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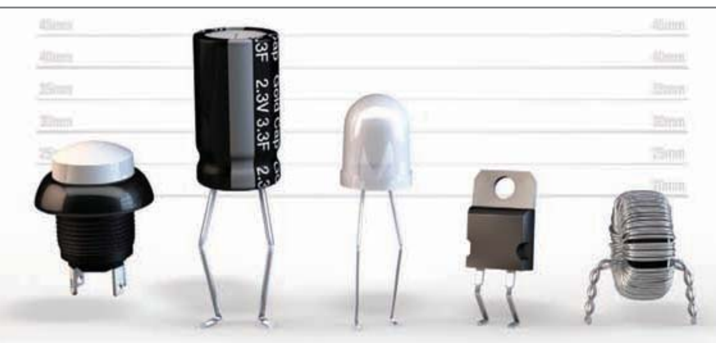

MOBILE/WIRELESS WEATHER FORECAST FOR 2011

> *Year 2011 will see the barometer rise for Enterprise Mobility*

Despite three years of global financial bleakness, 2010 brought huge growth to mobile/wireless. Global handset shipments rose to more than 1.3 billion units (Nokia), over 20% of them smartphones (Gartner). But the news wasn't just about volume – the mobile market (finally) changed its focus from hardware to software – but about applications and app stores.

VIRTUALIZATION, END-TO-END – Most forecasts for 2011 highlight evolved Cloud Computing as the weather pattern for the coming year. However, the impact of a robust and ubiquitous Cloud is mostly indirect for mobile/wireless: it lets developers and enterprise IT continue application-centric mobile strategies or move to thin clients using HTML5 or enablers like Citrix Receiver. It also lets mobile workers connect transparently to corporate Clouds and data centers, inside the office or on the road.

It's axiomatic that Cloud Computing is enabled by virtualization: hardware virtualization, platform virtualization and application virtualization (H/P/SaaS). We're already seeing virtualization of enterprise desktops and increasingly ubiquitous desktop-hosted virtualization for interoperability. In 2011, the paradigm of end-to-end virtualization will also encompass mobile end-points to meet enterprise, government, SMB and end user needs for security, interoperability and cost-savings.

ENTERPRISE MOBILITY – In 2010, enterprise employees increasingly worked outside corporate headquarters yielding enhanced productivity from use of mobile computing and communications, sourced both from traditional IT channels and from end user acquisition. Enterprise Mobility encapsulates this trend, precipitating key requirements from enterprise IT – especially for device security.

The coming year will see the barometer rise for Enterprise Mobility – organizations previously prohibiting mobile access to corporate assets will embrace, sanction and support it. Security will remain the biggest challenge; tools for sustaining Enterprise Mobility will include mobile versions of existing end point security (anti-virus, device wipe, etc.), mobile device management (MDM) suites, with underlying architectural innovation based on mobile virtualization.

A SEA OF SMARTPHONES – In 2010, worldwide smartphone deployments topped 250 million units. While this volume might constitute a burgeoning mass-market phenomenon, relatively pricey smartphones remain beyond the reach (or discretion) of most consumers.

In 2011, smartphone sales soar on this virtualization updraft. Enhancing organic segment growth will be in sharp decline in acquisition costs: OEMs will build and sell cheaper smartphones through dramatic reductions in handset Bills-of-Material (BoM). Merging multiple legacy chipsets (baseband, application processing, etc) onto a single mainstream ARM CPU lets OEMs ship sleeker devices – smartphone functionality at feature-phone prices. Critical to BoM consolidation is mobile virtualization, lending hardware independence to mobile platforms and enabling diverse legacy software to run on a single CPU.

4G, 4 REAL – In 2010, operators began tentative 4G rollouts with overhyped interim data services. 2011 will bring actual 4G LTE networks into service, but still without the promised revolution in user experience. Current handset designs throttle 4G bandwidth by limiting wireless input/output concurrency – slinging packets upstream and down at high speeds (megabits, not kilobits/sec) is the hallmark of LTE.

To address this need for speed, OEMs will start designing and deploying 4G phones using multicore silicon, enabled by mobile virtualization. This dynamic duo will help OEMs and operators deliver on promises of 4G data rates in late 2011 through 2012.

MAINSTREAM MULTICORE IN MOBILE – High-end smartphones already deploy multicore ARM CPUs to run applications OSes (and nothing else). The coming year will see dual-core silicon drop in price, with 2012 bringing 3x and 4x CPUs, including processors built on ARM Cortex-A15. As multicore chipsets go mainstream in 2011, extra computing power will consolidate gains by mass-market smartphones, enhancing the user experience without impacting price.

The future of multicore in mobile is sunny – more computing power at mass market price points. Challenges do arise from added complexity – taking full advantage of new silicon resources without introducing software vulnerabilities: shortening battery life or slowing delivery. A powerful tool for taming this complexity is mobile virtualization.

METATREND – SYNERGY POWERED BY VIRTUALIZATION – Distinct trends for 2011: virtualization enables Cloud Computing, multicore supports 4G, LTE data rates accelerate Enterprise Mobility adoption, etc. In synergy, mass-market smartphones drive application sales, and apps marketplaces create pull for smartphones running those apps.

Across the ecosystem, from silicon to software to services, the most significant enabler is virtualization: virtualization in the Cloud and data centre, on the desktop and in ubiquitous handsets. In 2011, mobile virtualization will reach its actual potential, reinforcing the above trends and other types of innovation.

So don't forget your sunglasses at home – 2011 will be a super bright year for mobile virtualization.

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Japanese Scientists Use Alcoholic Drinks to Induce Superconductivity

Japanese researchers have been immersing iron-based compounds in hot alcoholic beverages such as red wine, sake and shochu to induce superconductivity.

Scientists from the National Institute for Materials Science, Japan, found that immersing pellets of an iron-based compound in heated alcoholic beverages for 24 hours greatly increase their superconducting ability.

Iron-based compounds usually become superconductive after being exposed to air. This process however can take up to several months. This study demonstrated that superconductivity can be induced with alcohol in just one day. Samples of the iron-based compound were immersed in each beverage and heated at 70^{0}C for 24 hours. Red wine was shown to induce the best superconducting properties; however beverages with the same alcohol concentration showed a significant difference. This suggests that it may not be the alcohol contributing to the creation of superconductivity but, instead, another component present in the beverages.

Iron-based compounds undergo a process called magnetic order whereby the molecules align in a regular pattern. To achieve superconductivity, magnetic order must be suppressed. In order to become superconductive, the elements in the iron-based compounds must be substituted with elements present in alcohol.

The exact mechanism behind this effect is largely unknown, however the researchers suggest that it may be due to the insertion of electrically charged particles into the layers of the compound. An alternative theory is that the alcoholic beverages help to supply oxygen into the sample, which in turn causes superconductivity. A clearer understanding will be had by analysing the structure and composition of the beverages to identify the key factor in inducing superconductivity.

Japanese scientists used alcohol to induce superconductivity in iron-based compounds

Rambus Has Announced Breakthrough in Memory Signalling

Memory licencing giant Rambus has recently announced that it has advanced differential signalling for SoC-to-memory interfaces to a groundbreaking 20 gigabits per second (Gbps) and developed ways to extend single-ended memory signalling to 12.8Gbps.

Rambus has also developed solutions that enable a seamless transition for memory architectures from single-ended to differential signalling, as data rates rise to meet the performance requirements of future-generation graphics and gaming systems.

These latest technology advancements are part of Rambus's Terabyte Bandwidth Initiative, and have proved that there is room for big improvements in power efficiency and compatibility to single-ended memory architectures, including GDDR5 and DDR3. With the addition of Rambus's FlexMode interface technology – a multi-modal, SoC memory interface PHY (supporting both differential and single-ended signalling) can be implemented in a single SoC package design with no additional pins; this is achieved through programmable assignment of signalling I/Os to either data or command/address. The power efficiency is 6mW per Gbps when operating at 20Gbps in a 40nm-process silicon test vehicle.

"We have paved multiple paths for the industry by providing solutions that extend single-ended signalling beyond today's limits and developing the means for a seamless transition to differential signalling," said Sharon Holt, senior vice president and general manager of the Semiconductor Business Group at Rambus. "By advancing data rates in an extremely power-efficient way and, in enabling compatibility to current industry-standard memories, we have removed the technical and business barriers for customers to achieve unprecedented capabilities in their products."

The demand for photorealistic game play, 3D images and a richer end-user experience is constantly pushing system and memory requirements higher. Today's high-end graphics processors support as much as 128GB/s of memory bandwidth and future generations are expected to push memory bandwidth to upwards of one terabyte per second (TB/s).

NEWS IN BRIEF

- Technology experts from around the world have come to Queen's University in London to explore new ways to make computers more efficient and greener. Computing is now recognised as being responsible for significant electricity consumption and wastage around the world, as computing consumes more than 3% of the global electricity consumption; performing two Google searches from a desktop computer can generate about the same amount of carbon dioxide as boiling a kettle. As limitations on computing memory and energy waste increases, international experts are hoping to develop alternatives to reduce and prevent future waste.

- DuPont Microcircuit Materials (MCM) has announced a key collaboration with Holst Centre, an independent open-innovation R&D centre set up by Imec from Belgium and TNO from The Netherlands, focused on printed electronics. The collaboration is expected to advance technology specifically in the area of printed structures on flexible substrates, which has application in flexible display, RFID, lighting, biomedical and Organic Photovoltaic (OPV) markets.

ELEMENT SIX LAUNCHES NEW GRADE OF THERMAL CVD DIAMOND MATERIAL

Element Six's new Diafilm 200 boasts thermal conductivity in excess of 2000W/mK

Element Six has now commercially launched DIAFILM 200, the world's first diamond thermal material that can offer users thermal conductivity in excess of 2000W/mK.

This novel, top-end grade of CVD (chemical vapour deposition) diamond thermal material caters for advanced users that work with high power, or high power density, devices and require extreme performance for their thermal packaging needs.

The new material is fully isotropic, i.e. spreads the heat equally efficient in a planar direction as well as through the material. Its unique combination of properties, such as high thermal conductivity, electrical insulation, low density and chemical inertness make it the material of choice for advanced thermal management needs, such as the advanced packaging industry.

"Diamond is the highest thermally conductive material and this new product pushes thermal conductivity of commercially available diamond to groundbreaking new levels," said Thomas Obeloer, Business Development Manager for Thermal Applications at Element Six. "We have already had positive feedback from customers in the telecommunications and laser diode sector who were early adopters of this product and now the product is commercially available."

Keithley Introduces System SourceMeter Instrument Optimized for High Power Semiconductor Test

Keithley Instruments has added the Model 2651A High Power System as the latest instrument in its Series 2600A System SourceMeters. The latests model is specifically designed for characterizing high power electronics, including power semiconductors (IGBTs, FETs, diodes), high brightness LEDs (HBLEDs), DC-DC converters, batteries and the characterization of different compound materials and devices, among others.

Model 2651A is the latest system in Keithley's series of SourceMeter instruments

The 2651A offers a four-quadrant voltage and current source/load, coupled with precision voltage and current meters; it offers the functionality of a semiconductor characterization instrument, precision power supply, true current source, DMM, arbitrary waveform generator, V or I pulse generator, electronic load and trigger controller, and is fully expandable into a multi-channel, tightly synchronized system via the proprietary TSP-Link technology or LXI and the GPIB bus.

This model can source or sink up to 2000W of pulsed power (±40V, ±50A) or 200W of DC power (±10V@±20A, ±20V@±10A, ±40V@±5A). Its dynamic range is from 1 picoamp to 50A (100A if two of these models are linked in parallel via the TSP-Link) and from 1 microvolt to 40V, also doubled up to 80V if two of them are connected in parallel.

One of the instrument's unique features is that any test pin can be used for high voltage testing, whereas with other instruments only one and the same pin has to be selected at all times. "This feature allows a great flexiblity [to design and test engineers] and it is unique to us," said Mark Cejer, Director of Marketing at Keithley Instruments.

The range is pitched at R&D and production test applications equally.

SMOOTHING THE SUPPLY CHAIN

and speeding time-to-market for new devices and new equipment

Lynn Ma, Technical Marketing Manager–Europe, Farnell

For equipment and component manufacturers alike, a shorter time-to-market is a good indicator of an efficient, well managed and well resourced research and development process. Shortening the time-to-market can result in a greater share of market, especially if the new products incorporate cutting edge technology.

Well resourced, experienced and forward thinking distribution partners can play a pivotal role in shortening time-to-market for both their suppliers (the component manufacturers) and their customers (Electronic Design Engineers working for equipment manufacturers).

Electronic component manufacturers have to commit significant R&D investment in order to bring new devices to market that satisfy customer's future needs as well as keep them ahead of competitors from a technical perspective. This upfront investment means they need to recoup revenue through volume sales. The process of supporting customer product development activities with information and just handfuls of product can be resource sapping and does not offset the initial R&D investment.

Supplying small quantities of product on a short lead-time to support new product programs has always been a primary function of a good distributor and is something that Farnell has refined in its over 70 years in business. Offering the broadest possible choice of products helps design engineers adopt a single distributor as their partner in development.

In support of this it is vital that the distributor brings new and exciting technologies and components to the design engineer's attention as quickly as possible. Farnell helps engineers accomplish this by adding over 700 new products online every week.

The Internet has given engineers a wealth of information at their fingertips and fast, streamlined methods for ordering product. With often several hundreds of thousands of line items on offer, the distributor has to put a lot of thought and effort into how new products are presented to ensure that component selection is not a time consuming and challenging process for customers.

A good example is the approach taken by Farnell to make new technologies and products stand out. Farnell profiles the most important new devices on its Technology First New Product Microsite. The site provides clear and comprehensive information about the very latest products and technologies from the electronic industry's leading component manufacturers, and is designed to make it easier for engineers to select and design-in devices that can give them a competitive edge.

Each week, six products are carefully selected and showcased with quick, one-click access from the homepage to more detailed information and a useful product brief. Devices from previous weeks are also easily viewed from the homepage. The Technology First New Product Microsite also includes online audio training modules, video demonstrations, and other resources such as selection guides, application notes and reference designs.

Utilising the Internet and the popularity and power of social media is an area where Farnell has taken the lead by introducing the industry's first online technology portal and eCommunity – element14. This supplements basic product data by providing the opportunity for design engineers to discuss their applications with like-minded engineers and technical experts from industry and the component manufacturers themselves. Such interaction helps speed the design process and can provide valuable reassurance to engineers working in an unfamiliar area of technology. Online engineering communities such as element14 can help engineers quickly overcome the numerous hurdles encountered in any normal product development cycle.

Reference designs and evaluation boards are a further important resource in helping to speed the design process and encourage the adoption of new technology. The number and variety of reference designs, development boards and evaluation kits offered by OEMs has expanded considerably in recent years. With technology advancing so quickly and the demand to get new products to market more rapidly, they are a welcome addition to the pressured electronics design engineer's resources. OEMs now offer access to these tools via distribution channels as well as on their own website. . Farnell currently offers a range of over 2,000 evaluation boards, software tools, demo boards, debuggers and emulators. ●

For more information visit the Farnell website: www.farnell.co.uk, www.element14.com

Wi-Fi Direct and Bluetooth high-speed comparison chart

FILOMENA BERARDI, MARKET ANALYST AT THE CONNECTIVITY GROUP OF IMS RESEARCH, EXPLORES THE DIFFERENCES AND STRENGTHS OF TWO COMPETING WIRELESS TECHNOLOGIES

Bluetooth and Wi-Fi were previously seen as complementary technologies. However, the development of Bluetooth high speed and Wi-Fi Direct will bring the technologies head-to-head for the first time in certain applications. So, is there room for both in specific devices? Will one technology finally be winner long-term?

Bluetooth High-Speed

Let's begin with Bluetooth: Originally designed to provide a low-power, peer-to-peer, ad-hoc wireless link, it has served many applications well. So much so, according to IMS Research's latest Bluetooth annual report, cumulative shipments of Bluetooth devices are approaching 5 billion units, with over 1.2 billion devices shipped in 2010 alone.

The installed base for Bluetooth is dominated by cellular handsets; the overall attach rate across all tiers (smartphones, feature-rich and ultra-low cost) was estimated to be around 65% in 2010. Thus, key use-cases for Bluetooth include hands-free calling, audio streaming and small object file transfers.

Despite its success in several applications, Bluetooth in its classic form is incapable of high speeds. To address this issue, the concept of "Bluetooth high speed" was created by the Bluetooth community.

Bluetooth high speed was first announced in 2006. It first used UWB as its fast data-pipe, but is now using 802.11. The secondary radio, known as the Alternate MAC/PHY (AMP), will first implement the IEEE 802.11a/b/g specification. The Bluetooth Special Interest Group (SIG) intends to upgrade the AMP to 802.11n in 3Q 2011. Potential use-cases include downloading large files, synchronising music between two devices and, even, transferring video quickly.

A potential issue with this method is that both radios must be present at each end to enable the higher speeds of Bluetooth high speeds. If not, the link will revert back to the slower speeds of classic Bluetooth.

Today, there are a number of qualified Bluetooth high-speed products, namely in notebook PCs, for example Acer's Aspire 5943 notebook. IMS Research has estimated that over 2 million notebooks and around 12 million handsets will be enabled with Bluetooth high speed in 2011.

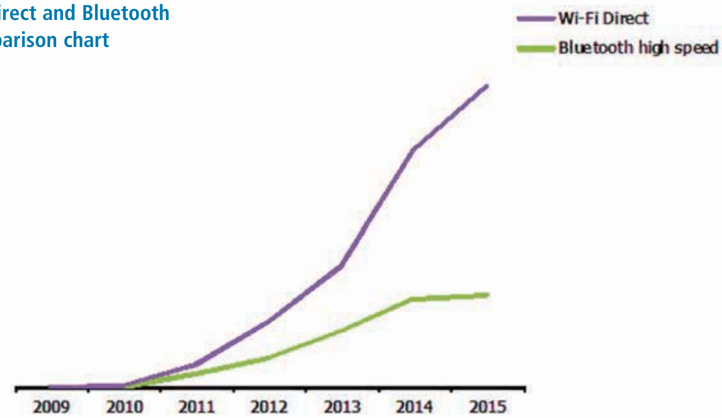
Wi-Fi's Strenghts

Wi-Fi, on the other hand, is a wireless networking technology; unlike Bluetooth, it has an installed base dominated by notebook PCs. IMS Research estimated that over 200 million notebooks in use in 2010 were Wi-Fi enabled. Cumulative device shipments are fewer than for Bluetooth. However, its recent incorporation into devices other than PCs, such as cellular handsets, portable media players, car head units, set-top boxes, game consoles and many other devices, would suggest its growth potential is bigger than that of Bluetooth.

To take smartphones as an example, according to IMS Research, over 78% of smartphones were enabled with Wi-Fi in 2010. But fundamentally unlike Bluetooth, Wi-Fi is not a peer-to-peer

Analysts at IMS Research have forecast that around 2 million handsets and nearly 9% of notebook PCs will be enabled with Wi-Fi Direct in 2012

Figure 1: Wi-Fi Direct and Bluetooth high-speed comparison chart



technology. It faces different challenges, such as link set-up, authorisation, pairing and system discovery. Bluetooth has already solved these issues; adding 802.11 will just provide a faster link.

Traditionally Wi-Fi uses a "star architecture". This consists of several terminals (STAs) connected to an Access Point (AP). The AP acts as a bridge to the network. Wi-Fi Direct has the aim of providing a peer-to-peer connection between Wi-Fi devices. It works by extending the existing AP and STA client-server architecture with the introduction of two new devices; a Group Owner and a Group Client. These can connect in an ad-hoc, peer-to-peer manner. In addition, Wi-Fi Direct, unlike Bluetooth high speed, uses an existing 802.11 radio and, therefore, is a single radio system.

Many in the industry were fearful that WiFi Direct technology would incur delays. However, the announcement made by Samsung in November 2010 has given the technology a real boost. The Galaxy S Smartphone was the first certified Wi-Fi Direct product, with more to follow. Analysts at IMS Research have forecast that around 2 million handsets and nearly 9% of notebook PCs will be enabled with Wi-Fi Direct in 2012. In addition, the outlook for this technology in other devices such as residential gateways and set-top boxes remains positive.

