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Radio Data System (RDS)

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Fujitsu Ten and the Toyota Motor Corporation have developed a radio cassette player incorporating a radio data system (RDS) and began marketing it in Europe in January 1991.
FM radio broadcasts are quite popular in Europe, and most major cities can boast at least 20 FM stations. Many studies are being carried out in Europe on the multiplexing of FM channel frequencies, and Germany has put its ARI system in operation.
The European Broadcasting Union (EBU) completed preparation of the RDS system in April 1984, and submitted it to the International Radio Consultative Committee (CCIR). The system was adopted as a recommendation in June 1986.
RDS broadcasts began in Sweden in April 1987, after which other European countries followed in promoting the system. Most major stations in each country have adopted RDS.
Fujitsu Ten has released a multi-functional RDS receiver which makes use of much more RDS data and incorporates a network follow feature which is insensitive to noise due to multipath. This paper describes the features of the receiver and its main technological aspects.

1. Introduction

The Radio Data System (RDS) is a data broadcasting system which uses available FM broadcast channels to provide information services offering a variety of data suitable for radio reception, traffic information, and other radio text information.

The main users of the radio spectrum in Europe are FM stations, which combine with public or private networks to broadcast the same program to all parts of a country. On Germany's Autobahns, the extensive intranational network of speed-limitless super highways, traveling at a speed of 200 km/h means that radio reception changes dramatically within 15 minutes. In Switzerland, radio reception on the roads winding through the valleys of the Alps alters by the minute. The Norwegian fjords pose similar difficulties to radio reception. Reception difficulties such as these make RDS extremely valuable to European radio stations.

Two of the most useful RDS services are the Alternative Frequency (AF) List and Program Identification (PI) Code. These services support network follow (NF), a feature which allows a radio to automatically switch to and track other station concurrently broadcasting the same program. Using the Program Type (PTY) code greatly enhances FM receiver functionality. For example, a single button is required for automatic tuning to a station broadcasting the desired program. Figure 1 shows the concept of the network follow feature, which works in response to signal strength.

2. Overview of the RDS system

This chapter explains the principle and structure of the RDS transmission system.

2.1 RDS codes and functions

In the RDS, a subcarrier is first modulated by digital data carrying a wide range of program material and then transmitted. The receiver decodes this data and allows the desired material to be selected. This form of operation has enabled the receiver to incorporate complicated functions which were previously unavailable. Table 1 lists the code names and corresponding functions.

Each broadcast station can also produce its own programs through selective transmission from among the functions and services offered. Most European countries have set up their own networks which cover the country entirely and utilization of the data is not so much distinguished by station as by country. Table 2 lists the extent of application of the data. Since the RDS now offers a wide range of services, the number of stations and countries adopting the system is increasing rapidly. Table 2 also indicates plans to adopt the system and shows the RDS logos.

2.2 Structure of RDS data

Figure 2 illustrates the structure of RDS data. RDS data is comprised of groups, each containing 104 bits. Each group is divided into four blocks of 26 bits each. Of the 26 bits, 16 are RDS information and the remaining 10 bits serve as a verification word. The verification word detects and corrects any errors which occur during transmission of data and identifies the start of each group (block), since the groups are transmitted without gaps and without special boundary signals.

The group type and block structure, that is, which code is carried by which bit, are predetermined. For instance, the first block always contains the PI code and the second block always contains the group type. Hence, the receiver reads this and determines how the third and fourth blocks are to be processed.

Because only limited information can be sent in one group, lengthy information such as the AF list and Program Service (PS) name is spread over several groups for transmission. For example, the PS name is assigned to the fourth block, so only two characters (16 bits: two 8-bit characters) can be sent in one group. Therefore, four groups are required to transmit an eight character PS name. If one character cannot be received due to noise, the receiver must wait for all four groups to arrive. Transmission of each group takes about 90 ms, so the correct PS name can be sent within one second even if one cycle is lost. However, transmission of large quantities of information such as the AF list and radio text takes several seconds, so loss of even one cycle can be annoying to the user. The gist of design is therefore how quickly and accurately data can be received.

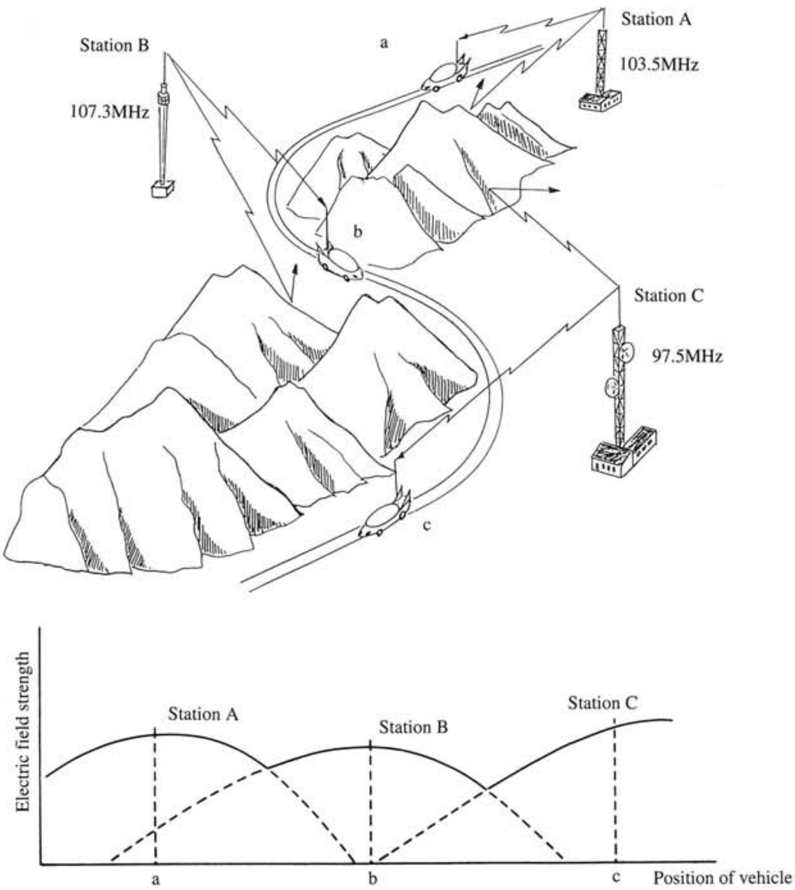


Figure 1. Network follow concept

2.3 Modulation of RDS data

Group information such as that shown in Figure 2 is generated in binary at a bit rate of 1187.5 bit/second and to a two-phase PSK signal (Fig. 4a). The 57-kHz subcarrier is modulated to DSB (double sideband), multiplexed with the stereo sound signal, and transmitted (Fig. 3).

