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Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 2: Physical Layer Specifications; Sub-part 1: Physical Layer Interface

Reference

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Satellite Earth Stations and Systems (SES).

The present document is part 2, sub-part 1 of a multi-part deliverable. Full details of the entire series can be found in ETSI TS 102 744-1-1 [i.4].

The forward and return bearer tables referred to in clauses B.1 and B.2 of the present document are contained in a separate attachment with filename ts_1027440201_AnnexB2_Bearer_Parameters_v010101p0.zip, contained in archive ts_1027440201v010101p0.zip which accompanies the present document.

The turbo-code interleaver tables referred to in clause C.1 of the present document and the puncturing, channel interleaving and symbol mapping tables referred to in clause C.2 of the present document are contained in separate attachments with filenames ts_1027440201_AnnexC1_v010101p0.zip and ts_1027440201_AnnexC2_v010101p0.zip, contained in archive ts_1027440201v010101p0.zip which accompanies the present document.

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

This multi-part deliverable (Release 1) defines a satellite radio interface that provides UMTS services to users of mobile terminals via geostationary (GEO) satellites in the frequency range 1 518,000 MHz to 1 559,000 MHz (downlink) and 1 626,500 MHz to 1 660,500 MHz and 1 668,000 MHz to 1 675,000 MHz (uplink).

1 Scope

The present document defines the Physical Layer of the Family SL Satellite Radio Interface between the Radio Network Subsystem (RNS) and the User Equipment (UE).

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at http://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 102 744-1-4: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 1: General Specifications; Sub-part 4: Applicable External Specifications, Symbols and Abbreviations".

[2] ETSI TS 102 744-2-2: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 2: Physical Layer Specifications; Sub-part 2: Radio Transmission and Reception".

[3] ETSI TS 102 744-3-1: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 1: Bearer Control Layer Interface".

[4] ETSI TS 102 744-3-2: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 3: Control Plane and User Plane Specifications; Sub-part 2: Bearer Control Layer Operation".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the reference document (including any amendments) applies.

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The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] "Decoder-Assisted Frame Synchronization for Turbo Coded Systems", M. Howlader, Y. Wu, B. Woerner, 2nd International Symposium on Turbo Codes and Related Topics, Brest, September 2000.

[i.2] "Performance of Turbo-Codes with Relative Prime and Golden Interleaving Strategies"', S. Crozier, J. Lodge, P. Guinand, A. Hunt, Sixth International Mobile Satellite Conference, Ottawa, June 1999.

[i.3] CCITT Red Book, Recommendation X.25.

[i.4] ETSI TS 102 744-1-1: "Satellite Earth Stations and Systems (SES); Family SL Satellite Radio Interface (Release 1); Part 1: General Specifications; Sub-part 1: Services and Architectures".

3 Symbols and abbreviations

3.1 Symbols

For the purposes of the present document, the symbols given in ETSI TS 102 744-1-4 [1], clause 3 apply.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 102 744-1-4 [1], clause 3 apply.

4 Overview of physical layer

The physical layer is the layer which transfers an information bitstream over the satellite link, and includes the following:

At a transmitter:

- scrambling, encoding and interleaving blocks of data and conversion to a serial symbol stream;
- modulation and filtering of a carrier at a specified frequency using the symbol stream; and
- transmission of the modulated and filtered carrier at the appropriate time and power level.

At a receiver:

- reception of a modulated carrier and measurement of carrier parameters;
- filtering and demodulation of the carrier into a received symbol stream;
- decoding, de-interleaving and de-scrambling of the symbol stream into a received block of data;
- channel equalization (Aeronautical Class UE Only).

Transmission between the satellite and mobile users is in spectrum allocated to mobile satellite services (see clauses 5.1.2 and 6.1.2). The particular physical layer characteristics may be different in the two directions of transmission (to and from UEs).

The physical layer operates with multiple physical bearer configurations, in both the forward and return direction, offering a choice of different modulation schemes as well as symbol and coding rates. The choice of the optimum bearer configuration is determined by the Bearer Control Layer based on various parameters, such as UE capabilities, satellite beam selection, required bitrate, etc.

