



BSI Standards Publication

Semiconductor devices

Part 16-1: Microwave integrated circuits - Amplifiers

National foreword

This British Standard is the UK implementation of EN 60747-16-1:2002+A2:2017. It is identical to IEC 60747-16-1:2001, incorporating amendment 1:2007 and amendment 2:2018. It supersedes BS EN 60747-16-1:2002+A1:2007, which is withdrawn.

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

The text of IEC amendment 2:2018 has been provided in its entirety at the beginning of this document. BSI's policy of providing consolidated content remains unchanged; however, in the interest of expediency, in this instance BSI have chosen to collate the relevant content at the beginning of this document.

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

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

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Amendments/corrigenda issued since publication

Date	Text affected
30 April 2008	Implementation of IEC amendment 1:2007 with CENELEC endorsement A1:2007
30 April 2018	Implementation of IEC amendment 2:2017 with CENELEC endorsement A2:2017

ICS 31.080.99; 31.200

English Version

**Semiconductor devices – Part 16-1: Microwave integrated
circuits – Amplifiers (IEC 60747-16-1:2001/A2:2017)**

Dispositifs à semiconducteurs – Partie
16-1: Circuits intégrés hyperfréquences –
Amplificateurs (IEC 60747-16-1:2001/A2:2017)

Halbleiterbauelemente – Teil 16-1:
Integrierte Mikrowellen-Verstärker
(IEC 60747-16-1:2001/A2:2017)

This European Standard was approved by CENELEC on 2002-02-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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European foreword

The text of document 47E/200/FDIS, future edition 1 of IEC 60747-16-1, prepared by SC 47E, Discrete semiconductor devices, of IEC/TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60747-16-1 on 2002-02-01.

The following dates were fixed:

- | | | |
|--|-------|------------|
| — latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2002-11-01 |
| — latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2005-02-01 |

Annexes designated "normative" are part of the body of the standard. In this standard, annex ZA is normative.

Endorsement notice

The text of the International Standard IEC 60747-16-1:2001 was approved by CENELEC as a European Standard without any modification.

European foreword to amendment 1

The text of document 47E/305/FDIS, future amendment 1 to IEC 60747-16-1:2001, prepared by SC 47E, Discrete semiconductor devices, of IEC/TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as amendment A1 to EN 60747-16-1:2002 on 2007-02-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at (dop) 2007-11-01
national level by publication of an identical national standard
or by endorsement
- latest date by which the national standards conflicting with the (dow) 2010-02-01
document have to be withdrawn

Annex ZA has been added by CENELEC.

Endorsement notice

The text of amendment 1:2006 to the International Standard IEC 60747-16-1:2001 was approved by CENELEC as an amendment to the European Standard without any modification

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Semiconductor devices
Part 16-1: Microwave integrated circuits -
Amplifiers
(IEC 60747-16-1:2001)

Dispositifs à semiconducteurs
Partie 16-1: Circuits intégrés
hyperfréquences -
Amplificateurs
(CEI 60747-16-1:2001)

Halbleiterbauelemente
Teil 16-1: Integrierte Mikrowellen-
Verstärker
(IEC 60747-16-1:2001)

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CENELEC

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

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

Foreword

The text of document 47E/200/FDIS, future edition 1 of IEC 60747-16-1, prepared by SC 47E, Discrete semiconductor devices, of IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60747-16-1 on 2002-02-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2002-11-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2005-02-01

Annexes designated "normative" are part of the body of the standard.
In this standard, annex ZA is normative.

Endorsement notice

The text of the International Standard IEC 60747-16-1:2001 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 47E/305/FDIS, future amendment 1 to IEC 60747-16-1:2001, prepared by SC 47E, Discrete semiconductor devices, of IEC TC 47, Semiconductor devices, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60747-16-1:2002 on 2007-02-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2007-11-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2010-02-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of amendment 1:2006 to the International Standard IEC 60747-16-1:2001 was approved by CENELEC as an amendment to the European Standard without any modification.

