IEC 62047-19

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Semiconductor devices – Micro-electromechanical devices –
Part 19: Electronic compasses

Dispositifs à semiconducteurs – Dispositifs microélectromécaniques –
Partie 19: Compas électroniques

IEC 62047-19:2013

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FOREWORD

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International Standard IEC 62047-19 has been prepared by subcommittee 47F: Micro-electromechanical systems, of IEC technical committee 47: Semiconductor devices.

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

FDIS	Report on voting
47F/156/FDIS	47F/163/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62047 series, published under the general title *Semiconductor devices – Micro-electromechanical devices*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability 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

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- amended.

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SEMICONDUCTOR DEVICES – MICRO-ELECTROMECHANICAL DEVICES –

Part 19: Electronic compasses

1 Scope

This part of IEC 62047 defines terms, definitions, essential ratings and characteristics, and measuring methods of electronic compasses. This standard applies to electronic compasses composed of magnetic sensors and acceleration sensors, or magnetic sensors alone. This standard applies to electronic compasses for mobile electronic equipment.

For marine electronic compasses, see ISO 11606.

Electronic compasses are called "e-compasses" for short. Types of e-compasses are: 2-axis e-compasses, 3-axis e-compasses, 6-axis e-compasses, etc., all of which are covered by this standard.

2 Normative references

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.

None

3 Terms and definitions

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

3.1
3-axis Helmholtz coil
three Helmholtz coils that generate magnetic fields at right angles to each other

3.2
zero magnetic field environment
magnetic field environments where magnetic field strength in a space including a device under test is lower than the strength specified

Note 1 to entry: The device under test (DUT) is defined in 4.1.7.

3.3
e-compass
electronic compass
compass that calculates and outputs an azimuth using the electrical output of sensors

Note 1 to entry: The term "e-compass" is used as an abbreviated term of electronic compass. (See the above Scope.)

3.4
2-axis e-compass
e-compass that uses a 2-axis magnetic sensor as a geomagnetism detection element

3.5
3-axis e-compass
e-compass that uses a 3-axis magnetic sensor as a geomagnetism detection element

3.6
6-axis e-compass
e-compass that uses a 3-axis magnetic sensor as a geomagnetism detection element, and a 3-axis acceleration sensor as an gravity detection element

3.7
magnetic north
direction of the horizontal component of an environment magnetic vector at a location, which is the same direction a compass points to

Note 1 to entry: Geomagnetism is sometimes warped by artificial structures (buildings, vehicles, etc.), or is sometimes affected by their magnetization especially in urban areas. Strictly, therefore, the geomagnetic vector should be called a kind of environmental magnetic vector. Although the environmental magnetic vector does not point to the magnetic north pole exactly, here "magnetic north" is defined as the horizontal component of an environmental magnetic vector.

3.8
true north
direction of the horizontal component of a vector pointing to the North Pole of the Earth (north end of rotational axis) at a location, which is the same as the north to which longitude lines or a meridian point

3.9
azimuth angle
rotational angle around z-axis of a terminal coordinate system, which is defined as zero degree when the xy-plane of a terminal coordinate system is horizontal and the yz-plane includes the North Pole, where a clockwise turn is defined as positive when the z-axis is viewed from the positive direction to the negative direction

Note 1 to entry: Azimuth angle is the same as the yaw angle, see Annex C.

Note 2 to entry: For coordinate systems of e-compasses, see Annex B.

Note 3 to entry: For an explanation with diagrams, see Annex C.

Note 4 to entry: Definitions for cases in which the xy-plane of a terminal coordinate system are not horizontal are under consideration.

