MEMS devices from Sensor to Energy Harvesting Solution

(MEMS devices on Energy Harvesting Wireless Sensor Platform)

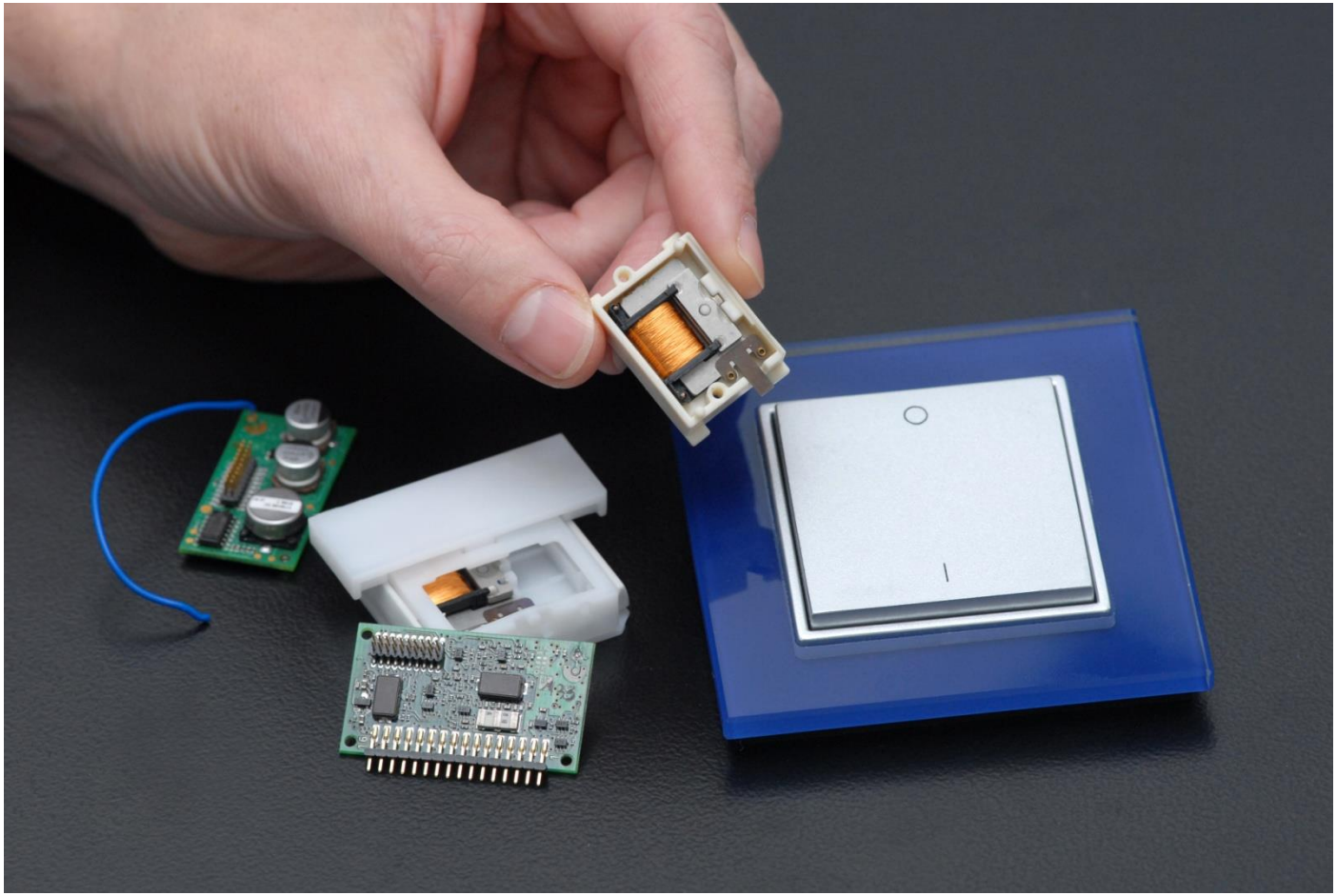
EnOcean Alliance
Kazuyoshi Itagaki
kazuyoshi.itagaki@enocean.com

Mar 14, 2013

Today's Agenda

1. About EnOcean
2. EnOcean energy harvesting switch & sensor platform
3. Applications
    1. Products
    2. Deployment (SmartHome, Building Automation, etc)
4. EnOcean evaluation and development tools
5. Energy harvesting wireless products with MEMS devices
6. Summary

EnOcean 1st Products in 2002



Green.Smart.Wireless.
enocean®

enocean® alliance
No Wires. No Batteries. No Limits.

No Wire !

No Battery !

No Limit !

enocean®
Wireless Standard
ISO/IEC 14543-3-10

About EnOcean & EnOcean Alliance

SIEMENS

Green. Smart. Wireless. enocean®

Wireless Switch & Sensor Solution by Energy Harvesting

- Spin off from Siemens, established in 2001
- World first wireless communication technology with tiny energy generated by energy harvesting
- Energy harvesting device and energy harvesting wireless device and module provider from 2002
- Energy harvesting wireless communication : EnOcean IPRs

enocean®

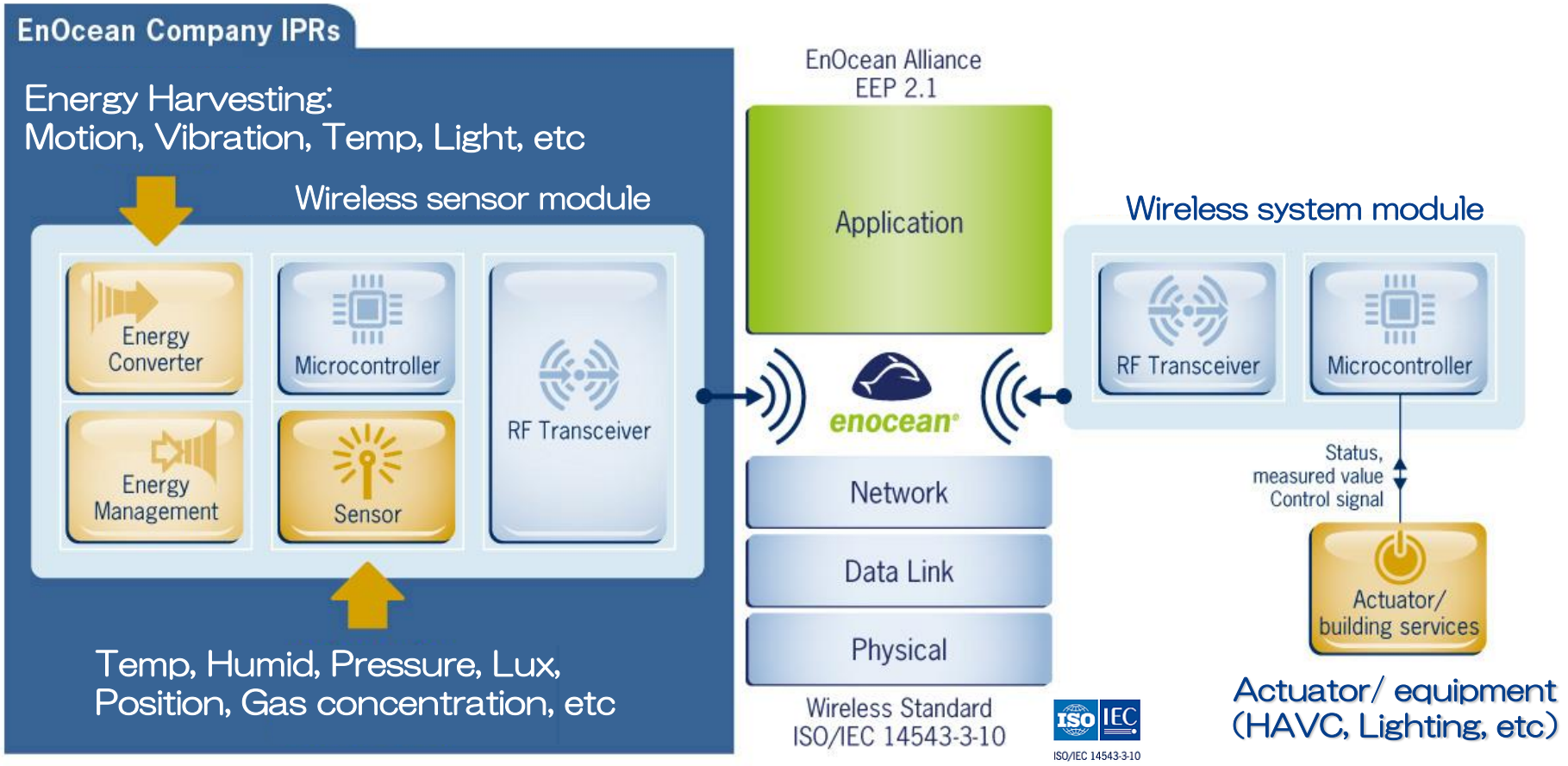
ISO/IEC 14543-3-10

Wireless communication standard for sustainable buildings

- Maintenance and development of wireless communication protocol aimed for interoperability between different vendors products
- International standardization (ISO/IEC-14543-3-10)
- Promotion of energy harvesting and EnOcean wireless technology
- >100 OEM vendors, >1000 commercial products
- Deployed in >250,000 building projects in the world

