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General methods of measurement for digital television receivers –

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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GENERAL METHODS OF MEASUREMENT FOR DIGITAL TELEVISION RECEIVERS

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
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International Standard IEC 62028 has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this standard is based on the following documents:

CDV	Report on voting
100/232/CDV	100/427/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

Annexes A, B, and C form an integral part of this standard.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

GENERAL METHODS OF MEASUREMENT FOR DIGITAL TELEVISION RECEIVERS

1 Scope

IEC 62028 deals with the standard conditions and methods of measurement on digital television receivers which receive digital television broadcast transmissions.

IEC 62028 deals with the determination of performance and allows the comparison of equipment by listing the characteristics which are useful for specifications and by laying down uniform measuring methods of these characteristics. Performance requirements are not specified, since they are specified by other international, regional or domestic standards for the systems.

It does not include the measurements specific to the transmission system, such as;

- measurements on receivers for satellite transmission systems,
- measurements on receivers for terrestrial transmission systems,
- measurements on receivers for cable transmission systems,
- measurements specific to sound channels, and
- measurements specific to data channels.

IEC 62028 does not include methods of measurement on outdoor units and antennas for satellite reception, for which reference is required to other appropriate IEC standards.

IEC 62028 does not deal with general safety matters, for which reference is required to IEC 60065, or other appropriate IEC safety standards, nor with radiation and immunity, which will be dealt with by CISPR.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60107-1:1997, *Methods of measurement on receivers for television broadcast transmissions – Part 1: General considerations – Measurements at radio and video frequencies*

ISO/IEC 13818-1:2000, *Information technology – Generic coding of moving pictures and associated audio: Systems*

ISO/IEC 13818-4:1998, *Information technology – Generic coding of moving pictures and associated audio information – Part 4: Conformance testing*

ISO/IEC 13818-9:1996, *Information technology – Generic coding of moving pictures and associated audio information – Part 9: Extension for real time interface for systems decoders*

ITU-R BT.500-10:2000, *Methodology for the subjective assessment of quality of television pictures*

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*

EN 300 744 *Digital video broadcasting (DVB) – Framing structure, channel coding and modulation for digital terrestrial television"*

ETR 211:1997, *Digital video broadcasting (DVB) – Guidelines on implementation and usage of Service Information (SI)*

ETS 300 468:2000, *Digital video broadcasting (DVB) – Specification for Service Information (SI) in DVB systems*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this publication, the following terms and definitions apply:

3.1.1
MPEG-2
refers to the ISO/IEC 13818 series. System coding is defined in part 1, video coding is defined in part 2, audio coding is defined in part 3

3.1.2
multiplex
stream of all the digital data carrying one or more services within a single physical channel

3.1.3
service information (SI)
digital data describing the delivery system, content and scheduling/timing of broadcast data streams etc. It includes MPEG-2 program specific information (PSI) together with independently defined extensions.

3.1.4
transport stream (TS)
a data structure defined in ISO/IEC 13818-1

3.2 Abbreviations

AGC	Automatic Gain Controller
ARIB	Association of Radio Industries and Business
ASCII	American Standard Code for Information Interchange
ATM	Asynchronous Transfer Mode
ATSC	Advanced Television Systems Committee
BAT	Bouquet Association Table
BEP	Bit Error Probability
BER	Bit Error Rate
BPSK	Biphase Shift Keying
bslbf	bit string, left bit first
CA	Conditional Access
CAT	Conditional Access Table

CATV	Community Antenna TeleVision
COFDM	Coded Orthogonal Frequency Division Multiplexing
CPE	Common Phase Error
CRC	Cyclic Redundancy Check
D/A	Digital-to-Analogue converter
DBS	Direct Broadcast Satellite
DFT	Discrete Fourier Transform
DIRD	Digital Integrated Receiver Decoder
DIT	Discontinuity Information Table
DTS	Display Time-Stamp
DQPSK	Differential Quadrature Phase Shift Keying
DVB	Digital Video Broadcasting
DVB-C	DVB-Cable
DVB-S	DVB-Satellite
DVB-SI	DVB-Service Information
DVB-T	DVB-Terrestrial
EB	Error Block
ECM	Entitlement Control Message
EIT	Event Information Table
EMM	Entitlement Management Message
EN	European Standard
EPG	Electronic Programme Guide
ETR	ETSI Technical Report
ETS	European Telecommunication Standard
ETSI	European Telecommunications Standards Institute
FEC	Forward Error Correction
FFT	Fast Fourier Transform
FIFO	First-in, First-out shift register
FS	Full Scale
HDTV	High Definition TeleVision
HEX	Hexadecimal notation
HP	High Priority bit stream
ICI	Inter-Carrier Interference
IF	Intermediate Frequency
IFFT	Inverse Fast Fourier Transform
IRD	Integrated Receiver Decoder
ISDN	Integrated Services Digital Network
JTC	Joint Technical Committee
LP	Low Priority bit stream
LSB	Least Significant Bit
MER	Modulation Error Ratio
MP@ML	Main Profile at Main Level
MPEG	Moving Picture Experts Group

MSB	Most Significant Bit
MUX	Multiplex
NIT	Network Information Table
NVOD	Near Video On Demand
OCT	Octal notation
OFDM	Orthogonal Frequency Division Multiplex
PAT	Program Association Table
PCR	Program Clock Reference
PES	Packetized Elementary Stream
PID	Packet IDentifier
PMT	Program Map Table
PRBS	Pseudo-Random Binary Sequence
PSK	Phase Shift Keying
PSI	Program System Information
PTS	Presentation Time-Stamp
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QEF	Quasi Error Free
QPSK	Quaternary Phase Shift Keying
RF	Radio Frequency
rpchof	remainder polynomial coefficients, highest order first
RS	Reed-Solomon
RST	Running Status Table
SHF	Super High Frequency
SDT	Service Description Table
SDTV	Standard Definition TeleVision
SI	Service Information
SIT	Selection Information Table
SMATV	Satellite Master Antenna TeleVision
SMD	System Management Descriptor
Smid	System Management identifier
ST	Stuffing Table
STB	Set Top Box
TC-8PSK	Trellis Code 8-level Phase Shift Keying
TDT	Time and Date Table
TEI	Transport Error Indicator
TOT	Time Offset Table
TPS	Transmission Parameter Signalling
TS	Transport Stream
TV	Television
uimsbf	unsigned integer most significant bit first
UTC	Universal Time, Co-ordinated
VSB	Vestigial Side Band

8VSB 8-level Vestigial Side Band

16VSB 16-level Vestigial Side Band

64QAM 64-level Quadrature Amplitude Modulation

4 Conceptual block diagram of digital television receivers

4.1 General

4.1.1 Types of receivers

Digital television receivers are usually designed to be capable of receiving digital television signals in a variety of ways. Examples are direct off-air reception or reception via cabled network in the VHF/UHF bands, and from satellite broadcasts in conjunction with an outdoor unit and a DBS tuner. Further digital signals can be delivered by the PSTN or ISDN. The signal will usually include information on the service supplied.

A return path can be present for interactive TV applications.

For non-broadcast signals, the receiver may be used as a monitor to display pre-recorded video or home movies.

The methods of measurement described in this standard take into account various options.

4.1.2 Peripheral connectors

Most receivers are provided with connectors for the interface with audio and video signals. Examples are the 21-pin connector described in IEC 60933-1 and IEC 60933-2 and the Y/C connector described in IEC 60933-5. An example for a digital interface is described in the IEC 61883 series and an example for an analogue interface is described in IEC 61880.

4.2 Basic common block diagram

4.2.1 General

The basic common conceptual block diagram of digital television broadcasting system is shown in figure 1.

After audio and video signals are converted from analogue to digital, they are compressed. Data signals, which might include EPG (Electronic Program Guide), SI (Service Information), teletext program, etc., are multiplexed with compressed audio and video signals. After channel coding, the TS is modulated and transmitted via satellite, terrestrial, or cable.

In digital television receivers, the transmitted signal is demodulated and sent to the error correction block. After error correction, audio, video, and data signals are demultiplexed, and audio and video signals are decompressed respectively. Audio and video signals are sent to a conventional (analogue) TV receiver (through the peritelevision socket) or to a display and loud speakers, and the data signal is sent to a conventional (analogue) TV receiver (through the peritelevision socket) or to data equipment.

4.2.2 Satellite broadcasting system

When the digital television signal is transmitted via satellite, BPSK, QPSK and TC-8PSK modulation formats are used.

4.2.3 Terrestrial broadcasting system

COFDM, band-segmented OFDM and 8VSB modulation formats are used in the terrestrial broadcasting system.

4.2.4 CATV system

64QAM and 16VSB modulation formats are used for the CATV system.

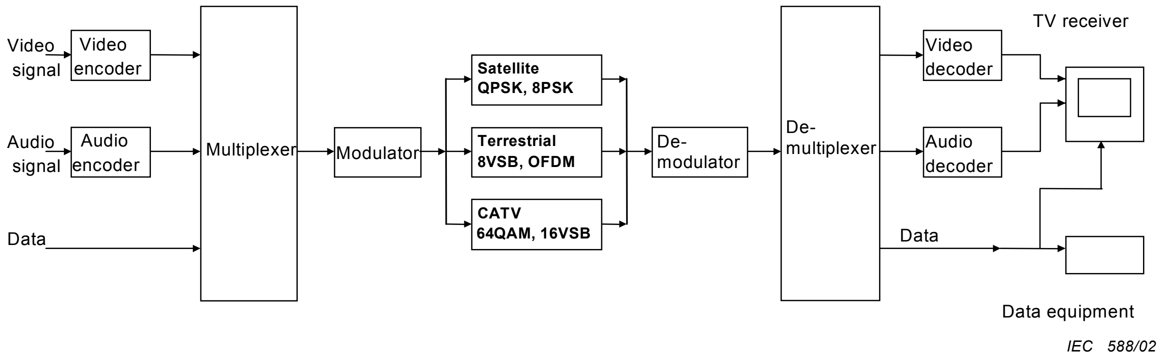


Figure 1 – Conceptual configuration of a digital broadcasting system

5 General notes on measurements

5.1 General conditions

General measuring conditions are according to 3.1 of IEC 60107-1.

5.2 Test signals

Test signals are common to all the transmission systems.

5.2.1 Video test signals

5.2.1.1 Still image video signal

The still image video signal shall be electronically generated.

a) Colour bar signal;
b) Ramp signal;
c) Modulated ramp signal;
d) Multiburst signal;
e) 5-steps signal.

5.2.1.2 Moving picture video signal

Under consideration.

5.2.2 Audio test signals

1 kHz sine-wave signal is used.

Frequency variable sine-wave signal is used for measuring frequency characteristics.

5.2.3 Data test signals

Under consideration.

5.3 RF (radio frequency) television signal

5.3.1 General

The RF signal is usually digitally modulated by a MPEG transport stream containing audio, video and service information data.

Subclauses 3.3 and 3.4 of IEC 60107-1 as far as relevant shall apply.

5.3.2 Reference modulation

The modulation shall be in accordance with the system for which the receiver under test is designed.

(1) Cable systems:

64QAM, 16VSB modulation formats are used on cable systems.

(2) Satellite broadcast:

QPSK, TC-8PSK, BPSK modulation formats are used for satellite broadcast.

(3) Terrestrial broadcast:

COFDM, band-segmented OFDM, 8VSB modulation formats are used for terrestrial broadcasting.

QPSK, DQPSK, 16QAM and 64QAM are used for modulating carriers when using OFDM (COFDM or band-segmented OFDM) modulation format for transmission.

In the following sections, the typical notation “QAM, PSK, OFDM and VSB” are used instead of 16QAM, 64QAM, 256QAM, QPSK, COFDM, band-segmented OFDM and 8VSB.

5.3.3 Signal level

The RF signal level shall be expressed by the r.m.s. voltage of the modulated carrier on a terminating resistor. The definition of the RF signal level is according to 3.4 of IEC 60107-1.

5.4 Measuring systems and test instruments

5.4.1 Measuring system

A notional block diagram for the measuring system is shown in figure 2.

5.4.2 Base band test signal generators

The video signal generator can be used for still picture image, and VCR and DVD can be used for moving picture image.

5.4.3 Service data generator

Under consideration.

5.4.4 Encoders

The video encoder shall be capable of encoding video signals in accordance with MPEG2 format.

The audio encoder shall be capable of encoding audio signals in accordance with MPEG2 or AC-3 or MPEG2-AAC format.

5.4.5 Modulator

The modulator shall modulate the transport stream at the output of the multiplexer according to the broadcasting system.

5.4.6 BER analyzer

Under consideration.

5.5 Standard measuring conditions

Unless otherwise specified, the standard conditions described in this subclause shall be applied.

5.5.1 Standard input signal levels

5.5.1.1 Standard RF input signal level for receivers for QAM systems

The standard level at the input terminal shall be 60 dB(μV) when terminated with a 75 Ω resistor.

5.5.1.2 Standard RF input signal level for receivers for OFDM systems

The standard level at the input terminal shall be 60 dB(μV) when terminated with a 75 Ω resistor.

5.5.1.3 Standard RF input signal level for receivers for VSB systems

The standard level at the input terminal shall be 60 dB(μV) when terminated with a 75 Ω resistor.

5.5.1.4 Standard RF input signal level for receivers for QPSK systems

The standard level at the input terminal shall be 60 dB(μV) when terminated with a 75 Ω resistor.

