GENERAL

QUALITY

Total Quality Management

Philips Semiconductors is a Quality Company, renowned for the high quality of our products and service. We keep alive this tradition by constantly aiming towards one ultimate standard, that of zero defects. This aim is guided by our Total Quality Management (TQM) system which is described in our Quality manuals. The basis is outlined in the following paragraphs.

QUALITY ASSURANCE

Based on ISO 9000 standards, customer standards such as FDC, QS9000 and IBM MDQ. Our factories are certified to ISO 9000 by external inspectorates.

PARTNERSHIPS WITH CUSTOMERS

PPM co-operations, design-in agreements, ship-to-stock, just-in-time, self-qualification programmes and application support.

PARTNERSHIPS WITH SUPPLIERS

Ship-to-stock, statistical process control and ISO 9000 audits.

QUALITY IMPROVEMENT PROGRAMME

Continuous process and system improvement, design improvement, complete use of statistical process control, realization of our final objective of zero defects, and logistics improvement by ship-to-stock and just-in-time agreements.

Advanced quality planning

During the design and development of new products and processes, quality is built-in by advanced quality planning. Through failure-mode-and-effect analysis the critical parameters are detected and measures taken to ensure good performance on these parameters. The capability of process steps is also planned in this phase in preparation for production under statistical process control.

Product conformance

The assurance of product conformance is an integral part of our quality assurance (QA) practice. This is achieved by:

- Incoming material management through partnerships with suppliers
- In-line quality assurance to monitor process reproducibility during manufacture and initiate any necessary corrective action. Process steps are under statistical process control
- Acceptance tests on finished products to verify conformance with the device specification. The test results are used for quality feedback and corrective actions. The inspection and test requirements are detailed in the general quality specifications SNW-EQ-611 part A.
- Periodic inspections to monitor and measure the conformance of products
- Qualification tests (see SNW-EQ-611 part A).

Product reliability

With the increasing complexity of Original Equipment Manufacturer (OEM) equipment, component reliability must be extremely high. Our research laboratories and development departments study the failure mechanisms of semiconductors. Their studies result in design rules and process optimization for the highest built-in product reliability. Highly accelerated tests are applied to the products reliability evaluation. Rejects from reliability tests and from customer complaints are submitted to failure analysis, to result in corrective action.

Customer response

Our quality improvement depends on joint action with our customer. We need our customer's inputs and we invite constructive comments on all aspects of our performance. Please contact our local sales representative.

Recognition

The high quality of our products and services is demonstrated by many Quality Awards granted by major customers and international organizations.

PRO ELECTRON TYPE NUMBERING SYSTEM

Basic type number

This type designation code applies to discrete semiconductor devices (not integrated circuits), multiples of such devices, semiconductor chips and Darlington transistors.

FIRST LETTER

The first letter gives information about the material for the active part of the device.

A Germanium or other material with a band gap of 0.6 to 1 eV

B Silicon or other material with a band gap of 1 to 1.3 eV

C Gallium arsenide (GaAs) or other material with a band gap of 1.3 eV or more

R Compound materials, e.g. cadmium sulphide.

SECOND LETTER

The second letter indicates the function for which the device is primarily designed. The same letter can be used for multi-chip devices with similar elements.

In the following list low power types are defined by $R_{th\ j\text{-}mb}$ > 15 K/W and power types by $R_{th\ j\text{-}mb} \leq$ 15 K/W.

A Diode; signal, low power

B Diode; variable capacitance

C Transistor; low power, audio frequency

D Transistor; power, audio frequency

E Diode; tunnel

F Transistor; low power, high frequency

G Multiple of dissimilar devices/miscellaneous devices; e.g. oscillators. Also with special third letter; see under Section “Serial number”.

H Diode; magnetic sensitive

L Transistor; power, high frequency

N Photocoupler

P Radiation detector; e.g. high sensitivity photo-transistor; with special third letter

Q Radiation generator; e.g. LED, laser; with special third letter

R Control or switching device; e.g. thyristor, low power; with special third letter

S Transistor; low power, switching

T Control or switching device; e.g. thyristor, power; with special third letter

U Transistor; power, switching

W Surface acoustic wave device

X Diode; multiplier, e.g. varactor, step recovery

Y Diode; rectifying, booster

Z Diode; voltage reference or regulator, transient suppressor diode; with special third letter.

THIRD LETTER

The third letter indicates a common feature of a group of devices:

D For power-doubler modules

E For economical modules

X For cascade push-pull modules

Y For cascode push-pull modules.

SERIAL NUMBER

The number comprises two to four digits:

6x For reverse amplifiers

8x For 40 to 450 MHz forward amplifiers

1xx For 40 to 450 MHz power doublers

5xx For 40 to 550 MHz amplifiers

6xx For 40 to 600 MHz amplifiers

7xx For 40 to 750 MHz amplifiers

8xx For 40 to 860 MHz amplifiers

10xx For 40 to 1000 MHz amplifiers.

Suffix letter(s)

One or two letters may be added to the basic type number to indicate a specific feature of the device:

D For Darlington modules

BO For optical modules.

RATING SYSTEMS

The rating systems described are those recommended by the International Electrotechnical Commission (IEC) in its publication number 134.

