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Semiconductor devices – Semiconductor devices for energy harvesting and generation –
Part 6: Test and evaluation methods for vertical contact mode triboelectric energy harvesting devices

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International Standard IEC 62830-6 has been prepared by IEC technical committee 47: Semiconductor devices.

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

FDIS	Report on voting
47/2573/FDIS	47/2585/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 62830 series, published under the general title *Semiconductor devices – Semiconductor devices for energy harvesting and generation,* 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 website 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- withdrawn,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.

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SEMICONDUCTOR DEVICES – SEMICONDUCTOR DEVICES FOR ENERGY HARVESTING AND GENERATION –

Part 6: Test and evaluation methods for vertical contact mode triboelectric energy harvesting devices

1 Scope

This part of IEC 62830 defines terms, definitions, symbols, and specifies configurations and test methods to be used to evaluate and determine the performance characteristics of vertical contact mode triboelectric energy harvesting devices for practical use. This document is applicable to energy harvesting devices as power sources for wearable devices and wireless sensors used in healthcare monitoring, consumer electronics, general industries, military and aerospace applications without any limitations on device technology and size.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

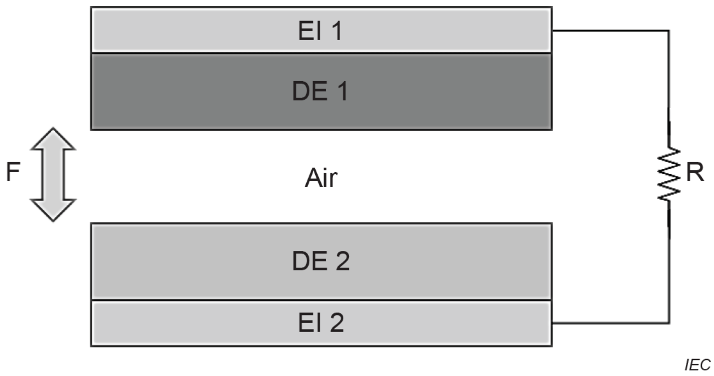
- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 General terms

3.1.1
vertical contact
physical touching of two objects having relative movement at right angles to their planes at the point of contact

Note 1 to entry: A vertical contact mode triboelectric energy harvester which converts physical contact to electricity and is comprised of dielectric materials, surface electrode, external load, and air gap between dielectric materials, is shown in Figure 1.

Note 2 to entry: The theories for four working modes of a contact triboelectric energy harvester are shown in Figure 2.



Key

Configuration of energy harvester

El 1, El 2	electrode
DE 1, DE 2	dielectric material

Components to operate an energy harvester

F	pressing and releasing force
R	external load

Figure 1 – Vertical contact mode triboelectric energy harvester

3.1.2
nanogenerator
type of technology that converts mechanical/thermal energy as produced by small-scale physical change into electricity

3.2 Triboelectric transducer

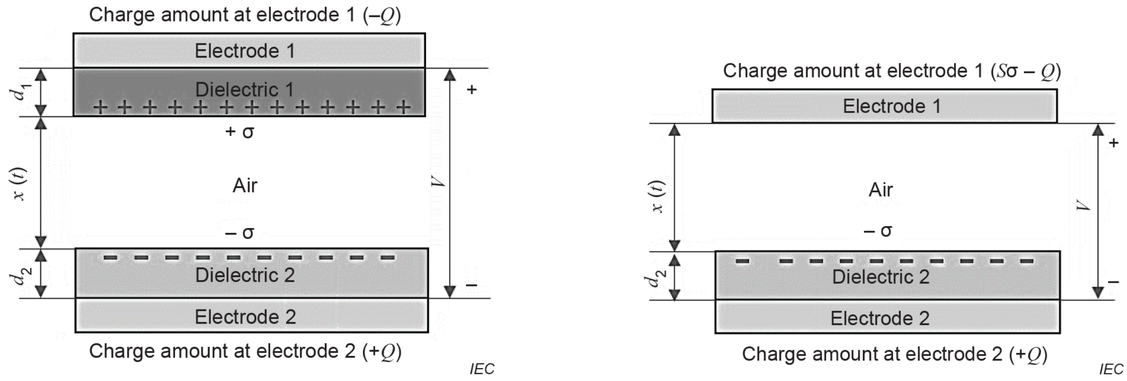
3.2.1
contact based energy harvester
energy transducer that transforms physical energy due to deceleration/acceleration of the moving contact into electrical energy

3.2.2
triboelectric effect
type of contact electrification in which certain materials become electrically charged after they come into frictional contact and separation action with a different material

3.2.3
triboelectric series
list of materials, some of which have a greater tendency to become positive (+) and the others have a greater tendency to become negative (−)