5.5.1.5 Standard input signal level for receivers for PSTN/ISDN systems

Under consideration.

5.5.2 Standard output signal levels

Under consideration.

5.5.3 Standard receiver settings

Under consideration.

5.5.4 General conditions

Under consideration.

5.6 Standard viewing conditions

The standard viewing condition to be applied shall be those of IEC 60107-1.

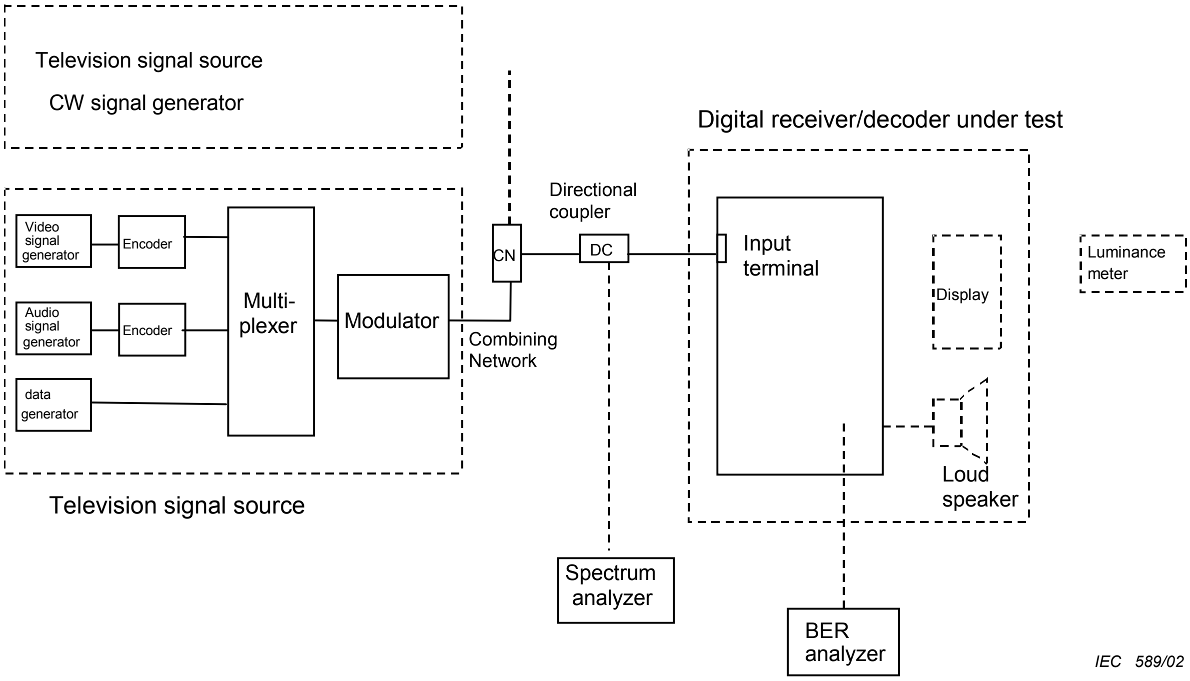


Figure 2 – Measuring set-up

6 Assessment of received picture and sound quality

6.1 Subjective tests of basic received quality

6.1.1 Objectives

The basic received quality tests will be conducted to assess the subjective quality of image and sound sequences that were encoded, modulated, transmitted, demodulated and decoded by the test digital system. Multiple modes of operation of the digital system may be tested.

6.1.2 Methodology

6.1.2.1 Testers

Testers should be recruited locally and screened for audio-visual abilities (normal or corrected-to-normal), and language comprehension. Those who meet the screening criteria will be permitted to participate in the tests.

Separate groups of testers were used in the different basic received quality tests. At least 15 testers shall participate in any given session.

6.1.2.2 Test material

Each sequence should consist of the central 10 s of a 15 s video clip. These sequences should be selected by a panel of experts to ensure that a broad range of image and sound attributes are represented.

Reference sequences for the each format tests of the digital system will always be displayed in the source format. Test sequences will be generated by processing (encoding, modulating, transmitting, demodulating and decoding) source sequences through the digital system.

6.1.2.3 Design and procedures

Tests are conducted in separate phases, for each format, using separate groups of testers.

The design of each phase of testing is identical. There are three factors: picture, replicate and tape order. Picture and replicate should be varied within subjects and tape order varied between subjects. Picture refers to the test sequences. Replicate refers to the number of times a condition occurred during a session; each condition was rated twice per session for both reference and test. Tape order refers to the random order of the trials. During each session, testers should complete all trials plus the practice trials. Some practice trials are to be completed at the start of testing, and the balance completed after a 30 min rest-break midway through the session.

The layout of a basic received quality assessment trial is shown schematically in figure 3, and is based on the double-stimulus continuous quality scale method described in ITU-R 500-10:2000. Each trial consists of a pair of reference and test sequences presented twice in succession. When sequence A is a reference, sequence B is a test, and vice-versa. Testers are not informed whether A or B is the reference or the test sequence.

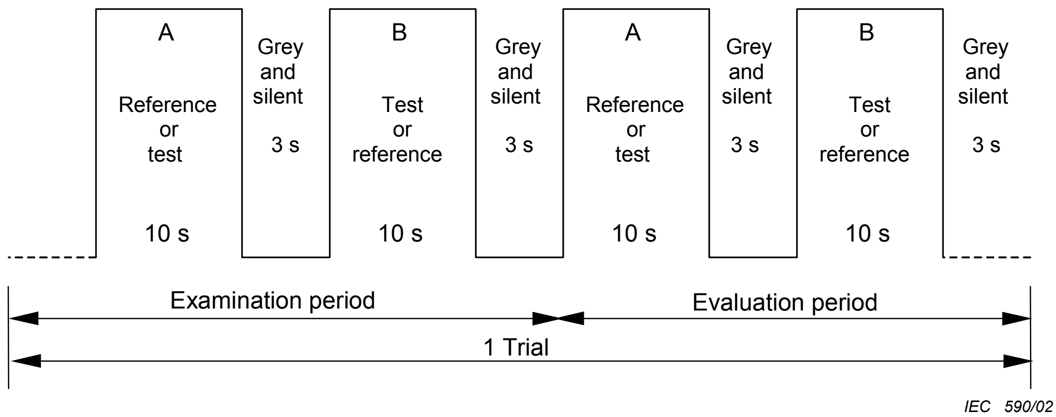


Figure 3 – Layout of a basic received quality assessment trial

Testers are to be instructed to rate the perceived image and sound quality of the "A" and the "B" sequences using scales shown in figure 4. These judgement scales are 100 mm in length. The labels "excellent", "good", "fair", "poor" and "bad" were printed at the locations shown in figure 4. Numerical values in brackets are presented for the reader's convenience only, and are not provided for the testers.

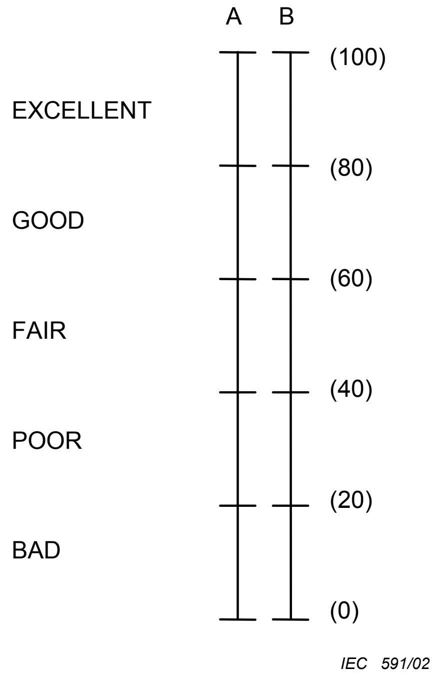


Figure 4 – Rating scales used in the basic received quality test

7 Methods of measurement of RF signals

7.1 General

This chapter describes the methods of measurement of the main characteristics of the RF signals to be applied at the input of the receiver under test.

These methods of measurement for digitally modulated signals are based on the assumption that:

a) The MPEG-2 transport stream (TS) is the specified input and output signal for all the baseline systems, i.e. for satellite, cable and terrestrial distribution.

b) The digitally modulated signals received by satellite are modulated in the PSK format, i.e. according to EN 300 421 for the QPSK format.

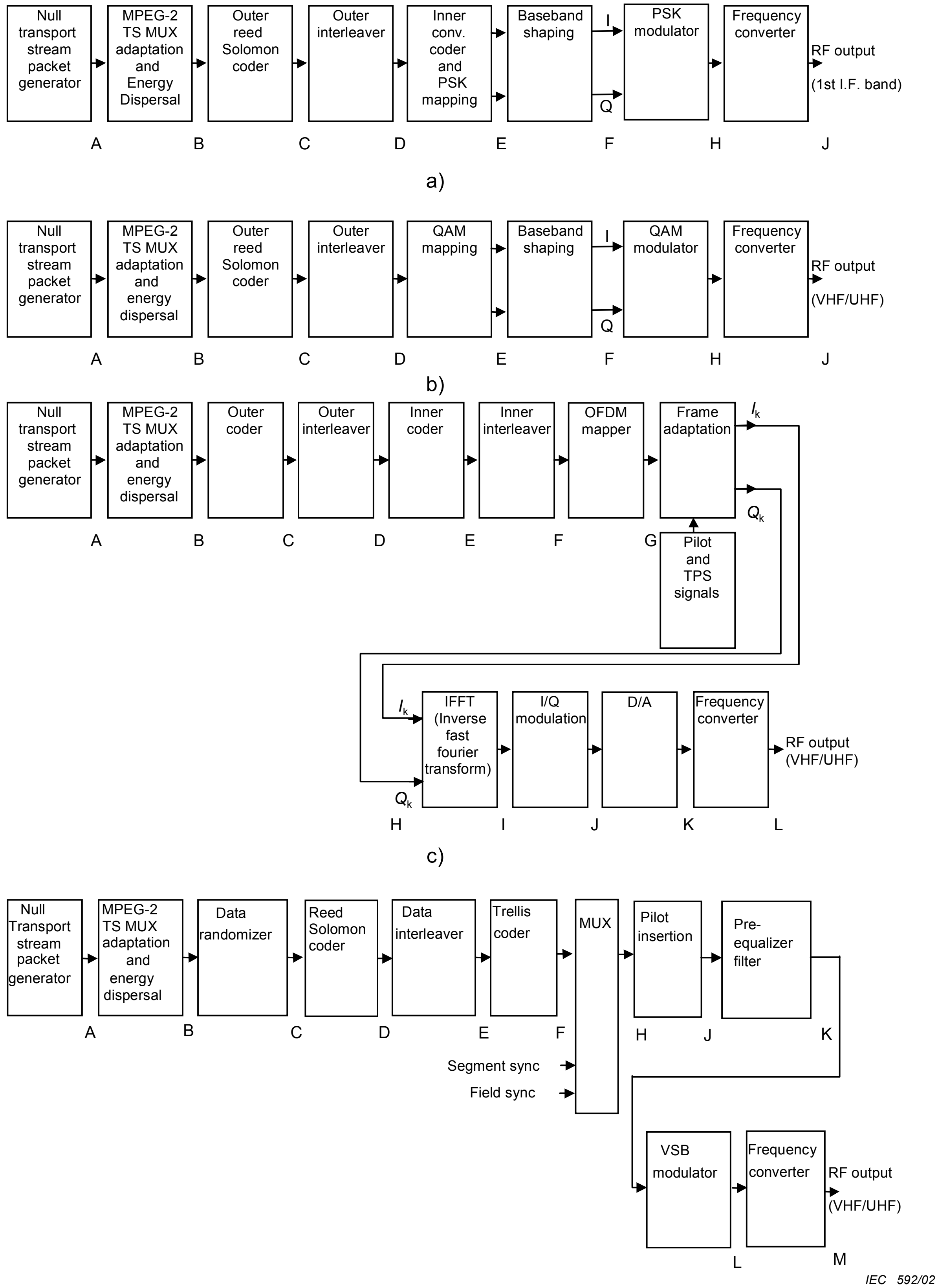
c) The digitally modulated signals received by satellite are distributed in cable systems in the QAM format, i.e. according to EN 300 429.

d) The digitally modulated signals received from terrestrial broadcasting are in the OFDM format, i.e. according to EN 300 744 or in the VSB format, i.e. according to ATSC A/53.

e) A signal source for PSK, QAM, OFDM or VSB formats is available, as described in figure 5.

f) A reference receiver for PSK, QAM, OFDM or VSB formats is available as described in figure 6, where appropriate interfaces are indicated.

g) The decoder implementation will not affect the consistency of the results. The MPEG-2 T-STD model constrains, as defined in ISO/IEC 13818-1 (MPEG-2 System), shall be satisfied as specified in ISO/IEC 13818-4 (MPEG-2 Compliance testing).