IMS Research is a supplier of market research and consultancy services on a wide range of global electronics markets. The company headquarters is in Wellingborough, UK with offices in Austin, Texas and Shanghai, China. IMS Research regularly publishes detailed research on the connectivity markets, among others.
www.imsresearch.com

Technologies' Pros and Cons

Clearly each technology has both technical and competitive advantages. Technically, with respect to throughput and range, on paper both technologies use IEEE 802.11a/b/g/n radios as their high-speed data pipe and, consequently, both offer the same PHY data rates. The stated objective of Bluetooth high speed is 250Mbps and Wi-Fi Direct's performance is expected to be similar. The range of Bluetooth high speed with a Class 2 radio is similar to that of classic Bluetooth (10m); however with a Class 1 radio the range can reach 100m. The range of Wi-Fi Direct is similar to normal Wi-Fi (100m).

Aside from technical differences the certification process of Wi-Fi Direct is far more straightforward, as it will use the current Wi-Fi Certification programs handled by the Wi-Fi Alliance. The certification of Bluetooth high speed can be considered more complicated. It will instead accept the Wi-Fi Alliance certification and run some extra tests for AMP in its own certification procedure to cover areas that the Wi-Fi Alliance will not cover.

Furthermore, in terms of conception to reality, it took Bluetooth high speed three years to come to market – Wi-Fi Direct has taken only one year. Therefore, one can't help but wonder what the situation might have been had Bluetooth high speed come to market sooner.

Further, Wi-Fi Direct has also taken the initiative in planning ahead. It was announced in May 2010 that the Wi-Fi Alliance would work with the Wireless Gigabit Alliance. The Wireless Gigabit Alliance is the official alliance for WiGig, a 60GHz technology. Together they have the intention of sharing technology specifications. This will mean that the next-generation of Wi-Fi Direct products will operate in the 60GHz frequency band. The idea is that Wi-Fi Direct will build the ecosystem for WiGig and, therefore, it will be a case of simply upgrading as opposed to building one for another competing technology.

The likely outcome is that initially Bluetooth high speed and Wi-Fi Direct may co-exist in specific products like handsets as they do already in classic form. Some device manufacturers have said they will take a "technology-neutral" approach and let consumers and the industry decide. However, Wi-Fi's long-term roadmap sets the two technologies very far apart. The Wi-Fi and WiGig collaboration is considered very compelling by many in the industry. The evolution into 60GHz technology is not only appealing, but has made many in the industry question the future of Bluetooth high speed. In my opinion, Wi-Fi Direct is the likely winner long-term. ●

That's odd!

Timing behaviour of "TRANSPARENT" wireless modems

MYK DORMER IS SENIOR RF DESIGN ENGINEER AT RADIOMETRIX LTD
WWW.RADIOMETRIX.COM

Designing a wireless data link from the ground up can be pretty daunting, even if all the scary "radio" bits are hidden away inside a module. That's why many manufacturers now offer complete "wireless modems", where the customer's RS232 stream (or frequently an inverted, logic level version of it) can be fed directly into the module interface, without worrying about all the coding, decoding, buffering, framing, synchronising and other things that are actually required to make a "radio" do something vaguely useful.

A lot of these devices are even "transparent", in that they try to behave as much like a simple wired connection as possible – provided little restrictions like programmed baud rates and half-duplex turn-around time are abided by, so that the actual complexities of the air interface can be ignored by the engineers using them. Which is just wonderful; until the device starts to be used in a real application, where other radios might be sharing the channel, or where spectrum occupancy, duty cycle or power consumption might matter. At this point, the way such a device operates, and the ways the user can optimise its behaviour, become far more important.

In order to send your data over a real data link, the modem device must buffer your data (so the radio on/off timings can be accommodated), add in checksums and framing sequences so the decoder has something to acquire, re-code the stream into a bit-level format that the noisy, AC coupled baseband path can handle (using scrambler-whitened GMSK, or phase coding, or something similar) and, finally, run the air-interface at a data rate sufficiently greater than the basic user interface speed, so that all the added overhead can be fitted into the timings.

Hidden in all this frantic activity is the innocuous word "buffer". The modem stores the user data as it arrives, byte by byte and then must, at some point, define how many (user) bytes are going to be associated with each parcel of preamble, synchronisation and framing. This gets called a "packet" in the industry, and it has an overwhelmingly important influence over the behaviour of your modem.

In the very simplest case, a packet could be one byte, but the resulting design would be terribly inefficient, as it would be adding at least 3-4 bytes of overhead to each byte sent (some simple short ranged wide-band radio modems approach this, with very short packets of 2 or 3 bytes and an air interface rate of over four times the user baud-rate, but these are unusual designs optimised for low data latency, not efficient use of bandwidth).

> *In the very simplest case, a packet could be one byte, but the resulting design would be terribly inefficient, as it would be adding at least 3-4 bytes of overhead to each byte sent*

Most radio modems adopt a longer packet, sometimes as short as 8 bytes but usually somewhere between 16 and 256 bytes. They combine this with a mechanism for sending shortened bursts where the user's average data throughput is significantly lower than the link maximum. It is at this point that a closer examination of how the modem operates is needed. The situation is very simple if data is streamed constantly at maximum baud rate. After the initial start-up sequence, packets will be transmitted end-to-end, with the actual packet length varying slightly as the transmit data buffer fills and empties.

If one byte is sent in isolation, the situation is at the opposite extreme, as the preamble/start-up sequence can begin immediately, followed by the transmission of a minimum length packet. The time taken between a single byte entering the transmitter and appearing at the serial output of the receiver is the single byte latency of the modem and will vary greatly depending on the switching speed of the RF hardware and the complexity and overhead in the packet structure. Practically it can be anywhere from about ten milliseconds to over a hundred.

Things become interesting when practical amounts of data begin to be

Low-Power Microcontrollers for Battery-Friendly Design

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- LCD drive
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Unfortunately, this "sweet spot" moves relative to data rate, packet length and inherent speed of the modem's internal processes, so users would be very lucky to find that a given device was already optimised for "their" data

sent (by which I mean infrequent bursts, between a few bytes to a few dozen bytes). In these cases a trade-off will be seen. If the modem has a long start-up sequence (or an over-long processing delay before the radio transmitter is activated) then all of a user's data burst will be sent in one packet, but the latency (or delay) will be excessive. If, on the other hand, the data burst is long compared to the modem start-up (or the modem processes are unusually fast) then an initial packet will be sent (in a truncated form) before all the user's data has been sent to the device and a second (and possibly a third) packet will follow the first before all the data has been sent. This will result in unusually long transmit sequences, possibly with the transmitter turning on and off several times and a very poor 'first byte in to last byte out' latency time.

In the ideal case, the start-up time for the modem would equal (or slightly exceed) the overall start-up time of the modem, so the last user data byte would arrive just before the modem commences to format the packet. In this instance the data will be sent in a single, optimally short packet, minimising latency times, spectrum usage and transmitter power use.

Unfortunately, this "sweet spot" moves relative to data rate, packet length and inherent speed of the modem's internal processes, so users would be very lucky to find that a given device was already optimised for "their" data.

FORTUNATELY THE DESIGNERS OF WIRELESS MODEMS ARE AWARE OF THESE PROBLEMS AND THE DEVICES GENERALLY INCLUDE ONE OR MORE MECHANISMS TO ALLOW THE USER TO OPTIMISE THE TIMINGS TO SUIT THEIR APPLICATION:

1.HANDSHAKING SIGNALS

An obvious hardware solution is to provide an additional logic input to the device, which inhibits the modem's start-up and packetising functions, while still allowing data to be loaded into the transmit buffer. The user asserts this input once all the data in a burst has been loaded, permitting the modem to complete its transmission operation. The name given to such a signal is not standardised. Some suppliers will use a simple description, while others will attempt to relate it to one of the defined RS232 handshaking lines (RTS or DTR for instance). This approach gives optimal control over the burst transmission timing (allowing more complex synchronising and timing schemes to be used) and avoids complex re-programming of the modem device, but calls for extra user hardware.

2. PROGRAMMABLE USER DATA RATE

Many modem devices allow the user to modify some of the operating parameters (via a range of methods, from the provision of a separate programming input port to the decoding of a specific "go into setup mode" command string in the user data stream). If the user port data-rate can be reprogrammed, then adopting a speed much higher than the devices rated average throughput can offer a simple solution. If the user data is loaded into the modem buffer very rapidly (for example, via a 57.6kbaud link), then the entire user burst will always be loaded before the first packet transmission begins.

This method requires no extra hardware, but the user's host device needs to have a fast enough data rate capability and care must be taken to limit the burst size and aggregate data throughput, to avoid data loss through a modem buffer overflow.

3. PROGRAMMABLE TIMING

Some wireless modems allow the user to change some of the fundamental timings of the device (usually via a configuration interface as described above).
Typical timing parameters provided are:
Transmit start delay: This is the provision of a time delay between the arrival of the first byte in the buffer and the start of the modem start up process. This would be zero for single bytes or for continuous streamed data (to minimise latency), but for short bursts should be set approximately equal to the length of the data sequence (to ensure all bytes are in the buffer before the modem begins formatting the data packet).
Preamble length: The amount of time allowed by the modem for the RF link hardware to stabilise, before real data is passed over the path. This parameter is critical to correct operation: set it too short and the link will fail entirely, too long and the transmit bursts will be lengthened un-necessarily.

When setting these timers, it will be necessary to carefully examine the modem's actual sequence of operations. Some designs format the packet after the preamble sequence (which allows the preamble time to be counted in with the transmit delay when optimising the timings), while others execute this function before preamble starts (in which case the transmit-delay needs to be long enough on its own).

Some devices have a third parameter (transmit off timer). This adds an extra delay to the end of a packet before a new transmission is allowed to commence. It is only really useful in bidirectional systems running sporadic data streams, where it may be necessary to inhibit transmission until a distant node has "replied" to a data burst, or in systems employing store and forward repeaters, where it gives time for the repeater node to go through its own packet transmit cycle before the next packet is sent, without imposing an increased initial latency, which would occur if a longer transmit start delay was used for the same purpose.

Taking the (small amount of) extra time to set the timing parameters to a best match for the user's data format and throughput will greatly improve the behaviour of the link, and will reap real benefits in terms of reduced burst lengths, and hence improved power consumption and spectrum usage.

BRIGHT FUTURE FOR ULTRA LOW POWER RF

THOMAS EMBLA BONNERUD, PRODUCT MANAGER FOR ULTRA LOW POWER WIRELESS WITH NORDIC SEMICONDUCTOR, IN THIS ARTICLE LIFTS THE VEIL FROM ULTRA LOW POWER (ULP) WIRELESS TECHNOLOGY, DESCRIBES THE CHIPS AND TAKES A LOOK AT HOW AND WHERE THEY'RE USED

Figure 1: The nRF24LU1+ allows PC peripheral manufacturers to make tiny USB dongles with a physical profile that hardly extends beyond the USB port of the host computer

Even though the chips ship in their tens of millions each week, the market for short-range, low-power RF technologies operating in the globally popular 2.4GHz ISM band – such as Wi-Fi, Bluetooth, ZigBee and a slew of proprietary solutions – is far from maturity. In the next few years, many impressive developments will emerge and wireless connectivity will pervade every aspect of our lives.

In particular, ultra low power (ULP) wireless applications – using tiny RF transceivers powered by coin cell batteries, waking up to send rapid "bursts" of data and then returning to nanoamp "sleep" states – are set to increase dramatically. For example, according to analysts ABI Research, the wireless sensor network (WSN) chips market grew by 300% in 2010, and the same company forecasts that no less than 467 million healthcare and personal fitness devices using Bluetooth low energy chips will ship in 2016.

ULP wireless connectivity can be added to any portable electronic product or equipment featuring embedded electronics, from tiny medical and fitness sensors, to cell phones, PCs, machine tools, cars and virtually everything in between. Tiny ULP transceivers can bestow the ability to communicate with thousands of other devices directly or as part of a network, dramatically increasing a product's usefulness.

Yet, for the majority of engineers, RF design remains a black art. But while RF design is not trivial – with some assistance from the chip supplier and a decent development kit – it's not beyond the design skills of a competent engineer.

Inside ULP Wireless

> ULP wireless connectivity can be added to any portable electronic product or equipment featuring embedded electronics

ULP wireless technology differs from so-called low power, short-range radios such as Bluetooth technology (now called Classic Bluetooth to differentiate it from the recently released Bluetooth v4.0 which includes ultra low power Bluetooth low energy technology) in that it requires significantly less power to operate. This dramatically increases the opportunity to add a wireless link to even the most compact portable electronic device.

The relatively high power demand of Classic Bluetooth – even for transmission of modest volumes of user data – dictates an almost exclusive use of rechargeable batteries. This power requirement means that Classic Bluetooth is not a good wireless solution for 'low bandwidth – long lifetime' applications and it's typically used for periods of intense activity when frequent battery charging is not too inconvenient.

Classic Bluetooth technology, for example, finds use for wirelessly connecting a mobile phone to a headset or the transfer of stored digital images from a camera to a Bluetooth-enabled printer. Battery life in a Classic Bluetooth-powered wireless device is therefore typically measured in days, or weeks at most. (Note: There are some highly specialised Classic Bluetooth applications that can run on lower capacity primary batteries.)

In comparison, ULP RF transceivers can run from coin cell batteries (such as a CR2032 or CR2025) for periods of months or even years (depending on application duty cycle). These coin cell batteries are compact and inexpensive, but have limited energy capacity, typically in the range of 90 to 240mAh (compared to, for example, an AA cell which has 10 to 12x that capacity) – assuming a nominal average current drain of just 200µA.

This modest capacity significantly restricts the active duty cycle of a ULP wireless link. For example, a 220mAh CR2032 coin cell can sustain a maximum nominal current (or discharge rate) of just 25µA if it's to last for at least a year (220mAh/(24hr x 365days)).

ULP silicon radios featuring peak currents of tens of milliamps – for example, current consumption of Nordic Semiconductor's nRF24LE1 2.4GHz transceiver is 11.1mA (at 0dBm output power) when transmitting and 13.3mA (at 2Mbps) when receiving. If the average current over an extended period is to be restricted to tens of microamps, the duty cycle has to be very low (around 0.25%) with the chip quickly reverting to a sleep mode, drawing just nanoamps, for most of the time.

Diverse Applications

If a transceiver is asleep for 99.75% of the time, it has to work very hard when awake to achieve anything useful. ULP transceivers do this by waking up quickly, sending very short but relatively high-bandwidth "bursts" of data (up to 1 or 2Mbps), before immediately returning to the low energy consumption sleep state.

As we've seen, because they draw on such modest power reserves, ULP RF transceivers are not capable of high duty cycle applications and, therefore, don't compete directly with Wi-Fi and Classic Bluetooth applications. However, ULP operation does open up a wide new range of applications that are beyond the capabilities of other wireless technologies.

The sheer diversity of these applications is remarkable. ULP wireless has already made inroads into the sports, health, entertainment, PC peripherals, remote control, gaming, mobile phone accessories, home automation and industrial control sectors and will spread to many others in the coming years.

These applications have one thing in common that plays to the strength of ULP wireless technology – they're based on compact sensors and peripherals with small batteries. These devices send small quantities of data (typically a few bits) infrequently (i.e. once every few seconds to a few times per second at most). Despite this commonality, applications as diverse as a wireless PC peripheral (for example, a wireless mouse), a bike computer and associated performance sensors (such as a speed and distance monitor), an RF remote control and a medical sensor (such as a heart rate monitor) demand very different engineering solutions.

In simple terms, wireless connectivity requires a radio (the transceiver), a protocol (the software code or "stack" that controls how the radio communicates) and an application processor (with its own code that supervises the specific application, such as a heart rate monitor). But how these elements are implemented affects the efficiency, size and cost of the wireless system.

To illustrate the point, let's consider two examples employing different approaches: a wireless mouse and a bike computer.

A wireless mouse is a relatively simple, but certainly not trivial, high-volume ULP RF application. Wireless mice manufacturers demand a compact, efficient and inexpensive connectivity solution. In other words, they want their wireless mouse to be sleek, feature long battery life and retail at a price that large numbers of consumers can afford.

This best alternative for this application is a System-on-Chip (SoC) comprising radio, a factory-supplied protocol and application processor on a single slice of

Figure 2: Nordic's proprietary ULP transceiver, the nRF24AP2, dominates wireless connectivity in the cycling sector. [Courtesy: Suunto]

EXTENDING BLUETOOTH

THE BLUETOOTH SIG HAS EXTENDED ITS BLUETOOTH TECHNOLOGY WITH A VERSION THAT CAN OPERATE FROM COIN CELL BATTERIES.

So-called Bluetooth low energy has been designed to allow sensors and peripherals to communicate with each other and devices such as the next generation of mobile phones.

In December 2009, Bluetooth low energy was adopted as part of Bluetooth Core Specification Version 4.0. Nordic Semiconductor has played a significant role in the development of the specification, donating its extensive ULP wireless design heritage to the technology.

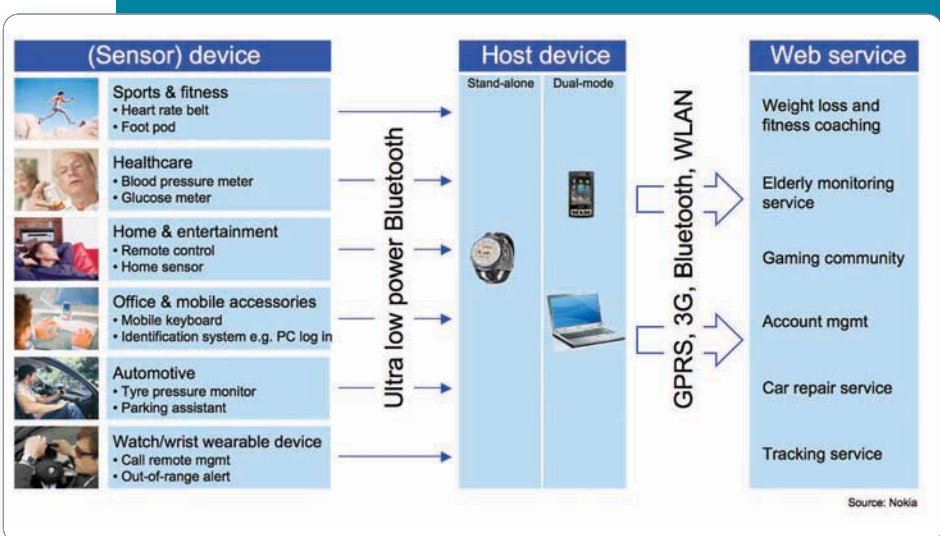
Semiconductor vendors are now shipping Bluetooth low energy chips. Nordic, for example, recently announced the first in its µBlue Series of Bluetooth low energy chips. The first product in the µBlue family is the nRF8001 – a complete Bluetooth low energy solution in a 32-pin 5 x 5mm QFN package incorporating a fully embedded radio, link controller and host subsystem – suitable for watches, sensors and remote controls among other applications. Casio's recently released G-SHOCK Bluetooth Low Energy Watch uses this chip, see left.

The watch is one of the first commercial products to employ Bluetooth low energy and includes features such as time correction from smartphone to watch, incoming call, email and SMS alert notifications from smartphone to watch and a finder function that enables users to locate a misplaced phone.

The Bluetooth SIG's stated intention is to follow up the publication of Bluetooth Version 4.0 with the release of Profiles for Bluetooth low energy technology including Personal User Interface Devices (PUID) (such as watches), remote control, proximity alarm, battery status and heart rate. Other health and fitness monitoring profiles such as blood-glucose and -pressure, cycle cadence and cycle crank power will follow, see Figure 4 below.

Figure 3a and 3b: Nordic's µBlue nRF8001 is the company's Bluetooth low energy chip and has been selected by Casio for its G-SHOCK Bluetooth low energy watch

Figure 4: Early applications for Bluetooth low energy will be in the sports, healthcare and entertainment sectors



silicon. The high volumes offset the vendor's higher non-recurring engineering (NRE) costs from developing a SoC. In addition, the vendor can optimise the hardware and software performance to meet the demands of the target application.