4 Essential ratings and characteristics

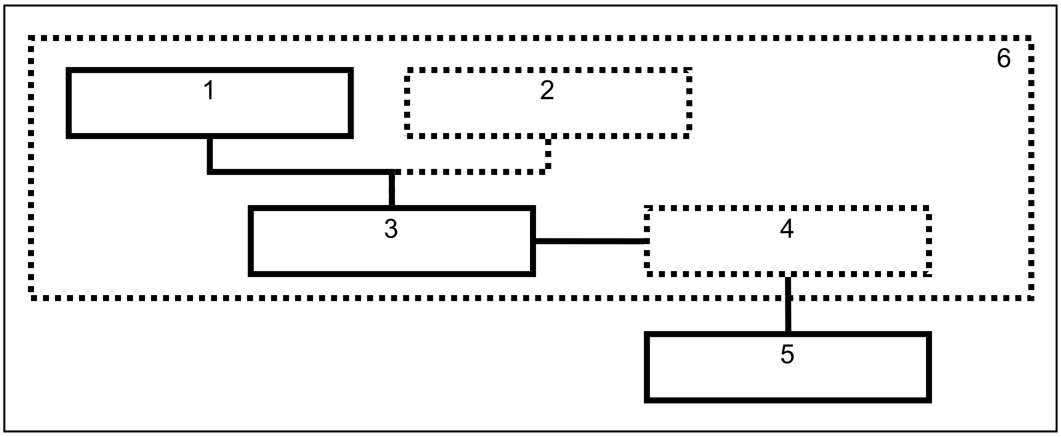
4.1 Composition of e-compasses

4.1.1 General

As shown in Figure 1, an e-compass is composed of the following sections:

– Magnetic sensor section;
– Acceleration sensor section;
– Signal processing section;
– Peripheral hardware sections;
– Peripheral software sections.

In some cases, an e-compass does not contain the acceleration sensor section and/or the peripheral hardware section.



Key

1	Magnetic sensor section	4	Peripheral hardware section
2	Acceleration sensor section	5	Peripheral software section
3	Signal processing section	6	DUT

Figure 1 – Composition of e-compasses

4.1.2 Magnetic sensor section

A magnetic sensor section is a magnetic sensor to measure magnetic fields of an Earth's magnetism level, which measures two or more axes of magnetic fields that are at right angles to each other for calculating azimuth angles using its output.

In the case of a 3-axis magnetic sensor, for example, the sensor section is composed of an x-axis sensor, a y-axis sensor, and a z-axis sensor, and the sensitivity axis of the x-axis sensor is set to the x-axis.

4.1.3 Acceleration sensor section

An acceleration sensor section is an acceleration sensor to measure gravity. Vertical direction (horizontal plane) is known from its output, and then an azimuth angle is calculated based on the information with correction considering the attitude of the magnetic sensor section (tilt angle).

In the case of a 3-axis acceleration sensor, for example, the sensor section is composed of an x-axis sensor, a y-axis sensor, and a z-axis sensor, and the sensitivity axis of the x-axis sensor is set to the x-axis.

4.1.4 Signal processing section

A signal processing section is a circuit section to drive the sensor section and to amplify its signal. In some cases, this section includes an analog-digital converter.

4.1.5 Peripheral hardware section

A peripheral hardware section includes sections of a digital interface, data storage for information to control registers and devices, and an information processing.

4.1.6 Peripheral software section

A peripheral software section includes not only a device driver section to acquire data but also software to convert the coordinate data from magnetic sensors and acceleration sensors and to calculate azimuth angles based on the results.

4.1.7 DUT

The DUT is a functional composition composed of the magnetic sensor section, the acceleration sensor section, the signal processing section, and the peripheral hardware section. For e-compasses not having the acceleration sensor section and/or the peripheral hardware section, the DUT is a functional composition composed of the magnetic sensor section and the signal processing section. Measurements of ratings and characteristics are made using the DUT.

4.2 Ratings (Limiting values)

The following items should be described in the specification, unless otherwise stated in the relevant procurement specifications. Stresses over these limits can be one of the causes of permanent damage to the devices:

– Power supply voltage;
– Input voltage;
– Input current;
– Storage temperature;
– Mechanical shock (requisite for 6-axis e-compasses);
– Maximum magnetic field (can be omitted).

4.3 Recommended operating conditions

The following items should be described in the specification, unless otherwise stated in the relevant procurement specifications. These conditions are recommended in order to keep the characteristics of the DUT (the devices) stable state during operation:

– Power supply voltage;
– Input voltage;
– Operating temperature.

4.4 Electric characteristics

4.4.1 General

Electric characteristics specified in this standard are those of sensor sections and DC characteristics. For the selection of essential ratings and characteristics, see Annex A.

4.4.2 Characteristics of sensor sections

Characteristics of sensor sections are listed as shown in Table 1.

