IS 13420-1 (2002): Cabled Distribution Systems for Television and Sound Signals, Part 1: Methods of Measurement and System Performance [LITD 7: Audio, Video and Multimedia Systems and Equipment]

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IS 13420 (Part 1) : 2002
IEC 60728-1 (2001)

भारतीय मानक

टेलीविजन और ध्वनि संकेतों के लिए केबलकृत वितरण तंत्र

भाग 1 मापन विधियाँ और तंत्र कार्यकारिता

(दूसरा पुनरीक्षण)

Indian Standard

CABLED DISTRIBUTION SYSTEMS FOR TELEVISION AND SOUND SIGNALS

PART 1 METHODS OF MEASUREMENT AND SYSTEM PERFORMANCE

(Second Revision)

ICS 33.060.40

BUREAU OF INDIAN STANDARDS
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NEW DELHI 110002

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Radiocommunication Sectional Committee, LTD 20

NATIONAL FOREWORD

This Indian Standard (Part 1) (Second Revision) which is identical with IEC 60728-1(2001) 'Cabled distribution systems for television and sound signals — Part 1 : Methods of measurement and system performance' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Radiocommunication Sectional Committee and approval of the Electronics and Telecommunication Division Council.

This standard (Part 1) was originally published in 1992 and subsequently revised in 1994. The original version was based on IEC 60728-1(1986). The first revision was published to incorporate the Amendment 1 (1992) to IEC 60728-1(1986). This standard is now being revised once again to bring it in line with the latest (third) edition of IEC, namely IEC 60728-1(2001).

In this adopted standard, certain conventions are not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.
b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

CROSS REFERENCES

In this adopted standard, reference appears to the following International Standard for which Indian Standard also exists. The corresponding Indian Standard which is to be substituted in its place is listed below along with its degree of equivalence for the edition indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60728-3 Cabled distribution systems for television and sound signals — Part 3 : Active coaxial wideband distribution equipment	IS 14231 (Part 3) : 1995 Cabled distribution systems for television and sound signals: Part 3 Active coaxial wideband distribution components	Technically equivalent

The concerned Technical Committee responsible for the preparation of this standard has reviewed the provisions of the following International Publications and has decided that they are acceptable for use in conjunction with this standard:

IEC 60050-713 International Electrotechnical Vocabulary — Part 713 : Radiocommunications : transmitters, receivers, networks and operation

ISO/IEC 13818-1 Information technology — Generic coding of moving pictures and associated audio information — Part 1 : Systems

ISO/IEC 13818-2 Information technology — Generic coding of moving pictures and associated audio information — Part 2 : Video

ISO/IEC 13818-3 Information technology — Generic coding of moving pictures and associated audio information — Part 3 : Audio

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

ITU-T Recommendation J.61 Transmission performance of television circuits designed for use in international connections

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Indian Standard
CABLED DISTRIBUTION SYSTEMS FOR TELEVISION AND SOUND SIGNALS
PART 1 METHODS OF MEASUREMENT AND SYSTEM PERFORMANCE
(*Second Revision*)

1 Scope

This part of IEC 60728 is applicable to any cabled distribution system (including individual receiving systems) having a coaxial cable output and primarily intended for television and sound signals operating between about 30 MHz and 2 150 MHz.

This standard specifies the basic methods of measurement of the operational characteristics of cabled distribution systems having coaxial cable outputs in order to assess the performance of these systems and their performance limits.

All requirements refer to the performance limits which are obtained between the input(s) to the headend or headends and any system outlet when terminated in a resistance equal to the nominal load impedance of the system, unless otherwise specified. Where system outlets are not used, the above applies at the subscriber's end of the subscriber's feeder.

NOTE 1 Basic methods of measurement are described in this standard. However, any equivalent method that ensures at least the same accuracy may be used.

NOTE 2 If the system operator wishes to subdivide the system into a number of parts, the accumulation of degradations should not exceed the figures given below.

NOTE 3 An extension of the frequency range to that from 5 MHz to 3 000 MHz will be considered for future work.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60728. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60728 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050-713, *International Electrotechnical Vocabulary – Part 713: Radiocommunications: transmitters, receivers, networks and operation*

IEC 60728-3, *Cabled distribution systems for television and sound signals – Part 3: Active coaxial wideband distribution equipment*

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

ISO/IEC 13818-2, *Information technology – Generic coding of moving pictures and associated audio information: Video*

ISO/IEC 13818-3, *Information technology – Generic coding of moving picture and associated audio information – Part 3: Audio*

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

ITU-T Recommendation J.61, *Transmission performance of television circuits designed for use in international connections*

ITU-T Recommendation J.63, *Insertion of test signals in the field-blanking interval of monochrome and colour television signals*

ITU-R Recommendation BT.470-6, *Conventional television systems*

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

EN 300421, *Digital Video Broadcasting (DVB); DVB framing structure, channel coding and modulation for 11/12 GHz satellite services*

EN 300429, *Digital Video Broadcasting (DVB); DVB framing structure, channel coding and modulation for cable systems*

EN 300468, *Digital Video Broadcasting (DVB); Specification for Service Information (SI) in DVB systems*

EN 300473, *Digital Video Broadcasting (DVB): DVB Satellite Master Antenna Television (SMATV) distribution systems*

EN 300744, *Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television*

ETR 211, *Digital Video Broadcasting (DVB); DVB guidelines on implementation and usage of Service Information (SI)*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purpose of this part of IEC 60728, the following terms and definitions apply.

3.1.1
headend
equipment which is connected between receiving antennas or other signal sources and the remainder of the cabled distribution system, to process the signals to be distributed

NOTE The headend may, for example, comprise antenna amplifiers, frequency converters, combiners, separators and generators.

3.1.2
local headend
a headend which is directly connected to the system trunk feeders or to a short haul trunk feeder replacement link

3.1.3
hub headend
a headend used to feed the entire operating network in the service area

3.1.4
remote headend
a headend from which signals are delivered to a local headend via a long-distance terrestrial link

3.1.5
distribution point
a point where signals are taken from the trunk feeder to energize branch and/or spur feeders

NOTE In some cases, a distribution point may be directly connected to the headend.

3.1.6
feeder
a transmission path forming part of a cabled distribution system. Such a path may consist of a metallic cable, optical fibre, waveguide, or any combination of them. By extension, the term is also applied to paths containing one or more radio links.

3.1.7
supertrunk feeder
a feeder which connects only between headends or between a headend and the first distribution point

3.1.8
trunk feeder
a feeder used for the transmission of signals between a headend and a distribution point or between distribution points

3.1.9
branch feeder
a feeder used for connecting a distribution point to spur feeders

3.1.10
spur feeder
a feeder to which splitters, subscriber taps, or looped system outlets are connected

3.1.11
subscriber feeder
a feeder connecting a subscriber tap to a system outlet or, where the latter is not used, directly to the subscriber's equipment

NOTE A subscriber feeder may include filters and balun transformers.

3.1.12
antenna amplifier
an amplifier (often a low-noise type) associated with an antenna

3.1.13
trunk amplifier
an amplifier to compensate for the attenuation in a trunk feeder

3.1.14
bridger amplifier
a) an amplifier for connection in a trunk feeder to energize a distribution point

b) an amplifier for connection in a branch feeder, to energize one or more branch or spur feeders

3.1.15
trunk-bridger amplifier
an amplifier to compensate for the attenuation in a trunk feeder and also to energize a distribution point

3.1.16
distribution amplifier
an amplifier designed to feed one or more branch or spur feeders

NOTE This is a general term embracing branch amplifier and spur amplifier.

3.1.17
branch amplifier
an amplifier to compensate for the attenuation in a branch feeder

3.1.18
spur amplifier (line extender)
an amplifier to compensate for the attenuation in a spur feeder

3.1.19
automatic level controlled amplifier
an amplifier which includes means to control automatically the level of the signal(s) at its output.

NOTE This may be achieved by controlling the variation of gain or slope or both, by means of:

- one or more pilot carriers;
- a temperature sensing device;
- remote control.

3.1.20
frequency converter
a device for changing the carrier frequency of one or more signals

3.1.21
combiner
a device in which signals arriving at two or more input ports are fed to a single output port

NOTE Some forms of this device may be used in the reverse direction as splitters.

3.1.22
separator
a device in which the signal energy, covering a frequency band, at one input port is divided between two or more output ports each of which covers a part of that frequency band

NOTE 1 For example, a diplexer is a two-output separator.

NOTE 2 Some forms of this device may be used in the reverse direction for combining.

3.1.23
splitter (spur unit)
a device in which the signal power at the (input) port is divided equally or unequally between two or more (output) ports

NOTE Some forms of this device may be used in the reverse direction for combining signal energy.

3.1.24
directional coupler
a splitter in which the attenuation between any two output ports exceeds the sum of the attenuations between the input port and each of those output ports

3.1.25
equalizer
a device designed to compensate, over a certain frequency range, for the amplitude/frequency distortion or the phase/frequency distortion introduced by feeders or equipment

NOTE This device is for the compensation of linear distortions only.

3.1.26
subscriber tap
a device for connecting a subscriber feeder to a spur feeder

3.1.27
system outlet
a device for interconnecting a subscriber feeder and a receiver lead

3.1.28
looped system outlet
a device through which the spur feeder passes and to which is connected a receiver lead, without the use of a subscriber feeder

3.1.29
receiver lead
a lead which connects the system outlet to the subscriber's equipment

NOTE A receiver lead may include filters and balun transformers in addition to the cable.

3.1.30
signal adaptor
a device which modifies the input signal to achieve conformity with the appropriate ITU system, without changing the baseband characteristics, for use in a cabled distribution system which distributes television signals not conforming to any ITU system (only in respect of RF structure)

3.1.31
decibel ratio
ten times the logarithm to the base 10 of the ratio of two quantities of power P_1 and P_2 i.e.

$$10 \lg \frac{P_1}{P_2} \text{ (dB)}$$

NOTE May also be expressed in terms of voltages.

$$20 \lg \frac{V_1}{V_2} \text{ (dB)}$$

3.1.32
standard reference power P_0
in cabled systems, the standard reference power P_0 is 1/75 pW

NOTE This is the power dissipated in a 75 Ω resistor with a voltage drop of 1 μV_{RMS} across it.

3.1.33
level
the decibel ratio of any power P_1 to the standard reference power P_0, i.e.

$$10 \lg \frac{P_1}{P_0} \text{ (dB)}$$

the decibel ratio of any voltage V_1 to the standard reference voltage V_0, i.e.

$$20 \lg \frac{V_1}{V_0} \text{ (dB)}$$

This may be expressed in decibels (relative to 1 μV in 75 Ω) or more simply in dB(μV) if there is no risk of ambiguity.

3.1.34
attenuation
the ratio of the input power to the output power of an equipment or system, usually expressed in decibels

3.1.35
gain
the ratio of the output power to the input power of any equipment or system, usually expressed in decibels

3.1.36
automatic gain control (AGC)
the automatic control of a device to maintain constant the level of the signal at its output, using that signal as the control stimulus

3.1.37
frequency amplitude response
the gain or loss of an equipment or system plotted against frequency

3.1.38
slope
the difference in gain or attenuation at two specified frequencies between any two points in a system

3.1.39
signal tilt
the difference in level deliberately established between specified signals at any point in a system. If groups of signals are established at differing levels, this is referred to as block tilt

3.1.40
crossview
the effect on a wanted television signal of the undesired transfer of one or more television signal(s) from other circuit(s)

3.1.41
crossmodulation
the undesired modulation of the carrier of a desired signal by the modulation of another signal as a result of equipment or system non-linearities

3.1.42
intermodulation
the process whereby non-linearity of equipment in a system produces output signals (called intermodulation products) at frequencies which are linear combinations of those of the input signals

3.1.43
carrier to intermodulation ratio
the difference in decibels between the carrier level at a specified point in a piece of equipment or a system and the level of a specified intermodulation product or combination of products

3.1.44
carrier to noise ratio
the difference in decibels between the vision or sound carrier level at a given point in a piece of equipment or a system and the noise level at that point (measured within a bandwidth appropriate to the television or radio system in use)

3.1.45
mutual isolation
the attenuation between two specified system outlets at any frequency within the range of the system under investigation. It is always specified, for any particular installation, as the minimum value obtained within specified frequency limits

3.1.46
echo rating *E*
The result of a system test with a $2T$ sine-squared pulse (as determined in ITU-T Recommendation J.61 and ITU-T Recommendation J.63) using the boundary line on a specified graticule (e.g. figure 25) within which all parts of the received pulse fall

NOTE The object of the graticule design is to ensure that the subjective effect of an echo of rating E % is the same as that of a single echo, with displacement greater than $12T$, of (E/2) % relative to the peak amplitude of the test pulse.

3.1.47
frequency designations
the frequency designations and abbreviations of IEC 60050-713 is to be used in relation to cabled systems (e.g. a VHF system includes frequencies between 30 MHz and 300 MHz)

3.1.48
well-matched
the matching condition when the return loss of the equipment complies with the requirements of table 1 of IEC 600728-3

3.1.49
definitions for digital radio
under consideration

3.1.50
definitions for return paths
under consideration

3.1.51
definitions for satellite broadcasting
outdoor unit
part of the TVRO installed in a position within line of sight to the satellite(s) to be received

It normally comprises two main parts:

a) the antenna sub-system which converts the incident radiation field into a guided wave. The antenna sub-system consists of:

- the main reflector, the secondary reflectors (if any) and the radiator;
- the feed network, which may include optional polarizing devices, to receive orthogonal linear polarizations, in a simultaneous or exclusive way.

Instead of reflector(s) / feed network sub-system, other types of antennas may be used, for example flat array antennas;

b) the LNB(s), which may include an optional filter, is a device with very low internal noise that amplifies the received signals in the radio frequency (RF) band and converts them to intermediate frequencies, (often called the 1st IF), for transmission to one or more indoor units where tuning, demodulation and decoding of the received signals are performed.

3.1.52
definitions for scrambled signals
under consideration

3.1.53
definitions for teletext
under consideration

3.1.54
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

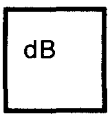
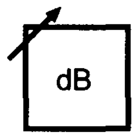
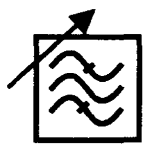
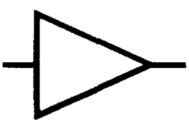
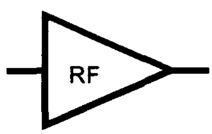
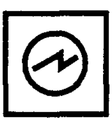
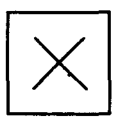
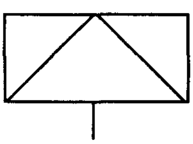
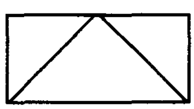
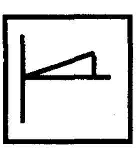
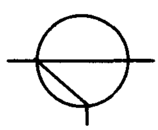
3.1.55
multiplex
a stream of all the digital data carrying one or more services within a single physical channel

3.1.56
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

3.1.57
transport stream (TS)
a data structure defined in ISO/IEC 13818-1. It is the basis of the digital video broadcasting (DVB) related standards

3.1.58
E_b/N_o
ratio between the energy of the bit (E_b) and the noise density power (N_o)

3.2 Symbols

Symbols	Terms	Symbols	Terms
	Attenuator		Variable attenuator
	Sine-wave generator		Low-pass filter
	Band-pass filter		Variable band-pass filter
	Amplifier		RF amplifier
	Oscilloscope		Mixer
	Modulator		Demodulator
	RF-choke		Resistor
	Detector		Directional coupler

3.3 Abbreviations

AC	alternating current
AFC	automatic frequency control
AGC	automatic gain control
AI	amplitude imbalance
ALC	automatic level control
AM	amplitude modulation
ASCII	American standard code for information interchange
ATM	asynchronous transfer mode
AWGN	additive white Gaussian noise
BAT	bouquet association table
BEP	bit error probability
BER	bit error rate
BPSK	binary phase shift keying
bslbf	bit string, left bit first
BW	bandwidth
C/N	carrier to noise ratio (ratio of RF or IF power to noise power)
CA	conditional access
CATV	community antenna television
CENELEC	Comité Européen de Normalisation Electrotechnique
COFDM	coded orthogonal frequency division multiplex
CPE	common phase error
CRC	cyclic redundancy check
CS	carrier suppression
CSO	composite second order beat
CTB	composite triple beat
CW	continuous wave
D/A	digital-to-analogue converter
DAB	digital audio broadcasting
DC	direct current
DFT	discrete Fourier transform
DSR	digital satellite radio
DVB	digital video broadcasting
DVB-C	digital video broadcasting baseline system for digital cable television (EN 300429)
DVB-CS	digital video broadcasting baseline system for SMATV distribution systems (EN 300473)
DVB-MC	digital video broadcasting baseline system for multi-point video distribution systems below 10 GHz (EN 300749)
DVB-MS	digital video broadcasting baseline system for multi-point video distribution systems at 10 GHz and above (EN 300748)

DVB-S	digital video broadcasting baseline system for digital satellite television (EN 300421)
DVB-T	digital video broadcasting baseline system for digital terrestrial television (EN 300744)
EB	error block
EIT	event information table
EMM	entitlement management message
EN	European norm
ENB	equivalent noise bandwidth
END	equivalent noise degradation
ES	errored second
ETR	ETSI technical report
ETS	European telecommunication standard
FDM	frequency division multiplex
FEC	forward error correction
FFT	fast Fourier transform
FIFO	first-in, first-out shift register
FM	frequency modulation
HDTV	high definition television
HEX	hexadecimal notation
HP	high priority bit stream
ICI	inter-carrier interference
IF	intermediate frequency
IFFT	inverse fast Fourier transform
ITS	insertion test signal
ITU	International Telecommunication Union
LDTV	limited definition television
LO	local oscillator
LP	low priority bit stream
LSB	least significant bit
MATV	master antenna television
MMDS	microwave multipoint distribution systems
MPEG	moving picture experts group
MSB	most significant bit
MUX	multiplex
MVDS	microwave video distribution systems
NICAM	near-instantaneously companded audio multiplex
NTSC	national television system committee
OCT	octal notation
OFDM	orthogonal frequency division multiplex
PAL	phase alternation line

PCR	program clock reference
PID	packet identifier
PRBS	pseudo-random binary sequence
PSK	phase shift keying
QAM	quadrature amplitude modulation
QEF	quasi error free
QPSK	quaternary phase shift keying
RF	radio frequency
RMS	root mean square
RS	Reed-Solomon
RSBW	resolution bandwidth
SDTV	standard definition television
SECAM	séquenciel couleur à mémoire
SFN	single frequency network
SMATV	satellite master antenna television
TC8PSK	trellis coded 8 phase shift keying
TPS	transmission parameter signalling
TV	television
TVRO	television receive only
UHF	ultra-high frequency
uimsbf	unsigned integer, most significant bit first
UTC	universal time co-ordinated
VHF	very high frequency
VSB	vestigial side band

4 Methods of measurement

General

The methods of measurement listed below are applicable to analogue and/or digitally modulated signals as indicated in table 1.

Table 1 – Application of the methods of measurement

Methods of measurement Subclause reference	Modulation of carriers										
	Analogue					Digital					
	Television				Radio FM	Television				Radio	
	Vision carrier AM-VSB			Vision and sound carriers	TV sound carrier	Vision and sound DVB			Sound		
	NTSC	PAL	SECAM	FM	FM/AM	PSK	QAM	OFDM	NICAM	DAB	DSR
4.1 Mutual isolation between system outlets	x	x	x	x	x	x	x	x	x	x	x
4.2 Amplitude response within a channel	x	x	x	x	x	x	x	x	x	x	x
4.3 Chrominance-luminance gain and delay inequalities		x	x								
4.4 Non-linear distortion	x	x	x	x	x						
4.5 Carrier to noise ratio	x	x	x	x	x						
4.6 Echoes	x	x	x								
4.7 AM-VSB television, FM radio and FM television signal level	x	x	x	x	x						
4.8 Data echo rating and data delay inequality	x	x	x								
4.9 Interference in FM sound radio channels					x						
4.10 Methods of measurement for digitally modulated signals						x	x	x			
4.10.3 Signal level						x	x	x		x	
4.10.4 S/N						x	x	x		x	
4.10.5 BER						x	x	x		x	
4.10.6 BER versus E_b/N_o						x	x	x		x	
4.10.7 Noise margin						x	x	x		x	
4.10.8 MER						x	x				
4.10.9 Phase jitter						x	x				
4.10.10 Phase noise of an RF carrier						x	x	x		x	

4.1 Mutual isolation between system outlets

4.1.1 Introduction

Although the method described applies also to the far ends of subscribers' feeders when no system outlets are used, isolation will usually be measured between:

a) system outlets connected to adjacent subscribers' taps;

b) system outlets connected to the same multiple subscribers' tap;

c) adjacent looped system outlets.

4.1.2 Equipment required

The test set-up shall be well-matched.

NOTE 1 "Wideband" is understood to mean of sufficient bandwidth to cover the full frequency range of the system under investigation.

NOTE 2 Some sweep frequency generators may include a terminating wideband detector.

a) A sweep frequency generator, with frequency range or ranges to suit the system to be examined, equipped with a frequency marking system.

b) A terminating wideband detector.

c) A variable attenuator, adjustable in steps of not more than 1 dB up to a value greater than the maximum mutual isolation to be measured.

d) A wideband amplifier with sufficient gain to raise the signal level at the system outlet to a level suitable to drive the detector.

e) An oscilloscope or other display unit suitable for operation with the sweep frequency generator.

f) A suitable coaxial cable of sufficient length to reach from one system outlet to an adjacent one in the cabled distribution system.

4.1.3 Connection of the equipment

The equipment shall be connected as in figure 4.

4.1.4 Measurement procedure

a) With the equipment connected as shown in figure 4a, set the variable attenuator to a value just greater than the maximum value of mutual isolation expected to be measured. Note this value a_1.

b) Adjust the output level of the sweep generator to give a level at the input to the amplifier approximately equal to that available at a system outlet.

c) Adjust the oscilloscope and amplifier gain controls to produce a display and note the amplitude of the display over the frequency range under inspection.

d) Remove from the section under test, the signals normally distributed on the system whilst maintaining the correct terminating conditions. Connect the equipment as shown in figure 4b. Note that the output from the sweep generator is connected to the "local" system outlet and the long cable (according to 4.1.2 f)) is used to connect to the "remote" outlet.

e) Reduce the attenuator setting until the peak of the display just reaches the same amplitude as that noted in item c) of this subclause for the frequency at which the peak occurs.

f) Note the new value of the attenuator a_2.

g) Mutual isolation is given by $a_1 - a_2$.

h) If the system outlets are of dual socket design, for example, TV – radio, the mutual isolation should also be measured at the appropriate frequencies between one socket, for example TV, of the "local" system outlet and the alternate socket, for example, radio, of the "remote" system outlet and vice versa. In these cases, it will be necessary also to measure mutual isolation with the unused sockets in both terminated and open-circuit conditions. The conditions of measurement should be stated when tabulating results. When unused sockets are terminated, the terminating resistance shall be 75 Ω.

i) Where the measurements are made in a number of discrete frequency bands, the lowest result obtained shall be taken as the mutual isolation between the two system outlets under investigation.

4.1.5 Presentation of the results

The results shall be presented in a table listing the values obtained for each couple of measured system outlets.

4.2 Amplitude response within a channel

4.2.1 Introduction

The method described is applicable to the measurement of the amplitude response of cabled distribution systems over the frequency range of an individual channel between two specified points within the system.

However, where input signals to the system are received at, or are reduced to, baseband, and modulated onto the system carrier frequencies, the response of any demodulator and modulator shall not be included. If it is required to include the characteristics of these items, a separate assessment shall be made using test techniques applicable to such equipment.

Where the system contains frequency changing equipment between the antenna input and the system outlet at which the tests are to be made, the calibration of the equipment (as detailed in 4.2.4 a) to 4.2.4 g)) shall be carried out at the output frequencies, having first checked that the output of the sweep frequency generator is also flat over the input channel.

4.2.2 Equipment required

The test set-up shall be well-matched.

a) A sweep frequency generator.

b) A terminating RF detector.

c) Two variable attenuators.

d) An amplifier.

e) A dual-trace oscilloscope.

f) A high output (at least 300 mV_{RMS} terminated) signal generator of known frequency calibration over the frequency range of the channel to be tested.

g) A balanced mixer.

h) A low-pass filter with cut-off at approximately 200 kHz for television channels or approximately 10 kHz for FM sound radio.

i) A directional coupler suitable for use in the frequency range of the channel to be tested.

j) A termination to match the output of the filter specified in item h) of this subclause.

4.2.3 Connection of the equipment

The equipment shall be connected as in figure 5a. If the tests are to be carried out in the presence of other signals on the system, a filter may be necessary at the input of the amplifier to prevent distortion of the display. This filter shall have a flat response and shall match the system correctly over the channel to be tested. It shall have sufficient attenuation at the frequencies of the other signals to reduce them to about 20 dB below the level of the swept test signal.

