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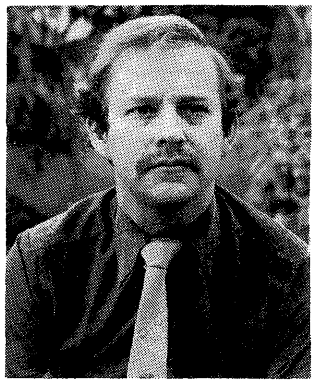

M. Saunders

Design considerations for the RDS car receiver

In the light of several years' operational experience of RDS on the BBC national, regional and local radio services, and discussions he has held with receiver manufacturers, the author presents a personal, but probably widely-shared, view regarding the desired response of RDS car receivers as they interpret RDS data.

The responses are appropriate to all normal conditions and to all countries where RDS has been implemented. They should be regarded as forming the basic minimum requirements for any receiver bearing the RDS logo, and manufacturers should be able to use their ingenuity to enhance their products further, once these basic requirements have been satisfied. As an example of such improvements, superior performance of many aspects of RDS can be achieved by exploiting the Enhanced Other Networks (EON) feature of RDS, which is already transmitted by some EBU Member-organizations; such performance nonetheless goes some way beyond the "bottom-line" requirements, essential for all RDS car receiver products, which are discussed here.*

1. Introduction

One of the problems that the Radio Data System poses for both the broadcaster and the receiver manufacturer is that, with the exception of obvious features such as the display of the Programme Service name, an RDS receiver is not apparently different in peformance, or looks, when observed in the static environment of the dealer's show-room.

From the point of view of the consumer, there are few tests they can do, prior to purchase, to ascertain how well a product will perform when fitted into their car. It is a sad fact that many early RDS receivers failed to perform even the basic tasks adequately, and many people may have been put off RDS for life, because of their experiences with RDS receivers that performed inadequately and which failed to live up to the promises which the broadcasters made for them.

The broadcasters are not, of course, entirely blameless in this respect; more should no doubt have been done at at an earlier stage in the development of RDS to give the receiver manufacturing industry some guidelines setting out the minimum levels of RDS performance that should be achieved.

This is not to suggest that the broadcasters should necessarily tell the receiver designers how their products should work, but it is clear that more can usefully be done to provide guidance to industry about what should happen under certain circumstances.

The article deals in turn with the four most basic features of RDS: auto-tuning, network-following, traffic information and programme-service display. Clock time, which is included in many receivers (especially those from the Far East countries), is also considered.

2. Tuning functions

One of the problems with VHF broadcasting is that, by its nature, the range of transmission is limited, particularly in relation to LF and MF services which are also provided by broadcasters.

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Even in a relatively small country such as the United Kingdom, almost 200 transmitters are used to obtain full national coverage of each main VHF/FM programme service. Several different frequencies need to be used. In other countries, and more especially in those with mountainous terrain, the problems are even more pronounced. The task of deciding — or guessing — which frequency should be used to receive a selected programme when in an unfamiliar location, is often daunting.

The fundamental feature of RDS is the Programme Identification (PI) code which is unique to each different Programme Service. Even if an RDS receiver can do nothing else, it should at least be able to search the VHF/FM band for a specific PI code, when the listener presses a memory button on the receiver which has been preset for that code.

Surprisingly, a very large number of early RDS receivers (and some more-recent models as well) fail in the fundamental task of storing the PI code and then using it to find the listener's choice of programme service when he pushes the preset button in an area different to that in which the required Programme Service was originally preset on the receiver.

2.1. Use of the preset memory PI and frequency stores: receiver requirements

2.2.1. General

When the listener stores his choice of transmission in one of the preset memory locations, the PI code must be stored together with the frequency to which the receiver is tuned at that time (the "current" frequency). At any time afterwards, when the listener presses the same preset button, the receiver should instantly begin to search for a transmitter which is broadcasting the same PI code as that which is held in the corresponding memory location. It will thus find the programme service corresponding to the listener's choice, regardless of the distance that has been travelled since the preset button was last programmed.

While the receiver is searching for the code, it is preferable if it informs the listener of its actions by displaying an indication such as "SEARCH", "SEEKING", etc. This will give the listener confidence that the receiver is attempting to find the Programme Service he has chosen.

