Self-powered RadioTechnology for Building Automation Systems

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EnOcean GmbH

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EnOcean Technology History

- **1995-2001:** Energy harvesting research projects at Siemens Corporate Technology
- **1997:** 1st patent for energy harvesting powered wireless sensors
- **2001:** EnOcean company spin-off from Siemens by management
- **2003:** 1st generation products shipped to customers and installed in buildings
- **2006:** 2nd generation energy harvesting products
- **2008:** EnOcean Alliance founded to internationalize & standardize technology & to educate users
- **2010:** >40 patent families, several 100.000 buildings deployed by >150 OEMs offering >450 final products, introduction of 3rd Generation Platform

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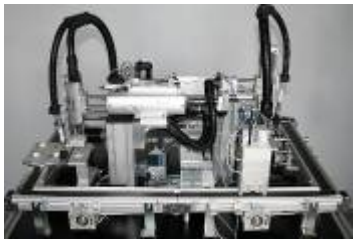
Energy Harvesting Wireless - Application Areas

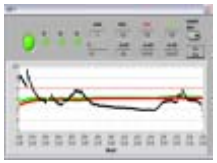
- **Building Automation**
  Lighting, Heating, Cooling, Ventilation, Security, Metering …

- **Industrial Automation**
  Condition Monitoring, Process Optimization, Control, Metering, Switching, …



- **Automotive & Aviation**
  Condition Monitoring, Switching, …

- **Medical**
  Temperature, Blood Pressure, Heart Beat, Monitoring, …



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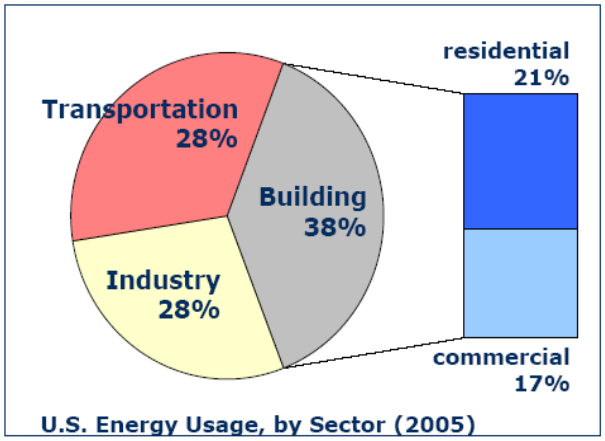
Energy Harvesting Wireless – Building Automation

- **Buildings Use 38 % of our Total Energy Requirements**
- **Energy Use Set to Double between 2003 and 2030**
- **You can Save 30 % with Building Automation Systems**



U.S. Energy Usage, by Sector (2005)

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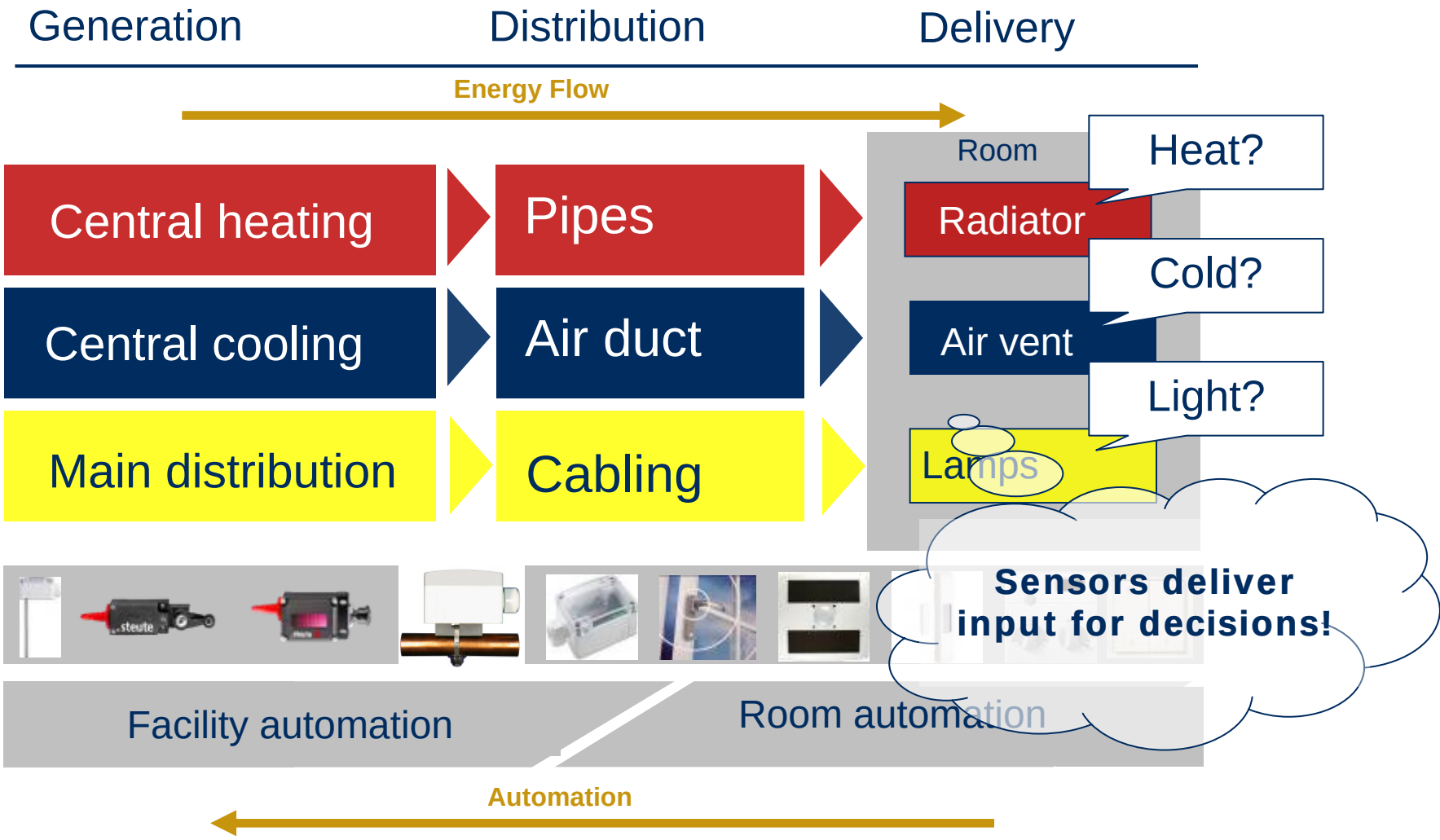
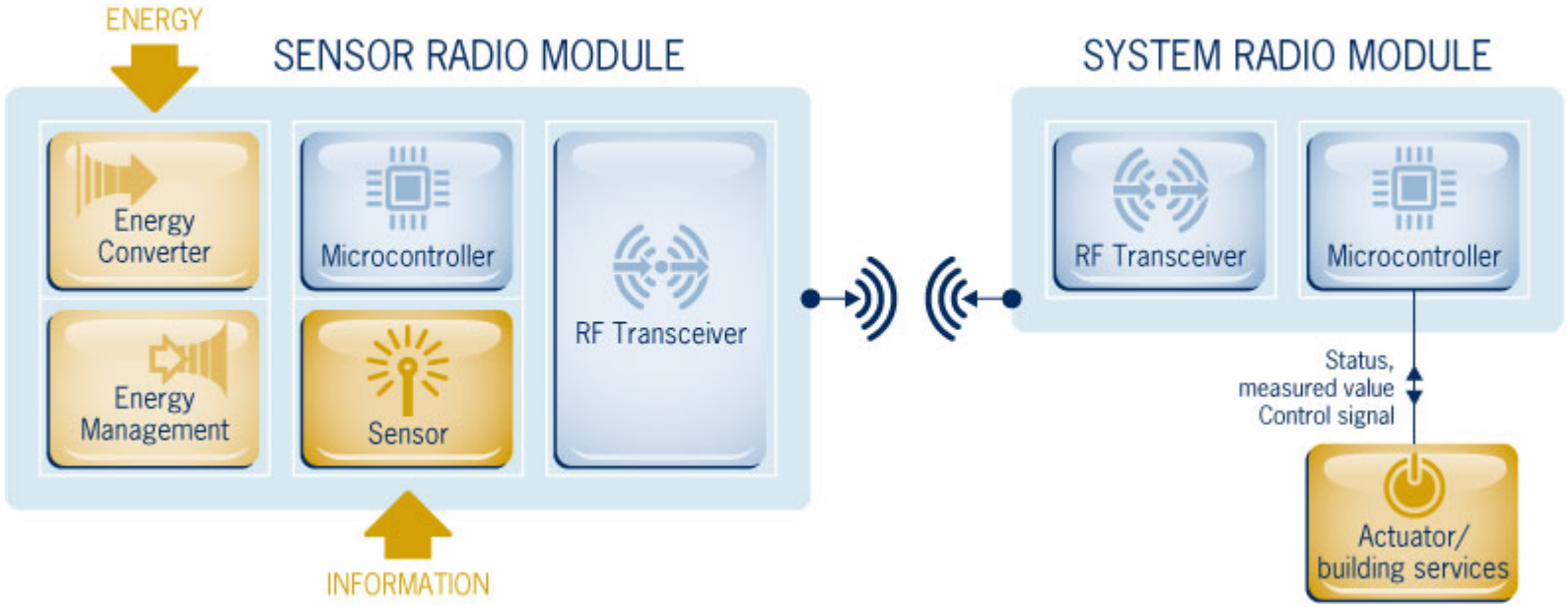
Sensors are essential for Building Automation