Baseband signals are encoded differentially: that is, they are in Non Return to Zero Inverted (NRZI) format. Two-phase PSK transmission is more immune to noise than amplitude-shift keying (ASK), frequency-shift keying (FSK), and quadrature phase-shift keying (QPSK: 4-phase ASK), and is more suitable to RDS. (Fig. 4b)

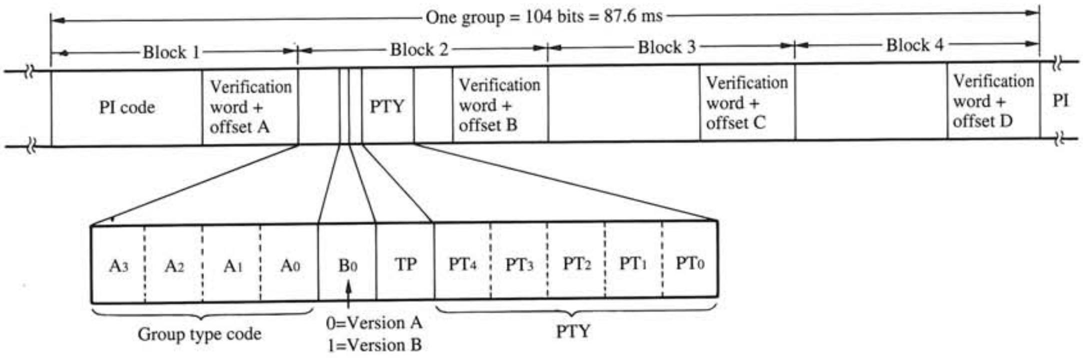


Figure 2. Configuration of RDS data

Table 1. RDS codes and functions

Code name	Brief description of function	Examples of application by the receiver
PS PROGRAM SERVICE	Indicates eight characters; transmitted in groups each containing two characters	Station name WRD2, for example
PI Program Identification	Identifies the country, program, and region with 16 bits	Recognition of identical programs (network follow)
PTY Program Type	Identifies one of 32 program types with 5 bits	Search for and identification of a program type, auto store of news stations only
TP Trafic Program	Identifies with 1 bit whether the station provides traffic information	Search for stations providing traffic information
TA Trafic Announcement	Identifies with 1 bit whether a station is currently announcing traffic information	Automatic switching from tape player to tuner at start of traffic information announcement
AF Alternative Frequency	Identifies with one bit a station on the frequency list for the stations belonging to the same network	Automatic switching to station broadcasting the same program whose field is strongest (network follow)
DI Decoder Identification	Provides information with four bits for selection on the receive circuit, including whether the program is stereo or mono	Control of the corrective network for special equalization and compression
M/S Music/Speech	Identifies with one bit whether a program is music or speech	Automatic volume increase for talk programs
PIN Program Item Number	Identifies with five bits the time of the next broadcast	Automatic switch-on and station selection at start of the desired program
RT Radio Text	Sends any message of up to 64 characters, four bits at a time	Playback and recording of traffic information using both characters and voice synthesis
EON Enhanceed Other Net's PI, PS, TA, PTY information	Other network information such as PI, PS, TA, and PTY	Automatic selection of other networks broadcasting traffic information and automatic return
TDC Transparent Data Channel	Reserved for personal computer communication, four bits per group	Personal computer communication, protocol unspecified
IH In-House application	Applications within a station, remote control	Remote control of repeater and substation settings
RP Radio Paging	Paging, message transmission	As described at left
CT Clock Time	Indicates the year, month, date, hour, minute, day of the week and time differences from 34 bits.	Date and time indication, automatic time difference correction, automatic calibration of internal clock

Table 2. RDS codes used in European countries and RDS logotypes

RDS codes adopted by each European conntry

Country/ organization	Function code														
	PI	PS	AF	TP	TA	PTV	DI	MS	PIN	EON	CT	RT	TDC	IH	RP
Austria ORF	I	I	I	I	I	—	—	—	—	—	—	—	—	—	—
Belgium BRT/RTBF	I	I	I	I	I	—	—	—	—	A	I	A	—	—	—
Denmark DR	I	I	I	I	L	—	—	—	—	L	—	—	—	—	—
Finland YLE	A_{90}	A_{90}	A_{90}	T	T	L	T	T	L	—	—	L	—	—	—
France Radio France	I	I	I	I	I	—	—	—	—	L	I	—	—	—	I
Germany. FR ARD	I	I	I	I	I	—	—	—	—	—	—	T	—	T	—
Ireland RTE	I	I	I	I	I	T	—	—	L	A_{91}	I	L	—	I	I
Italy RAI	I	I	I	I	I	—	—	—	—	—	—	T	T	—	—
Luxemburg RTL	T	T	—	—	—	—	—	—	—	—	—	—	—	—	—
Neitherlands NOS	I	I	I	I	I	—	—	—	—	—	—	T	—	—	—
Norway NRK	I	I	I	T	T_{90}	—	—	—	—	—	I	—	L	—	A_{90}
Portugal RDP	I	I	I	I	I	L	T	T	—	T	T	T	—	—	—
Spain RNE	T	T	T	L	L	—	—	—	—	—	T	T	—	—	—
C. Iberica	I	I	I	I	I	T	T	—	T	—	I	T	—	A_{90}	I
Sweden RR/SLR	I	I	I	I	I	P	P	P	P	A_{90}	P	P	L	L	I
Swizerland SSR	I	I	I	I	I	—	L	—	—	L	—	T	—	T	—
United Kingdom BBC	I	I	I	I	I	T	—	—	T	I	I	T	—	—	—
ILR	I	I	I	I	I	T	—	—	—	L	L	T	—	L	—
Yugoslavia	I	I	I	I	I	—	—	—	—	T_{90}	I	A_{90}	—	—	A_{90}

(Situation mid-1990)

Examples of RDS logos

A: Application approved
A_{90}: Application approved in 1990
I: Already introduced
L: Will be introduced shortly
P: Preliminary broadcasting started
T: Test broadcasting started

Letters and numbers in the map indicate the country code assigned to each country. The country code is represented by 4 bits in the 16-bit PI code. Areas where FM radio waves do not reach each other are assigned the same code.