English Version

Semiconductor devices -
Part 16-1: Microwave integrated circuits - Amplifiers
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Halbleiterbauelemente -
Teil 16-1: Integrierte Mikrowellen-Verstärker
(IEC 60747-16-1:2001/A2:2017)

This amendment A2 modifies the European Standard EN 60747-16-1:2002; it was approved by CENELEC on 2017-03-22. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document 47E/500/CDV, future IEC 60747-16-1:2001/A2, prepared by SC 47E "Discrete semiconductor devices" of IEC/TC 47 "Semiconductor devices" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60747-16-1:2002/A2:2017.

The following dates are fixed:

- latest date by which the document has to be (dop) 2017-12-22
implemented at national level by
publication of an identical national
standard or by endorsement
- latest date by which the national (dow) 2020-03-22
standards conflicting with the
document have to be withdrawn

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

Endorsement notice

The text of the International Standard IEC 60747-16-1:2001/A2:2017 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
<i>Replace the existing references to IEC 60617, IEC 60747-1, IEC 60747-4, IEC 61340-5-1 and IEC 61340-5-2, including modifications done by A1 as follows:</i>				
IEC 60617-DB	-	Graphical symbols for diagrams	-	-
IEC 60747-1	2006	Semiconductor devices - Part 1: General	-	-
+A1	2010		-	-
IEC 60747-4	2007	Semiconductor devices - Discrete devices - Part 4: Microwave diodes and transistors	-	-
+A1	2017		-	-
IEC 61340-5-1	-	Electrostatics - Part 5-1: Protection of electronic devices from electrostatic phenomena - General requirements	EN 61340-5-1	-
IEC/TR 61340-5-2	-	Electrostatics - Part 5-2: Protection of electronic devices from electrostatic phenomena - User guide	CLC/TR 61340-5-2	-

Replace the existing reference to IEC 60748-3 as follows:

IEC 60748-3	1986	Semiconductors devices - Integrated circuits - - Part 3: Analogue integrated circuits	-	-
+A1	1991		-	-
+A2	1994		-	-

Delete the existing references to IEC 60747-7:2000, IEC 60747-16-2:2001 and IEC 60747-16-4:2004

Add the following new reference:

IEC 60050-702	-	International electrotechnical vocabulary (IEV)- - Chapter 702: Oscillations, signals and related devices	-	-
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INTERNATIONAL STANDARD

NORME INTERNATIONALE

AMENDMENT 2 AMENDEMENT 2

Semiconductor devices – Part 16-1: Microwave integrated circuits – Amplifiers

Dispositifs à semiconducteurs – Partie 16-1: Circuits intégrés hyperfréquences – Amplificateurs

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FOREWORD

This amendment has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

The text of this amendment is based on the following documents:

CDV	Report on voting
47E/500/CDV	47E/518/RVC

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

CONTENTS

Replace the titles of Clause 3, Subclauses 5.7 and 5.18 with the following new titles:

- 3 Terms and definitions
- 5.7 Limiting output power ($P_{o(ltg)}$) and limiting output power flatness ($\Delta P_{o(ltg)}$)
- 5.18 Power added efficiency (η_{add})

Replace the titles of Subclauses 5.11, 5.19, 5.21, including the amendments brought to them by Amendment 1, with the following new titles:

- 5.11 Intermodulation distortion (two-tone) (P_n/P_1)
- 5.19 n th order harmonic distortion ratio (P_{nth}/P_1)
- 5.21 Spurious intensity under specified load VSWR (P_{sp}/P_o)

Replace the title of Subclause 5.22 added by Amendment 1 with the following new title:

- 5.22 Adjacent channel power ratio ($P_{adj}/P_{o(mod)}$)

2 Normative references

Replace the existing references IEC 60617, IEC 60747-1, IEC 60747-4, IEC 61340-5-1 and IEC 61340-5-2 including the amendments brought to them by Amendment 1 as follows:

IEC 60617, *Graphical symbols for diagrams* (available at: <<http://std.iec.ch/iec60617>>)

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*

Replace the existing reference IEC 60748-3 as follows:

IEC 60748-3:1986, *Semiconductor devices – Integrated circuits – Part 3: Analogue integrated circuits*

IEC 60748-3:1986/AMD1:1991

IEC 60748-3:1986/AMD2:1994

Delete the existing reference to IEC 60747-7:2000:

IEC 60747-7:2000, Semiconductor devices – Part 7: Bipolar transistors

Delete the references IEC 60747-16-2 and IEC 60747-16-4 added by Amendment 1:

IEC 60747-16-2:2001, *Semiconductor devices – Part 16-2: Microwave integrated circuits – Frequency prescalers*

IEC 60747-16-4:2004, *Semiconductor devices – Part 16-4: Microwave integrated circuits – Switches*

Add the new reference IEC 60050-702:

IEC 60050-702, *International Electrotechnical Vocabulary – Chapter 702: Oscillations, signals and related devices* (available at: <http://www.electropedia.org>)

3 Terminology

Replace the clause title with the following new title and introductory paragraph:

3 Terms and definitions

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

Replace entries 3.7, 3.14, and 3.16, including the amendments brought to them by Amendment 1, with the following new entries:

3.7

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.

3.14

n th order harmonic distortion ratio

$$P_{nth}/P_1$$

ratio of the power of the n th order harmonic component measured at the output port of the device to the power of the fundamental frequency measured at the output port

3.16

spurious intensity under specified load VSWR

$$P_{sp}/P_o$$

ratio of the power of the maximum spurious power measured at the output port of the device to the fundamental frequency measured at the output port under specified load VSWR

Replace entries 3.17 and 3.21 added by Amendment 1 with the following new entries:

3.17

output power

$$P_o$$

RF power measured at the output port

SOURCE: IEC 60747-4:2007/AMD1:2017, 7.2.2.

3.21

adjacent channel power ratio

$$P_{adj}/P_{o(mod)}$$

ratio of the total output power in a specified frequency band away from a specified carrier signal frequency to the total power in a specified carrier signal frequency band, when a modulation signal is supplied

Replace, in entry 3.9 as modified by Amendment 1, the words "see 3.5.2.1 of IEC 60747-7" by "see 7.4.3.10.2.2 of IEC 60747-4:2007".

Replace, in entry 3.10, the words "see 3.5.2.2 of IEC 60747-7" by "see 7.4.3.10.2.2 of IEC 60747-4:2007".

Replace, in entry 3.11, the words "see 3.5.2.4 of IEC 60747-7" by "see 7.4.3.10.2.2 of IEC 60747-4:2007".

4.4.2 Temperatures

Replace the existing item 1), with the following new item:

- 1) Operating temperature (ambient or reference-point temperature)

4.6.2 Dynamic or r.f. characteristics

Replace parameters 4.6.2.10, 4.6.2.20, 4.6.2.22 and 4.6.2.23 including the amendments brought to them by Amendment 1 with the following new parameters:

Parameters	Min.	Max.	Types			
			A	B	C	D
4.6.2.10 Intermodulation distortion		+			+	+
4.6.2.20 <i>n</i> th order harmonic distortion ratio (where appropriate) (note 2)		+				+
4.6.2.22 Spurious intensity under specified load VSWR (where appropriate) (note 2)		+				+
4.6.2.23 Adjacent channel power ratio (where appropriate)		+				+

5.7 Limiting output power ($P_{o(ltg)}$)

Replace the existing title and first line with the following new title:

5.7 Limiting output power ($P_{o(ltg)}$) and limiting output power flatness ($\Delta P_{o(ltg)}$)**5.11 Intermodulation distortion (two-tone) (P_1/P_n)**

Replace the existing title including the amendments brought to it by Amendment 1 with the following new title:

5.11 Intermodulation distortion (two-tone) (P_n/P_1)**5.11.3 Principle of measurement**

Replace, in the last paragraph of this subclause as modified by Amendment 1 " P_1/P_n " with " P_n/P_1 ".