Self-powered Wireless Sensor Technology

Ambient Energy:
Motion, Temperature, Light,
Rotation, Vibration



Temperature, Pressure,
Position, Movement, Air
quality etc.

EnOcean System Architecture

Energy Harvesting

- Self-powered wireless sensors from EnOcean collect and save the tiniest amounts of energy from their environment

Enocean Modules

- Easy to integrate
- For fast and low-cost equipment development

Software

- A Powerful & Easy to Use Operation System
- For modular and versatile, user-friendly integration in applications

Enocean Wireless Standard

- 868 & 315 MHz

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The best suited radio frequency - in buildings

315 MHz
North America, Japan, China

Optimal Performance

868 MHz
Europe

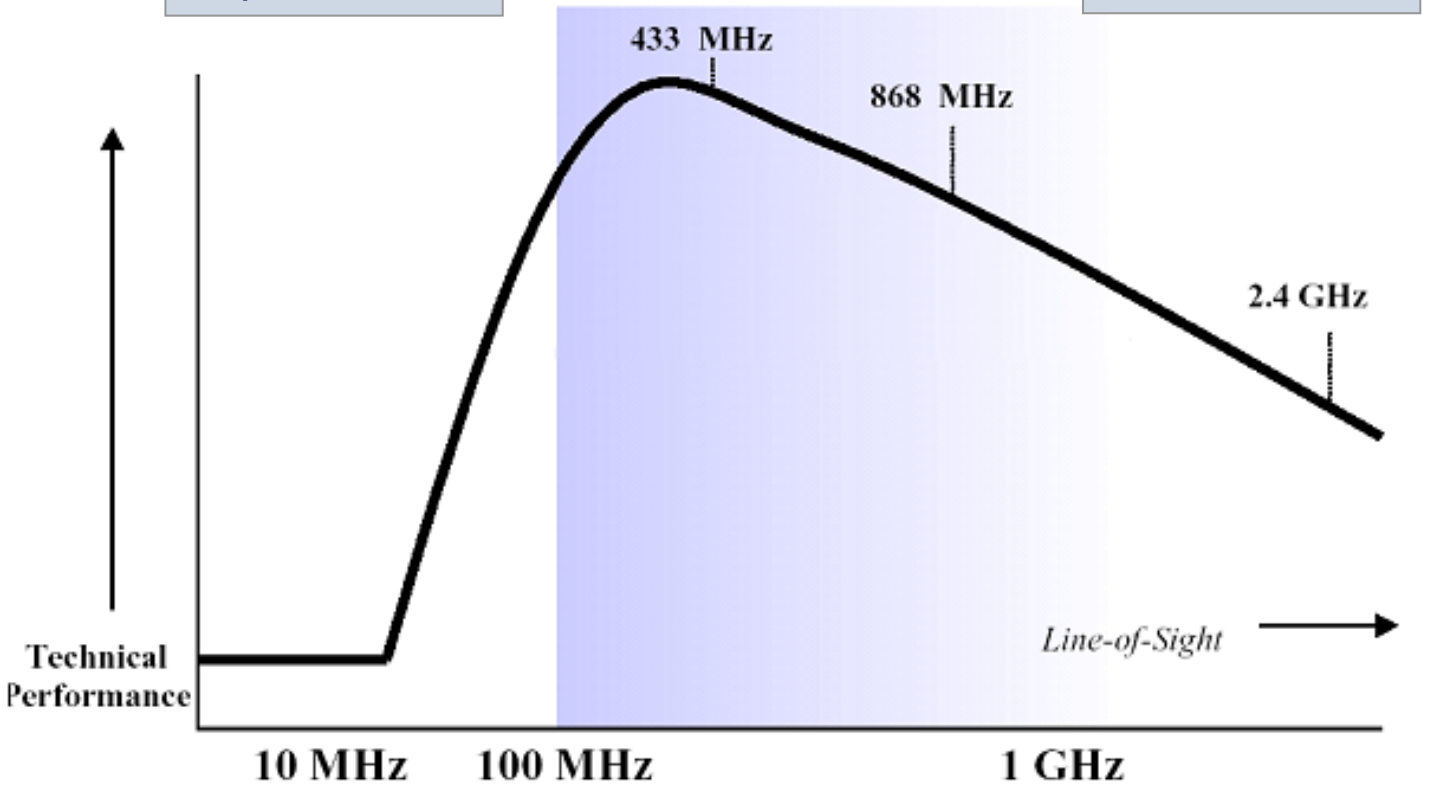

Figure 1. Frequencies between 100 MHz and 1 GHz offer the best technical performance for Active RFID.

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Energy Converters – in Detail

ECO 200

Mechanical: Energy by fingertip

- Electrodynamic Energy Generator
- User-independent energy conversion with button press
- Maintenance free 50.000 operations
- Allows small and flat rocker designs

ECS 300/(310)

Solar: natural and indoor light

- Small solar cell 13x35mm (20x50mm) with energy storage
- Energy harvesting with „quick start“
- Function follows design

ECT 310

Thermal: 2 Kelvin @ Peltier

- EnOcean ultra low power DC/DC converter for standard peltier elements
- Maintenance free, full integration possible
- Allows energy harvesting actuators

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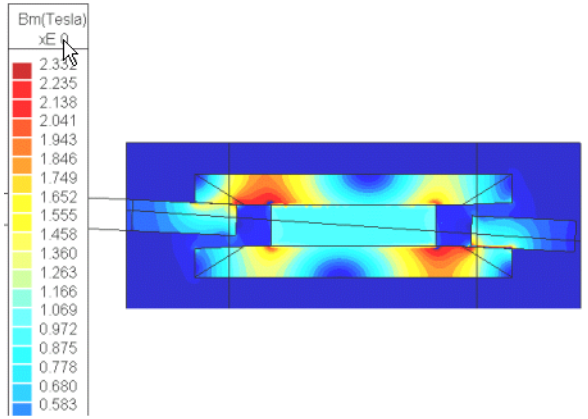
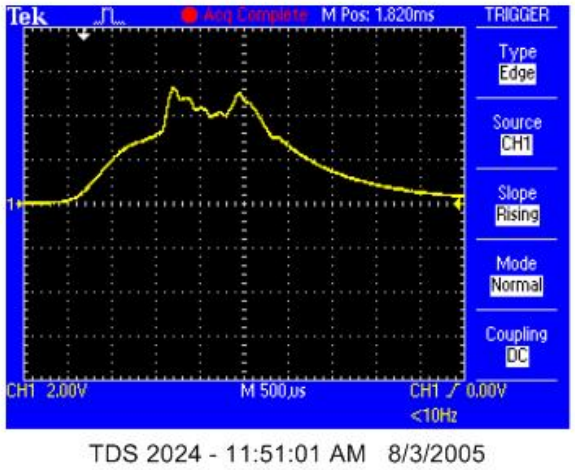
Mechanical Energy:
Linear Movement and Button Push

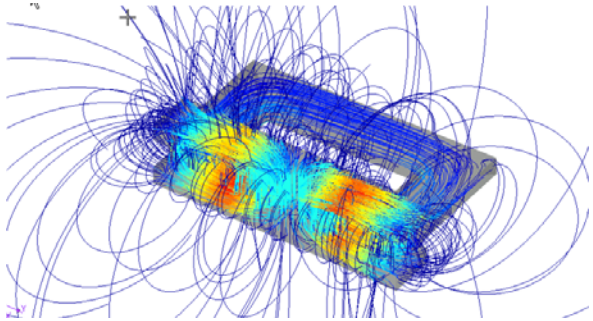
EnOcean ECO 200
converter module



FEM-Simulation magnetic flux
density within iron core



Voltage response



FEM-Simulation of external magnetical
field

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Mechanical Energy:
Linear Displacement and Button Push

Technical Data Button Push Converter	
Operating Force (N)	5
Displacement (mm)	1,5
Mechanical Input Energy (µWs)	7500
Electrical Output Energy (µWs)	350
Efficiency	4,67%
Radio	
Frequency (MHz)	315 or 868MHz
RF Power (dBm)	6
Modulation	FASK
Data Transmission	
Number of Repetitions	3...5
Single Telegram Duration (ms)	0,6
Information Content (Bits)	60