4.2.4 Measurement procedure

a) With the equipment connected as shown in figure 5a, adjust the output frequencies of the sweep generator to cover the channel to be tested and set the variable attenuator A1, so that the level of the signal at its output is that which will be required when connected to the system input.

b) Set the variable attenuator A2, so that the level of the signal at the input to the amplifier is about 3 dB to 4 dB below that expected at the system outlet at which the test will be made.

c) Adjust the oscilloscope controls to obtain a satisfactory display on the Y1 channel, which shall be DC coupled, locking the timebase to the leading edge of the display.

NOTE It may be necessary to operate the oscilloscope at a repetition rate equal to half that of the sweep generator and examine the "second" displayed response.

d) Adjust the frequency of the signal generator to that of the lower limit of the channel under investigation and arrange the level of this signal and the gain and shift controls of the Y2 channel of the oscilloscope to produce a satisfactory "marker".

e) Move the "marker" to the upper frequency limit of the channel and carefully note the amplitude of the display between the two marks (see "reference" in figure 6) and the level of the display during the blanking period.

f) Adjust the attenuator A_2 to values 3 dB either side of that set as specified in item b) of this subclause and check that the shape of the reference curve does not alter materially.

g) Connect the equipment to the cabled distribution system as shown in figure 5b removing the normal signal input to the channel under test, but retaining any pilot signals which may be necessary to maintain correct operation of the system.

NOTE Signal-operated AGC systems may not function correctly on swept input signals and may have to be rendered inoperative and manual gain control used during these tests.

h) Adjust the attenuator A_2 to produce the same general amplitude of display as obtained in item c) of this subclause, using the "reference" curve and carefully aligning the blanking level with that obtained in item e) of this subclause.

i) Mark the frequency limits of the channel as described in item d) and item e) of this subclause.

j) Using the attenuator A_2, set up the display so that within the frequency limits marked in item i) of this subclause:

1) the curve crosses the "reference" at the vision carrier frequency, interpolating if necessary; note the value a_0, with correction for interpolation;

2) the "peak" of the response touches the "reference", interpolating if necessary; note the value a_1, with correction for interpolation.

The "trough" of the response touches the "reference", interpolating if necessary.

Note the value a_2, with correction for interpolation.

k) The variation of amplitude/frequency response within the channel is given by $(a_1 - a_0)$ and $(a_2 - a_0)$.

4.2.5 Presentation of the results

The results are presented in a table or by a curve showing the amplitude response within the measured channel.

4.3 Chrominance-luminance gain and delay inequalities

NOTE This is relevant only for PAL and SECAM standards.

4.3.1 Introduction

The methods described are applicable to the measurement of chrominance/luminance gain and delay inequalities for complete systems and constituent items of equipment. The test signals employed are in both cases those recommended in ITU-T Recommendation J.61, and are shown in figure 7 and figure 8.

It is intended that these measurements are carried out with test signals inserted at the system headend. They may be either of the full frame type or, where convenient, may be inserted in the field blanking periods. The use of inserted test signals available on the broadcast television channel is not generally recommended as these are subject to variations beyond the control of the user. However, where such signals, of known stability and of adequate quality, are available, they may be used to carry out these measurements.

4.3.2 Equipment required

The test set-up shall be well-matched.

a) An oscilloscope which will not contribute significant distortion to the signal displayed.

b) A modulator (unless transmitted test signals in the field blanking interval are to be used) having the following characteristics:

   1) radio-frequency characteristics (excluding sound) corresponding to ITU-R Recommendation BT.470, and appropriate to the television transmission system used;

   2) video signal input requirement of 1 V peak-to-peak composite;

   3) a modulated output signal of a convenient amplitude.

c) A synchronous demodulator having characteristics appropriate to the television transmission system used.

d) Two attenuators variable in steps of not more than 1 dB.

e) A test signal generator (unless transmitted test signals are used) providing signals having characteristics appropriate to the television transmission system under consideration, as specified in ITU-T Recommendation J.61, and containing composite pulse and bar signal elements B2 and F.

   NOTE 1 Most commercially available test signal generators will provide this signal as part of a composite test line.

   NOTE 2 For measurement on system I, a composite pulse of half-amplitude duration = 1 µs would be an acceptable alternative to that shown as element F.

f) A test set capable of providing calibrated variable delay and attenuation in either the chrominance or luminance areas of the video spectrum.

4.3.3 Connection of the equipment

The equipment shall be connected as in figure 9.

4.3.4 Measurement procedure

a) With point A directly connected to point B (see figure 9), adjust attenuator A_1 for an output level sufficient to drive the system to be tested and attenuator A_2 to obtain the correct input level to the demodulator.

b) Adjust the oscilloscope Y gain, Y shift and time base to obtain a suitable display of the composite pulse.

For convenience, the oscilloscope may be triggered so that the top of the bar is superimposed over the pulse, as in figure 7.

Ensure that the distortion of the test signal due to the control loop (test equipment) is small compared with the limit specified for the system or equipment to be tested.

c) Connect the system or equipment to be tested between points A and B.

Adjust the attenuator A_2 to return the input level to the demodulator to that given in item a) of this subclause.

d) Using the oscilloscope controls, obtain a display as in item b) of this subclause.

e) With the controls on the test set, null the delay inequality so that the bottom edge of the pulse is symmetrical about the vertical centre line of the pulse (see figures 10b and 11b).

f) Using the calibrated attenuator on the test set, null the gain inequality so that the peak-to peak amplitude of the chrominance signal equals that of the luminance bar.

g) If necessary, repeat the procedure of 4.3.4 e) and 4.3.4 f).

h) Read the gain and delay inequalities from the calibrated test set.

NOTE 1 If the measurement is made in the presence of echoes generated by discontinuities in the system under test, the result obtained will be subject to an error of magnitude not exceeding that of the echo.

NOTE 2 It is possible, without the use of the test set, to estimate the delay or gain inequality by direct observation of the pulse against a calibrated graticule, and use of a suitable nomograph. The nomograph employed is that applicable to the half-amplitude duration of the particular composite pulse employed for the test. However, where non-linear distortion is present, particularly quadrature distortion in the demodulator, the results will be substantially in error.

4.3.5 Presentation of the results

The results are presented in a table showing the measured value of the chrominance-luminance gain and delay inequalities related to the measured channel.

4.4 Non-linear distortion

General

See IEC 60728-3. The methods described there are applicable to PAL and SECAM systems.

4.4.1 Intermodulation

See IEC 60728-3.

4.4.2 Composite beat

General

The method of measurement of composite beat using AM television signals is applicable to the measurement of the ratio of the carrier-to-composite beat at a specified point in a cabled distribution system. The method can also be used to determine the composite beat intermodulation performance of individual items of equipment. This measurement is made using the existing channels in the system with their normal modulation.

4.4.2.1 Introduction

When the input signals are at regularly spaced intervals (as is common in most frequency allocations for TV channels), the various distortion products tend to cluster in groups, close to the vision carriers and at other regular positions within the TV channels. The number of different products in each cluster increases rapidly with the number of channels. They combine in different ways, depending on the degree of coherence between the generating signals, and the relative phases of the different distortion products.

The method described in this subclause measures the non-linear distortion of a device or system by the composite effect of all the beats clustered close to the vision carrier or at other positions within a TV channel. During the measurement, that channel has to be turned off. The composite beat measured is that generated by all carriers except that or those of the measured channel.

NOTE On systems carrying more than 10 channels, removal of the wanted channel does not significantly affect the result.

If the major contribution to the composite beat is due to distortion products of a particular order, the composite beat will follow the standard level variation for that order. If the composite beat, as measured, does not follow a standard level variation, it shall have significant contributions from distortion products of different orders.

The method is used to support a specification of the following general format:

"The composite beat ratio for (list of carriers) in channel (A) at (B) dB(μV) is (C)dB".

(A) designates the channel in which the test is made. If omitted, the specification is understood to be a minimum specification for measurements at all the channels specified by the list of carriers.

(B) is the reference level at which all carriers are set during the measurement, unless otherwise specified. If all carriers are not at the same level, the specification should clearly indicate the level of each carrier relative to the reference level, which is that of the highest carrier level.

(C) is the composite beat ratio, usually given as a minimum specification.

The list of carriers will usually be specified as a list of standard channel designations, signifying test signals at the frequencies of the corresponding vision carriers.

The ratio of carrier-to-composite beat may not vary with output signal level in the way expected for distortion of a given order, and it may therefore be necessary to repeat the tests at levels higher and lower than those initially used. Repeat the tests at levels 2 dB higher and lower. It is recommended that these repeat tests are done on the channel which produced the lowest beat ratio during the test.

4.4.2.2 Equipment required

a) A spectrum analyzer with 30 kHz IF bandwidth and 10 Hz video bandwidth capability.

NOTE When using a spectrum analyzer with minimum video filtering capabilities greater than 10 Hz, the composite third-order distortion may be noisy and should be read at the middle of the trace.

b) A variable 75 Ω attenuator, adjustable in 1 dB steps.

c) A bandpass filter for each channel to be tested or a tunable bandpass filter. This filter should attenuate the other channels present on the system to be tested sufficiently to ensure that the products generated by non-linearity in the spectrum analyzer itself do not contribute significantly to the composite beat products to be measured. The passband of this filter shall at least be flat within 1 dB over the frequency range of interest.

NOTE If the linearity of the spectrum analyzer is sufficient and known, this filter is not necessary.

4.4.2.3 Connection of the equipment

The equipment is connected as in figure 14.

4.4.2.4 Measurement procedure

a) Connect point A directly to point B and disconnect the bandpass filter (see figure 14).

b) Adjust the spectrum analyzer as follows:

IF bandwidth:	30 kHz
Video bandwidth:	10 Hz
Scan width:	50 kHz/div.
Vertical scale:	10 dB/div.
Scan-time:	0,2 s/div

c) Tune the spectrum analyzer to the channel in which the measurement is to be made so as to display the vision carrier in a frequency range of 0,5 MHz towards the sound carrier.

d) Adjust the sensitivity of the spectrum analyzer together with its internal and external input attenuator in such a way that the response to the vision carrier corresponds to a full scale reference. At the same time the noise level shall be at least 60 dB, and preferably 65 dB, below the reference level.

e) Insert the bandpass filter (if necessary) corresponding to the channel to be measured and adjust the input attenuator to correct for the attenuation of the filter.

f) Disconnect the signal feed for the channel to be measured and terminate the input socket with its nominal impedance.

g) Verify that the intermodulation products generated in the spectrum analyzer over the entire channel are below the reference level by an amount at least 20 dB greater than the required distortion distance. If this is not the case, disconnect the bandpass filter and repeat the steps d) to g) of this procedure with an increased input attenuation of the spectrum analyzer.

h) Note the setting of the sensitivity control or the reference level control.

i) Reconnect the signal feed for the channel and repeat steps c) to h) of this procedure for all channels.

j) Connect the system to be tested between points A and B.

k) Adjust the centre frequency of the spectrum analyzer as in step c) and insert the appropriate band-pass filter, if necessary.

l) Adjust the input attenuator (internal and/or external) to return the response of the spectrum analyzer to the vision carrier to full scale with the appropriate setting of its sensitivity control (see step h)).

NOTE The external attenuator should be set to a minimum of 10 dB if the filter is in use, otherwise the system under test will see a serious mismatch.

m) Disconnect the signal feed for the channel to be measured and terminate the input socket with its nominal impedance.

n) Note the frequencies at which intermodulation products occur and the level of these products compared with the reference level in the frequency range displayed by the spectrum analyzer.

o) Reconnect the signal feed for the channel, adjust the analyzer tuning so as to display the next 0,5 MHz range.

p) Repeat steps k) to o) until the entire channel has been examined.

q) If the composite beats are clustered about the vision carrier, then the signal/composite beat ratio is read directly off the screen of the spectrum analyzer. In cases where there are several clusters, then the ratio is calculated and the subjective effect will be obtained by using the following formula which assumes power addition of the beats:

$$\text{Signal / composite beat} = -10\lg\sum_{j=1}^{M} 10^{-((L_j+K_j)/10)}$$

where

M is the number of different frequencies at which intermodulation products clusters occur;

L_j corresponds to the ratio, expressed in decibels, of the reference level, at the relevant frequency, to that of the intermodulation product;

K_j is the weighting factor expressed in decibels at the relevant frequency as obtained from figures 12, 13, 15 and 16.

NOTE A cluster is a group of beats (intermodulation products) falling around a carrier or inside a TV channel.

r) Repeat the steps k) to p) of this procedure for every channel used in this test.

s) The signal/composite beat ratio for the system under test is taken to be the lowest obtained in step r).

4.4.2.5 Presentation of the results

The results are presented in a table showing the measured values of composite beats (CTB/CSO) for each relevant TV channel.

4.4.3 Composite crossmodulation

Under consideration.

4.4.4 Hum modulation of carriers

4.4.4.1 Introduction

This is a method of measurement of the amplitude modulation (AM), at supply frequencies and harmonics thereof, of the signals on cabled distribution systems primarily intended for television and sound.

A simplified procedure for use where lower sensitivity will suffice is outlined in 4.4.4.6. For relatively high levels of hum modulation, the two methods will yield the same result. Both of the above methods use a DC reference.

An alternative method using an AC reference is described in 4.4.4.7 to 4.4.4.9.

NOTE These methods, are not suited to the measurement of "hum" modulation resulting from the use of switched-mode power supplies, due to the insertion of the 1 kHz low-pass filter. It may be possible to obtain such a measurement without the filter in the circuit, but the results may be inaccurate due to the presence of wide-band noise. A revised method of measurement is currently under consideration.

4.4.4.2 Definition

The signal / hum ratio measured by this method is defined as:

$$\text{signal/hum} = 20 \lg \frac{\text{reference modulation}}{\text{peak-to-peak "hum" modulation}} \text{ dB}$$

When the reference modulation is a vision signal, its amplitude is that of the peak-to-peak composite signal. For an AM sound signal, the reference modulation depth is taken to be 40 % (see figure 17).

4.4.4.3 Equipment required for DC method

The test set-up shall be well-matched.

NOTE 1 The items a), b), c) and e) of this subclause, if applicable, should preferably be powered from batteries (see also 4.4.4.4 b)).

NOTE 2 In item b) of this subclause "negligible" means small compared with the level of hum modulation expected to be measured.

a) A CW signal generator with output frequency range and output level to suit the system to be tested (see note 1).
b) A tuned signal amplifier to raise, with negligible distortion, the level of the test signal at the point of measurement to about 2 V_{RMS} (see notes 1 and 2).
c) An oscilloscope: dual channel, DC coupled, with differential facility, capable of measurement of a signal of 1 mV peak-to-peak (see note 1).
d) A terminating RF detector of impedance equal to the Z0 of the system under test.
e) A low-pass filter with 1 kHz cut-off; impedances to suit the detector output.

f) Two attenuators, variable in steps of 1 dB.

g) A calibrated potential divider (as shown in figure 19).

h) A stable variable DC source (as shown in figure 20).

4.4.4.4 Connection of the equipment

a) If battery-powered equipment is available, this shall be connected as in figure 18.

b) If mains-powered equipment is to be used, point A should be linked to point B and a check carried out in accordance with 4.4.4.5 a) and 4.4.4.5 c) to 4.4.4.5 f), to ascertain that the level of hum modulation within the test equipment is such that it may be neglected. It shall be small compared with the maximum allowed by the relevant system performance requirement. If this check is satisfactory, the system to be tested may be connected as shown in figure 18.

4.4.4.5 Measurement procedure

a) Set the signal generator frequency to that of the vision carrier (or sound carrier) of the channel to be tested.

b) Adjust attenuator A_1 to provide the correct level of CW signal at the input to the system. This level is equal to the RMS value of the relevant television signal during its modulation peaks, or the unmodulated carrier level for sound.

c) Adjust attenuator A_2 to give a signal of about 2 V_{RMS} across the RF termination of the detector.

d) With the switch of the potential divider set to "a", adjust the oscilloscope controls and the DC offset voltage to the Y_2 input to obtain a display of the demodulated hum signal. Note the peak-to-peak amplitude of the display.

e) Move the potential divider switch to "b" or "c", depending upon the amplitude of the displayed hum, and keeping all other settings adjusted as described in step d) of this subclause, note the change in DC level of the display. This change is equivalent to an amplitude reduction of 0,07 % for position "b", and of 0,3% for position "c".

f) Interpolate the result obtained in step d) of this subclause, in relation to the change observed in step e) of this subclause, as a percentage of peak-to-peak (see figure 21).

g) Calculate the signal/hum ratio (in dB) as follows:

$$\text{signal/hum} = 20 \lg \left(\frac{100}{\%\ \text{peak-to-peak hum}}\right) - R \quad \text{(dB)}$$

where R is appropriate to the system, as given in table 2.

4.4.4.6 Simplified procedure

a) Where suitable equipment is available and the levels of hum modulation to be measured are relatively high (signal/hum >> 34 dB to 40 dB), a simplified procedure may be adopted.

b) This entails the use of a tuned demodulator, for example, a signal level meter (having a DC coupled video output) and the measurement, with a suitable oscilloscope, of the DC and AC components of the hum modulated test carrier. Battery operation of the test equipment is again advisable and a low-pass filter (similar to that described in 4.4.4.3 e)) will also be required.

c) The calculation of signal/hum ratio (in dB) is then as follows:

$$\text{signal/hum} = 20 \lg \left(\frac{\text{measured DC voltage}}{\text{measured peak-to-peak AC voltage}}\right) - R \quad \text{(dB)}$$

Table 2 – Residual carrier reduction factors

Maximum modulation depth %	Residual carrier %	Reduction factor *R* dB
95	5	0,5
90	10	1
80	20	2
40 (see note)	(see note)	2
NOTE In the case of AC amplitude modulation of a sound carrier, the term "residual carrier" is not appropriate.		

4.4.4.7 Equipment required for AC method

The test set-up shall be well-matched.

a) A CW signal generator, with output frequency range and output level to suit the system to be tested, and with provision for sinewave modulation at a frequency up to 1 kHz (see notes 1 and 3).

b) A tuned signal amplifier, to raise, with negligible distortion, the level of the test signal at the point of measurement to about 2 V_{RMS} (see notes 1 and 2).

c) Two variable RF attenuators A_1 and A_2, variable in 1 dB steps and suitable for the frequency of operation and for the impedance of the system under test.

d) A terminating RF detector of impedance equal to that of the system under test.

e) An audio frequency amplifier, AC coupled and having sufficient gain to raise the level of the detected hum signal to a value providing a suitable display on the oscilloscope, and of output impedance to match the attenuator (see item f) and note 1).

f) An audio frequency attenuator A_3 variable in 1 dB steps and having a minimum range of 60 dB.

g) A low-pass filter with a 1,0 kHz cut-off frequency and impedance to match the output of the audio frequency attenuator (see item f) and note 3).

h) An audio frequency termination having an impedance matching the output of the low-pass filter (see item g)).

i) A single channel audio frequency AC coupled oscilloscope having a sensitivity depending on the choice of amplifier (see item e) and note 1).

NOTE 1 The equipment of items a), b), e) and i) of this subclause should be powered preferably from batteries. See also 4.4.4.9 b).

NOTE 2 "Negligible" is understood to mean small compared with the level of hum modulation expected to be measured.

NOTE 3 The use of a modulation frequency as low as 200 Hz with a corresponding low-pass filter may be preferable when the detected hum is largely affected by random noise.

4.4.4.8 Connection of the equipment

If battery-powered equipment is available this is connected as shown in figure 22.

If mains-powered equipment is to be used, point A should be linked to point B and a check carried out in accordance with 4.4.4.9 to ascertain that the level of hum modulation within the test equipment is such that it may be neglected. It shall be small compared with the maximum allowed by the relevant system performance requirement. If this check is satisfactory the system to be tested may be connected as shown in figure 22.

4.4.4.9 Measurement procedure

a) Ensure that the modulation depth indicator on the signal generator is correctly calibrated at the frequencies and modulation depths to be used in the measurement, see annex A and step c) below.

b) Set the signal generator frequency to that of the vision carrier (or sound carrier) of the channel to be tested.

c) Modulate the carrier to a depth of 1 % at a suitable frequency in the range 100 Hz to 1 kHz.

d) Adjust attenuator A_1 to provide the correct mean level of modulated CW signal at the input to the system. This level is equal to the RMS value of the relevant TV signal during its modulation peaks, or to the unmodulated carrier level for sound.

e) Adjust attenuator A_2 to give a signal of about 2 V_{RMS} across the RF termination of the detector.

f) With the audio attenuator A_3 set to 60 dB attenuation, adjust the oscilloscope controls and audio amplifier gain, if necessary, to provide a suitable display on the oscilloscope. Note the peak-to-peak amplitude of the display.

g) Remove the modulation of the carrier.

h) Readjust the audio attenuator to provide on the oscilloscope a display of the hum having a peak-to-peak amplitude equal to that noted in step f). Note the change in the attenuator reading α.

i) Calculate the signal/hum ratio (in dB) as follows:

   $$\text{signal/hum} = 34 + (\alpha - R)\ \text{dB}$$

   where

   α is the change in attenuator reading (in step h));

   R is a reduction factor given in table 2 of 4.4.4.6 c)).

4.4.4.10 Presentation of the results

The results are presented in a table showing the measured values of hum modulation for the vision carrier (or sound carrier) of each relevant TV channel.

4.4.5 Differential gain and phase

4.4.5.1 Introduction

The methods described are applicable to the measurement of differential gain and differential phase for complete systems and constituent items of equipment. The test signals employed are, in both cases, those recommended in ITU-T Recommendation J.61, and are shown in figures 23a and 23b. The definitions are also those given in the same recommendation.

It is intended that these measurements are carried out with test signals inserted at the system headend. They may be either of the full field type or, where convenient, may be inserted in the field blanking period.

The use of inserted test signals available on the broadcast TV channels is not generally recommended as these are subject to variations beyond the control of the user. However, where such signals, of known stability and of adequate quality are available, they may be used to carry out these measurements.

A) Differential gain

4.4.5.2 Definition

Differential gain is expressed by two values: *x* % and *y* %, which represent the two peak amplitudes of the sub-carrier relative to the amplitude of the sub-carrier at blanking level. In the case of a monotonic characteristic, either *x* or *y* will be zero.

Differential gain, in percentage referred to blanking level, can be found from the expressions below:

$$x = 100\ (\frac{A_{max}}{A_o} - 1) \quad \text{and} \quad y = 100\ (\frac{A_{min}}{A_o} - 1)$$

Peak-to-peak differential gain can be found from the expression:

$$100\ \frac{A_{max} - A_{min}}{A_o} = x - y$$

where

A_{max} and A_{min} are defined as shown in figure 25;

A_0 is the amplitude of the received sub-carrier at blanking level;

A is the amplitude of the sub-carrier of one of the other treads of the staircase.

4.4.5.3 Equipment required

The test set-up shall be well-matched.

a) An oscilloscope which will not contribute significant distortion to the signal displayed.

b) A modulator (unless transmitted test signals in the field blanking interval are to be used) having the following characteristics:

   1) radio-frequency characteristics (excluding sound) corresponding to ITU-R Recommendation BT.470, and appropriate to the television transmission system used;

   2) video signal input requirement of 1 V peak-to-peak composite;

   3) a modulated output signal of a convenient amplitude.

c) A synchronous demodulator having characteristics appropriate to the television transmission system used.

d) Two attenuators variable in steps of not more than 1 dB.

e) A band-pass filter having f_0 = 4,43 MHz or 3,58 MHz (the chrominance sub-carrier frequency) and a bandwidth of 0,5 MHz.

f) A test signal generator (unless transmitted test signals are used) providing signals having characteristics appropriate to the television transmission system under consideration, as specified in ITU-T Recommendation J.61 (signal D2), although a lower chrominance amplitude would be acceptable.

   NOTE Most commercially available test signal generators will provide this signal as part of a composite test line.

4.4.5.4 Connection of the equipment

The equipment shall be connected as in figure 26.

4.4.5.5 Measurement procedure

a) With point A directly connected to point B (see figure 26), adjust attenuator A_1 for an output level sufficient to drive the system to be tested and attenuator A_2 to obtain the correct input level to the demodulator.

b) Insert the appropriate band-pass filter after the demodulator (see figure 26) and measure the differential gain by examining the modified staircase waveform (see figure 25 and 4.4.5.2).

c) Ensure that the distortion of the test signal caused by the control loop (test equipment) is small compared with the maximum distortion allowed for the system or equipment to be tested.

NOTE Where the linearity of the modulator/demodulator is such that on systems B and G (10 % residual carrier) this requirement cannot be met, it will be necessary either to reduce the sub-carrier amplitude or to ignore the sixth (uppermost) tread.

d) Connect the system or equipment to be tested between points A and B, and disconnect the band-pass filter. Adjust attenuator A_2 to return the input level to the demodulator to that used in step a).

e) Reinsert the band-pass filter and measure the maximum differential gain by examining the modified staircase waveform (see figure 25 and 4.4.5.2).

NOTE This result includes the distortion due to the test equipment as well as the system under test.

B) Differential phase

4.4.5.6 Definition

Differential phase is expressed by two values *x* and *y*, in degrees, which represent the two peak phases of the sub-carrier relative to the phase of the sub-carrier at blanking level. In the case of a monotonic characteristic, either *x* or *y* will be zero.

