BRITISH STANDARD

BS EN 60747-16-4:2004 +A1:2011

# Semiconductor devices —

## Part 16-4: Microwave integrated circuits — Switches

ICS 31.080.99



British Standards

# National foreword

This British Standard is the official English language version of EN 60747-16-4:2004+A1:2011. It is identical with IEC 60747-16-4:2004, incorporating amendment 1:2009. It supersedes BS EN 60747-16-4:2004, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by [A1⟩ ⟨A1].

The UK participation in its preparation was entrusted to Technical Committee EPL/47, Semiconductors.

A list of organizations represented on this committee can be obtained on request to its secretary.

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 8 November 2004



ISBN 978 0 580 59783 1

**Amendments/corrigenda issued since publication**

| Date | Comments |
|---|---|
| 31 July 2011 | Implementation of IEC amendment 1:2009, with CENELEC endorsement A1:2011 |
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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

# EN 60747-16-4:2004+A1

January 2011

ICS 31.080.99

English version

## Semiconductor devices
## Part 16-4: Microwave integrated circuits –
## Switches
(IEC 60747-16-4:2004)

Dispositifs à semiconducteurs
Partie 16-4 : Circuits intégrés hyperfréquences –
Commutateurs
(CEI 60747-16-4:2004)

Halbleiterbauelemente
Teil 16-4: Integrierte Mikrowellenschaltkreise –
Schalter
(IEC 60747-16-4:2004)

This European Standard was approved by CENELEC on 2004-09-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC
European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**



Ref. No. EN 60747-16-4:2004 E

## Foreword

The text of document 47E/256/FDIS, future edition 1 of IEC 60747-16-4, prepared by SC 47E, Discrete semiconductor devices, of IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60747-16-4 on 2004-09-01.

The following dates were fixed:

| | | |
|---|---|---|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2005-06-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2007-09-01 |

Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the International Standard IEC 60747-16-4:2004 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

IEC 60747-16-1 NOTE Harmonized as EN 60747-16-1:2002 (not modified).

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## Foreword to amendment A1

The text of document 47E/358/CDV, future amendment 1 to IEC 60747-16-4:2004, prepared by SC 47E, Discrete semiconductor devices, of IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60747-16-4:2004 on 2011-01-02.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

| | | |
|---|---|---|
| – latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2011-10-02 |
| – latest date by which the national standards conflicting with the amendment have to be withdrawn | (dow) | 2014-01-02 |

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## Endorsement notice

The text of amendment 1:2009 to the International Standard IEC 60747-16-4:2004 was approved by CENELEC as an amendment to the European Standard without any modification.

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CONTENTS

# SEMICONDUCTOR DEVICES –

# Part 16-4: Microwave integrated circuits – Switches

## 1 Scope

This part of IEC 60747 provides new measuring methods, terminology and letter symbols, as well as essential ratings and characteristics for integrated circuit microwave switches.

There are many combinations for RF ports in switches, such as SPST (single pole single throw), SPDT (single pole double throw), SP3T (single pole triple throw), DPDT (double pole double throw), etc. Switches in this standard are based on SPDT. However, this standard is applicable to the other types of switches.

## 2 Normative references

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

[A1⟩ IEC 60617, *Graphical symbols for diagrams*

IEC 60747-1:2006, *Semiconductor devices – Part 1: General* ⟨A1]

IEC 60747-4, *Semiconductor devices – Discrete devices – Part 4: Microwave devices*

IEC 60748-2, *Semiconductor devices – Integrated circuits – Part 2: Digital integrated circuits*

IEC 60748-3, *Semiconductor devices – Integrated circuits – Part 3: Analogue integrated circuits*

IEC 60748-4, *Semiconductor devices – Integrated circuits – Part 4: Interface integrated circuits*

[A1⟩ IEC 60747-16-1:2001, *Semiconductor devices – Part 16-1: Microwave integrated circuits – Amplifiers*
Amendment 1 (2007)[1]

IEC 61340-5-1:2007, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

IEC/TR 61340-5-2:2007, *Electrostatics – Part 5-2: Protection of electronic devices from electrostatic phenomena – User guide* ⟨A1]

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**Terms related to electrical characteristics**

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[1] There exists a consolidated edition 1.1 published in 2007, including the base publication (2001) and its Amendment 1 (2007).

A1 **3.1**
**insertion loss**
$L_{ins}$
ratio of the input power to the output power at the switched on port, in the linear region of the power transfer curve $P_o$ (dBm) = $f(P_i)$

NOTE 1 In this region, $\Delta P_o$ (dBm) = $\Delta P_i$ (dBm).

NOTE 2 Usually the insertion loss is expressed in decibels.

**3.2**
**isolation**
$L_{iso}$
ratio of the input power to the output power at the switched off port, in the linear region of the power transfer curve $P_o$ (dBm) = $f(P_i)$

NOTE 1 In this region, $\Delta P_o$ (dBm) = $\Delta P_i$ (dBm).

NOTE 2 Usually the isolation is expressed in decibels. A1

**3.3**
**return loss**
$L_{ret}$
ratio of the incident power $P_{inc}$ at the specified port to the reflected power $P_{ref}$ at the same port in the linear region of the power transfer curve $P_{ref}$ (dBm) = $f(P_{inc})$

NOTE 1 In this region, $\Delta P_{ref}$ (dBm) = $\Delta P_{inc}$ (dBm).

NOTE 2 Usually the return loss is expressed in decibels.

**3.4**
**input power at 1 dB compression**
$P_{i(1\ dB)}$
input power where the insertion loss increases by 1 dB compared with insertion loss in linear region

**3.5**
**output power at 1 dB compression**
$P_{o(1dB)}$
output power where the insertion loss increases by 1 dB compared with insertion loss in linear region

**3.6**
**turn on time**
$t_{on}$
interval between the lower reference point on the leading edge of the control voltage and the upper reference point on the leading edge of the envelope of the output voltage in the linear region of the power transfer curve $P_o$ (dBm) = $f(P_i)$

NOTE In this region, $\Delta P_o$ (dBm) = $\Delta P_i$ (dBm).

**3.7**
**turn off time**
$t_{off}$
interval between the upper reference point on the trailing edge of the control voltage and the lower reference point on the trailing edge of the envelope of the output voltage in the linear region of the power transfer curve $P_o$ (dBm) = $f(P_i)$

NOTE In this region, $\Delta P_o$ (dBm) = $\Delta P_i$ (dBm).

**3.8**
**rise time**
$t_{r(out)}$
interval between the lower reference point on the leading edge of the output voltage and the upper reference point on the leading edge of the envelope of the output voltage in the linear region of the power transfer curve $P_o$ (dBm) = $f(P_i)$

NOTE In this region, $\Delta P_o$ (dBm) = $\Delta P_i$ (dBm).

