

Forum „Innovations for Industry“

Session:

Energy Harvesting and Wireless Sensor Networks

Hannover Messe 2010



enocean® alliance

No Wires. No Batteries. No Limits.

Self Powered Radio Systems in Practice: Concepts, Products & Prospects

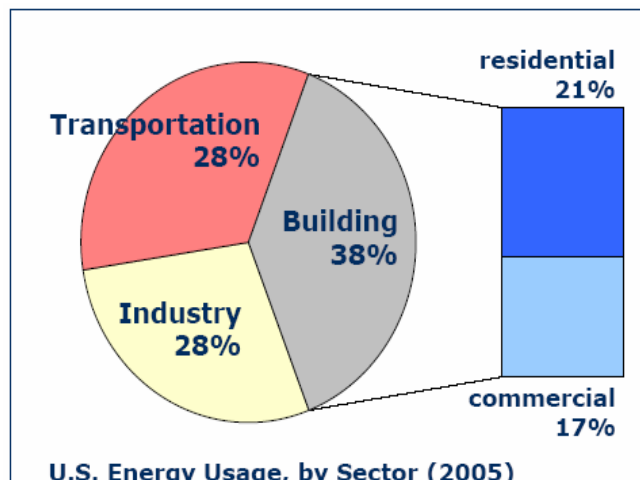
Frank Schmidt, Founder & CTO EnOcean GmbH

Energy Harvesting Wireless Sensors



Energy Harvesting Radio Sensors- Key Applications

➔ 1. You can Save 30% Energy with Building Automation Systems



➔ 2. Energy Harvesting Sensors are ideal for Status Monitoring



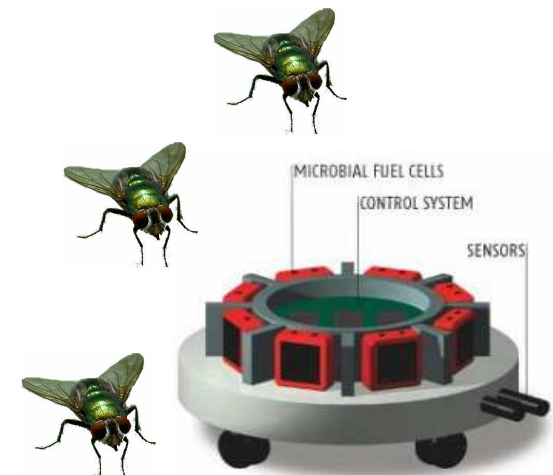
Energy Sources Ranking



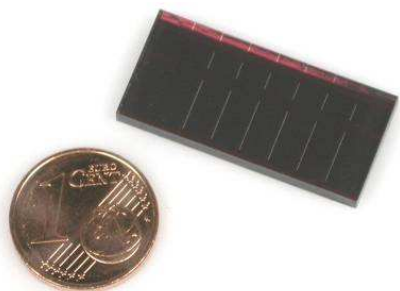
- **Solar**
- **Displacement**
- **Thermal**

- **Rotation & Flow**
- **Vibrations**

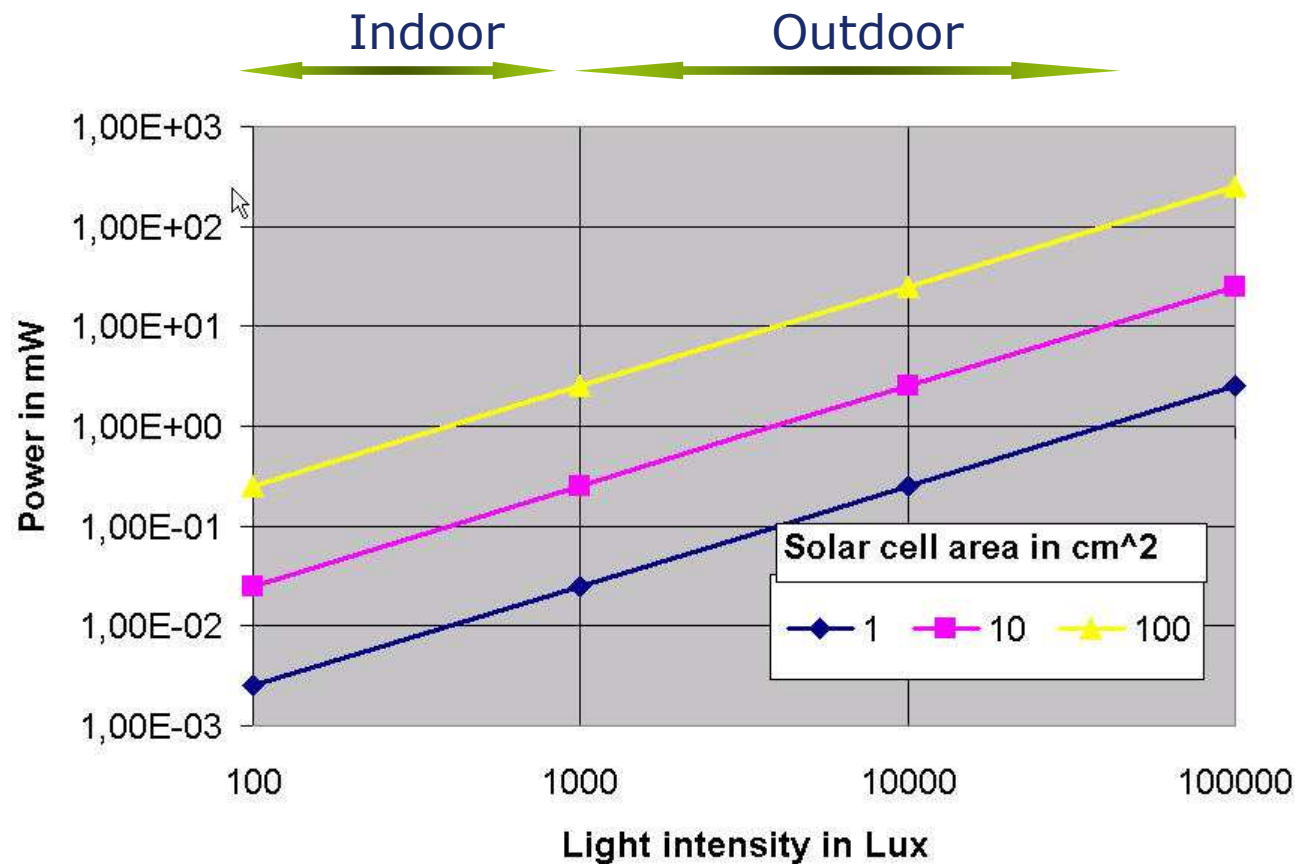
- **Radio waves**
- **Air pressure changes**
- **Muscle contraction**
- **Blood sugar fuel cells**
- **Organic material**



