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# ELECTRONICS WORLD

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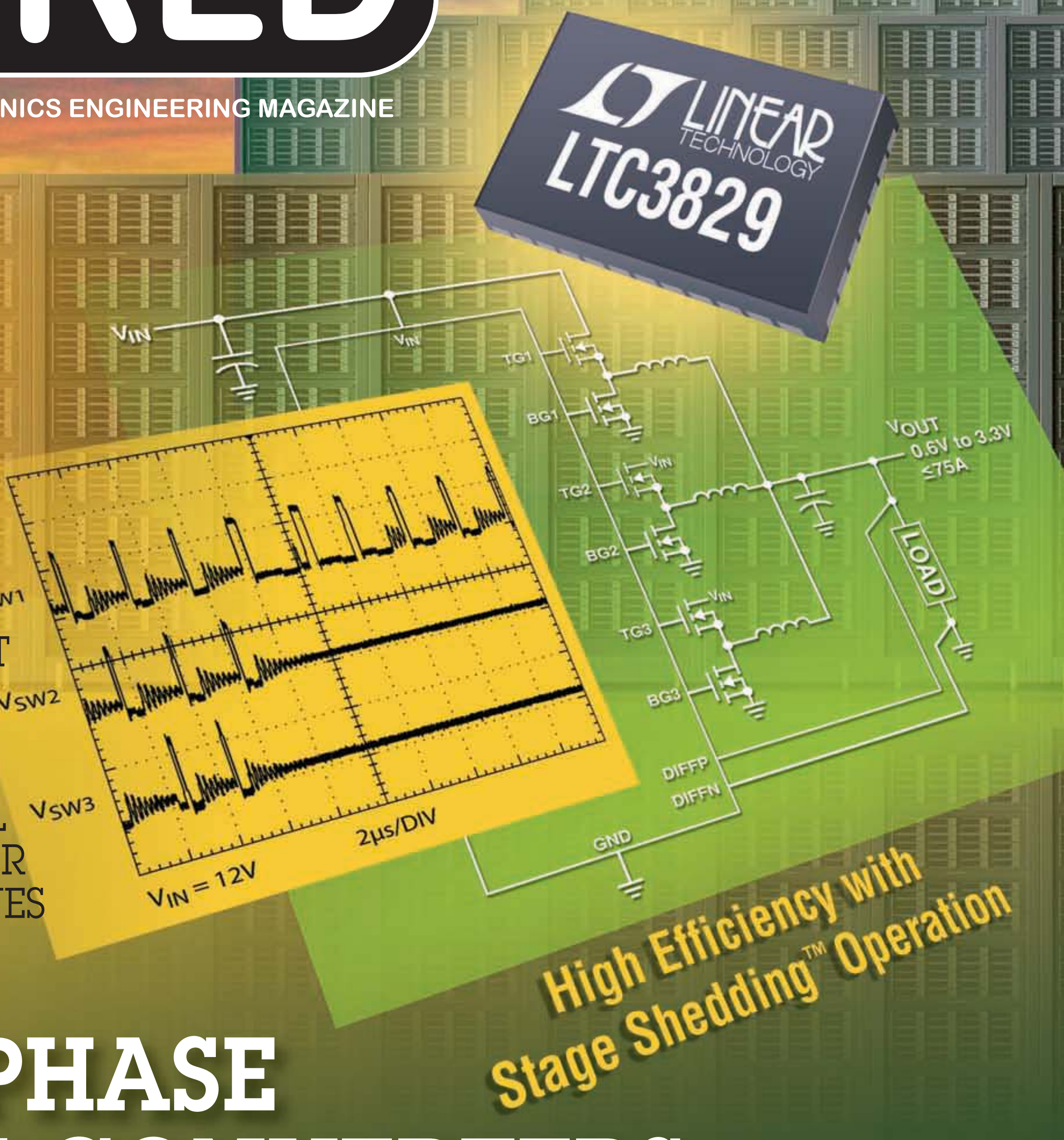


- SPECIAL REPORT ON POWER MANAGEMENT
- HIERARCHIC AND PARALLEL SEMANTICS FOR STATE MACHINES

## MULTIPHASE DC/DC CONVERTERS

FOR HIGHER ENERGY EFFICIENCY

**TECHNOLOGY**
BLIND SPOT BIO-MASS SENSOR HELPS DRIVERS


**FOCUS**
PRINTED ELECTRONICS NEEDS NEW DESIGN RULES

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COUNTDOWN TO THE LARGEST TRADE FAIR CONTINUES

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**Cover supplied by LINEAR TECHNOLOGY**
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## FEATURES





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# VERSATILE PARTNERSHIPS

## What this piece states is that intellectual property (IP) developers tend to enter new types of partnerships with various vendors to further enable the penetration of their solutions into systems.

One such IP provider is Nujira who offers Coolteq.L, a highly compact and efficient 4G (LTE and WiMAX) handset RF power amplifier extending its successful High Accuracy Tracking (HAT) technology from the base station to the terminal. Originally developed for the cellular and digital broadcast infrastructure markets, Nujira Coolteq power modulators for 3G, LTE Digital TV, DVB and WiMAX broadband radio frequency (RF) power amplifiers provide the technology to support flexible, power-efficient, smaller and cheaper base stations and transmitters.

Nujira markets Coolteq.L to existing providers of 4G terminal RF and baseband silicon as Intellectual Property (IP). However, to allow prospective silicon partners to evaluate the potential and performance of its technology and to help them develop their solutions, it decided to implement Coolteq.L as a test chip. To complement the chip, it required the development of a breadboard to interface its device to its customers' RF power management system. As its design resources were already fully allocated to the development of Coolteq.L itself, it made a decision to outsource this part of the project.

Commenting on the decision to use Sentec for this part of the programme, Julian Hildersley, VP of Handset Development at Nujira, said: "When we were weighing up proposals from the companies that had pitched to us, a key requirement for us was to find a partner with an excellent technical understanding of the drivers behind our market and products that would enable them to hit the ground running. A member of our team had established a good working relationship with Sentec while in a previous position, so we were already aware of its strong reputation. We were impressed by their knowledge of our space and we felt confident that it could partner with us to develop an effective solution around some very advanced technologies."

Initial discussions were opened up between Sentec and Nujira, going on to develop prototypes for a mobile phone power supply. In extending its existing technology to the handset, Nujira is working in partnership with established RF subsystem vendors to enable the design of cost-effective multi-mode, multi-band handsets with extended battery life.

Following the development of the prototypes, Sentec focused on in-depth testing and modelling of the system. The project included power supply development, control system design (including analogue and digital design), PCB layout and initial testing.

Matthew Storkey from Sentec said: "From the very start of the project, Nujira ensured we were working to a very clear brief, so we had an excellent understanding of their requirements. This meant that we were able to deliver exactly what they needed from us."

After just three months, Sentec delivered a prototype system, hardware and firmware, which is now being extensively tested and used as a starting point for discussions with potential partners.

Since the project began, Nujira has already seen concrete interest in its technology from top handset manufacturers, and a major global OEM has already signed a purchase agreement for its Coolteq.L handset development platform.

> **"A KEY REQUIREMENT FOR US WAS TO FIND A PARTNER WITH AN EXCELLENT TECHNICAL UNDERSTANDING OF THE DRIVERS BEHIND OUR MARKET AND PRODUCTS"**

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## SURREY NANOSYSTEMS'S PLATFORM HELPS DEVELOPERS

*Surrey NanoSystems has set a new benchmark for nanomaterials*

Surrey NanoSystems has set a new benchmark for the production of nanomaterials with the launch of an automated and a very versatile growth platform, NanoGrowth-Catalyst. Incorporating nine advanced nanomaterial processing techniques, the platform can synthesise a large variety of nanomaterials including graphene, nanowires and carbon nanotubes.

Application versatility is enhanced by a multi-chamber design – a first in this industry sector – that ensures the purest processing conditions by continuously maintaining the substrate under vacuum from deposition of catalysts to growth of nanomaterials. This end-to-end vacuum processing is critical for the precursors and catalysts used for nanomaterials, which are easily contaminated by exposure to atmosphere.

"Surrey NanoSystems's platform combines CVD and plasma-enhanced CVD nanomaterial growth techniques," says Ben Jensen of Surrey NanoSystems. "This new platform takes processing flexibility much farther. It offers the means to support and speed research across the spectrum of nanomaterials, combined with automated handling and control to help developers turn material growth ideas into practical and repeatable production processes."

NanoGrowth-Catalyst will replace multiple pieces of equipment with a single automated system. The processing techniques supported by the new platform are: LPCVD (low-pressure chemical vapour deposition) and PECVD (plasma-enhanced CVD), sputtering, sputter form of rapid thermal growth for nanomaterials called RTG which has been developed to prevent agglomeration of catalyst particles and others.

# Toshiba Develops Silicon Nanowire Transistor

Toshiba claims that it has developed a breakthrough technology for a nanowire transistor, a major candidate for a 3D structure transistor for system LSI in the 16nm generation and beyond. The company has achieved a 1mA/μm on-current, the world's highest level for a nanowire transistor, by reducing parasitic resistance and improving the on-current level by 75%. This is a major step towards practical application of nanowire transistors.

When the size of current planar transistors scales smaller, current leakage between the source and the drain at its off-stage (off-leakage) will become a critical problem in securing circuit reliability. To overcome this, transistors with a 3D structure, including silicon nanowire transistors, are being investigated as candidates for future generations of devices. The silicon nanowire transistor can suppress off-leakage and achieve further short-channel operation, because its thin wire-shaped silicon channel (nanowire channel) is effectively controlled by the surrounding gate. However, parasitic resistance in the nanowire-shaped source/drain, especially in the region under the gate sidewall, degrades the on-current.

Toshiba overcame this problem by optimizing gate fabrication and significantly reducing the thickness of the gate sidewall, from 30nm to 10nm. Low parasitic resistance was realized by epitaxial silicon growth on the source/drain with a thin gate sidewall, which leads to a 40% increase in on-current. The company also achieved a further 25% increase in current performance by changing the direction of the silicon nanowire channel to plane direction. This work was partly supported by (NEDO) Development of Nanoelectronic Device Technology.

## The First Vehicle Blind Spot Detection System Developed by tbp electronics

Benelux EMS manufacturer, tbp electronics, in association with the Delft University of Technology, has delivered the first vehicle blind spot detection system designed to sense the human body (or bio-mass). The first system was specifically developed for its Netherlands-based customer PerLex.

The PerLex Blind Spot Detector System is the first blind spot detector to measure the epsilon of the human body together with its capacitance and can detect a person within a distance of 50-100cm away from the vehicle.

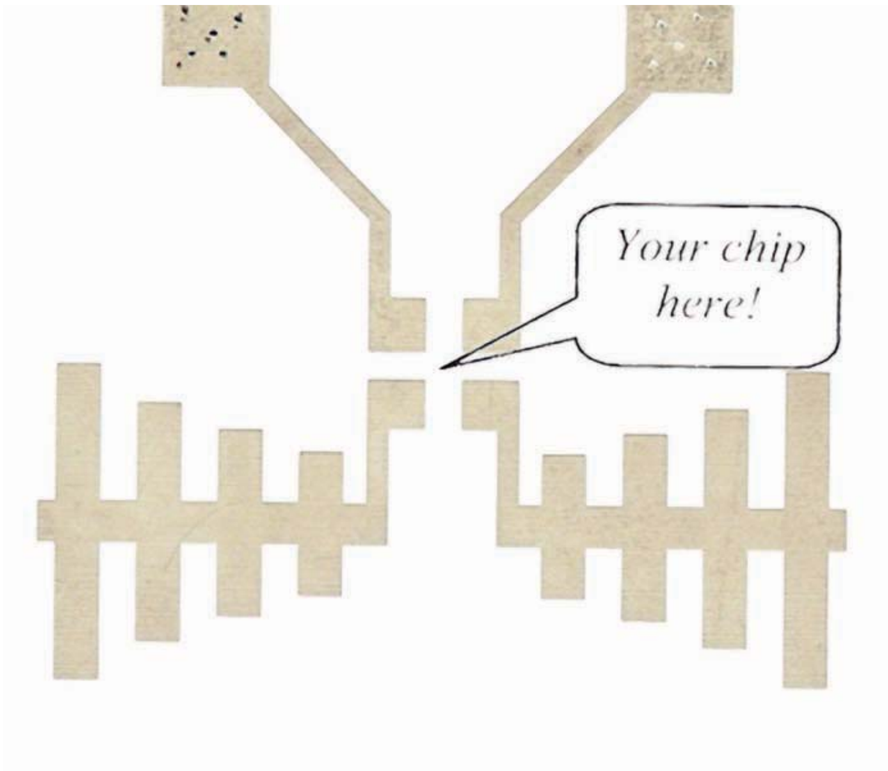
The stand-alone system operates on 24VDC and comprises a capacitive sensor that makes use of a transmitter and a receiver to build up a capacitive field. Rubber sensor strips housing an antenna are located on accident sensitive areas of vehicles such as trailer sides, bumpers, bodywork, or truck corners. Each sensor communicates via a coax cable to a programmable control box. Each control box, in turn, is connected to a cabin display located on the dashboard. Up to two sensor strips can be connected to each control box and up to eight control boxes can be connected to the cabin display via a power-line. The system conforms to the EC 2003/97 Class VI detection guideline.

*tbp electronics has created a bio-mass sensor that helps drivers detect persons in their blind spots*

Many active warning systems preventing blind spot accidents already exist. However, as these systems sound off several alarms, drivers are often overloaded and confused with them. PerLex addresses this issue as it detects the human body (or bio-mass) and, therefore, responds only when a person (bio-mass) is involved.

Once a person positioned in the vehicle's blind spot is detected by a strip sensor, the driver receives one of two signals, either a warning signal, consisting of an amber light and an audible warning sound located within the cabin, if a person is detected close to the vehicle or a distress signal if the vehicle touches a person.

The distress signal consists of a red light with an audible alarm located within the cabin of the vehicle.




*Bluespark printed manganese dioxide zinc battery, supporting integral antenna and interconnects*

# PRINTED ELECTRONICS NEEDS NEW DESIGN RULES

**Dr Peter Harrop,** Chairman at IDTechEx explains how printed electronics requires specific design rules, if it's to enter each sphere of everyday life

**THE FIRST CARS** looked like horse drawn carriages – suboptimal and using the design rules of the past. So it is with most printed electronics today. It is frequently burdened with old fashioned components like silicon chips, cylindrical capacitors, chip resistors and button batteries. It is often still made by soldering things together. It is very like a car designed as a "Surrey with a fringe on top."

The irony of the integrated circuit – the silicon chip – is that it integrates so little. It cannot incorporate a loudspeaker, microphone, push button or a reasonable battery or solar cell for example, because these are too big and silicon chips have to be small for viability. Large silicon chips are prohibitively expensive.

Printed electronics is very different. It can integrate all these things. For example, Palo Alto Research Center and Soligie in the US are printing components on top of each other. They connect but they can also interact – beneficially or problematically. The interaction of printed components and the use of new components that can only be made as thin films means that this new technology needs completely new design rules. This need is underpinned by the fact that the elements of the new electronics have new limitations, not just new capabilities.

### Research Needed

Universities should be researching the new design rules. For example, you can be profligate with transistors in a silicon chip but they are late to arrive into the printed electronics scene. They are often poorly performing and many have large feature size. Designers usually need to minimise the number of transistors in a printed electronics circuit and using the new flexible thin film component called the memristor – first made in 2008 – promises to be one way of doing this.

The first memristors were made by Hewlett Packard, and The National Institutes of Science and Technology have now developed flexible versions. Sometimes one can avoid transistors altogether as in an anti-theft tag, a Duracell on-battery tester or a Prelonic Technologies sequential multilayer display, where you press printed buttons to make successive layers reveal their text.

Plastic Electronics GmbH is creating a variety of printed devices relying on capacitive effects from smart shelves to thumb controls. However, printed inductance is very feeble but many companies already print even high power resistors on the desired flexible, low-cost substrates.

### Capacitors But Not As We Know Them

ACREO prints supercapacitors as gate dielectrics in its transistors. Indeed, flexible supercabatteries less than one millimeter thick were launched this year by Nanotecture. Printed metamaterial components are coming along.

What will we be able to do with the planned memcapacitors derived from memristors? Memory that takes no power is a possibility. Memristors are nonlinear and described by a variety of time-varying functions of net charge so there is no such thing as a generic memristor. Each device implements a particular function, either the integral of voltage determines the integral of current, or the opposite is true, so a linear time-invariant memristor is simply a resistor.

Memristor theory was formulated and named in the US by Leon Chua in 1971. He extrapolated the conceptual symmetry between the resistor, inductor and capacitor, and inferred that the memristor is a similarly fundamental device. Today he is looking at what happens if you combine the properties of memristors with capacitors and inductors to provide compound devices such as memcapacitors and meminductors and then what happens if you combine those two. New design rules indeed.

### The Toolkit Becomes Large

The toolkit for printed electronics is, therefore, advancing very rapidly, not just the multilayer assembly geometry. Those trying to sell individual printed components are rather like those selling mudguards or fenders for cars. They will sell a few but integration eliminated most of them some time ago. By contrast, Blue Spark Technologies wisely supports companies integrating its printed battery processes.

Power Paper had greater success when it moved from selling printed batteries to printing such things as smart skin patches delivering cosmetics that integrated the battery with the skin electrodes. Infinite Power Solutions sells its laminar batteries with energy harvesting interfaces that will increasingly be made in one process, providing near loss-less energy storage, highly efficient power management electronics and regulated output voltage, all in a miniaturized footprint.

### Three Dimensional

Conventional electronics – still essentially two dimensional – occasionally needs care with lateral inductive coupling between components at high frequencies, but the new printed electronics increasingly consists of components printed on top and alongside each other, the discrete component becoming a thing of the past. This can lead to capacitive coupling.

However, the various interactions can be turned to advantage as in the distributed LC circuits developed by Dr Richard Fletcher at Massachusetts Institute of Technology (MIT). These can perform filtering and RFID functions, for example.

A huge benefit made possible by printed electronics is its compatibility with smart substrates as in the stretchable electrodes on electroactive polymers that lead to loudspeakers, texture change and other types of human interface such as the reprogrammable Braille demonstrated by Tokyo University. At the recent IDTechEx Printed Electronics Asia event, it was shown how a stretchable circuit can be put over an entire egg without breaking it.

> "STRETCHABILITY, EDIBLE ELECTRONICS, TRANSPARENT AND TIGHTLY ROLLABLE ELECTRONICS AND OTHER TOTALLY NEW PARADIGMS COMPLETELY CHANGE THE DESIGN RULES"

Stretchability, edible electronics, transparent and tightly rollable electronics and other totally new paradigms completely change the design rules. For example, in a large number of potential applications, area is not a severe constraint in the way it is with conventional electronics and electrics. An unrolled printed photovoltaic or piezoelectric power source can be huge without being a problem as can the unrollable displays, keyboards etc printed at the same time. Printed electronics on a poster, billboard or even point of sale display has large area available so such things as transistor feature size or photovoltaic efficiency are not necessarily a primary issue if the materials are affordable. By contrast, in most potential printed electronics applications, cost is a much greater constraint than in most applications of conventional electronics.

Safe disposal is also more of a constraint, because such things as gift cards, skin patches and talking packages will be too numerous and ubiquitous to be put in a special disposal bin like today's lithium batteries. Reusability by reconfiguration as another product is one way out. The intended applications of printed electronics on consumer packaged goods, healthcare disposables and so on make them more likely to be chewed by children so the acids, heavy metals, gender bending polymers and other difficult materials of conventional electronics become a no no.