Forward and Return Bearers are configurable as follows:

- bandwidth efficient 64-QAM, 32-QAM, 16-QAM (forward and return) and power efficient QPSK (forward) and $\pi/4$ QPSK (return) modulation schemes;
- a choice of symbol rates in the forward direction: 8,4; 33,6; 84,0; 151,2 and 168,0 kBd;
- a choice of symbol rates in the return direction: 16,8; 33,6; 67,2; 84,0; 151,2 and 168,0 kBd; and
- variable coding rate allowing nominal 1 dB steps of change in required Carrier to Noise density ratio (C/No).

To minimize the constraints on system design further, different unique words are used to allow the receiver to decode transmissions without a-priori knowledge of the coding rate that the transmitter is applying to a specific burst or frame.

There is, in addition, a set of bearers for which the modulation rate is variable on an FEC-block basis between QPSK and 16-QAM. These bearers are defined as X4/16 rather than QPSK to highlight the distinction between these dynamic modulation bearers and QPSK or 16-QAM only bearers.

The concept of "UE Class" is used to make distinctions between User Equipment with different RF characteristics or different behaviour (at higher layers). The details of the different UE Classes are defined in ETSI TS 102 744-2-2 [2]. The present document defines all the possible bearers types. Not all of these bearers are applicable for each UE Class: the exact mapping between each UE Class and supported bearer types is described in ETSI TS 102 744-2-2 [2].

5 Forward bearers

5.1 Introduction

5.1.1 Forward bearer types

The forward bearers are capable of carrying nominal data rates in the range between 4,5 kbit/s and 858,0 kbit/s and are based upon the continuous transmission of Time-Division-Multiplexed (TDM) carriers. The forward bearer is transmitted with a constant mean power level.

This clause describes the physical attributes of the forward bearer types, and the general UE and Radio Network System (RNS) requirements when operating with these bearer types.

Individual Forward Bearer Types are summarized in Table 5.1.

Table 5.1: Overview of Forward Bearer Types

Bearer Type Identifier (see note)	Frame Duration (ms)	Symbol Rate (kBd)	Modulation	Channel bandwidth (kHz)	FEC Blocks per Frame
F80T0.25Q-1B	80	0,25 x 33,6	QPSK	10,50	1
F80T1Q-1B	80	1,0 x 33,6	QPSK	42,00	1
F80T1Q-4B	80	1,0 x 33,6	QPSK	42,00	4
F80T1X-4B	80	1,0 x 33,6	16-QAM	42,00	4
FR80T2.5X4/16-5B	80	2,5 x 33,6	4-QAM/16-QAM	94,92	5
FR80T2.5X16-5B	80	2,5 x 33,6	16-QAM	94,92	5
FR80T2.5X32-6B	80	2,5 x 33,6	32-QAM	94,92	6
FR80T2.5X64-7B	80	2,5 x 33,6	64-QAM	94,92	7
F80T4.5X-8B	80	4,5 x 33,6	16-QAM	189,00	8
FR80T5X4/16-9B	80	5,0 x 33,6	4-QAM/16-QAM	189,84	9
FR80T5X16-9B	80	5,0 x 33,6	16-QAM	189,84	9
FR80T5X32-11B	80	5,0 x 33,6	32-QAM	189,84	11
FR80T5X64-13B	80	5,0 x 33,6	64-QAM	189,84	13
NOTE: The bearer type identifier notation used in the present document is defined in Annex A.					

A block diagram of the forward bearer transmitter is shown in Figure 5.1. The functional blocks at the transmit end of each channel are as follows:

a) scrambler;

b) turbo FEC encoder;

c) transmit synchronizer; and

d) QPSK and 16/32/64 QAM modulator.