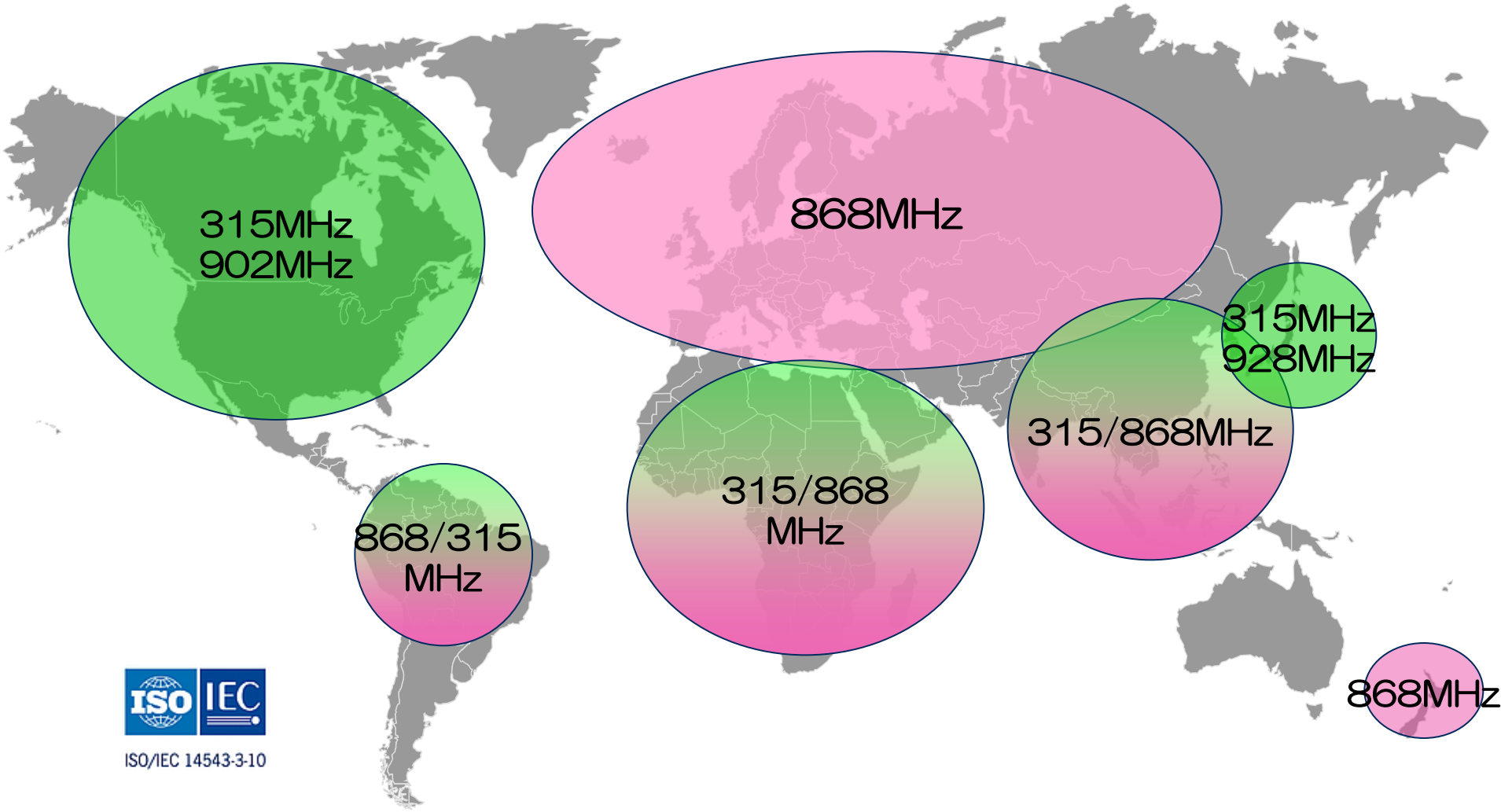
EnOcean Energy Harvesting Wireless Switch & Sensor System

No Wires. No Batteries. No Limits.

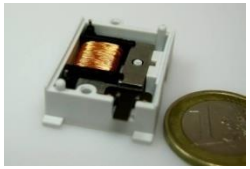


IPR: Intellectual Property Rights
ISO: International Organization for Standardization
IEC: International Electrotechnical Commission
EEP: EnOcean Equipment Profiles
RF: Radio Frequency

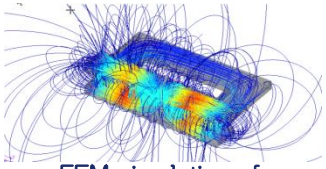
Radio Frequencies of EnOcean Wireless Telecommunication



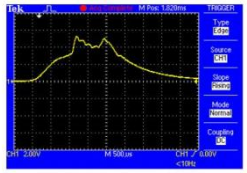
Combination with Energy Harvesting devices for commercial products



