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Contents

Dear readers,

Welcome to the PCIM 2019 issue of eeNews Embedded, a quarterly publication dedicated to the growing community of "embedded" Engineers designing the electronics devices and services of the future. This issue has a focus on Power management and Energy Harvesting.

The publication is edited by a team composed of Ally Winning Editor in chief and Wisse Hettinga video Editor who will be at the show to create new video content such as interviews with companies and product introductions.

The editorial mix of eeNews-Embedded includes Embedded hardware and software, the latest developments in Artificial Intelligence, automotive and EV, avionics, IoT (Internet of Things) Industrial IoT, smart power, energy harvesting and conversion, medical electronics as well as electronics modules and board level computers.

eeNews-Embedded 's web site www.eeNewsEmbedded.com is a central point for the community of Embedded design engineers in Europe looking for Embedded design, software, Development tools and product information. The site is also the home for Wisse's famous comics characters Hmm and Aha whose intriguing discussions can be followed on the site: https://www.eenewsembedded.com/videos-hmm-aha

André Rousselot - Publisher

Magnetic Sensors in IoT d evices

Tim Resker, Business Development Manager, Coto Technology

Recent advances in wireless technology have resulted in low cost, low power, SoC's (System on a Chip) supporting a multitude of wireless protocols such as Bluetooth, Zigbee, Z-Wave and ANT+. With these SoC's, developers can design devices around the home, the business, the factory and the environment – as well as devices on or implanted in human and animal bodies – that can sense surroundings and communicate through the internet. Such devices are commonly known as IoT (Internet of Things) devices. Three types of magnetic sensors commonly used in such IoT devices are TMR (tunneling magnetoresistive) sensors, bare reed switches and Hall sensors. Device designers should understand their options when making a determination of which magnetic sensor to choose for their designs.

Magnetic sensors play an important role in IoT devices, so let's look at some examples. Proximity sensing is very common use for magnetic sensors. The classic example of that would be the window and door sensors commonly found in home security systems (Fig.1) The sensor mounts on the door or window jamb or casing and a magnetic is mounted on the door or window sash in close proximity to the sensor. When the door or window opens, the sensor detects the absence of the magnetic field and wirelessly communicates the status to the security system base station.

Magnetic sensors can also be used for counting rotations in wheels and meters. In a factory setting, a flow meter (Fig. 2) measuring flow of a liquid often utilizes a magnetic sensor to sense rotations of an impeller. On a bicycle, a magnetic sensor counts rotations of the wheel and crank shaft. Magnetic sensors can also be used to measure fluid level using a magnetic float and a series of sensors that can sense the float as it moves with the fluid level. All of these applications utilize a magnetic sensor on a fixed surface working in conjunction with a magnet on a nearby surface that moves relative to the sensor.

Often IoT devices require a mode selection dial or bezel that allows the user to manually select the appropriate mode or level setting. The traditional means of implementation is to use electromechanical contacts that open and close as the dial is rotated. However, electrical engineers have discovered over time that electromechanical contacts are prone to failure and can be replaced with a contactless design using magnetic sensors at each mode position and a magnet that rotates to activate the sensors.

Finally, an increasingly common magnetic sensor application is to trigger a "power on" function. Particularly for hermetically sealed, small battery operated, IoT devices, designers need a way to keep the device in a "power off" or "sleep" mode until it is ready to be deployed by the user. A good example of this would be a wearable continuous glucose meter used to measure and communicate body glucose levels to the patient, doctor and insulin pump (Fig.3). Mechanical switches and battery "tabs" can keep a device powered down but, unfortunately, they also leave the electronics of the device vulnerable to harsh environments. A preferable method is to use a magnetic sensor inside the sealed device coupled with a small magnet outside the device, usually embedded in the protective packaging of the device. This way, when the device is removed from the packaging, (and simultaneously away from the magnet's field) the sensor output changes and a circuit "turns on" the device. Not only does this method conserve battery power; it also provides an "instant on" or "out of the box experience" for the user.

Important considerations in all of these magnetic sensor functions include power consumption, sensitivity, output response options, size, reliability and cost. There are several common magnetic sensor options – each with its strengths and weaknesses with respect to IoT devices.

The simplest magnetic sensor, which also has been around the longest, is the venerable bare reed switch. A reed switch is an electro-mechanical device comprised of two ferrous metal "reeds" each attached to leads and encapsulated within a glass tube. A magnetic field pulls the two reeds together closing a circuit. Reed switches are commonly used in various IoT devices, most notably window and door sensors used in security systems, meters and implantable medical devices. The biggest advantage to reed switches is that they are passive devices that consume zero power. Reed switches also have the advantage of being simple and cheap with a limited range of sensitivity. However, reed switches have several significant limitations. One of the limitations of reed switches is size. The most common reed switch is 10mm in length - acceptable for some IoT devices, but not for many wearable and implantable devices that require a sensor size less than the 1mm square range. Smaller reed switches are available, (down to 5mm length) but they are very expensive and difficult to obtain. Reed switches can also have poor reliability due to their mechanical nature and inherent fragility of their glass tube design. Overmolded reed switches improve reliability by protecting the glass tube and the seals around the leads exiting the tube, but this adds to the cost – as well as the size.

Another magnetic sensor type that has stood the test of time is the Hall effect sensor. The Hall effect is the production of a voltage difference (the Hall voltage) across an electrical conductor, transverse to an electric current in the conductor and to an applied magnetic field perpendicular to the current. Being a solid state, CMOS technology, Hall effect sensors are small, reliable and low cost. The biggest disadvantage of Hall sensors is their current consumption. Most Hall effect sensors exceed several microAmps of current which is problematic for many battery operated IoT devices.

The last class of magnetic sensors is the magnetoresistive (MR) sensor. Based on the principle that a conductor's resistance will change in the presence of a magnetic field, different MR technologies have been developed as the basis for MR sensors. While all of these sensors offer the benefits of a solid state IC, small size, low cost and reliability, the tunneling magnetoresistive (TMR) sensors provide the combination of highest sensitivity and lowest power. With power consumption as low as sub-200nA, TMR sensors represent a paradigm shift for battery operated IoT devices requiring a magnetic sensor function. Additionally, TMR sensors are the most sensitive of all the MR sensors and are equivalent to the sensitivity of the most sensitive reed switch. A highly-sensitive sensor enables the use of smaller, cheaper magnets or longer activation distances.

	Reed Switch	Hall Effect Sensor	TMR Sensor
			
Technology	Mechanical	Electronic	Spintronic
Power Consumption (μA)	0	5~5000	0.1~1
Switching Frequency	Low	High	>300KHz
Reliability	Medium	High (Solid State)	High (Solid State)
Sensitivity (mV/V/Oe)	Medium	0.01	10
Size	Large	Small	Tiny
Noise Immunity	High	Low	High
Cost	Medium	Low	Low

Table 1: A comparison of notable features of Reed Switch, Hall Effect and TMR Sensors.

Table 1 summarizes the relative strengths and weaknesses of the reed switch, the Hall sensor and the TMR sensor. Across power consumption, switching frequency, reliability, sensitivity, size, noise immunity and cost, the TMR Sensor comes out on top over the other magnetic sensing technologies.

Once the best sensor technology for your needs is chosen there are still decisions to be made about which sensor output, sensor polarity response, sensing frequency and magnetic sensitivity is right for your application. And then there is the challenge of designing your magnetic subsystem. (determination of orientation of the sensor, placement of the magnet, and size and type of magnet to meet operating requirements and limit cost). Most electrical and mechanical product design engineers do not have the experience, knowledge, or tools to properly design and validate the magnetic sensing design. In this case, these IoT device designers should choose magnetic sensor suppliers who offer specialized application engineering support, knowledge and tools to help with the magnetic sensing design process.

The "Internet of Things" may be an industry buzzword, but it is a very real trend that is touching many different applications throughout our world. While magnetic sensors provide the technology to support life-changing devices within the IoT world, device designers must understand the benefits of the different types in order to choose the right solution for their design.

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Coupled inductors

Coupled inductors are fundamental components used extensively in electrical applications from power distribution to radio transmission equipment. Specifically, coupled inductors differ from transformers in that, coupled inductors store some energy that is later released as part of the topology operation. In contrast, transformers are designed to instantly transfer energy between the windings with ideally minimal losses. Using a coupled inductor instead of a two discrete inductors has the obvious advantage of reducing board space and mass. However, their use allows for a range of other advantages such as decreased ripple current, voltage transformation, modification of the impedance of a circuit and galvanic isolation. The list of SMPS applications that utilizes these properties is extensive but includes SEPIC (Single-Ended Primary-Inductor Converter) topologies, isolated topologies, multiphase topologies and specialized topologies that mitigate negative characteristics such as hard switching. This article aims to cover the basic concepts of coupled inductors before going into details of the advantages of coupled inductors in different applications.

