

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Semiconductor devices –
Part 16-7: Microwave integrated circuits – Attenuators**

**Dispositifs à semiconducteurs –
Partie 16-7: Circuits intégrés hyperfréquences – Atténuateurs**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2022 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, ...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch

Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Semiconductor devices –
Part 16-7: Microwave integrated circuits – Attenuators**

**Dispositifs à semiconducteurs –
Partie 16-7: Circuits intégrés hyperfréquences – Atténuateurs**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.080.99

ISBN 978-2-8322-6116-3

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms and definitions	7
4 Essential ratings and characteristics.....	10
4.1 General requirements	10
4.1.1 Circuit identification and types	10
4.1.2 General function description	11
4.1.3 Manufacturing technology	11
4.1.4 Package identification.....	11
4.2 Application description	11
4.2.1 Conformance to system and/or interface information	11
4.2.2 Overall block diagram	11
4.2.3 Reference data	11
4.2.4 Electrical compatibility	11
4.2.5 Associated devices	12
4.3 Specification of the function	12
4.3.1 Detailed block diagram – Functional blocks	12
4.3.2 Identification and function of terminals.....	12
4.3.3 Function description	13
4.4 Limiting values (absolute maximum rating system).....	13
4.4.1 Requirements	13
4.4.2 Electrical limiting values	13
4.4.3 Temperatures	14
4.5 Operating conditions (within the specified operating temperature range).....	15
4.6 Electrical characteristics	15
4.7 Mechanical and environmental ratings, characteristics and data	15
4.8 Additional information	16
5 Measuring methods	16
5.1 General.....	16
5.1.1 General precautions	16
5.1.2 Characteristic impedance	16
5.1.3 Handling precautions	16
5.1.4 Types	16
5.2 Transmission loss (L_{trans}) and insertion loss (L_{ins}).....	17
5.2.1 Purpose	17
5.2.2 Measuring methods	17
5.3 Attenuation value (A_{att}).....	20
5.3.1 Purpose	20
5.3.2 Measuring methods	20
5.4 Attenuation range (A_{ran}).....	22
5.4.1 Purpose	22
5.4.2 Measuring methods	22
5.5 Attenuation accuracy (A_{aur}), Attenuation accuracy (RMS) ($A_{aur(RMS)}$)	24
5.5.1 Purpose	24
5.5.2 Measuring methods	24

5.6	Input return loss ($L_{\text{ret(in)}}$)	26
5.6.1	Purpose	26
5.6.2	Measuring methods	26
5.7	Output return loss ($L_{\text{ret(out)}}$)	29
5.7.1	Purpose	29
5.7.2	Measuring methods	29
5.8	Input power at n dB compression ($P_{i(\text{ndB})}$).....	31
5.8.1	Purpose	31
5.8.2	Circuit diagram	31
5.8.3	Principle of measurement	31
5.8.4	Circuit description and requirements	31
5.8.5	Precautions to be observed	31
5.8.6	Measurement procedure	31
5.8.7	Specified conditions.....	31
5.9	Intermodulation distortion (two-tone)(P_n/P_1)	32
5.9.1	Purpose	32
5.9.2	Circuit diagram	32
5.9.3	Principle of measurement	32
5.9.4	Circuit description and requirements	33
5.9.5	Precautions to be observed	33
5.9.6	Measurement procedure	33
5.9.7	Specified conditions.....	33
5.10	Power at the intercept point (for intermodulation products) ($P_n(\text{IP})$)	34
5.10.1	Purpose	34
5.10.2	Circuit diagram	34
5.10.3	Principle of measurement	34
5.10.4	Circuit description and requirements	34
5.10.5	Precautions to be observed	34
5.10.6	Measurement procedure	34
5.10.7	Specified conditions.....	34
5.11	Relative phase shift (θ_{rel})	35
5.11.1	Purpose	35
5.11.2	Circuit diagram	35
5.11.3	Principle of measurement	35
5.11.4	Circuit description and requirements	35
5.11.5	Precautions to be observed	35
5.11.6	Measurement procedure	36
5.11.7	Specified conditions.....	36
5.12	Turn on time(t_{on}), turn off time(t_{off}), rise time($t_{\text{r(out)}}$), fall time($t_{\text{f(out)}}$)	36
5.12.1	Purpose	36
5.12.2	Circuit diagram	36
5.12.3	Principle of measurement	36
5.12.4	Circuit description and requirements	38
5.12.5	Precautions to be observed	38
5.12.6	Measurement procedure	38
5.12.7	Specified conditions.....	38
5.13	Control voltage sensitivity (S_{vcont}).....	38