Once the receiver has successfully found a frequency which is transmitting the desired PI code, the new frequency must "over-write" the frequency that was previously stored in the preset memory location. In this way the receiver keeps an accurate record of the *last-known optimum frequency* associated with each memory button. The advantage is that if the listener selects a different Programme Service for a brief period (for example, to listen to the news headlines, known to be carried on another service), and he then returns to the original programme when the headlines have finished, the receiver will go instantly to the last-known optimum frequency; otherwise it would have to go to the frequency that was stored originally and then, unnecessarily, begin a fresh search for the wanted PI code.

2.1.2. Generically-related PI codes

There are of course circumstances in which the Programme Service allocated by the listener to a particular preset button will not be available across the whole of the country. This will occur, in particular, when the Programme Service is that of a local or regional station. Although the same Programme Service may not be available in another area, such services are nevertheless quite often part of a larger "family" of services. They must not carry the *same* PI code (which must be unique to each service), but it is desirable for the broadcaster to use PI codes for services in such "families" which are linked generically one to the other. All PI codes have 16 bits, allowing a unique code to be attributed to every *unrelated* service; in the PI codes of each of a set of generically related services, bits 1 to 4 and 9 to 16 are identical, whilst bits 5 to 8 may differ.

If a motorist has travelled so far since presetting his receiver that the original regional programme is no longer available, the receiver should accept as a substitute a different regional programme which belongs to the same "family" as the original. In other words, when the listener selects a preset Programme Service and the receiver is unable to find a transmission carrying the same PI code as the one stored when it was preset, the receiver may accept a related code as "next best".

The receiver may give the listener the option of enabling/disabling the acceptance of a related code, although this is not strictly necessary. In effect, the receiver should first make every effort to find an *exact* PI code match before resorting to a *related* match. The fact that the receiver has accepted a related match should in itself constitute a guarantee to the listener that his first choice of service really is unavailable in this area (or at this time).

It may be estimated that if this simple strategy had been adopted systematically from the start of RDS receiver design, and if the importance of PI storage and searching had been recognised, the majority of complaints about the performance of early RDS receivers would have been avoided.

2.2. Improving search times

2.2.1. General

In areas where a large number of stations transmitting RDS are on-air, the PI search is slow. The listener will therefore suffer from long periods of audio muting while the receiver is searching. The PI search is nevertheless the most certain way of finding the required service (if available), and this *must* be the "fall-back" mode of operation if other, faster, methods fail for any reason.

The broadcasters in fact adopt a strategy involving the Alternative Frequency (AF) List, which reduces the need to use a PI search. Alternative Frequency lists can be transmitted not only for the currently-tuned Programme Service, but also, using the Enhanced Other Networks (EON)* feature for all other services in the area.

2.2.2. *Network-following — use of Alternative Frequency lists*

The principle of the Alternative Frequency list, as a means of avoiding PI code searches and the accompanying long periods of audio muting, is that the broadcaster provides a "short-list" of frequencies, relevant to the area, on which the same Programme Service is (or may be) carried. The receiver therefore does not have to check all the frequencies in the FM band. To optimise the benefits of the method, the broadcaster should do everything possible to ensure that the AF lists are as short as possible, so that the receiver does not waste time, and memory, checking frequencies that are unlikely to be appropriate in the area.

As a result of the frequency plan in a given country (or, in some cases, because of the absence of a plan!), it is possible for some of the frequencies in the AF list to carry a programme which is not the same as that to which the receiver is currently tuned. This may also happen in the presence of illegal transmissions. It must therefore not be assumed that *all* frequencies in the AF list will in fact be carrying the same Programme Service as the tuned frequency, and before accepting any Alternative Frequency as a substitute tuned frequency the receiver must check that the PI code on the new frequency matches that of the current transmission. If there is a mis-match, or if the transmission on the Alternative Frequency is not carrying any RDS data, then that AF must be rejected.

When a suitable AF has been found, the PI has been checked and the receiver has re-tuned, the new

* See p. 4 of this issue.