The key advantage for the customer (the mouse maker) is that they don't have to spend development time and dollars selecting and purchasing an external processor (and associated development kit) and then generating the code to run the application. The transceiver vendor has already done the work as part of the SoC design. (Although, if desired, the customer can still develop their own protocol using development and evaluation kits supplied by the transceiver vendor.)

Nordic, for example, supplies its nRF24LE1 SoC to the desktop peripherals market. The nRF24LE1 comprises a Nordic nRF24L01+ 2.4GHz ULP transceiver, Gazell software protocol stack in flash or one time programmable (OTP) memory and an enhanced 8-bit microcontroller. This single-chip device measures just 5mm x 5mm, allowing it to fit into even the smallest of wireless mice designs.

An nRF24LU1+, another SoC that integrates a Nordic nRF24L01+ transceiver, USB 2.0 compliant device controller, flash (or OTP) memory an 8-bit microcontroller, that plugs into the USB port of the "host" PC to complete the wireless link. The nRF24LU1+ allows PC peripheral manufacturers to make tiny USB dongles whose physical profile hardly extends beyond the USB port of the host computer, see Figure 1.

Single-Chip Connectivity

A SoC has many advantages for high-volume applications. But there are some drawbacks; for example, the high level of integration required for a SoC increases the part's size and therefore its cost. As described earlier, wireless SoCs typically include a microcontroller, but many applications already employ such a device to run other functions which could also be used to control the wireless application.

Moreover, some design engineers prefer to choose their own microprocessor – because, for example, they have lots of expertise of working with a particular device – rather than being stuck with the one the comes with the transceiver. In these cases it would be more convenient (and cheaper) to buy a transceiver without an onboard microprocessor.

For example, consider a wireless bike computer. Professional and amateur cyclists

> If a transceiver is asleep for 99.75% of the time, it has to work very hard when awake to achieve anything useful

alike use these handlebar-mounted devices to monitor performance sensors such as heart rate monitors, speed and distance pods, cadence monitors and crank power meters. The bike computer is a sophisticated device that has its own processor that can also be used to supervise the wireless function so there is no need for the wireless chip to integrate an embedded processor, see Figure 2.

The chip used by the wireless sensors and bike computers preferred by the professionals is Nordic's nRF24AP2. This device features a 2.4GHz ULP transceiver, ANT wireless protocol and high-quality microcontroller/processor interface in a single chip. There is no application processor on the chip, saving cost, reducing power consumption and shrinking chip size. In use, the nRF24AP2 looks after the wireless connectivity and links seamlessly to the application processor in the bike computer that supervises the wireless application. Nordic refers to this approach as "Single-Chip-Connectivity" as it precisely describes the functionality offered.

Demand for Interoperability

A proprietary wireless connectivity solution (i.e. one that uses technology belonging to a single company) will always outperform an interoperable technology such as ZigBee or Bluetooth. Why? Because the manufacturer is able to optimise the protocol without the encumbrance of the additional overhead required for assured interoperability. The benefit is a more efficient solution with lower power consumption and reduced cost. The drawback is that lack of interoperability.

A proprietary wireless connectivity solution's lack of interoperability with devices from other chip manufacturers is a problem for OEMs that require a technology that's guaranteed to seamlessly connect with wireless chips in other companies' products; for example, the bike computer in the earlier example linking to sensors made by other firms. Such standardised interoperability is typically underwritten by a formal alliance of commercial companies such as the ZigBee Alliance, standards bodies such as IEEE, or trade associations such as the Bluetooth SIG. Products must be tested to the relevant specification in order to qualify for interoperability certification to a particular standard.

Although enhancements to standards can take a long time to emerge, and testing to gain certification takes time and adds expense for product developers, the advantages are significant. Interoperable solutions tend to stimulate market growth because equipment manufacturers gain confidence that the technology will be available for many years; there is a multiple source chip-supplier market, increasing competition and driving down prices, and quality is assured because chip makers have to pass a regulated certification process.

The ANT+ technology described here is one example of an interoperable ULP wireless technology. It is supervised by an alliance of over 220 companies and has been adopted as a de facto standard by manufacturers such as Garmin and Trek in the cycling sector. And, recently, in addition to Nordic Semiconductor, another semiconductor company has started to offer ANT chips.

However, the most successful interoperable short range RF solution (in terms of shipment volumes) is still Bluetooth wireless technology. ●

WIDESPREAD USE

THE LOW COST AND LOW MAINTENANCE (BECAUSE BATTERIES REQUIRE ONLY INFREQUENT CHANGES) OF BLUETOOTH LOW ENERGY SENSORS WILL ENCOURAGE WIDESPREAD USE IN PUBLIC PLACES.

One key application could be indoor location, where there is no GPS signal, whereby sensors around a large public building such as an airport or rail station constantly broadcast information about their location. A Bluetooth low energy equipped cell phone passing within range could then display that information to its owner. Sensors could transmit other information such as flight times and gates, location of amenities, or special offers from nearby shops, see Figure 5 below.

Bluetooth v4.0 chips are also becoming available. Devices such as cell phones should start to incorporate these chips in the second half of 2011. Once that happens, the full potential of this exciting new technology will start to be realised.

As Nordic Semiconductor's CEO, Svenn-Tore Larsen, puts it: "Once designers have an inexpensive way to add an interoperable wireless link to anything that's battery powered, even devices with the smallest batteries, the application potential is vast. Designers will come up with thousands of ways to use that link."

Figure 5: Inside a large building such as an airport terminal Bluetooth low energy tags could be placed in strategic locations to inform cell phone-equipped passengers of their location

NEW BENCHMARK FOR SIZE, POWER DENSITY AND SYSTEM DESIGN FLEXIBILITY FOR DC-DC CONVERTERS

C. R. SWARTZ, PRINCIPAL APPLICATIONS ENGINEER AT PICOR CORPORATION IN THE US, LOOKS AT THE BENEFITS OF COMBINING TWO POWER ARCHITECTURES TO DELIVER THE BEST OF BOTH WORLDS IN POWER CONVERSION

Today's circuit boards in leading-edge applications, such as communications and network servers, pack ever-increasing processing power into less and less board area. Power supplies must keep pace if they are not to become the limiting factor in such designs. The demands of high-density processors and other large ICs dictate point-of-load power regulation, yet board area devoted to power supply is lost to revenue-earning features.

Distributed power architectures have evolved over time to match system needs. For telecom systems operating between 36V-75V, the DPA (distributed power architecture) and the IBA (intermediate bus architecture) are commonly used, depending on the power level and the number of voltage rails employed. For higher powered systems, efficiency can benefit from busing 48V or higher voltages across the system backplane and converting 48V to the POL voltage level desired.

Figure 1 shows a typical DPA topology and Figure 2 shows a typical IBA architecture topology. The DPA converts AC to either 36V-75VDC or a narrower range of 36V-60VDC. Each output is supplied by an isolated DC-DC converter sized for the load current. This method maximizes overall efficiency due to the lower number of "serial" conversion stages and lower distribution losses, but at higher cost and larger board area.

Figure 1: Distributed Power Architecture (DPA)

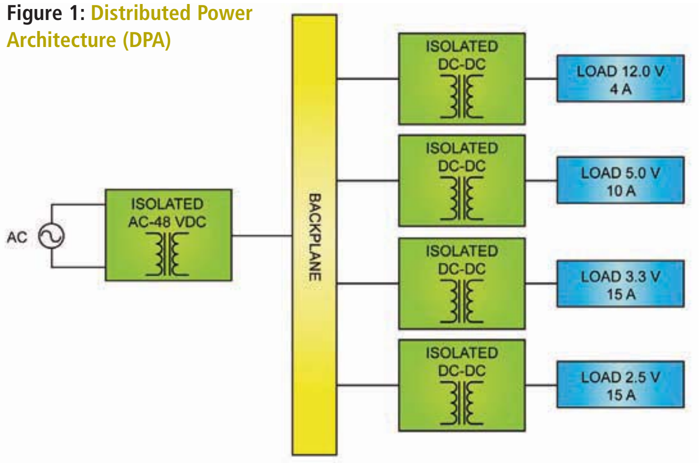
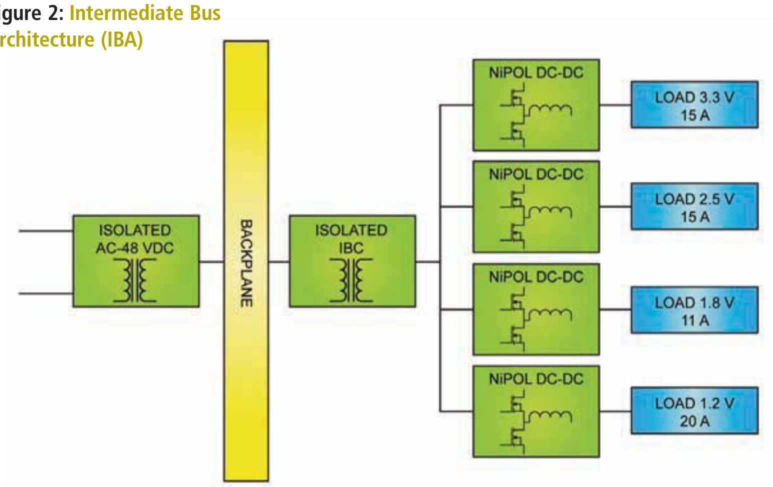


Figure 2: Intermediate Bus Architecture (IBA)



The IBA also uses wide or narrow-range AC/DC conversion. For wide range requirements a regulated or semi-regulated, isolated bus converter (IBC) steps down to the optimum level for narrow range non-isolated point-of-load converters (NiPOLs). For the narrow range case, the isolated DC-DC converter can be either semi-regulated or even unregulated completely, yielding highest power density and efficiency for an IBA topology, while the wider range regulated and semi-regulated cases give lower efficiency and density.

In the unregulated case; the input voltage to each NiPOL varies by 1/K, where K is the step down ratio of the IBC. The advantage of the IBA is that using smaller NiPOLs and one isolated power stage minimizes size and cost. Overall system efficiency vs DPA is reduced because each voltage rail undergoes a double conversion process

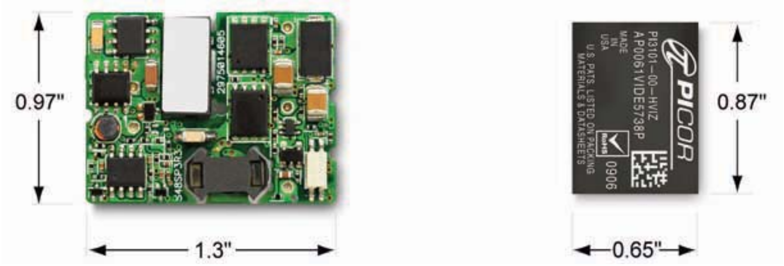


Figure 3: PI3101 compared with a competing solution

Figure 4: High Density PI3101 Solution

and the distribution losses increase by the square of the intermediate bus current. As the intermediate bus voltage is one-quarter or less than in DPA topology, currents are higher and the intermediate bus voltage may not yield the optimum efficiency for each NiPOL.

Combining Advantages

A topology that combines the advantages of both DPA and IBA could reduce system size, maintain efficiency and still bring power directly to the point of load, with potentially fewer conversion stages. Advances in isolated DC-DC converters allow this progression. A new design of 3.3V output, 60W ultra-high density isolated DC-DC converter achieves power density of $25W/cm^3$ and $16.5W/cm^2$ across an input voltage range of 36V-75V. A high efficiency soft-switching power architecture combined with an innovative integrated Power-System-in-Package (PSiP) packaging concept, delivers the power previously expected of an isolated 1/16th brick, from a package that is less than half the size, as shown in Figures 3 and 4.

This power converter can reduce the size of some existing DPA systems that use multiple 1/16th bricks simply by replacement. A range of available output voltages allows delivery of an isolated voltage at the point of load regardless of the topology of the bus architecture. The same solution is applicable to lower power solutions as well. The 22mm L x 16.5mm W x 6.7mm H package is believed to be the smallest available isolated power solution that combines isolation, transformation and regulation, even at 25W.

Chip-Style Package

Among the concepts employed within the IC-style package are:

- Patented Double-Clamped Zero Voltage Switched (DCZVS) Buck-Boost topology.
- Advanced planar magnetics with extremely low leakage inductance and superior power transfer from primary to secondary.
- A high level of silicon integration and proprietary gate drive techniques allow for precise timing and management of the power conversion stage, that switches in excess of 1MHz.
- Sampled feedback control removes optical isolation and simplifies feedback loop compensation requirements.
- Proprietary, high performance MOSFET technology has best-in-class figure-of-merit ratings.

The high density, surface-mount PSiP packaging facilitates PCB layout optimization for high switching frequency, offers several options for cooling and is mechanically rugged, improving reliability.

The package contains all of the necessary circuitry for a completely isolated and regulated power supply that can be trimmed ±10% using a resistor. For starting up into high capacitive loads, a soft start capacitor can be added externally.

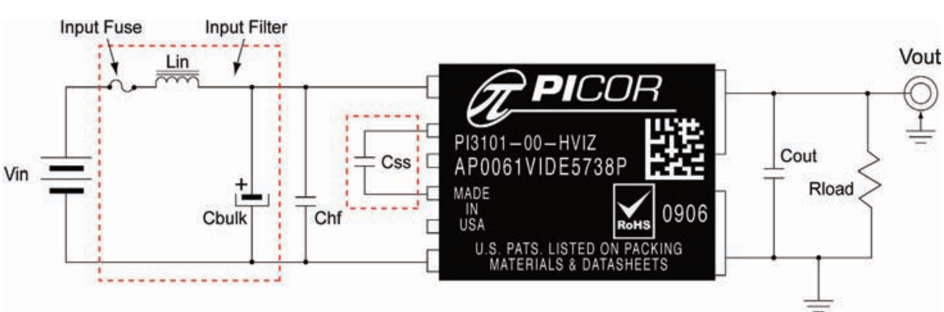


Figure 5: A complete power system; note that the fuse and input filter are likely to exist inside the system, and additional external soft-start capacitance is optional

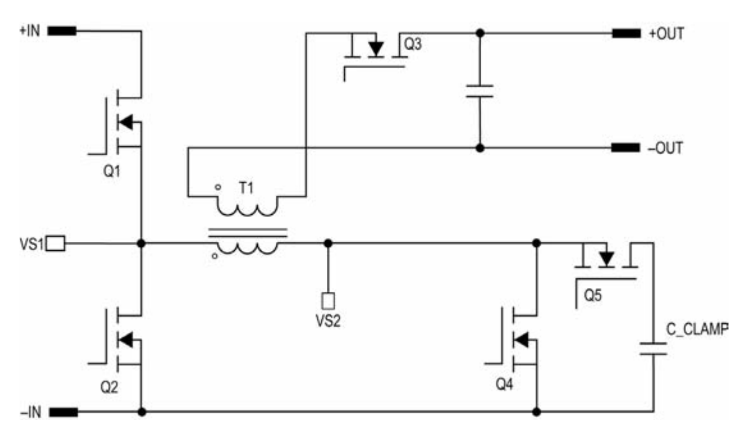
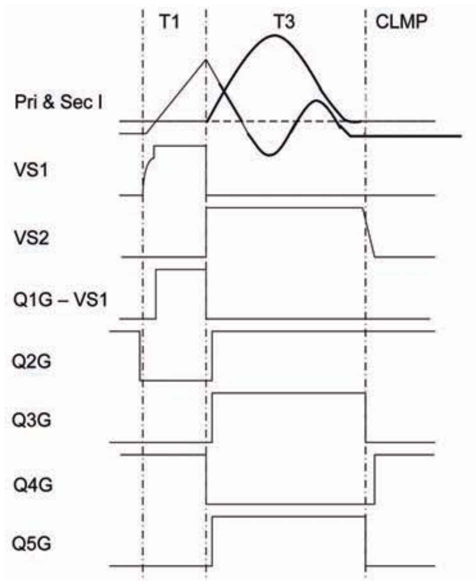


Figure 6: The topology of the DCZVS principle illustrates the basic theory of operation of the module

Figure 7: DCZVS power transfer process



> Overall, system efficiency of IBA vs DPA is reduced because each voltage rail undergoes a double conversion process and the distribution losses increase by the square of the intermediate bus current

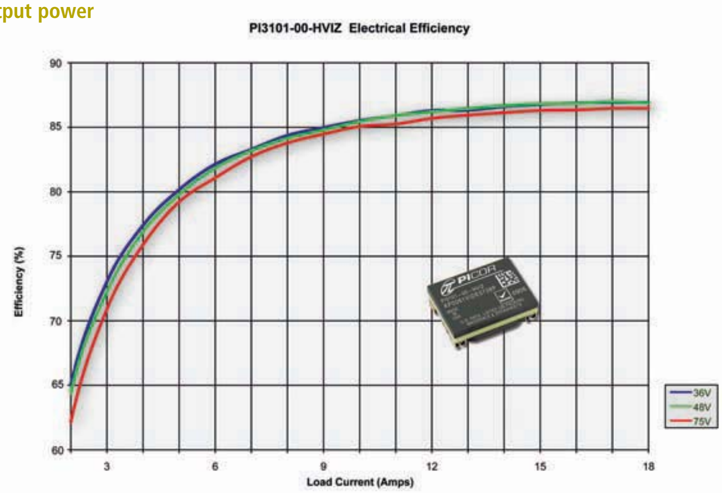
The device has remote on/off control, fault alarm indication and generates a 5V reference along with temperature measurement represented as an analog voltage. Protection features include two current limits to protect against short circuit and overload, input over voltage and under voltage lockout with auto restart, output over voltage protection with automatic recovery and over temperature shutdown with automatic recovery. Figure 5 shows how it can form a complete power supply.

Power Conversion Cycle

Operation is based on a Double-Clamped Zero Voltage Switched power stage (Figure 6), operating in discontinuous conduction mode at over 1MHz. Four primary MOSFETS and a synchronous MOSFET form the power delivery subsystem. Q1 and Q4 are power switches and Q2 and Q5 are clamp switches. Q3 depicts the synchronous MOSFET.

The power cycle has six distinct phases of operation beginning with the end of the previous cycle, as shown in Figure 7.

Figure 8: Electrical efficiency over line of the new device architecture, up to 60W output power



1. Transition to T1 From Clamp Phase: Q2 and Q4 are both on, Q5 and Q1 are both off. The clamp capacitor connected to Q5-D is charged up to the reflected voltage which is equal to Vout * (Np/Ns). If the transformer core is properly reset, the minimum period timer initiates Q2 turn off. If additional reset time is needed, the minimum period is extended until core reset is complete. The clamp current flows as long as Q2 and Q4 are both on and transitions to magnetizing current as Q2 is turned off and volt-seconds are developed across the primary winding. This magnetizing current must continue to flow and the VS1 node rises towards Vin as the D-S capacitance of Q2 charges and Q1 discharges. As VS1 rises, the monitoring of primary volt-seconds is enabled by the controller.

2. T1 Power Stroke Phase: Q1 turns on at virtually zero voltage and the primary current ramps up in the transformer, storing the required energy determined by the internal error amplifier, as a function of load current and line voltage. At this instant, Q1 and Q4 are both on. Monitoring of primary volt-seconds is started by the controller.

3. Transition to T3 Phase: Q1 and Q4 are turned off very rapidly. The driver and MOSFETs allow this transition to occur in a virtual lossless manner. Both the transitions of VS1 falling and VS2 rising occur very rapidly, setting the stage for power transfer from primary to secondary. All switches are off at this time.