5.13.1	Purpose	38
5.13.2	Measuring methods	38
Bibliography		41
Figure 1	– Circuit diagram for the measurement of the transmission loss and insertion loss (method 1)	17
Figure 2	– Circuit diagram for the measurement of the scattering parameters	19
Figure 3	– Circuit diagram for the measurement of the return loss (method 1)	27
Figure 4	– Circuit diagram for the measurement of intermodulation distortion	32
Figure 5	– Circuit diagram for the measurement of response times and switching times	36
Figure 6	– Input and output waveforms	37
Table 1	– Function of terminals	12
Table 2	– Electrical limiting values	14
Table 3	– Electrical limiting values in detail specification	14
Table 4	– Temperatures	14
Table 5	– Electrical characteristics	15

INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES –

**Part 16-7: Microwave integrated circuits –
Attenuators**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 60747-16-7 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
47E/794/FDIS	47E/798/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 60747 series, published under the general title *Semiconductor devices*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

SEMICONDUCTOR DEVICES –

Part 16-7: Microwave integrated circuits – Attenuators

1 Scope

This part of IEC 60747 specifies the terminology, essential ratings and characteristics, and measuring methods of microwave integrated circuit attenuators.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60747-1:2006, *Semiconductor devices – Part 1: General*
IEC 60747-1:2006/AMD 1:2010

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

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

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <https://www.electropedia.org/>
- ISO Online browsing platform: available at <https://www.iso.org/obp>

3.1

reference state

thru state

state of minimum attenuation

3.2

attenuation state

state in which the attenuation is greater than that in the reference state

3.3 transmission loss

L_{trans}

ratio of the input power to the output power, in the linear region of the power transfer curve
 $P_o(\text{dBm}) = f(P_i)$

Note 1 to entry: In this region, $\Delta P_o(\text{dBm}) = \Delta P_i(\text{dBm})$.

Note 2 to entry: Usually the transmission loss is expressed in decibels.

3.4 insertion loss

L_{ins}

ratio of the input power to the output power, in the linear region of the power transfer curve
 $P_o(\text{dBm}) = f(P_i)$ in the reference state

Note 1 to entry: In this region, $\Delta P_o(\text{dBm}) = \Delta P_i(\text{dBm})$.

Note 2 to entry: Usually the insertion loss is expressed in decibels.

[SOURCE: IEC 60747-16-4:2004/AMD 1:2009, 3.1, modified – “at the switched on port” has been deleted and “in the reference state” has been added.]

3.5 attenuation value

A_{att}

difference between the insertion loss and the transmission loss in the attenuation state

3.6 attenuation range

A_{ran}

difference between the maximum and minimum attenuation value

3.7 attenuation accuracy

A_{aur}

maximum difference between the measured and the nominal attenuation values

3.8 attenuation accuracy (RMS)

$A_{\text{aur}}(\text{RMS})$

root-mean-square value of the attenuation accuracy

3.9 input return loss

$L_{\text{ret(in)}}$

ratio of the incident power at the input port to the reflected power at the input port

[SOURCE: IEC 60747-16-6:2019, 3.4]

3.10 output return loss

$L_{\text{ret(out)}}$

ratio of the incident power at the output port to the reflected power at the output port

[SOURCE: IEC 60747-16-6:2019, 3.5]

3.11**input power at n dB compression** $P_{i(ndB)}$

input power where the transmission loss increases by n dB compared with transmission loss in linear region

Note 1 to entry: Usually n is 0,25 for voltage variable attenuators and 0,1 for digital step attenuators.

3.12**intermodulation distortion** P_n/P_1

ratio of the n th order component of the output power to the fundamental component of the output power

Note 1 to entry: The abbreviation “ IMD_n ” is in common use for the n th order intermodulation distortion.

[SOURCE: IEC 60747-4:2007/AMD1:2017, 7.2.19]

3.13**power at the intercept point (for intermodulation products)** $P_{n(IP)}$

output power at intersection between the extrapolated output powers of the fundamental component and the n th order intermodulation components, when the extrapolation is carried out in a diagram showing the output power of the components (in decibels) as a function of the input power (in decibels)

[SOURCE: IEC 60747-16-1:2001, 3.8]

3.14**relative phase shift** θ_{rel}

phase shift in the attenuation state relative to that in the reference state

3.15**switching time****3.15.1****turn on time** t_{on}

interval between the reference point on the leading edge of the control voltage and the reference point on the trailing edge of the envelope of the output voltage in the linear region of the power transfer curve $P_o(\text{dBm}) = f(P_i)$ when the state of attenuator changes from the reference state to the attenuation state

Note 1 to entry: In this region, $\Delta P_o(\text{dBm}) = \Delta P_i(\text{dBm})$.