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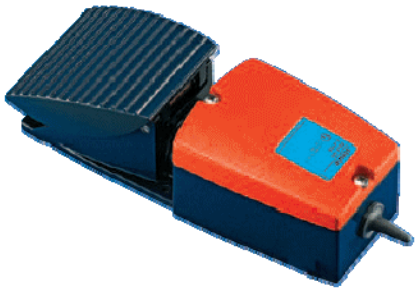
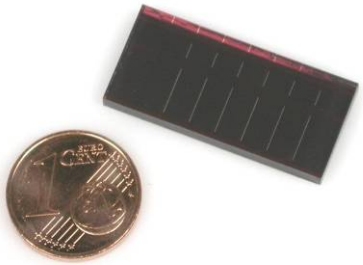
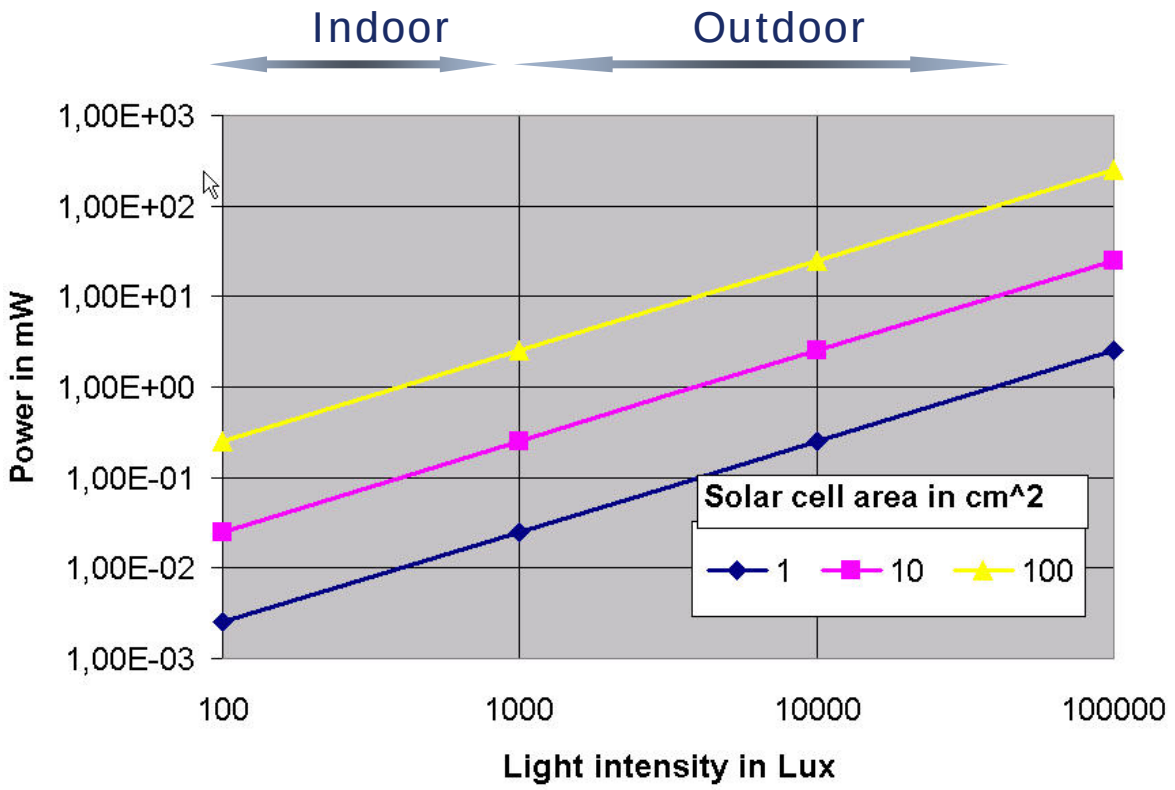
Mechanical Energy Harvesting Product Examples



Light Energy





Attainable power from low-cost thin film solar cells

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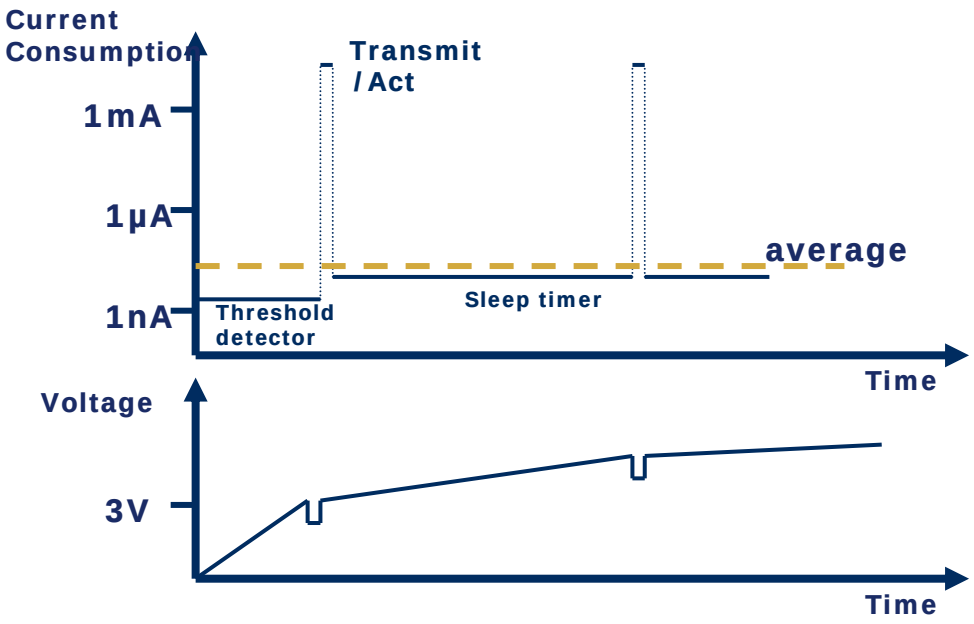
Energy Management & Storage



- Very short working periods of active components like CPU and RF (below 1ms)
- Optimized timers and threshold detectors with very low standby current (20-100nA)
- Efficient DC/DC converters and impedance adaptation
- Efficient long time storage for electrical energy

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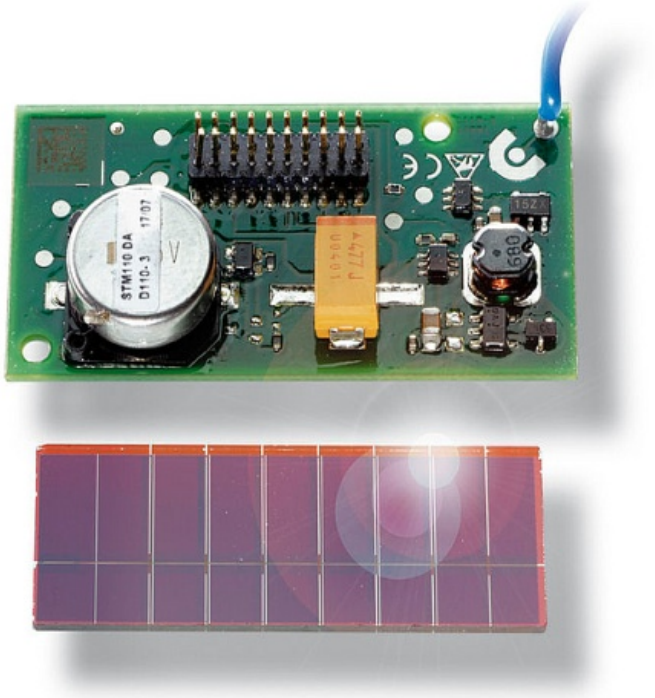
Light Energy -
Solar Powered Radio Sensor Module