**3.9**
**fall time**
$t_{f(out)}$
interval between the upper reference point on the trailing edge of the output voltage and the lower reference point on the trailing edge of the envelope of the output voltage in the linear region of the power transfer curve $P_o$ (dBm) = $f(P_i)$

NOTE In this region, $\Delta P_o$ (dBm) = $\Delta P_i$ (dBm).

**3.10**
**adjacent channel power ratio**
$P_{o(mod)}/P_{adj}$
ratio of the total power in the specified carrier signal frequency band to total output power in the specified frequency band away from the specified carrier signal frequency, at the specified output power when the modulation signal is supplied

[A1) **3.11**
***n*th order harmonic distortion ratio**
$P_1/P_{nth}$
See 3.14 of Amendment 1 of IEC 60747-16-1:2007. (A1]

## 4 Essential ratings and characteristics

This clause gives ratings and characteristics required for specifying integrated circuit microwave switches.

### 4.1 Circuit identification and types

#### 4.1.1 Designation and types

Identification of type (device name), category of circuit and technology applied should be given. Microwave switches comprise one category.

#### 4.1.2 General function description

A general description of the function performed by the integrated circuit microwave switches and the features for the application should be made.

#### 4.1.3 Manufacturing technology

The manufacturing technology, e.g. semiconductor monolithic integrated circuit, thin film integrated circuit, micro-assembly, etc. should be stated. This statement should include details of the semiconductor technologies such as Schottky-barrier diode, PIN diode, MESFET, Si bipolar transistor, etc.

IEC 60747-4 should be referred to for terminology and letter symbols, essential ratings and characteristics and measuring methods of such microwave devices.

#### 4.1.4 Package identification

The following statements should be made:

a) chip or packaged form;
[A1) b) IEC and/or national reference number of the outline drawing, or drawing of non-standard package including terminal numbering; (A1]
c) principal package material, for example, metal, ceramic, plastic.

#### 4.1.5 Main application

The main application should be stated. If the device has restrictive applications, these should be stated here.

### 4.2 Application description

Information on application of the integrated circuit and its relation to the associated devices should be given.

#### 4.2.1 Conformance to system and/or interface information

It should be stated whether the integrated circuit conforms to an application system and/or an interface standard or a recommendation.

Detailed information concerning application systems, equipment and circuits such as VSAT systems, DBS receivers, microwave landing systems, etc. should also be given.

#### 4.2.2 Overall block diagram

A block diagram of the applied systems should be given if necessary.

#### 4.2.3 Reference data

The most important properties that permit comparison between derivative types should be given.

#### 4.2.4 Electrical compatibility

It should be stated whether the integrated circuit is electrically compatible with other particular integrated circuits, or families of integrated circuits, or whether special interfaces are required.

Details should be given concerning the type of input and output circuits, e.g. input/output impedances, d.c. block, open-drain, etc. Interchangeability with other devices, if any, should also be given.

#### 4.2.5 Associated devices

If applicable, the following should be stated:

– devices necessary for correct operation (list with type number, name and function);
– peripheral devices with direct interfacing (list with type number, name and function).

### 4.3 Specification of the function

#### 4.3.1 Detailed block diagram – Functional blocks

A detail block diagram or equivalent circuit information of the integrated circuit microwave switches should be given. The block diagram should be composed of the following:

a) functional blocks;
b) mutual interconnections among the functional blocks;
c) individual functional units within the functional blocks;
d) mutual interconnections among the individual functional blocks;
e) function of each external connection;
f) inter-dependence between the separate functional blocks.

The block diagram should identify the function of each external connection and, where no ambiguity can arise, also show the terminal symbols and/or numbers. If the encapsulation has metallic parts, any connection to them from external terminals should be indicated. The connections with any associated external electrical elements should be stated, where necessary.

[A1) As additional information, the complete electrical circuit diagram can be reproduced, but not necessarily with indications of the values of the circuit components. The graphical symbol for the function shall be given. Rules governing such diagrams may be obtained from IEC 60617. (A1]

### 4.3.2 Identification and function of terminals

All terminals should be identified on the block diagram (supply terminals, input or output terminals, input/output terminals).

The terminal functions 1) to 4) should be indicated in a table as follows:

| Terminal number | Terminal symbol | 1) Terminal designation | 2) Function | Function of terminal | |
|---|---|---|---|---|---|
| | | | | 3) Input/output identification | 4) Type of input/ output circuits |
| | | | | | |

1) Terminal designation

   A terminal designation to indicate the function of the terminal should be given. Supply terminals, ground terminals, blank terminals (with abbreviation NC), non-usable terminals (with abbreviation NU) should be distinguished.

2) Function

   A brief indication of the terminal function should be given:

   – each function of multi-role terminals, i.e. terminals having multiple functions;

   – each function of integrated circuit selected by mutual pin connections, programming and/or application of function selection data to the function selection pin, such as mode selection pin.

3) Input/output identification

   Input, output, input/output and multiplex input/output terminals should be distinguished.

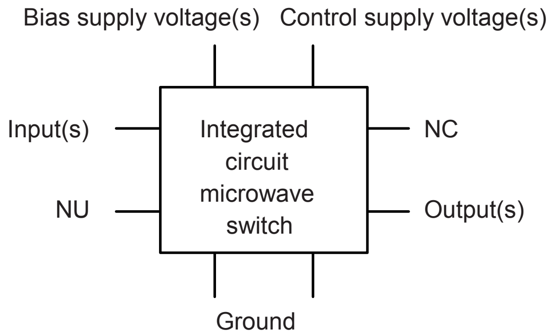
4) Type of input/output circuits

   The type of input and output circuit, e.g. input/output impedances, with or without d.c. block, etc., should be distinguished.

5) Type of ground

   If the baseplate of the package is used as ground, this should be stated.

   Example:



#### 4.3.3 Function description

The function performed by the circuit should be specified, including the following information:

- basic function;
- relation to external terminals;
- operation mode (e.g., set-up method, preference, etc.);
- interrupt handling.

#### 4.3.4 Family related characteristics

In this part, all the family specific functional descriptions shall be stated (referred to IEC 60748-2, IEC 60748-3 and IEC 60748-4).

If ratings and characteristics, as well as function characteristics exist for the family, the relevant part of IEC 60748 should be used (e.g. for microprocessors, see IEC 60748-2, Chapter III, Section Three).

NOTE For each new device family, specific items should be added the relevant part of IEC 60748.