Note 2 to entry: Usually the reference point is 50 % of the amplitude.

[SOURCE: IEC 60747-16-4:2004, 3.6, modified – Note 2 has been added, “the lower reference point” has been replaced by “the reference point”, “the upper reference point on the leading edge” has been replaced by “the reference point on the trailing edge” and “when the state of attenuator changes from the reference state to the attenuation state” has been added]

3.15.2 turn off time

t_{off}

interval between the reference point on the trailing edge of the control voltage and the reference point on the leading edge of the envelope of the output voltage in the linear region of the power transfer curve $P_o(\text{dBm}) = f(P_i)$ when the state of attenuator changes from the attenuation state to the reference state

Note 1 to entry: In this region, $\Delta P_o(\text{dBm}) = \Delta P_i(\text{dBm})$.

Note 2 to entry: Usually the reference is 50% of the amplitude.

[SOURCE: IEC 60747-16-4:2004, 3.7, modified – Note 2 has been added, “the upper reference point” has been replaced by “the reference point”, “the lower reference point on the trailing edge” has been replaced by “the reference point on the leading edge” and “when the state of attenuator changes from the attenuation state to the reference state” has been added]

3.16 response time

3.16.1 rise time

$t_{r(\text{out})}$

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 $P_o(\text{dBm}) = f(P_i)$

Note 1 to entry: In this region, $\Delta P_o(\text{dBm}) = \Delta P_i(\text{dBm})$.

[SOURCE: IEC 60747-16-4:2004, 3.8]

3.16.2 fall time

$t_{f(\text{out})}$

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 $P_o(\text{dBm}) = f(P_i)$

Note 1 to entry: In this region, $\Delta P_o(\text{dBm}) = \Delta P_i(\text{dBm})$.

[SOURCE: IEC 60747-16-4:2004, 3.9]

3.17 control voltage sensitivity

$S_{v\text{cont}}$

ratio of the change of attenuation value to the variation of the control voltage

4 Essential ratings and characteristics

4.1 General requirements

4.1.1 Circuit identification and types

The identification of type (device name), the category of circuit and technology applied shall be given.

Microwave attenuators comprise two categories:

- Type A: voltage variable attenuators;
- Type B: digital step attenuators.

4.1.2 General function description

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

4.1.3 Manufacturing technology

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

IEC 60747-4 shall 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 shall be made:

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

4.2 Application description

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 very small aperture terminal (VSAT) systems, broadcasting satellite (BS) 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, DC 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 attenuators shall be given. The block diagram shall 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 shall 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 shall be indicated. The connections with any associated external electrical elements shall be stated, where necessary.

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 can be obtained from IEC 60617.

4.3.2 Identification and function of terminals

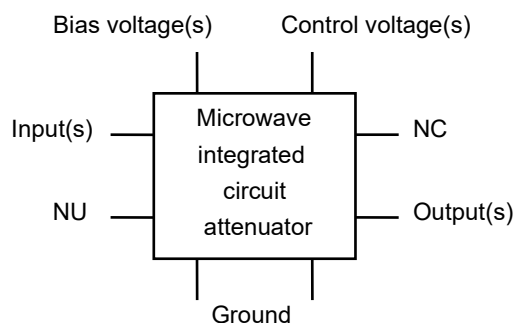
All terminals shall be identified on the block diagram (supply terminals, input or output terminals, input/output terminals). The terminal functions shall be indicated in Table 1.

Table 1 – Function of terminals

Terminal number	Terminal symbol	Terminal designation ^a	Function ^b	Function of terminal	
				input/output identification ^c	Type of input/output circuits ^d
^a A terminal designation to indicate the function of the terminal shall be given. Supply terminals, ground terminals, blank terminals (with abbreviation NC), non-usable terminals (with abbreviation NU) shall be distinguished.					
^b A brief indication of the terminal function shall 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.					
^c Input, output, input/output and multiplex output terminals shall be distinguished.					
^d The type of input and output circuit, e.g. input/output impedances, with or without DC block, etc., shall be distinguished.					

If the baseplate of the package is used as a ground terminal, the type of ground, e.g. analog ground, digital ground, shall be stated in the column of Function in Table 1.

EXAMPLE



4.3.3 Function description

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

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

4.4 Limiting values (absolute maximum rating system)

4.4.1 Requirements

These limiting values shall 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 shall be stated;
- all voltages are referenced to a specified reference terminal (U_{SS} , ground, etc.);
- 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, this dependence shall be indicated.