Bascis of Coupled Inductors

Coupled inductors have two windings that share a single core. The inductance value of a single winding depends on the core material, the geometry of the core material, the number of turns and the winding type. The mutual inductance between the two windings can be expressed as:

$$M = \sqrt{L_1 \cdot L_2} \qquad [1]$$

Where M is the mutual inductance (H) and, L1 and L2 are the inductances of the primary and secondary winding respectively. However, this assumes there is perfect coupling between the windings with no leakage flux. In reality, there is always some leakage flux although some designs are extremely closely coupled. A number to express the coupling between the windings is the coupling coefficient k. It is represented by a number between zero and one, whereby k = 0 indicates there is no coupling and k = 1 meaning there is perfect coupling. This coefficient can be used to modify equation (2).

$$M = k\sqrt{L_1 \cdot L_2} \qquad [2]$$

In coupled inductors, there are two windings that share a single core and are therefore coupled together. We know this principle from the transformer and Fig. 2 illustrates the correlations.

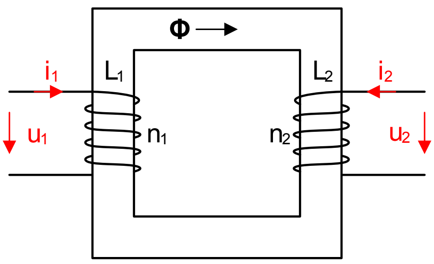


Fig. 1: Coupled inductors, two coils on one core

In figure 1 a current i1 in the inductor L1 causes via flux Φ a voltage u2 in the inductor L2 at the secondary side of the transformer. This effect is called mutual inductance and can be described by the following formula:

$$u_2 = M \cdot \frac{di_1}{dt} \qquad [3]$$

A transformer thus consists of two magnetically coupled inductors, the self-induction voltage and the mutual induction voltage. The voltages at the inductances can be described with:

$$u_1 = M \cdot \frac{di_2}{dt} + L_1 \cdot \frac{di_1}{dt} \qquad [4]$$

and

$$u_2 = M \cdot \frac{di_1}{dt} + L_2 \cdot \frac{di_2}{dt} \qquad [5]$$

Fig. 2 shows the corresponding circuit diagram.

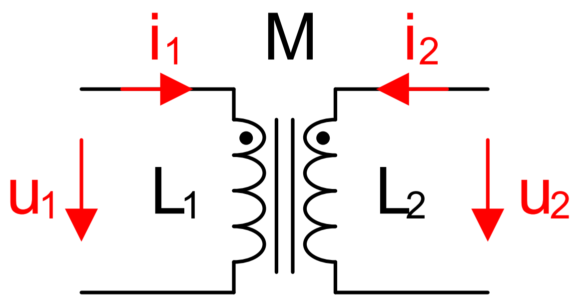


Fig. 2: Circuit diagram of the transformer or of the coupled inductance

The two dots in the circuit diagram indicate the winding direction. The ideal inductor has no losses and no stray field. No losses means, that there are no losses in the copper wire, in the ferrite core and in the insulation material, e.g. the wire resistance is 0 and the magnetic resistance of the ferrite core is 0 (u → ∞). In that case there is:

$$n_1 \cdot i_1 + n_2 \cdot i_2 = 0$$

Thus, the following relationship applies to the ideal transformer or coupled inductance:

$$-\frac{i_2}{i_1} = \frac{u_1}{u_2} = \frac{n_1}{n_2} = ü \qquad [6]$$

The corresponding circuit diagram of the ideal transformer or the ideal coupled inductance is shown in Fig. 3..

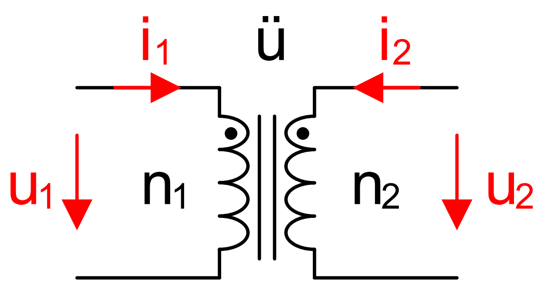


Fig. 3: Circuit diagram of the ideal transformer or the ideal coupled inductance

1.1.1 Parasitic Elements

There are a number of parasitic effects, which influence the behavior of coupled inductors. These parasitic effects are shown as components in the equivalent circuit diagram in Fig. 4.

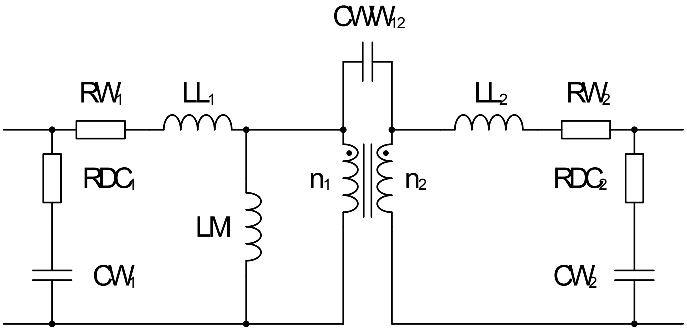


Fig. 4: Equivalent circuit diagram of the coupled inductance with parasitic components

The components in Fig. 4 represent the following effects:

- leakage inductance, LLx
- winding resistance, RWx

inter winding capacitance (capacitance between the windings), CWWxy

- turn to turn capacitance (capacitance within a winding), CWx with RDCx

One difficulty with the application of coupled inductances in SMPS is the handling of leakage flux energy caused by leakage inductances LLx. The result is a resonance between the parasitic capacitance and the parasitic inductance. The resonance causes high switching voltage peaks across the MOSFETs, which must be limited.

1.1.1.1 leakage inductance in coupled inductors

Looking at the two windings of the coupled inductance, the total amount of flux generated by one winding is not fully coupled to the second winding. Any magnetic flux component of the primary winding that is not coupled to the secondary winding acts as an inductive impedance in series with the primary winding. Therefore, this "leakage inductance" is shown in the equivalent circuit diagram in Fig. 4 as additional inductances LL1 and LL2. To illustrate the leakage effect, Fig. 5 shows the circuit diagram of a coupled inductance without losses, but with leakage inductances.

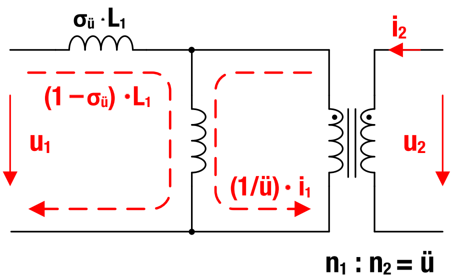


Fig. 5: Circuit diagram of a loss-free coupled inductance with leakage inductances

The leakage factor σü is a parameter for the part of the field that does not flow through both windings of the transformer. The leakage factor σü is described as follows:

$$0 \le \sigma_{ü} = 1 - \frac{M^2}{L_1 \cdot L_2} \le 1 \qquad [7]$$

σü = 0 means that there is no leakage inductance and in the case of σü = 1 that there is no coupling between the two windings of the transformer. The inductance σü L1 in the figure above is referred to as leakage inductance. (1 - σü) · L1 is the inductance that contributes to the desired function. The winding ratio is

$$ü = \sqrt{\frac{L_1}{L_2} \cdot (1 - \sigma_{ü})} \qquad [8]$$

From this, we can derive the mutual inductance, which is:

$$M = (1 - \sigma_{ü}) \cdot L_1 \cdot \frac{1}{ü} \qquad [9]$$

And the secondary inductance L2 which than is

$$L_2 = (1 - \sigma_{ü}) \cdot L_1 \cdot \frac{1}{ü^2} \qquad [10]$$

In order to understand how the leakage inductance can be minimized in practice, the parameters, which influence it, must be known. If a long cylindrical coil (figure 6) is considered, its inductance is produced by

$$L1 = \frac{\mu_0 \cdot N^2 \cdot A1}{l_W} \qquad [11]$$

where lW is the length of the coil.