### Three Generations?

Perhaps we are seeing three generations of printed electronics. Firstly it is just strung together like the conventional electronics that went before and using conventional circuit design. Then the components – still identifiable – are co-deposited, sometimes on top of each other, involving the theory of distributed circuits. Then there may be a third generation of printed electronics that is a swirl of materials giving the desired result with not a single identifiable component in sight. Research is needed on this rather than the incremental improvement of, say, the individual layers of a 40-year-old design of horizontal field effect transistor that just happens to be printed nowadays. Climb into the future: do not extrapolate the past. ■

# Multiphase DC/DC Converters Provide High Efficiency Over the Entire Load Range


**Bruce Haug**
Senior Product Marketing Engineer, Power Products
LINEAR TECHNOLOGY CORPORATION

## OVERVIEW

Data centers presently consume an astounding 2.5 percent of the total electric power in the United States – a figure that's rising by approximately 12 percent per year and does not show any signs of slowing. As this power demand continues to increase, the need for higher efficiency power conversion is required to reduce the amount of wasted power. Smart multiphase controller technology is an excellent solution for high current applications. This architecture allows a high current regulator to achieve well over 90 percent efficiency at full load. However, most of these types of designs do not address the need for higher efficiency at light to medium loads. Wasted power at a light to medium load is just as important to save as wasted power at heavy loads.

Most embedded systems are powered via a 48V backplane. This voltage is normally stepped down to a lower intermediate bus voltage of 24V, 12V or 5V to allow power to the racks of boards within the system. However, most of the sub-circuits or ICs on these boards are required to operate at voltages ranging from sub-1V to 3.3V at currents ranging from tens of milliamps to hundreds of amps. As a result, point-of-load (POL) DC/DC converters are necessary to step down from either of the 24V, 12V or 5V voltage rails to the desired voltage and current level required by the sub-circuits or ICs.

It is clear that the growing demand for increased current at ever decreasing voltages is driving power-supply development. Much of the progress in this area can be traced to gains made in power conversion technology, particularly improvements in power ICs and power semiconductors. In general, these components contribute to enhancing power supply performance by permitting increased switching frequencies with minimal impact on power-conversion efficiency. This is made possible by reducing switching and on-state losses thereby increasing efficiency while allowing for the efficient removal of heat. However, the migration to lower output voltages places more pressure on these factors, which in turn, creates significant design challenges.

## MULTIPHASE TOPOLOGY

Multiphase operation is a general term for conversion topologies where a single input is processed by two or more converters, where the converters are run synchronously with each other but in different, locked phases. This approach reduces the input ripple current, the output ripple voltage and the overall RFI signature while allowing high current single outputs, or multiple lower current outputs with fully regulated output voltages. It also allows smaller external components to be used, producing a higher efficiency converter and also providing the added benefit of improved thermal management with less cooling.

Multiphase topologies can be configured as step-down (buck), step-up (boost) and even as a forward converter, although generally the buck regulator is the more prevalent application. Conversion efficiencies of up to 90% from 12V in to 1.xV out are commonplace today.

At higher power levels, scaleable multiphase controllers reduce the size and cost of capacitors and inductors using input and output ripple current cancellation caused by interleaving the clock signals of several paralleled power stages. Multiphase converters help minimize the external component count and simplify the complete power supply design by integrating PWM current mode controllers, true remote sensing, selectable phasing control, inherent current sharing capability, high current MOSFET drivers plus overvoltage and overcurrent protection features into a single IC. The resulting manufacturing simplicity not only helps improve power supply reliability, but it is also scaleable. Such system can be expanded up to 12 phases for high current outputs as high as 300A.

Linear Technology has several multiphase DC/DC controllers with the LTC3856 and LTC3829 being the most recent single output synchronous step-down controllers for high current POL conversion. Not only can these parts increase full load efficiency, but they also have optional Stage Shedding™ that decreases light to medium load power loss as well. The circuit in Figure 1 shows a typical LTC3856 application schematic for developing a 1.5V/50A output from a 4.5V to 14V input voltage using two phases. The circuit in Figure 2 shows a typical LTC3829 application schematic for developing a 1.2V/75A output from a 6V to 28V input voltage with three phases.

The LTC3856 has two channels and up to 12 phases possible with multiple ICs. The LTC3829 has three channels and can operate at up to 6 phases when used with two ICs. The onboard differential amplifier provides true remote output voltage sensing of both the positive and negative terminals, enabling high accuracy regulation independent of IR losses in trace runs, vias and interconnects.

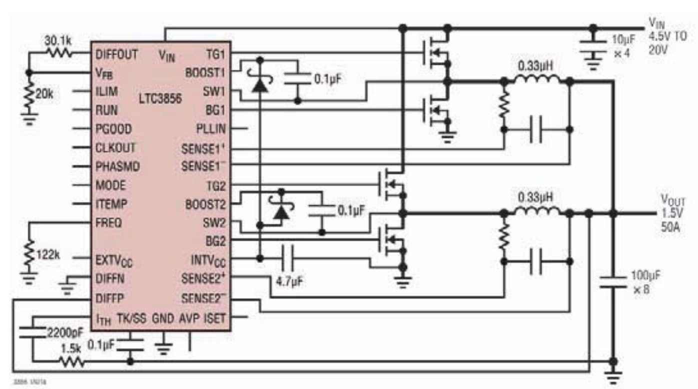



*Figure 1:* High Output Current 1.5V/50A Applications Schematic

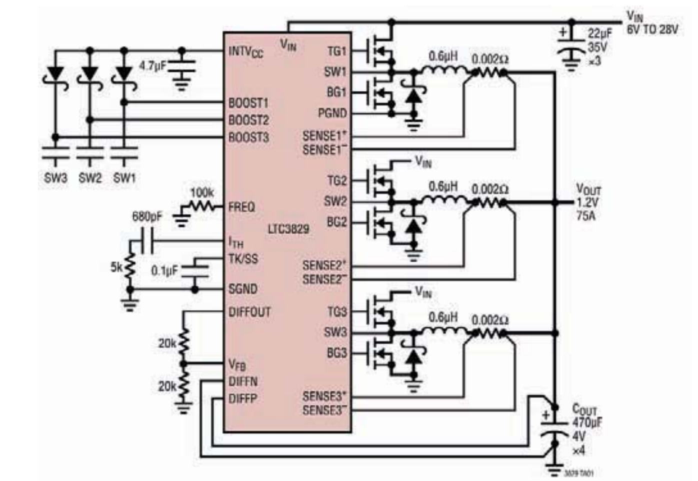



*Figure 2:* High Output Current 1.2V/75A Applications Schematic

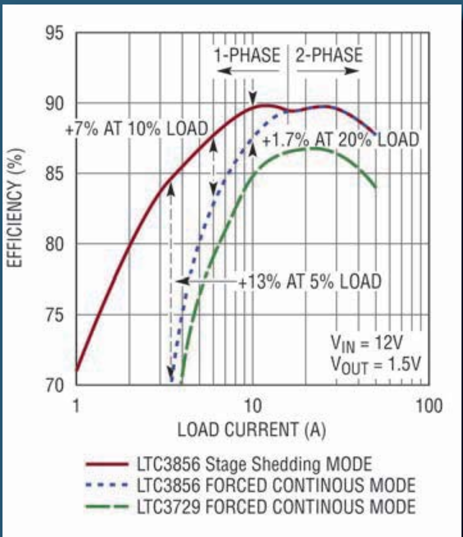



***Figure 3:*** *LTC3856 Efficiency Curve with Stage Shedding Phase vs. an Older Controller*

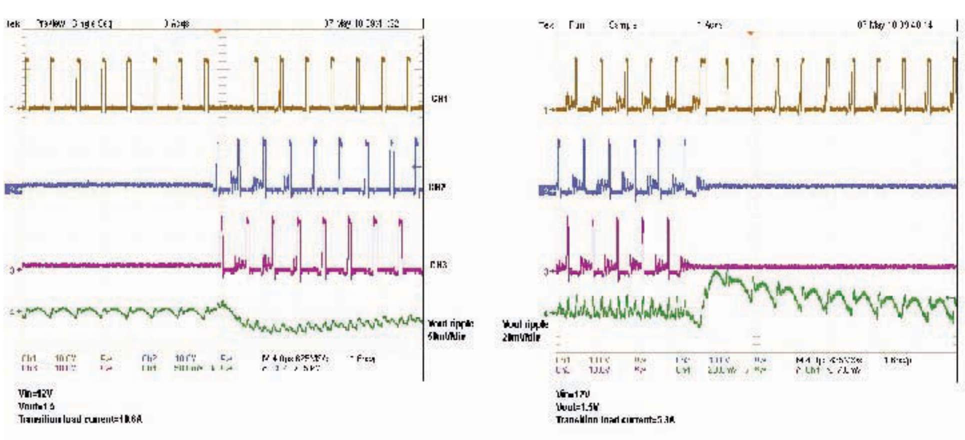


***Figure 4:*** *LTC3829 Stage Shedding Phase Waveforms*

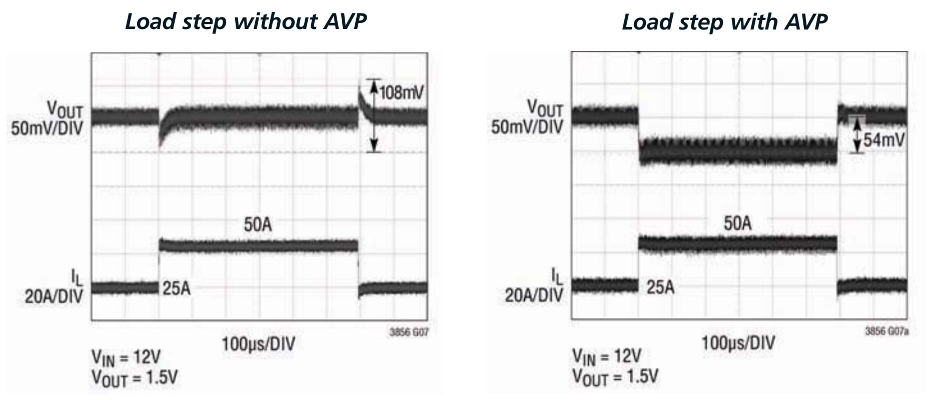



***Figure 5:*** *Active Voltage Positioning Load Step Characteristics*

## ADDITIONAL BENEFITS

These controllers operate with all N-channel MOSFETs from input voltages ranging from 4.5V to 38V, and can produce ± 0.75% accurate output voltages from 0.6V to 5V. The output current is sensed, monitoring the voltage drop across the output inductor (DCR) for highest efficiency or by using a sense resistor for highest current sharing/limit accuracy. Programmable DCR temperature compensation maintains a constant over current limit set point over a broad temperature range. The powerful onboard gate drivers minimize MOSFET switching losses and allow the use of multiple MOSFETs connected in parallel. A fixed operating frequency can be programmed from 250kHz to 770kHz or synchronized to an external clock with its internal PLL. A minimum on time of just 90ns makes them ideal for high step-down ratio/high frequency applications.

## STAGE SHEDDING OPERATION

At light loads, switching-related power losses normally dominate the total loss of a switching regulator. Eliminating the gate charge and switching losses of one or more of the output stages during a light load will significantly increase efficiency.

Stage Shedding allows one or more phases to be shut down to reduce switching related losses during a light load condition and is typically used when the load current is reduced to less than 15 amps. The overall efficiency can be increased by up to 13% as shown in Figure 3. This figure also shows the efficiency of an older comparable LTC3729 2-phase controller. Due to the stronger gate drive and shorter dead time, the LTC3856 can achieve around a 3-4% greater efficiency than the LTC3729 over the whole load range.

Stage shedding operation is triggered when the onboard feedback error amplifier output voltage, which is proportional to the output inductor current due to the current mode control, is less than a user programmable voltage. At this programmed voltage/load current level, the controller shuts down one or more of its phases and stops the power MOSFETs from switching on and off. This ability to program when Stage Shedding takes place provides the flexibility to determine when to enter this mode of operation. The diagrams in Figure 4 show the SW waveform and how the LTC3829 smoothly goes into and out of Stage Shedding operation.

The LTC3856 and LTC3829 can operate in any of three modes; Burst Mode® operation, forced continuous or Stage Shedding mode, all of which are user selectable. At heavy loads of greater than 15 amps, these devices operate in constant frequency PWM mode. At very light loads, Burst Mode operation can be selected and will produce the highest efficiency at load currents of less than 0.5A. Burst Mode operation switches in pulse trains of one to several cycles, with the output capacitors supplying energy during internal sleep periods.

## ACTIVE VOLTAGE POSITIONING

The LTC3856 and LTC3829 also have Active Voltage Positioning (AVP), which reduces the maximum voltage deviation during a step load and reduces the load power dissipation and thermal stress at heavier loads. Figure 5 shows the difference in behavior between the circuit in Figure 1 with and without AVP. Without AVP, the maximum voltage deviation for a 25A step load is 108mV. With AVP, the maximum voltage deviation is 54mV for the same 25A step load. In addition, the output voltage drops by 54mV with AVP when the output current goes from 25A to 50A, resulting in a lower 2.7W being dissipated by the load.

## CONCLUSION

The need to reduce the power dissipation in data centers will be a focus for the next several years. Designers of POL DC/DC converters for almost any kind of system face many challenges due to the multiple constraints of limited space and cooling within a given enclosure, as well as the need for high efficiency throughout the entire load range. Despite having to navigate through this myriad of constraints, many of the recently introduced multiphase regulators provide a simple, compact, efficient and feature-rich solution. By moving towards the diverse multiphase topologies, designers can effectively improve efficiency, save space, simplify the layout, lower capacitor ripple current, improve reliability and save cost.

# COMBINATION ICS – CHEAP AS CHIPS?

**Lisa Arrowsmith** from IMS research looks into the factors that are making combination ICs a reality but also a limitation for some OEMs

**IN A TIME** when cellular handset manufacturers and IC suppliers alike are fighting to maintain profit margins, whilst enhancing the competitiveness of their offerings, the use of combination ICs is an increasingly popular option. This is set to continue, with growth of combination wireless ICs forecast to increase at a CAGR of nearly 30% between 2008 and 2013.

Combination ICs can offer cost savings of 20-40% over the use of numerous standalone wireless ICs (dependant on the wireless technologies in question, the volumes being shipped and the level of integration). So are these ASP reductions solely responsible for the rise of combination ICs?

In the cellular handset environment, device convergence and emerging use-cases for wireless technologies are also driving the demand for wireless combination ICs. As well as significant cost savings, using a combination IC in a cellular handset instead of numerous standalone wireless ICs enables smaller form-factors, without the co-existence issues commonly associated with the use of multiple radios.

In general terms, the more radios there are in a handset, the higher the battery drain. Through integrating multiple technologies on a single IC, the sharing of some functions can reduce the power consumption. This is especially vital with the increased demand for power-hungry use-cases, such as mobile browsing and file downloading.

A key trend expected to affect mobile network operators is the drive to monetise content in order to increase ARPU (average revenue per user). This places more pressure on IC suppliers and handset manufacturers alike to reduce the power requirements of the technologies used to provide these services.

**"OTHER FACTORS DRIVING THE USE OF COMBINATIONS ICS IN HANDSETS ARE THE DEVELOPING MATURITY AND INCREASING ATTACH RATES OF CERTAIN WIRELESS TECHNOLOGIES IN CELLULAR HANDSETS"**

Other factors driving the use of combinations ICs in handsets are the developing maturity and increasing attach rates of certain wireless technologies in cellular handsets. This in turn is helping to determine which wireless combinations make economic sense for IC suppliers and handset manufacturers. So, what is stopping combination ICs becoming ubiquitous across all cellular handsets over the next few years? A key reason is that a significant volume of cellular handsets, such as those classed as ultra-low-cost (ULC), are aimed at segments that still do not include multiple wireless connectivity features, beyond basic 2G/3G cellular network capabilities. This is because the inclusion of ICs with multiple wireless functionality, though cheaper than multiple standalone ICs, is still too expensive and not required for the basic features and functionality ULC handsets are designed for.

At the opposite end of the scale, some handset segments require the latest, greatest versions of wireless technology standards. This can be a challenge for OEMs choosing to integrate combination ICs due to: different technologies maturing/requiring an upgrade at different rates; potentially longer design cycles, a longer testing phase and the time it takes to achieve certification for all wireless technology standards included on the chip. Additionally, the segment requiring the latest technology may be relatively small. Hence, it can make more sense to utilise existing solutions for the more common technology which is included in a high proportion of cellular handsets (such as classic Bluetooth), taking advantage of economies of scale benefits. This can then be supplemented with the addition of a standalone 802.11n IC for the highest tier segments, as opposed to investing in Bluetooth/802.11n combination ICs which are only required in a relatively small volume of handsets.

This is not to say that 802.11 does not have a place in cellular handsets – existing products such as the Apple iPhone have proved that there are popular use-cases that demand this. However, the majority of users are happy to utilise earlier versions of 802.11 standards, such as b/g, with only a relatively small proportion demanding 802.11n.

Combination ICs are clearly staking their claim on the cellular handset market. While price reductions do play a key role in the rise of ICs with multiple wireless functionalities, it is important not to overlook the other benefits that can be gained from this integration. These include silicon 'footprint' reductions and improved co-existence. Yet, despite these factors, there are still issues that will prevent combination ICs becoming ubiquitous across all cellular handsets. ■

# Does your digital power-supply design require high performance flexible on-chip peripherals?...

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Typical applications of the new 'GS' series DSC include: Lighting (HID, LED, fluorescent), uninterruptable power supplies, intelligent battery chargers, AC-DC and DC-DC power converters, solar and pure sine-wave inverters, induction cooking, and power factor correction.

- Digital control loops with 12 to 18 high-speed, 1 ns resolution PWMs
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# Workload

Myk Dormer

**IN THE ENGINEERING** community, how many of us are actually working a nine-to-five, Monday-to-Friday week anymore? Or does it seem that the workload required of the engineer is rising and rising, without apparent limit?

How many are beginning to forget what our homes looked like in daylight, what a non-working weekend felt like, or what our hobbies and pass-times used to be?

It is understood by anyone embarking on the career that engineering is a vocation and that a certain degree of commitment to the job is part of the package. We accept that the poor long-term prospects and average monetary rewards are balanced against satisfying, creative, fascinating, challenging work and a relative freedom from unnecessary red tape.

Over the last year or two, however, this unspoken balance seems to be breaking down, at least in the small corner of low power RF design that I inhabit. The cause, I fear, is all too simple. It's obvious that every company has felt the effect of the overall global economic downturn and, consequently, turnover and profits have declined. This, in turn has necessitated radical economies, with lab budgets and engineering staff levels being heavily cut. Of itself, this would be expected to simply cause an overall depression in the engineering community, but an additional factor has intruded.

In order to regain profitability, engineering companies have been obliged to make greater efforts to gain orders, leading to increases in the numbers of "customer special" jobs reaching the lab, and to cut waste, resulting in cost reduction redesigns and "value engineering" exercises. This has, in turn, increased engineering workload just as the staff levels fall.

In the short term, this is supportable. It is possible to "make the extra effort", to "work smarter" and to "do it for the company" – for a short time. Unfortunately, a new trend has appeared that is making matters even worse. Managers have realised that, despite the redundancies and short-time working, the engineering work is still getting done, even as the long-delayed economic recovery begins to favour the sales figures.

> "OVER THE LAST YEAR OR TWO, THIS UNSPOKEN BALANCE SEEMS TO BE BREAKING DOWN, AT LEAST IN THE SMALL CORNER OF LOW POWER RF DESIGN THAT I INHABIT"

The assumption is being made that the engineers will be able to continue willingly carrying the extra workload (that was necessary for corporate survival) indefinitely, even as order (and work) levels return to pre-slump levels. In other words that the short term economies can be made permanent.

My simple comment here is "No". The analogy is not perfect, but no-one would expect a sprinter to be able to keep the same speed over a marathon as is achieved in the hundred meters. Nor would it be reasonable to expect an engine to run at the 'red line' permanently.