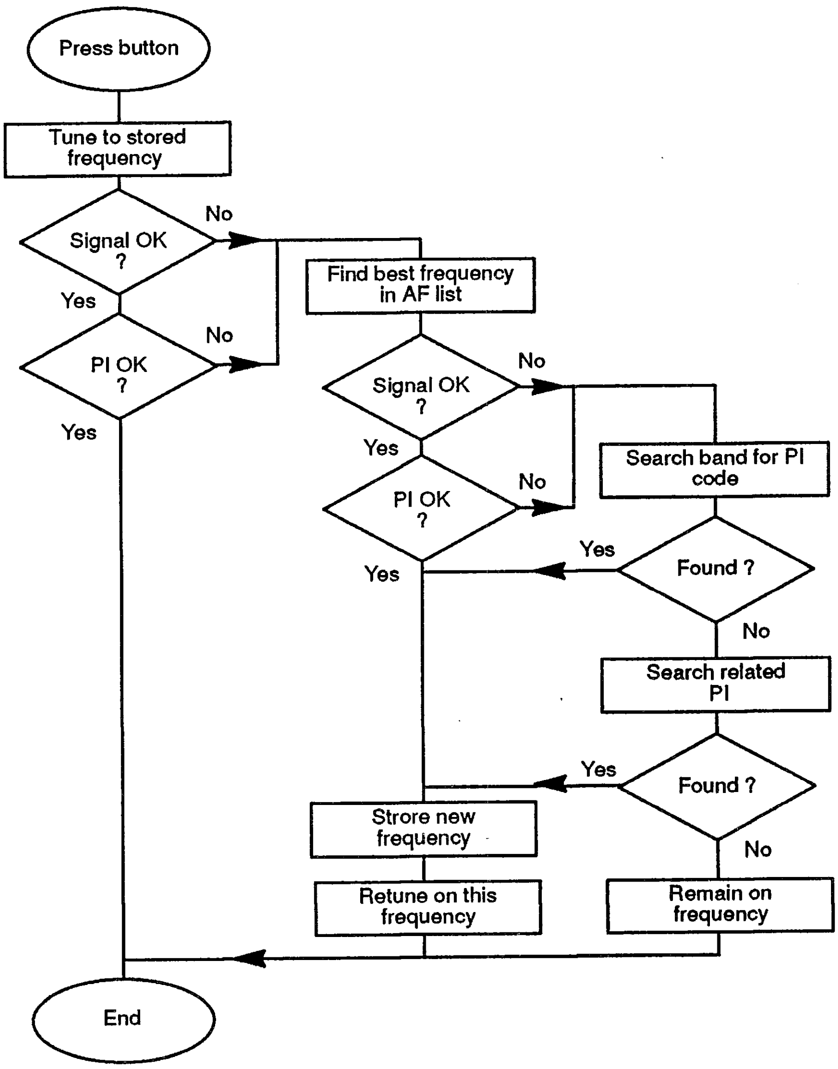

Fig. 1
Basic flowchart to be adopted when a receiver pre-set memory is selected.

frequency must "over-write" the stored frequency associated with the preset button (as when using a PI search) so that the receiver keeps an accurate record of the last-known optimum frequency associated with each Programme Service preset.

The PI code search and the AF list evaluation can be combined to establish an unambiguous routine which should be used by receivers to ensure that the listener always receives the Programme Service of his choice when pressing a preset button on his receiver. The routine has five steps which are illustrated in the flow-chart given in *Fig. 1*:

a) Tune to the last-known optimum frequency associated with that preset and check the signal quality and for correct PI code;
b) Test each frequency in the AF list (if provided) associated with the preset button, to find a transmission carrying the required PI code; if unsuccessful:
c) Begin a PI code search for a transmitter transmitting an exactly-matching PI code; if unsuccessful:
d) Search for a related PI code; if unsuccessful:
e) Return to the tuned frequency.

2.3. Modifications to received RDS information

It is possible for a receiver to become aware of a significant change in the received data signals while it is tuned to a frequency. The two principal causes are the almost complete loss of the RF signal at the currently-tuned frequency and a change in the PI code associated with this frequency.