Differential phase, in degrees, referred to blanking level, can be found from the expressions below:

$x = \Phi_{max} - \Phi_0$ and $y = \Phi_{min} - \Phi_0$

Peak-to-peak differential phase can be found from the expression:

$\Phi_{max} - \Phi_{min} = x - y$

where

Φ is the phase of the received sub-carrier on one of the other treads of the staircase;

Φ_0 is the phase of the received sub-carrier at blanking level;

Φ_{max} is the maximum value of Φ obtained by examining each tread of the staircase;

Φ_{min} is the minimum value of Φ obtained by examining each tread of the staircase.

4.4.5.7 Equipment required

a) A modulator (unless transmitted test signals in the field blanking intervals are to be used) having the following characteristics:

   1) radio-frequency characteristics (excluding sound) corresponding to ITU-R Recommendation BT.470, and appropriate to the television transmission system used;

   2) video signal input requirement of 1 V peak-to-peak composite;

   3) a modulated output signal of a convenient amplitude.

b) A synchronous demodulator having characteristics appropriate to the television transmission system used.

c) Two attenuators variable in steps of not more than 1 dB.

d) A test set capable of measuring the difference in phase of the sub-carrier at each tread of the staircase, compared with that at the reference (black) level.

e) A test waveform generator (unless transmitted test signals in the field blanking intervals are to be used) providing signals having characteristics appropriate to the television transmission system under consideration, as specified in ITU-T Recommendation J.61

(signal D2), although a lower amplitude of the chrominance component would be acceptable (see the note to 4.4.5.3 f)).

NOTE Certain types of test sets (see item d)) require the presence of a colour burst during the back porch period of the test signal.

4.4.5.8 Connection of the equipment

The equipment shall be connected as in figure 26.

4.4.5.9 Measurement procedure

a) With point A directly connected to point B (see figure 26) adjust attenuator A_1 for an output level sufficient to drive the system to be tested and attenuator A_2 to obtain the correct input level to the demodulator. Connect the differential phase test set.

b) Ensure that the distortion of the test signal due to the control loop (test equipment) is small compared with the maximum distortion allowed for the system or equipment to be tested (see also note to 4.4.5.5 c)).

c) Connect the system or equipment to be tested between points A and B. Adjust attenuator A_2 to return the input level to the demodulator to that used in step a) of this subclause.

d) Determine the relative sub-carrier phases corresponding to the six treads of the staircase waveform. The differential phase (x and y) of the system or equipment under test is the phase change between the blanking level tread and that of any other tread of the staircase as defined in 4.4.5.6. The peak-to-peak differential phase can be calculated according to 4.4.5.6.

4.4.5.10 Presentation of the results

The results of the measurement of the differential gain shall be presented indicating the two measured values x % and y %, referred to the relevant TV channel.

The results of the measurement of the differential phase shall be presented indicating the two measured values x and y, in degrees, referred to the relevant TV channel.

4.5 Carrier to noise ratio

4.5.1 Introduction

The method described is applicable to the measurement of the *carrier to random noise ratio* within a television channel at a specified point within a cabled distribution system. The method of measurement actually determines carrier (plus noise) to noise ratio; however, the difference between this and the carrier to noise ratio is very small if the value exceeds 20 dB..

The method assumes that the random noise is evenly distributed within the channel.

4.5.2 Equipment required

a) A measuring receiver with a known noise bandwidth less than that of the channel to be measured.

b) A CW signal generator covering the frequencies at which the tests are to be carried out.

c) A variable attenuator with a range greater than the carrier to noise ratio expected.

d) A shielded terminating resistor.

NOTE Additional items may be necessary, for example, to ensure correct calibration and operation of the test equipment (see annex B).

4.5.3 Connection of the equipment

The equipment shall be connected as in figure 27.

4.5.4 Measurement set-up

4.5.4.1 General

a) The test set-up shall be well-matched and the sensitivity of the measuring equipment (see annex C) shall be known over the frequency range of the channel to be measured.

b) Where the system to be measured includes:

   1) automatic gain control (AGC), tests should be carried out at minimum and maximum levels of signal input;

   2) automatic level control (ALC), pilot signals of the correct type, frequency and level shall be maintained throughout the tests.

c) The measuring receiver shall be calibrated and checked for satisfactory operation as explained in the next subclause.

4.5.4.2 Calibration

- Level correction, average/RMS or peak/RMS (see annex D).
- Noise bandwidth (see annex E).

4.5.4.3 Other checks

- Sensitivity (see annex B).
- Noise (see annex C).
- Intermodulation (see annex C).
- Overload (see annex C).

4.5.5 Measurement procedure

a) Set the signal generator frequency to the vision carrier frequency of the channel to be tested and adjust its output, and those of the different points of the system as far as the point of measurement, to obtain the specified system operating levels throughout.

b) Connect the variable attenuator and measuring receiver (and other items if required – see annex B) to the point of measurement. Tune the measuring receiver to the reference signal and note the attenuator value α_1 required to obtain a convenient measuring receiver reading R. The attenuator value α_1 should be slightly greater than the signal-to-noise ratio expected at the point of measurement.

c) Disconnect the generator and replace it by the shielded terminating resistor, or, if the reference signal is used for AGC, retune the measuring receiver within the channel such that it is influenced only by random noise. Reduce the attenuator setting to the value α_2 required to obtain the same measuring receiver reading R.

d) The carrier to noise ratio in decibel is given by:

   $$C / N = \alpha_1 - \alpha_2 - C_m - C_b$$

   where

   α_1 is the attenuator value for the reference signal;

   α_2 is the attenuator value for the noise;

   C_m is the measuring receiver level correction factor (see annex D);

   C_b is the bandwidth correction factor (see annex D).

4.5.6 Presentation of the results

The result of the measurement of the carrier to noise ratio shall be presented indicating the measured value referred to the relevant TV channel.

4.6 Echoes

4.6.1 Introduction

The method described is applicable to the measurement of the amplitude and time displacement of an echo at a specified point within a cabled distribution system by the use of a 2*T*-sine-squared pulse with the graticule as shown in figure 28. From these measurements an "echo-rating" is derived.

4.6.2 Equipment required

The test set-up shall be well-matched.

a) A test waveform generator providing a sine-squared pulse of half amplitude duration equal to 2*T*, where *T* is the period time; *T* = 100 ns. The test signals are in accordance with ITU-T Recommendation J.61.
b) A modulator having RF characteristics (excluding sound) appropriate to the television system under consideration (see ITU-R Recommendation BT.470) and input characteristics to suit the generator in item a).
c) A synchronous demodulator having characteristics appropriate to the television system under consideration.
d) Two attenuators variable in 1 dB steps.
e) An oscilloscope of negligible distortion up to 5 MHz, fitted with a graticule as shown in figure 28.

4.6.3 Connection of the equipment

The equipment shall be connected as in figure 24.

4.6.4 Measurement procedure

a) With the equipment connected as shown in figure 24, adjust the oscilloscope time-base speed to correspond with the T-scale on the graticule. Adjust the vertical gain and position controls to "fit" the pulse between the zero line and the pulse peak reference point. Examine the performance of the test equipment (control loop), which shall be such that an *E*-rating of not greater than 3 % is achieved. When frequency conversion is involved, the test equipment shall be checked at both the input and output channels.
b) Connect the test equipment to the system as shown in figure 24. Adjust the variable attenuator A_1 to provide an input signal to the system at a level equal to that at which it normally operates. Adjust the attenuator A_2 to provide an input signal to the demodulator equal to that used in step a) of this subclause.
c) Using the graticule as a reference, as before, determine the *E*-rating for each echo and note that of the echo with the highest rating.
d) Using the horizontal shift control of the oscilloscope slowly move the display to the left and examine any long-distance echoes. These should be rated using the parallel section of the graticule at the extreme right. Note the highest rating.
e) The *E*-rating for the system is the higher of the two figures noted in steps c) and d) of this subclause.

NOTE This result will not be that of the system alone. It is modified by the inherent distortion in the test equipment, usually due to group delay errors.

4.6.5 Presentation of the results

The result of the measurement of the echo shall be presented indicating the measured value of the *E*-rating referred to the relevant TV channel.

4.7 AM-VSB television, FM radio and FM television signal level

The method of measurement described is applicable to the measurement of AM or FM carriers.

4.7.1 Definitions for NTSC, PAL and SECAM systems

4.7.1.1 Signal level for AM-VSB vision carriers

The vision carrier signal level is the RMS value of the vision carrier at the peak of the modulation envelope, expressed in dB(μV) and measured across a 75 Ω termination or referred to 75 Ω.

This will correspond, in negative modulation systems, to the carrier amplitude during synchronizing pulses and, in positive modulation systems, to that at peak white level without a chrominance signal, as in ITU-R Recommendation BT.470, figure 1.

4.7.1.2 AM or FM sound carrier level

The level of an AM or FM sound signal is the RMS value of the unmodulated carrier expressed in dB(μV) and measured across a 75 Ω termination or referred to 75 Ω.

4.7.1.3 Signal level for FM radio or FM television

The level of an FM radio or a FM TV signal is the RMS value of the unmodulated carrier expressed in dB(μV) and measured across a 75 Ω termination or referred to 75 Ω.

4.7.2 Equipment required

A "well-matched" radio-frequency measuring receiver having:

a) a nominal input impedance of 75 Ω or transformed to 75 Ω and being calibrated in dB(μV);

b) a detection system capable of attaining the peak of the AM carrier to be measured;

c) facilities to adjust the detector characteristics for the measurement of AM and FM carriers;

d) a passband of at least 120 kHz, with sufficient selectivity to ensure that carriers other than those measured shall not influence the result.

NOTE The accuracy of the radio-frequency measuring receiver is not specified, since this will depend on the purpose of the measurement. Laboratory instrumentation can achieve better than ±0,5 dB, but most level measurements on an operating cabled distribution system are concerned with levels at system outlets. For this application, less expensive portable equipment, whose overall accuracy is unlikely to be better than ±2 dB, is usually found to be acceptable. A spectrum analyzer can also be used.

4.7.3 Measurement procedure

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

b) Connect the measuring receiver or spectrum analyzer to the point of measurement by means of a suitable coaxial cable, taking care to maintain correct impedance matching.

c) Read the signal level in accordance with the instructions provided by the instrument manufacturer and note the results. When recording the results, the measurement accuracy of the instrument shall be stated.

If the input impedance of the measuring receiver or spectrum analyzer is other than 75 Ω and a matching device is required, or if any other interface equipment is employed, then an allowance shall be made for the resultant change in voltage level. Losses in the interconnecting cables, where these are significant, shall also be taken into account.

For positive AM-VSB modulation TV systems, the measuring receiver shall remain connected for a sufficient period to ensure that the maximum reading is obtained. It may therefore be necessary to observe the picture in order to ensure that peak white is present in the signal during the measurement.

In the case of a dual outlet, the unused outlet shall be terminated with the correct characteristic impedance during the measurement.

When using a spectrum analyzer the peak hold mode shall be used.

4.7.4 Presentation of the results

The result of the measurement of the signal level shall be presented indicating the measured value, expressed in dB(μV) (being measured across a 75 Ω termination or referred to 75 Ω), and referred to the vision or sound carrier of the relevant TV channel.

4.8 Data echo rating and data delay inequality

Under consideration.

4.9 Interference in FM sound radio channels

Under consideration.

4.10 Methods of measurement for digitally modulated signals

4.10.1 Introduction

The methods of measurement for digitally modulated signals differ from those for analogue modulation for several reasons:

a) the carrier is not present in the modulated signal and therefore cannot be measured (i.e. DVB systems using PSK or QAM modulation) or there are thousands of carriers (i.e. DVB systems using OFDM modulation);
b) the modulated signal has a spectrum that is flat in the bandwidth and is similar to noise;
c) the parameters that affect the quality of the received signal are related to the bit and word errors introduced by the channel (noise, amplitude and phase response inequalities, echoes, etc.) before demodulation and error correction.

4.10.2 Basic assumptions and measurement interfaces

The 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, SMATV, MMDS/MVDS and terrestrial distribution;
b) the digitally modulated signals received by satellite are modulated in the PSK format, i.e. according to EN 300421 for the QPSK format, and can be distributed in the same format in cable systems (SMATV systems);
c) the digitally modulated signals received by satellite are distributed in CATV systems in the QAM format, i.e. according to EN 300429;
d) the digitally modulated signals received from terrestrial broadcasting in the OFDM format are distributed in SMATV/CATV systems in the same OFDM format;
e) a I/Q baseband signal source for PSK, QAM or OFDM formats is available, as described in figure 29; appropriate interfaces are accessible and are consistent with the DVB-SI documents (see document ETR 211 and EN 300468);

f) a reference receiver for PSK, QAM or OFDM formats is available as described in figure 30, 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).

4.10.3 Signal level

4.10.3.1 Introduction

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

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

NOTE Also a vector signal analyzer can be used or a suitable measuring set designed and calibrated for signal level measurement of digitally modulated signals.

The measurement can be performed at the system outlet, at the output of a distribution equipment (passive or active), at the output of the headend or at the output of an outdoor unit (SHF receiver) for satellite reception.

4.10.3.2 Equipment required

The equipment required is a spectrum analyzer having 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 to the nominal frequency range of the system.

4.10.3.3 Connection of the equipment

Connect the measuring equipment to the system outlet or to the point where the measurement shall be performed, using suitable cable and connectors, taking care to maintain correct impedance matching.

4.10.3.4 Measurement procedure

a) When 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 the meter and the 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 analyzer on the channel that shall be measured (selecting the centre frequency of the spectrum analyzer) and select the span and level settings to show the whole channel whose bandwidth depends on the type of modulation used. Examples of the equivalent signal bandwidth (BW) for digitally modulated signals are indicated in annex H.

c) Set the resolution bandwidth (RSBW) of the spectrum analyzer 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 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 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).

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

$$LS = S + 10 \lg \left[\frac{BW}{RSBW} \right] + K_{sa}$$

where

LS is the 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 (annex H);

$RSBW$ is the resolution bandwidth of the spectrum analyzer in kHz;

K_{sa} is the correction factor of the spectrum analyzer.

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 analyzer is about 1,7 dB (see annex I).

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 (LS) of the signal can be obtained from the measured maximum level (S) using the following formula:

$LS = S + 10 \lg (BW)$.

NOTE This measuring method actually measures the S+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 analyzer) 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) should be taken into account in the measurement of signal level (S) (see annex F).

4.10.3.5 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.

4.10.4 Signal to noise ratio (S/N)

4.10.4.1 Introduction

This measuring method applies to the measurement of the signal to noise ratio (S/N) of digitally modulated signals using PSK, QAM, OFDM format.

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

NOTE Also a vector signal analyzer can be used.

The measurement can be performed at the system outlet, at the output of a distribution equipment (passive or active), at the output of the headend or at the output of an outdoor unit (SHF receiver) for satellite reception.

4.10.4.2 Equipment required

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

The equipment shall be able to tune the nominal frequency range of the system or equipment under test.

4.10.4.3 Connection of the equipment

Connect the measuring equipment to the system outlet or to the point where the measurement shall be performed, using suitable cable and connectors, taking care to maintain correct impedance matching.

4.10.4.4 Measurement procedure

a) Tune the spectrum analyzer on the channel that shall be measured (selecting the centre frequency of the spectrum analyzer) and select the span and level settings to show the whole channel whose bandwidth depends on the type of modulation used. Examples of the equivalent signal bandwidth (BW) for digitally modulated signals are indicated in annex H.

b) Set the resolution bandwidth of the spectrum analyzer 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 analyzer supports this feature. Otherwise select a normal marker.

c) Measure the maximum level (*S*) 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 centre frequency (carrier frequency) of the signal spectrum. This value approaches the useful power.

d) Switch-off the channel at the input of the system or at the input of the device under test, 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 signal to noise ratio (*S*/*N*) by the following formula:

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

where

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

S is the 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 $(S+N)/N$ ratio. The measuring equipment (spectrum analyzer) 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*) should be taken into account (see clause F.2).

4.10.4.5 Presentation of the results

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

4.10.5 Bit error rate (BER)

4.10.5.1 Introduction

This method of measurement applies to the measurement of bit error rate (BER) of digitally modulated signals using PSK, QAM, OFDM formats.

BER is the primary parameter which describes the quality of the digital transmission link and shall be related to the signal to noise ratio at the input of the receiver.

The bit error rate is defined as the ratio between erroneous bits and the total number of transmitted bits.

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

This measuring method shall be performed under out of service conditions.

4.10.5.2 Equipment required

The equipment required is listed below:

a) I/Q baseband signal source for PSK, QAM or OFDM modulation format (figure 29);
b) RF modulator for PSK, QAM or OFDM modulation format (figure 29);
c) power splitter;
d) spectrum analyzer able to tune the nominal frequency range of the system;
e) reference receiver (figure 30) with good equalizer (influence of linear distorsion of the cable network to the BER measurement should be negligible);
f) counter of BER 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.

4.10.5.3 Connection of the equipment

The measuring set-up for BER measurement is showed in figure 31. The measuring equipment shall be connected taking care to maintain correct impedance matching.

4.10.5.4 Measurement procedure

a) Set the signal source (base band) to generate a sequence defined as the *null transport stream packet* in ISO/IEC 13818-1 with all bytes set to 0x00 (see annex G). A sequence of four bytes followed by a PRBS (pseudo random binary sequence) can also be used.

NOTE The *null transport stream packet* is defined as the four byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

b) Apply the signal source I and Q channels at the input of the RF modulator to obtain the desired PSK, QAM or OFDM modulation format.
c) Set the carrier frequency of the RF modulator to that of the channel where the measurement shall be performed.
d) Adjust the output carrier level of the RF modulator to obtain the same level at the system outlet as in normal operating conditions, so that non-linear distorsions (i.e. CSO, CTB) have no impact on BER measurement.
e) Tune the receiver and the spectrum analyzer to the same channel. Select the centre frequency of the spectrum analyzer, the span and level settings to show the whole channel.
f) Set the resolution bandwidth (RSBW) of the spectrum analyzer to 100 kHz and the video bandwidth to 100 Hz. Select a display line cursor if the spectrum analyzer supports this feature. Otherwise select a normal marker.
g) Switch-off the modulation and measure the carrier level (C) in dB(μV) or in dB(mW).

NOTE In case of QAM modulated signals, the carrier level (C) is assumed to be that measured according to 4.10.3, because the carrier level upon switching-off the modulation does not coincide with the carrier peak level.

h) Measure the noise level N beside carrier ($\Delta f \geq 0{,}5$ MHz) in the same units as the carrier level (in dB(μV) or in dB(mW)).

NOTE Pay attention to the amplitude response of the noise spectrum within the channel. If it is not white Gaussian spectrum (flat amplitude response) take care not to measure at maximum or minimum frequency points, but take the frequency points where the energy of noise reaches its average.

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

$$(C/N)_{\mathrm{dB}} = C - N - 10\ \lg\ (\mathrm{BW/RSBW}) - K_{\mathrm{sa}}$$

where

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

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

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

BW is the equivalent signal bandwidth of the channel in kHz (annex H);

$RSBW$ is the resolution bandwidth of the spectrum analyzer in kHz;

K_{sa} is the correction factor of the spectrum analyzer.

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 analyzer is about 1,7 dB (see annex I).

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 C/N ratio can be obtained from the following formula:

(C/N) dB = C [dB(mW)] – N [dB(mW/Hz)] – 10 lg (BW).

j) Switch-on the modulation and measure the BER counting the error bits for a sufficient long time 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 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 3/4 the conversion factor can be calculated as follows:

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

4.10.5.5 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 it shall be stated with the results. The interface point where the measurement of BER has been performed shall be indicated with the results.

4.10.6 BER versus E_b/N_o

4.10.6.1 Introduction

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

The measurement is performed at the system outlet of a cabled distribution network, while the modulated signal with the appropriate format is applied at the input of the headend or at the input of the distribution network, depending which part of the system is to be measured.

The headend can include modulation converters (from PSK to QAM format).

This measuring method shall be performed under out of service conditions.

4.10.6.2 Equipment required

The equipment required is listed below:

a) I/Q baseband signal source for PSK, QAM or OFDM modulation format (figure 29);

b) RF modulator for PSK, QAM or OFDM modulation format (figure 29);

c) noise source;

d) adjustable attenuator;

e) power combiner;

f) power splitter;

g) spectrum analyzer able to tune the nominal frequency range of the system;

h) reference receiver (figure 30) with good equalizer (influence of linear distorsion of the cable network to the BER measurement should be negligible);

i) counter of BER 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.

4.10.6.3 Connection of the equipment

The measuring set-up for BER versus E_b/N_0 measurement is shown in figure 32.

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

4.10.6.4 Measurement procedure

a) Set the signal source (base band) to generate a sequence defined as the *null transport stream packet* in ISO/IEC 13818-1 with all bytes set to 0x00 (see annex G). A sequence of four bytes followed by a PRBS (pseudo random binary sequence) can also be used.

   NOTE The *null transport stream packet* is defined as the four byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

b) Apply the signal source I and Q channels at the input of the RF modulator to obtain the desired PSK, QAM or OFDM modulation format.

c) Set the carrier frequency of the RF modulator to that of the channel where the measurement shall be performed.

d) Adjust the output carrier level of the RF modulator to obtain the same level at the system outlet as in normal operating conditions, so that non-linear distorsions (i.e. CSO, CTB) have no impact on BER measurement.

e) Tune the receiver and the spectrum analyzer on the same channel. Select the centre frequency of the spectrum analyzer, the span and level settings to show the whole channel.

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

g) With the noise generator switched-off, measure the BER at the receiver output.

h) Switch-off the modulation and measure the carrier level (C) in dB(μV) or in dB(mW).

   NOTE In the case of QAM modulated signals, the carrier level (C) is assumed to be that measured according to 4.10.3, because the carrier level upon switching-off the modulation does not coincide with the carrier peak level.

i) Measure the noise level N beside carrier ($\Delta f \geq 0,5$ MHz) in the same units as the carrier level (in dB(μV) or in dB(mW)).

   NOTE Pay attention to the amplitude response of the noise spectrum within the channel. If it is not white Gaussian spectrum (flat amplitude response), take care not to measure at maximum or minimum frequency points, but take the frequency points where the energy of noise reaches its average.

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

   $$(C/N)_{dB} = C - N - 10 \lg (BW/RSBW) - K_{sa}$$

   where

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

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

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

BW is the equivalent signal bandwidth of the channel in kHz (annex H);

$RSBW$ is the resolution bandwidth of the spectrum analyzer in kHz;

K_{sa} is the correction factor of the spectrum analyzer.

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 analyzer is about 1,7 dB (see annex I).

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 C/N ratio can be obtained from the following formula:

$(C/N)_{dB} = C$ [dB(mW)] – N [dB(mW/Hz)] – 10 lg (BW).

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

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

where

f_S is the symbol rate;

m is the number of bits per symbol (m = 1 for BPSK, m = 2 for QPSK and TC8PSK, m = 4 for 16 QAM, m = 6 for 64 QAM) modulating the carrier (PSK or QAM) or each pilot carrier (OFDM).

l) Switch-on the modulation and the noise generator, add noise changing the attenuator setting and measure again the BER at the 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 an 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

4.10.6.5 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 shown in figure 33. The interface point where the measurement of BER has been performed shall be indicated with the results.

4.10.7 Noise margin

4.10.7.1 Introduction

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

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

The measurement is performed at the system outlet of a cabled distribution network, while the modulated signal with the appropriate format is applied at the input of the headend or at the input of the distribution network, depending which part of the system is to be measured.

The headend can include modulation converters (from PSK to QAM format).

This measuring method shall be performed under out-of-service conditions.

4.10.7.2 Equipment required

The equipment required is listed below:

a) I/Q baseband signal source for PSK, QAM or OFDM modulation format (figure 29);

b) RF modulator for PSK, QAM or OFDM modulation format (figure 29);

c) noise source;

d) adjustable attenuator;

e) power combiner;

f) power splitter;

g) spectrum analyzer able to tune the nominal frequency range of the system;

h) reference receiver (figure 30) with good equalizer (influence of linear distorsion of the cable network to the BER measurement should be negligible);

i) counter of BER 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.

4.10.7.3 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 32.

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

4.10.7.4 Measurement procedure

a) Set the signal source (base band) to generate a sequence defined as the *null transport stream packet* in ISO/IEC 13818-1 with all bytes set to 0x00 (see annex G). A sequence of four bytes followed by a PRBS (pseudo random binary sequence) can also be used.

NOTE The *null transport stream packet* is defined as the four byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

b) Apply the signal source I and Q channels at the modulator to obtain the desired PSK, QAM or OFDM modulation format.

c) Set the carrier frequency of the RF modulator to that of the channel where the measurement shall be performed.

d) Adjust the output carrier level of the RF modulator to obtain the same level at the system outlet as in normal operating conditions, so that non-linear distortions (i.e. CSO, CTB) have no impact to BER measurement.

e) Tune the receiver and the spectrum analyzer to the same channel. Select the centre frequency of the spectrum analyzer, the span and level settings to show the whole channel.

f) Add noise to the modulated signal at the cable network output until BER is 10-4.

g) Switch-off the modulation and measure the noise level $N1$ (dB(mW)) beside the carrier ($\Delta f \geq 0,5$ MHz).