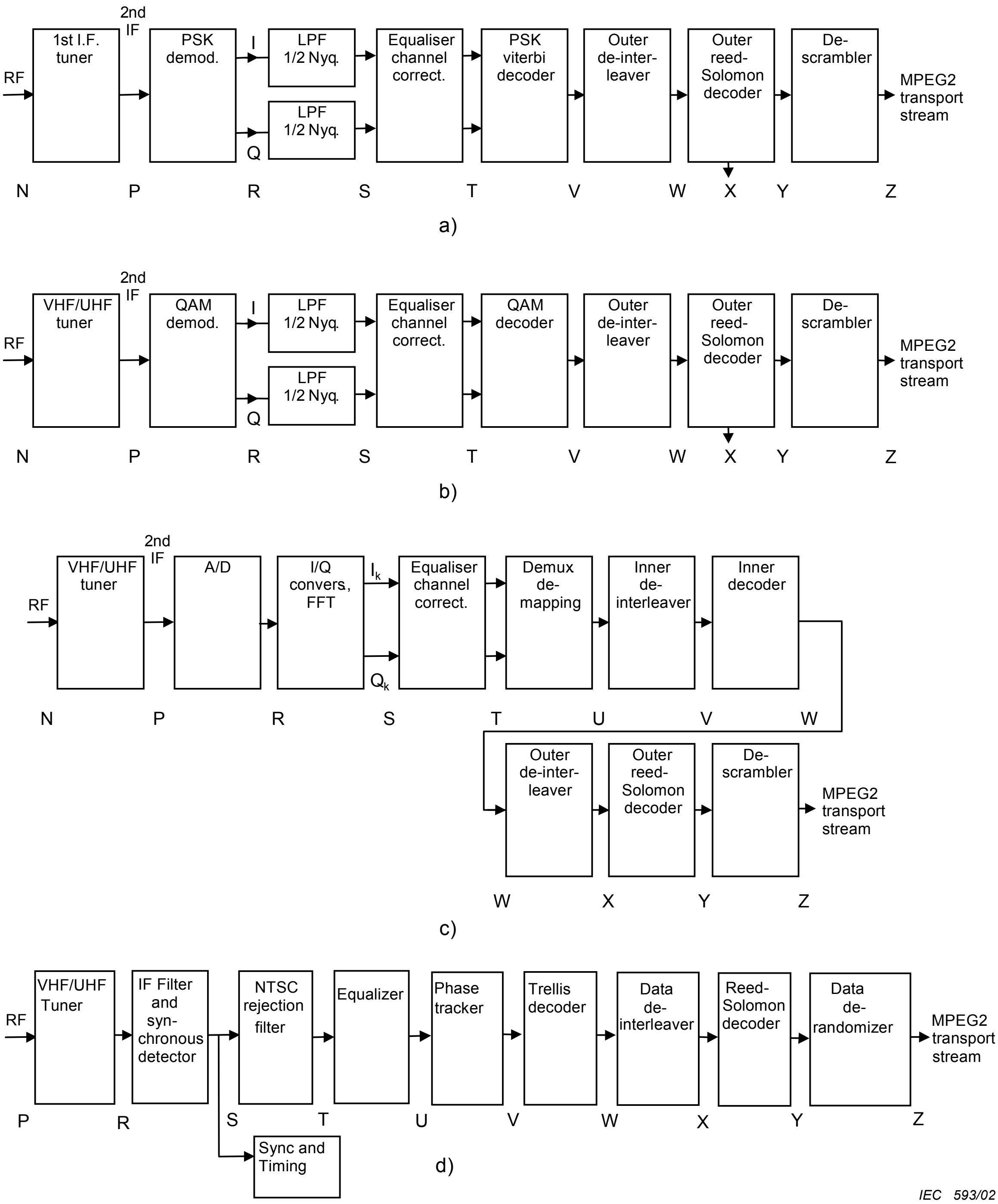


Key

a) PSK modulation (QPSK,BPSK or TC8PSK)
b) QAM modulation
c) OFDM modulation
d) VSB modulation

NOTE The null transport stream packet generator can be replaced by a PRBS (Pseudo Random Bit Sequence) generator.

Figure 5 – Reference RF signal source – I/Q signal source and RF modulator



Key

a) PSK demodulation (QPSK,BPSK or TC8PSK)
b) QAM demodulation
c) OFDM demodulation
d) VSB demodulation

NOTE The frequency range of the bands for the 1st IF and VHF/UHF tuners depends on the frequency allocation plan of each country. Examples are given below:

1st IF: 0,95 – 2,15 GHz

VHF/UHF: 40 – 862 MHz (Europe)
90 – 770 MHz (Japan)
54 – 806 MHz (USA)

Figure 6 – Reference receiver

7.2 Method of measurement of RF signal level

7.2.1 Introduction

This method of measurement applies to the measurement of the level of digitally modulated RF signals using PSK, QAM, OFDM or VSB formats.

Because the modulated RF signal is similar in characteristics to white noise, the measurement is based on the use of a suitable spectrum analyser, able to tune the frequency range of the channel and to display the whole bandwidth, to measure spectral power density.

NOTE A vector signal analyser or a suitable measuring set designed and calibrated for signal level measurement of digitally modulated RF signals can also be used.

The measurement is performed at the output of a RF signal source to be applied at the input of the receiver under test. For measuring purpose it can be useful to use a suitable signal splitter that feeds both the receiver under test and the measuring equipment. The attenuation of the signal splitter shall be taken into account in the presentation of the results.

The RF signal to be measured is that which is available at the system outlet of a cable system, at the output of an antenna for individual terrestrial reception or at the output of an outdoor unit (SHF receiver) for individual satellite reception.

7.2.2 Equipment required

The equipment required is a spectrum analyser with a known noise bandwidth and a calibrated display of the tuned signal. The calibration accuracy should be preferably within ±0,5 dB and shall be stated with the results.

The equipment shall be able to tune the nominal frequency range of the RF signal to be measured.

7.2.3 Connection of the equipment

Connect the measuring equipment to the RF signal source directly or by means of a signal splitter, whose other output port is connected to the input of the receiver under test, using suitable cables and connectors, taking care to maintain correct impedance matching.

7.2.4 Measurement procedure

a) When RF signal levels are to be measured where a high ambient field is present, the measuring equipment shall be checked for spurious readings. Connect a shielded termination to its input cable, place both meter and lead approximately in their measuring positions and check that there is a negligible reading at the frequency(ies) and on the meter ranges to be used.

b) Tune the spectrum analyser on the channel where the measurement shall be performed (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel whose bandwidth depends on the type of modulation used.

c) Set the resolution bandwidth (RSBW) of the spectrum analyser to 100 kHz and set the video bandwidth to 100 Hz or lower to obtain a smooth display.

d) Measure the level (S) of the RF signal at the flat top of the displayed signal in dB(μV) or in dB(mW) using the display line cursor, if this feature is available.

   NOTE If the spectrum of the RF signal does not have a flat top, due to echoes, measure the signal level at the centre frequency of the channel.

e) Measure on the displayed channel the two frequencies at which the level is 3 dB lower than the maximum level (S); the difference between these two frequencies is assumed to be the equivalent signal bandwidth (BW) (see also annex A).

f) Calculate the level (C) of the RF signal using the following formula:

$$C = S + 10\lg\frac{BW}{RSBW} + K_{sa}$$

where

- C is the RF signal level in dB(μV) or in dB(mW);
- S is the flat top signal level in dB(μV) or in dB(mW);
- BW is the equivalent signal bandwidth of the channel in kHz (see annex A);
- $RSBW$ is the resolution bandwidth of the spectrum analyser in kHz;
- K_{sa} is the correction factor of the spectrum analyser.

The correction factor (K_{sa}) depends on the measuring equipment used and shall be provided by the manufacturer of the measuring equipment or obtained by calibration. The value of the correction factor for a typical spectrum analyser is about 1,7 dB (see annex B).

The correction factor is not necessary if the measuring equipment can be set to display the level in dB (mW/Hz) units. In this case, the level (C) of the RF signal can be obtained from the measured maximum level (S) using the following formula:

$$C = S + 10\lg(BW)$$

NOTE This method of measurement actually measures the $C + N$ level. The contribution of noise is considered negligible if the level of noise displayed outside the equivalent signal band is at least 15 dB lower than the maximum level displayed within the equivalent signal band. This noise level includes that of the measuring equipment (spectrum analyser) which should be at least 10 dB lower than the noise level displayed outside the channel band in order not to affect the results. Otherwise, the contribution of noise (due to the system or the equipment under test and to the measuring equipment) shall be taken into account in the measurement of RF signal level (C) (see annex C).

7.2.5 Presentation of the results

The measured level is expressed in dB(μV) referred to 75 Ω or in dB(mW). The accuracy of the measuring equipment shall be stated with the results.

7.3 Method of measurement of carrier to noise ratio (*C/N*)

7.3.1 Introduction

This method of measurement applies to the measurement of the carrier to noise ratio (*S*/*N*) of digitally modulated RF signals using PSK, QAM, OFDM or VSB formats.

Because the modulated RF signal is similar to the noise distributed in the bandwidth of the channel, the measurement is based on the use of a suitable spectrum analyser, able to tune the frequency range of the channel and to display the whole bandwidth.

NOTE A vector signal analyser can also be used.

The measurement is performed at the output of a RF signal source to be applied at the input of the receiver under test. For measuring purposes, it can be useful to use a suitable signal splitter that feeds both the receiver under test and the measuring equipment.

The RF signal to be measured is that which is available at the system outlet of a cable system, at the output of an antenna for individual terrestrial reception or at the output of an outdoor unit (SHF receiver) for individual satellite reception.

7.3.2 Equipment required

The equipment required is a spectrum analyser having a calibrated display of the tuned signal.

The equipment shall be able to tune the nominal frequency range of the RF signal to be measured.

7.3.3 Connection of the equipment

Connect the measuring equipment to the RF signal source directly or by means of a signal splitter, whose other output port is connected to the input of the receiver under test, using suitable cables and connectors, taking care to maintain correct impedance matching.

7.3.4 Measurement procedure

a) Tune the spectrum analyser on the channel where the measurement shall be performed (selecting the centre frequency of the spectrum analyser) and select the span and level settings to show the whole channel whose bandwidth depends on the type of modulation used.

b) Set the resolution bandwidth of the spectrum analyser to 100 kHz and the video bandwidth to 100 Hz. If a different setting is used, this shall be the same when measuring the signal level and the noise level. Select a display line cursor if the spectrum analyser supports this feature. Otherwise select a normal marker.

c) Measure the maximum level (*C*) of the displayed signal in dB(μV) or in dB(mW).

   NOTE If the spectrum of the signal is not flat, due to echoes, measure the *S* value at the center frequency (carrier frequency) of the signal spectrum. This value approaches the useful power.

d) Switch off the channel at the input of the RF signal source, terminating the input port with a matched impedance (or depointing the antenna, if the measurement is performed at the output of an outdoor unit for satellite reception) and measure the noise level (*N*) in the same units as the signal level (in dB(μV) or in dB(mW)).

NOTE. When switching off the input signal all equipment with built-in AGC will show a different behaviour. In this case the noise level shall be measured in between the channels.

e) Calculate the carrier to noise ratio (C/*N*) by the following formula:

$$(C/N)_{\mathrm{dB}} = \mathrm{C} - N \qquad \text{(dB)}$$

   where

   $(C/N)_{\mathrm{dB}}$ is the carrier to noise ratio in dB;

   C is the RF signal level in dB(μV) or in dB(mW);

   N is the noise level in dB(μV) or in dB(mW).

NOTE This method of measurement actually measures the $(C+N)/N$ ratio. The measuring equipment (spectrum analyser) should have a noise level at least 10 dB lower than the noise level displayed outside the channel band in order not to affect the results. Otherwise the contribution of the measuring equipment noise in the measurement of the noise level (*N*) shall be taken into account (see annex C).

7.3.5 Presentation of the results

The measured signal to noise ratio (*C*/*N*) is expressed in dB.

7.4 Method of measurement of Bit Error Rate (BER)

7.4.1 Introduction

This method of measurement applies to the measurement of Bit Error Rate (BER) of digitally modulated RF signals using PSK, QAM, OFDM or VSB formats.

BER is the primary parameter which describes the quality of the RF signal source and shall be related to the carrier to noise ratio at the input of the receiver.

The BER is defined as the ratio between erroneous bits and the total number of transmitted bits.

If error rates range from 10^{-2} to 10^{-4}, the measurement can be done in a reasonable amount of time. Above a BER of 10^{-2}, the result is assumed to be inaccurate.

The measurement is performed at the output of a RF signal source to be applied at the input of the receiver under test. The RF signal to be measured is that which is available at the system outlet of a cable system, at the output of an antenna for individual terrestrial reception or at the output of an outdoor unit (SHF receiver) for individual satellite reception.

7.4.2 Equipment required

The equipment required is listed below:

a) power splitter,

b) spectrum analyser able to tune the nominal frequency range of the RF signal,

c) reference receiver (see figure 6) with good equaliser (influence of linear distortions to the BER measurement should be negligible),

d) BER counter connected at the appropriate interface (V or U) of the reference receiver, depending where BER shall be evaluated. If it is connected after the Reed-Solomon decoder (interface Y or Z), decoding should be deactivated in order to reduce the duration of the measurement.

7.4.3 Connection of the equipment

The measuring set-up for BER measurement is showed in figure 7. The measuring equipment shall be connected taking care to maintain correct impedance matching.

