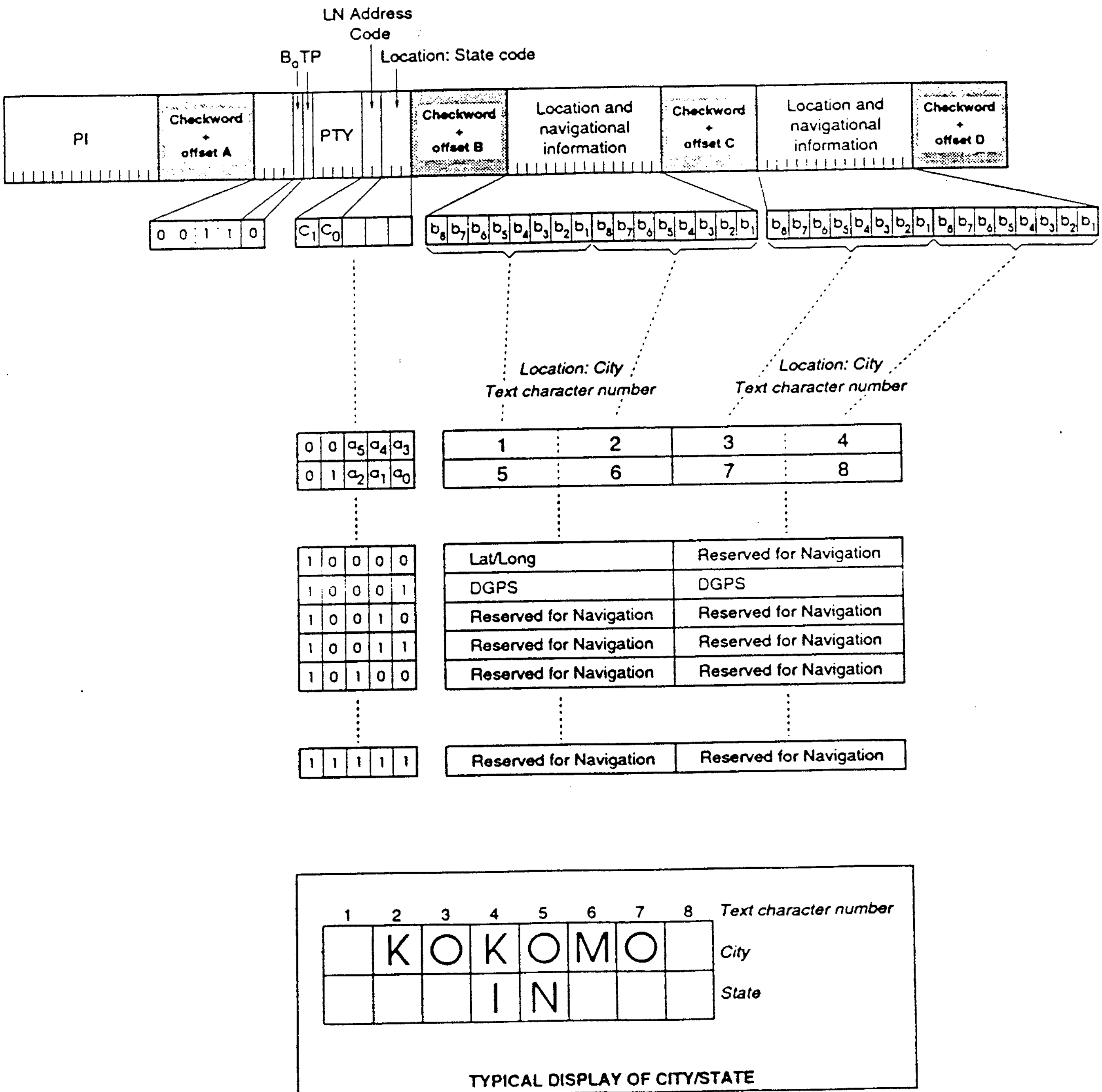


Figure 10: Location and Navigation - Group type 3A

This group allows the user to have information on station location to help service other RDS and program related material to a location. Group 3A can give the location of a transmitter's state, city, latitude and longitude. Group 3A utilizes 6 address characters (a_5 - a_0) that correspond to a state using the state table in Section 3.2.8.1. City names can be displayed using characters taken from appendix E Figure E.1. Group 3A also has the capability of transmitting DGPS (Differential GPS) information. The capability for future Navigational Information or additional DGPS infomation is reserved and set aside in this group definition.

Notes on Type 3A groups:

1) *Location: State code is a six bit code a_5 - a_0 that references the state table in section 3.2.8.1. The two bit address code, C_1C_0, of the second block serves to locate the bits in the state code $a_5a_4a_3$ and $a_2a_1a_0$.*
2) *Location: City Name (for display) is transmitted as 8-bit characters as defined in appendix E. Eight characters (including spaces) are allowed for each transmitter and are transmitted as a 4-character segment in each type 3A group. These segments are located in the displayed name by the two bit address code C_1 and C_0 in block 2. The addresses of the characters increase from left to right in the display. The most significant bit (b_8) of each character is transmitted first.*
3) *The two bit address code, C_1 and C_0, of the second block serves to distinguish state and city information from navigational information. C_1C_0 = 00 and 01 represent state and city information. C_1C_0 = 10 and 11 represent navigational information. For C_1C_0 = 10 and 11, a further breakdown of navigational information is available. Sixteen coding possibilities exist (locations 10000 - 11111).*
4) *Location = 10000 is reserved for Latitude and Longitude encoding of a sixteen bit grid number as defined in section 3.2.8.3.*
5) *Location = 10001 is reserved for DGPS (Differential GPS) - auxillary data information*
6) *Locations = 11XXX are reserved for DGPS - differential correction data*
7) *Remaining locations 10010..10111 to be used for future navigational systems or additional DGPS information.*

3.1.3.5 Type 4A groups : Clock-time and date

The transmitted clock-time and date shall be accurate; otherwise the transmitted CT codes shall all be set to zero.

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

When this application is used, one type 4A group will be transmitted every minute.

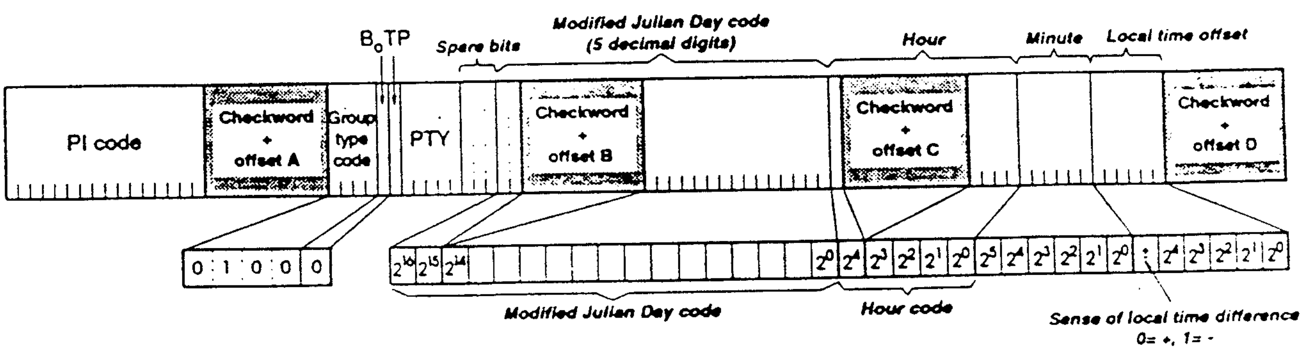


Figure 11: Clock-time and date transmission - Group type 4A

<u>*Notes on Type 4A groups:*</u>

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 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 G. Note that the Modified Julian Day date changes at UTC midnight, not at local midnight.*
7. *The local time difference is expressed in multiples of half hours with the range -12 h to +12 h and is coded as a six-bit binary number. "0" = positive offset, and "1" = negative offset (e.g. USA).*

3.1.3.6 Type 5 groups : Transparent data channels

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

This group is used for I-RDS updates for station identification and PTY scanning in all bands, SCA information, and transparent data transmission. See notes on type 5 groups.

For transparent data transmissions, the 5-bit address-code in the second block identifies the "channel-number" (out of 32) to which the data contained in blocks 3 (version A only) and 4 are addressed. Unlike the fixed-format radiotext of type 2 groups, messages of any length and format can be sent using these channels. Display control characters (such as line-feed and carriage-return) will, of course, be sent along with the data.

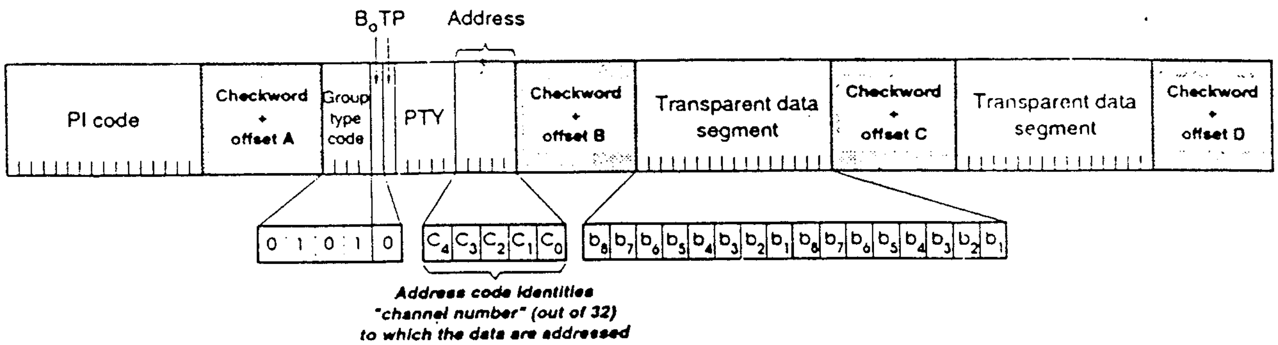


Figure 12a: Transparent data channels - Group type 5A

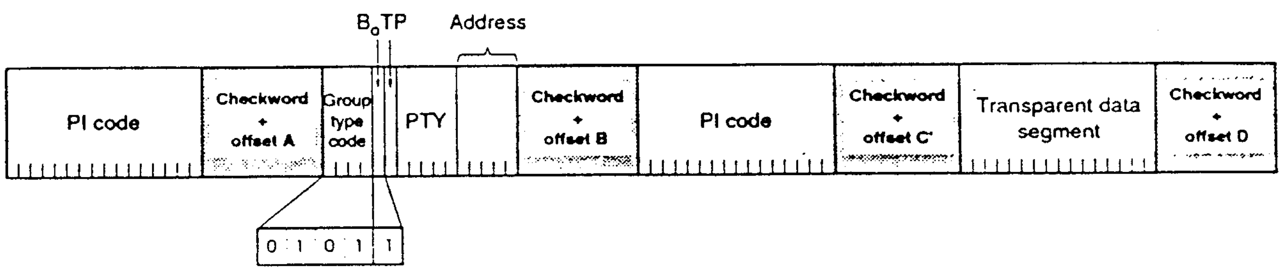


Figure 12b: Transparent data channels - Group type 5B

* Reserved: Channels 0 and 1 are reserved for I-RDS database updates. Channel 2 reserved for SCA information.

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. 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.

Notes on Type 5 groups:

1) *Channels 0 and 1 are reserved for data updates to databases resident in receivers to provide current data on broadcast stations in any receivable band. When such updating data is transmitted, channel 0 indicates that an update header is being transmitted, while channel 1 indicates the transmission of the updated data itself.*

2) *The database feature is provided to permit receivers to offer some of the significant RDS identification and scanning services while tuned to or searching for stations which do not broadcast the RDS subcarrier data. In particular, updates to the database can be sent by one transmitter to cover changes affecting all non-RDS transmitters in that market (whether AM or FM). This will permit the automatic updating of the in-receiver databases while tuning to non-RDS stations which is especially important in the AM band. Database receivers will continuously scan group 5A for the channel 0, expecting the bit pattern 4944hex (ASCII "ID") in the first data segment and a unique serial number of the update in the second data segment. Once alerted that a desired update is forthcoming, the data in channel 1 will be decoded by the database receiver's processor to update the database until an EOM (End of Message) code is received. Note that included in the database are flags pointing to RDS update-giving stations so that a system of self-tuning can be used to allow the receivers to seek such stations upon actuation by the user or automatically upon the receiver being turned on or, better yet, off.*

3) *Channel 2 is reserved for SCA information. The intent is for specialized receivers to decode channel 2 information to determine the type of SCA available and have a flag to indicate to the receiver when to switch the main audio program to the SCA information. Channel 2 will be decoded by the following bit definition: The first 8 bits of Block 3 will indicate the information of the 67 kHz SCA and the second 8 bits the information of the 92 kHz SCA. Switching information for both SCA channels will be accomplished using bit b_8 shown in block 3 of figure 12a to indicate to the receiver to switch to the respective SCA channel. Bit b_8 of the first eight bits indicates a switch to the 67 kHz SCA. Bit b_8 of the second eight bits indicates a switch to the 92 kHz SCA. Bit $b_8 = 1$ indicates to switch audio from the main program channel to the appropriate SCA. Bit $b_8 = 0$ indicates to return the audio to the main program channel. Bits b_7 through b_1 indicate the content of the appropriate SCA. This yields 128 content possibilities for each SCA (67 kHz and 92 kHz). The possibilities are as follows:*

(0) = Emergency
(1) = Traffic
(2) = Weather
(3) - (127) = Spare

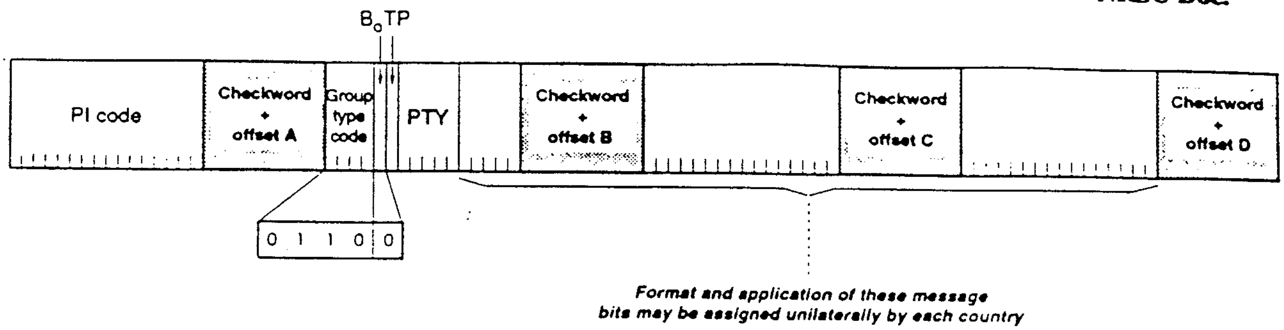
3.1.3.7 Type 6 groups : In-house applications

Figure 13 shows the format of type 6A groups and 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.

Type 6A group:



Type 6B group:

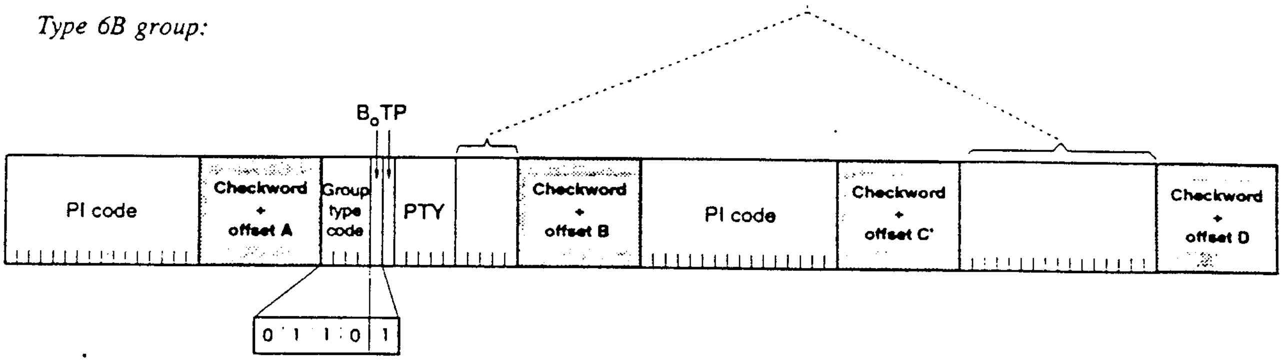


Figure 13: In-house applications - Group type 6A and 6B

3.1.3.8 Type 7A groups: Radio Paging

Figure 14 shows the format of type 7A groups. These groups are transmitted if Radio Paging (RP) is implemented. The specification of the relevant protocol, which also makes use of group types 1A and 4A, is given in 3.2.6.

For coding of MMBS Radio Paging please see Appendix K.

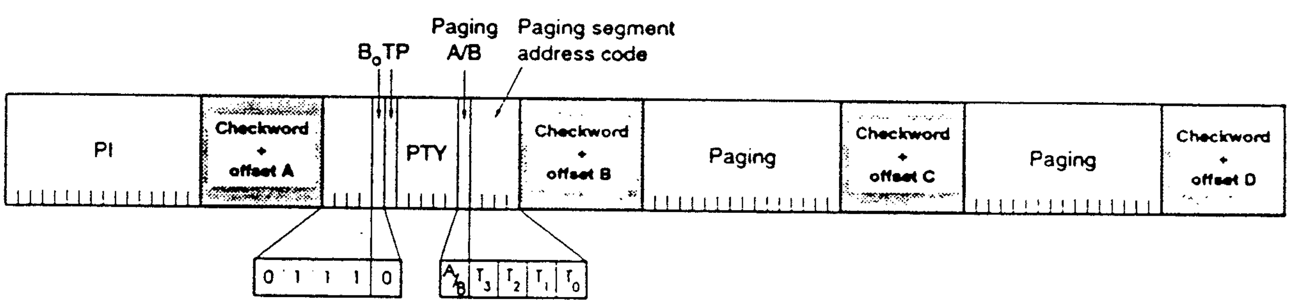


Figure 14: Radio Paging - Group type 7A

3.1.3.9 Type 9A groups: Emergency warning systems

Figure 15a shows the format of type 9A groups. This group compromises 37 useful bits containing the actual emergency information. It is transmitted very infrequently, unless a serious incident occurs or test transmissions are required.

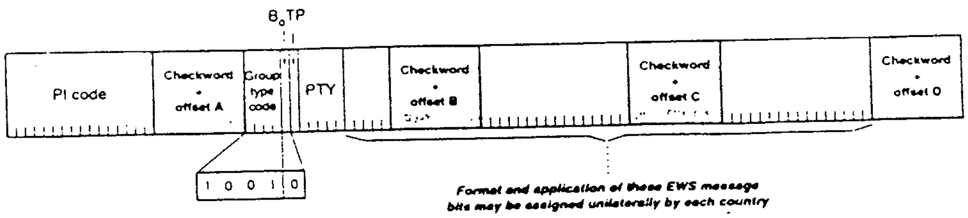


Figure 15a: Allocation of EWS message bits - Group type 9A

3.1.3.10 Type 10A group: PTY Name

Figure 15b shows the format of type 10A groups. Type 10B groups are not yet defined.

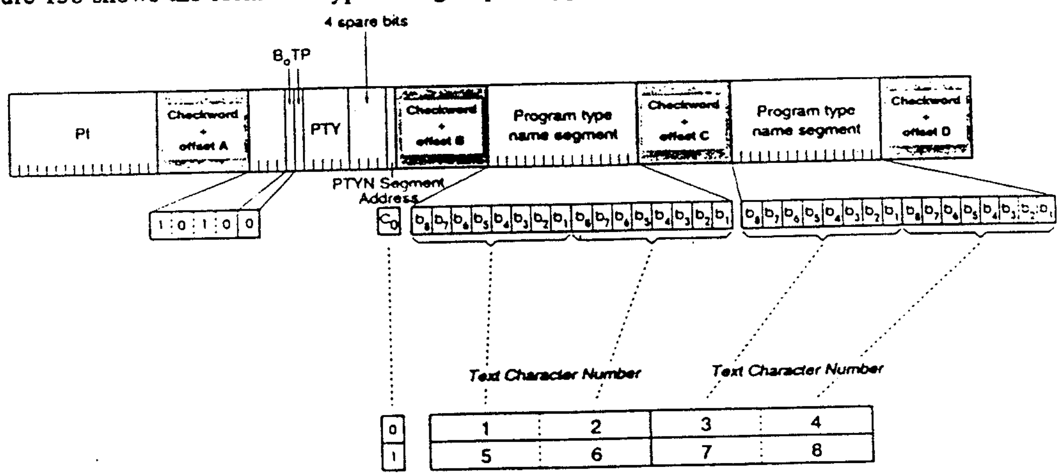


Figure 15b: Program type name - Group type 10A

This group allows the user to replace the default PTY display given in Appendix F with any 8 characters for PTY name display. If this group is not transmitted, the display will use the 8 character default PTY name described in Appendix F.

<u>Notes on Type 10A groups:</u>

1. For details of Program identification (PI), Program type (PTY) and traffic program (TP) codes, see Section 3.2.1 and appendices D and F.

2. Program type name (PTYN) (for display) is transmitted as 8-bit characters as defined in the 8-bit code tables in Appendix E. Eight characters (including spaces) are allowed for each PTYN and are transmitted as four character segments in each type 10A group. These segments are located in the displayed PTY name by the code bit C_0 in block 2. The addresses of the characters increase from left to right in the display. The most significant bit (b_8) of each character is transmitted first.

3.1.3.11 Type 14 groups: Enhanced Other Networks information

Figure 16 shows the format of type 14A and 14B groups. These groups are transmitted if Enhanced Other Networks information (EON) is implemented. The specification of the relevant protocol is given in 3.2.1.8.

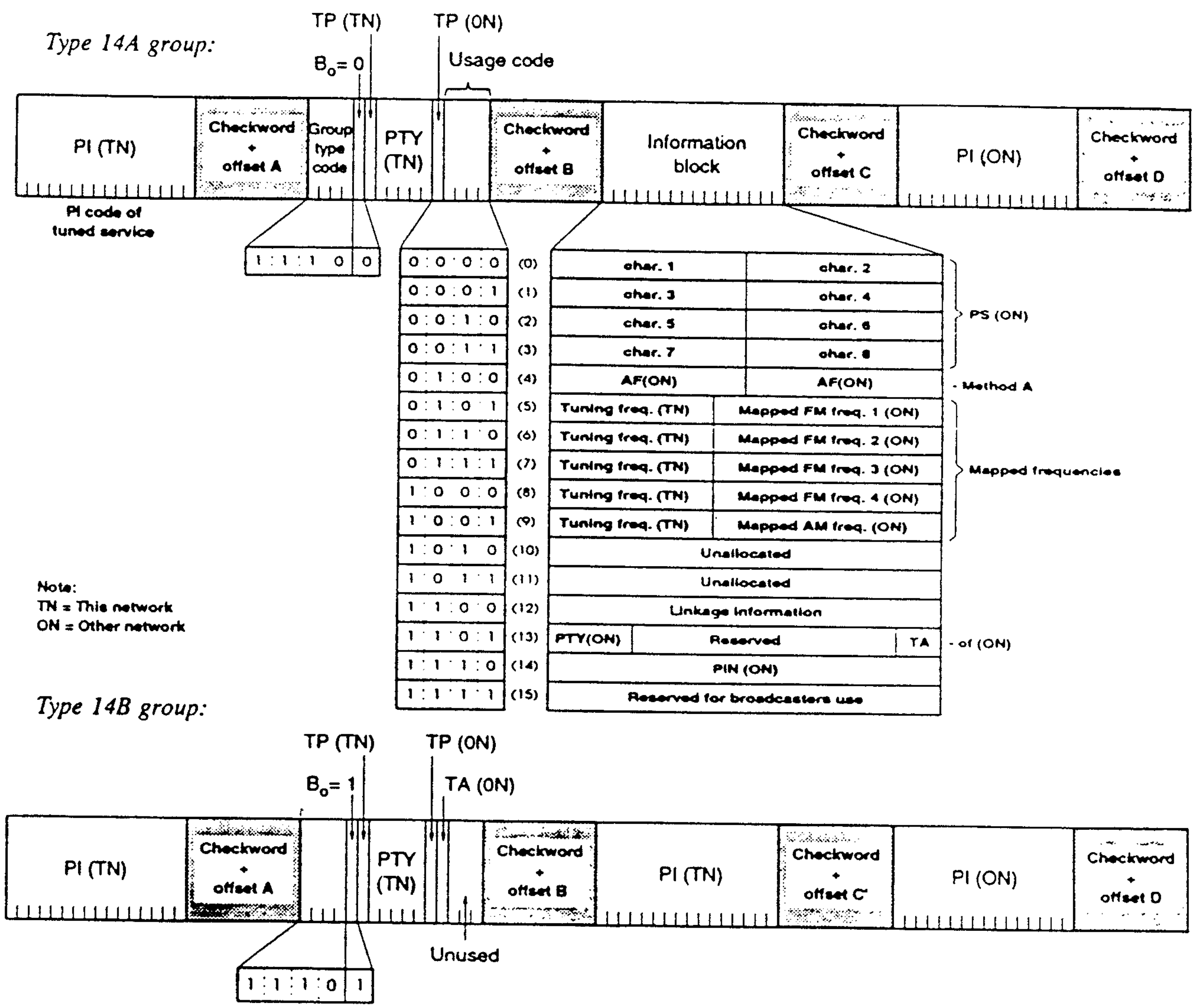


Figure 16: Enhanced Other Networks information - Group type 14A and 14B

3.1.3.12 Type 15 groups: Fast basic tuning and switching information

Figure 17a shows the format of type 15A groups and figure 17b the format of type 15B groups.

It is intended that type 15A groups should be inserted where it is desired to speed up acquisition time of the PS name. No alternative frequency information is included in 15A groups, and this group will be used to supplement type 0B groups. If alternate frequencies exist, type 0A will still be required.

It is intended that type 15B groups should be inserted where it is desired to increase the repetition rate of the switching information contained in block 2 of type 0 groups without increasing the repetition rate of the other information contained in these groups. No alternative-frequency information or program-service name is included in 15B groups, and this group will be used to supplement rather than to replace type 0A or 0B groups.

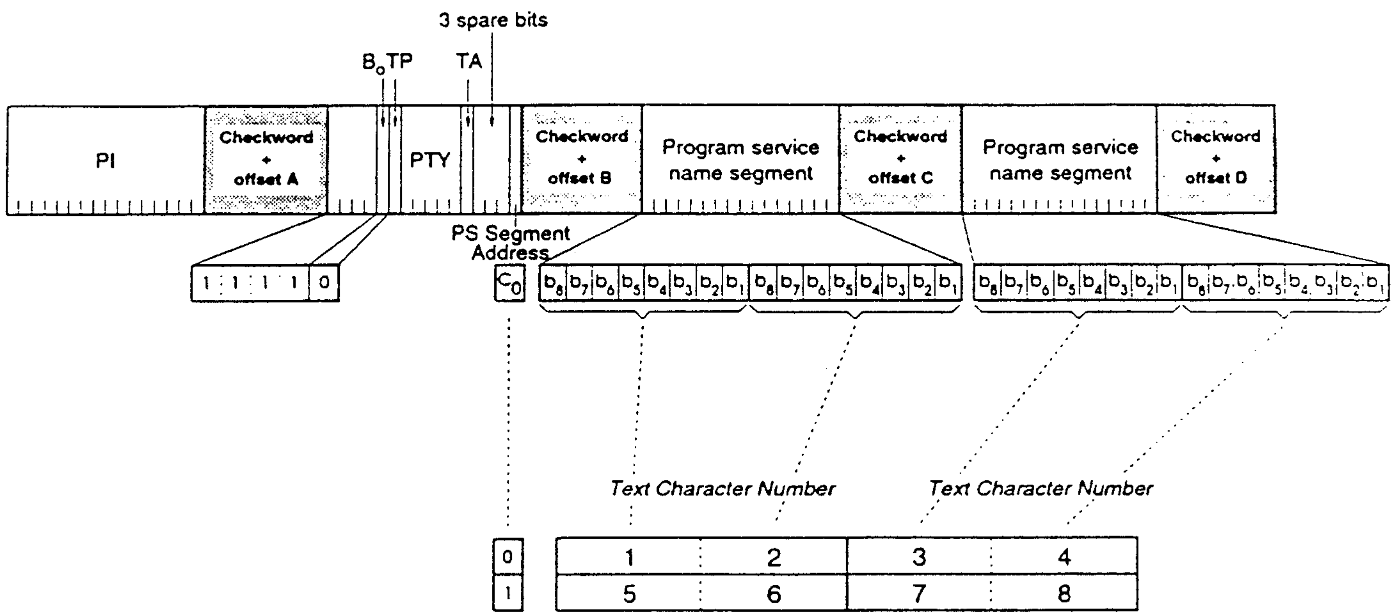


Figure 17a: Fast basic tuning and switching information - Group type 15A

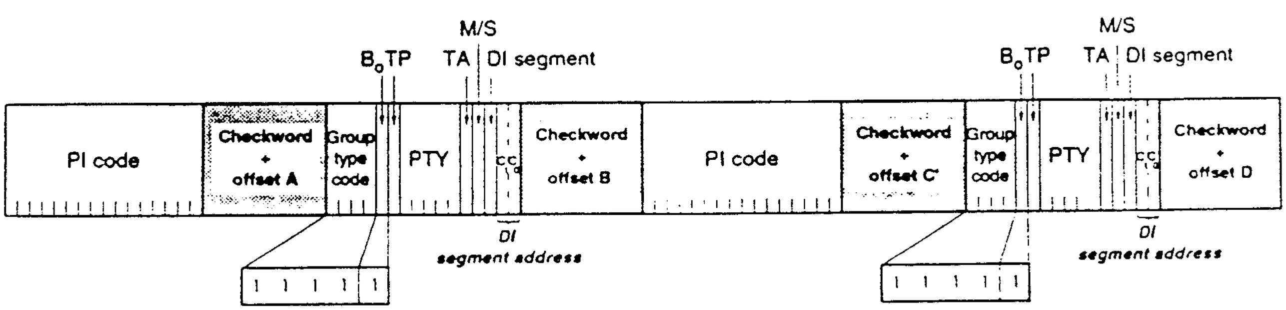


Figure 17b: Fast basic tuning and switching information - Group type 15B

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.