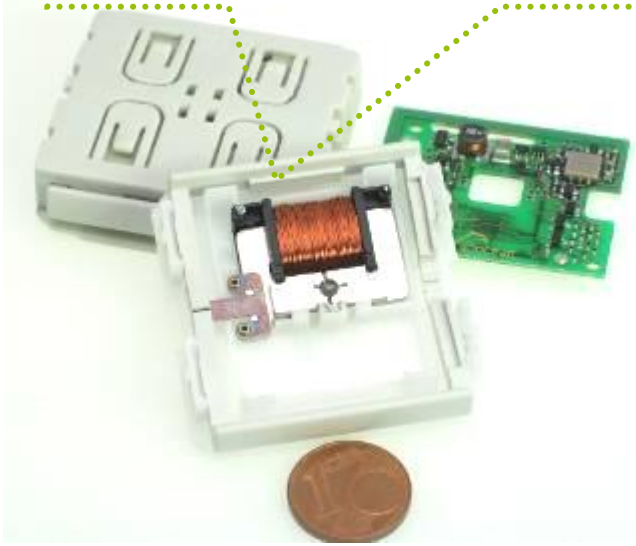
ECO100
40mm x 40mm x 10mm



FEM-simulation of
Electromagnetic field iron core surface

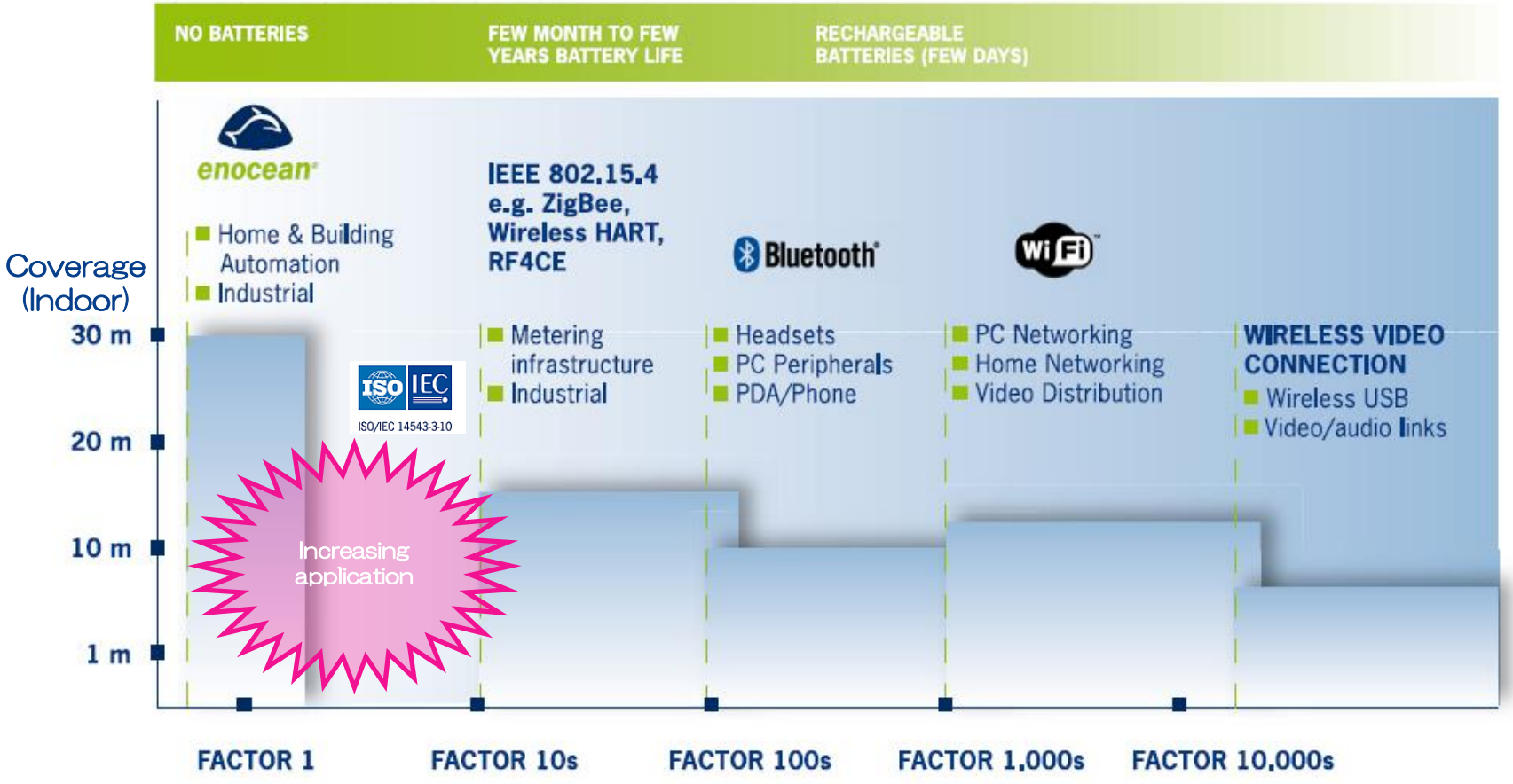


ECO 100 operating characteritics
Max Voltage5V@19μF(237.5μWsec)



- Various energy harvesting devices (Motion, Light, ΔT, etc) have been deployed
- Under development & evaluation of vibration power generator device deployed wireless sensor product

Comparison of Power Comsuption with other wireless communcation

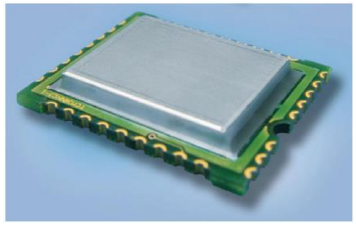


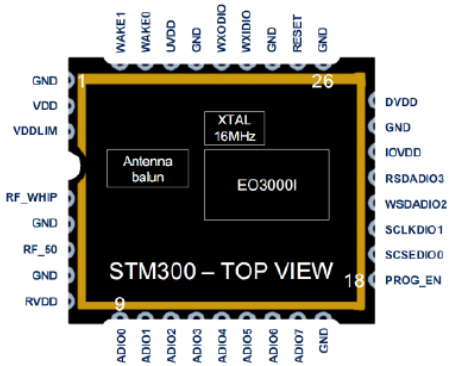
Enegy required for wireless communication（EnOcean = Factor 1）

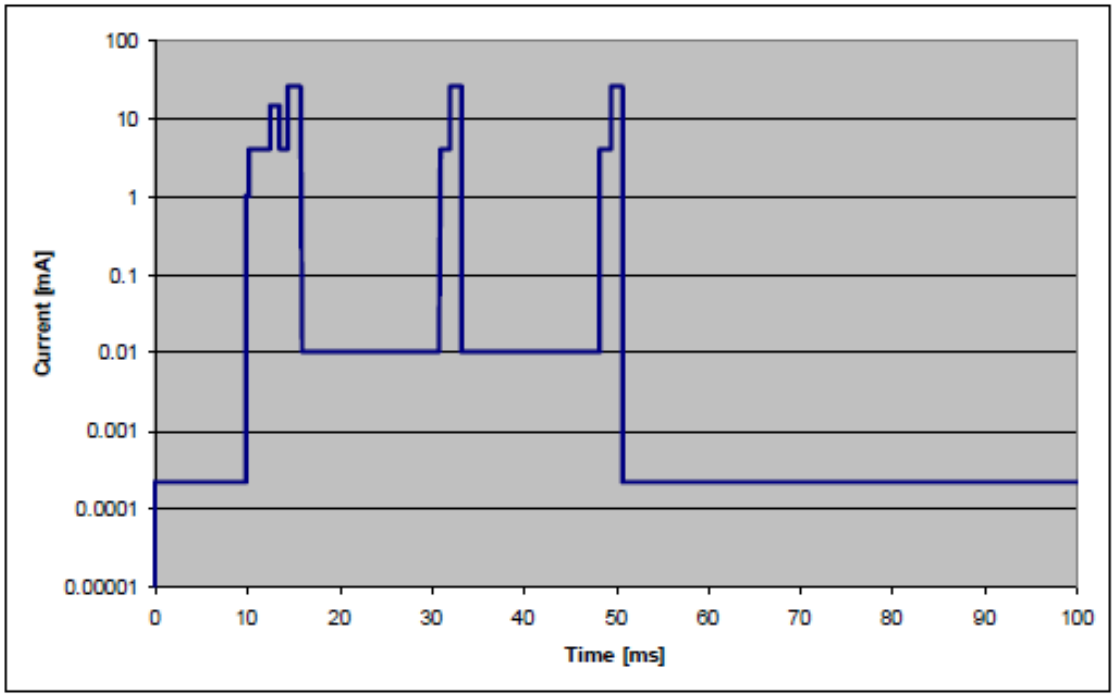
Comparison with other wireless communcation

	EnOcean	IEEE 802.15.4 /ZigBee	Z-wave	Bluetooth (low energy)	WLAN
Frequency (MHz)	315/868	868/915/ 2400	868/915	2400 (2400)	2400
Battery-less & Maintenance Free	YES	NO (few months to few years)	NO (few months to few years)	NO (rechargeable batteries (standard batteries))	NO (line power)
Minimum Telegram Length (ms)	0.7	30/4	20	0.7 (~ 0.25)	--
Data Rate (kbps)	125	20/250	9.6/40	2100 (1000)	11000 - 54000
Interference Risk	Extremely Low	Medium (WiFi)	Medium	Low	Low
Interoperable end products	> 1000	>200	> 600	> 10000 (--)	> 10000
Successfully Field Proven Application Areas	Home & Building Automation, Industrial Control	Smart Metering Trials (Line Powered Nodes), RF4CE (point to point RC)	High-End Residential Aftermarket	Mobile Phones, Headsets, Laptops, Printers, PDAs	Computer (Web, E-Mail, Video etc)

EnOcean Wireless Communication for Energy Harvesting Wireless Switch & Sensor



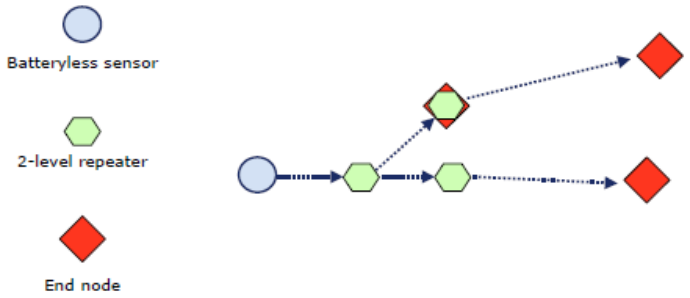




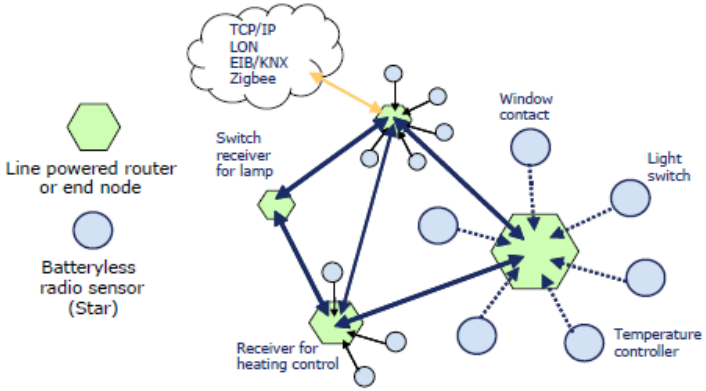
EnOcean (ISO/IEC 14543-3-10) data transmission = 30 μWs x 3≒100 μWs