NOTE Pay attention to the amplitude response of the noise spectrum within the channel. If it is not white Gaussian spectrum (flat amplitude response), take care not to measure at maximum or minimum frequency points, but take the frequency points where the energy of noise reaches its average.

h) Switch-off the noise source and measure the noise level $N2$ (dB(mW)) beside the carrier.

i) Calculate the noise margin NM by the following formula:

$NM_{dB} = N1 - N2$ (dB)

4.10.7.5 Presentation of the results

The measured noise margin is expressed in dB. An example of measurement of noise margin is shown in figure 33 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.

4.10.8 Modulation error ratio (MER)

4.10.8.1 Introduction

This measuring method is able to provide a single "figure of merit" analysis of the received 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 system outlet of a cabled distribution network, while the modulated signal with the appropriate format is applied at the input of the headend or at the input of the distribution network, depending which part of the system is to be measured.

The headend can include modulation converters (from PSK to QAM format).

This measuring method shall be performed under out-of-service conditions.

4.10.8.2 Equipment required

The equipment required is listed below:

a) I/Q baseband signal source for PSK or QAM modulation format (figure 29);

b) RF modulator for PSK or QAM modulation format (figure 29);

c) reference receiver (figure 30);

d) constellation analyzer

4.10.8.3 Connection of the equipment

The measuring set-up for the modulation error ratio (MER) measurement is shown in figure 34.

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

4.10.8.4 Measurement procedure

a) Set the signal source (base band) to generate a sequence defined as the *null transport stream packet* in ISO/IEC 13818-1 with all bytes set to 0x00 (see annex G). A sequence of four bytes followed by a PRBS (pseudo random binary sequence) can also be used.

NOTE The *null transport stream packet* is defined as the four byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

b) Apply the signal source I and Q channels at the input of the modulator to obtain the desired PSK or QAM modulation format.

c) Set the carrier frequency of the RF modulator to that of the channel where the measurement shall be performed.

d) Adjust the output carrier level of the RF modulator to obtain the same level at the system outlet as in normal operating conditions.

e) Tune the receiver to the channel where the measurement shall be performed. The measurement of the modulation error ratio does not assume the use of an equalizer. However the measuring receiver may include a commercial quality equalizer to give more accurate results when the signal at the measurement point has linear impairments.

f) Connect the constellation analyzer to the appropriate interface (S or T of the reference receiver shown in figure 30). If the constellation analyzer has its own tuner, the use of the reference receiver can be avoided.

g) The carrier frequency and symbol timing are recovered, which removes frequency error and phase rotation. Origin offset (e.g. caused by a residual carrier or DC offset), quadrature error and amplitude imbalance are not corrected.

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

i) 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.

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

An example of representation of the constellation diagram for a 64 QAM modulation format and the distance (δI_j , δQ_j) for each of the N received symbols in the ith point from the ideal position (I_j, Q_j) is shown in figure 35.
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):

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

NOTE Before starting the measurement, check the modulator performance, connecting the receiver with the constellation analyzer at the output of the signal generator modulated by the digital source. The displayed constellation diagram shall be noted and assumed as the reference position for the measurement.

4.10.8.5 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.

4.10.9 Phase jitter

4.10.9.1 Introduction

This measuring method is able to provide an indication of the phase or frequency fluctuations of an oscillator used in a piece of equipment of the cabled distribution 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 system outlet of a cabled distribution network, while the modulated signal with the appropriate format is applied at the input of the headend or at the input of the distribution network, depending which part of the system is to be measured.

The headend can include modulation converters (from PSK to QAM format).

This measuring method shall be performed under out-of-service conditions.

4.10.9.2 Equipment required

The equipment required is listed below:

a) I/Q baseband signal source for PSK or QAM modulation format (figure 29);

b) RF modulator for PSK or QAM modulation format (figure 29);

c) reference receiver (figure 30);

d) constellation analyzer.

4.10.9.3 Connection of the equipment

The measuring set-up for the phase jitter measurement is shown in figure 34.

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

4.10.9.4 Measurement procedure

a) Set the signal source (base band) to generate a sequence defined as the *null transport stream packet* in ISO/IEC 13818-1 with all bytes set to 0x00 (see annex G). A sequence of four bytes followed by a PRBS (pseudo random binary sequence) can also be used.

NOTE The *null transport stream packet* is defined as the four byte sequence 0x47, 0x1F, 0xFF, 0x10, followed by 184 zero bytes (0x00). This sequence can be available as an encoding system option.

b) Apply the signal source I and Q channels at the input of the modulator to obtain the desired PSK or QAM modulation format.

c) Set the carrier frequency of the RF modulator to that of the channel where the measurement shall be performed.

d) Adjust the output carrier level of the RF modulator to obtain the same level at the system outlet as in normal operating conditions.

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

f) Connect the constellation analyzer to the appropriate interface (S or T of the reference receiver shown in figure 30). If the constellation analyzer has its own tuner the use of the reference receiver can be avoided.

g) The carrier frequency and symbol timing are recovered, which removes frequency error and phase rotation but not phase jitter. Origin offset (e.g. caused by residual carrier or DC offset), quadrature error and amplitude imbalance are not corrected.

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

i) 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 36 for the four "corner decision boundary boxes".

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):

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

NOTE Before starting the measurement, check the modulator performance, connecting the receiver with the constellation analyzer at the output of the signal generator modulated by the digital source. The displayed constellation diagram should be noted and assumed as the reference position for the measurement.

4.10.9.5 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.

4.10.10 Phase noise of an RF carrier

4.10.10.1 Introduction

This measuring method 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 cabled distribution system (i.e. in a frequency converter).

For PSK or QAM 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 that cannot 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 peculiar 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 system outlet of a cabled distribution network, while an unmodulated carrier is applied at the input of the headend or at the input of the distribution network, depending which part of the system is to be measured.

The headend can include modulation converters (from PSK to QAM format).

This measuring method shall be performed under out-of-service conditions.

4.10.10.2 Equipment required

The equipment required is listed below:

a) RF signal generator for the frequency bands of input signals at the headend or the distribution network;

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

b) spectrum analyzer able to tune the nominal frequency range of the system.

4.10.10.3 Connection of the equipment

The measuring set-up for the phase noise measurement is shown in figure 37.

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

4.10.10.4 Measurement procedure

a) Set the carrier frequency of the RF signal generator to that of the channel where the measurement shall be performed.
b) Adjust the carrier level of the RF signal generator to obtain the same level at the system outlet as in normal operating conditions.
c) Tune the spectrum analyzer on the same channel. Select the centre frequency of the spectrum analyzer, 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 analyzer 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 one hertz bandwidth, using the following formula:

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

   where

   $RSBW$ is the resolution bandwidth of the spectrum analyzer.

   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 analyzer is about 1,7 dB (see annex I).

   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:

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

   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.

4.10.10.5 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 system) the spectrum mask shall be specified at least in three points (frequency offsets and levels, as seen in the example of figure 38.

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 3.

Table 3 – Frequency offsets for 2k and 8k systems

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

5 Performance requirements

General

This clause defines system performance limits which will, with an unimpaired input, produce picture and sound signals where the impairment to any single parameter will be not worse in normal operating conditions for any channel than grade four on the five-grade impairment scale contained in ITU-R Recommendation BT.500 as given below:

5 – imperceptible;

4 – perceptible but not annoying;

3 – slightly annoying;

2 – annoying;

1 – very annoying.

The system parameters specified are mainly related to analogue frequency division multiplexed (FDM) signals. When different techniques are used, the overall quality requirements should be met. A supplement with relevant new parameters will be issued later.

The performance limits set out in this clause apply when the methods of measurement given in clause 4 are employed, and, where appropriate, in the presence of all the signals for which the system was designed. The performance limits shall be met for those specified conditions of temperature, humidity, mains supply voltage and frequency which apply to the location in which the system is situated.

NOTE1 If a higher grade than 4 is desired, the figures quoted in clause 5 should be modified accordingly. For instance for grade 4.5, the figures quoted in 5.6 and 5.7 should be increased by 3 dB; the echo rating in 5.8.2 should be reduced to 3 %.

NOTE 2 If PALplus signals are conveyed in a system at the same level as PAL and SECAM signals, they will have a slightly lower grade than the PAL or SECAM signals.

NOTE 3 Performance requirements that are frequency dependent are specified up to 2 150 MHz. Requirements for the frequency range 2 150 MHz to 3 000 MHz are under consideration.

For digital signals, the system performance limits ensure a service that is quasi-free of interruption, corresponding to a bit error rate, before Reed-Solomon error correction, of 10^{-4} in a DVB signal.

5.1 Impedance

The nominal impedance of the system shall be 75 Ω. It should be noted that this value applies to all coaxial feeder cable and system outlets and shall be used as the reference impedance for all measurements.

5.2 Carrier levels at system outlets

5.2.1 Minimum and maximum carrier levels

The minimum and maximum carrier levels will depend on many factors including the performance of typical receivers in use and local installation practices. The maximum levels shall not exceed, and the minimum levels shall be not less than those shown in table 4.

Table 4 – Carrier signal levels at any system outlet

Type of service	Systems	Modulation	Frequency range	Minimum level dB(μV)	Maximum level dB(μV)
Television	PAL-SECAM	AM-VSB	VHF/UHF	60*	80**
	NTSC	AM-VSB	30 to 300 MHz	57	83
	NTSC	AM-VSB	300 to 1 000 MHz	60	83
	PAL-SECAM	FM	1st IF	47	77
	NTSC	FM	240 to 770 MHz	60	83
	NTSC	FM	1 035 to 1 335 MHz	57	81
	DVB-S	QPSK	1st IF	47	77
	DVB-C	64 QAM	VHF/UHF	47	67
	DVB-C	16 QAM	VHF/UHF	u.c.	u.c.
	DVB-C	256 QAM	VHF/UHF	u.c.	u.c.
	DVB-T	CODFM	VHF/UHF	u.c.	u.c.
Radio	Sound mono	FM	VHF	40	70 see note 1
	Sound stereo	FM	VHF	50	70 see note 1
	DSR		HF	56	see note 3
	DSR		1st IF	47	see note 3

* 57 dB(μV) for systems with 8 MHz and 12 MHz spacing only.

** 77 dB(μV) for systems with >20 channels load.

NOTE 1 In order not to overload certain receivers, the figures quoted above for the maximum levels might have to be reduced for example by means of a separate attenuator at a specific outlet.

NOTE 2 The level of the television sound carrier relative to that of the vision carrier which is permissible varies according to the television system and performance of typical receivers.

NOTE 3 Signal levels and methods of measurement for these transmission standards are under consideration.

NOTE 4 Other types of modulation are under consideration.

5.2.2 Carrier level differences

The differences in carrier levels shall not exceed the values given in table 5.

Table 5 – Maximum level differences at any system outlet between distributed television channels

Systems	Modulation	Frequency range	Maximum level difference dB
PAL-SECAM	AM-VSB	47 MHz to 862 MHz	12
NTSC	AM-VSB	30 MHz to 1 000 MHz	15
NTSC	AM-VSB	30 MHz to 300 MHz	12
PAL-SECAM	AM-VSB	Any 60 MHz range in VHF	6
NTSC	AM-VSB	Any 60 MHz range in VHF	8*
PAL-SECAM, NTSC	AM-VSB	Adjacent channel	3
PAL-SECAM	FM	950 MHz to 2 150 MHz	15
NTSC	FM	950 MHz to 2 150 MHz	u.c.
PAL-SECAM	FM	up to 470 MHz	15
NTSC	FM	up to 470 MHz	u.c.
DVB-S	QPSK	950 MHz to 2 150 MHz	u.c.
DVB-C	64 QAM	Adjacent channel	3
DVB-C	64 QAM	Adjacent channel to AM-VSB	13**
DVB-T	COFDM	Adjacent channel	u.c.
DVB-T	COFDM	Adjacent channel to AM-VSB	u.c.
* The 64 QAM signal must be below the level of the adjacent AM signal. ** NOTE – Values for other QAM signals are under consideration.			

If FM sound signals are present at the system outlet intended for AM-VSB television signals, the level of any FM carrier shall be at least 3 dB lower than the lowest television signal level at the outlet.

NOTE 1 The difference applies to signals having the same type of modulation.

NOTE 2 The value includes the possible coexistence of signals of 27 MHz bandwidth FM and 7 MHz to 12 MHz bandwidth AM-VSB which may be in the close vicinity. They also take into account the characteristics of the connected customers' receivers (selectivity, image rejection, oscillator radiation). In some cases, it may be necessary, in order to obtain that figure, to incorporate channel by channel processing. The levels of FM satellite channels relative to AM-VSB terrestrial channels should be 0 to –10 dB.

NOTE 3 When equal level FM radio signals are transmitted from the headend, then the maximum difference between these signals at the system outlet should be 6 dB.

5.3 Mutual isolation between system outlets

5.3.1 Isolation between two subscribers

The minimum isolation at any frequency between any two subscribers' system outlets connected separately to a spur feeder system shall be as in table 6 below.

Table 6 – Mutual isolation

Type of service	Frequency range	Mutual isolation dB
TV / TV	47 MHz to 862 MHz	42*
TV / TV	950 MHz to 2 150 MHz	30
FM sound / FM sound	VHF	42
TV / FM sound		u.c.

* 36 dB for frequency ranges having 8 MHz or 12 MHz channel spacing

NOTE 1 For systems carrying channels chosen so that TV local oscillators do not fall within any distributed channels, the figure for mutual isolation may be reduced.

NOTE 2 In systems using a return path, the requirement cannot be fulfilled at the lower frequency of 47 MHz but at a convenient higher frequency, depending on the return path band.

5.3.2 Isolation between individual outlets in one household

Under consideration.

5.4 Frequency response within a television channel at any system outlet

5.4.1 Amplitude response

The amplitude response variations within any television channel shall not exceed the values given in table 7.

Table 7 – Amplitude response variation

Signal modulation	Occupied or channel bandwidth MHz	Maximum variation (peak-to-peak) dB	Maximum slope of variation dB/MHz
AM-VSB television	6	2	1
	8	2,5	1
FM television	27-36	u.c.	u.c.
QPSK (DVB-S)	37,125	8	0,25
TC8PSK (Japan)	34,5	–	–
64 QAM (DVB-C)	8	8	1,5
64 QAM (Japan)	6	6	u.c.
COFDM (DVB-T)	8	8	u.c.
OFDM (Japan)	6	6	u.c.

5.4.2 Group delay

The group delay variation within any television channel shall not exceed the values given in table 8.

Table 8 – Group delay variation

Signal modulation	Frequency range MHz	Maximum group delay variation ns
AM-VSB television (PAL) with teletext	0,5 – 4,43	100
AM-VSB television (PAL) without teletext	0,5 – 4,43	200
QPSK	u.c.	u.c.
OFDM	u.c.	u.c.
QAM	u.c.	u.c.

5.5 Long-term frequency stability of distributed carrier signals at any system outlet

The frequency stability is determined by the headend equipment and the figures given for headend equipment apply.

At any system outlet the maximum frequency deviation from the nominal value of the carrier frequency of the channel shall not exceed the values given below.

For *FM television* the conversion frequency (i.e. the difference between the frequency of an input signal and the output frequency of that signal) shall not deviate by more than ±5 MHz from its nominal value with the following factors taken into account:

a) temperature variations in the range –20 °C to +55 °C;

b) supply voltage variations: as stated by the manufacturer;

c) LO setting error: as stated by the manufacturer;

d) ageing.

The deviation of the conversion frequency from the nominal value due to a) and b) above together shall not exceed ±3 MHz.

For *QPSK digitally modulated signals (DVB-S)* the conversion frequency (i.e. the difference between the frequency of an input signal and the output frequency of that signal) shall not deviate by more than ±1,5 MHz from its nominal value.

For *64 QAM digitally modulated signals (DVB-C)* the conversion frequency (i.e. the difference between the frequency of an input signal and the output frequency of that signal) shall not deviate by more than ±100 kHz from its nominal value.

For *COFDM digitally modulated signals (DVB-T)* the conversion frequency (i.e. the difference between the frequency of an input signal and the output frequency of that signal) shall not deviate by more than ±30 kHz from its nominal value.

5.6 Random noise

At any system outlet, the level of the noise voltage generated in the system in any channel shall be such that the carrier to noise ratio shall be not less than the values shown in table 9. The test method for TV carrier to noise ratio is given in 4.5. For FM sound radio signals the same method can be used, but in this case, the noise bandwidth is taken to be 200 kHz.

Table 9 – Carrier to noise ratios at system outlet

Type of service	Systems	Modulation	Minimum carrier to noise ratio dB	Equivalent noise bandwidth BW MHz
Television	I B, G, D1 L D, K NTSC System M	AM-VSB	44 44 44 44 43 42	5,08 4,75 5,00 5,75 u.c. u.c.
	PAL-SECAM	FM	15	27
	NTSC	FM	14	
	DVB-S•	QPSK Code rate 2/3	11	Independent of bandwidth
	DVB-C	64QAM	31	Independent of bandwidth
	DVB-C	16QAM	u.c.	
	DVB-C	256QAM	u.c.	
	DVB-T	COFDM 8k Code rate 2/3	24	Independent of bandwidth
Radio	Mono	FM	38 (Pal-Secam countries) 41 (NTSC countries)	0,2
	Stereo	FM	48 (Pal-Secam countries) 51 (NTSC countries)	0,2

5.7 Interference to television channels

5.7.1 Single frequency interference

This subclause refers to single frequency interference which may result from intermodulation or the presence of other interfering signals (e.g. local oscillators, ingress signals).

At any system outlet the level of any unwanted signal within the system shall be such that the lowest carrier to interference ratio within a wanted television channel shall be not less than:

- 57 dB for AM signals;
- 33 dB for FM signals;
- 35 dB for DVB – 64QAM signals;
- 13 dB for DVB – QPSK signals;
- u.c. for DVB – 16QAM and 256QAM.

Where a frequency assignment, taking account of known future off-air and distributed channels, is adopted so that interference signals fall only in the less sensitive areas of the television channel spectrum, a limit lower than that given above is acceptable (see curves given in figures 12, 13, 15, 16). The test methods are given in 4.4.1.

Single freguency interference NTSC digital subcarrier:

- not lower than 31 dB.

NOTE Special precautions may be needed when the dual sound channel is carried in a lower adjacent channel if interference between the additional subcarrier and the lower vestigial sideband of the adjacent channel is to be avoided.

5.7.2 Single channel intermodulation interference

In this special case of single frequency interference, the ratio of the reference level relative to the interference signal shall be not less than 54 dB.

NOTE This subclause does not apply to television channels carrying DVB signals.

5.7.3 Multiple frequency intermodulation interference

At any system outlet, the level of the multiple frequency intermodulation interference, in any wanted television channel, shall be such that the carrier to interference ratio shall be not less than:

- 57 dB for each cluster of composite beats in negative modulation;
- 52 dB for each cluster of composite beats in positive modulation;
- 52 dB for negative modulation and 47 dB for positive modulation for the summed clusters, calculated according to the method of measurement given in 4.4.2;
- 37 dB for the sum of all clusters falling within a DVB – 64QAM channel;
- 13 dB for DVB – QPSK;
- u.c. for FM television.

NOTE 1 When coherent carriers are used lower limits are acceptable.

NOTE 2 Because intermodulation products between multiple, closely spaced, digital TV channels are similar to random noise, this intermodulation shall be taken into account in the carrier to noise measurements.

5.7.4 Crossmodulation

The wanted signal to intermodulation ratio at any system outlet shall be not less than $46 + 10\ \lg(N\text{-}1)$, where N is the total number of television channels for which the system is designed.

5.8 Video baseband requirements

5.8.1 Differential gain and phase in any television channel

The differential gain and phase in any television channel shall not exceed the figures given in table 10.

Table 10 – Differential gain and phase in television channels

Systems	Maximum peak-to-peak differential gain %	Maximum peak-to-peak differential phase
PAL	10	12
SECAM	40	32
NTSC	10	5
NOTE This clause does not apply to channels carrying DVB signals.		

5.8.2 Echoes

The echo rating in any television channel, at any system outlet, when measured by the method defined in 4.6 shall not exceed 7 %.

5.8.3 Amplitude and phase response for PALplus signals

Under consideration.

NOTE The recommended test method is to use a sin x/x ITS signal.

5.9 Hum modulation of carriers in television channels

At any system outlet the unwanted modulation of any vision carrier at the frequency of the supply mains and harmonics thereof shall be such that the reference modulation to hum modulation ratio is not less than 46 dB.

The unwanted modulation of any AM sound carrier shall be such that this ratio is not less than 60 dB.

For system M, the vision carrier ratio of reference modulation to hum modulation shall not be less than 35 dB.

The hum modulation of NTSC digital subcarrier shall be not less than 50 dB.

The test method for both cases is given in 4.4.4.

Hum modulation requirements for FM television and DVB are under consideration.

5.10 Requirements for data signal transmission

5.10.1 Data signals carried in the structure of a television signal

Under consideration.

5.10.1.1 Data signals carried in the vertical interval of a television signal

Under consideration.

5.10.1.1.1 Data echo rating

E_d < 10 %.

5.10.1.1.2 Data delay inequality

The data delay inequality in any television channel shall not exceed 50 ns.

5.10.1.2 Data signals using the whole television field

Under consideration.

5.10.1.2.1 Data echo rating

E_d < 10%

5.10.1.2.2 Data delay inequality

The data delay inequality in any television channel shall not exceed 50 ns.

5.10.1.3 Data signals on the audio or additional carriers within a television signal

Under consideration.

5.10.1.4 Data signals using other parts of the television signal

Under consideration.

5.10.2 Data signals other than those carried within the structure of a television signal

Under consideration.

5.11 Digitally modulated signals – Additional performance requirements

5.11.1 DVB (PSK, QAM, OFDM) performance

5.11.1.1 BER

For a service quasi-free of interruption the bit error rate (BER) for any DVB signal shall be lower than 10^{-4}, before Reed-Solomon error correction.

5.11.1.2 Noise argin

For any DVB signal received by satellite, the noise margin shall be higher than 4 dB.

5.11.1.3 MER

For any DVB signal the modulation error ratio (MER) shall be not lower than the value given in table 11.

Table 11 – Modulation error ratio (MER) of a DVB signal

Signal modulation	MER dB
QPSK	15
64 QAM	30
COFDM	30

5.11.1.4 Phase jitter

For any DVB signal the phase jitter shall be lower than the value given in table 12.

Table 12 – Phase jitter of a DVB signal

Signal modulation	Phase jitter (degrees)
QPSK	±15
64 QAM	±5
COFDM	±5

5.11.1.5 Phase noise of a RF carrier

For any RF carrier of a digitally modulated signal (PSK or QAM) the phase noise shall be lower than the value given in table 13 at the frequency distance f_m from the carrier.

Table 13 – Phase noise of a DVB signal (PSK and QAM)

Signal modulation	Phase noise dB(Hz^{-1})	Frequency distance f_m
QPSK	u.c.	10 kHz
64QAM	–50	100 Hz – 10 kHz
	–70	100 kHz

For a digitally modulated signal in the OFDM format the phase noise can cause common phase error (CPE) which affects all the carriers simultaneously and inter-carrier interference (ICI).

For any RF carrier of a DVB signal modulated in the OFDM format, measured with the method of measurement given in clause 4.10.10, the value of CPE and that of ICI shall be lower than the values L_a, L_b, L_c given in table 14 at the frequency distances f_a, f_b, f_c from the carrier.

Table 14 – Phase noise of a DVB signal (OFDM)

Signal modulation	Frequency distance	CPE dB			ICI dB		
		L_a	L_b	L_c	L_a	L_b	L_c
COFDM		u.c.	u.c.	u.c.	u.c.	u.c.	u.c.
2 k system	f_a , f_b , f_c	10 kHz	50 kHz	500 kHz	4,5 kHz	8,9 kHz	13,4 kHz
COFDM		u.c.	u.c.	u.c.	u.c.	u.c.	u.c.
8 k system	f_a , f_b , f_c	·2 kHz	10 kHz	100 kHz	1,1 kHz	2,2 kHz	3,4 kHz

5.11.2 NICAM performance

The performance for NICAM systems is determined largely by the headend equipment and the limits given in IEC 60728-5 apply.

5.11.3 DAB/DSR performance

Under consideration.

5.12 FM sound radio – Additional performance requirements

5.12.1 Amplitude response within a FM channel

The amplitude response as a function of frequency for the entire system shall be such that the maximum amplitude variation over any FM channel (bandwidth appropriate for the transmission system in use) is not more than 3 dB with the slope not exceeding 0,3 dB per 10 kHz within 75 kHz of the carrier.

5.12.2 Phase response within a FM channel

Under consideration.

5.12.3 Interference within a FM channel

Under consideration.

5.12.4 AM hum modulation on FM sound carriers

Hum modulation sidebands shall be at least 46 dB below the carrier level.