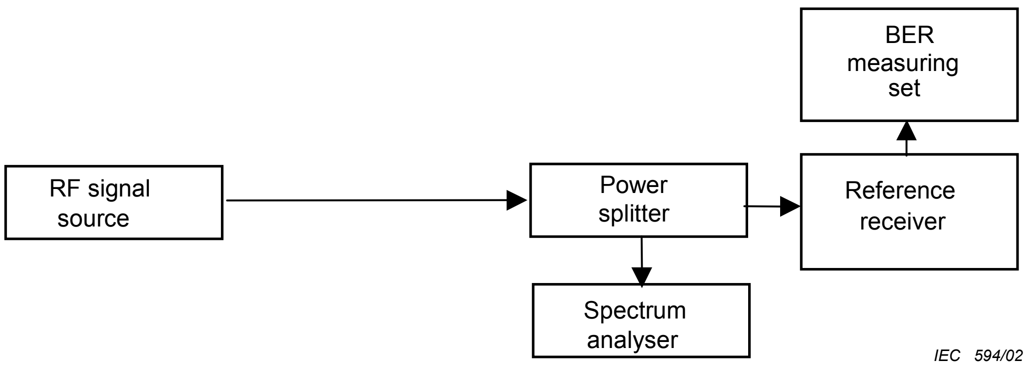


Figure 7 – Test set-up for BER measurement

7.4.4 Measurement procedure

a) Tune the reference receiver and the spectrum analyser on the channel where the measurement shall be performed. Select the centre frequency of the spectrum analyser, the span and level settings to show the whole channel.

b) Set the resolution bandwidth (*RSBW*) of the spectrum analyser to 100 kHz and the video bandwidth to 100 Hz. Select a display line cursor if the spectrum analyser supports this feature. Otherwise select a normal marker.

c) Measure the carrier to noise ratio (*C*/*N*) according to the procedure indicated in 7.3.

d) Measure the BER, for a sufficiently long time in order to count at least 100 error bits and refer this number to the total number of transmitted bits in that time. This is the gross bit rate that is referred to the measured *C*/*N* value.

NOTE 1 When measuring a QAM modulated signal, the *C*/*N* value referred to the net bit rate can be calculated using the RS rate, i.e. using the following conversion factor for RS(204, 188) code:

$$10 \lg (204/188) = +0{,}35 \text{ dB}$$

NOTE 2 When measuring a PSK or a OFDM modulated signal, the *C*/*N* value referred to the net bit rate value can be calculated taking into account both the inner code rate and the RS rate. If the inner code rate is ¾, the conversion factor can be calculated as follows:

10 lg (4/3)(204/188) = +1,6 dB

7.4.5 Presentation of the results

The measured BER is indicated with reference to a certain *C*/*N* value. If the measured BER is referred to, the gross bit rate or the net bit rate shall be stated with the results. The interface point where the measurement of BER has been performed shall be indicated with the results.

7.5 Method of measurement of BER versus E_b/N_o

7.5.1 Introduction

This method of measurement applies to the measurement of BER of digitally modulated signals using PSK, QAM, OFDM or VSB formats. The measurement of BER versus E_b/N_o enables a graph to be drawn which shows the quality of the RF signal over a range of bit error rates. The residual BER at high E_b/N_o values is an indicator of possible receiving system problems. The BER range of interest is 10^{-7} to 10^{-3}.

The measurement is performed at the output of a RF signal source to be applied at the input of the receiver under test. The RF signal to be measured is that which is available at the system outlet of a cable system, at the output of an antenna for individual terrestrial reception or at the output of an outdoor unit (SHF receiver) for individual satellite reception.

7.5.2 Equipment required

The equipment required is listed below:

a) noise source,
b) adjustable attenuator,
c) power combiner,
d) power splitter,
e) spectrum analyser able to tune the nominal frequency range of the RF signal,
f) reference receiver (see figure 6) with good equaliser (influence of linear distortions to the BER measurement should be negligible),
g) BER counter connected at the appropriate interface (V or U) of the reference receiver, depending where BER shall be evaluated. If it is connected after the Reed-Solomon decoder (interface Y or Z), decoding should be deactivated in order to reduce the duration of the measurement.

7.5.3 Connection of the equipment

The measuring set-up for BER versus E_b/N_o measurement is showed in figure 8.

The measuring equipment shall be connected taking care to maintain correct impedance matching.

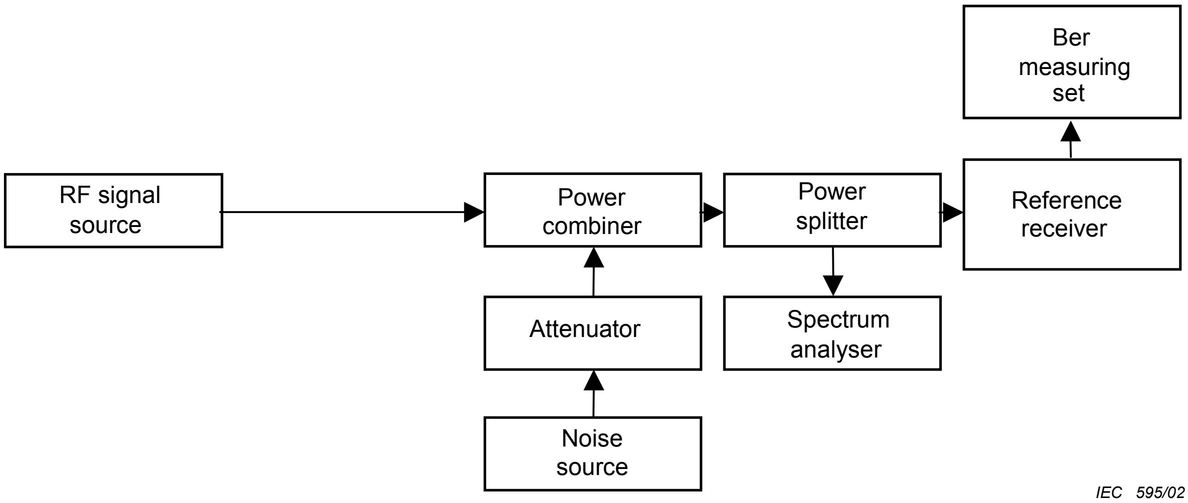


Figure 8 – Test set-up for BER measurement versus E_b/N_o

7.5.4 Measurement procedure

a) Tune the reference receiver and the spectrum analyser on the channel where the measurement shall be performed. Select the centre frequency of the spectrum analyser, the span and level settings to show the whole channel.

b) Set the resolution bandwidth (*RSBW*) of the spectrum analyser to 100 kHz and the video bandwidth to 100 Hz or lower to obtain a smooth display.

c) With the noise generator switched off measure the BER at the reference receiver output.

d) Measure the carrier to noise ratio (*C*/*N*) according to the procedure indicated in 6.2.

e) Calculate the E_b/N_o from the following formula:

$$(E_b/N_o)_{dB} = (C/N)_{dB} + 10 \lg (BW) - 10 \lg (f_s) - 10 \lg m$$

where:

f_s is the symbol rate,

m is the number of bits per symbol (m = 2 for QPSK, m = 3 for 8VSB, m = 4 for 16QAM, m = 6 for 64QAM) modulating the carrier (PSK, QAM or VSB) or each pilot carrier (OFDM).

f) Switch-on the noise generator, add noise changing the attenuator setting and measure again the BER at the reference receiver output and the E_b/N_o at the input of the receiver. Repeat this step several times to obtain the plot of BER versus E_b/N_o.

NOTE 1 When measuring a QAM modulated signal, the E_b/N_o value referred to the net bit rate can be calculated using the RS rate, i.e. using the following conversion factor for RS(204, 188) code:

10 lg (204/188) = +0,35 dB

NOTE 2 When measuring a PSK or OFDM modulated signal, the E_b/N_o value referred to the net bit rate value can be calculated taking into account both the inner code rate and the RS rate. If the inner code rate is ¾, the conversion factor can be calculated as follows:

10 lg (4/3)(204/188) = +1,6 dB

7.5.5 Presentation of the results

The measured BER is plotted versus E_b/N_o (dB). An example of measurement of BER versus E_b/N_o is showed in figure 9. The interface point where the measurement of BER has been performed shall be indicated with the results.

The theoretical curves are for the QPSK and 64QAM modulation formats.

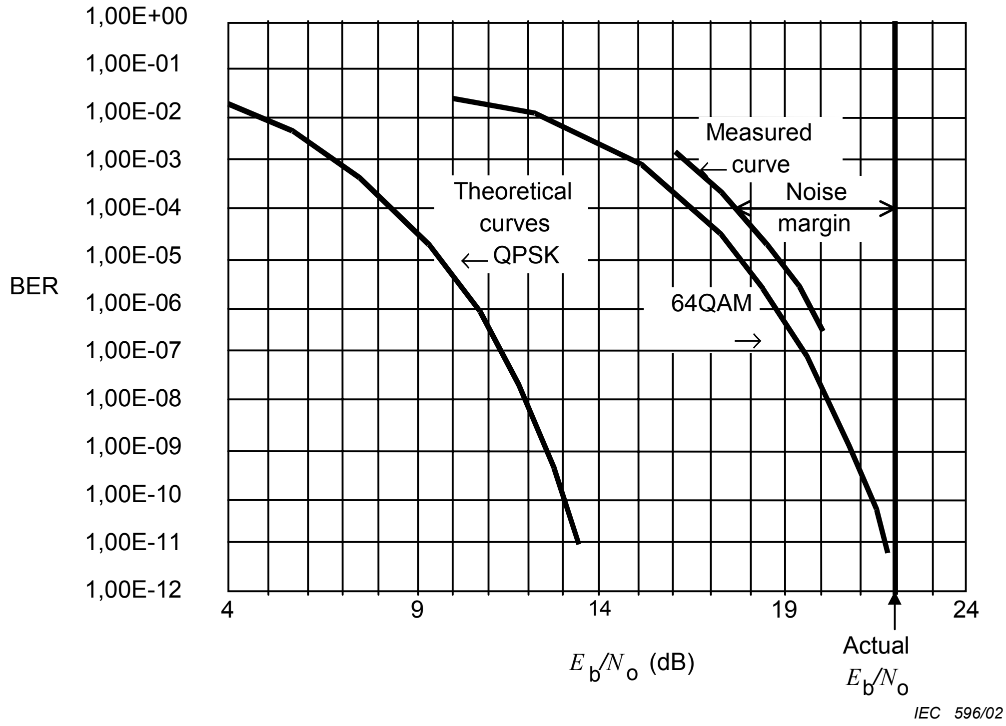


Figure 9 – Example of BER measurement versus E_b/N_o

7.6 Method of measurement of noise margin

7.6.1 Introduction

This method of measurement applies to the measurement of noise margin of digitally modulated RF signals using PSK, QAM, OFDM or VSB formats.

The purpose of this method of measurement is to provide an indication of the reliability of the transmission channel. The noise margin measurement is a more useful measure of the receiving system operating margin than a direct BER measurement due to the steepness of the BER curve versus E_b/N_o ratio.

The measurement is performed at the output of a RF signal source to be applied at the input of the receiver under test. The RF signal to be measured is that which is available at the system outlet of a cable system, at the output of an antenna for individual terrestrial reception or at the output of an outdoor unit (SHF receiver) for individual satellite reception.

7.6.2 Equipment required

The equipment required are listed below:

a) noise source,
b) adjustable attenuator,
c) power combiner,
d) power splitter,
e) spectrum analyser able to tune the nominal frequency range of the RF signal source,
f) reference receiver (see figure 6) with a good equaliser (influence of linear distortions to the BER measurement should be negligible),

g) BER counter connected at the appropriate interface (U or V) of the reference receiver, depending where BER shall be evaluated. If it is connected after the Reed-Solomon decoder (interface Y or Z), decoding should be deactivated in order to reduce the duration of the measurement.

7.6.3 Connection of the equipment

The measuring set-up for noise margin measurement is the same as that for the measurement of BER versus E_b/N_o and is shown in figure 10.

The measuring equipment shall be connected taking care to maintain correct impedance matching.

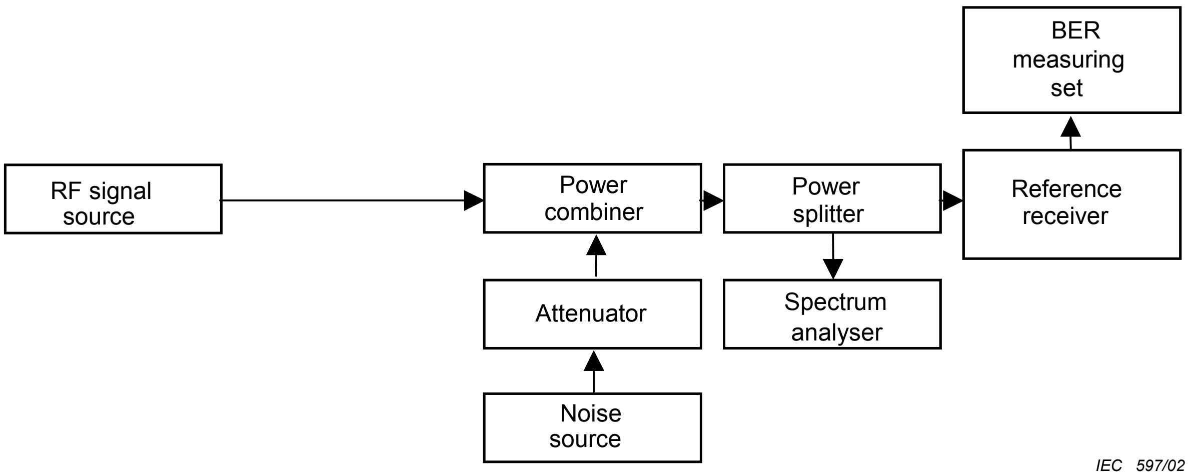


Figure 10 – Test set-up for noise margin measurement

7.6.4 Measurement procedure

a) Tune the reference receiver and the spectrum analyser on the channel where the measurement shall be performed. Select the centre frequency of the spectrum analyser, the span and level settings to show the whole channel.

b) Set the resolution bandwidth (*RSBW*) of the spectrum analyser to 100 kHz and the video bandwidth to 100 Hz or lower to obtain a smooth display.

c) With the noise generator switched off, measure the BER at the reference receiver output. This value should be lower than 10^{-4}.

d) Measure the carrier to noise ratio (C/N_1) according to the procedure indicated in 7.3.

e) Add noise to the RF signal until BER measured at the reference receiver output is 10^{-4}.

f) Measure again the carrier to noise ratio (C/N_2) according to the procedure indicated in 7.3.

g) Calculate the Noise Margin *NM* by the following formula:

$$NM_{dB} = (C/N_1) - (C/N_2) \qquad \text{(dB)}$$

7.6.5 Presentation of the results

The measured noise margin is expressed in dB. An example of measurement of noise margin is showed in figure 9 where BER versus E_b/N_o is also plotted. The interface point where the measurement of BER has been performed shall be indicated with the results.