In the same way it is unrealistic, and utterly unfair, to expect professional staff to continue to work at 'crisis' levels for months and years on end. Something is going to break. ■

*Myk Dormer is Senior RF Design Engineer at Radiometrix Ltd*
***www.radiometrix.com***

# The SRPP Gain Stage

**Burkhard Vogel** presents a series of short features with general remarks on triodes in audio applications

**SRPP MEANS** Shunt Regulated Push Pull. It consists of a gain stage with two triodes in a sequence and it goes back to a US patent from 9th Feb1943, called *'Balanced direct and alternating current amplifiers'* by Maurice Artzt, US Patent No 2,310,342.

The output is taken from the cathode of the second triode V2 whereas the input is fed via the grid of the first valve V1. Both triodes are coupled together at the anode of V1 and the 'cold' side of the V2 cathode resistor $R_{c2}$ as well as at the V2 grid (see **Figure 1**).

Generally this concept leads to rather high output resistances that make the SRPP gain sensible to output loads. However, the low distortion in A-class operation makes it useful for many applications, from low-level amp input stages to driving stages for very high output levels.

As function of the output load $R_L$, with $r_{g1}$ and $r_{g2}$ = infinite and an un-bypassed ($_u$) resistor $R_{c1}$ the general SRPP gain equation becomes:

$$G_u(R_L) = \frac{v_o}{v_i} = -\mu_1 \frac{r_{a2} + \mu_2 R_{c2}}{r_{a1} + r_{a2} + (1+\mu_1)R_{c1} + (1+\mu_2)R_{c2} + B} \qquad (1)$$

$$B = \frac{1}{R_L}\left[r_{a2}\left(r_{a1} + R_{c2}\right) + R_{c1}\left(r_{a1} + \mu_1 r_{a2}\right)\right]$$

It was not part of the patent, however, to increase the gain by bypassing $R_{c1}$ with a capacitance of a size that does not hurt a flat frequency and phase response in $B_{20k}$ (this is the short-cut across $R_{c1}$ in **Figure 2**) leads to the bypassed ($_b$) gain $G_b(R_L)$:

$$G_b(R_L) = \frac{v_o}{v_i} = -\mu_1 \frac{r_{a2} + \mu_2 R_{c2}}{r_{a1} + r_{a2} + (1+\mu_2)R_{c2} + \frac{1}{R_L} r_{a2}\left(r_{a1} + R_{c2}\right)} \qquad (2)$$

V1 and V2 can be different triodes. The only requirement is the equal operating current $I_a$ at the anodes of V1 and V2.

The special case of a double-triode for V1 and V2 simplifies **Equations 1** and **2**. With $\mu = \mu_1 = \mu_2$, $r_a = r_{a1} = r_{a2}$ and $R_c = R_{c1} = R_{c2}$ the gains $G_u(R_L)$ and $G_b(R_L)$ become:

$$G_u(R_L) = -\mu \frac{r_a + \mu R_c}{2\left[r_a + (1+\mu)R_c\right] + \frac{r_a}{R_L}\left[r_a + (2+\mu)R_c\right]} \qquad (3)$$

***Figure 1:*** *Basic SRPP circuit*

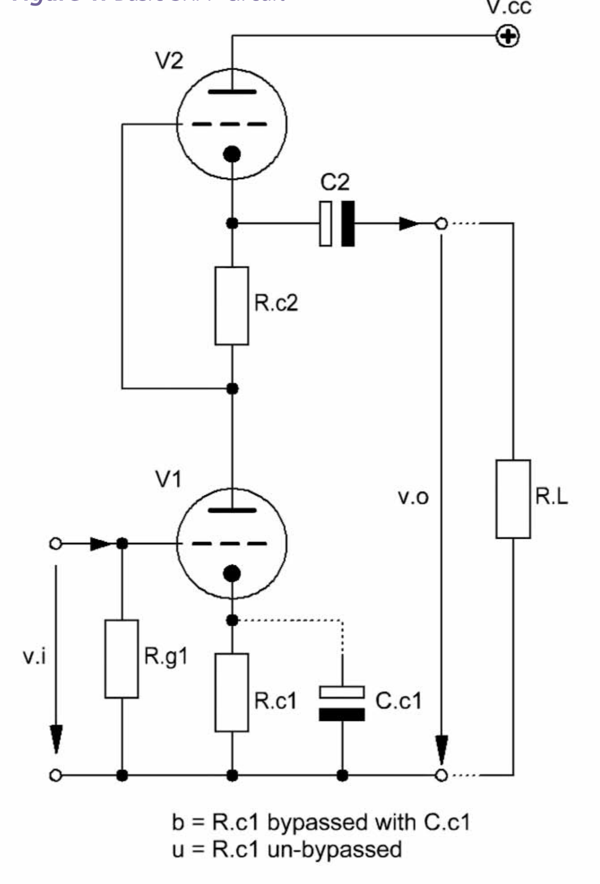
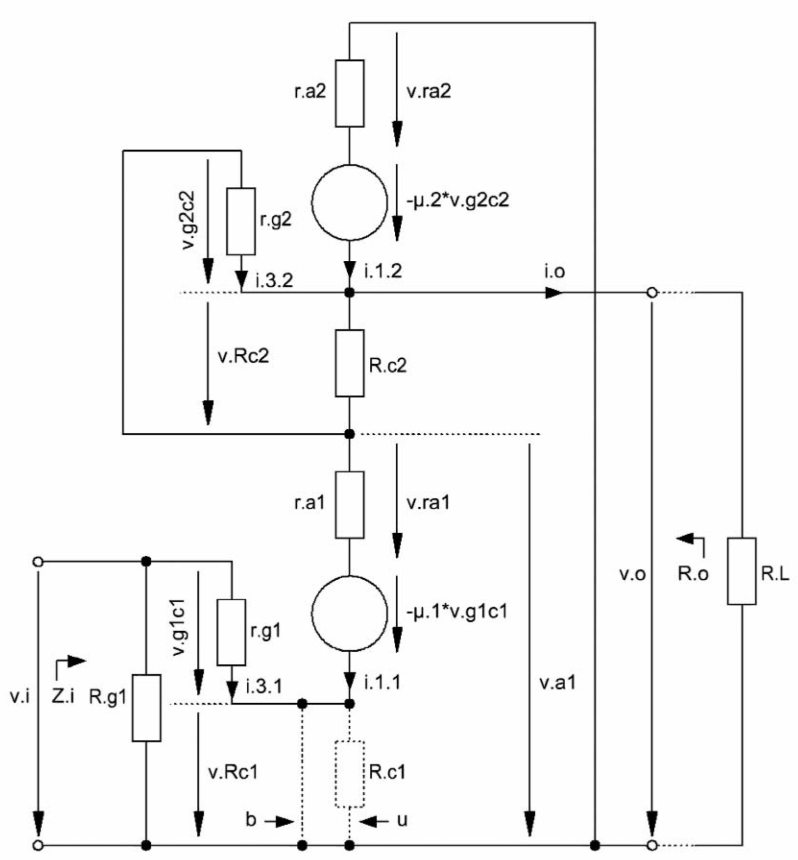



***Figure 2:*** *Equivalent circuit of Figure 1*



$$G_b(R_L) = -\mu \frac{r_a+\mu R_c}{2r_a+(1+\mu)R_c+\frac{r_a}{R_L}(r_a+R_c)} \qquad (4)$$

A further simplification step could be: $R_L$ = infinite, hence, in the above shown Equations 1-4, the term with $R_L$ as numerator will disappear.

The output resistance $R_{o.u}$ for any kind of used triodes (left) or for a double-triode (right) becomes:

$$\frac{r_{a1}(r_{a2}+R_{c1})+r_{a2}(R_{c2}+\mu_1 R_{c1})}{r_{a1}+r_{a2}+(1+\mu_1)R_{c1}+(1+\mu_2)R_{c2}} = R_{o.u} = r_a\frac{r_a+(2+\mu)R_c}{2[r_a+(1+\mu)R_c]} \qquad (5)$$

The output resistance $R_{o.b}$ for any $R_{c1}$ bypassed triode (left) or double-triode (right) becomes:

$$r_{a2}\frac{r_{a1}+R_{c2}}{r_{a1}+r_{a2}+(1+\mu_2)R_{c2}} = R_{o.b} = r_a\frac{r_a+R_c}{2r_a+(1+\mu)R_c} \qquad (6)$$

Whereas the output capacitance $C_o$ can be ignored and by ignoring the $C_{gc1}$ reducing $R_{c1}$ effect, the $R_L$ dependent input capacitance $C_i$ at the grid of V1 becomes:

$$C_i(R_L) = [1+|G(R_L)|]C_{ga1}+C_{gc1}+C_{stray1} \qquad (7)$$

$G(R_L)$ must be adequately chosen from Equations 1-4 and the V1 stray capacitance $C_{stray1}$ must be guessed (≈ 2pF-10pF). Thus, we get the frequency and load resistance dependent SRPP input impedance $Z_i(f,R_L)$:

$$Z_i(f,R_L) = |C_i(R_L)\,\|\,R_{g1}| \qquad (8)$$

With constant DC values $V_{a1} = V_{a2}$ = 100V for the circuit of Figure 1 we can plot graphs for an ECC83/12AX7 example double-triode ("$_k$" indicates the number of the ten $I_a$ values from 0.2mA to 1.6mA):

**Coming in the next issue is**
***Part 6: 'The Cathode Follower CF'***

**If you missed any of the previous parts, you can order them online by going to Electronics World's website at www.electronicsworld.co.uk**

***Figure 3:*** *SRPP gains $G_u$ and $G_b$ vs. anode current $I_a$ ($R_L$ = 100kΩ)*

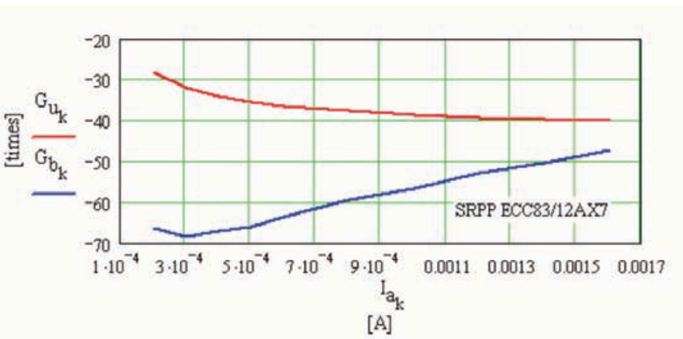



***Figure 5:*** *SRPP output resistances $R_{o.u}$ and $R_{o.b}$ vs. plate current $I_a$*

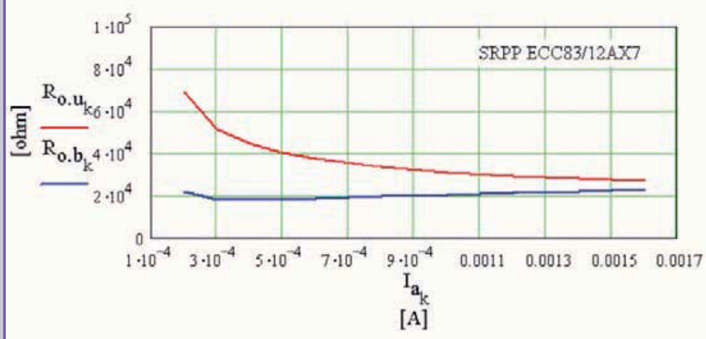



***Figure 4:*** *SRPP gains $G_u(R_L)$ and $G_b(R_L)$ vs. load resistance $R_L$ ($I_a$ = 1.2mA, $R_c$ = 417Ω)*

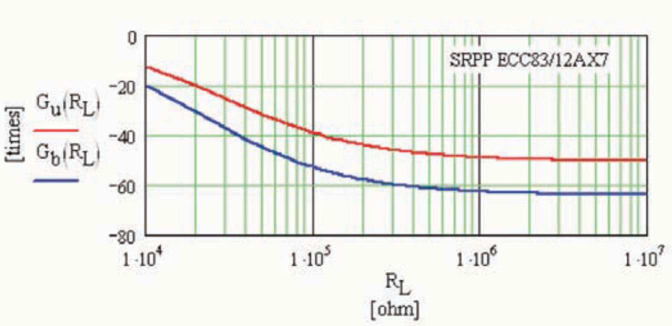
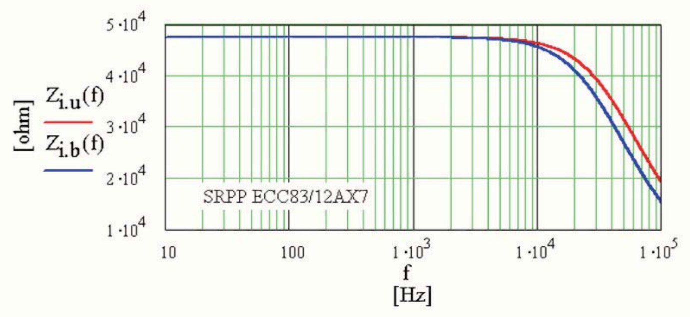



***Figure 6:*** *SRPP input impedances $Z_i(f)$*



*electronica 2010 opens its doors to visitors between November 9th and 12th in Munich, Germany*

# The Countdown to EUROPE'S LARGEST TRADE FAIR electronica 2010 – Continues

The electronics industry was severely affected by the global economic crisis over the past couple of years. Sales on the world market for electronic components in 2008 amounted to just under $400bn. In 2009 the corresponding figure was only approximately $330bn.

The substantial decreases in sales of up to 16% are due to the worldwide slumps on the largest submarkets, i.e. automotive and industrial electronics.

The downward trend has now come to an end and companies are enjoying growth again.

The German Electrical and Electronic Manufacturers' Association ZVEI – Zentralverband Elektrotechnik und Elektronikindustrie e.V, is predicting a market recovery in 2010 accompanied by sales increases of around 7%.

Sales are also increasing on the different submarkets. For example, sales on the worldwide semiconductor market in February 2010 amounted to $22bn, i.e. 56% above the previous year's figure in February 2009.

Automotive electronics, another highly relevant submarket, is expecting sales to rise by around 10%.

Although there is a positive mood in the industry, companies are showing caution as regards investments and current expenditure. However, electronics is an enormous future market. As the world's largest product market, the global electromarket has reached a volume of more than 2.5 trillion Euro.

## electronica – World's Leading Trade Fair

The electrical and electronics industry has enormous social responsibility on account of its size. It also provides solutions for the most urgent social challenges such as the future of mobility and people's energy supplies. electronica 2010 will, therefore, be more than just the world's largest and most important trade fair for the electrical and electronics industry:

- It will provide a major boost towards the development of the industry;
- It will feature future-oriented solutions from the world's most innovative companies;
- It will supply answers to the most important social questions;
- It will systematically focus on the future.

Due to this future orientation, electronica 2010 will also be the world's most important event for companies in the electric and electronics industry in terms of its thematic content.

Starting from the show held in Munich, electronica has become the international cornerstone of the worldwide electronics industry.

It acts as a stimulus for the industry since it is the only trade fair which covers the entire spectrum of the electronics industry – from individual components and electronic systems through to applications – and as such it creates value-added and synergies which are found at no other event. This is also shown by the fact that companies present their pioneering innovations at electronica.

**www.electronica.de/en**

## Focus on Growth Markets

The objective of electronica 2010 will be to focus closely on these future markets:

- Automotive
- e-Mobility and power electronics
- Displays and e-Signage
- Embedded systems and software
- Medical electronics and MEMS
- Photovoltaics and renewable energies.

The electronics industry has always been a pioneer for future developments. However, the current challenges facing industry and society are greater than ever, seen through the call for e-Mobility, improved power electronics to cope with the large number of applications in automobiles and other applications, or the questions of medical electronics and renewable energies. This is accompanied by demands on display technologies and embedded systems.

And a most important aspect affecting all topics is the demand for energy efficiency.

## Valuable Meeting Grounds

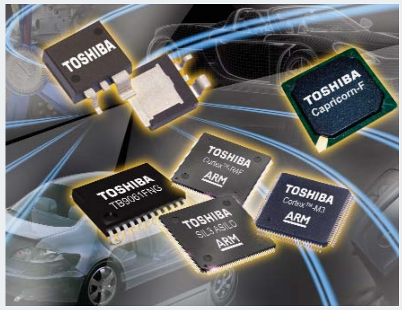
Just like the key players in the electronics industry exhibit at electronica, the visitors include representatives of the most important user industries who come to the trade fair to obtain information.

Some 35% of visitors work in industrial electronics, with 18% coming from the automotive sector and 12% from electronics for other consumer goods.

electronica is often regarded as a trade fair for decision-makers; around 52% of visitors occupy a leading position in their company. However, developers are just as well-represented, i.e. 51% of visitors.

electronica is also a valuable information and communication platform for visitors from purchasing and acquisition, as well as from manufacturing and production.

## TOSHIBA ELECTRONICS TO SHOWCASE ADVANCED SEMICONDUCTOR SOLUTIONS FOR AUTOMOTIVE DESIGNS




At Electronica 2010 Toshiba Electronics Europe (TEE) will be showcasing a selection of advanced semiconductor solutions for automotive applications and presenting a paper on new microcontroller technologies for automotive safety systems.

Visitors to the Toshiba stand in the Hall 6 automotive sector will have the opportunity to see the latest 'Capricorn' system-on-chip (SoC) solutions for driving and managing high-quality automotive displays; new ARM Cortex-M3 microcontroller technologies that address ISO26262 ASIL (Automotive Safety Integrity Level) requirements for safety-critical systems; and automotive-qualified ASSP (application specific standard products) driver ICs that simplify the implementation of brushless DC (BLDC) motor control. The company will also be unveiling a new BiCDMOS semiconductor process platform for next-generation automotive ICs and showcasing automotive LEDs and power MOSFETs.

Capricorn display processors are highly integrated, scalable SoCs targeted at automotive digital instrument clusters and head up display (HUD) applications. Among the Capricorn SoCs on show at Electronica will be Capricorn-F, the first member of the family to provide support for 3D graphics and to incorporate APIX Gigabit digital serial data link transmission.

**www.toshiba-components.com**
**Hall A6, Stand 530**

## ADI TO INTRODUCE PRECISION CONTROL, MEASUREMENT AND MONITORING SOLUTIONS AT ELECTRONICA 2010


Analog Devices (ADI) plans to unveil new technologies for precision control, measurement and monitoring solutions for industrial and instrumentation, healthcare and automotive applications at electronica 2010. The company will feature a series of demonstrations at its stand (Hall 4, Stand 159) that will showcase ADI's latest innovations in data conversion, high-performance linear, motion sensing, RF and DSP technologies as they are being applied to a wide range of applications.

Among the demonstrations and new product announcements will be on energy metering, motor and process control, security, robotics, medical imaging, home health and wellness, driver assistance and passive safety systems, among others.

Max Liberman from ADI's MEMS and Sensor Group will participate in the panel discussion "MEMS in Automotive" on Thursday, November 11th (13:00 to 14:00 hrs, Hall location to be announced) moderated by iSuppli's analyst, Richard Dixon.

Additionally, Wayne Meyer from the ADI's MEMS and Sensor Group will participate in a "MEMS in Consumer" panel discussion on Wednesday, November 10th (12:00 to 13:00 hrs, Hall location to be announced) moderated by iSuppli analyst, Jérémie Bouchard.

**www.analog.com**
**Hall 4, Stand 159**

## PEI-GENESIS TO HIGHLIGHT 48-HOUR ASSEMBLY SERVICE FOR HARSH-ENVIRONMENT CONNECTORS

At this year's Electronica exhibition, franchised connector assembly specialist PEI-Genesis will be highlighting the 48-hour assembly service it offers across a huge range of connectors for harsh-environment applications.

