

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Semiconductor devices –  
Part 16-3: Microwave integrated circuits – Frequency converters**

**Dispositifs à semiconducteurs –  
Partie 16-3: Circuits intégrés hyperfréquences – Convertisseurs de fréquence**

IEC 60747-16-3:2002

<https://standards.iteh.ai/catalog/standards/iec/5aab671-7064-4c3c-9e6b-72f8946afd5f/iec-60747-16-3-2002>





## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2010 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 la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland  
Email: [inmail@iec.ch](mailto:inmail@iec.ch)  
Web: [www.iec.ch](http://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 corrigenda or an amendment might have been published.

- Catalogue of IEC publications: [www.iec.ch/searchpub](http://www.iec.ch/searchpub)

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 It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: [www.iec.ch/webstore/custserv](http://www.iec.ch/webstore/custserv)

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: [csc@iec.ch](mailto:csc@iec.ch)  
Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00

### A propos de la CEI

La Commission Electrotechnique Internationale (CEI) 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 CEI

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

- Catalogue des publications de la CEI: [www.iec.ch/searchpub/cur\\_fut-f.htm](http://www.iec.ch/searchpub/cur_fut-f.htm)

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: [www.iec.ch/online\\_news/justpub](http://www.iec.ch/online_news/justpub)

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: [www.electropedia.org](http://www.electropedia.org)

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: [www.iec.ch/webstore/custserv/custserv\\_entry-f.htm](http://www.iec.ch/webstore/custserv/custserv_entry-f.htm)

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: [csc@iec.ch](mailto:csc@iec.ch)  
Tél.: +41 22 919 02 11  
Fax: +41 22 919 03 00



IEC 60747-16-3

Edition 1.1 2010-04

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



---

**Semiconductor devices –**  
**Part 16-3: Microwave integrated circuits – Frequency converters**

**Dispositifs à semiconducteurs –**  
**Partie 16-3: Circuits intégrés hyperfréquences – Convertisseurs de fréquence**

IEC 60747-16-3:2002

<https://standards.iteh.ai/catalog/standards/iec/5aab671-7064-4c3c-9e6b-72f8946afd5f/iec-60747-16-3-2002>

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

COMMISSION  
ELECTROTECHNIQUE  
INTERNATIONALE

---

ICS 31.080.99

ISBN 978-2-88910-282-2

## CONTENTS

FOREWORD.....	4
1 Scope.....	6
2 Normative references .....	6
3 Terms and definitions .....	7
4 Abbreviated terms .....	8
5 Essential ratings and characteristics.....	8
5.1 General.....	8
5.2 Application description .....	9
5.3 Specification of the function .....	10
5.4 Limiting values (absolute maximum rating system) .....	12
5.5 Operating conditions (within the specified operating temperature range) .....	14
5.6 Electrical characteristics.....	14
5.7 Mechanical and environmental ratings, characteristics and data.....	15
5.8 Additional information.....	15
6 Measuring methods .....	16
6.1 General.....	16
6.2 Conversion gain ( $G_c$ ).....	17
6.3 Conversion gain flatness ( $\Delta G_c$ ).....	19
6.4 LO/IF isolation ( $P_{LO} / P_{LO(IF)}$ ).....	21
6.5 LO/RF isolation ( $P_{LO} / P_{LO(RF)}$ ).....	22
6.6 RF/IF isolation.....	24
6.7 Image rejection ( $P_o / P_{o(im)}$ ).....	28
6.8 Sideband suppression ( $P_o / P_{o(U)}$ ) .....	29
6.9 Output power ( $P_o$ ) .....	31
6.10 Output power at 1-dB conversion compression ( $P_{o(1dB)}$ ).....	32
6.11 Noise figure ( $F$ ) .....	33
6.12 Intermodulation distortion ( $P_n / P_1$ ).....	35
6.13 Output power at the intercept point (for intermodulation products) ( $P_n(IP)$ ) .....	38
6.14 LO port return loss ( $L_{ret(LO)}$ ).....	39
6.15 RF port return loss ( $L_{ret(RF)}$ ).....	40
6.16 IF port return loss ( $L_{ret(IF)}$ ).....	42
Figure 1 – Electrical terminal symbols.....	11
Figure 2 – Circuit diagram for the measurement of conversion gain .....	17
Figure 3 – Circuit diagram for the measurement of the LO/IF isolation .....	21
Figure 4 – Circuit diagram for the measurement of the LO/RF isolation.....	23
Figure 5 – Circuit diagram for the measurement of the RF/IF isolation for type A .....	24
Figure 6 – Circuit diagram for the measurement of the RF/IF isolation for type B .....	26
Figure 7 – Circuit diagram for measurement of noise figure .....	33
Figure 8 – Circuit for the measurement of intermodulation distortion .....	36
Figure 9 – Circuit for the measurement of the LO port return loss .....	39
Figure 10 – Circuit for the measurement of the RF/IF port return loss .....	41

