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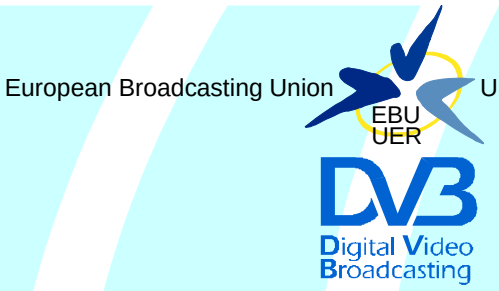
European Standard (Telecommunications series)

Digital Video Broadcasting (DVB); OFDM modulation for microwave digital terrestrial television



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Contents

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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.

The present document presents manufacturers and broadcasters the opportunity to apply DVB-T standards to microwave transmission as well as terrestrial transmission at UHF/VHF. Consequently this standard refers to the DVB-T document EN 300 744 [1], for the framing structure, channel coding and modulation. Only issues that apply to the use of the microwave transport layer which are not covered by EN 300 744 [1] are detailed within this specification.

The present document is not intended to replace the existing microwave transmission standards EN 300 748 [5] and EN 300 749 [6], which use QPSK and QAM modulation for frequencies greater and less than 10 GHz respectively. These standards remain valid but there is now the option of adopting the benefits of OFDM modulation for microwave transmission in any frequency band.

National transposition dates	
Date of adoption of this EN:	26 May 2000
Date of latest announcement of this EN (doa):	31 August 2000
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	28 February 2001
Date of withdrawal of any conflicting National Standard (dow):	28 February 2001

1 Scope

The present document describes an optional downlink or broadcast transmission system for digital microwave Television (TV) and data broadcasting using OFDM modulation.

It refers to the framing structure, channel coding and modulation system intended for digital terrestrial television (EN 300 744 [1]) with additional details that apply to multi-programme microwave services.

The scope is as follows:

- it gives a general description of how a digital terrestrial based transmission scheme may be applied to a digital microwave transport layer;
- it identifies the differences in performance requirements and features of the system, compared to UHF/VHF broadcasting;
- it provides design guidelines for achieving the phase noise targets required for using OFDM at high frequencies.

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 300 744: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television".

[2] ISO/IEC 13818-1: "Information technology - Generic coding of moving pictures and associated audio information: Systems".

[3] ISO/IEC 13818-2: "Information technology - Generic coding of moving pictures and associated audio information: Video".

[4] ISO/IEC 13818-3: "Information technology - Generic coding of moving picture and associated audio information - Part 3: Audio".

[5] EN 300 748: "Digital Video Broadcasting (DVB); Multipoint Video Distribution Systems (MVDS) at 10 GHz and above".

[6] EN 300 749: "Digital Video Broadcasting (DVB); Microwave Multipoint Distribution Systems (MMDS) below 10 GHz".

3 Symbols and abbreviations

3.1 Symbols

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

D	Time duration of the guard interval
F1	Lower frequency limit of microwave band
F2	Upper frequency limit of microwave band
TU	Time duration of the useful part of a symbol, without the guard interval

3.2 Abbreviations

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

AFC	Automatic Frequency Control
DVB	Digital Video Broadcasting
DVB-T	DVB-Terrestrial
LMDS	Local Microwave Distribution System
MF	Microwave Frequency
MMDS	Multichannel Microwave Distribution System
MPEG	Moving Picture Experts Group
MVDS	Multipoint Video Distribution System
MWS	Multimedia Wireless System
OFDM	Orthogonal Frequency Division Multiplexing
QAM	Quadrature Amplitude Modulation
QPSK	Quaternary Phase Shift Keying
RF	Radio Frequency
SFN	Single Frequency Network
STB	Set Top Box
TV	Television
UHF	Ultra-High Frequency
VHF	Very-High Frequency

4 Terrestrial Baseline & Microwave Transport systems

4.1 Terrestrial Baseline System

The baseline system is defined as the functional block of equipment performing the adaptation of the baseband TV signals from the output of the MPEG-2 transport multiplexer, to the UHF/VHF channel characteristics. The following processes shall be applied to the data stream (see figure 1):

- transport multiplex adaptation and randomization for energy dispersal;
- outer coding (i.e. Reed-Solomon code);
- outer interleaving (i.e. convolutional interleaving);
- inner coding (i.e. punctured convolutional code);
- inner interleaving;
- mapping and modulation;
- Orthogonal Frequency Division Multiplexing (OFDM) transmission.

