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)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 31.080.99

ISBN 978-2-8322-6116-3

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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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- withdrawn,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.

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:

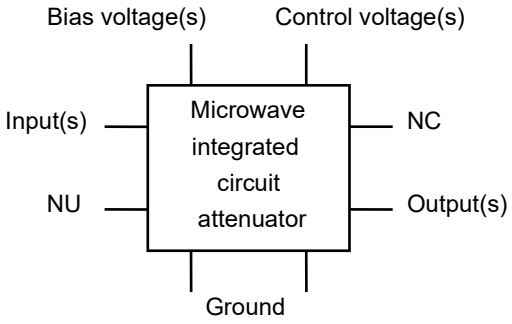
– each function of multi-role terminals, i.e. terminals having multiple functions;
– each function of integrated circuit selected by mutual pin connections, programming and/or application of function selection data to the function selection pin, such as mode selection pin.

[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.