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Incorporating corrigendum March 2012



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Semiconductor devices — Micro-electromechanical devices

Part 5: RF MEMS switches

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The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by IEC corrigendum March 2012 is indicated in the text by AC1 AC1.

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**Semiconductor devices -
Micro-electromechanical devices -
Part 5: RF MEMS switches
(IEC 62047-5:2011)**

Dispositifs à semiconducteurs -
Dispositifs microélectromécaniques -
Partie 5: Commutateurs MEMS-RF
(CEI 62047-5:2011)

Halbleiterbauelemente -
Bauelemente der Mikrosystemtechnik -
Teil 5: Hochfrequenz-MEMS-Schalter
(IEC 62047-5:2011)

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Foreword

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The following dates were fixed:

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| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2012-05-17 |
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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62047-5:2011 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 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.

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60747-1 + corr. August	2006 2008	Semiconductor devices - Part 1: General	-	-
IEC 60747-16-1	-	Semiconductor devices - Part 16-1: Microwave integrated circuits - Amplifiers	EN 60747-16-1	-
IEC 60747-16-4	2004	Semiconductor devices - Part 16-4: Microwave integrated circuits - Switches	EN 60747-16-4	2004
IEC 60749-5	-	Semiconductor devices - Mechanical and climatic test methods - Part 5: Steady-state temperature humidity bias life test	EN 60749-5	-
IEC 60749-10	-	Semiconductor devices - Mechanical and climatic test methods - Part 10: Mechanical shock	EN 60749-10	-
IEC 60749-12	-	Semiconductor devices - Mechanical and climatic test methods - Part 12: Vibration, variable frequency	EN 60749-12	-
IEC 60749-27	-	Semiconductor devices - Mechanical and climatic test methods - Part 27: Electrostatic discharge (ESD) sensitivity testing - Machine model (MM)	EN 60749-27	-

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 5: RF MEMS switches

1 Scope

This part of IEC 62047 describes terminology, definition, symbols, test methods that can be used to evaluate and determine the essential ratings and characteristic parameters of RF MEMS switches. The statements made in this standardization are also applicable to RF (Radio Frequency) MEMS (Micro-Electro-Mechanical Systems) switches with various structures, contacts (d.c. contact and capacitive contact), configurations (series and shunt), switching networks (SPST, SPDT, DPDT, etc.), and actuation mechanism such as electrostatic, electro-thermal, electromagnetic, piezoelectric, etc. The RF MEMS switches are promising devices in advanced mobile phones with multi-band/mode operation, smart radar systems, reconfigurable RF devices and systems, SDR (Software Defined Radio) phones, test equipments, tunable devices and systems, satellite, etc.

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 normative documents (including any amended documents) referred to applies.

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

IEC 60747-16-1, *Semiconductor devices – Part 16-1: Microwave integrated circuits – Amplifiers*

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

IEC 60749-5, *Semiconductor devices – Mechanical and climatic test methods – Part 5: Steady-state temperature humidity bias life test*

IEC 60749-10, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

IEC 60749-12, *Semiconductor devices – Mechanical and climatic test methods – Part 12: Vibration, variable frequency*

IEC 60749-27, *Semiconductor devices – Mechanical and climatic test methods – Part 27: Electrostatic discharge (ESD) sensitivity testing – Machine model (MM)*

3 Terms and definitions

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

NOTE In the text of this standard, the term of switch is used instead of RF MEMS switch to improve the readability.

3.1 Switching operation

3.1.1

capacitive switch

switch whereby an RF signal is passed or blocked by a change of impedance ratio caused by the capacitive effect of making contact using a movable metal plate onto a dielectric film presented on a fixed metal plate

3.1.2

d.c. contact switch

switch whereby an RF signal is passed or blocked by a movable metal contact

3.2 Switching configuration

3.2.1

series switch

switch whereby an RF signal applied to the input port is directly passed to the output port when a movable plate makes contact with a fixed plate

3.2.2

shunt switch

switch whereby an RF signal applied to the input port is passed to the ground plane when a movable plate makes contact with a fixed plate

3.3 Actuating mechanism

3.3.1

electro-statically actuated switch

switch whereby a $\overline{AC_1}$ moving plate $\overline{AC_1}$ is pulled down onto the fixed plate by an electrostatic force caused by the applied d.c. bias voltage, the moving plate returns to its original position when the bias voltage is removed

NOTE Advantages are virtually zero power consumption, small electrode size, relatively short switching time, and relatively simple fabrication and disadvantage is higher actuation voltage.

3.3.2

electro-magnetically actuated switch

switch whereby a movable plate or armature is pulled down onto a fixed plate by a magnetic force generated by a permanent magnet or an energised electromagnet

NOTE Advantage is a low actuation voltage and disadvantages are complexity of fabrication and high power consumption.