Light Energy (1)



Thin Film Solar Cell:
1cm² active Area
“Quick Start”



Power, attainable from Low Cost Thin Film Solar Cells

Light Energy (2) Typical Illumination



School

- Blackboard 500 - 1000 lx
- General class room 300 - 500 lx

Office Building

- PC workplace 200 - 500 lx
- Conference room 300 - 700 lx
- Corridor 50 - 100 lx

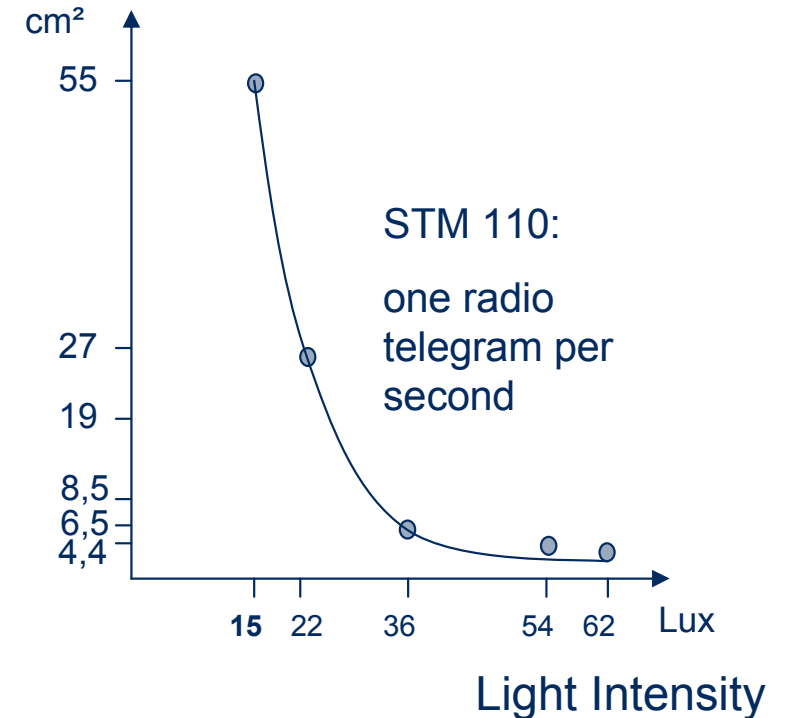
Hotel

- Reception 300 - 700 lx
- Restaurant 150 - 300 lx
- Staircase 50 - 150 lx

Industry

- Assembly Lines 50 - 500 lx
- Machinery 30 - 300 lx
- Storage Halls 200 - 1000 lx

Solar Cell Size



Light Energy Harvesting Product Examples



Solar Powered
Sensor Module STM 110



Outdoor Temp.
Sensor



Duct Temp. Sensor



Room control panels



gas sensor (CO,
CO2)