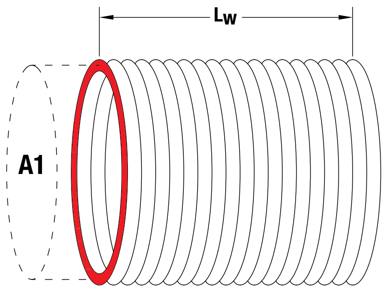


Figure 6: Long inductor (solenoid) with A1 the area and lw the length of the solenoid

If a second winding is now wound over the first one (figure 6), the second winding has the inductance L2 as illustrated in figure 7.

$$L_2 = \frac{\mu_0 \cdot N^2 \cdot A2}{l_W} \qquad [12]$$

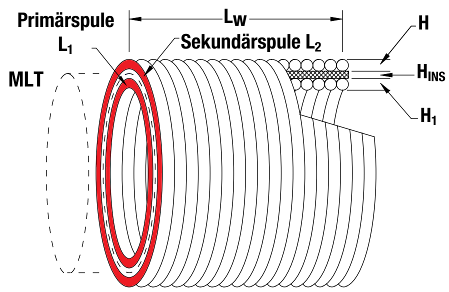


Figure 7: Long solenoid with a second winding added over the first one

where A1, A2 are the areas of each individual winding. The difference of the inductance between the two windings is

$$L_d = \frac{\mu_0 \cdot N^2 \cdot Ad}{l_W} \qquad [13]$$

The difference of the individual inductor area can be calculated using

$$Ad = MLT \cdot \left(H_{ins} + \frac{1}{3}H_1 + \frac{1}{3}H_2\right) \qquad [14]$$

where MLT is the average winding length, Hins is the distance between the windings (insulation) and; H1 and H2 are the thickness of windings 1 and 2 respectively.
The leakage inductance is thus independent of the core material and of any air gap in a core. Main influence factors for the stray inductance are the geometric differences of the two inductors. For the minimization of the leakage inductance of the coil in figure 7, either the length of the coil L1 must be increased, or the distance between the windings must be reduced thus the area A1 must be the same as area A2, which can be achieved by e.g. bifilar winding.
Figure 8 shows various possible winding configurations. For existing geometry, the most used means is a sandwich design (figure e), where the secondary winding is wound between the primary winding divided into two halves.

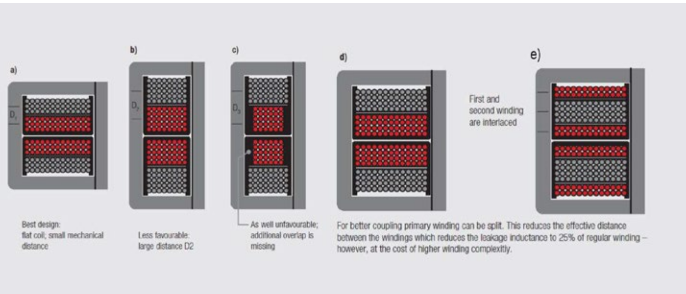


Figure 8: Different winding structures.

1.1.2 Turn to turn and inter winding capacitance

Fig. 5 shows the parasitic capacities. These include

- inter winding capacitance (capacitance between the windings)
- turn to turn capacitance (capacitance within a winding)

The coupling capacitance between the two windings can be imagined as a plate capacitor between the two windings and is called inter winding capacitance. This capacitance can be reduced by increasing the distance between winding layers, or by reducing the surface area of the windings. However, both measures directly result in increasing the leakage inductance. The turn-to-turn capacitance establishes itself turn by turn as these are insulated from each other and on a different potential. The more turns are required within a winding, the more it increases. It can be reduced by various winding techniques and partially by using of an isolation lack of the wire with a low dielectric constant.

Some samples of construction techniques are shown in figure 9.

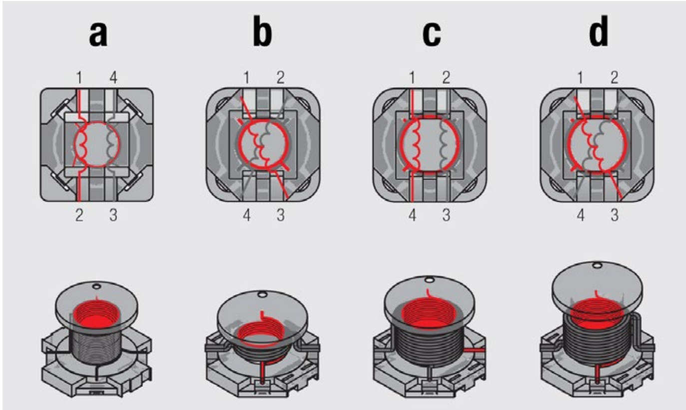


Fig. 9: Possible winding designs of coupled inductors, example Würth "WE-DD".

The bifilar wound inductors, shown in Figures 9a and 9c, do not have an exact 1:1 length and thus transmission ratio, since an additional 90 degree rotation (1/4 of a revolution) must be added to the connection pin for the connection. However, the bifilar winding provides a close mutual coupling between the windings, but has the disadvantage that the capacitances between the windings increase, resulting in a lower resonant frequency. The inductors with crossed windings (Figs. 9b and 9d) have separate layers for each winding package and thus an exact 1:1 winding ratio, which results in a lower leakage inductance. Due to the separate winding packages, the capacitance between the windings is lower, but the mutual coupling is also lower.
Fig. 10 shows some available coupled inductors from Würth Elektronik.

2. Coupled inductors from Würth Elektronik

Fig. 10: Coupled inductors with different designs from Würth Elektronik

The range of coupled inductors from Würth Elektronik extends from designs with excellent coupling factors to high-current or high-voltage series. These products have been carefully adapted to withstand high voltages over time by using Fully Insulated Wire (FIW) or Triple Insulated Wire (TIW) depending on insulation requirements. Versions with different transmission ratios and different wire structures are also available.

Small, high-performance PC for kiosk and desktop applications

Giada's BQ67 high-end fat client measures only 180 x 177mm but is a versatile PC with desktop CPU performance. The BQ67

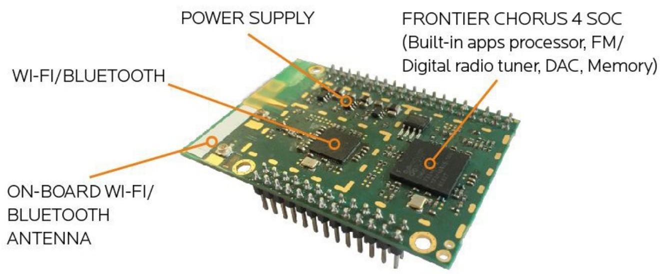
provides an LGA1151 Socket for Intel Core Skylake-S and Kabylake-S series CPUs in two variants featuring Intel's H110 and Q170 chipsets. The BQ67 Q170 chipset version offers three HDMI and 12 USB ports, while the H110 version supports two HDMI and 10 USB ports. The BQ67 is powered by Intel's 6th/7th desktop CPUs, with Intel integrated HD Graphics 520/620, up to 32 GB DDR3L memory, and a socket for a speedy M.2 SSD (in 2242/2280 formats). The high-performance BQ67 has a 2230 M.2 socket for WiFi and Bluetooth, Intel I219LM gigabit Ethernet, and a legacy RS232 serial port. The PC also includes audio input and output. It supports operating systems including Windows, 7, 8.1, and 10 (including 64-bit versions), as well as Linux.

Giadatech

www.giadatech.com/index/product/detail/aid/635.html

Internet connectivity, DAB / DAB+ and FM in one package

Frontier Smart Technologies' Chorus 4 is what the company claims to be the world's first integrated Smart Radio chip,



designed for a new generation of solutions for radios offering internet connectivity, DAB / DAB+ and FM. The first of these new solutions offered by Frontier , Venice X, is a cost-optimised, customisable turnkey system which enables brands and manufacturers to build high quality Smart Radios quickly and cost-effectively. The inclusion of DAB and FM ensures that the radio can operate even when there is no internet connectivity, for example outdoors, or if users want to use less power or data. Additional features include Bluetooth and full colour user displays. The Chorus 4 integrated SoC represents a distillation of Frontier's extensive experience in Smart Radio design and combines DAB+/FM radio tuners, an application processor and audio processing with integrated memory.

