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**Wearable electronic devices and technologies –
Part 402-1: Performance measurement of fitness wearables – Test methods of glove-type motion sensors for measuring finger movements**

**Technologies et dispositifs électroniques prêts-à-porter –
Partie 402-1: Mesure des performances des dispositifs prêts-à-porter d'activité physique – Méthodes d'essai des capteurs de mouvement type gant pour le mesurage des mouvements digitaux**

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The text of this International Standard is based on the following documents:

Draft	Report on voting
124/195/FDIS	124/204/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.

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WEARABLE ELECTRONIC DEVICES AND TECHNOLOGIES –

Part 402-1: Performance measurement of fitness wearables – Test methods of glove-type motion sensors for measuring finger movements

1 Scope

This document specifies test methods for wearable glove-type motion sensors to measure finger movements. The measurement methods include goniometric parameters related to the finger postures and flexion dynamics. Glove-type motion sensors are the type of gloves considered within the scope of this document for testing and measurement. This document describes direct and indirect measurement methods. In the direct measurement method, the angles of the joints of each finger are directly measured by a goniometer. The indirect method uses a measurement device such as a servomotor-based angle-measuring device. This document is applicable to angle measurement of all gloves with glove-type motion sensors without limitation of the device technology or size.

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 62047-6, *Semiconductor devices – Micro-electromechanical devices – Part 6: Axial fatigue testing methods of thin film materials*

IEC 62951-1, *Semiconductor devices – Flexible and stretchable semiconductor devices – Part 1: Bending test method for conductive thin films on flexible substrates*

ISO 291, *Plastics – Standard atmospheres for conditioning and testing*

ISO 21420:2020, *Protective gloves – General requirements and test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62047-6, IEC 62951-1, ISO 291, ISO 21420, and the following 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 General terms

3.1.1
glove-type motion sensor
sensor mounted in or on a glove which is worn for gesture recognition

Note 1 to entry: See Annex A for details.

3.1.2
resistive-type glove sensor
sensor mounted in or on a glove that detects and measures changes in electrical resistance in or on a glove

Note 1 to entry: The resistive-type glove sensor shows a resistance change due to the movement in the hand by applying a simple resistive sensor in a glove.

3.1.3
capacitive-type glove sensor
sensor mounted in or on a glove that detects and measures changes in electrical capacitance in or on a glove

Note 1 to entry: The capacitive-type glove sensor shows a capacitance change due to hand movements by applying a simple capacitive sensor in a glove.

3.1.4
piezoelectric-type glove sensor
sensor mounted in or on a glove that detects and measures changes in piezoelectricity in or on a glove

Note 1 to entry: The piezoelectric-type glove sensor shows a voltage change due to movement in the hand by applying a simple piezoelectric sensor in a glove.

3.2 Angle between finger joints

3.2.1
phalanx,
phalanges, pl
bone(s) of the fingers or toes

3.2.2
metacarpal joint
MCP
first joint of the finger, connecting the metacarpal bone to the proximal phalange

Note 1 to entry: See Figure 1 for the position of the MCP.

3.2.3
proximal interphalangeal joint
PIP
second joint of the finger, connecting the proximal phalange to the intermediate phalange

Note 1 to entry: See Figure 1 for the position of the PIP.

3.2.4
distal interphalangeal joint
DIP
third and final joint of the finger, connecting the intermediate phalange to the distal phalange

Note 1 to entry: See Figure 1 for the position of the DIP.

3.2.5
interphalangeal joint
IP
second and final joint of the thumb finger, connecting the intermediate phalange to the distal phalange

Note 1 to entry: See Figure 1 for the position of the IP.