Definitions of terms used

ELECTRONIC DEVICE

An electronic tube or valve, transistor or other semiconductor device. This definition excludes inductors, capacitors, resistors and similar components.

CHARACTERISTIC

A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic or nuclear, and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

BOGEY ELECTRONIC DEVICE

An electronic device whose characteristics have the published nominal values for the type. A bogey electronic device for any particular application can be obtained by considering only those characteristics that are directly related to the application.

RATING

A value that establishes either a limiting capability or a limiting condition for an electronic device. It is determined for specified values of environment and operation, and may be stated in any suitable terms. Limiting conditions may be either maxima or minima.

RATING SYSTEM

The set of principles upon which ratings are established and which determine their interpretation. The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

Absolute maximum rating system

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type, as defined by its published data, which should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

The equipment manufacturer should design so that, initially and throughout the life of the device, no absolute maximum value for the intended service is exceeded with any device, under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

Design maximum rating system

Design maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and throughout the life of the device, no design maximum value for the intended service is exceeded with a bogey electronic device, under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

Design centre rating system

Design centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply voltage.

LETTER SYMBOLS

The letter symbols for transistors and signal diodes detailed in this section are based on IEC publication number 148.

Letter symbols for currents, voltages and powers

BASIC LETTERS

I, i current

V, v voltage

P, p power.

Upper-case letter symbols are used to represent all values except instantaneous values that vary with time, these are represented by lower-case letters.

SUBSCRIPTS

A, a	anode terminal
(AV), (av)	average value
B, b	base terminal
C, c	collector terminal
D, d	drain terminal
E, e	emitter terminal
F, f	forward
G, g	gate terminal
K, k	cathode terminal
M, m	peak value
O, o	as third subscript: the terminal not mentioned is open-circuit
R, r	as first subscript: reverse. As second subscript: repetitive. As third subscript: with a specified resistance between the terminal not mentioned and the reference terminal
(RMS), (rms)	root-mean-square value
S, s	as first or second subscript: source terminal (FETs only). As second subscript: non-repetitive (not FETs). As third subscript: short circuit between the terminal not mentioned and the reference terminal.
X, x	specified circuit
Z, z	replaces R to indicate the actual working voltage, current or power of voltage reference and voltage reference diodes.

No additional subscript is used for DC values.

Upper-case subscripts are used for the indication of:

- Continuous (DC) values (without signal), e.g. I_B
- Instantaneous total values, e.g. i_B
- Average total values, e.g. $I_{B(AV)}$
- Peak total values, e.g. I_{BM}
- Root-mean-square total values, e.g. $I_{B(RMS)}$.

Lower-case subscripts are used for the indication of values applying to the varying component alone:

- Instantaneous values, e.g. i_b
- Root-mean-square values, e.g. $I_{b(rms)}$
- Peak values, e.g. I_{bm}
- Average values, e.g. $I_{b(av)}$.

If more than one subscript is used, the subscript for which both styles exist are either all upper-case or all lower-case.

ADDITIONAL RULES FOR SUBSCRIPTS

Transistor currents

If it is necessary to indicate the terminal carrying the current, this should be done by the first subscript (conventional current flow from the external circuit into the terminal is positive).

Examples: I_B, i_B, i_b, I_{bm}.

Diode currents

To indicate a forward current (conventional current flow into the anode terminal), the subscript F or f should be used. For a reverse current (conventional current flow out of the anode terminal), the subscript R or r should be used.

Examples: I_F, I_R, i_F, $I_{f(rms)}$.

Transistor voltages

If it is necessary to indicate the points between which a voltage is measured, this should be done by the first two subscripts. The first subscript indicates the terminal at which the voltage is measured and the second the reference terminal or the circuit node. Where there is no possibility of confusion, the second subscript may be omitted.

Examples: V_{BE}, v_{BE}, v_{be}, V_{bem}.

Diode voltages

To indicate a forward voltage (anode positive with respect to cathode), the subscript F or f should be used. For a reverse voltage (anode negative with respect to cathode), the subscript R or r should be used.

Examples: V_F, V_R, v_F, V_{rm}.

Supply voltages or currents

Supply voltages or supply currents are indicated by repeating the appropriate terminal subscript.

Examples: V_{CC}, I_{EE}.

If it is necessary to indicate a reference terminal, this should be done by a third subscript.

Example: V_{CCE}.

Subscripts for devices with more than one terminal of the same kind

If a device has more than one terminal of the same kind, the subscript is formed by the appropriate letter for the terminal, followed by a number. In the case of multiple subscripts, hyphens may be necessary to avoid confusion.

Examples:

I_{B2} continuous (DC) current flowing into the second base terminal

V_{B2-E} continuous (DC) voltage between the terminals of second base and emitter terminals.

Subscripts for multiple devices

For multiple unit devices, the subscripts are modified by a number preceding the letter subscript. In the case of multiple subscripts, hyphens may be necessary to avoid confusion.

Examples:

I_{2C} continuous (DC) current flowing into the collector terminal of the second unit

V_{1C-2C} continuous (DC) voltage between the collector terminals of the first and second units.

Application of the rules

Fig.1 represents a transistor collector current as a function of time. It comprises a continuous (DC) current and a varying component.