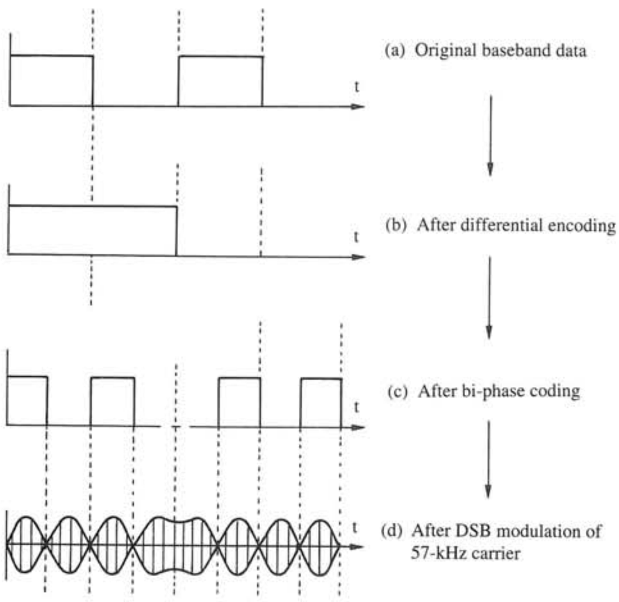
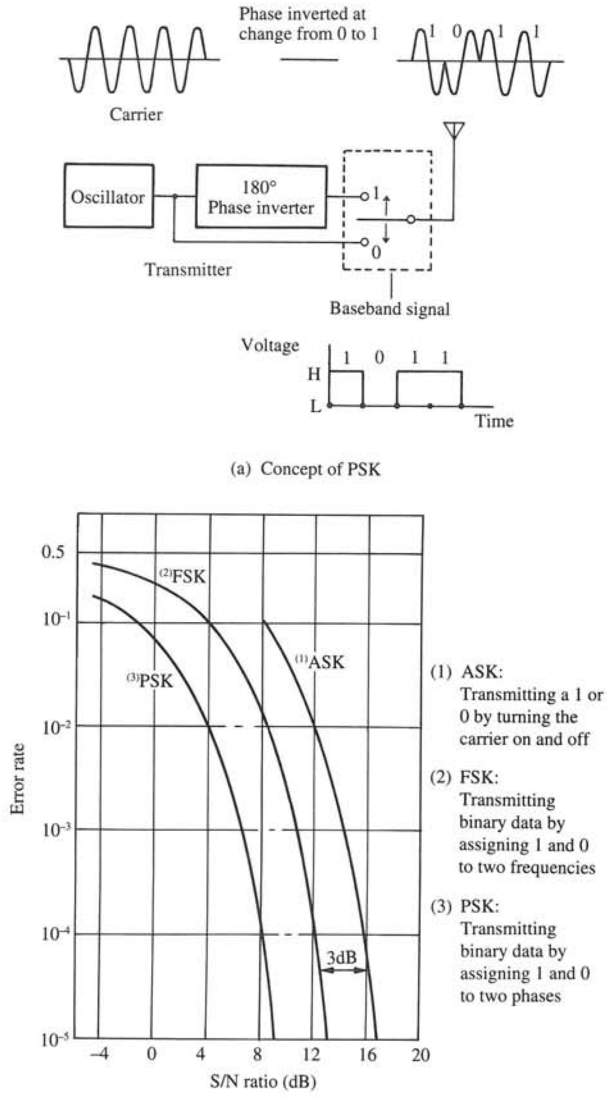


Figure 3. Modulation of RDS signal



(a) Concept of PSK

(b) Comparison of modulation

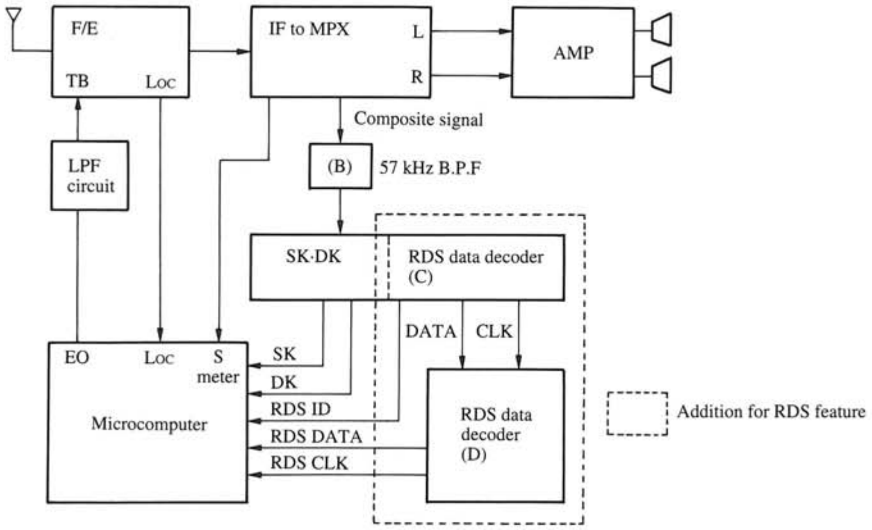
Figure 4. Concept and advantages of PSK

2.4 Demodulation of RDS data

Figure 5 shows the structure of the RDS receiver. As stereo sound signals are superimposed on the broadcast signal (composite signal) which have been obtained by FM detection, the RDS signals cannot be decoded as they are (Fig. 6). Therefore, a 57-kHz bandpass filter (BPF) is used to remove excess noise and modulation components, and the signal is then fed to the RDS decoder. Inside the decoder, the signal undergoes DSB demodulation at 57 kHz, bi-phase decoding, clock regeneration, and differential decoding (reverse of what is shown in Fig. 3). The signal is thereby converted to the RDS data and then sent to the data decoder. The role of the data decoder is to extract the RDS information by restoring the original group synchronization. Next, the main microprocessor uses the extracted data for memory contents revision as well as frequency switching (network follow) and other processing which takes advantage of RDS.

The most attractive feature of the RDS is the network follow (NF) feature based on AF data. This is the area of the system into which the most effort has been expended to achieve speedy and reliable performance. This is covered in more detail in Section 5.

A correction feature utilizing verification words has been developed to protect data from destruction due to noise, which is usually unavoidable in automotive radios. However, the system discussed here does not fully rely on this feature, because the feature is effective only for errors of up to five consecutive bits (a time interval of about four milliseconds) and is insufficient to handle the noise due to fading and multipath interference which may occur while the vehicle is moving. On the contrary, it is possible that the feature may have the opposite effect for errors which are beyond its capacity, as shown in Figure 7. In other words, it may judge destroyed data as correct. This misjudgment confuses the PS indicator or tunes receiver to the wrong station. For example, the receiver may suddenly switch to a rock music channel in the middle of a classical music broadcast. Considering the disturbing effect that such misoperation can have on the driver, we considered it best to avoid use of corrected data. A significant improvement of the S/N ratio of the receiver and provision of a multipath fading suppression/ rejection circuit would enable the error correction feature,



(B): Removes modulated sound signals and noise from the detector output signal (composite signal) and extracts modulated signals close to 57 kHz.

(C): Demodulates SK, DK, and RDS recognition signal output and RDS-modulated analog data to digital data.
where SK (Sender Kennung): Identification of station that regularly transmits traffic information
DK (Durchsage Kennung): On/off flag signal of traffic bulletins

(D): Converts demodulated data to 8-bit serial data that can be read by the microprocessor.

