

REPORT ITU-R BO.1227-2

**SATELLITE-BROADCASTING SYSTEMS OF INTEGRATED
SERVICES DIGITAL BROADCASTING**

(Questions ITU-R 101/10 and ITU-R 101/11)

(1990-1994-1998)

1 Introduction

The progress of digital technology such as multimedia and digital television has made the general public more and more accustomed to high-quality, reliable and easy-to-use consumer digital devices. This, as a matter of course, has likewise prompted consumers to seek the advantages inherent in the digitalization of broadcasting. Integrated services digital broadcasting (ISDB) enables the transmission of various kinds of information, digitally encoded and systematically integrated in a single digital broadcasting channel.

This Report discusses the basic concept and technical considerations of the ISDB system.

2 Concept of ISDB system

In the ISDB system, many kinds of information such as video, audio, teletext, still pictures, facsimile, computer software and even high definition television (HDTV), from different origination sources, are digitally encoded, systematically integrated, and transmitted by a single digital broadcasting channel. Digitalization in the ISDB system not only makes possible high-quality transmission but also allows greater flexibility and efficiency in operation. It also makes possible the provision of multimedia services, and simplifies both information selection and access for the user.

It could become possible at some point in the future to incorporate into ISDB almost all kinds of broadcasting services now or under development.

3 Basic functions

It is desirable for ISDB to realize the following functions:

3.1 Flexibility

- Many kinds of signals, from high-speed video signals to low-speed data signals, and the combination of them should be able to be multiplexed on the same transmission channel.
- Various service signals which have a wide variety of transmission rates should be able to be transmitted.
- Organization of service should be able to be arranged freely.
- Signals should be able to be multiplexed based on their priorities.
- The grade of service quality should be able to be selected for each receiver.

3.2 Extensibility

- New services should be able to be introduced easily in the future.
- New broadcasters should be able to take part in the broadcasting business easily.

3.3 Inter-operability

- Transcoding among various digital broadcasting systems should be able to be done with ease.
- Interconnection with other systems such as the communication system, package media, or computer system should be able to be easily established.
- The multiplex method should be applied to a variety of transmission channels with widely-spread transmission capacity.

3.4 Emission characteristics

- Efficient emission should be realized.
- Good emission quality, such as robustness against channel errors, should be obtained.
- Stable synchronization should be regenerated.
- Recovery time should be short after interruption.
- Signals should be transmitted with minimum delay.

3.5 Reception

- Programmes should be able to be easily selectable.
- Services should be able to be multiplexed and demultiplexed easily.
- Signal components should be able to be displayed synchronously with each other.
- Links among services or signal components should be able to be established.
- Waiting time after selecting channel should be able to be decreased.
- Common receiver should be able to be realized for all transmission media.

3.6 Conditional access

- A wide range of applications requiring conditional access should be able to be introduced.

3.7 Other requirements

- Operational costs for broadcasters should be reduced.
- The receiver circuitry should be made simple and low-cost.

4 Technical considerations**4.1 Emission aspects**

Use of a direct broadcasting satellite is considered an effective medium for ISDB. The service requires a wide bandwidth channel and at present almost all of the terrestrial broadcasting frequencies are in use in some areas. Broadcasting satellites would also more effectively serve ISDB's goal of economically providing consistent high-quality, reliable services over broad geographical areas.

A transmission system for satellite ISDB and the results of experimental measurements on this system carried out by Japan are described in Annexes 1 and 2. A comparison between satellite digital multi-programme transmission systems and the ISDB system is presented in Annex 3.

4.2 Framework of ISDB transport system

In order to meet the functions mentioned in § 3, it is appropriate that the service transport methods for ISDB have the following functions:

- multiplexing a variety of digitized video or audio signals and various kinds of data so that the signals are transmitted on a single channel and are received separately at the receiver;
- optionally, error correction coding for the signals transmitted on various kinds of channels, so that they can be received correctly under various receiving conditions, such as severe noise or interference;
- modulating the digital signals, which are integrated into a single bit-stream including the error correcting codes, by means of the multiplexing methods, using appropriate modulation and emission methods based on the characteristics of each transmission channel;
- introducing conditional access systems which can be applied to each of the various kinds of digital signals, using appropriate conditional access systems;
- data access method for the transport method mentioned above which enables easy reception of the desired service or programme at the receiving side.