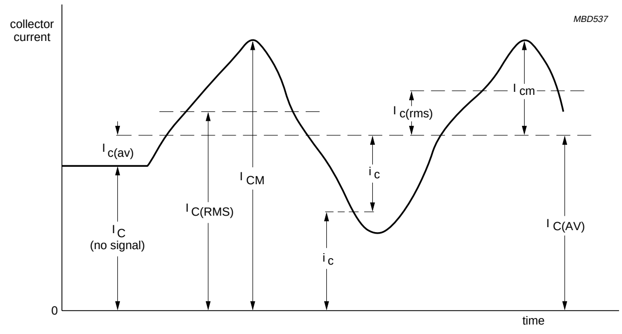

Fig.1 Collector current as a function of time.

Letter symbols for electrical parameters

DEFINITION

For the purpose of this publication, the term ‘electrical parameter’ applies to four-pole matrix parameters, elements of electrical equivalent circuits, electrical impedances and admittances, inductances and capacitances.

BASIC LETTERS

The following list comprises the most important basic letters used for electrical parameters of semiconductor devices.

B, b susceptance (imaginary part of an admittance)

C capacitance

G, g conductance (real part of an admittance)

H, h hybrid parameter

L inductance

R, r resistance (real part of an impedance)

X, x reactance (imaginary part of an impedance)

Y, y admittance

Z, z impedance.

Upper-case letters are used for the representation of:

- Electrical parameters of external circuits and of circuits in which the device forms only a part
- All inductances and capacitances.

Lower-case letters are used for the representation of electrical parameters inherent in the device, with the exception of inductances and capacitances.

SUBSCRIPTS

General subscripts

The following list comprises the most important general subscripts used for electrical parameters of semiconductor devices.

F, f forward (forward transfer)

I, i (or 1) input

L, l load

O, o (or 2) output

R, r reverse (reverse transfer)

S, s source.

Examples: Z_s, h_f, h_F.

The upper-case variant of a subscript is used for the designation of static (DC) values.

Examples:

h_{FE} static value of forward current transfer ratio in common-emitter configuration (DC current gain)

R_E DC value of the external emitter resistance.

The static value is the slope of the line from the origin to the operating point on the appropriate characteristic curve, i.e. the quotient of the appropriate electrical quantities at the operating point.

The lower-case variant of a subscript is used for the designation of small-signal values.

Examples:

h_{fe}	small-signal value of the short-circuit forward current transfer ratio in common-emitter configuration
$Z_e = R_e + jX_e$	small-signal value of the external impedance.

If more than one subscript is used, subscripts for which both styles exist are either all upper-case or all lower-case.

Examples: h_{FE}, y_{RE}, h_{fe}.

Subscripts for four-pole matrix parameters

The first letter subscript (or double numeric subscript) indicates input, output, forward transfer or reverse transfer.

Examples: h_i (or h_{11}), h_o (or h_{22}), h_f (or h_{21}), h_r (or h_{12}).

A further subscript is used for the identification of the circuit configuration. When no confusion is possible, this further subscript may be omitted.

Examples: h_{fe} (or h_{21e}), h_{FE} (or h_{21E}).

DISTINCTION BETWEEN REAL AND IMAGINARY PARTS

If it is necessary to distinguish between real and imaginary parts of electrical parameters, no additional subscripts should be used. If basic symbols for the real and imaginary parts exist, these may be used.

Examples: $Z_i = R_i + jX_i$, $y_{fe} = g_{fe} + jb_{fe}$.

If such symbols do not exist, or if they are not suitable, the following notation is used:

Examples:

Re (h_{ib}) etc. for the real part of h_{ib}

Im (h_{ib}) etc. for the imaginary part of h_{ib}.

CATV PARAMETERS

Gain (G_p)

DEFINITION

The power gain, expressed in dB, is the ratio of output and input power of a module, operating in a 75 Ω (Z_0) system.

MEASUREMENT

The power gain is measured at several frequencies throughout the band, although the gain performances are mostly given only at the start and stop frequencies.
The gain is measured by applying a single tone signal to the module and measuring the output power. The input power is measured before connecting the module using a thru-line and feeding the system with exactly the same signals.

EQUIPMENT

Input and output power levels are measured with a power meter.

Flatness of frequency response (FL)

DEFINITION

The flatness of gain of a CATV amplifier module is defined as the maximum deviation from an absolute flat gain over a given frequency range, after the slope of the amplifier over this frequency range has been optimized and equalized by means of a certain cable length to give the best result for flatness (see Fig.2 and Fig.3). This means that an ‘ideal gain curve’ for the module is calculated and the flatness is the maximum deviation of this ‘ideal gain’ curve.