7.7 Method of measurement of Modulation Error Ratio (MER)

7.7.1 Introduction

This method of measurement is able to provide a single "figure of merit" analysis of the received RF signal.

This figure is computed to include the total signal degradation likely to be present at the input of a commercial receiver's decision circuits and so give an indication of the ability of that receiver to correctly decode the signal.

The measurement is performed at the output of a RF signal source to be applied at the input of the receiver under test. The RF signal to be measured is that which is available at the system outlet of a cable system, at the output of an antenna for individual terrestrial reception or at the output of an outdoor unit (SHF receiver) for individual satellite reception.

7.7.2 Equipment required

The equipment required are listed below:

a) reference receiver (see figure 6),

b) constellation analyser.

7.7.3 Connection of the equipment

The measuring set-up for the MER measurement is shown in figure 11. The measuring equipment shall be connected taking care to maintain correct impedance matching.

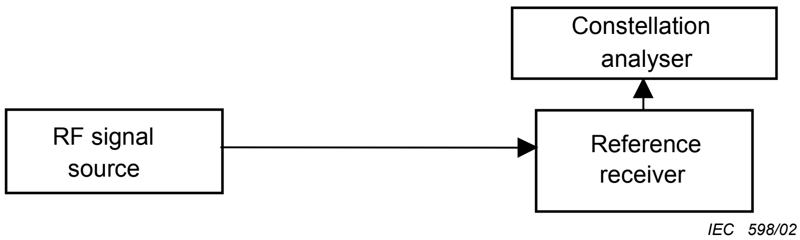


Figure 11 – Test set-up for MER measurement

7.7.4 Measurement procedure

a) Tune the reference receiver on the channel where the measurement shall be performed. The measurement of the MER does not assume the use of an equaliser. However the measuring receiver may include a commercial quality equaliser to give more accurate results when the RF signal to be measured has linear impairments.

b) Connect the constellation analyser to the appropriate interface (S or T of the reference receiver shown in figure 6). If the constellation analyser has its own tuner, the use of the reference receiver can be avoided.

c) The carrier frequency and symbol timing are recovered, which removes frequency error and phase rotation. Origin offset (for example, caused by residual carrier or d.c. offset), quadrature error and amplitude imbalance are not corrected.

d) A time record of N received symbol co-ordinate pairs (I_j, Q_j) is captured by the constellation analyser. N shall be significantly larger than the M symbol points.

e) For each received symbol, a decision is made as to which symbol was transmitted. The error vector is defined as the distance from the ideal position of the chosen symbol (the centre of the decision box) to the actual position of the received symbol.

   The distance can be expressed as a vector (δI_j, δQ_j) .

   An example of representation of the constellation diagram for a 64QAM modulation format and the distance (δI_j, δQ_j) for each of the N received symbols in the i^{th} point from the ideal position (I_j, Q_j) is shown in figure 12.

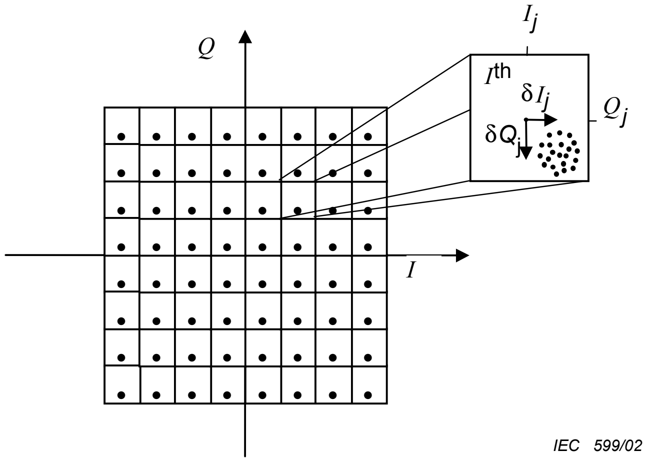


Figure 12 – Example of constellation diagram for a 64QAM modulation format where the I^{th} point has been enlarged to show the co-ordinates of the symbol error vector

The sum of the squares of the magnitude of the symbol error vectors is divided by the sum of the squares of the magnitudes of the ideal symbol vectors. The result, expressed as a power ratio in dB, is defined as the Modulation Error Ratio (MER).

$$MER = 10\lg\frac{\sum_{j=1}^{N}(\delta I_j^{\,2} + \delta Q_j^{\,2})}{\sum_{j=1}^{N} I_j^{\,2} + Q_j^{\,2})}\ \text{dB}$$

7.7.5 Presentation of the results

The measured Modulation Error Ratio (MER) is expressed in dB. The interface of the receiver where the measurement has been performed shall be stated with the results.

7.8 Method of measurement of phase jitter

7.8.1 Introduction

This method of measurement is able to provide an indication of the phase or frequency fluctuations of an oscillator used in an equipment of the receiving system (i.e. in a frequency converter). Using such an oscillator with digitally modulated signals may result in a sampling uncertainty in the receiver, because the carrier regeneration cannot follow the phase fluctuations.

The measurement is performed at the output of a RF signal source to be applied at the input of the receiver under test. The RF signal to be measured is that which is available at the system outlet of a cable system, at the output of an antenna for individual terrestrial reception or at the output of an outdoor unit (*SHF* receiver) for individual satellite reception.

7.8.2 Equipment required

The equipment required is listed below:

a) reference receiver (see figure 6),
b) constellation analyser.

7.8.3 Connection of the equipment

The measuring set-up for the phase jitter measurement is shown in figure 13.

The measuring equipment shall be connected taking care to maintain correct impedance matching.

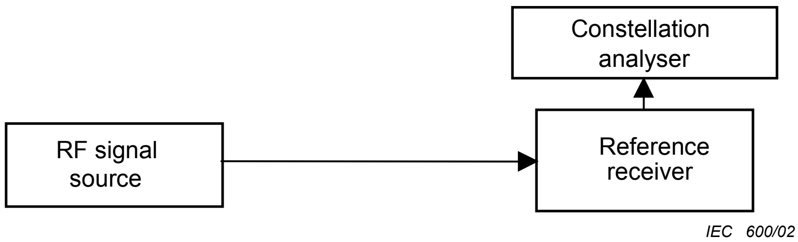


Figure 13 – Test set-up for phase jitter measurement

7.8.4 Measurement procedure

a) Tune the reference receiver on the channel where the measurement shall be performed. The measurement of the phase jitter does not assume the use of an equaliser. However the measuring receiver may include a commercial quality equaliser to give more accurate results when the signal at the measurement point has linear impairments.

b) Connect the constellation analyser to the appropriate interface (S or T of the reference receiver shown in figure 6). If the constellation analyser has its own tuner, the use of the reference receiver can be avoided.

c) The carrier frequency and symbol timing are recovered, which removes frequency error and phase rotation. Origin offset (for example, caused by residual carrier or d.c. offset), quadrature error and amplitude imbalance are not corrected.

d) A time record of N received symbol co-ordinate pairs (I_j, Q_j) is captured by the constellation analyser. N shall be significantly larger than the M symbol points.

e) The signal points affected by phase jitter are arranged along a curved line crossing the centre of each decision boundary box as shown in figure 14 for the four "corner decision boundary boxes".

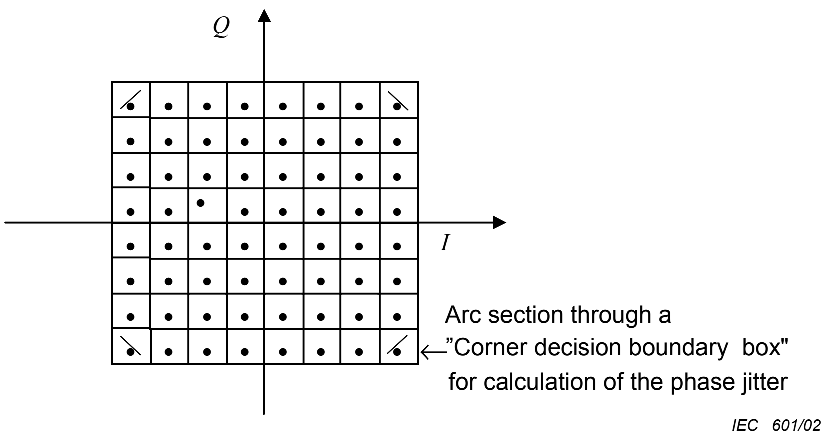


Figure 14 – Example of constellation diagram for a 64QAM modulation format where are shown the "corner decision boundary boxes" for the phase jitter

The phase jitter can be calculated using the following procedure. For each received symbol:

- Calculate the angle between the I-axis of the constellation and the vector to the received symbol (I_{rcvd}, Q_{rcvd}):

  ϕ_1 = arctan (Q_{rcvd}/I_{rcvd})
- Calculate the angle between the I-axis of the constellation vector to the corresponding ideal symbol (I_{ideal}, Q_{ideal}):

  ϕ_2 = arctan (Q_{ideal}/I_{ideal})
- Calculate the error angle:

  $\phi_E = \phi_1 - \phi_2$

From these *N* error angles calculate the RMS phase jitter (*PJ*):

$$PJ = \sqrt{(1/N)\sum_{i=1}^{N}\phi_{Ei}^{\,2} - (1/N^2)\left(\sum_{i=1}^{N}\phi_{Ei}\right)^2}$$

7.8.5 Presentation of the results

The measured phase jitter is expressed in degrees. The interface of the receiver where the measurement has been performed shall be stated with the results.

7.9 Method of measurement of phase noise of a RF carrier

7.9.1 Introduction

This method of measurement is able to provide an indication of the phase noise of a carrier due to the phase or frequency fluctuations of an oscillator used in an equipment of the receiving system (i.e. in a frequency converter).

For PSK, QAM or VSB modulation formats, using such an oscillator with digitally modulated signals may result in a sampling uncertainty in the receiver, because the carrier regeneration cannot follow the phase fluctuations. Phase noise outside the loop bandwidth of the carrier recovery circuit leads to a circular smearing of the constellation points in the I/Q plane. This reduces the operating margin (noise margin) of the system and may directly increase the BER.

In an OFDM system, the phase noise can cause Common Phase Error (CPE) which affects all carriers simultaneously, and which can be corrected by using continual pilots, and Inter-Carrier Interference (ICI) which is noise-like and that can not be corrected.

The effects of CPE are similar to any single carrier system and the phase noise, outside the loop bandwidth of the carrier recovery circuit, leads to a circular smearing of the constellation points in the I/Q plane. This reduces the operating margin (noise margin) of the system and may directly increase the BER.

The effects of ICI are particular to OFDM and cannot be corrected for. This has to be taken into account as part of the total noise of the system.

The measurement is performed at the output of the receiving system while an unmodulated carrier is applied at its input.

The receiving system to be measured can be a cable system, an antenna system for individual terrestrial reception or an outdoor unit (*SHF* receiver) for individual satellite reception.

7.9.2 Equipment required

The equipment required is listed below:

a) RF signal generator for the frequency bands of input signals of the receiving system,

NOTE The phase noise characteristic of the signal generator shall be sufficiently lower (at least 10 dB) than that to be measured. If is not known, a preliminary check shall be performed.

b) spectrum analyser able to tune the nominal frequency range of the output signals of the receiving system.

7.9.3 Connection of the equipment

The measuring set-up for the phase noise measurement is shown in figure 15.

The measuring equipment shall be connected taking care to maintain correct impedance matching.

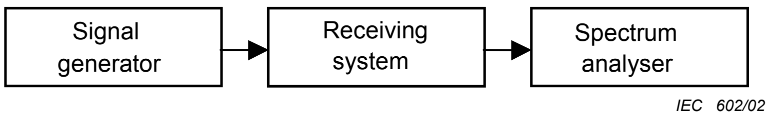


Figure 15 – Test set-up for phase noise measurement

7.9.4 Measurement procedure

a) Set the carrier frequency of the RF signal generator to that of the input channel of the receiving system where the measurement shall be performed.

b) Adjust the carrier level of the RF signal generator to obtain the same level at the output of the receiving system as in normal operating conditions.

c) Tune the spectrum analyser on the output channel of the receiving system. Select the centre frequency of the spectrum analyser, the span and level settings to show the carrier and its sidebands due to the phase noise.

d) Set the resolution bandwidth (*RSBW*) of the spectrum analyser to 300 Hz and the video bandwidth to 30 Hz or 10 Hz.

e) Measure the unmodulated carrier level (*C*) in dB(mW).

f) Measure the level [$PN(f_m)$], in dB(mW), of each component in one noise sideband and note its frequency (f_m).

g) Convert the measured value of *PN* to 1 Hz bandwidth, using the following formula:

$$PN_o(f_m) = PN(f_m) - 10 \lg (RSBW) + K_{sa} \text{ dB}$$

where: *RSBW* is the bandwidth of the resolution bandwidth filter of the spectrum analyser.

