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Technical Report

Digital Video Broadcasting (DVB); Implementation of Binary Phase Shift Keying (BPSK) modulation in DVB satellite transmission systems

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ETSI Secretariat

Postal address

F-06921 Sophia Antipolis Cedex - FRANCE

Office address

650 Route des Lucioles - Sophia Antipolis
Valbonne - FRANCE
Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16
Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

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Internet

secretariat@etsi.fr
http://www.etsi.fr

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Foreword

This Technical Report (TR) has been produced by the DVB Project and submitted for publication to the Joint Technical Committee (JTC) of the European Broadcasting Union (EBU), Comité Européen de Normalisation ELECtrotechnique (CENELEC) and the European Telecommunications Standards Institute (ETSI).

NOTE: The EBU/ETSI JTC was established in 1990 to co-ordinate the drafting of standards in the specific field of broadcasting and related fields. Since 1995 the JTC 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 *.

* European Broadcasting Union
Case Postale 67
CH-1218 GRAND SACONNEX (Geneva)
Switzerland
Tel: +41 22 717 21 11
Fax: +41 22 717 24 81

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.

1 Scope

The present document supplements EN 300 421 [1] which describes the transmission of MPEG-2/DVB Transport Stream (TS) via satellite.

The present document covers a special case, where the use of Binary Phase Shift Keying (BPSK) modulation is required, rather than that specified in EN 300 421 [1].

2 References

References may be made to:

a) specific versions of publications (identified by date of publication, edition number, version number, etc.), in which case, subsequent revisions to the referenced document do not apply; or

b) all versions up to and including the identified version (identified by "up to and including" before the version identity); or

c) all versions subsequent to and including the identified version (identified by "onwards" following the version identity); or

d) publications without mention of a specific version, in which case 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.

Because of the rapid development of specifications and standards it is recommended to verify in each case whether the following documents have been replaced by more recent versions. The following list was compiled in August 1997.

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

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the definitions given in EN 300 421 [1] apply.

3.2 Abbreviations

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

BPSK	Binary Phase Shift Keying
C/N	signal to noise ratio
DVB	Digital Video Broadcasting
DTH	Direct-To-Home
E_b/N_o	ratio between the Energy per useful bit and twice the Noise power spectral density
I	Interference
I, Q	In-phase, Quadrature phase components of the modulated signal
MPEG-2	Moving Picture Experts Group
N	additive white Gaussian Noise
QPSK	Quaternary Phase Shift Keying
R_u	useful bit-rate after RS outer coder
TS	Transport Stream

4 Background

Under typical conditions for Direct-To-Home (DTH) emissions by satellite, the Quaternary Phase Shift Keying (QPSK) modulation adopted in EN 300 421 [1] achieves an optimum trade-off between spectrum and power efficiencies. Compared to BPSK, QPSK offers a double spectrum efficiency and a comparable power efficiency at the same useful bit-rate R_u, in the presence of additive white Gaussian Noise (N) and Interference (I).

In general, the best system performance by satellite is met by adopting QPSK at the maximum symbol rate compatible with the transponder bandwidth (see EN 300 421 [1], annex C). This configuration is indicated in the present document as "full-band" transmission, in contrast with a "reduced-band" transmission, where part of the transponder bandwidth is not exploited by the signal. The maximization of the useful bit-rate R_u compatible with the available C/N + I is achieved by considering **full-band** QPSK associated with progressively decreasing coding rates (from 7/8 to 1/2).
If a configuration is found which meets the C/N + I requirements, there is no BPSK scheme with comparable or better performance in terms of R_u or in terms of generated interference power density affecting other services.
For example, comparing **full-band** QPSK 1/2 with **full-band** BPSK 7/8 (i.e. at the same symbol rate), the latter shows a 12,5 % loss in terms of R_u and at the same time a power loss of about 1,3 dB, while the generated interference power density affecting other services is similar.

Only under exceptionally critical transmission conditions, **full-band** BPSK can out-perform **reduced-band** QPSK 1/2 at the same R_u. This can happen when the available C/N + I ratio can not even support the bit-rate R_u of **full-band** QPSK 1/2, and in the presence of strong narrow-band co-channel interference (I).
For example, assuming a narrow-band interference at C/I = 10 dB, and taking as a reference **reduced-band** QPSK 1/2 at the same R_u, **full-band** BPSK 2/3 requires similar E_b/N_o, but generates an interference power density 1,7 dB lower. Under the same conditions but at even smaller bit-rates R_u, **full-band** BPSK 1/2 offers reductions of about 0,8 dB in terms of required E_b/N_o, and of 3 dB in terms of generated interference power density. On the other hand, in some cases the lower spectrum occupation of QPSK can allow to avoid co-channel interference, by shifting the signal within the transponder bandwidth.

The present document describes a preferred implementation of BPSK for those applications which do not conform to EN 300 421 [1] in the modulation format only.

5 BPSK implementation

The inner code puncturing conforms to table 2 of EN 300 421 [1] (relevant to QPSK modulation), to generate the I and Q parallel signals.

By means of a parallel-to-serial conversion, these two signals I and Q are merged in a single signal R, at double rate, following the rule: R = I, Q.

This results in the puncturing scheme summarized in table 1.

Table 1: Puncturing scheme for BPSK

Code Rates	1/2	2/3	3/4	5/6	7/8
X:	1	1 0	1 0 1	1 0 1 0 1	1 0 0 0 1 0 1
Y:	1	1 1	1 1 0	1 1 0 1 0	1 1 1 1 0 1 0
R =	$X_1 Y_1$	$X_1 Y_1 Y_2 X_3 Y_3 Y_4$	$X_1 Y_1 Y_2 X_3$	$X_1 Y_1 Y_2 X_3 Y_4 X_5$	$X_1 Y_1 Y_2 Y_3 Y_4 X_5 Y_6 X_7$

The mapping of signal R into the BPSK constellation is absolute (no differential coding).

Baseband filtering for spectrum shaping conforms to the QPSK specification.

History

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