Table 1 – Function of terminals.....	11
Table 2 – Electrical limiting values.....	13
Table 3 – Electrical characteristics.....	15

**iTeh Standards**  
**(<https://standards.iteh.ai>)**  
**Document Preview**

[IEC 60747-16-3:2002](https://standards.iteh.ai/catalog/standards/iec/5aab671-7064-4c3c-9e6b-72f8946afd5f/iec-60747-16-3-2002)

<https://standards.iteh.ai/catalog/standards/iec/5aab671-7064-4c3c-9e6b-72f8946afd5f/iec-60747-16-3-2002>

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## SEMICONDUCTOR DEVICES –

**Part 16-3: Microwave integrated circuits –  
Frequency converters**

## 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.

**This consolidated version of IEC 60747-16-3 consists of the first edition (2002) [documents 47E/212/FDIS and 47E/219/RVD] and its amendment 1 (2009) [documents 47E/357/CDV and 47E/372/RVC]. It bears the edition number 1.1.**

**The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience. A vertical line in the margin shows where the base publication has been modified by amendment 1. Additions and deletions are displayed in red, with deletions being struck through.**

International Standard IEC 60747-16-3 has been prepared by subcommittee 47E: Discrete semiconductor devices, of IEC technical committee 47: Semiconductor devices.

This bilingual version, published in 2010-03, corresponds to the English version.

The French version of this standard has not been voted upon.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

**IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.**

iteh Standards  
(<https://standards.iteh.ai>)  
Document Preview

[IEC 60747-16-3:2002](https://standards.iteh.ai/catalog/standards/iec/5aab671-7064-4c3c-9e6b-72f8946afd5f/iec-60747-16-3-2002)

<https://standards.iteh.ai/catalog/standards/iec/5aab671-7064-4c3c-9e6b-72f8946afd5f/iec-60747-16-3-2002>

## SEMICONDUCTOR DEVICES –

### Part 16-3: Microwave integrated circuits – Frequency converters

#### 1 Scope

This part of IEC 60747 provides new measuring methods, terminology and letter symbols, as well as essential ratings and characteristics for integrated circuit microwave frequency converters.

#### 2 Normative references

The following referenced documents are indispensable for the application 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 60050-702:1992, *International Electrotechnical Vocabulary – Chapter 702: Oscillations, signals and related devices*~~

~~IEC 60617-12, *Graphical symbols for diagrams – Part 12: Binary logic elements*~~

~~IEC 60617-13, *Graphical symbols for diagrams – Part 13: Analogue elements*~~

~~IEC 60747-1:1983, *Semiconductor devices – Discrete devices and integrated circuits – Part 1: General*~~

~~IEC 60747-16-3:2002~~

~~IEC 60617, *Graphical symbols for diagrams* 71-7064-4c3c-9e6b-72f8946afd5f/iec-60747-16-3-2002~~

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

IEC 60747-16-1:2001, *Semiconductor devices – Part 16-1: Microwave integrated circuits – Amplifiers*  
Amendment 1 (2007)<sup>1</sup>

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

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

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

IEC 61340-5-1:2007, *Electrostatics – Part 5-1: Protection of electronic devices from electrostatic phenomena – General requirements*

IEC/TR 61340-5-2:2007, *Electrostatics – Part 5-2: Protection of electronic devices from electrostatic phenomena – User guide*

<sup>1</sup> There exists a consolidated edition 1.1 published in 2007, including the base publication (2001) and its Amendment 1 (2007).