### 4.4 Limiting values (absolute maximum rating system)

The table for these values should contain the following:

- Any interdependence of limiting conditions shall be specified.
- If externally connected and/or attached elements, for example heatsinks, have an influence on the values of the ratings, the ratings shall be prescribed for the integrated circuit with the elements connected and/or attached.
- If limiting values are exceeded for transient overload, the permissible excess and their durations shall be specified.
- Where minimum and maximum values differ during programming of the device, this should be stated.
- All voltages are referenced to a specified reference terminal ($V_{SS}$, ground, etc.).
- In satisfying the following clauses, if maximum and/or minimum values are quoted, the manufacturer shall indicate whether he refers to the absolute magnitude or to the algebraic value of the quantity.
- The ratings given shall cover the operation of the multi-function integrated circuit over the specified range of operating temperatures. Where such ratings are temperature-dependent, these dependence should be indicated.

#### 4.4.1 Electrical limiting values

Limiting values should be specified as follows:

| Subclause | Parameters | Min. | Max. |
|---|---|---|---|
| 4.4.1.1 | Bias supply voltage(s) (where appropriate) | | + |
| 4.4.1.2 | Bias supply current(s) (where appropriate) | | + |
| 4.4.1.3 | Control supply voltage(s) (where appropriate) | | + |
| 4.4.1.4 | Control supply current(s) (where appropriate) | | + |
| 4.4.1.5 | Terminal voltage(s) (where appropriate) | + | + |
| 4.4.1.6 | Terminal current(s) (where appropriate) | | + |
| 4.4.1.7 | Input power | | + |
| 4.4.1.8 | Power dissipation | | + |
| NOTE It is necessary to select either 4.4.1.1 or 4.4.1.2, either 4.4.1.3 or 4.4.1.4, and either 4.4.1.5 or 4.4.1.6. | | | |

The detail specification may indicate those values within the table including notes 1 and 2.

| Parameters (Note 1, Note 2) | Symbols | Min. | Max. | Unit |
|---|---|---|---|---|
| | | | | |

NOTE 1 Where appropriate, in accordance with the type of circuit considered.

NOTE 2 For power supply voltage range:

– limiting value(s) of the continuous voltage(s) at the supply terminal(s) with respect to a special electrical reference point;

– where appropriate, limiting value between specified supply terminals;

– when more than one voltage supply is required, a statement should be made as to whether the sequence in which these supplies are applied is significant: if so, the sequence should be stated;

– when more than one supply is needed, it may be necessary to state the combinations of ratings for these supply voltages and currents.

#### 4.4.2 Temperatures

[A1) a) Operating temperature (ambient or reference-point temperature)

b) Storage temperature

c) Channel temperature

d) Lead temperature (for soldering). (A1]

The detail specification may indicate those values within the table including the note.

| Parameters (Note) | Symbols | Min. | Max. | Unit |
|---|---|---|---|---|
| | | | | |

NOTE Where appropriate, in accordance with the type of circuit considered.

### 4.5 Operating conditions (within the specified operating temperature range)

They are not to be inspected, but may be used for quality assessment purposes.

#### 4.5.1 Power supplies – Positive and/or negative values

#### 4.5.2 Initialization sequences (where appropriate)

If special initialization sequences are necessary, power supply sequencing and initialization procedure should be specified.

#### 4.5.3 Input voltage(s) (where appropriate)

#### 4.5.4 Output current(s) (where appropriate)

#### 4.5.5 Voltage and/or current of other terminal(s)

#### 4.5.6 External elements (where appropriate)

#### 4.5.7 Operating temperature range

### 4.6 Electrical characteristics

[A1) The characteristics shall apply over the full operating temperature range, unless otherwise specified. Each characteristic should be stated either (A1]

a) over the specified range of operating temperatures, or

b) at a temperature of 25 °C, and at maximum and minimum operating temperatures.

The parameters should be specified corresponding to the type as follows:

| Subclause | Parameters | Min. | Typical[a] | Max. |
|---|---|---|---|---|
| 4.6.1 | Bias supply operating current | | + | + |
| 4.6.2 | Control supply operating current | | + | + |
| 4.6.3 | Insertion loss | | + | + |
| 4.6.4 | Isolation (where appropriate) | + | + | |
| 4.6.5 | Return loss | | + | + |
| 4.6.6[b] | Input power at 1 dB compression point (where appropriate) | + | + | |
| 4.6.7 | Output power at 1 dB compression point (where appropriate) | + | + | |
| 4.6.8 | Turn-on time | | + | + |
| 4.6.9 | Turn-off time | | + | + |
| 4.6.10 | Rise time (where appropriate) | | + | + |
| 4.6.11 | Fall time (where appropriate) | | + | + |
| [A1⟩ 4.6.12 | Adjacent channel power ratio (where appropriate) | + | + | |
| 4.6.13 | *n*th order harmonic distortion ratio (where appropriate) | + | + | ⟨A1] |

[a] Optional.
[b] It is necessary to select either 4.6.6 or 4.6.7.

The detail specification may indicate those values within the table.

| Characteristics | Symbols | Conditions | Min. | Typical[a] | Max. | Units |
|---|---|---|---|---|---|---|
| | | | | | | |

[a] Optional.

### 4.7 Mechanical and environmental ratings, characteristics and data

[A1⟩ Any specific mechanical and environmental ratings applicable should be stated (see also 5.10 and 5.11 of IEC 60747-1). ⟨A1]

### 4.8 Additional information

Where appropriate, the following information should be given:

#### 4.8.1 Equivalent input and output circuit

Detail information should be given regarding the type of input and output circuits, e.g. input/output impedances, d.c. block, open-drain, etc.

#### 4.8.2 Internal protection

A statement shall be given to indicate whether the integrated circuit contains internal protection against high static voltages or electrical fields.

#### 4.8.3 Capacitors at terminals

If capacitors for the input/output d.c. block are needed, these capacitances should be stated.

#### 4.8.4 Thermal resistance

#### 4.8.5 Interconnections to other types of circuit

Where appropriate, details of the interconnections to other circuits should be given.

#### 4.8.6 Effects of externally connected component(s)

Curves or data indicating the effect of externally connected component(s) that influence the characteristics may be given.

#### 4.8.7 Recommendations for any associated device(s)

For example, decoupling of power supply to a high-frequency device should be stated.

#### 4.8.8 Handling precautions

[A1⟩ Where appropriate, handling precautions specific to the circuit should be stated (see also IEC 61340-5-1 and IEC 61340-5-2, concerning electrostatic-sensitive devices. ⟨A1]

#### 4.8.9 Application data

#### 4.8.10 Other application information

#### 4.8.11 Date of issue of the data sheet

## 5 Measuring methods

### 5.1 General

This clause prescribes measuring methods for electrical characteristics of integrated circuit microwave switches used at microwave frequency bands.

#### 5.1.1 General precautions

The general precautions listed in [A1⟩ 6.3, 6.4 and 6.6 of IEC 60747-1:2006 apply ⟨A1]. In addition, special care should be taken to use low-ripple d.c. supplies and to decouple adequately all bias supply voltages at the frequency of measurement. Although the level of the input and/or output signal can be specified in either power or voltage, in this standard it is expressed in power, unless otherwise specified.