Notes on Type 15 groups

1. *Version B differs from version A in the contents of blocks 2, 3, and 4, the offset word in block 3, and, of course, the version Code B_0.*
2. *For details Program identification (PI), Program type (PTY) and traffic program (TP) code, see figure 6, 3.2.1 and appendixes D and F.*
3. *TA = Traffic announcement code (1 bit (see 3.2.1.3).*
4. *Program service name (for display) is transmitted as 8-bit characters as defined in the 8-bit code-tables in Appendix E. Eight characters (including spaces) are allowed for each network and are transmitted as four character segments in each type 15A group. These segments are located in the displayed name by the code bit C_0 in block 2. The addresses of the characters increase from left to right in the display. The most significant bit (b_8) of each character is transmitted first.*

3.2 Coding of information

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

3.2.1 Coding of information for control

3.2.1.1 Program-identification (PI) codes and Extended country codes (ECC)

The coding model for program-identification information and extended country codes in radio-data transmissions is given in appendix D.

3.2.1.2 Program-type (PTY) codes

The applications of the 5-bit program type codes are specified in appendix F. The last two numbers in the table in appendix F are reserved for alarm codes. Code Number 30 is a test code and Code Number 31 indicates an alarm.

For European applications a different PTY code assignment must be used. Please see Cenelec EN50067 [15] Annex F. Receivers that do not implement the European PTY code table will not function properly for European applications.

3.2.1.3 Traffic-program (TP) and traffic-announcement (TA) codes

Table 5

Traffic Program code (TP)	Traffic Announcement code (TA)	Applications
0	0	This program does not carry traffic announcements nor does it refer, via EON, to a program that does.
0	1	This non traffic program carries EON information about another program which gives traffic announcements.
1	0	This program carries traffic announcements but none are being broadcast at present.
1	1	A traffic announcement is being broadcast on this program at present.

3.2.1.4 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".

3.2.1.5 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.

Table 6

Decoder identification code				Decimal value	Operating mode[1])
d_3	d_2	d_1	d_0		
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[2])
0	1	0	1	5	Stereo, compressed
0	1	1	0	6	Not yet assigned
0	1	1	1	7	Stereo, compressed[2]), artificial head
				8-15	Not yet assigned

[1]) 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.

[2]) See CCIR Study Programme 46A/10 (Dubrovnik, 1986).

3.2.1.6 Coding of alternative frequencies (AFs) in group 0A

3.2.1.6.1 Assignment of AF codes

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

Table 7

Number	Binary code	Carrier frequency
0	00000000	Not to be used
1	00000001	87.6 MHz
2	00000010	87.7 MHz
.	.	.
.	.	.
.	.	.
204	11001100	107.9 MHz
205	11001101	Filler code[1])

[1]) Used where the list of AF codes do not completely fill the available space.

Numbers 206 to 223 are not assigned. 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 frequencies excluding filler words are included in the list. This number precedes the list of AF codes:

Table 8

Number	Binary code	Meaning
224	11100000	No AF exists[1])
225	11100001	1 frequency follows
.	.	.
.	.	.
.	.	.
249	11111001	25 frequencies follow

[1]) If this feature is used for a local program service which is broadcast on a single frequency only, then either code 224 (no AF exists) followed by code 205 (filler code), or code 225 followed by the code for the single frequency, may be used.

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

Numbers 251 to 255 are not assigned. If the AF feature is not required then group type 0B and 15A should be used.

The following numbers then apply for AM:

Table 9

Number	Binary code	Carrier frequency
1	00000001	reserved
.	.	.
.	.	.
15	00001111	reserved
AM 16	00010000	530 kHz
AM 17	00010001	540 kHz
.	.	.
.	.	.
.	.	.
133	10000101	1710 kHz

3.2.1.6.2 Protocol for the transmission of AFs

The number of alternative frequencies should be as small as possible in order to facilitate the automatic tuning process. Ideally the AFs should comprise only the frequencies of neighboring transmitters or repeater stations.

Method A

The protocol uses a list of up to 25 frequencies which are preceded by a header code indicating the number of frequencies in the list. Filler codes, AM channel indicators and the header code itself are not included in this number. The coding is done according to 3.2.1.6.1. The frequency of the station originating the list need only be included if the list is also broadcast by repeater stations.

Method B

For European applications decoding of Method B is necessary. Reference Cenelec EN50067 [15] for details of protocol. Method B will not be required for U.S. applications. However, receivers that do not implement Method B decoding will not function properly for European applications.

3.2.1.7 Program-item number (PIN) codes

The transmitted program item number code will be the scheduled broadcast start time and day of month as published by the broadcaster. For the coding of this information see 3.1.3.2.

If group type 1 is transmitted without a valid PIN, the day of the month shall be set to zero. In this case a receiver which evaluates PIN shall ignore the other information in block 4.

3.2.1.8 Coding of Enhanced Other Networks information (EON)

The enhanced information about other networks consists of a collection of optional RDS features relating to other program services, cross-referenced by means of their PI codes (see 3.2.1.1). Features which may be transmitted under EON for other program services are: AF (see 3.2.1.8.1), PIN (see 3.2.1.7), PS (see 3.2.2), PTY (see 3.2.1.2), TA (see 3.2.1.3), TP (see 3.2.1.3).

The format of the Type 14 group is shown in figure 16. It has two versions: A and B. The A version is the normal form and shall be used for the background transmission of Enhanced Other Networks information. The maximum cycle time for the transmission of all data relating to all cross- referenced program services shall be less than two minutes. The A version has sixteen variants which may be used in any mixture and order. Attention is drawn to the fact that two distinct options, namely Method A and the Mapped Frequency Method, exist for the transmission of frequencies of cross-referenced program services (see 3.2.1.8.1). A broadcaster should choose the most appropriate method for each cross-referenced program service.

The B version of group Type 14 is used to indicate a change in the status of the TA flag of a cross-referenced program service (see 3.2.1.8.2 for more details).

3.2.1.8.1 Coding of frequencies for cross-referenced program services

Two methods exist for the transmission of AF's in the EON feature. These are Method A (variant 4 of group type 14A, see figure 16) and the Mapped Frequency Method (variant 5 to 9 of group type 14A, see figure 16). Method A is coded in precisely the same way as a Method A using 0A groups (see 3.2.1.6). The Mapped Frequency Method provides a means whereby an FM frequency carrying a cross-referenced service may be correlated to a frequency of the tuned service (as carried in 0A groups).

Variants 5 to 9 of group Type 14A contain a mapped frequency pair in block 3. The codes for these pairs of frequencies shall be interpreted as follows:

- In all variants the first frequency is one which carries the tuned program service in a certain reception area.
- In variant 5 the second frequency is the corresponding FM frequency for the cross-referenced program service in the same reception area.
- If it is necessary to map one tuning frequency to more than one FM frequency for the cross-referenced program service, then variants 6, 7 and 8 are used to indicate second, third, and fourth mapped frequencies, respectively.
- Variant 9 is used if a cross-reference to an AM frequency is needed.

In all cases the frequencies are coded in accordance with 3.2.1.6.1 except that the prefix (code 250) for AM frequency codes is not needed in variant 9.

A broadcaster may utilize the most appropriate method for each cross-referenced program service, but within the reference to any single service these two methods must not be mixed.

3.2.1.8.2 Use of the TP and TA features (Group types 0, 15B and 14)

For the tuned program service, the code TP=0 in all groups and TA=1 in Type 0 and Type 15B groups indicates that this program broadcasts EON information which cross-references at least to one program service which carries traffic information. RDS receivers which implement the EON feature may use this code to signify that the listener can listen to the tuned program service and nevertheless receive traffic messages from another program service. RDS receivers which do not implement the EON feature must ignore this code. Program services which use the code TP=0, TA=1 must broadcast groups of Type 14 B (at the appropriate times) relating to at least one program service which carries traffic information, and has the flag TP=1.

The TA flag within variant 13 of group Type 14A is used to indicate that the cross-referenced service is currently carrying a traffic announcement. This indication is intended for information only (e.g. for monitoring by broadcasters) and must <u>not</u> be used to initiate a switch <u>even if</u> traffic announcements are desired by the listener. A switch to the cross-referenced service should only be made when a TA=1 flag is detected in group type 14B.

The B version of group 14 is used to cause the receiver to switch to a program service which carries a traffic announcement. When a particular program service begins a traffic announcement, all transmitters which cross-reference this service via the EON feature shall broadcast at least eight appropriate group 14B messages within the shortest practicable period of time. At the discretion of the broadcaster, a sequence of Type 14B may be transmitted also when the TA flag is cleared. This option is provided only to assist in the control of transmitters; receivers must use the TA flag in the type 0 or 15B groups of the service which carries the traffic announcements in order to switch back to the tuned program service at the end of the received traffic announcement.

The mechanism described above for switching to and from cross-referenced traffic announcements is designed to avoid the delivery of incomplete traffic messages by receivers operating under adverse reception conditions.

3.2.1.8.3 Method for linking RDS program services (Group types 1A and 14A) - Linkage information

Linkage information provides the means by which several program services, each characterized by its own PI code, may be treated by a receiver as a single service during times a common program is carried.

During such times each program service retains its unique identity, i.e. the program service must keep its designated PI code and its AF (Alternative Frequency) list(s), but may change program related features such as PS, PTY, RT, TP and TA to reflect the common program.

Linkage information is conveyed in the following four data elements:

1) LA - Linkage Actuator (1 bit)
2) EG - Extended Generic indicator (1 bit)
3) ILS - International Linkage Set indicator (1 bit)
4) LSN - Linkage Set Number (12 bits)

This information is carried in block 3 of variant 12 of type 14A groups, and informs the receiver to which set of program services any particular service, defined by PI (ON) carried in block 4 of the same group, belongs.

When linkage information regarding the tuned program service is transmitted, the PI code carried in block 4 of the group, PI (ON), will be identical to the PI code carried in block 1.

Usage	Bit allocation in Block 3															
Group type 1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Usage code 7	LA	1	1	1	Identification of EWS channel											

Usage code (bits 2–4)

Linkage Actuator 1) (bit 1)

Figure 18: Structure of Block 3 of Type 1A groups

In order to achieve rapid de-linkage at the end of a common program, the Linkage Actuator (LA) for the tuned network is also carried in group type 1A, as bit 1 of block 3 (see 3.1.3.2). This group type should normally be transmitted at least once every 5 seconds, preferably more frequently when a change in status occurs.

The four data elements used to convey linkage information are defined as follows:

LA - Linkage Actuator (see figures 18, 19 and 20)

This bit is set to 1 to inform the receiver that the program service (indicated by PI(ON) in block 4) is linked to the set of services described by LSN, the Linkage Set Number, at the present moment. If this bit is set to zero, a potential future link is indicated. The receiver may then use the linkage data to determine those services for which EON data might usefully be acquired.

EG - Extended Generic indicator (see figures 19 and 20)

This bit is set to 1 to inform the receiver that the program service, defined in block 4 of group type 14A, is a member of an extended generic set. Such a set of services is characterized by PI codes of the form WXYZ, where W is the common country code, X is the area code (and must lie in the range R1 to R12), Y is common to all such related services, and Z may assume any value. This mechanism permits a generically related set of services to comprise more than twelve members, each with a unique PI code.

ILS - International Linkage Set indicator (see figures 19 and 20)

In case of an international link, the indicator ILS (bit 4 of block 3 in variant 12 of group type 14A) will be set to 1.

LSN - Linkage Set Number

National link (see figure 19)

The Linkage Set Number consists of altogether 16 bits. Bits 5 to 16 are carried in block 3 of variant 12 of type 14A groups, whereas bits 1 to 4 are derived from the country code of the PI(ON) carried in block 4 of the same group. The resultant number is common to all program services linked together as a set. It is unique to the set of linked program services, and must be agreed nationally, or internationally if ILS is set to 1. No link exists (potential or active) if bits 5 to 16 of the LSN are all set to zero.

International link (see figure 20)

In this particular case (ILS is set to 1), the Linkage Set Number (LSN) consists of the following elements:

CI-Country Identifier: Bits 1 to 4 of the LSN (derived from block 4) shall be disregarded, and instead bits 5 to 8 of block 3 shall be the country code of one of the two (or more) participating countries. For example, if Switzerland and Italy share a program, they shall choose either HEX 4 or 5 for CI, and then agree on bits 9 to 16 for a unique Linkage Identifier (LI).

LI-Linkage Identifier: Bits 9 to 16 shall be assigned in the same way as the LSN, and are used to relate program services internationally. Such services share the same CI and LI.

Usage	Bit allocation in Block 3															
Group type 14A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
National Link	LA	EG	X	0	Linkage Set Number (LSN)											

International Linkage Set (ILS) indicator
Extended Generic Indicator
Linkage Actuator

Figure 19: Structure of variant 12 of block 3 of type 14A groups (linkage information) - National link

Usage	Bit allocation in Block 3															
Group type 14A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
International Link	LA	EG	X	1	Linkage Set Number (LSN)											
					CI				LI							

Linkage Identifier
Country Identifier
International Linkage Set (ILS) indicator
Extended Generic indicator
Linkage Actuator

Figure 20: Structure of variant 12 of block 3 of type 14A groups (linkage information) - International link

In figures 19 and 20 the bit indicated by "X" is not assigned to the linkage application and may be assumed to be in either state.

Conventions for application regarding the use of the LSN:

A link (potential or active) between any two or more program services is considered to be valid only when the program services are all linked with a common Linkage Set Number (LSN). No more than one Linkage Set Number will apply to any given program service at the same time. Interleaving of different Linkage Set Numbers relating to the same program service, e.g. an active link and a future potential link, is not permitted. An active link between m program services out of n potentially linked services (m < n) is considered to be valid only when the Linkage Actuators (LA) in the linkage worbds concerning those m services are set to one.

3.2.2 Coding of information for display

Code tables for the displayed 8-bit text characters relating to the program service name, radiotext, alphanumeric paging, program type name, and location: city name are given in appendix E.

3.2.3 Coding of clock-time and date

The transmitted clock-time and date shall be accurate; otherwise the transmitted CT codes shall all be set to zero.

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, the broadcast time and date codes will use Coordinated Universal Time (UTC) and Modified Julian Day (MJD) in accordance with CCIR Recommendations 457 and 460. 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 G).

3.2.4 Coding of information for transparent data channels [3])

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).

Channel 0 and 1 are reserved for data updates to databases resident in receivers to provide current data on broadcast stations in any receivable band. When such updating data is transmitted, channel 0 indicates that an update header is being transmitted, while channel 1 indicates the transmission of the updated data itself. Channel 2 is reserved for SCA information.

This feature is provided to permit receivers to offer some of the significant RDS identification and scanning services while tuned to or searching for stations which do not broadcast the RDS subcarrier data.

3.2.5 Coding of information for in-house applications [4])

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

---

[3]) **MMBS coding may be used as an alternative to RDS coding. MBS messages are variable length ranging from 1 to 8 blocks. The MBS block is structured identically to the RDS block, except that the offset word E consists of all zeros. See Appendix K, Table K.2 - MMBS message. The MMBS group consisting of MBS blocks is modulo-4 length, i.e., 0,4,8,-blocks. For a complete description of the RDS/MMBS multiplex sequence, see Appendix K.**

[4]) Id.

3.2.6 Coding of Radio paging (RP) [5])

3.2.6.1 Introduction

The radio-paging system explained here is also described in Specification No. 1301/A694 3798 (issued by Swedish Telecom Radio) [9]. A summary of the Specification is included in CCIR Report 900, Appendix II, Dubrovnik, May 1986 [10].

The system offers the following features:

- Support for a wide range of message types, including international paging calls.
- It is possible to use simultaneously more than one program service (up to four) to carry the paging information. This allows flexibility to meet peak demands for the transmission of paging codes.
- Battery-saving techniques are employed.

3.2.6.2 Coding characteristics for paging

3.2.6.2.1 General

3.2.6.2.1.1 Group type 4A[6]), clock-time and date (CT), is transmitted at the start of every minute.

3.2.6.2.1.2 Group type 1A, program-item number (PIN), is transmitted at least once per second. The five last bits of its block 2 are used for radio paging codes as follows:

- bits B_4-B_2: 3-bit transmitter network group designation
- bits B_1-B_0: battery saving interval synchronization and identification.

3.2.6.2.1.3 Group type 7A is used to convey the paging information.

---

[5]) Id.

[6]) The transmitted CT (see 3.1.3.4 and 3.2.3) must be accurate, otherwise the CT codes must all be set to zero.

3.2.6.2.2 Transmitter network group designation

The first three bits of the five last bits of block 2 of Group type 1A (radio paging codes, as defined in 3.2.6.2.1.2) are used to designate the transmitter network to a group of pager group codes. Pagers not belonging to the designated group codes must not lock to the transmitter.

The group designations are as follows:

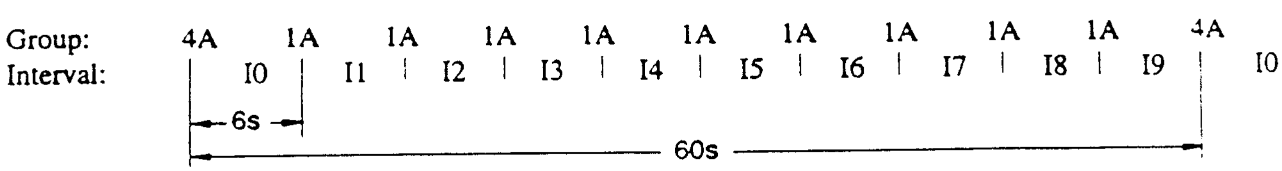
Table 10

B_4	B_3	B_2	Group codes	Number of group codes
0	0	0	No paging on channel	
0	0	1	00-99	100
0	1	0	00-39	40
0	1	1	40-99	60
1	0	0	40-69	30
1	0	1	70-99	30
1	1	0	00-19	20
1	1	1	20-39	20

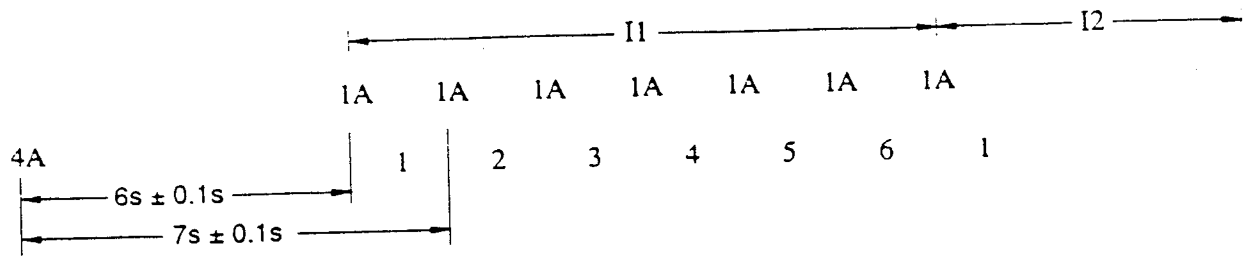
The transmitter network group designation makes it possible to distribute the paging calls over one to four networks, e.g. several networks during day-time and a single network during the night-time. The number of group codes in each network is shown below for the different number of networks in operation.

Number of transmitter networks	Number of group codes respectively
1	100
2	40/60
3	40/30/30
4	20/20/30/30

*3.2.6.2.3 **Transmission sequence** (battery saving)*



Timing within intervals:



1A number within interval	1	2	3	4	5	6	1
Bit B_1	1	1	0	0	0	0	1
Bit B_0	0	J3	J2	J1	J0	1	0

Figure 21

For battery saving purposes, each minute is divided into ten intervals of equal length (I0 ... I9). Each paging receiver belongs to the interval corresponding to the last digit of its individual code (digit 0 belongs to I0 and so on). Paging calls are placed within the interval corresponding to the last digit or within the two intervals following that interval.

To enable the receivers to synchronize to the correct interval, the last two bits, B_1 and B_0, of the five last bits of block 2 of Group type 1A are used. The start of an interval is indicated by the transmission of two 1A groups with $B_1 = 1$ (in interval I0 the first 1A group is replaced by 4A). The first 1A (or 4A for I0) group is transmitted at the start interval and the other one second later. Within an interval at least three more 1A groups are transmitted (bit $B_1 = 0$). Bit B_0 of 1A groups number 2, 3, 4 and 5 is used to sequentially transmit the four bits J3, J2, J1, J0 of the BCD-coded interval number 0 ... 9. Excessive 1A groups within an interval have their bit B0 = 1.

For the paging receiver, one minute is the interval between two consecutive 4A groups. This minute contains either 685 or 686 RDS groups. For the paging receiver, one second is the interval between two consecutive 1A groups. This second contains 11 or 12 RDS groups. Consequently, for a paging receiver, the duration of the relevant time intervals is equal to one second or one minute plus or minus the length of one RDS group.

The receiver may enter battery saving mode after start of its interval:

- if at least 10 groups differing from group type 7A have been received;
- if a paging call, belonging to an interval different from the receivers' own and the two preceding intervals, has been received;
- after the start of the third interval after its own interval.

The receiver shall be considered to have lost its interval synchronization:

- if there is a paging call within the receivers' own interval to a receiver not belonging to the interval or the two preceding intervals, or
- if an error-free reception of the interval marking (J3, J2, J1, J0) is not the one expected.

Checking of J3, J2, J1, J0 is not necessary each time the receiver leaves battery saving mode.

3.2.6.2.4 Locking to a channel

3.2.6.2.4.1 The receiver searches for one of the offset words A ... D. When this is found, it searches for the next expected offset word at a distance of: n times 26 bits, $n = 1 \ldots 6$. When two offset words have been found, the receiver is synchronized to both block and group. After block and group synchronization, the receiver must find the correct country code (within the PI-code) and group designation of the transmitter network.

3.2.6.2.4.2 When scanning the frequency band, block and group synchronization must occur within 1 sec. and correct country code and group designation must be found within 2 sec. after block and group synchronization. Otherwise the receiver must leave the channel.

3.2.6.2.4.3 When locking to the channel after battery saving mode, block and group synchronization and the reception of correct country code and transmitter group designation must occur within 15 sec. Otherwise the receiver shall leave the channel.

3.2.6.2.4.4 For quick scanning, the information about alternative frequencies in group type 0A may be used.

3.2.6.2.5 Loss of synchronization

3.2.6.2.5.1 Clockslip may be detected by using the fact that the program identification (PI) code is rarely altered. By calculating the syndrome for this block and the block shifted plus/minus one bit, it is possible to see whether clockslip has occurred. If the information becomes correct after a one bit shift, it is considered that a clockslip has occurred, all received data is shifted accordingly and the receiver is correctly synchronized.

3.2.6.2.5.2 When 43 out of the last received 45 blocks have a syndrome different from zero (for the respective offset words), the channel locking is lost and the receiver shall scan the band for a better channel.

3.2.6.2.5.3 If the group code of the receiver is no longer in accordance with the transmitter group designation code, the receiver shall leave the channel and scan the band for a new channel.

3.2.6.2.6 Group type 7A message format

3.2.6.2.6.1 General

Group type 7A:

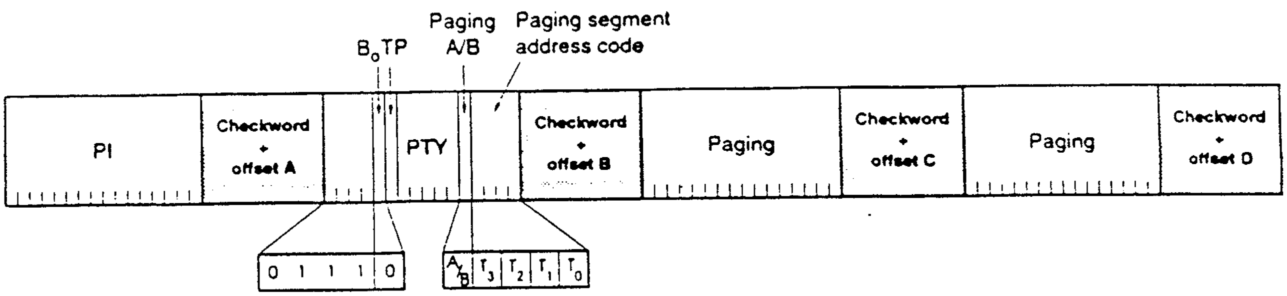


Figure 22 - Group type 7A message format for Radio Paging

Block 1 comprises the PI code found as the first block of every RDS group type. Blocks 3 and 4 are used for paging information.

In block 2 the five last bits are used to control the paging information. Bit AB, paging A/B, is used as a flag which changes its value between different paging calls thus indicating the start of a new or repeated call. Bits T_3-T_0 are used as a 4-bit paging segment address code and to indicate the type of additional message that follows:

Table 11

T_3	T_2	T_1	T_0	*Message contents*
0	0	0	0	No additional message
0	0	0	1	Part of functions message
0	0	1	X	10 digit numeric message or part of functions message
0	1	X	X	18 digit numeric message or 15 digit numeric message in international paging
1	X	X	X	Alphanumeric message
X indicates state 0 or 1				

3.2.6.2.6.2 Paging without additional message

Group type 7A:

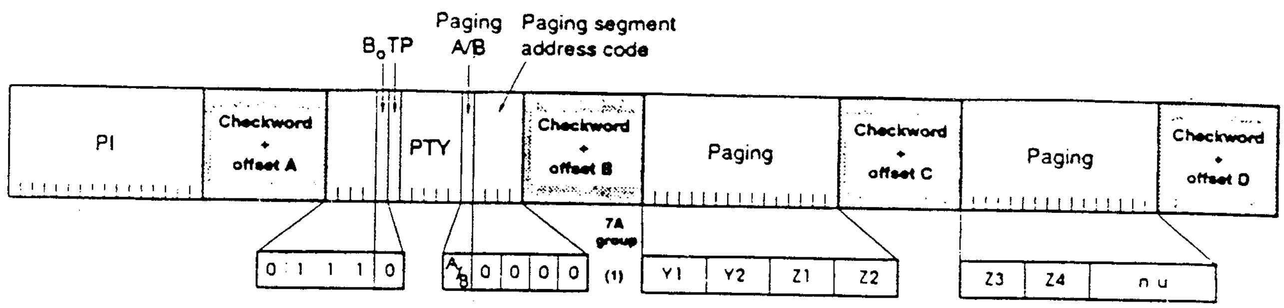


Figure 23: Group type 7A paging without additional message

Y1Y2	denotes the group code
Z1...Z4	denotes the individual code within the group
Y*n* and Z*n*	denote BCD-coded digits 0 ... 9
n.u.	8 last bits of block 4 not used.

The paging segment address code, used to indicate the contents of blocks 3 and 4, is set to 0000.

3.2.6.2.6.3 Paging with additional numeric message

The additional numeric message is transmitted in one or two 7A groups following the first 7A group of the call. Other group types may be transmitted in between:

Other group types	7A group 1	Other group types	7A group 2	Other group types	7A group 3 ... etc

Third 7A group only transmitted in case of an 18 digit message.