The system is directly compatible with MPEG-2 coded TV signals ISO/IEC 13818 [2] to [4].

This baseline system is covered in detail in the DVB-T specification (EN 300 744 [1]).

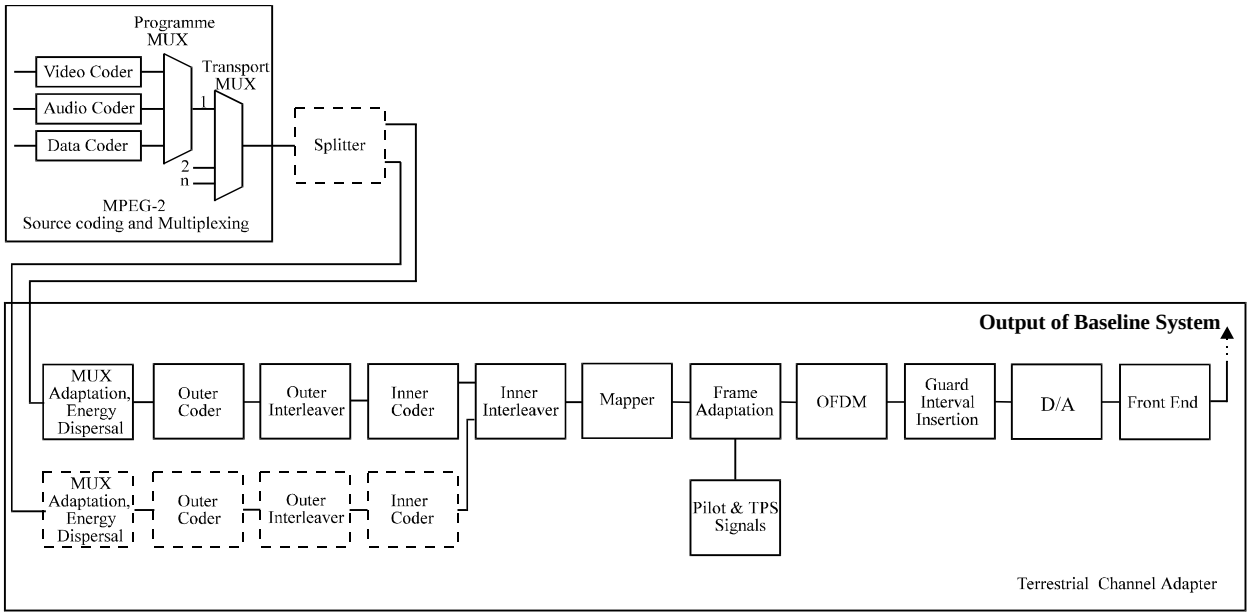

Figure 1: Functional block diagram of the Baseline System

4.2 Microwave Transport System

Microwave DVB-T Transport System uses the same modulation characteristics as the Terrestrial Baseline System but frequency translates it to a microwave transport layer as can be seen in figure 2. It can then be frequency translated back to the VHF/UHF band where it is compatible with the Terrestrial Baseline DVB-T demodulators and decoders.

