RECOMMENDATION ITU-R BS.643-2*,**

System for automatic tuning and other applications in FM radio receivers for use with the pilot-tone system

(1986-1990-1995)

The ITU Radiocommunication Assembly,

considering

a) that, in VHF/FM broadcasting, the density of transmissions in many parts of the world is increasing to the extent that tuning to a given programme service is becoming more and more difficult, particularly for listeners using FM portable or car radios;

b) that, on the other hand, new technologies offer the possibility of adding auxiliary data signals to the sound-programme signals which will offer a wide variety of methods for identifying the transmissions, thereby facilitating the implementation of assisted and automatic tuning in future radio receivers;

c) that such radio-data signals can be added to existing VHF/FM broadcasts in such a way that they are inaudible, thus achieving good compatibility with reception of the normal stereophonic or monophonic sound-programme signals;

d) that receiver technology is available to implement assisted or automatic tuning using radio-data signals, and that such technology can be inexpensive provided that it is mass-produced;

e) that such a system offers the flexibility to implement a wide range of optional applications to suit the particular needs of individual broadcasting organizations;

f) that most European Broadcasting Union (EBU) Member countries have colllaborated in the development of an internationally agreed standard for such a system;

g) that many countries have implemented this system on their broadcasts;

h) than an international standard is necessary to support mass-production of receivers using the system, thereby minimizing the cost of receivers to the consumer, and that an international standard is necessary also to permit receivers, especially FM portables and car radios, to be used abroad by travellers,

recommends

that broadcasters wishing to introduce the transmission of supplementary information for station and programme identification in FM broadcasting and other applications, should use the radio-data system (RDS), as specified in Annex 1.

NOTE 1 – Information regarding the operational characteristics of RDS is given in Annex 2.

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* This Recommendation should be brought to the attention of the International Electrotechnical Commission (IEC).

** Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2002 in accordance with Resolution ITU-R 44.

ANNEX 1

Specifications of the radio data system*

1 Modulation of the data channel

1.1 Sub-carrier frequency: 57 kHz, locked in phase or in quadrature to the third harmonic of the pilot tone 19 kHz (±2 Hz) in the case of stereophony. (Frequency tolerance: ±6 Hz.) If RDS is used simultaneously with the ARI traffic broadcast identification system (see Report ITU-R BS.463), the RDS sub-carrier will have a phase difference of 90° ± 10°, and the recommended nominal deviation of the main carrier will be ±1.2 kHz due to the RDS signal and ±3.5 kHz due to the unmodulated ARI sub-carrier.

1.2 Sub-carrier level: the recommended nominal deviation of the main FM carrier due to the modulated sub-carrier is ±2 kHz. The decoder should, however, be designed to work with sub-carrier levels corresponding to between ±1 kHz and ±7.5 kHz deviation.

1.3 Method of modulation: the sub-carrier is amplitude-modulated by the shaped and biphase-coded data signal. The sub-carrier is suppressed (see Figs. 1a) to 1c)).

1.4 Clock frequency and data rate: the basic clock frequency is obtained by dividing the transmitted sub-carrier frequency by 48. Consequently the basic data rate is 1 187.5 bit/s ± 0.125 bit/s.

1.5 Differential coding: when the input data-level from the coder at the transmitter 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.

2 Baseband coding

2.1 Coding structure: the largest element in the structure is called a "group" of 104 bits. Each group comprises 4 blocks of 26 bits. Each block comprises an information word and a checkword, of 16 and 10 bits respectively.

2.2 Order of bit transmission: all information words, checkwords and addresses have their most significant bit transmitted first.

2.3 Error protection: the 10-bit cyclic redundancy checkword, to which a 10-bit offset word is added for synchronization purposes, is intended to enable the receiver/decoder to detect and correct errors which occur in reception.

2.4 Synchronization of blocks and groups: the data transmission is fully synchronous and there are no gaps between the groups or blocks. The beginning and end of the data blocks may be recognized in the decoder by using the fact that the error-checking decoder will, with a high level of confidence, detect block synchronization slip. The blocks within each group are identified by different offset words added to the respective 10-bit checkwords.