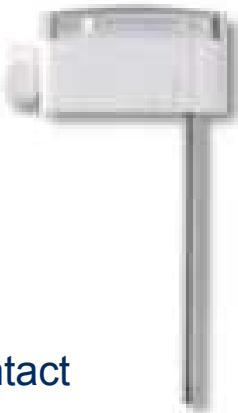
Industrial Temp. Sensor



Industrial Fridge
Sensor



Window Contact



Industrial Temp.
Sensor

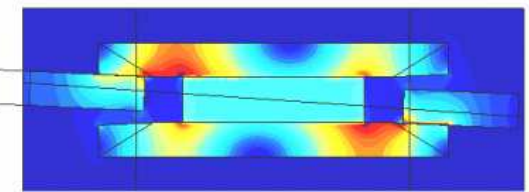
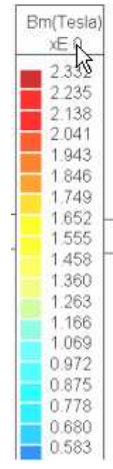
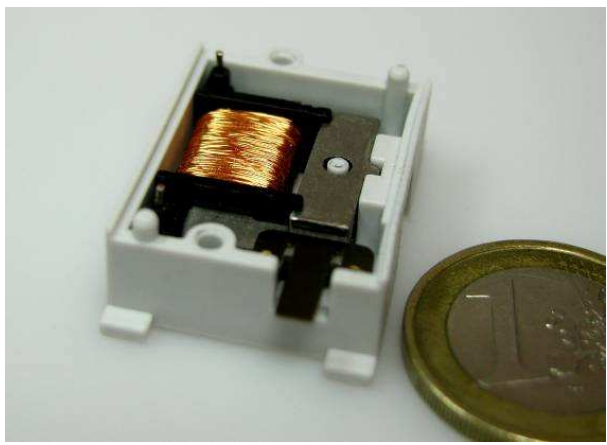


Light
Sensor



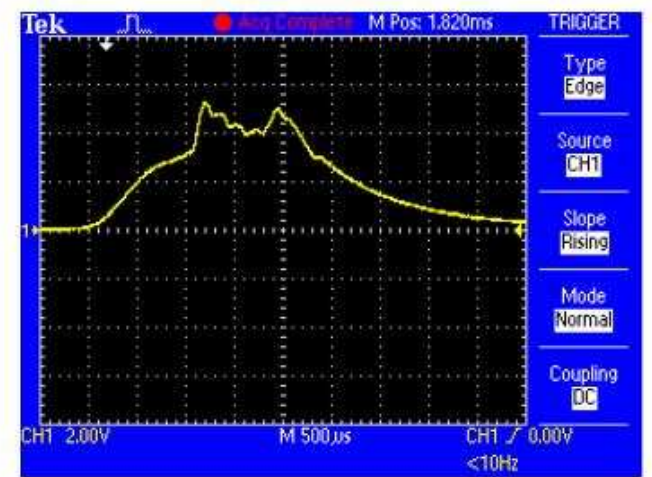
PIR Presence Detection

Mechanical Energy (1): Linear Movement



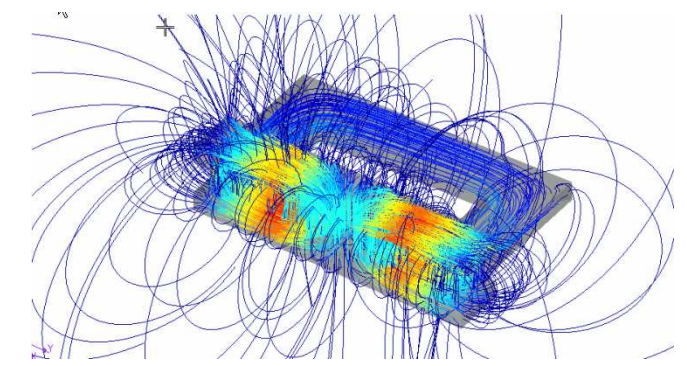
FEM-Simulation magnetic flux density within iron core

- EnOcean ECO 100 converter module



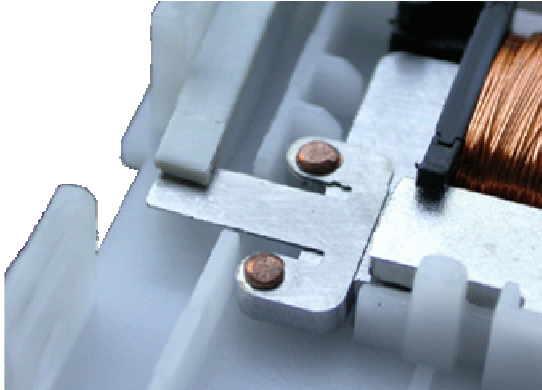
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EnOcean ECO 100 voltage response



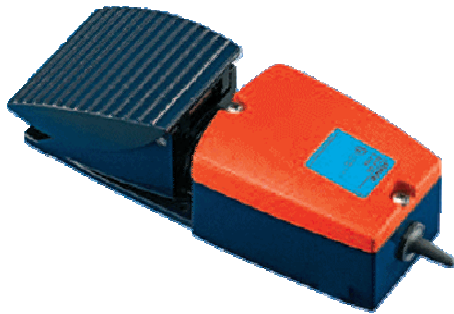
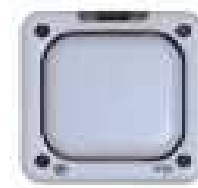
FEM-Simulation of external magnetical field

Mechanical Energy (2): Linear Movement



Technical Data Button Push Converter	
Operating Force (N)	5
Displacement (mm)	1,5
Mechanical Input Energy (μ Ws)	7500
Electrical Output Energy (μ Ws)	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