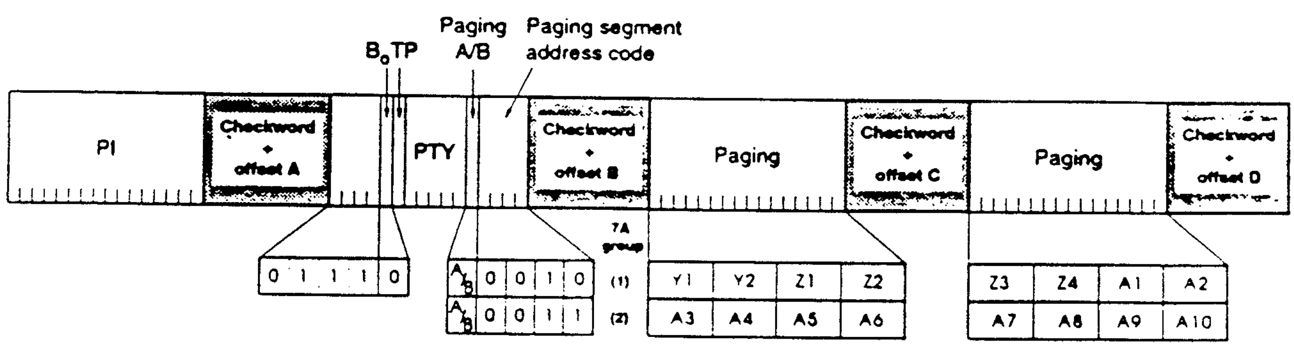


Figure 24: Group type 7A paging with additional 10 digit message

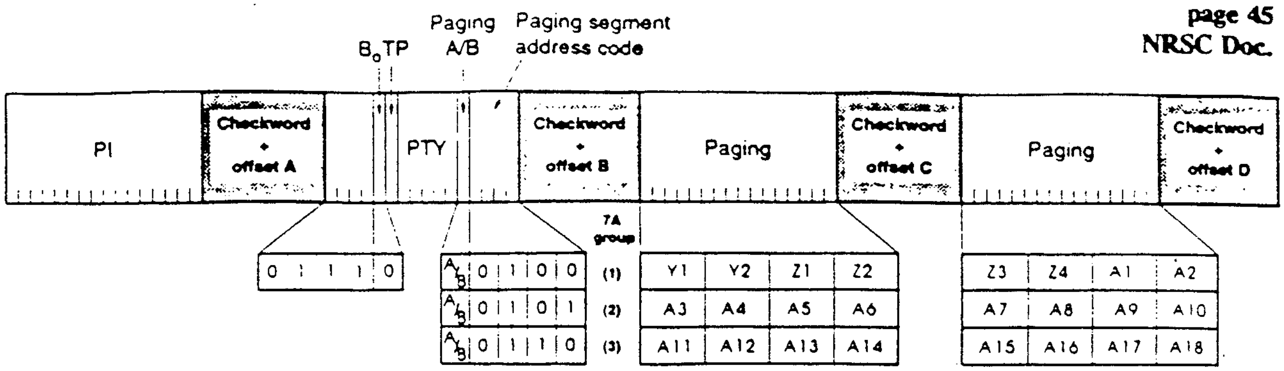


Figure 25: Group type 7A paging with additional 10 digit message

The paging segment address code is used to indicate the contents of blocks 3 and 4 in respective groups:

Table 12

T_1	T_2	T_3	T_4	*Contents of blocks 3 and 4*
				10 digit message:
0	0	1	0	Group and individual code Y1Y2 Z1...Z4 plus message digits A1...A2
0	0	1	1	Message digits A3...A10
				18 digit message:
0	1	0	0	Group and individual code Y1Y2 Z1...Z4 plus message digits A1...A2
0	1	0	1	Message digits A3...A10
0	1	1	0	Message digits A11...A18

Y1Y2	denotes the group code
Z1...Z4	denotes the individual code within the group
Y*n* and Z*n*	denote BCD-coded digits 0 ... 9
A1...A18	denotes the numeric message
A*n*	denotes a hexadecimal character 0 ... A Hexadecimal A is used to indicate a space character in the message

A new or repeated call is marked by altering the "paging A/B" flag.

3.2.6.2.6.4 Paging with additional alphanumeric message

The additional message is transmitted in consecutive 7A groups. Other group types may be transmitted in between:

Other group types	7A group 1	Other group types	7A group 2	Other group types	7A group ... etc 3

Each of the groups contains 4 characters coded in 8 bits each

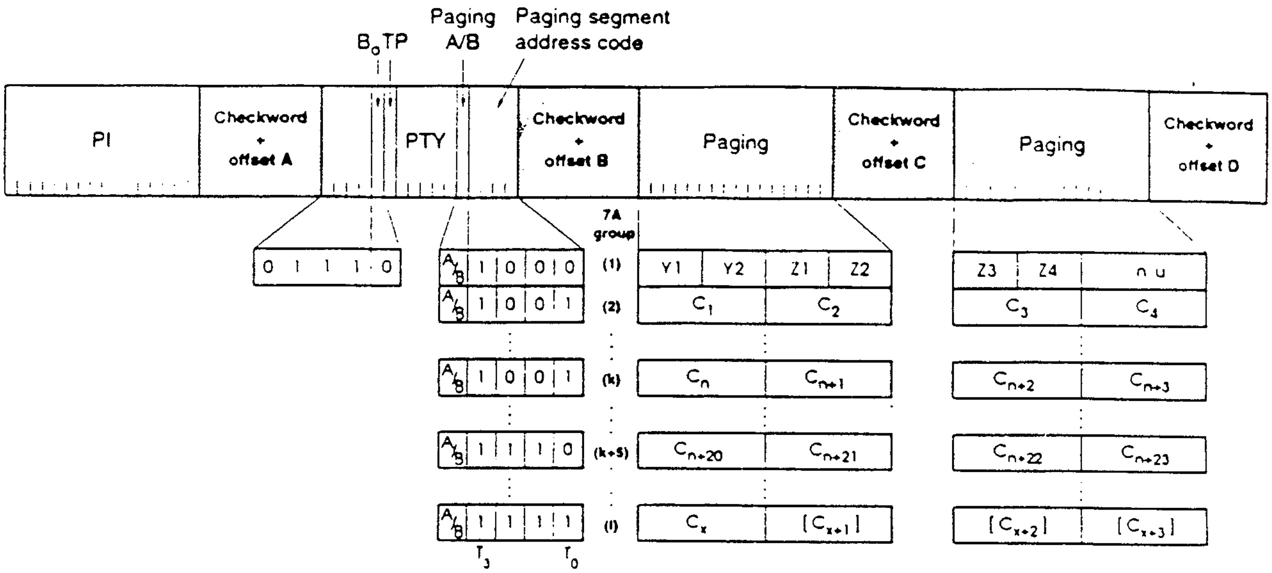


Figure 26: Group type 7A paging with additional alphanumeric message

The paging segment address code is used to indicate the contents of blocks 3 and 4 in respective groups:

Table 13

T_3	T_2	T_1	T_0	*Contents of blocks 3 and 4*
1	0	0	0	Group and individual code Y1Y2 Z1 to Z4
1	0	0	1	Message characters C_n C_{n+3}
1	0	1	0	Message characters C_{n+4} C_{n+7}
1	0	1	1	Message characters C_{n+8} C_{n+11}
1	1	0	0	Message characters C_{n+12} C_{n+15}
1	1	0	1	Message characters C_{n+16} C_{n+19}
1	1	1	0	Message characters C_{n+20}...C_{n+23}
1	1	1	1	End of alphanumeric message: last four or fewer message characters

Paging segment address code is repeated cyclically 1001 ... 1110 for every 24 characters of the message transmitted (n is increased by 24 for each cycle).

End of message is indicated by the transmission of paging segment address code 1111 or by a new call (indicated by altering the "paging A/B" flag). Maximum length of message is 80 characters.

Y1Y2	denotes the group code
Z1...Z4	denotes the individual code within the group
Yn and *Zn*	denote BCD-coded digits 0 ... 9
$C_n \ldots C_{n+23}$	denotes a message character coded in 8 bits according to Appendix E.
n.u.	8 last bits of block 4 of Group 1 not used

3.2.6.2.6.5 International paging with additional numeric 15 digit message

The additional numeric message is transmitted in two 7A groups following the first 7A group of the call. Other group types may be transmitted in between:

Other group types	7A group 1	Other group types	7A group 2	Other group types	7A group 3	... etc

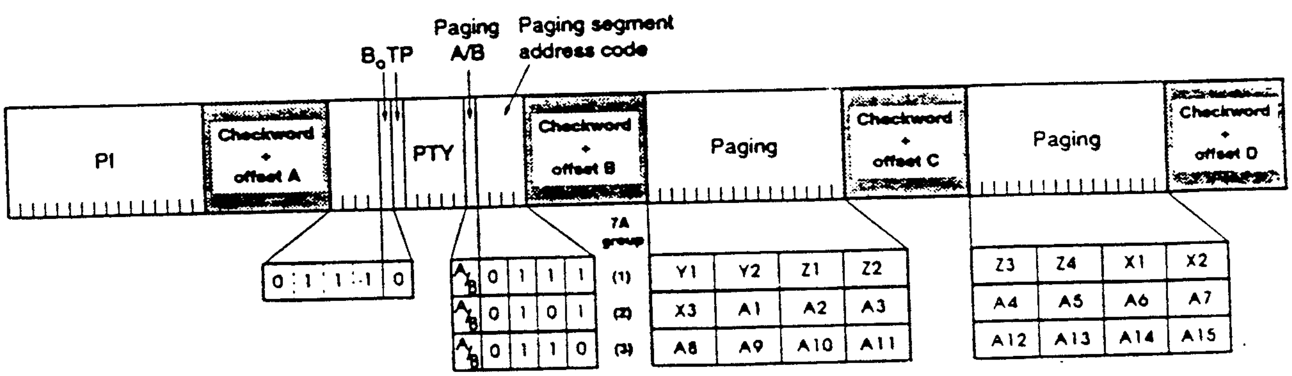


Figure 27: Group type 7A paging with additional numeric 15 digit message

The paging segment address code is used to indicate the contents of block 3 and 4 in respective groups:

Table 14

T_1	T_2	T_3	T_4	*Contents of blocks 3 and 4 International 15 digit message*
0	1	0	1	Country code digit 3 plus additional information digits 1 to 7
0	1	1	1	Group and individual code plus country code digit 1 and 2
0	1	1	0	Additional information digits 8 to 15

Y1Y2	denotes the group code
Z1...Z4	denotes the individual code
X1...X3	denotes the country code according to CCITT Rec. E212
X*n*, Y*n* and Z*n*	denote BCD-coded digits 0 ... 9
A1...A15	denotes the additional numeric message
A*n*	denotes a hexadecimal character 0 ... A. Hexadecimal A is used to indicate a space character in the message.

A new or repeated call is marked by altering the "paging A/B" flag.

3.2.6.2.6.6 Functions message in international paging

The functions message is transmitted in one 7A group following the first 7A group of the call.

Other group types may be transmitted in between:

Other group types	7A group 1	Other group types	7A group 2	... etc

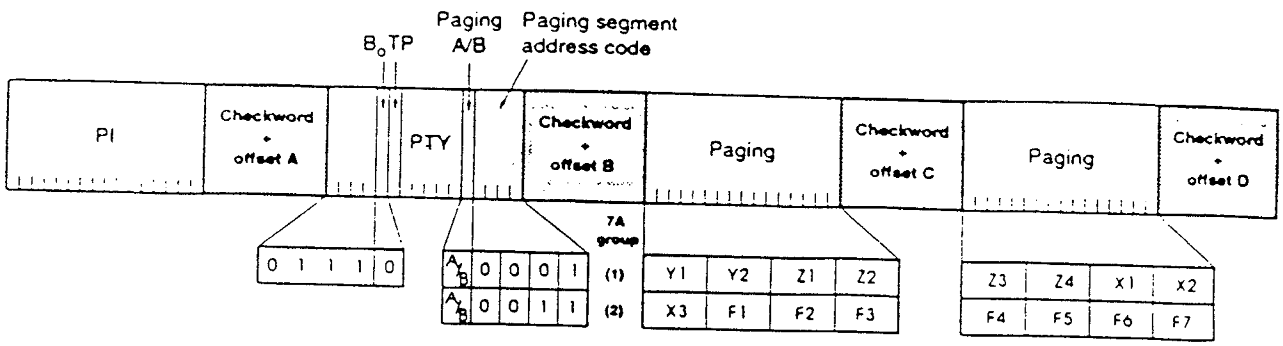


Figure 28: Functions message in international paging

The paging segment address code is used to indicate the contents of block 3 and 4 in respective groups:

Table 15

T_3	T_2	T_1	T_0	*Contents of blocks 3 and 4 Functions message*
0	0	0	1	Group and individual code plus country code digit 1 and 2
0	0	1	1	Country code digit 3 plus functions message number 1 to 7

Y1Y2	denotes the group code
Z1...Z4	denotes the individual code
X1...X3	denotes the country code according to CCITT Rec. E212
X*n*, Y*n* and Z*n*	denote BCD-coded digits 0 ... 9
F1...F7	denotes the functions message (e.g. for future applications such as control of paging receivers)
F*n*	denotes a hexadecimal character 0 ... F

A new or repeated functions message is marked by altering the "paging A/B" flag.

3.2.6.3 **Examples of the traffic handling capacity of the specified radio paging system**

The assumptions for the plotted graphs are:

- Numeric message (10 digits) is conveyed
- One paging call occupies two RDS groups per second
- Each time interval, assigned for battery saving, is fully utilized
- Formula:

$$S = \frac{G/2 * 3600}{C(R+1)} * N$$

where
S = number of subscribers
G = number of 7A Groups/sec.
R = number of repetitions
N = number of networks
C = busy-hour call rate

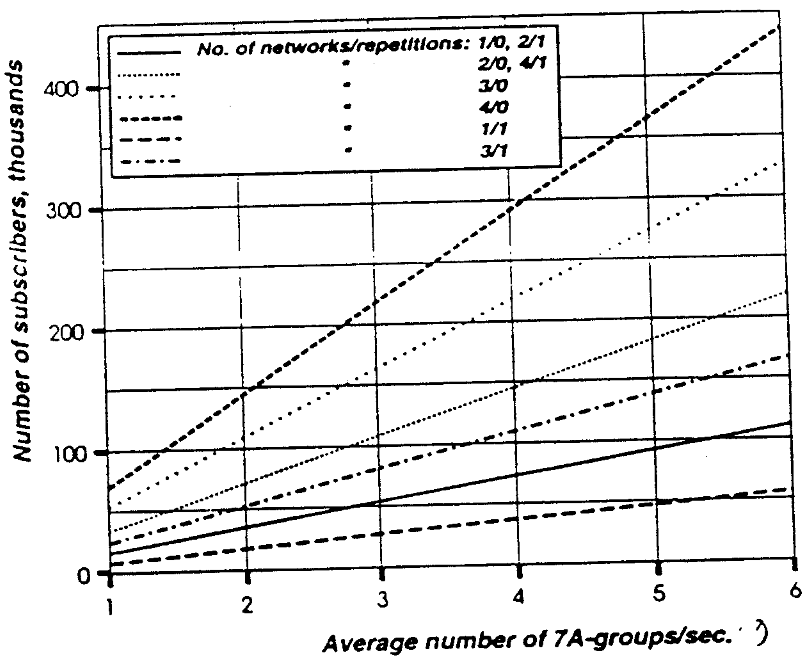


Figure 29: Traffic handling capacity, busy hour, call rate = 0.10 calls/pager/hour 7)

7) The system also requires the transmission of one type 1A group per second and one type 4A group on every minute on each network (see 3.2.6.2.1 and 3.2.6.2.2).

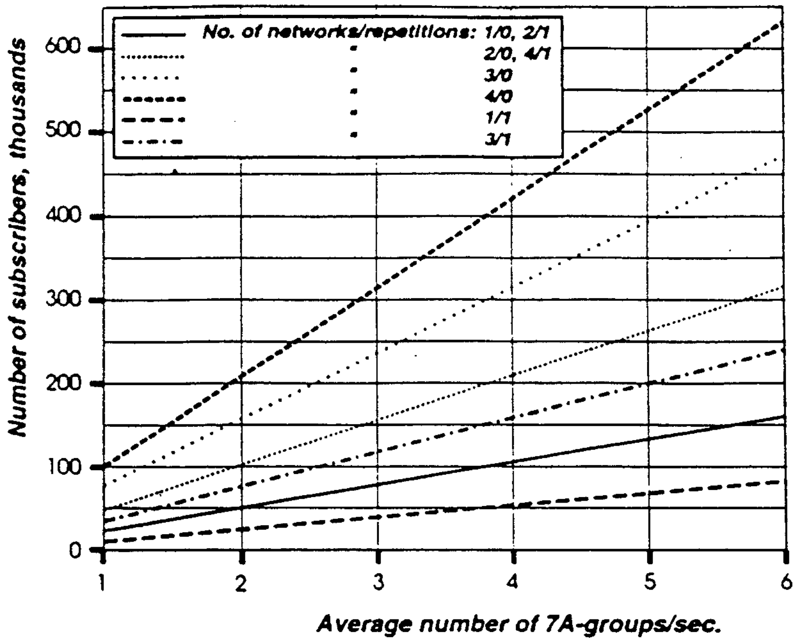


Figure 30: Traffic handling capacity, busy hour, call rate = 0.067 calls/pager/hour

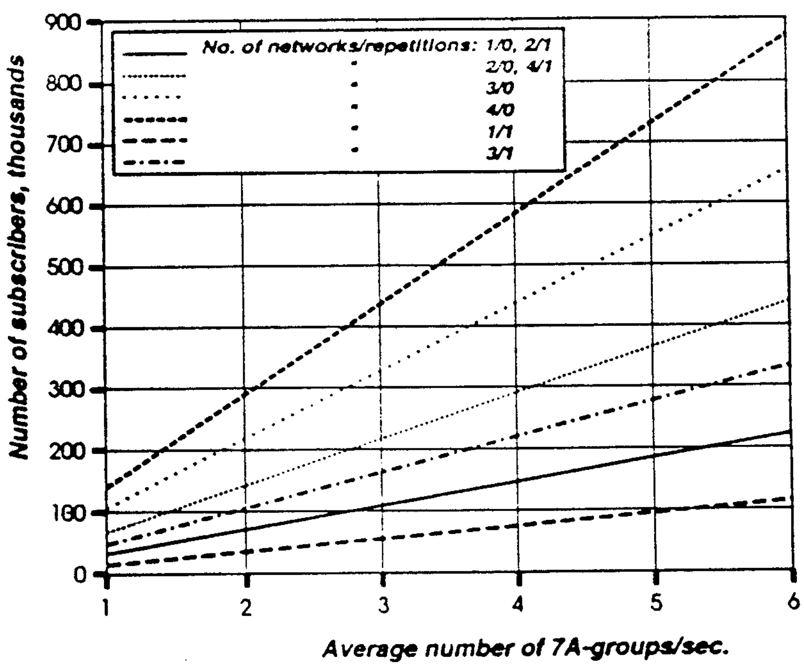


Figure 31: Traffic handling capacity, busy hour, call rate = 0.05 calls/pager/hour

3.2.7 Coding of Emergency warning systems (EWS) *)

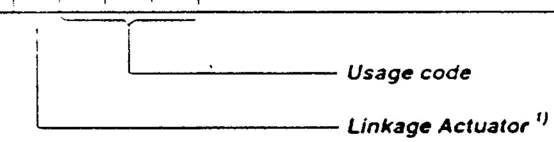
There is a need for comprehensive emergency broadcast system information, using codes that for reason of security cannot be fully detailed. The information is carried by Group type 9A (see 3.1.3.9) and will only be broadcast in cases of extreme emergency, and will thus not unduly overload the RDS channel. The service may incorporate the already specified alarm codes PTY 30 and 31. Standard consumer receivers should not be activated by PTY 30.

The following identification is also required to operate EWS:

Group type 1A

Variant 7 (Usage code) in Block 3 of Group type 1A (see Fig. 32) is used to identify the station(s) that carries these warning messages to enable special receivers to automatically tune to the appropriate station. The repetition rate depends on the exact implementation, but should normally not exceed one Group type 1A every two seconds.

Usage	Bit allocation in Block 3															
Group type 1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Usage code 7	LA[1]	1	1	1	Identification of EWS channel											



Note: 1) The Linkage Actuator is defined in Method for Linking RDS Program Services (See 3.2.1.8.3).

Figure 32: Structure of Variant 7 of Block 3 of Type 1A groups (Identification of a station(s) carrying EWS information)

*) See, supra note 3 (MMBS coding as an alternative to RDS coding)

3.2.8 Coding of Location and Navigation Information

3.2.8.1 Location: State Code

This six bit code is used to identify one of 64 state codes in Table 16 below:

Table 16

STATE CODE

$a_5a_4a_3a_2a_1a_0$	STATE	$a_5a_4a_3a_2a_1a_0$	STATE
000000	AK = Alaska	100000	NY = New York
000001	AL = Alabama	100001	NC = North Carolina
000010	AZ = Arizona	100010	ND = North Dakota
000011	AR = Arkansas	100011	OH = Ohio
000100	CA = California	100100	OK = Oklahoma
000101	CO = Colorado	100101	OR = Oregon
000110	CT = Connecticut	100110	PA = Pennsylvania
000111	DE = Delaware	100111	RI = Rhode Island
001000	DC = District of Columbia	101000	SC = South Carolina
001001	FL = Florida	101001	SD = South Dakota
001010	GA = Georgia	101010	TN = Tennessee
001011	HI = Hawaii	101011	TX = Texas
001100	ID = Idaho	101100	UT = Utah
001101	IL = Illinois	101101	VT = Vermont
001110	IN = Indiana	101110	VA = Virginia
001111	IA = Iowa	101111	WA = Washington
010000	KS = Kansas	110000	WV = West Virginia
010001	KY = Kentucky	110001	WI = Wisconsin
010010	LA = Louisiana	110010	WY = Wyoming
010011	ME = Maine	110011	
010100	MD = Maryland	110100	
010101	MA = Massachusetts	110101	
010110	MI = Michigan	110110	
010111	MN = Minnesota	110111	
011000	MS = Mississippi	111000	
011001	MO = Missouri	111001	
011010	MT = Montana	111010	
011011	NB = Nebraska	111011	
011100	NV = Nevada	111100	
011101	NH = New Hampshire	111101	
011110	NJ = New Jersey	111110	
011111	NM = New Mexico	111111	NOT USED

3.2.8.2 Location: City Name

Using characters of appendix E Figure E.1, the broadcast program city location can be written using eight characters. If city name is longer than eight characters abbreviate as necessary.

3.2.8.3 Navigation: Latitude/Longitude

The continent is divided into rows and columns spaced at a resolution of 1/5 of 1° latitude/longitude. Each rectangle so formed represents a grid unit (G).

Each grid unit is encoded such that the first grid unit at the bottom right (southeast) corner of the grid has a code of 1 (G=1). The grid unit directly West of G=1 has a code of 2 (G=2), and so on until the western most grid unit of the first (southernmost) row is reached. The numbering then continues, likewise sequentially from right to left, with the second row (North of the first row), and so on from bottom to top until the whole grid is completed.

Latitude and longitude information are thus encoded into a single integer grid code (G), converted to a 16 bit binary number, representing a unique "grid number" with:

$$G = 1 + \{[(LON-55) + (LAT-24) \bullet 381] \bullet 5\}$$

where:

G	=	grid number
LON	=	rounded decimal longitude to the lowest 1/5°
LAT	=	rounded decimal latitude to the lowest 1/5°

Appendix J gives examples of the calculation and how to recover the latitude and longitude information from a grid number so encoded.

Exceptions:

Locations within the following states and province are assigned a default grid code of:

Alaska	->	grid code = 1
Hawaii	->	grid code = 2
Newfoundland	->	grid code = 3
Canadian areas North of Latitude 54'N	->	grid code = 4

3.2.8.4 Navigation: Navigational Information

These blocks are reserved for future navigational systems.

The material in Section 4 and Appendix L is proprietary and requires the acquisition of a license from its owner for its implementation in hardware, firmware and/or software.

4. In-Receiver Database System (I-RDS)

The in-receiver database system (I-RDS) permits the automatic identification of any station and offers format scanning in both AM and FM. (See Appendix L for implementation details.)

4.1 Architecture

I-RDS consists of a database of information relating to radio stations stored in read-only memory (ROM) and of a database of contingent updating information stored in a random-access memory (RAM). The ROM and the RAM are accessed by the receiver's central processor unit (CPU).

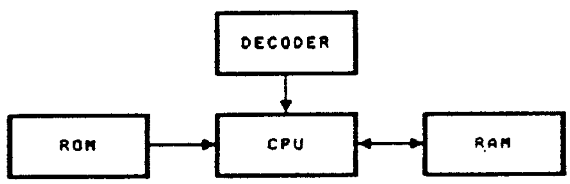


Fig. 33 - Hardware architecture

The ROM database is burned-in during manufacture. The update data is collected by the RDS decoder from the subcarrier group 5A data stream (see section 3.1.3.6) and stored in the RAM.

The ROM database describes the AM and FM radio stations which are broadcasting in the continent in terms of:

- Call sign
- Frequency and band
- Format (usual PTY)
- RBDS update capability
- City and state of license

In addition the ROM contains a description of a large number of North American cities in terms of:

- City and state abbreviation
- Latitude and longitude

The RAM database consists of updating data and the location (address) at which the ROM data it supersedes is located.

4.2 Automatic Identification and Updates

- While tuned to an RBDS station, the receiver uses the RBDS data available in the subcarrier.

- If the RBDS station is also an update giving station, any relevant update can be collected from the group 5A datastream and stored in the RAM. (See section 3.1.3.6).

- If tuned to any other (non-RBDS) station -- <u>whether in AM or FM,</u> the receiver uses the ROM database, checking the RAM for updated information, if any.

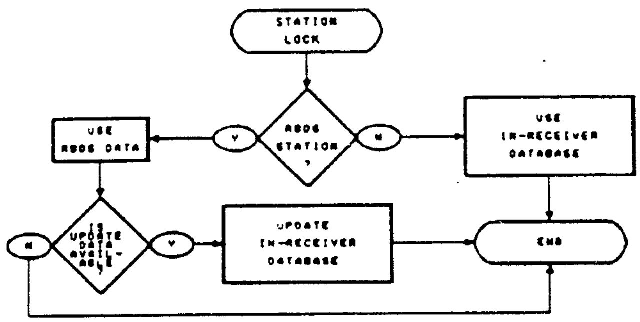


Fig. 34 - RBDS vs. I-RDS decision

4.3 PTY/Format Scanning

Although PTY (program type) and format mean essentially the same thing, they do adopt different meanings within RBDS and I-RDS:

Within RBDS, the PTY means the type of program which is <u>currently</u> being broadcast; whereas within I-RDS, the format of a station means the type of program which is <u>generally</u> broadcast by that station. As the RBDS data is very dynamic, when the user initiates a PTY search, the RBDS system must first scan the participating stations in the FM band to determine if the desired program type is being currently broadcast; whereas I-RDS can immediately find in the database if the desired format is available -- in either band.

Since there are advantages in both approaches, it is suggested that a switch be provided for the user to choose the preferred method.

4.4 Automatic/Manual Update

As mentioned above, part of the ROM data describing a station indicates whether that station is an update-giving station (Updating Station) or not. I-RDS is thus capable to tune itself to an Updating Station either automatically or on demand.

Several modes of update seeking can be offered in the receiver:

- Automatic update 1: When the receiver is turned off (preferred) and before going to sleep, it can immediately tune itself to the local Updating Station and load whatever update is relevant.

- Automatic update 2: When the receiver is turned on and before resuming normal operation.

- Automatic update 3: If a in-receiver clock is available, the receiver can wake up at a predetermined time (e.g., at 4:00 AM) and seek any relevant update.

- Automatic update 4: Whenever the receiver travels into new territory (see below), it can seek the Updating Station serving that new area and load any relevant update.

- Manual update: Whenever an Update key is actuated by the user.

4.5 Geographical Reference

For geographical reference, the continent is divided into a matrix of rectangles of 1/2 degree latitude by 1/2 degree longitude resolution. Each rectangle (Grid) is coded by a unique number which identifies both station location and the location of the receiver at any given time.

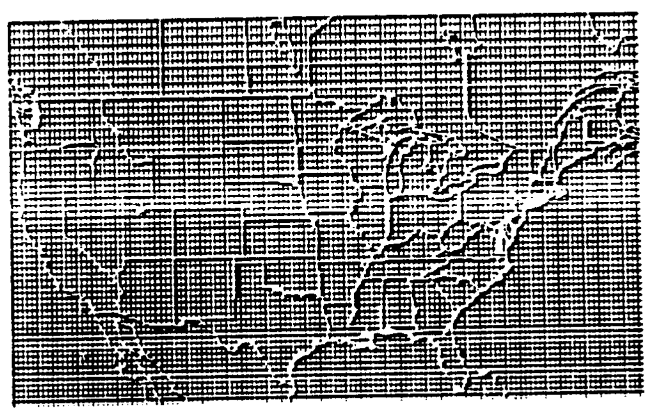


Fig. 35 - Grid system

When searching the ROM for information on local radio stations, the processor typically first searches the Grid defined by the location of the receiver (e.g., Baltimore in Fig. 4.5.2). Then it searches in the eight Grids directly contiguous to that location.

