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European Standard (Telecommunications series)

Digital Video Broadcasting (DVB); Co-ordination channels associated with Digital Satellite News Gathering (DSNG)

European Broadcasting Union EBU UER Union Européenne de Radio-Télévision

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Foreword

This European Standard (Telecommunications series) has been produced by the Joint Technical Committee (JTC) Broadcast of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE: The EBU/ETSI JTC Broadcast was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC Broadcast became a tripartite body by including in the Memorandum of Understanding also CENELEC, which is responsible for the standardization of radio and television receivers. The EBU is a professional association of broadcasting organizations whose work includes the co-ordination of its members' activities in the technical, legal, programme-making and programme-exchange domains. The EBU has active members in about 60 countries in the European broadcasting area; its headquarters is in Geneva.

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Digital Video Broadcasting (DVB) Project

Founded in September 1993, the DVB Project is a market-led consortium of public and private sector organizations in the television industry. Its aim is to establish the framework for the introduction of MPEG-2 based digital television services. Now comprising over 200 organizations from more than 25 countries around the world, DVB fosters market-led systems, which meet the real needs, and economic circumstances, of the consumer electronics and the broadcast industry.

National transposition dates	
Date of adoption of this EN:	18 June 1999
Date of latest announcement of this EN (doa):	30 September 1999
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 March 2000
Date of withdrawal of any conflicting National Standard (dow):	31 March 2000

1 Scope

According to ITU-R Recommendation SNG.770-1, Satellite News Gathering (SNG) is defined as "Temporary and occasional transmission with short notice of television or sound for broadcasting purposes, using highly portable or transportable up-link earth stations …". EN 301 210 [2] describes the frame structure, channel coding and modulation system for Digital Satellite News gathering (DSNG).

For SNG technical and/or programme co-ordination, and interruptible feed-back, ITU-R Recommendation SNG.771-1 recommends "*that SNG earth stations should be equipped to provide two-way satellite communication circuits which must be available prior to, during and after, the transmission of the vision and associated sound or sound programme signal. These circuits will provide communications between the SNG operator, the satellite operator and the broadcaster; that two or more duplex circuits should be provided, whenever possible within the same transponder as the programme vision and associated sound or sound programme signal*". The same Recommendation considers "*that throughout the world, where news events take place, uniform technical and operational standards for communication should be established to ensure prompt activation of the SNG service*". The availability of co-ordination (communication) circuits by satellite may be particularly useful in areas where access to the public switched or cellular telephone networks is difficult or impossible. For these purposes, the same antennas of the DSNG stations may often be used, and the same frequency resources (or at least the same satellite transponder) as the main DSNG signal may be exploited. Other frequency resources may also be chosen according to the operational conditions and requirements.

To achieve a two-way (i.e. full-duplex) communication channel, two independent carriers have to be transmitted, one from the DSNG terminal, the other from a fixed station. Depending on the service requirements, various scenarios are possible, some of which require reduced communication capacity, others are more demanding (in terms of the number of required connections and up-link facilities). Figure 1 shows two examples of implementation of the co-ordination channels between the DSNG terminal, the broadcaster, the DSNG operator (when required) and the satellite operator:

Scenario A (two up-links for co-ordination carriers): the DSNG terminal and a central station (e.g. the broadcaster's fixed station) up-link a single co-ordination carrier each, containing U multiplexed circuits. In this scenario, the terrestrial infrastructure (e.g. PSTN) is used to forward the co-ordination circuits from the central station to the DSNG operator and the satellite operator and the co-ordination equipment at the DSNG terminal has to transmit and receive a single co-ordination carrier.

Scenario B (four up-links for co-ordination carriers): the DSNG terminal up-links a single co-ordination carrier, containing three multiplexed channels (U=3), while the broadcaster, the DSNG operator and the satellite operator up-link a total of three co-ordination carriers, each with a single circuit. In this scenario, the co-ordination equipment at the DSNG terminal has to transmit a single co-ordination carrier, and to receive three carriers at the same time.

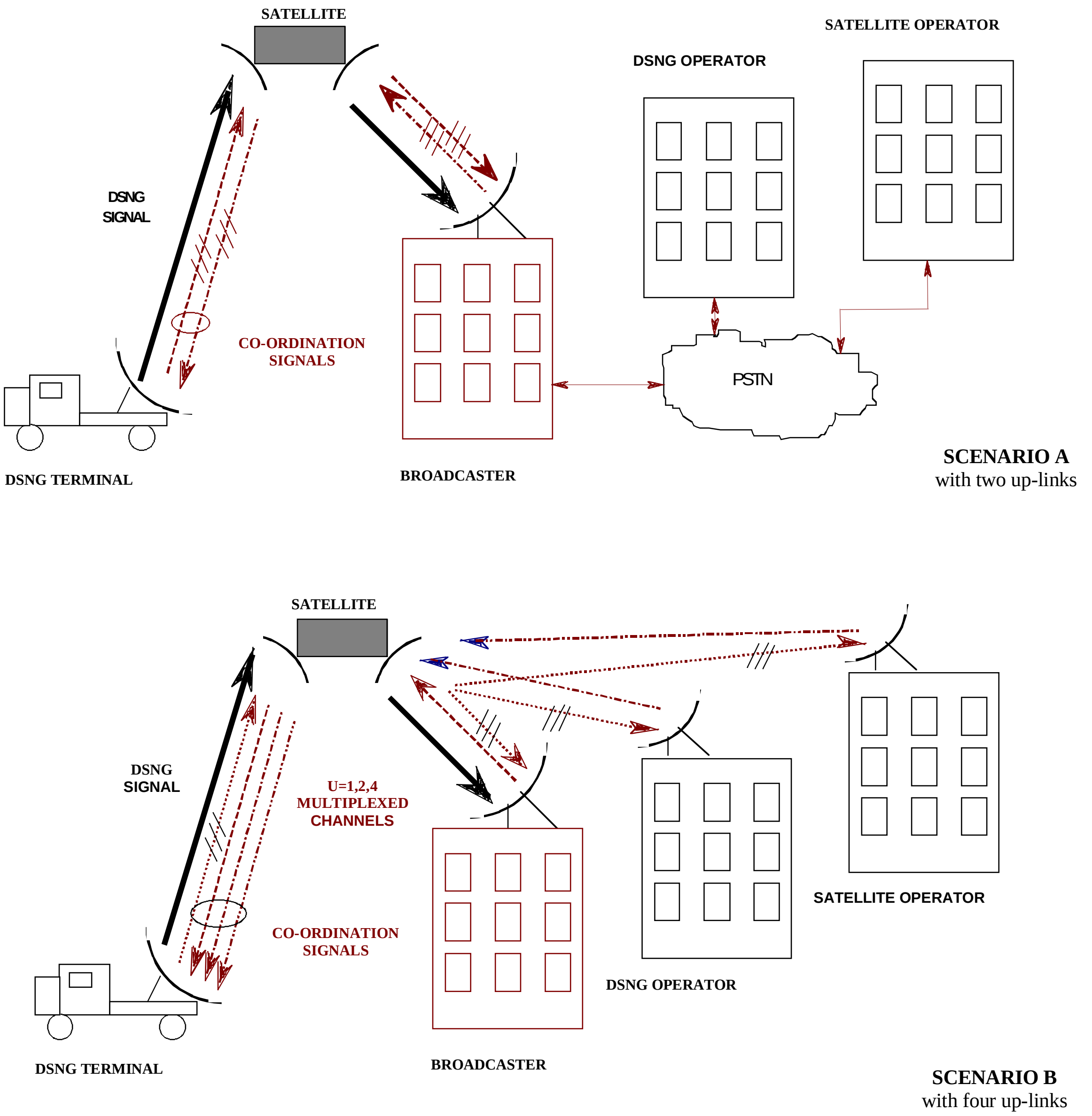


Figure 1: Example environments for DSNG and co-ordination transmissions by satellite

The present document describes the source coding (for voice and data), multiplexing, channel coding and modulation system (denoted as the "System" for the purposes of the present document) for the optional co-ordination (communication) channels by satellite associated with DSNG services. The integration of this System in a DSNG station shall be optional, since other communication systems (e.g. PSTN, cellular phones connected to terrestrial or satellite networks) may be used, according to the prevailing operational needs.

Maximum compatibility with existing ETSI and ITU standards is maintained. In particular voice coding is performed according ITU-T Recommendation G.729 [5] (see note), offering high voice quality at 8 kbit/s (i.e. better than ADPCM at 32 kbit/s).

Data transmission is performed in synchronous RS-422 format, at bit-rates of 8, 16, or 32 kbit/s. Optionally it may be performed in asynchronous RS-232 [7] format at a maximum bit-rate of 9,6; 19,2 or 38,4 kbit/s.

The System defined in the present document provides up to four full-duplex co-ordination (voice) channels at 8 kbit/s by satellite, or data capacity for other applications. A co-ordination channel may also convey FAXes. A fixed time-division multiplex allows the transmission of one, two or four 8 kbit/s channels producing an output bit-stream at 8,16 kbit/s, 2 × 8,16 kbit/s, 4 × 8,16 kbit/s, respectively. The multiplex provides a signalling byte which indicates the multiplex configuration to the receiver.

The system provides randomization for energy dispersal and inner convolutional coding (rate 1/2 only) for error correction, to achieve high ruggedness against noise and interference. Reed-Solomon coding and convolutional interleaving are not used in the System, as the target BER (10^{-3}) after FEC decoding is adequate for voice communication using ITU-R Recommendation G.729 [5], and additionally since they would generally introduce a large end-to-end delay which may cause problems on voice communications in DSNG applications.