In addition to its extensive portfolio of industrial, military, aerospace and railway connectors, PEI-Genesis will be displaying a recently introduced family of ATEX-approved connectors, which are designed for use in oil and gas exploration, petrochemical plants and fuel storage sites.

By holding a massive $60m inventory of connector components and using automated assembly machines, the company is able to assemble connectors to customers' exact specifications and despatch them in less than 48 hours.

PEI-Genesis works in close partnership with leading manufacturers of connectors and accessories, including Amphenol, ITT Interconnect Solutions (Cannon and VEAM), Glenair and Polamco.

The line-up of ATEX-approved connectors is spearheaded by Amphenol's Amphe-EX series. These are versatile miniature connectors that accept copper, coaxial or fibre-optic contacts and can also be specified with RJ45 or USB inserts for applications such as data acquisition, process control, communications systems and embedded computers.

**www.peigenesis.co.uk**
**Hall B4, Stand 433**

## LOW-LOSS INDUCTIVE COMPONENTS FROM SMP AT ELECTRONICA THIS YEAR

SMP Sintermetalle Prometheus (SMP) is presenting inductive components at this year's Electronica trade show in Munich, Germany. These components feature low-loss and good EMC characteristics and a space-saving design. Their cores consist of powder composites, which SMP specifically engineers for each application.

Depending on their application, they are constructed either as single-conductor chokes for high-current applications, individual chokes, choke modules or LC filters. They are used in inverters for wind turbines and photovoltaic plants, railway engineering, medical engineering as well as in drives and power electronics.

SMP manufactures all components to application requirements using in-house developed powder composites. These parts offer a high energy storage capacity in a compact and cost-conscious design as well as reduced losses and good EMC characteristics.

SMP's inductive components can be produced for frequencies of up to 200kHz and currents of up to 1000 amperes. Their sizes range from 36mm to 300mm diameter and their weight from 50g to 130kg. All products are RoHS and REACH compliant and the materials used are UL-listed.

**www.smp.de**
**Hall B3, Stand 153**

## FTDI TO SHOWCASE ITS POWERFUL FPGA PLATFORM AT ELECTRONICA

USB silicon and software specialist Future Devices Technology International Limited (FTDI) has launched a flexible and powerful development platform that speeds the creation of FPGA-based applications and simplifies the integration of Hi-Speed 480Mbit/s USB communication in advanced logic circuit designs.

The Morph-IC-II platform combines an Altera Cyclone-II FPGA with high-performance USB 2.0 capabilities that facilitate Hi-speed communications with ultra-fast, sub-100ms FPGA programming/re-programming. This makes Morph-IC-II ideal for applications which require users to reconfigure hardware functionality 'on-the-fly' by downloading new software over USB: "morphing" the hardware. As well as enhancing application flexibility, hardware reconfiguration via USB can also reduce BoM costs as the FPGA need only be sized for the most complex discrete function rather than all potential functions.

FTDI's new platform incorporates all of the hardware, software and documentation needed for 'out-of-the-box' FPGA development. The hardware comprises a compact development module incorporating an Altera EP2C5F256C8N Cyclone-II FPGA and an FTDI FT2232H USB-to-multi-purpose UART/FIFO IC. One channel of the FT2232H is utilized for FPGA-to-PC communications and supports data transfer speeds of up to 40Mbyte/s. The second channel of the FT2232H is used to configure and reconfigure the FPGA over USB.

**www.ftdichip.com**
**Hall A5, Stand 3513**

## KEMTRON'S RFI/EMI SHIELDING PORTFOLIO ON SHOW AT ELECTRONICA


Kemtron Ltd will be exhibiting on at Electronica 2010 its range of RFI/EMI shielding gaskets and components. The range includes highly conductive elastomers which consist of silicone and fluoro silicones, loaded with conductive particles such as silver plated copper, silver plated aluminium and nickel coated graphite. These elastomers can be extruded in various gasket profiles, moulded as components or sheet for die cutting.

Knitted wire mesh gasket strip in either monel, tin plated copper clad steel, stainless steel or aluminium, still the most cost effective all round performing gasket. In applications where low frequencies in the magnetic field are a problem the bulk of metal in knitted mesh gaskets make it the best performer. At 10kHz, H field, a solid high permeability "Tin Plated Copper Clad Steel" (TCS) mesh will achieve a shielding effectiveness of 62dB attenuation making it suitable for EMP applications, at higher frequencies such as 10GHz, attenuation's of above 45dB can be achieved.

Kemtron will also be exhibiting conductive fabric over foam gasket strip, beryllium copper finger strips, shielded optical windows for display devices and more solutions for all EMC requirements.

*[Right: David Wall]*

**www.kemtron.co.uk**
**Hall A2, Stand 379**

## INTRAACTION ELECTRONICS EUROPE TO EXHIBIT AT ELECTRONICA 2010

IntraAction Electronics Europe is pleased to announce its participation at Electronica 2010. The firm plans to exhibit its professional capability of producing high quality, low cost, custom designed membrane switch circuit technology products: ■ Flexible Membrane Switch Panels. ■ Rigid PCB Membrane Switch Panels. ■ Graphic Overlays & Decals.
■ Mimic Diagrams.

"We shall be displaying our expertise in producing our customers' specific requirements at the price quoted and delivered on time," said Alan Fox, European Sales Director at IntraAction Electronics Europe.

Some of the features we shall be exhibiting will include: ■ Switch tactile feedback options.
■ Embedded LEDs. ■ Specific embossing. ■ Rear mounted customer designated circuit & components.
■ Membrane switch panels + Support plate/mounting options.

"We look forward to meeting our current customers and prospective customers during Electronica 2010," added Fox.

**www.intraAction Electronics.eu**
**Hall B5, Stand 530/4**

## SILICON LABS TO UNVEIL LATEST HUMAN INTERFACE, WIRELESS, TIMING AND AUDIO IC SOLUTIONS AT ELECTRONICA 2010

Silicon Laboratories plans to demonstrate innovative semiconductor solutions for the wireless, embedded and consumer electronics markets at electronica 2010 from November 9-12 in Munich, Germany.

These will include hands-on demonstrations of the latest proximity and touch sensing, sub-GHz wireless, timing, embedded control and connectivity, and consumer audio technologies, all designed from the ground up to reduce cost, power and complexity of electronic designs.

Silicon Labs also will provide a free half-hour technical presentation for all electronica attendees, giving embedded designers an opportunity to learn more about adding touch-based and touchless human interface capabilities to their applications. The presentation will be part of the Embedded Forum and will be held in Hall A6 near the Main Entrance East at electronica 2010 on November 11 at 1:00 p.m.

In addition, Silicon Labs will demonstrate the following mixed-signal IC solutions in booth A4.361 at the show: the QuickSense family of touch-sense microcontrollers (MCUs) and infrared and ambient light proximity sensors, Si4010 EZRadio and chip technology, state-of-the-art mixed-signal IC technology for consumer audio applications, and the next wave in clock generator technology.

**www.silabs.com**
**Hall A4, Booth 3610/4**

## VTI TO ANNOUNCE NEW MEMS SOLUTIONS AT ELECTRONICA

VTI Technologies plans to announce new MEMS solutions at Electronica 2010. The company product line will expand to meet the demands of the rapidly growing consumer electronics MEMS market.

"Both applications and devices develop quickly in this booming market," said Sten Stockmann, Vice President at VTI Consumer Electronics. "Gaming devices, remote controllers and cell phones become more and more intelligent, changing our way of using these devices and also making life more enjoyable. MEMS technology enables this development and inspires manufacturers to continuously create and innovate new applications."

"Based on VTI's MEMS and application expertise we have developed unique solutions that will challenge the current market offering", Stockmann added. "Thanks to our proprietary 3D MEMS technology we are well positioned to offer products with the most preferred features. The very low power consumption, high accuracy and extremely small size of VTI's MEMS devices make them ideal for use in battery-operated consumer electronic products."

**www.vti.fi**
**Hall A2, Booth 428**

# Consumer Electronics Drive The Need For A **TOTAL POWER MANAGEMENT** Solution


This article outlines some of the challenges met in the convergence of multifunctional electronics to the silicon circuits needed to convert the battery energy to a format suitable to power processors, memory circuits and real world interfaces. By **Jess Brown**, Product Line Manager for Power Management at Wolfson Microelectronics

**IN THE PAST** it was fairly easy to categorise consumer electronics: a phone was used to make calls; a music player to listen to music; a DVD player to watch films; and a computer to access the Internet. However, electronics has changed and consumers no longer expect to have separate gadgets to access different applications. Nowadays each device has to include multiple functionalities, and each consumer segment and its associated technology is converging and will continue to do so.

There will, of course, be exceptions as new technology is introduced, but consumer expectation is that handsets must now connect to the Internet, play advanced games, make video calls and play music. As well as integrating more applications, consumers also expect faster response times, brighter displays with high definition (HD), smarter devices enabling multi-tasking, increased content such as HD and 3D videos, 3D displays, social networking and the ability to handle future applications that develop over the next few years.

These consumer requirements drive two main areas of development: firstly, the need for increased processing capabilities for these consumer devices and, secondly, a reduction in the size of its component parts.

## Increased Power Management Requirements

From a power management architecture point of view, the increased requirements associated with the processor translate to higher output current demands on the DC-DC converters. Consumers have driven the demand for ever smaller portable devices, with an increasing number of features. This desire for more compact form-factors has

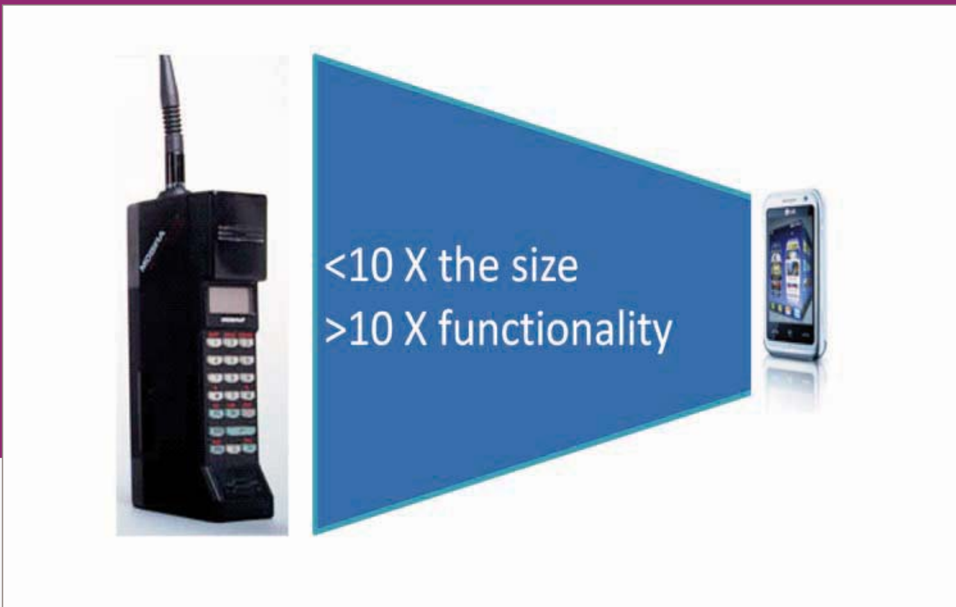



***Figure 1:*** *In two decades the mobile phone has transcended several application areas, whilst reducing form-factor*

resulted in the adoption of smaller devices, yet more features require more components and consequently additional power.

If all the factors are considered then increased features, such as WIFI, WIMAX, 3G, 4G, HD Video, active noise cancellation and 3D displays, result in the requirement for more power. In order to maintain advanced user-cases and to process data associated with the increased feature set, then the processor needs to execute instructions quicker resulting in more processing power and, therefore, increased power dissipation.

The increased feature set also results in more components so, to maintain form-factor requirements, all the components need to reduce, but the laws of physics mean that smaller components can handle less power. An easy way of reducing external component size in a DC-DC converter is to increase the switching frequency, but this typically results in an increase in power dissipation and a reduction in efficiency. So the aims of increased functionality and smaller form factor all conflict with the power management of the system.

The consequences mean that power management circuits face huge challenges, and it will no longer be sufficient to provide a stable power supply. There will be requirements for smarter devices that can dynamically manage system power to maintain the most optimum solution to increase battery life-time and user experience.

## Methods for Increasing Battery Life

Typical processor core currents for small portable consumer applications with ARM processors are now approaching 2A and above. With a 1000mAHr battery, a processor running at 2A continuously would potentially discharge this battery (to a usable level) in an hour. Therefore, this would make the consumer device unusable, so the processor must limit how long it draws the full current. This is typically achieved by switching the processor to low power modes, which can mean the processor voltage can be reduced to as low as 0.7V.

There are two key elements to supply the voltages in low power modes. The first is the DC-DC supplying the processor switch between high power voltages (say 1.2V) and

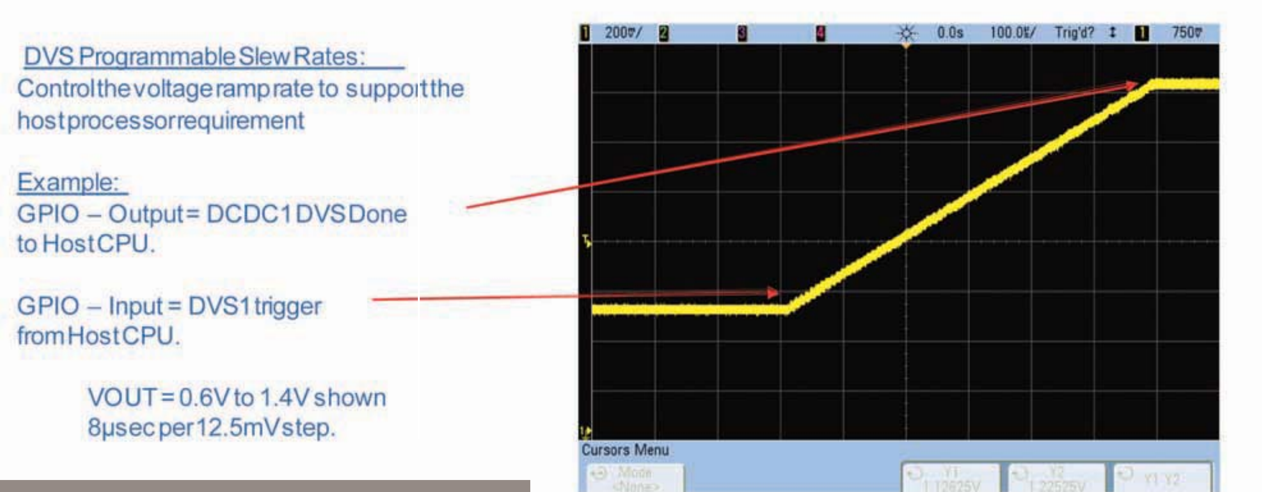



***Figure 2:*** *Example of Programmable Dynamic Voltage Scaling using the WM8312*

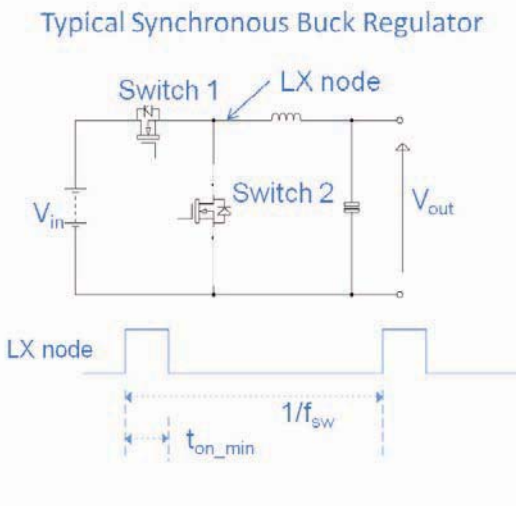



Figure 3: *Typical DC-DC showing minimum duty cycle with Peak Current Mode Control*

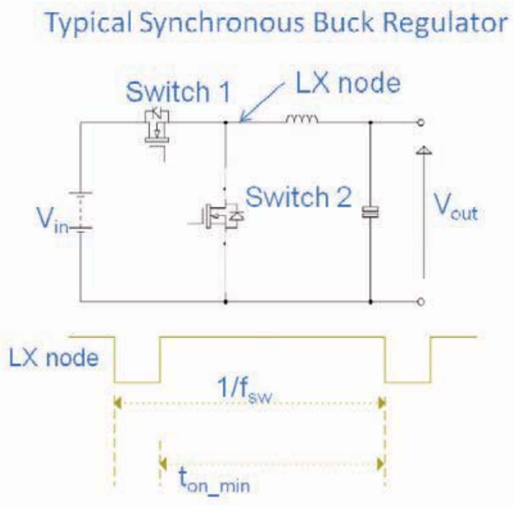



Figure 4: *Typical DC-DC showing maximum duty cycle with Valley Current Mode Control*

low power voltages (say 0.7V). A discrete regulator typically does not have any interface to enable it to be controlled via a software interface, such as I2C. In this instance, some form of external discrete circuit would be required to achieve this. This conflicts with the requirements of saving space and cost.

An integrated Power Management IC (PMIC) typically has some form of software interface to change the output voltage of the DC-DC converter, but this alone does not mean that it will meet the requirements of the processor. In order to do this and to change the voltage in a PMIC, a dynamic voltage scaling (DVS) system is typically employed. These typically use one register write or a hardware pin to change voltages and allow an element of scalability. For instance the WM831x family of PMICs employs four different ramp rates during DVS (12.5mV/32μs; 12.5mV/16μs, 12.5mV/8μs and immediate), which ensures that the designer can determine which slew rate is best to minimise the time changing modes and ensure that there are no significant voltage overshoots due to parasitic elements in the design, which would cause damage to the processor or cause the processor to under-voltage. **Figure 2** shows the WM8312 switching between low power mode (0.6V) and high power mode (1.4V).

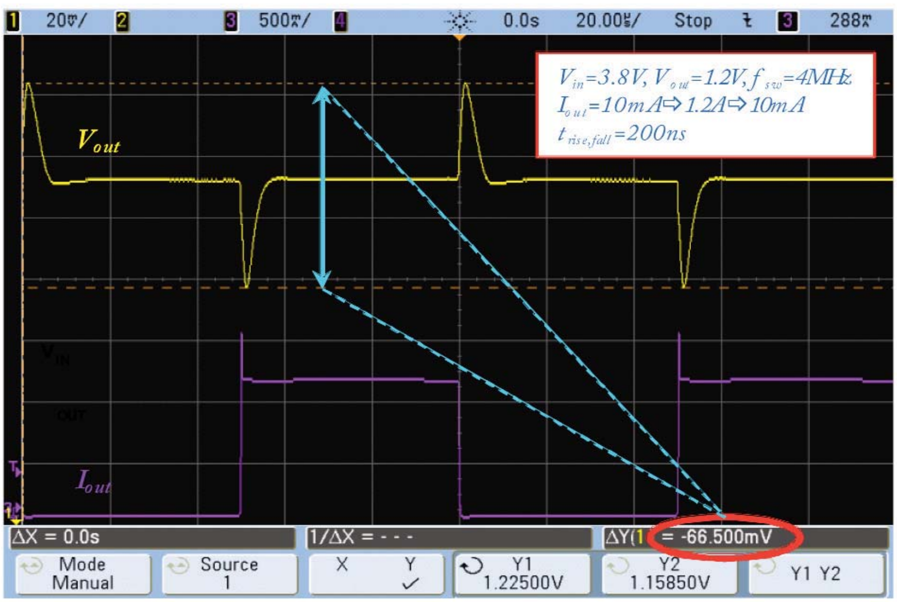
Low power processor modes mean low DC-DC output voltages, however this is not straightforward to achieve. Typically, the majority of control schemes employ Peak Current Mode Control to regulate the output voltage. But, there are limitations on the lowest output voltages achievable with this control scheme, since the minimum duty cycle is limited by a minimum on-time of the high-side switch in the DC-DC (shown in **Figure 3** and **Equation 1**). With high input voltages and low output voltages, a new control scheme is required to ensure the processor can operate at the lowest voltage node possible.

$$V_{out\_min}=f_{sw}\times t_{on\_min}\times V_{in} \quad (1)$$

One such control scheme is Valley Current Mode Control where the regulation is controlled with the low-side switch (switch2). This results in a limitation in the maximum output voltage, but does not result in any limitation in the minimum voltage, as shown in **Figure 4** and **Equation 2**. This means that even with multiple Li-Ion battery cells in series it is possible to achieve the low voltage requirements of the processors.

$$V_{out\_max}=V_{in}(1-f_{sw}\times t_{on\_min}) \quad (2)$$

Figure 5: *Transient performance of the Valley Mode Current Control WM8312 DC-DC*



In the past, the transient response of a DC-DC converter was critical to make sure there were no over voltage transients seen by the load. This could cause catastrophic failure of the load and hence was critical in the design of DC-DC converters. However, it has now become critical to ensure that during the transition from low power mode to high power mode the voltage must not drop to such an extent that the processor 'under voltages'. The minimum voltage supplied to the processor must be such that any voltage disturbance must not fall below the minimum voltage required by the processor and, hence, cause it to shut down.