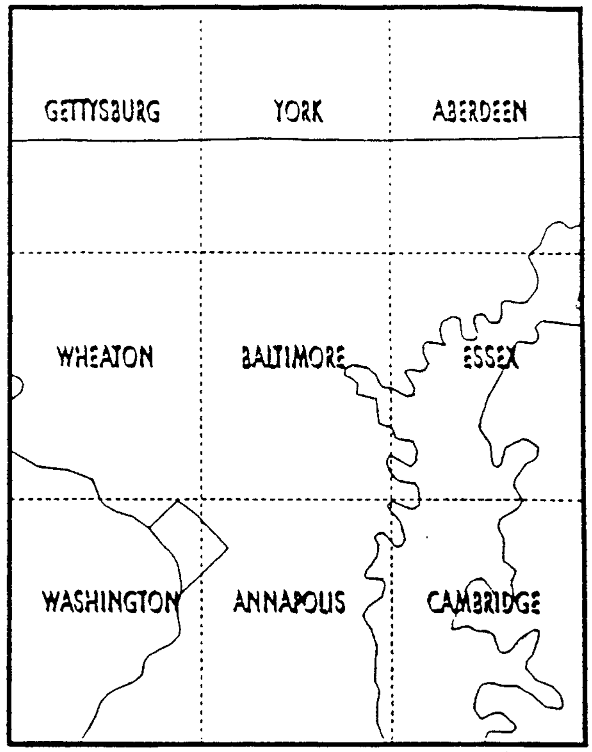


Fig. 36 Nine-grid pattern example

The approximate location of the receiver can be determined automatically by using the latitude/longitude information encoded in Group 3A as defined in section 3.2.8.3 and Appendix J.

However, since it is possible for a receiver to be located in an area which is not serviced by an RBDS station, provision for manual location entry should also be offered. Upon installation, the user must be able to pick the name of the city defining his or her location. This is achieved by scrolling through a displayed alphabetical listing of states, and then, likewise, through a list of cities within the state of interest. Each city is referenced in the ROM by its unique Grid number. This provides I-RDS with the center location of the nine-grid system as described above. Then, if the receiver travels outside of its original Grid, the user must be able to press one (or two) of four compass keys (i.e., N/E/S/W) to indicate the general direction of travel. In the absence of any RBDS station in the area and given the grid resolution of 1/2 degrees latitude and longitude, this direction entry may be needed at most every 30 miles or so.

A well designed system should provide feedback to the user upon the actuation of a compass key. This is achieved by displaying the largest city in the new grid as described in Fig. L.9 and section L.12.5.

4.6 I-RDS ROM Structure

A 2 megabit (256 kilobyte) ROM is required to store the in-receiver database.

As seen in the following figure, the database is composed of the following files:

- Header File
- Format File
- Map File
- State File
- City File
- AM Band File
- FM Band File

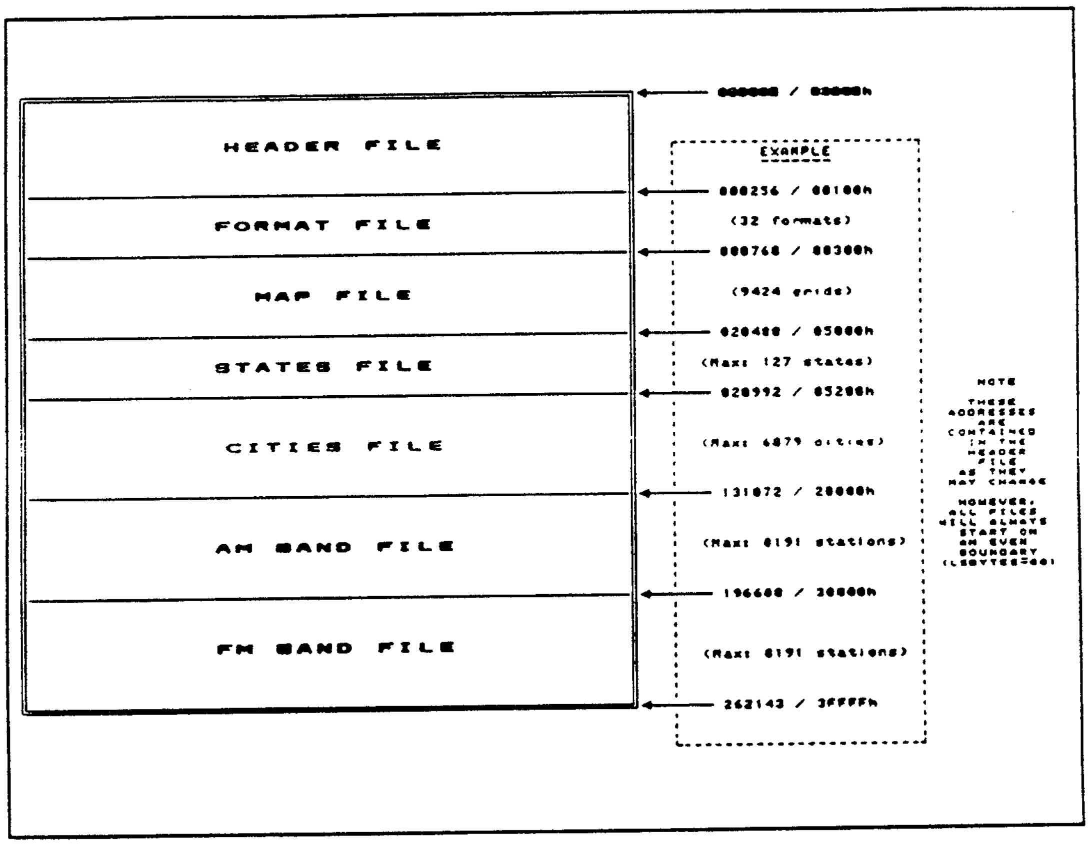


Figure 37 - 256 kilobyte ROM structure

The addresses shown in Fig. 4.6 are contained in the Header File as they may change. However, all files will always start on an even boundary (L.S.Bytes = 00 or modulo 100hex).

All I-RDS files are discussed in detail in Appendix L.

4.7 Update Transmissions

Updates can be stored manually or received automatically via the RBDS group 5A.

See section 3.1.3.6 for a description of group 5A (Transparent Data Channels) and in particular the notes following figures 12a and 12b.

4.7.1 Transmission scope

Each update transmitted via group 5A contains updates concerning the stations in the 1 to 81 grids surrounding the Updating Station (depending on the density of Updating Stations).

There are two kinds of updates:

- Total updates: These updates convey all changes that occurred in the region since the manufacture of the ROM.

- Partial updates: These updates convey all changes that occurred in the region since the previous partial update.

4.7.2 Transmission structure

Each transmission contains two types of data which are transmitted in their own dedicated channels:

- An identifying Update Transmission Header (in Channel 0)
- The Update Data proper (in Channel 1)

4.7.3 Update Transmission Header (UTH)

The UTH contains the following information in four 16-bit blocks (8 bytes):

- A unique two-byte ASCII code (4944_{hex} or ID), the I-RDS Indicator
- The ROM class number to which the update is destined (5 bits)
- The serial number of the update transmission (10 bits)
- The scope flag of the update: partial or total (1 bit)
- The Grid number at the center of the update region (14 bits)
- The coverage index of the update (number of grids covered) (2 bits).
- The update length (in bytes)

4.7.3.1 - <u>I-RDS Indicator:</u> The first two bytes (first block) of the UTH must contain the two ASCII characters ID to indicate a I-RDS update.

4.7.3.2 - <u>ROM class number:</u> This 5 bit number identifies the class of the ROMs which are targeted by the update. This number ranges from 0 to 31.

4.7.3.3 - <u>Update serial number:</u> The next 10 bits contain a serial number which uniquely identifies the transmission. This number ranges from 0 to 1023.

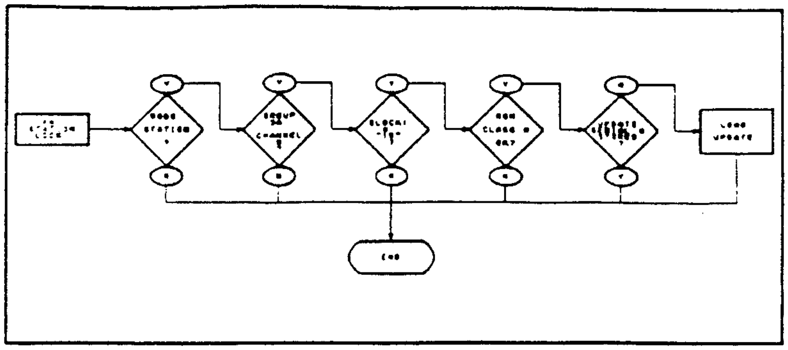


Figure 38 - Relevant Update Search

Figure 4.7.1 illustrates the six steps required before loading an update:

- Step 1: Lock onto an FM station
- Step 2: It must be an RBDS station
- Step 3: Wait for a Group 5A - Channel 0 address
- Step 4: The first two bytes of Channel 0 must contain the characters ID
- Step 5: The ROM class number must match that of the receiver's
- Step 6: The update serial number must be different from any stored during previous updates.

4.7.3.4 - Scope flag: The last bit of the second 16-bit block of the UTH determines whether the update is partial or total.

Depending on the frequency of update changes and the data load required by all of the RBDS applications, the broadcaster may choose to send a mixture of partial (shorter) and total (longer) updates.

Shorter partial updates are *additive* updates. I-RDS does not provide for partial updates which may change updates previously loaded in RAM. Total updates, on the other hand provide the updating data concerning all changes of interest which have occurred since the manufacture of the ROM. Note however that total updates can also be additive in the sense that it is possible fr the RAM to contain several total updates relevant to *different* areas.

4.7.3.5 - Center Grid of updated region: The first 14 bits of the UTH's third 16-bit block identifies the number of the Grid at the center of the region whose stations' data is being updated. (See sections 4.5, L.9 and L.12.5) This number ranges from 0 to 16383.

Note: 14 bits are required as the standard Grid system contains a total of 9424 Grids.

4.7.3.6 - Coverage index: The width of the area which is addressed by an update may vary. This is provided since the density of stations throughout the continent is not equal. Within a densely populated area with many stations, the update coverage may be kept small (e.g., 1 Grid – a rectangular area with sides of about 34 miles), whereas a region with very few stations should permit the updating of a much larger geographical region (e.g., 81 Grids – a rectangular area of sides of about 310 miles).

The coverage index is contained in the last two bits of the UTH's third 16-bit block. It can have the following values:

00_b	=	0	=	1 Grid
01_b	=	1	=	9 Grids (3 by 3)
10_b	=	2	=	25 Grids (5 by 5)
11_b	=	3	=	81 Grids (9 by 9)

4.7.3.7 - Update length: The last 16-bit block of the UTH indicates the length (in byte) of the update message which is sent in Channel 1. This number ranges from 0 to 65535.

4.7.4 Update Data Message (UDM)

The Update Data Message proper is sent in Channel 1 of Group 5A. The UDM starts immediately upon the end of the Channel 0 UTH transmission.

A complete Channel 1 UDM is composed of several back-to-back update data records.

Each update data record is divided into three fields:

- Update data type (1 byte)
- Pointer (2 bytes)
- Update data (variable length)

4.7.4.1 - Update Data Type: Each update data record is type-coded to indicate two things:

- The type of the update data
- The length of that update data.

The length of the data is derived from the Update Data Type which is always one byte long.

The following table lists all possible Update Data Types and their associated lengths:

Table 17 - Transmitted Update Data Types

	UPDATE DATA TYPE	DATA LENGTH (in byte)
0	= Channel	(2)+1
1	= Call sign	(2)+4
2	= Format (incl. RBDS flags)	(2)+1
3	= Channel + Call sign	(2)+5
4	= Channel + Format	(2)+2
5	= Call sign + Format	(2)+5
6	= Channel + Call sign + Format	(2)+6
7	= Erased Station	(2)+4
8	= New Station	10
255	= End Of Message (EOM)	0

The number in parentheses (2) is the length of the address (see below) in the ROM which contains the record to be updated.

4.7.4.2 - Pointer: The next two bytes of the Update Data Record contain a pointer which references the ROM address which is occupied by the record to be updated. All update data is preceded by such an address except for type 8 (New Station) data and the type 255 (EOM) which signifies the end of the update message.

Note 1: The pointer must be multiplied by 4 to get a real address. (See section L.13.1.3)

Note 2: The EOM mark (255_{10}) can be used to double-check the integrity of the received update data message as it must correlate with the update length contained in the UTH. (See section 4.7.3.7)

4.7.4.3 - Update data: The update data follows the Update Data Type and the ROM address. Its length is derived from the Update Data Type as shown above.

The data sent is the actual data which must be stored in the RAM (see Fig. L.13.1). All update types less than 8 indicate the data must be stored in the Update Data File, whereas a type 8 update must be stored in the New Stations File.

The only possible exception is the type 7 update (Erased Station) which may refer either to a station stored in ROM (in which case the pointer -- see 4.7.4.2 -- indicates a valid ROM address) or to a new station which was previously stored in the New Stations File (in RAM). In the latter case the pointer will be a dummy pointer (equal to 0) and the four bytes following the pointer will contain the Callsign of the new station to be deleted (if present in the RAM).

5. Transmission of RDS data by AM broadcast stations (reserved)

This section is reserved for the inclusion of dynamic data transmission methods which will allow AM broadcast stations to transmit RDS data and dynamically participate in RDS features. The NRSC shall study various AM RBDS data transmission schemes, from time to time, as they are presented to the NRSC. The NRSC reserves the right to include material within this Section relevant to AM data systems that can co-exist with all aspects of this Standard.

6. Glossary of terms for the applications

6.1 Program identification (PI)

This information consists of a code enabling a receiver to identify a program. The code is not intended for direct display and is calculated by each individual radio program, to enable it to be distinguished from all other programs. 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 program 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 program identification code.

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

a) A "scanning" receiver (with or without a memory for alternative frequencies having the same program 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 frequency range even if the audio output is switched off.

c) A receiver equipped with two RF front-ends, one of which would feed the audio output while the other would search for the same program 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 3.1.3).

6.2 Program service (PS) name

This is a text consisting of not more than eight alphanumeric characters coded in accordance with appendix E [*]), which is displayed by RDS receivers in order to inform the listener what program service is being broadcast by the station to which the receiver is tuned (see 3.1.3.1). Examples for PS names are 'WABC', 'Z-100' and 'Hot 94'. In the case of a local program, the broadcaster may use any designation (up to 8 characters). The length of this name has to be limited for economic reasons. The program service name is not intended to be used for automatic search tuning.

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*) Attention is drawn to the fact that low cost receivers may be able to display only the following characters in figure E.1 of appendix E: Column 2 lines 0, 7, 12, 13, 14 and 15; Column 3 lines 0 to 9; Column 4 lines 1 to 15; Column 5 lines 0 to 10.

6.3 Program type (PTY)

This is an identification number to be transmitted with each program and which is intended to specify the program type within 31 possibilities (see appendix F). This code could also be used for selective seeking (searching stations by format (Top 40, country, etc.)). The last two numbers, i.e. 30 and 31, are reserved for alarm codes. PTY number 30 is for alarm test and PTY number 31 is for alarm notification which is intended to switch on and/or raise the volume of the alerting audio signal of a receiver when it is operating in a waiting, playback, or standard reception mode. During an alert (PTY 31), an audible warning tone should be heard, if available from the station, and the receiver should switch the PS display to "Alert".

6.4 Traffic-program 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 program on which announcements are usually made for motorists. The signal could be taken into account during automatic search tuning.

6.5 List of alternative frequencies (AF)

The list(s) of alternative frequencies give information on the various transmitters broadcasting the same program in the same or adjacent reception areas, and enable receivers equipped with a memory to store the list(s), to reduce the time for switching to another transmitter. This facility is particularly useful in the case of car and portable radios. The protocol is explained in 3.2.1.6.2.

6.6 Location and navigation (LN)

This feature gives the following information on station location: transmitter's state, city (eight 8-bit characters from appendix E, Figure E.1), and latitude/longitude in terms of a 'grid number.' Location information (state and city) are used to supplement other RDS features and are intended for display. Latitude/Longitude and Navigational information (to be determined) may be used for future navigational systems.

6.7 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 any audio 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 program carrying no traffic information to one carrying a traffic announcement, according to those possibilities which are given in 3.2.1.3 or 3.2.1.8.2.

After the end of the traffic announcement the initial operating mode will be restored. The only methods of restoring the previous operating mode is by: (1) the station sending a TA=0, or (2) by a manual operation of the listener.

6.8 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.

6.9 Music/speech switch (M/S)

This is a two-state signal to provide information on whether music or speech is being broadcast.

6.10 Program-item number (PIN)

The code should enable receivers and recorders designed to make use of this feature to respond to the particular program item(s) that the user has preselected. Use is made of the scheduled program time, to which is added the day of the month in order to avoid ambiguity (see 3.2.1.7).

6.11 Radiotext (RT)

This refers to text transmissions coded in accordance with appendix E, primarily addressed to home receivers, which would be equipped with suitable display facilities (see 3.2.2). In car receivers where a text display may be undesirable for safety reasons, the radiotext transmission could be used to control a speech synthesizer; details of.operation in this mode require further study.

6.12 Enhanced other networks information (EON)

This feature can be used to update the information stored in a receiver about program services other than the one received. Alternative frequencies, the PS name, Traffic-program and announcement identification as well as Program-type and Program-item-number information can be transmitted for each other service. The relation to the corresponding program is established by means of the relevant program identification (see 3.2.1.8). Linkage information (see 3.2.1.8.3), consisting of four data elements, provides the means by which several program services may be treated by the receiver as a single service during times a common program is carried.

6.13 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.

Channel 0 and 1 are reserved for data updates to databases resident in receivers to provide current data on broadcast stations in any receivable band. Channel 2 is reserved for SCA information.

6.14 In-house application (IH)

This refers to data to be decoded only within the broadcasting organization. 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 organization itself.

6.15 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 3.2.3 and appendix G. 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.

6.16 Radio paging (RP)

The RP Feature is intended to provide radio paging using the existing FM broadcasts as a transport mechanism, thereby avoiding the need for a dedicated network of transmitters. Subscribers to a paging service will require a special pocket paging receiver in which the subscriber address code is stored. Four types of call messages are possible, in principle:

- a simple call (beeper) without message,
- a 10 or 18 digit numeric message, restricted to 15 digits in international paging,
- an alphanumeric message of up to 80 characters,
- a functions message in international paging.

The detailed coding protocol options are given 3.2.6.

6.17 Emergency warning systems (EWS)

The EWS feature is intended to provide for the coding of audio and digital warning messages that for reasons of security cannot be fully detailed. These messages will be broadcast in cases of emergency and will be evaluated by receivers that automatically tune to the station carrying the appropriate identification as an EWS station. The EWS may also include receivers activated by PTY 30 or 31 (see 3.2.8). Standard consumer receivers should only be activated by PTY 31.

6.18 Traffic Message Channel (TMC)

This feature is intended to be used for the coded transmission of traffic information. Group type 8A is reserved for this purpose and details are still under discussion (see 3.1.3).

6.19 Program Type Name (PTYN)

This feature is intended to provide a text display on RBDS receivers in order to inform the listener what program type is being broadcast by the station to which the receiver is tuned. The PTYN is not intended to be used for automatic search tuning.

6.20 Mobile Search (MBS) (Mobilsökning)

The Swedish Telecommunications Administration (Televerket) Specification for the Swedish Public Radio Paging System.

6.21 Modified MBS (MMBS)

MBS modified for multiplexing with RDS.

7. Marking

Equipment using any of the features of this voluntary standard in an over-the-air data transmission format in the United States may be marked with one of the symbols given in Appendix I.

There is on behalf of NRSC, a trademark application pending for United States ownership of the symbols given in Appendix I.

APPENDICES

A - Offset words to be used for group and block synchronization

The offset words are chosen in such a way that the content in the offset 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 B).

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 five offset words (A, B, C, C', D) of the table below are used for all RDS applications. **For MMBS applications an additional offset word E (binary value 0000000000) is used to maintain synchronization.**

Table A.1

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

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 2.3, Error protection).

B - 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-synchronization-slip by the addition (modulo-two) of chosen binary sequences (offset words, see appendix A) to the check bits of each codeword [4, 6, 7] .

B.1 Encoding procedure

B.1.1 Theory

A definitive description of the encoding of the information is given in 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 A) to the basic code vector v(x).

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

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

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

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 x 1 column 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).

$$G = \begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 \\
0 & 1 & & & & & & & & & & & & & & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 \\
0 & & 1 & & & & & & & & & & & & & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 \\
0 & & & 1 & & & & & & & & & & & & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 \\
0 & & & & 1 & & & & & & & & & & & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 1 \\
0 & & & & & 1 & & & & & & & & & & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\
0 & & & & & & 1 & & & & & & & & & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\
0 & & & & & & & 1 & & & & & & & & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 \\
0 & & & & & & & & 1 & & & & & & & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 \\
0 & & & & & & & & & 1 & & & & & & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 \\
0 & & & & & & & & & & 1 & & & & & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 \\
0 & & & & & & & & & & & 1 & & & & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 \\
0 & & & & & & & & & & & & 1 & & & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\
0 & & & & & & & & & & & & & 1 & & 0 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\
0 & & & & & & & & & & & & & & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 0 & 1
\end{pmatrix}$$

Figure B.1 Generator matrix of the basic shortened cyclic code in binary notation

Thus,

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

where

$$c_9 = (m_{15} \times 0) \oplus (m_{14} \times 1) \oplus (m_{13} \times 1) \oplus ... \oplus (m_1 \times 1) \oplus (m_0 \times 0)$$
$$c_8 = (m_{15} \times 0) \oplus (m_{14} \times 0) \oplus (m_{13} \times 1) \oplus ... \oplus (m_1 \times 1) \oplus (m_0 \times 1), \text{ etc.}$$

($\oplus$ 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

B.1.2 Shift-register implementation of the encoder

Figure B.2 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.

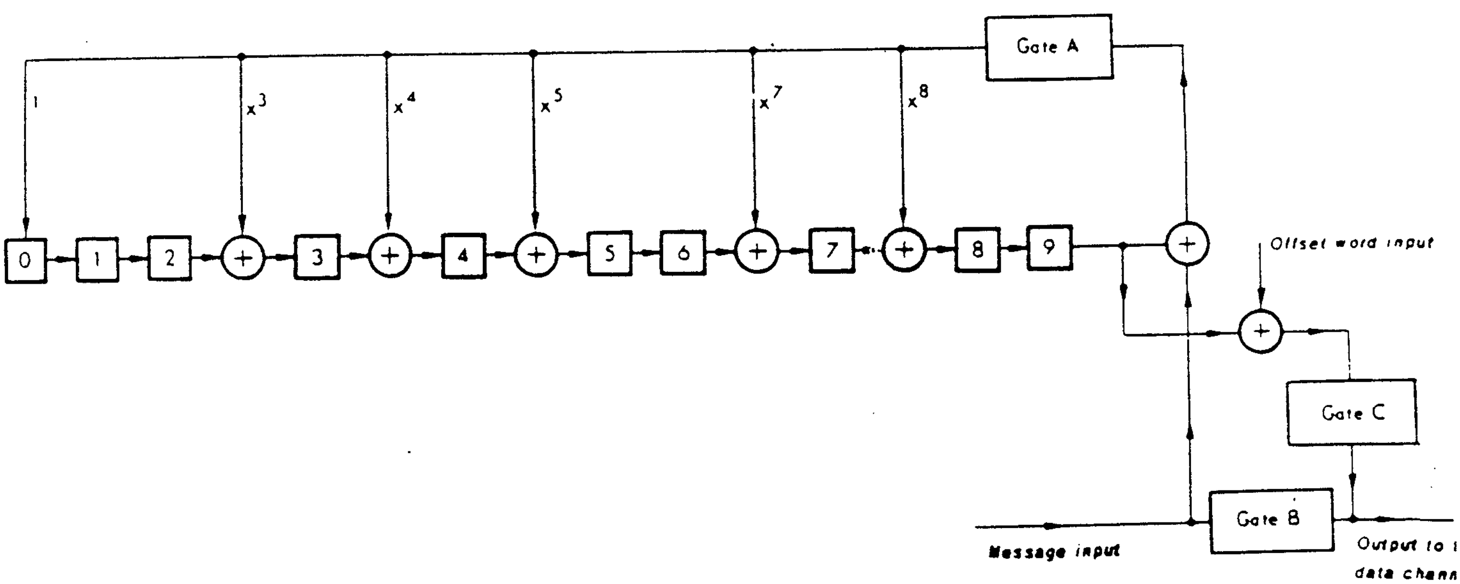


Figure B.2: Shift-register implementation of the encoder

B.2 Decoding procedure

B.2.1 Theory

For a received binary sequence, $\bar{y}$, the syndrome $\bar{s}$ can be calculated as $\bar{s} = \bar{y}\mathbf{H}$, where $\mathbf{H}$ is a parity-check matrix such as that given in figure B.3. If $\bar{x}$ is the transmitted binary sequence and $\bar{y}$ is the received sequence, then $\bar{y} \oplus \bar{x}$ is a sequence that contains a 1 in each position in which $\bar{x}$ and $\bar{y}$ differ. This sequence is called the error sequence $\bar{z}$. The definition of the parity-check matrix $\mathbf{H}$ is such that $\bar{x}\mathbf{H}=0$, if $\bar{x}$ is a codeword. Thus,

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

i.e.

$$\bar{s} = \bar{z}\mathbf{H}$$

If the errors introduced on the channel are known then the syndrome is also known. This relation is used for synchronization 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 $\bar{s} = \bar{y}\mathbf{H}$.

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: $\vec{z}$ = 0000000000000000 | 0011111100 |

(labels under $\vec{z}$: m_{15} … m_0 | c_9 … c_2 c_1 | c_0)

Now the parity-check matrix **H** is:

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

Figure B.3: Parity-check matrix of the basic shortened cyclic code.
It is this matrix which is used in the decoder of figure B.4

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 D calculated using the matrix of figure B.3, are shown in the table below:

Table B.1

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

B.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.

Figure B.4 shows a shift-register arrangement for decoding the transmitted 26-bit blocks and performing error-correction and detection.

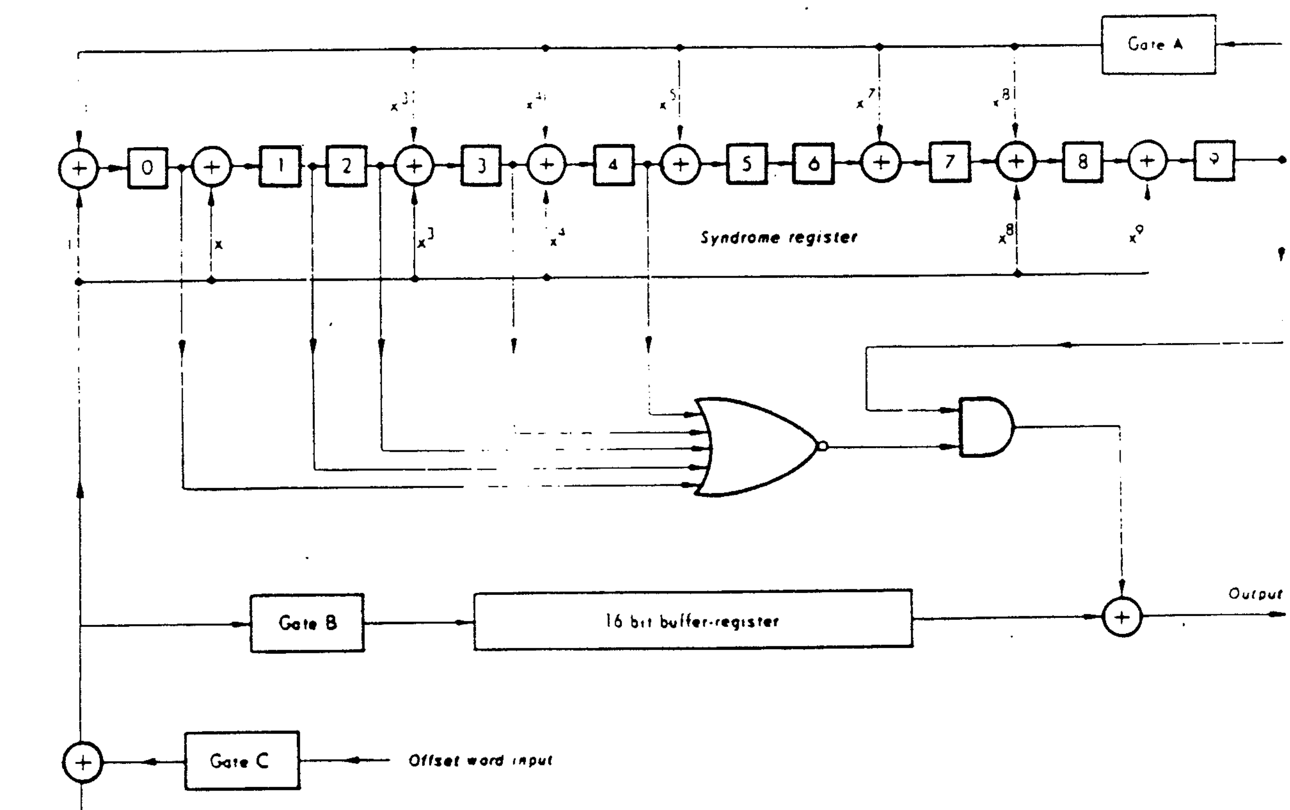


Figure B.4: Shift-register implementation of the decoder

The decoding procedure is as follows, assuming that in this explanation group and block synchronization have already been acquired (see appendix C):

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.