Frontier Smart Technologies

www.frontiersmart.com

MagnaChip looks to standardise HMI interfaces

OLED driver manufacturer MagnaChip Semiconductor announced it intends to develop individual strategic partnerships with leading manufacturers of touch, stylus, fingerprint technologies, and associated OLED display technologies to design innovative UI interfaces while enabling cost reduction synergies. Each of these companies will collaborate with MagnaChip to develop and standardize innovative human-interface solutions based upon smart touch, stylus and fingerprint technologies that are suitable for MagnaChip's industry leading OLED display driver integrated circuits (DDIC). The goal in each instance will be to improve the functionality of OLED displays on end user devices. MagnaChip also anticipates specific collaborations with shared intellectual property that will extend into new applications, for instance in the IoT and automotive sectors. More than a dozen smartphone OEMs currently use MagnaChip's OLED DDICs in their smartphone lineups and over the past 10 years, the company has shipped more than 400 million OLED DDICs and developed a broad portfolio of patents related to the design and manufacturing of OLED display drivers. "The series of strategic ecosystem partnerships will create a new de facto OLED display ecosystem that can help us better identify customer needs and develop best-in-class products," explained YJ Kim, Chief Executive Officer of MagnaChip. "Further, by working together, we can achieve innovative and high performance OLED platform solutions, shorten the OLED platform validation cycle, hence reduce "design-in" costs for smartphone and other mobile solutions." In this perspective, MagnaChip's first announced partner is Elan Microelectronics, a developer of smart Human Machine Interface (HMI) applications, including capacitive touchscreen controllers, capacitive trackpads, and fingerprint sensors. The two companies aim to bring Elan's stylus technologies to both rigid and flexible OLED displays. Currently, Elan supports pen protocols defined by Microsoft, Wacom, and Huawei and has enabled stylus features on smartphones, tablets, and Notebook PCs for Out-Cell, On-Cell and In-Cell LCDs. MagnaChip expects the collaboration with Elan to improve its OLED DDIC technologies for next-generation applications by supporting Elan's development of de facto industry standard stylus solutions optimized for its OLED display drivers.

MagnaChip Semiconductor

www.magnachip.com

Low-power silicon process enables intelligent energy harvesting applications

Graeme Clark, Principle Engineer, Renesas Electronics

People have dreamt for decades of developing intelligent devices that harvest the energy required for their operation from their immediate environment. However, until now, very few applications have managed to run reliably on the small amounts of energy that are typically harvested in this way.

The ability to create intelligent, communicating devices without wires or batteries – that are also effectively maintenance free and usable almost anywhere – would see the emergence of a completely new class of sensing devices. Until today, this idea was almost impossible to realise.

This is now about to change with a new generation of advanced, low power embedded controllers, based on Renesas' new Silicon on Thin Buried Oxide (SOTB) process technology. Devices based on the SOTB flash process exhibit significantly lower active and standby power consumption figures than those using traditional bulk silicon technology. SOTB allows the manufacture of low power devices that can have a higher level of CPU performance and larger on-chip memories as well as extremely low power consumption. This makes this process ideal for energy harvesting devices as well as any other product that demands low power consumption.

The first embedded controller to be implemented on this new process is the new Renesas R7F0E017 family. This device can achieve active power consumption of 20 µA / MHz with operation at up to 32 MHz and leakage current down to 150 nA in deep standby mode. These figures are unmatched for a device with 1.5 Mbytes of on-chip flash and 256 Kbytes of SRAM on-chip.

One of the huge breakthroughs in the development of this technology is the creation of a hybrid silicon structure, where we can combine the benefits of the new SOTB process and the existing standard bulk silicon technology on the same design. This means we can use the new SOTB technology in parts of the chip design where ultra-low power consumption is required. However, we can still use standard silicon for features such as the I/O ring and analogue components as well as the embedded Flash memory. As a result, the devices still have similar electrical characteristics to today's existing microcontrollers.

This diagram also shows some of the benefits of the SOTB gate structure. In a traditional bulk silicon gate design, we have to inject channel impurities or dopant atoms into the silicon

		Max. Frequency		Active Current		Standby Current	
		Higher	Lower	High	Low	High	Low
Conventional Technology	Larger Geometry		■	■			■
	Smaller Geometry	■			■	■	
SOTB Technology		■			■		■

Figure 1: Comparison of SOTB characteristics with other process geometries

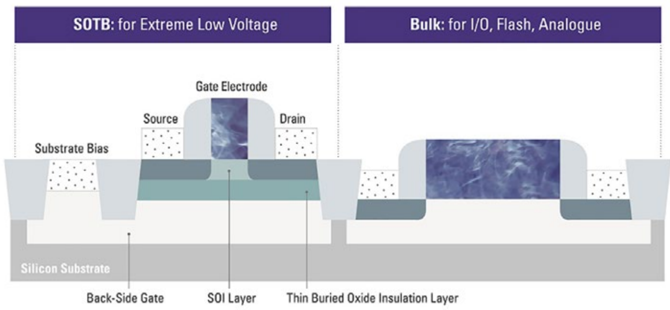


Figure 2: SOTB hybrid structure

during the manufacturing process. This enables the gate to conduct when required. The number of atoms injected into each gate is extremely hard to control accurately, so the gate characteristics are variable – especially with smaller silicon geometries when the number of atoms involved is very small. This means that there can be significant variability in the number of dopant atoms in each gate, which in turn results in significant variability in the switching characteristics of each gate within the device.

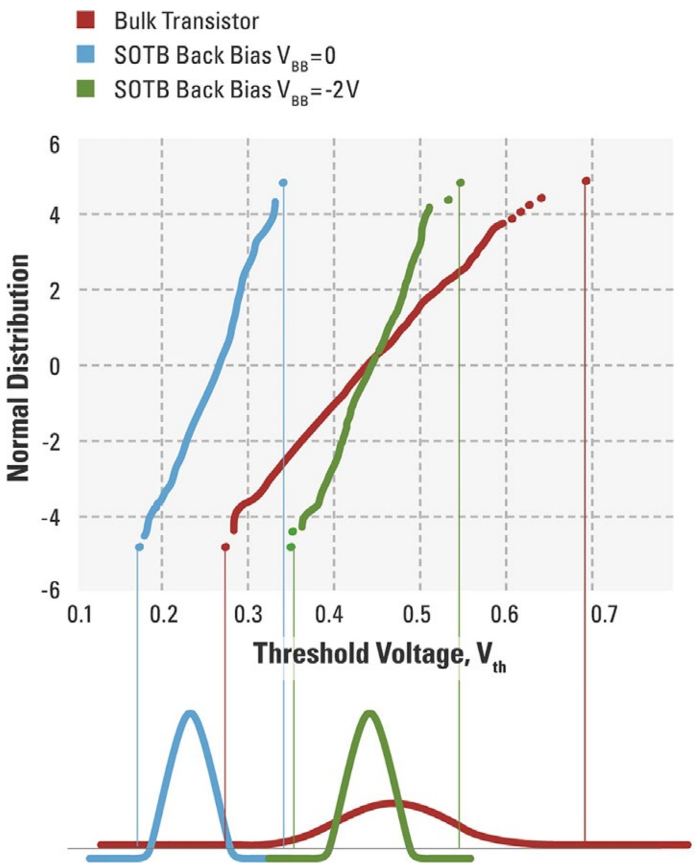


Figure 3: SOTB and standard process threshold comparison

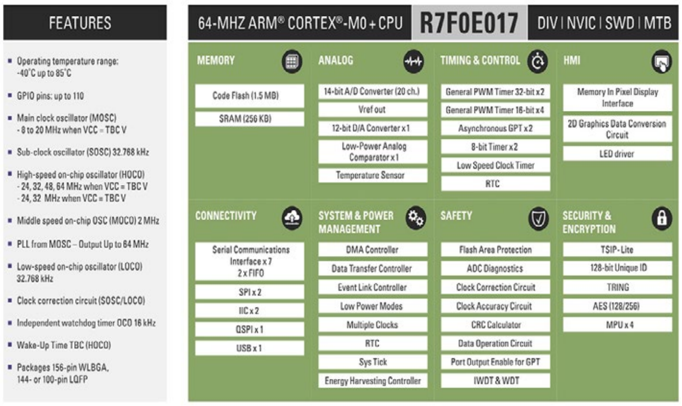


Figure 4: The first microcontroller using the SOTB process

The SOTB gate is a dopantless channel design and its characteristics are controlled by the extremely thin isolation layer within the gate. Using modern process technology, this is well controlled and therefore highly repeatable across the device. The variation between each gate is much lower than with the traditional bulk silicon gate design. As will be seen in a moment, this reduction in the variation between gates on a SOTB device allows us to greatly reduce the operating voltage and hence the energy used to switch the gate.

Figure 3 shows another benefit of the SOTB technology. We have the ability to apply a negative back bias voltage to each gate, allowing us to manipulate the switching thresholds of each gate on the device, either individually or across the entire device.

Figure 3 shows a comparison between an SOTB device and one made on a standard bulk silicon process. The red line shows the range of switching characteristics for a typical device implemented on a bulk silicon process. It illustrates the variation in switching thresholds between the 1 million individual transistors on the test device. It is clear from the diagram that the best gates will switch at around 0.3v, while the worst gates will switch at around 0.7v due to the inherent variability of the process. To guarantee the operation of every gate on the device, we have to operate at voltages significantly above 1.0v. And that will naturally have a direct impact on the power consumed by the device.