Replace Equation (16) as modified by Amendment 1 as follows:

$$P_n/P_1 = P_n - P_1 = P_c - P_b \quad (16)$$

5.18 Power added efficiency

Replace the existing title with the following new title:

5.18 Power added efficiency (η_{add})**5.19 n th order harmonic distortion ratio (P_1/P_{nth})**

Replace the existing title including the amendments brought to it by Amendment 1 with the following new title:

5.19 n th order harmonic distortion ratio (P_{nth}/P_1)**5.19.3 Principle of measurement**

Replace the existing first sentence and Equation (29) including the amendments brought to them by Amendment 1 as follows:

In the circuit diagram shown in Figure 9, n th order harmonic distortion ratio P_{nth}/P_1 in dBc is derived from Equation (29):

$$P_{nth}/P_1 = P_{nth} - P_1 \quad (29)$$

5.21 Spurious intensity under specified load VSWR (P_o/P_{sp})

Replace the existing title including the amendments brought to it by Amendment 1 with the following new title:

5.21 Spurious intensity under specified load VSWR (P_{sp}/P_o)

5.21.3 Principle of measurement

Replace the existing last sentence and Equation (35) including the amendments brought to them by Amendment 1 as follows:

The spurious intensity P_{sp}/P_o in dBc is defined as follows:

$$P_{sp}/P_o = P_{sp} - P_o \quad (35)$$

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

Replace the title of this subclause added by Amendment 1 with the following new title:

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

5.22.3 Principle of measurement

Replace the existing second sentence in the first paragraph as follows:

Adjacent channel power ratio $P_{adj}/P_{o(mod)}$ is the ratio of P_{adj} to $P_{o(mod)}$.

Replace the existing second paragraph and Equation (39) as follows:

$P_{adj}/P_{o(mod)}$ in dBc is given as the following equations in the circuit of Figure 12.

$$P_{adj}/P_{o(mod)} = P_{adj} - P_{o(mod)} = P_3 - P_2 \quad (39)$$

Replace the existing last line as follows:

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

5.22.6 Measurement procedure

Replace the existing twelfth paragraph as follows:

Adjacent channel power ratio $P_{adj}/P_{o(mod)}$ is calculated from Equation (39).

6.1.2.4 Test procedure

Replace the sixth sentence of this subclause added by Amendment 1 as follows:

The phase angle is swept continuously by varying the length of the line stretcher.

6.1.3.4 Test procedure

Replace the fifth sentence as follows:

The phase angle is swept continuously by varying the length of the line stretcher.

6.2.2.4 Test procedure

Replace the sixth sentence as follows:

The phase angle is swept continuously by varying the length of the line stretcher.

6.2.3.4 Test procedure

Replace the fifth sentence as follows:

The phase angle is swept continuously by varying the length of the line stretcher.

6.3.5 Test procedure

Replace the sixth sentence as follows:

The phase angle is swept continuously by varying the length of the line stretcher.

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SEMICONDUCTOR DEVICES –

Part 16-1: Microwave integrated circuits – Amplifiers

1 Scope

This part of IEC 60747 provides the terminology, the essential ratings and characteristics, as well as the measuring methods for integrated circuit microwave power amplifiers.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60747. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60747 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

[A1] IEC 60617:2001, *Graphical symbols for diagrams*

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

IEC 60747-4:-, *Semiconductor devices – Discrete devices – Part 4: Microwave diodes and transistors*¹ **[A1]**

IEC 60747-7:2000, *Semiconductor devices – Part 7: Bipolar transistors*

[A1] IEC 60747-16-2:2001, *Semiconductor devices – Part 16-2: Microwave integrated circuits – Frequency prescalers*

