IEC 60747-16-9

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices –
Part 16-9: Microwave integrated circuits – Phase shifters

Dispositifs à semiconducteurs –
Partie 16-9: Circuits intégrés hyperfréquences – Déphaseurs

IEC 60747-16-9:2024-10(en-fr)

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SEMICONDUCTOR DEVICES –

Part 16-9: Microwave integrated circuits – Phase shifters

FOREWORD

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IEC 60747-16-9 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/835/FDIS	47E/842/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- withdrawn, or
- revised.

SEMICONDUCTOR DEVICES –

Part 16-9: Microwave integrated circuits – Phase shifters

1 Scope

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

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/AMD1:2010

IEC 60747-4:2007, *Semiconductor devices – Discrete devices – Part 4: Microwave diodes and transistors*
IEC 60747-4:2007/AMD1:2017

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 terminology 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
state where the phase difference between input and output of the phase shifter is a particular value

Note 1 to entry: The condition for the reference state shall be specified.

Note 2 to entry: Though the phase difference at the reference state is usually maximum, median, or minimum value of all available phase differences of the phase shifter, other values can be acceptable.

3.2
phase shift state
state where the phase difference between input and output of the phase shifter is different from that of the reference state (3.1)

3.3
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) = $f(P_i)$

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.

Note 3 to entry: The insertion loss in the reference state (3.1) is expressed by L_{ref}.

[SOURCE: IEC 60747-16-4:2004/AMD1:2009, 3.1, modified – "at the switched-on port" has been deleted and Note 3 has been added.]

3.4
phase shift value
S_{ph}
difference between the phase in the phase shift state (3.2) and that in the reference state (3.1)

3.5
phase shift range
R_{ph}
difference between the maximum and minimum phase among all phase shift states (3.2) and reference state (3.1)

3.6
phase shift accuracy
S_{acc}
difference between the measured and the nominal phase shift value (3.4)

3.7
phase shift accuracy root mean square
$S_{acc(RMS)}$
root-mean-square value of the differences between the measured and the nominal phase shift values (3.4)

3.8
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]

3.9
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]

3.10
amplitude flatness
F_{amp}
difference between the maximum and minimum insertion loss (3.3) value in working frequency range

3.11
insertion loss ripple
L_{rip}
difference between the maximum and minimum insertion loss (3.3) value among all phase shift states

3.12
input power at 1 dB compression
$P_{i(1\ dB)}$
input power where the insertion loss (3.3) increases by 1 dB compared with insertion loss (3.3) in linear region

[SOURCE: IEC 60747-16-4:2004, 3.4]

3.13
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 "*IMDn*" is in common use for the nth order intermodulation distortion.

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

3.14
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 nth 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]

3.15
switching time

3.15.1
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) = $f(P_i)$ when the state of phase shifter changes from the reference state (3.1) to the phase shift state (3.2)

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, 3.6, modified – The words "when the state of phase shifter changes from the reference state to the phase shift state" have been added, as well as Note 2 to entry.]

3.15.2
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) = $f(P_i)$ when the state of phase shifter changes from the reference state (3.1) to the phase shift state (3.2)

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 – The words "when the state of phase shifter changes from the reference state to the phase shift state" have been added, as well as Note 2.]

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 in the detail specification.

Microwave phase shifters comprise two categories:

– Type A: Digital phase shifters;
– Type B: Analog phase shifters.

4.1.2 General function description

A general description of the function performed by the microwave integrated circuit phase shifters 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 in the detail specification. This statement shall include details of the semiconductor technologies such as P_i N diode, heterostructure field effect transistor (HFET), pseudomorphic high electronic mobility transistor (PHEMT), 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 stated in the detail specification:

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 shall be stated in the detail specification whether the integrated circuit conforms to an application system and/or to an interface standard or a recommendation.

Detailed information concerning application systems, equipment, and circuits such as radar systems, communication systems, Wi-Fi wireless network systems, etc. should also be given.

4.2.2 Overall block diagram

A block diagram of the applied systems shall be given in the detail specification, if necessary.

4.2.3 Reference data

The most important properties that permit comparison between derivative types should be given in the detail specification.

4.2.4 Electrical compatibility

It should be stated in the detail specification 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 phase shifters shall be given in the detail specification. 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 electric 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), as shown below.

EXAMPLE:

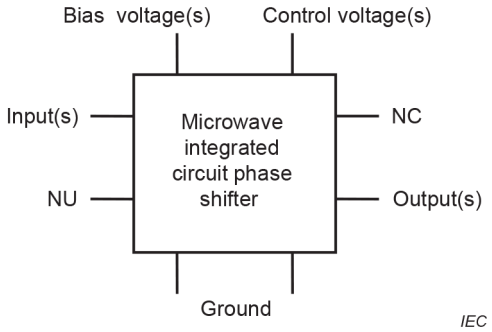

Figure 1 – Example block diagram

The terminal functions shall be indicated in Table 1.

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.

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 P_{i} n connections, programming and/or application of function selection data to the function selection P_{i} n, such as mode selection P_{i} n;
– 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.

[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.

4.4 Limiting values (absolute maximum rating system)

4.4.1 Requirements

These limiting values shall contain the following and be given in the detail specification:

– 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 specified for the integrated circuit with the elements connected and/or attached;