The blue line in Figure 3 shows the characteristics of the SOTB gate as well as the huge reduction in variability and the narrow range of switching characteristics that can be achieved with this process. With devices based on the SOTB process, we can safely run at much lower voltages and guarantee that every gate will operate correctly, resulting in a huge reduction in active power consumption.

The green line in Figure 3 shows the result of the back bias being applied. Here, we can put individual gates into an extremely low leakage state for part or all of the device, which greatly reduces standby current.

Renesas has now finished development of the first microcontroller using the SOTB process. The use of the SOTB process allows us to produce a device with a unique combination of performance, integration and low power consumption. The first device combines a Cortex M0+ core running at up to 64 MHz with a high level of peripheral integration, up to 1.5 Mbytes of flash and 256 Kbytes of on-chip SRAM. Figure 4 shows a block diagram of this device.

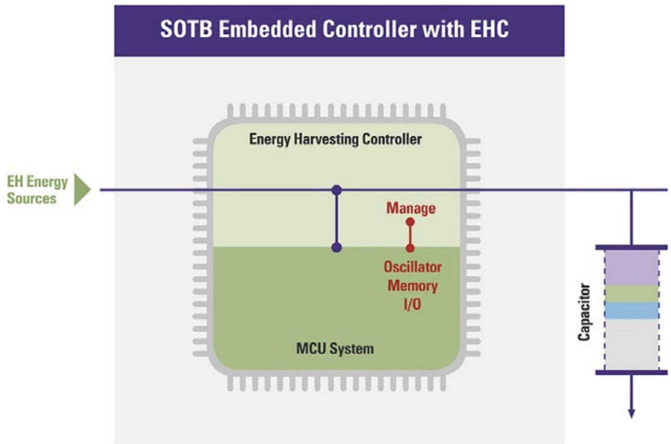


Figure 5: The energy harvesting controller

One of the purposes of this new device is to enable operation using energy harvested from the environment. This is why the R7F0E017 implements a unique energy harvesting controller (EHC) that allows energy to be harvested from a wide range of different renewable energy sources, while enabling the device to automatically control an external rechargeable battery or super capacitor. The EHC can also supply power to external devices, such as radios and sensors, so that they can also operate from harvested energy.

One of the biggest problems with any embedded device in energy harvesting applications is the “inrush” current. This is the current that the device requires when it is initially switched on and is typically quite large. The risk here is that it swamps most of the power sources typically used for energy harvesting, causing the device to operate incorrectly. The EHC is designed specifically to avoid this issue. It manages the small amounts of energy available to enable the safe and reliable start-up of the microcontroller from low energy power sources supplying as little as 5 µA of current. This means that, for almost the first time, real energy harvesting applications are within reach.

With the correct power dimensioning circuitry, the energy harvesting controller enables these devices to operate with a wide range of power sources including solar cells, vibration harvesters, thermal harvesters and many more.

The development of the Silicon on Thin Buried Oxide technology will enable a new range of intelligent, communicating devices that can operate without batteries or external power, by simply harvesting their energy from the environment.

Samples of the R7F0E017 with the integrated energy harvesting controller, along with a complete suite of development tools, will be available to beta customers in early 2019 with general samples available in the second half of 2019.
www.renesas.com/SOTB

Tiny certified sub-GHz module enables proprietary networks for enhanced security

Microchip has launched the industry's smallest IEEE 802.15.4-compliant module, which measures 12.7 x 11 mm and combines an ultra-low-power MCU with a sub-GHz radio. Based on IEEE 802.15.4, the SAM R30 module allows proprietary networks that can be easily customised and configured. This is ideal for applications where interoperability is not desired due to their inherent vulnerability to remote attacks. IEEE 802.15.4-based network devices can sleep for extended periods of time and still remain part of the network. The SAM R30 module features ultra-low-power sleep modes, with wake from GPIO or its built-in RTC while consuming approximately 800 nA. The SAM R30 module eliminates the need for a separate MCU in the design. The device also offers up to 256 KByte Flash and 40 KByte RAM, as well as serial data interfaces, USB, and digital and analogue I/O for advanced sensor development. Due to its operation in the sub-GHz RF spectrum, the SAM R30 module offers double the connectivity range and better penetration of walls and floors than similarly powered devices using the 2.4 GHz frequency band. The SAM R30 module is certified with the FCC, Industry Canada (IC) and Radio Equipment Directive (RED), reducing time to market and RF testing certification costs. Microchip also provides the free MiWi protocol stack to allow the easy implementation of proprietary point-to-point, star or self-healing mesh networks. Developers can select a single-chip 32- or 48-pin SAM R30 System-in-Package (SiP) for flexible design layout or the certified SAM R30 module for fastest time to market. To help development, the ATSAMR30M-XPRO Extension Development Board is supported by the Atmel ICE Debugger/Programmer (ATMEL-ICE) and the Atmel Studio 7 IDE with demo code examples supporting each network configuration.

Microchip
www.microchip.com

Cypress Low-Power Bluetooth MCUs

Deliver Mesh Networking with Smartphone Connectivity. Cypress Semiconductor announced it is sampling two low-power, dual-mode Bluetooth® 5.0 and Bluetooth Low Energy (BLE) microcontrollers (MCUs) that include support for Bluetooth mesh networking for the Internet of Things (IoT). The new CYW20819 and CYW20820 MCUs each provide simultaneous Bluetooth 5.0 audio and BLE connections, delivering low-power wireless solutions that enable music and voice commands for battery-powered fitness bands, health monitoring devices, and voice remotes. Designers can also use the solutions to develop low-cost, low-power Bluetooth mesh network devices that can communicate with each other—and with smartphones, tablets and voice-controlled home assistants—via simple, ubiquitous, and hub-free Bluetooth connectivity. Previously, users needed to be in the immediate vicinity of a Bluetooth device to control it without an added hub. Using Bluetooth mesh networking technology, combined with the high-performance integrated PA in the CYW20820, the devices within a network can communicate with each other to easily provide coverage throughout even the largest homes, allowing users to conveniently control all of the devices via apps on their smartphones, tablets, and smart-speakers. The CYW20819 and CYW20820 MCUs are supported by Cypress' ModusToolbox™ development tools, which provide sample code and applications for Bluetooth mesh and sensor kits. Cypress also offers the CYW20719, CYW20706, and CYW20735 BLE solutions and the CYW43438 and CYW43570 Wi-Fi® and Bluetooth combo solutions, delivering fully compliant Bluetooth mesh for devices and Wi-Fi connected smart homes. More information on Cypress' Bluetooth mesh solutions is available at www.cypress.com/ble-mesh.

Cypress Semiconductor
www.cypress.com/ble-mesh.

Low-power LoRa solution now available at Mouser

Mouser is now stocking Microchip's SAM R34 LoRa Sub-GHz SiP, which provides low-power performance and integrates a 32-bit MCU, software stack, and sub-GHz LoRa transceiver in a 6 mm × 6 mm package.
The Microchip SAM R34 feature a Microchip SAM L21 MCU based on the 32-bit Arm Cortex-M0+ core with up to 256 Kbytes Flash and 40 Kbytes RAM. The UHF transceiver supports LoRa and FSK modulation and covers frequencies from 137 MHz to 1020 MHz with maximum transmit power up to +20 dBm without external amplification. The SAM R34 family uses Microchip's LoRaWAN protocol stack and supports Class A and Class C end devices, as well as proprietary point-to-point connections. The SiPs offer sleep modes as low as 790 nA. They include a USB interface for USB dongle applications or software updates. Mouser will also sell the SAM R34 Xplained Pro evaluation kit, supported by Atmel Studio 7. The kit includes reference designs and software examples. It is certified with the Federal Communications Commission (FCC), Industry Canada (IC), and Radio Equipment Directive (RED).

Mouser
www.mouser.com/microchip-sam-r34

Multiple source energy harvesting in the Internet of Things

Mark Patrick, Mouser Electronics

Collecting energy from solar, vibration and wireless signals can be used to extend battery life for remotely deployed or portable IoT sensors. Reducing the need for frequent battery replacement 'truck rolls' than can represent a significant cost in deployments in the industrial Internet of Thing (IIoT).

As strange as it may seem, batteries are not that popular in the Internet of Things. Yes, they allow sensors and wireless nodes to be placed in many more locations around the home, office or factory without having to worry about power lines or power sockets, but this convenience is their drawback. As billions of nodes are added to the industrial Internet of Things (IIoT), connecting up all kinds of equipment, so the challenge of replacing those batteries becomes an expensive reality. Replacing hundreds of thousands of batteries around a manufacturing site could well be a full time job for several people, costly in both employee time and the batteries themselves. The aim is to have these nodes in as many places as possible to be able to monitor the activity in the warehouse or on the factory floor to make operations more efficient.