The correction factor (K_{sa}) depends on the measuring equipment used and shall be provided by the manufacturer of the measuring equipment or obtained by calibration. The value of the correction factor for a typical spectrum analyser is about 1,7 dB (see annex C).

The correction factor is not necessary if the measuring equipment can be set to display the noise level in dB(mW/Hz) units. In this case, the $PN_o(f_m)$ value is obtained directly.

h) Calculate the phase noise performance of the carrier, defined as the ratio of the measured power in one sideband component, on a per hertz bandwidth spectral density basis, to the total signal power:

$$\alpha(f_m) = PN_o(f_m) - C \quad \text{dB(Hz}^{-1}\text{)}$$

NOTE For this measurement, it is assumed that contributions from amplitude modulation to the noise spectrum are negligible compared to those from frequency modulation and that the measurement bandwidth (*RSBW*) is much smaller than f_m.

7.9.5 Presentation of the results

The measured phase noise, expressed in dB(Hz^{-1}), is plotted versus the frequency distance (f_m) away from the carrier.

For the measurement of CPE (OFDM systems) the spectrum mask shall be specified at least in three points (frequency offsets and levels, as seen in the example of figure 16.

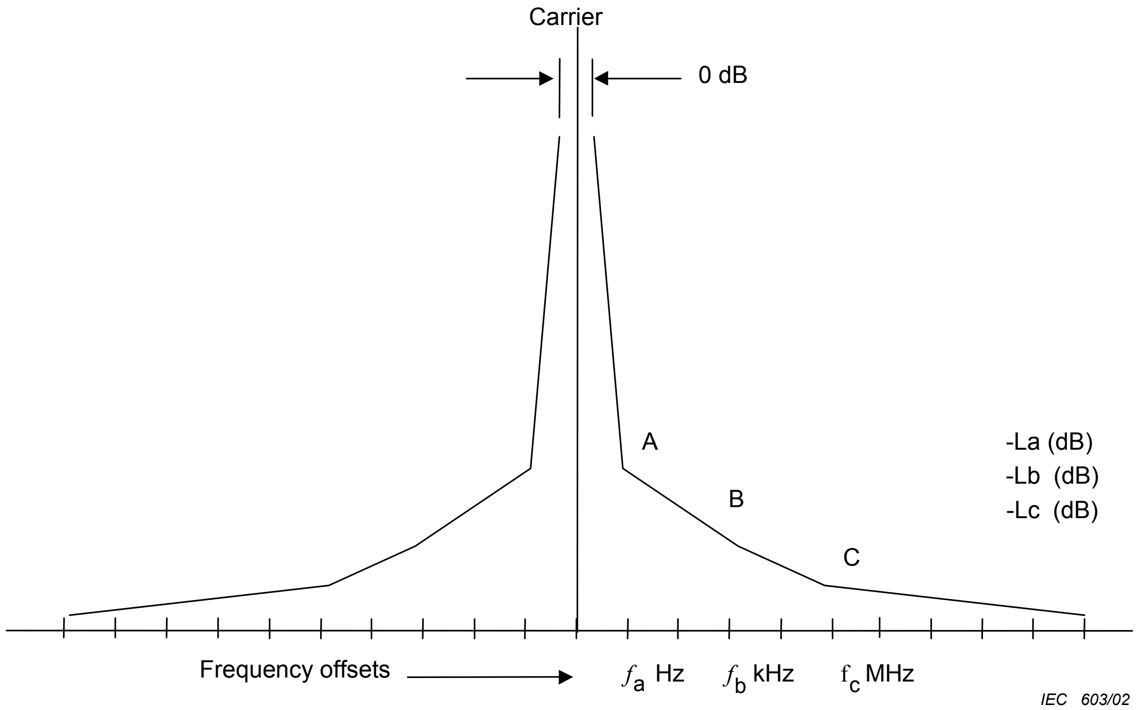


Figure 16 – Possible mask for CPE measurements – the points A, B and C to be defined

For the measurement of ICI (OFDM systems), the use of multiples of carrier spacing is recommended for the frequencies f_a, f_b and f_c indicated in table 1.

Table 1 – Frequency offsets for 2k and 8k OFDM systems

Symbol rate	f_a	f_b	f_c
2k system	4,5 kHz	8,9 kHz	13,4 kHz
8k system	1,1 kHz	2,2 kHz	3,4 kHz

8 Measurements of the MPEG-2 transport stream

8.1 Introduction

Details of the MPEG-2 transport stream and a list of parameters recommended for evaluation can be found in clause 5 of ETR 290.

8.2 Method of measurement

8.2.1 Introduction

The measurement on the MPEG-2 transport stream requires that the parameters recommended above shall be evaluated, starting from the input port (input interface) of the communication link (transmitter side) and ending at the output port (output interface) of the communication link (receiver side).

The communication link can include QPSK demodulators, QAM modulators, multiplexers and demultiplexers or telecom network adaptors.

The interfaces use the 188 byte packet structure as specified in ISO/IEC 13818-1. Reed Solomon (RS) coded packet can also be used, as specified in EN 50083-9. The incoming data stream shall be RS encoded as specified in EN 300 421.

8.2.2 Equipment required

The following equipment is required:

– a digital test signal generator able to provide suitable (endless) MPEG-2 sequences,
– a decoder of the MPEG-2 digital signal provided with a memory able to acquire a sufficient amount of transport stream data (at least 2 Mbit),
– a data analyser able to evaluate the recommended parameters of the transport stream.

8.2.3 Connection of the equipment

Connect the MPEG-2 test signal generator to the input port of the communication link and the MPEG-2 decoder to the output port of the communication link, a shown in figures 17, 18, 19 and 20 for synchronous and asynchronous transmission over coaxial cables or fibre-optic cables. The connections for a satellite communication link feeding a CATV network or a SMATV network are shown in figure 21 and figure 22 respectively.

8.2.4 Measurement procedure

Using the MPEG-2 test signal generator apply at the input port of the communication link a transport stream sequence consisting of several (up to 6) substreams carrying video, audio and data signals.

At the output of the decoder (connected at the output port of the communication link) firstly check the TS_sync_loss bit (indicator 2.1)(see table 2).

If this test is positive then check the other indicators of table 2, carefully looking at the preconditions and taking into account the ISO/IEC specifications.

If required, check the indicators from numbers 3.1 to 3.6 in table 3 and also the indicators from numbers 4.1 to 4.10 in table 4.

Table 2 – First priority – necessary for de-codability (basic monitoring)

No.	Indicator	Precondition	Reference
2.1	TS_sync_loss	Loss of synchronization with consideration of hysteresis parameters	ISO/IEC 13818-1, Subclause 2.4.3.3 and annex G.01
2.2	Sync_byte_error	Sync_byte not equal 0x47	ISO/IEC 13818-1, Subclause 2.4.3.3
2.3	PAT_error	PID 0x0000 does not occur at least every 0,5 s a PID 0x0000 does not contain a table_id 0x00 (i.e. a PAT) Scrambling_control_field is not 00 for PID 0x0000	ISO/IEC 13818-1, Subclauses 2.4.4.3, 2.4.4.4
2.4	Continuity_count_error	Incorrect packet order a packet occurs more than twice lost packet	ISO/IEC 13818-1, Subclauses 2.4.3.2, 2.4.3.3
2.5	PMT_error	Sections with table_id 0x02, (i.e. a PMT), do not occur at least every 0,5 s on the PID which is referred to in the PAT Scrambling_control_field is not 00 for all PIDs containing sections with table_id 0x02 (i.e. a PMT)	ISO/IEC 13818-1, Subclauses 2.4.4.3, 2.4.4.4, 2.4.4.8
2.6	PID_error	Referred PID does not occur for a user specified period	ISO/IEC 13818-1, Subclause 2.4.4.8

Table 3 – Second priority – recommended for continuous or periodic monitoring

No.	Indicator	Precondition	Reference
3.1	Transport_error	Transport_error_indicator in the TS-Header is set to "1"	ISO/IEC 13818-1, Subclauses 2.4.3.2, 2.4.3.3
3.2	CRC_error	CRC error occurred in CAT, PAT, PMT, NIT, EIT, BAT, SDT or TOT table	ISO/IEC 13818-1, Subclauses 2.4.4, annex B ETS 300 468, Subclause 5.2
3.3	PCR_error	PCR discontinuity of more than 100 ms occurring without specific indication Time interval between two consecutive PCR values is more than 40 ms	ISO/IEC 13818-1, Subclauses 2.4.3.4, 2.4.3.5 ISO/IEC 13818-4, Subclause 9.11.3 ETR 154, Subclause 4.5.4
3.4	PCR_accuracy_error	PCR accuracy of selected programme is not within ±500 ns	ISO/IEC 13818-1, Subclause 2.4.2.2
3.5	PTS_error	PTS repetition period more than 700 ms	ISO/IEC 13818-1, Subclauses 2.4.3.6, 2.4.3.7, 2.7.4
3.6	CAT_error	Packets with transport_scrambling_control not 00 present, but no section with table_id = 0x01 (i.e. a CAT) present Section with table_id other than 0x01 (i.e. not a CAT) found on PID 0x0001	ISO/IEC 13818-1, Subclause 2.4.4

Table 4 – Third priority – application dependant monitoring

No.	Indicator	Precondition	Reference
4.1	NIT_error	Section with table_id other than 0x40 or 0x41 or 0x72 (i. e. not an NIT or ST) found on PID 0x0010 No section with table_id 0x40 or 0x41 (i.e. an NIT) in PID value 0x0010 for more than 10 s	ETS 300 468, Subclause 5.2.1 ETR 211, Subclauses 4.1, 4.4
4.2	SI_repetition_error	Repetition rate of SI tables outside of specified limits	ETS 300 468, Subclause 5.1.4 ETR 211 [8]: Subclause 4.4
4.3	Buffer_error	**TB_buffering_error** overflow of transport buffer (TB n) **TBsys_buffering_error** overflow of transport buffer for system information (Tb sys) **MB_buffering_error** overflow of multiplexing buffer (MB n) or if the vbv_delay method is used: underflow of multiplexing buffer (Mb n) **EB_buffering_error** overflow of elementary stream buffer (EB n) or if the leak method is used: underflow of elementary stream buffer (EB n) though low_delay_flag and DSM_trick_mode_flag are set to 0 else (vbv_delay method) underflow of elementary stream buffer (EB n) **B_buffering_error** overflow or underflow of main buffer (B n) **Bsys_buffering_error** overflow of PSI input buffer (B sys)	ISO/IEC 13818-1, Subclause 2.4.2.3 ISO/IEC 13818-4, Subclauses 9.11.2, 9.1.4
4.4	Unreferenced_PID	PID (other than PAT, CAT, CAT_PIDs, PMT_PIDs, NIT_PID, SDT_PID, TDT_PID, EIT_PID, RST_PID, reserved_for_future_use PIDs, or PIDs user defined as private data streams) not referred to by a PMT within 0,5 s (note)	ETS 300 468 Subclause 5.1.3
4.5	SDT_error	Sections with table_id = 0x42 (SDT, actual TS) not present on PID 0x0011 for more than 2 s Sections with table_ids other than 0x42, 0x46, 0x4A or 0x72 found on PID 0x0011	ETS 300 468, Subclause 5.1.3 ETR 211, Subclauses 4.1, 4.4
4.6	EIT_error	Sections with table_id = 0x4E (EIT-P/F, actual TS) not present on PID 0x0012 for more than 2 s Sections with table_ids other than in the range 0x4E – 0x6F or 0x72 found on PID 0x0012	ETS 300 468, Subclause 5.1.3 ETR 211, Subclauses 4.1, 4.4
4.7	RST_error	Sections with table_id other than 0x71 or 0x72 found on PID 0x0013	ETS 300 468, Subclause 5.1.3
4.8	TDT_error	Sections with table_id = 0x70 (TDT) not present on PID 0x0014 for more than 30 s Sections with table_id other than 0x70, 0x72 (ST) or 0x73 (TOT) found on PID 0x0014	ETS 300 468, Subclauses 5.1.3, 5.2.6 ETR 211, Subclauses 4.1, 4.4

No.	Indicator	Precondition	Reference
4.9	Empty_buffer_error	Transport buffer (TB n) not empty at least once per second or transport buffer for system information (TB sys) not empty at least once per second or if the leak method is used multiplexing buffer (MB n) not empty at least once per second.	ISO/IEC 13818-1, Subclauses 2.4.2.3, 2.4.2.6 ISO/IEC 13818-9, annex E ISO/IEC 13818-4, Subclauses 9.1.1.2, 9.1.4
4.10	Data_delay_error	Delay of data (except still picture video data) through the TSTD buffers superior to 1 s or delay of still picture video data through the TSTD buffers superior to 60 s	ISO/IEC 13818-1, Subclauses 2.4.2.3, 2.4.2.6
NOTE It is assumed that transition states are limited to 0,5 s, and these transitions should not cause error indications.			