C - Implementation of group and block synchronization using the modified shortened cyclic code

C.1 Theory

C.1.1 Acquisition of group and block synchronization

To acquire group and block synchronization 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 synchronized 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 B).

C.1.2 Detection of loss of synchronization

It is very important to detect loss of synchronization as soon as possible. One possibility is to check the syndrome continuously as for acquisition of synchronization. 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 synchronization 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.

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

There are several methods using either hardware or software techniques for deriving group and block synchronization information. One possible method is described below. Figure C.1 shows a block diagram of a shift-register arrangement for deriving group and block synchronization information from the received data stream. It may be seen to comprise five main elements:

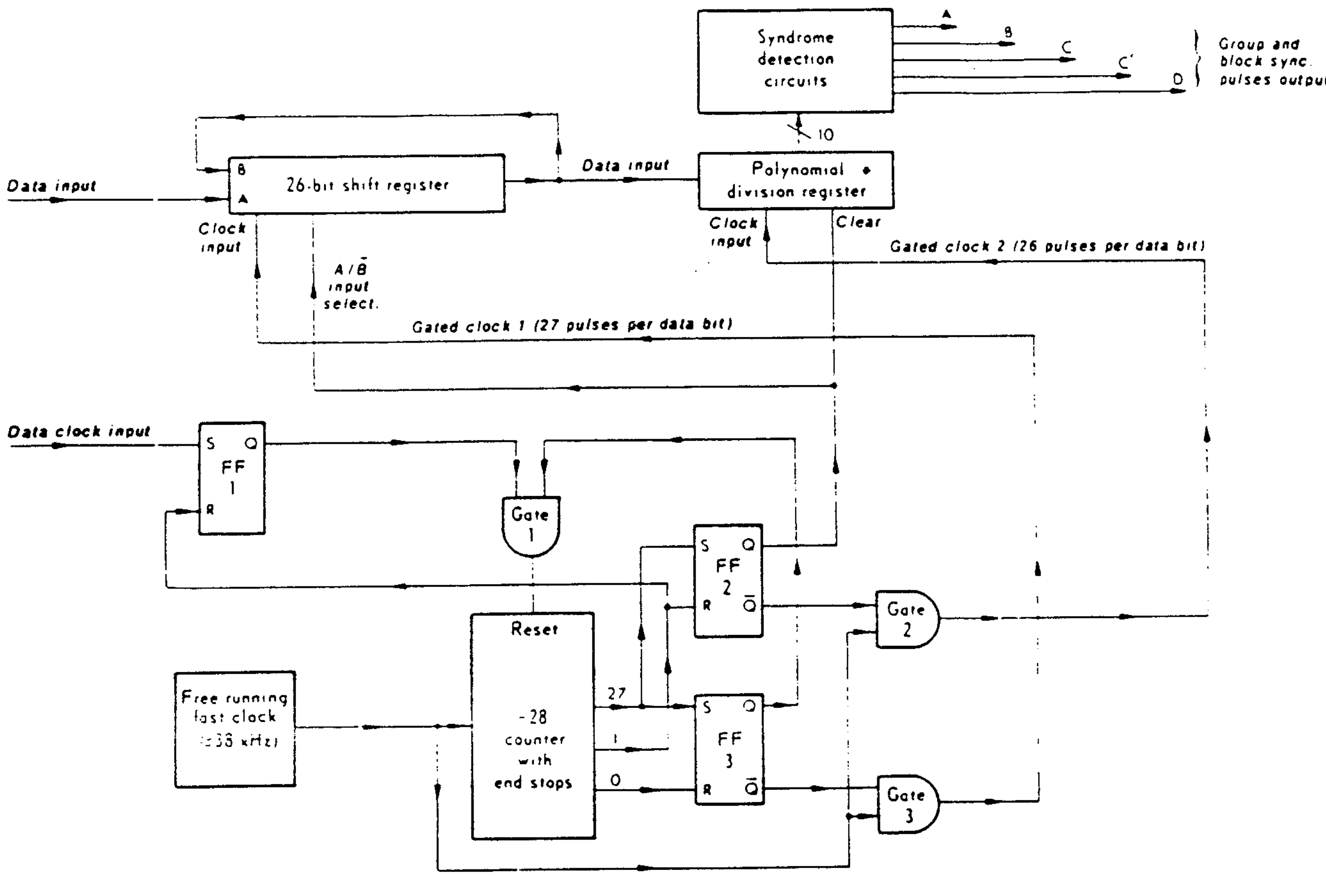
a) a 26-bit shift-register which may either act as a straight 26-bit delay (A/B input selector high) or as a recirculating shift-register (A/B input selector low);

b) a polynomial division circuit comprising a 10-bit shift-register with feedback taps appropriate to the generator polynomial, g(x), described in 2.3 and appendix B;

c) a combinational logic circuit with five outputs 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 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).



• The circuit of this register is represented in figure B.2

Figure C.1: Group and block synchronization detection circuit

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 is $d(x)$ = 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 figure B.3 or the circuit of figure B.4. The syndromes corresponding to offset words A to D are shown in the table below.

Table C.1

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

When the syndrome corresponding to one of the five offset words is found, a block synchronization pulse is given out of the appropriate one of the six 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 (≈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 synchronization 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 synchronization is also achieved.

These group and block synchronization pulses cannot, however, be used directly because although with this system false synchronization 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 synchronization pulses will be missed because even with correct block synchronization 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 synchronization flywheel to eliminate spurious synchronization 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.

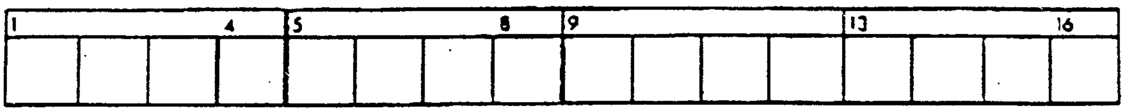
D - Program identification codes and Extended country codes

D.1 General principles

PI codes are the key to the automatic tuning and follow-me features of RDS: they act as digital signatures to prevent false switching between stations carrying different program signals (but perhaps sharing alternate frequencies). Care must be taken, therefore, especially in the region of borders between different countries, to avoid two stations which are both receivable at the same location, having the same PI code.

D.2 PI structure

The PI code consists of 16 bits. The most significant bit is designated here as bit 1 and the least significant bit as bit 16. These 16 bits are structured into four elements (nibbles), as follows (see also figure D.1):



Nibble 1 = Bits 1...4
Nibble 2 = Bits 5...8
Nibble 3 = Bits 9...12
Nibble 4 = Bits 13...16

Figure D.1

Nibble 1 is used for country identification, and the HEX codes assigned for all countries in the world can be found in SPB485 [16]. The codes assigned to the USA are HEX 1,2,3,4,5,6,7,8,9,A,B,D,E. The code for Canada is HEX C and for Mexico HEX F. HEX 0 is reserved and shall not be used.

D.3 Extended country codes

Extended country codes should be transmitted in Type 1A groups to render the country identification in Nibble 1 (bits 1 to 4 of the PI code unique). The Extended country code (ECC) is carried in Variant 0 of Block 3 of Type 1A groups and consists of eight bits. This Variant should be transmitted at least once every minute. For comprehensive table of ECC and country identification see SPB485 [16].

The Extended country codes are:

	ECC	Nibble 1 of PI code
USA	**HEX A0**	1,2,...A,B,D,E
Canada	**HEX A1**	C
Mexico	**HEX A4**	F

The bit allocation of the Extended country codes is given in figure D.2.

Usage	Bit allocation in Block 3															
Group type 1A	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Usage code 0	LA[1]	0	0	0	X	X	X	X	Extended Country Code							

Usage code (bits 2–4)
Linkage Actuator [1] (bit 1)

Bits indicated by "X" are not assigned and may be either in state "1" or "0".

1) The Linkage Actuator is defined in the Method for linking RDS program services (see 3.2.1.8.3).

Figure D.2: Structure of Variant 0 of Block 3 of Type 1A groups (Extended Country Codes)

D.4 PI Coding

D.4.1 Call letter conversion method

NOTE: Call letters or slogan to be displayed by the receiver are sent using the PS (program service) data.

1) Assign decimal values to last 3 letters of call letters:

Table D.1

LETTER	DECIMAL VALUE	LETTER	DECIMAL VALUE
A	0	N	13
B	1	O	14
C	2	P	15
D	3	Q	16
E	4	R	17
F	5	S	18
G	6	T	19
H	7	U	20
I	8	V	21
J	9	W	22
K	10	X	23
L	11	Y	24
M	12	Z	25

2) Assign weighted value according to call letter's position and add together to obtain a DECIMAL value for last 3 letters.

K	3rd letter position	2nd letter pos.	1st letter pos.
W	3rd letter position	2nd letter pos.	1st letter pos.

3rd letter position x 676
\+ 2nd letter position x 26
\+ 1st letter position
decimal value for 3 letters = *DECIMAL*

3) If station begins with K, HEX {*DECIMAL* +4096} (value obtained above + 4096) to obtain four digit PI code. However, if station begins with W, HEX {*DECIMAL* +21672} to obtain four digit PI code.

IF K... HEX[*DECIMAL* +4096] = FOUR DIGIT PI CODE
IF W... HEX[*DECIMAL* +21672] = FOUR DIGIT PI CODE

EXCEPTIONS TO ABOVE ASSIGNMENTS:

1) CALL LETTERS THAT MAP TO PI CODES = _ 0 _ _. European receivers will treat a PI code that has a second nibble of zero as a local station (unique broadcast) and will not AF switch. If a station's call letters map to a PI code = _0_ _, the PI code assignment needs to be reassigned into the A _ _ _ group as follows:

P1 0 P3 P4 →→ A P1 P2 P3: Examples: 1045 →→ A145; 30F2 →→ A3F2; 80A1 →→ A8A1; etc.

2) CALL LETTERS THAT MAP TO PI CODES = _ _ 0 0. If station's PI code ends with 00h, some European receivers will go into a test mode. Therefore, 00h will be reassigned into the A F _ _ group as follows:

P1 P2 0 0 →→ A F P1 P2: Examples: 1C00 →→ AF1C; 3200 →→ AF32; 8C00 →→ AF8C ; etc.

NOTE: For 9 special cases 1000,2000,..,9000 a double mapping occurs utilizing exceptions 1 and 2:
1000→→A100→→AFA1;2000→→A200→→AFA2;..;8000→→A800→→AFA8;9000→→A900→→AFA9

3) TWO STATIONS CARRY THE IDENTICAL PROGRAMMING (example WYAY and WYAI in Atlanta, Georgia). These stations will need to assign the same PI code for both stations. The radio will need an identical PI code match to switch to the alternate frequency. The call letters can still be displayed independently with the PS information. Therefore, either the mapping of WYAY PI code = 4F78 or WYAI PI code = 4F68 will need to be used.

4) 3-LETTER-ONLY CALL LETTERS (example KYA in San Francisco). For 3 letter call sign stations, a mapping of pre-assigned PI codes is shown in Table D.2, TABLE OF PI CODE POSSIBILITIES. The mapping of 3-letter-only call letters is reserved in PI codes ranging from 9950 to 9EFF.

5) NATIONALLY-LINKED RADIO STATIONS CARRYING DIFFERENT CALL LETTERS (example NPR). These stations will need to be assigned a PI code with a first nibble of B (B_01 to B_FF). NOTE: Nibble 2 can only be filled with 1 through F. If a 0 is used, some receivers may not switch to Alternate Frequencies.

6) Reserve Nibble 1 equal to C and F for Canada and Mexico respectively.

Table D.2
TABLE OF PI CODE POSSIBILITIES

HEX CODE = FOUR DIGIT PI CODE
HEX[0000-0FFF] RESERVED

CALL LETTERS(K)	DECIMAL + 4096	HEX CODE = FOUR DIGIT PI CODE
KAAA	0 + 4096 = 4096	HEX[4096] = 1000
KAAB	1 + 4096 = 4097	HEX[4097] = 1001
:	:	:
:	:	:
KZZY	17574 + 4096 = 21670	HEX[21670] = 54A6
KZZZ	17575 + 4096 = 21671	HEX[21671] = 54A7

CALL LETTERS(W)	DECIMAL + 21672	HEX CODE = FOUR DIGIT PI CODE
WAAA	0 + 21672 = 21672	HEX[21672] = 54A8
WAAB	1 + 21672 = 21673	HEX[21673] = 54A9
:	:	:
:	:	:
WZZY	17574 + 21672=39246	HEX[39246] = 994E
WZZZ	17575 + 21672=39247	HEX[39247] = 994F

3-LETTER-ONLY CALL LETTERS

AM STATIONS WITH 3 LETTER CALLS

KEX	9950		
KFH	9951	WGH	9970
KFI	9952	WGL	9971
KGA	9953	WGN	9972
KGO	9954	WGR	9973
KGU	9955	WGY	9974
KGW	9956	WHA	9975
KGY	9957	WHB	9976
KID	9958	WHK	9977
KIT	9959	WHO	9978
KJR	995A	WHP	9979
KLO	995B	WIP	997A
KLZ	995C	WJR	997B
KMA	995D	WKY	997C
KMJ	995E	WLS	997D
KNX	995F	WLW	997E
KOA	9960	WMC	997F
KOH	9961	WMT	9980
KOY	9962	WOC	9981
KPQ	9963	WOI	9982
KQV	9964	WOL	9983
KSL	9965	WOR	9984
KUJ	9966	WOW	9985
KVI	9967	WSB	9986
KWG	9968	WSM	9987
KXL	9969	WWJ	9988
KXO	996A	WWL	9989
KYW	996B		
WBT	996C		
WBZ	996D		
WDZ	996E		
WEW	996F		

FM STATIONS WITH 3 LETTER CALLS

KDB	9990
KGB	9991
KOY	9992
KPQ	9993
KSD	9994
KUT	9995
KXL	9996
KXO	9997
KYA	9998
WBT	9999
WGH	999A
WGY	999B
WHP	999C
WIL	999D
WMC	999E
WMT	999F
WOI	99A0
WOW	99A1
WRR	99A2
WSB	99A3
WSM	99A4

99BC - 9FFF Reserved

TV STATIONS WITH 3 LETTER CALLS

KBW	99A5
KCY	99A6
KDF	99A7
KGO	99A8
KGW	99A9
KHQ	99AA
KOB	99AB
KSL	99AC
KYW	99AD
WBZ	99AE
WGN	99AF
WHA	99B0
WHO	99B1
WHP	99B2
WIS	99B3
WJW	99B4
WJZ	99B5
WLS	99B6
WMC	99B7
WOI	99B8
WRC	99B9
WSB	99BA
WWL	99BB

Table D.2 (continued)
TABLE OF PI CODE POSSIBILITIES

CALL LETTERS MAPPING TO _0_ _	HEX CODE = FOUR DIGIT PI CODE
1000	A100
1001	A101
:	:
90FF	A9FF

CALL LETTERS MAPPING TO _ _ 0 0	HEX CODE = FOUR DIGIT PI CODE
1000 →→ A100	AFA1
1100	AF11
1200	AF12
:	:
1F00	AF1F
2000 →→ A200	AFA2
2100	AF21
2200	AF22
:	:
AF00	AFAF

NATIONALLY-LINKED RADIO STATIONS	HEX CODE = FOUR DIGIT PI CODE
NPR	B_01
?	B_02
:	:
?	B_FF

CANADA RADIO STATIONS	HEX CODE = FOUR DIGIT PI CODE
?	C000
?	C001
:	:
?	CFFF

MEXICO RADIO STATIONS	HEX CODE = FOUR DIGIT PI CODE
?	F000
?	F001
:	:
?	FFFF

NOTE: This will map all possible K___, W___, 3-LETTER-ONLY CALL LETTERS, CALL LETTERS MAPPING TO _0_ _, CALL LETTERS MAPPING TO __00, and NATIONALLY-LINKED RADIO STATIONS into a four digit hex PI code. Radio will distinguish AM/FM if AM RDS PI codes need to become established.

NOTE: Standards thus far only use 0000 - BFFF. To avoid two stations on US-Canada border or US-Mexico border from using the same PI code, recommendations will be made for Canada and Mexico to assign PI codes utilizing a first nibble of C and F respectively. This mapping does not use Nibble 1 equal to D or E.

D.4.2 Examples of assigning PI codes from Call letters:

STATION 1: KGTB
G = 6 X 676 = 4056
T = 19 X 26 = 494
B = 1 = 1
= 4551

SINCE STATION BEGINS WITH K: 4551 + 4096 = 8647 = STATION DECIMAL VALUE
HEX [8647] = 21C7 = KGTB'S PI CODE

STATION 2: WKTI
K = 10 X 676 = 6760
T = 19 X 26 = 494
I = 8 = 8
= 7262

SINCE THIS STATION BEGINS WITH W: 7262 + 21672 = 28934 = STATION DECIMAL VALUE
HEX [28934] = 7106 = WKTI'S PI CODE

TO CHECK HEX CODE:

4TH DIGIT X 4096
\+ 3RD DIGIT X 256
\+ 2ND DIGIT X 16
\+ 1ST DIGIT X 1 =
SHOULD EQUAL STATION DECIMAL VALUE

EXAMPLES OF CHECKS:

KGTB'S CHECK:
PI = 21C7, FROM STATION DECIMAL VALUE OF 8647

2 X 4096
\+ 1 X 256
\+ 12 X 16
\+ 7 X 1
= 8647 = STATION DECIMAL VALUE

WKTI CHECK:
PI = 7106, FROM STATION DECIMAL VALUE OF 28934

7 X 4096
\+ 1 X 256
\+ 0 X 16
\+ 6 X 1
= 28934 = STATION DECIMAL VALUE

D.4.3 Application: Receiver functionality to PI code assignments

Some current European receivers store PI codes into presets in addition to storing frequencies into presets. This function is to recognize the broadcast first by program rather than frequency. Thus, if a preset is pushed and the PI code has changed, the European RDS receivers would not recognize the new PI code and go into a PI search.

EBU DOC TECH 3260 January 1990 Chapter 4 pg. 49 states:

> If however the PI code changes completely, the receiver should initiate a PI search for a frequency whose PI code exactly matches the PI code of the original tuned frequency. Failing an exact PI code match, the receiver should search for a PI code differing only in the regional element (bits 5-8) from the original PI code. If neither of these criterion are met, the receiver should remain on the original tuned frequency.

Therefore, since call letters are used to create the PI code, the receiver would have to do a PI search every time a station would change call letters or a preset is pushed in a new listening area having a station at the same frequency as the preset station. For PI codes < B000h, future receivers could check the AF list associated to a preset and if no AF's are acceptable, a PI search could be initiated. If no identical PI is found, the receiver should return to the original tuned frequency and store the new PI code. This will prevent the user from experiencing the searching event every time he pushes the preset until he finally realizes that he has to reset the preset.

If a PI search is performed, the regional variant search (the second search to match PI codes differing only in bits 5-8) should be eliminated in a PI search if the tuned PI is below B000h. There may be a possibility a second PI search could find another program with AF's whose call letters mapped to a PI code that varies only in bits 5-8.

If a feature similar to European regional variants is desired, a grouping in the B block could be designated as follows:

> If NPR broadcasts break off national programming to go local for a period of time, it could be assigned a PI of B_01. NOTE: Cannot use 0 as the second nibble because current receivers will not search for AF's: therefore use 1-F for indication of a variant. If no AF's or identical PI's are found via the AF list or an identical PI search, the receiver could, while tuned to NPR station 1 (PI=B101), accept a variant NPR station 2 whose PI varies only in the second nibble (bits 5-8). Thus B201, B301, B401, . . . could be accepted.

PI codes starting with the B nibble yield 255 possibilities (B_01 - B_FF) for "regional" programming. PI's could be assigned using B, D, and E for Nibble 1 as needed. NOTE: The problem here becomes that a "telephone book" needs to be kept; however, there should not be too many broadcasts that fit in this category and not many would be used. It would be very unlikely that PI codes utilizing Nibble 1 equal to D or E would need to be assigned.

For PI codes assigned above B000, the receiver, with prior knowledge of regional variants existing, could attempt a PI search based on a regional variant. For current receivers, a regional on/regional off button allows the user to not accept/accept a regional variant respectively. This feature will also allow current receivers to function properly for stations with AF's but that have no regional variants (stations with PI < B000) by not falsely accepting another PI code as a regional variant. Example: If PI = 3488 and PI = 3588 are two mappings based on call letters of stations in the same reception area, the regional on would tell the receiver not to accept these as similar and thus not switch to completely different broadcast.

Canada and Mexico would be handled similar to PI code assignments of Nibble 1 equal to B, which is the same as European regional variants are handled. Canada and Mexico should assign PI codes utilizing Nibble 1 equal to C and F as described in Appendix D of CENELEC EN50067:1992.

E - Character definition for Program Service name, Radiotext, Alphanumeric Radio Paging, Program Type name, and Location: City Name

Receivers must not respond to any characters of columns 0 or 1 of the code-tables which are reserved for possible future extensions of the system.

Displayable characters from the code table of ISO Norm 646: (columns 2–7)

Additional displayable characters for: *EBU common-core (7 languages)* (columns 8–9); *Complete Latin-based repertoire (25 languages)* (columns 10–15)

b4	b3	b2	b1		2	3	4	5	6	7	8	9	10	11	12	13	14	15
				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
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	Ǧ	±	Í	Î	Ŷ	ŷ
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)	ß	ǧ	↑	½	Ž	ž	Ź	ź
1	1	1	0	14	.	>	N	―	n	¯	¡	ı	→	¾	Đ	đ	Ŧ	ŧ
1	1	1	1	15	/	?	O		o		Ĳ	ĳ	↓	§	Ŀ	ŀ	ð	

Figure E.1: 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 Publication 646 that do not appear in the complete Latin-based repertoire given in Appendix 2 of EBU document Tech. 3232 (2nd edition, 1982).

Attention is drawn to the fact that low cost receivers may be able to display only the characters in Column 2 lines 0, 7, 12, 13, 14 and 15; Column 3 lines 0 to 9; Column 4 lines 1 to 15; Column 5 lines 0 to 10.

If low cost receivers cannot reproduce characters of Figure E.1 refer to Figure E.2 for a mapping to be used if an undisplayable character is received. If no mapping, leave the display blank for undisplayable characters.

				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						P	A	A						
0	0	0	1	1					A	Q	A	A						
0	0	1	0	2					B	R	E	E						
0	0	1	1	3					C	S	E	E						
0	1	0	0	4					D	T	I	I						
0	1	0	1	5					E	U	I	I						
0	1	1	0	6					F	V	O	O						
0	1	1	1	7					G	W	O	O						
1	0	0	0	8					H	X	U	U						
1	0	0	1	9					I	Y	U	U						
1	0	1	0	10					J	Z		N						
1	0	1	1	11					K			C						
1	1	0	0	12					L									
1	1	0	1	13					M									
1	1	1	0	14					N									
1	1	1	1	15					O									

Figure E.2

F- Program Type Codes

PROGRAM TYPE	8 CHARACTER DISPLAY
0. No Program Type Code	_ **** _
1. News	NEWS
2. Information	INFORM
3. Sports	SPORTS
4. Talk	TALK
5. Rock	ROCK
6. Classic Rock	CLS_ROCK
7. Adult Hits	ADLT_HIT
8. Soft Rock	SOFT_RCK
9. Top 40	TOP_40
10. Country	COUNTRY
11. Oldies	OLDIES
12. Soft	SOFT
13. Nostalgia	NOSTALGA
14. Jazz	JAZZ
15. Classical	CLASSICL
16. R&B	R_ &_B
17. Soft R&B	SOFT_R&B
18. Language	LANGUAGE
19. Religious Music	REL_MUSC
20. Religious Talk	REL_TALK
21. Personality	PERSNLTY
22. Public	PUBLIC
23-29. Spares	
30. Emergency Test	TEST
31. Emergency	ALERT!

NOTE 1: It is anticipated that the codes listed above will cover most existing formats and will be capable of handling the future evolution of new formats.

NOTE 2: _ refers to a space in 8 character display

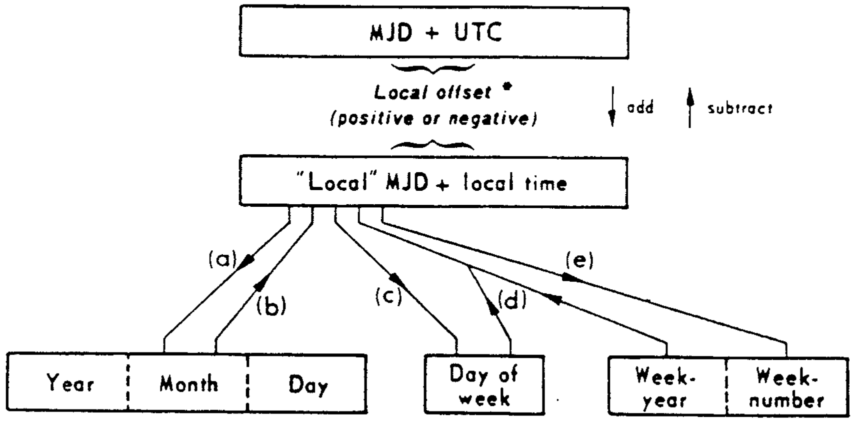
Program type name (PTYN)

This is a text consisting of not more than eight alphanumeric characters coded in accordance with Appendix E, which is displayed by RDS receivers in order to inform the listener what program type is being broadcast by the station to which the receiver is tuned. The PTYN is not intended to be used for automatic search tuning. This will still be the function of the 5-bit PTY code. The search will take place under the heading of the default PTY name given in this Appendix. Once the receiver matches the PTY code, the receiver should terminate the search and display the PTYN if available. If the PTYN is not received, the default PTY name given in this Appendix should be used.

The repetition rate needed for the PTYN display is equivalent to the PS name repetition (all 8 characters should be transmitted at least once per second). Thus an additional overhead of at least 2 groups/second will be required to support this feature. If default PTY is acceptable, this feature is not needed and the additional groups will not be required. Also, in fringe area reception, the PTYN may not be displayed immediately . In this case the default PTY will be used.

G - Conversion between time and date conventions

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



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

Figure G.1: Conversion routes between Modified Julian Date (MJD) and Coordinated Universal Time (UTC)

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**

$Y' = \text{int}\,[\,(MJD - 15\,078{,}2) / 365{,}25\,]$

$M' = \text{int}\,\{\,[\,MJD - 14\,956{,}1 - \text{int}\,(Y' \times 365{,}25)\,] / 30{,}6001\,\}$

$D = MJD - 14\,956 - \text{int}\,(Y' \times 365{,}25) - \text{int}\,(M' \times 30{,}6001)$

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

$Y = Y' + K$

$M = M' - 1 - K \times 12$

b) **To find MJD from Y, M, D**

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

$MJD = 14\,956 + D + \text{int}\,[\,(Y - L) \times 365{,}25] + \text{int}\,[\,(M + 1 + L \times 12) \times 30{,}6001\,]$

c) **To find WD from MJD**

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

d) **To find MJD from WY, WN, WD**

$MJD = 15\,012 + WD + 7 \times \{\,WN + \text{int}\,[\,(WY \times 1\,461 / 28) + 0{,}41]\,\}$

e) **To find WY, WN from MJD**

$W = \text{int}\,[\,(MJD / 7) - 2\,144{,}64\,]$

$WY = \text{int}\,[\,(W \times 28 / 1\,461) - 0{,}0079]$

$WN = W - \text{int}\,[\,(WY \times 1\,461 / 28) + 0{,}41]$

Example:

MJD = 45 218	W = 4 315
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.