EnOcean Wireless Communication Network (Installation, and Routing)

1st level and/or 2nd Level Routing



Mesh Routing



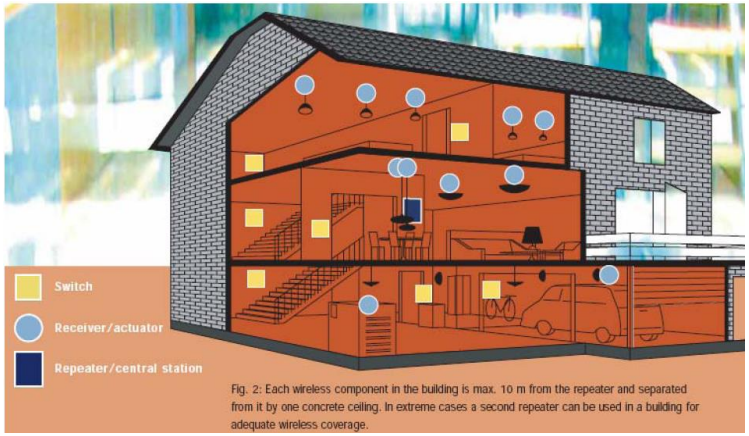
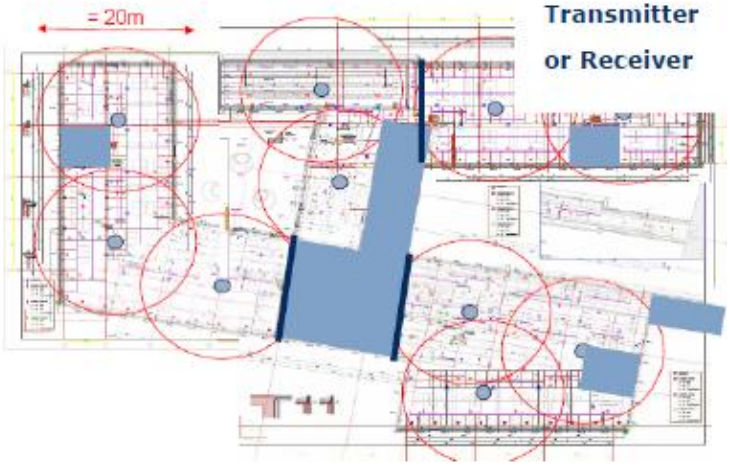
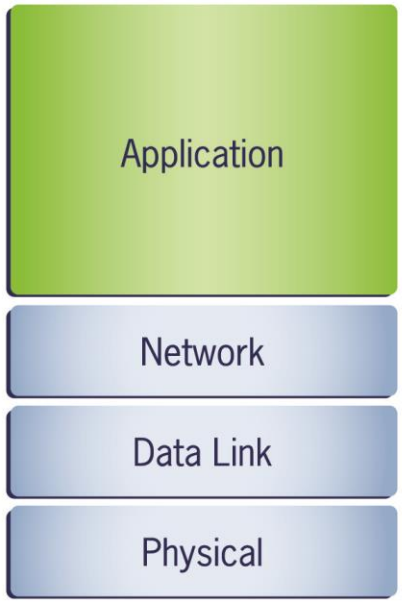


Fig. 2: Each wireless component in the building is max. 10 m from the repeater and separated from it by one concrete ceiling. In extreme cases a second repeater can be used in a building for adequate wireless coverage.



International standardized EnOcean Protocol



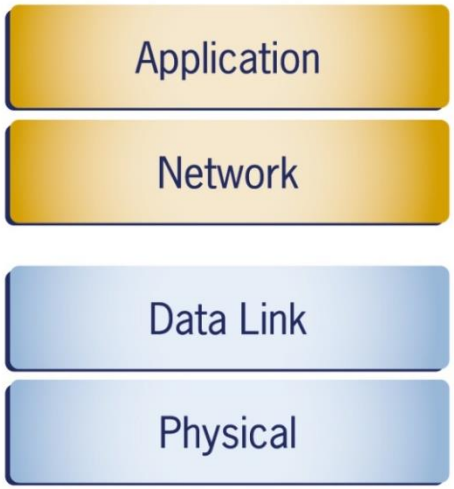
enocean alliance
No Wires. No Batteries. No Limits.

EnOcean Equipment Profiles (EEP)

ISO IEC

ISO/IEC 14543-3-10

Other standardized protocols



example

- IEEE 802.11 (basis for WiFi)
- IEEE 802.15.1 (basis for Bluetooth)
- IEEE 802.15.4 (basis for RF4CE, ZigBee, Wireless HART etc.)

EnOcean for Various Applications

Smart Home, Building Automation

- Lighting
- Air Conditioner, Heating, Cooling)
- Security
- Measurement

Industrial Automation

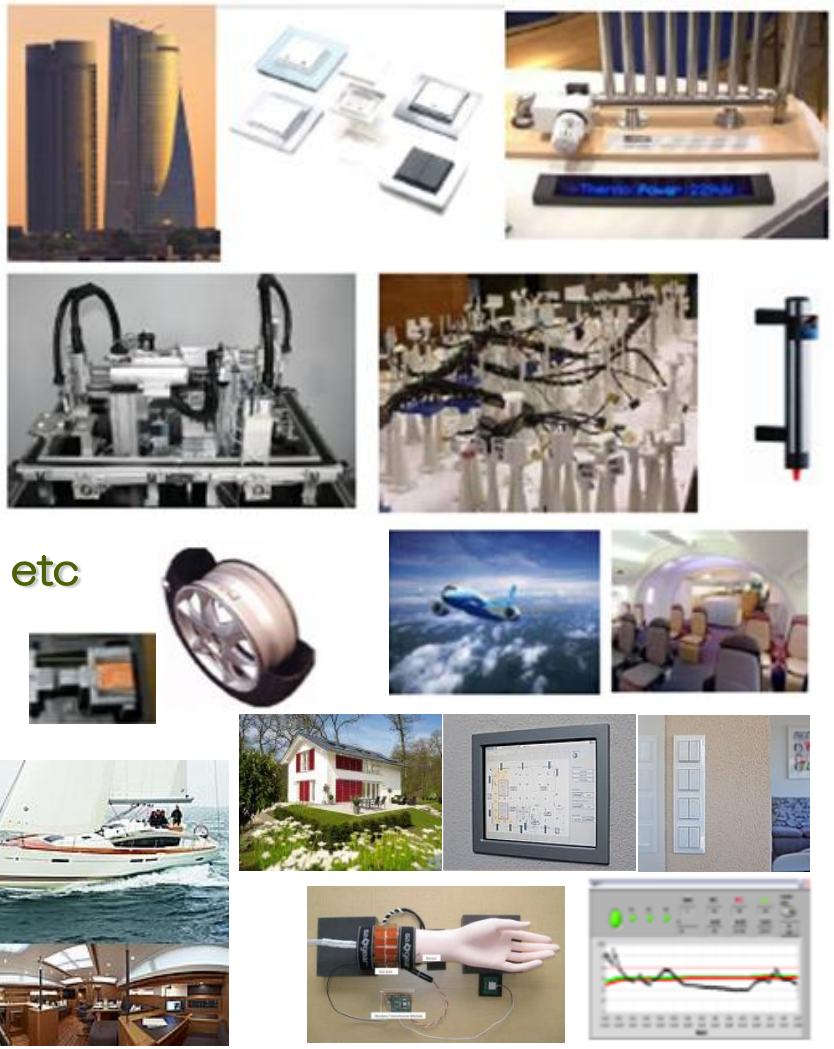
- Control & Status supervision
- Process optimization
- Manipulations for measurement & switch, etc

