IEC®

IEC 62830-3

Edition 1.0 2017-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Semiconductor devices – Semiconductor devices for energy harvesting and generation –
Part 3: Vibration based electromagnetic energy harvesting

Dispositifs à semiconducteurs – Dispositifs à semiconducteurs pour récupération et génération d'énergie –
Partie 3: Récupération d'énergie électromagnétique basée sur des vibrations

IEC 62830-3:2017-03(en-fr)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
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.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) 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 IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l’édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue
Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d’études,…). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org
Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary
65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 62830-3

Edition 1.0 2017-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Semiconductor devices – Semiconductor devices for energy harvesting and generation –
Part 3: Vibration based electromagnetic energy harvesting

Dispositifs à semiconducteurs – Dispositifs à semiconducteurs pour récupération et génération d'énergie –
Partie 3: Récupération d'énergie électromagnétique basée sur des vibrations

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.080.99

ISBN 978-2-8322-4141-7

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

SEMICONDUCTOR DEVICES – SEMICONDUCTOR DEVICES FOR ENERGY HARVESTING AND GENERATION –

Part 3: Vibration based electromagnetic energy harvesting

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.

International Standard IEC 62830-3 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
47/2363/FDIS	47/2380/RVD

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

This document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document 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 document using a colour printer.

SEMICONDUCTOR DEVICES – SEMICONDUCTOR DEVICES FOR ENERGY HARVESTING AND GENERATION –

Part 3: Vibration based electromagnetic energy harvesting

1 Scope

This part of IEC 62830 describes terms, definitions, symbols, configurations, and test methods that can be used to evaluate and determine the performance characteristics of vibration based electromagnetic energy harvesting devices. This part of IEC 62830 specifies the methods of tests and the characteristic parameters of the vibration based electromagnetic energy harvesting devices for evaluating their performances accurately and practical use. This part of IEC 62830 is applicable to energy harvesting devices for consumer, general industries, military and aerospace applications without any limitations of device technology, shape and 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 60749-5:2003, *Semiconductor devices – Mechanical and climatic test methods – Part 5: Steady-state temperature humidity bias life test*

IEC 60749-10:2002, *Semiconductor devices – Mechanical and climatic test methods – Part 10: Mechanical shock*

IEC 60749-12:2002, *Semiconductor devices – Mechanical and climatic test methods – Part 12: Vibration, variable frequency*

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

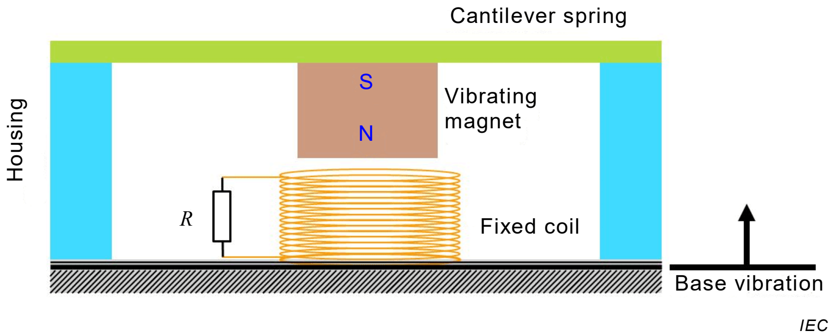
3.1.1
vibration
mechanical oscillations occurring about an equilibrium point

[SOURCE: IEC 62830-1:2017, 3.1.1]

3.1.2
vibration based energy harvester
energy transducer that transforms vibration energy into electric energy

Note 1 to entry: A vibration based energy harvester to convert vibration to electricity by using electromagnetic transduction mechanism is comprised of magnet (inertial mass), cantilever spring, and coil as shown in Figure 1. The induced vibration introduces the reciprocating motion to the mass. The spring which suspends the magnetic mass is bended and the bending of spring introduces a relative displacement between the magnet and coil within the magnetic field and an e.m.f. is induced in the coil which is obtained across the coil terminals.

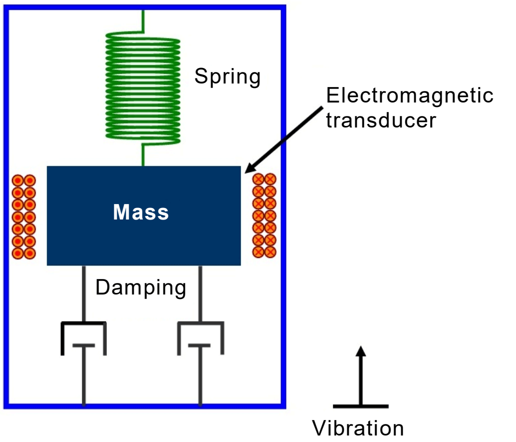
Note 2 to entry: A vibration based electromagnetic energy harvester can be represented as shown in Figure 2. It is configured by mass, spring, damping (mechanical and electrical), and electromagnetic transducer.