#### 5.1.2 Characteristic impedances

The input and output characteristic impedances of the measurement system, shown in the circuit in this standard, are 50 Ω. If they are not 50 Ω, they should be specified.

#### 5.1.3 Handling precautions

[A1⟩ When handling electrostatic-sensitive devices, the handling precautions given in IEC 61340-5-1 and IEC 61340-5-2, shall be observed. ⟨A1]

#### 5.1.4 Types

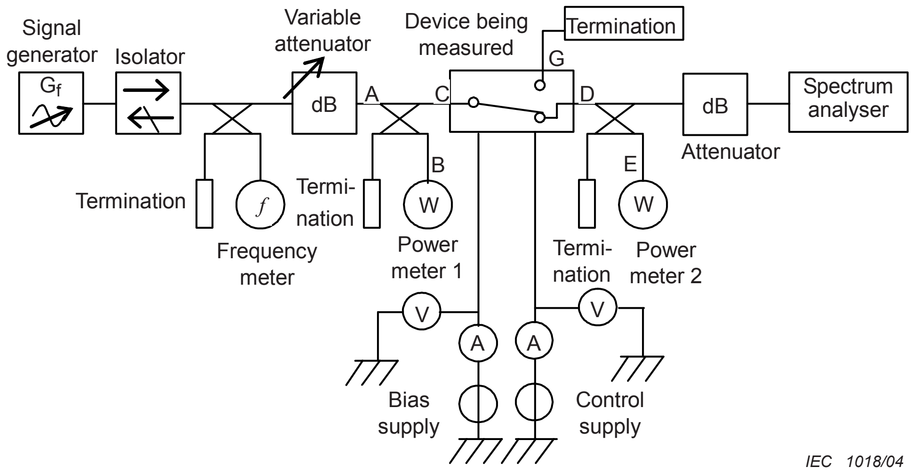
The devices in this standard are both packaged and chip types, measured using suitable test fixtures.

### 5.2 Insertion loss ($L_{ins}$)

#### 5.2.1 Purpose

To measure the insertion loss under specified conditions.

#### 5.2.2 Circuit diagram




NOTE 1 Connect the point C to the input port, the point D to one of the output ports, and the point G to the other output port of the device being measured.

NOTE 2 The control bias is supplied to become ON between the point C and D.

**Figure 1 – Circuit diagram for the measurement of the insertion loss $L_{ins}$**

#### 5.2.3 Principle of measurement

Insertion loss $L_{ins}$ is derived from the input power $P_i$ in dBm and the output power $P_o$ in dBm of the device being measured as follows:

$$L_{ins} = P_i - P_o \quad (1)$$

In the circuit diagram shown in Figure 1, $P_i$ and $P_o$ are derived from the following equations:

$$P_i = P_1 - L_1 \quad (2)$$

$$P_o = P_2 + L_2 \quad (3)$$

where

$P_1$ is the value indicated by the power meter 1;

$P_2$ is the value indicated by the power meter 2;

$L_1$ is the power at the point B in dBm, less the power at the point C in dBm;

$L_2$ is the power at the point D in dBm, less the power at the point E in dBm.

$P_i$, $P_o$, $P_1$ and $P_2$ are expressed in dBm. $L_{ins}$, $L_1$ and $L_2$ are expressed in dB.

### 5.2.4 Circuit description and requirements

The purpose of the isolator is to enable the power level to the device being measured to be kept constant, irrespective of impedance mismatched at its input. The value of $L_1$ and $L_2$ should be measured beforehand.

### 5.2.5 Precautions to be observed

Harmonics or spurious responses from the signal generator should be reduced so as to be negligible. Insertion loss $L_{ins}$ shall be measured without the influence at the input and output ports.

### 5.2.6 Measurement procedure

The frequency of the signal generator shall be set to the specified value.

[A1) The bias under specified conditions is applied. (A1]

An adequate input power shall be applied to the device being measured.

By varying the input power, confirm that a change of output power in dBm is the same as that of the input power.

The value $P_1$ is measured at the power meter 1.

The value $P_2$ is measured at the power meter 2.

[A1) The insertion loss is calculated from Equations (2), (3) and (1). (A1]

### 5.2.7 Specified conditions

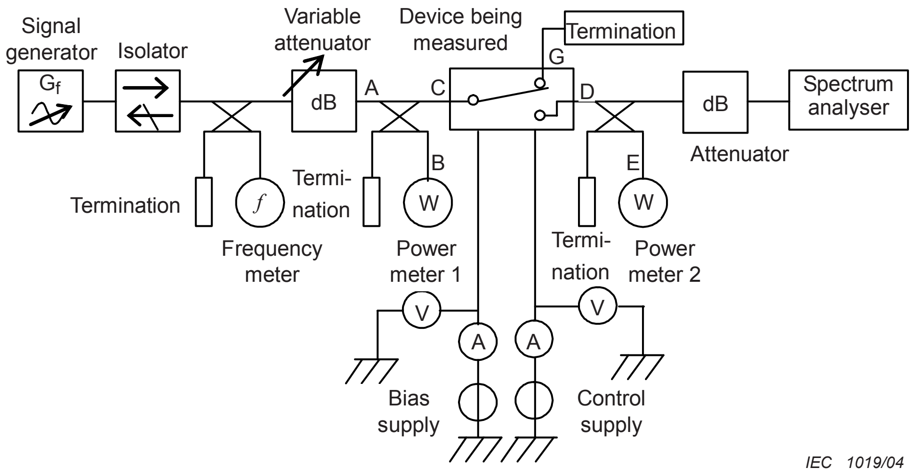
– Ambient or reference-point temperature
– Bias conditions
– Frequency.

## 5.3 Isolation ($L_{iso}$)

### 5.3.1 Purpose

To measure the isolation between the input and output ports under specified conditions.

### 5.3.2 Circuit diagram




NOTE 1 Connect the point C to the input port, the point D to one of the output ports, and the point G to the other output port of the device being measured.

NOTE 2 The control bias is supplied to become ON between the point C and G.

**Figure 2 – Circuit diagram for the measurement of the isolation $L_{iso}$**

The following description is for the measurement of the isolation between points C and D in Figure 2. The isolation between points D and G is also able to be measured in the same way.

### 5.3.3 Principle of measurement

Isolation $L_{iso}$ is derived from the input power $P_i$ in dBm and the output power $P_o$ in dBm of the device being measured as follows:

$$L_{iso} = P_i - P_o \quad (4)$$

In the circuit diagram shown in Figure 2, $P_i$ and $P_o$ are derived from the following equations:

$$P_i = P_1 - L_1 \quad (5)$$

$$P_o = P_2 + L_2 \quad (6)$$

where

$P_1$ is the value indicated by the power meter 1;

$P_2$ is the value indicated by the power meter 2;

$L_1$ is the power at the point B in dBm, less the power at the point C in dBm;

$L_2$ is the power at the point D in dBm, less the power at the point E in dBm.

