WHITE PAPER

EnOcean Technology – Energy Harvesting Wireless

1. Technology Quick Overview

Highly innovative components for self-powered wireless controlling, monitoring and signaling systems

EnOcean pushes technology and environmental responsibility to the limits. EnOcean modules combine micro-energy converters with ultra low power electronics and reliable wireless communications. This enables EnOcean customers to create self-powered wireless sensor solutions that are fundamental for efficiently managing energy in buildings and industrial applications.

System Features

- Strongly optimized system solution, easy to integrate components: Energy converters, energy management & radio modules, system & communication software
- Radio modules without batteries: The required operating energy is typ. 50 µWs per radio telegram only (comparable to lifting a mass of 1 gram up a 5 mm altitude)
- Operating energy is generated by pressure, movements, light, temperature, vibration, rotation, etc.
- High transmission range: Up to 300 m outdoor (= length of three soccer fields), up to 30 m indoor (= typical coverage of a private home or an fire protection area of a commercial building)
- Minimal emission energy: Less than the spark radiation of a conventional light switch, one million times less a mobile phone (certified from ECOLOG institute)
- Reliable signal transmission, suited for systems with hundreds of sensors (since signal transmission time is a thousand of a second only)
- Reliable against external disturbances: Repeated radio signal transmission delayed at random, using of regulated frequency ranges approved for pulsed signals only
- Prearranged transmitter to receiver assignment: Four billion code numbers are fixed, easy learning procedure (push receiver learn button and activate transmitters)

Technical Data

- Frequency: 868.3 MHz or 315 MHz for world-wide use
- Radio Regulations: R&TTE EN 300220 or FCC CFR-47 Part 15
- Transmission power: typ. 6 dBm (antenna input)
- Receiver sensitivity: typ. -97 dBm
- Modulation type: ASK
- Data rate: 125 kHz
- Channel bandwidth: 280 kHz
- Radio telegram: typ. 1 ms, variable telegram length (e.g. 53-130 bit incl. 32 Bit sensor ID, 1-4 byte sensor data, checksum)
- Transmission time: typ. 40 ms for three identical radio telegrams, delayed at random

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2. The EnOcean Concept

Energy harvesting wireless switches and sensors from EnOcean – Green. Smart. Wireless.

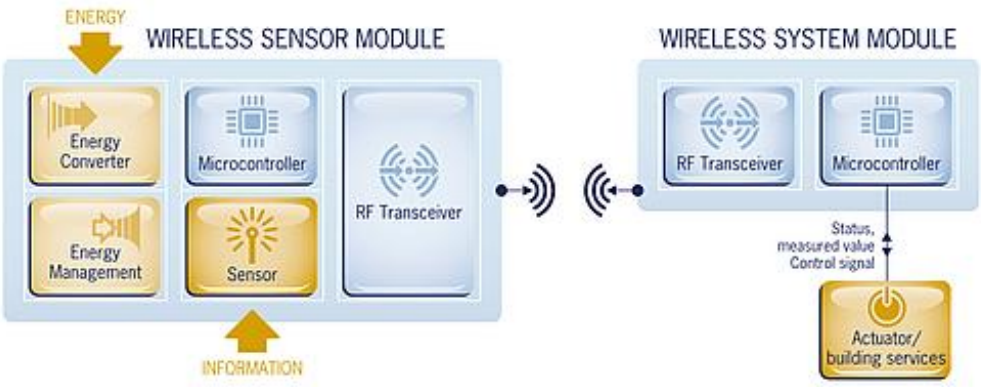
The idea that led to this innovative technology is based on a very simple observation: where sensors capture measured values, the energy state constantly changes. When a switch is pressed, the temperature alters or the luminance level varies. All these operations generate enough energy to transmit wireless signals.

EnOcean technology

The strength of EnOcean lies in the **Combination of three key technologies**:

- wireless sensors from EnOcean use motion converters, solar cells and thermo converters (Energy Harvesting)
- Using optimal techniques for energy management, that make sure, that our devices function with even the tiniest amounts of energy, to transmit sensor information via radio.
- Usage of **intelligent software-stacks**, which enable a modular, versatile and user-friendly integration into the customer application.