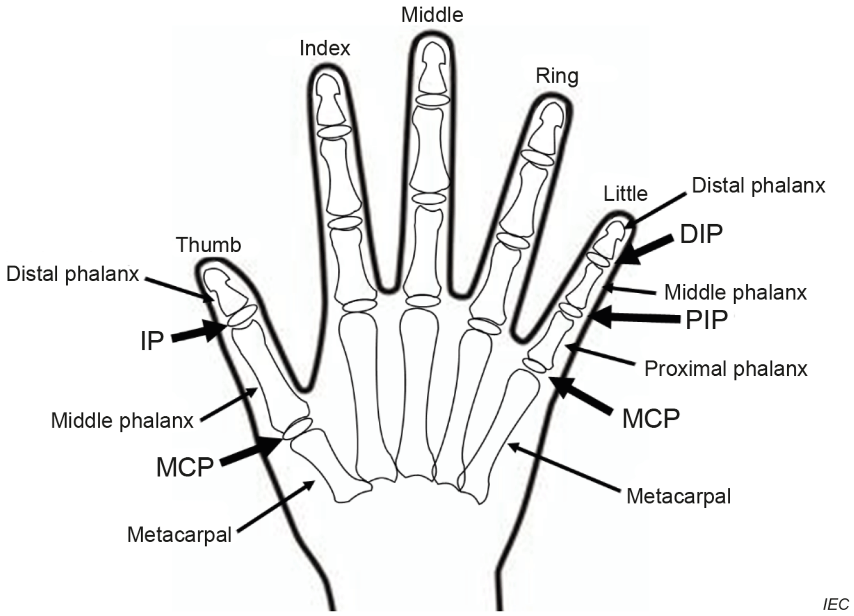


Figure 1 – Position of DIP, PIP, IP and MCP

4 Test conditions and method

4.1 Test conditions

The standard atmosphere for specimen test and storage is 23,0 °C ± 2,0 °C (ambient or atmospheric temperature) and 36,5 °C ± 1,0°C (body temperature) with 50 % ± 10 % relative humidity, which conforms to standard atmosphere class 2 as specified in ISO 291. If conditioning is necessary, the same standard atmosphere as that specified above shall apply.

4.2 Preparation of gloves under test

The gloves with glove-type motion sensors are prepared and can be applied in either direct or indirect measurement methods.

4.3 Test methods

4.3.1 Direct measurement test procedure: angle between finger joints

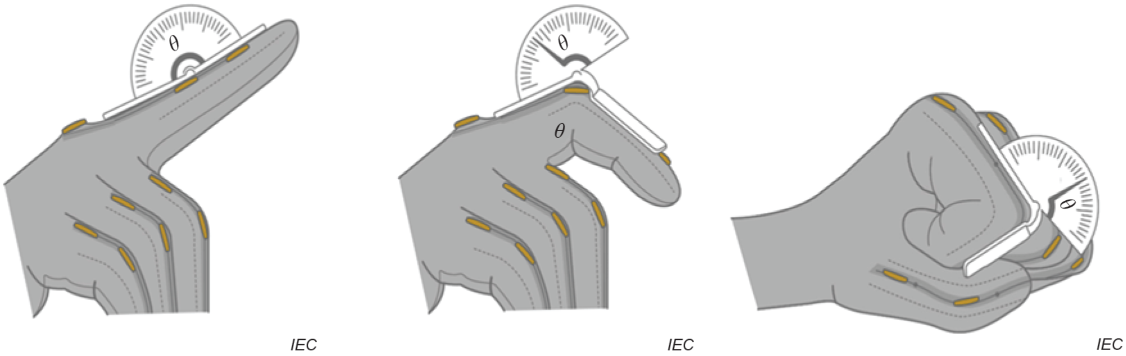
Figure 2 shows the test setup to measure the angle between finger joints using the goniometer under test. A goniometer is required to measure the angle between the fingers in an environment consistent with 4.1. In the direct measurement method, the glove may be worn on the hand while the sensor is inserted into the glove. Proceed to measure each finger as follows and write down the results in Table 1.

a) The glove with the sensor for testing shall be worn on the hand. At this point in the procedure, the sensor's fixed position is important. The sensor shall be fixed parallel to the finger's longitudinal direction, and the goniometer shall be accurately positioned at the joint to measure the angle in the finger's longitudinal direction.

b) Attach a manual goniometer (with 5° resolution) to a finger joint.

c) Adjust the joint maximum angle (180°) to the minimum angle with 5° resolution. Measure the resistance change for 10 s at each angle. The minimum angular position is the angle at which the finger is flexed, as shown in Figure 2 c). The method of obtaining the resistance value is as follows. At both ends of the sensor, there is a terminal to measure the sensor signal. Each terminal is connected to either the measuring device or to the measuring circuit board. The glove sensor data depends on the sensor type. The types can produce resistance, capacitance, voltage, or analog-to-digital converter (ADC) values. It is necessary to measure the sensors for all five fingers because the bending radius of the joints in each finger are different, as are the minimum and maximum bending angles.

d) Sequentially measure each joint on each finger repeatedly from 4.3.1 a) to c) and quantify the sensors' responses.



a) Measuring maximum angle (180°) **b) Measuring 90°** **c) Measuring minimum angle**

Figure 2 – Direct measurement method using a manual goniometer

Table 1 – Comparison of angle data measured with a glove sensor and goniometer

	Thumb														
Joints	**MCP**					**IP**									
Actual angle (θ) [°]	180	175	170	…	min.	180	175	170	…	min.					
Glove sensor data [kΩ]	[e.g.] 7	7,015	7,022	…	8,038	7	7,009	7,02	…	8,338					
	Index finger														
Joints	**MCP**					**PIP**					**DIP**				
Actual angle (θ) [°]	180	175	170	…	min.	180	175	170	…	min.	180	175	170	…	min.
Glove sensor data [kΩ]															
	Middle finger														
Joints	**MCP**					**PIP**					**DIP**				
Actual angle (θ) [°]	180	175	170	…	min.	180	175	170	…	min.	180	175	170	…	min.
Glove sensor data [kΩ]															
	Ring finger														
Joints	**MCP**					**PIP**					**DIP**				
Actual angle (θ) [°]	180	175	170	…	min.	180	175	170	…	min.	180	175	170	…	min.
Glove sensor data [kΩ]															
	Little finger														
Joints	**MCP**					**PIP**					**DIP**				
Actual angle (θ) [°]	180	175	170	…	min.	180	175	170	…	min.	180	175	170	…	min.
Glove sensor data [kΩ]															

NOTE MCP, PIP, DIP and IP definitions are given in 3.2.