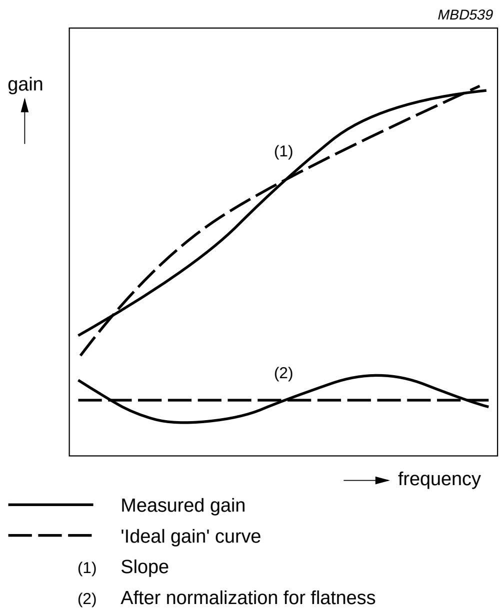

Fig.2 Gain curve before optimizing.

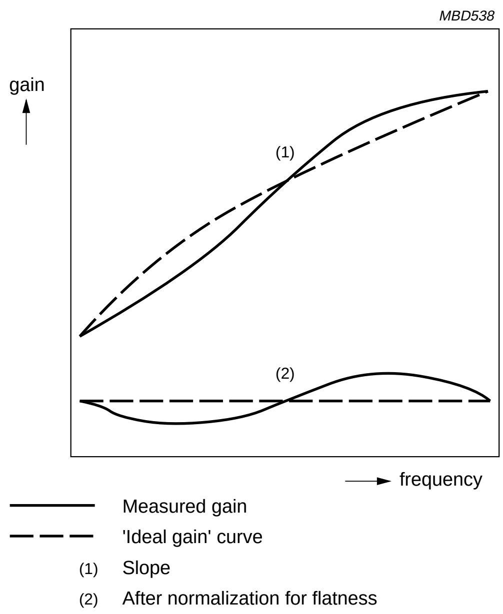

Fig.3 Gain curve after optimizing.

CALCULATION

To determine the flatness, the measured gain values are compared with an 'ideal gain' curve derived from a mathematical model. The formula used is as follows:

$$\text{Gain} = G + C\sqrt{\frac{f_x}{f_1}}$$

where

G = constant gain (frequency independent)

C = cable constant

f_x = desired frequency

f_1 = start frequency.

The cable constant (C) must be optimized during the flatness determination so that the gain curve best fits the measured gain figures. The start value for C is calculated using the formula:

$$C_{start} = \frac{G_n - G_1}{\sqrt{\frac{f_n}{f_1}} - 1}$$

where

G_n = the measured gain at stop frequency

G_1 = the measured gain at start frequency

f_n = stop frequency.

The value of G is chosen so that the maximum positive deviation of the measured gain from the 'ideal gain' curve is the same as the maximum negative deviation. The value of C is adapted by ±0.001 until the 'ideal gain' curve best fits the measured curve.

The flatness of the module gain is the maximum deviation in measured gain from the optimized gain formula.

Slope (SL)

DEFINITION

The slope of a module is the difference between the 'ideal gain' at the start frequency and the 'ideal gain' at the stop frequency (see 'Flatness').

Flatness (S-curve method)

DEFINITION

For some high-slope modules the flatness is calculated according to the ‘S-curve’ method. The ideal S-curve is defined as:

$$G_f = G_{f_1} + \delta G \cdot a \cdot (f - f_1) + \delta G \cdot b \cdot (f - f_1)^2 + \\ + \delta G \cdot c \cdot (f - f_1)^3$$

where

$\delta G = G_{f_n} - G_{f_1}$

f_1 = start frequency

f_n = stop frequency

a = 3.1224×10^{-3}

b = 1.9932×10^{-6}

c = -8.934×10^{-9}.

The flatness is the maximum deviation between the measured gain and the ‘ideal gain’ curve.

Delta gain

DEFINITION

Delta gain is the difference in gain between two given frequencies (mostly the start and stop frequencies).

Intermodulation distortion (d_{im})

In accordance with DIN 45004B 6.3, 3-tone.

DEFINITION

The intermodulation distortion product is the difference in dB between the peak of the RF signal in the measuring channel and the peak of the distortion signal caused by the influence of a signal in a neighbouring channel (see Fig.4).

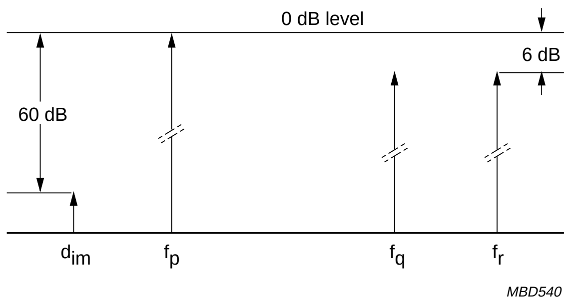

Fig.4 Intermodulation distortion.

To measure 3-tone d_{im}, three CW signals are applied to the module:

f_p = f	level =	0 dB
f_q = f + 7 MHz	level =	–6 dB
f_r = f + 9 MHz	level =	–6 dB.

The distortion product is measured at f – 2 MHz. This distortion product consists of the ($f_p + f_q - f_r$) beats and is expressed in dB referenced to the 0 dB level (the f_p signal level).

This 0 dB level should be chosen so that the distortion product (d_{im}) is –60 dB. For practical reasons the given output level (V_o) for 3-tone distortion is defined as the 0 dB level and the modules are rejected if the distortion level is worse than –60 dB.