Direct-Sequence Spread-Spectrum (DS-SS) processing is applied before Quaternary Phase Shift Keying (QPSK) modulation, generating a modulated signal whose bandwidth occupation is expanded and whose power spectral density level is reduced accordingly. DS-SS technique permits the superposition of a number of co-ordination signals in the frequency domain (Code Division Multiple Access, CDMA), using the same centre frequency. For example the scenarios in Figure 1 may be efficiently implemented by using this technique. For system simplicity, the spreading processes are asynchronous at each terminal, therefore the number of channels which may be superimposed is limited by mutual interference. Compared to conventional modulations, DS-SS techniques offer significant performance improvements in the presence of interferences (e.g. from and to co-channel narrow-band signals) and also produce less intermodulation noise density over a non linear transponder. DS-SS signals also require less frequency precision in the transmission/reception equipment.

The co-ordination carriers may be transmitted at a power level significantly lower than that of the DSNG carrier, since their bit-rate is typically some hundred times lower than the DSNG bit-rate, therefore they do not significantly modify the transponder operating point.

Flexible, user-definable frequency assignments may be used for the co-ordination channels, allowing the selection on a case-by-case basis of the best frequency division multiplex (FDM) configuration in the satellite transponder. For example, the System is capable of operating, if required, within the same frequency slot as the main DSNG signal, while keeping the level of mutual interference between the main DSNG signal and the co-ordination carriers at an acceptable level (see Annex D for further details). To achieve this, the co-ordination channels may be superimposed onto the main DSNG signal (e.g. same centre frequency), at the cost of some performance degradation due to mutual interference, which may be more or less critical depending on the modulation/coding scheme of the DSNG system and on the mutual signal levels. As an alternative, the co-ordination channels using a low spreading factor (e.g. 0,5 MHz or 1 MHz bandwidth occupation) may be allocated within the "roll-off" region of the DSNG signal, in order to reduce the mutual interference between co-ordination and DSNG signals. In other cases, a clear frequency slot may be allocated to co-ordination channels, on the same transponder as the DSNG signal, or even on another transponder/satellite, according to the service requirements.

The transmission parameters, such as the frequency, the symbol-rate and the spreading sequences are to be manually set-up in the co-ordination terminals; user definable configurations may be defined to simplify the link set-up (see Annex B).

The present document:

- gives a general description of the System;
- specifies source coding, multiplexing, channel coding and modulation of the signal, in order to allow compatibility between equipments developed by different manufacturers. This is achieved by describing in detail the signal processing principles at the transmitting side, while the processing at the receive side is left open to different implementation solutions. However, it is necessary in the present document to refer to certain aspects of reception;
- identifies the global performance requirements and features of the System, in order to meet the service quality targets.

NOTE: The adoption of Annex A of ITU-T Recommendation G.729 [5] is under evaluation. Comments are invited during the ETSI Public Enquiry.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] EN 300 421 (V.1.1.): "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services".

[2] EN 301 210: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for Digital Satellite News Gathering (SNG) and other contribution applications by satellite".

[3] ITU-R Recommendation SNG 770-1: "Uniform operational procedures for Satellite News Gathering (SNG)".

[4] ITU-R Recommendation SNG 771-1: "Auxiliary co-ordination satellite circuits for SNG terminals".

[5] ITU-T Recommendation G.729: "Coding of speech at 8 kbit/s using Algebraic-Coded-Excited Linear-Prediction (CS-ACELP)".

[6] ITU-T Recommendation V.11: "Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s".

[7] TIA/EIA RS-232: "Interface between data terminal equipment and data-circuit terminating equipment employing serial binary data interchange".

[8] 4 wire E&M, 2 wire E&M.

[9] ITU-T Recommendation G.711: "Pulse code modulation (PCM) of voice frequencies".

[10] ITU-T Recommendation G.712: "Transmission performance characteristics of pulse code modulation channels".

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the following symbols apply:

A	Interference power suppression of each co-ordination channel by the baseband filter of the DSNG receiver
a	Roll-off factor
C/N	Carrier-to-noise power ratio
dfree	Convolutional code free distance
Δ	Eb/N0 degradation at the target BEREb/N0 Ratio between the energy per useful bit and twice the two sided noise power spectral density
fN	Nyquist frequency
f0	Centre frequency of a modulated signal
G1,G2	Convolutional code generators

GLR,GLS	ML-sequence generators
GSS1, GSS2	Spreading sequences generators
Γ	Ratio of the spectrum density of the DSNG signal and of each co-ordination signal divided by the spreading factor L
H(f)	Baseband square root Raised Cosine filtering in the modulator
η	Modulation/coding spectral efficiency (bits per transmitted symbol)
I, Q	In-phase, Quadrature phase components of the modulated signal
K	Convolutional code constraint length
L	Spreading sequence length (Spreading Factor) (bit)
M	Number of co-ordination carriers transmitted in CDMA configuration
R	Useful bit-rate before multiplexer
Rs	Symbol rate corresponding to the bilateral Nyquist bandwidth of the modulated signal before spread-spectrum
Rs,chip	Chip symbol rate corresponding to the bilateral Nyquist bandwidth of the modulated signal after SS
Ru	Useful bit-rate after multiplexer, before channel encoder
Ts	Period of unspread symbol
Ts,chip	Period of the spread symbol, equal to 1/ Rs,chip
U	Number of channels at the MUX input (U = 1, 2, 4)
X,Y	Di-bit stream after rate 1/2 convolutional coding

The sub-script "COOR" refers to the co-ordination signals.

The sub-script "DSNG" refers to the main DSNG signal.

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

AWGN	Additive White Gaussian Noise
BB	Baseband
BER	Bit Error Ratio
BS	Bandwidth of the frequency Slot allocated to a service
BW	Bandwidth (at -3 dB) of the transponder
CCITT	International Telegraph and Telephone Consultative Committee
CDMA	Code Division Multiple Access
DEMUX	De-multiplexer
DSNG	Digital Satellite News Gathering
DS-SS	Direct-Sequence Spread-Spectrum
DTH	Direct To Home
EBU	European Broadcasting Union
ETS	European Telecommunication Standard
FDM	Frequency Division Multiplex
FEC	Forward Error Correction
FIFO	First-in, First-out shift register
FSS	Fixed Satellite Service
HEX	Hexadecimal notation
IBO	Input Back Off
IF	Intermediate Frequency
IMUX	Satellite transponder Input Multiplexer - Filter
IRD	Integrated Receiver Decoder
ITU	International Telecommunications Union
MPEG	Moving Pictures Experts Group
MSB	Most Significant Bit
MUX	Multiplex
OBO	Output Back Off
OCT	Octal notation
OMUX	Satellite transponder Output Multiplexer – Filter
PCM	Pulse-Code Modulation
ppm	parts per million

PRBS	Pseudo Random Binary Sequence
PSTN	Public Switched Telephone Network
QPSK	Quaternary Phase Shift Keying
RF	Radio Frequency
SNG	Satellite News Gathering
SS	Spread Spectrum
TBD	To Be Defined
TDM	Time Division Multiplex
TV	Television
TWTA	Travelling Wave Tube Amplifier
8PSK	Octonary Phase Shift Keying
16QAM	16 points Quadrature Amplitude Modulation

4 System definition

The integration of this System in a DSNG station shall be optional, since other communication systems (e.g. PSTN, portable phones connected to terrestrial or satellite networks) may be used, according to the operational needs.

The co-ordination channels for DSNG applications consist of bi-directional (full-duplex) connections, therefore a transmitting and a receiving unit is necessary both at the DSNG up-link terminal, and at the fixed station(s).

The System is defined as the functional block of equipment performing voice coding, data transport, service multiplexing, channel coding and modulation to achieve adaptation to the satellite channel characteristics. With reference to Figure 2, the external interfaces of the System shall be interface A (baseband interface) and interface C (Intermediate frequency interface). In Figure 2, the functional blocks "power and frequency adaptation" and the combiner with the DSNG signal are not specified. Implementation of these is left to equipment designers. (Annex D gives user guidelines for the use of the co-ordination channels). Interface B is an internal synchronous interface but it can be made externally available as an option.

In particular, the following processes shall be applied to the data stream (see Figure 2):

- Voice coding at 8 kbit/s according to ITU-T Recommendation G.729 [5].
- Data coding (Optional).
- Multiplexing and framing.
- Multiplex adaptation and signal randomization for energy dispersal.
- Rate 1/2 convolutional inner coding with constraint length 7, according to EN 300 421 [1].
- Direct-Sequence Spread-Spectrum (DS-SS) processing (with five possible spreading factors: L=31, 63, 127, 255 and 511).
- Bit mapping into QPSK constellation, according to EN 300 421 [1].
- Square-root raised cosine baseband shaping (roll-off factor a=0,35), according to EN 300 421 [1].
- Quadrature modulation, according to EN 300 421 [1].