5.12.5 Echoes within an FM channel

Under consideration.

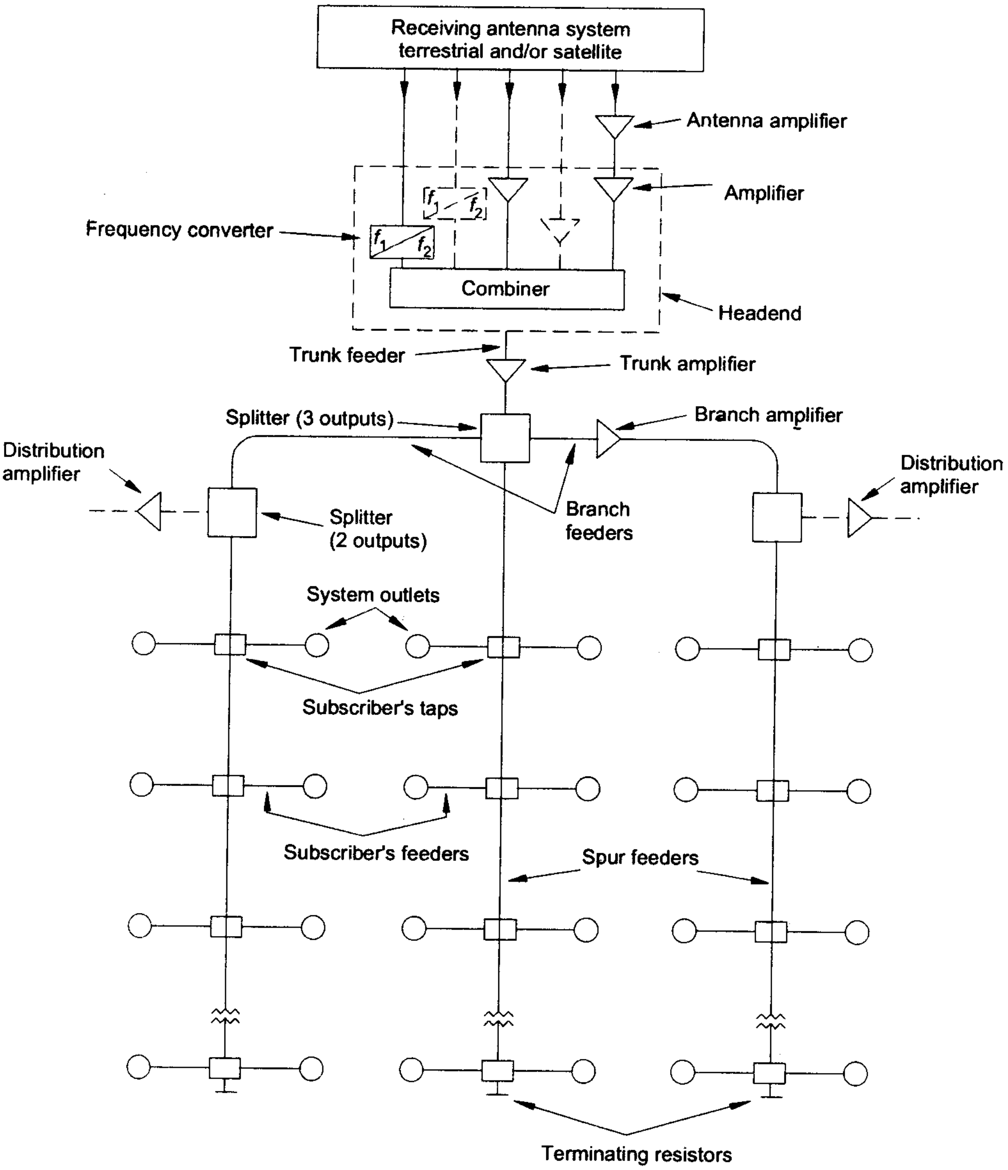


Figure 1 – Example of a master antenna television system for terrestrial (MATV) and/or satellite (SMATV) reception

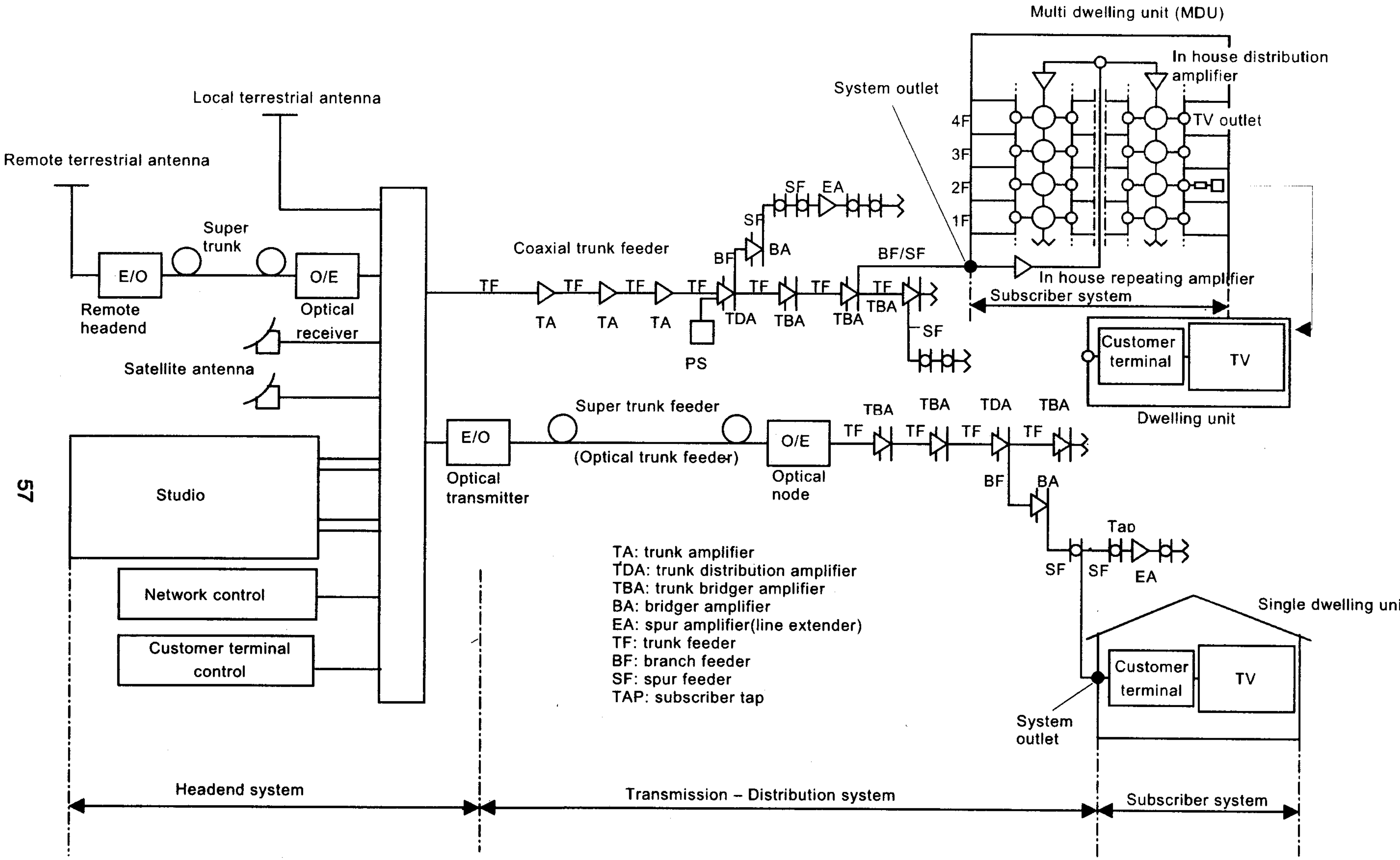


Figure 2 – Example of a cabled distribution system for television and sound signals

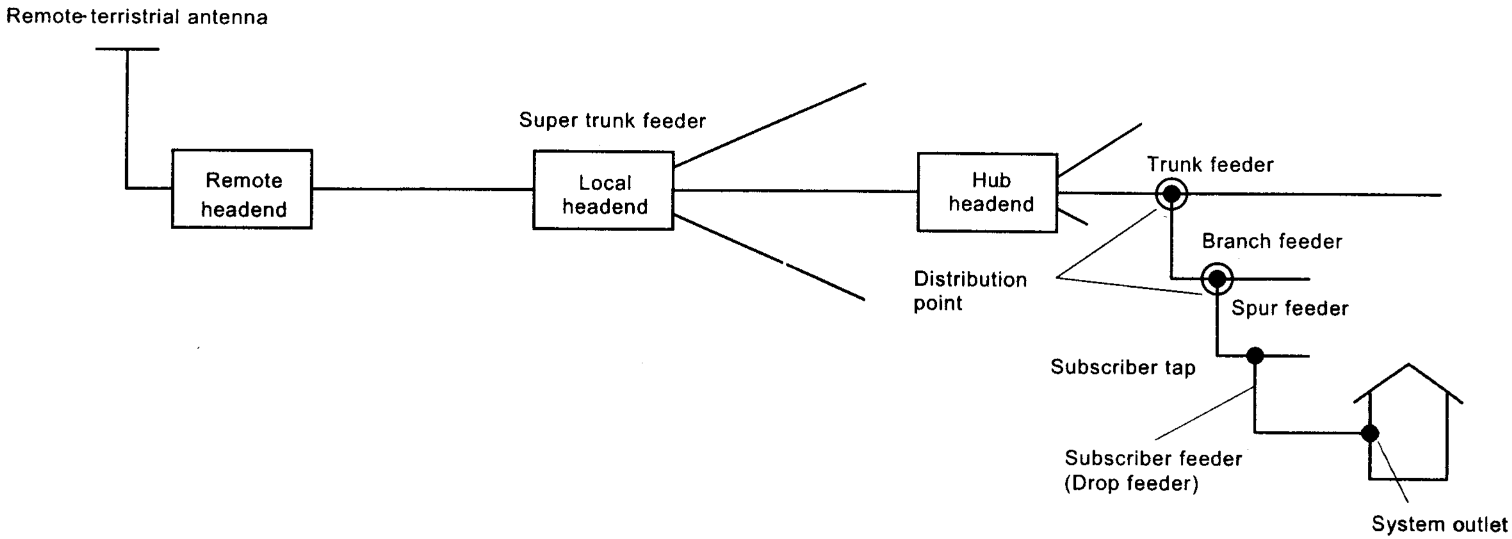


Figure 3 – System model of a cabled distribution system for television and sound signals

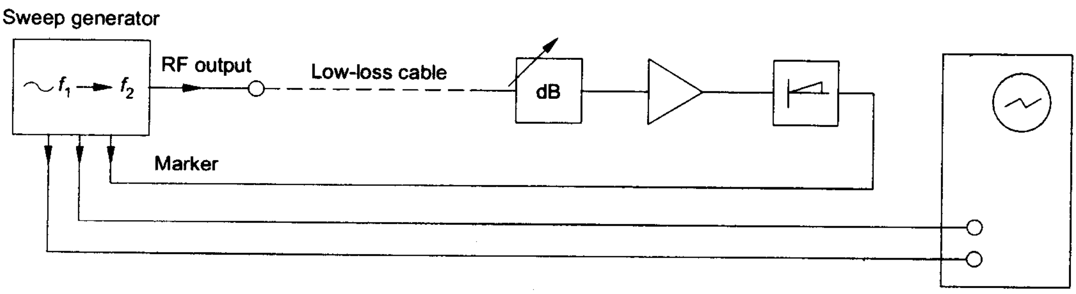


Figure 4a

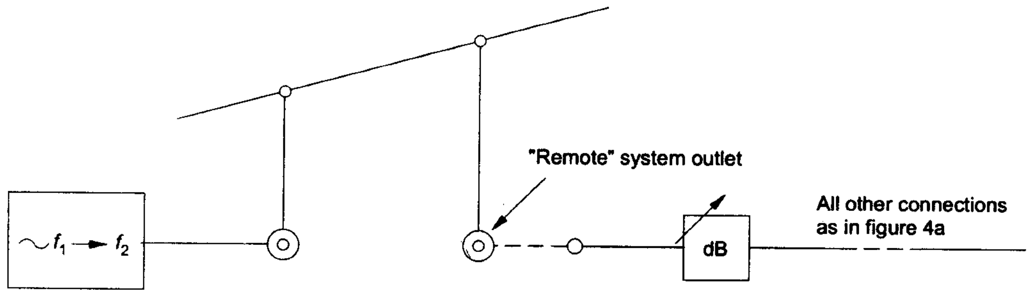


Figure 4b

Figure 4 – Arrangement of test equipment for measurement of mutual isolation between system outlets

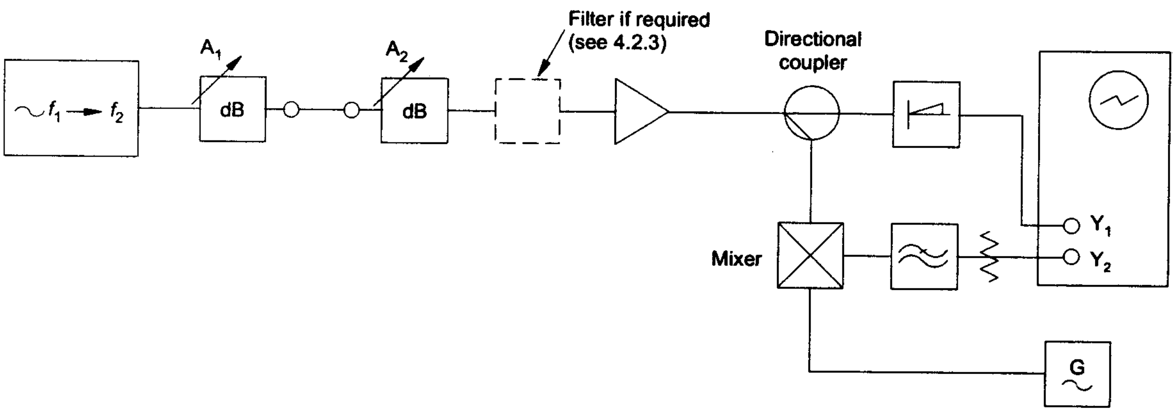


Figure 5a

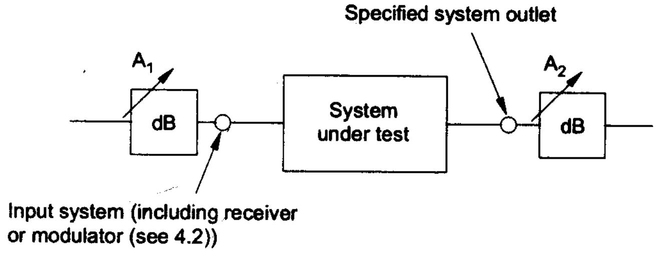


Figure 5b (otherwise as figure 5a)

Figure 5 – Arrangement of test equipment for measurement of frequency response within a channel

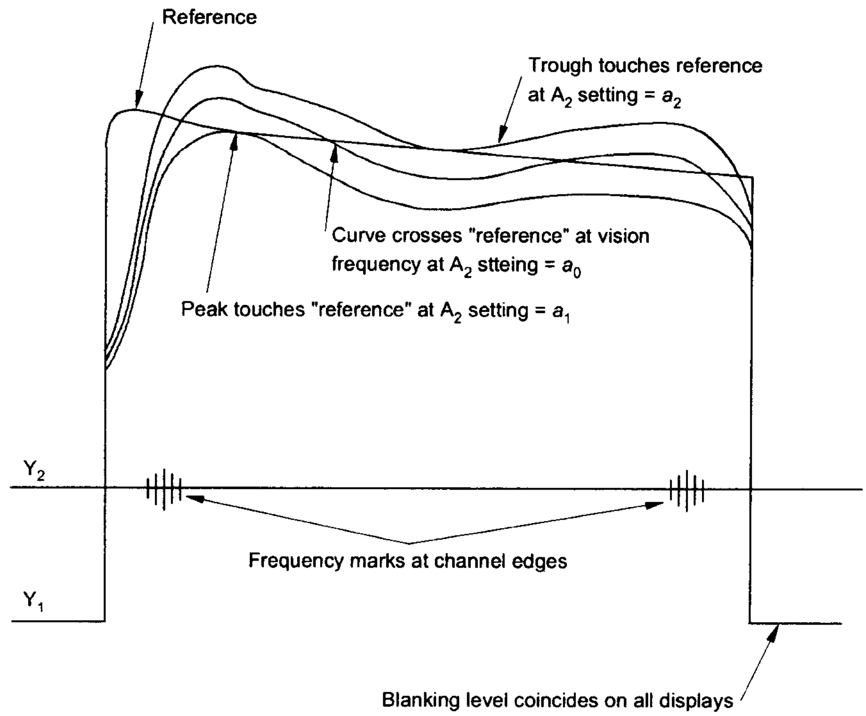


Figure 6 – Interpretation of displays for measurement of frequency response within a channel

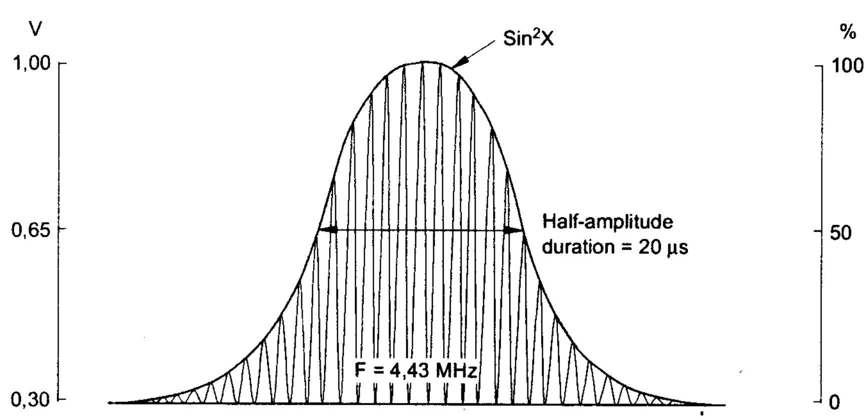
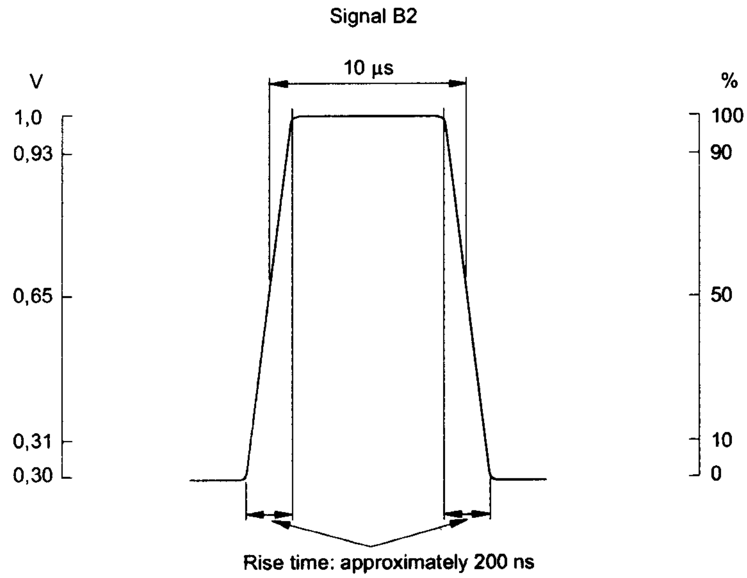


Figure 7 – Test signal (signal F for 625 line systems) employed for chrominance/luminance gain and delay inequality



NOTE In France, the nominal rise time B2 is approximately 110 ns.

Figure 8 – Test signal (signal B2 for 625 line systems) employed for chrominance/luminance gain and delay inequality

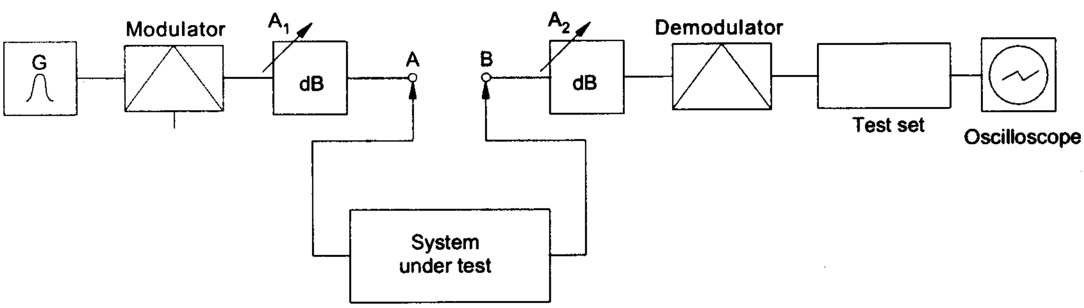


Figure 9 – Arrangement of test equipment for measurement of chrominance/luminance gain and delay inequality

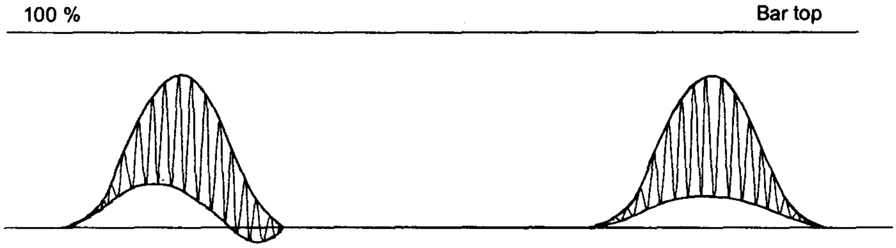


Figure 10a – Before nulling delay **Figure 10b – After nulling delay**

Figure 10 – Displayed pulses: chrominance low and lagging

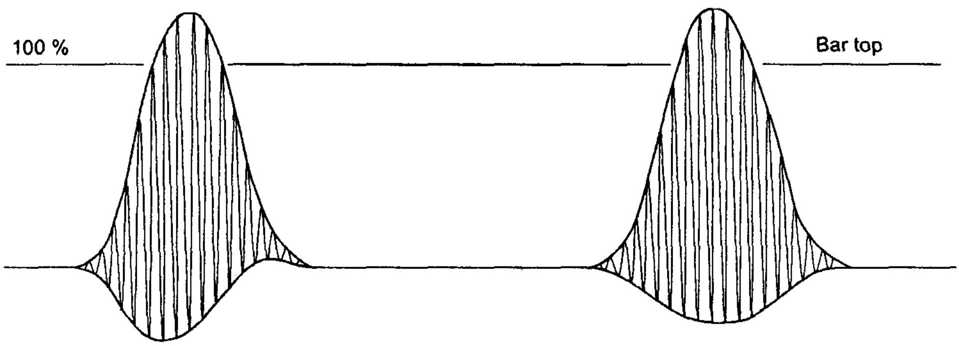


Figure 11a – Before nulling delay **Figure 11b – After nulling delay**

Figure 11 – Displayed pulses: chrominance high and leading

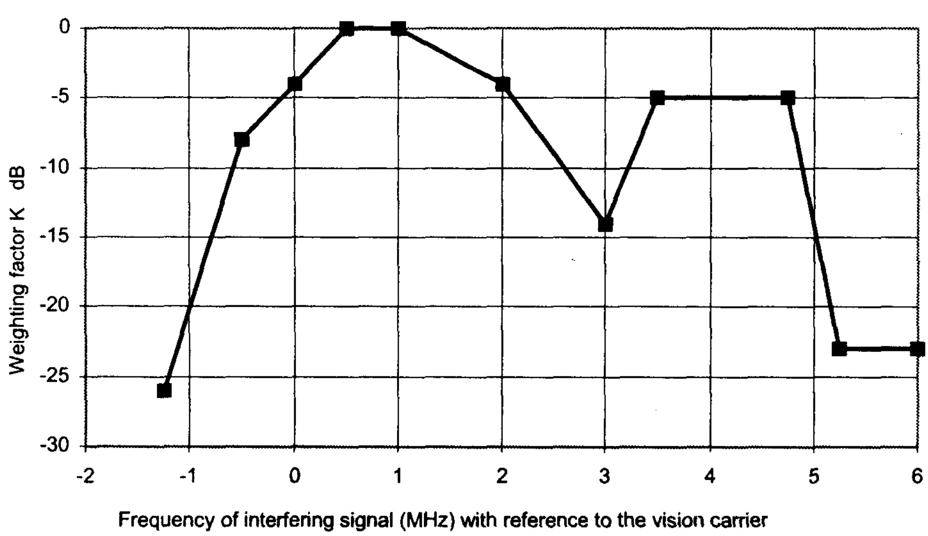


Figure 12 – Weighting curve for 625 lines system B, G and D1 (PAL); CW interference with no special (frequency offset) control