- Complete plug and play sensor system
  - Small solar cell
  - Energy storage
  - Ultra-low-power timer
  - Signal scanning and evaluation
  - Radio transmission
- Designed for ultra low power consumption, e.g. 20 nA sleep timer.
- **5 days function with no light**



EnOcean STM 110
Solar Sensor Module

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Light Energy Harvesting Product Examples

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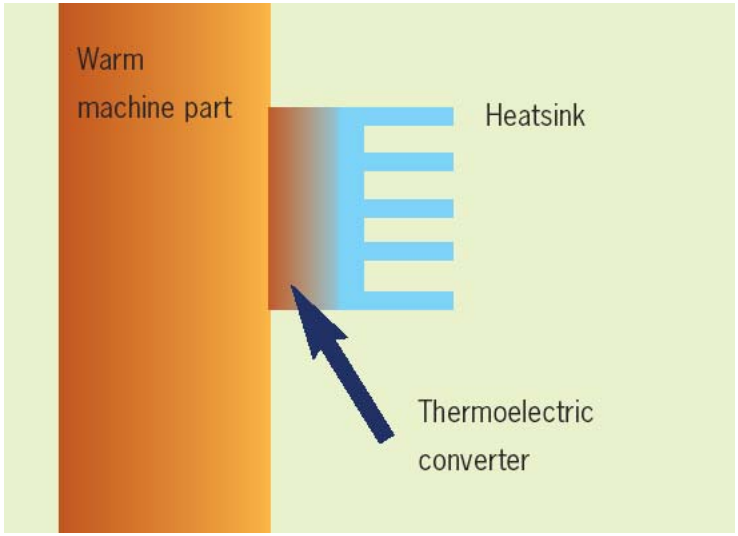
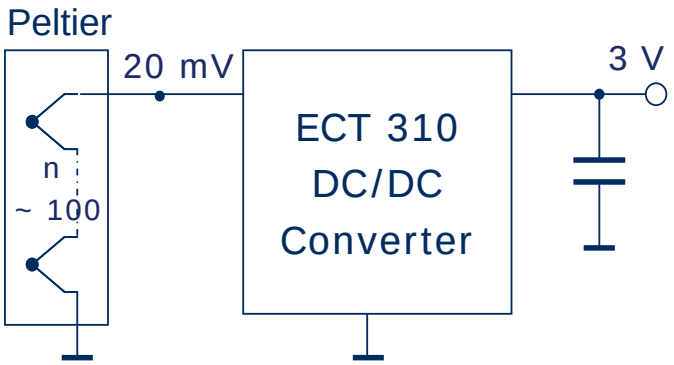
Thermo Energy - Challenges



Challenge:

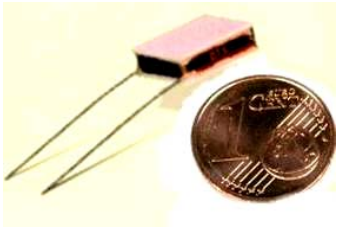
Low cost thermoelectric elements produce only tiny voltages

Solution:



Concept:

Standard component usage for short development cycles and low cost



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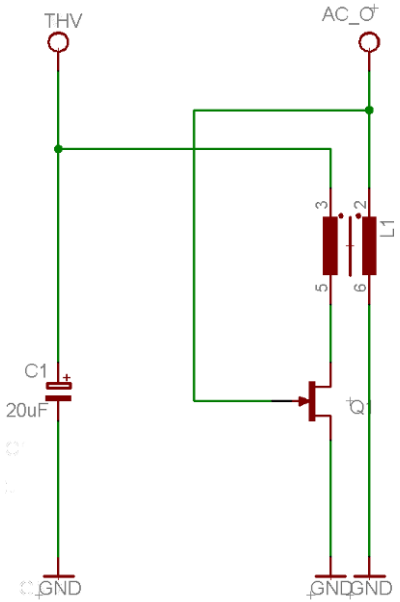
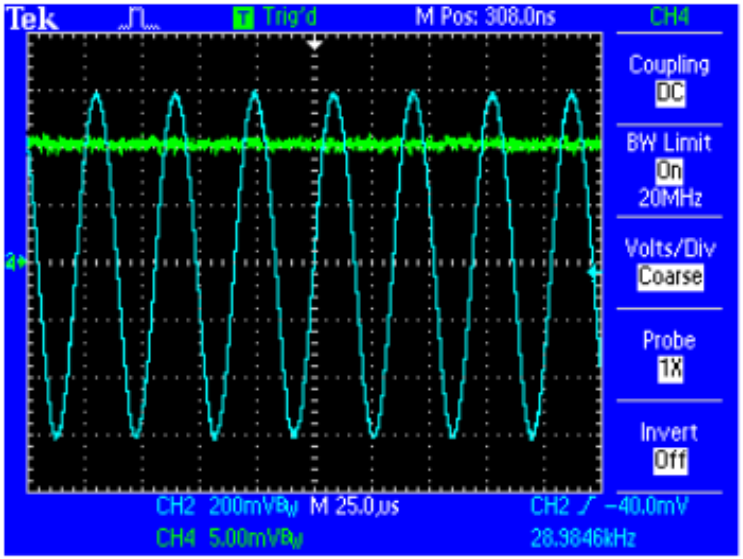
ECT 310 - Working Principle

- New converter concept – Highly optimized blocking oscillator for very low voltages





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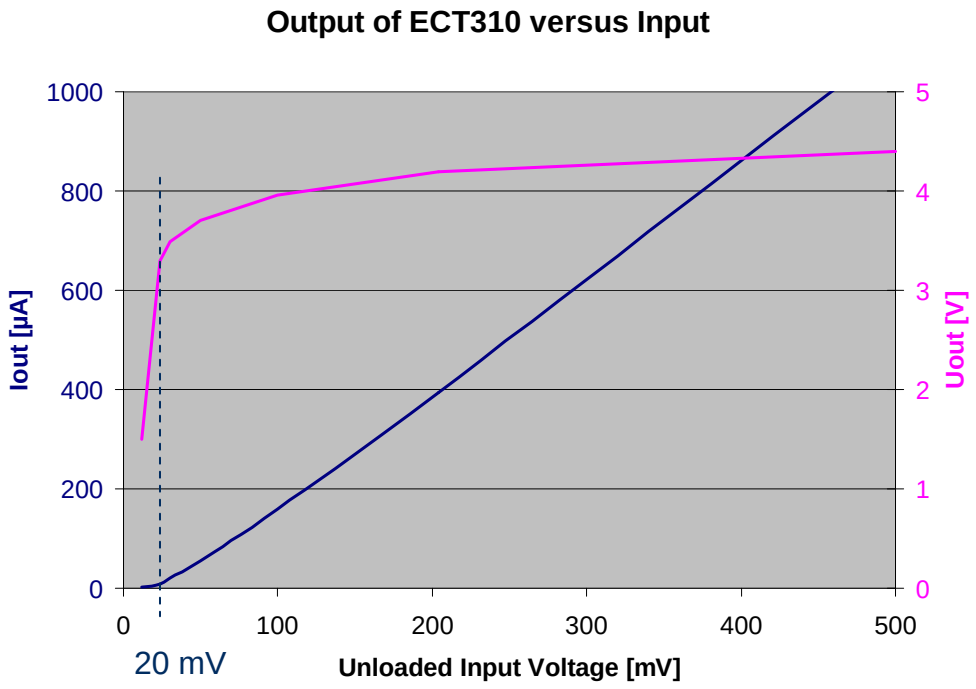
ECT 310 - Conversion Characteristics

