

## EnOcean – Dolphin Platform



### Introduction

Nowadays, the wireless sensor market is expanding rapidly and wireless sensor products are predominantly powered by disposable batteries to power the sensor, the on-board radio, etc. The lifetime of such is limited by the amount of energy that the batteries can store and thus, the batteries require continuous replacement to keep running, necessitating ongoing battery monitoring and maintenance. Recent progress in the development of energy harvesting technologies now permits sensors to be free from the constraints of operation from primary batteries. EnOcean is one of such self-powered wireless sensors (besides Ubiwave GreenPeak technologies), MicroStrain, Texas Instruments (TI), etc.

This article is aimed at giving an overview about the EnOcean wireless system concepts and about its new Dolphin platform. The first section gives a basic understanding of EnOcean, technical features, applications, etc. All of the remaining sections consist of the main elements of the latest Dolphin platform based modules; thereby describing technical advancements and software updates apart from the previous wireless modules. Since information about some of the previous modules will also be briefed further, there is no pre-requirement to refer about them.

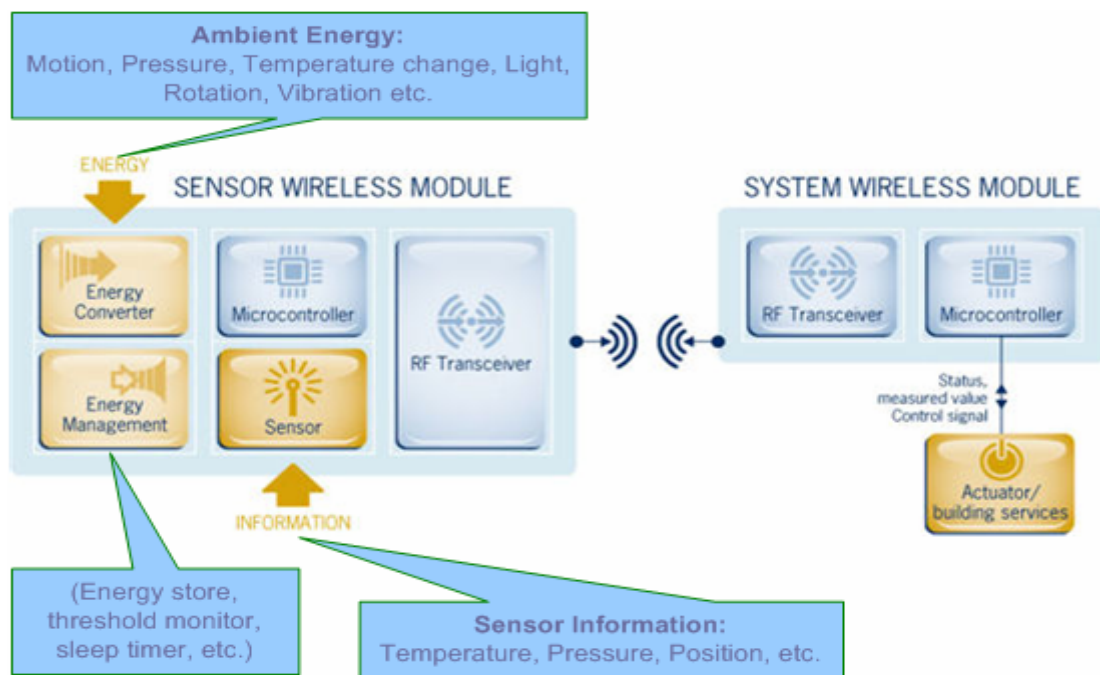
This article will give you some background knowledge about this technology trends, right from the start till date. Henceforth, no pre-knowledge about it is required for the reader to understand and target audience can be system architects, project managers, software developers and hardware engineers or any body who want to know about different energy harvesting wireless systems available in the market. The following entire description constitutes the information gathered from different articles, our comments and also from the meeting with EnOcean.

### EnOcean

Since 2001, EnOcean GmbH, headquartered in Oberhaching near Munich, has been developing wireless sensor modules based on its proprietary / patented EnOcean radio technology and is claiming to be commercially pioneering within the concept of energy scavenging. It targets mainly Building Automation market and offers energy-autonomous wireless system solutions, addressing the requirements of building automation applications.