$P_i$, $P_o$, $P_1$ and $P_2$ are expressed in dBm. $L_{iso}$, $L_1$, and $L_2$ are expressed in dB.

### 5.3.4 Circuit description and requirements

See the circuit description and requirements described in 5.2.4.

### 5.3.5 Precautions to be observed

Harmonics or spurious responses of the signal generator should be reduced to be negligible. Isolation $L_{iso}$ shall be measured without the influence at the input and output ports.

### 5.3.6 Measurement procedure

The frequency of the signal generator shall be set to the specified value.

[A1] The bias under specified conditions is applied. [A1]

An adequate input power shall be applied to the device being measured.

By varying the input power, confirm the change of the output power in dBm is the same as that of the input power.

The value $P_1$ is measured at the power meter 1.

The value $P_2$ is measured at the power meter 2.

[A1] The isolation is calculated from Equations (5), (6) and (4). [A1]

### 5.3.7 Specified conditions

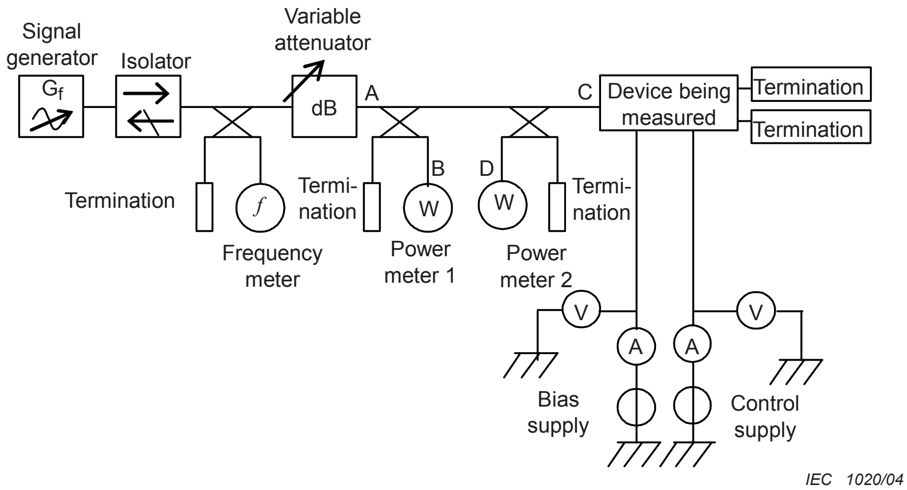
– Ambient or reference-point temperature
– Bias conditions
– Frequency.

### 5.4 Return loss ($L_{ret}$)

#### 5.4.1 Purpose

To measure the return loss under specified conditions.

#### 5.4.2 Circuit diagram




NOTE 1 Connect point C to the port to be measured and terminate the other ports of the device being measured.

NOTE 2 The control bias is supplied to become ON or OFF for the port to be measured.

**Figure 3 – Circuit for the measurements of the return loss**

#### 5.4.3 Principle of measurement

The return loss $L_{ret}$ (dB) is derived from the following equation:

$$L_{ret} = P_1 - P_2 \quad (7)$$

In the circuit diagram shown in Figure 3, the input power is derived from the following equation:

$$P_i = P_a - L_1 \quad (8)$$

where

$P_1$ is the value indicated by the power meter 2 when the point C is either short-circuited or made open-circuit;

$P_2$ is the value indicated by the power meter 2 when the device being measured is inserted;

$P_i$ is the input power at the point C;

$P_a$ is the value indicated by the power meter 1;

$L_1$ is the power at the point B, less the power at the point C.

$P_1$, $P_2$, $P_i$ and $P_a$ are expressed in dBm, $L_{ret}$ and $L_1$ are expressed in dB.

#### 5.4.4 Circuit description and requirements

The purpose of the isolator is to enable the power level to the device being measured to be kept constant irrespective of impedance mismatches at its input. The value of $L_1$ should be measured beforehand.

### 5.4.5 Precautions to be observed

See the precautions to be observed of 5.2.5.

### 5.4.6 Measurement procedure

The point C is either short-circuited or made open-circuit.

The frequency of the signal generator shall be set to the specified value.

An adequate input power shall be applied to the device being measured.

By varying the input power, confirm the change of the output power in dBm is the same as that of the input power.

The power $P_1$ is measured by the power meter 2.

The specified port of the device being measured is connected with the point C.

[A1⟩ The bias under specified conditions is applied. ⟨A1]

The power $P_2$ is measured by the power meter 2.

The return loss $L_{ret}$ is calculated from Equation (7).

### 5.4.7 Specified conditions

– Ambient or reference-point temperature
– Bias conditions
– Frequency
– Port being measured.

### 5.5 Input power at 1 dB compression ($P_{i(1dB)}$) and output power at 1 dB compression ($P_{o(1dB)}$)

#### 5.5.1 Purpose

To measure the input power and the output power at 1 dB compression under specified conditions.

#### 5.5.2 Circuit diagram

See the circuit diagram described in 5.2.2.

#### 5.5.3 Principle of measurement

[A1) See the principle of measurement of 5.2.3. The input power at 1 dB compression $P_{i(1dB)}$ and the output power at 1 dB compression $P_{o(1dB)}$ are the powers where the ratio of input power to output power increases by 1dB compared with $L_{ins}$. (A1]

#### 5.5.4 Circuit description and requirements

See the circuit description and requirements described in 5.2.4.

#### 5.5.5 Precaution to be observed

See the precaution to be observed described in 5.2.5.

#### 5.5.6 Measurement procedure

The frequency of the signal generator shall be set to the specified value.

[A1) The bias under specified conditions is applied. (A1]

An adequate input power shall be applied to the device being measured.

By varying the input power, confirm that a change of output power in dB is the same as that of input power.

The values of $P_1$ and $P_2$ are measured at the power meter 1 and the power meter 2, respectively.

The insertion loss, $L_{ins}$, is calculated from Equations (1), (2) and (3).

[A1) The input power is increased up to the ratio of the input power to the output power increases by 1dB, compared with $L_{ins}$. (A1]

The power level $P_1$ and $P_2$ are measured.

The input power at 1 dB compression $P_{i(1dB)}$ is calculated from Equation (2).

The output power at 1 dB compression $P_{o(1dB)}$ is calculated from Equation (3).