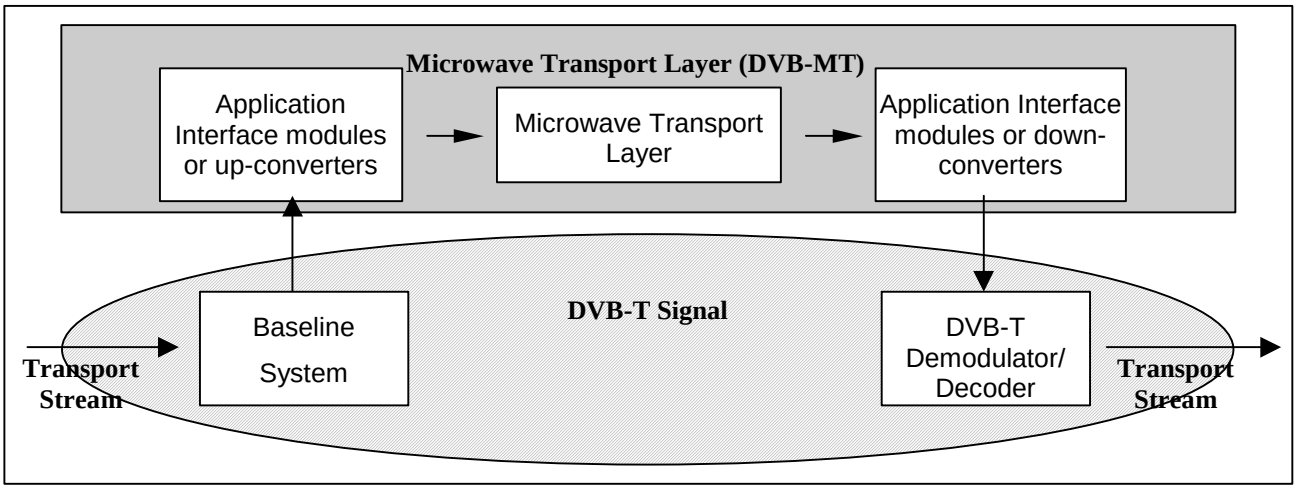

Figure 2: Functional block diagram of the Baseline & Transport System

4.3 Frequency translation

It is possible to generate and/or receive channels via frequency translations to and from VHF/UHF. Each channel or a block of channels may be upconverted to any frequency within the microwave transport layer and may be downconverted to any appropriate UHF/VHF channel. It is recommended that the upconverted channel should follow the same channel spacing as defined for the Terrestrial Baseline System in EN 300 744 [1] without frequency inversion. It is important to remember from EN 300 744 [1] that a possible cause of the inversion error is if the signal is shifted in frequency by some heterodyning process. This can cause inversion of the spectrum as well as inversion of the imaginary axis, however if such a process is repeated, the resulting signal will comply with the specification.

An example of an "off air" fed system is shown in the next diagram (figure 3).