EQUIPMENT

Spectrum analyzer with settings:

Internal attenuator	40 dB
Resolution bandwidth	3 kHz
Video bandwidth	100 Hz
Span	50 kHz.

The three signals are obtained from three different generators (see Appendix A).

Composite third order distortion: composite triple beat (CTB) in CW carriers

In accordance with National Cable Television Association recommendations.

DEFINITION

Composite third order modulation is the amplitude distortion of desired signals, caused by third order curvature of non-linear transfer characteristics in system equipment. It is the ratio, expressed in dB, of the peak level of the RF signal to the peak level of the cluster of distortion components centered around the carrier.

MEASUREMENT

To measure the CTB, a signal at the measuring frequency is set to the specified V_o level. This output level is defined as the 0 dB level. During the measurement[(1)] all channels in the band are set to the specified V_o level, see Appendix E. Now, at the measuring frequency, the distortion product is measured with a spectrum analyzer or distortion analyzer.

The CTB distortion is measured high in the band because here the distortion products have most amplitude (although the greatest number of beats ($f_1 \pm f_2 \pm f_3$ and $2 \times f_1 \pm f_2$) are found in the centre of the band).

EQUIPMENT

Spectrum analyzer with settings:

Resolution bandwidth	30 kHz
Video bandwidth	100 kHz
Span	500 kHz.

A bandpass filter is used to eliminate the distortion products caused by the spectrum analyzer itself.
If desired, a distortion analyzer can be used instead of the spectrum analyzer.

The carrier signals are obtained from a multi-channel generator. The frequency deviation of each channel must be less than 5 kHz.

(1) In the USA, an equally spaced frequency raster is used with a space of 6 MHz between the channels. In Germany frequency distribution of the space between the channels is 7 MHz up to 300 MHz, and 8 MHz above 300 MHz. In general, the Philips measurements are made in accordance with the American frequency raster. For the German market, measurements can be made with a set-up which appoximates as closely as possible to the German raster.
A list of both rasters is given in Appendix D.

Composite third order distortion: cross modulation (X_{mod}) in modulated carriers

DEFINITION

Cross modulation distortion is a form of distortion where modulation of interfering stations appears as a modulation of the desired station, caused by third order curvature of non-linear transfer characteristics in system equipment.
It is the ratio, expressed in dB, of the peak level of the modulated RF signal to the peak level of the distortion components centered around the carrier (Figs 5, 6 and 7).

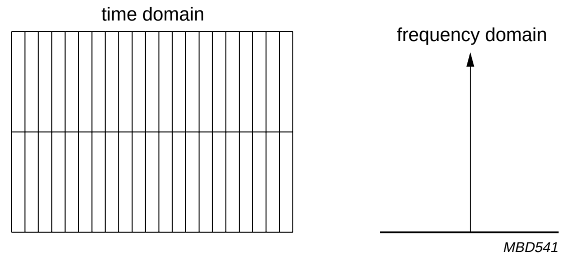

Fig.5 CW signal (sinewave), no other signals switched on.

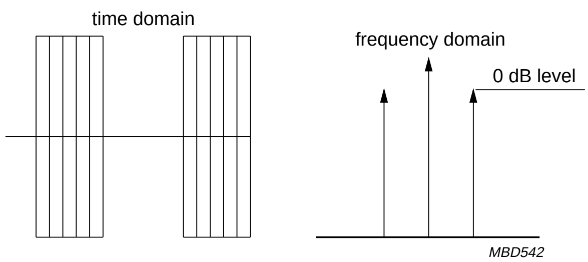

Fig.6 One signal switched on 100% modulated.

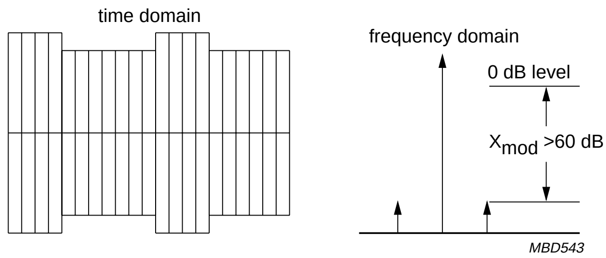

Fig.7 CW signal with X_{mod} distortion caused by other modulated signals.

MEASUREMENT

To measure X_{mod}, the carrier of the desired channel is set to the specified V_o level. This channel is then 100% modulated with a 15.75 kHz square wave(1). The peak level of this modulation signal (15.75 kHz on the carrier) is defined as the 0 dB level. The distortion product is now measured by setting each individual CW channel to the specified V_o level and switching them on in modulated mode, see Appendix E. Only the carrier in the channel where the X_{mod} distortion is to be measured, is not modulated. The X_{mod} distortion peak now appears as 15.75 kHz on the carrier.

The X_{mod} distortion is most easily measured at the low end of the frequency band.

EQUIPMENT

Bandpass filter:

Tuned to the channel in which the distortion product is to be measured.

Spectrum analyzer with settings (for most types):

Resolution bandwidth	300 kHz
Video bandwidth	30 Hz
Span	5 kHz.

A multi-channel generator is required for the test signals.

A distortion analyzer will be required if the X_{mod} is to be measured at a high frequency in the band. This is because phase noise will make spectrum analyzer measurements inaccurate.