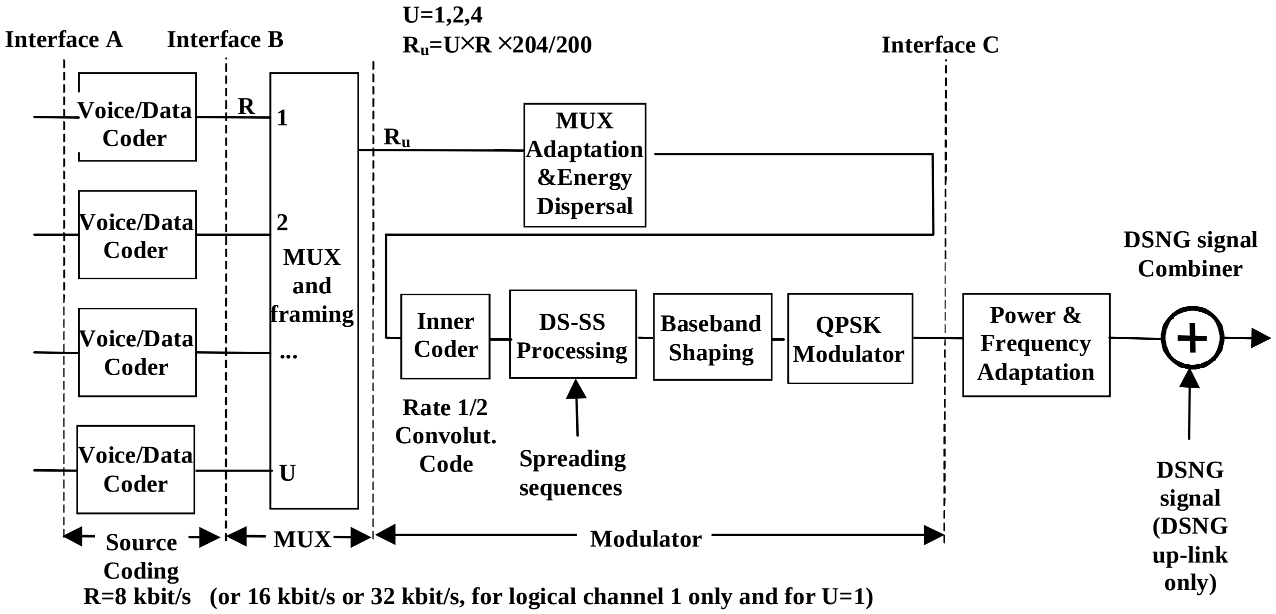


Figure 2: Functional block diagram of the System

5 Source coding and interfaces

5.1 Voice coding

Voice coding shall follow ITU-T Recommendation G.729 [5] at 8 kbit/s. This coder is designed to operate with a digital signal obtained by first performing telephone bandwidth filtering (ITU-T Recommendation G.712 [10]) of the analogue input signal, then sampling it at 8 kHz, followed by conversion to 16-bit linear PCM for the input to the encoder. Following ITU-T Recommendation G.729 [5] other input characteristics, such as those specified by ITU-T Recommendation G.711 [9] for 64 kbit/s PCM data, should be converted to 16-bit linear PCM before encoding. The bitstream at the encoder output is defined by ITU-T Recommendation G.729 [5].

This coding algorithm is transparent also to FAX signals, encoded according to ITU-T Recommendation (TBD).

Interface A (input of voice coder) shall be: 4-wire E&M, 2-wire E&M, Group 3 FAX [8]. The output of the voice coder is according to interface B as defined in Clause 6.

NOTE: Echo cancellation may be implemented in the receiver to overcome the effects on voice signals of the satellite transmission delay.

5.2 Data coding (Optional)

Transparent synchronous data streams at bit-rates of 8 kbit/s (logical channel 1, 2, 3, 4), 16 or 32 kbit/s (logical channel 1 only) may be directly input to interface B. When externally available interface B (input of MUX) shall be synchronous serial RS-422 (Clock and data). The clock shall be synchronous on the U MUX inputs (U=1,2,4). The clock frequency shall be 8 kHz (or 16 kHz or 32 kHz for logical channel 1 only), with a precision of ± 10 ppm.

Data coding shall adapt serial asynchronous RS-232 [7] signals at different bit-rates at interface A, to the synchronous stream at interface B.

In the cases of bit-rates of 8, 16 or 32 kbit/s at interface B, interface A (input to data encoder) shall be asynchronous RS-232 [7] at bit-rates up to 9,6; 19,2 or 38,4 kbit/s, respectively. The input characters shall be composed by 1 start bit, 8 data bits (1 byte), 1 parity bit (even parity), 1 stop bit.

The data encoder shall remove the start, parity and stop bits of the RS-232 [7] characters. The synchronous stream at interface B shall be composed of "sections" of 25 bytes, delimited (at the beginning and at the end) by inverted or non-inverted reference-bytes to form 27-byte packets. The sections can be classified into two types:

- "transport sections", delimited by R = 11110000 (binary notation) reference-bytes;
- "counter sections", delimited by $\underline{R}$ = 00001111 (binary notation) inverted reference-bytes.

The transport sections shall be filled by the useful bytes (after elimination of start, parity and stop bits), starting from the first transmitted byte following the reference-byte. In the case there are not sufficient input bytes to fill a 25-byte section, the section shall be completed by E padding bytes, corresponding to P = 01001101 (binary notation). A partially or totally empty transport section shall be followed by the relevant "counter section". A transport section totally filled by useful bytes shall be followed by another transport section, thus avoiding efficiency losses when the maximum capacity is required.

A counter section shall contain a repeated counter-byte E signalling the number of empty bytes of the preceding transport section. E shall be coded in binary format (e.g. E = 0000 0011 means 3 empty bytes in the previous transport section). To increase the reception reliability in the presence of transmission errors, the counter-byte E shall be repeated 13 times in the section, interleaved with inverted padding bytes $\underline{P}$ = 10110010 (binary notation). The configurations E = 0 (full transport section) and E > 25 (decimal notation) are not permitted.

A counter section shall have the structure:

$\underline{R}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{P}$ | E | $\underline{R}$

NOTE 1: The data coding protocol allows reliable reconstruction of the RS-232 [7] characters (e.g., elimination of "padding bytes" and of "counter sections") in the receiver also in presence of burst errors after Viterbi decoding. In fact the "counter sections" are characterized by the presence of two inverted reference-bytes $\underline{R}$ and of 12 inverted padding-bytes $\underline{P}$, the counter-byte E is repeated 13 times and the padding bytes P in the transport section are known a priori by the receiver.

NOTE 2: Data coding according to this section reduces the bit-rate of an input data stream at 9,6 kbit/s to 9,6 x (8/11) x (27/25) = 7,54 kbit/s, compatible to the minimum capacity at interface B (i.e., 8 kbit/s - 10 ppm = 7,99992 kbit/s), with an additional tolerance of about 6% on the RS-232 [7] clock. Similar tolerances apply to the bit-rates of 19,2 and 38,4 kbit/s.

5.3 Signalling

For connection to the PSTN, voice-band signalling may be carried out using multi-frequency (MF) devices.

6 Multiplexing and interfaces

The multiplex shall provide U synchronous input channels at 8 kbit/s (U = 1, 2, 4) or one input channel (logical channel 1) at 16 kbit/s or at 32 kbit/s. Multiplexing of the U input channels shall be carried out by taking one byte per signal, starting from logical channel 1 to logical channel U.

For easy synchronization acquisition in the receiver (de-multiplexer, and QPSK phase ambiguity removal), the multiplexed data stream shall be framed in packets of 200 payload bytes, the first of which being a byte from logical channel 1, the I-th from logical channel I.

A two-byte Sync Word ($47B8_{HEX}$), plus one byte for signalling MUX configuration to the receiver and one spare byte (not defined, for future applications) shall be inserted at the beginning of each 200-byte packet, to obtain a 204-byte packet.

The MUX configuration signalling byte shall have the format b_0 b_1 b_2 b_3 b_4 b_5 b_6 b_7, where bits $b_{2\cdot(I-1)}$ $b_{2\cdot I-1}$ (I = 1, 2, 3, 4) refer to channel I, and shall have the following values and meaning:

$b_{2\cdot(I-1)}$ $b_{2\cdot I-1}$ = 0 0 = channel I not used;

0 1 = voice transmission (interface A);

1 0 = Synchronous data transmission, RS-422 format at interface B;

1 1 = Asynchronous data transmission, RS-232 [7] format at interface A.

The MUX configuration shall be static during a transmission. No error protection is inserted on the signalling byte since, due to its static nature and the repetitive transmission on each packet, it may be correctly recovered in presence of errors (for example, by multiple acquisition and majority logic decoding).

The output bit-rate of the MUX shall be R_u = U x (204/200) x R, where:

R = 8 kbit/s, 16 kbit/s or 32 kbit/s (for logical channel 1 when U = 1).

R = 8 kbit/s (for logical channels 1, 2, when U = 2; for logical channels 1, 2, 3, 4 when U = 4). Interface B (input to the MUX) shall be an internal interface or optionally shall be made externally available using synchronous serial RS-422 (clock and data) according to ITU-T Recommendation V.11 [6] using 25 pin D connectors. The clock shall be synchronous on the U inputs (U = 1,2,4). The clock frequency shall be 8 kHz; when U = 1 the additional rates 16 kHz or 32 kHz may be used on logical channel 1. A clock precision of 10 ppm is required at interface B, since it determines the modulation symbol rate.

7 Transmission system and interfaces

The transmission system shall be delimited by the following interfaces given in Table 1:

Table 1: Transmission system interfaces

Equipment type	Interface	Interface type	Connection
Transmit	Input	Internal at R_u	from MUX
	Output (interface C)	70/140 MHz IF, L-band IF, RF	to IF or RF devices
Receive	Input	70/140 MHz IF, L-band IF, RF	from IF or RF devices
NOTE: R_u = U x (204/200) x R kbit/s, where R = 8 kbit/s (in addition R = 16 kbit/s or 32 kbit/s for logical channel 1 only, when U = 1).			

7.1 Randomization for energy dispersal

In order to comply with ITU Radio Regulations and to ensure adequate binary transitions, the data stream at the output of the MUX unit shall be bit-by-bit randomized. The polynomial of the PRBS generator shall be (see the scheme of Figure 3 according to EN 300 421 [1]):

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

The processing order at the transmitting side shall always start from the Most Significant Bit (MSB) of the incoming serial byte sequence, and the Sync Word shall be inserted so that the MSB (i.e. bit 0 of the 01000111 byte) is processed first. The randomizer shall be loaded with the initialization sequence "1001 0101 0000 000" sequence at the beginning of each 204 byte packet. The first bit at the output of the PRBS generator shall be applied to the first bit (MSB) of the first byte following the Sync Word. The Sync Word shall not be randomized. The randomization process shall be active also when the modulator input bit-stream is non-existent.