H - 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 Section 6).

a) RDS features:

AF	List of alternative frequencies
CT	Clock time and date
DI	Decoder identification
EON	Enhanced information on other networks
EWS	Emergency warning systems
IH	In-house application
LN	Location and navigational information
M/S	Music/speech switch
PI	Program identification
PIN	Program-item number
PS	Program service name
PTY	Program type
PTYN	Program type name
RDS	Radio Data System
RP	Radio paging
RT	Radiotext
TA	Traffic-announcement identification
TDC	Transparent data channel
TMC	Traffic message channel (Application under discussion)
TP	Traffic-program identification

b) Other abbreviations:

CI	Country identifier (see 3.2.1.8.3)
ECC	Extended country code (see appendix D)
EG	Extended Generic indicator (see 3.2.1.8.3)
ILS	International Linkage Set indicator (see 3.2.1.8.3)
LA	Linkage Actuator (see 3.2.1.8.3)
LI	Linkage Identifier (see 3.2.1.8.3)
LSN	Linkage Set Number (see 3.2.1.8.3)
MBS	Mobil sökning - Swedish Public Radio Paging System - Mobil search
MMBS	Modified MBS (see appendix K)
RBDS	Radio Broadcast Data System
I-RDS	In-Receiver Database System

I - Logo

Note: The wording "RADIO DATA SYSTEM" may be omitted, if the logo has to be reduced to a very small size.

J - Navigation Information

J.1 Latitude/Longitude Encoding and Decoding

J.1.1 Latitude/Longitude Encoding

An advantage can be had by encoding latitude/longitude data in the navigational information since it can be used by many different applications.

Since data space is limited, latitude and longitude coordinates are encoded as a single decimal integer (converted to binary form) representing a unique "grid number" as follows:

The continent is divided into rows and columns spaced at a given resolution (1/R) expressed as a fraction of degree. For example, a resolution of 1/5 degree latitude by 1/5 degree longitude (R=5) overlays the continent with a grid of contiguous rectangles roughly 14 miles by 9 to 13 miles each (depending on latitude.)

Each grid unit (G) is encoded such that the first grid unit at the bottom right (southeast) corner of the grid has a code of 1 (G=1). The grid unit directly West of G=1 has a code of 2 (G=2), and so on until the westernmost grid unit of the first (southernmost) row is reached. The numbering then continues, likewise sequentially from right to left, with the second row (North of the first row), and so on from bottom to top until the whole grid is completed.

Stations Distribution
at resolution = 1/2 degree

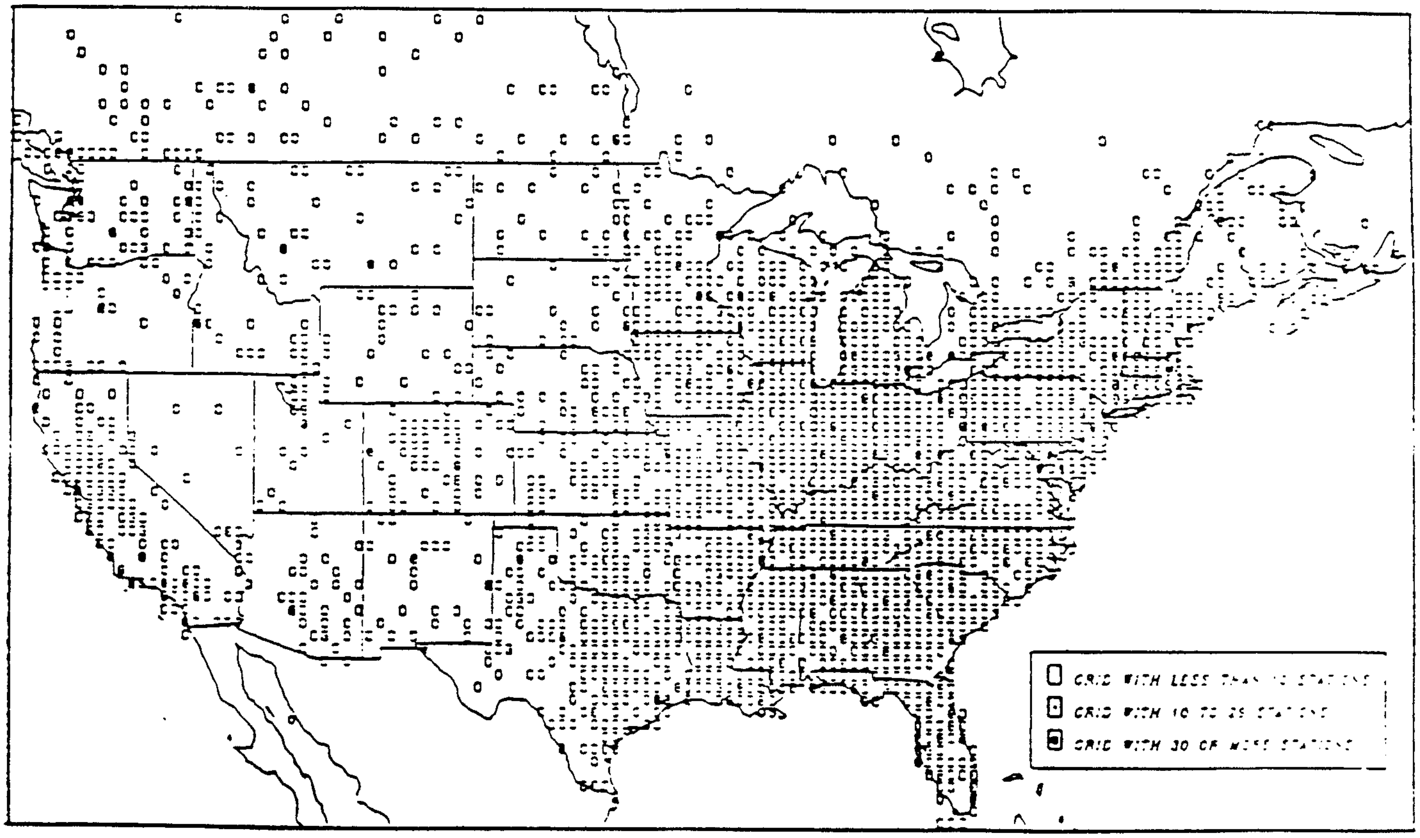


Figure J.1

Since the grid code is normalized to the southeast corner of the grid, the coordinates of that point need to be fixed. In addition, the westernmost longitude needs also be fixed to determine the left (western) edge of the grid.

The following values are used for North America's normalization (in decimal degrees):

Minimum latitude	(LA_{min})	=	24° N
Minimum longitude	(LO_{min})	=	55° W
Maximum longitude	(LO_{max})	=	131° W

The following formula is then used to calculate the grid number of a point:

$$G = 1 + \{[(LO-LO_{min}) + [(LA-LA_{min}) \bullet (1 + [(LO_{max}-LO_{min}) \bullet R])]] \bullet R\}$$

where:

G = grid number	LA_{min} = minimum latitude = 24.0
LO = longitude	LO_{min} = minimum longitude = 55.0
LA = latitude	LO_{max} = maximum longitude = 131.0

1/R = degree resolution = 1/5th of a degree = 12'

Note: this formula is valid only for northern latitudes and western longitudes.

<u>Note that a resolution of 1/5 degree (R=5) is used to stay within the constraints of a 16 bit number (see J.1.3)</u>. The formula can therefore be simplified to:

$$G = (5 * ((381 * (LAT-24)) + (LON-55))) + 1$$

where:

G = grid number
LON = rounded decimal longitude (*)
LAT = rounded decimal latitude (*)

A simple BASIC program would look like:

```
INPUT "Enter the Latitude", LAT
INPUT "Enter the Longitude", LON
G = (5*((381*(LAT-24))+(LON-55)))+1
PRINT G
```

(*) Note: All coordinates MUST be rounded <u>down</u> to the nearest 1/5th of a decimal degree before entry in the formula. Therefore the decimal can only be EVEN: .0, .2, .4, .6, or .8

Thus 30.0, 30.2, 30.4, 30.6, 30.8, etc... are valid, while
30.1, 30.3, 30.5, 30.7, 30.9, etc... are NOT valid.

Examples:

The grid number of Philadelphia, PA (39° 57'N 75° 07'W) is:

after transformation (39° 57'N 75° 07'W) to decimal degrees (rounding to the lowest 1/5th of a degree) with:

57' = 57/60 = 0.95; rounding to lowest 1/5th = 0.8
07' = 7/60 = 0.12; rounding to lowest 1/5th = 0.0

(39° 57'N 75° 07'W) is entered as: LAT=39.8, LON=75.0

so, (5 * ((381 * (39.8-24)) + (75.0-55))) + 1 = 30,200

The grid number of Seattle, WA (47° 36'N 122° 20'W) is:

(5 * ((381 * (47.6-24)) + (122.2-55))) + 1 = 45,295

In order to avoid extending the grid over half the Pacific, and further North than possible for the available space, the following states and province are re-assigned to the following grid numbers that have no land locations:

Alaska	=	grid 1
Hawaii	=	grid 2
Newfoundland	=	grid 3
Canadian areas North of Lat 54° N	=	grid 4

J.1.2 Latitude, Longitude Decoding

The following formulas are used to recover the latitude and longitude (in that order) from a grid number:

$$LA = \{INT[(G-1) / ([R \bullet (LO_{max}-LO_{min})] + 1)] / R\} + LA_{min}$$

$$LO = \{[(G-1) / R] - [(LA-LA_{min}) \bullet ([(LO_{max}-LO_{min}) \bullet R] + 1)]\} + LO_{min}$$

where:

G = grid number — LA_{min} = minimum latitude = 24.0
LO = longitude — LO_{min} = minimum longitude = 55.0
LA = latitude — LO_{max} = maximum longitude = 131.0
1/R = degree resolution; (e.g. 1/5° -> R=5)
INT(x) means the integer portion of x (no rounding up) e.g: INT(5.9) = 5.0

Note: these formulas are valid only in the western hemisphere for latitudes North of the equator.

J.1.3 Notes pertaining to the choice of R

The maximum resolution (R) possible is desirable to construct grid squares (rectangles) as small as possible.

The Great Circle Distance (D) equation is used:

$$D = 69.05 \cos^{-1}[\sin(LA_1)\sin(LA_2) + \cos(LA_1)\cos(LA_2)\cos(LO_2 - LO_1)]$$

The distance between each one degree latitude is practically always 69.05 miles (60 nautical miles). Thus the vertical distance of a grid square of 1 degree resolution is always 69.05 miles. (In fact, given the Earth's uneven curvature that distance varies between 68.7 miles at the equator and 69.4 at the poles.)

However, the horizontal distance of a grid square of 1 degree depends on its latitude:

LAT = 0°	->	69 miles (Equator)
LAT = 20°	->	65 miles (Hawaii Island, HI)
LAT = 25°	->	63 miles (Florida Keys, FL)
LAT = 30°	->	60 miles (Houston, TX)
LAT = 35°	->	57 miles (Memphis, TN)
LAT = 40°	->	53 miles (Philadelphia, PA)
LAT = 45°	->	49 miles (Bangor, ME)
LAT = 50°	->	44 miles (North of Vancouver, BC)
LAT = 55°	->	40 miles (Ketchikan, AK)
LAT = 60°	->	35 miles (South of Anchorage, AK)
LAT = 90°	->	0 mile (North Pole)

The mean values for a grid square can be approximated with:

Mean Area (A) = 69.05 x (69.05 / 2) = 2,384 sqmi
Mean Side (S) = SQRT(2,384) = 48.82 miles

Mean sides are obtained for the following resolutions:

R = 1	->	Mean Side = 49 miles
R = 2	->	Mean Side = 24 miles
R = 4	->	Mean Side = 12 miles
R = 5	->	Mean Side = 10 miles (16 bits)
R = 85	->	Mean Side = .6 miles (24 bits)
R = 1372	->	Mean Side = 188 feet (32 bits)

For n available bits to encode the grid number, the largest grid number can be:

8 bits	->	G_{max} = 256
16 bits	->	G_{max} = 65,536
24 bits	->	G_{max} = 16,777,216
32 bits	->	G_{max} = 4,294,967,296

The chosen resolution is thus limited by the highest grid number generated at the northwestern corner of the grid.

Assuming the use of a northern grid limit of 54 degree latitude, the following values are obtained:

Minimum latitude	(LA_{min})	=	24
Maximum latitude	(LA_{max})	=	54
Minimum longitude	(LO_{min})	=	55
Maximum longitude	(LO_{max})	=	131

R = 1	->	G_{max} =	2,387	
R = 2	->	G_{max} =	9,333	
R = 4	->	G_{max} =	36,905	
R = 5	->	G_{max} =	57,531	(Max for 16 bits)
R = 85	->	G_{max} =	16,482,011	(Max for 24 bits)
R = 1372	->	G_{max} =	4,291,980,953	(Max for 32 bits)

Since the grid will only be coded for a sixteen bit number in group 3A, the highest R resolution is R = 5 (resolution of 1/5°), the following grid unit sizes are obtained:

Vertical:	LAT 0°-90°	->	14 miles	
Horizontal:	LAT 20°	->	13 miles	(Hawaii Island, HI)
	LAT 30°	->	12 miles	(Houston, TX)
	LAT 40°	->	11 miles	(Philadelphia, PA)
	LAT 50°	->	09 miles	(North of Vancouver, BC)

K - Coding of MMBS Radio Paging, Data and In-House Application

RDS/MMBS multiplex signalling format will transmit RDS data in a time multiplexed fashion between modulo-4 blocks of MMBS. To obtain RDS information from this data stream, the receiver must be able to decode the E = 0 offset. Details of the multiplex signalling are given in this appendix.

K.1 Baseband coding structure

RDS consists of fixed length groups having 4 blocks each. MMBS is also transmitted in modulo-4 groups of 4 E blocks. MMBS blocks are identical to RDS blocks, each having 16 information bits and 10 check bits with the exception that MMBS uses the E = 0 offset word (see section 2.1).

K.2 Synchronization of blocks and groups

All MMBS blocks employ an offset word E consisting of all zeros. MMBS blocks thus do not utilize an offset word, but other receivers must recognize a null offset word to avoid interpreting the MMBS error-protecting syndrome as flawed RDS blocks. The E offset word is thus necessary for maintaining the synchronization of the flywheel (see section 2.4).

K.3 RDS principal features

MMBS blocks do not contain any of the RDS principal features as defined in 3.1.2.

K.4 Group types

The recommended group sequencing for RDS/MMBS multiplexing to maximize MMBS data capacity is shown in Table K.1.

M represents four MMBS blocks and #A represents any RDS group (see section 3.1.3).

Table K.1

												1 Second											2 Second
Skeleton structure w/ AF's	0A		0A	3A		0A		0A				1A	0A		0A	3A		0A		0A			1A
Skeleton structure w/o AF's	0B		15A	3A		0B		15A				1A	0B		15A	3A		0B		15A			1A
Normal Run w/ AFs		2A			0A		2A		0A	0A	2A			2A			0A		2A		0A	0A	
Normal Run w/o AFs		2A			15A		2A		15A	15A	2A			2A			15A		2A		15A	15A	
Normal Run w/ AFs w/ PTYN		10A			0A		10A		0A	0A	10A			10A			0A		10A		0A	0A	
Normal Run w/o AFs w/ PTYN		10A			15A		10A		15A	15A	10A			10A			15A		10A		15A	15A	
Every Minute																							4A
Every 12 hours		9A												9A									
Before and after Traffic Message		2A			15B		2A		15B	15B	2A			2A			15B		2A		15B	15B	
Emergency (EWS)		9A			9A		1A		9A	9A	9A			9A			9A		1A		9A	9A	
Paging		2A			7A		2A		7A	7A	7A			2A			7A		2A		7A	7A	
Paging (peak) - alt.		7A			7A		7A		7A	7A	7A			7A			7A		7A		7A	7A	
TMC (peak)		2A			8A		2A		8A	8A	8A			2A			8A		2A		8A	8A	
Inhouse applic.		2A			6A		2A		6A	6A	6A			2A			6A		2A		6A	6A	
Navigational		3A			0A		3A		0A	0A	0A			3A			0A		3A		0A	0A	
Navigat. (peak)		3A			0A		3A		3A	0A	3A			3A			3A		3A		3A	0A	15A
Transparent Data Channel		2A			5A		2A		5A	5A	5A			2A			5A		2A		5A	5A	
RDS+MMBS **	0A	M	15A	0A	M	M	0A	15A	M	M	M	15A	0A	M	15A	0A	M	M	0A	15A	M	M	
RDS+MMBS (peak) **	0A	M	M	M	M	0A	M	M	M	M	M	0A	M	M	M	M	M	0A	M	M	M	M	M
GROUP 1A BLOCK 3 VARIANT SEQUENCING *																							
TMC	0	1	1	1	1	1																	
EWS	0	7	7	7	7	7																	

*When Group 1A is transmitted, slow labeling codes (as defined in Section 3.2.1.9) located in block 3 will need to be sequenced by variants. These variants contain certain information relating to several RDS options. Thus, the sequencing of the block 3 variant of Group 1A given in the above table are to optimize the data transfer for the specific RDS operations: TMC, EWS, and RDS paging respectively.

**Broadcasters with translators or multiple transmitters who use the multiplexed RDS+MMBS signal may experience slower AF switching due to a reduced repetition rate of the AF information.

K.5 Offset Word to be used for group and block synchronization

MMBS blocks use offset word E of all zeros i.e. d_9 - d_0 = 0000000000 (see appendix A). Thus the message code vector becomes the transmitted code vector (see section B.1.1). In an error free transmission of an MMBS block the syndrome $\bar{s}$ = 0000000000 (see section B.1.2 and Table K.2).

Table K.2

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

If RDS/MMBS multiplex signalling, block sequence can be A-B, B-C, C-D, D-A or D-E, and E-E or E-A i.e. a modulo-4 number of E blocks can be inserted between RDS groups (between offsets D and A) so a fixed cyclic rhythm of occurrence of the offset words would be A, B, C, D, (4 E blocks), (4 E blocks), A, B, C, etc. The syndromes corresponding to offset words A to E are shown in Table K.3.

Table K.3

Offset	Offset word $d_9,d_8,d_7\_d_0$	Syndrome $S_9,S_8,S_7\_S_0$
A	0011111100	0101111111
B	0110011000	0000001110
C	0101101000	0100101111
C'	1101010000	1011101100
D	0110110100	1010010111
E	0000000000	0000000000

K.6 Acquisition of group and block synchronization

To acquire group and block synchronization 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] (if RDS/MBS multiplex signalling, block sequence can be A-B, B-C, C-D, D-A or D-E, and E-E or E-A i.e. a modulo-4 number of E blocks can be inserted between RDS groups (between offsets D and A) so a fixed cyclic rhythm of occurrence of the offset words would be A, B, C, D, (4 E blocks), (4 E blocks), A, B, C, etc.) are found n x 26 bits apart (where n = 1, 2, 3, etc.). When this is achieved, the decoder is synchronized 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 C.1.1).

K.6.1 Shift register arrangement for deriving group and block synchronization

There are several methods using either hardware or software techniques for deriving group and block synchronization information. One possible method is described below. Figure K.1 shows a block diagram of a shift-register arrangement for deriving group and block synchronization 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 feedback taps appropriate to the generator polynomial, g(x), described in 2.3 and appendix B;
c) a combinational logic circuit with six outputs indicating the presence of the "correct" syndromes resulting from the six offset words A, B, C, C', D and E (for maintaining synchronization);
d) a fast-running clock operating 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).

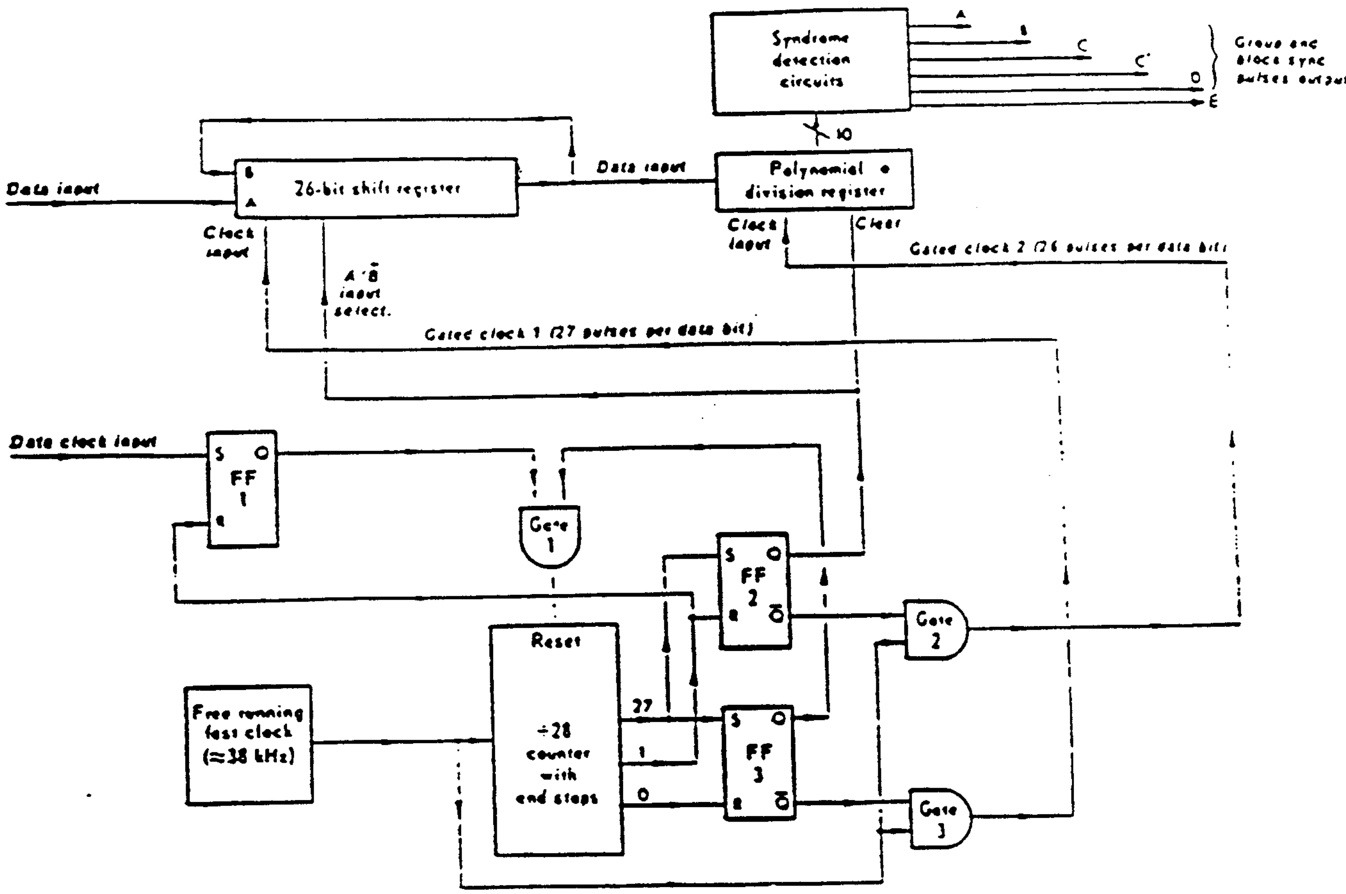


Figure K.1: Group and block synchronization flywheel detection circuit for RDS/MMBS multiplex signals

K.7 MMBS Group Structure

The MMBS message is of variable length, ranging from one to eight blocks. The MMBS block is structured identically to the RDS block except that the offset word, E, consists of all zeros. See Figure K.2 - MMBS message. The MMBS group consisting of MMBS blocks is modulo-4 length (i.e. 0,4,8,.. blocks).

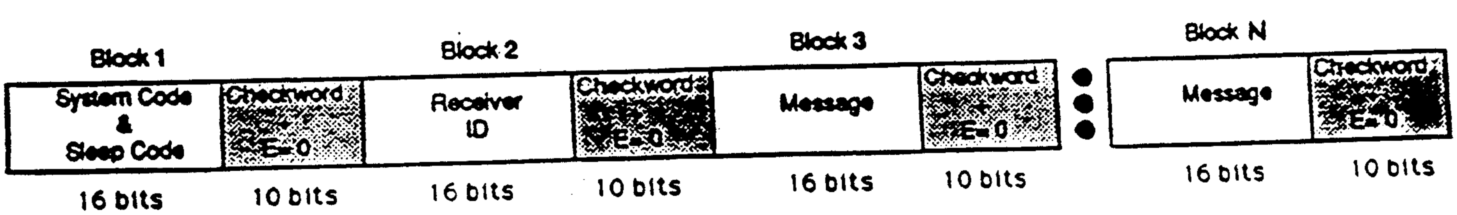


Figure K.2: MMBS message

K.8 RDS/MMBS Multiplex Transmission Sequence

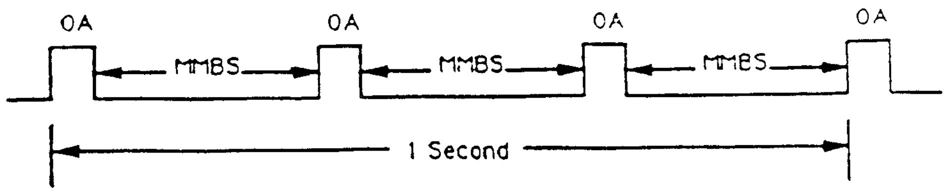


Figure K.3: Typical multiplex coding

a) At least two 0A, 0B, 15A, or 15B groups, as appropriate, will be transmitted each second. A 4A group will be transmitted at the start of each minute. Type 2 and 15 groups will be transmitted as required.

b) The MMBS transmission will consist of variable length MMBS messages assembled to yield MMBS groups formatted to lengths of modulo-4 blocks.

c) Whenever there are no pages or RDS groups due for transmission, then filler MMBS blocks or additional 0A groups will be transmitted.

K.9 MMBS Radio Paging

K.9.1 MMBS Numeric Paging

The current numeric pagers can receive messages of one to 12 decimal digits. These digits are transmitted as hexadecimal characters. Hex character A is used as a filler or spacer in the page. Since the smallest unit of transmission is the 26 bit block with 16 information bits, the telephone number 1234567 would be transmitted as 123A 4567 to provide a space on the display to emulate the normal seven digit telephone number format. The number 12345 would be transmitted as 12345AAA to provide three blank spaces in the 26 bit block dedicated to transmitting the integer 5. As the data right shifts on the display, the lead A's are ignored. The number of blocks included in the page is the minimum necessary to convey the input numeric.

K.9.2 MMBS Alphanumeric Paging

Alphanumeric paging and text transmission generally imply message lengths exceeding five blocks and require stringing multiple MMBS groups into one lengthy message. The alphanumeric message header is shown below. Subsequent groups for the same message will substitute text information in the receiver ID and length blocks.

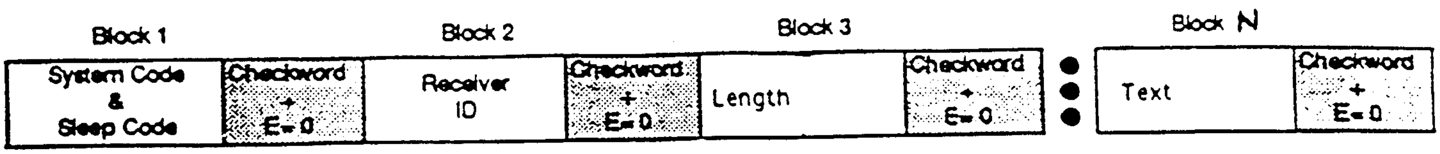


Figure K.4

Although the figure implies a byte oriented coding, it is best to view the transmission as bit oriented in packets of 16 bits. The user can then employ optimized variable length codes to achieve optimal efficiency. In this case, alphanumeric pages and text transmission are transmitted in groups ranging from three to eight blocks in length.

It is essential that the system code not appear in the first 8 bits of any message block. Violation of this rule could cause a false synchronization of the receiver.

K.10 Battery Saving Transmission Sequence

a) The MMBS pager operates on a battery saving cycle, commonly referred to as a "sleep cycle". The pagers are divided into groups corresponding to the sleep code defined above. The sleep code must appear twice within 12 consecutive blocks to initiate the battery saving power-down of the pager. The power-down occurs 12 blocks after the last occurrence of the pager's sleep code. The pager stays powered-down for 31 seconds and then, on power-up, resynchronizes to the MMBS signal. The resync algorithm will fly-wheel through any 0A, 4A, or other RDS group which may actually be in transmission at that instant.

b) The MMBS paging cycle lasts a minimum of 1494 blocks, during which all existing pager groups are provided their pages, if any, or at least their sleep codes to initiate the power-down process.

K.11 Pager Synchronization

K.11.1 Locking to a Channel

a) The receiver looks for the system code within an error-free block. It must find at least one additional error free block within the next nine blocks to establish synchronization.

b) When the receiver is in scan mode, it must establish synchronization within one-half (0.5) second. If it does not, it must leave the channel.

c) When powering up from the battery saving mode, it must establish synchronization within fifteen (15) seconds. If it does not, it must leave the channel.

K.11.2 Loss of Synchronization

When 43 of the last 45 blocks have a syndrome different from zero, the receiver will try to achieve resynchronization by the synchronization rule used in channel scan. If it does not resynchronize within fifteen (15) seconds, it must initiate channel scan.