Mechanical Energy Harvesting Product Examples

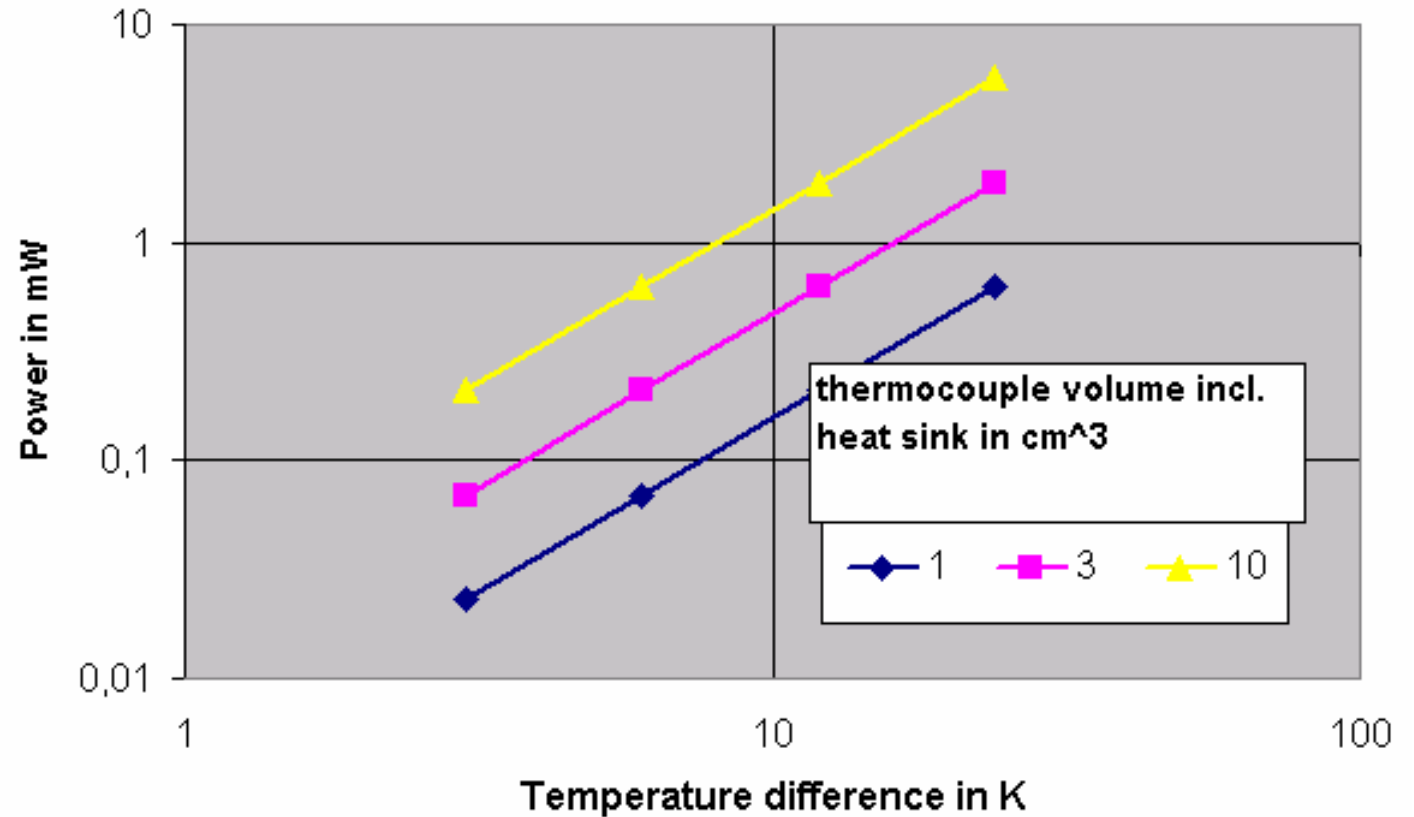


Thermal Energy (1)



Cooling down one drop of water by 1 degree frees enough energy for

**25.000 EnOcean
Radio telegrams!**



Attainable power from thermoelectric converters depending on size and temperature difference