Source	Source Power	Harvested Power
Light		
Indoor	0.1 mW/cm²	10 μW/cm²
Outdoor	100 mW/cm²	10 mW/cm²
Vibration/Motion		
Human	0.5m at 1 Hz	
	1m/s² at 50 Hz	4 μW/cm²
Machine	1m at 5 Hz	
	10m/s² at 1 kHz	100 μW/cm²
Thermal		
Human	20 mW/cm²	30 μW/cm²
Machine	100 mW/cm²	1-10 mW/cm²
RF		
GSM BSS	0.3 μW/cm²	0.1 μW/cm²

Table 1: The power available from different types of energy harvesting.

So designers are looking at ways to pull energy from the environment to power these nodes. This energy can be used to power the nodes directly without a battery at all, but in many situations the energy harvesting is used to charge a battery or supercapacitor, extending the lifetime of a battery from a year or so to over a decade and dramatically cutting the cost of maintenance and replacement.

This move to energy harvesting is helped by the lower power consumption of the latest microcontrollers, sensors and wireless transceivers, but the designers face some significant challenges when dealing with the fluctuating power coming from a wide range of these sources.

Some of these sources are obvious. Small solar panels have been used for years to power LED lights and calculators, but more efficient solar cells that work under fluorescent lights in factories are being coupled with power management devices

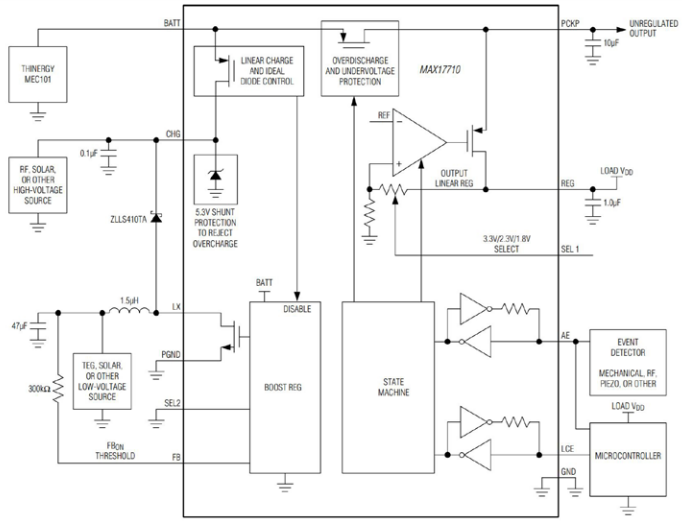


Figure 1: The MAX17710 is a complete system for charging a cell from a range of energy harvesting sources.

that can handle the peaks and troughs demanded by a wireless transceiver.

Other techniques for harvesting energy, particularly in the factory, include tapping the difference in heat with thermoelectric generators (TEG) and the vibration of machines with piezoelectric devices. Both of these approaches can now produce enough energy to send through regular updates on the health of a machine or the activity of a system and highlighting any potential problems early.

A TEG consists of an array of thermocouples connected together in series, with one side on a hot surface and the other on a cold one. The temperature difference, whether in an industrial heating system or even on the heatsink of control electronics, can be used to recycle energy that would otherwise be lost as heat. For example, the latest thermal energy harvesting modules running at 50°C can deliver over 6mAh, the equivalent of three to four AA batteries. It is now even possible to tap into the radio energy that surrounds us. RF energy harvesting, particularly at the frequencies used by WiFi or GSM mobile phones, can provide up to 50mA to charge up a battery and send signals.

The big challenge however is to be able to use the wide range of energy harvesting approaches with a single power management front end, rather than have to design a separate sub-system for the different power sources.

The MAX17710 from Maxim Integrated Products for example is a complete system for charging and protecting micropower-storage cells. The key capability is that the chip can manage poorly regulated sources such as energy harvesting devices with output levels ranging from 1fW to 100mW. The device also includes a boost regulator circuit for charging the cell from a source as low as 0.75V (typ). An internal regulator protects the cell from overcharging and output voltages supplied to the target applications are regulated using a low-dropout (LDO) linear regulator with selectable voltages of 3.3V, 2.3V, or 1.8V. The output regulator operates in a selectable low-power or ultra-low-power mode to minimize drain of the cell. Internal voltage protection prevents the cell from overdischarging.

A key way to achieve this is for the charging and regulation functions to operate completely independently of one another. Initial power-up of the device occurs when a cell is connected to the battery pin (BATT), pulling just 1nA from the cell with the LDO functions disabled. Once the energy harvesting source is up and running and the voltage on the charge (CHG) pin rises above 4.15V (VCE), the device initialises and allows discharging. It then charges the cell from the external energy source connected to the CHG pin. Whenever the voltage on CHG is greater than the voltage on BATT, the energy-harvesting circuit directly passes current to the cell without any interaction from the device. When CHG rises above VCE, the input linear regulator turns on to limit the charging voltage to 4.125V and protects the cell from overcharge.

Size is also important as these nodes have to fit into as small a footprint as possible, so the chip is available in an ultra-thin, 3mm x 3mm x 0.5mm 12-pin UTDFN package.

Similarly the bq25570 from Texas Instruments is specifically designed to efficiently extract microwatts to milliwatts of power from high output impedance sources such as solar cells or TEGs without the voltage collapsing. The battery management features ensure that a rechargeable battery is not overcharged by this extracted power, with voltage boosted, or depleted beyond safe limits by a system load. In addition to the highly efficient boosting charger, the bq25570 integrates a highly efficient, nanopower buck converter for providing a second power rail to systems such as wireless sensor networks (WSN) which are an essential element in the IoT and have stringent power demands, delivering a peak output of 110mA. The device is packaged in a small foot-print 20-lead 3.5-mm x 3.5-mm QFN package.

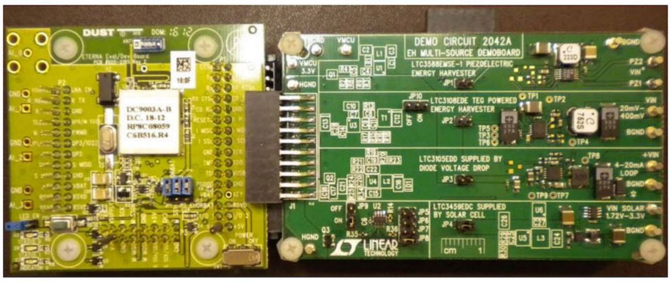


Figure 2: The DC2042A demo board combines power managers for all kinds of energy harvesting and connects to ultra low power wireless boards.

Analog Devices Inc (ADI), through its Linear Technology business, is demonstrating ways to capture energy from all these different sources in one board. The DC2042A demo board accepts inputs from piezoelectric, solar, 4mA to 20mAloops, thermal-powered energy sources or any high impedance AC or DC source. The board contains four independent circuits using the LTC3588-1 piezoelectric power supply linked to the LTC3108 ultralow voltage Step-Up converter and power manager and the LTC31: Step-Up DC-DC converter with power point control and LDO regulator. The power point controller tracks the optimum voltage at which to make the conversion, particularly for solar cells. Alongside these on the board is the LTC3459 10V micropower synchronous boost converter and the LTC2935-2/LTC2935-4 ultralow power supervisor to manage the whole design.

Capturing the energy is only part of the story of course, and the output of the board can be used to power ultra low power wireless board such as the Dust DC9003A-BMote or the Microchip STK development kit. This allows designers to fully test out the nodes they want to use for the Industrial Internet of Things with a wide range of energy harvesting sources. This allows the nodes to be used in as many places as possible without having to regularly replace the batteries, providing all the benefits of the IIoT without the drawbacks.
www.mouser.com

Buildings consume less power with energy harvesting

Tony Armstrong, Business Development Director, Analog Devices Inc.

In todays "green" environmentally friendly on-the-planet mindset, constructing smart buildings that will conserve energy; encompassing both commercial and residential structures; is a necessary pre-requisite to ensure energy efficient structures.

Specifically, for commercial buildings, making them smart can be critical for the organization that is housed in them, since having a building that is energy efficient and streamlined reduces energy costs and provides a productive environment for the workers within them. However, to get there, these buildings will require an infrastructure that can provide the necessary feedback to enable efficient operation of heating and cooling systems, lighting control and efficient space utilization. This will necessitate the use of the Internet of things (IoT) as a methodology to monitor and control the environment to effectively manage and control these elaborate buildings.