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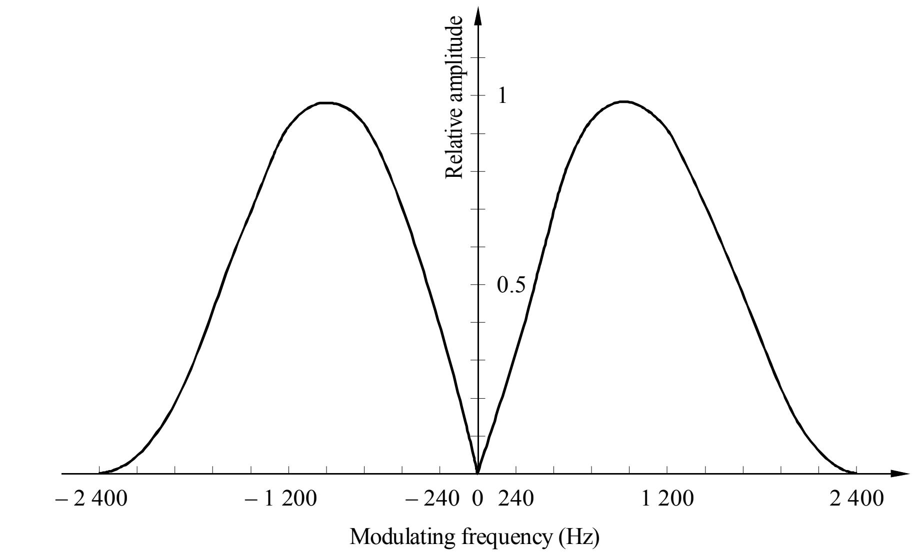
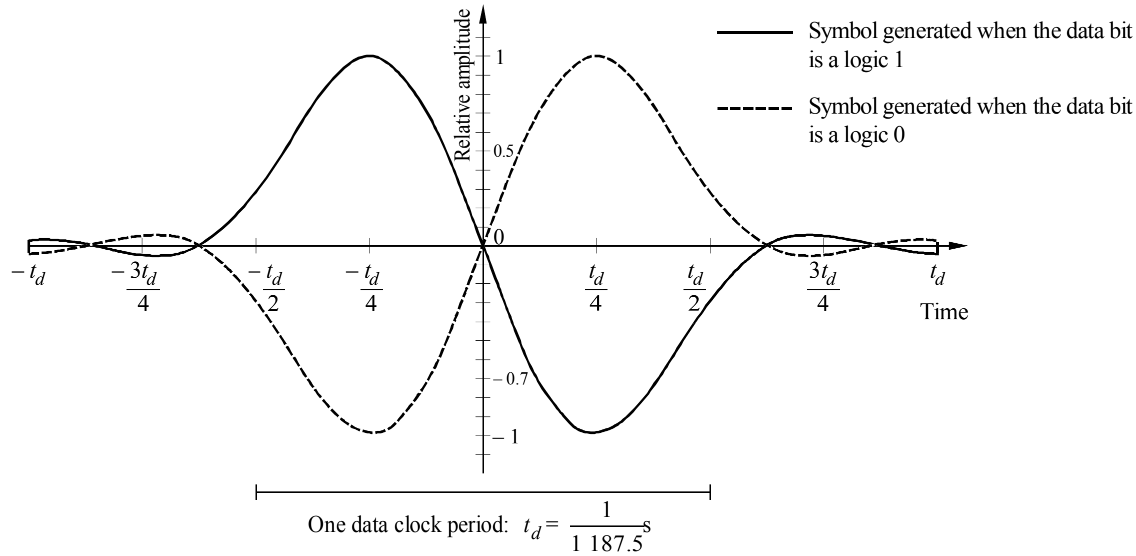
* The characteristics published here are only a summary drawn from a more detailed text which is published separately.