4.4.2 Electrical limiting values

Electrical limiting values shall be specified as shown in Table 2.

Table 2 – Electrical limiting values

Parameters	Min.	Max.
Bias voltage(s) (where appropriate)	+	+
Bias current(s) (where appropriate)		+
Control supply voltage(s) (where appropriate)	+	+
Control supply current(s) (where appropriate)		+
Terminal voltage(s) (where appropriate)	+	+
Terminal current(s) (where appropriate)		+
Input power		+
Power dissipation		+
It is necessary to select either bias voltage(s) or bias current(s), either terminal voltage(s) or terminal current(s).		

The detail specification may indicate those values within Table 3.

Table 3 – Electrical limiting values in detail specification

Parameters ^{a, b}	Symbols	Min.	Max.	Unit
^a Where appropriate, in accordance with the type of circuit considered. ^b 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 shall be made as to whether the sequence in which these supplies are applied is significant: if so, the sequence shall be stated; – when more than one supply is needed, the combinations of ratings for these supply voltages and currents shall be stated.				

4.4.3 Temperatures

The detail specification can indicate the following temperature values within Table 4:

- a) operating temperature (ambient or reference-point temperature);
- b) storage temperature;
- c) channel temperature;
- d) lead temperature (for soldering).

Table 4 – Temperatures

Parameters ^a	Symbols	Min.	Max.	Unit
^a Where appropriate, in accordance with the type of circuit considered.				

4.5 Operating conditions (within the specified operating temperature range)

Operating conditions are not to be inspected, but may be used for quality assessment purpose.

- a) power supplies – positive and/or negative values (where appropriate);
- b) initialization sequences (where appropriate), if special initialization sequences are necessary, power supply sequencing and initialization procedure shall be specified;
- c) input voltage(s) (where appropriate);
- d) output current(s) (where appropriate);
- e) voltage and/or current of other terminal(s);
- f) external elements (where appropriate);
- g) operating temperature range.

4.6 Electrical characteristics

The characteristics shall apply over the full operating temperature range, unless otherwise specified. Each characteristic shall be stated either:

- 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 shown in Table 5.

Table 5 – Electrical characteristics

Parameters	Min.	Typ.	Max.	Types	
				A	B
Bias supply operating current(where appropriate)		+	+	+	+
Control supply operating current(where appropriate)		+	+	+	+
Insertion loss(L_{ins})		+	+	+	+
Attenuation value (A_{att})	+	+	+	+	+
Attenuation range (A_{ran})	+	+	+	+	+
Attenuation accuracy (A_{aur})		+	+	+	+
Attenuation accuracy RMS ($A_{aur(RMS)}$)		+	+	+	+
Input return loss ($L_{ret(in)}$)	+	+		+	+
Output return loss ($L_{ret(out)}$)	+	+		+	+
Input power at n dB compression ($P_{i(ndB)}$)	+	+		+	+
Intermodulation distortion (P_n/P_1)		+	+	+	+
Power at the intercept point ($P_{n(IP)}$)	+	+		+	+
Relative phase shift (θ_{rel})		+	+	+	+
Turn on time (t_{on})		+	+	+	+
Turn off time (t_{off})		+	+	+	+
Rise time ($t_{r(out)}$)		+	+	+	+
Fall time ($t_{f(out)}$)		+	+	+	+
Control voltage sensitivity (S_{vcont})	+	+	+	+	

4.7 Mechanical and environmental ratings, characteristics and data

Any applicable mechanical and environmental ratings, characteristics and data specified in 5.10 and 5.11 of IEC 60747-1:2006 shall be stated.

4.8 Additional information

Where appropriate, the following information shall be given:

- a) equivalent input and output circuit: Detail information shall be given regarding the type of input and output circuits, e.g. input/output impedances, DC block, open-drain, etc;
- b) internal protection: A statement shall be given to indicate whether the integrated circuit contains internal protection against high static voltages or electrical fields;
- c) capacitors at terminals: If capacitors for the input/output DC block are needed, these capacitances shall be stated;
- d) thermal resistance;
- e) interconnections to other types of circuit: Where appropriate, details of the interconnections to other circuits shall be given, for example, detector circuit for automatic gain control (AGC), sense amplifiers, buffer, etc;
- f) effects of externally connected component(s): Curves or data indicating the effect of externally connected component(s) that influence the characteristics may be given;
- g) recommendations for any associated device(s): For example, decoupling of power supply to a high-frequency device shall be stated;
- h) handling precautions: Where appropriate, handling precautions specific to the circuit shall be stated (see also IEC 61340-5-1 and IEC TR 61340-5-2);
- i) application data;
- j) other application information;
- k) date of issue of the data sheet.