Vehicle (Automobile, Airplane , Ship, etc)

- Condition Monitoring
- Operation of switch, etc

Medical

- Body temp, blood pressure heart beat measurement
- Monitoring, etc



Interoperable products from multiple vendors

Lighting control equipment

- Lighting switch, Dimming
- Occupancy sensor
- Lux sensor
- Card key
- Timer

HVAC Sensor, Setting Panel

- Temp, Humid
- Occupation, Motion
- Gas concentration (eg, CO_2)
- Positioning of door & window

Automation Systems Gateway

- LON, BACnet, TCP/IP, KNX, etc

>1000 commercial products from >100 OEMs

Latest EnOcean Device/Module Integrated Commercial Products



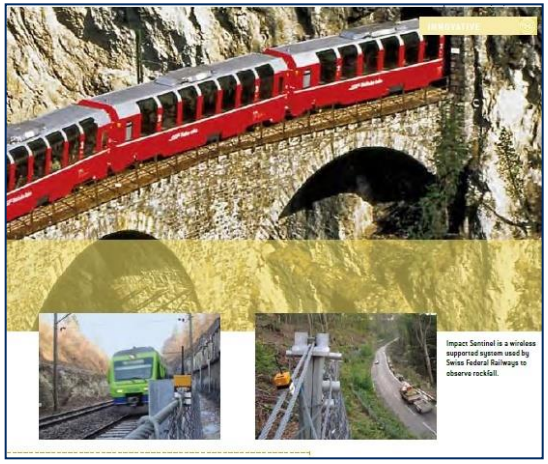









Various Application: No limits!



EnOcean Deployed Building Project

Office Tower Building & Corporate HQs

Hospitality

Hospitals

Schools, Colleges, Nurseries

Exhibition Facilities

Historical/Listed Building

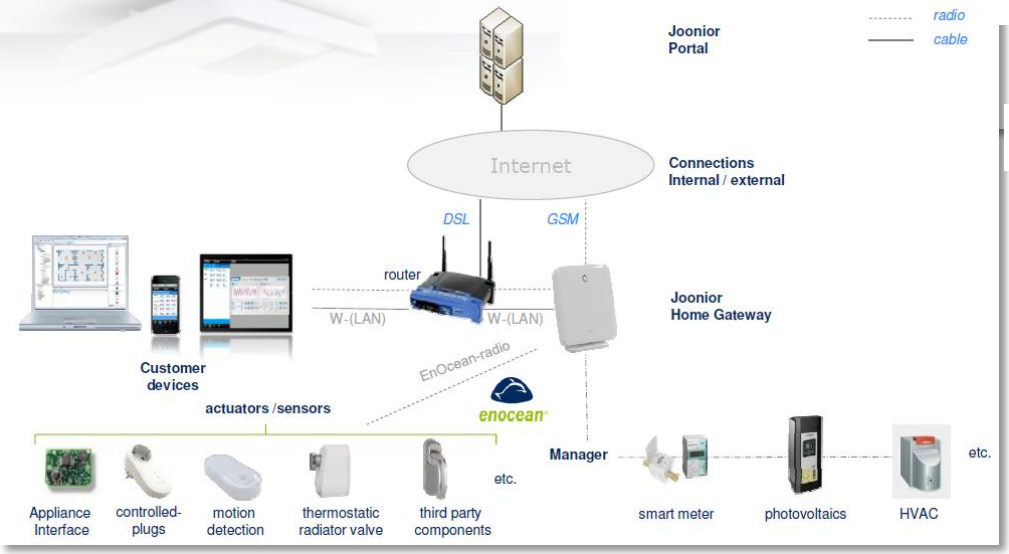
Industrial Plants

Residential

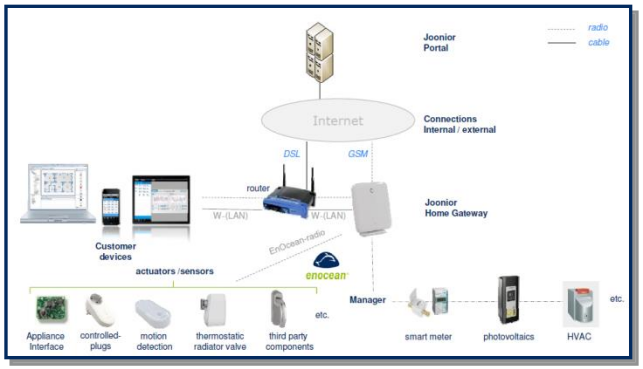
Successfully deployed in >250,000 building projects

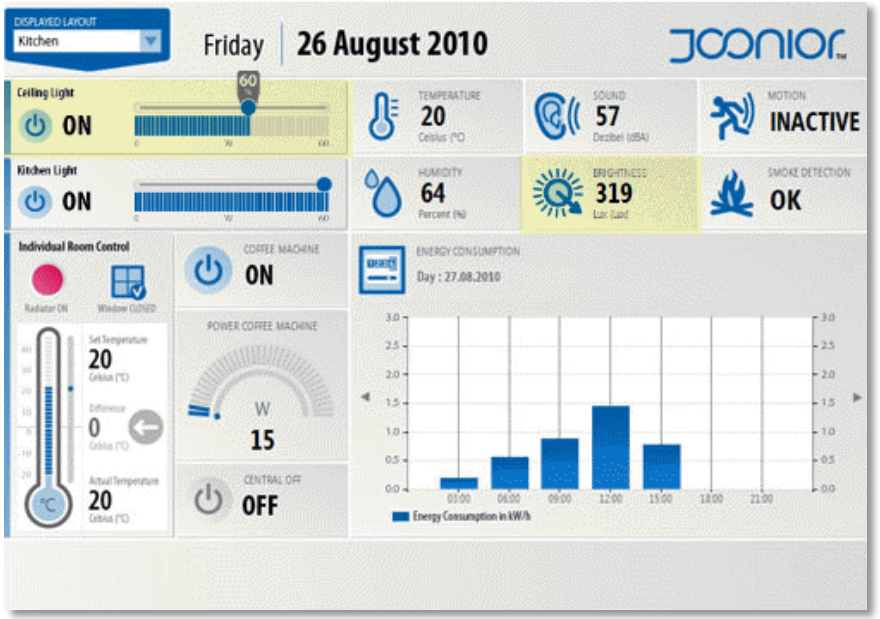
EnOcean related products deployed in living areas

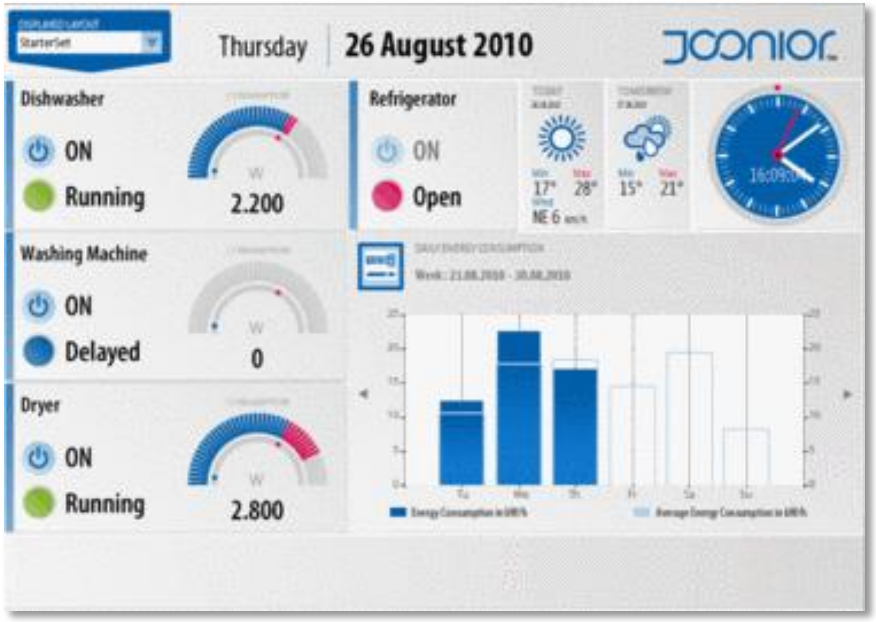
EnOcean in Smart Home



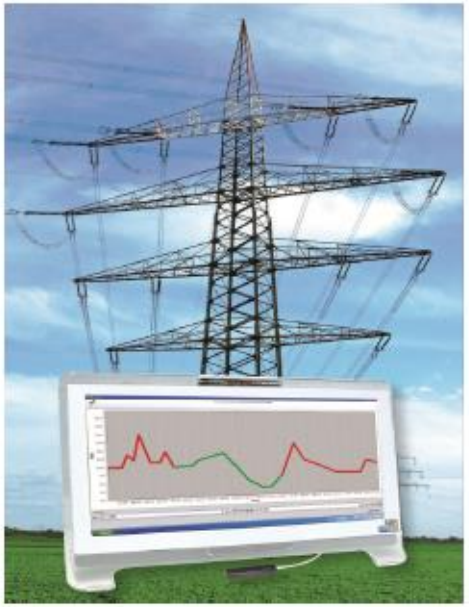
Visualization of EnOcean Based Smart Home Example