FIGURE 1

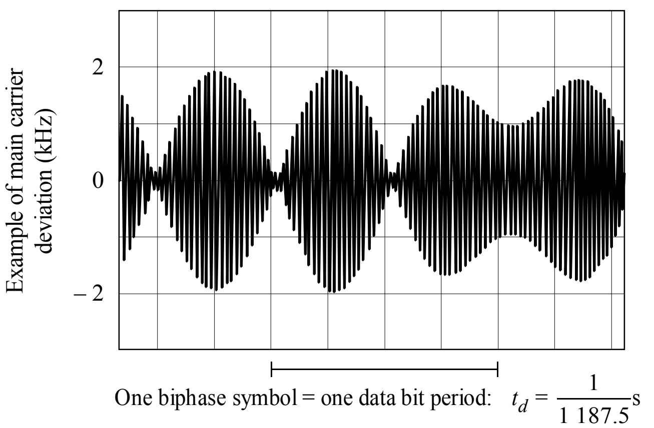
Spectrum and time-functions of RDS signals



a) Spectrum of biphase coded radio-data signals



b) Time-function of a single biphase symbol



c) 57 kHz radio-data signals

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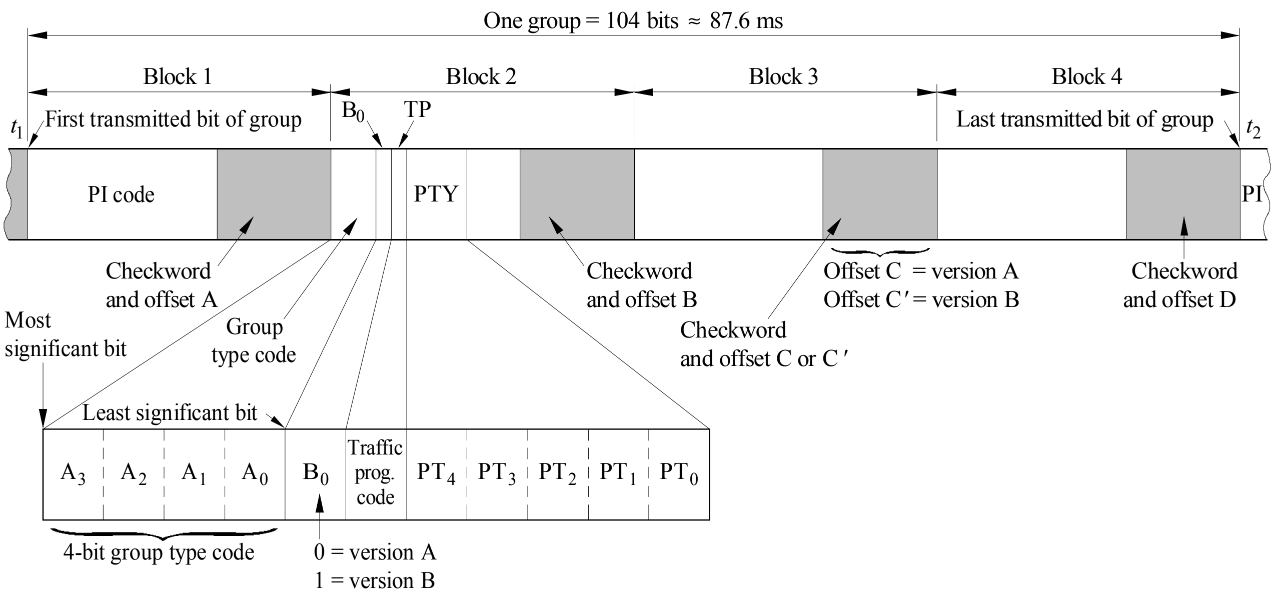
2.5 Message format: the first five bits of the second block of every group are allocated to a five-bit code which specifies the application of the group and its version. The group types specified are given in Table 1. There is also space left to add at a later stage applications yet to be defined.

A large part of the data-transmission capacity of the RDS system will be used for features relating to the automatic or assisted tuning functions of an FM receiver. Such messages are repeated frequently so that a short data-acquisition time for tuning or retuning may be achieved. Many of the relevant codes occupy fixed positions within every group. They can therefore be decoded without reference to any block outside the one which contains this information.

FIGURE 2

Message format and addressing



Note 1 – Group type code = 4 bits.

Note 2 – B_0 = version code = 1 bit.

Note 3 – PI code = programme identification code = 16 bits.

Note 4 – TP = traffic programme identification code = 1 bit.

Note 5 – PTY = programme type code = 5 bits.