4.3 Service multiplex methods

There are basically two service multiplex methods: structured transmission and packet transmission.

4.3.1 Structured transmission method

In the structured transmission method, data corresponding to each service are located in fixed positions in the transmission frame. This method has the following characteristics:

- it allows for optimum transmission of each service, assigning it to an appropriate frame area and position according to the required transmission rate;
- the desired data can be easily separated, because data can be identified based on their position in the frame;
- transmission efficiency is high if the transmission rate of each service is constant;
- it has poor extensibility, because it is difficult to accommodate new services once the system has been specified.

4.3.2 Packet transmission method

A packet consists of a header and data field for each particular service. The header indicates data attributes. In the packet transmission method, the packet is located arbitrarily in the transmission frame. This method has the following characteristics:

- various services can be specified with a common transmission protocol and handled in the same manner;
- it requires data separation processing to select the desired packets from all transmitted packets;
- transmission efficiency is high, because it allows for optimum transmission of variable bit rate services, thus compensating for the somewhat higher overhead due to the presence of packet headers;
- new services can be easily added, which means that it provides high extensibility and flexibility.

For obtaining robustness against transmission error, the transmitted data should be constructed within the transmission frame which has periodicity. The frame should have a frame synchronization code which has sufficient length for regenerating synchronization quickly and reliably. The depth of interleaving, the method of randomizing transmission signals, and the schemes for error correction should be determined based on the requirements for each system and the transmission channel characteristics.

4.4 Information identification function

ISDB makes it possible to integrate and transmit a large variety of services.

Such features underscore the importance of identification and index capabilities. These would enable the user easily to receive, select, use directly, or store automatically and retrieve the required information.

4.5 Other aspects

Other aspects are also expected to be studied and combined in an optimum manner to develop ISDB. These would include:

- source coding;
- channel coding;
- digital modulation;
- conditional access; and
- the concept of a universal receiver.

5 Conclusion

ISDB is expected to be able to include various services such as multimedia, multichannel television and HDTV. A practical, well-organized model should be studied for implementing future broadcasting systems.



Transmission system for satellite ISDB

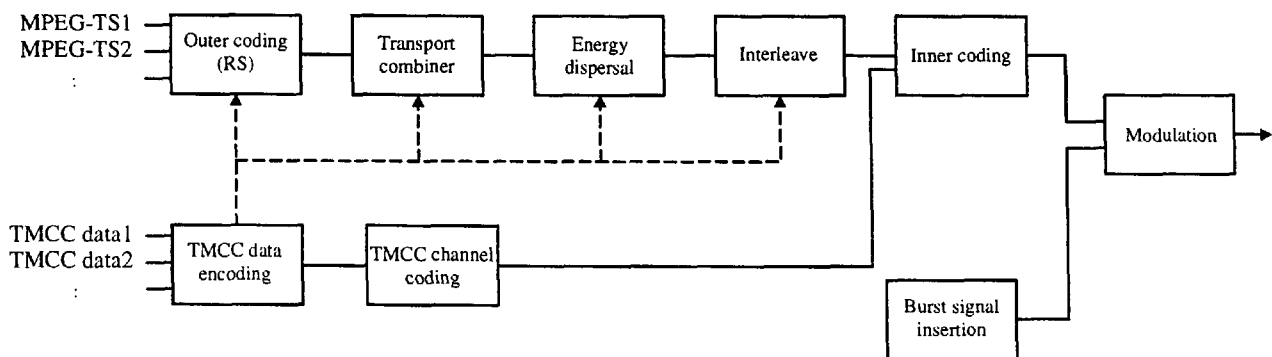
1 Block definition

Multiple MPEG-2 transport streams (MPEG-TSs) from MPEG-2 multiplexers are processed as the input signals to the system. This block contains the following processes:

- combined transport for making a transport frame structure,
- outer forward error correcting (FEC) coding (i.e. Reed-Solomon (RS)),
- randomization for energy dispersal,
- interleaving,
- control code transmission and multiplexing configuration control (TMCC) encoding and its channel coding,
- insertion burst signal for stable carrier recovery under low receiving carrier-to-noise ratio, C/N ,
- inner FEC (i.e. trellis or convolutional code),
- modulation.

Detailed information for such processes is described in Fig.1.