To start with, devices that efficiently convert the smallest amounts of energy and make extremely economical use of energy drawn from the environment are the keys to what is

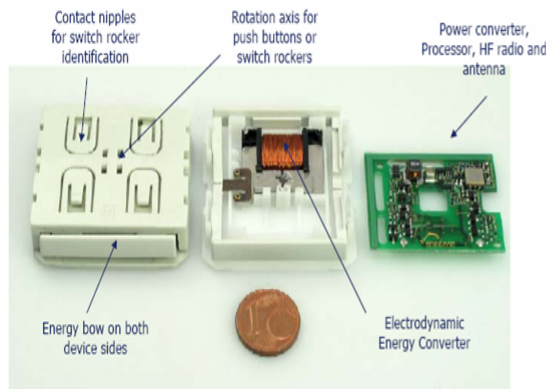
called Energy Harvesting. EnOcean combines this “Energy Harvesting” with “Wireless Technology” to offer a simple, self-powered wireless communication solution which can be easily installed and also maintenance-free. Unlike other radio technologies like ZigBee, Z-Wave, etc EnOcean sensors do not require any batteries for operation. The wireless modules basically scavenge minute amounts of energy from the environment around them, perhaps from a small temperature change, or the vibration of a movement, or the pressure of someone turning a switch, etc. Then, that energy is used to transmit very short, low energy radio signals containing data collected by the sensor. The result is that sensors do not need batteries and therefore do not need maintenance.



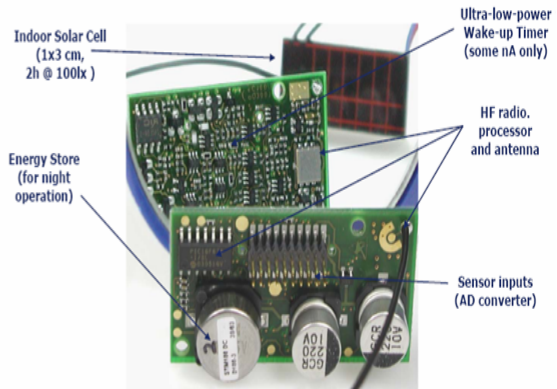
EnOcean’s first generation energy harvesting solutions are based upon linear motion or solar energy, then upon thermal energy and further down the road, they are even including rotation and vibration energy harvesters to open up new markets.

### Some examples

Switch on and off or dim a light with standard size light switch without any batteries nor any wires – utilizing merely the mechanical energy necessary to press the switch; as shown in the following figure. The mechanical energy used to move a window or door handle can be utilized to send a wireless signal to a security system or to control an HVAC unit for saving large amount of energy.



Maintenance free power supply via push-button



Maintenance free power supply via solar energy

## Basic features

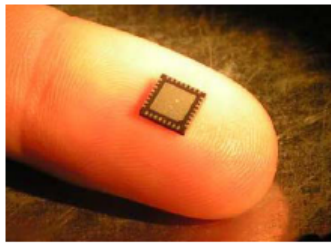
In general, EnOcean covers the two ISM frequency band frequencies 868.3 MHz and 315.0 MHz for worldwide license-free operation, using ASK (Amplitude shift keying) modulation, ranging up to 300m in the open space or 30m through walls and ceilings inside buildings, sending short wireless telegrams lasting approx 1.2 ms at a data rate of 125 kbit/s. The available radio modules do not appear to support security mechanisms. To foster interoperability of products from different OEMs, protocol uses unique 32 bits transmission ID (i.e. 4.2 billion combinations) which is observed to be not just enough and henceforth, EnOcean Alliance will focus on formalizing the specifications for the interoperability of the Sensor profiles.