- Input voltage larger than 20 mV is converted to an output voltage ≥ 3 V
- Efficiency ≈ 30 % at 25 mV



Energy source impedance = Peltier element impedance (around 1.5 Ohm)

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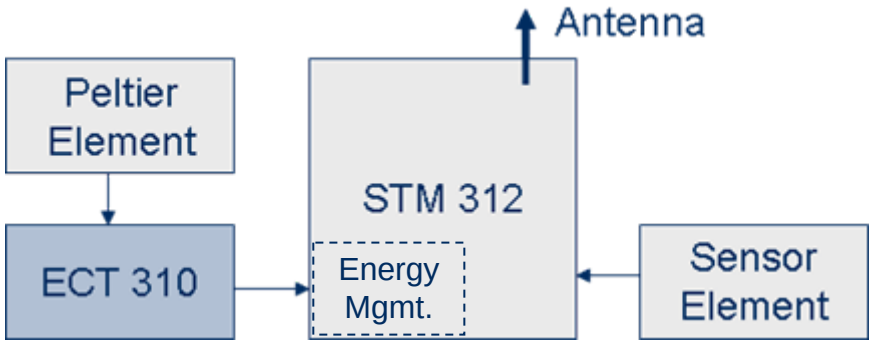
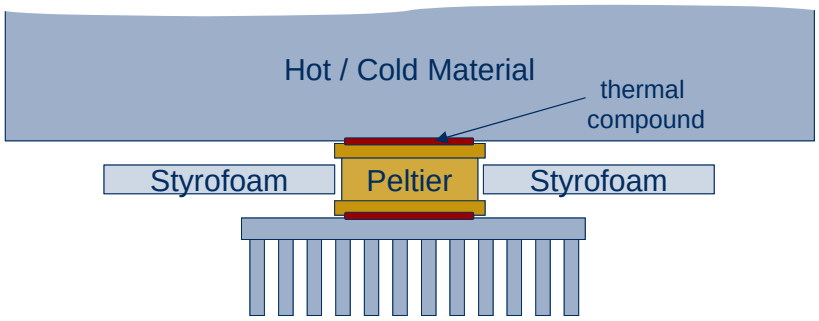
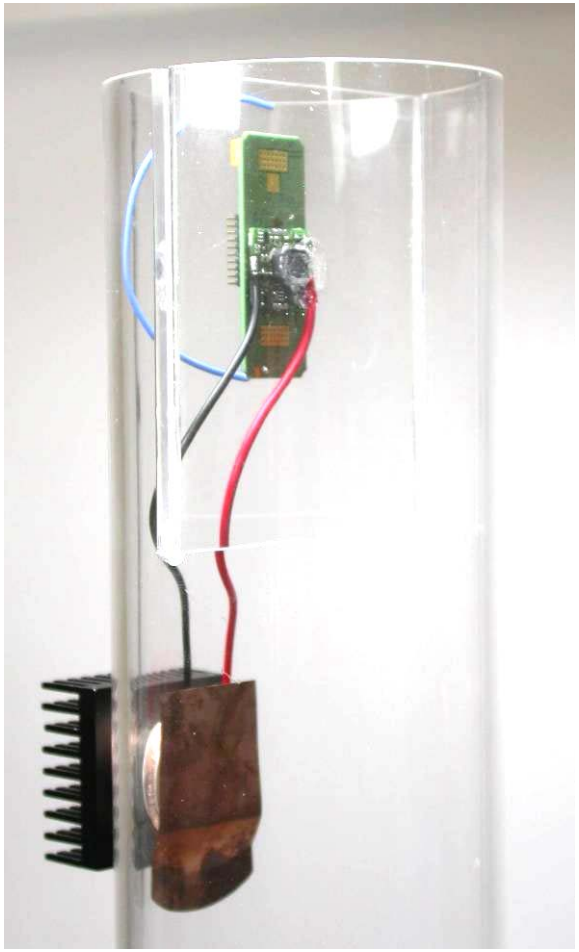
Sensor powered by temperature difference