5 Measuring methods

5.1 General

5.1.1 General precautions

The general precautions listed in 6.3, 6.4 and 6.6 of IEC 60747-1:2006 shall be applied. In addition, special care shall be taken to use low-ripple DC power supplies and to decouple adequately all supply terminals at the frequency of measurement. Although the level of the signal can be specified in either power or voltage, in this document it is expressed in power unless otherwise specified. Correct calibration shall be performed to the measurement fixture, and calibration method should be described.

5.1.2 Characteristic impedance

The characteristic impedance of the measurement system, shown in the circuit in this document, is 50 Ω . If it is not 50 Ω , it shall be specified.

5.1.3 Handling precautions

When handling electrostatic-sensitive devices, the handling precautions given in IEC 61340-5-1 and IEC TR 61340-5-2 shall be observed.

5.1.4 Types

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

5.2 Transmission loss (L_{trans}) and insertion loss (L_{ins})

5.2.1 Purpose

To measure the transmission loss and insertion loss under specified conditions.

5.2.2 Measuring methods

5.2.2.1 General

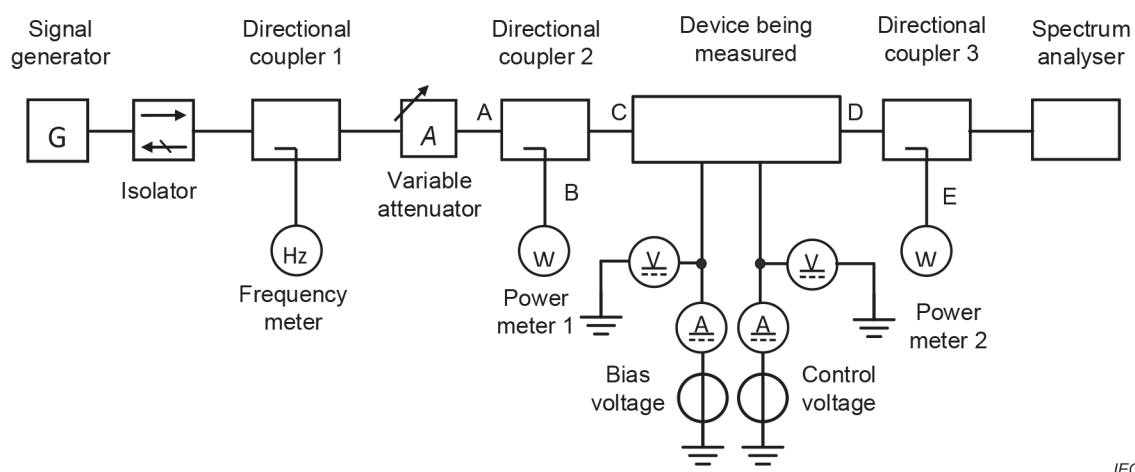
Two measuring methods are given:

- Method 1, using a signal generator and spectrum analyser;
- Method 2, using a network analyser.

5.2.2.2 Measuring method 1

5.2.2.2.1 Circuit diagram

The measuring circuit is shown in Figure 1.



IEC

Figure 1 – Circuit diagram for the measurement of the transmission loss and insertion loss (method 1)

5.2.2.2.2 Principle of measurement

Transmission loss L_{trans} is derived from the input power P_i and the output power P_o of the device being measured from Equation (1).

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

In the circuit diagram shown in Figure 1, P_i and P_o are derived from Equations (2) and (3).

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

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

where

- P_1 is the power indicated by the power meter 1;
 P_2 is the power indicated by the power meter 2;
 L_1 is the power at the point B, less the power at the point C;
 L_2 is the power at the point D, less the power at the point E;
 P_i , P_o , P_1 and P_2 are expressed in dBm, L_{trans} , L_1 and L_2 are expressed in dB.

5.2.2.2.3 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 shall be measured beforehand.

5.2.2.2.4 Precautions to be observed

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

5.2.2.2.5 Measurement procedure

The measurement procedure is as follows:

- the frequency of the signal generator is set to the specified value;
- the bias under specified conditions is applied;
- the control voltage is supplied so as to be in the specific state for the transmission loss measurement. For the insertion loss measurement, the control voltage is supplied so as to be in the reference state;
- an adequate input power is applied to the device being measured;
- by varying the input power, confirm that a change of output power is the same as that of the input power;
- the value P_1 is measured by the power meter 1;
- the value P_2 is measured by the power meter 2;
- The transmission loss L_{trans} is derived from Equations (1), (2) and (3). The insertion loss L_{ins} is the transmission loss when the attenuator is in the reference state.