4. T3 Power Delivery Phase: Q2 and Q5 turn on followed by the Synchronous MOSFET Q3. Q3 turns on (and off) at

Figure 9: Efficiency of a representative 1/16th brick converter, over line, up to 50W output power

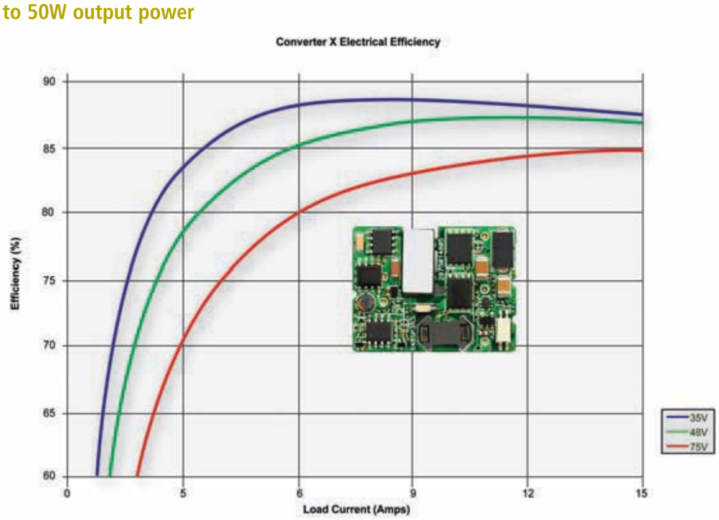


Figure 10: DPA using four 1/16th bricks

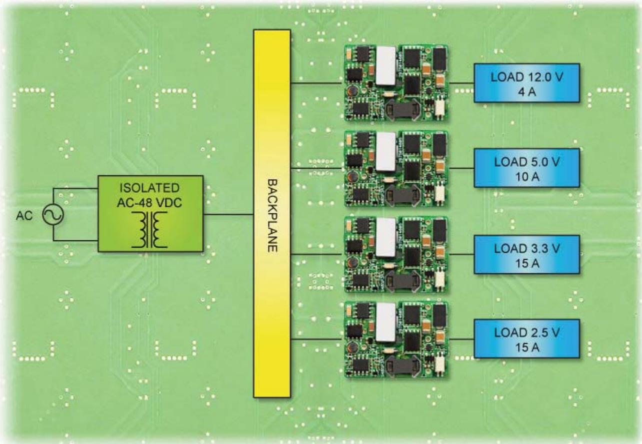


Figure 11: DPA using the new modules with board space saving of 50%

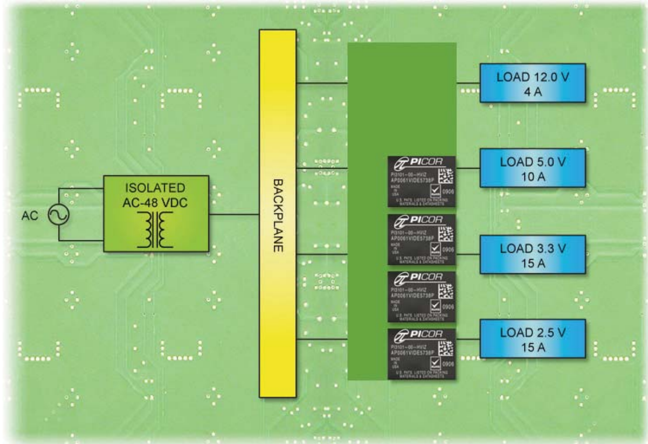


Figure 12: IBA using an isolated 1/8th brick and four DOSA NiPOLs

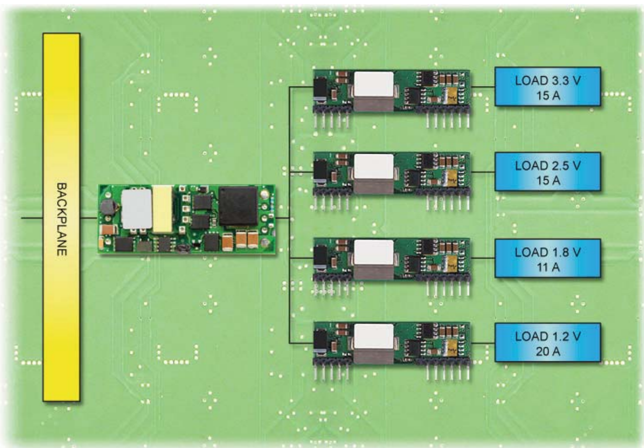
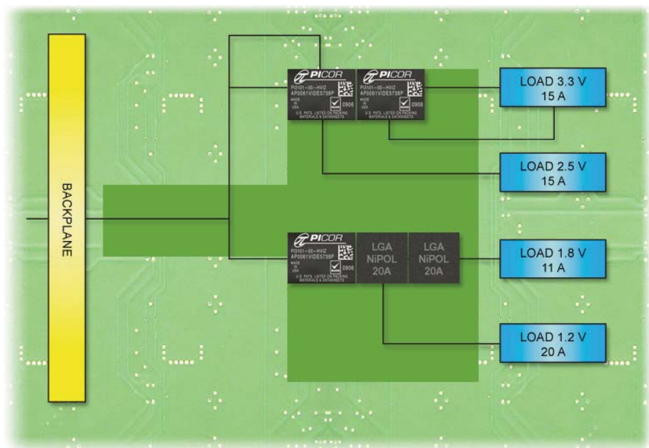


Figure 13: Reconfigured IBA using PI3101 with over 60% board space savings



the optimum time for lossless switching due to the resonant circuit formed by the transformer inductance and the clamp capacitor and the intelligent gate driver. The secondary current ramps up as the stored energy in the transformer is released to the load and output capacitors

5. Clamp Phase Transition: At the end of T3 when the energy has been delivered to the load, Q3 turns off as dictated by its driver. The main controller monitors the primary volt-seconds and determines when transformer reset is complete and turns Q5 off. VS2 falls and allows for the zero-voltage turn on of Q4.

6. Clamp Phase: Q2 and Q4 are turned on again. The output voltage is monitored through a sampled feedback interface. The next cycle is started by the time-out of the minimum period timer. The energy remaining from the clamp phase is used to zero voltage switch the VS1 node.

Relative Performance

Figure-of-merit (FOM) comparisons among isolated power converters in terms of size, power density, efficiency and transient response are straightforward, but few isolated precursor products exist. The nearest comparison is with the best of today's 1/16th brick isolated converters; the new device has comparable efficiency

Figure 14: A typical discrete based embedded isolated DC-DC converter schematic

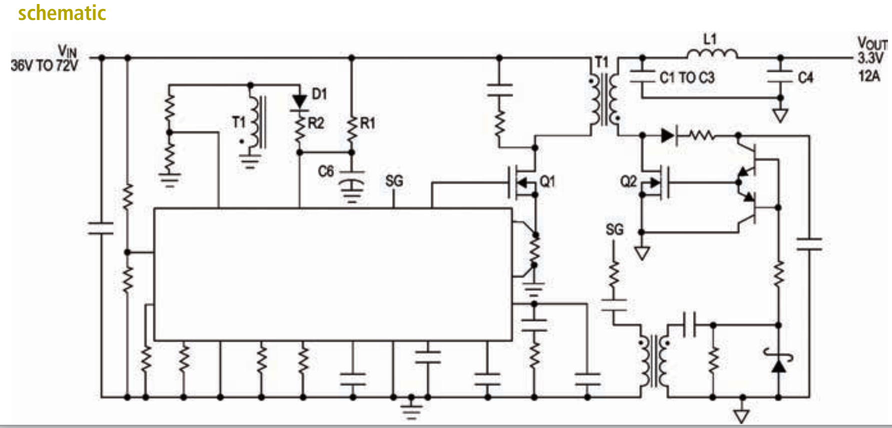


Figure 15: A module-based 60W total solution versus embedded solution recommended transformer size for a 40W solution

but, in a footprint occupying less than half the PCB area, offers better than twice the power density of the highest power 1/16th brick and nearly 3.5 times the power density of the industry average for a regulated 1/16th brick. In fact, if a leading-specification 1/16th Brick converter had equal power density to the new architecture, it could produce nearly 180W of output power from that footprint, rather then the 82.5W it does achieve. Figures 8 and 9 show efficiency curves over the power range of interest. The new architecture also meets typical requirements in terms of average load capabilities, transient response and output accuracy.

Freeing valuable PCB space

Conventionally, the DPA configuration of Figure 1 could be realised with our 1/16th bricks; using the new modules, total size could be halved. Figure 10 shows a scaled version of the actual 1/16th bricks employed and Figure 11 shows the resulting difference in size.

The IBA solution shown in Figure 2 has a total output power of roughly 130W. If the input bus is a wide-range 36-75V and a fixed-bus IBA is used, the isolated converter will probably need to be an 1/8th brick. We can show each output NiPOL to be a DOSA-compatible [DOSA – Distributed-power Open Standards Alliance, **www.dosapower.com**] DC-DC converter. The system diagram in scaled version would look like Figure 12. One might argue that the DC-DC NiPOLs can be mounted vertically, so they don't take up much space flat on the board. However, the new package format can also be mounted in a similar fashion. High current, high density NiPOLs could be employed for the 1.8V and 1.2V rails, stepped down from the 3.3V output. The resulting system could be reduced in size as shown in Figure 13. This approach saves over 60% board space by eliminating the area of an 1/8th brick and the equivalent space of two 1/16th bricks.

The fully isolated module is only 0.22 inches longer than state-of-the art high density non isolated DC-DC converters, and is also lower-profile than typical DOSA DC-DC converters, realizing the ambition of iPOL (Isolated Point-of-Load) conversion; 48V busing of isolated power can be applied immediately at the low voltage point-of-load for maximum flexibility.

The Custom-Designed Alternative

An alternative approach for the power system designer is to develop a custom power supply using an embedded isolated DC-DC converter based on the PWM controllers available from several semiconductor suppliers. Figure 14 illustrates an example of a typical reference design, a Synchronous Flyback Converter which does not require optical feedback. This design claims low parts count compared to some other alternatives, and it is optimized to deliver 40W or 12A at 3.3V output. Its bill-of-materials runs to 45 components – possibly including two custom magnetic parts if output voltage or current differ from those in the reference design.

Figure 15 shows that just the recommended power transformer for the reference design is larger than the complete solution using the new-technology converter – before the other 44 components are placed and routed. A smaller transformer would likely be possible, but only by exploring higher switching frequency, planar magnetics and a design process to ensure the transformer has the lowest leakage inductance, core losses and winding losses; sub-optimal magnetic design can cost 2-3% or more in efficiency. Then, a custom design will require safety testing and abnormal fault testing before transitioning to production.

Other Applications

These high density converters are also suited to the new high power standard of Power-over-Ethernet (PoE). A single module can provide the maximum power permitted under the standard, from the minimum area and volume. Similarly, the package's very low weight suits it to weight sensitive applications such as aircraft and man-mobile equipment. Applications that require very tight regulation, such as remote sensing, are also ideal candidates.

New Generation

The evolutionary pressures arising from high-power, high-density system design have given rise to a new generation of isolated DC-DC converter capable of delivering 60W of isolated, regulated power from a package 50% reduced in size. System designers can cut the size of their existing power solutions and devote the freed space on their PCBs to increased system functionality; they can place power exactly where it is needed with relative ease and with very short design cycle times. ●

> System designers can cut the size of their existing power solutions and devote the freed space on their PCBs to increased system functionality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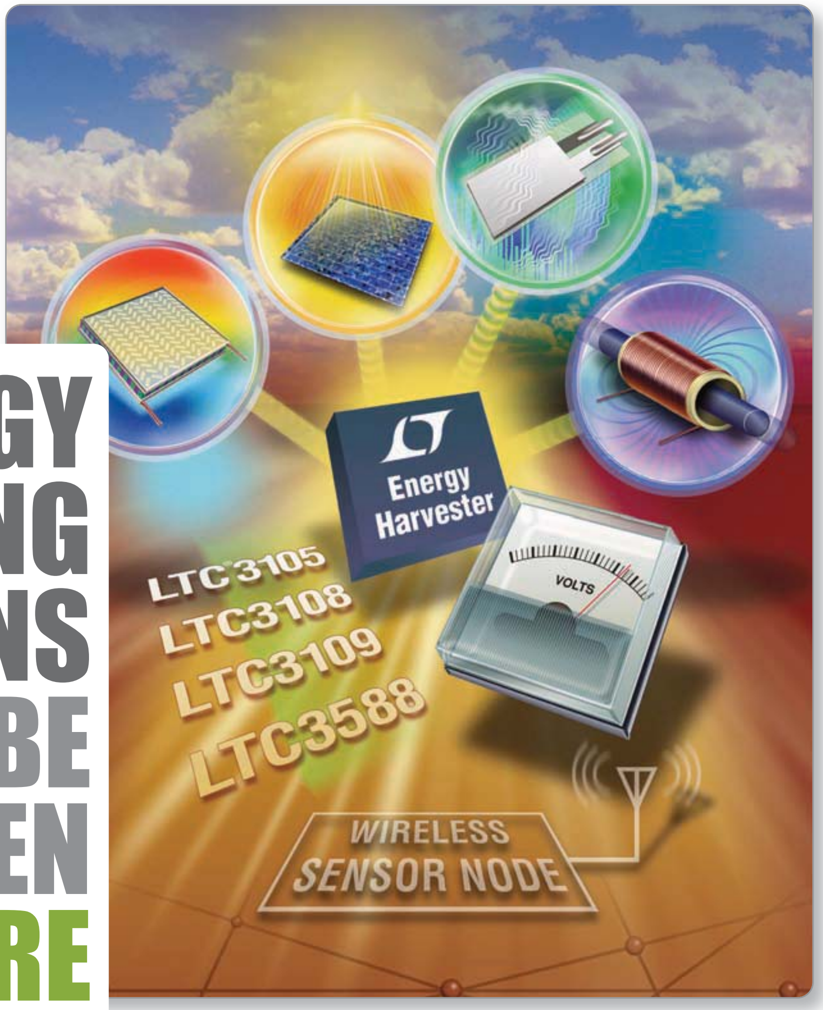
TONY ARMSTRONG, DIRECTOR OF PRODUCT MARKETING FOR POWER PRODUCTS AT LINEAR TECHNOLOGY, LOOKS AT THE CONCEPT OF ENERGY HARVESTING AND THE SOLUTIONS THAT ALREADY EXIST READY FOR DESIGN-INS



ENERGY HARVESTING APPLICATIONS BEGIN TO BE SEEN EVERYWHERE

The concept of energy harvesting has been around for over a decade, but 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 among others.

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. By way of illustration, consider the breakout of energy usage in the United States. Buildings are the number one user of energy production on an annual basis and account for approximately 38% of total energy consumption, closely followed by the transportation and industrial segments at 28% each. Furthermore, buildings can be further broken down into commercial and residential buildings, representing 17% and 21%, respectively of this 38% total. Moreover, this residential building figure of 21% energy consumption can be further broken down, where heating, ventilation and air conditioning (HVAC for short) account for nearly three quarters of the total energy consumption. With energy usage forecast to double between 2003 and 2030, energy savings of up to 30% could be attained by adopting building automation systems according to the World Energy, Technology and Climate policy outlook (WETO) – a consortium of European Union research teams.

Similarly, 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

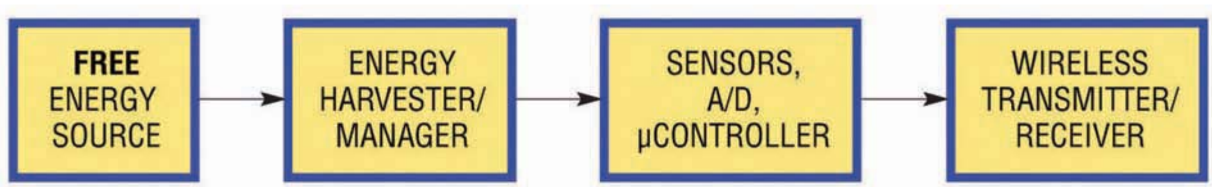


Figure 1: The main blocks of a typical energy harvesting system or wireless sensor node

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.

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.

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. In addition, otherwise wasted energy from industrial processes, solar panels or internal combustion engines can be harvested for useful purposes.

Problems, Issues and Characterization of Energy Harvesting Applications

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.

Several factors affect the power consumption characteristics of an energy harvesting system of wireless sensor node. These are outlined in Table 1.

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

ELEMENTS WITHIN THE WSN	FACTORS AFFECTING POWER CONSUMPTION
Power Supply (or battery)	Discharge rate
	Battery dimensions
	Supply voltages
	Type of electrode material used
	DC/DC efficiency
Sensors	Physical to electrical signal conversion
	Complexity of supporting components
	Signal sampling
	Signal conditioning
ADC	Sampling rate
	Aliasing
	Dither
Microprocessor	Core operating frequencies
	Operating voltages
	Power proportional to process & computational load
	Ambient temperature
	Application code
	Peripheral utilization
Radio	Modulation scheme
	Data rate
	Transmission range
	Operational duty cycle

Table 1: Factors affecting power consumption of a wireless sensor node

> With respect to the energy source choice, there are trade-offs between thermal and piezoelectric sources

ENERGY SOURCE	TYPICAL ENERGY LEVEL PRODUCED	TYPICAL APPLICATION
Small solar panels	100s of mW/cm^2 (Direct sunlight)	Handheld electronic devices
Small solar panels	100s of µW/cm^2 (Indirect sunlight)	Remote wireless sensors
Seebeck devices (which convert heat energy into electrical energy)	10s of µW/cm^2 (Body heat)	Remote wireless sensors
Seebeck devices continued	10s of mW/cm^2 (Furnace exhaust stack)	Remote wireless actuators
Piezoelectric devices (which produce energy by either compression or deflection of the device) wireless actuators	100s of µW/cm^2	Handheld electronic devices or remote
RF energy from an antenna	100s of pW/cm^2	Remote wireless sensors

Table 2: Energy sources and the amount of energy they can produce

	PROS	CONS
Thermal	Able to continuously supply DC power.	Temperature differentials can be difficult to implement in enclosed environments (Note 1).
Piezoelectric	Does not need to be manually charged. The Aircraft provides plenty of vibrational force.	Each element has to be manually tuned to the aircraft's vibrational frequency

Table 3: Comparison between different energy type sources

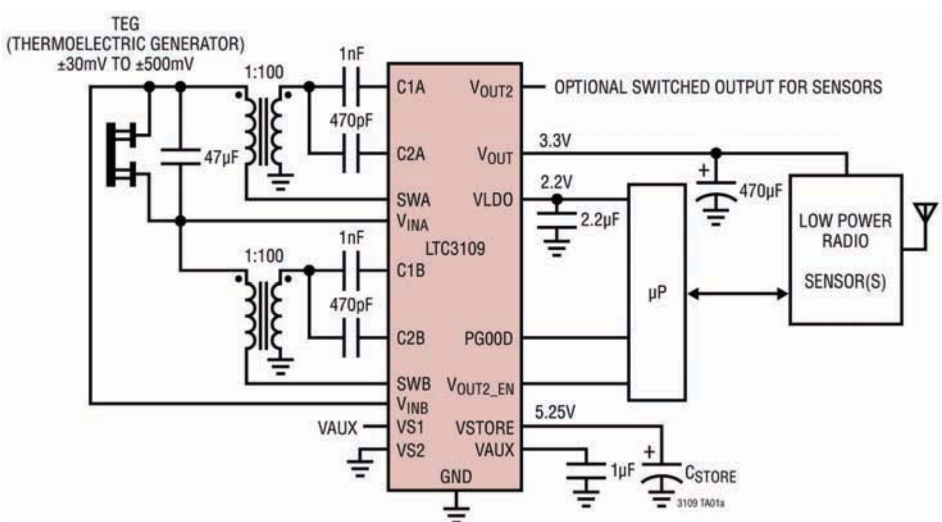


Figure 2: LTC3109 typical application schematic

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. Of course, from a system designer's perspective, this adds a further degree of complexity since they must now take into consideration how much energy must be stored in the secondary reservoir to compensate for the lack of an ambient energy source. Just how much they will require will depend on several factors. These will include:

(1) The length of time the ambient energy source is absent.

(2) The duty cycle of the WSN (that is the frequency with which a data reading and transmission has to be made).

(3) The size and type of a secondary reservoir (capacitor, supercap or battery).

(4) Is enough ambient energy available to act as both the primary energy source and have sufficient energy left over to charge up a secondary reservoir when it is not available for some specified period?

State-of-the-art and off-the-shelf energy harvesting technologies, for example in vibration energy harvesting and indoor photovoltaics, yield power levels in the order of milliwatts under typical operating conditions. While such power levels may appear restrictive, the operation of harvesting elements over a number of years can mean that the technologies are broadly comparable to long-life primary batteries, both in terms of energy provision and the cost per energy unit provided. Furthermore, systems incorporating energy harvesting will typically be capable of recharging after depletion, something that systems powered by primary batteries cannot do.