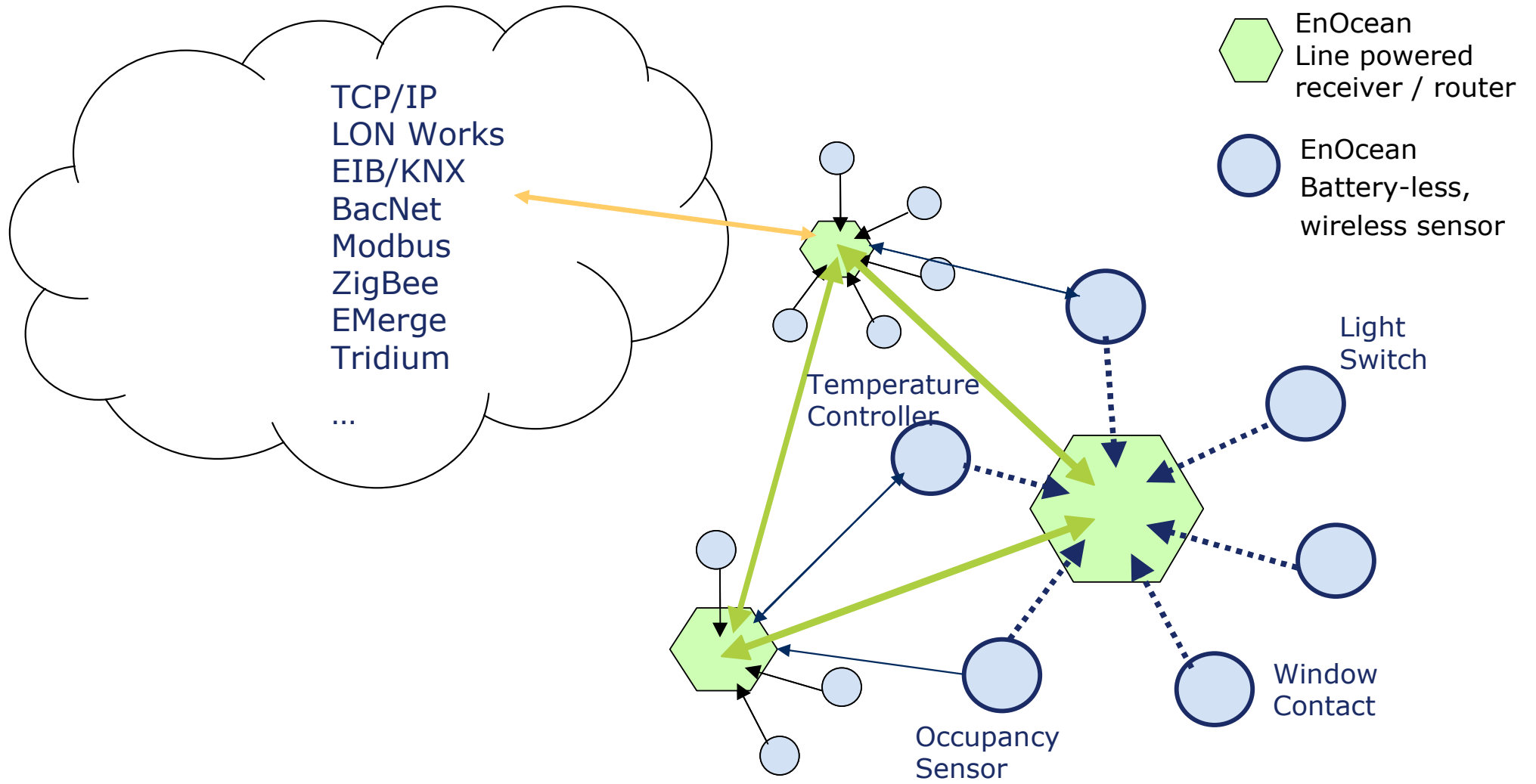
Thermal Energy Application Example

**Human body heat
operated radio sensor**

**Thermal powered
heating valve**



Interoperable Products & Connectivity



Multi-Vendor Interoperable Products

Lighting Controls



Heating & Cooling Systems Sensors



Building Automation Systems Gateways





➤ Automotive Engine Production (D)

➤ Status: Product

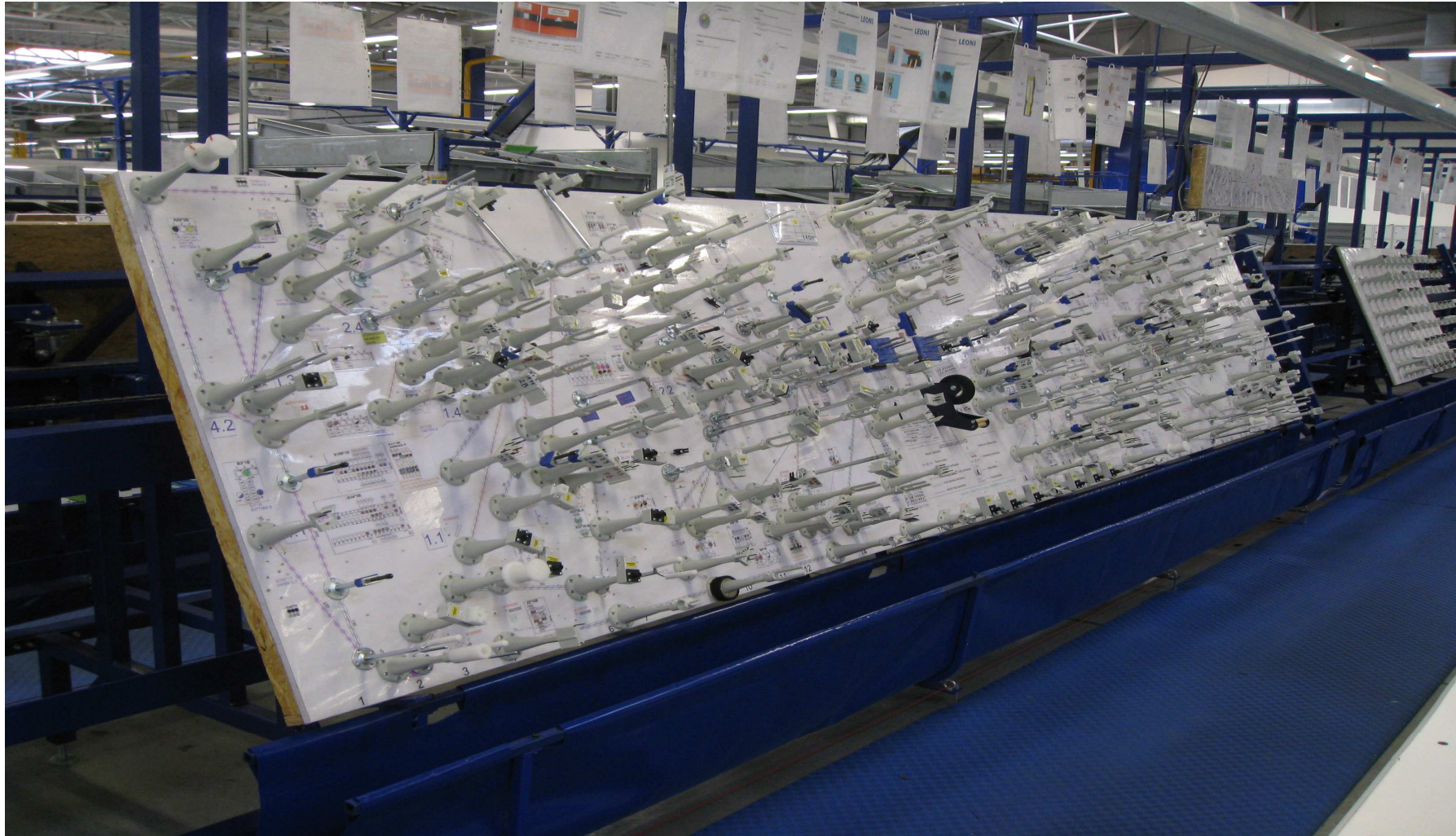
- Process Monitoring & Control
- Material Flow Control