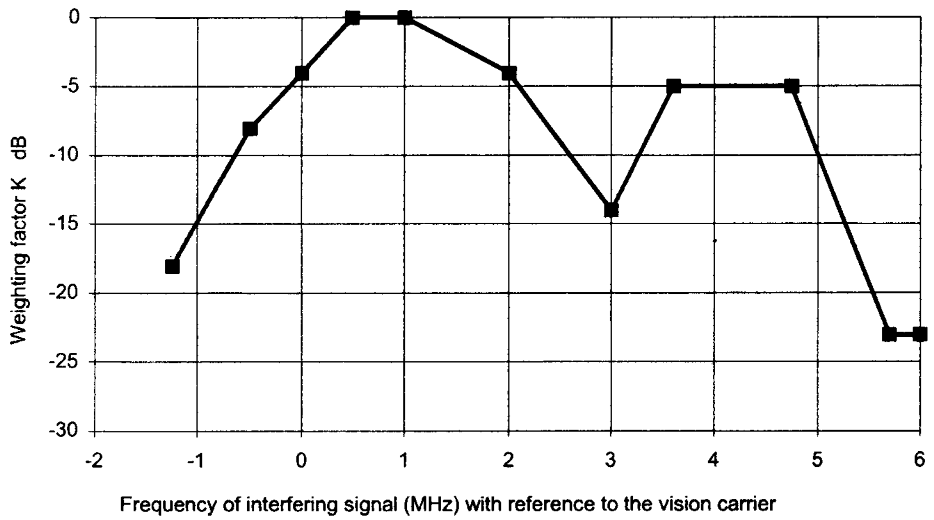


Figure 13 – Weighting curve for 625 lines system I (PAL); CW interference with no special (frequency offset) control

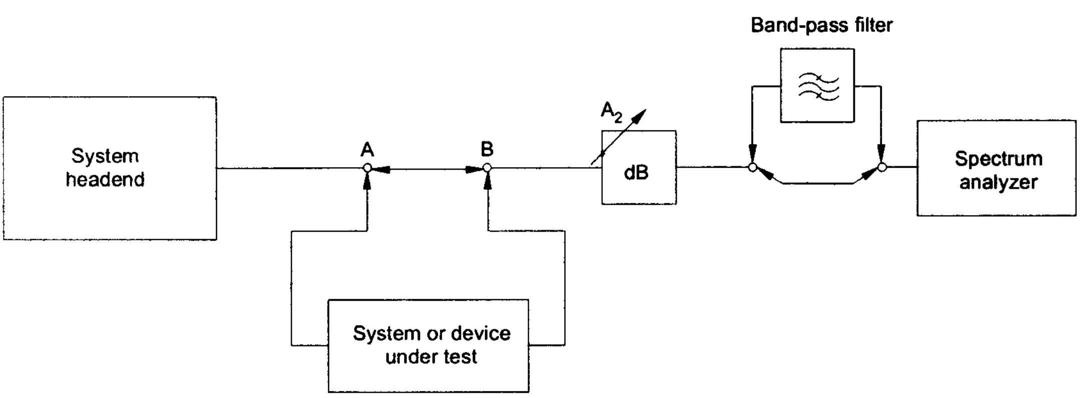


Figure 14 – Connection of test equipment for the measurement of non-linear distortion by composite beat

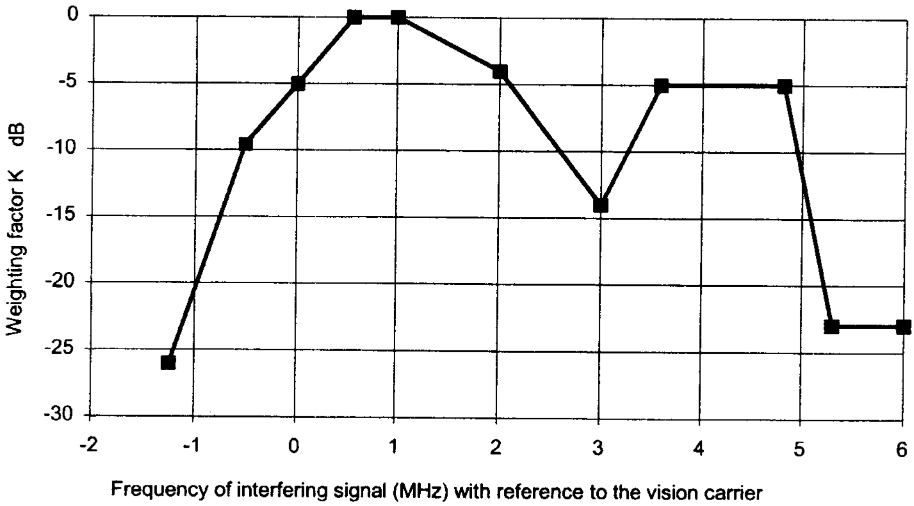


Figure 15: Weighting curve for 625 lines systems D and K (PAL); CW interference with no special (frequency offset) control

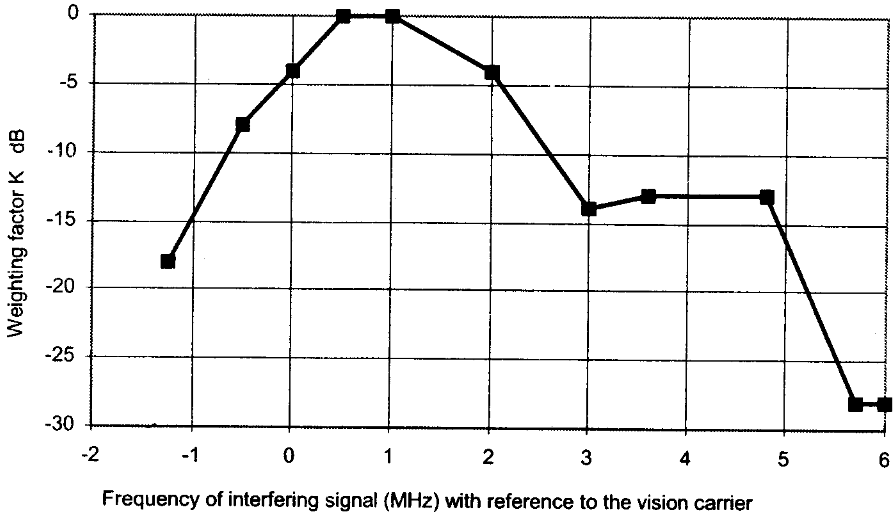


Figure 16 – Weighting curve for 625 lines system L (SECAM); CW interference with no special (frequency offset) control

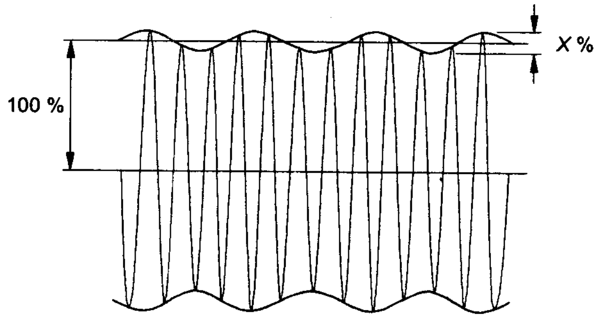


Figure 17 – Hum modulation envelope
(x = percentage peak-to-peak hum modulation)

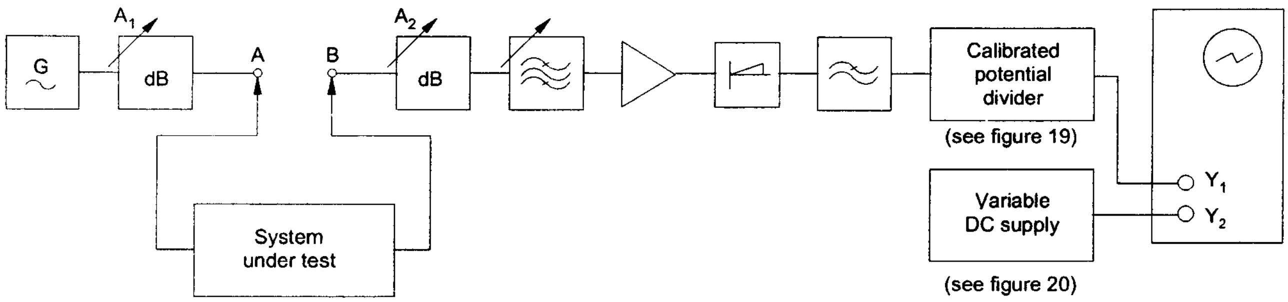
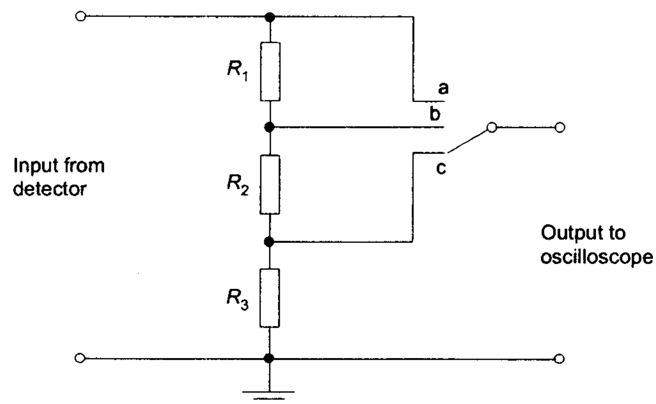
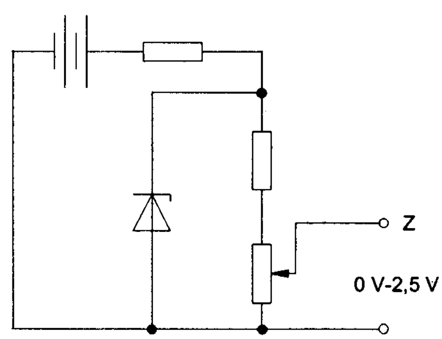


Figure 18 – Connection of equipment for measurement of hum modulation (DC method)



NOTE These values take account of the input impedance of a typical oscilloscope (1 MΩ).

Figure 19 – Calibrated potential divider

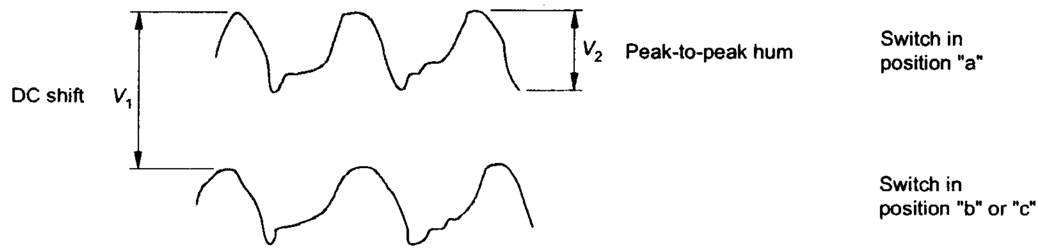


NOTE 1 Arrange polarity to suit detector and oscilloscope in use.

NOTE 2 Values chosen to suit the voltage of the battery and the Zener diode employed.

NOTE 3 Multi-turn potentiometer preferred for precise setting.

Figure 20 – Stable variable DC source



Percentage peak-to-peak hum = $V_2 / V_1 \times 0{,}07$ % for position "b" or

$V_2 / V_1 \times 0{,}3$ % for position "c"

Figure 21 – Oscilloscope display

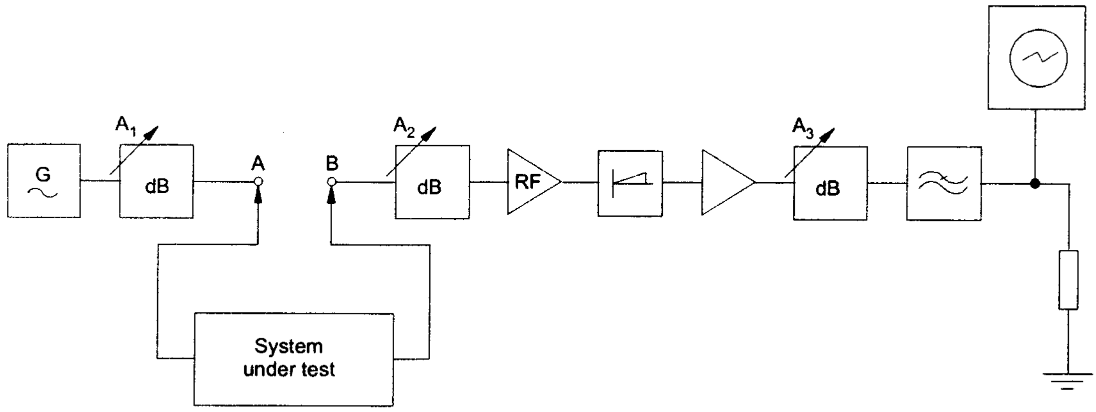
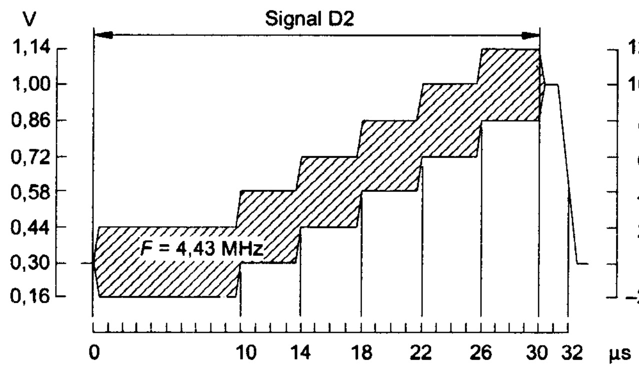
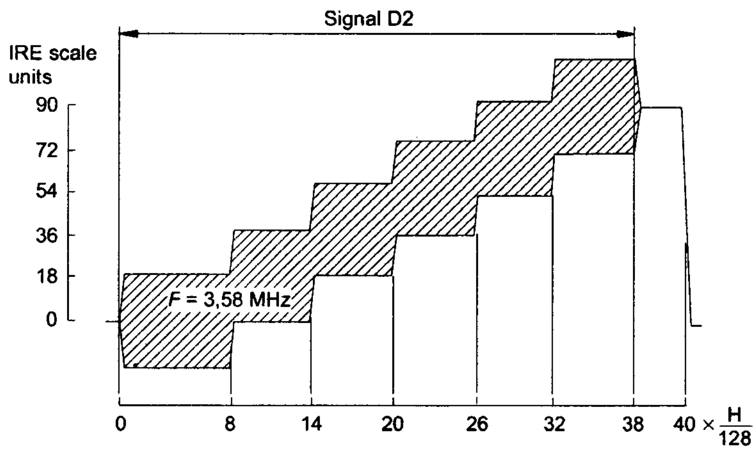


Figure 22 – Connection of equipment for hum modulation measurement (AC method)



NOTE In full field-test signals, each tread of the staircase may have a duration of 8,66 µs.

Figure 23a – Signal D2 for 625-line system



NOTE 1 Scale refers to tread levels.

NOTE 2 Sub-carrier amplitude is ±20 IRE units.

Figure 23b – Signal D2 for 525-line system

Figure 23 – Signal D2

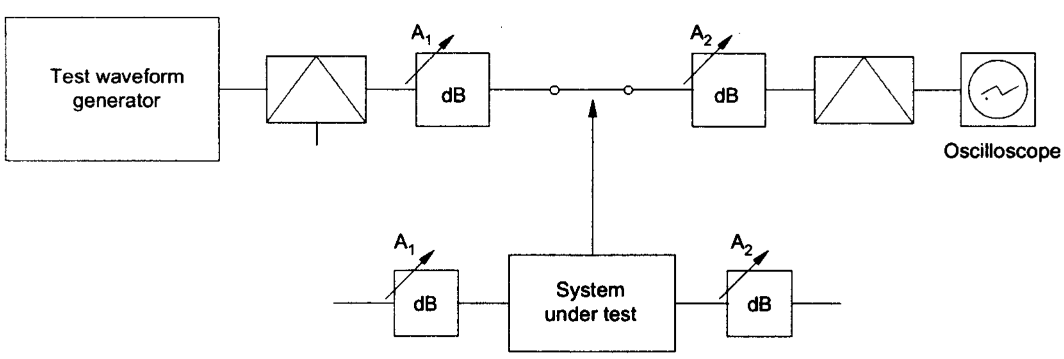


Figure 24 – Arrangement of test equipment for measurement of echo rating

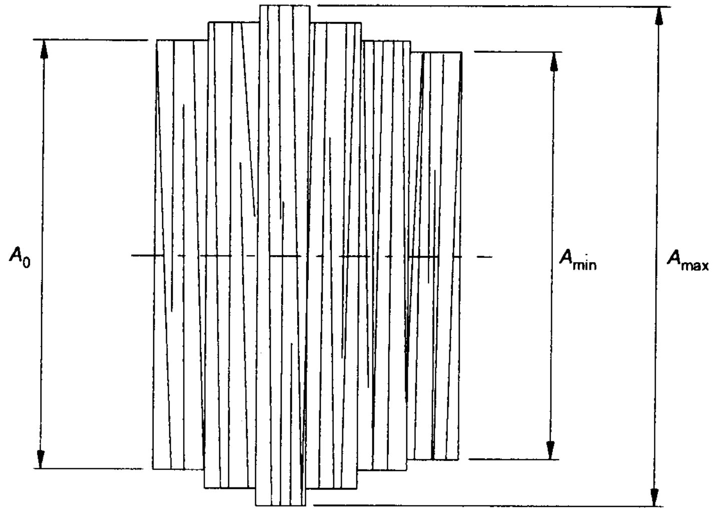


Figure 25 – Example of the modified staircase waveform

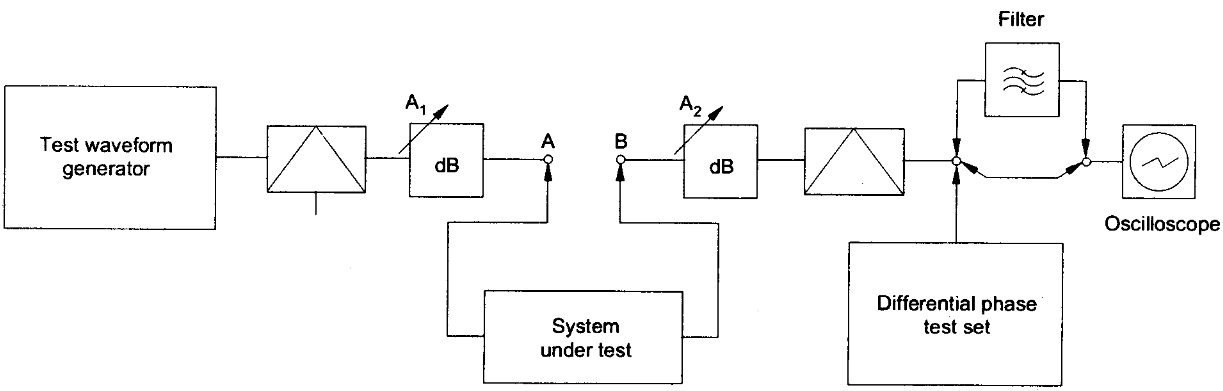
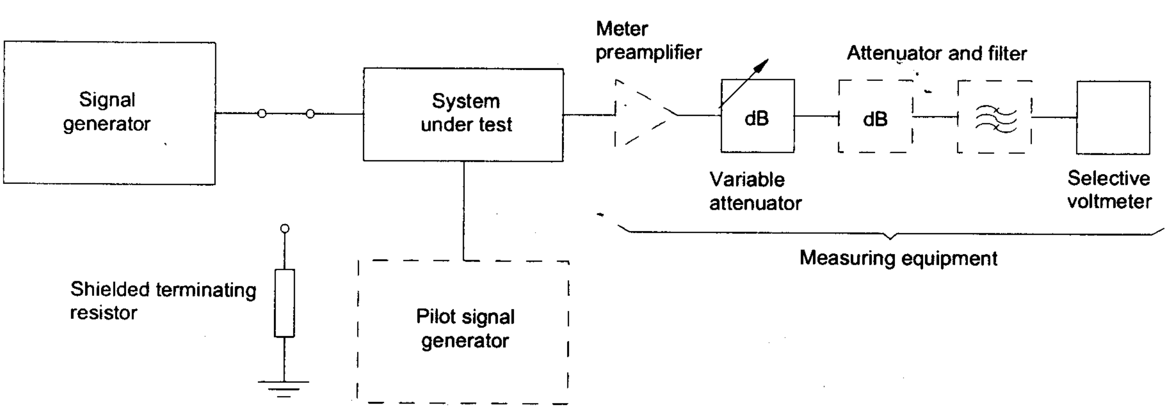
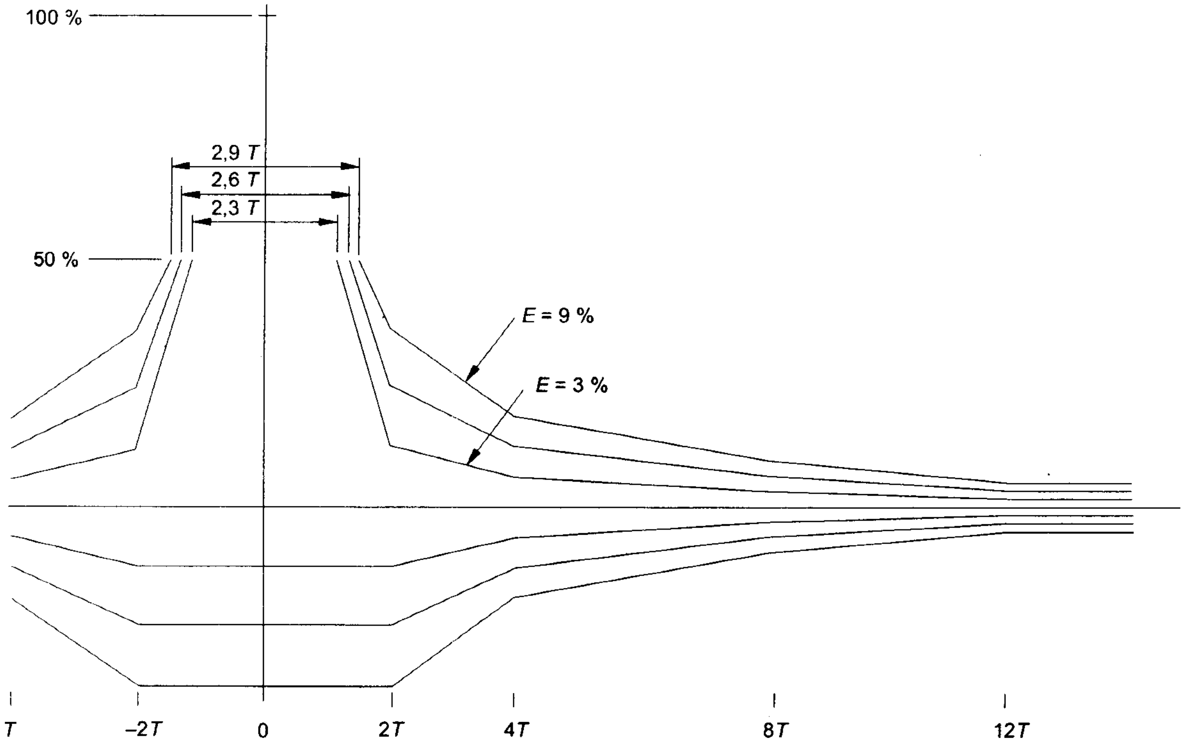


Figure 26 – Arrangement of test equipment for measurement of differential gain and phase



NOTE Dotted lines signify additional items which may be required.