Figure 5. Configuration of RDS receiver

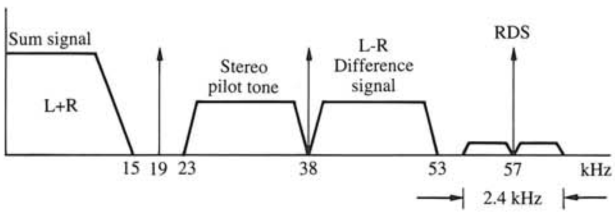


Figure 6. Spectrum of FM baseband with RDS signal

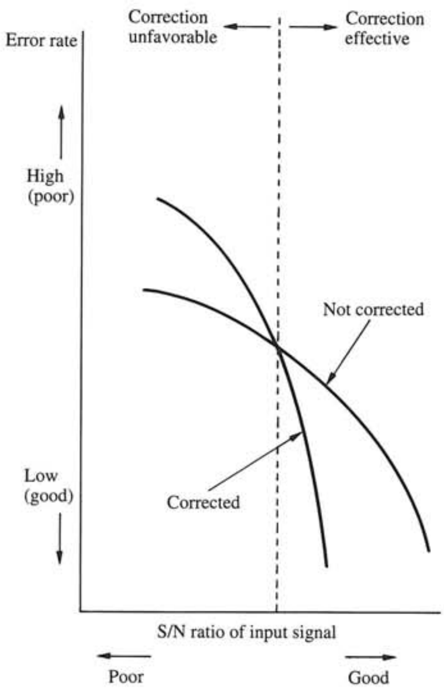


Figure 7. Evaluation of error correction

effective in stationary use, to be useful in automotive radios as well.

3. RDS receiver

3.1 Purpose

1) Prompt Response to Introduction of RDS Broadcasting in Europe

The RDS has been introduced in many countries worldwide. Tests are being conducted to multiplex data with FM broadcasts and to receive it using conventional receivers. This is attracting the attention of broadcast industries in an countries.

European manufacturers of car audio equipment have already begun marketing RDS receivers, and Japanese manufacturers desiring to expand into Europe are also striving to release such products. However, none of the manufacturers are even close to completing an RDS system which precisely meets the reception conditions of European countries.

Fujitsu Ten had two receiver developement objectives. First, the company aimed at producing a system which takes full advantage of RDS broadcast data through examination and analysis of the reception performance, RDS features, and data processing methods of each of the RDS receivers marketed by other manufacturers. Second, to promptly meet market demand, the company aimed to conduct on-site investigations and construct its own system suited to the reception conditions of Europe.

2) Development of new technology

To ensure that the receiver accurately demodulates RDS data multiplexed with sound signals, it was necessary to improve the receiver's basic performance (namely, the demodulation sensitivity of the tuner, the S/N ratio, and the removal of multipath signals and other noise), to build up new technology related to tuners, and to develop a multifunction receiver whose operation relies on accurate digital processing.

3) Establishing the Fujitsu Ten RDS system (incorporating automatic tracking as the main feature)

In Europe, where network broadcasts are numerous, the automatic tracking (AF) function based on the RDS has become essential for car radios.

For this reason, audio equipment manufacturers are continuing to strive to develop receivers, and by relying on trial and error methods, manufacturers are attempting to determine how accurately they can achieve network tracking.

To improve the automatic tracking function for a single-tuner system, Fujitsu Ten considered local conditions when developing hardware which secures reception performance, and software which processes the set AF list and determines if there is a drop in reception quality.

3.2 Network follow (automatic tracking function)

1) Circuit design

The network follow feature operates best when a dual-tuner system is used. One tuner receives the broadcast and outputs the sound component. The other tuner receives another station on the AF list (list of frequencies belonging to the same network) provided as RDS data, checks whether the station is broadcasting the same program as that currently being received, and checks how strong its field is.

Since this method divides the work to be done between tuners, one receiving sound and the other receiving data, it is possible to receive data alone, keep a constant check on the AF list, and gather data only so that the network follow feature switches smoothly between stations. However, as shown in Figure 8, the circuit required for this is extremely large and expensive.

In contrast, the single-tuner method uses a circuit equal in size to conventional circuits and allows sufficient design space. It is, however, slower than the dual-tuner system in gathering data. This is because the system which interrupts sound reception during a broadcast to

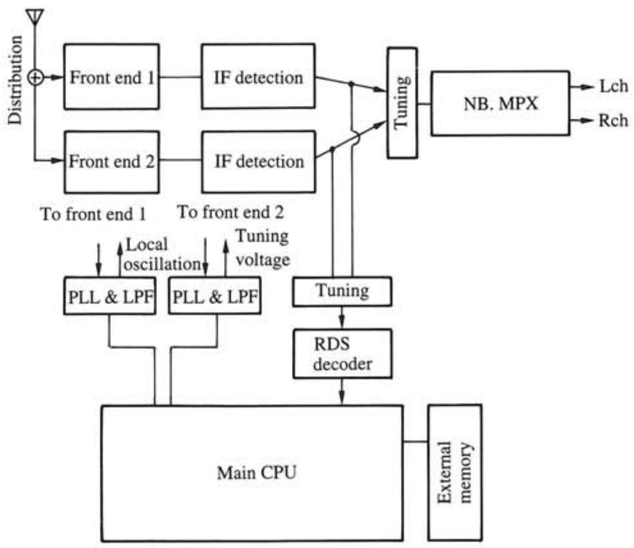


Figure 8. Reception block of RDS receiver with two tuners

receive and check the AF list and then resumes sound reception can only make a check which is so short that no break in sound reception is apparent.

Checks must be quick and must be made at some definite interval. Otherwise, breaks in the sound would be noticeable and unpleasant. The time during which the sound is interrupted can be divided into the following four intervals.

① The time required to tune from the station currently being received to the AF list station
② The time required to check field strength
③ The time required to tune from the AF list station to the previous station
④ The time required for other operations and pre- and postmuting

The first and third tasks take the most time. The required time is determined by the characteristics of the PLL and LPF circuits. Since existing circuits take 50 to 60 ms, the AF list check time takes at least 120 ms. Thus a complete break in sound is perceivable.

A study carried out to determine the maximum break that would be acceptable showed that a break of between 10 and 15 ms is not disturbing to the listener under the conditions inside a car. By providing an LPF circuit exclusively for reception of the FM band and designing the system appropriately, it has become possible to cut the tuning time to between 3 and 5 ms. Thus the RDS automatic tracking function using the single-tuner system has become a physical possibility in terms of hardware. Many of the products released by other companies exhibit a break in sound of about one second when the network follow feature is operating, and cut the sound for several seconds during reception while the system searches for the next AF list station. Fujitsu Ten's RDS system, released later than other products in this field, aims at providing a network follow feature which assures satisfactory listening (see Figure 9).

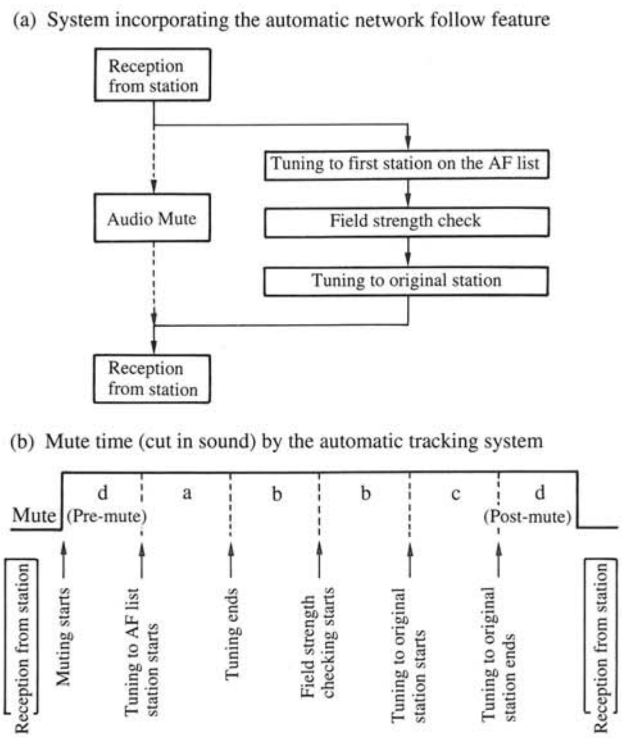


Figure 9. Development of network follow software (1)

2) Development of software

The time required for checking the AF list has been reduced to between 10 and 15 ms. Therefore, despite the fact that the receiver is a single-tuner system, it can check several stations within one minute and keeps the list of frequencies constantly sorted in order of field strength. Since alternate stations are determined beforehand, the receiver can switch instantly to the next strongest broadcast of the same program currently being received.