FIGURE 1
Block diagram of transmission system



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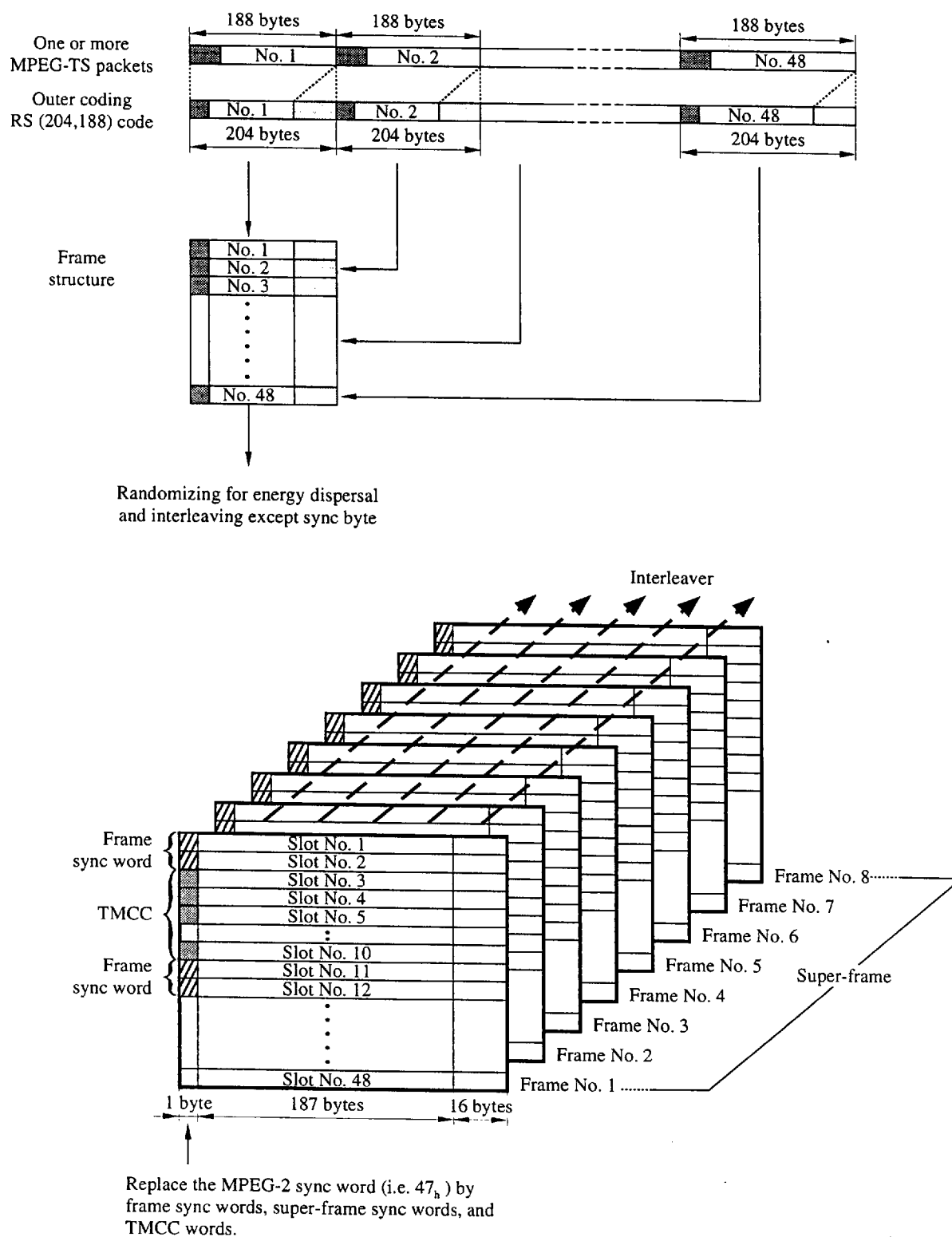
2 Transport combiner

2.1 Framing structure

The transport combiner receives a maximum of eight MPEG-TS from MPEG-2 multiplexers and composes a frame that consists of 48 TS packets with outer coding parity bits. A super-frame coming from 8 frames according to the control code derived from the MPEG-2 multiplexers. Each absolute row in the frame is called "slot". The transport combiner replaces the MPEG-2 synchronization word (i.e. 0×47) at the top of each packet by frame sync words, super-frame sync words, and control words termed TMCC.