Figure 27 – Arrangement of test equipment for carrier to noise ratio measurement



±T	Maximum amplitude for a given E rating (%)		
	3	6	9
0	+100, −12	+100, −24	+100, −36
2	±12	±24	±36
4	±6	±12	±18
8	±3	±6	±9
12	±1,5	±3	±4,5

Figure 28 – Echo rating graticule

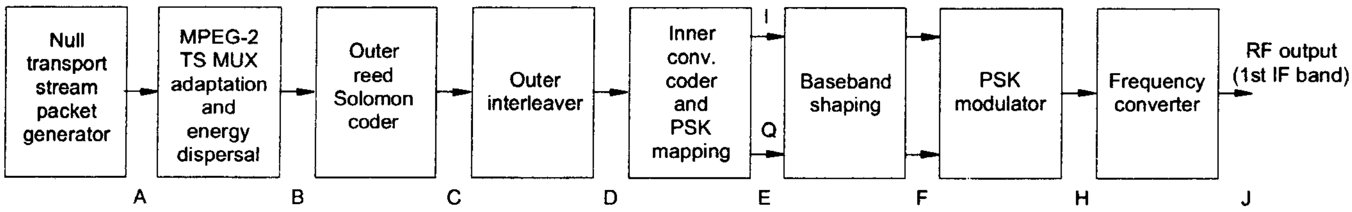


Figure 29a

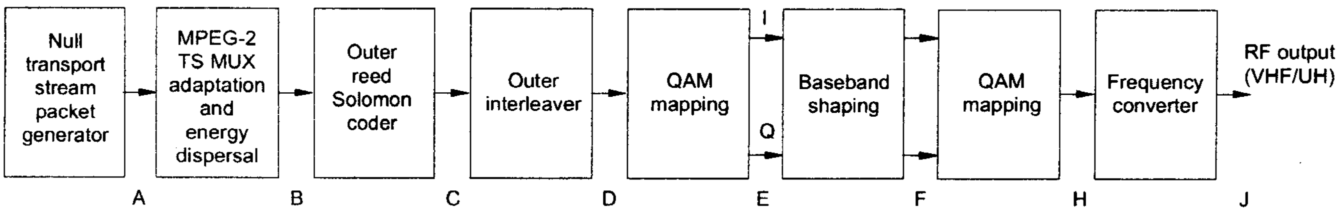


Figure 29b

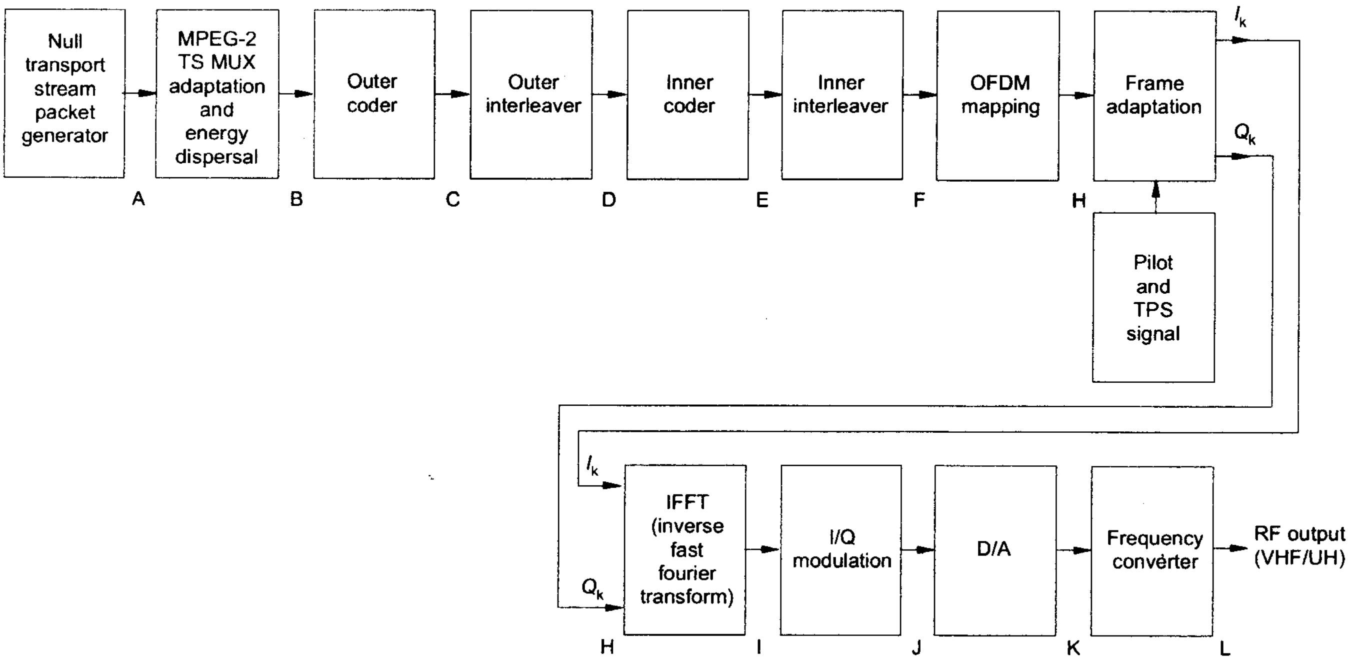


Figure 29c

NOTE The *null transport stream packet* generator can be replaced by a PRBS (pseudo random bit sequence) generator.

Figure 29 – I/Q signal source and RF modulator:
a) PSK modulation (QPSK, BPSK or TC8PSK)
b) QAM modulation
c) OFDM modulation

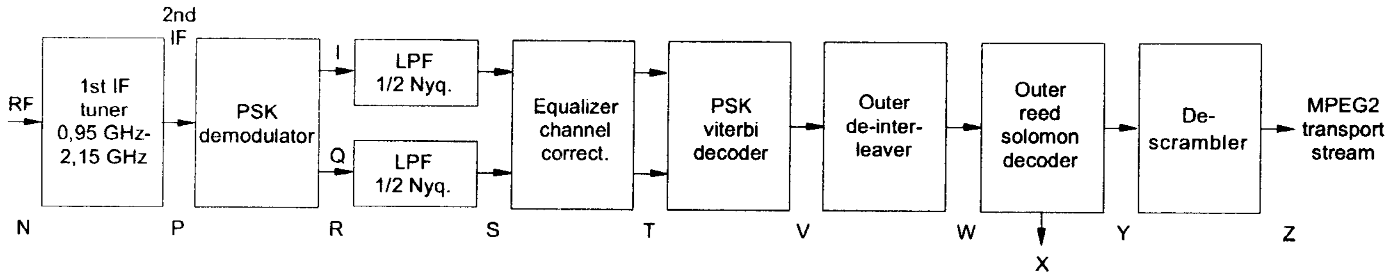


Figure 30a

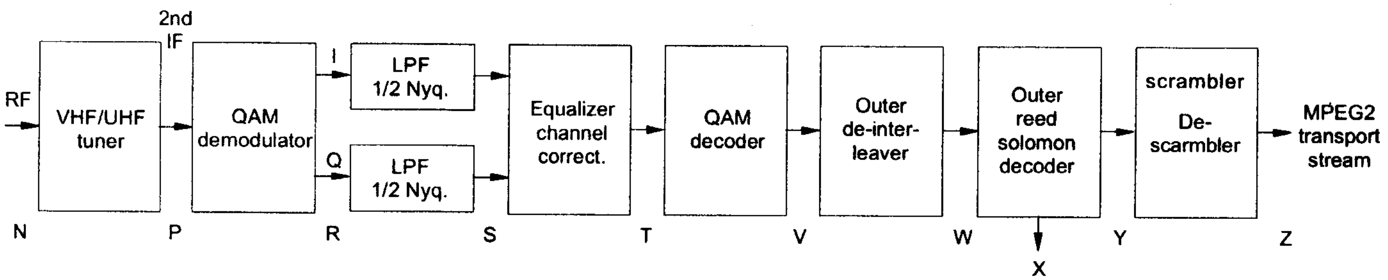


Figure 30b

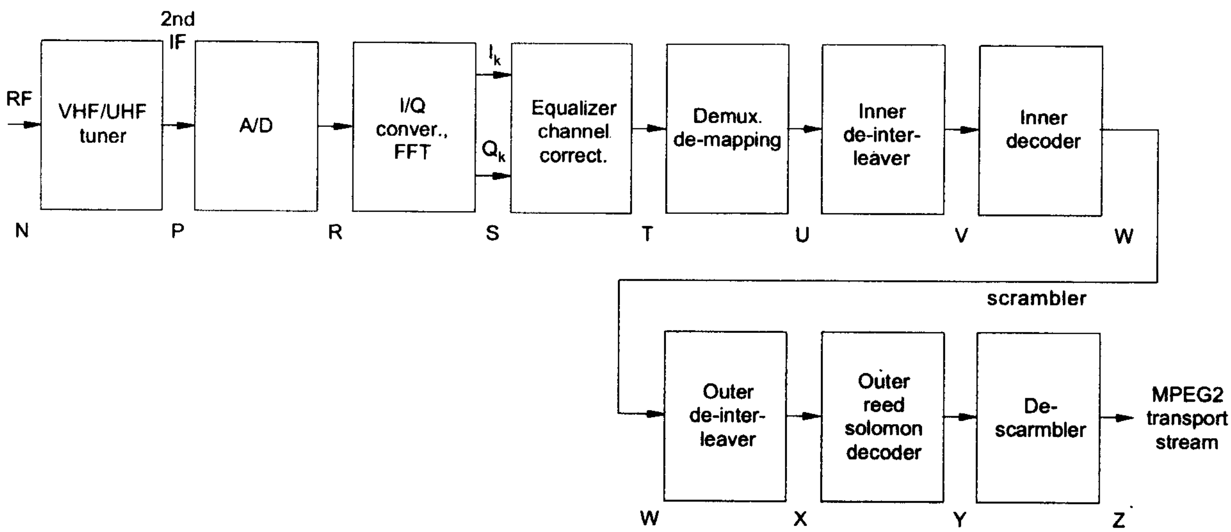


Figure 30c

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

1st I.F. :	0,95 GHz to 2,15 GHz
VHF/UHF:	40 MHz to 862 MHz (Europe)
	90 MHz to 770 MHz (Japan)

Figure 30 – Reference receiver:
a) PSK demodulation (QPSK, BPSK or TC8PSK)
b) QAM demodulation
c) OFDM demodulation

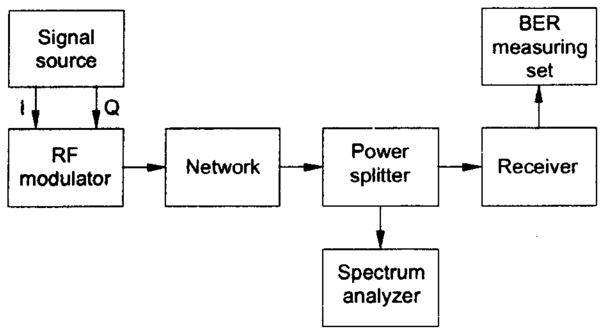


Figure 31 – Test set-up for BER measurement

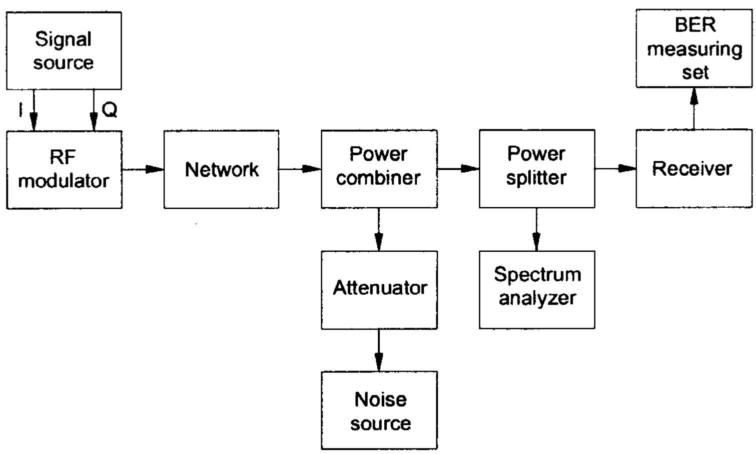
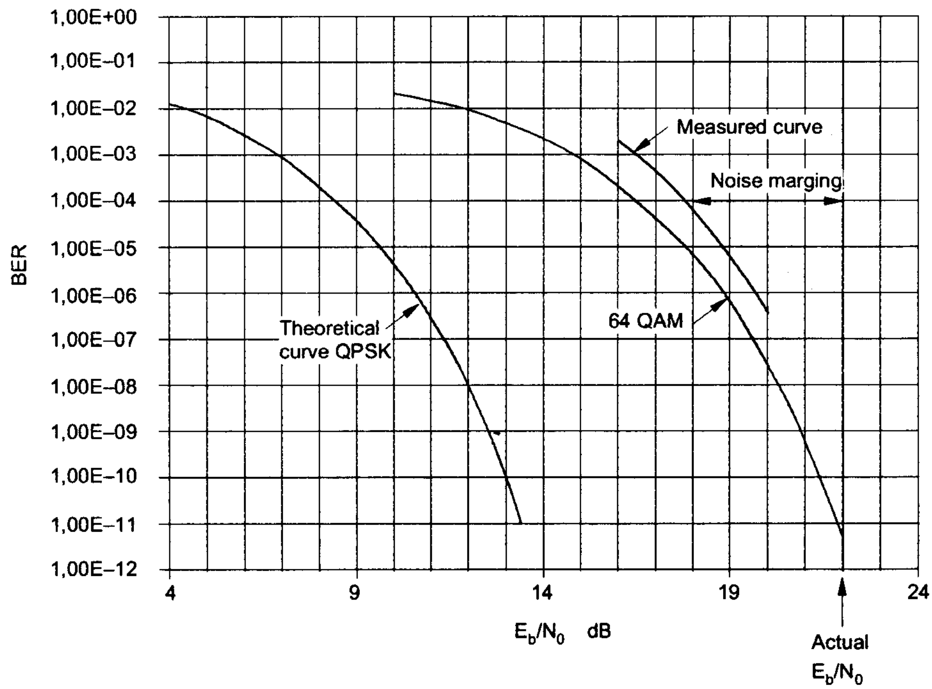


Figure 32 – Test set-up for BER measurement versus E_b/N_o and noise margin measurement



NOTE The theoretical curves are for QPSK and 64 QAM modulation format.

Figure 33 – Example of BER measurement versus E_b/N_o

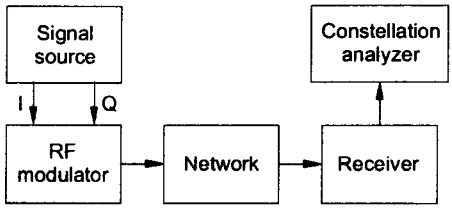


Figure 34 – Test set-up for modulation error ratio (MER) measurement and phase jitter measurement

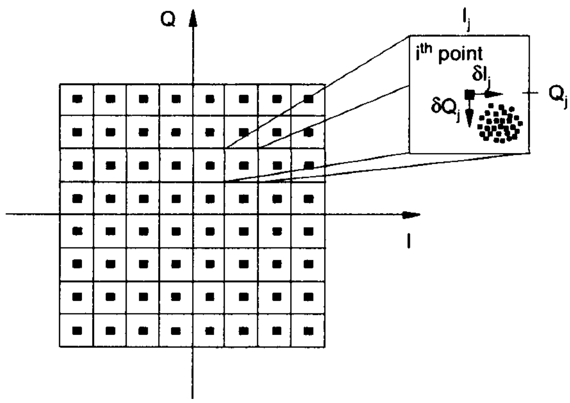


Figure 35 – Example of constellation diagram for a 64 QAM modulation format where the i^{th} point has been enlarged to show the co-ordinates of the symbol error vector

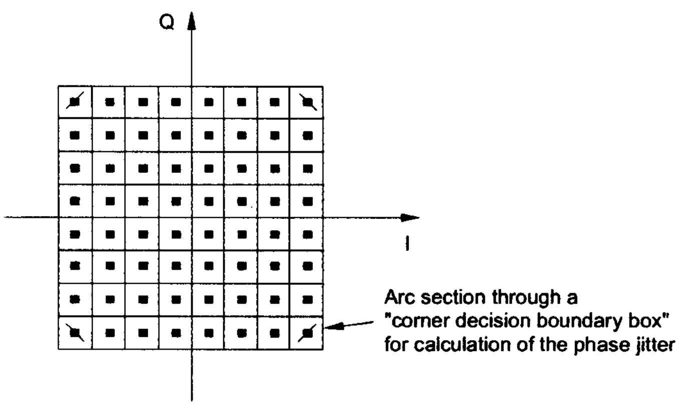


Figure 36 – Example of constellation diagram for a 64 QAM modulation format where are shown the "corner decision boundary boxes" for the phase jitter measurement

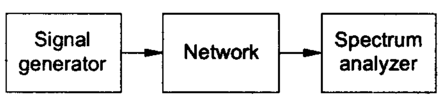


Figure 37 – Test set-up for phase noise measurement

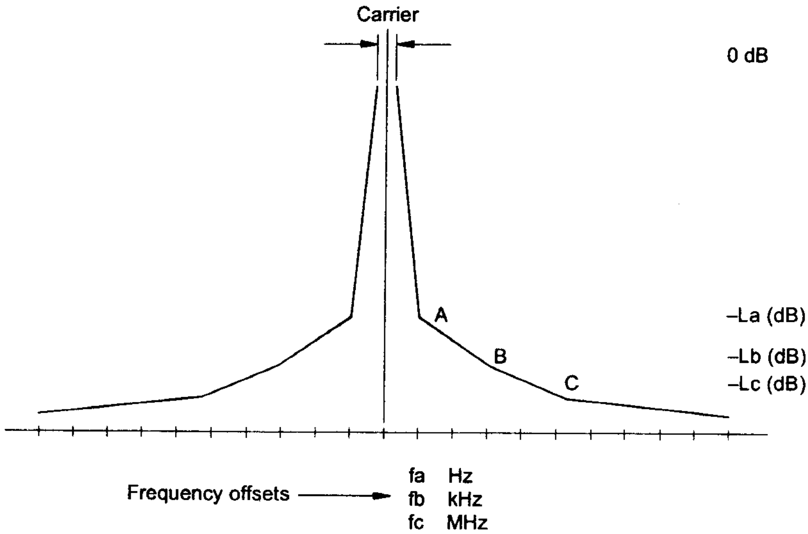


Figure 38 – Example of mask for CPE measurements (points A, B and C to be defined)

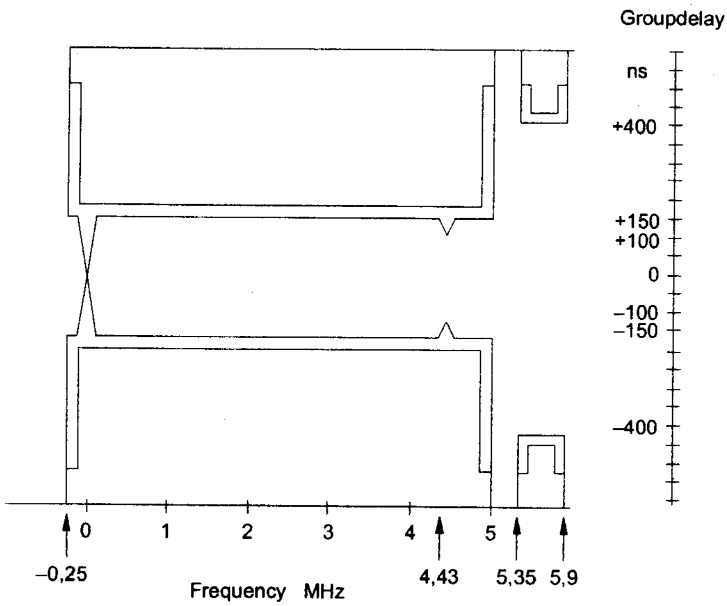


Figure 39 – Mask group delay characteristic for PAL signals with FM-FM sound *(Netherlands)*

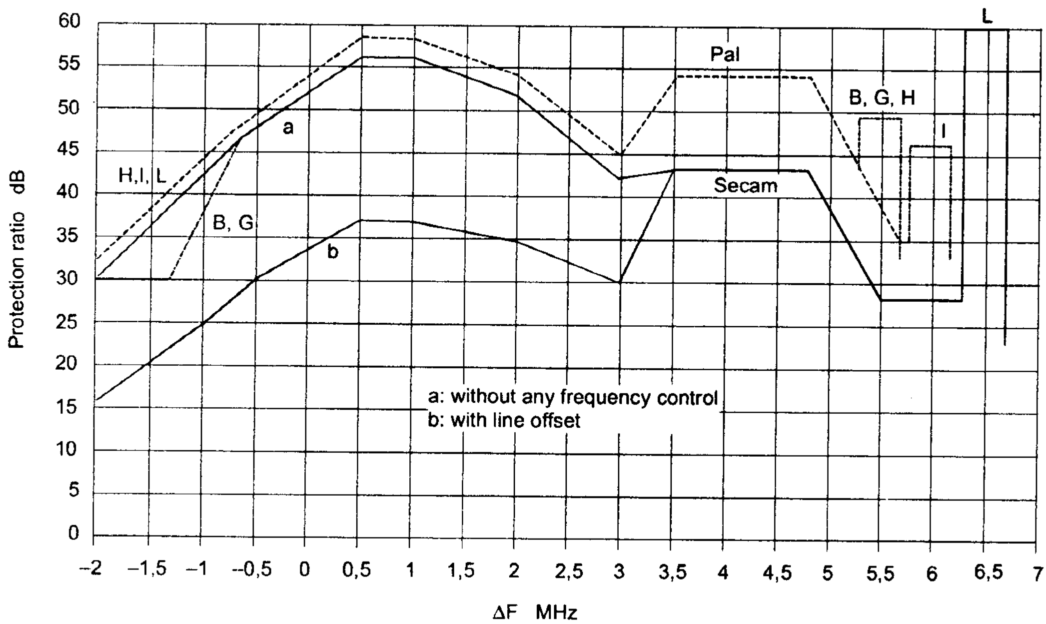


Figure 40 – Templates for the B, G, H, I, L standards RF protection ratio *(France)*

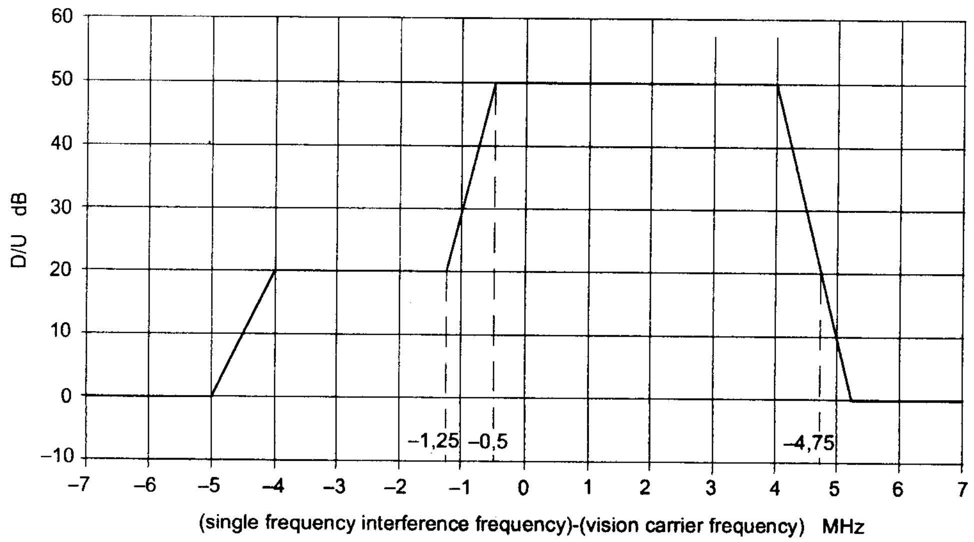


Figure 41 – Single frequency interference (VSB-AM NTSC) *(Japan)*

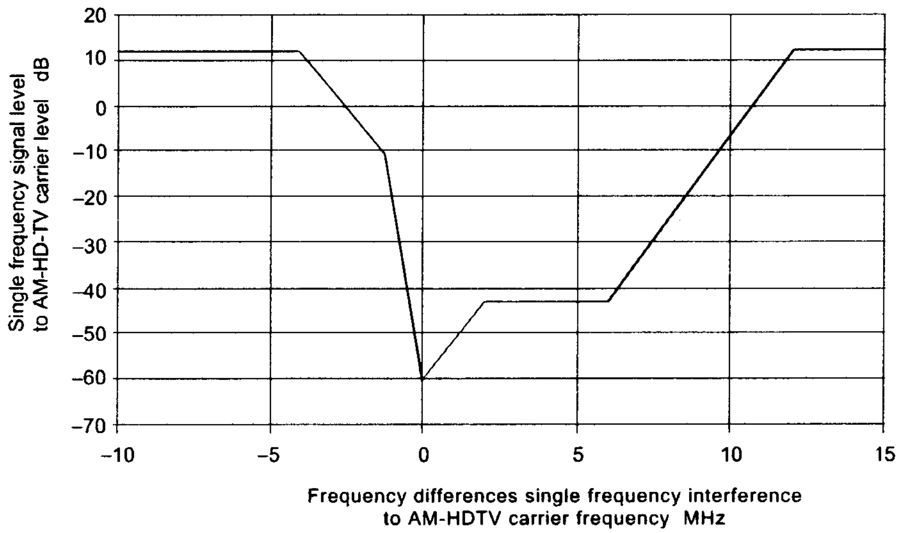


Figure 42 – Single frequency interference (VSB-AM HDTV) *(Japan)*

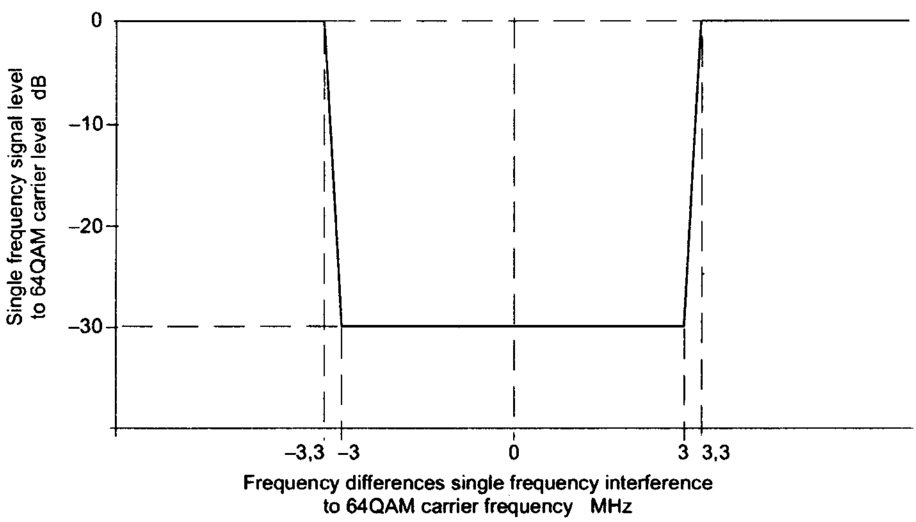


Figure 43 – Single frequency interference (64QAM digital) *(Japan)*

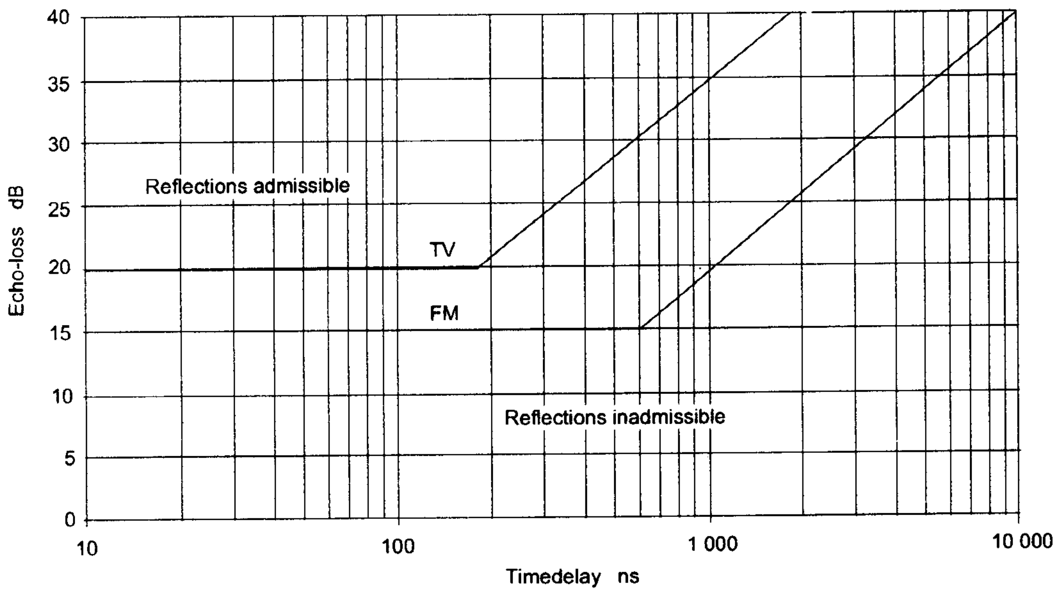


Figure 44 – Requirement for echo loss in relation to the time delay of the reflected signal *(Netherlands)*