Another task the receiver must perform is to judge the quality of reception of the current broadcast and determine when to switch to the next frequency. The concept diagram (Fig. 1) shows that the network follow feature relies on the field strength only to determine when to switch to the next frequency. However, the results of several months of on-the-spot investigation revealed that the receiver operates in response to deterioration in the reception quality due to caused by multipath fading noise. In fact, it identifies multipath fades by counting occurrences of noise.

Time-related factors must also be taken into account to determine the field strength and the number of multipath fades. It is also essential that software be designed by determining noise counts, noise density, and the conditions before and after noise occurrences, not only through the results of bench tests, but also through consideration of actual local conditions (see Figure 10).

(a) Most suitable reception system

AF data — List of other frequencies belonging to the same network

↓

Check of field strength of stations in the same network

↓

Reception of station whose field is strongest

(b) Overview and operation of software

① When the RDS is turned on, the software checks the field strength of the stations in the AF list held in memory and re-numbers them in order of field strength. The software conducts this check several times per minute, checking one station at a time.

No. 1	102.27MHz
No. 2	94.45MHz
No. 3	106.65MHz
No. 4	97.99MHz
...	...
No. 23	88.1MHz
No. 24	98.1MHz
No. 25	105.1MHz

The software checks the field strength of each station beginning from No. 1. →

1st	98.1MHz	80dB
2nd	87.5MHz	72dB
3rd	105.1MHz	68dB
4th	95.1MHz	62dB
...	...	...
23th	107.9MHz	38dB
24th	89.9MHz	35dB
25th	94.5MHz	20dB

(Memory capable of holding a maximum of 25 stations in the AF list.)

② When the software has finished checking all stations in the AF list, it compares the current station and the 1st station in the AF list. If the 1st station in the list is stronger and has the same PI code, the receiver switches to the 1st station.

Figure10. Development of network follow software (2)

3.3 Multifunction display

In addition to a conventional function display, the display on an RDS receiver must also show the station name in eight characters. As shown in Figure 11, this requires 112 segments and 56 pins when a conventional 50% duty cycle LCD is used. It is difficult to install an LCD having so many pins in the DIN 1 display space specified for vehicles. We therefore developed a 25% duty cycle LCD having 32 pins. Generally, the duty factor N (duty cycle = $1/N$) of an LCD is in inverse proportion to the effective voltage ratio $[\frac{V_{on}}{V_{off}}]$ as expressed by the following equation.

$$\frac{V_{on}}{V_{off}} = \sqrt{\frac{\sqrt{N}+1}{\sqrt{N}-1}}$$

As the duty factor increases, the display contrast decreases. Since this causes a drop in the visibility of the display, we developed a new LCD and obtained good visibility by reviewing the threshold voltage and using the segment configuration shown in Figure 12.

3.4 Other technologies

In order to include the RDS functions in an integrated piece of equipment that fits one DIN unit, we miniaturized the front end and simplified the circuits to meet space restrictions.

50%-duty cycle

56 pin=7pin × 8 characters

25%-duty cycle

32 pin=4pin × 8 characters

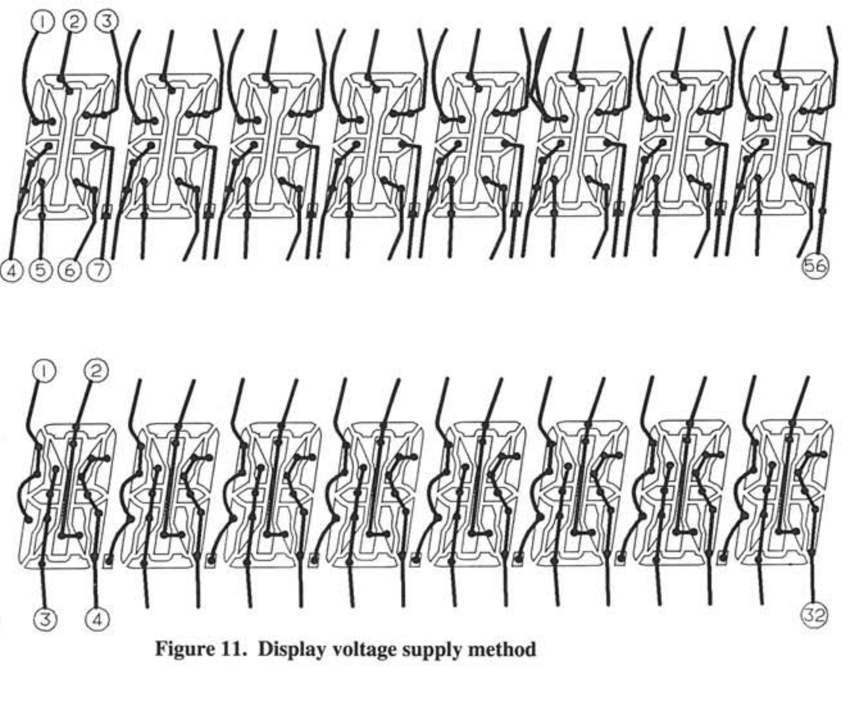


Figure 11. Display voltage supply method

1) Miniaturization of front end [*1]

By using an upconverter for AM frequency conversion, we reduced the LW and MW tuner modules to half their previous size. We also improved sensitivity and image interference.

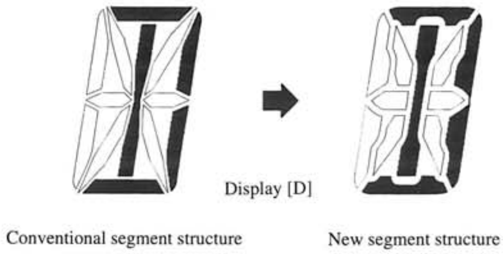


Figure 12. Display segment structure

We miniaturized the FM receiver by concentrating all components, from the tuning circuit to the multiplex output, in one module (Fig. 13). The FM section was designed to meet the needs of the United States and Japan as well, the main countries to which the receiver is to be dispatched, thereby cutting costs which would be increased if design were made only for the relatively small European market.