8.2.5 Presentation of the results

The results of the evaluation of the indicators are reported in a list or in a table. The interfaces (input and output ports), the communication link main characteristics and structure shall be recorded with the results.

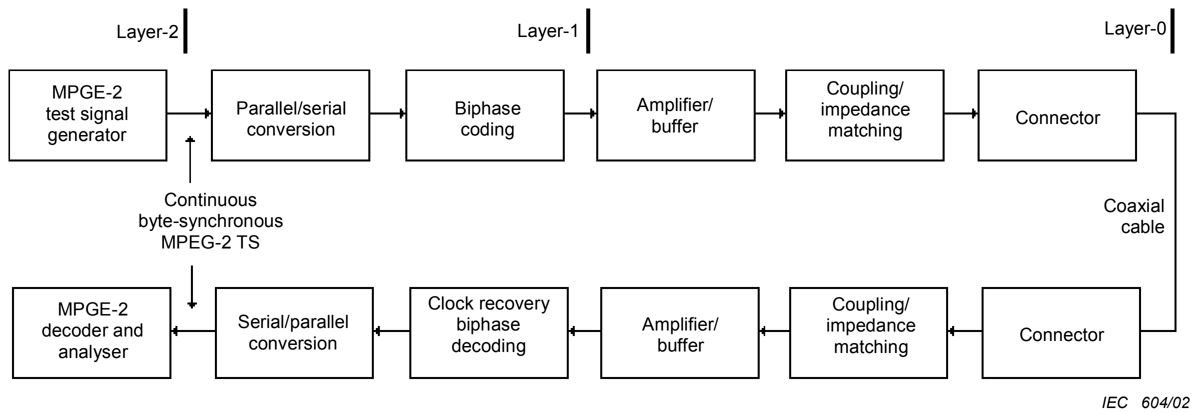


Figure 17 – Measurement set-up for the evaluation of the MPEG-2 transport stream parameters for a communication link using a coaxial cable and synchronous serial transmission (SSI type)

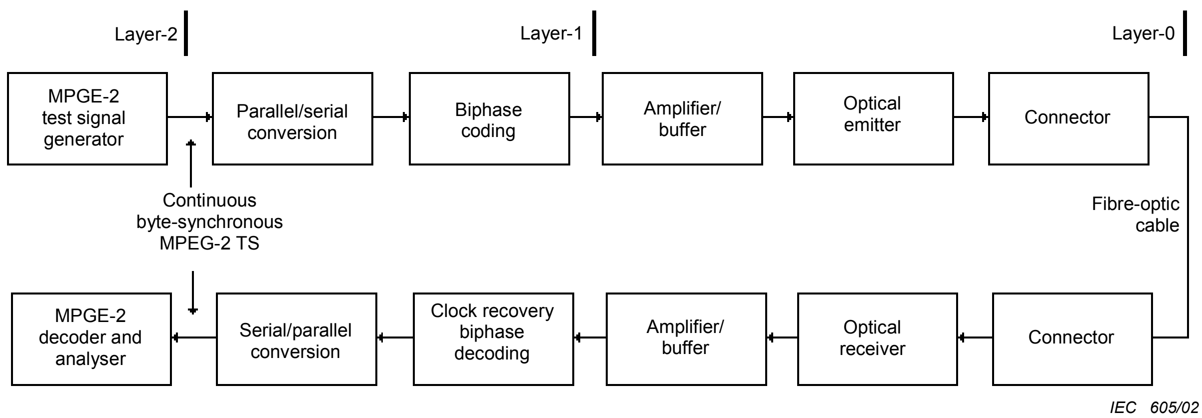


Figure 18 – Measurement set-up for the evaluation of the MPEG-2 transport stream parameters for a communication link using a fibre-optic cable and synchronous serial transmission (SSI type)

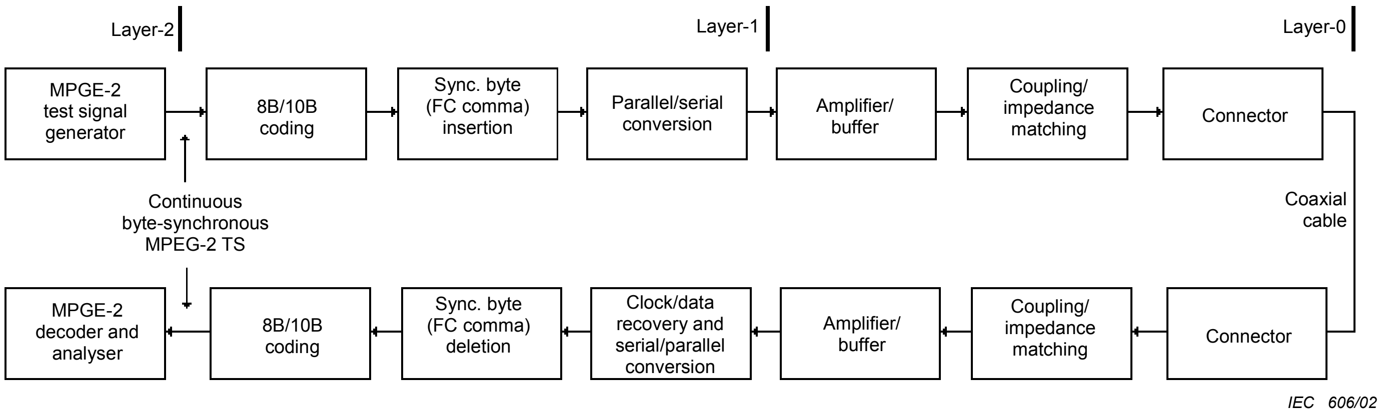


Figure 19 – Measurement set-up for the evaluation of the MPEG-2 transport stream parameters for a communication link using a coaxial cable and asynchronous serial transmission (ASI type)

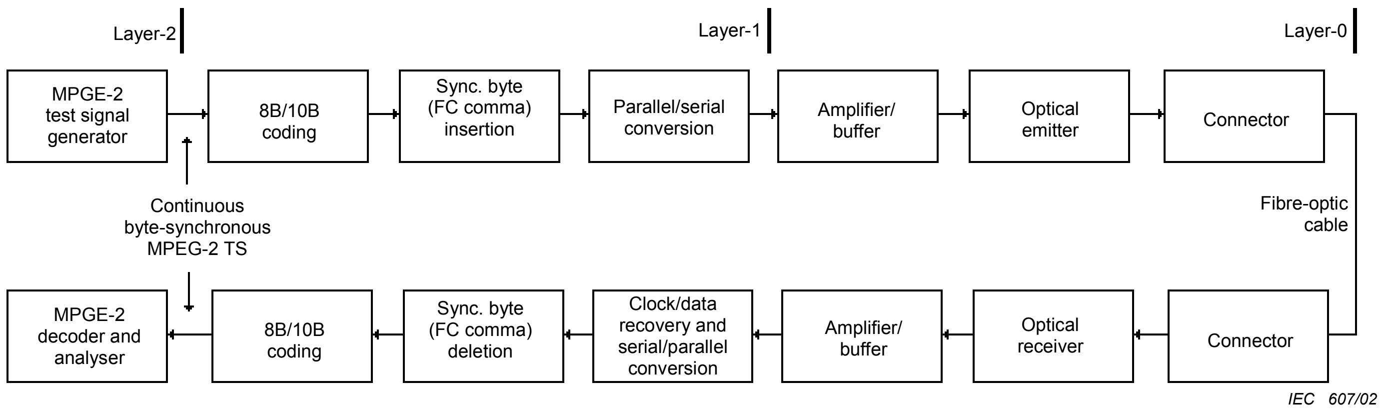


Figure 20 – Measurement set-up for the evaluation of the MPEG-2 transport stream parameters for a communication link using a fibre-optic cable and asynchronous serial transmission (ASI type)

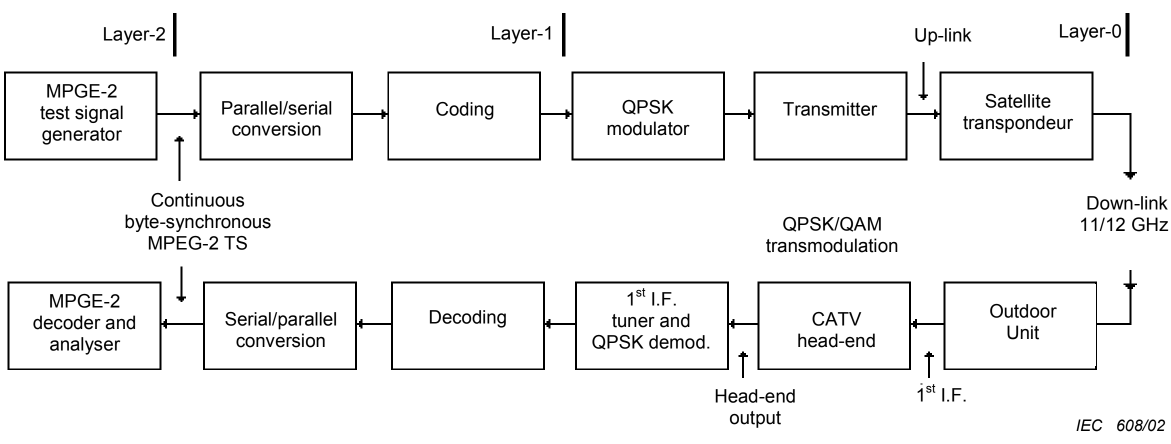


Figure 21 – Measurement set-up for the evaluation of the MPEG-2 transport stream parameters for a communication link that feeds a CATV system using a satellite transponder and a down link in the 11/12 GHz band

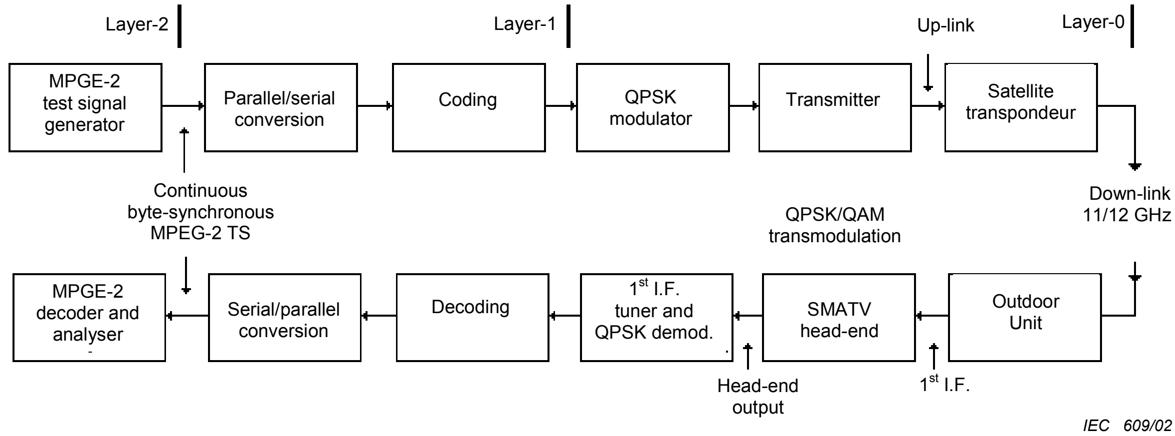


Figure 22 – Measurement set-up for the evaluation of the MPEG-2 transport stream parameters for a communication link that feeds a SMATV system using a satellite transponder and a down link in the 11/12 GHz band

Annex A
(normative)

Digital signal level and bandwidth

A.1 RF/IF power ("carrier")

When describing the Quadrature Amplitude Modulated (QAM) signals employed by DVB-C or the Quadrature Phase Shift Keying (QPSK) signals employed by DVB-S, it is common to refer to the modulated RF/IF signal as "carrier" (*C*), mainly to distinguish it from "signal" (*S*) which is generally used to refer to the baseband demodulated signal.

Strictly, it is incorrect to describe this signal as "carrier" because QAM and QPSK (which is equivalent to 4-state QAM) are suppressed carrier modulation schemes. For OFDM, with thousands of suppressed carriers and assorted pilot tones, the label "carrier" is even more inappropriate. Also for VSB, the carrier is suppressed and a low level pilot is transmitted.

Therefore the term "wanted information power" should be more appropriately used to consider the "RF/IF power" in the transmitted channel, but most of the engineers and technical people involved in CATV work will continue to use the term "carrier" for this parameter, particularly when talking about the "carrier"-to-noise ratio.

The "carrier", or the "RF/IF power", is the total power of the modulated RF/IF signal as would be measured by a thermal power sensor in the absence of any other signals (including noise).

If the measuring set is able to measure the power in a small part of the channel spectrum, the total power can be obtained taking into account the bandwidth of the channel or what is called "equivalent signal bandwidth" of the digital channel.

A.2 Bandwidth of a digital signal

A.2.1 Occupied bandwidth

a) QAM/PSK modulation

For DVB systems using the QAM/PSK modulation, the passband spectrum is shaped by root raised cosine filtering with a roll-off factor (α) of:

0,15 for DVB-C systems		(QAM)
0,18 (ITU J.83 annex B)	USA	(QAM)
0,13 (ITU J.83 annex C)	Japan	(QAM)
0,35 for DVB-S systems		(QPSK)

For an ideal QAM/PSK system, this means that all the RF/IF power will lie in the frequency band $f_C \pm (1+\alpha)\, f_S/2$, where:

f_C is the carrier frequency,

f_S is the symbol rate of the modulation,

α is the filter roll-off factor.