Note 6 – Checkword + offset "N" = 10 bits added to provide error protection and block and group synchronisation information.

Note 7 – $t_1 < t_2$: block 1 of any particular group is transmitted first and block 4 last.

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TABLE 1

Group type codes

Group type						Applications
Decimal value	Binary code					
	A_3	A_2	A_1	A_0	B_0	
0	0	0	0	0	X [1]	Basic tuning and switching information
1	0	0	0	1	X	Programme item number
2	0	0	1	0	X	Radiotext
3	0	0	1	1	X	Application not yet defined
4	0	1	0	0	0	Clock-time and date
5	0	1	0	1	X	Transparent channels for text or other graphics (32 channels)
6	0	1	1	0	X	In-house applications
7	0	1	1	1	0	Radio paging
8-13						Applications not yet defined
14	1	1	1	0	X	Enhanced other networks information
15	1	1	1	1	1	Fast basic tuning and switching information

[1] X indicates that value may be “0” (version A) or “1” (version B).

Table 2 explains the abbreviations used and the features to which they are relevant.

TABLE 2

List of abbreviations and features

Tuning functions	Other functions
PI: Programme identification	TA: Traffic announcement identification
PS: Programme service name	DI: Decoder identification
AF: List of alternative frequencies	M/S: Music/speech switch
TP: Traffic programme identification	PIN: Programme item number
PTY: Programme type	RT: Radiotext
EON: Enhanced other networks information	TDC: Transparent data channel
	IH: In-house applications
	CT: Date and time
	RP: Radio paging

2.6 Repetition rates: Table 3 indicates the appropriate repetition rates for some of the main applications, when and if they are implemented by the broadcaster.

TABLE 3

Appropriate repetition rates

Applications	Group types which contain this information	Appropriate repetition rate per second
Programme identification (PI) code	All	11.4 [(1)]
Programme type (PTY) code	All	11.4 [(1)]
Traffic programme (TP) identification code	All	11.4 [(1)]
Programme service (PS) name	0A, 0B	1 [(2)]
Alternative frequency (AF) code pairs	0A	4 [(2)]
Traffic announcement (TA) code	0A, 0B, 15B	4
Decoder identification (DI) code	0A, 0B, 15B	1
Music/speech (M/S) code	0A, 0B, 15B	4
Radiotext (RT) message	2A, 2B	0,2 [(3)]
Enhanced Other Networks information (EON)	14A, 14B	Up to 2 [(4)]

(1) Valid codes for this item will normally be transmitted with at least this repetition rate whenever the transmitter carries a normal broadcast programme.

(2) A total of four 0A groups are required to transmit the entire PS name and therefore four 0A groups will be required per second. The repetition rate of group type 0A may be reduced if more capacity is needed for other applications. A minimum of two type 0A groups per second is necessary to ensure correct functioning of PS and AF features. It should be noted that in this case transmission of the complete PS will take 2 s. However, under typical reception conditions the introduction of errors will cause the receiver to take 4 s or more to acquire the PS name for display.

(3) A total of 16 type 2A groups are required to transmit a 64 character radiotext message and therefore 3.2 type 2A groups will be required per second. For certain character sets, the maximum number of transmitted characters may be lower than 64. For example, a Korean character is composed of a 2-byte character code.

(4) The maximum cycle time for the transmission of *all* data relating to *all* cross-referenced programme services shall be less than 2 min.

NOTE 1 – Some administrations outside of Region 1 still have some of these issues under study and require more time before they can accept this Recommendation.

ANNEX 2

Operational characteristics of the radio data system “RDS”

1 Compatibility with existing VHF/FM broadcasts

1.1 Compatibility with the pilot-tone stereophonic main programme

The frequency, level and method of modulation of the sub-carrier used to convey the data signals have been carefully chosen so as to avoid interference to reception of the main stereo or mono programme signals. Because of the extreme importance of these compatibility considerations, extensive and prolonged field-trials have been conducted in several countries. It has been found that over a wide variety of propagation conditions, and with a wide variety of receivers, good compatibility is achieved. However, in some locations where the received signals are affected by severe multipath propagation, interference to the main programme signal may occur. In such circumstances, however, even in the absence of RDS signals, the quality of the received programme signal is usually poor due to distortion.