5.2.2.2.6 Specified conditions

The specified conditions are as follows:

- ambient or reference-point temperature;
- bias conditions;
- control voltages;
- frequency;
- input power.

5.2.2.3 Measuring method 2

5.2.2.3.1 Circuit diagram

The measuring circuit is shown in Figure 2.

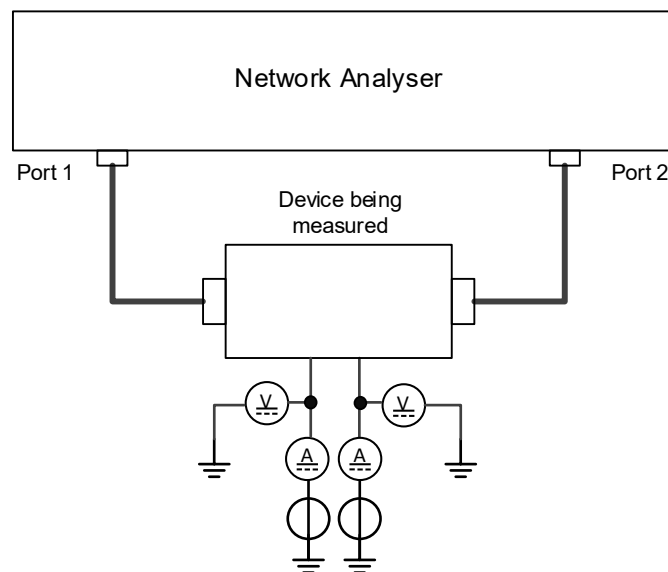


Figure 2 – Circuit diagram for the measurement of the scattering parameters

5.2.2.3.2 Principle of measurement

The transmission loss of the attenuator is derived from the measured scattering parameter, S_{21} , which is defined as forward transmission coefficient. The transmission loss L_{trans} is derived from Equation (4) below:

$$L_{\text{trans}} = -20\log(|S_{21}|) \quad (4)$$

where

L_{trans} is the numerical value of the insertion loss, expressed in dB.

NOTE A definition of scattering parameters is provided in 7.4.3.10.2.2 of IEC 60747-4:2007.

5.2.2.3.3 Circuit description and requirements

The measurement set-up is shown in Figure 2. The input port of the device being measured is connected to the port 1 of the network analyser, and the output port is connected to port 2.

5.2.2.3.4 Precautions to be observed

Harmonics or spurious responses from the signal generator of the network analyser should be reduced so as to be negligible. Transmission loss L_{trans} shall be measured without the influence at the input and output ports.

5.2.2.3.5 Measurement procedure

The measurement procedure is as follows:

- a) the frequency of the network analyser is set to the specified value;
- b) the output power of the network analyser is adjusted to the appropriate value that the specified input power is applied to the device being measured;
- c) a calibration shall be made in order to eliminate systematic errors in the network analyser, cable, and connectors;
- d) the device being measured is connected at the place indicated in Figure 2;

- e) the bias under specified conditions is applied;
- f) the control voltage is supplied so as to be in the specific state for the transmission loss measurement. For the insertion loss measurement, the control voltage is supplied so as to be in the reference state;
- g) the transmission loss L_{trans} is derived from Equation (4). The insertion loss L_{ins} is the transmission loss when the attenuator is in the reference state.

5.2.2.3.6 Specified conditions

The specified conditions are as follows:

- ambient or reference-point temperature;
- bias conditions;
- control voltages;
- frequency;
- input power.

5.3 Attenuation value (A_{att})

5.3.1 Purpose

To measure the attenuation value under specified conditions.

5.3.2 Measuring methods

5.3.2.1 General

Two measuring methods are given:

- Method 1, using a signal generator and spectrum analyser;
- Method 2, using a network analyser.

5.3.2.2 Measuring method 1

5.3.2.2.1 Circuit diagram

See the circuit diagram of 5.2.2.2.1.

5.3.2.2.2 Principle of measurement

See the principle of measurement of 5.2.2.2.2.

The attenuation value is derived from Equation (5) below:

$$A_{\text{att}} = L_{\text{trans}} - L_{\text{ins}} \quad (5)$$

where

L_{trans} is the measured transmission loss of specified attenuation state;

L_{ins} is the insertion loss.

A_{att} , L_{trans} and L_{ins} are expressed in dB.