#### 5.5.7 Specified conditions

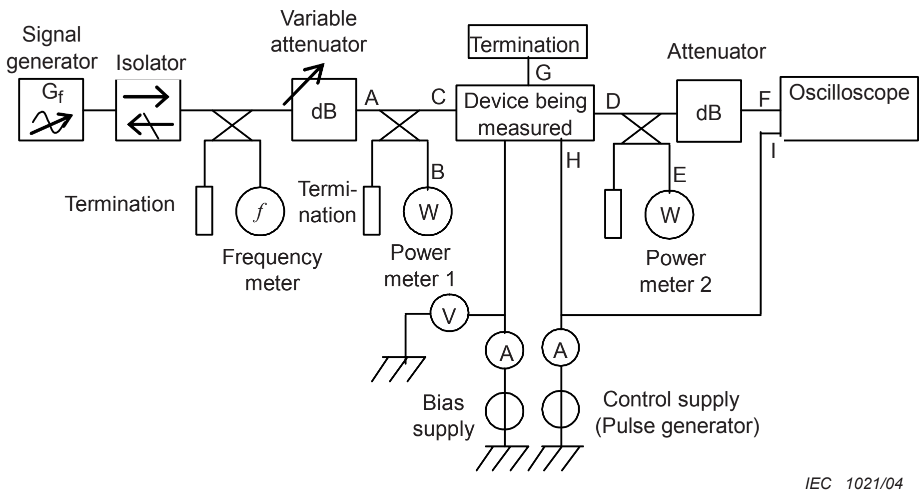
– Ambient or reference-point temperature
– Bias conditions
– Frequency.

### 5.6 Turn-on time ($t_{on}$), turn-off time ($t_{off}$), rise time ($t_{r(out)}$), and fall time ($t_{f(out)}$)

#### 5.6.1 Purpose

To measure the turn-on time, the turn-off time, the rise time, and the fall time under specified conditions.

#### 5.6.2 Circuit diagram



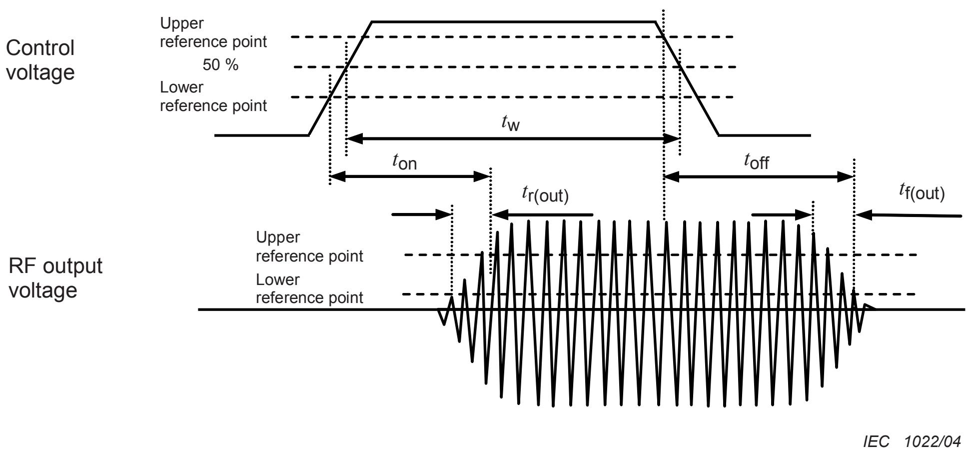

NOTE 1 Connect point C to the input port, point D to one of the output ports, and point G to the other output port of the device being measured.

NOTE 2 The control bias is supplied by the pulse generator to become ON and OFF between points C and D.

**Figure 4 – Circuit for the measurements of switching times**

#### 5.6.3 Principle of measurement

Turn-on time $t_{on}$, turn-off time $t_{off}$, rise time $t_{r(out)}$ and fall time $t_{f(out)}$ are illustrated in Figure 5.




A1) NOTE $t_w$: Average pulse duration. Determined as the pulse duration at 50 % relative pulse amplitude of the control voltage. (A1

**Figure 5 – Input and output waveforms**

Turn-on time $t_{on}$ is derived from the interval $t_{on,IF}$ between the lower reference point on the leading edge of the control voltage and the upper reference point on the leading edge of the envelope of the RF output voltage between point I and F, the RF signal delay $t_{d,DF}$ between points D and F, and the control signal delay $t_{d,HI}$ between the point H and I as follows:

$$t_{on} = t_{on,IF} - t_{d,DF} + t_{d,HI} \quad (9)$$

Turn-off time $t_{off}$ is derived from the interval $t_{off,IF}$ between the upper reference point on the trailing edge of the control voltage and the lower reference point on the trailing edge of the envelope of the RF output voltage between the point I and F, the RF signal delay $t_{d,DF}$ between the point D and F, and the control signal delay $t_{d,HI}$ between the point H and I as follows:

$$t_{off} = t_{off,IF} - t_{d,DF} + t_{d,HI} \qquad (10)$$

Rise time $t_{r(out)}$ is determined as the interval between the lower reference point and the upper reference point of the envelope of the RF output voltage.

Fall time $t_{f(out)}$ is determined as the interval between the upper reference point and the lower reference point of the envelope of the RF output voltage.

$t_{on,IF}$, $t_{d,DF}$, $t_{d,HI}$, $t_{off,IF}$, $t_{d,DF}$, $t_{d,HI}$, $t_{r(out)}$ and $t_{f(out)}$ are the values indicated by the oscilloscope.

[A1) *Note deleted* (A1]

### 5.6.4 Circuit description and requirements

The purpose of the isolator is to enable the power level to the device being measured to be kept constant, irrespective of impedance mismatched at its input. A pulse generator should be used as the control supply. The values of $t_{d,DF}$ and $t_{d,HI}$ should be measured beforehand.

### 5.6.5 Precautions to be observed

Harmonics or spurious responses from the signal generator should be reduced so as to be negligible.

### 5.6.6 Measurement procedure

The frequency of the signal generator shall be set to the specified value.

[A1) The bias under specified conditions is applied. (A1]

The control voltage is supplied so as to become ON between points C and D.

An adequate input power shall be applied to the device being measured.

By varying the input power, confirm that a change of output power in dBm is the same as that of the input power.

The control bias is supplied so as to become ON and OFF between points C and D by applying the specified amplitude and average pulse duration of the control voltage from the pulse generator.

$t_{on,IF}$ and $t_{off,IF}$ are measured by the oscilloscope.

$t_{on}$ and $t_{off}$ are calculated from Equations (9) and (10).

$t_{r(out)}$ and $t_{f(out)}$ are measured by the oscilloscope.