Any margin overhead over the minimum voltage is directly related to an increase in power dissipation, due to the power dissipated being directly related to the square of the supply voltage. For instance with Wolfson's BuckWise technology, the voltage disturbance for a 1.2A load is 33mV (**Figure 5**) and, when compared to an industry standard of 63mV, this equates to a possible 10% increase in battery life.

## Total System Power Control

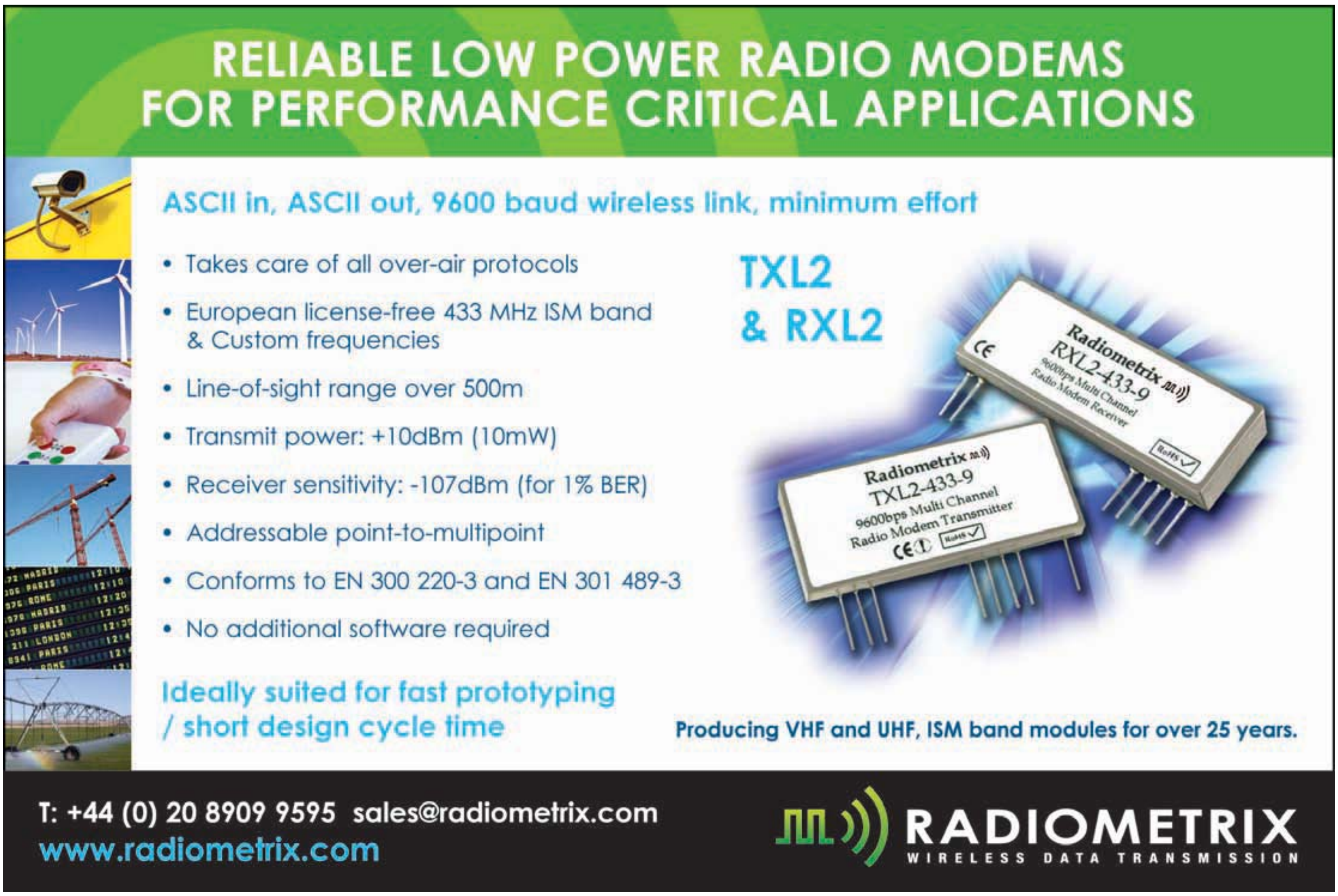
In order to maintain form-factor and preserve the enhanced user experience of multi-functional portable consumer electronics, the power management has to control the total system power requirements in order to maximise the battery life. There are several factors which can be implemented to improve the efficiency if, for instance, the application is put into standby mode, then the application is not using the processor fully and the processor can be put into standby mode.

If, for example, the core voltage is reduced from 1.2V to 0.9V then, with everything else being equal, the consumer device immediately saves over 44% of processor power losses. The power dissipated by the processer is a factor of the voltage squared, so reducing the voltage supply instantly saves power. The more frequently the processor can transfer to a lower voltage (i.e. a low power mode), the more power can be saved. So the quicker the DC-DC converter can facilitate this, the more frequently the device can go into low power mode.

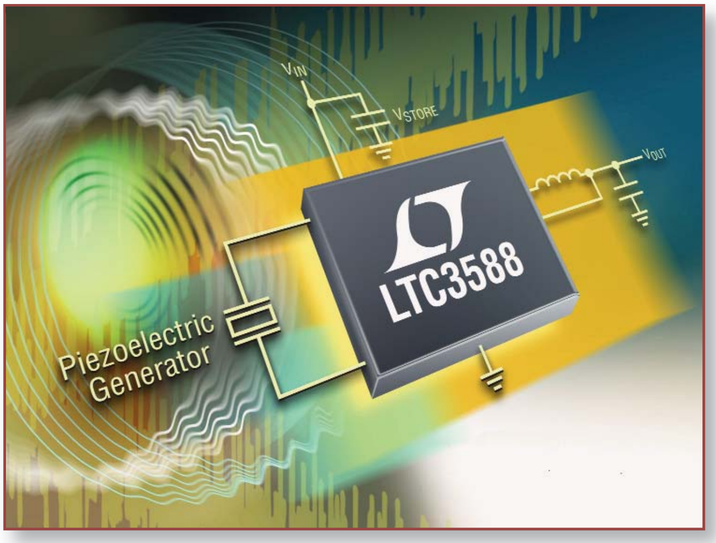
The converse of this operation is transferring from low power mode to high power mode. If the DC-DC converter cannot switch voltages quickly, then the user may experience lag in switching modes, DVS is required to make sure the device switches between power modes with no degradation of the user experience.

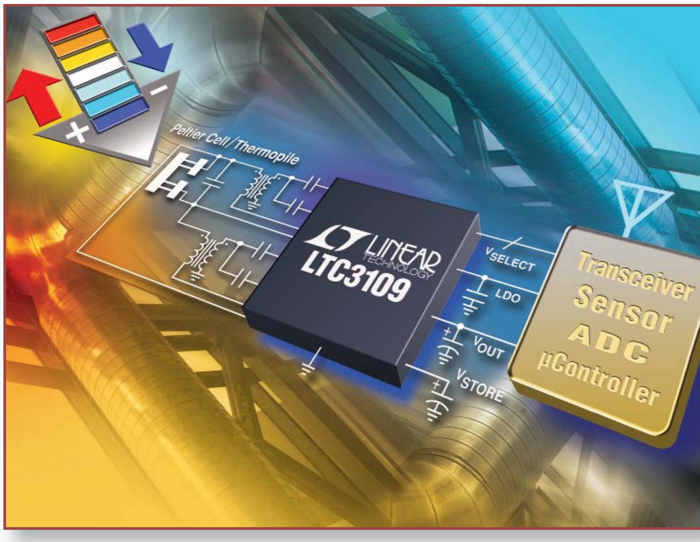
Power is one of the key elements of the system to maximise user experience. Individual power devices can no longer operate in isolation; they have to become part of the total system solution. Without an optimum power solution, the user experience can be greatly degraded and, in the worst case scenario, the devices can fail due to extreme heat caused by power dissipation.

The technology associated with PMICs will continue to develop and efficiency will continue to improve, however it is how the power is managed and how the developing technologies are incorporated into the PMIC that will determine its success. ■



# Energy Harvesting for BEGINNERS




**WITH ELECTRONIC** circuits now capable of operating at microwatt 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.

Energy harvesting can power smart wireless sensor networks to monitor and optimize complex industrial processes, remote field installations and building heating, ventilating and air conditioning (HVAC) systems. In addition, otherwise wasted energy from industrial processes, solar panels, or internal combustion engines, can be harvested for useful purposes.

Ambient energy sources include light, heat differentials, vibrating beams, 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 heat, 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.

Even though the concept of energy harvesting has been around for a number of years, the implementation of a system in a real world environment has been cumbersome, complex and costly. Nevertheless, examples of markets where an energy harvesting approach has been used include transportation infrastructure, wireless medical devices, tire pressure sensing and building automation systems. In the case of building automation systems, such things as occupancy sensors, thermostats and light switches can eliminate the power or control wiring, normally associated with their installation, and use a localized energy harvesting system instead.

Similarly, a wireless network utilizing an energy harvesting technique can link any number of sensors together in a building to reduce HVAC and lighting costs by turning off power to non-essential areas when the building has no occupants. Furthermore, the cost of

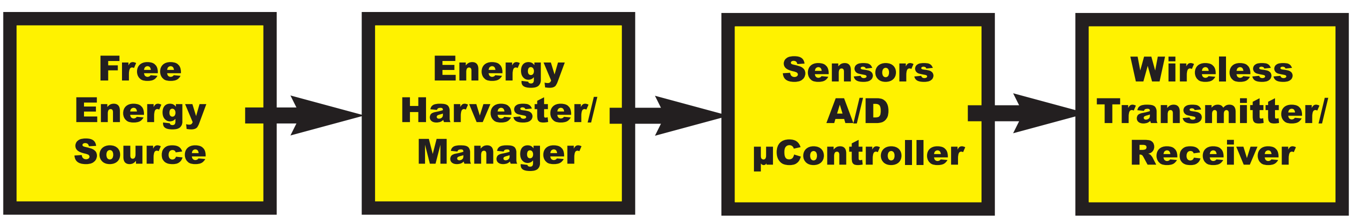



***Figure 1:*** *The main blocks of a typical energy harvesting system or wireless sensor node*

**Tony Armstrong**, Director of Product Marketing for Power Products at Linear Technology Corporation, looks into a wireless network utilizing an energy harvesting technique that can link any number of sensors together to monitor and optimize various industrial and residential processes

energy harvesting electronics is often lower than running supply wires, 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.

## Energy Harvesting Systems

A typical energy harvesting configuration or wireless sensor node is comprised of four blocks, see **Figure 1**. These are: (1) an ambient energy source; (2) a power conversion component to power the rest of the node; (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 neighbouring 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 window pane. 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 analogue-to-digital converter for transmission via an ultra low 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 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 used.

| | |
|---|---|
| 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*

| 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) | Handheld electronic devices |
| 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) | 100s of µW/cm$^2$ | Handheld electronic devices or remote wireless actuators |
| 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*

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.

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 and account for 38% of total energy consumption, closely followed by the transportation and industrial segments at 28% each. Moreover, buildings can be further broken down into commercial and residential buildings, representing 17% and 21%, respectively. Furthermore, the residential building figure of 21% energy consumption can be further broken down, where heating and cooling is 76% of the total energy consumption. With energy usage forecast to double between 2003 and 2030, energy savings of up to 30% could be attained with building automation systems.

## Characterization of Ambient Energy Sources

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. **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 of 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 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 and LTC3588-1 can bring a new level of performance and simplicity.

## New IC Energy Harvesters

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-self 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 VAUX pin, providing charge to the external VAUX capacitor and then the other outputs.

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

The VSTORE 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 VSTORE 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/cm$^2$ 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 accumulate on the storage capacitor until the buck converter can efficiently transfer a portion of the stored charge to the output.

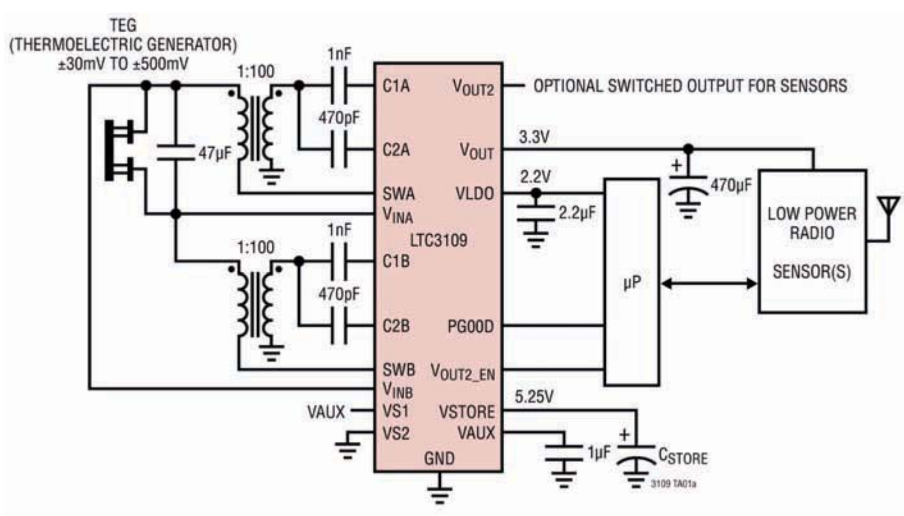



***Figure 2:*** *LTC3109 typical application schematic*

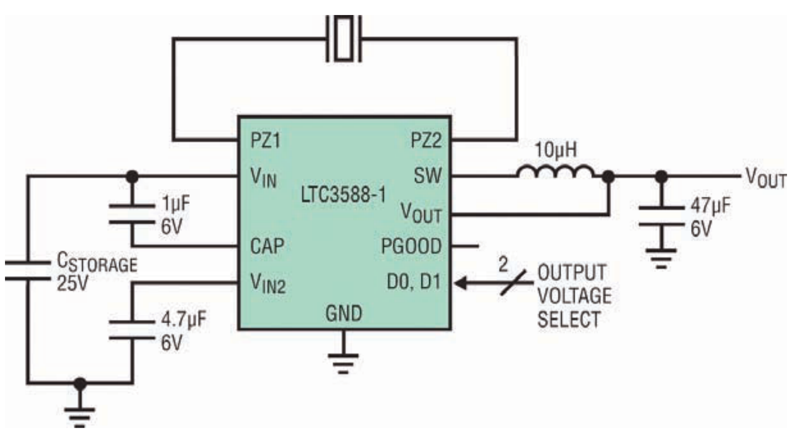



***Figure 3:*** *LTC3588 typical application schematic*

## Key to Remote Wireless Sensing

Power management is the key aspect to enabling remote wireless sensing. However, it must be implemented right from the concept of the design. 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, recent energy harvesting power management IC introductions from the leading high performance analog IC manufacturers greatly simplify this task. ■

# Making the case for HIERARCHICAL and

## In this article, **Anders Holmberg** of IAR Systems looks at how hierarchic and parallel semantics for state machines can help in reducing software design complexity for a mainly state/event oriented problem

**THE NOTION OF** hierarchic and parallel state machines has been around since the middle of the 80s. Firstly, what is a hierarchic and/or parallel state machine notation? It is a state machine notation that allows for some states on a design to contain one or more state machines in its own right.

To use a more formalized language, we call states containing other states "superstates" and states contained in other states "substates". To complicate matters further, a superstate can contain not only one state machine, but can be divided in two or more orthogonal regions of more or less independent state machines that in turn can contain substates with regions. In this way a parallel and hierarchic state machine can be created. So, what do we gain by allowing for hierarchy and parallelism? Let us consider the following problem: If we are modeling a car compartment light as a state machine, we will have to take into account the following factors:

- Are the doors locked or unlocked?
  Unlocking the doors means for most cars that the lights should be turned on.
- What about the position of the switch where you can choose if the roof light inside your car should always be on, always off, or sensitive to the doors?
- Are one or more doors open? In most cases the lights should go on

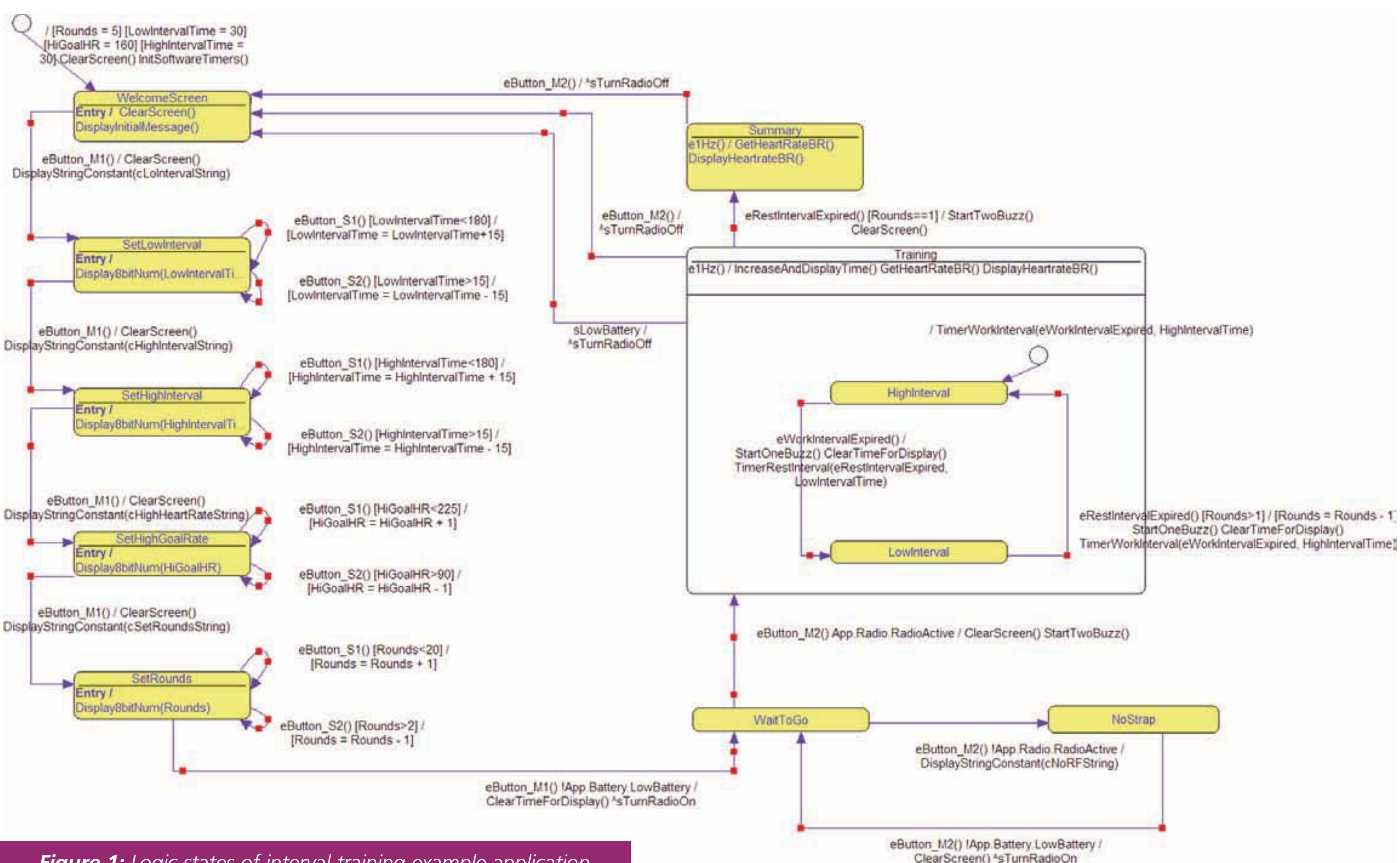



***Figure 1:*** *Logic states of interval training example application*

# parallel state machines

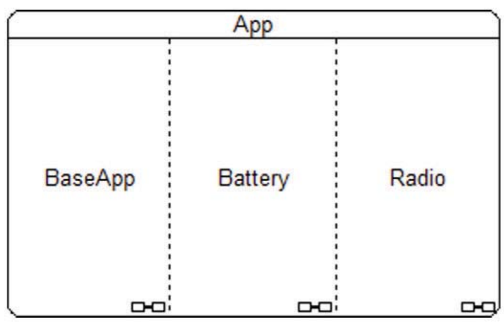



***Figure 2:** Top level view of complete application subsystems*

when the first door is opened, but only if the switch is in the door sensitive position.