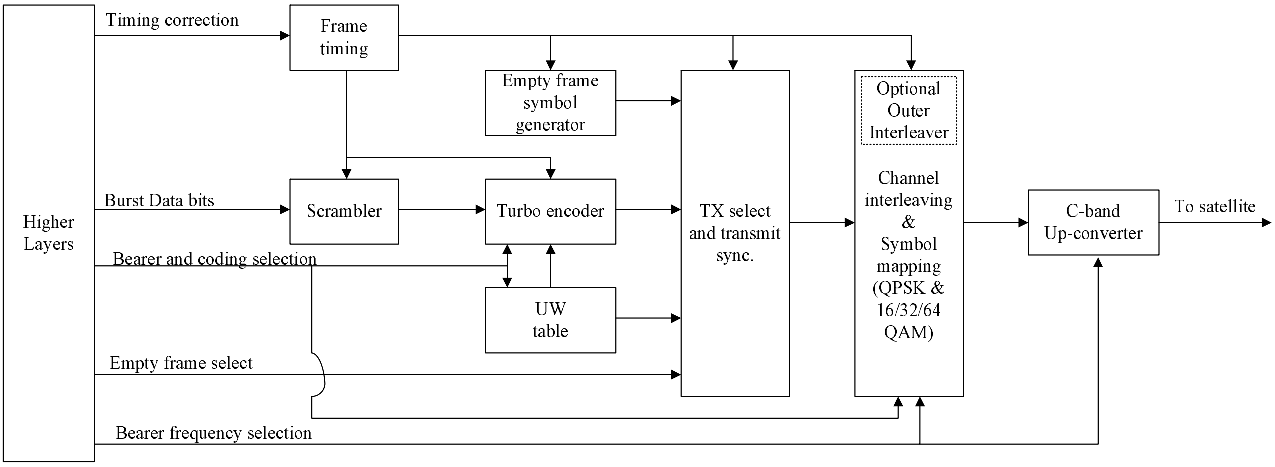


Figure 5.1: UE Transmit Channel Unit Configuration

The forward transmit channel units shall be able to apply different coding rates on an FEC block basis as directed by the Bearer Control Layer in order to adapt transmissions to different UE types on the same forward bearer. Furthermore, the transmitter shall also be able to change modulation on an FEC block basis between QPSK and 16-QAM modulations in the FR80T2.5X4/16 and FR80T5X4/16 family of bearers. The "Optional Outer Interleaver" is only applied in the case of FR80T2.5 and FR80T5 (see clause 5.3.8.5).

A block diagram of the forward bearer receiver is shown in Figure 5.2. The functional blocks at the receive end of each forward channel are the corresponding complementary functions to the transmit end.

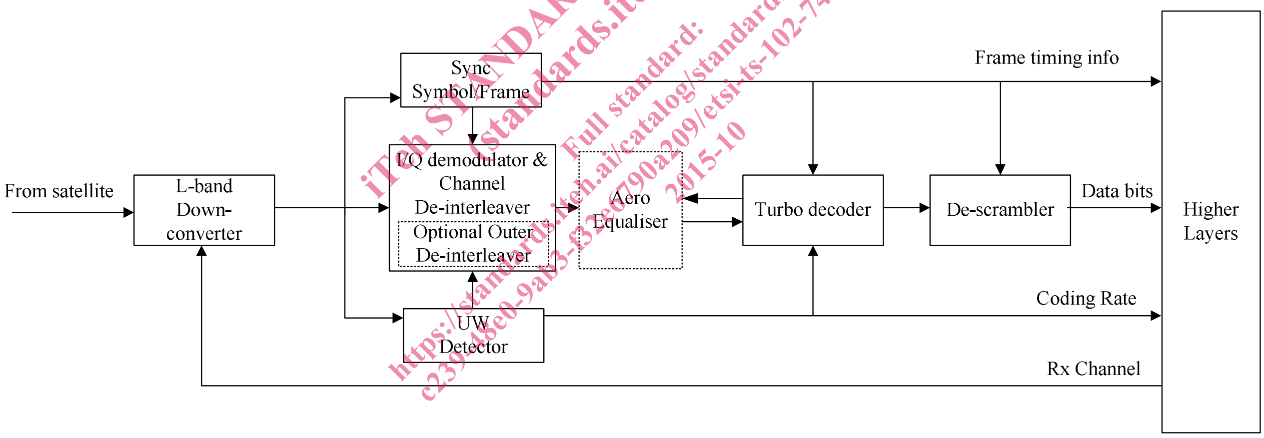


Figure 5.2: UE Receive Channel Unit Configuration

5.1.2 L-Band Forward Frequency Range

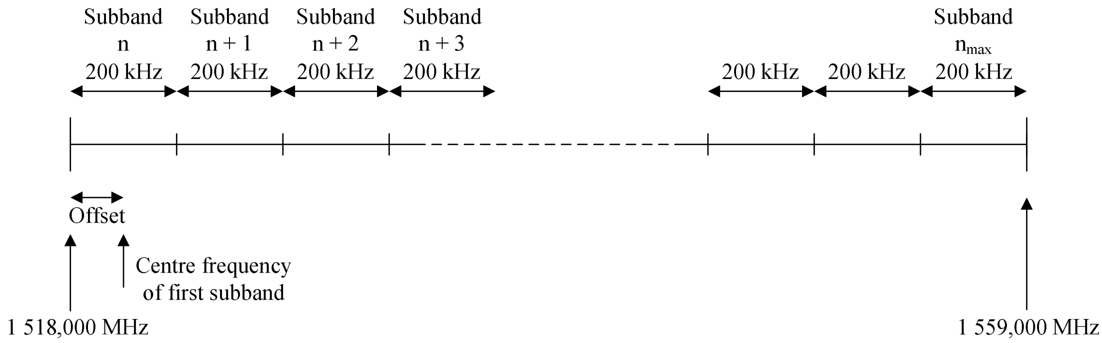
The L-Band forward (downlink) frequency range used by the Family SL satellite radio interface is 1 518,000 MHz to 1 559,000 MHz.