IEC 60747-16-4:2004, *Semiconductor devices – Part 16-4: Microwave integrated circuits – Switches* **[A1]**

IEC 60748-2:1997, *Semiconductor devices – Integrated circuits – Part 2: Digital integrated circuits*

IEC 60748-3:1986, *Semiconductor devices – Integrated circuits – Part 3: Analogue integrated circuits*

IEC 60748-4:1997, *Semiconductor devices – Integrated circuits – Part 4: Interface integrated circuits*

[A1] IEC/TS 61340-5-1:1998, *Electrostatics - Part 5-1: Protection of electronic devices from electrostatic phenomena - General requirements*

IEC/TS 61340-5-2:1999, *Electrostatics - Part 5-2: Protection of electronic devices from electrostatic phenomena - User guide* **[A1]**

[A1]

¹ The second edition of IEC 60747-4, which is cited in this standard, and to which terms introduced in this amendment refer, is currently in preparation (ADIS). **[A1]**

3 Terminology

3.1

linear (power) gain G_{lin}

power gain in the linear region of the power transfer curve $P_o \text{ (dBm)} = f(P_i)$

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

3.2

linear (power) gain flatness ΔG_{lin}

power gain flatness when the operating point lies in the linear region of the power transfer curve

3.3

power gain G_p , G

ratio of the output power to the input power

NOTE Usually the power gain is expressed in decibels.

3.4

(power) gain flatness ΔG_p

difference between the maximum and minimum power gain for a specified input power in a specified frequency range

3.5

(maximum available) gain reduction ΔG_{red}

difference in decibels between the maximum and minimum power gains that can be provided by the gain control

3.6 Output power limiting

3.6.1

output power limiting range

range in which, for rising input power, the output power is limiting

NOTE For specification purposes, the limits of this range are specified by specified lower and upper limit values for the input power.

3.6.2

limiting output power $P_{o(ltg)}$

output power in the range where it is limiting

3.6.3

limiting output power flatness $\Delta P_{o(ltg)}$

difference between the maximum and minimum output power in the output power limiting range:

$$\Delta P_{o(ltg)} = P_{o(ltg, \max)} - P_{o(ltg, \min)}$$

A1 3.7

intermodulation distortion P_1/P_n

ratio of the fundamental component of the output power to the n th order component of the output power, at a specified input power A1

3.8**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)

3.9**magnitude of the input reflection coefficient**

(input return loss)

$|S_{11}|$

see 3.5.2.1 of IEC 60747-7

3.10**magnitude of the output reflection coefficient**

(output return loss)

$|S_{22}|$

see 3.5.2.2 of IEC 60747-7

3.11**magnitude of the reverse transmission coefficient**

(isolation)

$|S_{12}|$

see 3.5.2.4 of IEC 60747-7 **A1**

3.12**conversion coefficient of amplitude modulation to phase modulation $\alpha_{(AM-PM)}$**

quotient of

the phase deviation of the output signal (in degrees) by

the change in input power (in decibels) producing it

3.13**group delay time $t_{d(grp)}$**

ratio of the change, with angular frequency, of the phase shift through the amplifier

NOTE Usually group delay time is very close in value to input-to-output delay time.

3.14 **n th order harmonic distortion ratio P_1/P_{nth}**

ratio of the power of the fundamental frequency measured at the output port of the device to the power of the n th order harmonic component measured at the output port for a specified output power **A1**

3.15**output noise power P_N**

maximum noise power measured at the output port of the device within a specified bandwidth in a specified frequency range for a specified output power

3.16**spurious intensity under specified load VSWR P_o/P_{sp}**

ratio of the power of the fundamental frequency measured at the output port of the device to the maximum spurious power measured at the output port under specified load VSWR

3.17**output power**

P_o

see 3.3 of IEC 60747-16-2 **A1**