Energy Harvesting Wireless Sensor Solution from EnOcean



Advantages at a glance

- Flexibility of the applications: no cabling, easy assembly and disassembly
- Time-savings: quickly integrated, mounted and configured
- Quality improvement: maintenance free, no batteries
- Ecological compatibility: Usage of existing minimal amounts of energy, battery-less, reduction of wiring material (copper, sheathing, etc.),
- Reduced fire risk and inductive fields
- Cost benefits: in integration, in installation and while operating

3. Energy Converter

Green – energy harvesting wireless switches and sensors from EnOcean collect and save the tiniest amounts of energy from their environment

Sensor modules from EnOcean harvest tiny amounts of energy from their surroundings, enabling them to register detected values and transmit them wirelessly.

Surrounding sources of useful energy:

- linear motion/ pressure
- Light
- Temperature change
- Rotation
- Vibration

Maintenance-free energy converters:

a) Motion converter: Energy from a switching operation (button pressure)

- Electrodynamic energy converter
- User-dependent energy generation from button motion
- Service-free for 50,000 switching cycles
- For small and flat switch designs

b) Solar cells: for exterior and interior applications

- Small solar cell 13x35mm with energy storage
- Energy gathering by „quick start" and 24h non-stop operation
- Function follows design

c) Thermo converter: Heat dissipation as energy source

- Standard peltier element
- Operation by minimum temperature difference
- Maintenance free, full integration possible

d) Rotation converter: Gas and water meters rotate just like car tires and tools, and you cannot fit cables for measurement - an ideal application for wireless sensors powered by the energy of rotation.

e) Vibration converter: Machines, motor vehicles, persons when they are running and many technical devices generate vibrations – why not make use of it?

Energy harvesting

EnOcean's technical breakthrough was to reduce the energy needed to transmit a signal to an incredibly small amount. As a result, EnOcean energy harvesting wireless sensors can work where other technologies cannot. A simple example is that of our energy harvesting wireless switches and sensors, which can even operate inside buildings where light levels are low.

Self-powered wireless switches, sensors and controls

- Energy harvesting wireless switches
- Energy harvesting wireless sensors
- Actuators & Controllers
- Gateway & Building Management Systems
- Accessories

4. Radio Technology

Wireless – an incredibly small amount of ambient energy can produce a signal of astonishing range

Patented EnOcean energy harvesting wireless sensor solution is able to generate a signal of astonishing range from an extremely small amount of energy. From just 50 µWs a standard EnOcean energy harvesting wireless module can easily transmit a signal 300 meters (in a free field). The secret lies in the signal duration - the entire process is started, executed and completed in no more than a thousandth of a second.

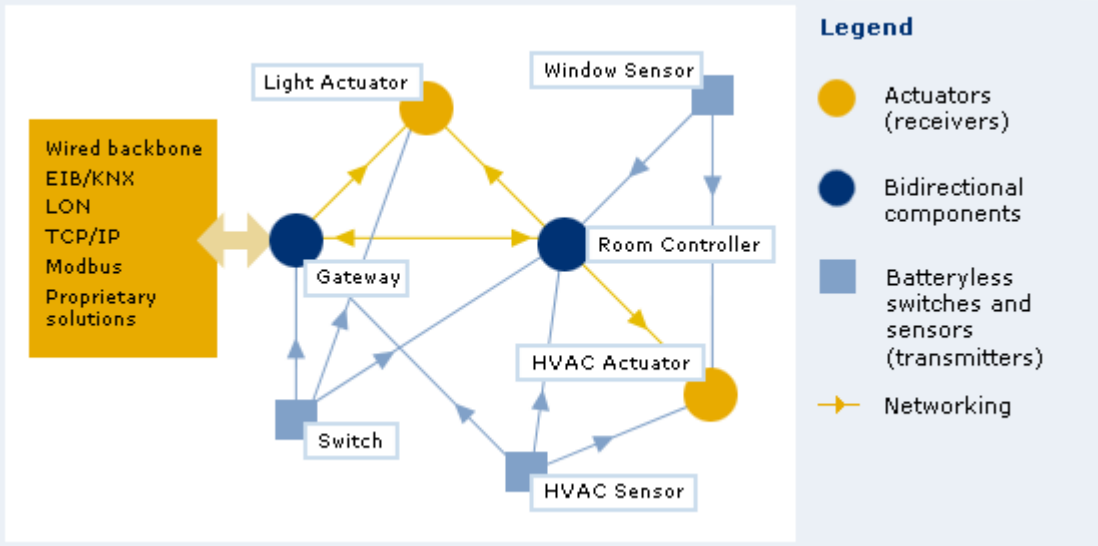


Image: EnOcean system architecture

Energy harvesting wireless standard from EnOcean:

High reliability

- Use of regulated Frequency ranges with highest air time availability (approved for pulsed signals only)
  - 868 MHz according to R&TTE regulation EN 300220
  - 315 MHz according to FCC regulation CFR-47 Part 15
- Multiple telegram transmission with checksum, delayed by random
- Short telegrams (approx. 1 ms) for little probability of collision
- Long range: Up to 30 meters in buildings and 300 meters in free field
- Repeater available for range extension
- One-way and bidirectional communication

Low energy need

- High data transmission rate for sensor information of 125 kbit/s
- Smallest possible data overhead
- ASK modulation

Interoperability

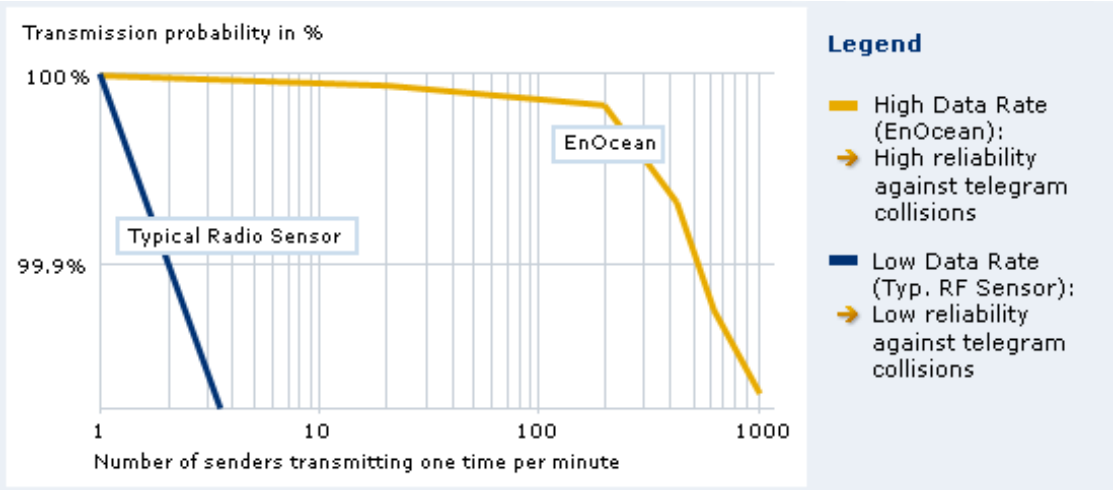
- Wireless protocol defined and integrated in modules
- Sensor profiles specified and implemented by users
- Unique transmission ID (32 bits)

Coexistence with other wireless systems

- No interference with DECT, WLAN, PMR systems, etc
- System design verified in industrial environment

High reliability of wireless transmission

Reliable wireless transmission in systems with many sensors - the extremely short telegrams of EnOcean wireless modules enable operation of a large number of transmitters all in the same cell. Any error rate caused by telegram collisions remains extremely low. Expressed in statistics, transmission reliability is still better than 99.99% for 100 wireless sensors each transmitting their data once a minute. In other words, even large office buildings or extensive industrial plants can be equipped with high numbers of EnOcean sensors, and all operating simultaneously.



5. Intelligence and Sensor Solution

Inspired by nature

The major concepts of energy-autonomous wireless sensors are:

- Harvesting of energy from their surroundings
- Strategy for minimal energy consumption
- Organization in collectives
- Communication even in disturbed conditions

But that is what most living things do - and to a much greater degree of perfection. Models in nature consequently inspired EnOcean's technical solutions and continue to influence them.

EnOcean uses a system of distributed intelligence so that everything keeps working if a component fails. This means that each functional node has its own local processor that detects measured data for example, controls energy management and wireless transmission, and can make its own decisions.

Energy management

How do you use available energy so that as little as possible is needed for each action? How do you achieve what you want with fewer actions? The more intelligence is invested in energy management, the more powerful and cost-attractive the components become and the system too.

Topology of wireless sensor networks

Wireless technology is not the best solution to all problems. Wired communication is bound to keep its place. What does the optimal mixture of batteryless wireless nodes, line powered wireless nodes and wired information channels look like? Our answer to this is smart routing.

Software concept

EnOcean wireless modules always come with software. This is either so specialized that no modifications are necessary like with the PTM 200 light switch module, or it allows application-specific configuration as in the TCM 300 transceiver module. The aim in every case is easy use of the technology without special knowledge.

Sensor links

Instead of separate wireless sensor modules for each measured variable, EnOcean presents general-purpose modules to which the user can simply connect a variety of different sensors. What are the important things to watch out for?