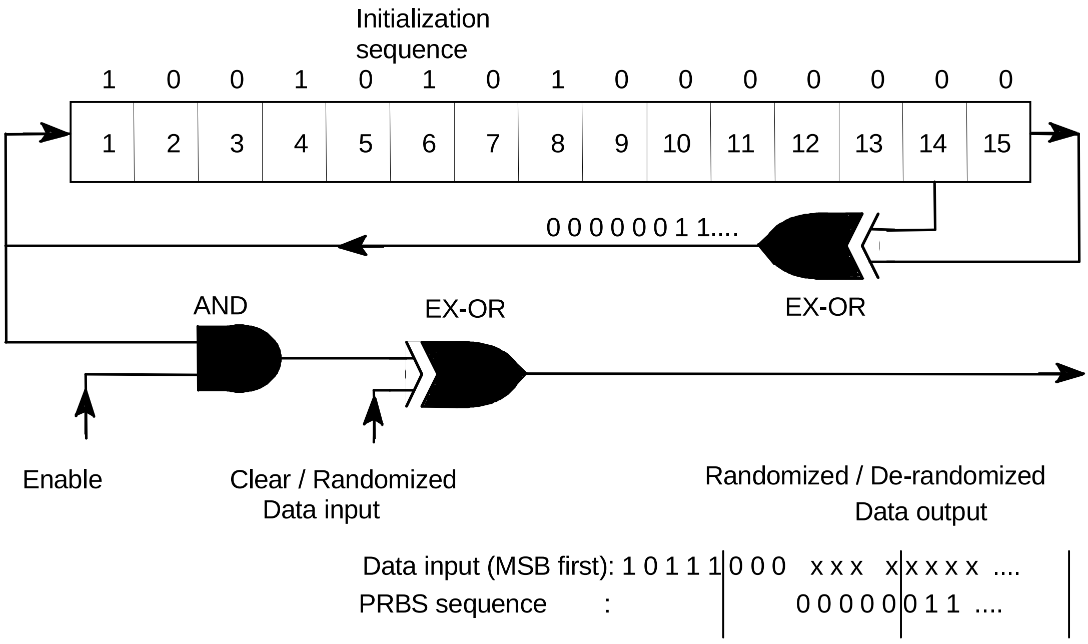


Figure 3: Randomizer / de-randomizer schematic diagram

7.2 Inner coding (convolutional)

The System shall use a rate 1/2 convolutional code, with constraint length K = 7 corresponding to 64 trellis states (Figure 4) and $d_{free} = 10$, according to EN 300 421 [1] and EN 301 210 [2] (only rate 1/2 shall be used). The code generator polynomials shall be:

G_1 = 171 (OCT) X output, I -Branch;

G_2 = 133 (OCT) Y output, Q-Branch.

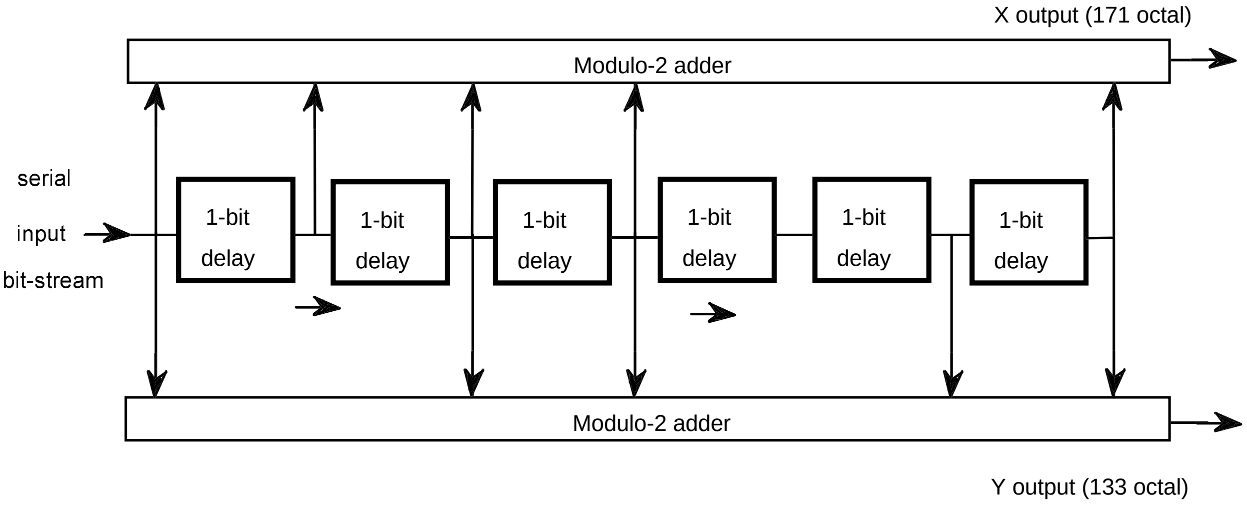


Figure 4: Principle scheme of the rate 1/2 convolutional code

7.3 Spread Spectrum

Direct-Sequence Spread-Spectrum (DS-SS) coding shall be applied to the output data stream of the convolutional encoder. According to Figure 5, DS-SS shall consist of multiplying (digital EX-OR) each symbol of duration TS by a defined binary sequence of length L (spreading factor). The duration of the symbol of the spreading sequence, i.e. the "chip", shall be $T_{S,chip}$, where $T_{S,chip}$ = TS / L (T_s being the symbol duration of the unspread sequence). Therefore the data rate and also the RF bandwidth are increased by the factor L. Independent spreading sequences shall be applied to the I-Branch and to the Q-Branch (dual BPSK mode), in order to minimize possible I-Q cross-talk effects.

Figure 5 shows the basic principle of Direct-Sequence Spread-Spectrum coding.

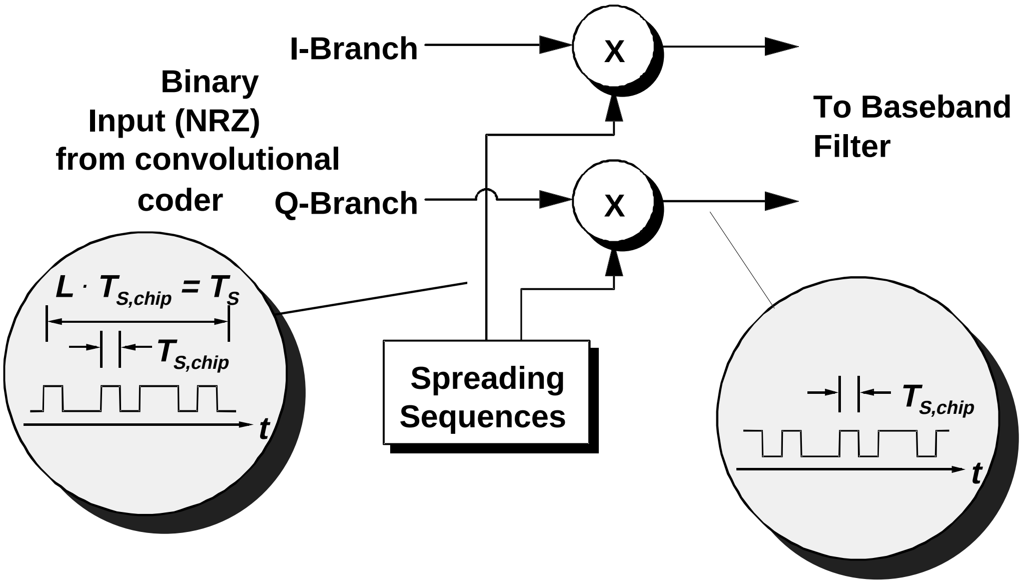


Figure 5: Basic principle of Direct-Sequence Spread-Spectrum coding

The System shall implement five spreading factors, L = 31, 63, 127, 255 and 511 in order to offer flexibility in spectrum occupation. The relevant bandwidth occupations (at -3 dB after baseband filtering), corresponding also to the chip symbol rates, is $R_{S,chip} = L\ R_S$. Table 2 gives the bandwidth occupation versus the number of channels U and the spreading factor L.

Table 2: Bandwidth occupation [MHz] at –3 dB

	Data rates at interface B	L = 31	L = 63	L = 127	L = 255	L = 511
U=1	8 kbit/s (note)	0,25296	0,51408	1,03632	2,08080	4,16976
U=2	16 kbit/s	0,50592	1,02816	2,07264	4,16160	8,33952
U=4	32 kbit/s	1,01184	2,05632	4,14528	8,32320	Not allowed
NOTE: When bit-rates of 16 kbit/s and 32 kbit/s are used at logical channel 1 (for U=1), the bandwidth figures relevant to U=2 and U=4 apply, respectively.						

The spreading sequences are based on ML-sequences (ML = Maximum Length) and Gold-sequences. For each of the spreading lengths L, two ML-sequences $R_L(n)$ and SL(n), produced by the generator polynomials GLR(x) and GLS(x), shall be used, according to Table 3.

Table 3: Generator polynomials of the adopted ML-sequences

Spread. Factor L	Seq.	Generator Polynomial (note) $G_{LR}(x)$ (OCT)	Initial value (OCT)	Seq.	Generator Polynomial (note) $G_{LS}(x)$ (OCT)	Initial value (OCT)
31	$R_{31}(n)$	45	1	$S_{31}(n)$	67	35
63	$R_{63}(n)$	103	1	$S_{63}(n)$	147	32
127	$R_{127}(n)$	211	1	$S_{127}(n)$	277	177
255	$R_{255}(n)$	435	1	$S_{255}(n)$	675	222
511	$R_{511}(n)$	1021	1	$S_{511}(n)$	1333	733
NOTE: Highest degree term on the left.						

Figure 6 represents the schematic diagram of the shift register implementing the generator of sequence $R_{127}(n)$. Table 4 gives for each generator polynomial and initial value the first two output bytes of the generated sequence.