The forward frequency range is divided into a set of contiguous 200 kHz subbands. The nominal position of these subbands is aligned with the edges of the band, as illustrated in Figure 5.3. The centre frequency of each subband is offset from this nominal 200 kHz grid as shown: this offset is referred to as the "subband centre frequency offset" and has a default value of 100 kHz.

NOTE: This division into subbands is designed to support the assignment of satellite transponder bandwidth in multiples of 200 kHz.

The value of the subband centre frequency offset may be changed within the range 0 kHz to 200 kHz. If the value of the Subband Centre Frequency Offset is changed from the nominal value of 100 kHz, it shall be signalled to the UEs in the Subband Centre Frequency Offset Bearer Control AVP (see ETSI TS 102 744-3-1 [3]). The Subband Centre Frequency Offset is a system-wide variable and the same value shall be used in every beam.

The centre frequency is always at the centre of the subband. Hence any change to the value of the subband centre frequency offset implies a corresponding offset in the position of all the subbands.



NOTE: The figure illustrates the subband alignment for the L-band downlink. The lower boundary of the frequency range is 1 518,000 MHz and the upper boundary is 1 559,000 MHz.

Figure 5.3: Subband Alignment for L-Band Downlink

Each forward bearer is fully contained within one subband (i.e. the full channel bandwidth is within the subband). Some classes of UE are required to support faster retuning between forward bearers within the same subband: see ETSI TS 102 744-2-2 [2] for more details of this requirement.

The centre frequency of a given forward bearer is based on a frequency grid of 1,25 kHz, and is signalled to the UEs via the forward channel number. When receiving a forward bearer, the UE shall calculate the centre frequency of the full subband to which it shall tune from the forward channel frequency and the subband centre frequency offset using the following formula:

$$F_{CentreFwd} = 1518000 + Offset + \left(floor\left(\frac{F_{Fwd} - 1518000 - Offset + 100}{200} \right) \cdot 200 \right) \quad [kHz]$$

Where:

$F_{CentreFwd}$ is the Centre Frequency of the Forward Link Subband (in kHz)
Offset is the Subband Centre Frequency Offset (default 100 kHz or as signalled)
F_{Fwd} is the desired forward channel frequency (in kHz)
floor is a function that returns the integer part of the argument.

F_{Fwd} is obtained from the forward channel number as defined in ETSI TS 102 744-3-1 [3].

5.2 Modulation

5.2.1 Symbol rate

The symbol rate used depends on the type of forward bearer as shown in Table 5.2.

Table 5.2: Forward Bearer Symbol Rates

Bearer Type Identifier	Symbol Rate (kBd)
F80T0.25Q-1B	8,4
F80T1X-4B	33,6
F80T1Q-4B	33,6
FR80T2.5X4/16-5B	84,0
FR80T2.5X16-5B	84,0
FR80T2.5X32-6B	84,0
FR80T2.5X64-7B	84,0
F80T4.5X-8B	151,2
FR80T5X4/16-9B	168,0
FR80T5X16-9B	168,0
FR80T5X32-11B	168,0
FR80T5X64-13B	168,0

5.2.2 Modulation schemes

5.2.2.1 16-QAM (X/X16) bearers

The signal set and mapping for the 16-QAM modulation scheme are shown in Figure 5.4 and Table 5.3. Table 5.3 shows the mapping to the In-phase (I) and Quadrature (Q) components for a signal set with minimum distance D. Table 5.3 also shows the relationship between the binary data and the I and Q channels of the modulator and demodulator.