### 3 Terms and definitions

For the purpose of this part of IEC 60747, the following terms and definitions apply:

#### 3.1

**conversion gain,  $G_c$** 

ratio of the desired converted output power to the input power

NOTE Usually, the conversion gain is expressed in decibels.

#### 3.2

**conversion gain flatness,  $\Delta G_c$** 

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

#### 3.3

**LO/RF isolation,  $P_{LO}/P_{LO(RF)}$** 

ratio of the incident local power to the local leakage power at the RF port with the IF port terminated in a specified impedance

#### 3.4

**LO/IF isolation,  $P_{LO}/P_{LO(IF)}$** 

ratio of the incident local power to the local leakage power at the IF port with the RF port terminated in a specified impedance

#### 3.5

**RF/IF isolation,  $P_{RF}/P_{RF(IF)}$** 

ratio of the incident RF power to the RF feedthrough power at the IF port for a specified local power

NOTE Usually, the RF/IF isolation is applied to the down-converter.

#### 3.6

**IF/RF isolation,  $P_{IF}/P_{IF(RF)}$** 

ratio of the incident IF power to the IF feedthrough power at the RF port for a specified local power

NOTE Usually, the IF/RF isolation is applied to the up-converter.

#### 3.7

**image rejection,  $P_o/P_{o(im)}$** 

ratio of the output power when the RF signal is applied, to the output power when the image signal is applied

NOTE Usually, the image rejection is applied to the down-converter.

#### 3.8

**sideband suppression,  $P_o/P_{o(U)}$** 

ratio of the output power of the desired sideband to the output power of the undesired sideband

NOTE Usually, the sideband suppression is applied to the up-converter.

#### 3.9

**LO port return loss,  $L_{ret(LO)}$** 

ratio of the specified incident power at the LO port to the reflected power at the LO port, with the RF port and the IF port terminated in each specified impedance

**3.10****RF port return loss,  $L_{\text{ret(RF)}}$** 

ratio of the incident power at the RF port to the reflected power at the RF port for a specified local power, with the IF port terminated in a specified impedance

**3.11****IF port return loss,  $L_{\text{ret(IF)}}$** 

ratio of the incident power at the IF port to the reflected power at the IF port for a specified local power, with the RF port terminated in a specified impedance

**3.12****output power,  $P_o$** 

see IEC 60747-16-2, 3.32

**3.13****output power at 1-dB conversion compression,  $P_{o(1dB)}$** 

output power where the conversion gain decreases by 1 dB compared with the linear conversion gain

**3.14****noise figure,  $F$** 

see IEC 60747-1 Chapter IV, 5.4.4 see 702-08-57 of IEC 60050-702

NOTE The term "noise figure" expresses "noise factor" in decibels.

**3.15****intermodulation distortion,  $P_n/P_1$ ,  $P_1/P_n$** 

ratio of the output power of the  $n$ th order component to the output power of the fundamental component, at a specified input power see 3.7 of Amendment 1 of IEC 60747-16-1

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

output power at the 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)

**4 Abbreviated terms**

The abbreviations used in this part of IEC 60747 are as follows:

- RF Radio Frequency;
- IF Intermediate Frequency;
- LO Local Oscillator.

**5 Essential ratings and characteristics****5.1 General**

This clause gives ratings and characteristics required for specifying integrated circuit microwave frequency converters.

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

### 5.1.1 Circuit identification and types

#### 5.1.1.1 Designation and types

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

Microwave frequency converters are divided into two categories:

- type A: down-converter;
- type B: up-converter.

#### 5.1.1.2 General function description

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

#### 5.1.1.3 Manufacturing technology

The manufacturing technology, for example, semiconductor monolithic integrated circuit, thin film integrated circuit, micro-assembly, shall be stated. This statement shall include details of the semiconductor technologies such as Schottky-barrier diode, MESFET, Si bipolar transistor, HBT.

#### 5.1.1.4 Package identification

The following shall be stated:

- a) chip or packaged form;
- b) IEC and/or national reference number of the outline drawing, or ~~of~~ drawing of non-standard package including terminal numbering;
- c) principal package material, for example, metal, ceramic, plastic;
- d) for chip form: outlines, dimensions, pad sizes, contact material, and recommended contact technologies.