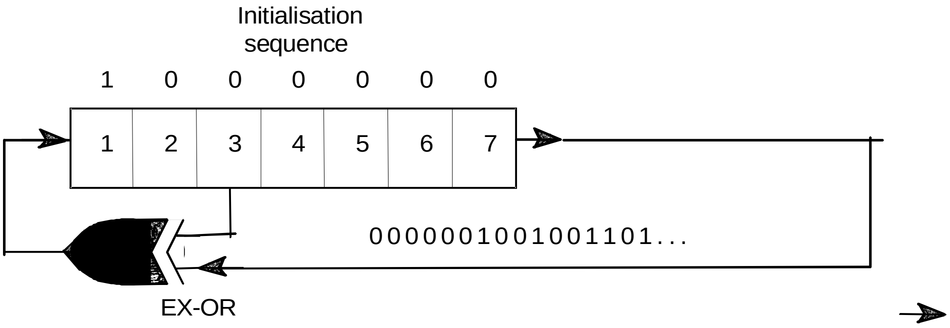


Figure 6: Schematic diagram of the shift register implementing the sequence generator $R_{127}(n)$

Table 4: First two output bytes for each generator polynomials of the adopted ML-sequences

Seq.	First two output bytes (binary, first bit on the left)
R_{31} (n)	0 0 0 0 1 0 1 0 1 1 1 0 1 1 0 0
$S_{31}(n)$	1 1 1 0 1 1 0 0 1 1 1 0 0 0 0 1
$R_{63}(n)$	0 0 0 0 0 1 1 1 1 1 1 0 1 0 1 0
$S_{63}(n)$	0 1 1 0 1 0 0 0 1 0 0 0 0 1 0 1
$R_{127}(n)$	0 0 0 0 0 0 1 0 0 1 0 0 1 1 0 1
$S_{127}(n)$	1 1 1 1 1 1 1 0 1 1 1 1 1 0 0 0
$R_{255}(n)$	0 0 0 0 0 0 0 1 0 1 1 0 0 0 1 1
$S_{255}(n)$	1 0 0 1 0 0 1 0 1 1 1 0 1 0 0 1
$R_{511}(n)$	0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 0
$S_{511}(n)$	1 1 1 0 1 1 0 1 1 0 1 0 0 1 1 0

To implement a number of bi-directional co-ordination channels, Gold-sequences shall be adopted, produced by fixing the $R_L(n)$ ML-sequence, and performing a bit-by-bit EX-OR (indicated as * in the following formulas) with the SL(n + i) ML-sequence, corresponding to the SL(n) sequence cyclically shifted by i positions (i = 0, 1, 2,...). The sequences shall be used according to Table 5. In the third column, the mnemonics designing the sequences (e.g., 1FIL(n)) have the following meaning (in order): logical channel #, Forward/Backward; I/Q modulator branch; L = spreading factor. Forward means from the DSNG terminal to the Fixed station, Backward means from the Fixed station to the DSNG terminal.

Table 5: Adopted SS sequences

DS-SS channel #	**Link type**	**Modulator I-Branch**	**Modulator Q-branch**
1	Forward (DSNG->Fixed)	$1FI_L(n) = R_L(n)$ (note 1)	$1FQ_L(n) = S_L(n)$ (note 2)
	Backward (Fixed->DSNG)	$1BI_L(n) = R_L(n) \ast S_L(n)$	$1BQ_L(n) = R_L(n) \ast S_L(n + 1)$
2	Forward/Backward (note 3)	$2FI_L(n) = R_L(n) \ast S_L(n + 2)$	$2FQ_L(n) = R_L(n) \ast S_L(n + 3)$
	Backward	$2BI_L(n) = R_L(n) \ast S_L(n + 4)$	$2BQ_L(n) = R_L(n) \ast S_L(n + 5)$
3	Forward	$3FI_L(n) = R_L(n) \ast S_L(n + 6)$	$3FQ_L(n) = R_L(n) \ast S_L(n + 7)$
	Backward	$3BI_L(n) = R_L(n) \ast S_L(n + 8)$	$3BQ_L(n) = R_L(n) \ast S_L(n + 9)$
j	Forward	$jFI_L(n) = R_L(n) \ast S_L[n + 4j - 6)$	$jFQ_L(n) = R_L(n) \ast S_L(n + 4j - 5)$
(for j>1)	Backward	$jBI_L(n) = R_L(n) \ast S_L(n + 4j - 4)$	$jBQ_L(n) = R_L(n) \ast S_L(n + 4j - 3)$

NOTE 1: ML-sequence generated by $G_{LR}(x)$.
NOTE 2: ML-sequence generated by $G_{LS}(x)$.
NOTE 3: Channel 2 may be a backward channel to implement scenario B in Figure 1.

The maximum number of DS-SS carriers (uni-directional links) sharing the same RF bandwidth shall be $2j_{max} = 4$ for L = 31, $2j_{max} = 8$ for L = 63, $2j_{max} = 16$ for L = 127, $2j_{max} = 32$ for L = 255 and $2j_{max} = 64$ for L = 511 (see note).

NOTE: the limitation on the number j_{max} of usable sequences is fixed in order to maintain the mutual interference between asynchronous DS-SS channels at an acceptable level (C/N degradation lower than 1,5 dB). In order to optimize the co-ordination channels' performance, their number should be kept as low as the operational requirements permit. The mutual interference between DS-SS channels may be reduced by synchronizing the spreading sequences and the carriers (see Annex E Bibliography 4). This can be easily achieved when the carriers are generated at the same location and the modems are suitably designed.

7.4 Bit mapping, baseband shaping and modulation

7.4.1 Bit mapping to QPSK constellation

The System shall employ conventional Gray-coded bit mapping into QPSK constellation with absolute mapping (no differential coding) in accordance with EN 300 421 [1] (Figure 7). If the normalization factor 1/√2 is applied to the I and Q components, the corresponding average energy per symbol becomes equal to 1.

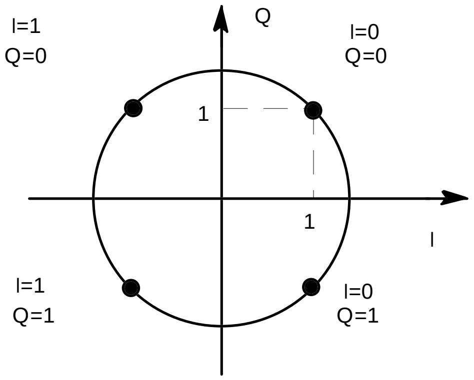


Figure 7: Bit mapping into QPSK constellation

7.4.2 Baseband shaping and quadrature modulation

Prior to modulation, the I and Q signals (mathematically represented by a succession of Dirac delta functions, multiplied by the amplitudes I and Q, spaced by the chip symbol duration $T_{S,chip} = 1/R_{S,chip}$) shall be square root raised cosine filtered. The roll-off factor shall be $\alpha = 0{,}35$.

The baseband square root raised cosine filter shall have a theoretical function defined by the following expression:

$$\mathrm{H}(\mathrm{f}) = 1 \text{ for } |f| < f_N(1-\alpha)$$

$$H(f) = \left\{\frac{1}{2} + \frac{1}{2}\sin\frac{\pi}{2f_N}\left[\frac{f_N - |f|}{\alpha}\right]\right\}^{1/2} \text{ for } f_N(1-\alpha) \le |\mathrm{f}| \le f_N(1+\alpha)$$

$$H(f) = 0 \text{ for } |f| > f_N(1+\alpha),$$

where

$$f_N = \frac{1}{2T_{S,chip}} = \frac{R_{S,chip}}{2}$$ is the Nyquist frequency and α is the roll-off factor.

A template for the signal spectrum at the modulator output is given in Annex A.

8 Error performance requirements

The modem, connected in IF loop, shall meet the BER versus E_b/N_o performance requirements given in Table 6.

Table 6: IF-Loop performance of the System

Modulation	Convolutional code rate	Spectral efficiency Before spreading (bit/symbol)	Required E_b/N_0 [dB] for BER = 10^{-3}
QPSK	1/2	0,9804	3,6
NOTE: The figure of E_b/N_0 is referred to the bit-rate after Viterbi decoding (i.e., R_u) and include a modem implementation margin of 0,8 dB.			

BER levels up to 10^{-3} may be tolerated by voice services. Lower BER levels may be required for some data services; in this cases additional error protection may be applied externally to the modem.

Examples of possible use of the System are given in Annex D.

Annex A (normative): Signal spectrum at the modulator output

The signal spectrum at the modulator output ideally correspond to a roll-off factor α = 0,35.

Figure A.1 gives a template for the signal spectrum at the modulator output.

Figure A.1 also represents a possible mask for a hardware implementation of the Nyquist modulator filter as specified in subclause 7.4.2. The mask for the filter frequency response is based on the assumption of ideal Dirac delta input signals, spaced by the symbol period $T_{s,chip} = 1/R_{s,chip} = 1/2f_N$, while in the case of rectangular input signals a suitable x/sin x correction shall be applied on the filter response.

Figure A.2 gives a mask for the group delay for the hardware implementation of the Nyquist modulator filter.