Second order distortion (d_2)

In accordance with DIN 45004-A1.

DEFINITION

The second order distortion product is the difference in dB between the peak level of an RF signal at the measuring frequency, and the peak level of the signal at the measuring frequency caused by two CW signals with their second order modulation product ($f_1 \pm f_2$) at the measuring frequency (see Fig.8).

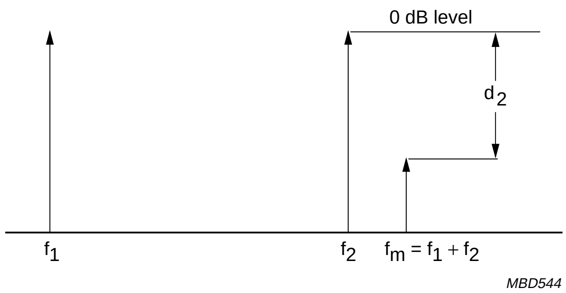

Fig.8 Second order distortion (d_2).

MEASUREMENT

Second order modulation is measured at the frequency in the band where the distortion product is found to be worst. In general this will be at the high end of the band.

In most cases the measuring procedure will be as follows:

Signals f_1 and f_2 are chosen so that f_1 is the lowest channel in the band and f_2 is the highest. This means that $f_1 + f_2$ lays within the band.

The peak levels of f_1 and f_2 are equal and are defined as the 0 dB level. For frequency sets, see Appendix B.

EQUIPMENT

Spectrum analyzer with settings:

Resolution bandwidth	3 kHz
Video bandwidth	100 Hz
Span	50 kHz.

A tunable bandpass filter is used to eliminate the distortion caused by the spectrum analyzer.

Composite second order (CSO) distortion

DEFINITION

Composite second order distortion is the ratio, expressed in dB, of the peak level of the RF signal to the peak level of the cluster of distortion components centered around the desired signal. This distortion is caused by a compilation of components of second order intermodulation products of interfering signals with frequencies f_1 and f_2, so that
$f_m = f_1 \pm f_2$ or
$f_m = 2 \times f_1$ or
$f_m = 2 \times f_2$.

(1) The 15.75 kHz square wave modulation signal, used with X_{mod} measurements, found its origin in the American broadcasting method. Using the NTSC system, the 15.75 kHz is defined by the 60 Hz mains frequency and the number of 525 TV lines, i.e. (NTSC) = $60 \times 525 \div 2$ = 15.75 KHz.
The modulation frequency for PAL (one of the European methods) is 15.625 kHz. This is because in Europe the mains frequency is 50 Hz and the number of TV lines using PAL is 625.

MEASUREMENT

Measurement is made by setting a signal with the desired frequency to the specified level for V_o. This V_o level is defined as the 0 dB level.

During the measurement, all channels in the band are levelled to the specified V_o. Now at the measurement frequency, the distortion product is measured by use of a spectrum analyzer.

The CSO distortion is measured high in the band because it is here that this distortion product has most influence, see Appendix E.

EQUIPMENT

Spectrum analyzer with settings:

Resolution bandwidth	30 kHz
Video bandwidth	100 Hz
Span	400 kHz.

A bandpass filter is used at the input of the spectrum analyzer.

S-parameters S_{11} and S_{22} (return losses)

In accordance with IEC 747-7.

DEFINITION

The return losses or reflection coefficients of a module can be defined as the S_{11} and the S_{22} of a two-port network (see Fig.9).

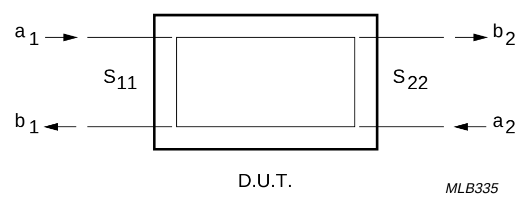

Fig.9 Two-port network with reflection coefficients S_{11} and S_{22}.

$$b_1 = S_{11} \cdot a_1 + S_{12} \cdot a_2 \quad (1)$$

$$b_2 = S_{21} \cdot a_1 + S_{22} \cdot a_2 \quad (2)$$

where:

$$a_1 = \frac{1}{2 \cdot \sqrt{Z_0}} \cdot (V_1 + Z_0 \cdot i_1) = \text{signal into port 1} \quad (3)$$

$$a_2 = \frac{1}{2 \cdot \sqrt{Z_0}} \cdot (V_2 + Z_0 \cdot i_2) = \text{signal into port 2} \quad (4)$$

$$b_1 = \frac{1}{2 \cdot \sqrt{Z_0}} \cdot (V_1 + Z_0 \cdot i_1) = \text{signal out of port 1}$$

$$b_2 = \frac{1}{2 \cdot \sqrt{Z_0}} \cdot (V_2 + Z_0 \cdot i_2) = \text{signal out of port 2}$$

From (1) and (2) formulae for the return losses can be derived:

$$S_{11} = \left.\frac{b_1}{a_1}\right| a_2 = 0 \quad (5)$$

$$S_{22} = \left.\frac{b_2}{a_2}\right| a_1 = 0 \quad (6)$$

In (5), $a_2 = 0$ means output port terminated with Z_0 (derived from formula (4)).