To model this as a flat non-hierarchic state machine, you will have to come up with distinct states that capture all the valid combinations of locked and unlocked doors, open and closed doors and all possible switch positions; for example: DoorsUnlocked_DoorOpen_SwitchInOff, or DoorsUnlocked_DoorOpen_SwitchInSensitive.

There will of course also be a number of transitions between all of these states to cater for all possible changes in state. For anything but the most trivial problem, this will lead to a big number of states and a rather messy transition structure. Or to put it another way, adding parallelism and hierarchy to a state machine model generally simplifies the complete state machine by avoiding a combinational nightmare when trying to keep track of all relevant sub-system state information for all different scenarios in just one non-hierarchic state machine.

## An Application Example

We will now take a look at a different application scenario. One of the staples of cardiovascular training is interval training. Interval training comes in an almost endless number of different variants, but the main theme is to alternate high intensity work with periods of rest. A classic scenario for a runner is to run at close to maximum speed for 30 seconds and then walk or jog for 30 seconds. This sprint/walk combination is repeated for maybe 5 to 10 times. When you practice interval training it can be a good help to have a gadget that keeps track of the intervals for work and rest and the desired number of work/rest cycles. Many interval-training schemes also specify an intensity level as a percentage of maximum heart rate. Thus it would be a good thing if the gadget could also monitor heart rate.

This kind of application can be lab-prototyped on most micro-controllers and/or evaluation boards, but to be really useful in the field the chosen hardware should support the following:

- A display.
- A radio interface that can talk to a chest strap or other device for heart rate monitoring.
- A few buttons to enable interaction with the application.
- If it's also wearable and reasonably water-resistant you cannot only prototype the application, but actually use it for real training.

Interestingly enough, Texas Instruments released a development system that fulfills all the requirements above in late 2009. It's the eZ430-Chronos development platform. This is an MSP430 based development kit in a sports watch form-factor, complete with RF interface and some other useful peripherals like a temperature sensor, a pressure sensor and a three-way accelerometer. So, given that we have a copy of the Chronos kit available, can we build an application to help us with the training? Let's look at the application requirements:

- The application should be able to keep track of a cycle combined of a work interval and a rest interval.
- The duration of the work interval and the rest interval should be possible to specify independently of each other.
- The desired goal heart rate should be possible to specify.
- The application should display the number of seconds spent in the current interval.
- The number of work/rest cycles should be possible to specify.
- The application should monitor and display heart rate.
- The application should be well behaved in the case of a low battery condition. A sensible thing to do might be to disable the radio when the battery voltage drops too low.
- The radio communication with the chest strap should only be active when it needs to be active.

It actually seems like the eZ430-Chronos platform is a perfect fit for this application.

Note that the Chronos kit does not come with a chest strap for heart rate monitoring, but the kit includes an RF access point that you connect to your PC and that among other things can simulate a chest strap. Chronos compatible chest straps can be bought from a third party, see information in the kits documentation.

## The Application

The application will be designed as a small state machine, because the modal profile of the application lends itself well to the state machine paradigm. When the application is downloaded to the watch and started it will display a welcome message on the screen. The user can then press the top left button to proceed with specifying first the rest interval duration and then the work interval duration, the desired goal heart rate and the number of complete training cycles to perform.

In each stage the value is adjusted by pressing the watch's buttons on the right, top button to adjust upwards and bottom button to get smaller values. When the desired value is reached, the user proceeds to

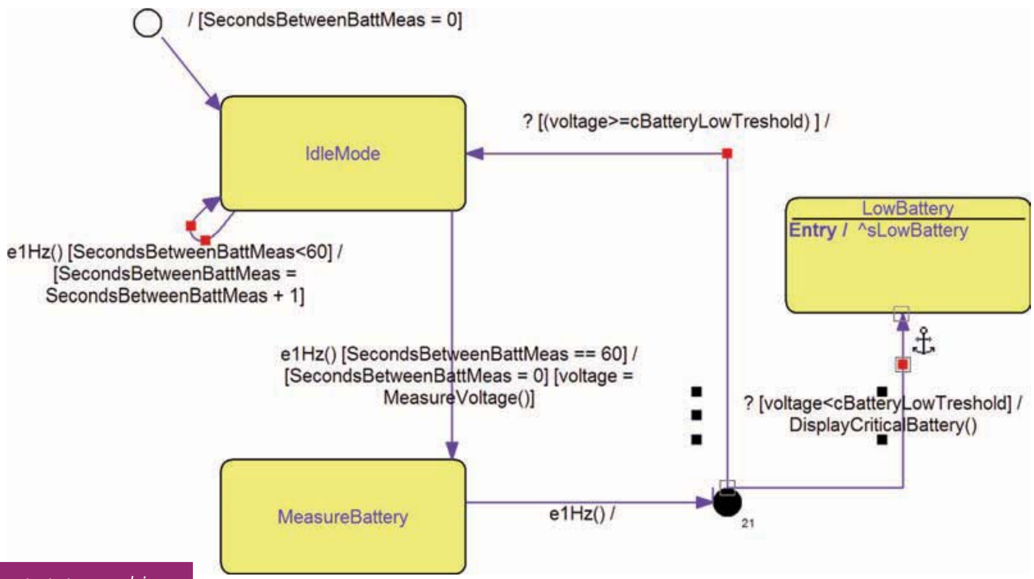



***Figure 3:*** *Battery management state machine*


***Figure 4:*** *Battery state machine transition used to determine radio status*

the next training parameter by pressing the top left button.

When finally the number of cycles has been set and the user presses the top left button, the radio will be activated to search for an active chest strap (or for an active RF access point configured for BlueRobin communication).

When the radio link is established, the user can press the bottom left button to start the training session. The application will now start counting and displaying the number of seconds spent in each interval as well as displaying the current heart rate. A sound will be generated to indicate the expiry of an interval. When the pre-defined number of intervals has been run another sound signal will indicate that the training program is over. The logic can be seen in **Figure 1**.

## Designing a State Machine for the Application

We will now take a look at a possible state machine design for the interval training application. We will use IAR visualSTATE as the design tool. By doing so we also get automatic code generation for the state machine logic, as well as the possibilities to simulate the behaviour of the design and subject it to formal verification techniques to find unwanted problems.

A visualSTATE application is often though not always organized around a main loop where most of the high-level logic is taken care of by feeding events into the state machine. This architecture simplifies the interrupt routines as far as possible to only detect and report events to the application.

A big advantage is that it is possible to achieve a clean separation between input device drivers, application logic and output device drivers. The code for input detection and output handling could then easily be reused in different projects on the same hardware without the need to 'wash' the driver code to remove application specific knowledge.

How do we go about creating a state machine design from a quite general problem description or set of requirements? One way is to use the following six steps:

1. Identify events and actions. Events are the things that can happen in the environment and that the state machine should know about. For example button presses, or expired timers or any kind of interrupt that should be made known to the state machine. On an abstract level an event is basically a symbol referring to one or more physical events.

Actions are the things that should be performed on the environment by the state machine. For example writing a character on a display, copy a string to or from a UART buffer, setting up a timer etc, or turning on an LED etc. A good action just performs one small function and does not mix a lot of functionality. In visualSTATE an action is a function or a simple assignment.

2. Identify states. A state is an abstraction of the current situation in the system. We saw two examples above for possible states in a car light application. However, we will try to attack the problem by using hierarchy and parallelism, and then we focus our state-finding effort on each sub-system. Examples for the interval application might be RadioOn, BatterLow and TrainingInProgress. Each of these state names captures possible state in a small part of the full application.

3. Group states by hierarchy. This essentially means that you group related states together, either by function or by sub-system. For example, if we have identified the states RadioOn, RadioOff and RadioSearchingForChestStrap, we can group these states as substates to a Radio superstate.

4. Group by concurrency. For example, the radio subsystem functionality can be seen as parallel to battery monitoring and to the interval training logic.

5. Add transitions. Transitions are what connects the states to each other and makes the control flow in the state machine. Transitions are labelled with event names and optional guard conditions, indicating that if the state machine is in the start state of the transition and the event on the transition is received from the environment and the guard condition evaluates to true, then the transition will be taken and possibly a set of specified actions will be carried out.

6. Add synchronizations. It is possible, by various means, to make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different subsystems aware of each other. These mechanisms are called synchronizations and can, for example, be the requirement for one subsystem to be in a particular state for a transition in another subsystem to fire. It can also be the sending of a state machine internal event to indicate to another subsystem that some condition holds.

This is not an exact recipe for success, but if you follow the spirit of these rules the first time you are attacking a new state-oriented problem, you might be surprised how well it works and how well the first design outline will hold up when you later refine the design.

What might seem a little bit backwards is the fact that you are advised to look for events and actions before even considering the states. But doing it this way will ensure that you get a very good grip on the input and output boundaries of the problem without mixing it up with implementation details.

## The Detail

We have discussed the virtues of parallelism and hierarchy without going into any detail on how that would fit into the application design we are considering. By looking at the problem description it seems that it is reasonable to say that we have three different subsystems to consider: battery monitoring, radio handling and the interval training logic. All these subsystems are basically freestanding, but dependent on each other in various ways (see **Figure 2**).

We will start by talking about a possible way to deal with one issue that a real world application would run into – the battery voltage level. It is highly application-specific what to do in case of low voltage levels, but for a gadget incorporating an RF radio and running from a coin cell battery it seems like a sensible approach to disallow radio communication when the voltage level reach a critical low.

We have a region called Battery in the top-level state. This region contains a small state machine that monitors the battery voltage by sampling it approximately once a minute. If the voltage level goes below a predefined critical level, the Battery state machine will transition to a special LowBattery state and at the same time display a blinking battery icon on the clock display. **Figure 3** shows a picture of that state machine.

Ok, so what have we gained so far? It might not look like much to just end up in the LowBattery state, but the real gain is that the information that the Battery state machine is in the LowBattery state is now available in all other parts of the full state machine system. So we can now guard voltage sensitive activities in the application specific state machine, so that they are not performed if the battery is low.

How can this be utilized? In this example application we have chosen to guard the transition going from the state SetRounds to the state WaitToGo on the fact that the Battery state machine is not in the LowBattery state. This transition is responsible for turning on the radio and starting the heart rate monitoring. **Figure 4** indicates a picture of the transition.

Notice how the name of the LowBattery state is part of the transition guard condition; it is also preceded by an exclamation mark to indicate a negative condition.

An important observation is that to achieve the same functionality without the separate region for the battery monitor, we basically have two options: (a) complicate the interval logic state machine design by introducing battery monitoring functionality in all places where knowledge about the battery status is needed, or (b) implement functionality outside the state machine to monitor the battery, making that information available somehow to the state machine functionality and then checking it inside the state machine.

Once again, this implementation is simplified and a real-world application might chose to implement more elaborate functionality. One alternative might be to have two transitions from the SetRounds state to WaitToGo. In this case one transition looks like the current one. The other transition can check that the battery state machine actually is in the LowBattery state. In that case the radio is not started, but the intervals will still be meted out and the athlete will have to do without any feedback on heart rate.

There is another mechanism available in a visualSTATE state machine model that we mentioned briefly before; when taking a transition or enter/exiting a state a so-called signal can be emitted for further processing in the state machine.

A signal is an internal event and can be used as a transition trigger just like an ordinary event. The semantics is that if a signal is emitted when processing an event, the signal will be processed before any new external events will be processed. In this example we use that mechanism in a number of places; we did not, for example, mention above exactly how the radio was turned on. If you look again at the transition in Figure 4, you can see the symbol ^sTurnRadioOn mentioned on the action side of the transition.

It is a convention to name signals "sSignalName", but not enforced by the tool. The example uses this convention. As noted above, signals are like internal events that can be emitted by the state machine. If a signal is emitted, it will be processed by the state machine before any new external event is processed. This way it is possible to communicate internally in the state machine.

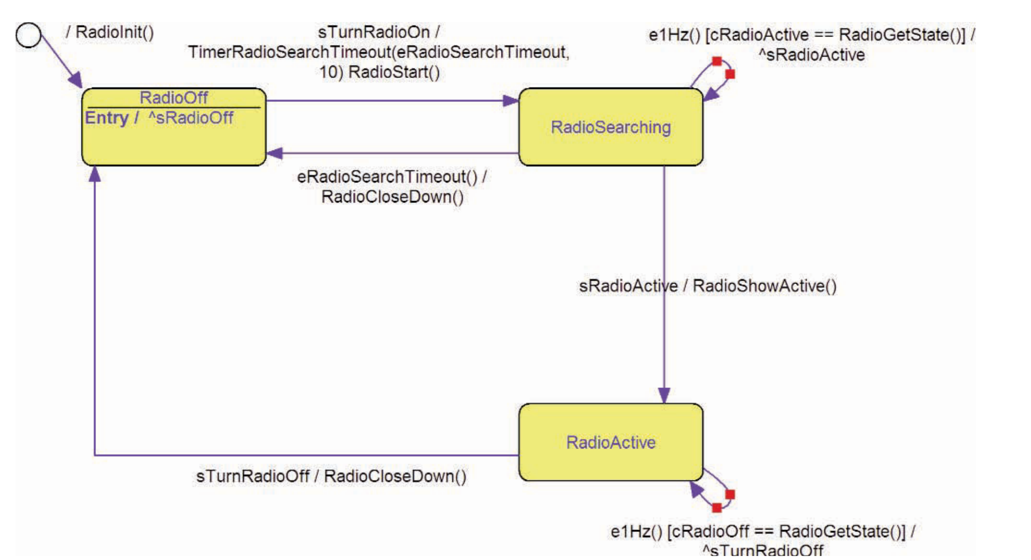


***Figure 5:*** *Radio state machine used to poll for heart pulse data*

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Signals are a complement to using positive and negative state conditions for synchronization inside the state machine. If a transition emits a signal the signal name can be found on the right hand side of the transition label preceded by a "^" sign.

The radio state machine is indicated in **Figure 5**.

In this example the application state machine sends signals to start and close down the radio when needed. The radio state machine then takes care of monitoring the radio etc.

So this example can both deal with low battery and radio failures in a fairly graceful way, although a real world application probably would take the error handling a step further.

You might think that the radio state machine looks suspiciously simple and in a way that is true. The radio hardware and protocol used for heart rate monitoring is hidden behind a proprietary library that exposes an interface that is very easy to use and, essentially, based on polling the interface periodically to retrieve pulse data.

## Simulation and Code Generation

When you have worked on your design for a while, you can exercise it a bit in the state machine simulator to see that it behaves as intended. In the simulator you have full access to all available information about the state machine and the possibility to record your actions and their results for later playback and analysis. Once you have a design that is consistent, but maybe far from completed, you can code generate the state machine logic, so you can start testing the application on hardware.

The interesting thing is that as the design evolves, you often rather soon come to a point where the identified events and actions are enough for almost any addition to the logic you might consider. So at this stage you will encounter true graphical programming!

Another revelation is when using the same hardware platform for a new application, you will most likely find that almost all of your events and especially the action functions can be reused "as is" for the new project.

## A Final Word on Verification

visualSTATE can perform formal model checking on state machine models to look for potential problems like unreachable states or dead-ends (states or state combinations you can enter but never exit.) The verification process will also look for potentially conflicting transitions within the same state machine region and also unused and/or un-activated design elements. For this example the verification will find a few states that it considers to be dead ends. Look closely at the LowBattery state for example.

This reflects the design decision that further processing is not meaningful if the battery level goes below the threshold. The LowBattery state is used as a negative guard condition in other parts of the state machine, which means that those states can become potential dead ends in themselves. This design decision can of course be altered. ■

# The Solution to FM DISTORTION due to Multipath Transmission Part 3

**Archie Pettigrew** revisits the issues behind receiving the perfect broadcast radio signals

**IN THE PREVIOUS** two articles, the basic building blocks that form the new FM demodulator are the AGC, the ALL and the DQD. These elements allow the demodulation of an FM signal when in an MPD zone. Severe distortion arises due to the removal of the unmodulated carrier and the subsequent phase reversal. By using the ALL, there is no excess jitter on these DQD spikes and these occur exactly at the time when the carrier envelope is zero.

### The Corrective Time Function (CTF)

A secondary level of demodulation will now be presented which will produce a waveform called the corrective time function (CTF). This will be used in conjunction with the DQD output to improve the quality of the demodulation when passing through MPD zones, see **Figure 1**.

The output of the AGC is applied to a pure squaring circuit to provide a modulus square signal from DC to about 60kHz. The square root function is converted to a linear sinusoidal function. This signal is filtered to remove the 2F term at 21.4MHz and to align it with the audio signal from the DQD.

From simple simulation, the shape of the demodulated signal in an MPD zone can be described thus:

$$v_{MPDzone}(t) = \frac{(1+m\cos 2\omega_{mod}t)}{(1+2m\cos 2\omega_{mod}t+m^2)}k\cos(\omega_{mod}t+\frac{3\pi}{4})$$

where the first term represents the spike and

$k\cos(\omega_{mod}t+\frac{3\pi}{4})$ represents the desired signal

*Simplifying*

$$v_{MPDzone}(t) = \frac{A(t)}{B(t)}k\cos(\omega_{mod}t+\frac{3\pi}{4})$$

The objective of the CTF is to create the reciprocal of the numerator and denominator term that pre-multiplies the audio term.

$$v_{CTF}(t) = \frac{B(t)}{A(t)}$$

$$v_{CTF}(t) = \frac{(1+2m\cos 2\omega_{mod}t+m^2)}{(1+m\cos 2\omega_{mod}t)}$$

$$v_{MPDzone}(t)\, v_{CTF}(t) = \frac{B(t)}{A(t)}\frac{A(t)}{B(t)}k\cos(\omega_{mod}t+\frac{3\pi}{4})$$

$$v_{MPDzone}(t)\, v_{CTF}(t) = k\cos(\omega_{mod}t+\frac{3\pi}{4})$$

This equation defines the process by which the spike will be removed. The filtered output from the squaring circuit is split into a numerator and denominator function. The denominator is typically one half the amplitude of the numerator and a small DC offset is added to this value to set up the pulse width of the CTF. This needs to be matched to the pulse width of the DQD spike, see **Figures 2** and **3**.