Table 5.3: 16-QAM Constellation Mapping

16-QAM	b_3	b_2	b_1	b_0	I	Q
0	0	0	0	0	-D/2	-D/2
1	0	0	0	1	-D/2	-3D/2
2	0	0	1	0	-D/2	D/2
3	0	0	1	1	-D/2	3D/2
4	0	1	0	0	-3D/2	-D/2
5	0	1	0	1	-3D/2	-3D/2
6	0	1	1	0	-3D/2	D/2
7	0	1	1	1	-3D/2	3D/2
8	1	0	0	0	D/2	-D/2
9	1	0	0	1	D/2	-3D/2
10	1	0	1	0	D/2	D/2
11	1	0	1	1	D/2	3D/2
12	1	1	0	0	3D/2	-D/2
13	1	1	0	1	3D/2	-3cD/2
14	1	1	1	0	3D/2	D/2
15	1	1	1	1	3D/2	3D/2

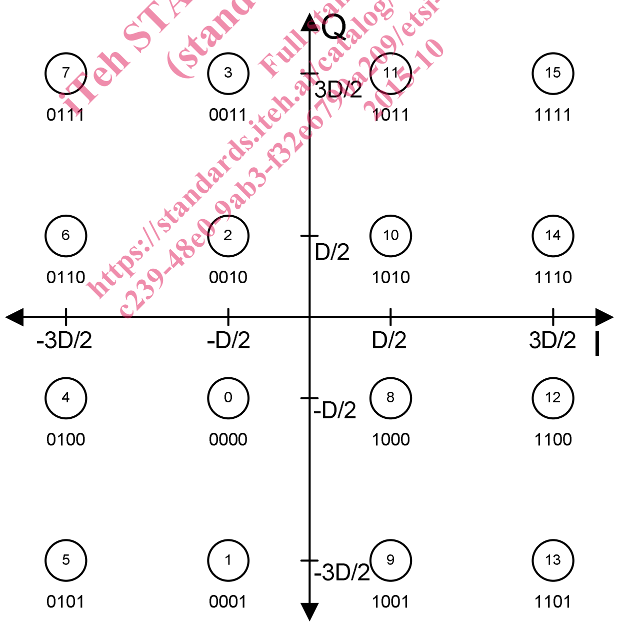


Figure 5.4: 16-QAM Modulation Symbol Mapping

5.2.2.2 32-QAM (X32) bearers

The signal set and mapping for the 32-QAM modulation scheme are shown in Figure 5.5 and Table 5.4. Table 5.4 shows the mapping to the In-phase (I) and Quadrature (Q) components for a signal set with minimum distance D. Table 5.4 also shows the relationship between the binary data and the I and Q channels of the modulator and demodulator.

Table 5.4: 32-QAM Constellation Mapping

32-QAM	b_4	b_3	b_2	b_1	b_0	I	Q
0	0	0	0	0	0	-D/2	D/2
1	0	0	0	0	1	D/2	D/2
2	0	0	0	1	0	-D/2	-D/2
3	0	0	0	1	1	D/2	-D/2
4	0	0	1	0	0	-D/2	3D/2
5	0	0	1	0	1	D/2	3D/2
6	0	0	1	1	0	-D/2	5D/2
7	0	0	1	1	1	D/2	5D/2
8	0	1	0	0	0	-D/2	-5D/2
9	0	1	0	0	1	D/2	-5D/2
10	0	1	0	1	0	-D/2	-3D/2
11	0	1	0	1	1	D/2	-3D/2
12	0	1	1	0	0	-3D/2	3D/2
13	0	1	1	0	1	3D/2	3D/2
14	0	1	1	1	0	-3D/2	5D/2
15	0	1	1	1	1	3D/2	5D/2
16	1	0	0	0	0	-3D/2	D/2
17	1	0	0	0	1	3D/2	D/2
18	1	0	0	1	0	-3D/2	-D/2
19	1	0	0	1	1	3D/2	-D/2
20	1	0	1	0	0	-5D/2	D/2
21	1	0	1	0	1	5D/2	D/2
22	1	0	1	1	0	-5D/2	-D/2
23	1	0	1	1	1	5D/2	-D/2
24	1	1	0	0	0	-3D/2	-5D/2
25	1	1	0	0	1	3D/2	-5D/2
26	1	1	0	1	0	-3D/2	-3D/2
27	1	1	0	1	1	3D/2	-3D/2
28	1	1	1	0	0	-5D/2	3D/2
29	1	1	1	0	1	5D/2	3D/2
30	1	1	1	1	0	-5D/2	-3D/2
31	1	1	1	1	1	5D/2	-3D/2