Table 1 – Characteristics of sensor sections

Parameter	Mandatory	optional	Value			Measuring method	Remarks
			Min	Typ	Max		
Measuring time of magnetic sensor (at one time)	x			x		See 5.1	NOTE 1
Sensitivity of magnetic sensor	x			x		See 5.1	NOTE 1
Measuring range of magnetic sensor	x		x		x	See 5.1	NOTE 1 NOTE 4
Linearity of magnetic sensor		x			x	See 5.2	NOTE 1
Zero magnetic field output of magnetic sensor		x			x	See 5.3	NOTE 1
Cross axis sensitivity of magnetic sensor		x			x	See 5.4	NOTE 1 NOTE 2
Frequency range of magnetic sensor (analog output)	x		x		x	See 5.6	NOTE 1
Measuring time of acceleration sensor (at one time)	x (only 6-axis)			x		See 5.5	NOTE 3
Sensitivity of acceleration sensor	x (only 6-axis)		x	x	x	See 5.5	NOTE 3
Measuring range of acceleration sensor	x (only 6-axis)		x		x	See 5.5	NOTE 3 NOTE 4

NOTE 1 Measurement at the magnetic sensor section is made using 1 Magnetic sensor section, 3 Signal processing section, 4 Peripheral hardware section and 5 Peripheral software section of Figure 1.

NOTE 2 As there are two types of definitions, describe which one is followed. See 5.4.3.1 and 5.4.4.1 for these two definitions.

NOTE 3 Measurement at acceleration sensor section is performed using 2 Acceleration sensor section, 3 Signal processing section, 4 Peripheral hardware section and 5 Peripheral software section of Figure 1.

NOTE 4 It is specified as the minimum value of the positive direction and the negative direction.

4.4.3 DC characteristics

DC characteristics of e-compasses are listed as shown in Table 2.

Table 2 – DC characteristics of e-compasses

Parameter	Mandatory	optional	Value			Measuring method
			Min	Typ	Max	
Average current consumption during magnetic field measurement in a described measuring period	x			x		See 5.7
Max. current consumption during measurement		x			x	See 5.7
Current consumption during standby		x		x		See 5.7
Average current consumption during intermittent measurement		x		x		See 5.7

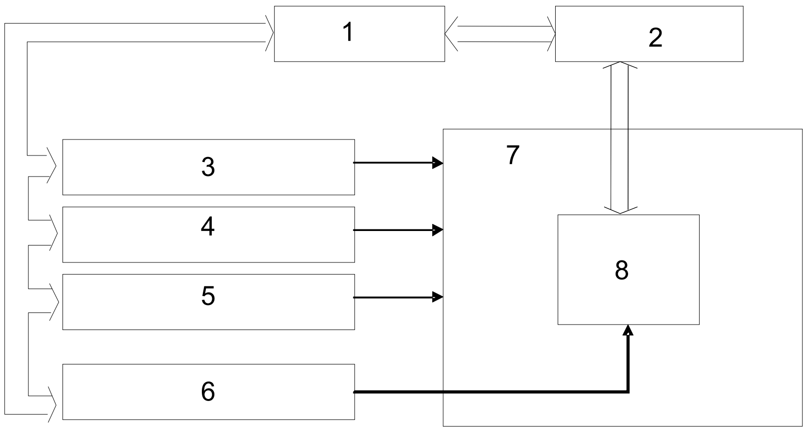
5 Measuring methods

5.1 Sensitivity of the magnetic sensor section

5.1.1 Purpose

To measure the sensitivity of the magnetic sensor section under specified conditions.

5.1.2 Circuit diagram



Key

1 Computer for data processing

2 Data reader

3 Power supply for x-axis coil

4 Power supply for y-axis coil

5 Power supply for z-axis coil

6 Power supply for DUT

7 3-axis Helmholtz coil

8 DUT

Figure 2 – Circuit to measure sensitivity

The same configuration is used for analogue output sensors.

5.1.3 Principle of measurement

5.1.3.1 General

The sensitivity is defined as the output change by application of a magnetic field in the direction of the sensitivity axis of each sensor (x-axis, y-axis, or z-axis sensor) divided by the strength of the magnetic field applied.

5.1.3.2 Principle of measurement for sensitivity of x-axis sensor

Sensitivity of the x-axis sensor, A_{x}, is given by the following equation:

$$A_{\mathrm{x}} = \frac{V_{\mathrm{xp}} - V_{\mathrm{xn}}}{2H} \tag{1}$$

where

A_x is the sensitivity of the x-axis sensor, given in V·m/A represented with LSB (Least Significant Bit). ‘A’ (current), s (time), etc., may be also used as the units;

V_{xp} is the output of the x-axis sensor at the magnetic sensor section when a magnetic field of strength H is applied in the positive direction of x-axis at the magnetic sensor section, and the unit is ‘V’ represented with LSB;

V_{xn} is the output of the x-axis sensor at the magnetic sensor section when a magnetic field of strength H is applied in the negative direction of x-axis at the magnetic sensor section, and the unit is ‘V’ represented with LSB;

H is the magnetic field strength in A/m. (See the note below).