### Removing the Distortion Spike

The CTF pulse multiplies the demodulated audio signal from the DQD and the spikes are removed by mathematical reciprocal action as shown in **Figure 4**. There is no excess timing jitter in the CTF so that each spike occurs exactly at the right time. No spikes are missed and no spikes are injected into the signal at the wrong time. Both spike functions are continuous analogue functions and increase in size as m increases from zero to unity.

The product multiplication of the DQD by the CTF is low-pass filtered to provide a final output shown in **Figure 5**.

The distorted output is in red and the final filtered output in blue.

### The FMDA ASIC

Prototype demodulators, incorporating the described AGC, ALL, DQD and CTF technology, were initially designed around discreet multipliers and op-amps. This solution would have been too costly for the consumer electronics market. The next phase of the development was the design of an application specific integrated circuit (ASIC). The application diagram of the FM demodulator revision A (FMDA) is shown in **Figure 6**.

This consists of a 44-pin IC which takes an

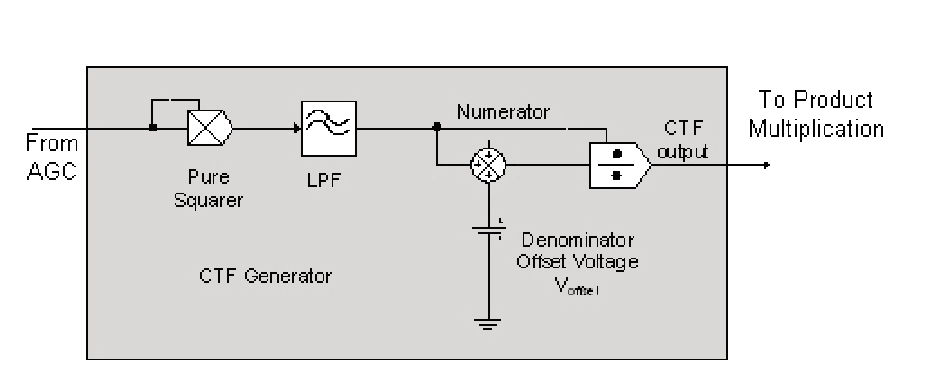


***Figure 1:*** *The Amplitude Locked Loop (ALL)*

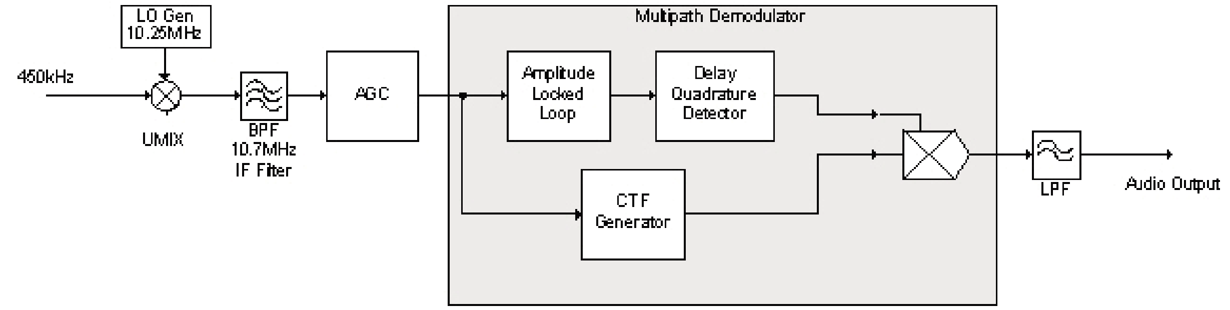


***Figure 2:*** *Multiplication of the DQD and CTF outputs produces the final audio signal with spike removed*

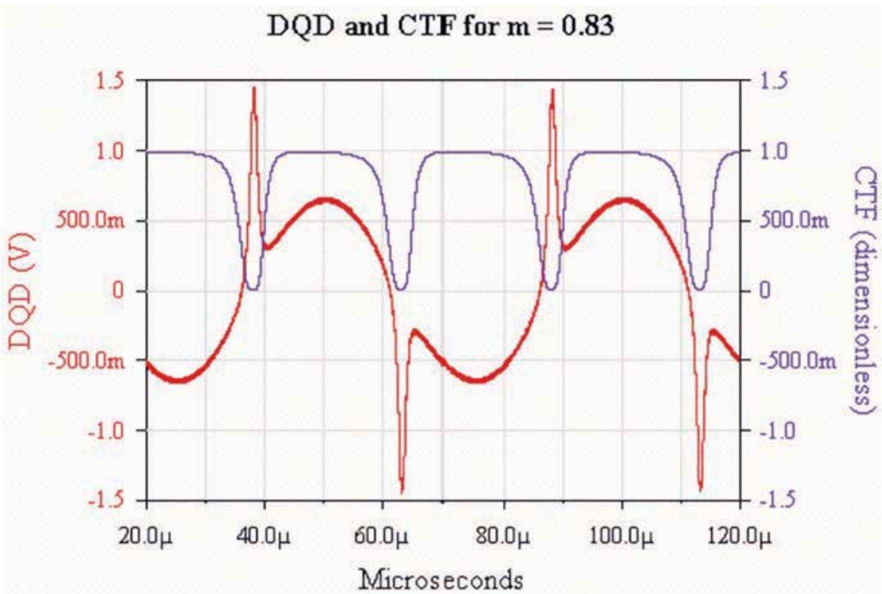


***Figure 3:*** *The correlation between the spikes on the DQD signal shown in red and the CTF waveform shown in blue. These waveforms are multiplied together to remove the distortion spike on the DQD*

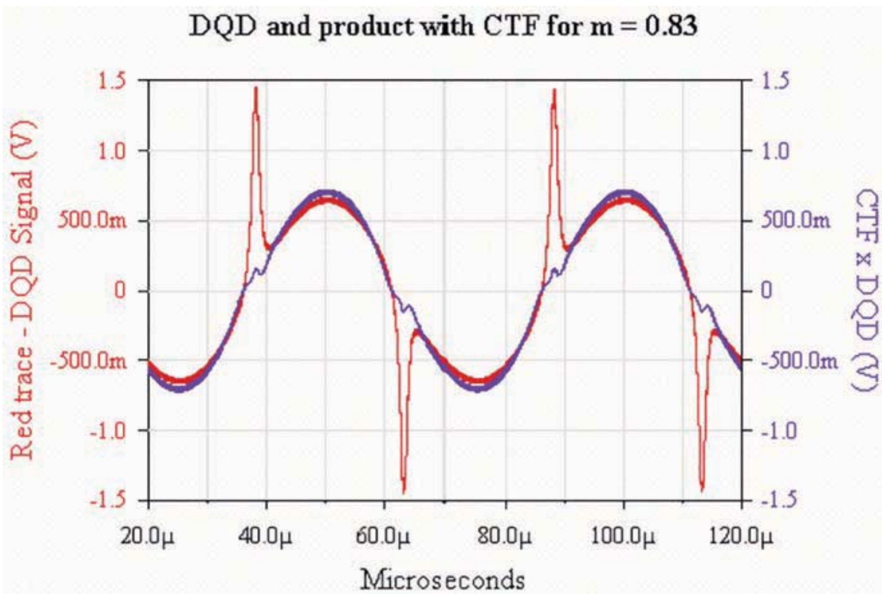


***Figure 4:*** *The red trace shows the DQD signal. The blue trace shows the product of the DQD and CTF signals with the spike removed*

IF carrier at 450kHz (or 10.7MHz) after pre-amplification and before any limiting action. The 450kHz is up-mixed to 10.7MHz and applied to an AGC circuit.

The various components of the demodulator can now be seen as one entity. They are the:

- Up mixer stage to 10.7MHz.
- AGC (60kHz bandwidth) with external 10.7MHz ceramic filter to remove the image frequency resulting from the mixing process.
- ALL of 2MHz bandwidth.
- DQD with external delay-line ceramic filter and associated quadrature phase matching circuitry.
- CTF with Bessel delay filters.
- Multiplication of ALL and DQD signals.
- Final scaling and MPX (composite audio) output.

## Measurements

Due to the lack of understanding about the exact cause of FM audio distortion during multipath events, there is no industry standard specification that defines the distortion level for a given multipath input signal.

A common testing procedure is to drive a car around a known test route where multipath distortion is prevalent, and listens to the speaker outputs.

Attempts at laboratory measurements using kilometre fibre optic cables similar to Corrington have proved unsatisfactory and do not correlate well with road tests or listening experience.

A much simpler test procedure is to use a multi-element Yagi antenna and place it in an MPD zone. The directionality of the antenna means that it can be rotated to adjust the relative strengths of the two multipath signals that invariably come from different directions. Due to the

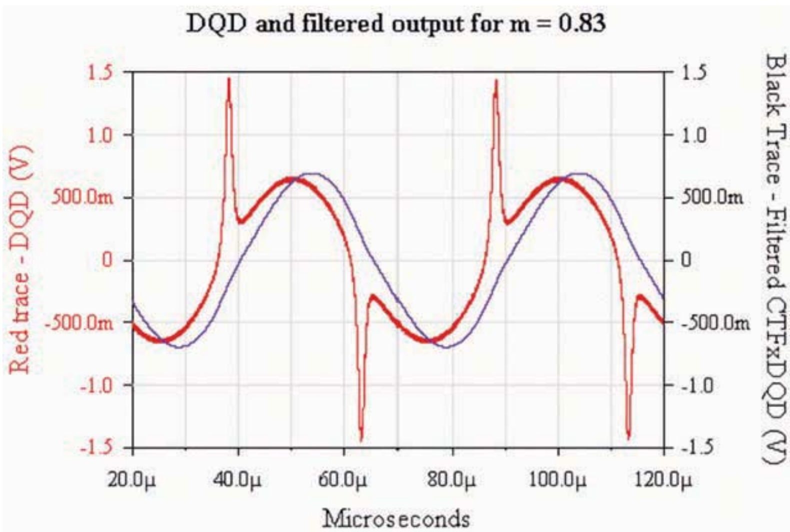


***Figure 5:** DQD demodulated signal and low-pass filtered product of DQD x CTF*

omnipresence of MPD zones, it is a fairly simple task to set up the antenna. This brings the test conditions into the laboratory where measurement, analysis and improvement can be made in a more practical environment. However, it is still difficult to quantify the results using off-air transmissions.

It is worthwhile to point out that the demodulator reduces MPD distortion but not the threshold level of the receiver. White noise cannot be removed using this circuitry.

## ASIC Performance

Using this Yagi antenna set up in the centre of an MPD zone, distortion reduction has been estimated to be about ten to twenty fold, changing the distortion from say 40% down to 2- 4%. This has the effect of recovering the pleasure of listening to music instead of the intolerable grating sound normally experienced.

When listening in a moving vehicle (with normal vehicle antenna), road, wind and engine noise contribute to a masking effect where the remaining distortion is barely noticeable under typical conditions.

## Alternative Technology

In the current state of the car radio market, techniques that involve means to combat multipath distortion may be classed as follows:

- DAB radios – these have not lived up to the expectations of the Eureka 147 project whereby the intention was to provide compact disc quality audio in the car. It is beyond the scope of this series of articles to apply the analysis of the MPD

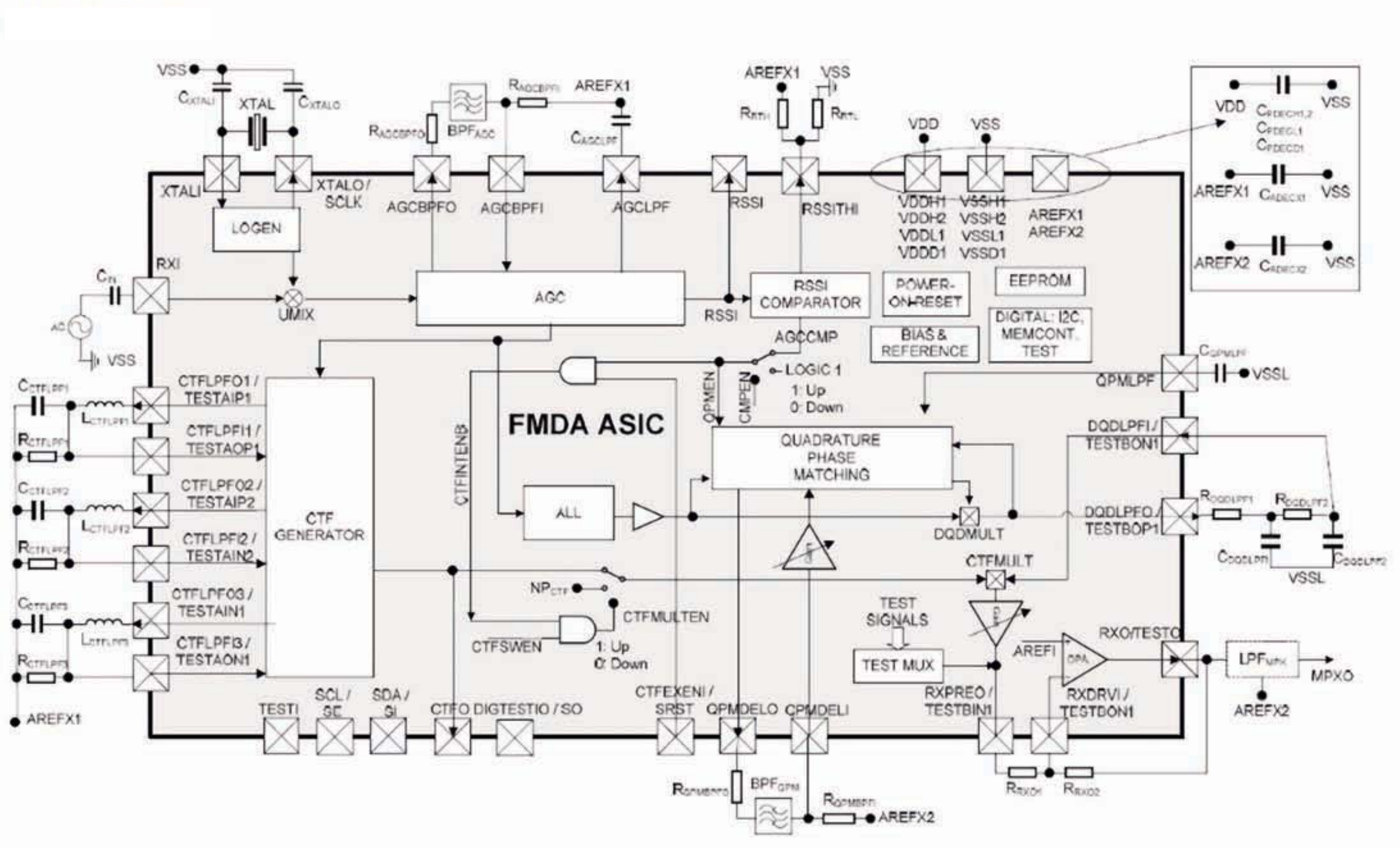


***Figure 6:** Application block diagram of the FM Demodulator ASIC*

equation to the DAB format. FM broadcast suffers a loss of 50dB with 100kHz peak modulation, at the centre of and MPD zone with a delay of one half wavelength. DAB with its low peak modulation (1kHz) and the carrier frequency at 200MHz, has a loss of 200 times more or -46dB extra. This gives -96dB for the carrier at 200MHz. This is a formidable loss for any transmission scheme.

- Diversity receivers use multiple antenna/tuner systems and have complex switching control systems that make them costly to use. They can also be caught out by the near instantaneous entry and exit from an MPD zone.
- Satellite radios require line of sight transmission. If this is blocked, as often happens in urban areas, reception is lost and this requires a network of terrestrial fill-in transmitters.
- Digital Signal Processing (DSP) radios which simply emulate the concepts of the existing analogue radios do not represent any step forward in reducing multipath distortion. DSPs cannot correct for MPD zones unless they try to emulate the FMDA ASIC.

Standard FM radio will continue to exist with single antenna applications for the foreseeable future. However, with the addition of this new low cost ASIC, the benchmark in FM audio quality is raised to a new level.

## New Mathematical Definition

Starting with Lord Kelvin through Corrington to the present, a new mathematical definition of multipath transmission distortion has been proposed.

In an MPD zone, the mean carrier is attenuated to a precisely defined level depending on the peak modulation and the length of the delay distance. More importantly, the unmodulated carrier is removed or sucked out of the composite FM signal. This causes severe phase discontinuity in the demodulator with large spikes and intolerable distortion.

Using an ALL circuit in place of the limiter, the envelope of the carrier can be employed to detect and remove these spikes. By generating the inverse of the spike and multiplying this into the standard demodulated signal, the bulk of the noise energy is removed and the listening quality of the music is recovered.

Multipath transmission distortion has been measured, understood and improved so that it is no longer the nuisance it has always been.

Lord Kelvin's words are still valid today. ■

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# TIP 1: ONE FOR ALL IN PORTABLE ELECTRONICS

*By Marty Merchant, Applications Engineer, Linear Technology*

**THE LTC3577/LTC3577-1** integrates a number of portable device power management functions into one IC, reducing complexity, cost and board area in handheld devices. The major functions include:

- Five voltage regulators to power memory, I/O, PLL, CODEC, DSP or a touch-screen controller;
- A battery charger and PowerPath manager;
- An LED driver for backlighting an LCD display, keypad and/or buttons;
- Pushbutton control for debouncing the on/off button, supply sequencing and allowing end-users to force a hard reset when the microcontroller is not responding.

By combining these functions, the LTC3577/LTC3577-1 does more than just reduce the number of required ICs; it solves the problems of functional interoperability, where otherwise separate features operate together for improved end-product performance. For instance, when the power input is from USB, the limited input current is logically distributed among the power supply outputs and the battery charger.

The LTC3577/LTC3577-1 offers other important features, including PowerPath control with instant-on operation, input overvoltage protection for devices that operate in harsh environments and adjustable slew rates on the switching supplies, making it possible to reduce EMI while optimizing efficiency. The LTC3577-1 features a 4.1V battery float voltage for improved battery cycle life and additional high temperature safety margin, while the LTC3577 includes a standard 4.2V battery float voltage for maximum battery run time.

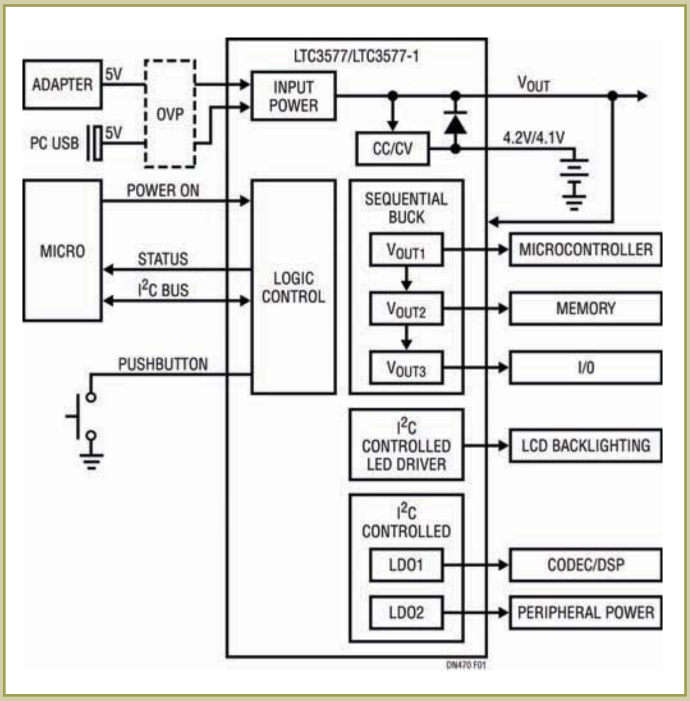


***Figure 1:*** *Portable device power distribution block diagram featuring the LTC3577/LTC3577-1*

## Pushbutton Control

The built in pushbutton control circuitry of the LTC3577/LTC3577-1 eliminates the need to debounce the pushbutton and includes power-up sequence functionality. A PB Status output indicates when the pushbutton is depressed, allowing the microprocessor to alter operation or begin the power-down sequence. Holding the pushbutton down for five seconds produces a hard reset. The hard reset shuts down the three bucks, the two LDOs and the LED driver, allowing the user to power down the device when the microprocessor is no longer responding.

