IEC 60747-16-7

Edition 1.0 2022-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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



IEC 60747-16-7:2022-11 (en-fr)



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 Varembé
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 It also gives information on projects, replaced and withdrawn publications.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.

IEC 60747-16-7

Edition 1.0 2022-11

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.

® Registered trademark of the International Electrotechnical Commission
Marque déposée de la Commission Electrotechnique Internationale

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 ($L_{ret(in)}$) 26
5.6.1 Purpose 26
5.6.2 Measuring methods 26
5.7 Output return loss ($L_{ret(out)}$) 29
5.7.1 Purpose 29
5.7.2 Measuring methods 29
5.8 Input power at n dB compression ($P_{i(ndB)}$) 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) ($P_{n(IP)}$) 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($t_{r(out)}$), fall time($t_{f(out)}$) 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(dBm) = $f(P_i)$

Note 1 to entry: In this region, ΔP_o(dBm) = ΔP_i(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(dBm) = $f(P_i)$ in the reference state

Note 1 to entry: In this region, ΔP_o(dBm) =ΔP_i(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)
$A_{aur\ (RMS)}$
root-mean-square value of the attenuation accuracy

3.9
input return loss
$L_{ret(in)}$
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
$L_{ret(out)}$
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 nth 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 nth 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(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, ΔP_o(dBm) = ΔP_i(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(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, ΔP_o(dBm) = ΔP_i(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
$t_{r(out)}$
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 1 to entry: In this region, ΔP_o(dBm) = ΔP_i(dBm).

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

3.16.2
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 1 to entry: In this region, ΔP_o(dBm) = ΔP_i(dBm).

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

3.17
control voltage sensitivity
S_{vcont}
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.