### 5.6.7 Specified conditions

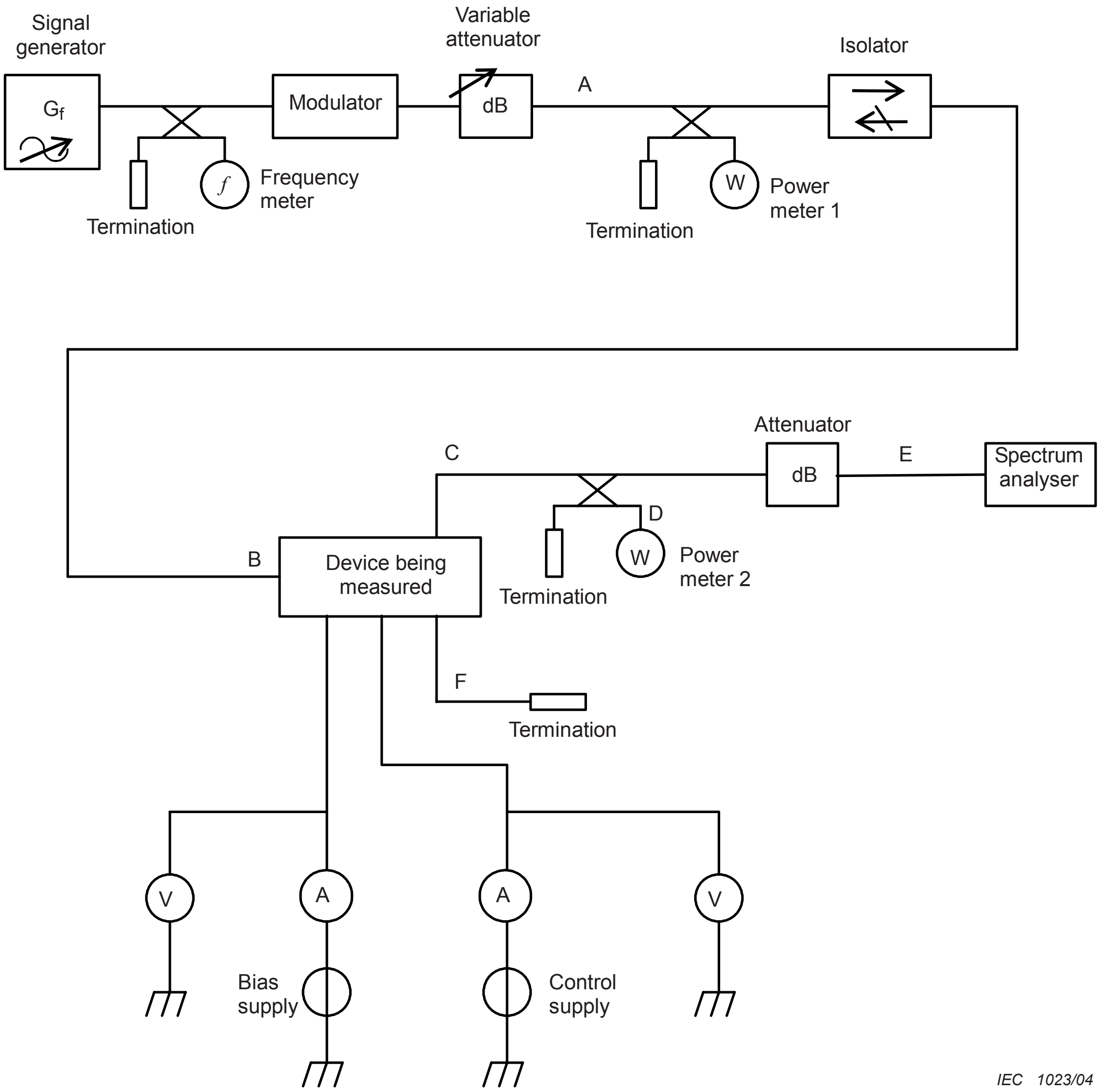
- Ambient or reference-point temperature
- Bias conditions
- Amplitude of the control voltage
- Average pulse duration of the control voltage
- Frequency.

### 5.7 Adjacent channel power ratio ($P_{o(mod)}/P_{adj}$)

#### 5.7.1 Purpose

To measure the adjacent channel power ratio under the specified conditions.

#### 5.7.2 Circuit diagram




NOTE 1 Connect point B to the input port, point C to one of the output ports, and point F to the other output port of the device being measured.

NOTE 2 The control bias is supplied to become ON between points B and C.

**Figure 6 – Circuit for the measurement of the adjacent channel power ratio**

#### 5.7.3 Principle of measurements

Under the condition that the modulated signal is supplied for the device being measured in order to obtain the specified output power ($P_o$), $P_{adj}$ is the total output power in the specified bandwidth at the specified frequency away from the carrier signal, and $P_{o(mod)}$ is the total output power in the specified bandwidth at the carrier signal. Adjacent channel power ratio $P_{o(mod)}/P_{adj}$ is the ratio of $P_{o(mod)}$ to the $P_{adj}$. The adjacent channels are in both upper side band and lower side band of the carrier. The modulation signal is the carrier signal modulated with standard test signal having same rate as specified code transmission rate.

$P_{o(mod)} / P_{adj}$ is given as the following equation in the circuit of Figure 6:

$$P_o = P_1 + L_1 \quad (11)$$

$$P_{o(mod)} = P_2 + L_2 \quad (12)$$

$$P_{adj} = P_3 + L_2 \quad (13)$$

$$P_{o(mod)} / P_{adj} = P_{o(mod)} - P_{adj} = P_2 - P_3 \quad (14)$$

where

$P_1$ is the value indicated by the power meter 1;

$P_2$ is the value of total power in the specified bandwidth at the carrier signal indicated by the spectrum analyser;

$P_3$ is the value of total output power in the specified channel bandwidth at the specified frequency that is equal to the channel spacing away from the carrier signal indicated by the spectrum analyser;

$L_1$ is the power at point C in dBm, less the power at point D in dBm;

$L_2$ is the power at point C in dBm, less the power at point E in dBm.

$P_o$, $P_{o(mod)}$, $P_{adj}$, $P_1$, $P_2$ and $P_3$ are expressed in dBm;

$L_1$ and $L_2$ are expressed in dB;

$P_{o(mod)} / P_{adj}$ is expressed in dB.

### 5.7.4 Circuit description and requirement

The circuit losses $L_1$ and $L_2$ should be measured beforehand.

### 5.7.5 Precautions to be observed

The output signal and oscillation should be checked by the spectrum analyser. Oscillation should be eliminated during these measurements. Harmonics or spurious responses of the signal generator should be reduced so as to be negligible. An adequate attenuator should be inserted at the input of the spectrum analyser when the output power is high.

### 5.7.6 Measurement procedure

The frequency of the signal generator shall be set to the specified value.

[A1) The bias under specified conditions is applied. (A1]

An adequate input power shall be applied to the device being measured.

The following items of the modulator are set to the specified values according to the standard code of the test signal: modulation method, signal transmission rate and modulation bandwidth.

The following items of the spectrum analyser are set to the specified values: carrier frequency, sweep range, resolution bandwidth, video bandwidth, number of sampling and sweep time.

The value of $P_1$ is measured at the power meter 1.