Industrial Applications 2



Industrial Applications 3



- **Cable Tree Radio Sensors for Automotive**
- **Status: Products**

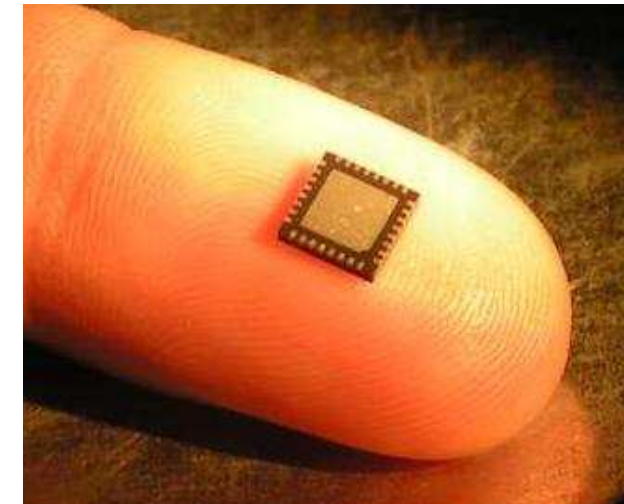
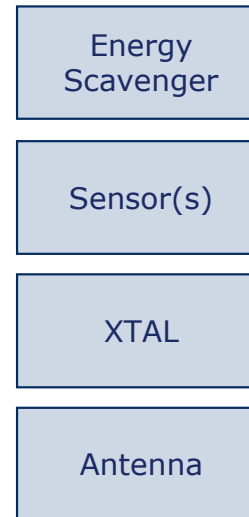
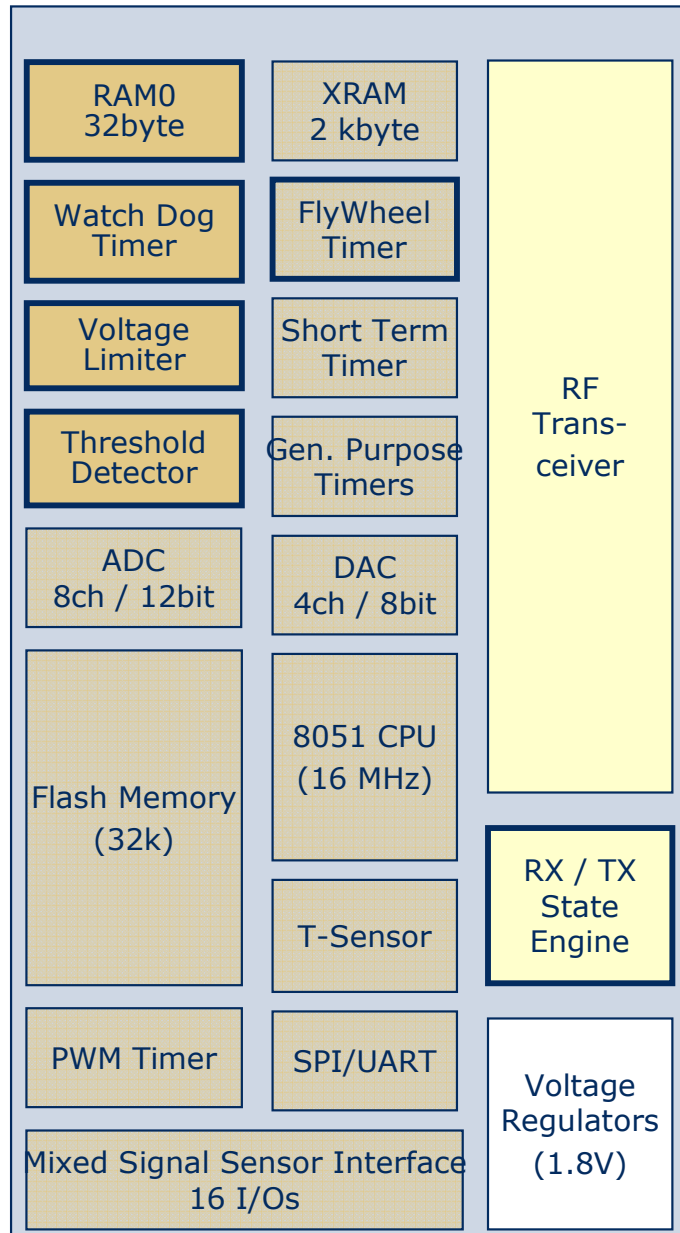
Industrial Applications 4