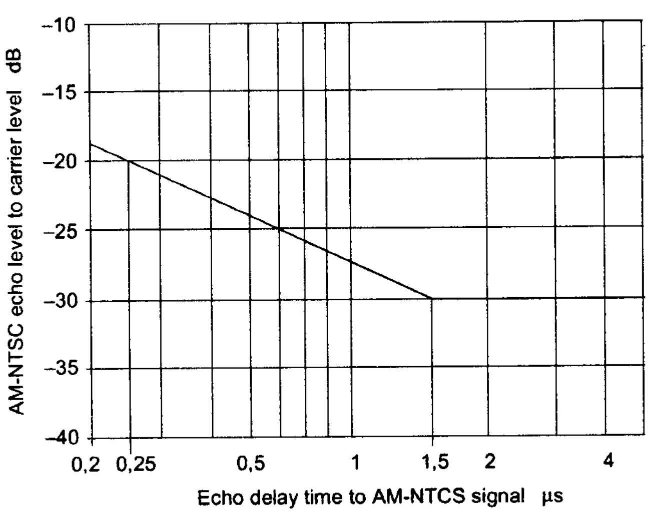


Figure 45 – Echoes (VSB-AM NTSC) *(Japan)*

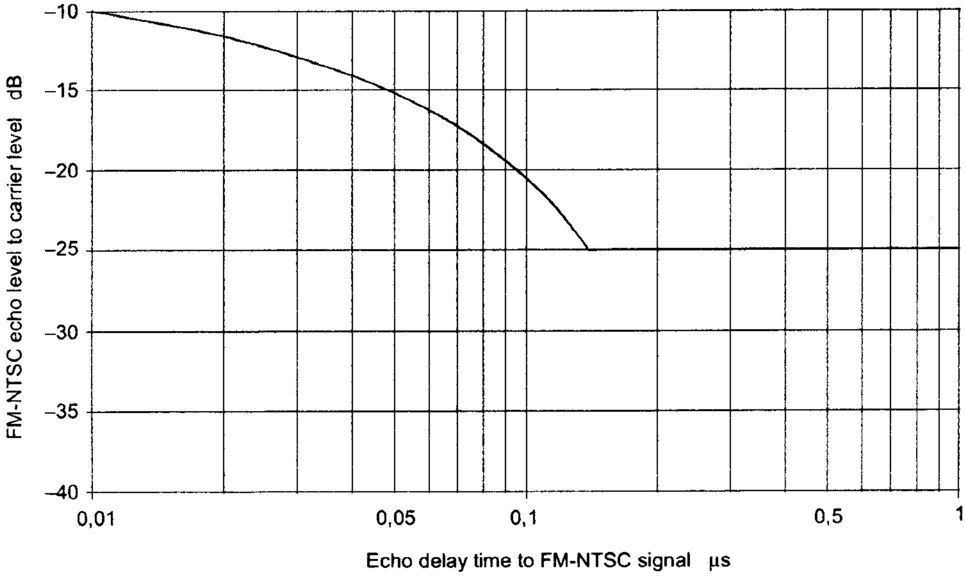


Figure 46 – Echoes (FM NTSC) *(Japan)*

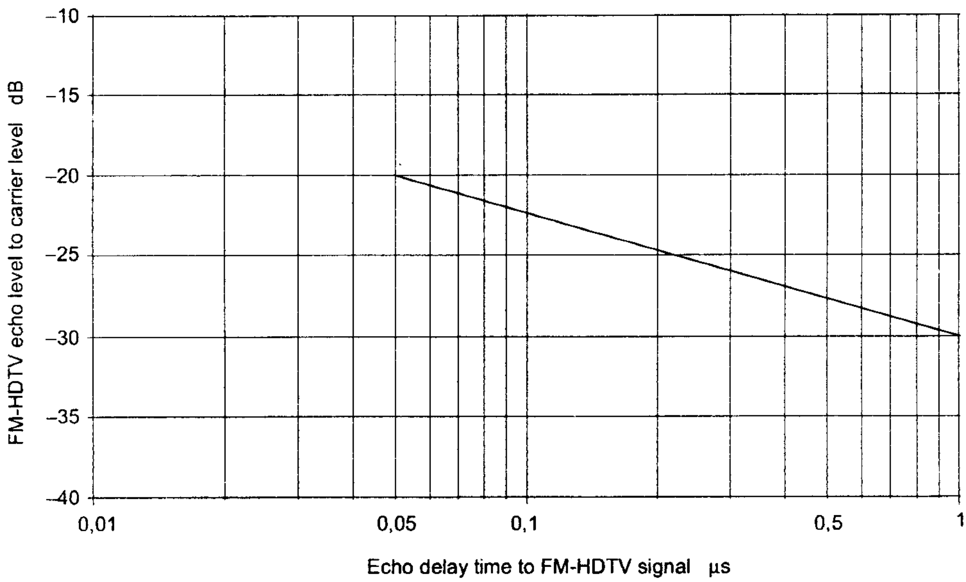


Figure 47 – Echoes (FM HDTV) *(Japan)*

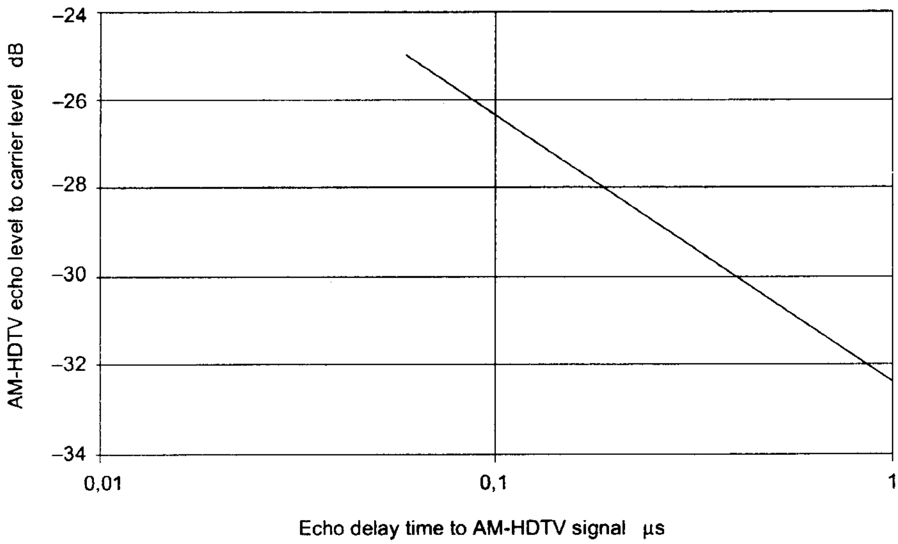


Figure 48 – Echoes (VSB-AM HDTV) *(Japan)*

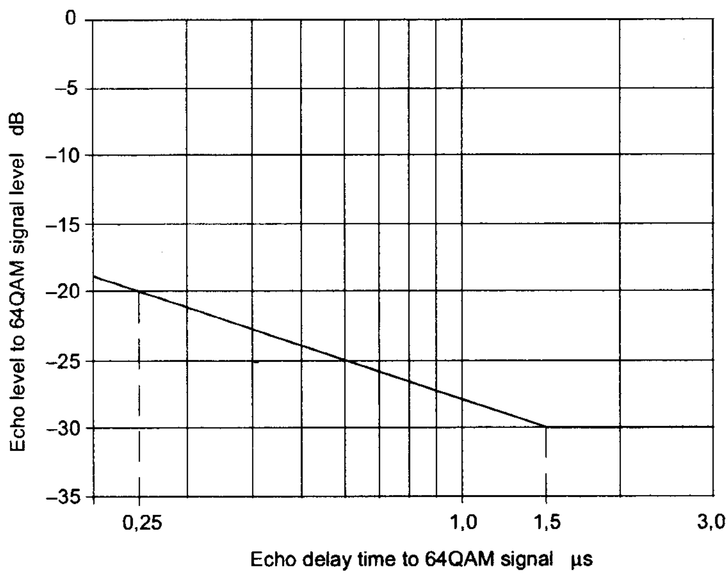


Figure 49 – Echoes (64QAM digital) *(Japan)*

Table 15 – Test carrier frequencies for CTB measurement *(France)*

n	f/MHz	n	f/MHz	n	f/MHz	n	f/MHz
1	136	9	327,25	17	519,25	25	711,25
2	160	10	339,25	18	543,25	26	735,25
3	184	11	351,25	19	567,25	27	759,25
4	208	12	363,25	20	591,25	28	783,25
5	232	13	375,25	21	615,25	29	807,25
6	256	14	399,25	22	639,25	30	831,25
7	280	15	471,25	23	663,25		
8	303,25	16	495,25	24	687,25		

Annex A
(normative)

Calibration of modulation depth

A.1 Equipment required

A.1.1 A signal generator, G_2, capable of being tuned to within about 10 MHz of the test frequency.

A.1.2 A balanced wide band mixer suitable for the test frequencies.

A.1.3 An oscilloscope suitable for a frequency of around 10 MHz.

A.1.4 A low-pass filter with a cut-off frequency of about 15 MHz if required.

A.2 Connection of the equipment

The equipment is connected as in figure A.1.

A.3 Calibration procedure

A.3.1 Set the signal generator G_1 to the test frequency f_1 and the modulation of the carrier to an indicated depth of 10 %.

A.3.2 Set the signal generator G_2 to $f_1 \pm 10$ MHz.

A.3.3 Adjust the attenuator to ensure correct operation of the mixer and a convenient display on the oscilloscope.

A.3.4 The actual modulation depth is then determined from the oscilloscope display; if necessary the modulation depth is then readjusted to the required 10 % and the calibration correction noted.

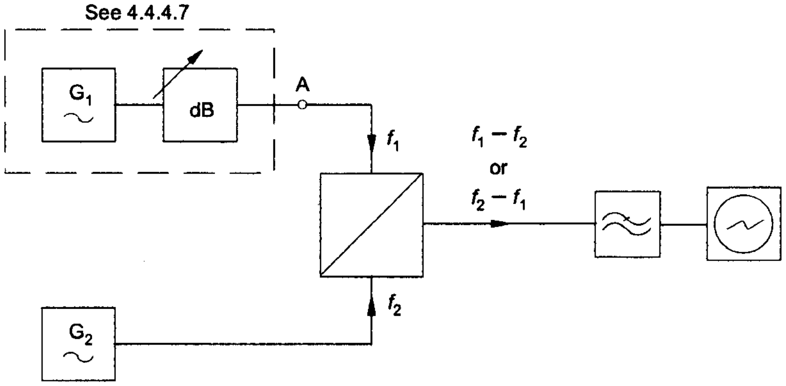


Figure A.1 – Calibration of modulation depth

Annex B
(normative)

Equipment required – additional items

B.1 Measuring receiver preamplifier

If the sensitivity of the measuring receiver is not adequate for the levels of noise expected at the point of measurement, a suitable preamplifier of the correct input impedance and flat response over the channel to be measured will be necessary. This preamplifier should be included as part of the measuring equipment when making the checks described in annex C.

B.2 Measuring receiver input filter

If the selectivity of the measuring receiver is not adequate to reduce to an insignificant level the effects of "out-of-channel" signals on the measurement of the noise voltage, a suitable filter having a flat response over the channel to be measured will be required as shown in figure 24.

In this case, it is important that the matching between the filter and the preceding equipment shall be such that it results in a return loss ratio of not less than 20 dB within the frequency range of the channel to be measured, and that the whole measuring equipment shall satisfy all the requirements of annex C.

Where this is in doubt, an attenuator of sufficient value to satisfy this requirement should be included as shown in figure 24.

Annex C
(normative)

Preliminary checks on the measuring equipment for carrier to noise ratio

C.1 Noise

With the input to the measuring equipment terminated and the variable attenuator set to zero, tune the measuring receiver over the frequency range of interest and check that the reading remains negligible relative to that expected when measuring the system noise.

C.2 Intermodulation

Connect signals, corresponding to those which will be present at the point of measurement, via a matched directional coupler, to the measuring equipment. Tune the meter to any significant intermodulation products and note the lowest value of the signal/intermodulation ratio within the channel being considered.

This ratio should exceed the minimum carrier to noise ratio expected at the point of measurement by an amount relevant to the accuracy desired. For example, 20 dB would result in an error of less than 1 dB.

If this requirement is not met, an appropriate channel pass-band filter to attenuate one of the signals should be included as indicated in figure 24, and the checks indicated in clauses C.1 and C.2 should be repeated.

NOTE This check relating to intermodulation is necessary only if automatic level control (ALC) pilot signals or other signals are present during the carrier to noise ratio tests.

C.3 Overload

Connect signals as in clause C.2 and attenuate one of them to a level comparable with that of the noise voltage expected at the point of measurement. Tune the meter to the low level signal. Tune the low level signal and the meter in step over the frequency range of the channel to be measured and check that the meter reading does not change when the high level signals are switched off and on.

If this requirement is not met, a filter to attenuate one or more of the signals should be included as indicated in figure 24 and all the above checks should be repeated as mentioned in clause C.2.

Annex D
(normative)

Correction factors

D.1 Level correction factor C_m

If a measuring receiver responding to the average value of the applied voltage but calibrated in RMS values (assuming a sinusoidal input signal) is employed, it will indicate a level approximately 1 dB below the RMS value of the applied noise voltage in its noise bandwidth. In this instance C_m may be taken as 1 dB.

If a measuring receiver of the peak reading type is used, a correction appropriate to the particular instrument shall be employed as C_m.

D.2 Bandwidth correction factor C_b

This correction factor takes into account the difference between the noise bandwidth of the measuring receiver B_m and that of the appropriate television system B_{TV}.

$$C_b = 10 \lg \frac{B_{TV}}{B_m} \text{ (dB)}$$

Annex E
(normative)

Calibration of the measuring receiver

Noise bandwidth (B_m)

A well-matched noise generator is required, having a known bandwidth B_g (see note 1), and an output voltage of known RMS value V_g sufficient to give a convenient reading on the measuring receiver.

The measuring receiver is connected to the noise generator (see note 2) and tuned to a test frequency. The true RMS voltage V_m is measured (see annex D). This procedure is repeated at each test frequency. The noise bandwidth of the measuring receiver (B_m) is given by:

$$B_m = B_g\,(V_m/V_g)^2$$

where

B_m and B_g are in the same units, for example megahertz, and

V_m and V_g are in the same units, for example microvolts.

NOTE 1 B_g will usually be taken as 1 MHz and V_g is calculated for this bandwidth from information provided by the manufacturer of the noise generator.

NOTE 2 The noise generator may consist of a noise diode source followed by an appropriate amplifier.

Annex F
(normative)

Correction factors for noise

F.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 F.1 or figure F.1 derive the correction factor (CF) and apply it to obtain the signal level (S) using the following formula:

$$S = S_m - CF$$

F.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 F.1 and in figure F.1, that depends on the difference (D) between the noise level (N_m) measured when the measuring equipment is connected to the system or equipment under test and that (N_{EUT}) measured when the input of the measuring equipment is terminated on its characteristic impedance.

Firstly, calculate the difference D:

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

then from table F.1 or figure F.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 F.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

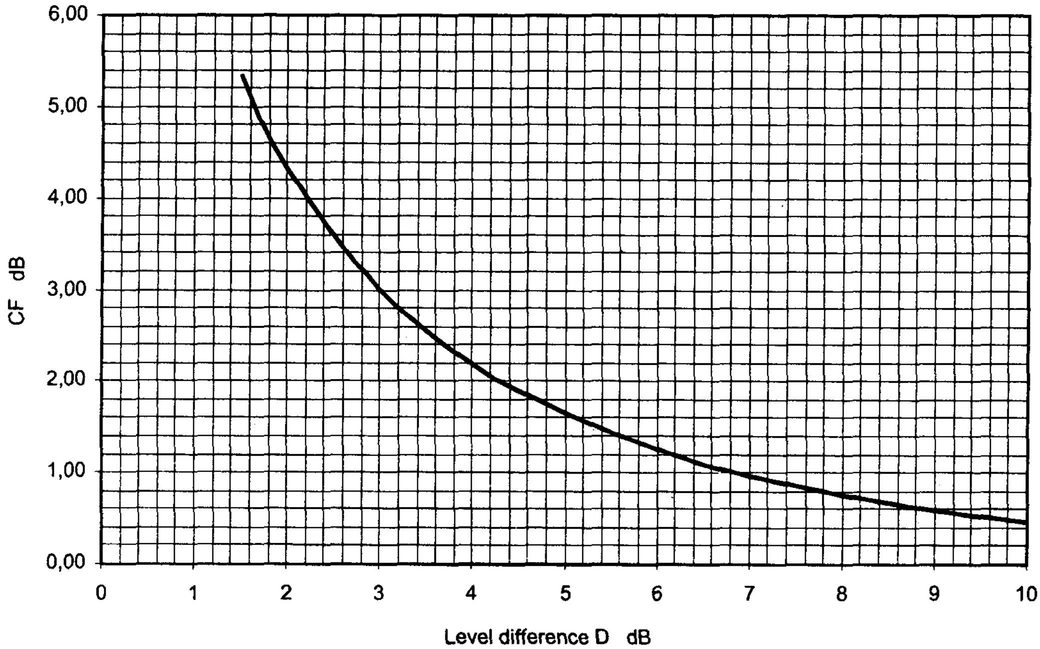


Figure F.1 – Noise correction factor $(CF)_{dB}$ versus measured level difference $(D)_{dB}$.

Annex G
(normative)

Null packet and PRBS definitions

G.1 Null packet definition

The null packet defintion from ISO/IEC 13818-1 is extended for the purpose of the recommended test mode.

ISO/IEC 13818-1 defines a *null transport stream packet* for the purpose of date rate stuffing.

Table G.1 shows the structure of a *null transport stream packet* using the method of describing bit stream syntax defined in 2.3 of ISO/IEC 13818-1.

This description is derived from table 2-2 Transport packet in ISO/IEC 13818-1. The abbreviation "bslbf" means "bit string, left bit first", and "uimsbf" means "unsigned integer, most significant bit first".

The column titled "Value", gives the bit sequence for the recommended null packet.

A null packet is defined by IEC/IEC 13818-1 as having:

- **payload_unit_start_indicator** = '0';

- **PID** = 0x1FFF;

- **transport_scrambling_control** = '00';

- **adaptation_field_control** value = '01'. This corresponds to the case "*no adaptation field, payload only*"

The remaining fields in the null packet that shall be defined for testing purposes are:

- **transport_error_indicator** which is '0' unless the packet is corrupted: for testing purposes this bit is defined as '0' when the packet is generated;

- **transport_priority** which is not defined by ISO/IEC 13818-1 for null packet. For testing purposes this bit is defined as '0';

- **continuity_counter** which ISO/IEC 13818-1 states is undefined for a null packet. For testing purposes this bit field is defined as '0000';

- **data_byte** which ISO/IEC 13818-1 states may have any value in a null packet. For testing purposes this bit field is defined as '00000000'.

Table G.1 – *Null transport stream packet* definition

Syntax	No of bits	Identifier	Value
null_transport_packet(){			
sync_byte	8	bslbf	'01000111'
transport_error_indicator	1	bslbf	'0'
payload_unit_start_indicator	1	bslbf	'0'
transport_priority	1	bslbf	'0'
PID	13	uimsbf	'1111111111111'
transport_scrambling_control	2	bslbf	'00'
adaptation_field_control	2	bslbf	'01'
continuity_counter	4	uimsbf	'0000'
for (i=0;i<N;i++){**data_byte**}	8	bslbf	'00000000'
}			

G.2 PRBS definition

A PRBS (pseudo random bit sequence) generator can be used instead of a null packet generator. A PRBS of $10^{23}-1$ inverted is recommended.

Annex H
(normative)

Digital signal level and bandwidth

H.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.

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.

H.2 Bandwidth of a digital signal

H.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-T J.83, annex B) USA (QAM);
- 0,13 (ITU-T 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:

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

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:

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

where

n = 6 817 (8 k mode) and $f_{SPACING}$ = 1 116 Hz (8 k mode) (DVB-T)

n = 1 705 (2 k mode) and $f_{SPACING}$ = 4 464 Hz (2 k mode) (DVB-T)

n = 5 617 (mode 3) and $f_{SPACING}$ = 992 Hz (mode 3) (ISDB-T) Japan

n = 2 809 (mode 2) and $f_{SPACING}$ = 1 984 Hz (mode 2) (ISDB-T) Japan

n = 1 405 (mode 1) and $f_{SPACING}$ = 3 968 Hz (mode 1) (ISDB-T) Japan.

In a multi-signal system (e.g. 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 analyzer 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.

H.2.2 Noise bandwidth

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

$$BW_{NOISE(QAM/PSK)} = f_S \tag{H.3}$$

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:

$$BW_{NOISE(OFDM)} = BW_{OCC(OFDM)}. \tag{H.4}$$

H.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:

$$BW_{(\mathrm{QAM/PSK})} = f_{\mathrm{S}} \qquad \text{(H.5)}$$

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:

$$BW_{(\mathrm{OFDM})} = BW_{\mathrm{OCC(OFDM)}}. \qquad \text{(H.6)}$$

H.3 Examples

In table H.1, examples for the "occupied bandwidth" or "channel bandwidth", the "noise bandwidth" and the "equivalent signal bandwidth" for the QAM, PSK and OFDM modulation techniques are indicated.

Table H.1 – Examples of bandwidths 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 (mode2)	5,573 (mode 2)

Annex I
(normative)

Correction factor for a spectrum analyzer

The correction factor (K_{sa}) for a typical spectrum analyzer 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 analyzer is greater than its nominal resolution bandwidth (RSBW) by a factor of 1,2.

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

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

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

(*Continued from second cover*)

ITU-T Recommendation J.63 Insertion of test signals in the field-blanking interval of monochrome and colour television signals

ITU-R Recommendation BT.470-6 Conventional television systems

ITU-R Recommendation BT 500-10 Methodology for the subjective assessment of the quality of television pictures

EN 300421 Digital Video Broadcasting (DVB); DVB framing structure, channel coding and modulation for 11/12 GHz satellite services

EN 300429 Digital Video Broadcasting (DVB); DVB framing structure, channel coding and modulation for cable systems

EN 300468 Digital Video Broadcasting (DVB); DVB Specification for Service Information (SI) in DVB systems

EN 300473 Digital Video Broadcasting (DVB); DVB Satellite Master Antenna Television (SMATV) distribution systems

EN 300744 Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television

ETR 211 Digital Video Broadcasting (DVB); DVB guidelines on implementation and usage of Service Information (SI)

Only the English language text of the International Standard has been retained while adopting it in this Indian Standard.

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Amendments Issued Since Publication

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