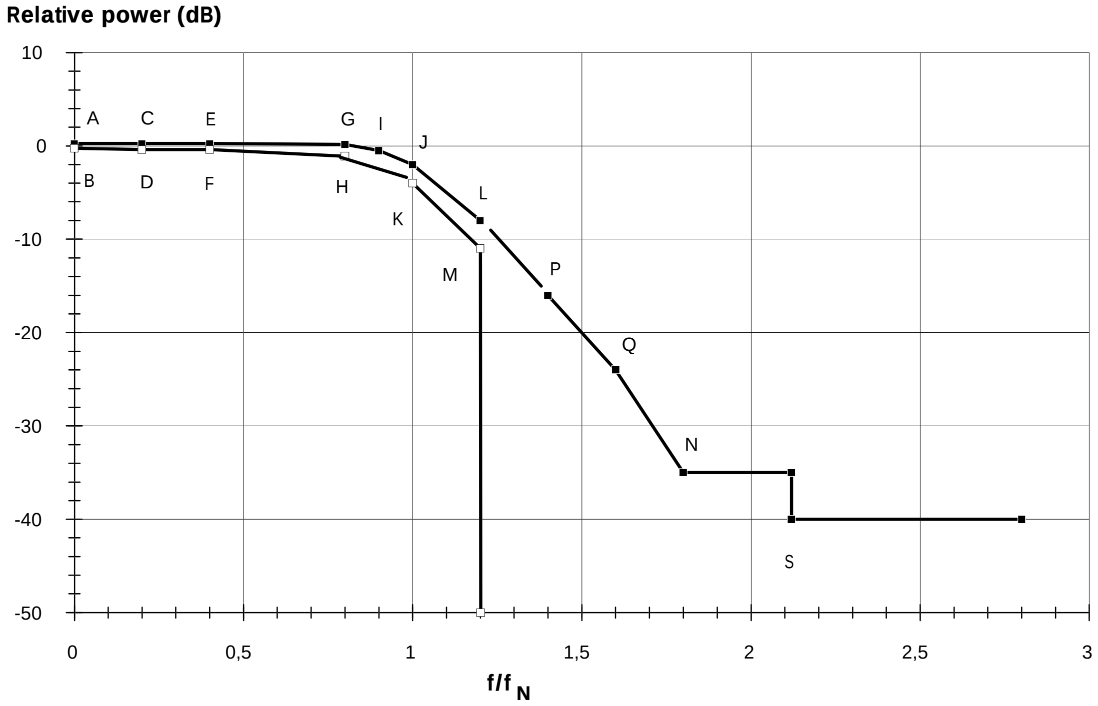


Figure A.1: Template for the signal spectrum mask at the modulator output represented in the baseband frequency domain

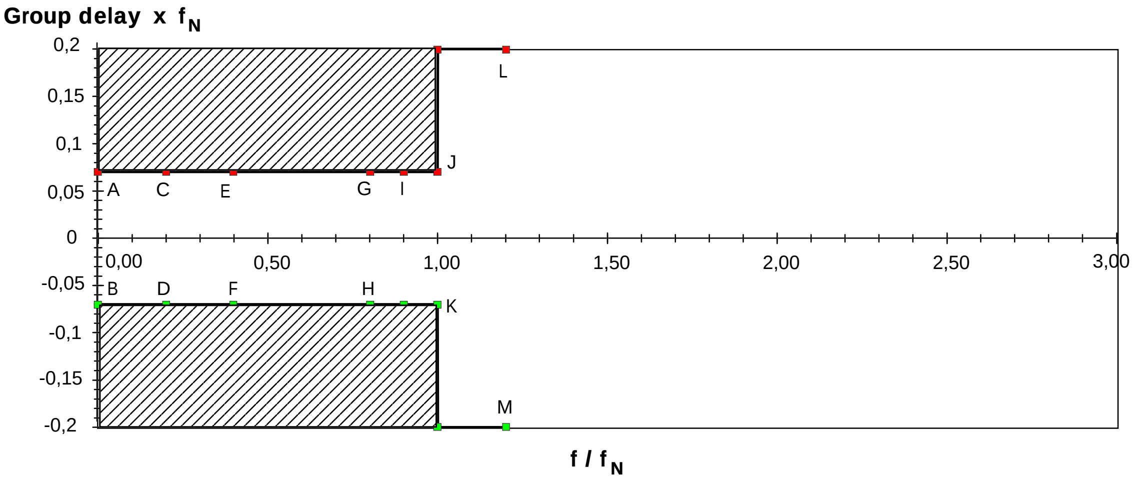


Figure A.2: Template of the modulator filter group delay

Table A.1: Definition of points given in Figures A.1 and A.2

Point	Frequency For α=0,35	Relative power (dB)	Group delay
A	0,0 f_N	+0,25	+0,07 / f_N
B	0,0 f_N	-0,25	-0,07 / f_N
C	0,2 f_N	+0,25	+0,07 / f_N
D	0,2 f_N	-0,40	-0,07 / f_N
E	0,4 f_N	+0,25	+0,07 / f_N
F	0,4 f_N	-0,40	-0,07 / f_N
G	0,8 f_N	+0,15	+0,07 / f_N
H	0,8 f_N	-1,10	-0,07 / f_N
I	0,9 f_N	-0,50	+0,07 / f_N
J	1,0 f_N	-2,00	+0,07 / f_N
K	1,0 f_N	-4,00	-0,07 / f_N
L	1,2 f_N	-8,00	-
M	1,2 f_N	-11,00	-
N	1,8 f_N	-35,00	-
P	1,4 f_N	-16,00	-
Q	1,6 f_N	-24,00	-
S	2,12 f_N	-40,00	-

Annex B (normative): Transmission setups

The centre frequency and the power level of the co-ordination channels shall be selectable by the operator, in order to allow flexible access to the satellite frequency resources, including the superposition of the co-ordination channels to the main DSNG signal, or the exploitation of the roll-off part of the DSNG spectrum, or the use of frequency slots specifically assigned to co-ordination channels.

At least one user definable frequency and power set-up shall be provided by the co-ordination channel equipment, to facilitate rapid link set-up in emergency situations. This frequency and power set-up shall be easily selectable in the equipment.

NOTE 1: For frequencies, bit-rates and symbol rates, typical accuracy is ± 10 ppm. For RF carriers higher accuracy may be required when low spreading factors are adopted.

NOTE 2: When the co-ordination signals are superimposed to the main DSNG signal, the power ratios of the DSNG and co-ordination channels have to be maintained at a suitable level, in order to guarantee the mutual performance (see Annex D). Furthermore, the co-ordination carriers have to be maintained at balanced power level (within about 2 dB at the receiver input), in order to guarantee a low level of mutual interference.

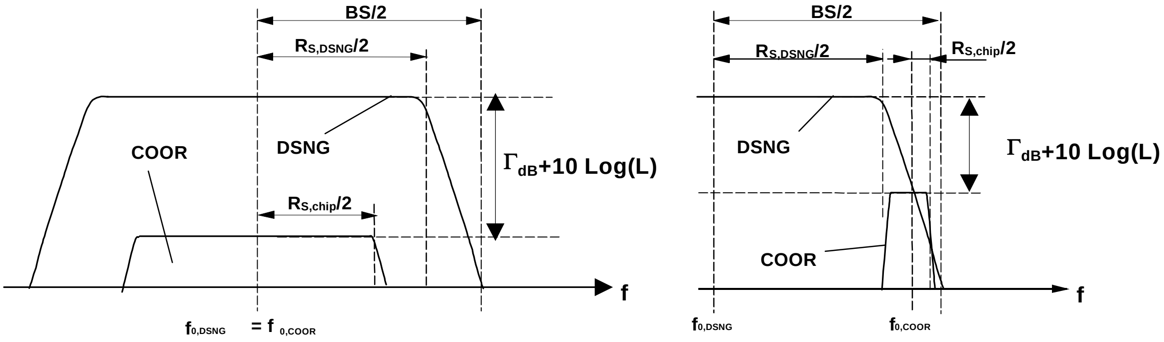
Annex C (normative): Implementation of "optional" features

Within the present document, a number of features has been defined as "optional". For example data coding is optional. Features explicitly indicated as "optional" within the present document need not be implemented in the equipment to comply with the present document. Nevertheless, when an optional feature is implemented, it shall comply with the specification as given in the present document.

Annex D (informative): Examples of possible use of the System

A DSNG transmission may consist of the main DSNG signal, compliant with the DSNG specification [2] plus various co-ordination signals (full-duplex links). Different frequency allocations may be adopted for the co-ordination channels, depending on the available bandwidth, spectrum occupation of the main DSNG transmission, number of co-ordination channels, and other service requirements. The co-ordination signals may be placed in a clear frequency slot of the transponder, and in this case no co-channel interference to and from the DSNG signal is present, but only the mutual interference among the co-ordination channels (in addition to the typical interferences in the transponder). As an alternative, they can share the same frequency slot (bandwidth BS) as the DSNG signal, accepting some performance degradation for both the co-ordination signals and the DSNG signal. In this latter case (see Figure D.1), the co-ordination signals may be superimposed to the DSNG signal or may be placed in its roll-off region, in order to reduce the mutual interference. The superimposed configuration may have the operational advantage to use the same centre frequency for the DSNG carrier ($f_{0,DSNG}$) as for the co-ordination carriers ($f_{0,COOR}$), while the roll-off configuration may have the advantage to reduce the mutual interference between DSNG and co-ordination signals, thus allowing better RF performance.

The co-ordination channels sharing the same DSNG frequency slot may use different bit-rates, spreading sequences and spectral density levels, according to the operational requirements. Nevertheless the number of co-ordination channels should be maintained as low as the operational requirements permit, in order to limit the mutual DSNG/co-ordination channels interference. Furthermore to guarantee an adequate mutual signal to interference ratio due to the other co-ordination channels, the different co-ordination channels should be kept at the same spectral density level.



NOTE: The E_b/N_0 ratios displayed by demodulators are usually evaluated from BER measurements. Therefore they refer to an effective $E_b/(N_0 + I_0)$ ratio, where I_0 is the equivalent spectral density of the interfering signals (e.g., the co-ordination channels) and N_0 the spectral density of the thermal noise. As a consequence, in the presence of co-ordination channel interference, care should be taken by the operators while evaluating the real thermal noise margin and allowed rain attenuation of the link.