#### 5.1.1.5 Main application

The main application shall be stated if necessary. If the device has restrictive applications, these too shall be stated here.

### 5.2 Application description

Information on the application of the integrated circuit and its relation to the associated devices shall be given.

#### 5.2.1 Conformance to system and/or interface information

It shall be stated whether the integrated circuit conforms to an application system and/or an interface standard or recommendation.

Detailed information about application systems, equipment and circuits such as VSAT systems, DBS receivers, microwave landing systems shall also be given.

#### 5.2.2 Overall block diagram

A block diagram of the applied systems shall be given if necessary.

### 5.2.3 Reference data

The most important properties required to permit comparison between derivative types shall be given.

### 5.2.4 Electrical compatibility

It shall 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 shall be given concerning the type of the input and output circuits, for example, input/output impedances, d.c. block, open-drain.

Interchangeability with other devices, if any, shall be given.

### 5.2.5 Associated devices

If applicable, mention shall be made here of

- devices necessary for correct operation (list with type number, name, and function);
- peripheral devices with direct interfacing (list with type number, name, and function).

## 5.3 Specification of the function

### 5.3.1 Detailed block diagram – functional blocks

A detail block diagram or equivalent circuit information of the integrated circuit microwave frequency converters 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) interdependence between the separate functional blocks.

The block diagram shall identify the function of each external connection, and, where no ambiguity can arise, it can 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.

For the purpose of providing additional information, the complete electrical circuit diagram can be reproduced, though this will not necessarily involve giving indications of the function. Rules governing such diagrams may be obtained from ~~IEC 60617-12 or IEC 60617-13~~ IEC 60617.

### 5.3.2 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 1) to 4) shall be indicated, as shown in table 1 below.

**Table 1 – Function of terminals**

Terminal number	Terminal symbol	1 Terminal designation	2 Function	3 Input/output identification	4 Type of input/output circuits

### 5.3.2.1 Function 1: Terminal designation

The terminal designation to indicate the terminal function shall be given. Supply terminals, ground terminals, blank terminals (with abbreviation NC) and non-usable terminals (with abbreviation NU) shall be distinguished.

### 5.3.2.2 Function 2: Function

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 the integrated circuit selected by mutual pin connections, or programming and/or application of function selection data to the function selection pin such as mode selection pin.

### 5.3.2.3 Function 3: Input/output identification

Input, output, input/output, and multiples of the input/output terminal shall be distinguished.

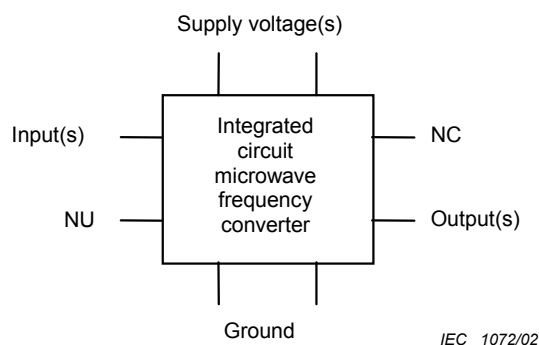
### 5.3.2.4 Function 4: Type of input/output circuits

The type of input and output circuits, for example, input/output impedances, with or without d.c. block, etc., shall be distinguished.

### 5.3.2.5 Function 5: Type of ground

If the baseplate of the package is used as ground, this shall be stated.

EXAMPLE:



**Figure 1 – Electrical terminal symbols**

### 5.3.3 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.

### 5.3.4 Family related characteristics

All family-specific functional descriptions shall be stated (with reference to IEC 60748-2, IEC 60748-3 and IEC 60748-4).

If ratings, characteristics and function characteristics exist for the family, the relevant part of IEC 60748 shall be used (for example, for microprocessors, see IEC 60748-2, chapter III, section 3).

NOTE For each new device family, specific items shall be added to the relevant part of IEC 60748.

## 5.4 Limiting values (absolute maximum rating system)

The table giving these values shall specify the following:

- any interdependence of limiting conditions;
- 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 referenced to a specified reference terminal ( $V_{SS}$ , GND, etc.);
- in satisfying the following clauses, 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, such dependence shall be indicated.