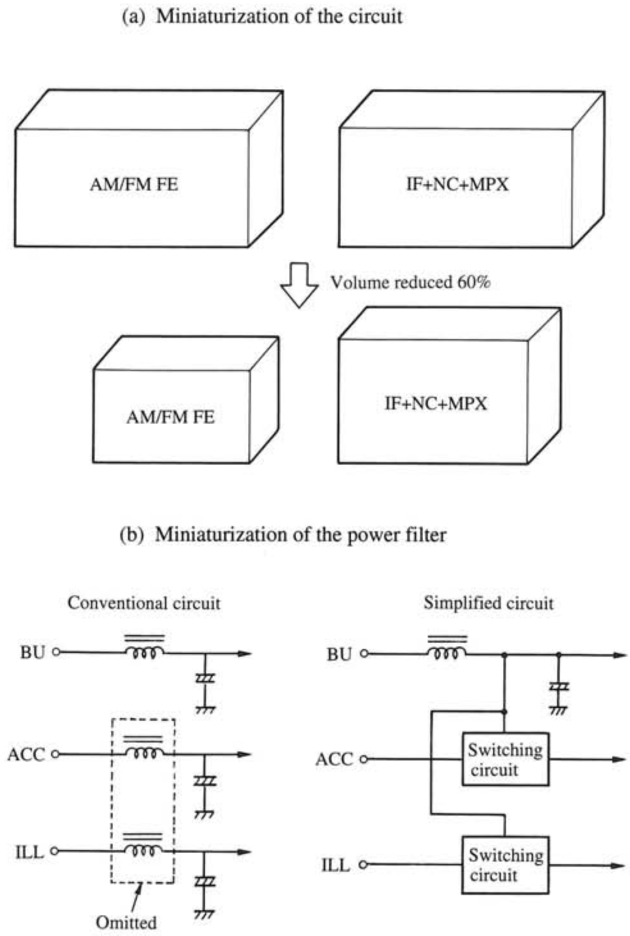


Figure 13. Miniaturization

4. Evaluation of RDS

The main point with a single-tuner RDS receiver is how well the receiver switches to a stronger frequency without disturbing the listener, and whether it switches before noise begins to increase.

We therefore evaluated the RDS receiver in the field, observing how suitable the threshold value was when the frequency changed, how effectively the receiver selected the most suitable alternate station from the AF list, and how smoothly the receiver switched over to the new frequency in response to deterioration in the quality of the signal due to multipath interference and a drop in field strength. For our evaluation, we prepared a monitor receiver capable of software change and that allows memory contents or flag monitoring even when the car is running. Such aids which enable software modification are indispensable for checking receiver performance.

In bench tests, we evaluated how quickly and accurately the receiver picked up data. In practice, we used a multipath simulator to generate multipath fading and resulting noise under various conditions, and measured the time taken before the receiver displayed the PS and detected the TP code (traffic information identifier) (Fig. 14). Based on the results of this evaluation, we were able to make the receiver operation stable and reliable through optimizing characteristics of the IF filter and 57-kHz bandpass filter and decoder capture range, and averaging data by software.

The chart indicates the time taken for the PS (eight characters) to be displayed and the time taken for the TP code to be identified for various combinations of values of γ (ratio of direct to reflected waves) and delay.

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*1 Upconversion is used in receivers whose IF is higher than the received frequency. Since the image frequency is quite different, this method is beneficial in that it allows simplification of the tuning circuit. No band change is required from LW to MW due to the lower local oscillation variation ratio. This method would prove favorable in receivers designed for use in Europe.

4.1 European broadcasting conditions and RDS

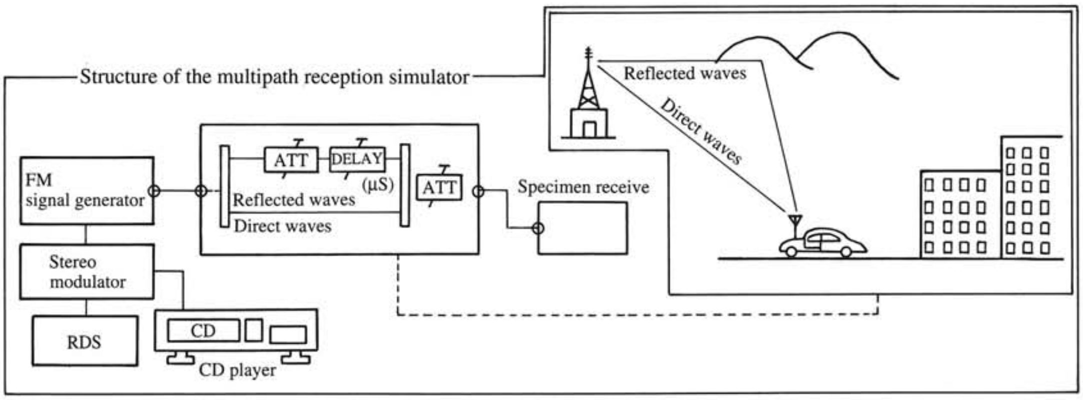
From May to October 1990 we conducted investigations and field tests focusing on local RDS conditions and developed software on site. A comparison of the final product and the original prototype we prepared in Japan showed very clearly the importance of familiarity with the conditions in Europe, where the land and atmosphere are quite different from those in Japan.

The main test areas were Germany, Switzerland, the United Kingdom, and Norway. The characteristics of each country are given below, along with notes on application of the RDS.

1) Germany

Germany was our base for European activities, which started from Dusseldorf.

Since the autobahns linking cities pass through terrain almost free of mountains, Network Follow operation on a long-distance drive can be based on relatively gradual increases and decreases in electric field strength. Since traffic information broadcasts are widely used, the receiver must be able to reliably detect the Traffic Program (TP) and Traffic Announcement (TA) codes in urban regions which are susceptible to multipath interference.



(1) Name of set 00-0000

(2) Conditions of SG MO/ST:ST/SK: × DK: × BK: ×

(3) Source of music CD: RFBECCA First minute on track 1

(4) Facing mode : 2 Frequency : 89.9 MHz

Out ATT : 20 dB Fading FREQ: 6.0 Hz

RDS•MOD : 2 kHz

γ / DELAY	0 dB	2 dB	4 dB	6 dB	8 dB	10 dB
14	PS ○ TP ×	PS ○ TP ×	PS ○ TP ×	PS ○ TP ×	PS ○ TP ○	PS ○ TP ○
12	PS ○ TP ×	PS ○ TP △	PS ○ TP △	PS ○ TP ○	PS ○ TP ○	PS ○ TP ○
10	PS ○ TP ×	PS ○ TP △	PS ○ TP ×	PS ○ TP ○	PS ○ TP ○	PS ○ TP ○

Example simulation evaluation sheet

The chart indicates the time taken for the PS (eight characters) to be displayed and the time taken for the TP code to be identified for various combinations of values of γ (ratio of direct to reflected waves) and delay.