➤ **Paper Mill Radio Sensors (Spremberg, Germany)**

➤ **Status: Evaluation**

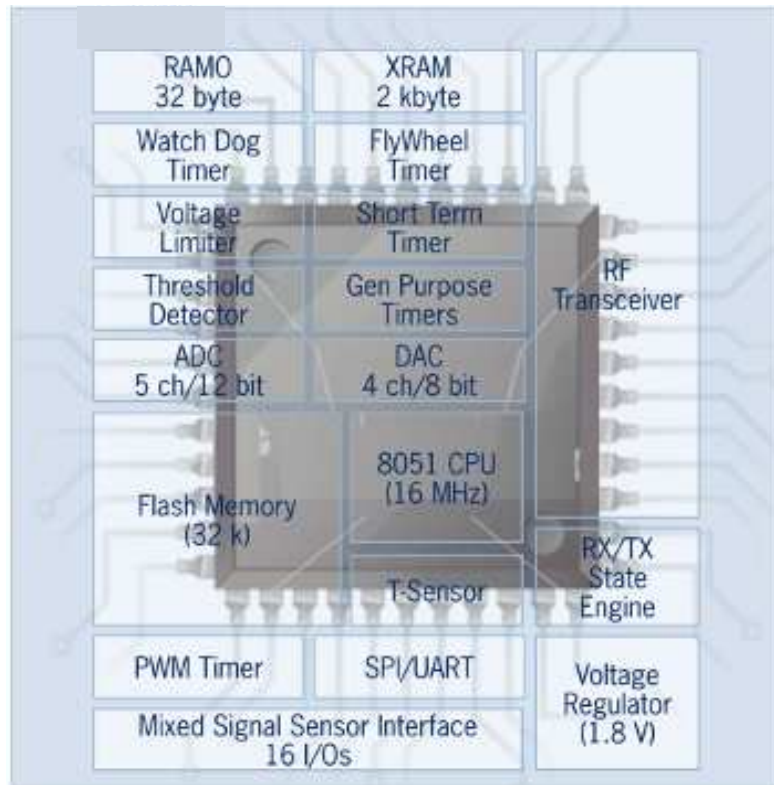
Electronics for 3rd Generation Devices: Dolphin Single Chip Solution



Superior Low Energy Need

- **OFF Mode** **~20nA**
 - **Deep Sleep Timer Mode** **~200nA**
 - **Flywheel Sleep Mode** **~500nA**
 - **Short Term Sleep Mode** **~15µA**
 - **Standby Mode** **~1.3mA**
 - **CPU Mode** **~4mA**
 - **TX (868MHz, 10dBm)** **~20mA**
 - **RX (868MHz)** **~28mA**
- **Fast operation mode changes**
 - **Only a few additional components needed**

SoC for EH-powered WSN: Microcontroller, Peripherals and RF Transceiver



→ CPU

- 16 MHz CPU 8051 assisted by system timers, CPU timers, and memories as boot ROM, 2 kbyte XRAM, 32 kbyte FLASH, and the serial SPI/UART interface

→ Mixed Signal Sensor Interface

- Digital control and digital sense by up to 16 configurable digital I/O's
- Sensing up to 5 single ended or differential analog values by a high performance 12-bit A/D converter
- Output of an analog signal by using a D/A converter
- PWM output

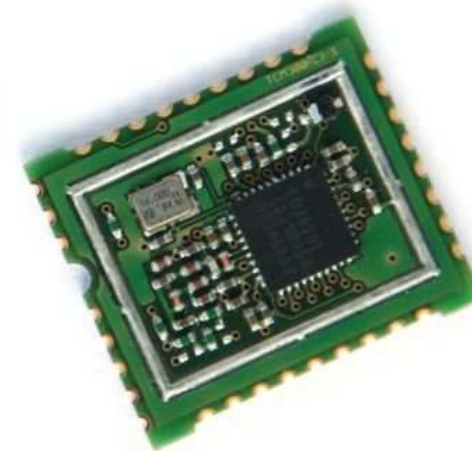
→ Radio Transceiver

- RF transceiver part with integrated state engines for the reception (RX) and transmission (TX) of radio telegrams
- EH optimized EnOcean radio protocol