Figure D.1: Possible frequency allocations of the co-ordination signals in the DSNG frequency slot: (left) superimposed to the DSNG signal; (right) in the roll-off region of the DSNG signal

To estimate, to a first approximation, the impact of the co-ordination channels on the DSNG signal performance, the following hypotheses have been adopted: (a) the transponder is operated in a quasi linear mode; (b) the interference of the DSNG signal on the co-ordination channels (and vice-versa) and the co-ordination channel interference due to the other co-ordination channels is equivalent to Gaussian noise of the same power. The latter approximation may be slightly pessimistic compared to digitally modulated signals, and applies under the assumption of non-synchronized and therefore non-orthogonal spreading sequences. In this case the co-ordination channel signal to interference ratio due to the other co-ordination channels can be approximated by the power ratio L/(M-1), where L indicates the spreading factor and M the number of co-ordination carriers in CDMA (ref. 4 Annex E). (When the co-ordination channels are synchronized, the signal to interference power ratio can be approximated by the ratio $L^2/(M-1)$).The E_b/N_0 performance degradation of the main DSNG signal Δ_{DSNG}, due to the co-ordination channel interference, can be computed with the formulae:

$$\Delta_{DSNG} = \rho_{DSNG} / (\rho_{DSNG} - 1)$$

$$\rho_{DSNG} = R_{DSNG}\, A^2/(M\, R_{COOR}\, (E_b/N_0)_{COOR}\, (E_b/N_0)_{DSNG}\, \rho_{COOR}\, \eta^2{}_{DSNG})$$

$$\rho_{COOR}{}^{-1} = 1 - \Delta_{COOR}{}^{-1} - ((L/(M-1)) / (E_b/N_0)_{COOR})^{-1}$$

where M indicates the number of communication carriers (M = 2 corresponds to a single full-duplex connection), R_{DSNG} and R_{COOR} the useful bit-rate for the main and co-ordination signals respectively, η_{DSNG} the modulation/coding spectral efficiency (bit/symbol) of the DSNG signal, Δ_{COOR} the E_b/N_0 performance degradation of the co-ordination signal, ρ is a parameter related to the ratio between C/N and C/I. A is the mutual interference power suppression of the DSNG and each co-ordination channel due to the baseband filtering in transmitters and receivers, assuming matched filters (see Figure A.1) (A = 1 for co-ordination signals superimposed to the DSNG signal). The factor A may be computed by using the formula:

$$A = \frac{1}{R_{S,COOR}} \int_{-\infty}^{\infty} H^2_{DSNG}(f) \quad H^2_{COOR}[f - (f_{0,DSNG} - f_{0,COOR})] \quad df$$

where H_{DSNG} is the transfer function of the DSNG receive / transmit baseband filters and H_{COOR} is the transfer function of the co-ordination receive/ transmit baseband filters (ideally corresponding to square root raised cosines).

Given the previously defined E_b/N_0 performance degradation of the co-ordination signal Δ_{COOR}, and therefore the factor ρ_{COOR}, the ratio Γ between the spectral densities of the DSNG signal and of each co-ordination signal divided by the spreading factor L can be estimated as:

$$\Gamma = A/((E_b/N_0)_{COOR}\, \rho_{COOR}\, \eta_{COOR}) \qquad \text{where: } \eta_{COOR} = 0{,}9804$$

Table D.1 reports a list of the symbols and their meanings.

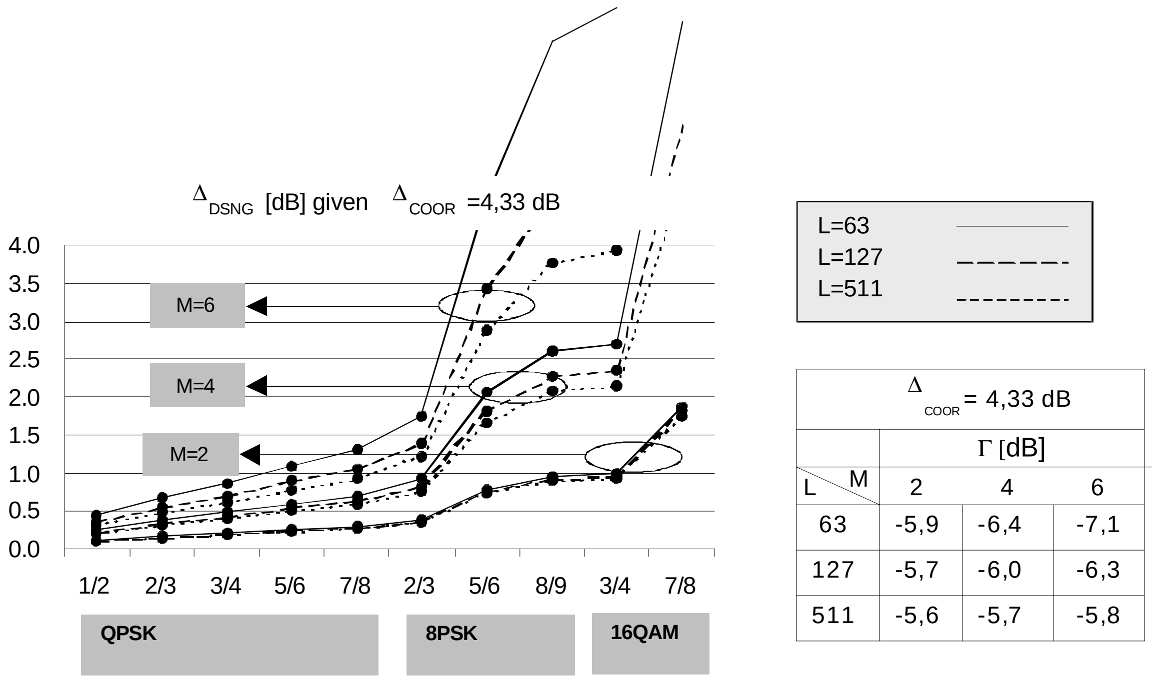
Table D.1: List of the symbols

A	Interference suppression in the baseband filters
Δ	E_b/N_0 degradation at the target BER
E_b/N_0	Ratio between the energy per useful bit and twice the two sided thermal noise power spectral density
Γ	Ratio of the spectrum density of the DSNG signal and of each co-ordination signal divided by the spreading factor L
η	Modulation/coding spectral efficiency (bits per transmitted symbol)
L	Spreading sequence length (Spreading Factor) (bit)
M	Number of co-ordination carriers transmitted in CDMA configuration
R	Useful bit-rate before multiplexer
NOTE: The sub-script COOR refers to the co-ordination signals. The sub-script DSNG refers to the main DSNG signal.	

Assuming superimposed frequency sharing as in Figure D.1 (left), Figures D.2 and D.3 give examples of the main DSNG signal E_b/N_0 performance degradation Δ_{DSNG}. The main DSNG signal has a symbol rate of 6,666 MBaud, thus occupying a frequency slot of 9 MHz. A fixed degradation of the co-ordination channel performance of 4,33 dB (see note) has been imposed, due to interferences from DSNG signal and from other co-ordination channels. The required $(E_b/N_0)_{COOR}$ is 3,6 dB at target BER of 10^{-3} (see Table 6). The DSNG schemes considered are QPSK, 8PSK, 16QAM, assuming the IF-loop performance given in [2]. In Figures D.2 and D.3, the adopted Γ factor is also given, representing the ratio between the DSNG and co-ordination channel spectral density divided by the spreading factor L. Other Γ factors may be chosen, according to the performance requirements. Lower Γ figures improve the performance of the co-ordination channels, while larger Γ figures improve the DSNG performance.

NOTE: This corresponds to a fixed BER of about 10^{-5} after Viterbi decoder in the absence of thermal noise.

Example 1 (Figure D.2): 8 kbit/s per co-ordination carrier, different number of unidirectional channels M.



Δ_{COOR} = 4,33 dB			
	Γ [dB]		
L \ M	2	4	6
63	-5,9	-6,4	-7,1
127	-5,7	-6,0	-6,3
511	-5,6	-5,7	-5,8

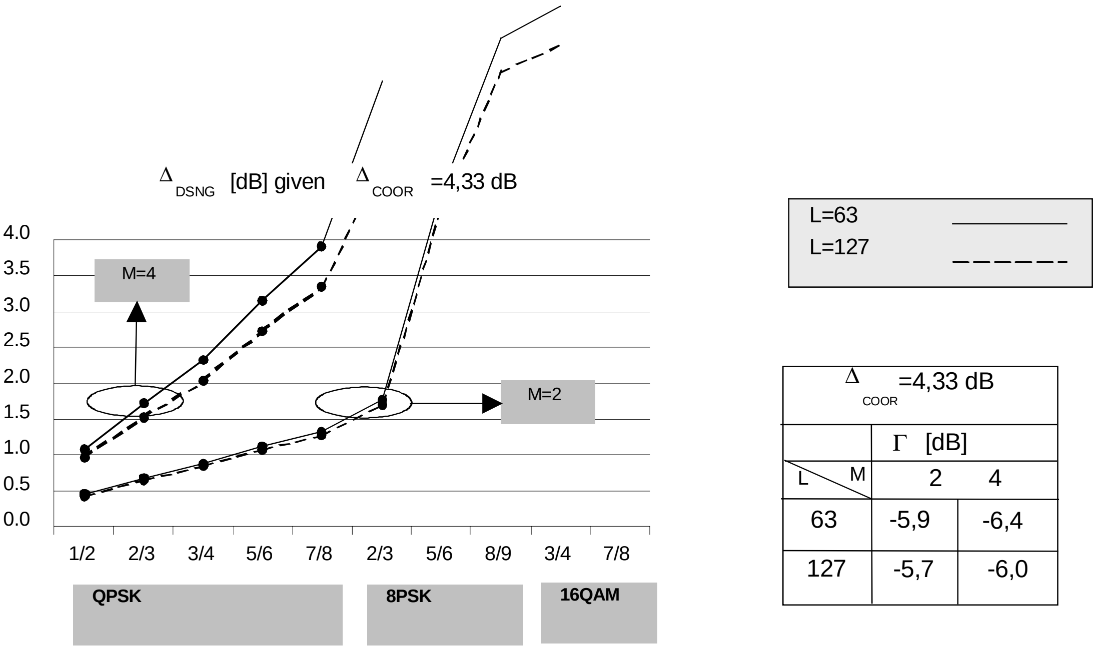
Figure D.2: 8 kbit/s co-ordination channels superimposed to DSNG. Example performance degradation of DSNG (R_S = 6,666 MBaud) interfered with by M co-ordination signals, with L = 63, L = 127 and L = 511. The degradation of the co-ordination channels has been assumed to be Δ_{COOR} = 4,33 dB

Table D.1 reports the meaning of the symbols.