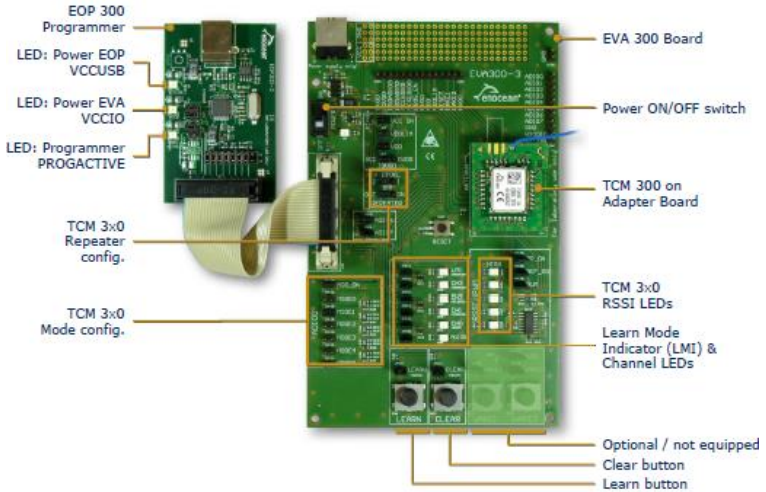


EnOcean Monitoring & Remote Control
Smart Home/Smart Grid Examples

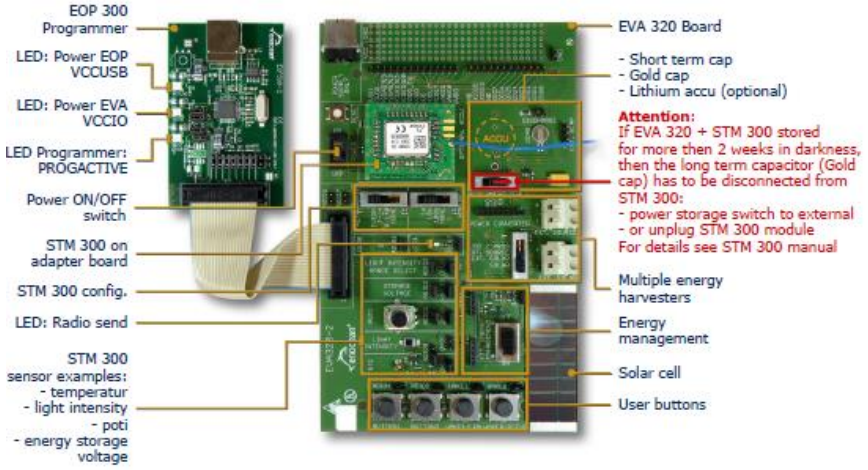


EnOcean Development Kit (EDK300C)

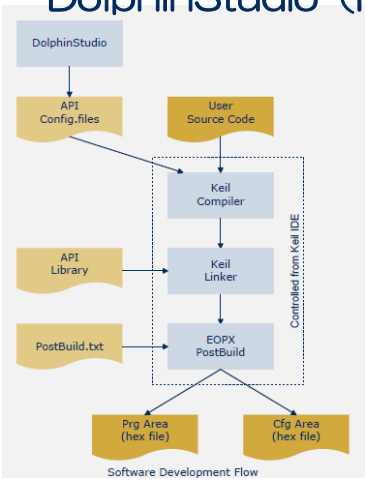
Receiver Board (Rx/Tx)

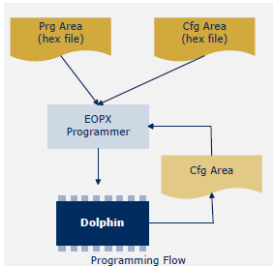


Energy Harvesting Development Board(Rx/Tx)



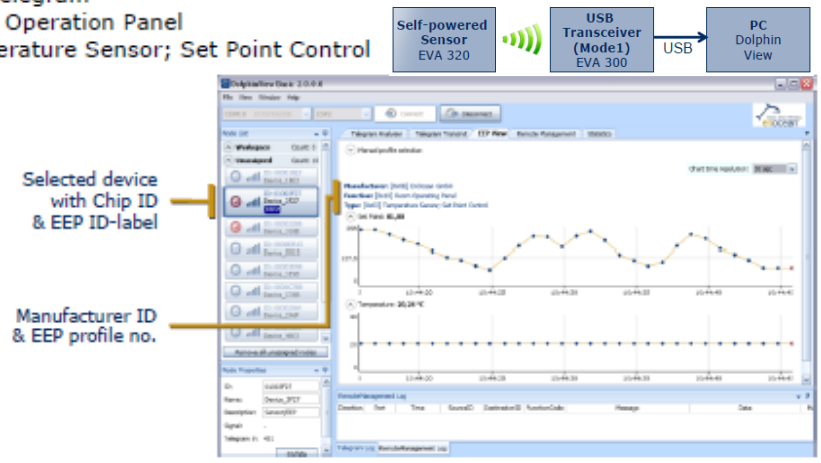
DolphinStudio (Programming)



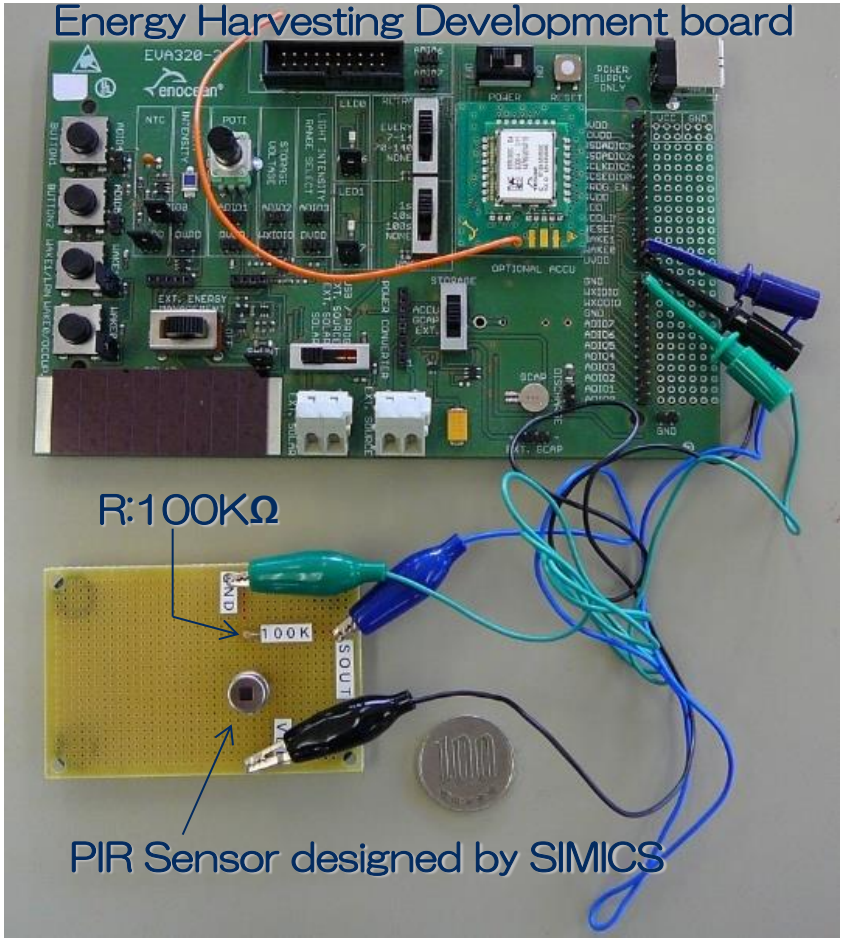


DolphinView (Evaluation)

0x07: 4BS Telegram
0x10: Room Operation Panel
0x03: Temperature Sensor; Set Point Control



PIR Sensor + Development Board



- Works at 50lx
- >50lx

  Charged in G-cap

  Once fully charged(0.25F), will work out for 7days w/o additional charging

SIMICS
http://www.simics.co.jp/

Energy Harvesting Wireless Occupancy Sensor

EnOcean Devices & Modules

Green.Smart.Wireless. enocean®

enocean® alliance
No Wires. No Batteries. No Limits.