In (6), $a_1 = 0$ means input port terminated with Z_0 (derived from formula (3)).

MEASUREMENT

The return losses are measured with a network analyzer after calibration, where the influence of the test jig is eliminated. The necessary termination of the other port with Z_0 is done automatically by the network analyzer.

The network analyser must have a directivity of at least 40 dB to obtain an accuracy of 0.5 dB when measuring return loss figures of 20 dB. A full two-port correction method can be used to improve the accuracy.

Noise figure (F)

In accordance with IEC 747-7.

DEFINITION

The noise figure is defined as the ratio of the total available noise power output from the module when connected to a noise source to that which is generated solely by the noise source.

MEASUREMENT

Noise figure is measured with a noise figure meter at the output of the module, while a noise is connected to the input of the module. Measurements should be done in an electrically-shielded room to prevent pick-up of unwanted signals.

APPENDIX A - COMMON FREQUENCY SETS FOR d_{dim} MEASUREMENTS

f_m (MHz)	f_p (MHz)	f_q (MHz)	f_r (MHz)
33.25	35.25	42.25	44.25
163.25	165.25	172.25	174.25
185.25	187.25	194.25	196.25
285.25	287.25	294.25	296.25
335.25	337.25	344.25	346.25
339.25	341.25	348.25	350.25
385.25	387.25	394.25	396.25
438.25	440.25	447.25	449.25
481.25	483.25	490.25	492.25
538.25	540.25	547.25	549.25
849.25	851.25	858.25	860.25

APPENDIX B - COMMON FREQUENCY SETS FOR d_2 MEASUREMENTS

f_p (MHz)	f_q (MHz)	f_m (MHz)
83.25	109.25	192.50
66.00	144.00	210.00
55.25	211.25	266.50
55.25	343.25	398.50
55.25	391.25	446.50
55.25	493.25	548.50
300.00	450.00	750.00

APPENDIX C - DISTORTION RESULTS USING THE CENELEC FREQUENCY RASTER

The CENELEC Frequency Raster is increasingly being used in Europe. This raster has less channels and these are no longer equally spaced as with the USA Frequency Raster. This results generally in much better distortion readings.

The distortion figures of the CATV hybrids are measured using the standard USA Frequency Raster. A different number of channels is used, however, depending on the frequency range.

The following table based on calculations and correlation measurements using several different hybrid types provides a means of converting the standard measured distortion figures (USA Frequency Raster) into CENELEC Frequency Raster readings.

FREQUENCY RANGE (MHz)	CHANNELS		CTB	X_{mod}	CSO
	USA	CENELEC	(dB)	(dB)	(dB)
40 - 600	85	29	–11.00	–8.00	–6.00
40 - 750	110	35	–12.00	–9.00	–9.00
40 - 860	49	42	+2.00	–1.00	+1.00

APPENDIX D - LIST OF FREQUENCY RASTERS FOR USA AND GERMANY

USA	
CHANNEL	**FREQUENCY (MHz)**
2	55.25
3	61.25
4	67.25
5	77.25
6	83.25
A2	109.25
A1	115.25
A	121.25
B	127.25
C	133.25
D	139.25
E3	145.25
F	151.25
G	157.25
H	163.25
I	169.25
7	175.25
8	181.25
9	187.25
10	193.25
11	199.25
12	205.25
13	211.25
J	217.25
K	223.25
L	229.25
M	235.25
N	241.25
O	247.25
P	253.25
Q	259.25
R	265.25
S	271.25
T	277.25
U	283.25
V	289.25
W	295.25

USA (CONTINUED)	
CHANNEL	**FREQUENCY (MHz)**
X	301.25
Y	307.25
Z	313.25
H1	319.25
H2	325.25
H3	331.25
H4	337.25
H5	343.25
H6	349.25
H7	355.25
H8	361.25
H9	367.25
H10	373.25
H11	379.25
H12	385.25
H13	391.25
H14	397.25
H15	403.25
H16	409.25
H17	415.25
H18	421.25
H19	427.25
H20	433.25
H21	439.25
H22	445.25
H23	451.25
H24	457.25
H25	463.25
14	469.25
15	475.25
16	481.25
17	487.25
18	493.25
19	499.25
20	505.25
21	511.25
22	517.25
23	523.25
24	529.25

USA (CONTINUED)	
CHANNEL	FREQUENCY (MHz)
25	535.25
26	541.25
27	547.25
28	553.25
29	559.25
30	565.25
31	571.25
32	577.25
33	583.25
34	589.25
35	595.25
36	601.25
37	607.25
38	613.25
39	619.25
40	625.25
41	631.25
42	637.25
43	643.25
44	649.25
45	655.25
46	661.25
47	667.25
48	673.25
49	679.25
50	685.25
51	691.25
52	697.25
53	703.25
54	709.25
55	715.25
56	721.25
57	727.25
58	733.25
59	739.25
60	745.25
61	751.25
62	757.25
63	763.25

USA (CONTINUED)	
CHANNEL	FREQUENCY (MHz)
64	769.25
65	775.25
66	781.25
67	787.25
68	793.25
69	799.25
70	805.25
71	811.25
72	817.25
73	823.25
74	829.25
75	835.25
76	841.25
77	847.25
78	853.25
79	859.25
80	865.25
81	871.25
82	877.25
83	883.25
84	889.25
85	895.25