The next Generation: SoC allows compact and low-cost WSN solutions

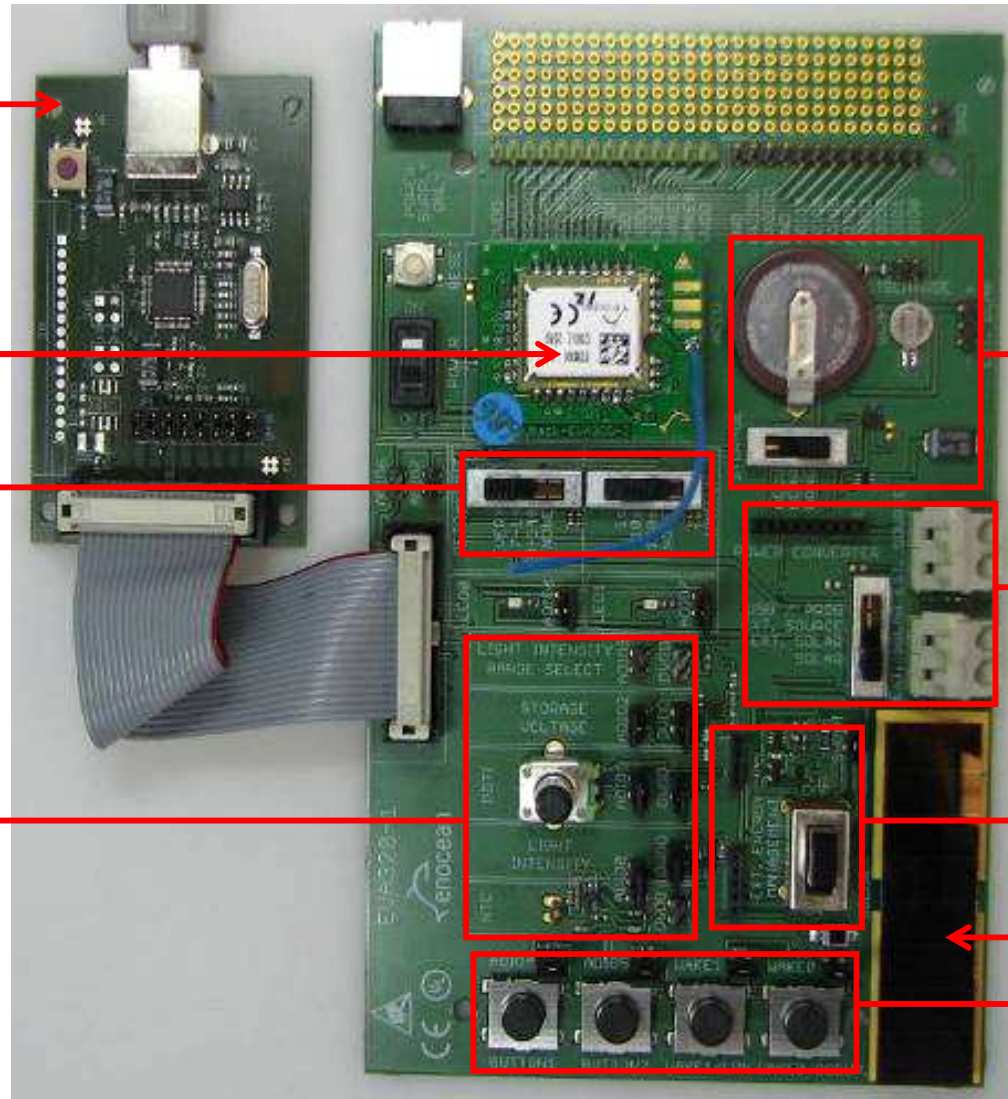


Generation 1 (2003):
Discrete components on both PCB sides,
42 x 24 x 5 mm, 5V, 33 mA



Generation 3 (2009):
SMD device,
22 x 19 x 3 mm, 2.5V, 30 mA

SoC Evaluation Board



Programmer

STM 300 on Adapter Board

Module firmware configuration

Sensor examples:

- Temperature
- Light intensity
- Poti
- Energy storage voltage

Multiple energy storage

Multiple energy harvesters

Energy source switch

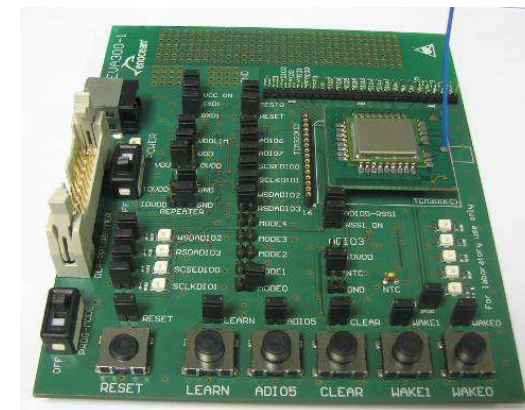
Solar cell
Buttons

Development Kit for Self-powered Devices



EDK 300 / 300C (EnOcean Dev Kit)

- Two plug&play transceiver modules with basic FW, no need for programming:
 - EDK300: TCM300 on piggyback + TCM310
 - EDK300C: TCM300C on piggyback + TCM320C
- Two evaluation boards for easy communication setup
- Self-powered switch (868 or 315 MHz)
- EPM 100 / 100C
- Programmer to load customer specific applications
- "Dolphin Studio" for easy chip configuration
- C source code of sample apps (e.g. light control, temperature sensor, etc.)
- Keil C-compiler & Keil Linker (Trial)



The EnOcean Standard



ENOCOAN ALLIANCE PROMOTER				
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www.masco.com	www.mkelectric.co.uk	www.omio.ch	www.thermokon.com	
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- ➔ > **350 Interoperable products**
- ➔ > **100,000 buildings deployed**
- ➔ **Award Winning Green Technology**
- ➔ **IEC Standardization**
- ➔ **THE ONLY WIRELESS STANDARD WITH ENERGY HARVESTING**