This means that the occupied bandwidth is given by the formula:

$$BW_{OCC(QAM/PSK)} = (1+\alpha)\, f_S \qquad (A.1)$$

The RF/IF power (or "carrier") is the total power in this "rectangular" bandwidth, with no further filtering applied. This bandwidth is used for defining the channel width, the transponder bandwidth and so on. The formula above can be used to obtain the useable symbol rate in a given channel bandwidth: $f_S = BW_{OCC}/(1+\alpha)$.

b) OFDM modulation

For DVB systems using OFDM modulation, the definition of occupied bandwidth is expressed differently because of the radically different modulation technique, although the principle is very similar. The OFDM "shoulders" are not considered to be wanted information power, and are not included in the RF/IF power calculation, even though the power does actually come out of the transmitter:

$$BW_{OCC(OFDM)} = n \times f_{SPACING} \tag{A.2}$$

where:

- n = 6 817 (8k mode) and $f_{SPACING}$ = 1 116 Hz (8k mode) (DVB-T)
- n = 1 705 (2k mode) and $f_{SPACING}$ = 4 464 Hz (2k mode) (DVB-T)
- n = 5617 (Mode 3) and $f_{SPACING}$ = 992 Hz (mode 3) (ISDB-T) Japan
- n = 2809 (Mode 2) and $f_{SPACING}$ = 1 984 Hz (mode 2) (ISDB-T) Japan
- n = 1405 (Mode 1) and $f_{SPACING}$ = 3 968 Hz (mode 1) (ISDB-T) Japan.

In a multi-signal system (for example, a CATV network), measurement of the RF/IF power in a single channel requires a frequency selective technique. This could employ a thermal power meter preceded by a suitably calibrated channel filter, a spectrum analyser with band power measurement capability, or a measuring receiver. Depending on the measurement technique, a filter may be required to exclude the "shoulders" of a single OFDM signal.

c) VSB modulation

The 8-level symbols combined with the binary data segment sync and data field sync signals shall be used to suppressed-carrier modulate a single carrier. Before transmission, however, most of the lower sideband shall be removed. The resulting spectrum is flat, except for the band edges where a nominal square root raised cosine response results in 620 kHz transition regions. The nominal VSB transmission spectrum is shown in figure A.1.

At the suppressed-carrier frequency, 310 kHz from the lower band edge, a small pilot shall be added to the signal.

$$BW_{OCC(VSB)} = 5{,}38 \text{ MHz} \tag{A.3}$$

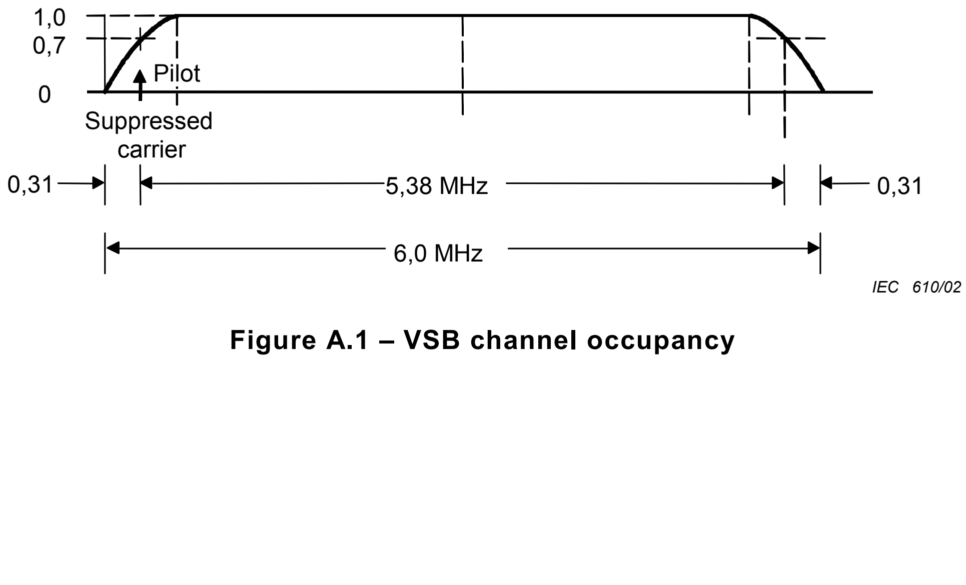


Figure A.1 – VSB channel occupancy

A.2.2 Noise bandwidth

The transmission of digitally modulated signals employs Nyquist filtering split equally between the transmitter and the receiver.

a) QAM/PSK modulation

The noise bandwidth of the receiver equals the symbol rate f_S. This is considered to be appropriate for *C*/*N* measurements of digital TV systems since this reflects the amount of noise entering the receiver. This leads to the following formula:

$$BW_{\mathrm{NOISE(QAM/PSK)}} = f_S \tag{A.4}$$

b) OFDM modulation

Because the OFDM "shoulders" are not considered to be wanted information power, the noise bandwidth can be assumed to equal the occupied bandwidth:

$$BW_{\mathrm{NOISE(OFDM)}} = BW_{\mathrm{OCC(OFDM)}} \tag{A.5}$$

c) VSB modulation

Because the VSB "shoulders" are not considered to be wanted information power, the noise bandwidth can be assumed to equal the occupied bandwidth:

$$BW_{\mathrm{NOISE(VSB)}} = BW_{\mathrm{OCC(VSB)}} \tag{A.6}$$

A.2.3 Equivalent signal bandwidth

The transmission of digitally modulated signals employs Nyquist filtering split equally between the transmitter and receiver; therefore the RF/IF channel bandwidth (transmitter bandwidth) has a -3 dB bandwidth that is equal to the receiver bandwidth.

a) QAM/PSK modulation

The "equivalent signal bandwidth" (*BW*) (–3 dB bandwidth) is equal to the receiver noise bandwidth for QAM/PSK modulation:

$$BW_{\mathrm{(QAM/PSK)}} = f_S \tag{A.7}$$

b) OFDM modulation

Because the OFDM "shoulders" are not considered to be wanted information power, the "equivalent signal bandwidth" (*BW*) (–3 dB bandwidth) can be assumed equal to the occupied bandwidth for OFDM modulation:

$$BW_{\mathrm{(OFDM)}} = BW_{\mathrm{OCC(OFDM)}} \tag{A.8}$$

c) VSB modulation

Because the VSB "shoulders" are not considered to be wanted information power, the "equivalent signal bandwidth" (*BW*) (–3 dB bandwidth) can be assumed equal to the occupied bandwidth for VSB modulation:

$$BW_{\mathrm{(VSB)}} = BW_{\mathrm{OCC(VSB)}} \tag{A.9}$$

A.3 Examples

Table A.1 indicates examples for the "occupied bandwidth" or "channel bandwidth", the "noise bandwidth" and the "equivalent signal bandwidth" for the QAM, PSK and OFDM modulation techniques.

Table A.1 – Examples of bandwidth for digital modulation techniques

Digital modulation	Roll-off factor α	Occupied or channel bandwidth MHz	Noise bandwidth (BW_{NOISE}) MHz	Equivalent signal bandwidth (BW) MHz
QPSK (DVB-S)	0,35	37,125	27,5	27,5
TC8PSK (Japan)	0,35	34,5	28,860	28,860
QAM (DVB-C)	0,15	8	6,95	6,95
		7	6,09	6,09
64QAM (Japan)	0,13	6	5,274	5,274
COFDM (DVB-T)	–	8	7,61	7,61
	–	7	6,66	6,66
OFDM (ISDB-T) (Japan)	–	6	5,573 (mode 2)	5,573 (mode 2)
VSB (ATSC) (USA)	0,1152	6	5,38	5,38

Annex B
(normative)

Correction factor for spectrum analyser

The correction factor (K_{sa}) for a typical spectrum analyser is about 1,7 dB and is due to two contributions:

- a +2,5 dB term for the effect of the detector/log amplifier (it accounts for the correction of 1,05 dB due to the narrowband envelope detection and the 1,45 dB due to the logarithmic amplifier);
- a –0,8 dB term that takes into account that the equivalent noise bandwidth of the IF filter of the spectrum analyser is greater than its nominal resolution bandwidth (RSBW) by a factor of 1,2.

Annex C
(normative)

Correction factors for noise

C.1 Signal level measurement

When measuring a signal level, the contribution of noise can be taken into account by reducing the measured signal level (S_m) by an amount (CF) that depends on the difference (D) between the measured signal (S_m) and noise (N_m) levels.

Firstly calculate the difference D:

$$D = S_m - N_m$$

then from table C.1 or figure C.1, derive the correction factor (CF) and apply it to obtain the signal level (S) using the following formula:

$$S = S_m - CF.$$

C.2 Noise level measurement

When measuring a noise level, the contribution of the measuring equipment noise can be taken into account by reducing the measured noise level by an amount given by the correction factor (CF) indicated in table C.1 and in Figure C.1, that depends on the difference (D) between the noise level (N_m) measured when the measuring equipment is connected to the receiving system or equipment under test and that (N_{EQT}) measured when the input of the measuring equipment is terminated on its characteristic impedance.

Firstly calculate the difference D:

$$D = N_m - N_{EQT}$$

then from table C.1 or figure C.1, derive the correction factor (CF) and apply it to obtain the noise level (N) using the following formula:

$$N = N_m - CF.$$

NOTE If the level difference (D) is lower than 2 dB, the reliability of the measurement becomes very low due to the big value of the correction factor (CF).

Table C.1 – Noise correction factor

Level difference D dB	**Correction factor CF** dB	**Level difference D** dB	**Correction factor CF** dB
1,5	5,35	6,0	1,26
2,0	4,33	7,0	0,97
3,0	3,02	8,0	0,75
4,0	2,20	9,0	0,58
5,0	1,65	10,0	0,46

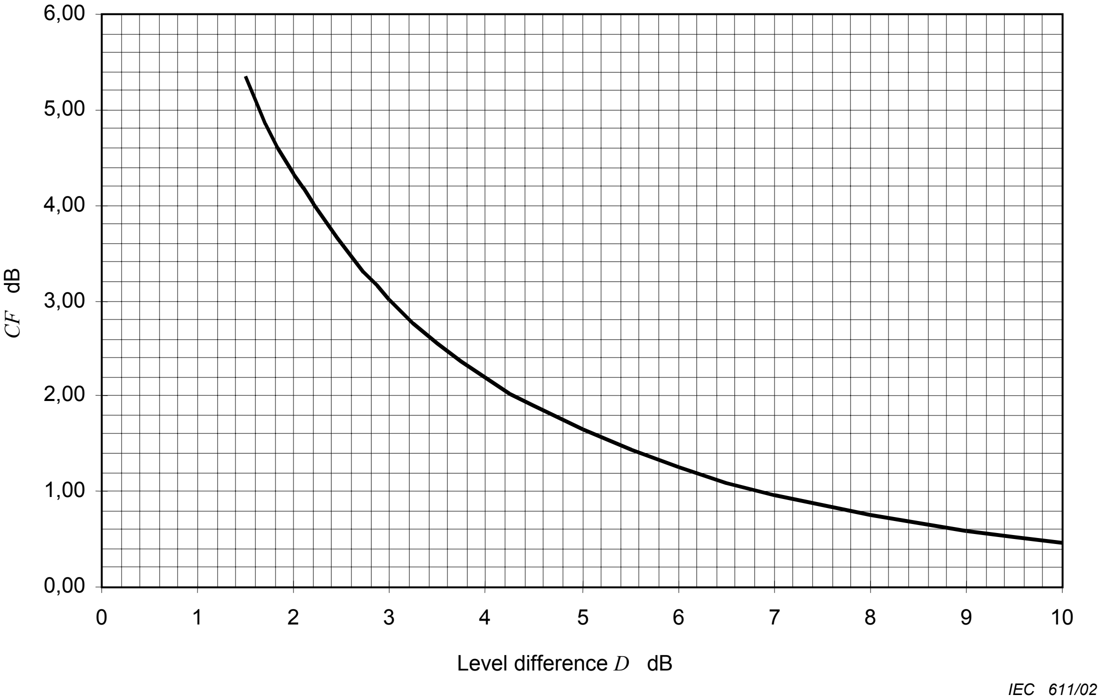


Figure C.1 – Noise correction factor *CF* (dB) versus measured level difference *D* (dB)

Bibliography

The following publications contain useful information that is relevant to the subject of this standard.

ETR 154:1997, *Digital Video Broadcasting (DVB); Implementation guidelines for the use of MPEG-2 Systems, Video and Audio in satellite, cable and terrestrial broadcasting applications*

ETR 290:1997, *Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems*

EN 300 473 (DVB-CS, SMATV): *Digital broadcasting systems for television, sound and data services; Satellite Master Antenna Television (SMATV) distribution systems*

EN 50083-9: *Cable networks for television signals, sound signals and interactive services – Part 9: Interfaces for CATV/SMATV headends and similar professional equipment for DVB/MPEG2 transport stream*

ARIB STD-B1 (Desirable Specification): 1998, Digital Receiver for Digital Satellite Broadcasting Services using communication satellite (1.1 edition)

ATSC Doc. A/53:1995, *Digital Television Standard*

ATSC Doc. A/54:1995, *Guide to the Use of the ATSC Digital Television Standard*

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