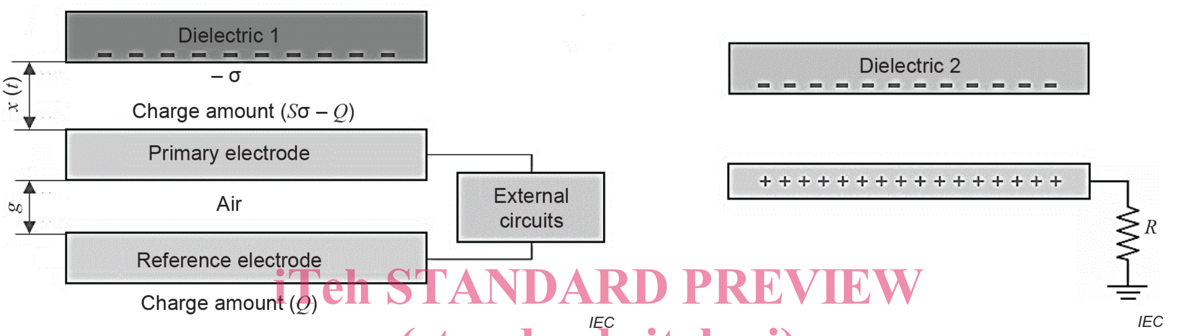
3.2.4
triboelectric transducer
energy converter to generate electricity from mechanical energy by means of triboelectric effect

3.2.5
surface roughness
quantified surface texture by the deviations in the direction of the normal vector of a real surface from its ideal form



a) dielectric-to-dielectric contact double electrode mode

b) dielectric-to-conductor contact double electrode mode



c) dielectric-to-primary conductor contact single electrode mode

d) dielectric-to-conductor contact single electrode mode

Key

Parameters of basic operation

d	dielectric thickness	Q	transferred charge
$x(t)$	gap between dielectric materials	V	potential difference
σ	charge	g	gap between two electrodes

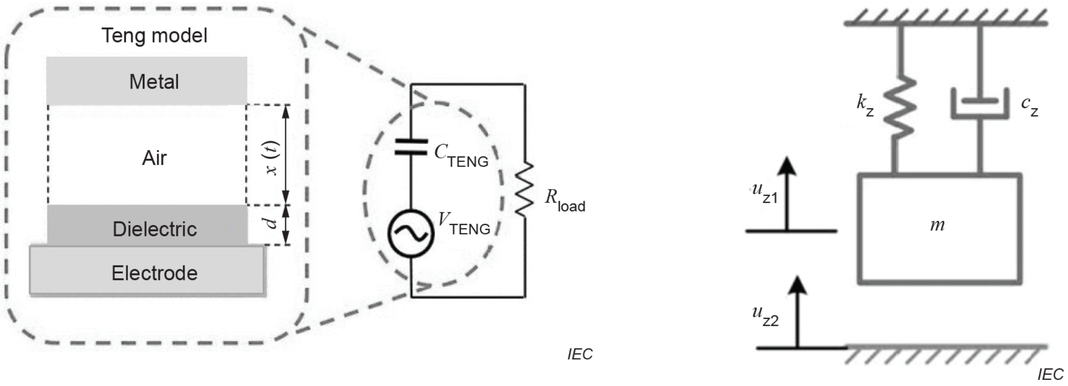
NOTE: The two major vertical contact modes, i.e. double electrode mode and single electrode mode, are described in Annex A (informative).

Figure 2 – Fundamental theories of four working modes of vertical contact mode triboelectric energy harvester

3.3 Characteristic parameters

3.3.1
equivalent circuit
arrangement of ideal circuit elements that has circuit parameters, over a range of interest, electrically equivalent to those of a particular circuit or device

Note 1 to entry: A vertical contact mode triboelectric energy harvester can be shown into parts as shown in Figure 3. The equivalent circuit consists of capacitance C which stores the charge as $+Q$ and $-Q$, open-circuit voltage source V_{oc} and external load R.



a) b)

Key parameters

C_{TENG}	capacitance	R_{load}	external load
d	dielectric thickness	V_{TENG}	open-circuit voltage
TENG	Tribo-electric nano-generator	$x(t)$	gap between dielectric materials
m	movable mass	k_z	spring
c_z	damper	u_{z1}, u_{z2}	substrates

Figure 3 – Equivalent circuit of triboelectric energy harvester

3.3.2
optimum load impedance
R_{opt}
value of load impedance at which the load absorbs the maximum energy

3.3.3
contact area
area of physical contact of one object with the other object

Note 1 to entry: When two objects touch, a certain portion of their surface areas will be in contact with each other. The contact area is the fraction of this area that consists of the atoms of one object in contact with the atoms of the other object. Because objects are never perfectly flat due to asperities, the actual contact area (on a microscopic scale) is usually much less than the contact area apparent on a macroscopic scale. The contact area can depend on the normal force between the two objects due to deformation.

3.3.4
input frequency
rate at which a repetitive force is applied

3.3.5
surface contact time
time of contact between two triboelectric surfaces

Note 1 to entry: The bigger the surface contact, the greater the net charge on the two surfaces after separation.

3.3.6
relative humidity range
range of humidity as measured on the enclosure over which the energy harvester will not sustain permanent damage though not necessarily functioning within the certain tolerances