GERMANY	
CHANNEL	FREQUENCY (MHz)
K2	48.25
K3	55.25
K4	62.25
–	69.25
–	76.25
S2	112.25
S3	119.25
S4	126.25
S5	133.25
S6	140.25
S7	147.25
S8	154.25
S10	168.25

GERMANY (CONTINUED)	
CHANNEL	FREQUENCY (MHz)
K5	175.25
K6	182.25
K7	189.25
K8	196.25
K9	203.25
K10	210.25
K11	217.25
K12	224.25
S11	231.25
S12	238.25
S13	245.25
S14	252.25
S15	259.25
S16	266.25
S17	273.25
S18	280.25
S19	287.25
S20	294.25
S21	303.25

GERMANY (CONTINUED)	
CHANNEL	FREQUENCY (MHz)
S22	311.25
S23	319.25
S24	327.25
S25	335.25
S26	343.25
S27	351.25
S28	359.25
S29	367.25
S30	375.25
S31	383.25
S32	391.25
S33	399.25
S34	407.25
S35	415.25
S36	423.25
S37	431.25
S38	439.25
S39	445.25

APPENDIX E - TEST CHANNELS

Channels used during CTB, X_{mod} and CSO measurements

RANGE	NAMES	FREQUENCIES (MHz)	CHANNELS
5 - 200 MHz 22 channels	T7 - T13 2 - 4 5 - 6 A - 7	7.00 - 43.00 55.25 - 67.25 77.25 - 83.25 121.25 - 175.25	7 3 2 10
40 - 300 MHz 32 channels	2 - 4 5 - 6 A2 A - F H - S W	55.25 - 67.25 77.25 - 83.25 109.25 121.25 - 151.25 163.25 - 271.25 295.25	3 2 1 6 19 1
40 - 450 MHz 52 channels	2 - 4 5 - 6 A2 A - F H - H14	55.25 - 67.25 77.25 - 83.25 109.25 121.25 - 151.25 163.25 - 397.25	3 2 1 6 40
40 - 450 MHz 60 channels	2 - 4 5 - 6 A - H22	55.25 - 67.25 77.25 - 83.25 121.25 - 445.25	3 2 55
40 - 550 MHz 77 channels	2 - 4 5 - 6 A - 27	55.25 - 67.25 77.25 - 83.25 121.25 - 547.25	3 2 72
40 - 600 MHz 85 channels	2 - 4 5 - 6 A - 35	55.25 - 67.25 77.25 - 83.25 121.25 - 595.25	3 2 80
40 - 750 MHz 110 channels	2 - 4 5 - 6 A - 60	55.25 - 67.25 77.25 - 83.25 121.25 - 745.25	3 2 105

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APPENDIX E - TEST CHANNELS (CONTINUED)

Channels used during CTB, X_{mod} and CSO measurements

RANGE	NAMES	FREQUENCIES (MHz)	CHANNELS
40 - 860 MHz 49 channels	2	55.25	1
	4	67.25	1
	6	83.25	1
	7	175.25	1
	9	187.25	1
	12	205.25	1
	J	217.25	1
	M	235.25	1
	O	247.25	1
	R	265.25	1
	T	277.25	1
	W	295.25	1
	Y	307.25	1
	H2	325.25	1
	H4	337.25	1
	H7	355.25	1
	H9	367.25	1
	H12	385.25	1
	H14	397.25	1
	H17	415.25	1
	H19	427.25	1
	H22	445.25	1
	H24	457.25	1
	15	475.25	1
	17	487.25	1
	20	505.25	1
	22	517.25	1
	25	535.25	1
	27	547.25	1
	30	565.25	1
	32	577.25	1
	35	595.25	1
	37	607.25	1
	40	625.25	1
	42	637.25	1
	45	655.25	1
	47	667.25	1
	50	685.25	1
	52	697.25	1
	55	715.25	1
	57	727.25	1
	60	745.25	1
	62	757.25	1
	65	775.25	1
	67	787.25	1
	70	805.25	1
	73	823.25	1
	76	841.25	1
	79	859.25	1

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APPENDIX E - TEST CHANNELS (CONTINUED)

Channels used during CTB, X_{mod} and CSO measurements

RANGE	NAMES	FREQUENCIES (MHz)	CHANNELS
40 - 860 MHz 129 channels	2 - 4 5 - 6 A - 79	55.25 - 67.25 77.25 - 83.25 121.25 - 859.25	3 2 124
40 - 450 MHz 36 channels German raster (For test purposes, USA frequency rasters are used to emulate the German raster)	2 - 3 C - F H 7 9 12 J L - M O - S U - X Z - H2 H4 H6 H8 - H10 H12 - H13 H16 - H18 H20	55.25 - 61.25 133.25 - 151.25 163.25 175.25 187.25 205.25 217.25 229.25 - 235.25 247.25 - 271.25 283.25 - 301.25 313.25 - 325.25 337.25 349.25 361.25 - 373.25 385.25 - 391.25 409.25 - 421.25 433.25	2 4 1 1 1 1 1 2 5 4 3 1 1 3 2 3 1