As already discussed, ambient energy sources include light, heat differentials, vibrating beams, transmitted RF signals, or just about any other source that can produce an electrical charge through a transducer.

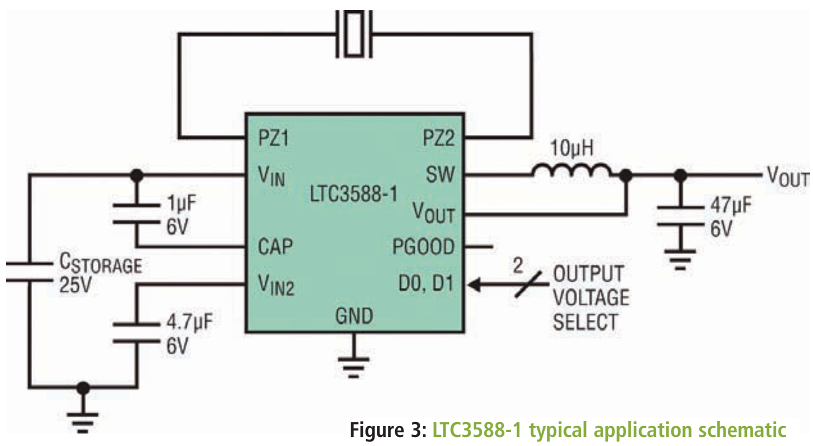


Figure 3: LTC3588-1 typical application schematic

Table 2 illustrates the amount of energy that can be produced from different energy sources.

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. Fortunately low cost and low power sensors and microcontrollers have been available for a couple of years or so; however, it is only recently that ultralow power transceivers have become commercially available. Nevertheless, the laggard in this chain has been the energy harvester.

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. The low conversion efficiency will increase the amount of time required to power up a system, which in turn increases the time interval between taking a sensor reading and transmitting this data.

A Real-Life Example: Aircraft Health Monitoring

The structural fatigue of today's large fleet of aircraft is a real world issue since it can lead to catastrophic consequences if ignored. Currently, airframes are monitored through more inspections, through improved structural analysis and tracking methods and by incorporating new and innovative ideas for assessing structural integrity. This is sometimes referred to as "health monitoring of aircraft". This process incorporates sensors, artificial intelligence and advanced analytical techniques to produce real time and continual health assessment.

Acoustic emission detection is a well-established method of locating and monitoring crack development in metal structures. It can be readily applied for the diagnosis of damage in composite aircraft structures. A clear requirement is a level form of "go", "no go" indications of structural integrity or immediate maintenance actions. The technology comprises low profile detection sensors using piezoelectric wafers encapsulated in polymer film and optical sensors. Sensors are bonded to the structure's surface and enable acoustic events from the loaded structure to be located by triangulation. Instrumentation is then used to capture and parameterize the sensor data in a form suitable for low-bandwidth storage and transmission.

> Systems incorporating energy harvesting will typically be capable of recharging after depletion, something that systems powered by primary batteries cannot do

Thus, although wireless sensor modules are often embedded in various airplane sections for structural analysis, wings or fuselage for example, powering them can be cumbersome. Therefore, these sensor modules are more convenient and efficient when powered wirelessly, or even self-powered. In an aircraft environment there are a number of "free" energy sources available to power such sensors. Two obvious methods which could readily be utilized are thermal energy harvesting and/or piezoelectric energy harvesting.

In the case of a typical airplane engine, its temperature can vary anywhere from a few 100°C to 1,000 to 2,000°C. Although most of this energy is lost in the form of mechanical energy (from combustion and thrust), there is a portion dissipated purely as heat. Since the Seebeck effect is the underlying thermodynamic phenomenon that converts thermal heat to electric power, the main equation to take into consideration is:

$$P = \eta Q$$

where P is electrical power, Q is heat and η is efficiency.

Larger TEGs that use more heat, Q, will produce more power, P. Similarly, the use of twice as many power converters will naturally produce twice the power given that they can capture twice the heat. Larger TEGs are created by putting more P-N junction in series; however, while this created more millivolts per delta T (mV/dT), it also increases the series resistance of the TEG. This increased series resistance limits the power available to the load. Therefore, depending on the application requirements,

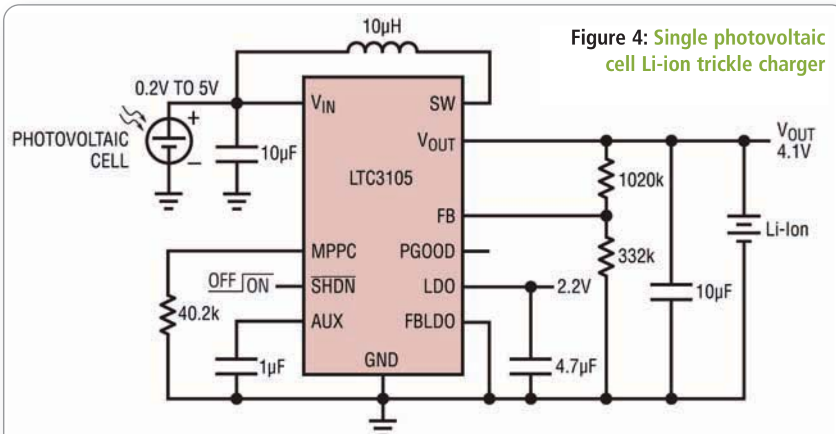


Figure 4: Single photovoltaic cell Li-ion trickle charger

it is sometimes better to use smaller TEGs in parallel rather than using a larger TEG. Regardless of the configuration, TEGs are commercially available from a number of suppliers.

Piezoelectricity can be generated by applying stress to an element, which in turn creates an electric potential. The piezoelectric effect is reversible in that materials exhibiting the direct piezoelectric effect (the production of an electric potential when stress is applied) also exhibit the reverse piezoelectric effect (the production of stress and/or strain when an electric field is applied).

In order to optimize a piezo transducer, one needs to characterize their source for vibration frequency and displacement. Once these levels have been determined, a piezo manufacturer can design a piezo which is mechanically tuned to the specific vibration frequency and size it to provide the necessary amount of power. The vibration in the piezo material activates the Direct Piezo effect, which results in the accumulation of charge on the output capacitance of the device. This is usually pretty small so the AC open circuit voltage is high – of the order of 200V in many cases. Since the amount of charge generated from each deflection is relatively small, it is necessary to full-wave rectify this AC signal and accumulate the cycle-by-cycle charge on an input capacitor.

With respect to the energy source choice, there are trade-offs between thermal and piezoelectric sources. Nevertheless, regardless of which method is selected, both are viable and practical solutions and can be readily deployed with current technology. Table 3 summarizes the pros and cons between these two methods.

Energy Harvesting Power Conversion ICs

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 in Figure 2 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.

For input voltages as low as 30mV, a primary-secondary turns ratio of about 1:100 is recommended. For higher input voltages, a lower turns ratio can be used to obtain greater output power. These transformers are standard, off-the-shelf components, and are readily available from magnetic suppliers such as Coilcraft.

The LTC3109 takes a "systems level" approach to solving a complex problem. It converts the low voltage source and manages the energy between multiple outputs.

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 V_{AUX} pin, providing charge to the external V_{AUX} capacitor and then the other outputs.

The internal 2.2V LDO can support a low power processor or other low power ICs. The LDO is powered by the higher value of either V_{AUX} or V_{OUT}. This enables it to become active as soon as V_{AUX} has charged to 2.3V, while the V_{OUT} storage capacitor is still charging. In the event of a step load on the LDO output, current can come from the main V_{OUT} capacitor if V_{AUX} drops below V_{OUT}. The LDO is capable of providing 3mA of output current.

The V_{STORE} capacitor may be a very large value (thousands of microfarads or even Farads), to provide holdup at times when the input power may be lost. Once power-up has been completed, the main, backup and switched outputs are all available. If the input power fails, operation can still continue by operating off the V_{STORE} capacitor.

The LTC3588-1 is a complete energy harvesting solution optimized for low energy sources, including piezoelectric transducers. Piezoelectric devices produce energy by either compression or by deflection of the device. These piezoelectric elements can produce 100s of uW/cm² depending on their size and construction.

It should be noted that the piezoelectric effect is reversible in that materials exhibiting the direct piezoelectric effect (the production of an electric potential when stress is applied) also exhibit the reverse piezoelectric effect (the production of stress and/or strain i.e. deflection when a voltage is applied).

The LTC3588-1 operates from an input voltage range of 2.7V to 20V, making it ideal for a wide array of piezoelectric transducers, as well other high output impedance energy sources. Its high efficiency buck DC/DC converter delivers up to 100mA of continuous output current or even higher pulsed loads. Its output can be programmed to one of four (1.8V, 2.5V, 3.3V or 3.6V) fixed voltages to power a wireless transmitter or sensor. Quiescent current is only 950nA with the output in regulation (at no load), maximizing overall efficiency.

The LTC3588-1 is designed to interface directly with a piezoelectric or alternative high impedance AC power source, rectify a voltage waveform and store harvested energy in an external storage capacitor while dissipating any excess power via an internal shunt regulator. An ultralow quiescent current (450nA) undervoltage lockout (ULVO) mode with a 1-1.4V hysteresis window enables charge to

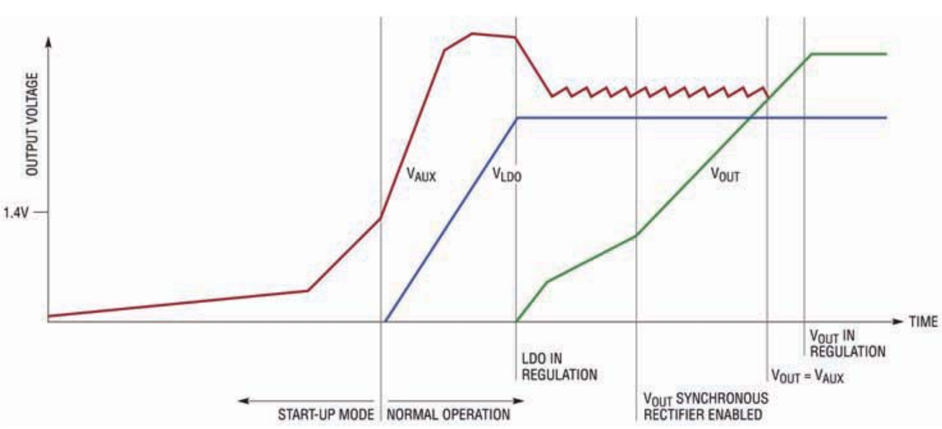


Figure 5: Typical LTC3105 start-up sequence

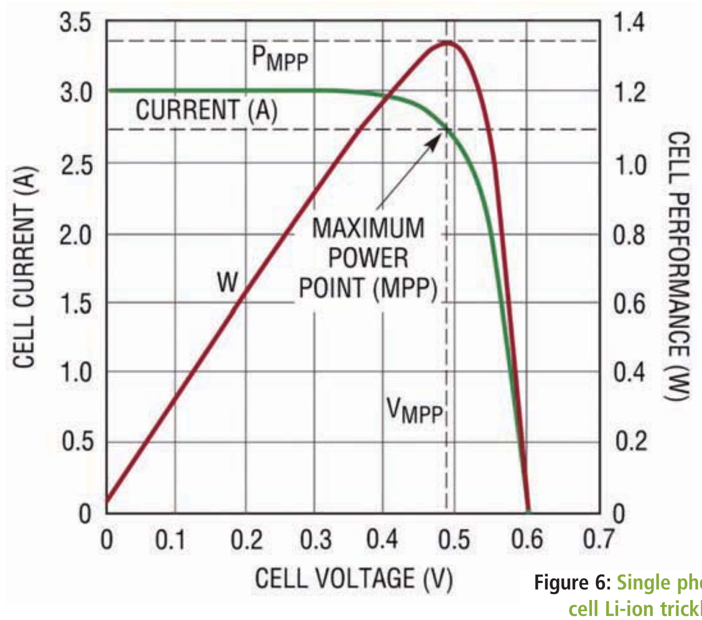


Figure 6: Single photovoltaic cell Li-ion trickle charger

accumulate on the storage capacitor until the buck converter can efficiently transfer a portion of the stored charge to the output.

The LTC3105 is an ultralow voltage step-up converter and LDO specifically designed to dramatically simplify the task of harvesting and managing energy from low voltage, high impedance alternative power sources such as photovoltaic cells, TEGs and fuel cells. Its synchronous step-up design starts-up from input voltages as low as 250mV making it ideal for harvesting energy from even the smallest photovoltaic cells in less than ideal lighting conditions. Its wide input voltage range of 0.2V to 5V makes it ideal for a wide array of applications. An integrated maximum power point controller (MPPC) enables the LTC3105 to extract the maximum available power that the source is capable of providing. Without MPPC, the power converter can only produce a fraction of the source's theoretical maximum capability. Peak current limits are automatically adjusted to maximize power conversion efficiency while BurstMode operation reduces quiescent current to only 22uA minimizing the drain from the energy storage element. The ultra-low Iq LDO is capable of directly powering popular low power microcontrollers or sensor circuitry.

The circuit shown in Figure 4 uses the LTC3105 to charge a single-cell Li-Ion battery from a single photovoltaic cell. This circuit enables the battery to continually charge when the solar source is available and in turn the battery can power the application from the stored energy when the solar power is no longer available.

The LTC3105 provides the capability to start with voltages as low as 250mV. During start-up the AUX output initially is charged with the synchronous rectifiers disabled. Once V_{AUX} has reached approximately 1.4V, the converter leaves start-up mode and enters normal operation. Maximum power point control is not enabled during start-up; however, the currents are internally limited to sufficiently low levels to allow start-up from weak input sources. While the converter is in start-up mode, the internal switch between AUX and V_{OUT} remains disabled and the LDO is disabled. Refer to Figure 5 for an example of a typical start-up sequence.

When either V_{IN} or V_{AUX} is greater than 1.4V, the converter will enter normal operation. The converter continues charging the AUX output until the LDO output enters regulation. Once the LDO output is in regulation, the converter begins charging the V_{OUT} pin. V_{AUX} is maintained at a level sufficient to ensure the LDO remains in regulation. If V_{AUX} becomes higher than required to maintain LDO regulation, charge is transferred from the AUX output to the V_{OUT} output. If V_{AUX} falls too low, current is redirected to the AUX output instead of being used to charge the V_{OUT} output. Once V_{OUT} rises above V_{AUX}, an internal switch is enabled to connect the two outputs together.

If V_{IN} is greater than the voltage on the driven output (V_{OUT} or V_{AUX}), or the driven output is less than 1.2V the synchronous rectifiers are disabled and operate in critical conduction mode enabling regulation even when $V_{IN}>V_{OUT}$.

When the output voltage is greater than the input voltage and greater than 1.2V, the synchronous rectifier is enabled. In this mode, the N-channel MOSFET between SW and GND is enabled until the inductor current reaches the peak current limit. Once current limit is reached, the N-channel MOSFET turns off and the P-channel MOSFET between SW and the driven output is enabled. This switch remains on until the inductor current drops below the valley current limit and the cycle is repeated. When V_{OUT} reaches the regulation point, the N- and P-channel MOSFETs connected to the SW pin are disabled and the converter enters sleep.

In order to power microcontrollers and external sensors, an integrated LDO provides a regulated 6mA rail. The LDO is powered from the AUX output allowing the LDO to attain regulation while the main output is still charging. The LDO output voltage can be either a fixed 2.2V or adjusted via resistor divider.

ENERGY-HARVESTING ICS

A 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 Linear's recent product introductions, the LTC3109, LTC3588-1 and LTC3105 can bring a new level of performance and simplicity. These energy harvesting ICs bring a new level of performance that was just not possible with discrete implementations. As a result, they have become a catalyst for growth for the makers of energy harvesting systems because they can harvest energy from very low levels. This level of performance, coupled with the cost effective price points of the transducers, microcontrollers, sensors and transceivers has led to an increase in market acceptance. This is one of the reasons why there is a significant amount of attention being given to such systems in a variety of applications around the globe.

The integrated maximum power point control circuit allows the user to set the optimal input voltage operating point for a given power source, see Figure 6. The MPPC circuit dynamically regulates the average inductor current to prevent the input voltage from dropping below the MPPC threshold. When V_{IN} is greater than the MPPC voltage, the inductor current is increased until V_{IN} is pulled down to the MPPC set point. If V_{IN} is less than the MPPC voltage, the inductor current is reduced until V_{IN} rises to the MPPC set point.

The LTC3105 incorporates a feature that maximizes efficiency at light load while providing increased power capability at heavy load by adjusting the peak and valley of the inductor current as a function of load. Lowering the peak inductor current to 100mA at light load optimizes efficiency by reducing conduction losses. As the load increases, the peak inductor current is automatically increased to a maximum of 400mA. At intermediate loads, the peak inductor current can vary between 100mA to 400mA. This function is overridden by the MPPC function and will only be observed when the power source can deliver more power than the load requires.

In applications such as photovoltaic conversion, the input power source may be absent for long periods of time. To prevent discharge of the outputs in such cases, the LTC3105 incorporates an undervoltage lockout (UVLO) which forces the converter into shutdown mode if the input voltage falls below 90mV (typical). In shutdown, the switch connecting AUX and V_{OUT} is enabled and the LDO is placed into reverse-blocking mode and the current into V_{OUT} is reduced to 4μA typical. Reverse current through the LDO is limited to 1μA in shutdown to minimize discharging of the output.

Tackling the Power Management Difficulties

With analog Switchmode power supply design expertise in short supply around the globe, it has been difficult to design an effective energy harvesting system as illustrated in Figure 1. The primary hurdle being the power management aspects associated with remote wireless sensing. However, with the introduction of the LTC3105, LTC3109 and LTC3588-1 that's all about to change. These devices can extract energy from almost any source of light, heat or mechanical vibration. Furthermore, with their comprehensive feature set and ease of design, they greatly simplify the hard-to-do power conversion design aspects of an energy harvesting chain. This is good news for the designers of WSN because their high integration, including power management control and off-the-shelf external components, make them the smallest, simplest and easy-to-use solutions available.

As a result, system designers and systems planners have to prioritize the need of their power management from the onset in order to ensure efficient designs and successful long term deployments. Fortunately, there is now a growing number of energy harvesting power management ICs from the leading high performance analog IC manufacturers to greatly simplify this task. ●

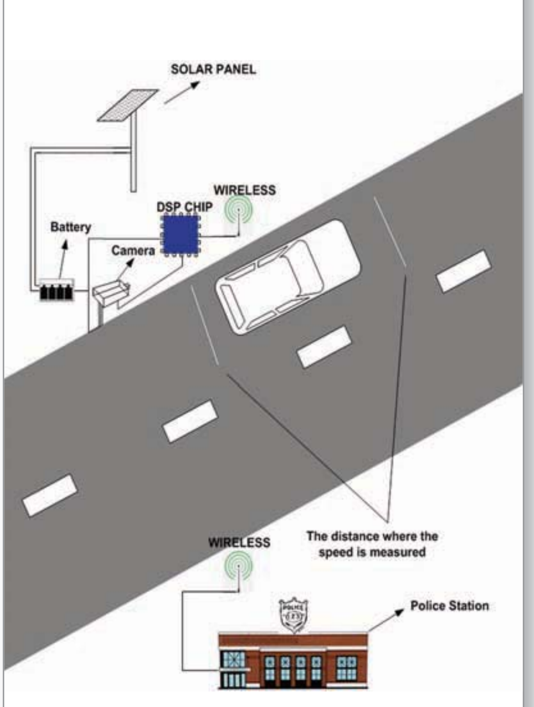
IN THIS ARTICLE, **HÜSEYIN KUSETOĞULLARI** FROM THE UNIVERSITY OF WARWICK AND **TURGAY CELIK** FROM THE NATIONAL UNIVERSITY OF SINGAPORE PROPOSE A ROAD SURVEILLANCE SYSTEM THAT RELIES ON SOLAR POWER FOR ITS WIRELESS COMMUNICATION

A ROAD SURVEILLENCE SYSTEM POWERED BY SOLAR ENERGY AND WIRELESS TRANSMISSION

The ever increasing vehicle numbers in urban and rural areas has brought about many major problems on the roads. In order to prevent accidents involving speeding vehicles, speed camera systems are widely used as a deterrent.