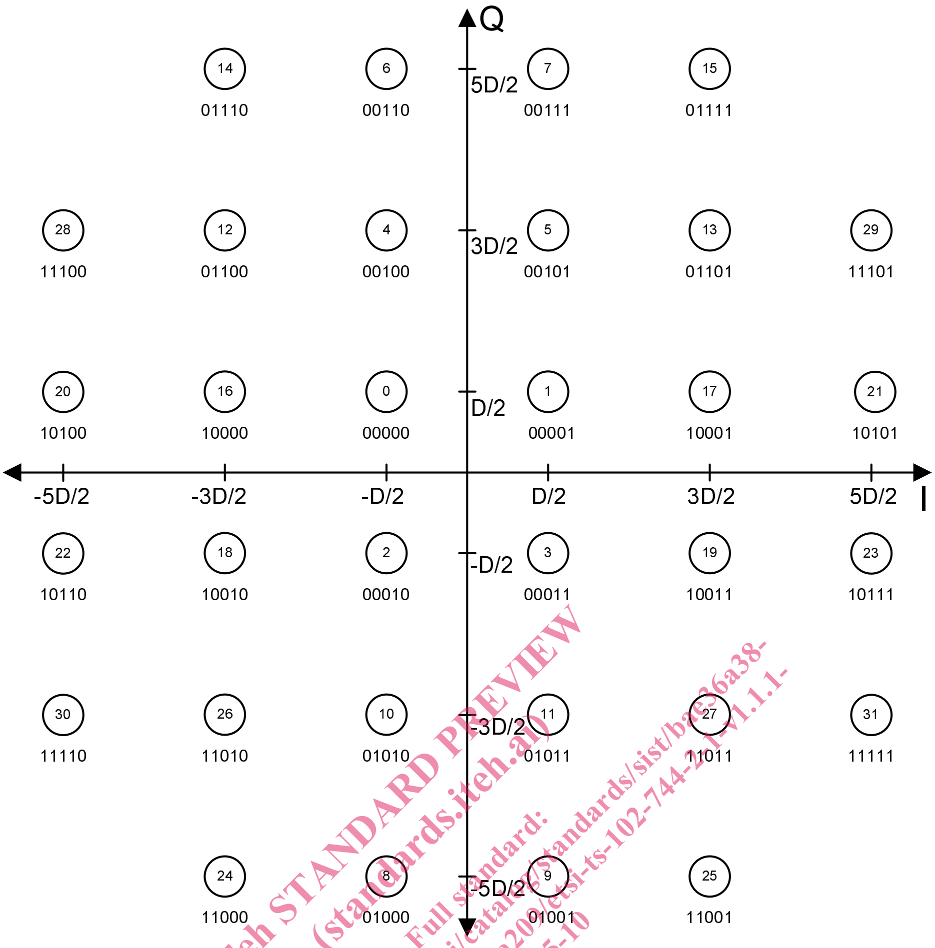


Figure 5.5: 32-QAM Modulation Symbol Mapping

5.2.2.3 64-QAM (X64) bearers

The signal set and mapping for the 64-QAM modulation scheme are shown in Figure 5.6 and Table 5.5. Table 5.5 shows the mapping to the In-phase (I) and Quadrature (Q) components for a signal set with minimum distance D. The table also shows the relationship between the binary data and the I and Q channels of the modulator and demodulator.

Table 5.5: 64-QAM Constellation Mapping

64-QAM	b_5	b_4	b_3	b_2	b_1	b_0	I	Q
0	0	0	0	0	0	0	3D/2	3D/2
1	0	0	0	0	0	1	3D/2	D/2
2	0	0	0	0	1	0	3D/2	5D/2
3	0	0	0	0	1	1	3D/2	7D/2
4	0	0	0	1	0	0	3D/2	-3D/2
5	0	0	0	1	0	1	3D/2	-D/2
6	0	0	0	1	1	0	3D/2	-5D/2
7	0	0	0	1	1	1	3D/2	-7D/2
8	0	0	1	0	0	0	D/2	3D/2
9	0	0	1	0	0	1	D/2	D/2
10	0	0	1	0	1	0	D/2	5D/2
11	0	0	1	0	1	1	D/2	7D/2
12	0	0	1	1	0	0	D/2	-3D/2
13	0	0	1	1	0	1	D/2	-D/2
14	0	0	1	1	1	0	D/2	-5D/2