## Interference

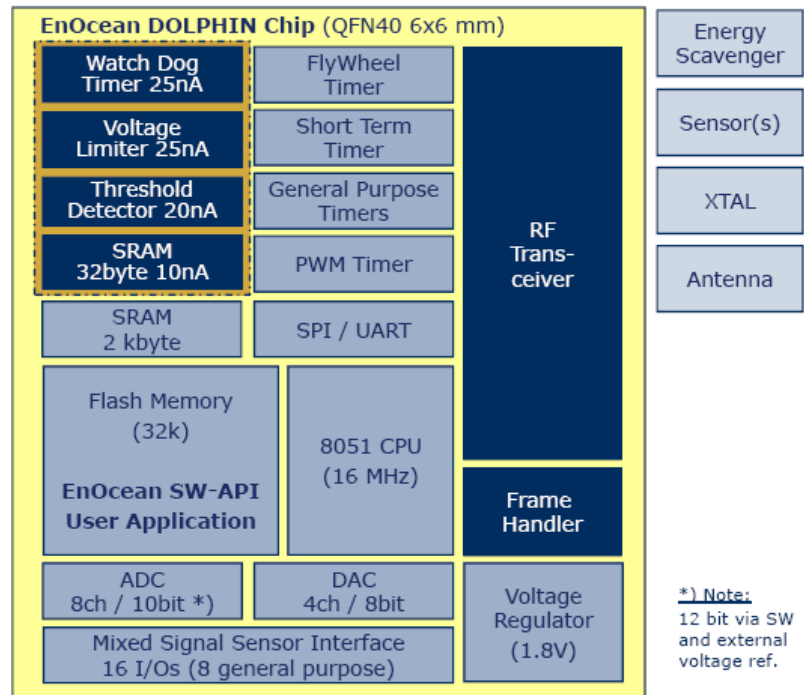
EnOcean advertises that it can co-exist with other wireless systems such as WLAN, DECT, Private Mobile Radio (PMR), etc due to No-Interference. Apparently these systems do not operate in the same band as EnOcean; so it's quite obvious not to have interference. But there are other technologies like Z-Wave (EU), ZigBee/802.15.4 (EU), and KNX RF which are evident to be mentioned; since they do support the same 868 MHz band and also target some similar applications in the Home & Building Automation industry, as EnOcean. Henceforth, it is quite evident to think about the possibility of interference under collocation of EnOcean with any of the above technologies, though it argues to have low statistical probability for collisions due to its short frame transmission duration (below 1ms).

On November 11, 2008, EnOcean has announced that availability of its first energy harvesting wireless sensor IC EO3000I specifically designed for its new Dolphin Platform for in-building control systems. It's system architecture is regarded as next generation EnOcean architecture and fully downward compatible with former unidirectional, self-powered wireless switches, sensors and actuators. With this, some optimization is observed apart from the forerunner or existing systems; i.e. for example power consumption has been reduced, measuring accuracy has been increased, there is now the possibility of bidirectional wireless data transmission with energy-autonomous wireless sensors and actuators devices, user-programmable software components, software functions such as SMART ACK (bidirectional wireless transmission) are effortlessly integrated as ready macros, transmission security and low power energy management in a single chip device.

## Energy Harvesting Single-chip IC



- Microprocessor, peripherals and Flash memory for application software
- Whole energy management for self-powered radio sensors (80nA Sleep Mode)
- Low-power supply (2.5V, 23mA Rx)



TCM300, STM300 series modules are the first set of Dolphin system architecture based modules; with System-on-Chip (SoC) IC EO3000I as its core comprising 16 MHz 8051 MCU, 32kB on-board Flash, 2kB RAM, 16 configurable I/Os, 10 bit ADC & 8 bit DAC and size of 6mm \* 6mm \* 1mm. EO3000I's RF transceiver is operating at the same 868, 315 MHz frequencies with programmable output power from -2 to +10 dBm / -95 dBm@10-3 BER and manageable to around 5 low power modes down to 80nA current consumption. The ASK transmission, bandwidth and data rates are in accordance with the EnOcean wireless standard. Only a few extra components, such as a crystal oscillator, an antenna and the energy supply, are necessary to form a complete, bidirectional wireless sensor system.