In this article, we propose a solar-powered road surveillance system and wireless transmission of the image of the speeding vehicles that can be implemented at suitable locations without requiring main power supply wiring.

Figure 1: Illustration of the solar-powered road surveillance system



Also in this system, solar energy is used to charge the battery that provides energy for the hardware part of the system, especially when there's lack of sunlight such as on a cloudy day or during night time. Solar panels are providing the energy for this road surveillance system so that speeding vehicles can be detected and tracked by using a different type of image processing method. Previously we've presented an article in Electronics World where image processing techniques were used for traffic security and safety that include queue detection, incident detection, vehicle classification, vehicle counting and to estimate the speed of a car, but these projects did not use solar powered energy and wireless communication. Early designs included vehicle speed measurement sensors, such as magnetic loop detector and radar. In this system, the known physical distance between two marking lines has been applied to distinguish the speed of the vehicles.

In order to determine binary images and measure the speed accurately, a 320 x 240 pixel images caught by a fixed camera are processed by a digital signal processor (DSP). However, delivering such images to a police station/traffic centre may take a long time. Therefore, the license plate is also 'snapped' as the speeding vehicle passes the camera and a smaller image size is sent to the closest police station wirelessly.

There are many different techniques for license plate detection reported in the literature; techniques such as edge detection morphological operators, Hough transform and neural networks. Amidst them there's typically a DSP chip that processes the captured images of the speeding vehicles and their licence plates by a video acquisition device.

System Configuration

Our proposed system here consists of one fixed USB camera that captures the frames; a DSP chip that is used to estimate the speed of the vehicles with image processing techniques; three solar panels that are used to provide electricity and charge the batteries; and an RF transmission system that transmits the licence plate of the speeding vehicle to a nearby traffic centre or police station. The system configuration is shown in Figure 1.

The power supply of the proposed system includes: (1) solar panels, (2) battery charger and (3) battery array. The main principle of the solar panel is to convert sunlight into electricity. The number of sunshine hours per day depends on (1) latitude of the location, (2) inclination angle of the earth and (3) the day of the year. The current solar panels will produce 150W per square meter and, therefore, approximately 2 square meters of solar panels are needed for a smooth operation. The proposed system requires about 268.3W for each day. With two 12V batteries and 100AH, the system can operate for a day without charging of the batteries.

We've tested the system in real conditions, on a road. Two different image processing techniques have been used to estimate the speed of the vehicles. These are:
(1) background subtraction and
(2) interframe difference techniques.

In our measurements, it was determined an average of 97.41% for frame difference and 97.17% for background removal technique for the accuracy of speed measurements. For the speed measurements, using the interframe technique gives better speed estimation results compared to the background removal technique, but the latter is better for tracking of vehicles.

The proposed system operates on a two-lane road using a USB camera to perform its tasks. The camera is fixed to a pole and monitors the traffic in the outgoing direction. The acquired video data is analyzed, where the speed of a vehicle is calculated by measuring the time it travels between two lines of predetermined distance on the road monitored by the camera.

The system has four invisible lines on the road to detect vehicles and estimate their speed. Once a vehicle enters the 'tracking' area, it is tracked in each frame. The video of the tracked vehicles is useful for visual analysis where the vehicles tracked in one direction are enclosed by a blue rectangular box. The speed of each vehicle is measured and the respective frame containing the license plate number is saved for further analysis. Later on the license plate is detected and sent by a wireless link to a police station.

The two pre-determined lines on each lane, used for the calculation of the vehicle speed, are shown in Figure 2. The algorithm can be separated into two stages: binary image generation and tracking of binary moving objects in consecutive frames.

Binary image generation

1. Start the system.
2. Get a reference RGB frame and convert it to a gray scale image.
3. Get the current RGB frame and convert it to a gray scale image.
4. Subtract the current frame from the reference frame to find the difference image, i.e:
5. Calculate the dynamic threshold value using the difference image, i.e:
6. Convert the difference image to a binary image by applying automatic threshold extracted in step 5, i.e:
7. Save the current frame as a reference frame and go to Step 2.

Tracking of binary moving objects

1. Use the binary image and the segment binary image into groups of moving objects.
2. Track each moving object in consecutive frames and for each moving object, find its spatial bounding box coordinates, i.e. upper left side coordinate (x_{b1},y_{b1}), and lower right side coordinate (x_{b2},y_{b2}).
3. Trigger the timing t_1 when the object (in this case a vehicle) passes the first line x_1, i.e $x_{b1} < x_1$.
4. Trigger the timing t_2 when the object passes the second line x_2, i.e. $x_{b2} < x_2$
5. Estimate the speed of the vehicle by:
6. If the speed V is lower than the speed limit then discard the object and go to Step 1.
7. Extract the licence plate using colour information.
8. Send the licence plate image to the police office via wireless network.
9. Go to Step 1.

License Plate Detection

The system detects the speed of the vehicles and takes the images of the vehicles that break the speed limits. The detected license plates of the speeding vehicles are then sent to a nearby police station by wireless communication. However, since the size of the frames is huge, it may take a long time to transmit the image, which makes the system cumbersome as many vehicles use the road and there may be many speed violations. The size of an image taken of the license plates of the speeding vehicles are much smaller and as such they can be sent out in a shorter time, which leads to fast processing of the traffic fines.

Solar Energy and Wireless Transmission

In our system there are three PV (photovoltaic) cells used to convert sunlight to electricity. The cells have a life span of at least 25 years. Our batteries' charging time is changing according to the number of sunshine hours in a day. In our research we found that the Sun is at its lowest angles during the months of January and December and at the highest angles in June and July (we tested the system in Cyprus). The solar panel used in the system is 565 x 1250 x 34mm in size.

For instance, the camera needs 850mA current with 12V in an hour and it means that the required power to run the camera is 10.2W per hour.

The charging time (CT) of the battery (2.25 days) is calculated for the worst case scenario of 5.5 hours of sunlight in a day, based on a sunny day in December.

Figure 2: Configuration of the speed measurement system

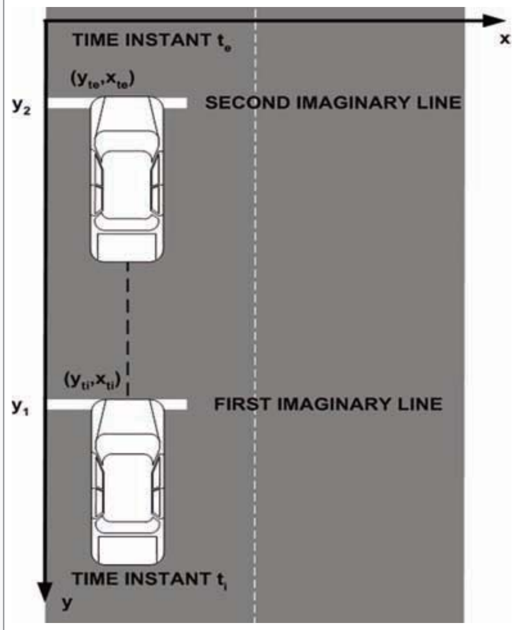


Figure 3: Frame samples of a tracked vehicle in the outgoing direction

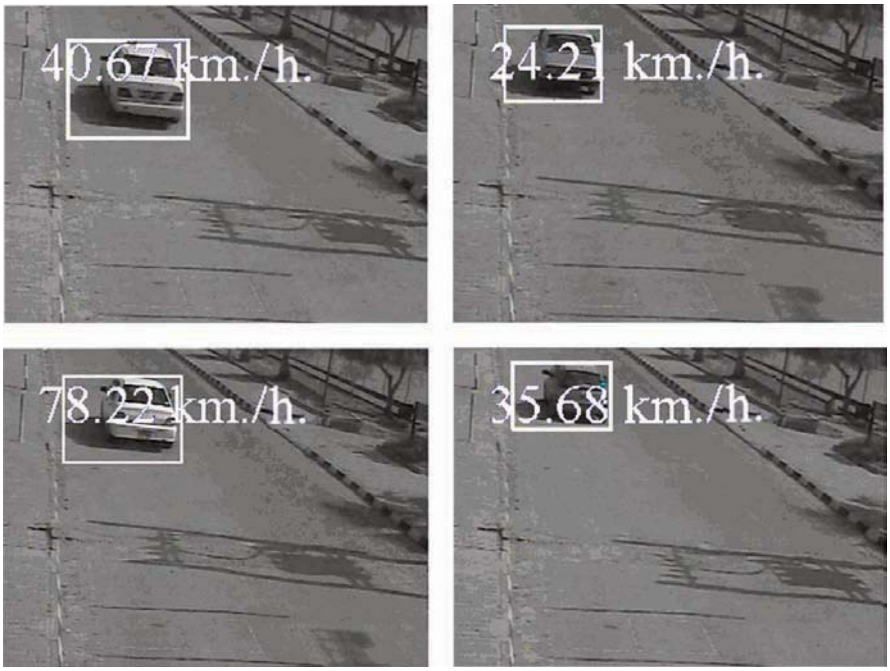


Figure 4: Captured speeding vehicles and their license plates

Therefore, the hardware part of the system can work regularly at least 2.25 days without any sunlight.

The images of the detected licence plates are either 10 x 40 pixels or 20 x 30 pixels in size and are sent to a programmable interrupt controller (PIC) that's connected to the DSP. The data transfer from the DSP chip to PIC is done by serial communication. The PIC sends the detected licence plate images to another PIC that sits in a nearby police station. The communication process between these two PICs is done wirelessly.

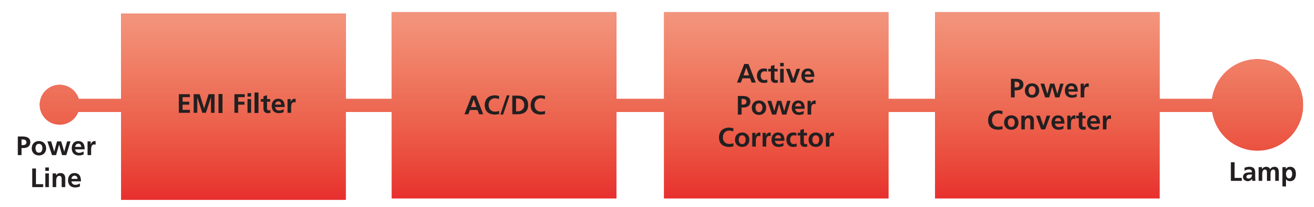
The PIC gets the licence plate and stores it in an integer array. The elements of the array are sent to another PIC located in the nearby police station. The PIC residing at the camera end has an RF transmitter connected to it that can operate up to 50 meters without losing signal strength. The other PIC is located at the nearby police station, which has a receiver connected to it. The PIC in the police station receives and stores the data that has been sent. Then the data from the PIC's memory is send to a computer via the serial port.

Implementation

There are many reasons to implement the proposed system, the first being that it helps the police do their job easier and faster, and another reason is to use alternative and renewable energy sources to energize the system in order to make it environmentally friendly, low cost, long life and independent from any local electricity supplier. ●

THE ELECTRONICS BEHIND LIGHTING – PART 1

Figure 1: General lighting electronics block diagram



HAKKI CAVDAR FROM THE KARADENIZ TEHNICAL UNIVERSITY IN TURKEY PREPARES THIS FIVE-PART SERIES ON LIGHTING ELECTRONICS – THE FUNDAMENTALS AND THE TYPES OF BALLAST CIRCUITS USED, WITH THIS FIRST PART COVERING THE IMPORTANT AREAS OF DEVELOPMENTS AND STANDARDS IN THIS FIELD

Lighting is one of the important areas of electrical and electronics engineering. Although an incandescent lamp is directly powered by the mains – AC power supply (110VAC or 220-240VAC), the other type of lamps such as fluorescent, metal halide (HID), halogen etc, need a ballast.

The ballast may be magnetics or electronics based. Electronics type ballasts increase the lamp-ballast efficacy, leading to increased energy efficiency and lower operating costs. Electronic ballasts are more efficient than magnetic ones in converting input power to the light, and their operating of fluorescent lamps at higher frequencies reduces end-losses, resulting in an overall lamp-ballast system efficacy increase of 15% to 20%.

Electronic ballasts have a number of other advantages over magnetic ballasts too. They are readily available and can operate three or four lamps, allowing the use of a single ballast in 3-lamp and 4-lamp luminaires. This reduces both installation and field wiring labour costs. Other advantages of the electronic ballast include reduced weight, quieter operation and reduced lamp flicker. Electronic ballasts are directly interchangeable with magnetic ballasts, and they can operate most full-sized and compact fluorescent lamps.

On the other hand, however, a new lamp has recently joined the lamp family: the LED lamp! The LED lighting has been growing rapidly in uses from day to day. Its main advantages over the other lamps is that, when designed properly, an LED circuit will offer efficiency of over 80%, which means over 80% of the electrical energy is converted to light. The operational life of the currently-available white LED lamps is very long, some 100,000 hours, which is around eleven

> Electronic ballasts have a number of advantages over magnetic ballasts, and they can operate three or four lamps

years of continuous operation or 22 years of 50% operation. The long operational life of an LED lamp is a stark contrast to the average life of an incandescent bulb, which is approximately 5000 hours. If the lighting device needs to be embedded into a very inaccessible place, using LEDs would virtually eliminate the need for routine bulb replacement.

There is no comparison between the cost of LED lights vs traditional incandescent options. With incandescent bulbs, the true cost of the bulb is the cost of replacement bulbs and the labour expense and time needed to replace them. These are significant factors, especially where there are a large number of installed bulbs. For office buildings and skyscrapers, the maintenance costs in replacing bulbs can be enormous. These issues can all be virtually eliminated with the LED option.

When designed properly, an LED circuit will approach over 80% efficiency, the remaining 20% is lost as heat. Compare that with incandescent bulbs which operate at about 20% efficiency and 80% of the electrical energy is lost as heat. In real money terms, if a 100W incandescent bulb is used for one year, with an electrical cost of 10 cents/kilowatt hour, $88 will be spent on electricity costs. Of the $88 expense, $70 will have been used to heat a room and not light it. If an 80%-efficient LED system had been used, the electricity cost would be $23 per year – there would be a cost savings of $65 on electricity during the year. Realistically the cost-savings would be higher as most incandescent light bulbs blow out within a year and require replacements, whereas LED light bulbs can be used easily for a decade without burning out.

In addition, research shows that LED lights exhibit characteristics that are better for overall health and safety than those of fluorescent, incandescent and halogen fixtures. LED lights exhibit very little to no flickering because they are typically powered by constant DC voltage (or use an adapter to go from AC to DC power). Equally, LEDs work silently and safely, offering the full-spectrum of light, and they do not produce any hum.

LEDs' slower burnout rate allows for longer colour consistency throughout the life of the fixture. Colour matching across a group of lighting fixtures reduces eyestrain, and slower burnout rates means fixtures will retain colour consistency for a longer period of time. LEDs do not emit UV radiation, and are, thus, safe for desktop, close-proximity applications.

LED light fixtures stay relatively cool (around room temperature) even when turned on for long periods of time. Fluorescent lamps can reach temperatures of 180F degrees, and halogen and incandescent lights can reach 200F degrees. Besides safety issues that arise from touching hot bulbs, these temperatures can also create hot spots and unsanitary conditions in places like grocery stores where raw meat is stored.

LEDs do not contain mercury, and so can be disposed of safely and easily. Mercury is an extremely dangerous and toxic substance that exists in most kinds of bulbs – incandescent and fluorescent – except for LEDs. The presence of mercury makes disposing of other bulbs dangerous and time consuming.

Needing a Ballast

All lamps except the incandescent ones need a ballast. Using electronics ballast will give a unity power factor, great efficiency, loudless operations, long lamp life, good health operations etc.

The general block diagram of the lighting electronics system is shown in Figure 1. It can be seen that the EMI filter, AC/DC rectifier and the power factor corrector (PFC) are the same circuit parts in all electronics ballasts, but these parts may be changed with the lamp power and the type of lamp used.

All lighting electronics equipment must adhere to the main standards, sumarized here:

1. Efficiency;
2. Power factor;
3. Crest factor;
4. Emmission and Radiation;
5. Safety;
6. Surge testing;
7. RoHs.

Efficiency

Efficiency is always the main target of all areas of electronics areas and lighting electronics is no exception. Before the use of electronic ballast, the efficiency was low in the magnetic ballasts. For example, in the fluorescent and HID lamps magnetic ballasts use large inductances, with big core and coil losses. Efficiency is about 50-60% in the magnetic ballasts for fluorescent and HID lamps. In the electronic type ballasts, efficiency is over 85% for both fluorescent and HID lamps but also LED ballasts.

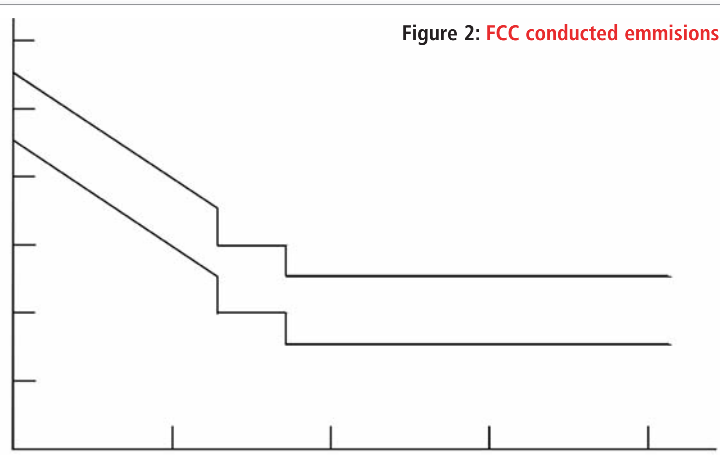


Figure 2: FCC conducted emmisions limits

Power Factor

Power factor (PF) is the same as in Equation 1 for sinusoidal quantities:

$$PF = \frac{P}{S}$$

$$PF = \frac{V_s I_{s1} \cos\theta_1}{V_s I_s} = \frac{I_{s1}}{I_s} \cos\theta_1$$

The deplecament power factor (DPF), which is the same as the power factor in linear circuits with sinisoidal voltages and currents) is defined as follows:

$$DPF = \cos\theta_1$$

Therefore, the power factor with a nonsinusoidal current is:

$$PF = \frac{I_{s1}}{I_s} DPF$$

On the other hand, if the currents are nonsinusioidal, there're large distortions and harmonics, small value of I_{s1}/I_s and hence a low power factor. The power factor can be expressed as:

$$PF = \frac{1}{\sqrt{1 + THD_i^2}} DPF$$

In this equation, P is the active power, S is the complex power, V is the source voltage, I_s and I_{s1} are the source and fundemental harmonic currents, respectively, θ_1 is the phase shift between current and voltage, and *THD* is the total harmonic distortion in current.

Power Factor Corrector

Power factor may be corrected by using a suitable capacitor for inductive loads in linear sinusoidal power circuits. But this is not possible in nonsinusoial circuits due to the circuit's capacitive behaviour. So, in power electronics circuits, especially in switching converters, there is a need for active power corrector (PFC) circuits in order to obtain the necessary power factor of nearly 1.0.

Crest Factor

The crest factor is equal to the peak amplitude of a waveform divided by the RMS value. The purpose of the crest factor calculation is to give a quick idea of how much impacting is occurring in a waveform. In a perfect sine wave, the crest factor is 1.41.

If there is a need for sinusoidal waveform at the output, the crest factor of the generated signal must be 1.41.

Emmission and Radiation

In lighting electronics, the main part of

> In lighting electronics, the main part of the electronic circuit are the power converters

the electronic circuit are the power converters. Because of the rapid changes in voltages and currents within a switching converter, power electronic equipment is typically a source of EMI. The EMI is transmitted in two forms: radiated and conducted. The switching converters applied the power lines generate conducted noise into the lines that is usually several orders of magnitudes higher than the radiated noise into free space. Metal cabinets used for housing power converters reduce the radiated component of EMI.