Key

Configuration of energy harvester		**Components to operate an energy harvester**	
Magnetic mass	Inertial mass with a field of magnetic force to introduce mechanical motion coupling from induced vibration	*R*	External load
Spring	To couple the induced vibration to the mass by suspending it		
Coil	Induces electric potential by cutting magnetic flux within vibrating magnetic field		

Figure 1 – General structure of a vibration based electromagnetic energy harvester



Key

Configuration of energy harvester		Components to operate an energy harvester	
Damping	Reduction of oscillation of the mass with time	Electromagnetic transducer	Functional device to operate as a transducer to transform vibration energy to electric energy via electromagnetic induction
Spring stiffness	a measure of the resistance offered by an elastic body to deformation		

Figure 2 – Conceptual diagram of a vibration based electromagnetic energy harvester

[SOURCE: IEC 62830-1:2017, 3.1.2]

3.1.3
mass-spring-damper system
system to derive the motion of the vibration energy harvester by using equivalent mass, spring and damper from that

[SOURCE: IEC 62830-1:2017, 3.1.3]

3.2 Electromagnetic transducer

3.2.1
electromagnetic transducer
energy converter to generate electricity from mechanical energy by means of electromagnetic induction effect

3.2.2
electromagnetic induction
phenomenon in which an induced voltage or an induced current produced by relative motion between a permanent magnet and a coil winding

[SOURCE: IEC 60050-121:2008, 121-11-30, modified]

3.2.3
transformation factor
ϕ
measure of the performance of the electromagnetic transducer related to the flux density, B, the length of the coil, l and the number of turns per unit length of the coil, N, given by,

$$\phi = NBl \quad (1)$$

3.2.4
coil-resistance
R_{coil}
coil-resistance that is related to the resistivity of the coil material, length of the coil winding and diameter of the coil (circular)

3.2.5
coil-inductance
L_{coil}
coil-inductance that induces a proportional voltage across the coil due to a change in current in the coil

3.3 Characteristic parameters

3.3.1
equivalent circuit, <of a vibration based electromagnetic energy harvester>
electrical circuit which has the same output voltage from induced vibration as electromagnetic vibration energy harvester in the immediate neighborhood of resonance

Note 1 to entry: Electrical equivalent circuit representation of a vibration based electromagnetic energy harvester is shown in Figure 3. It consists of an e.m.f. source, $\phi v(t)$ that induces current, $i(t)$ and series inductance, L_{coil} and resistance R_{coil} with a load resistance, R_{load}. The damper is, typically a moving magnet linking flux with the stationary coil, the latter having series inductance and resistance. The operating principle is that voltage is induced in the coil due to the varying flux linkage, with the resultant currents causing forces which oppose the relative motion between the magnet and coil.

Key

$\phi v(t)$: e.m.f. is induced due to the relative motion between the magnet and coil

$i(t)$: current starts flowing due to induced vibration

b_m: Damping occurs by the flux linkage between the magnet and the coil with series resistance R_{coil} and inductance L_{coil}

R_{load}: external load

Figure 3 – Equivalent circuit of a vibration based electromagnetic energy harvester

3.3.2
resonant frequency
f_r
lowest frequency of the induced vibration of the energy harvester to generate largest output power

$$f_r = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \quad (2)$$

where

k is the spring constant and m is the mass (of the magnet) attached to the cantilever spring

[SOURCE: IEC 62830-1:2017, 3.3.2]

3.3.3
bandwidth
Δf
separation of frequencies between which the output power shall be equal to or larger than a specified value (50 %)

3.3.4
damping ratio
ζ
dimensionless measure describing how oscillations in a system decay after a disturbance, expressing the level of damping in a system relative to critical damping

Note 1 to entry: For a damped harmonic oscillator with mass m, damping coefficient b, and spring constant k, it can be expressed as:

$$\zeta = \frac{b}{2\sqrt{km}} \tag{3}$$

3.3.5
quality factor,<vibration based energy harvesters>
Q
dimensionless parameter that describes how underdamped an oscillator or resonator, or equivalently, characterizes a resonator's bandwidth relative to its centre frequency

Note 1 to entry: In the context of resonators, Q is defined in terms of the ratio of the resonant frequency, f_r to the half-power bandwidth Δf of the resonator

$$Q = \frac{f_r}{\Delta f} = \frac{\omega_r}{\Delta\omega} \tag{4}$$

Note 2 to entry: For a single damped mass-spring system, the Q factor represents the effect of simplified viscous damping or drag, where the damping force or drag force is proportional to velocity. The formula for the Q factor is:

$$Q = \frac{1}{2\zeta} \tag{5}$$

where ζ is the damping ratio.

3.3.6
open circuit voltage
V
electrical potential difference relative to a reference node of an energy harvester when there is no external load connected to the terminal of the energy harvester

Note 1 to entry: V is defined as an open circuit voltage of the energy harvester.

[SOURCE: IEC 62830-1:2017, 3.3.4]

3.3.7
output power
P
electrical power transferred to the external load connected to the terminal of an energy harvester

[SOURCE: IEC 62830-1:2017, 3.3.5]

3.3.8
output current
I
current through the external load connected to the terminals of energy harvester

Note 1 to entry: *I* is defined as an output current of the energy harvester.

[SOURCE: IEC 62830-1:2017, 3.3.6]

3.3.9
optimal load
R_{opt}
specified value of the external load transferred to the largest electrical energy from energy harvester

[SOURCE: IEC 62830-1:2017, 3.3.7]

3.3.10
temperature range
range of temperature as measured on the enclosure over which the energy harvester will not sustain permanent damage though not necessarily functioning within the specified tolerances

[SOURCE: IEC 62830-1:2017, 3.3.9]

3.3.11
input vibration
range of acceleration of induced vibration to the energy harvester as measured on the enclosure over which the energy harvester will not sustain permanent damage though not necessarily functioning within the specified tolerances

[SOURCE: IEC 62830-1:2017, 3.3.10]

3.3.12
mean-time-to-failure
the expectation of the time to failure in the operation of the energy harvester

[SOURCE: IEC 60050-192:2015, 192-05-11, modified]

4 Essential ratings and characteristic parameters

4.1 Identification and type

The vibration energy harvester shall be clearly and durably marked in the order given below:

a) year and week (or month) of manufacture;
b) manufacturer's name or trade-mark;
c) terminal identification (optional);
d) serial number;