Compared to the TCM300's predecessor TCM 120, the standby power consumption is more than halved and it is user in-system programmable. It offers some built-in operating modes for switching and dimming. In addition, repeater functionality (1 or 2 level) can be activated. The STM 300 differs from the TCM 300 through its extensive energy management (threshold switch, voltage limiter, wakeup circuit) of miniature converters which harvest energy from differences in temperature, rotation, light or vibration; for energy autonomous wireless sensors / actuators. Both modules have options to select with either integrated antenna, connector (or) for automatic insertion and flexible connection of different antennas and SMT300 is giving Application note for different external energy storage mechanisms. From the market point of view, this IC based wireless sensor transceiver modules are expected to be available in Q2 2009.

## Bi-directional Communication

With the former (or present) EnOcean modules, it was only uni-directional transmissions and since it has no mechanism to exchange any acknowledgement of receipt, the sensor data telegram is transmitted three times in a short space of time. If this gets disturbed, it is transmitted with the next periodic update of the sensor, for example. EnOcean assumes to be

having reliability with these spontaneously transmitted unidirectional telegrams with redundant repetition. Even then, this unidirectional functionality is considered to be the major hindrance for some OEMs to opt for this wireless technology. Apparently it is quite obvious that, a wireless sensor that can both transmit & receive has better reliability than unidirectional multiple transmissions.

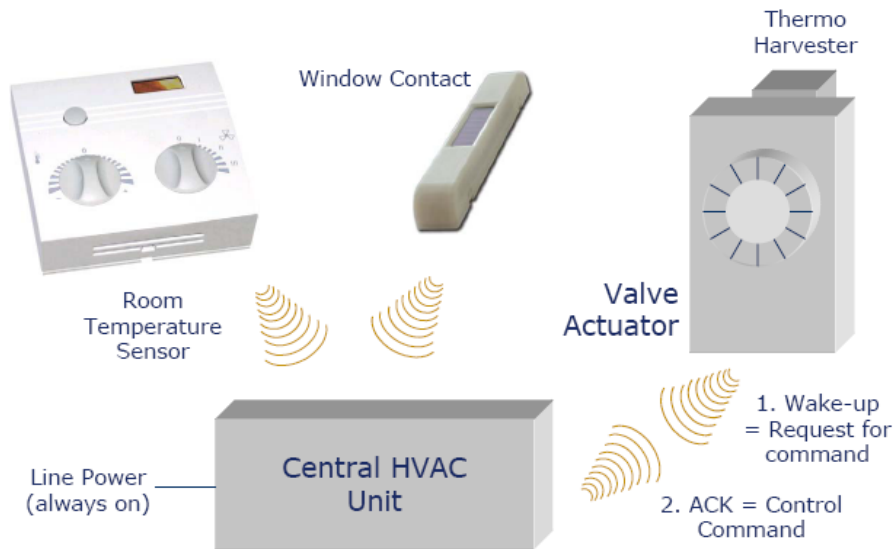
In addition, to solve some applications associated with sensors that require some form of check-back, there is a need of bi-directional functionality. To quote some example applications like: the state of a window may have to be indicated on a room sensor with some display, a hotel control centre or reception desk may want to reset a room sensor when a guest checks out, integration of a display with the sensor to show a centrally determined figure like current time, etc.

Answering to this EnOcean has introduced this “SMART ACK” principle supported by Dolphin platform based STM300, TCM300 transceiver modules. It is the key software library function that enables self-powered wireless sensors to work bi-directionally. In the same way as in unidirectional transmission, the wireless sensor sends its measured figures with as usual “three attempts rule”, which stop transmitting after three unsuccessful attempts. After any of the successful transmission, the sensor gets a signal back from the receiver to acknowledge reception. This return transmission also contains the data the sensor is expecting to receive. Hence, the reply is referred as a SMART ACK. Apparently, EnOcean has interpreted this principle with a quite fancy name, though it does almost the same as other short-range wireless protocols such as ZigBee, Z-Wave, 6LoWPAN, etc.