2.3.1. Loss of RF signal

If the RF signal on the currently-tuned frequency disappears — for example, when the receiver is driven into a tunnel — the receiver should remain on the tuned frequency; it should not begin a PI search.

If it did begin such a search, the receiver would probably still be searching when the receiver emerged from the tunnel and this would unnecessarily extend the period during which the receiver was muted.

It would nonetheless be appropriate in such circumtances if the receiver were to test the stored AF list, just in case the programme was still available, inside the tunnel, on a different frequency.

2.3.2. Changes in received PI code

In some countries it is possible for the received PI code on the currently-tuned frequency to change, even though the RF signal remains strong. This might occur, for example, if the receiver is driven through a mountain tunnel and the same frequency is used to carry different programmes on either side. The original service might still be available in the new area, but on a different frequency.

In this situation, regardless of the signal level, a receiver which discovers that the PI code no longer corresponds to that which had been selected previously should act as if the listener had re-selected the same preset button. The procedure should therefore be as follows:

a) Test the frequencies in the AF list in an attempt to find a transmission with the required PI code; if unsuccessful:
b) Begin a PI code search for a transmitter transmitting an exactly-matching PI code; if unsuccessful:
c) Search for a related PI code match; if unsuccessful:
d) Return to the tuned frequency.

It should be noted that although the PI code on the tuned frequency has changed, there are no circumstances in which an unrelated PI code should "over-write" a PI code stored in a preset memory. If this were done, the listener's wanted preset listening choices whould be destroyed.

3. Traffic news features

The Traffic Announcement (TA) features of RDS are regarded as being very important in most, if not all, of the countries where there are EBU Members. In those countries where an ARI* service has not been offered, in particular, RDS traffic information is a new and important feature which needs to be marketed and promoted to the listening public.

3.1. Selection of traffic services

The RDS Traffic Programme (TP) code is set to logic "1" to identify stations which provide regular bulletins of traffic information and are equipped to initiate the corresponding switching of RDS receivers.

A second RDS code — Traffic Announcement (TA) — is set to logic "1" for the duration of each traffic announcement.

Receivers which are not equipped for the Enhanced Other Networks (EON) feature usually have a facility permitting the identification and selection of TP stations only. These receivers also allow the listener to reduce the volume of the receiver, or to listen to the tape cassette or CD player, until a Traffic Announcement is broadcast.

When it is in TP mode, a receiver without EON should search for, and stop at, only transmitters whose TP flag is set to logic "1".

ARI: Autofahrer Rundfunk Information (Broadcast information for motorists). The ARI system is specified in CENELEC document EN 50067, Annex H.

When a transmitter has both TP and TA set to logic "1", the sound volume should increase to a level at which the Traffic Announcement will be clearly audible in normal driving and in-car listening conditions. It is preferable if this listening level can be set by the driver. If the driver has selected tape cassete or CD listening mode, the tape or disc should be set to "pause" and the receiver should switch to "radio" mode allowing the announcement to be heard. When the TA flag is restored to logic "0" at the end of the announcement, the receiver should revert to the original mode and settings.

It is important to ensure that the interruption of the tape or CD player, and the increase in volume, occur only when *both* TA *and* TP are set to logic "1". This is to avoid erroneous operation of receivers in countries which have introduced the EON feature where the combination of TP = "0" and TA = "1" is valid for transmitters which cross-reference Traffic Programmes.

The listener should be able to disable the Traffic Announcement feature when not required, other than by re-tuning to a transmitter which has the TP flag set to logic "0".

Finally, receivers which respond to the traffic features of both RDS and the ARI system must process the SK/DK* signals of ARI separately; the SK and DK signals can be used in a manner corresponding to the TP and TA codes of RDS, respectively. In Germany, Austria, Luxembourg and Switzerland ARI transmissions are being continued only because of the large number of car radios in use which have ARI decoders. ARI will gradually be replaced by RDS, and ARI transmissions may be expected to cease in about fifteen years' time.