5.3.2.2.3 Circuit description and requirements

See the circuit description and requirements described in 5.2.2.2.3.

5.3.2.2.4 Precautions to be observed

See the precautions to be observed of 5.2.2.2.4.

5.3.2.2.5 Measurement procedure

The measurement procedure is as follows:

- a) the frequency of the signal generator is set to the specified value;
- b) the bias under specified conditions is applied;
- c) the control voltage is supplied so as to be in the reference state;
- d) an adequate input power is applied to the device being measured;
- e) by varying the input power, confirm that a change of output power is the same as that of the input power;
- f) the values of P_1 and P_2 are measured by the power meter 1 and the power meter 2, respectively;
- g) the insertion loss L_{ins} is derived from Equations (1), (2) and (3);
- h) the control voltage is changed so as to be in specified attenuation state by applying the specified amplitude of the control voltage;
- i) the values of P_1 and P_2 are measured by the power meter 1 and the power meter 2, respectively;
- j) the transmission loss of specified attenuation state L_{trans} is derived from Equations (1), (2) and (3);
- k) the attenuation value A_{att} is derived from Equation (5).

5.3.2.2.6 Specified conditions

See the specified conditions in 5.2.2.2.6.

5.3.2.3 Measuring method 2

5.3.2.3.1 Circuit diagram

See the circuit diagram of 5.2.2.3.1.

5.3.2.3.2 Principle of measurement

See the principle of measurement of 5.2.2.3.2.

The attenuation value is derived from Equation (5).

5.3.2.3.3 Circuit description and requirements

See the circuit description and requirements described in 5.2.2.3.3.

5.3.2.3.4 Precautions to be observed

See the precautions to be observed of 5.2.2.3.4.

5.3.2.3.5 Measurement procedure

The measurement procedure is as follows:

- a) the frequency of the network analyser is set to the specified value;
- b) the output power of the network analyser is adjusted to the appropriate value that the specified input power is applied to the device being measured;
- c) a calibration shall be made in order to eliminate systematic errors in the network analyser, cable, and connectors;
- d) the device being measured is connected at the place indicated in Figure 2;
- e) the bias under specified conditions is applied;
- f) the control voltage is supplied so as to be in the reference state;
- g) the insertion loss L_{ins} is derived from Equation (4);
- h) the control voltage is changed so as to be in specified attenuation state by applying the specified amplitude of the control voltage;
- i) the transmission loss of specified attenuation state L_{trans} is derived from Equation (4);
- j) the attenuation value A_{att} is derived from Equation (5).

5.3.2.3.6 Specified conditions

See the specified conditions in 5.2.2.3.6.

5.4 Attenuation range (A_{ran})

5.4.1 Purpose

To measure the attenuation range under specified conditions.

5.4.2 Measuring methods

5.4.2.1 General

Two measuring methods are given:

- Method 1, using a signal generator and spectrum analyser;
- Method 2, using a network analyser.

5.4.2.2 Measuring method 1

5.4.2.2.1 Circuit diagram

See the circuit diagram of 5.2.2.2.1.

5.4.2.2.2 Principle of measurement

See the principle of measurement of 5.3.2.2.2.

The attenuation range A_{ran} is the maximum attenuation value that can be provided by the attenuation control.

5.4.2.2.3 Circuit description and requirements

See the circuit description and requirements described in 5.2.2.2.3.

5.4.2.2.4 Precautions to be observed

See the precautions to be observed of 5.2.2.2.4.

5.4.2.2.5 Measurement procedure

The measurement procedure is as follows:

- a) the frequency of the signal generator is set to the specified value;
- b) the bias under specified conditions is applied;
- c) the control voltage is supplied so as to be in the reference state;
- d) an adequate input power is applied to the device being measured;
- e) by varying the input power, confirm that a change of output power is the same as that of the input power;
- f) the values of P_1 and P_2 are measured by the power meter 1 and the power meter 2, respectively;
- g) the insertion loss L_{ins} is derived from Equations (1), (2) and (3);
- h) the control voltage is changed so as to be in maximum attenuation state by applying the specified amplitude of the control voltage;
- i) the values of P_1 and P_2 are measured by the power meter 1 and the power meter 2, respectively;
- j) the maximum transmission loss $L_{\text{trans(max)}}$ is derived from Equations (1), (2) and (3);
- k) the attenuation range A_{ran} is derived from Equation (5).

5.4.2.2.6 Specified conditions

See the specified conditions in 5.2.2.2.6.

5.4.2.3 Measuring method 2

5.4.2.3.1 Circuit diagram

See the circuit diagram of 5.2.2.3.1.