The transport combiner also generates a frame sync pulse (FP) and a super-frame sync pulse (SF) and distributes them to each process. A block diagram of the frame structure is shown in Fig. 2.

FIGURE 2
Block diagram of the frame structure



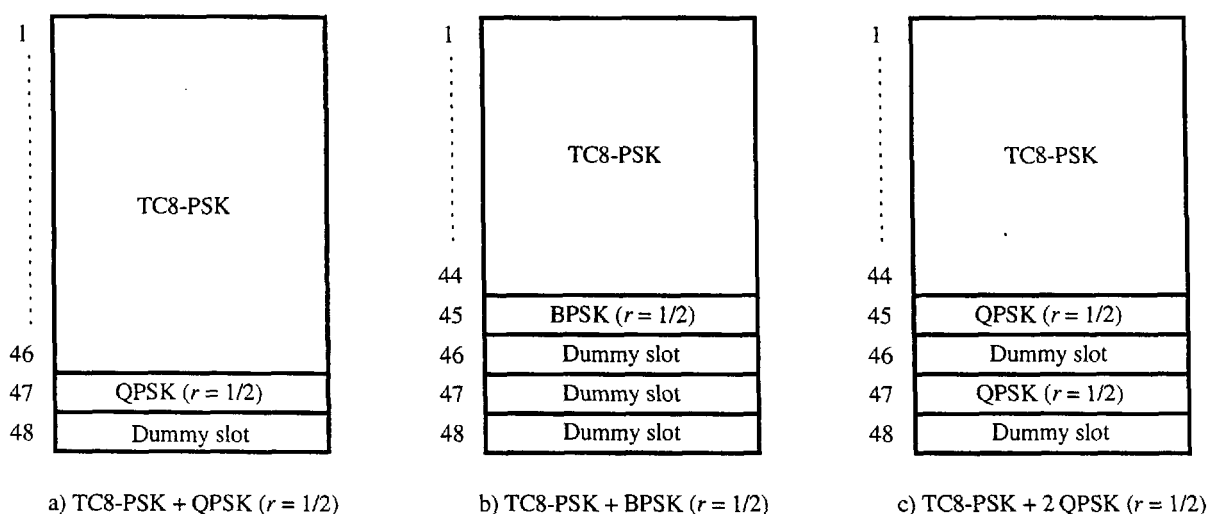
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2.2 Slot assignment

In the case where more than one modulation scheme is adopted for one carrier, slots which are transmitted by each modulation scheme are arranged in frame in decreasing order of rate of frequency utilization (e.g. TC8-PSK $\rightarrow$ QPSK(3/4) $\rightarrow$ QPSK(1/2) $\rightarrow$ BPSK(1/2)).

Program data which are transmitted by trellis coded octophase shift keying (TC8-PSK) are assigned to a part of the frame by slots and are able to occupy all the assigned slots. On the other hand, program data which are transmitted by quaternary PSK (QPSK) with an inner code rate of n/m are assigned to a part of the frame by m slots and are able to occupy n slots in m slots. The $m-n$ slots called "dummy slots" are not used for data transmission. Program data which are transmitted by binary PSK (BPSK) with an inner code rate of $1/2$ are assigned to a part of the frame by four slots and are able to occupy one slot in four slots. Three slots are dummy slots. Dummy slots are used to maintain processing clock frequency in any frame structure (see Fig. 3).

FIGURE 3
Example of slot assignment



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3 Outer Code

A RS (204,188, $T=8$) shortened code is applied to each transport packet (188 bytes). The shortened RS code may be implemented by adding 51 bytes, all set to zero, before the information bytes at the input of a (255,239) encoder. After the RS coding procedure these null bytes are discarded.

- Code generator polynomial: $g(x) = (x + \lambda^0)(x + \lambda^1)(x + \lambda^2) \dots (x + \lambda^{15})$, where $\lambda = 02_{\text{hex}}$
- Field generator polynomial: $p(x) = x^8 + x^4 + x^3 + x^2 + 1$.