3.2. Receiver response if the TP flag is lost

If the receiver is in TP listening mode and the TP flag on the currently-tuned service changes from logic "1" to "0", the receiver should inform the driver that the service to which it is tuned is no longer able to deliver travel news. This warning could take the form of either:

a) an audible "bleep" which informs the driver of the need to re-tune to another station carrying TP if he still requires traffic information; or:

b) automatic re-tuning to another TP transmitter.

The change from TP = logic "1" to "0" may cause different responses according to whether the driver is listening to the radio or the tape cassette/CD player at the time of the change. A sensible implementation would be to "bleep" in normal radio mode but to "re-tune" if in cassette/CD mode, or if in radio mode but with the volume muted.

If he is listening to the radio, the driver will find it particularly annoying if the receiver automatically re-tunes for no other reason than the loss of the TP flag. This might occur in the conditions described earlier when the vehicle enters a tunnel where no signal is available. The driver will expect to continue listening to the same Programme Service when emerging from the tunnel a few moments later. If the receiver "bleeps" on loss of the TP flag in this situation, the driver is warned that the traffic information is no longer available and can choose freely either to cancel TP mode if he wishes to hear the remainder of the radio programme or to initiate a search for a new TP flag, by pressing the search button, if he considers that traffic information is more important than the service to which he is currently tuned.

4. Programme Service identification

RDS transmissions include a code which serves to display eight alpha-numeric characters to identify the name of the Programme Service (PS code).

The RDS specification [1] allows broadcasters to transmit upper and lower-case letters, numerals and punctuation. The characters are sent two at a time, so the complete PS name is transmitted in four data groups of type 0A.

The receiver is expected to display the name of the Programme Service correctly, with each character occupying the correct position. It is recognised that some display units cannot reproduce the entire character set defined in the RDS specification, but manufacturers should ensure maximum legibility of the PS name, in particularby:

a) ensuring clarity of the display under diverse lighting conditions;

b) using a character set which is as complete as possible. A minimum requirement would be upper-case A to Z, numerals 0 to 9, and five more-common punctuation marks: ',-./

5. Clock time and date feature

Many broadcasters include accurate clock time and date (Clock Time — CT) information in their RDS services. The data for this feature is transmitted once every minute in a standardized format which enables calculation of the year/month/date as well as the time.

The time reference is based on Universal Coordinated Time (UTC), with a "Local Offset", in

* S: Senderkennung — traffic programme identification achieved by the presence of the 57-kHz ARI subcarrier.
DK: Durchsagekennung — traffic announcement identification achieved by modulation of the 57-kHz subcarrier at 125 Hz.

half-hour increments, to correct for different times zones and daylight saving schemes.

Receivers should not rely exclusively on reception of the CT data for the display of clock and date information. The receiver should have its own free-running clock which uses the CT data to set, and then continuously to correct, the displayed time.

If the receiver relied only on the reception of CT to maintain time accuracy the clock will stop if the receiver is tuned to a transmitter which is not transmitting CT or if it is switched off (for example, while parked). In such circumstances the clock will not show the current time but, instead, the time at which the receiver was last tuned to a station carrying CT!

It cannot be assumed that all RDS information will be accurately received at all times and, in areas of multipath reception, it is likely that several minutes may elapse between successive occurrences of successful reception and decoding of the 4A groups carrying the CT data. An intelligent receiver may be expected to assess the likelihood of the CT data being correct, and to warn the driver (for example by flashing, or suppressing, the time display) if the clock is probably showing the incorrect time.

6. General considerations

The performance of an RDS car receiver may be enhanced further if attention is paid to the following points.

It is preferable if the RF tuner and RDS processing stages of the receiver are continuously active whenever the vehicle ignition is switched on. The on/off switch on the receiver front panel should only control the power amplifiers and display functions. The advantage of powering the receiver all the time while the vehicle is moving is that, even though the driver is not listening to the receiver, it is continuously being up-dated by RDS data, in the same way as if he is listening to the cassette/CD player. If the vehicle has an electrically-powered antenna, arrangements should be made to ensure that it is raised whenever the vehicle is moving (with an over-ride switch allowing the driver to avoid damage when entering a garage or car-park).

* * *

Bibliographical reference

[1] **Specifications of the radio data system RDS for VHF/FM sound broadcasting.**
EBU document Tech. 3244, March 1984.