○: 0 to 5 seconds
△: 5 to 30 seconds
×: More than 30 seconds

Figure 14. Bench evaluation of RDS

2) Switzerland

Although the country is mountainous, transmission facilities are provided along main roads and proper service areas have been developed. In towns located away from the roads, radio waves from transmitters aimed toward the roads are extremely weak and weak-field multipath interference is serious. The quality of reception of list frequencies is also often much the same. These areas put harsh demands on the receiver since selection of and synchronization with an alternate frequency, once reception quality drops, must be effected within a very short time. Method A is used for the AF function*2 (As of October 1990).

3) United Kingdom

In the U.K., are no singular characteristics in terms of electric field strength or topography. The BBC has developed a Travel Service which makes much use of the Enhanced Other Net Information (EON) function. This service lets the user know when a traffic information announcement begins on another station. To achieve this, data links have been established between the main BBC stations (1 to 4) and local BBC stations in all areas. This is possible become the BBC therefore covers virtually the entire country. The receiver discussed here does not have an EON function because of memory and other limitations.

4) Norway

Norway is mostly mountainous and all main roads are winding. To handle these conditions, transmitters for the two public networks (NRK1 and 2) are placed more densely than those in any other country, and cover the entire country. For the Network Follow feature to operate effectively, the receiver must switch to a new frequency each time the vehicle follows a bend in the road. Given such unfavorable conditions, if the Network Follow feature operates reliably in Norway, it is certain to operate correctly in all other countries (see Figure 15).

The next chapter describes Fujitsu Ten's first RDS receiver, which was developed in consideration of the local conditions explained above.

5. Overview of Fujitsu TEN's RDS receiver

We developed four 1991 model audio systems for the European market, including two models incor-porating RDS functions. The table in Figure 16 lists these functions. One of the RDS models is standard audio equipment; the other is provided with optional features (see Figure 16).

The standard and optional models share the same design in a number of features. As listed below, their hardware and software are nearly identical.

① FM tuner unit – Uses an FM receiver unit with four functions (FE + IF + NC + MPX) combined into one unit.
② LCD - Developed for display of eight-character PS names
③ Control circuit for LCD (driver) - 25% duty cycle
④ Software - Same operating system and RDS software
⑤ RDS signal demodulation circuit and RDS data decoder

Other functions are compatible with the ARI traffic information system currently operational in Europe.

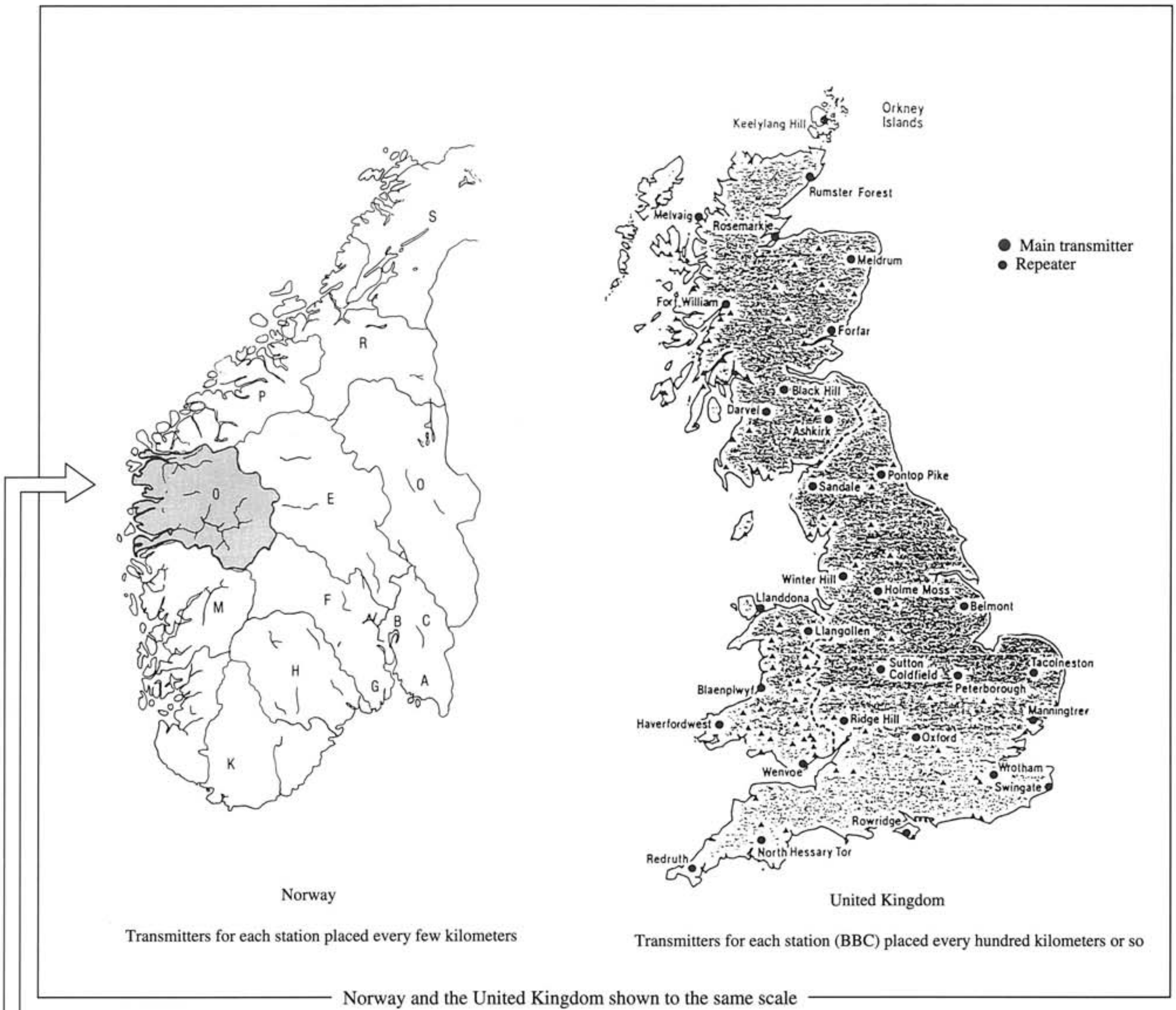
The ARI system*1 uses the SK and DK signals. The RDS data contains code (TP/TA) corresponding to the SK/DK signal. Fujitsu Ten's receiver uses the TP/TA code in addition to the SK/DK signal so that its ARI*3 functions work accurately.

The Clock Time (CT) and Program Type (PTY) RDS functions have been included in the optional model (see Figure 17). In addition, this model is equipped with a function which enables six stations to be preset in memory in order of relative field strength.

*2 Methods A and B

There are two methods used for transmission of the Alternate Frequency (AF) list: Method A and the more recent Method B. While Method A transmits only a total of 25 frequencies in the whole area, the Method B has no such limitation and transmits the frequencies considered necessary for effective Network Follow operation in the current region for each network frequency group. That is, Method B assures that effective Network Follow operation can be achieved simply by using data whose header contains the same frequency as that currently being received. It is expected that Method B will become the standard for future RDS systems.

*3 ARI (Autofahrer Rundfunk Information): Broadcast of traffic information multiplexed with FM broadcast.