Output power of the device being measured $P_o$ is calculated from Equation (11).

By adjusting the variable attenuator, $P_o$ is set to the specified value.

The channel spacing and the channel bandwidth are set to the specified values.

The values of $P_2$ and $P_3$ are measured at the spectrum analyser.

$P_{o(mod)}$, $P_{adj}$ are calculated from Equations (12) and (13).

Adjacent channel power ratio $P_{o(mod)} / P_{adj}$ is calculated from Equation (14).

NOTE The display of the spectrum analyser is set to maximum hold mode. The detection mode of the spectrum analyser is set to positive peak mode.

### 5.7.7 Specified conditions

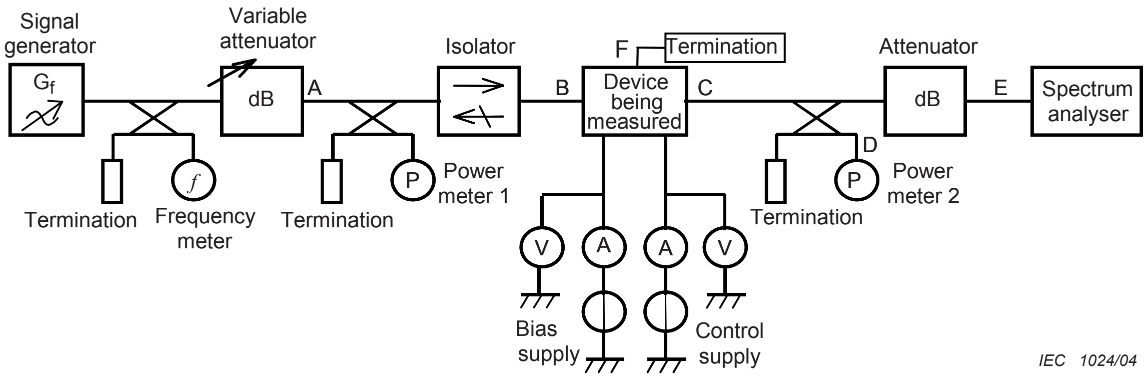
- Ambient or reference-point temperature
- Bias conditions
- Frequency (carrier frequency)
- Output power
- Standard code of the test signal:
  - channel spacing
  - channel bandwidth
  - modulation method
  - signal transmission rate
  - modulation bandwidth
- Spectrum analyser:
  - sweep range
  - resolution bandwidth
    * video bandwidth of a spectrum analyser
    * sampling numbers of a spectrum analyser
    * sweep time of a spectrum analyser.

## A1 5.8 *n*th order harmonic distortion ratio ($P_1/P_{nth}$) A1

### 5.8.1 Purpose

To measure the n-th order harmonic distortion ratio under specified conditions.

### 5.8.2 Circuit diagram




NOTE 1 Connect point B to the input port, point C to one of the output ports, and point F to the other output port of the device being measured.

NOTE 2 The control bias is supplied to become ON between points B and C.

**Figure 7 – Circuit diagram for the n-th order harmonic distortion ratio**

### 5.8.3 Principle of measurements

A1 The *n*th order harmonic distortion ratio $P_1/P_{nth}$ is the ratio of the power of the fundamental frequency to the power of the *n*th order harmonic components measured at the output port of the device. The $P_1/P_{nth}$ is derived from the following equations: A1

$$P_{o(1st)} = P_{E(1st)} + L_{(1st)} \quad (15)$$

$$P_{o(nth)} = P_{E(nth)} + L_{(nth)} \quad (16)$$

A1 $$P_1/P_{nth} = P_{o(1st)} - P_{o(nth)} \quad (17)$$ A1

where

$P_{E(1st)}$ is the value indicated by the spectrum analyser (at point E) for the fundamental frequency;

$P_{E(nth)}$ is the value indicated by the spectrum analyser (at point E) for the n-th order harmonic components;

$L_{(1st)}$ is the power attenuation, including circuit loss from points C to E, for the fundamental frequency;

$L_{(nth)}$ is the power attenuation, including circuit loss from points C to E, for the n-th order harmonic components.

A1 $P_1/P_{nth}$, $P_{o(1st)}$, $P_{o(nth)}$, $P_{E(1st)}$ and $P_{E(nth)}$ are expressed in dBm. $L_{(1st)}$ and $L_{(nth)}$ are expressed in dB. A1

### 5.8.4 Circuit description and requirements

Circuit losses $L_{(1st)}$ and $L_{(nth)}$ should be measured beforehand.

### 5.8.5 Measurement procedure

The frequency of the signal generator shall be set to the specified value.

[A1) The bias under specified conditions is applied. (A1]

The specified input power ($P_i$) shall be supplied to the device being measured.

The values of $P_{E(1st)}$ and $P_{E(nth)}$ are measured by the spectrum analyser.

[A1) The n-th order harmonic distortion ratio $P_1/P_{n\text{th}}$ is calculated from Equations (15), (16) and (17). (A1]

[A1) *Text deleted* (A1]

### 5.8.6 Specified conditions

- Ambient or reference-point temperature
- Bias conditions
- Frequency (fundamental frequency)
- Input power.

## Annex ZA
(normative)

### Normative references to international publications with their corresponding European publications

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

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

| Publication | Year | Title | EN/HD | Year |
|---|---|---|---|---|
| IEC 60617 | - | Standard data element types with associated classification scheme for electric components - Part 4: IEC reference collection of standard data element types and component classes | - | - |
| IEC 60747-1 | 2006 | Semiconductor devices - Part 1: General | - | - |
| IEC 60747-4 | - | Semiconductor devices - Discrete devices - Part 4: Microwave diodes and transistors | - | - |
| IEC 60747-16-1<br>+ A1 | 2001<br>2007 | Semiconductor devices - Part 16-1: Microwave integrated circuits - Amplifiers | EN 60747-16-1<br>+ A1 | 2002<br>2007 |
| IEC 60748-2-1 | - | Semiconductors devices - Integrated circuits - Part 2: Digital integrated circuits - Section one - Blank detail specification for bipolar monolithic digital integrated circuit gates (excluding uncommitted logic arrays) | - | - |
| IEC 60748-3 | - | Semiconductors devices - Integrated circuits - Part 3: Analogue integrated circuits | - | - |
| IEC 60748-4 | - | Semiconductor devices - Integrated circuits - Part 4: Interface integrated circuits | - | - |
| IEC 61340-5-1 | 2007 | Electrostatics - Part 5-1: Protection of electronic devices from electrostatic phenomena - General requirements | EN 61340-5-1 | 2007 |
| IEC/TR 61340-5-2 | 2007 | Electrostatics - Part 5-2: Protection of electronic devices from electrostatic phenomena - User guide | CLC/TR 61340-5-2 | 2008 |

[A1⟩ *Text deleted* ⟨A1]

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