5.4.2.3.2 Principle of measurement

See the principle of measurement of 5.2.2.3.2.

The attenuation range A_{ran} is the maximum attenuation value that can be provided by the attenuation control.

5.4.2.3.3 Circuit description and requirements

See the circuit description and requirements described in 5.2.2.3.3.

5.4.2.3.4 Precautions to be observed

See the precautions to be observed of 5.2.2.3.4.

5.4.2.3.5 Measurement procedure

The measurement procedure is as follows:

- a) the frequency of the network analyser is set to the specified value;
- b) the output power of the network analyser is adjusted to the appropriate value that the specified input power is applied to the device being measured;
- c) a calibration shall be made in order to eliminate systematic errors in the network analyser, cable, and connectors;
- d) the device being measured is connected at the place indicated in Figure 2;

- e) the bias under specified conditions is applied;
- f) the control voltage is supplied so as to be in the reference state;
- g) the insertion loss L_{ins} is derived from Equation (4);
- h) the control voltage is changed so as to be in maximum attenuation state by applying the specified amplitude of the control voltage;
- i) the maximum transmission loss $L_{\text{trans(max)}}$ is derived from Equation (4);
- j) the attenuation range A_{ran} is derived from Equation (5).

5.4.2.3.6 Specified conditions

See the specified conditions in 5.2.2.3.6.

5.5 Attenuation accuracy (A_{aur}), Attenuation accuracy (RMS) ($A_{\text{aur(RMS)}}$)

5.5.1 Purpose

To measure the attenuation accuracy under specified conditions.

5.5.2 Measuring methods

5.5.2.1 General

Two measuring methods are given:

- Method 1, using a signal generator and spectrum analyser;
- Method 2, using a network analyser.

5.5.2.2 Measuring method 1

5.5.2.2.1 Circuit diagram

See the circuit diagram of 5.2.2.2.1.

5.5.2.2.2 Principle of measurement

See the principle of measurement of 5.3.2.2.2.

The attenuation accuracy A_{aur} of specified attenuation state is derived from Equation (6) below:

$$A_{\text{aur}} = A_{\text{att}} - A_{\text{nom}} \quad (6)$$

where

A_{att} is the measured attenuation value of specified attenuation state;

A_{nom} is the nominal attenuation value of specified attenuation state.

A_{aur} , A_{att} , and A_{nom} are expressed in dB.

The attenuation accuracy RMS $A_{\text{aur(RMS)}}$ is derived from Equation (7) below:

$$A_{\text{aur(RMS)}} = \sqrt{\frac{\sum_{i=1}^N A_{\text{aur}(i)}^2}{N}} \quad (7)$$

where

$A_{\text{aur}(i)}$ is the attenuation accuracy of state i ;
 $i = 1, 2, 2^M$; attenuation state counter for M-bit attenuator.

5.5.2.2.3 Circuit description and requirements

See the circuit description and requirements described in 5.2.2.2.3.

5.5.2.2.4 Precautions to be observed

See the precautions to be observed of 5.2.2.2.4.

5.5.2.2.5 Measurement procedure

The measurement procedure is as follows:

- a) the frequency of the signal generator is set to the specified value;
- b) the bias under specified conditions is applied;
- c) the control voltage is supplied so as to be in the reference state;
- d) an adequate input power is applied to the device being measured;
- e) by varying the input power, confirm that a change of output power is the same as that of the input power;
- f) the values of P_1 and P_2 are measured by the power meter 1 and the power meter 2, respectively;
- g) the insertion loss L_{ins} is derived from Equations (1), (2) and (3);
- h) the control voltage is changed so as to be in specified attenuation state by applying the specified amplitude of the control voltage;
- i) the values of P_1 and P_2 are measured by the power meter 1 and the power meter 2, respectively;
- j) the transmission loss of specified attenuation state L_{trans} is derived from Equations (1), (2) and (3);
- k) the attenuation value A_{att} is derived from Equation (5);
- l) the attenuation accuracy A_{aur} is derived from Equation (6);
- m) the attenuation accuracy (RMS) $A_{\text{aur(RMS)}}$ is derived from Equation (7).

5.5.2.2.6 Specified conditions

See the specified conditions in 5.2.2.2.6.

5.5.2.3 Measuring method 2

5.5.2.3.1 Circuit diagram

See the circuit diagram of 5.2.2.3.1.

5.5.2.3.2 Principle of measurement

See the principle of measurement of 5.2.2.3.2 and 5.5.2.2.2.

5.5.2.3.3 Circuit description and requirements

See the circuit description and requirements described in 5.2.2.3.3.