4 Randomization

For the purpose of energy dispersal, the polynomial for the pseudo-random binary sequence (PRBS) is adopted. The PRBS generator is:

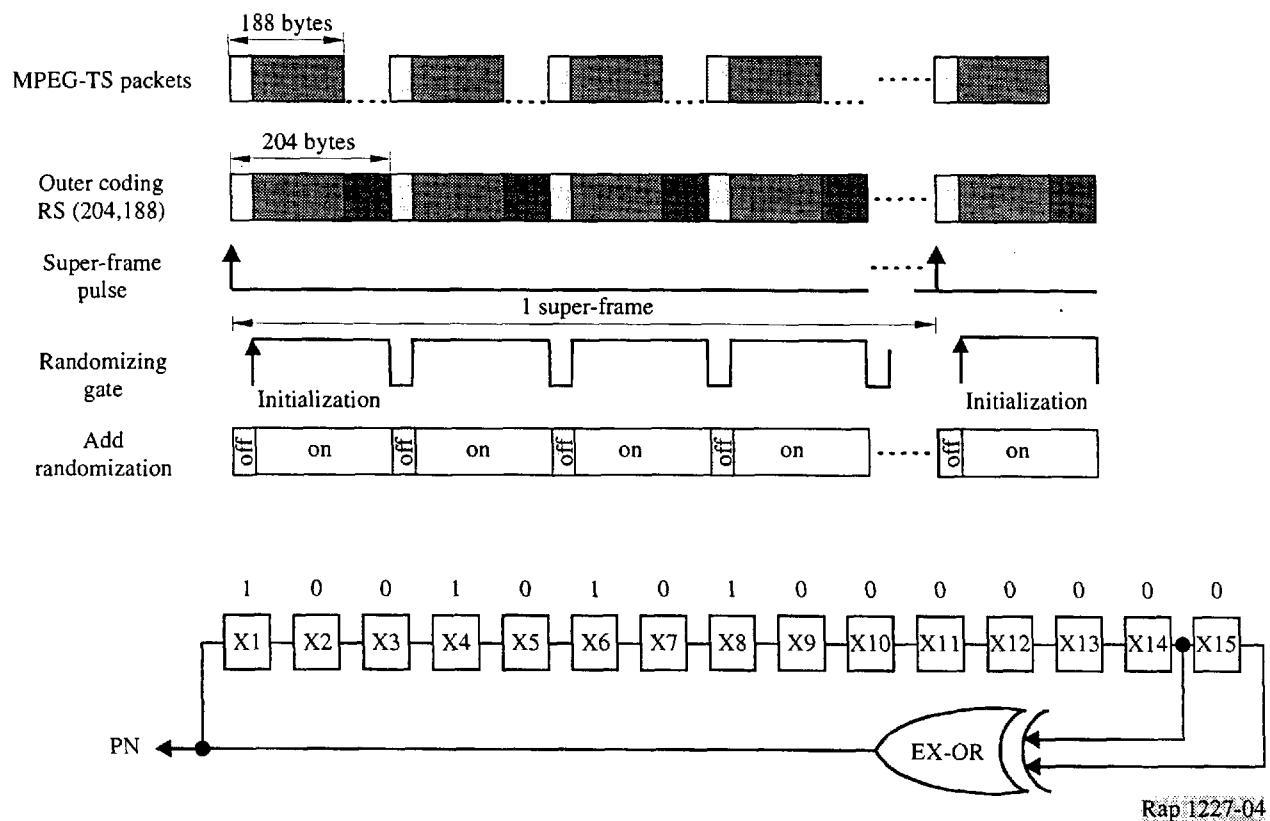
$$1 + x^{14} + x^{15}$$

Loading of the sequence "100101010000000" into the PRBS registers, as indicated in Fig. 4, is initiated at the second byte of every super-frame.

The PRBS is added to the data of each slot except the first byte of every slot. During the first byte of every slot, the PRBS generation continues, but its output is disabled, leaving this byte unrandomized.

When modulation schemes except TC8-PSK are adopted, the frame contains dummy slots. In this case, the randomization is also implemented for dummy slots.

FIGURE 4
Randomizer schematic diagram



PN : pseudo-noise

5 Interleaving

Block interleaving with 8×203 bytes is applied to the slots following the conceptual scheme shown in Fig. 5. The first byte of the slot is not interleaved. The interleaver writes 203 bytes in the i -th slot of all frames composing one super-frame, to the interleave matrix horizontally. And the interleaver reads the data every 203 bytes from the matrix vertically and puts the data back into the slots. Table 1 shows the write/read addresses of i -th slot.