The number of institutions involved in regulations and recommandations that concern EMI is quite large, and to an average person the issue of EMC standards can be somewhat confusing; EMC is defined as the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable disturbances within that environment.

FCC conducted emmisions limits are shown in Figure 2. Class A devices are those used in commercial applications, while those for domestic applications belong to Class B.

Conducted noise consists of two catagories commonly known as the differential mode and common mode. The differential mode noise is a current or a voltage measured between the lines of the source, that is a line to line voltage or current. The common mode noise is a voltage or current measured between the power lines and ground. Any filter that is called EMI filter design has to take into account both of these modes of noise. EMI filter should be used as the first stage in lighting electronics systems too, between power lines and the input of the circuits.

Radiated noise is defined as the radiated signal from the power electronics equipment. These radiated signals may interfere with other systems, especially if they are operating near sensitive medical and communications equipment. Generally, the radiated noise is effectively shielded by metal cabinets the power electronic equipment is housed in. But, just as important is the layout of PCB of power electronic equipment, which should be designed carefully with reducing radiation in mind.

Safety

Galvanic isolation is generaly UL (Underwrites Laboratories) safety requirement for off-line power converters. The exception is where the applications are double insulated, thereby making it impossible for the user to come into contact with live parts.

UL8750 output types are: isolated, direct (no isolation/basic insulation) or class 2. If a lamp works with a DC source, for example LED, the output voltage is less than 60VDC, for safety reasons. The power supplies used in lighting electronics should have the isolated types.

Surge Testing

High energy transients appearing in parts of electronic equipment could be caused by lightning strikes or power system disturbances such as fault clearance or capacitor bank switching. Lightning can produce destructive surges by the following mechanisms:

a) Direct strike to primary or secondary circuits: the secondary strike is expected to destroy protective devices and connected equipment; the primary strike will pass through the transformers by capacitive or transformer coupling.

b) Indirect cloud-to-ground or cloud-to-cloud strikes create fields which induce voltages in all conductors.

c) Ground current flow IG from nearby cloud-to-ground discharges couples into the grounding network via common impedance paths, and causes substantial potential differences between different ground points.

d) Primary surge arrestor operation or flashover in the internal building wiring causes voltage transients. As lightning phenomena are quite common in real life situations, there is still a need to ensure that individual products can show a degree of immunity from lightning-induced surges.

Fault clearance upstream in the mains supply distribution network produces transients with currents that can go up to hundreds of amps in residential or commercial circuits, and higher for some industrial supplies. Power factor correction capacitor switching operations generate damped oscillations at very low frequencies (typically kHz) lasting for several hundred microseconds.

Surges striking electronic devices may cause hardware damage and/or complete failure. It may also cause the system to malfunction or hang. Some electronics components may be damaged and will need replacement.

The common standard used to simulate surge testing is IEC 61000-4-5. Its waveform is a combination wave which is generated by a generator to deliver a 1.2/50us voltage surge across a high resistance load of more than 100 ohms and an 8/20us current surge into a short circuit.

RoHS (Restriction of Hazardous Substances)

RoHS is the acronym for Restriction of Hazardous Substances. RoHS originated as Directive 2002/95/EC in the European Union (EU) and restricts the use of specific hazardous materials found in electrical and electronic products. All applicable products produced in the EU market after July 1, 2006 must pass RoHS compliance.

The substances banned under RoHS include: Lead (Pb), Mercury (Hg), Cadmium (Cd), Hexavalent chromium (CrVI), Polybrominated biphenyls (PBB) and Polybrominated biphenyl ethers (PBDE). These restricted materials are hazardous to the environment and are dangerous in terms of occupational exposure during manufacturing and recycling.

All of the magnetic HID ballasts are RoHS compliant. An initiative is also in place to make all of our fluorescent ballasts compliant too. ●

IN THE NEXT ISSUE

THIS SERIES CONTINUES IN THE NEXT ISSUE OF ELECTRONICS WORLD MAGAZINE

with Part 2 focusing on the different circuit topologies used in lighting electronics. If you don't want to miss out, subscribe now by going to www.electronicsworld.co.uk

DEVELOPING VINCULUM-II BASED APPLICATION PROGRAMS – PART 1

JOHN HYDE FROM FUTURE TECHNOLOGY DEVICES INTERNATIONAL (FTDI) WILL IMPLEMENT A SERIES OF USB PROJECTS OVER THE COURSE OF SEVERAL EDITIONS OF *ELECTRONICS WORLD*

This month's column will focus on using the Vinculum-II development tools to create a variety of application programs. Although the text should be helpful, it is recommended to download the more comprehensive book "*USB Design by Example*" (see next page), which gives access to source code and other material on each of the sections covered here.

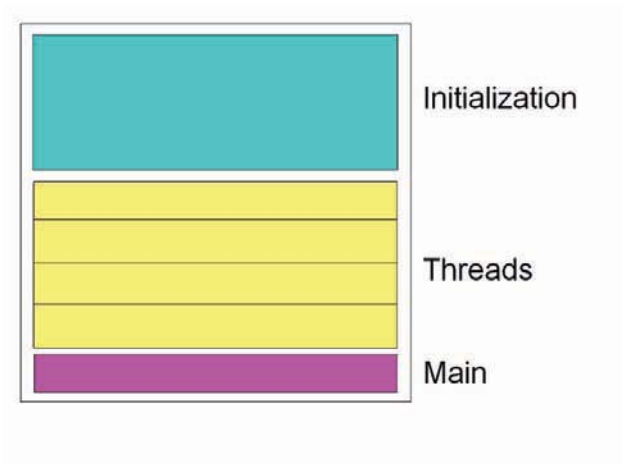
A Vinculum-II evaluation board with a 64-pin module attached was used in these examples and FTDI provides an integrated Development Environment (IDE) for the Vinculum-II. This Windows-based product runs on all versions of Windows since Win XP and is also free to download from the FTDI website.

Each application program developed follows the same structure as shown in Figure 1. When the main program is at the end, it calls initialization routines which are at the beginning and run-time threads are defined in the body of the program. The initial stage of our first example is contained within just two modules but later stages will use many more and they will follow the same structure. This consistency will help us develop and debug larger Vinculum-II application examples later on.

In the initial stage of this example we are going to blink an LED. This sounds easy, but there are several new concepts to learn when using the Vinculum-II. Before diving into the example code, I should make a general comment about Vinculum-II RTOS programming – there is a lot of initialization to do! One downside about having a fully programmable set of peripherals, and a flexible real-time operating system, is that you have to initialize it. The Vinculum-II Operating System (VOS) provides a consistent view of the on-chip peripherals using a driver interface and this includes IO-Control commands that are used to set the many programmable features of each peripheral. All IO-Control commands use the following format:

```
Iocb.ioctl_code = VOS_IOCTL_TYPE;
Iocb.value = ValueSpecificToType;
Status = vos_dev_ioctl (devicehandle, &Iocb);
```

Figure 1: All VOS application programs have the same structure



A returned status value of '0' means NO_ERROR and this is what we would typically expect. It is tedious and takes a lot of code to check status after every system call, but it is dangerous not to check status at all. So the approach I take is to start with a status value of '0' then OR in the return value then, after several commands, I check status. I am expecting '0' but if I don't get this then I have to back track and resolve the error. I use a debugger breakpoint to trap bad status.

Stage 1: Blinking an LED

There are no global variables to initialize in this first stage so this section is empty. Next follow two standard functions used to initialize VOS. VOS will create data areas for each device driver that we use. This first stage only uses one driver, it will be a GPIO driver called LEDs and defined in main.h, and we will initialize this in InitDevices. InitDevices first checks if we are using a 64-pin device and continues if so. The first programmable peripheral I set up is the IOMUX (see below).

The V2Eval board has four user LEDs. I chose LED3 since it is on pin 12 for all package types. Check the schematic and note that pin 12 is GPIO1 – Vinculum-II groups IO pins in sets of 4 so we must connect this pin to an IOPort using bit1 or bit5.

FOR DETAILED EXPLANATION

OF THE IOMUX YOU CAN REFER TO THE FTDI APPLICATION NOTE
AN_139_Vinculum-II_IO_Mux_Explained.pdf

I chose to use IOPortE.bit1. I then initialize the GPIO device driver and, after checking status, I return to main.

The next step is to initialize the program threads – there is only one in this stage. Note that the thread does not start running yet. We are still initializing the environment. Finally we call vos_start_scheduler and if all of the initialization is correct, VOS starts running, else this routine returns indicating that we have an error that we must resolve.

Our Blink program thread, repeated in Figure 2, is simple. It contains an initialization section then a loop that is run forever. After waiting for a VOS-controlled delay, the state of the LED is toggled.

THE MORE COMPREHENSIVE BOOK "*USB DESIGN BY EXAMPLE*"

WHICH GIVES ACCESS TO SOURCE CODES AND OTHER MATERIAL ON EACH OF THE SECTIONS COVERED IN THIS COLUMN, IS AVAILABLE FREE OF CHARGE AT:
http://www.ftdichip.com/Support/Documents/TechnicalPublications/USBDesignByExample_registration.htm.

Registration is required.

I modelled this function after the C printf function but I limited my implementation to only supporting one variable per string. This solves most of my display needs.

I should mention that a real printf function is available in one of the FTDI-supplied libraries. I chose not to use this in Stage 2 since it masks some of the points I need to make concerning RTOS program construction. Use of the dprint function is shown in the Blink thread which is repeated in Figure 3.

```
void Blink(void) {
BYTE PortData = LED3;
StartupDevices();
while (1) {
vos_delay_msecs(512);
PortData ^= LED3;
// Now write pattern to the GPIO port.
vos_dev_write(hDevice[LEDs] ,&PortData, 1, NULL);
}
}
```

Figure 2: The Blink thread is a 'do forever' loop

You should now see LED3 blinking at about 1Hz. If you click the IDE 'Pause' button you will be presented with a disassembly listing of the program – this is not a place that I want you to dwell. I have written many Vinculum-II programs, they have all been in C and I haven't even learnt all of the assembler mnemonics. So quickly close this window.

If you want to stop execution, choose a line in your C program and click the left margin to set a breakpoint (a red diamond will appear) and click 'start'. The debugger will stop program execution once this line is reached. You can now single step, look at program variables etc as described in FTDI's application note AN_142. It is easy to include a 'debug console' into a Vinculum-II application and this is described in the Stage 2 of this example. Included within the FTDI development toolset is a terminal emulator program called V2EvalTerm. Spin this up now, choose a 3000000 baud rate, no flow control and click 'connect'.

Stage 2: Adding a Debug Console

The V2Eval board contains an FT4232H and channel A of this component can be connected to the Vinculum-II. No additional cables are required since all communications take place on the same USB connection that the IDE and debugger are using. For our program to use this capability we must include a UART device driver and this is the main addition in Stage 2. The initialization of the UART is extensive so I moved the InitDevices and SetupDevices procedures to their own module – you should study this now in initialize.c. I had to add UART IO pin routing and UART driver initialization to InitDevices and UART configuration to StartupDevices. Note that the structure of the UART code is the same as the GPIO code. You write to the UART using the same vos_dev_write function that is used to write the LED. Unfortunately, I found this cumbersome for displaying text strings and variables so I wrote adprint function which is shown in display.c.

```
void Blink(void) {
BYTE PortData = LED3;
StartupDevices();
dprint("Blink has started\n", 0);
while (1) {
vos_delay_msecs(512);
PortData ^= LED3;
// Now write pattern to the GPIO port.
vos_dev_write(hDevice[LEDs] ,&PortData, 1, NULL);
dprint("LED %s", PortData & LED3 ? "Off":"On");
}
}
```

Figure 3: Adding progress messages to the Blink thread

Stage 3: Hello World

In Stage 3 we add another task, called HelloWorld, which also wants to use the dprint capability that we added in Stage 2. When you create a thread you must assign a priority to it. A value of 1 is the lowest and the maximum value for a user task is 32; VOS uses higher priorities for its internal operation. Should VOS find more than one task on the ReadyToRun list (Figure 3 in previous article) then it chooses the higher priority task to run. If two, or more, tasks have the same priority then it will select each in a round-robin fashion. In general you should set output threads with a higher priority than the input rates.

The Blink thread calls StartupDevices as before to initialize the UART device driver, but what happens if the HelloWorld thread runs first, before the UART driver has been initialized? The HelloWorld thread has a dependency on the Blink thread and their operation must be synchronized. VOS has a variety of synchronization primitives and the simplest one for this situation is a semaphore.

When the HelloWorld thread starts up it will discover that the DevicesStarted semaphore is cleared and will, therefore, wait until it is set. I set this semaphore at the end of StartupDevices in initialize.c. This will allow the HelloWorld thread to continue.

The next thing that the HelloWorld thread does is signal the semaphore again. Although not required in this example, it is important if other threads are also waiting on this semaphore. The semaphore mechanism allows threads to signal each other and can be used to control initialization sequences such as this example has shown.

Run the program and note that if you look carefully at the progress messages you will see that occasionally the messages from the two threads are intermingled. This is typically not what you want and the mechanism to stop this intermingling is the subject of the next article. ●

The move from assembler to higher level languages like C/C++ dramatically improved developer performance and made the source easier to read

Hardware, Software and USER EXPERIENCES

IN THIS THREE-PART SERIES **MIKE HALL** OF MICROSOFT DISCUSSES THE CURRENT TRENDS IN HARDWARE, SOFTWARE AND EMERGING TECHNOLOGY THAT AFFECT THE EMBEDDED DEVICE DEVELOPER

In the May issue of Electronics World, we discussed how to enable connectivity for embedded devices and the pros and cons for wired, wireless and cell-based networking, but we didn't discuss what the underlying device was, or how trends in hardware and software impact device developers. This month's column focuses on hardware, software and emerging technology trends, and what this means for you, the embedded device developer.

During the past 50 years we've seen advancement in computing from mainframes through Internet-connected desktop computing to smart connected devices. Embedded hardware has also undergone a similar transformation, from simple 4-bit, 8-bit, 16-bit computing devices to 32-bit single core and multicore silicon and for some classes of embedded devices 64-bit multicore silicon. An extension of the single core, the multicore trend incorporates the addition of connectivity, which enables a device to play as part of a distributed embedded system rather than a single standalone device.

Programming a single threaded process running on a single core CPU is fairly straightforward. However, developing multithreaded code can become more involved. If we go a step further and consider developing multithreaded code that runs on multicore machines and is able to load balance work across the cores, a developer's job can become increasingly complicated. If that process wasn't challenging enough, layer on the ability for your device to be part of a distributed embedded system and life for the embedded developer looks to be quite complex.

There are similar trends in the software space; a number of years ago most software developed was written in assembler. This was immensely time-consuming; printouts would contain approximately six characters per line on 132 column fanfold listing paper and was hard for someone else to pick up, debug and decipher. The move from assembler to higher level languages like C/C++ dramatically improved developer performance and, thankfully, made the source easier to read. Productivity came not only from a higher level programming language but also from associated runtime libraries.

A good example of this is the ease of developing a Windows application using the Microsoft Foundation Classes compared to raw Win32 programming. The evolution of programming languages and frameworks continues with C# and the Microsoft .NET Framework. These frameworks provide rapid application development and an array of helper classes that take most of the heavy lifting away from the developer. This allows developers to focus on the code that makes their application unique, rather than on the underlying primitives and plumbing that are required for their application to work.

The next trend is around user experiences (note that I didn't say user interface). There have been many advances in this arena, specifically the inclusion of Windows Embedded Compact 7 CTP and Silverlight – enhancing and improving user interaction and experience. User experiences can include a number of input and output modalities. If we roll back 30 years, the primary user experience was command prompt and keyboard. Roll back 20 years and graphical user interfaces with keyboard and mouse were the order of the day. Today, users expect a more immersive user experience and input-output modalities that match the device type and usage scenarios. Although some devices may work well with 2D graphics, keyboard and mouse, other devices may use speech for input and output and others may use 3D hardware-accelerated graphics and touch, gesture and multitouch.

The key message to take away is that developers need to choose the appropriate language and framework to build their device experience. This can include anything from dealing with multicore or distributed systems programming to interacting with cloud-based services and building immersive user experiences.

Examples of how high-level languages and appropriate frameworks can enable developers to rapidly build solutions can be found at .NET Gadgeteer, POS.NET and Parallel programming in .NET. ●

ABOUT MIKE HALL

MIKE HALL IS A PRINCIPAL SOFTWARE ARCHITECT in the Windows Embedded Business at Microsoft, working with Windows Embedded Compact and Windows Embedded Standard.

SIMPLE CALIBRATION CIRCUIT MAXIMIZES ACCURACY IN LI-ION BATTERY MANAGEMENT SYSTEMS

BY **JON MUNSON**, SENIOR APPLICATIONS ENGINEER AT LINEAR TECHNOLOGY

In Li-Ion battery systems it is important to match the charge condition of each cell to maximize pack performance and longevity. Cell life improves by avoiding both deep discharge and overcharge, so typical systems strive for operation between 20% and 80% states of charge (SOC).

Detection and correction of charge imbalances assures that all cells track within the desired SOC window, preventing premature aging of some cells that could compromise the entire pack capacity. Highly accurate measurements are required to determine SOC with Li-Ion cells due to their exceptionally flat discharge characteristics, particularly with the lower voltage chemistries (see example in Figure 1).

Although the popular LTC6802 Battery Stack Monitor offers high accuracy analog-to-digital conversion, some applications demand accuracy that is only attainable with a dedicated voltage reference IC. The LT1461 is especially suited as a high performance calibration source, available in the small SO-8 package. Figure 2 illustrates this configuration. The calibration reference is measured with an ADC channel normally intended for temperature measurement. A programmable I/O bit controls power to the reference.

Accounting for the Error Sources

Fundamentally, there are several key characteristics that comprise an overall accuracy specification:

- Quantization error of the ADC;
- Initial accuracy of the ADC (or calibration reference);
- Variation from channel to channel;
- Variation with temperature;
- Hysteresis effects, primarily that of the soldering process;
- Variation with operating time (long-term drift).

The maximum specified error in the data sheet for the LTC6802IG-2 includes the first four items and is ±0.22%; about ±7mV when measuring 3.3V – the most demanding region of the discharge curve. The spec budgets is ±3.3mV (±0.1%) with the maximum variation over the -40°C to 85°C operating temperature. Since the differential nonlinearity (DNL) of the ADC is about ±0.3 LSB, the quantization error contribution is about ±0.8 LSB, or ±1.2mV.

[Battery] Cell life improves by avoiding both deep discharge and overcharge, so typical systems strive for operation between 20% and 80% states of charge

Typical channel-to-channel variation is minimal, under ±1mV, leaving about ±1.5mV for trim resolution and accuracy in the IC manufacturing process. Thermal hysteresis is specified as 100ppm, and an additional approximately ±0.1% error may develop from the shift of the printed circuit soldering process.

Projected typical long-term drift is under 60ppm/√khr. An uncertainty of around ±0.5mV could develop if the practical vehicle battery system active life cycle is targeted at 5khr (about 15 years or 150,000 miles). This is a relatively small contribution to total error.

The LT1461AIS8-3.3 voltage reference IC has an output tolerance of ±0.04% and less than ±1.2mV of change over temperature with its exemplary 3ppm/°C worst-case stability. The LT1461 exhibits a long-term drift of under 60ppm/√kHr and thermal hysteresis of 75ppm. Solder reflow shift is expected to be under 250ppm (±0.8mV).

Since a significant portion of the LTC6802 ADC error accumulates after the initial delivery of the IC, an external calibration technique improves accuracy in a finished product.