Assuming a DSNG signal using QPSK FEC rate 2/3, from Figure D.2 (8 kbit/s channels) an estimated DSNG degradation of 0,7 dB is obtained for M = 6 and L = 63. For higher DSNG spectrum efficiency modes (e.g. 8PSK and 16QAM), the interference degradation progressively increases and may become unpractical.

Example 2 (Figure D.3): 32 kbit/s per co-ordination carrier, different number of unidirectional channels M.

For 32 kbit/s co-ordination channels and M = 2, a degradation on the DSNG signal (QPSK 1/2, 2/3 and 3/4) lower than 1 dB is achieved.



Δ_{COOR} =4,33 dB		
	Γ [dB]	
L \ M	2	4
63	-5,9	-6,4
127	-5,7	-6,0

Figure D.3: 32 kbit/s co-ordination channels superimposed to DSNG. Example performance degradation of DSNG (R_S = 6,666 MBaud) interfered with by M co-ordination signals, with L = 63 and L = 127. The degradation of the co-ordination channels has been assumed to be Δ_{COOR} = 4,33 dB

Table D.1 reports the meaning of the symbols.

As indicated in Figure D.1 (right), to reduce mutual interference, the co-ordinations channels may be placed in the roll-off region of the DSNG signal. In order to minimize the mutual interference, the co-ordination signals may use a low spreading factor (i.e. L = 31, L = 63 or L = 127, according to the co-ordination channel bit-rate) and may be placed, for example, in the upper part of the frequency slot allocated to DSNG. In this configuration the centre frequency $f_{0,COOR}$ of the co-ordination signals may be computed by the following formula:

$$f_{0,COOR} = f_{0,DSNG} + BS / 2 – (1,35 / 2) R_{S,COOR}$$

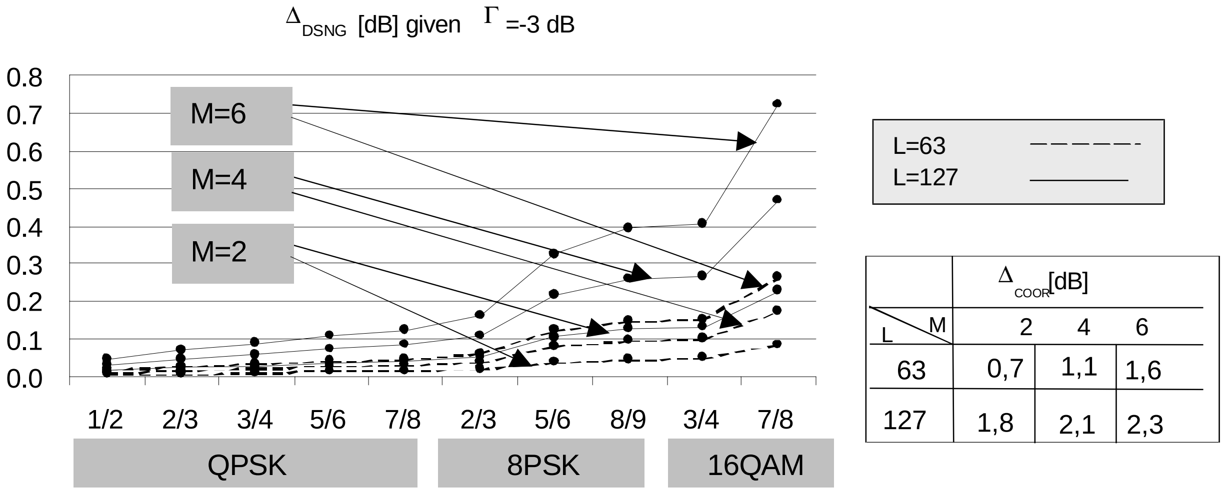
where:

$f_{0,DSNG}$ is the centre frequency of the DSNG signal and BS the bandwidth of the frequency slot, $R_{S,COOR} = R_{S,chip}$ is the co-ordination channel symbol rate.

In the following, the achievable performance is given for two example configurations, based on the frequency allocations of formula (2) and choosing Γ equal – 3 dB as a reasonable practical upper limit for the power density level of the co-ordination channels.

Example 3 (Figure D.4): 8 kbit/s co-ordination channels

M unidirectional co-ordination channels are considered, each at 8 kbit/s, with a spreading factor of 63 and 127. The main DSNG signal has a symbol rate of 6,666 MBaud, thus occupying a frequency slot of 9 MHz. The roll-off region (from the –3 dB point to the slot margin) is 1,167 MHz wide, while the co-ordination signal bandwidth is about 0,5 MHz for spreading factor 63 and 1 MHz for spreading factor 127. Due to the roll-off filter effect, the mutual interference suppression A is about 5,5 dB for L = 127 and 9,7 dB for L = 63. The resulting performance degradations of the DSNG signal are reported in Figure D.3, assuming a Γ factor (ratio between the DSNG and each co-ordination channel spectral density divided by the spreading factor L) of -3 dB (the – sign indicates that the co-ordination channels before SS have a spectral density higher than that of the DSNG signal). In the example, even in the case of M = 6 the DSNG degradation may be maintained below 0,5 dB for DSNG modulations up to 16QAM FEC rate 3/4.



L \ M	Δ_{COOR} [dB] 2	4	6
63	0,7	1,1	1,6
127	1,8	2,1	2,3

Figure D.4: 8 kbit/s co-ordination channels in the "Roll-off" region of DSNG. Example performance degradation of DSNG (RS = 6,666 MBaud) interfered with by M co-ordination signals, with L = 63 and L = 127. The ratio between the DSNG and each co-ordination channel spectral density divided by the spreading factor L has been assumed to be Γ = -3 dB

Table D.1 reports the meaning of the symbols.

Example 4 (Figure D.5): 32 kbit/s co-ordination channels.

M unidirectional co-ordination channels are considered, each at 32 kbit/s, with a spreading factor of 31. The main DSNG signal has a symbol rate of 6,666 MBaud, thus occupying a frequency slot of 9 MHz. The roll-off region (from the –3 dB point to the slot margin) is 1,167 MHz wide, while the co-ordination signal bandwidth is about 1 MHz. Due to the roll-off filter effect, the mutual interference suppression A is about 5,5 dB. The resulting performance degradations of the DSNG signal are reported in Figure D.5, assuming a Γ factor of - 3 dB (the – sign indicates that the co-ordination channels before SS have a spectral density higher than DSNG). In the example, in the case of M = 4 the DSNG degradation may be maintained below 0,5 dB for DSNG modulations up to 8PSK FEC rate 2/3.

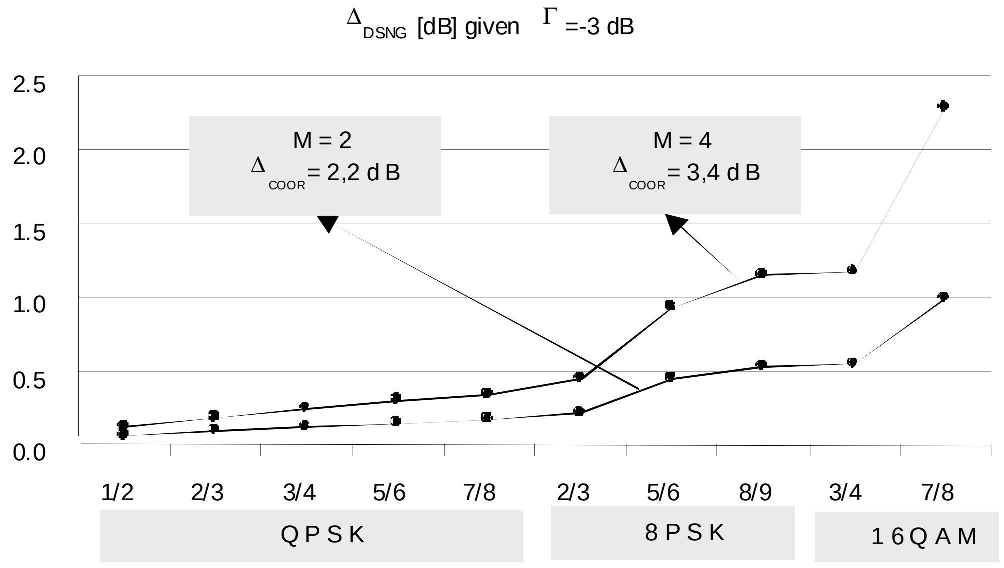


Figure D.5: 32 kbit/s co-ordination channels in the "Roll-off" region of DSNG. Example performance degradation of DSNG (RS = 6,666 MBaud) interfered with by M co-ordination signals, with L = 31. The ratio between the DSNG and each co-ordination channel spectral density divided by the spreading factor L has been assumed to be Γ –3 dB

Table D.1 reports the meaning of the symbols.

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ETS 300 673: "Radio Equipment and Systems (RES); ElectroMagnetic Compatibility (EMC) standard for 4/6 GHz and 11/12/14 GHz Very Small Aperture Terminal (VSAT) equipment and 11/12/13/14 GHz Satellite News Gathering (SNG) Transportable Earth Station (TES) equipment".

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