Self-powered air flow temperature sensor

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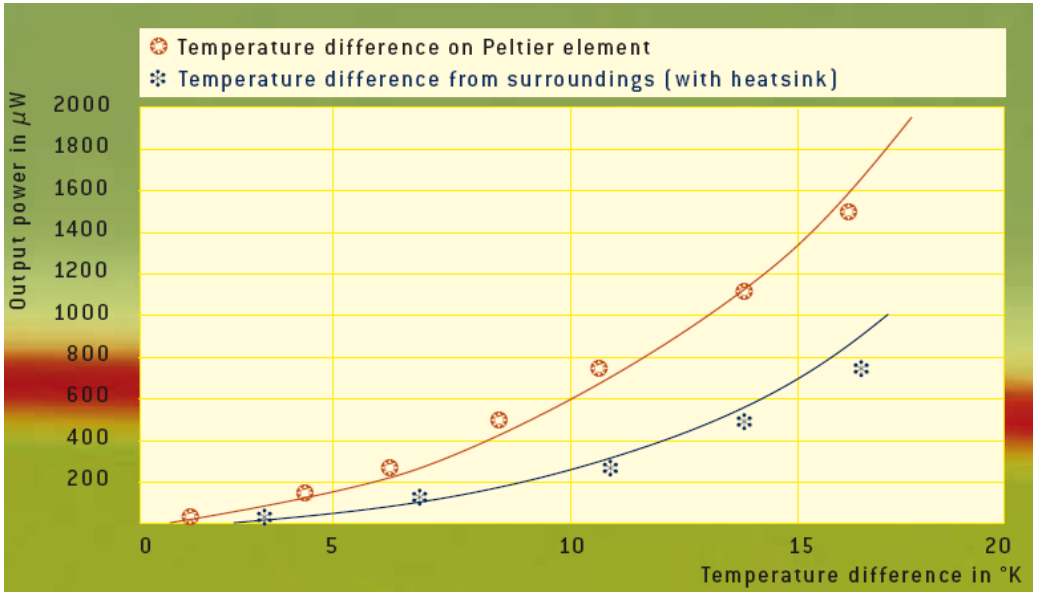
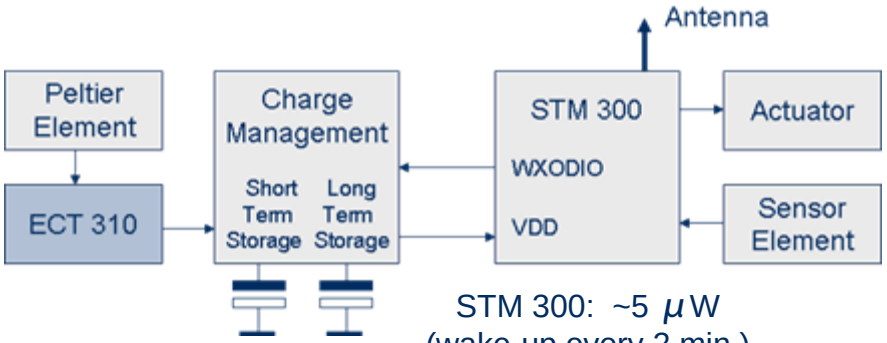
Thermo-powered Wireless Actuator



~100 µW energy available at 7 Kelvin temperature difference



STM 300: ~5 µW
(wake-up every 2 min.)

Enough energy is left even to power some actuators !

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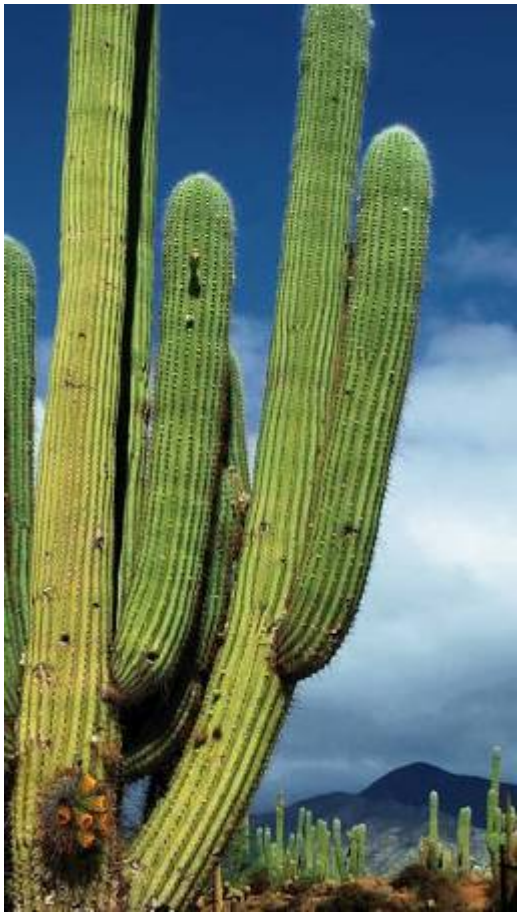
Energy Harvesting Sources for Wireless Sensors



Products available

- Linear Motion
- Solar
- Thermal

Prototypes

- Vibrations
- Rotation

Unlimited Possibilities

- Daily temperature changes
- Air pressure changes
- Radio waves
- Muscle contraction
- Blood sugar fuel cells

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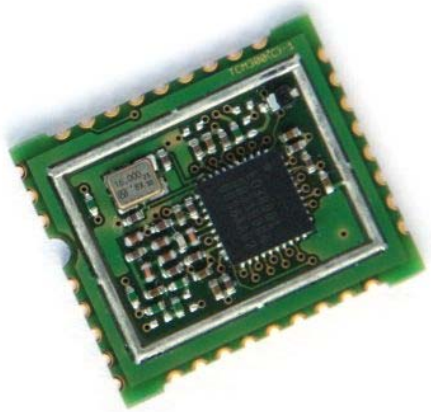
Bi-directional radio solutions based on Dolphin

Generation 1 (2004):
Discrete components on both PCB sides,
42 x 24 x 5 mm, 5V, 33 mA



Generation 3 (2009):
SMD device,
22 x 19 x 3 mm, 2.5V, 27 mA

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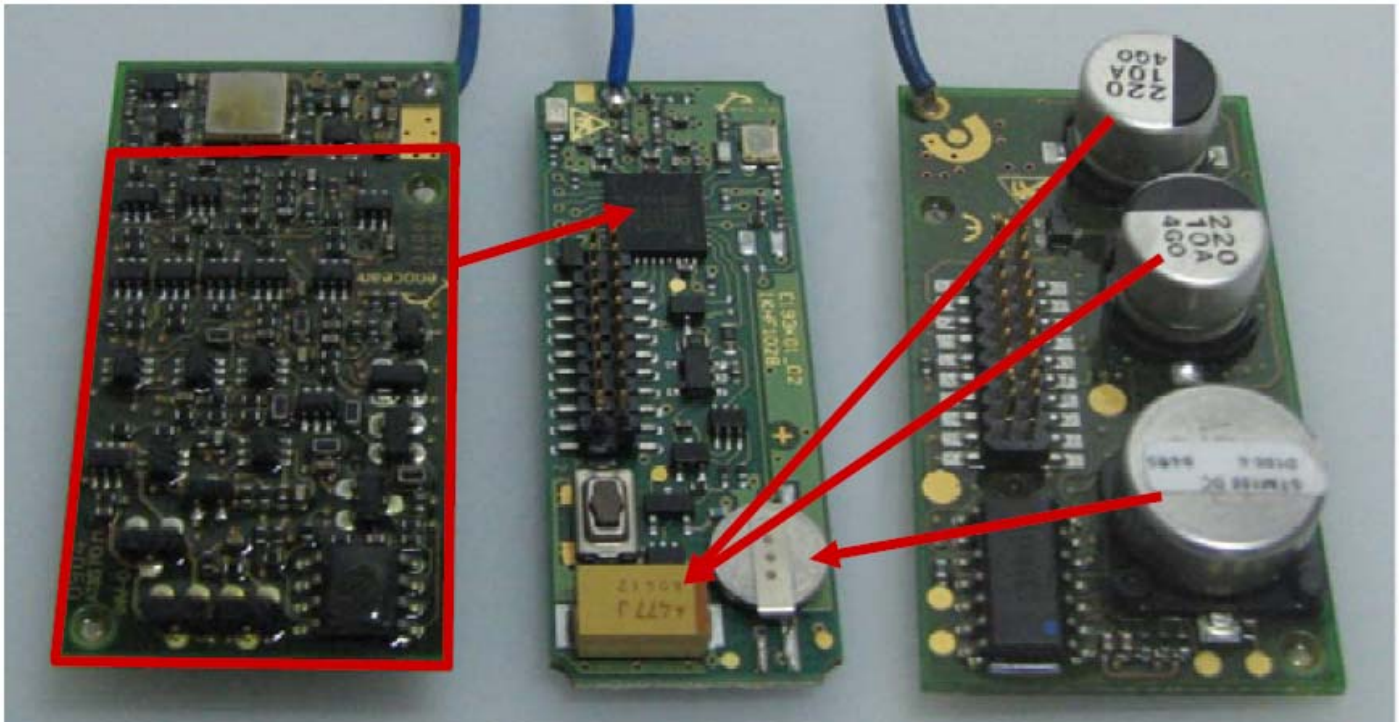
All-in-one sensor solution based on Dolphin