NOTE The magnetic flux density (unit: T) can be used instead of the magnetic field strength, H.

5.1.3.3 Principle of measurement for sensitivity of y-axis sensor

The principle of measurement for y-axis sensors is as described in 5.1.3.2.

5.1.3.4 Principle of measurement for sensitivity of z-axis sensor

The principle of measurement for z-axis sensors is as described in 5.1.3.2.

5.1.4 Precaution to be observed

The sensitivity axis of the sensor shall correspond to the direction of the magnetic field of the coil. Measurement for magnetic sensors with analogue output shall be made pursuant to this measurement.

5.1.5 Measurement procedure

5.1.5.1 Measurement procedure of the sensitivity of the x-axis sensor

The measurement of the sensitivity of the x-axis sensor will be taken as follows.

a) Set an ambient temperature.
b) Apply power supply voltage to the DUT, and initialize registers if necessary.
c) Apply a specified magnetic field in the positive direction of x-axis of the DUT.
d) Measure the x-axis sensor output of the DUT.
e) Apply a specified magnetic field in the negative direction of x-axis of the DUT.
f) Measure the x-axis sensor output of the DUT.
g) Calculate the sensitivity with Equation (1) using the output value of the x-axis sensor.

5.1.5.2 Measurement procedure of the sensitivity of the y-axis sensor

The measurement procedure for the y-axis sensor is as described in 5.1.5.1.

5.1.5.3 Measurement procedure of the sensitivity of the z-axis sensor

The measurement procedure for the z-axis sensor is as described in 5.1.5.1.

5.1.6 Specified conditions

– Strength of the magnetic field applied;
– Ambient temperature;
– Power supply voltage.

5.2 Linearity of the magnetic sensor section

5.2.1 Purpose

To measure the linearity of the magnetic sensor section under specified conditions.

5.2.2 Measuring circuit

The same circuit as shown in Figure 2 is used.

5.2.3 Principle of measurement

The output values of the magnetic sensor are measured against a magnetic field applied. Then, the least square line is plotted from the output values as shown in Figure 3.

Linearity, L, is given by the following equation:

$$L = a_{max}/b \tag{2}$$

where

L is the linearity represented in %;

a_{max} is the maximum of a, the difference between the sensor output value calculated for each measuring point and the least squares line;

b is the difference between the maximum and minimum values of the sensor output.

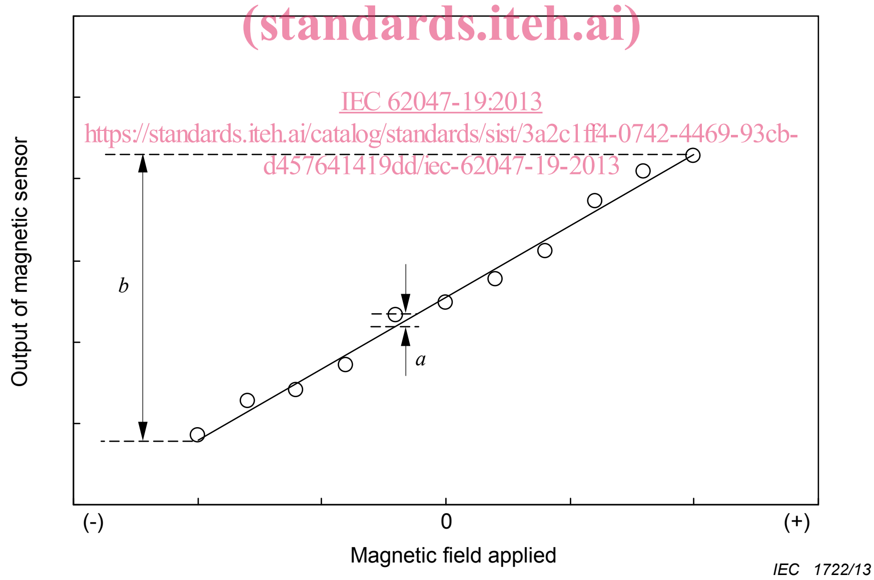


Figure 3 – Measuring method of linearity

5.2.4 Precaution to be observed

- When a magnetic field is applied, the strength can be increased from negative to positive, or decreased from positive to negative;
- If there is a difference in the sensor output value between the case the magnetic field is increased and the case it is decreased, evaluation shall be made by applying the magnetic field in both directions (from positive and from negative);
- The range of the magnetic field applied shall be the entire range of the measurement, or a particular range of the actual Earth's magnetism.