3.3.3

electro-thermally actuated switch

switch whereby a movable plate constructed of two or more differing materials with differential thermal expansion coefficients deflects to contact a fixed plate or electrode

NOTE Advantages are nearly linear deflection-versus-power relations and environmental ruggedness and disadvantages are high power consumption, low bandwidth, and relatively complex fabrication.

3.3.4

piezo-electrically actuated switch

switch whereby a movable $\overline{AC_1}$ plate $\overline{AC_1}$ constructed of piezoelectric materials deflects to contact a fixed plate or electrode

3.4 Switching network configurations

3.4.1

single-pole-single-throw switch

SPST

device with a single input and a single output, which is providing an ON-OFF switching function with switch actuation

3.4.2

single-pole-double-throw switch

SPDT

device with a single input and two outputs, which is transferring the through connection from one output to the other output with switch actuation

3.4.3

single-pole-multi-throw switch

SPMT

device with one input and multiple outputs whereby connection to one or the other of the multiple outputs is determined by switch actuation

3.4.4

double-pole-double-throw switch

DPDT

device with two inputs and two outputs, which is transferring the through connection from one output to the other output with switch actuation

3.4.5

multi-pole-multi-throw switch

MPMT

device with multi inputs and outputs, which is transferring the through connection from multi outputs to the other multi outputs with switch actuation

3.5 Reliability (performance)

3.5.1

life time cycles

number of actuating times which the switches are operating with satisfactory electrical performances in the on/off positions

NOTE Unlike the electronic switch, a mechanical switch may fail due to stiction (micro-welding and material transfer) of a moving part and degradation of metal to metal contact used, whereas at electronic RF switches (capacitive switch) the reliability is limited by dielectric charging (charge injection and charge trapping).

3.5.2

cold switching

performed switching where the RF power is not applied during the switch operation

NOTE It is useful for examining the durability of the switch electrode to see if it can withstand the physical stresses of repeated switching.

3.5.3

hot switching

performed switching where the RF power is applied during the switch operation

NOTE The hot-switching tests are indicative of how the switch will survive under actual operating conditions, with current flowing through the device.

3.6 Electrical characteristics

3.6.1

d.c. characteristics

3.6.1.1

actuation voltage

d.c. voltage for the movable electrode (or membrane) of the switch being collapsed down onto the fixed plate and kept securing RF characteristics desired

3.6.1.2

on resistance – DC contact type

electrical resistance which is measured across fully closed contacts at their associated external terminals

3.6.1.3

off resistance – DC contact type

electrical resistance which is measured across fully opened contacts at their associated external terminals

3.6.1.4

on capacitance – Capacitive type

electrical capacitance which is measured in the down-state position (the movable electrode collapsed down on the dielectric layer on top of the fixed electrode) of the switch

3.6.1.5

off capacitance – Capacitive type

electrical capacitance which is measured in the up-state position of the switch (before the movable electrode is being actuated)

3.6.1.6

power consumption

power consumed to pull down and hold the movable plate onto the fixed electrode when the switch is ON

3.6.2

RF characteristics

3.6.2.1

insertion loss

[IEC 60747-16-4:2004, 3.1]

3.6.2.2

isolation

[IEC 60747-16-4:2004, 3.2]

NOTE It is caused by a RF energy leak from one conductor to another by radiation, ionization, capacitive coupling, or Inductive coupling.

3.6.2.3

return loss

[IEC 60747-16-4:2004, 3.3]

3.6.2.4

voltage standing wave ratio

VSWR

ratio of the electrical field strength at a voltage maximum on a transmission line to the electrical field strength of an adjacent voltage minimum

3.6.2.5

resonant frequency

frequency occurred at LC series resonance when the switch is up-state and down-state position, respectively

3.6.2.6

bandwidth

frequency range where the switch has good RF characteristics enough to use in subsystems and system applications

NOTE It is usually expressed as either the frequency or percentage differences between the lower or the upper relative 1 dB points of the frequency response curve.

3.6.2.7

power handling capability

capability of a switch to transmit a given amount of power through the device when the switch is on

3.6.3

Switching characteristics

3.6.3.1

self actuation power

radio frequency power where the switch movable plate is self-actuated without any voltages being applied directly to it

3.6.3.2

switching time

3.6.3.2.1

turn on time

[IEC 60747-16-4:2004, 3.6]

3.6.3.2.2

turn off time

[IEC 60747-16-4:2004, 3.7]

3.6.3.2.3

rise time

transition time of the switch from OFF to ON state

NOTE OFF state: 10 % of C_{up} , ON state: 90 % of C_{down} .

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

3.6.3.2.4

falling time

transition time of the switch from ON to OFF state

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

4 Essential ratings and characteristics

4.1 Identification and types

General description of the function of RF MEMS switches and their applications should be stated. The statement should include the details of manufacturing technologies about the RF MEMS switches with different operation, configuration, and actuation mechanism. The