ENERGY HARVESTING WIRELESS SENSOR MODULES

+ NEW +

PTM 210/PTM 215 (868 MHz) and PTM 200C (315 MHz)
Ideal for energy harvesting wireless switches.
The variant PTM 215 contains also rolling code functionality

ECO 200 & PTM 330
The perfect combination for unique switch applications

STM 300
Ideal for bidirectional energy harvesting wireless sensors and innovative actuators

STM 310
Energy harvesting wireless sensor module – with solar cell and whip antenna

STM 311
Energy harvesting wireless sensor module – with solar cell and helical antenna

STM 312
Energy harvesting wireless sensor module – with solar cell but without whip antenna

STM 320
Energy harvesting magnet contact transmitter module with helical antenna

STM 330
Energy harvesting wireless temperature sensor module with whip antenna

ENERGY CONVERTERS

Mechanical
Harvests linear motion for use in wireless switches

Solar
Harvests indoor light for energy harvesting wireless sensors and actuators

Thermo-electric
Harvests temperature differentials for energy harvesting

WIRELESS RECEIVER AND TRANSCEIVER MODULES

TCM 300, TCM 310, TCM 320 and USB 300 – ideal for permanently powered system components

- Time to market
- Decrease of development cost & risk

TTM : Variety of Wireless products by EnOcean module

Solar powered wireless acceleration sensor

STM310C

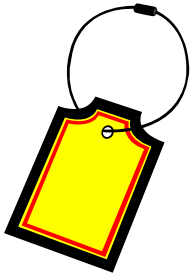
+ MEMS Sensor (e.g. Acceleration)

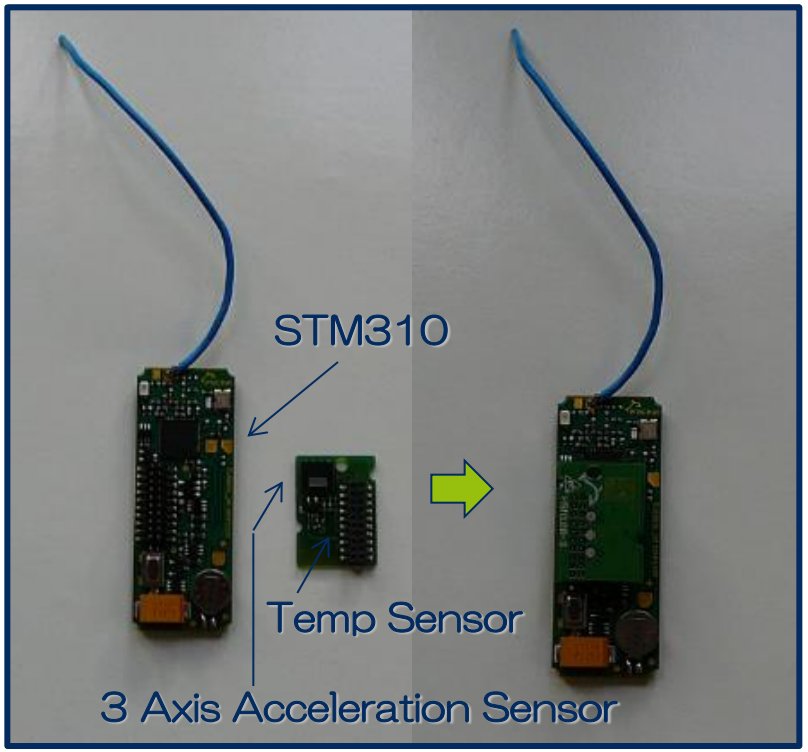
Vibration powered sensor

STM312C

+ MEMS Sensor + Vibration Power Generator

RF Tag Application for Logistic & Identification

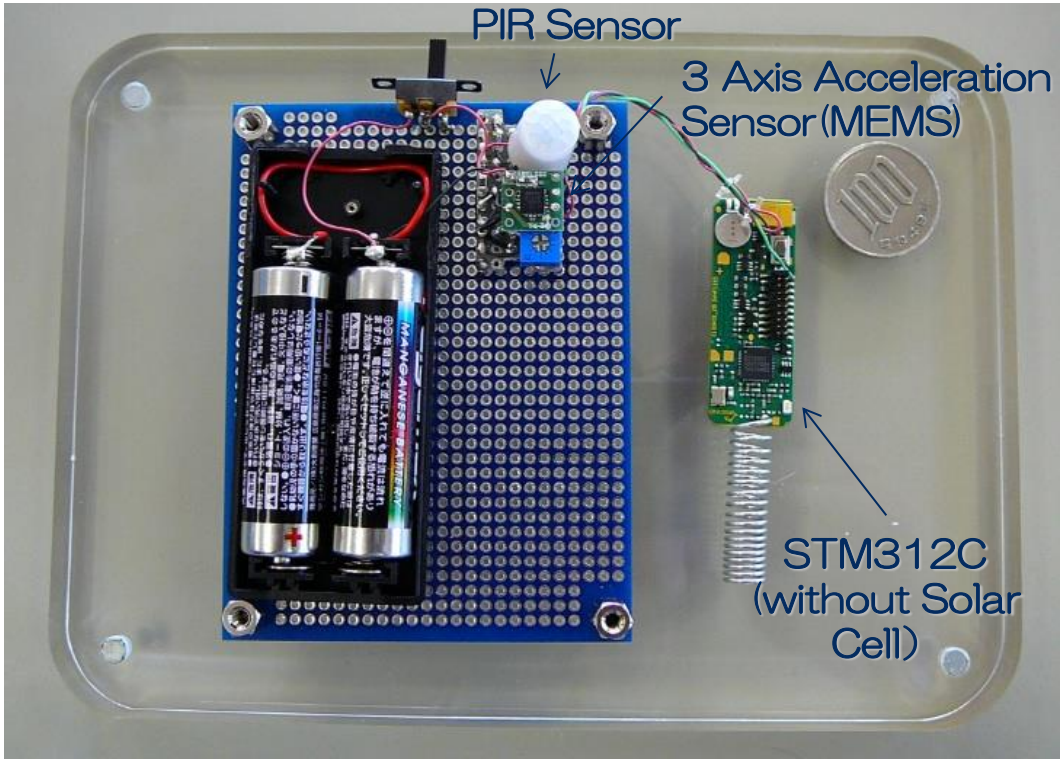


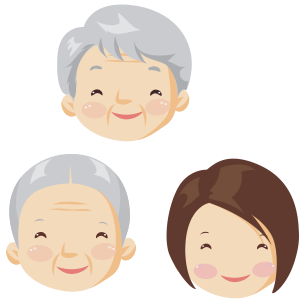


SiMICS サイミックス株式会社
http://www.simics.co.jp/

PIR Sensor + MEMS Acceleration Senor

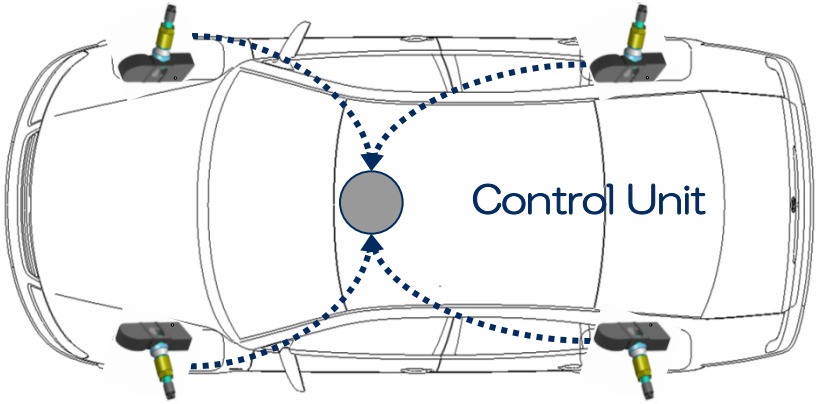
PIR sensor to respond when only human walked