## Self-Powered Wireless Actuators

SMART ACK can also be used to enable remotely controlled actuators. Self powered actuators using energy-harvesting principles offer a solution to minimize energy consumption of the HVAC system in the energy efficient buildings. They can be used to control heating radiator valves, for example. They draw their energy from the difference in temperature between the heating and their surroundings through the use of Peltier-Seebeck effect. To ensure that the energy generated is sufficient to supply the valve-control motor as well as the electronic circuitry to receive the control signals and drive the motor, it operates on average for a short time.

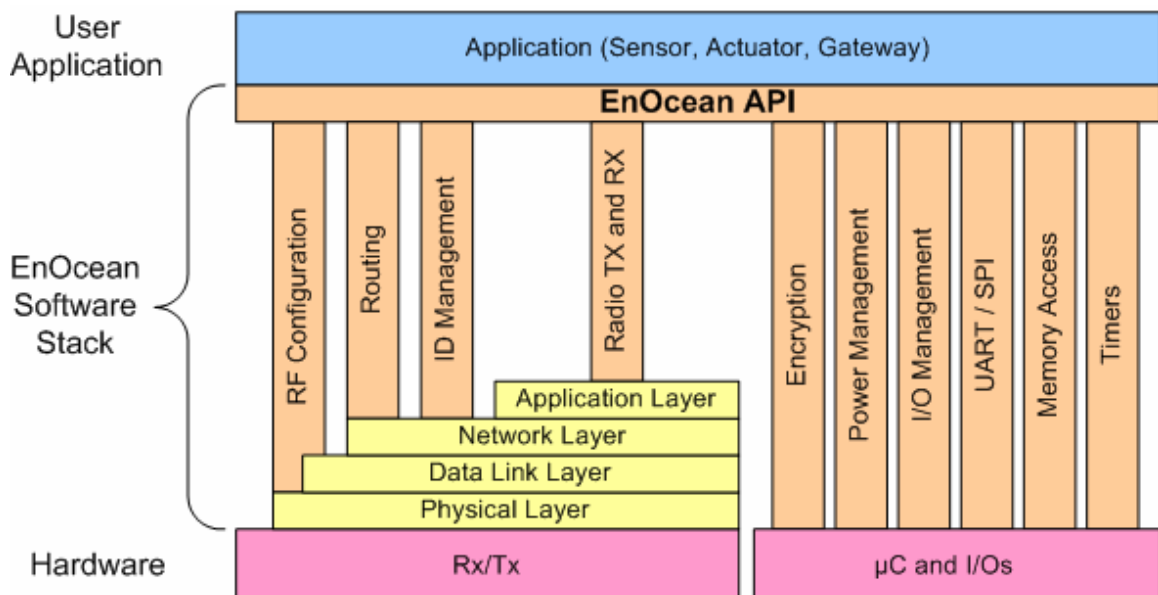
This is when the bidirectional Smart Acknowledge function comes in. SMART ACK allows return messages from self-powered EnOcean wireless sensors, so that the processor of an actuator can communicate bidirectionally with the central control point. The processor inquires of the central point through the wireless transmitted whether there is need for action, and receives a response in a precisely defined time interval. In this way actuator components with a high power requirement only operate on demand for a short time.



### Dolphin Application Programming Interface (API)

Until the introduction of this new API, there was no possibility to configure the EnOcean software stack of the earlier modules; though the software API provided for TCM 120 modules was quite limited supporting some basic functionalities. The New API allows for programming the Application-Specific software in the high-level C language. EnOcean is even providing the Dolphin Studio development environment as a development tool used together with API library files and Keil as a tool chain C-Compiler for generation of firm ware i.e. hex file. OEM's customized application software resulting in higher code sizes has to even consider purchasing full-version Keil C-Compiler.

This studio offers a simple graphical user interface (GUI) for EO3000I Configuration where one can just configure in it instead of hard coding in the source code, thus saving time and can be also used for flashing the generated firmware on the modules just like with other sources such as Keil IDE, EOP Command Line Application.



This API supports access to EnOcean protocol stack for RF Configuration, Routing, Network Management, transmission/reception of radio telegrams, SMART ACK, Encryption, UART/SPI, Energy Management for example, use of the digital or analog I/Os, access to flash memory & the continuously powered RAM0 and control of timer functions, etc.

## References

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