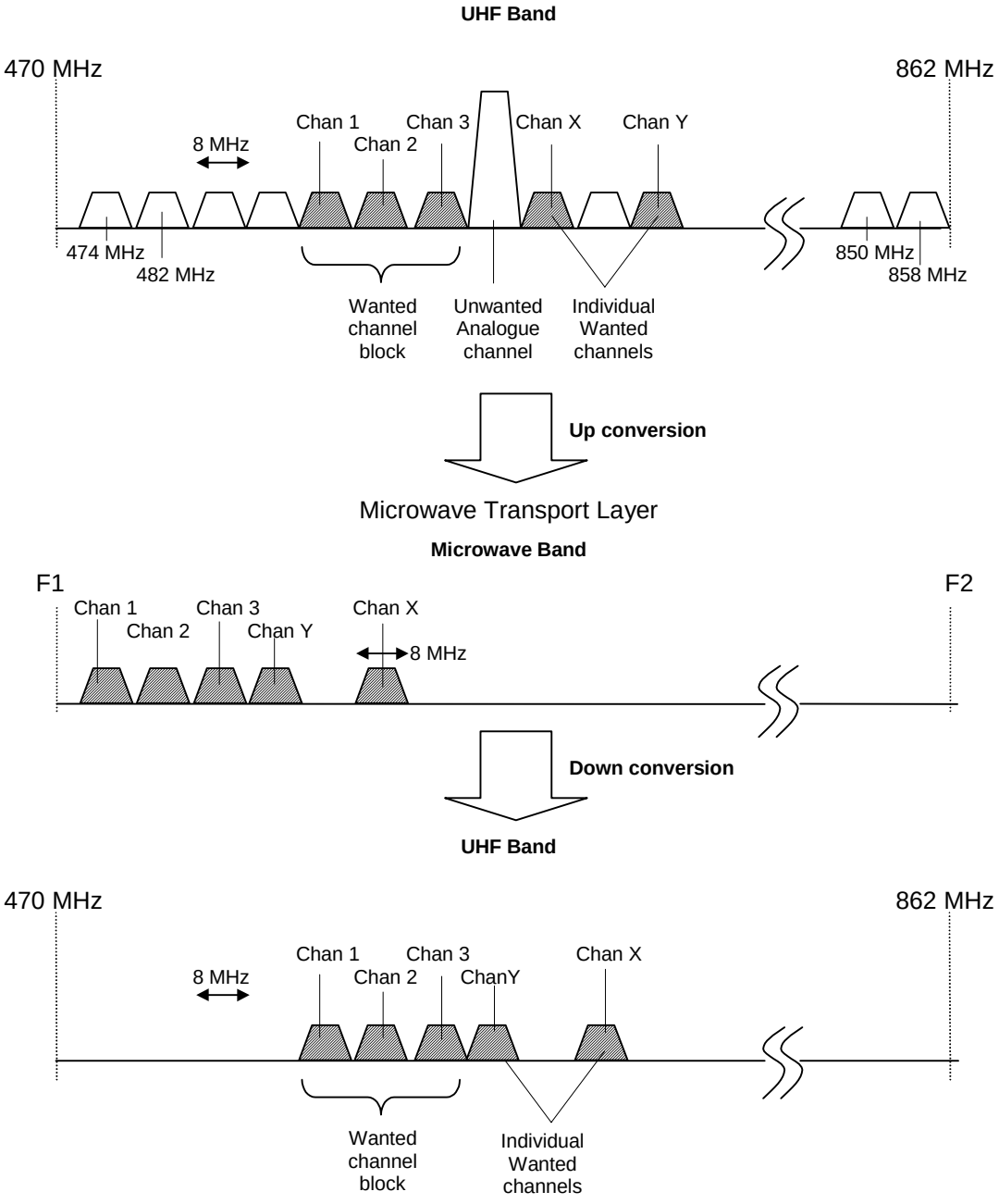

Figure 3: Example of frequency translations between UHF and Microwave for an 'off air' fed system

The use of a microwave transport layer may be applied to various microwave bands [F1-F2] depending on those available or appropriate for the application. In this example "wanted" 8 MHz channels are selected from the air, ignoring the analogue channels. These wanted channels, which may be a block or individual, are then upconverted to the microwave band. The upconversion may be such that the order of the channels may be re-arranged, as in the case of channel X & Y. The wanted channels are then downconverted to the UHF channel range where they will be processed using a normal UHF receiver.

4.4 Modulation parameters

All variants of code rates, modes and modulation rates specified in EN 300 744 [1] are valid for microwave distribution.

4.5 Spectrum characteristics and spectrum mask

A theoretical DVB OFDM transmission is illustrated in figure 4. Applying appropriate filtering can reduce the level of the spectrum at frequencies outside the nominal bandwidth. EN 300 744 [1] provides spectrum masks and tables of breakpoints for:

a) cases where a transmitter for UHF digital terrestrial television is co sited with and operating on a channel adjacent to a transmitter for analogue television; and

b) critical cases such as television channels adjacent to other services.

Where similar spectrum occupancy environment exists in the microwave band being employed then the masks specified in EN 300 744 [1] are applicable.