K.12 Data Transmission

K.12.1 Extended Addressing

Data transmission can be carried out by either the numeric or alphanumeric formats described above. In data application calling for very large numbers of receiver, the capacity of 1 million addresses, per system code, described in section 3.2.7.1.3 could be insufficient, depending on other applications in the network. In this situation, one SSSCIIII address can be allocated to the date application and then receivers can be uniquely addressed via the next one or two message blocks. Alternately, one system code SSSC, block could be allocated and the next one or two blocks made available for addressing. Since hex characters are employed in the address space, the individual address characters can range from 0 to F, rather than only 0-9. However, it is essential that the system code not appear in the first 8 bits of any extended addressing or message block. The occurrence of the system code in the first 8 bits would cause a false resynchronization of the receiver.

K.12.2 Synchronization

If the data receiver is a scanning receiver and is kept in a stationary position, then the receiver should use the following rules for declaring synchronization.

a) The receiver must find the system code in an error-free block followed by 9 error-free or correctable blocks.

b) When the receiver is in scan mode, it must establish synchronization within one second. If it does not, it must leave the channel.

c) When powering up from the battery saving mode, it must establish synchronization within fifteen (15) seconds. If it does not, it must leave the channel.

K.12.3 Loss of Synchronization

When 43 of the last 45 blocks have a syndrome different from zero, the receiver will try to achieve resynchronization by the synchronization rule in a above. If it does not resynchronize within fifteen (15) seconds, it must initiate channel scan.

If the data receiver is a mobile receiver it may use the pager synchronization rules in K.11.1 and K.11.2.

K.13 In-House Applications

These applications can be met by the methods described in section K.12. The MMBS protocol is flexible and efficient in channel utilization.

The material in Section 4 and Appendix L is proprietary and requires the acquisition of a license from its owner for its implementation in hardware, firmware and/or software.

L - I-RDS Files Structure

L.1 I-RDS Header File

The I-RDS Header File is shown in Fig. L.1. This file contains pointers to (addresses of) the start and end of each of the other files in the ROM. Each of these pointers are at absolute (unchanging) locations. This permits the location and size of each file in the ROM to vary as needed. In other words the Header File is the only file which is always located at the same address in the ROM (always address 0) and whose structure is fixed.

HEADER FILE LAYOUT

ADDRESS DECIMAL	ADDRESS HEX	DESCRIPTION	LENGTH (byte)
0	0	Copyright Notice...	32
32	20	Compilation Date	3
35	23	Manufacturer's Name (11 char max.)	11
46	2E	Manufacturer's Code	1
47	2F	ROM Manufacturer's Code	1
48	30	Continent's Code	1
49	31	Receiver Type Code	1
50	32	STATE FILE START ADDRESS	3
53	35	State File Last Byte Address	3
56	38	State File Record Length	1
57	39	CITY FILE START ADDRESS	3
60	3C	City File Last Byte Address	3
63	3F	City File Record Length	1
64	40	AM BAND FILE START ADDRESS	3
67	43	AM Band File Last Byte Address	3
70	46	AM Band File Record Length	1
71	47	AM Lowest Frequency (/ 1 kHz)	2
73	49	AM Highest Frequency (/ 1 kHz)	2
75	4B	AM Channel Separation (/ 1 kHz)	1
76	4C	FM BAND FILE START ADDRESS	3
79	4F	FM Band File Last Byte Address	3
82	52	FM Band File Record Length	1
83	53	FM Lowest Frequency (/ 0.1 Mhz)	2
85	55	FM Highest Frequency (/ 0.1 Mhz)	2
87	57	FM Channel Separation (/ 0.1 Mhz)	1
88	58	MAP FILE START ADDRESS	3
91	5B	Map File Last Byte Address	3
94	5E	Map File Record Length	1
95	5F	Highest Square in Main Grid	3
98	62	Latitude Square Increment (South to North)	2
100	64	Number of Solitary Squares	1
101	65	First Solitary Square No.	3
104	68	Second Solitary Square No.	3
...	...	Etc...	3
107	6B	Reserved space in Header File	
246	F6	FORMAT FILE START ADDRESS	3
249	F9	Format File Last Byte Address	3
252	FC	Format File Record Length	1
253	FD	Number of Formats	1
254	FE	Default Grid Number	2
255	FF	END OF HEADER FILE	

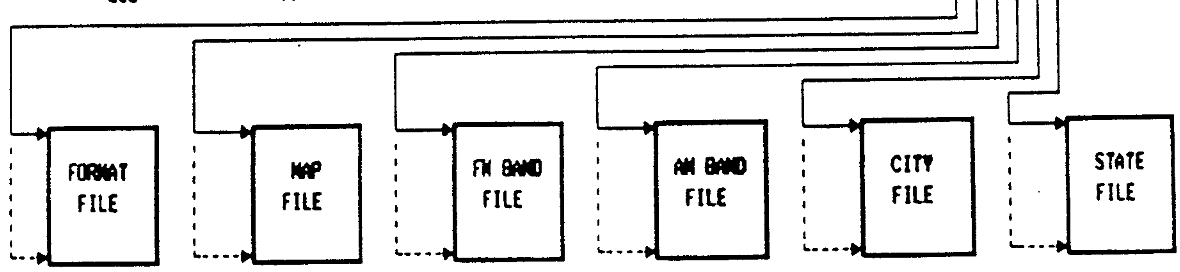


Figure L.1 The Header File

NOTE: All pointers in the Header are three bytes long and are given in the following order: Byte1 of the pointer - most significant byte of the address; Byte2 of the pointer - middle byte of the address; Byte3 of the pointer - least significant byte of the address.

L.2 Cross-referencing Pointers and Counters

The In-Receiver Database System relies on a system of cross-referencing pointers and counters which permits the CPU to locate records related to each other, whether they belong in the same file or not.

For example a record in the FM Band File describing a radio station will point to an address in the City File where that station's city of license is located and described. Likewise that city's record will contain pointers to the AM and FM Band Files to indicate the first radio station in each band (defined as the station with the lowest frequency) which can be found in the Grid in which the city is located.

Similarly, the City File contains a State Counter in each of its records. This counter permits the CPU to determine the proper state (or province) for each city.

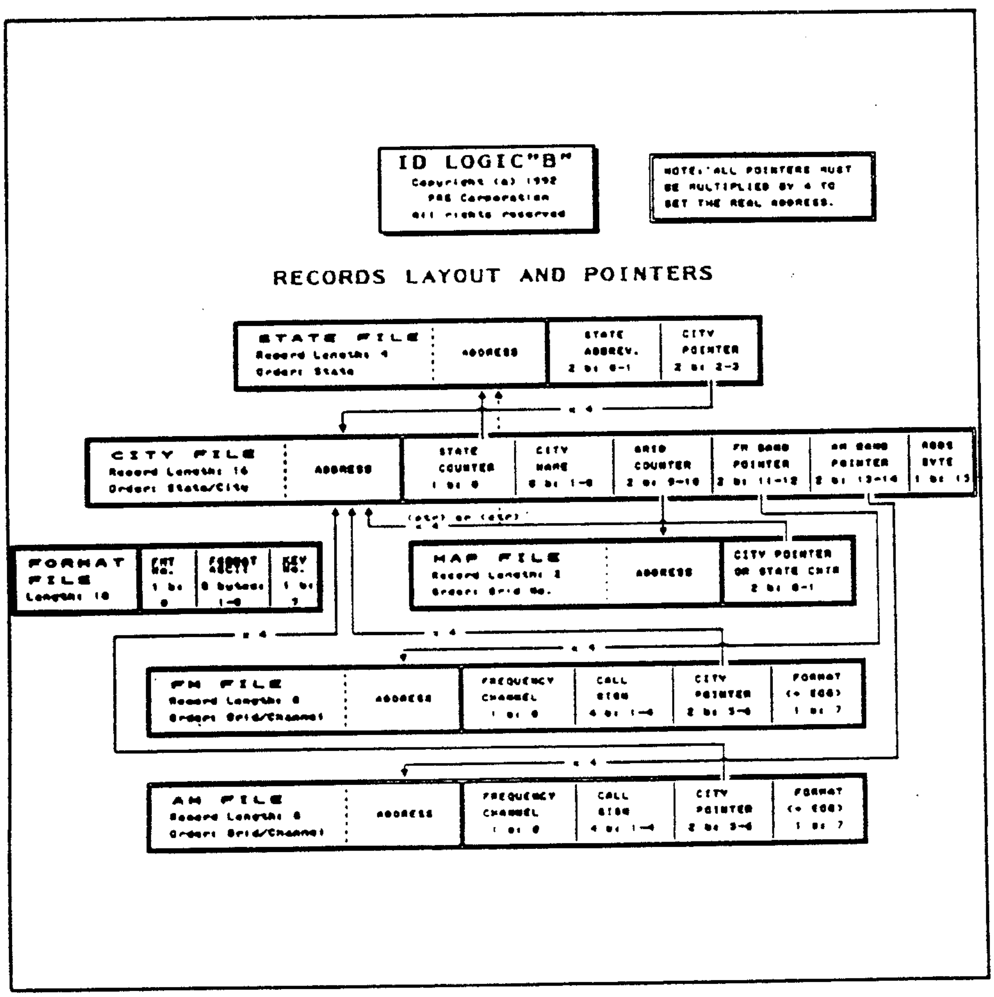


Figure L.2 Records layout and pointers

L.3 Pointer Arithmetic

Since the I-RDS ROM has an address space of 256 kilobytes, each discrete address would require 18 bits. In order to conserve space in the files, all pointers have been reduced to two bytes.

This is achieved in three steps:

1) All files start on an even boundary (L.S.Bytes = 00 or modulo 100hex)

2) The files which are referenced by pointers (the City File, and both Band Files) are formed of records of 16 bytes and 8 bytes respectively. This ensures that each record in these files also starts at an address of modulo 8 -- where at minimum the least significant two bits are always equal to 0.

3) All pointers which reference these three files are first divided by 4 (two bitwise shift to the right) before they are stored in the files. (NOTE: This is true of all files except of the Header File where all pointers are 3 bytes long and where they denote real addresses.)

Then, when actually using such a pointer, a two bitwise shift to the left (a multiplication by 4) is performed to restore the actual real address of interest.

L.4 Counter Arithmetic

When appropriate, counters are used instead of pointers. An address is derived from a counter with the following formula:

Address = (Counter - 1)*Record_Length + File_Start

Figure L.4 Counter arithmetic

Each of the variables (record length and file start address) can be found in the Header File at their own addresses (See Fig. L.1). Since all record lengths are powers of 2 the multiplications required can be reduced to simple bitwise shifts to the left.

L.5 State File Layout

Each record in the State File is composed of two fields:

- The state (or province) abbreviation (two ASCII characters)
- The city pointer which refers to the <u>largest</u> city in the state or province.

The high bit of both bytes of the state abbreviation are used to code the country. (See section L.12.2)

$00_b = 0 =$ USA
$01_b = 1 =$ Canada
$10_b = 2 =$ Mexico

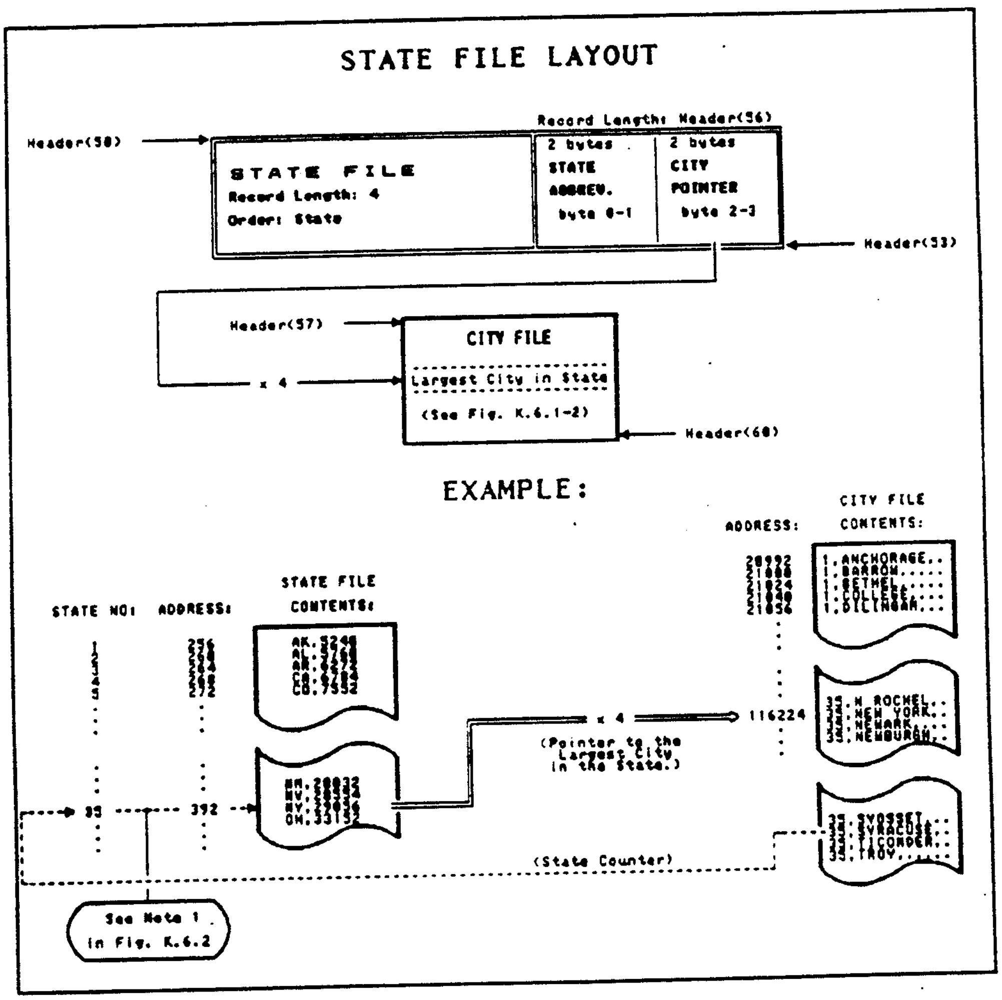


Figure L.5 State File layout

The State File is ordered alphabetically by state abbreviations.

L.6 - City File Layout

Each record in the City File is composed of six fields:

- The state counter
- The city name (abbreviated to eight characters)
- The Grid counter which indicates the location of the city in the grid system
- The FM band pointer referencing the first (lowest frequency) FM station in the Grid
- The AM band pointer referencing the first (lowest frequency) AM station in the Grid
- Unassigned RBDS flags (eight bits available)

NOTE: In addition to the eight bits of the last byte, the eight high bits of the city name are also available for RBDS flags (for a total of 16 bits).

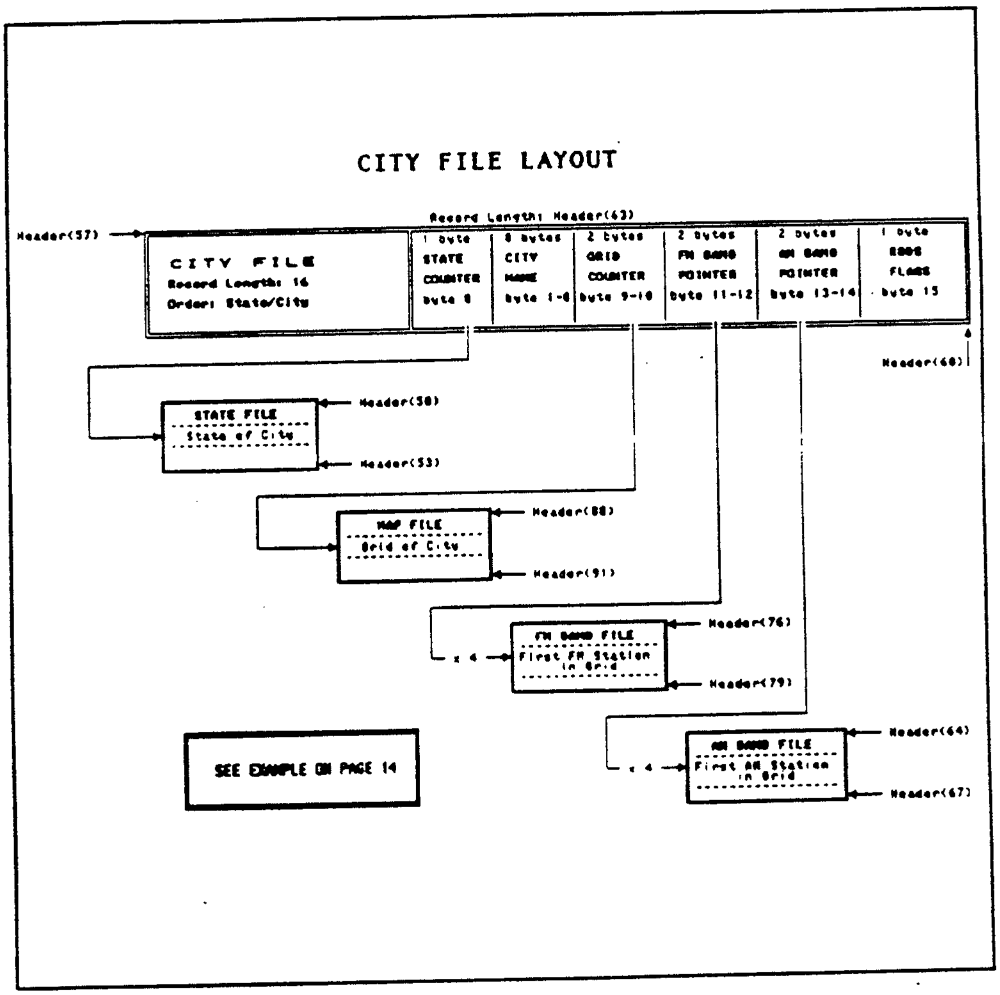


Figure L.6.1 - City File layout

The City File is ordered alphabetically by states and by cities (full name) within each state.

See section L.12.3 for application notes.

The following figure provides an example of the application of the City File as illustrated in Fig. L.6.1.

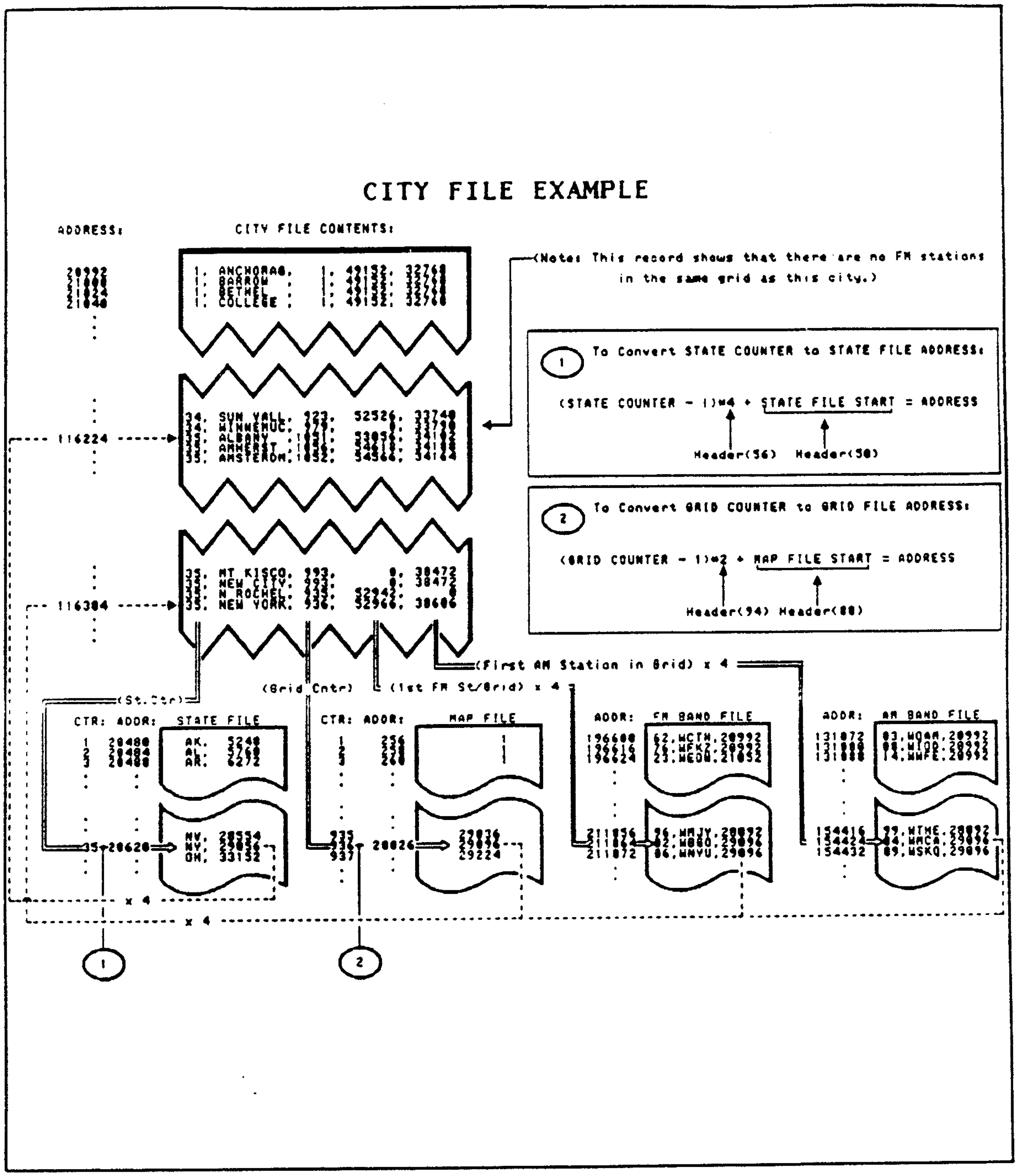


Figure L.6.2 - City File layout example

Notes 1 and 2 of Fig. L.6.2 apply the equation defined in Fig. L.4 (Counter Arithmetic) converting counters to addresses.

L.7 AM Band File Layout

See section L.12.4 for application notes.

Each record in the AM Band File is composed of four fields:

- The channel (frequency)
- The callsign (four ASCII characters)
- The city pointer (indicating the city of license)
- The format (usual PTY)

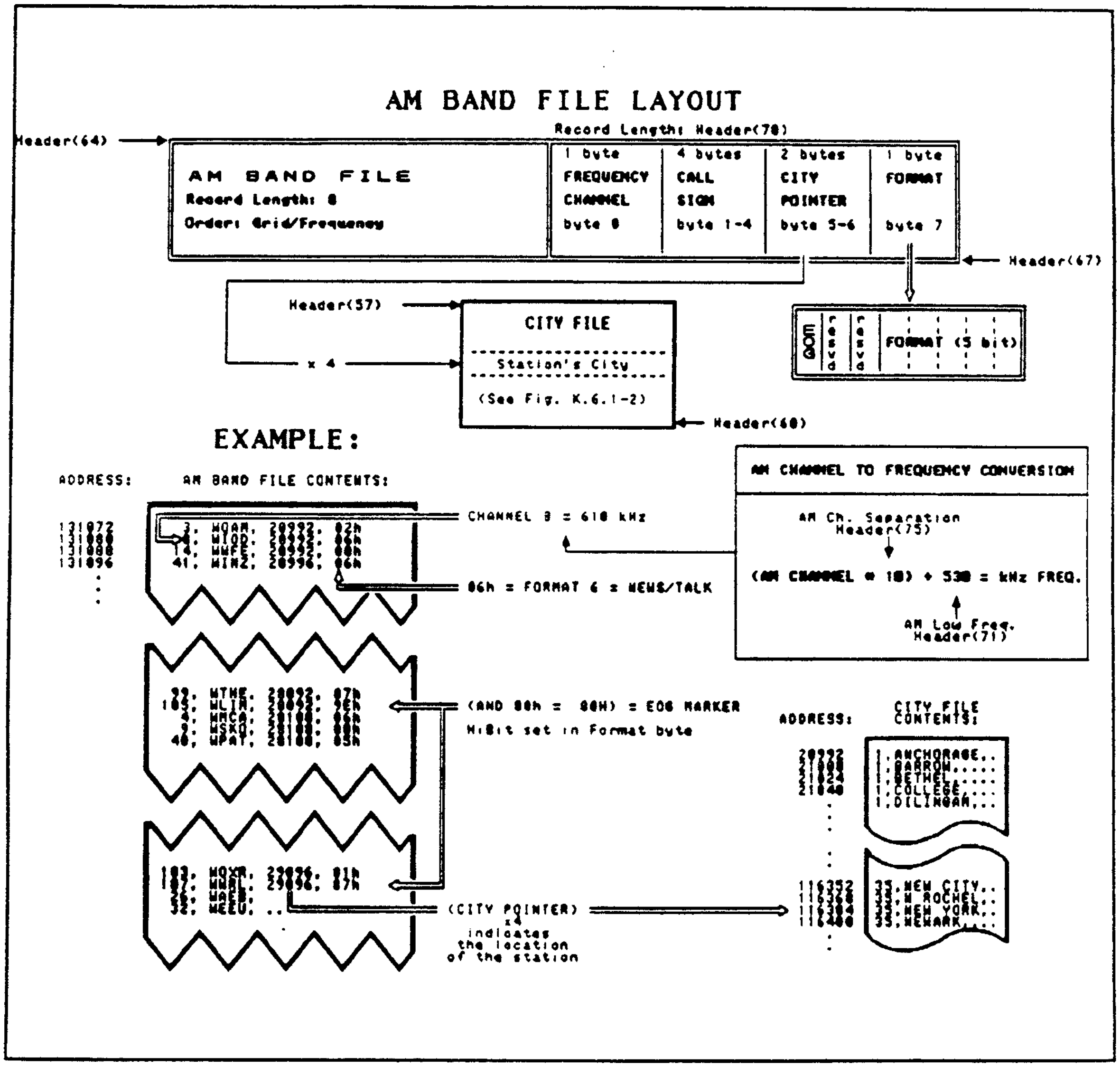


Figure 12 - L.7 - AM Band File layout

The AM Band File is ordered by ascending Grid number and by ascending frequencies within each Grid.

L.8 - FM Band File Layout

See section L.12.4. for application notes.

Each record in the FM Band File is composed of four fields:
- The channel (frequency)
- The callsign (four ASCII characters)
- The city pointer (indicating the city of license)
- The format (usual PTY)

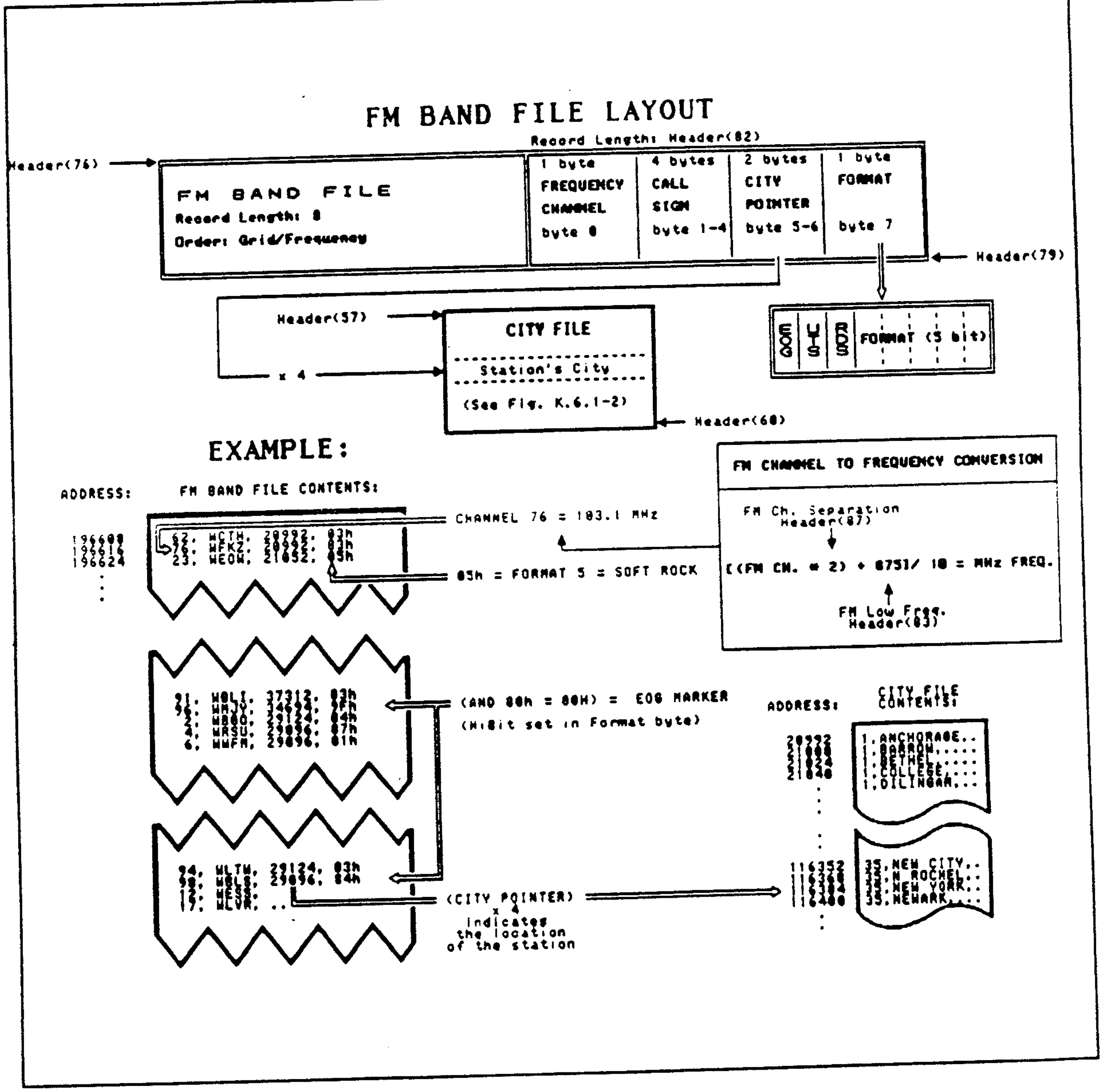


Figure K.8 - FM Band File layout

The FM Band File is ordered by ascending Grid number and by ascending frequencies within each Grid.