Figure 1: Discharge characteristics of a 3.3V Li-Ion cell

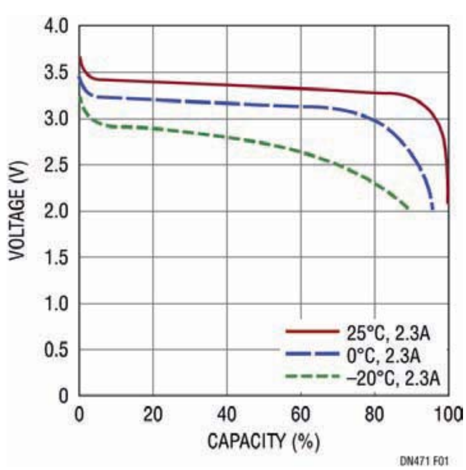
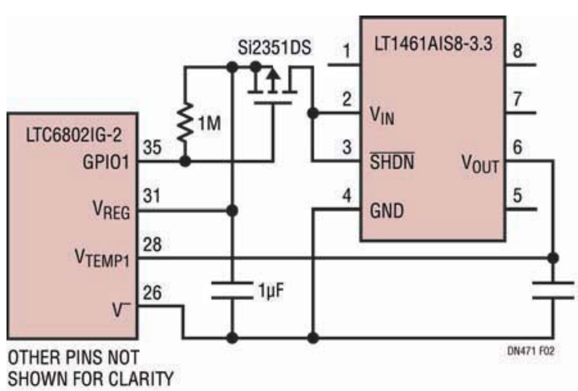


Figure 2: LT1461 as an external calibration source for an LTC6802 Li-Ion battery monitor



Examining Calibration Strategies

There are a number of options to improve system accuracy, at the expense of additional complexity. With the simple circuit of Figure 2, several options are available that take advantage of the external calibration reference. Accuracy projections of several methods are shown in Table 1 and described below.

Table 1: **Accuracy of calibration methods described for 3.3V measurements**

EXTERNAL CALIBRATION METHOD (ALL TOLERANCES SHOWN IN ±mV)	QUANTIZATION	FACTORY TRIM	SOLDERING SHIFT	CHANNEL MATCH	THERMAL VARIATION	THERMAL HYSTERESIS	LONG-TERM DRIFT	TOTAL ERROR
LTC6802 Without External Calibration	1.2	1.5	3.3	1.0	3.3	0.3	0.5	11.1
1: Calibration with LT1461, No Stored Information	1.2	1.3	0.8	1.0	1.2	0.2	0.5	6.2
2: Calibration with LT1461, Store Calibration Values for Reference Voltage	1.2	-	-	1.0	1.2	0.2	0.5	4.1
3: Calibration with LT1461, Store Calibration Values for Reference Voltage and Each Input	1.2	-	-	-	1.2	0.2	0.5	3.1

The simplest scheme (method 1) involves no local memory or measurements at production. This method takes readings of the nominal 3.300V calibration voltage periodically and normalizes all ADC readings with the same computed correction factor. The tolerance and drift of the reference and channel-to-channel variations are left uncorrected but the net uncertainty would be improved by almost a factor of 2, to ±6.2mV.

A slightly more complex technique (method 2) involves storage of a single correction factor that accounts for the true reference voltage as measured with high accuracy test-fixture instrumentation. This then eliminates the initial error of the LT1461, improving the overall accuracy to ±4.1mV, nearly a 3x total improvement.

While small, there is still some channel-to-channel variation that can be calibrated out with a method that uses more initial test-fixture measurements (method 3). This is similar to method 2, but with high accuracy measurements of every channel taken (including the reference) and the saving of individual correction factors for each. This further reduces the error to ±3.1mV (almost a 4x total improvement).

A Simple Addition

A precision voltage reference, such as the LT1461, can improve the accuracy of an LTC6802-based battery management system to about ±3mV worst-case. The reference is a simple addition to the highly integrated LTC6802 Li-Ion monitoring solution, thanks to the spare general-purpose ADC channels available. The low operating current of the LT1461 voltage reference also makes it ideal for this and other battery-powered applications. ●

Farnell First with New Ranges of Switches From Würth Elektronik

Multi-channel distributor of electronic and industrial components Farnell has introduced eight new ranges of switches from electronic interconnect & electromechanical solutions provider Würth Elektronik.

The addition of new switches will strengthen the product portfolio offered by Farnell and help to increase business levels further.

The new switches are all rated for use between -40°C and +85°C and include combinations of compact, piano style and tactile flat actuator switches in both surface mount and through-hole formats. The diversity of the new switch ranges will allow Farnell to better address the needs of design engineers working in a wide range of end markets.

Access to data for the new switch ranges and discussion is available via element14 to help customers with their new applications and speed time to market for their new designs.

www.farnell.co.uk

REAL-TIME MATHEMATICS OPTION BOOSTS POWER MEASUREMENTS ON DL850 SCOPECORDER

A new real-time mathematics option for the Yokogawa DL850 ScopeCorder introduces many new DSP-based functions that boost the instrument's power analysis capabilities, as well as adding features such as sensor linearisation and electrical to mechanical conversion.

In addition to 30 powerful mathematical functions, the new /G3 option expands the instrument's standard bandwidth filters with a set of steep digital filters that can be used for triggering specific measurement sequences based on waveform characteristics.

With the /G3 option, the DL850 ScopeCorder offers up to 16 real-time DSP channels and 30 mathematical functions including calculations of power, sensor linearisation, rotary encoding and mechanical displacement. The mathematical sampling rate is up to 10MS/s, while the filter sample rate is up to 1MS/s. The fast acquisition rate results from the fact that there is no processing after waveform acquisition, apart from a fixed calculation delay in the DSP channel.

www.tmi.yokogawa.com/ea

Apacer Military Standard-Compliant Memory Module

Apacer Technology and Diamond Systems Corporation (DSC) developed SODIMM – a specification for rugged SODIMM memory dedicated to DSC's single-board computers (SBCs). Meeting the US military MIL-STD-202G 12G vibration requirements, the newly unveiled memory module is optimal for use in military vehicle applications and other harsh environments.

Apacer's newly launched memory module supports wide temperature operation (-40°C ~ 85°C). The military standard-compliant module can effectively address the problem of loosening of parts caused by vibration. In addition to military devices, it can also be widely applied to industrial computers in various fields (e.g. medical application, mass transportation, aviation, automation, etc) to optimize system performance.

Apacer SODIMM features an outside-the-box design with focus on ruggedness. Its support of SODIMM slot eliminates the need to re-design the motherboard for customers, making it a more stable storage option.

www.apacer.com

LeCroy Introduces 12-bit Oscilloscope for General Purpose Market

LeCroy Corporation has introduced a new line of 12-bit resolution WaveRunner oscilloscopes – the WaveRunner HRO 6 Zi (High Resolution Oscilloscope) – with 400MHz (HRO 64 Zi) and 600MHz (HRO 66 Zi) models.

The WaveRunner HRO features an industry leading 12-bit ADC, deep memory of up to 256Mpts/ch with 64Mpts/ch standard and superior DC accuracy specifications. These features are in addition to the extensive analysis capabilities of the WaveRunner 6 Zi Series (400MHz to 4GHz), which was launched in February 2011. Engineers no longer have to compromise the analysis functions of an oscilloscope to get the high resolution they need.

Designed for the medical, automotive and electromechanical markets, the WaveRunner HRO has higher resolution and greater measurement precision than 8-bit alternatives. Traditional oscilloscopes use 8-bit ADCs to digitize the data, which is not precise enough for applications that require viewing signals with both a large and small voltage component.

www.lecroy.com

Mixed Technology Connector Series From Harwin Now Available Off-The-Shelf

Harwin is making certain configurations of its Datamate Mix-Tek range of mixed power and signal 2mm connector family available as standard off-the-shelf products, reducing lead time.

Harwin's Datamate Mix-Tek connector range can be customer-specified in a huge number of configurations of signal, power and coax, effectively allowing the customer to design their own Datamate connector, specific to their application, by mixing and matching the required contacts up to a maximum of 50 low frequency contacts or 12 special (coax and power) contacts.

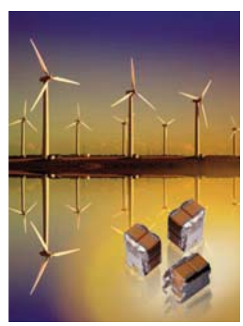
Power contacts are rated for use at up to 20A, signal contacts are rated at up to 3A and coax contacts are rated at 50 ohms. They are available in Male PC Tail, Female Crimp, Male Crimp and Female PC Tail options. Mouldings are polarized and have a UL94V-0 rating. Mix-Tek connectors comply with the following standards: BS9525-F0033; CECC 75101-008.

harwin.co.uk

AVX'S MINIATURE, HIGH CV STACKED CAPACITORS REDUCE COMPONENT COUNT

AVX Corporation has expanded its switch mode power supply (SMPS) capacitors series, TurboCap, to include miniature versions. The miniature TurboCap Series features a unique double-stacked construction, which are vertically and horizontally stacked capacitors, to provide high CV values, low ESR values, high current carrying capacity and excellent high frequency performance. The rugged devices are also mechanically robust.

The miniature TurboCap Series capacitors are available in an X7R dielectric and feature a voltage range of 50V to 100V with a capacitance value of 100uf. The stacked capacitors are ideal for DC/DC converters, hybrid vehicles, military/COTS Plus power supplies, medical electronics equipment, industrial equipment, telecom and alternate energy applications.



The expanded TurboCap Series capacitors are assembled using AVX's industry proven lead frame technology, which places the ceramic up off the board and dramatically reduces cracking issues as well as susceptibility to shock and vibrations.

www.avx.com

HDCP GMSL CHIPSET ENABLES SECURE TRANSMISSION OF DIGITAL CONTENT

Maxim Integrated Products has introduced the latest members of its high-speed LVDS serializer/deserializer (SerDes) family, consisting of the MAX9263/MAX9265 serializer and MAX9264 deserializer. This gigabit multimedia serial link (GMSL) chipset features high-bandwidth digital content protection (HDCP) and forms a complete, secure, bidirectional digital-video link (HDCP-GMSL) for transmission of digital video and audio over a single DC-balanced twisted-pair or differential line. The chipset manages all HCDP protocol transactions, supports touch-screen communications and eliminates the CAN/LIN bus for diagnostics. The MAX9263/MAX9265 and MAX9264 HDCP-GMSL chipset is optimized for automotive infotainment and rear-seat entertainment applications.

Maxim's proprietary differential, full-duplex control channel handles all HDCP protocol transactions. It eliminates the need for an external CAN or LIN interface, thus simplifying design while saving space and cost. This approach also enables bidirectional communication with the display module for touch-screen applications. Additionally, programmable spread-spectrum modulation reduces EMI, making it easier to pass automotive compliance tests.

www.maxim-ic.com

Roband Launches 30kV Mains-Powered, High-Voltage DC Power Supply

The specialist developer and manufacturer of electronic power supplies for the defence market Roband Electronics has launched a mains-powered, high-voltage, DC-output, bench-top power supply. The RO-HV 30-1 provides variable output voltages and currents up to a maximum of 30kV and 1mA, these being displayed via digital meters on the front panel of the instrument to resolutions of 100V and 1µA respectively. Maximum power output is 30W.

Output voltage and current limits can be set before the output is enabled and these may be adjusted when in use. Current limit can either be constant or trip, selectable from the front panel. At switch-on, or following a power interruption, the unit defaults to 'output-disabled' or 'constant current' mode. Polarity is factory preset and must be specified at time of ordering.

The output is via a screened connector, with 2m of cable supplied as standard.

www.roband.co.uk

IQD LAUNCHES MINIATURE TELEMETRY CRYSTAL

IQD has launched a new crystal, the CX-16 series which is designed for use in medical implantable devices. The new device is specifically targeted at applications in the fast growing medical RF telemetry market.

Housed in a hermetically sealed ceramic package, the tiny crystal measures just 2.0 x 1.2 x 0.4mm and is manufactured using a photolithographic and chemical milling processes and then sealed within a ceramic package for high stability and low ageing.

Initially offered in frequencies of 24MHz and 26.5MHz, other frequencies are being developed throughout 2011 including 32.768kHz. The CX-16 offers a calibration tolerance of ±5ppm and will deliver temperature stabilities of ±10ppm over the commercial operating temperature range of -10 to +70 degrees C and ±30ppm over the extended military temperature range of -55 to +125 degrees C.

The ceramic package with glass lid design prevents out-gassing and contamination which is crucial to achieving its excellent ageing characteristic of better than ±3ppm max over the first year.

www.iqdfrequencyproducts.com

Enclosure and Door Sealing Made Easy With Kemtron

Extruded gasket profiles in soft easy to compress silicone sponge suitable for enclosure and door sealing. The material is approved to UL94V0 for flame retardency making it suitable for indoor applications.

The material will seal dust and water up to IP65, can be self-adhesive backed for easy mounting and can be bent around corners ensuring sealing integrity. Silicone sponge has very low compression set and a life of 20 years making it suitable for all applications. Kemtron also manufactures an EMC version for RFI/EMI shielding by adding a conductive knitted wire mesh over silicone sponge section.

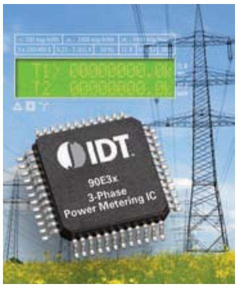
This gasket gives a good EMC performance with 100dB+ in the electric field 1MHz to 1GHz and 40-70dB in the magnetic field 10kHz to 1MHz.

www.kemtron.co.uk

Widest Range Poly-Phase Power Metering Products for Smart Grid Applications

Integrated Device Technology (IDT) has announced a new family of poly-phase power metering ICs that offer the widest dynamic range and lowest temperature coefficient in the industry. These new devices allow smart energy meter manufacturers to increase performance while consolidating functionality and lowering cost. The poly-phase power metering ICs expand on IDT's award-winning 90E2x family of single-phase devices.

The 90E32 and 90E36 poly-phase metering ICs feature the industry's widest dynamic range of 5000:1 (90E32) and 6000:1 (90E36), and the lowest temperature coefficient with proprietary temperature compensation technology, offering superior performance over a wide range of usage patterns and environmental conditions, increasing flexibility for meter manufacturers.



In addition, the IDT 90E36 features an on-chip Discrete Fourier Transform (DFT) analysis engine with Total Harmonic Distortion (THD) detection, raw analog to digital converter (ADC) data access via a direct memory access (DMA) port and other versatile parameter measurement functions.

www.idt.com/go/powermeter

FOREMOST ELECTRIC CAR CHARGING CONNECTORS MEET GLOBAL STANDARDS

Foremost Electronics is now stocking the E-Mobility range of electric vehicle charging connectors manufactured by FCT Electronic GmbH.

FCT has developed this new range of charging connectors for the worldwide net integration of electric vehicles. These 16 or 33 Amp connectors meet the needs of increasingly powerful electric vehicles which are being developed by car manufacturers worldwide and the requirements of IEC 62196-2, the proposed European standard for electric vehicle charging connectors.

Due to the rapid pace of development of electric vehicles the need for harmonisation and consolidation of charging connectors, their electrical characteristics and the charging network architecture has become urgent. No existing standards are available so the international standards committee and representatives of automobile manufacturers and energy providers are cooperating to establish a standardised form.

One and three-phase connections of 16A up to 63A are incorporated with high current contacts having a diameter of 6mm.

www.4most.co.uk

Myrra Transformers Now Available From Rapid Electronics

Rapid Electronics has added two new ranges of high performance PCB mounting and flyback power transformers from Myrra.

The 44000 series of encapsulated PCB mounting transformers carry a primary voltage of 230V and secondary voltages of between 6V and 2 x 24V. Rated between 1.5VA and 30VA, they are vacuum filling, two-compartment bobbin structure components with an inherent proofing against short circuit, and made of self-extinguishing plastics to UL 94 VO.

The 4400 series meets all the requirements of EN 61558-2-6, EN 60950 and UL 1585, as well as carrying a full range of European approvals including UL, VDE, SEMKO, DEMKO, FIMKO and KEMA.

Also recently introduced is the 74000 series of Myrra flyback transformers – the first flyback options to be available in Rapid's extensive range of power transformers. Offering a high voltage step down capacity, these components are commonly found in switched mode applications where the primary winding is fed by a pulse-width modulated source.

www.rapidonline.com

ROBUST AUTOMOTIVE-GRADE BUCK REGULATOR ICS WITH WIDE INPUT VOLTAGE RANGE

The new A8582 and A8583 from Allegro MicroSystems Europe are robust automotive-grade buck regulator ICs with high switching frequency and output current and a wide input voltage range.

Each device integrates a low-resistance high-side N-channel MOSFET, and incorporates current-mode control to provide excellent loop stability and transient response.

The A8582/83 devices use external compensation to accommodate a wide range of power components and optimise transient response without sacrificing stability. Both devices regulate input voltages from 4.7V to 36V down to output voltages as low as 0.8V, and are able to supply load current of at least 2A (A8582) or 3.5A (A8583).

Protection features include input undervoltage lockout protection, cycle-by-cycle overcurrent protection, "hiccup" mode short-circuit protection, overvoltage protection and thermal shutdown. In addition, the A8583 provides unique missing-diode protection, open-circuit, adjacent pin short-circuit and short-to-ground protection at every pin to satisfy the most demanding applications.

www.allegromicro.com

EFFECTIVE ICT REGULATION CRITICAL TO ECONOMIC GROWTH

ITU's ICT regulatory report *Trends in Telecommunication Reform* takes an in-depth look at one of the most significant social trends of the past ten years: the increasingly pervasive presence of ICT in virtually every facet of modern life.

The report reveals an increasingly robust yet complex regulatory landscape which has emerged in response to the tremendous influence ICTs now have on the shape and growth of other economic sectors.

At the beginning of 2011, more than 80% of markets worldwide have separate ICT regulatory agencies, making for a total of 158 ICT regulators worldwide – up from 106 just one decade ago.

Worldwide, mobile cellular subscriptions now total over 5.3 billion, including 940 million subscriptions to mobile broadband services – a figure which is expected to reach one billion before mid-2011.

As effective regulation becomes crucial to economic growth across all sectors, two broad themes emerge in the report: the ubiquity of ICTs, and the critical role of telecom/ICT regulators in creating an enabling digital environment.

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IVOR CATT, Engineer and Scientist, UK:
This is a very good report pointing to a remarkable development in the whole world. The most significant demonstration of the international impact of the electronics industry is the way it created a new situation in the central square in Cairo. This was an unprecedented new way in which "the people" combined, bypassing the old structures. The later possible return of Egypt to dictatorship and also the mess in Lybia demostrate the way in which new hi-tech developments are not properly linked with the old forms of government and communication. I am astonished that "... mobile cellular subscriptions now total over 5.3 billion...", which means almost the whole world, including the poorest, are now engaged in at least some of the new facilities.

PROFESSOR DR DOGAN IBRAHIM, Near East University in Nicosia, Cyprus:
As a result of the recent advances in ICT, serious competition in this field has become inevitable. With the growing number of ICT regulatory agencies around the world there is considerable pressure on these agencies to co-ordinate with each other in order to regulate the market in a positive manner. The use of Internet and related products are increasing at an alarming rate and Internet is no longer a luxury, but a necessity for social, economic and political interaction of people. It is my opinion that the ICT regulatory bodies around the world should co-operate with each other in the international markets with the aim of promoting investment in super products and, at the same time, they should battle against the creation and distribution of destructive products such as viruses, trojans and malware.

> Due to the huge amount of worldwide subscribers, I call for a flat rate of 1 EURO per month of connection usage in Europe

BURKHARD VOGEL, Managing Director, Germany:
Seeing the report's subscription and separate regulatory agency figures will lead to a growing nightmare feeling if we would continue to live with a non-regulated global ICT rank growth. ICT has become a living standard for many users – right from the socket and into the wall. Everything must be done to assure a stable ICT access everywhere. I guess the worldwide regulation is overdue for a long time.

However, regulation of ICT is only one part of the game. The other one will be the subscription price of access to any connection offered by any ICT provider. Because of the economy of scale with huge amount of worldwide subscribers, I call for a flat rate of 1 EURO per month for connection usage in Europe. Things should not become expensive because of their regulation!

MAURIZIO DI PAOLO EMILIO, Telecommunications Engineer, INFN – Laboratori Nazionali del Gran Sasso, Italy:
Technological progress in ICT goods and services is continuing at a rapid pace, driving prices down and leading to a wide range of new applications. Broadband is diffusing rapidly and several applications, such as e-commerce, are still in their early stages and may have a large potential for future growth. I think that ICT can be a technology that can underpin future growth and innovation. Capital deepening through investment in ICT is important for economic growth. It establishes the infrastructure for the use of ICT (the ICT networks) and provides productive equipment and software to businesses.