Smart buildings will continuously transform how people carry out their activities on daily basis. Furthermore, along with conserving energy, smart buildings will help save money. Some of the biggest IoT smart building trends to shape this transition include the following:

A) Predictive maintenance will make use of sensors (IoT) and other hardware devices to get a report on the state of a commercial building and all equipment in it. This feedback will enable the timing of any necessary maintenance when it is actually needed, in a timely and effective manner. Since unforeseen issues that usually crop up with a preventive maintenance schedule can be overcome by using a predictive maintenance approach.

B) Worker productivity can be adversely affected by air quality. Industry research in this area has shown that workers are 10 percent more efficient in their duty when they work from buildings with good indoor environmental quality than the conventional buildings. Again, IoT devices can be used to measure and check the air quality, as well as carbon dioxide levels in the air using various sensors that are part of a mesh network. These devices are connected to all areas of the building infrastructure, thereby enabling a way to keep the environment and everyone in it healthy and productive.

C) A new trend that is expected going forward, is the use of IoT supported applications in smart buildings. A good example is the use of thermal imaging will allow facility managers to check for equipment that are outside of the temperature range. These can be easily detected, and maintenance can be done before the equipment disrupts the system.

D) IoT will transform the way commercial facility managers can track information, measure and collect data; including inaccessible areas that were previously too hard to get to. Install sensors in various parts of the building will track all information that they never had access to in the past. By using IoT interconnected systems, facility managers will now have access to all pertinent information using these systems.

E) IoT also makes it possible for commercial owners to have buildings that are energy sufficient. It also influences the design of the buildings and allows them to be eco-friendly and resource efficient. Moreover, these intelligent building management systems can be remotely managed from anywhere.

F) IoT also makes it possible to replace outdated heavy construction equipment with sensors that can be controlled using indicators like vibrations and temperature fluctuations. Thus, saving a lot of energy, money reduces the maintenance cost.

G) One of the most important impact that IoT can have on buildings is energy efficiency. Sensor networks help to provide information that helps managers to control their assets better while also reducing harmful waste in the environment. Examples are:

1) Using sensors for temperature control
2) Using actuators for HVAC controls
3) Complex applications like providing complete energy automation for a building
4) Considers weather forecasts to save real-time energy costs

Energy Harvesting

The concept of energy harvesting has been around for over a decade; however, the implementation of ambient energy-powered systems in the real-world environment has been cumbersome, complex and costly. Nevertheless, examples of markets where an energy harvesting approach has been used successfully include transportation infrastructure, wireless medical devices, tire pressure sensing, and building automation. Specifically, in the case of building automation systems, such things as occupancy sensors, thermostats and even light switches have eliminated the power or control wiring normally associated with their installation and used localized energy harvesting systems instead.

A key application of energy harvesting systems is radio sensors in building automation systems. In the United States, buildings are the number one user of energy production on an annual, closely followed by the transportation and industrial segments.

A wireless network utilizing an energy harvesting technique can link any number of sensors together in a building to reduce HVAC and electricity costs by adjusting the temperature or turning off lights to non-essential areas when the building or rooms within are unoccupied. Furthermore, the cost of energy harvesting electronics is often lower than running supply wires, or the routine maintenance required to replace batteries, so there is clearly an economic gain to be had by adopting a harvested power technique.

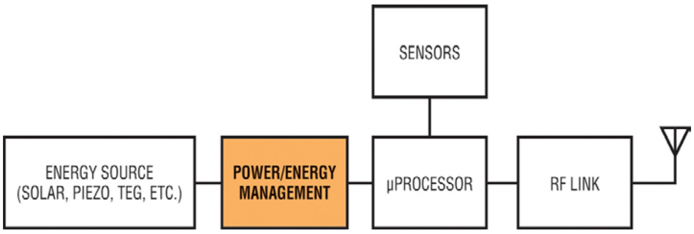


Figure 1. The main blocks of a typical energy harvesting system.

Nevertheless, many of the advantages of a wireless sensor network disappear if each node requires its own external power source. Despite the fact that ongoing power management developments have enabled electronic circuits to operate longer for a given power supply, this has its limitations, and power energy harvesting provides a complementary approach. Thus, energy harvesting is a means of powering wireless sensors nodes by converting local ambient energy into useable electrical energy. Ambient energy sources include light, heat differentials, mechanical vibration, transmitted RF signals or any source that can produce an electrical charge through a transducer. These energy sources are all around us and they can be converted into an electrical energy by using a suitable transducer, such as a thermoelectric generator (TEG) for temperature differential, a piezoelectric element for vibration, a photovoltaic cell for sunlight (or indoor lighting) and even galvanic energy from moisture. These so called "free" energy sources can be used to autonomously power electronic components and systems.

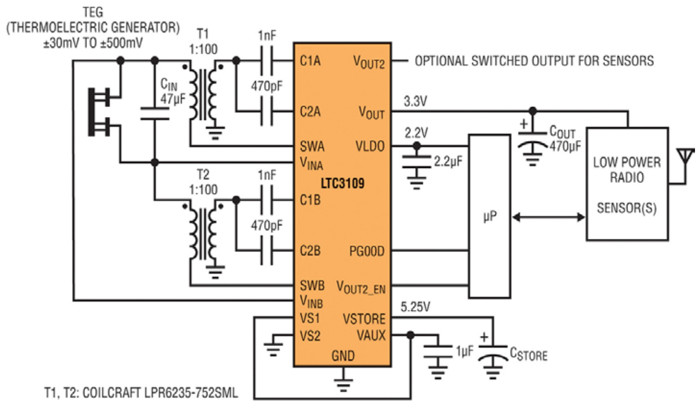


Figure 2. LTC3109 Typical application schematic.

With entire wireless sensor nodes now capable of operating at microwatt average power levels, it is feasible to power them from non-traditional sources. This has led to energy harvesting, which provides the power to charge, supplement or replace batteries in systems where battery use is inconvenient, impractical, expensive or dangerous. It can also eliminate the need for wires to carry power or to transmit data.

A typical energy harvesting configuration or wireless sensor node (WSN) is comprised of four blocks, as illustrated in Figure 1. These are: 1) an ambient energy source, 2) a transducer element and a power conversion circuit to power downstream electronics, 3) a sensing component that links the node to the physical world and a computing component consisting of a microprocessor or microcontroller that processes measurement data and stores them in memory, and 4) a communication component consisting of a short range radio for wireless communication with neighboring nodes and the outside world.

Examples of ambient energy sources include a thermoelectric generator (TEG) or thermopile attached to a heat-generating source such as a HVAC duct, or a piezoelectric transducer attached to a vibrating mechanical source such as a windowpane. In the case of a heat source, a compact thermoelectric device (commonly referred to as a transducer) can convert small temperature differences into electrical energy. And in the case where there are mechanical vibrations or strain, a piezoelectric device can be used to convert these into electrical energy.

Once the electrical energy has been produced, it can then be converted by an energy harvesting circuit and modified into a suitable form to power the downstream electronics. Thus, a microprocessor can wake up a sensor to take a reading or measurement, which can then be manipulated by an analog-to-digital converter for transmission via an ultralow power wireless transceiver.

Of course, the energy provided by the energy harvesting source depends on how long the source is in operation. Therefore, the primary metric for comparison of scavenged sources is power density, not energy density. Energy harvesting is generally subject to low, variable and unpredictable levels of available power so a hybrid structure that interfaces to the harvester and a secondary power reservoir is often used. The harvester, because of its unlimited energy supply and deficiency in power is the energy source of the system. The secondary power reservoir, either a battery or a capacitor, yields higher output power but stores less energy, supplying power when required but otherwise regularly receiving charge from the harvester. Thus, in situations when there is no ambient energy from which to harvest power, the secondary power reservoir must be used to power the WSN.

Successfully designing a completely self-contained wireless sensor system requires readily available power-saving microcontrollers and transducers that consume minimal electrical energy from low energy environments Existing implementations of the energy harvester block shown in Figure 1 typically consist of low performing discrete configurations, usually comprising 30 components or more. Such designs have low conversion efficiency and high quiescent currents. Both of these deficiencies result in compromised performance in an end system.

High quiescent current limits how low the output of the energy-harvesting source can be, since it must first overcome the current level needed for its own operation before it can supply any excess power to the output. This is where ADI's Power by Linear's products can bring a new level of performance and simplicity.

Energy Harvesting IC Example

The LTC3109 is a highly integrated DC-DC converter and power manager. It can harvest and manage surplus energy from extremely low input voltage sources such as TEG (thermoelectric generators), thermopiles and even small solar cells. Its unique proprietary auto-polarity topology allows it to operate from input sources as low as 30mV, regardless of polarity.

The circuit above uses two compact step-up transformers to boost the input voltage source to the LTC3109 which then provides a complete power management solution for wireless sensing and data acquisition. It can harvest small temperature differences and generate system power instead of using traditional battery power.