4.3.2 Indirect measurement test procedure: angle between finger joints with sensors

The indirect measuring method is designed to measure the bending angle of the glove sensor using a servomotor-based test apparatus. Figure 3 shows the test setup to measure the bending angle of the sensor using finger-like and similar instruments. The finger joint angle is determined using an experimental device based on a servomotor, as shown in Figure 3. When the servomotor-based bending angle measuring apparatus is used, the relationship between the number of counts in the servomotor's encoder and the sensor's angle, as provided by the servomotor's manufacturer, can be used as a reference table lookup. Figure 4 shows the system configuration schematic. Measure the bending angle of the glove sensor as follows and compare the results with the values in Table 2.

The following test procedures are performed:

a) Wear on your hand (or the hand of another person) a glove with the sensor for testing. The glove size is in accordance with ISO 21420:2020, 5.1 and ISO 21420:2020, Annex B.

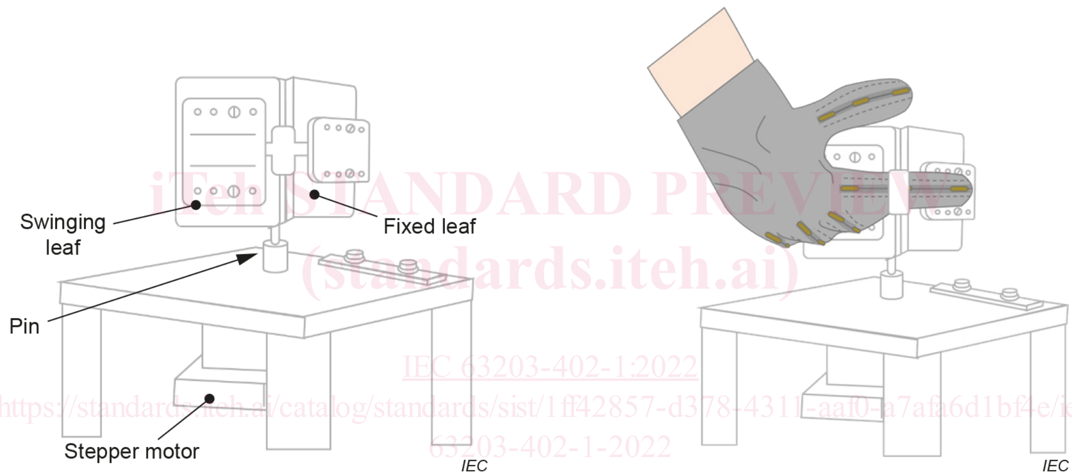
b) Fix the glove with the sensor that is worn on the hand to the servomotor-based equipment.

c) The sensor is fixed with the fixed leaf. The glove sensor bends according to the rotation of the stepper motor that controls the swinging of one leaf of the hinge.

d) Insert the input angle using the software program connected to the servomotor-based equipment.

e) After the servomotor-based equipment has been positioned at the input angle, measure the resistance, capacitance, voltage or ADC value obtained from the sensor. The method to measure the sensor signals is described in 4.3.1 c).

f) Compare the measured resistance, capacitance, voltage or ADC value to that in the reference table provided by the servomotor's manufacturer.



a) Example with a servomotor **b) Example with a glove sensor mounted on the equipment**

Figure 3 – Test setup based on the servomotor for sensor angle measurement

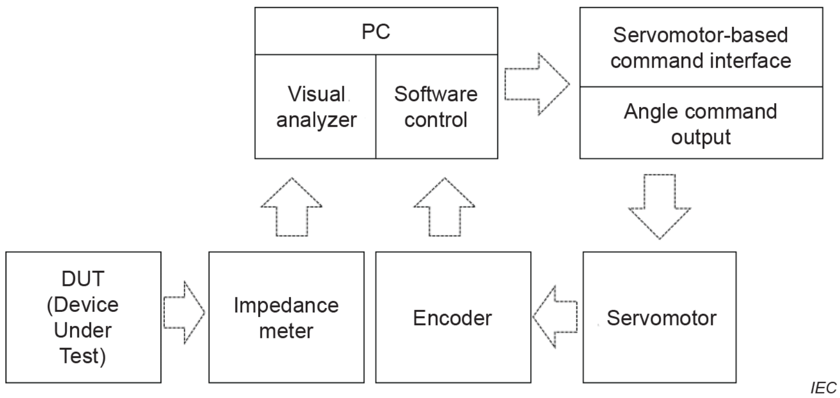


Figure 4 – Test procedure of angle measurement in the wearable glove based on the servomotor