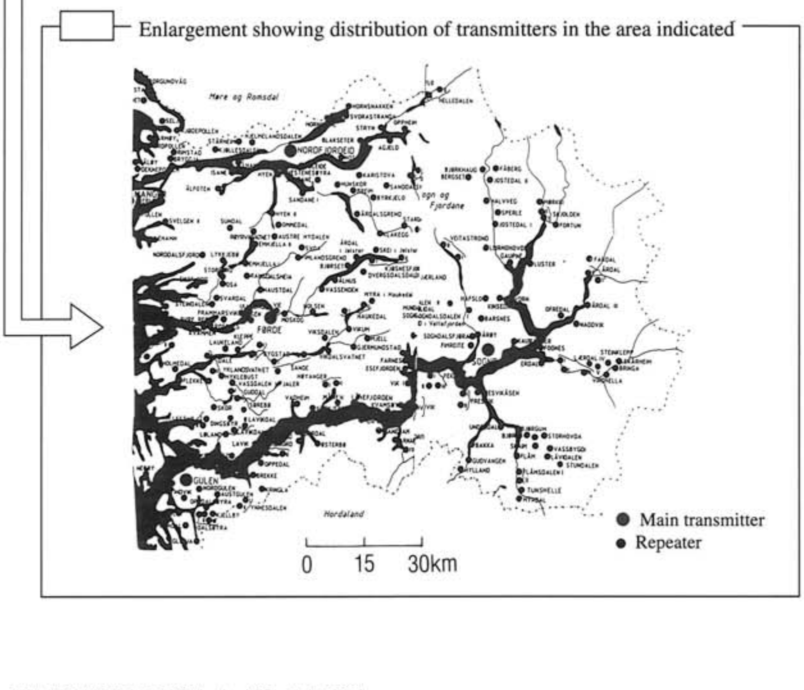
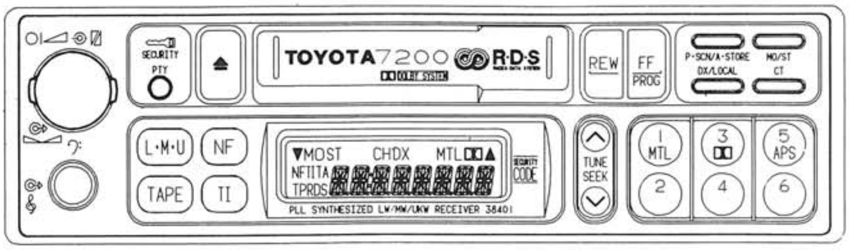
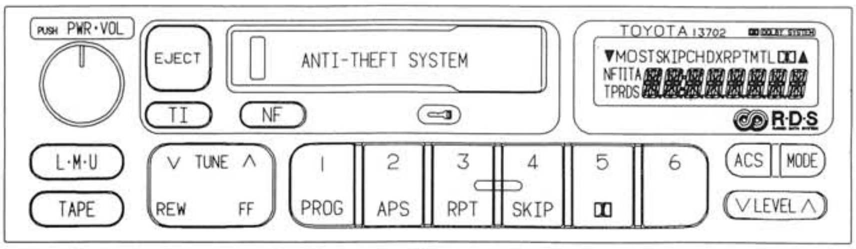


Figure 15. Locations of transmitters in Norway and the United Kingdom

(a) Optional model



(a) Standard model



Function	Standard model	Option model		
		HI	MID	LOW
LM/MW/UKW STEREO ELECTRONIC TUNINGRADIO	●	●	●	●
PRESET TUNING (GLW/MW, 12UXW) WITH EASY ONE-TOUCH ACCESS TO THE SELECTED STATION		●	●	●
PRESET TUNING (GLW.GMW, 12UXW) WITH EASY ONE-TOUCH ACCESS TO THE SELECTED STATION	●			
AUTO SEEK TUNING (UP/DOWN)	●	●	●	●
ONE TOUCH ELECTRONIC STATION MEMORY	●	●	●	●
PRESET SCAN		●	●	●
AUTO STATION MEMORY (AUTO STORE)		●	●	●
MONO/STEREO SWITCH		●	●	●
LOCAL/DX SWITCH	AUTO	●	●	●
RDS FUNCTION	●	●		
SK/DK TRAFFIC INFORMATION RECEPTION SYSTEM	●	●	●	●
AUTO REVERSE CASSETTE DECK	LOGIC	MECH	MECH	MECH
DOLBY B NOISE REDUCTION SYSTEM	●	●	●	
INDEPENDENT FF/REW OPERATION	●	●	●	●
TAPE TYPE SELECTOR FOR METAL/CHROME OR NORMAL TAPE	AUTO	●	●	
AUTOMATIC PROGRAM SELECTOR (APS)	●	●		
DUAL AZIMUTH TAPE HEAD MECHANISM	●	●	●	●
BLANK SKIP	●			
REPEAT	●			
4 SPEAKER CAPABILITY		●	●	●
BASS/TREBLE CONTROL	●	●	●	TONE
FADER CONTROL	●	●	●	●
AUTO LOUNDESS	AUTO	SM	●	
ACOUSTIC FLAVOR	●			
ILLUMINATION CONTROL	●			
DIGITAL CODE SECURITY SYSTEM WITH SECURITY INDICATOR	●	●	●	

Figure 16. Front panel of RDS and function table

Figure 17. Example of display NEWS by PTY

6. Future trends in the RDS

In the future, inclusion of RDS functions, especially Network Follow, in receivers manufactured for the European market will be essential. The technological base established by Fujitsu Ten in its development of a single-tuner RDS system will lead to development of other models intended for use in Europe.

Efficient use of the Network Follow feature in the RDS receiver enables noise to be eliminated through switching to another station broadcasting the same program on a different frequency when multipath fades occur. This feature relies on the fact that, since the locations and transmission directions of stations on other frequencies are different from those of the station currently being received, there is a strong possibility that reception from another station during momentary noisy reception is better than that from the current station. This function is identical to diversity reception already in use, a system which greatly enhances reception performance by switching momentarily to an antenna whose electric field conditions are favorable for signal reception. Due to this similarity, the NF feature is also known as the frequency diversity system. In this sense, it is an effective means of transmission in Europe where installation of multiple antennas is not yet the norm.

The main technological points of the RDS receiver are how well it can detect information on other frequencies (data codes) without interfering with the received sound, how quickly it can switch between frequencies, and how well it can handle a momentary drop in reception quality due to multipath interference. In this sense, the dual-tuner system is ideal, but poses difficulties in terms of cost and size. Therefore, for the time being we plan to focus on improving the single-tuner system, as explained below.

① Enhancement of the NF feature through faster frequency switching (improved smoothness of sound)
② Expansion and speeding up of data management by increasing the capacity and speed of the microprocessor
③ Improvement of basic reception performance and miniaturization by developing new devices
④ Addition of new functions such as EON and Radio Text (RT) once basic performance has been improved through implementation of the above.

We also aim to promote inclusion of RDS functions in radios manufactured for the European market.

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