1.2 Compatibility with existing auxiliary signals

The radio data system, RDS, is designed so that its signals do not interfere with the existing auxiliary signals used in some countries to identify broadcast information for motorists (the ARI system (see Report ITU-R BS.463)). This is achieved by shaping the transmitted spectrum of the RDS signals in such a way as to minimize overlap with the spectrum of the ARI signals. However, in those cases where the signals of both the RDS system and the ARI system are broadcast either simultaneously from the same transmitter or from different transmitters, the injection level of the RDS signal should be reduced so that the deviation of the main FM carrier due to the RDS signal is ±1.2 kHz; this has been found necessary to ensure the required compatibility with some types of ARI receiver. Simultaneously, the deviation of the main FM carrier due to the unmodulated ARI sub-carrier should be reduced to ±3.5 kHz. However, increases in deviation by the RDS signal may become possible in the future.

2 Reliability of reception of radio-data signals

When assessing the reliability of reception of radio-data signals it is important to divide the applications of the RDS system into two categories: those using short and frequently repeated messages, for example, automatic tuning functions; and those using longer messages which are repeated rarely, for example, radiotext (RT) messages.

In the case of field-strength limited reception conditions, as might be experienced in a fixed domestic installation, and with the recommended RDS injection level of ±2 kHz, adequately reliable reception of short messages is possible for an input e.m.f. to the receiver down to about 15 dBμV (from a 50 Ω source) whilst adequately reliable reception of the longer messages required an input e.m.f. of about 20 dBμV. It should be stressed that the values given above depend on the noise figure of the receiver which is typically about 7 dB. These input voltages correspond to bit error-ratio in the received signal before error correction of 1×10^{-2} and 1×10^{-4}, respectively. Under these field-strength limited conditions, the bit error-ratio in the received signal decreases exponentially with increasing receiver antenna input level. Furthermore, for RDS injection levels at the transmitter in the specified range ±1 kHz to ±7.5 kHz, the receiver antenna input signal level needed to attain a given error-ratio increases almost proportionally with decreasing injection level and *vice versa*. For example, decreasing the injection level from ±2 kHz to ±1 kHz increases the antenna input e.m.f. needed by an RDS receiver to attain a given bit error-ratio by 6 dB.

In determining the best level for the injected RDS signals, it was found that a compromise had to be found between compatibility with the main programme signals on the one hand and reliability of RDS signal reception on the other. Overall, the recommended RDS injection level corresponding to ±2 kHz deviation of the main FM carrier was found to give the best compromise over a wide range of reception conditions.

In the case of mobile reception in vehicles, multipath propagation is often found to be the dominant impairment to RDS signal reception. In order to obtain information about the performance of the RDS system under multipath limited reception conditions, extensive field trials were carried out in several countries.