SiMICS サイミックス株式会社
http://www.simics.co.jp/

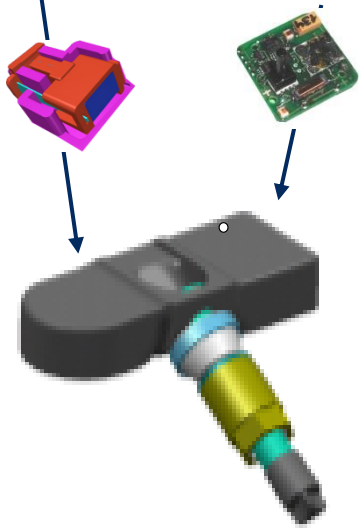
Vibration Power Generation Application: TPMS by EnOcean



Energy Harvester

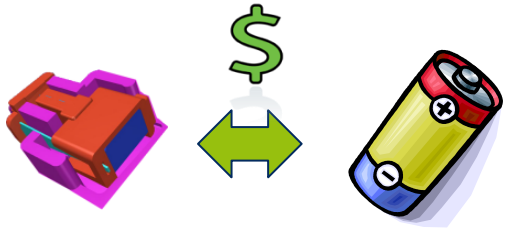
Wireless Sensor Module

(Temp and Pressure)



Snap shot of lab test
(300Km/h, 72hrs)

What is the barrier to replace the battery?



Mass production technology by MEMS must be one of solutions

Latest MEMS Vibration Power Generator

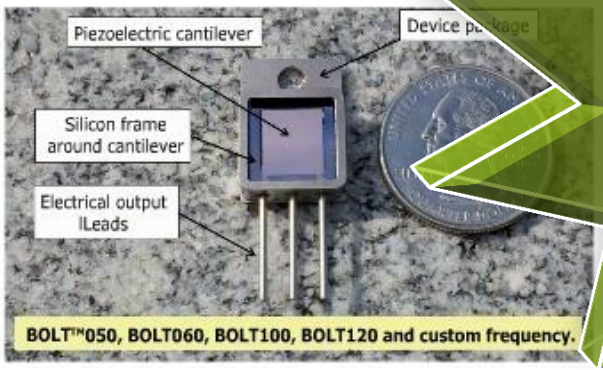
Just examples

OMRON

- Dimension: 20mm x 20mm x 4mm
- Power generation*: 100μW*@30Hz, 0.15G
- Adjustable frequency: a few ～100Hz
- Commercial sample

＊Power generation target = 200μW

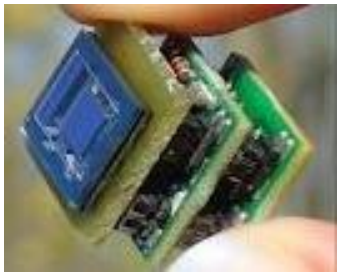
Practical for
EnOcean Wireless Sensor application



microGen

- Power generation : 200μW@60Hz 0.5G
- Commercial sample : from July 2013
- Target cost: < $1@ serial production

Power generation:
200μW@155Hz, 1.5G
（University of Michigan）



Power generation:
Max 85μW (IMEC, Holst Centre, TNO, IEDM2009)

Summary

<EnOcean>

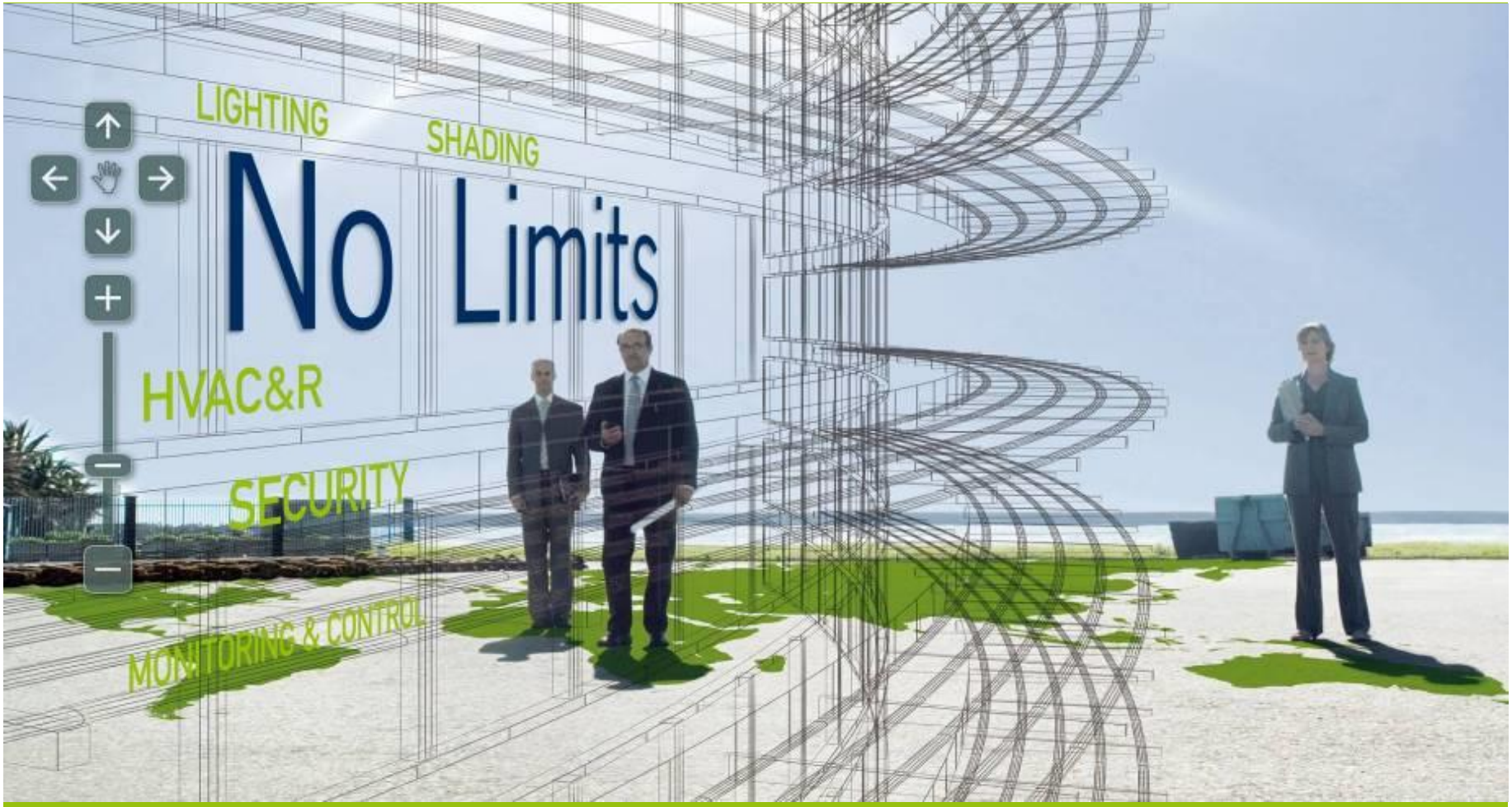
- Possessing fundamental technology and IPRs of energy harvesting wireless switches and sensors
- Track record in the market: >10 years and >1000 interoperable commercial products and deployed in >250K building

<Advantages>

- More than one or two orders of magnitude less power compared to other wireless communications
- Enabled the operation by energy harvesting (Light, Pressure, Vibration, ΔT, etc)
  ⇒ Battery less : Eco friendly and maintenance free (drastic reduction of maintenance cost)
  ⇒ Wireless : Easy & low cost installation (especially when renovated), and providing flexible design

Combination with MEMS devices

- TTM for development by use EnOcean development kit & devices/modules
- Practically usable for MEMS vibration power generation



Thank you for your attention.

enocean alliance
No Wires. No Batteries. No Limits.