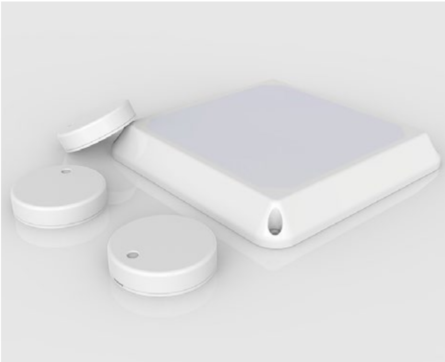
The AC voltage produced on the secondary winding of each transformer is boosted and rectified using an external charge pump capacitor and the rectifiers internal to the LTC3109. This rectifier circuit feeds current into the VAUX pin, providing charge to the external VAUX capacitor and then the other outputs. The internal 2.2V LDO can support a low power processor or other low power ICs.

Conclusion

With analog Switchmode power supply design expertise in short supply around the globe, it has been difficult to design an effective energy harvesting system for use in buildings. The primary hurdle being the power management aspects associated with remote wireless sensing. Nevertheless, products like the LTC3109 can extract energy from almost any thermal source, thereby enabling a system designer with their power source in an energy harvesting application.

Open-source environmental sensing and asset tracking solution

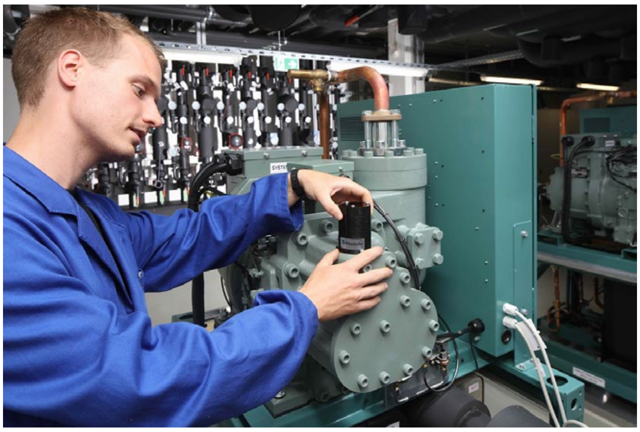
Ruuvi Innovations' Ruuvi Node is an open-source node solution with cellular connectivity, energy harvesting, GPS, and NFC that is built around Nordic Semiconductor technology. The Ruuvi Node uses both the Nordic Semiconductor nRF9160 SiP cellular IoT module (LTE-M and NB-IoT) and an ultra-low power Nordic nRF52840 Bluetooth 5 multi-protocol (Thread, Zigbee) System-on-Chip SoC. The Ruuvi Node is maintenance-free and will include an embedded solar panel to support energy harvesting, a full range of environmental sensors, GPS positioning (using the Nordic nRF9160 SiP's embedded GPS support), and NFC (through the embedded NFC feature on Nordic's nRF52840 SoC). A 45Wh battery, multi-use expansion ports, and support for an external power source is also included. The device can also act as a cellular gateway for any of Ruuvi's 'RuuviTag' Bluetooth sensor beacons. Ruuvi is looking to launch the first pilots of the Ruuvi Node during Q2-3 this year.



Ruuvi
https://ruuvi.com

Vibration energy harvesting system powers sensors

For the operation of sensors in the Industrial Internet of Things (IIoT), the Fraunhofer Institute for Integrated Circuits IIS (Erlangen, Germany) has developed a self-sufficient power supply technique that uses vibrations, for example from machines, to generate electrical energy. These sensors can thus be used for operating and condition monitoring in production and require neither power cables nor battery replacement. Sensors are increasingly being used in manufacturing environments. IIoT system architectures are designed to network machines, systems and IT systems to achieve better resource efficiency, productivity and maintenance. Smart sensors that transmit information to the entire system by radio are needed to collect the necessary data. However, these sensors require sufficient energy. The advantage of a self-sufficient power supply is that neither a disturbing power cable nor a battery change is necessary. Wi th these energy harvesting technologies, sensors for detecting wear or damage to machines in condition monitoring can be independently supplied with energy. Such technologies offer enormous advantages over conventional power supplies, especially in hard-to-reach locations or where data is frequently collected. With the extremely efficient power management electronics from Fraunhofer IIS , even very low smallest currents or voltages from vibration or thermal converters can be harnessed. Existing vibrations and temperature differences in production plants are thus used to generate energy for sensors. Thus, machine conditions can be monitored and analyzed permanently and maintenance-free. Even very small accelerations of 100 milli-G are sufficient to generate enough electrical energy to supply several sensors and to transmit the data generated to an IT system every second. The developed voltage converters and maximum power point trackers can work with minimum voltages and currents and are thus able to use and store the smallest amounts of mechanical or thermal energy from the environment. The optimum mechanical and electrical design of all system components enables highly efficient applications to be implemented in the smallest possible space and thus clearly sets itself apart from the state of the art thanks to minimum installation and maintenance costs.



Fraunhofer Institute
www.iis.fraunhofer.de

Energy harvesting technology helps track animals

e-peas' AEM10941 devices for photovoltaic energy harvesting are at the centre of animal tracking equipment used on Australian cattle ranches. e-peas worked with Dutch systems integrator SODAQ on the development and implementation of livestock monitoring hardware for Brisbane-based mOOvement. mOOvement's smart tracker acquires data on cattle herds' position and grazing patterns and can set alarms if individual animals are stationary or have breached boundaries. The tracker is attached to one of the cattle's ears. The tracker has an accelerometer, a LoRa communication module (with built-in MCU), a GPS transceiver and a passive NFC tag. The size and weight of the unit had to be low, restricting the surface size of the solar panel (19mm x 43mm), which would need to generate 0.089W. This required an ultra-efficient power management system. The units also have to be robust, with an expected lifespan of 5 years. The full project took two years, with e-peas' involvement lasting a year. The high energy conversion rate and the small footprint of the dual LDO regulated-output AEM10941 met this key criterion, as well as supporting a prolonged operational lifespan even in the Australian Outback, where exposure to extreme temperature conditions would be expected. Thousands of tracking units have already been deployed, with plans to scale further up in the near future.

e-peas
https://e-peas.com

Energy harvester is only one millimetre thick

Face International Corporation has granted its first license for its Evercell thermal energy harvesting technology to QuantumDrive, for its use in self-powered quartz watches. An Evercell power cell is made up of very thin, self-contained energy harvesting modules called "stacks." By "stacking the stacks" in a single, solid state structure manufactured much like a semiconductor, the output of the Evercell can be multiplied. A typical Evercell to power an IoT wireless sensor will contain 30 to 50 stacks and will still be only a millimeter thick.The horizontal dimensions may vary but Evercell power cells will always be thin, explains the company's website. Evercell is a passive-structure, semiconductor-based thermal energy harvester that exploits principles of quantum physics to produce a small, continuous flow of electric power (enough to power a quartz watch, for example) in virtually any environment. As well as being extremely thin and lightweight, the Evercell power cells have no need for a measurable thermal gradient, explains the company in a demonstration video, noting that the actual physics happen at angström-thick level. In contrast to Evercell, conventional thermal energy harvesters require both significant thermal gradients and a bulky heatsink for operation, limiting the form factors of consumer products. The company says it has had an Evercell demonstrator running since October 2016 which is still running, with the same output, in the few microwatts range. "This will be a game-changing development for the quartz watch industry, as it eliminates the most unpleasant part of the ownership experience — looking at your watch only to find its battery is dead and having to spend the time, energy and money to have the battery replaced every couple

of years," stated Stefan Popov, managing partner of QuantumDrive. "In the future, it is conceivable that Evercell can play a role in the rapidly growing smart watch market as well." The two partners anticipate that Evercell-powered quartz watches could be on the market in 2020 or 2021.

QuantumDrive
www.QuantumDriveForever.com

TTI adds Alps' energy harvesting switches

Now available in Europe through TTI, the Energy Harvester SPGA Series from Alps Electric Europe employs electromagnetic induction to generate power with each push or release. Combined with external low-power wireless technology, the 17.5×23×17.9mm device can function as a switch. It can be installed away from a main board, for example in places where connection to a power source, or a battery replacement is difficult. The product is well suited for frequently operated equipment. The main target applications are remote-control for ceiling lights and outdoor lights as well as gate open/close, open/close operation detection of a door/locker or emergency call button. The SPGA Series Energy Harvester has a long operating life of one million cycles and generates more than 170µJ for each action (press or return). In addition the component also features excellent operational feeling with a specified operating force of 6±1.5N.

TTI, Inc.
www.ttieurope.com