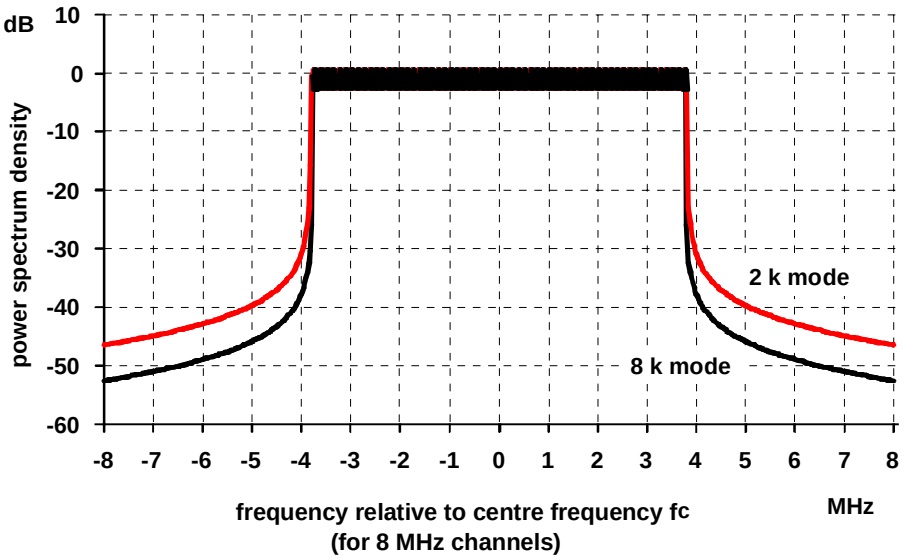

Figure 4: Theoretical UHF DVB transmission signal spectrum for guard interval $\Delta = T_u/4$

5 Informative Annex

5.1 Phase Noise Requirements

Meeting the phase noise requirements for OFDM systems at microwave frequencies is more difficult to achieve than it is at UHF or VHF frequencies. The dependence of the system behaviour with respect to the phase noise is a function of the total phase noise power. This means that it is important to specify the phase noise between 1 KHz and 1 MHz from the carrier. For example, a synthesizer may have a very good phase noise at both 1 KHz and 10 KHz from the carrier; but if the phase noise density is high between 10 KHz and 1 MHz the total phase noise power could be too high for a good reception of the signal.

As a rough guide, the following phase noise values have been used in a number of research projects:

-65 dBc/Hz @ 1 kHz;

-68 dBc/Hz @ 10 kHz;

-86 dBc/Hz @ 100 kHz;

-105 dBc/Hz @ 1 MHz.

5.2 Frequency stability requirements

Meeting the frequency stability requirements for OFDM systems at microwave frequencies is more difficult to achieve than it is at UHF or VHF frequencies. The frequency stability requirements of the system will usually depend on the receiver's sensitivity to frequency drift. The frequency drift that can be accommodated may vary from receiver to receiver according to the manufacturer specifications.

Typical AFC lock range in consumer receivers is ±70 kHz, but most of this tolerance may be required to compensate for internal frequency inaccuracies within the receiver.

In more complicated systems where very high microwave frequencies are used, pilot recovery circuitry may be used to correct the frequency errors due to all previous oscillators. The extent to which these pilot signals can restore frequency stability may be limited and loop recovery systems may not work with high levels of drift.

Where a similar spectrum occupancy environment exists between downconverted microwave channels and other UHF/VHF transmitted channels then use the frequency stability requirements specified in EN 300 744 [1].

Bibliography

The following material, though not specifically referenced in the body of the present document (or not publicly available), gives supporting information.

- EN 300 421: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for 11/12 GHz satellite services".
- EN 300 429: "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for cable systems".

History

Document history		
V1.1.1	January 2000	One-step Approval Procedure OAP 200021: 2000-01-26 to 2000-05-26
V1.1.1	August 2000	Publication