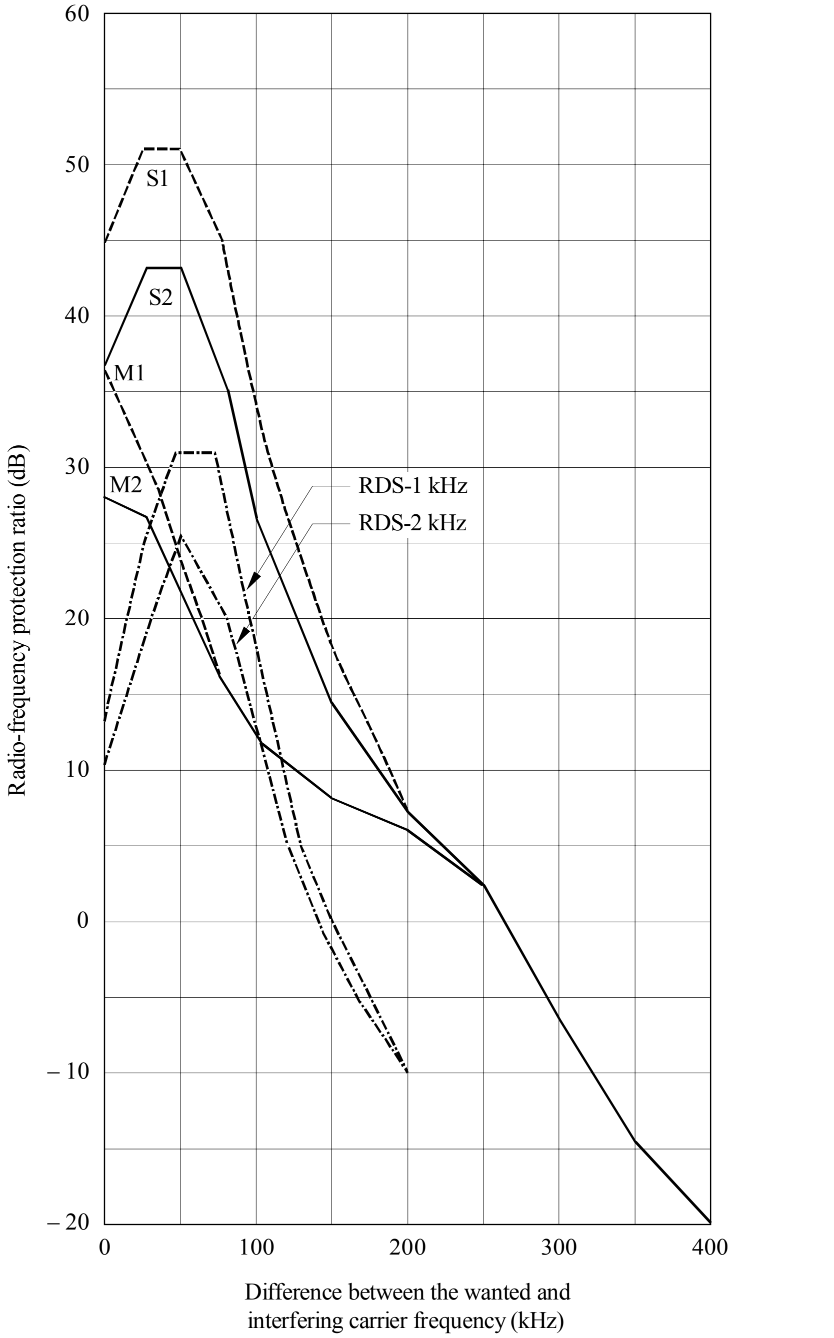
In these field trials, which were conducted on roads where reception of signals from the local broadcast transmitter was severely impaired by multipath propagation, it was found that the frequently repeated messages needed for the automatic tuning functions of RDS receivers could be reliably received even though the received programme signal was often severely impaired by distortion and noise. As in the case of field-strength limited reception conditions, reception reliability was found to improve with increasing RDS injection level at the transmitter. However, it was found that adequate performance was maintained down to the minimum injection level of ±1 kHz allowed by the specifications of the RDS system.

The RF protection ratio needed by the RDS system against interference from unwanted broadcast signals in the same or adjacent channels was determined by laboratory measurements using a procedure similar to that used to derive the protection ratios given in Recommendation ITU-R BS.412. The results of these measurements for steady interference are given in Fig. 3. It may be noted that for transmissions using the recommended channel spacing of 100 kHz, the protection ratio needed by the RDS system is much less than that needed for the stereo programme signal. Figure 3 shows that RDS protection ratios are close to those for monophonic programme signals; these can be improved, if desired, by using an increased level of RDS sub-carrier.

The existing protection ratios needed for the monophonic and stereophonic broadcasting services were found to be unaffected by the inclusion of an RDS sub-carrier in the interfering signal. This was found to be true for deviation of the main carrier, by the sub-carrier, of up to ±7.5 kHz.

FIGURE 3

Comparison of protection ratios for monophony and stereophony given in Recommendation ITU-R BS.412 with those measured for the radio-data system RDS



Curves M1: monophonic broadcasting, steady interference

M2: monophonic broadcasting, tropospheric interference

S1: stereophonic broadcasting, steady interference

S2: stereophonic broadcasting, tropospheric interference

RDS-1 kHz: radio-data transmission at ± 1 kHz deviation, steady interference, bit-error rate 1×10^{-3}

RDS-2 kHz: radio-data transmission at ± 2 kHz deviation, steady interference, bit-error rate 1×10^{-3}