L.9 Map File Layout

Each record in the Map File is composed of only one field:

- The city pointer which references the largest city in the Grid.

In some instances (e.g., in a desert, mountain, lake, etc.) there is no city in a Grid. In this case the record contains a <u>state counter</u> (as opposed to a city pointer) where the value is < 128.

A city pointer of zero (0) indicates an out-of-bound area (which should not be traveled to).

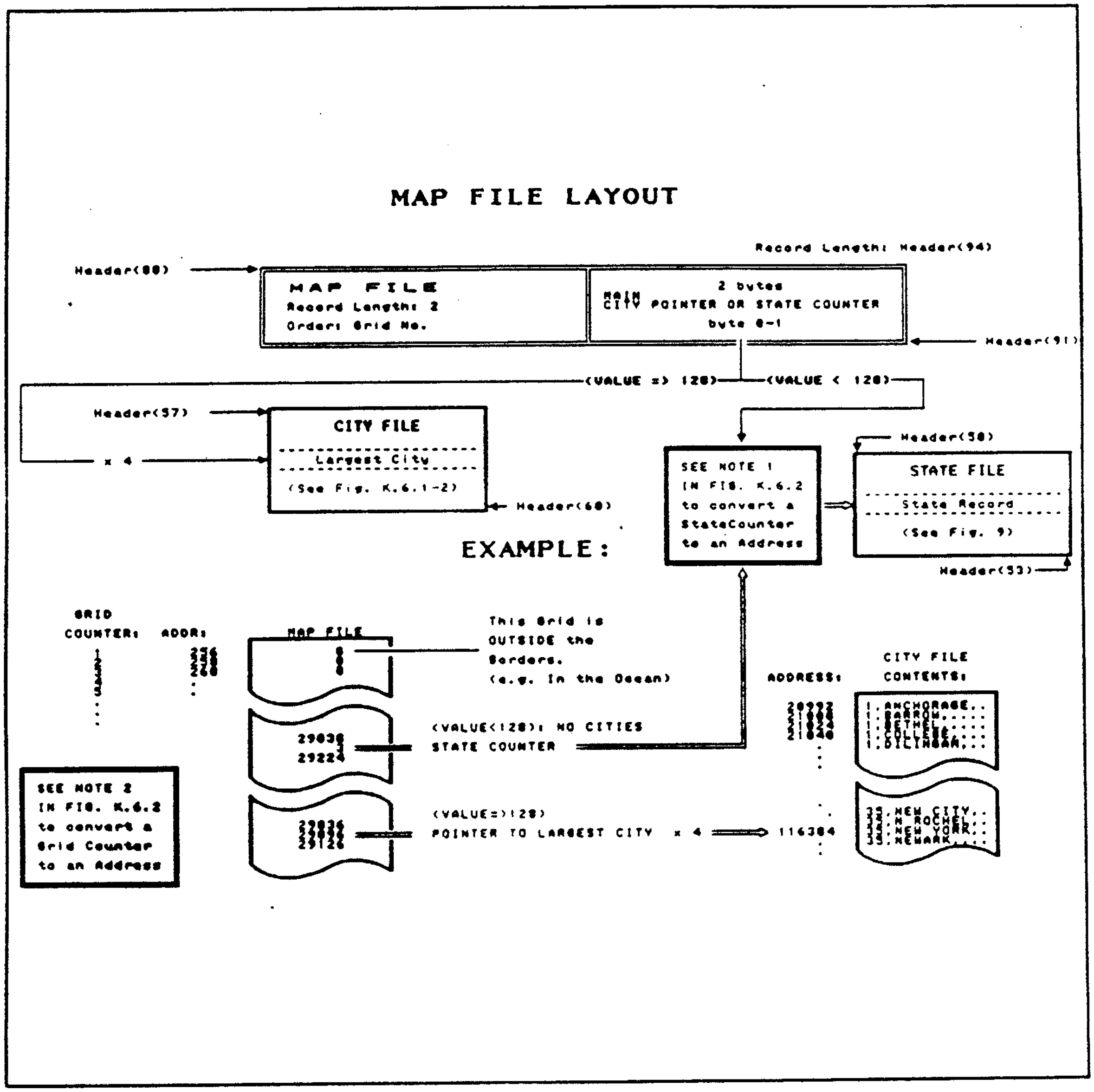


Figure L.9 Map file layout

Note: Remember to multiply all pointers (but <u>not counters</u>) by 4 to get an address.

L.10 Travel and Map File Calculations

The figure below illustrates the calculations needed to find the Grid number of the eight Grids that are contiguous to a particular location.

The value of the constant needed (L) is found in the Header File at address 98_{10}.

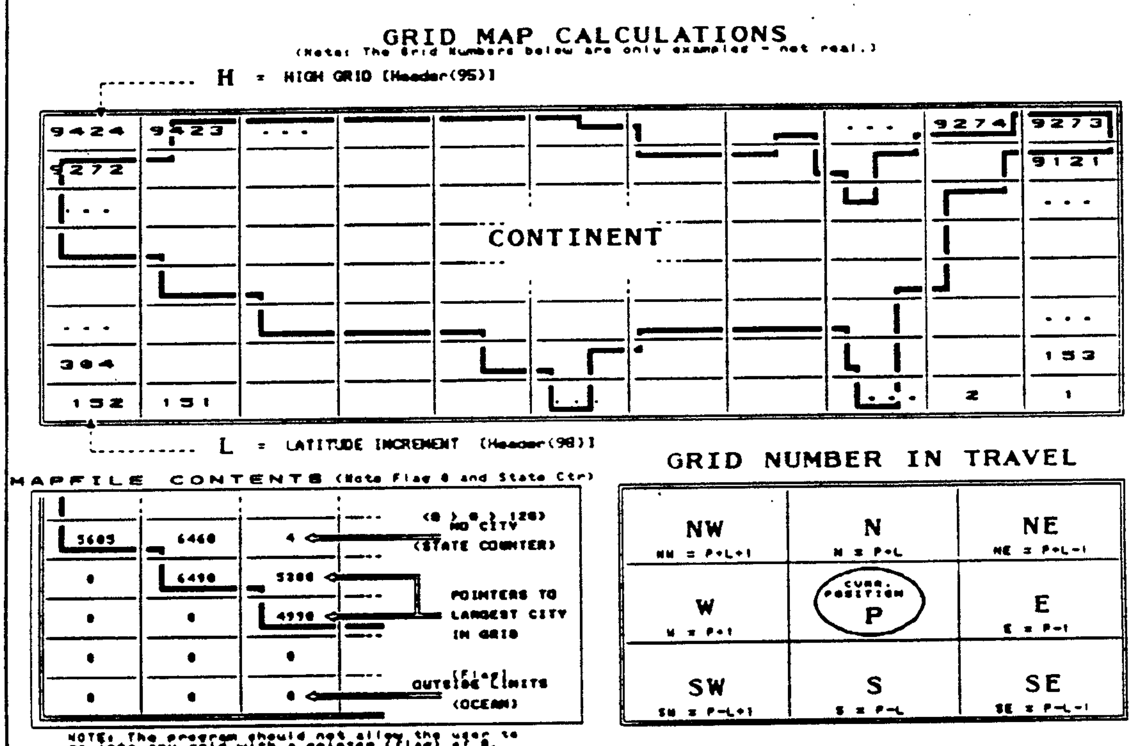


Figure L.10 Map file calculations

See section L.12.5 for application notes.

L.11 Format File Layout

Each record in the Format File is composed of three fields:

- The format number (0 - 31) which indexes a precise format
- The format name (eight ASCII characters)
- The format key (group) number which indexes the front panel fixed format keys.

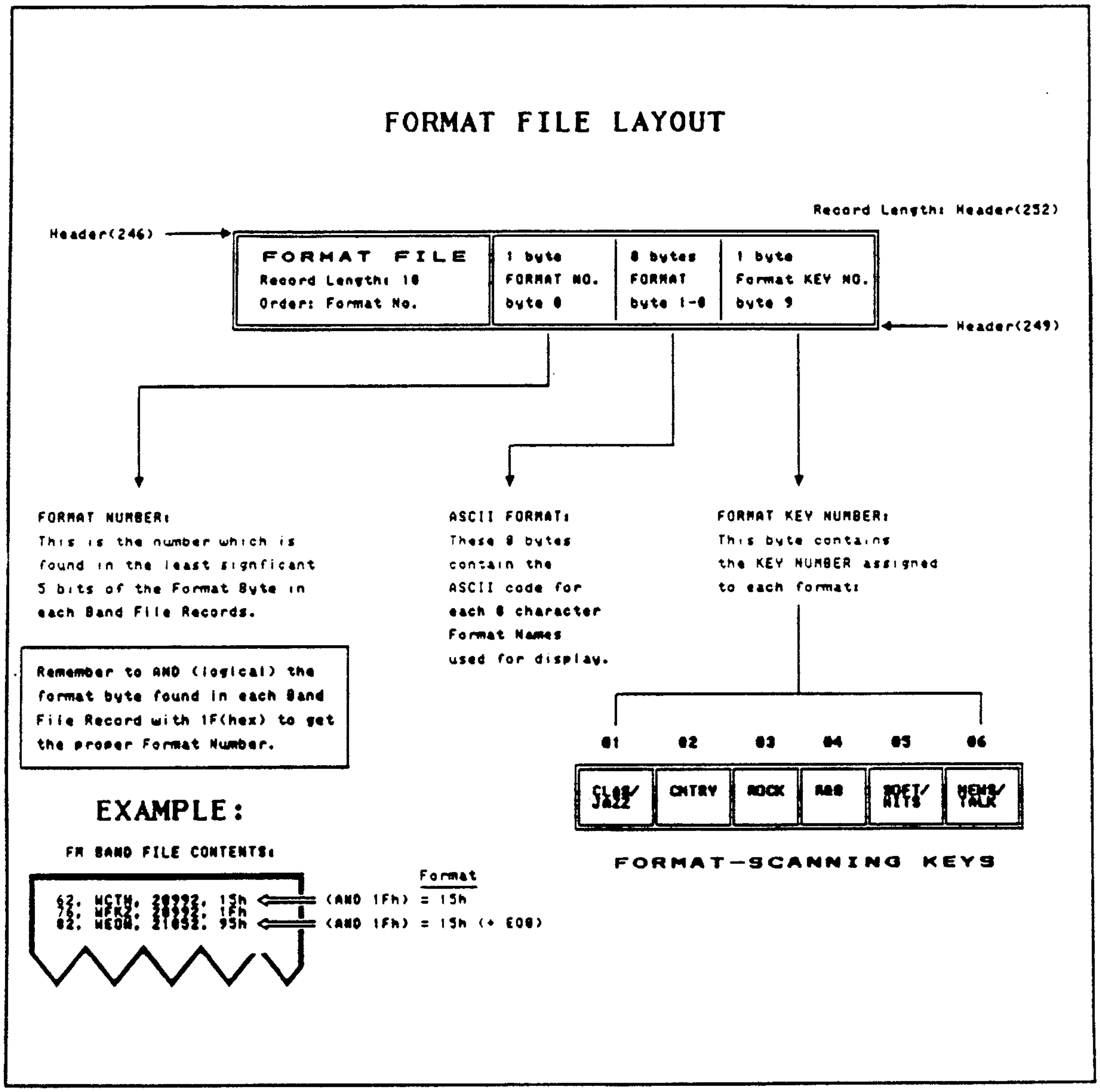


Figure L.11 Format file layout

See section L.12.6 for application notes.

L.12 Application Notes

L.12.1 Header File

L.12.1.1 Address: The Header File always starts at address 0 of the ROM. Its structure is fixed. (See Fig. L.1).

L.12.2 State File

L.12.2.1 Header references: The State File is referenced in the Header File as follows:

Address 50_{10} = State File start address
Address 53_{10} = State File end address
Address 56_{10} = State File record length

L.12.2.2 Order: The State File is ordered alphabetically by state abbreviation -- as opposed to the City File which is ordered alphabetically by city full name.

L.12.2.3 Count: In the current implementation of I-RDS, there are 61 states/provinces in the file:

50 U.S. states + the District of Columbia
10 Canadian provinces whose territories lie partly below 54 degree latitude
1 entry for Mexico
61

L.12.2.4 City pointer: Each city pointer in the State File points to the largest (most populated) city in the state or province referenced.

L.12.3 City File

L.12.3.1 Header references: The City File is referenced in the Header File as follows:

Address 57_{10} = City File start address
Address 60_{10} = City File end address
Address 63_{10} = City File record length

L.12.3.2 Band pointers: As can be seen in Fig. L.6.1, each City File record contains two band pointers (FM in bytes 11-12 and AM in bytes 13-14). These band pointers reference the first (lowest frequency) station in the Grid in which the city is located.

L.12.3.3 Null band pointer: If, for example, the FM pointer is equal to zero (0), this indicates the Grid does not contain any FM station. The same applies to AM pointers.

L.12.3.4 Filler cities: Some filler cities (cities with no AM or FM stations) may be added to the City File (and the Map File) to provide a meaningful feedback when a travel (compass) key is actuated. This is particularly needed when traveling through a sparsely populated region. If these cities are located in a Grid where no station exist, then both band pointers will be equal to zero.

L.12.4 Band File (AM and FM)

L.12.4.1 Header references: The Band Files are referenced in the Header File as follows:

Address 64_{10} = AM Band File start address
Address 67_{10} = AM Bnd File end address
Address 70_{10} = AM Band File record length
Address 71_{10} = AM lowest frequency (/1 kHz)
Address 73_{10} = AM highest frequency (/1 kHz)
Address 75_{10} = AM channel separation (/1 kHz)
Address 76_{10} = FM Band File start address
Address 79_{10} = FM Band File end address
Address 82_{10} = FM Band File record length
Address 83_{10} = FM lowest frequency (/100 kHz)
Address 85_{10} = FM highest frequency (/100 kHz)
Address 87_{10} = FM channel separation (/100 kHz)

L.12.4.2 Order: The Band Files contain the list of all stations in the continent. They are placed in ascending Grid order and, within each Grid, ordered by ascending frequency.

L.12.4.3 End-of-Grid flag (EOG): Each record of the City File provides a pointer to each Band File. This pointer references the first station (lowest frequency), in each Grid, in its respective Band File. An end-of-grid flag (EOG) is provided in the high bit of the Format byte found in the Band Files record (On = EOG; Off = normal) of the last (highest frequency) station of each Grid.

Note: The EOG flag is needed as it is possible for two successive Grids to follow each other in which the first station in the second Grid is of a lower frequency than that of the last station in the first Grid.

L.12.4.4 RBDS Reserved bits:

- Bit 5 (RDS) of the Format byte is reserved to indicate the station is a participating RBDS station

- Bit 6 (UTS) of the Format byte is reserved to indicate the station is a participating RBDS station and that it is providing in-receiver database updates via Group 5A.

- There are another two bits available for RBDS flags. These are the high bits (bit 7) of byte 2 and 3 of the station's callsign. Bit 7 of byte 0 is reserved to indicate an off-the-air or erased status. Bit 7 of byte 1 is reserved for band indication (see sections L.13.3.3 and L.13.3.4).

Note: One application of these bits is to indicate that the station is a null station -- that is one which is currently not on the air. Another possible application is the indication that a station is part of an emergency network so that the receiver can tune to it immediately upon the reception of a signal or user prompting.

L.12.5 Map File

L.12.5.1 Header references: The State File is referenced in the Header File as follows:

Address 88_{10} = Map File start address
Address 91_{10} = Map File end address
Address 94_{10} = Map File record length
Address 95_{10} = Index of highest -- Northwesternmost -- Grid (H)
Address 98_{10} = Latitude Grid increment (L) -- South to North
Address 100_{10} = Number of Solitary Grids (see below).

L.12.5.2 Contents: As indicated in Fig. L.9, each record of the Map File can contain one of three types of information:

- A city pointer (referencing the largest city in the Grid)
- A state counter (indicating the Grid's state)
- A boundary flag (0).

L.12.5.3 State counter: A state counter is present if there is no city in that Grid. This is necessary to give a usable amount of feedback to the user even if he or she travels through a desert or mountainous region or other sparsely populated area. In that case and when the user crosses a state boundary that information can be conveyed on the display.

L.12.5.4 Boundary flag: The boundary flag is provided for two reasons:

- To forbid travel to off-limit areas (for example in the ocean)
- To avoid a mathematical wrap-around effect which would permit a user, for example, to travel East from, say, Georgia and arrive in California.

L.12.5.5 Solitary Grids: Some grids are special cases. These are called Solitary Grids and travel to and from such grids should not be permitted while using the travel (compass) keys.

Some of the areas covered by the in-receiver database lie well outside the continental U.S.A. (e.g., Alaska, Hawaii, Northern Canada). In order not to extend the grid system to cover such areas and make the Map File inordinately large, those areas have been assigned special status and have been placed in the first few Grids of the main grid system (as they are out of bounds -- in the ocean). These are:

- Grid 1 = Alaska
- Grid 2 = Hawaii
- Grid 3 = Newfoundland
- Grid 4 = Canadian areas above the 54th parallel.

The number and index of such Solitary Grids can be found in the Header File (see Fig. L.1) as follows:

Address 100_{10} = Number of Solitary Grids
Address 101_{10} = Solitary Grids No. 1
Address 104_{10} = Solitary Grids No. 2
Address 107_{10} = Etc.

Addresses 101_{10} to 245_{10} have been reserved in the Header File for the listing of such Solitary Grids.

L.12.5.6 Default Grid: At address 254_{10} of the Header File, one can find a Default Grid which indicates the location of Washington, DC.

Note: Upon installation, or upon software reset, the program can automatically relocate itself in the Default Grid.

L.12.6 Format File

L.12.6.1 Header references: The Format File is referenced in the Header File as follows:

Address 246_{10} = Format File start address
Address 249_{10} = Format File end address
Address 252_{10} = Format File record length
Address 253_{10} = Number of (detailed) formats

L.12.6.2 Contents: As indicated in Fig. L.11, each record of the Format File is formed of three fields:

- A (precise) format number
- An ASCII representation of the (precise) format -- for display
- A (group) format key number.

L.12.6.3 Precise Format: The precise format indicates one of 32 possibilities. I-RDS proposes to use formats identical to the RBDS program types (PTY) as defined in Appendix F.

L.12.6.4 Format Groups and Keys: Each precise format is assigned to a group which, in turn, is assigned to one of the receiver's front panel format scanning keys.

The current assignment is as follows:

Table L.12.6.4

1 - Classical / Jazz / Public	4 - Rhythm & Blues
2 - Country & Western	5 - Soft / Hits
3 - Rock	6 - News / Talk

L.13 - Update RAM Layout

The 2 kilobyte update RAM is divided into four main areas:

- The RAM Header File
- The Update Data File
- The New Station File
- The Preset Memory area and a General Purpose RAM area.

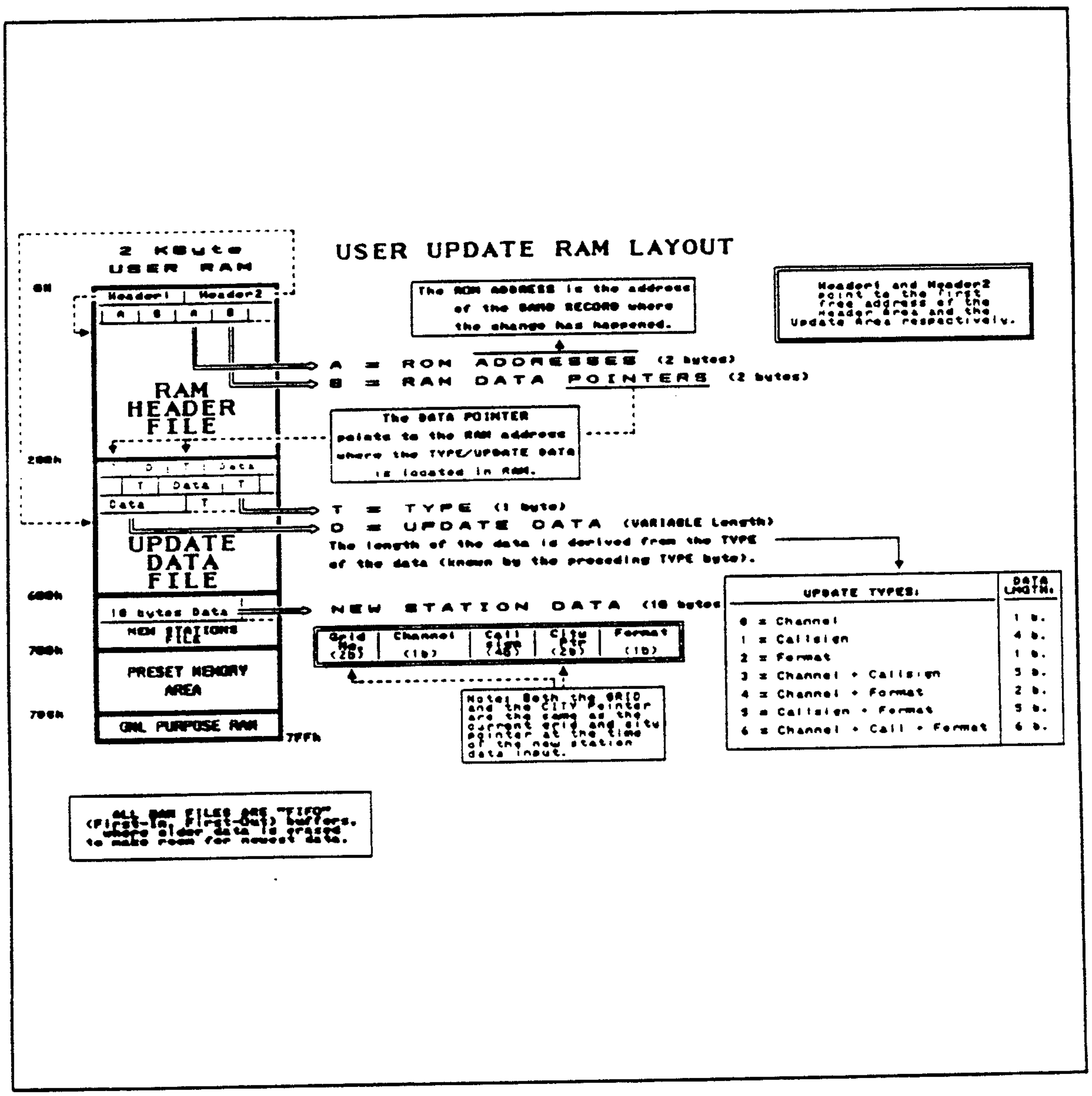


Figure L.13.1 - Update RAM layout

L.13.1 - RAM Header File

The RAM Header File contains four types of information:

- The Header1 (two bytes)
- The Header2 (two bytes)
- ROM pointers (two bytes each)
- RAM data pointers (two bytes each)

L.13.1.1 - Header1: This header points to the address of the first free byte in the RAM Header File.

L.13.1.2 - Header2: This header points to the address of the first free byte of the Update Data File.

Header1 and Header2 are provided to permit data entry by both the user (manually) and by the automatic downloading method via RDS group 5A.

L.13.1.3 - ROM pointers: These pointers reference the address in ROM which is occupied by the record to be updated. Remember to multiply these pointers by 4 (two bitwise shifts to the left) in order to get the actual ROM address as these pointers are stored in only two bytes.

The actual update data (in the RAM Update Data File) is referenced by the pointer immediately following the ROM pointer.

L.13.1.4 - RAM Data pointers: These pointers reference the address in the RAM Update Data File in which the update data is located. Each such pointer is immediately preceded by the ROM pointer (see L.13.1.3) referencing the address in ROM where the record to be updated is located.

The ROM pointers and the RAM Data pointers always form a pair.

L.13.2 - Update Data File

The Update Data File contains two types of information:

- The Update Data Type (1 byte)
- The Update Data (variable length).

L.13.2.1 - Stored Update Data Type (SUDT): Each update data is type-coded to indicate two things:

- The type of the update data
- The length of that update data.

The length of the data is derived from the SUDT.

The following table lists all possible Stored Update Data Types and their lengths:

STORED UPDATE DATA TYPE	DATA LENGTH (in byte)
0 = Channel	1
1 = Call sign	4
2 = Format	1
3 = Channel + Call sign	5
4 = Channel + Format	2
5 = Call sign + Format	5
6 = Channel + Call sign + Format	6

Table L.13.2 - Stored Update Data Types

L.13.2.3 - Housekeeping: When storing update data, both Header1 and Header2 (see L.13.1.1 and L.13.1.2) should be updated to reflect the address of the first free bytes in the RAM Header File and the Update Data File.

All RAM files are FIFO (first in, first out) buffers, where (if necessary) oldest data is erased to make room for newest data.

L.13.2.4 - Number of updates: The space reserved for each file in the RAM dictates the maximum number of updates which can be stored. With the recommended boundaries as shown in Fig. L.13.1, the maximum number of (non-new stations) updates possible is $[(27F_{hex} - 4)/4] = 158$.

Note: The Update Data File (from 280_{hex} to $5FF_{hex}$) can store 202 average entries or 127 maximum length entries (of 7 bytes each).

L.13.3 New Station File

The New Station File is composed of fixed-length records of 10 bytes each:

- Grid number (2 bytes)
- Channel (1 byte)
- Call sign (4 bytes)
- City pointer (2 bytes)
- Format (1 byte)

This file is provided to store the details of stations which come can on the air after ROM manufacture.

L.13.3.1 Header: The first byte of the New Station File is reserved to contain the number (N) of new station entries in the file. The address of the first free byte in the file can be calculated with:

$$Address = Start\_of\_file + 1 + 10*N$$

L.13.3.2 Grid number: This counter references the Grid in which the station is located.

Note: Although this information can be deduced from the City pointer (see section L.13.3.5 and Fig. L.6.1) it is provided to speed up RAM lookup when scanning for stations in a particular area.

L.13.3.3 Channel: The channel is converted to a frequency by using the formula in Fig. L.7 (for AM) or Fig. L.8 (for FM) depending on the high bit of byte 2 of the call sign. This bit is set (1) to indicate an FM station and reset (0) to indicate an AM station.

L.13.3.4 Call sign: The high bits (bit_7) of the four ASCII characters composing the call sign are used as follows:

High bit of byte 0:	0 = normal; 1 = off-the-air
High bit of byte 1:	0 = AM; 1 = FM
High bit of byte 2:	available (see section L.12.4.4)
High bit of byte 3:	available (see section L.12.4.4)

Note that the AM/FM flag (bit 7 of byte 1) is used only in the New Station File (in RAM) and is not necessary in the ROM band files since there the AM and FM stations are separated. However, to avoid confusion, this bit of byte 1 should not be used in the ROM.

L.13.3.5 City pointer: This references the city of license of the station. Remember to multiply this pointer by 4 to get a real ROM address.

L.13.3.6 Format: The format byte is identical to that described in Fig. L.11 and in section L.12.4.4.

- Bit 5 indicates the station is a participating RBDS station

- Bit 6 indicates the station is a participating RBDS station and that it is providing in-receiver database updates via Group 5A.

- Bit 7 of the format byte (EOG) is not used in the RAM.

L.13.3.7 Number of new stations: The space reserved for each file in the RAM dictate the maximum number of updates which can be stored. With the recommanded boundaries as shown in Fig. L.13.1, the maximum number of new station updates possible is ($6FF_{hex}$ - 601_{hex})/10 = 25.

L.13.3.8 Housekeeping: When storing update data, the header (see L.13.3.1) should be updated to reflect the address of the first free byte of the New Station File.

Note: All RAM files are FIFO (first in, first out) buffers, where (if necessary) oldest data is erased to make room for newest data.

L.13.4 - Other RAM areas

The RAM area starting at 700_{hex} and ending at $7FF_{hex}$ is available for other use such as the storage of presets, Update Transmission Header information (see section 4.7.3) and the like.

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