2003
Front side
STM 100

2010
Back side
STM 310

2003
Front side
STM 100



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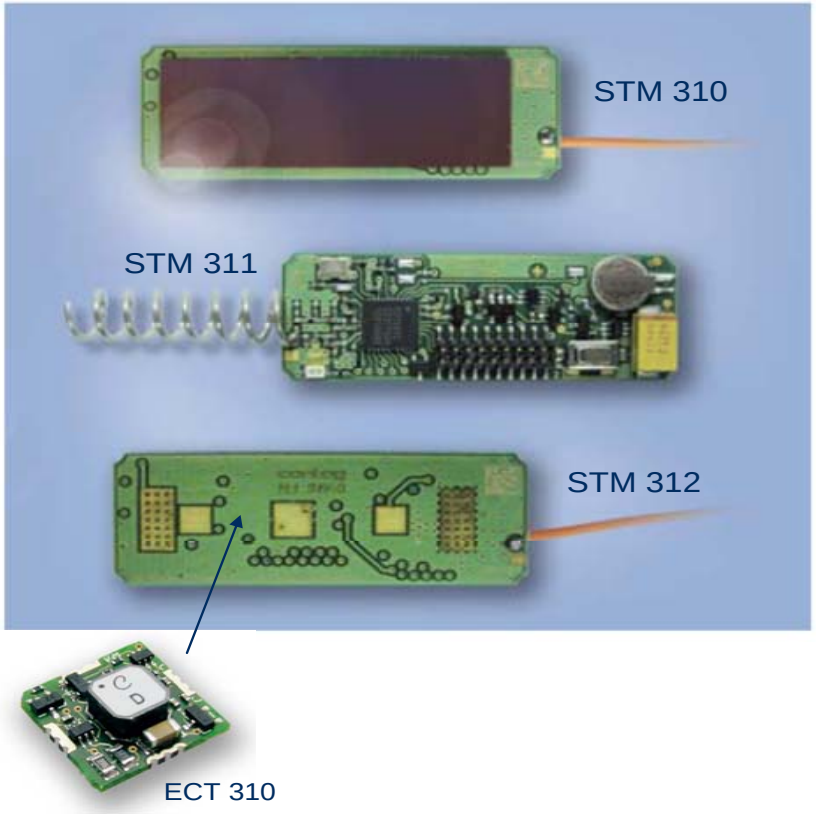
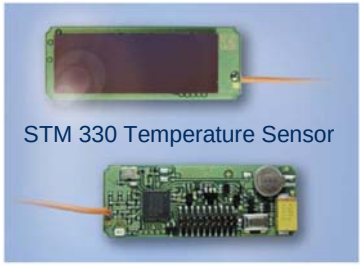
STM 310 Family:
All-in-one solution for battery-less radio sensors

- Energy storage and management
  Typical 4 days without energy supply
- Processor for data processing
  Preinstalled Firmware, programmable
- Analogue & digital measurement inputs
  3 x analog (e.g. 10/8/6 bit), 3 x digital
- Software stack for radio protocol
  Equipment profiles according to EEP 2.0 spec
- RF transmitter with integrated antenna
  868 MHz or 315 MHz, Whip or Helix





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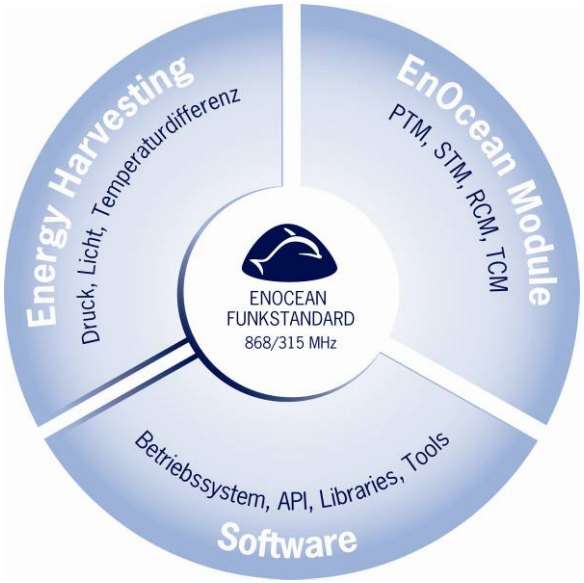
Energy Harvesting Wireless: EnOcean Overview



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EnOcean Alliance - Standardization

- **EnOcean – the wireless standard for sustainable buildings**
  - Over 160 product manufacturers
  - With over 600 interoperable products
  - Deployed in >> 100,000 buildings
- **EnOcean Equipment Profiles v2.1**
  - Interoperability of products
  - Connectivity to BAM systems
  - Application Layer
- **IEC Standardization**
  - Physical Layer

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Connectivity & Interoperability

Lighting Controls

Heating & Cooling Systems Sensors

Building Automation Systems Gateways

LonMark® International

BACnet

Modbus-IDA
the architecture for distributed automation

KNX®

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