## Battery, USB, Wall and High Voltage Input Sources

The LTC3577/LTC3577-1 is designed to direct power from two power supply inputs and/or a Li-Ion/Polymer battery. The VBUS input has selectable input current limit control, designed to deliver 100mA or 500mA for USB applications, or 1A for higher power applications.

A high power voltage source such as a 5V supply can be connected via an externally controlled FET. The voltage control (VC) pin can be used to regulate the output of a high voltage buck, such as the LT3480, LT3563 or LT3505 at a voltage slightly above the battery for optimal battery charger efficiency.

**Figure 1** shows a system block diagram of the LTC3577/LTC3577-1. An overvoltage protection circuit enables one or both of the input supplies to be protected against high voltage surges. The LTC3577/LTC3577-1 can provide power from a 4.2V/4.1V Li-Ion/Polymer battery when no other power is available or when the VBUS input current limit has been exceeded.

## Battery Charger

The LTC3577/LTC3577-1 battery charger can provide a charge current up to 1.5A via VBUS or wall adapter when available. The charger also has an automatic recharge and a trickle charge function. The battery charge/no-charge status, plus the NTC status can be read via the I2C bus. Since Li-Ion/Polymer batteries quickly lose capacity when both hot and fully charged, the LTC3577/LTC3577-1 reduces the battery voltage when the battery heats up, extending battery life and improving safety.

## Three Bucks, Two LDOs and a Boost/LED Driver

The LTC3577/LTC3577-1 contains five resistor-adjustable step-down regulators: two bucks, which can provide up to 500mA each, a third buck, which can provide up to 800mA, and two LDO regulators, which provide up to 150mA each and are enabled via the I2C interface. Individual LDO supply inputs allow the regulators to be connected to low voltage buck regulator outputs to improve efficiency. All regulators are capable of low-voltage operation, adjustable down to 0.8V.

The three buck regulators are sequenced at power up ($V_{OUT1}$, $V_{OUT2}$ then $V_{OUT3}$) via the pushbutton controller or via a static input pin. Each buck can be individually selected to run in Burst Mode operation to optimize efficiency or pulse-skipping mode

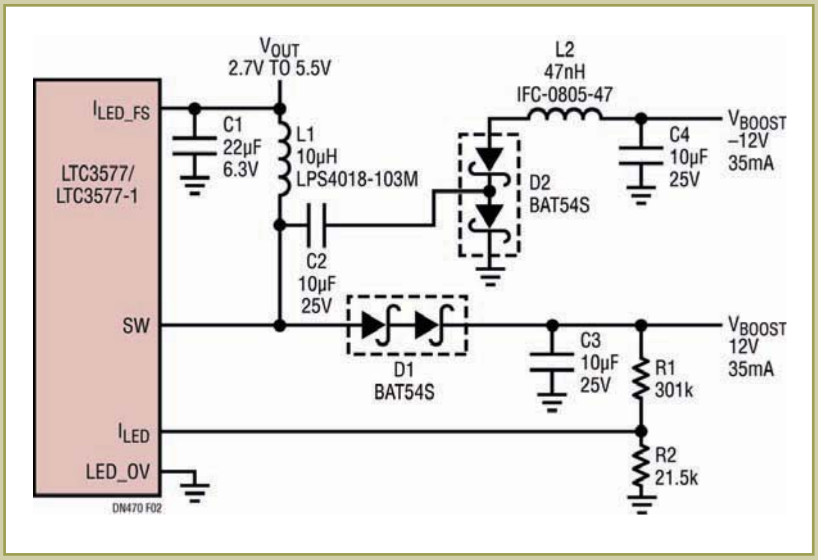


***Figure 2:*** *Dual polarity boost converter*

for lower output ripple at light loads. A patented switching slew rate control feature, set via the I2C interface, allows the reduction of EMI noise in exchange for efficiency.

The LTC3577/LTC3577-1 LED boost driver can be used to drive up to ten series white LEDs at up to 25mA or be configured as a constant voltage boost converter. As a LED driver, the current is controlled by a 6-bit, 60dB logarithmic DAC, which can be further reduced via internal PWM control. The LED current smoothly ramps up and down at one of four different rates. Overvoltage protection prevents the internal power transistor from damage if an open circuit fault occurs. Alternatively, the LED boost driver can be configured as a fixed voltage boost, providing up to 0.75W at 36V.

Many circuits require a dual polarity voltage to bias op amps or other analogue devices. A simple charge pump circuit, as shown in **Figure 2**, can be added to the boost converter switch node to provide a dual polarity supply. Two forward diodes are used to account for the two diode voltage drops in the inverting charge pump circuit and provide the best cross-regulation. For circuits where cross-regulation is not important, or with relatively light negative loads, using a single forward diode for the boost circuit provides the best efficiency. ■

# A NEW 555-TIMER BASED PHASE-TO-VOLTAGE CONVERTER

**PHASE-TO-VOLTAGE** converters are widely used in many instrumentation and measurement applications. Over the years many techniques have been developed for converting the phase angles between two pulse trains into voltage. In this regard, phase-to-voltage converters based on the ExOr digital gate and the R-S flip-flop are two of the simplest techniques used.

Despite its simplicity, the ExOr-based phase-to-voltage converter can provide a voltage linearly changing with phase angle for phase angles between 0 and $\pi$ only. While the R-F flip-flop based phase-to-voltage converter can provide a voltage that is linearly changing with the phase angle, by virtue of its operation it cannot covert very small phase angles, approaching 0, or very large phase angles, approaching $2\pi$.

The intention of proposed circuit presented here is to show that a 555-timer based circuit can be used for phase-to-voltage conversion for phase angles in the range between 0 and $2\pi$. Thus, despite its simplicity, it covers a wider range than any other known simple phase-to-voltage converter.

## The Proposed Circuit

The proposed circuit, shown in **Figure 1**, comprises a 555-timer configured in the monostable mode. It is required to convert the phase angle between waveforms A and B, shown in **Figure 2**, to a voltage. The $R_1$ - $C_1$ circuit acts as a differentiator. Thus, the voltage at node F will be as shown in Figure 2. Similarly, the $R_2$ - $C_2$ circuit acts as a differentiator. Thus, the voltage at node D will be as shown in Figure 2.

The operation of the 555-timer will be as follows: At the negative going edge of the voltage waveform A, the voltage at pin 2 will be pulled to a value less than $V_{cc}/3$, the 555-timer will be triggered and the capacitor *C* will start a charging process heading towards $V_{cc}$, as long as the voltage at pin 4 is large enough to enable the 555-timer. However, at the negative going edge of the voltage waveform B, the voltage at pin 4 will be pulled down sufficiently to reset the 555-timer and stop the charging process of the capacitor *C*. Thus, the period of the resulting pulse at pin 3 will be decided by the phase angle between the negative going edged of two consecutive pulses of the waveforms A and B.

It is important here to make sure that the value CRln3 is always larger than period of the pulse trains A and B. This is to guarantee that the width of the pulse at terminal 3 will be decided only by the phase angle between the two pulse trains A and B. Obviously, a low-pass filter connected to pin 3 will produce a DC voltage that is linearly proportional to the phase angle between pulse trains A and B for values of phase angle between 0 and $2\pi$. ■

**Muhammad Taher Abuelma'atti** and **Husam Al-Shammari**
**King Fahd University of Petroleum and Minerals**
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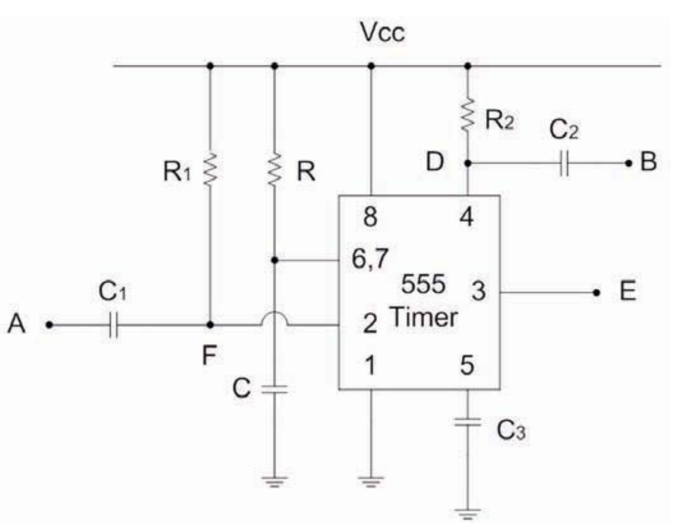



***Figure 1:*** *A 555-timer based phase-to-voltage converter*

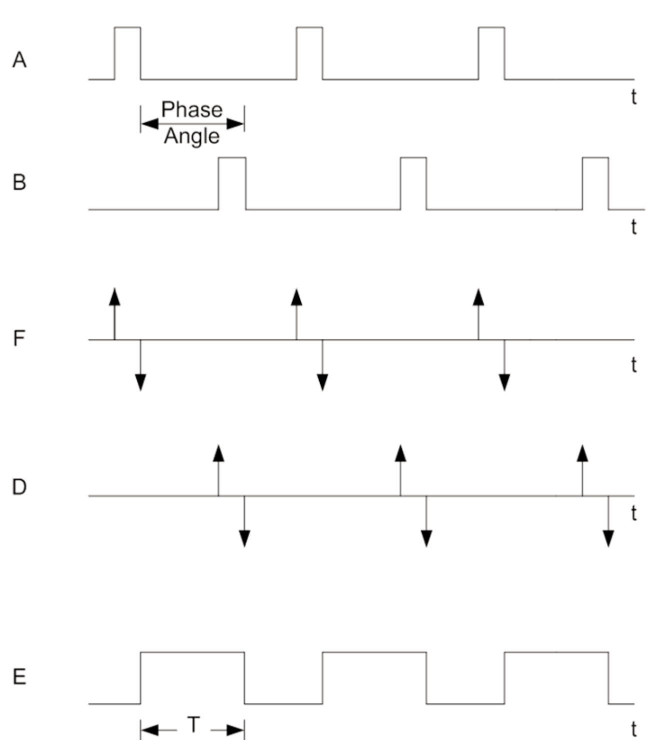



***Figure 2:*** *Waveforms at different nodes in Figure 1*

## DYNAMIC 3D ONLINE MODELLING FROM ITT INTERCONNECT SOLUTIONS

ITT Interconnect Solutions has announced a new capability on its website which allows design engineers to dynamically create virtual 3D connector models, even designs which have yet to be manufactured.

This new online facility builds on ITT ICS's existing web-based configurator technology and unique single field search to enable users to utilize a single interface to search for ITT ICS's industrial, commercial, military-specified and Hi-Rel products. Design engineers are able to select from various output model formats, provided the requested product represents a standard configured item.

There are hundreds of thousands of available configurable parts in the ICS online system servicing a wide range of requirements from hi-rel military equipment to space applications and medical products. The new 3D modelling capability is currently available for ITT ICS 38999 Series III connectors with further product lines being added on an ongoing basis.

Registration is free.

**www.ittcannon.com**

## ARM UNVEILS CORTEX-A15 MPCORE PROCESSOR


ARM introduced the Cortex-A15 MPCore processor that delivers a 5x performance improvement over today's advanced smartphone processors, within a comparable energy footprint.

In advanced infrastructure applications the Cortex-A15 processor running at up to 2.5GHz will enable highly scalable solutions within constantly shrinking energy, thermal and cost budgets. The Cortex-A15 processor is available for licensing today and is targeted at manufacture in 32nm, 28nm and future geometries.

As the latest addition to ARM's Cortex-A family of processors, the Cortex-A15 MPCore processor will enable a new and vast array of products ranging from next-generation smartphones, tablets, large-screen mobile computing and high-end digital home entertainment devices through to wireless basestations and enterprise infrastructure products.

The Cortex-A15 MPCore processor is expected to become the next major step along the industry's energy efficient computing roadmap and open up a wide range of new application possibilities for its partners.

**www.arm.com**

## MULTI-PURPOSE TEMPERATURE SENSORS

ATC Semitec's AT-11 series temperature sensor offers the best accuracy/cost/quality ratio available around. Precise to ±0.3degK at 25degC and with a fast-response tip (only 6 x 5 x 15mm long), the AT-11 accurately controls the air or water temperature in your application up to 105degC.

The AT-11 also has a 3kV di-electric rating and owing to the sensor tip/lead-wire insulation being made from the same material, it offers peace of mind in applications where moisture ingress has previously been a problem.

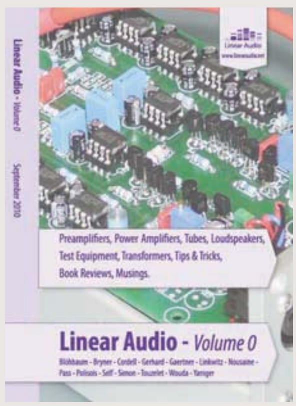
These cost-effective sensors are perfectly suited for use in energy-recovery systems, air handling units, underfloor heating and other HVAC applications.

**www.atcsemitec.co.uk**

## NEW HIGH-QUALITY TECHNICAL AUDIO PERIODICAL

Linear Audio Publishers of Hoensbroek, The Netherlands, have announced the publication of the premier issue of their new semi-annual 'bookzine' *Linear Audio*. The printed publication's goal is to provide high quality, in-depth technical audio information and construction projects to professionals and serious hobbyists.

*Linear Audio Volume 0* packs over 160 pages of technical audio articles and includes solid state pre- and power amps, vacuum tube power- and low noise preamps, loudspeaker systems and stereo reproduction, audio transformers, book reviews, test equipment and more. *Volume 0* authors include Nelson Pass, Douglas Self, Bob Cordell, Tom Nousaine and Siegfried Linkwitz. A full list of article abstracts is available at www.linearaudio.net . *Linear Audio Volume 0* can be ordered online.




**www.linearaudio.net**

## SYSTEM MANAGEMENT MCU CUTS POWER AND COOLING COSTS IN ENTERPRISE EQUIPMENT

Maxim Integrated Products introduced the MAX31782, a system management microcontroller (MCU) that combines six temperature measurement channels with six channels of closed-loop fan control.


By monitoring multiple temperature points throughout the system, the MAX31782 enables enterprise system designers to implement highly precise zoned-cooling schemes. This approach minimizes system power consumption and cooling costs by individually adjusting the speed of each fan to deliver the exact amount of cooling required by each zone. Added benefits of this technique include increased reliability through reduced fan wear, compensation for fan speed variances due to dust accumulation, and acoustic noise reduction.

A completely C-language programmable solution, the MAX31782 allows system designers to quickly and easily customize algorithms for precision zoned cooling in complex systems such as servers, network switches and routers and base stations.

**www.maxim-ic.com**

## 150W DC/DC CONVERTER MODULES FROM POWERSOLVE ARE IP55 RATED

Power supply specialist Powersolve announces the TEP150WI Series of high performance DC/DC converter modules that provide up to 150W output power. An ultra-wide 4:1 input voltage range (9-36V or 18-75V), efficiency levels to 87% and selectable output characteristics make the new converters suitable for a wide range of applications.

There are 10 models in the range with output voltages ranging from 12 to 48VDC. The TEP150WI units are rated to IP55 and they can be chassis or wall-mounted making them ideal for use in industrial environments. Connection is by screw terminals.

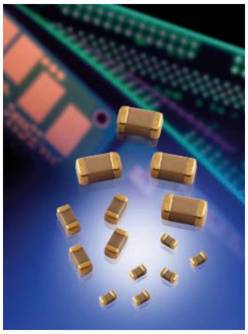
The converters are suitable for temperatures of -40°C to +50°C with natural convection cooling and up to 75°C with derating and airflow.

The DC/DC converters meet the EMI requirements of EN 55022 Class A without external components, and feature reverse input and short circuit protection as well as thermal shutdown and remote on/off.

**www.powersolve.co.uk**

## AVX EXPANDS MLCC FAMILY TO INCLUDE GOLD PLATED TERMINATIONS

AVX Corporation has expanded its extensive family of multilayer ceramic chips (MLCCs) to include gold plated terminations. Designated the Au Series, the RoHS compliant MLCC eliminates the use of tin and lead and subsequent tin wiskering events on the PCB.



Available for most standard MLCC values, AVX offers a range of gold thicknesses for flash terminations (soldering applications) from 1.9µin to 7.87µin, while the gold Std termination thicknesses start at 100µin minimum (epoxy/wire bonding applications).

Wisker growth is caused by deposit stress, such as heat, to pure tin plated components. The gold plated termination series from AVX eliminates a printed circuit board's susceptibility to tin wiskering, which can significantly affect the performance and reliability of a system.

This series further strengthens AVX's commitment to alternate terminations. Other alternate terminations offered are SnPb, PdAg, Flexiterm and Flexisafe.

**www.avx.com**

## LED ILLUMINATED MULTIMEC PUSHBUTTON SWITCHES FROM FOREMOST


Foremost Electronics, the Essex based specialist distributor of electromechanical components, announces the availability of additional models and features in the MEC multimec switch range. MEC Switches was established in 1938 and is one of the leading European manufacturers of high quality switches with a reputation for leading-edge design and the use of top quality materials delivering maximum reliability under all conditions.

The latest innovations in the multimec switch range include Orange & White LED illumination, frosted caps for more even light dispersion and Foremost offers end users a custom cap printing service.

There are four basic switch modules, 3A, 3C, 3E and 3F, in the multimec range which provide the components to assemble a very wide variety of options of both illuminated and non-illuminated switches. A 1mm actuator travel combined with 3N actuation force (300g) provides a strong, audible, tactile feel throughout the 10 million cycle mechanical life of the switch.

**www.4most.co.uk**

## INDUCTIVE COMPONENTS FOR INVERTERS IN WIND TURBINES

SMP's chokes for inverters in wind turbines are now also approved for use in offshore installations. These inductive components feature low losses, very low stray fields and a highly compact design. The chokes' cores consist of powder composites, which SMP has specifically engineered for this application.

The direct current from the wind turbines must be converted into a sinusoidal waveform with the values required by the grid. The converter's filters, which consist of capacitors and filter chokes, ensure that the current being fed into the grid exhibits a near sinusoidal waveform.

To maximize the inverter's efficiency, its components must exhibit low losses. The materials that SMP developed especially for use in its energy-efficient, high-performance chokes have low magnetostriction and exceptionally low eddy current and hysteresis losses. Their encapsulated design ensures that the power converters emit only low-intensity stray fields, so that they do not affect other components.

**www.smp.de**

## COMPREHENSIVE COM EXPRESS COM.0 R 2.0 PORTFOLIO

Kontron announced its full support of the recently launched PCI Industrial Computer Manufacturers Group (PICMG) COM Express COM.0 R 2.0 specification. The new COM Express specification COM.0 Revision 2 further leverages the development of applications, improving time-to-market and TCO.

Furthermore, two new pin-out types (type 6 and type 10) are detailed in the new revision.

An additional feature of the COM Express COM.0 Revision 2 specification is the creation and adoption of a sister specification EeeP (Embedded EEPROM Specification). EeeP facilitates describing the carrier functionality and embedding the system descriptor information (manufacturer, serial number, PCIe configuration, etc) on the carrier, simplifying system provisioning and maintenance in Multi Platform, Multi Vendor environments.

While maintaining maximum compatibility to the existent pin-outs, these new pin-out types offer dedicated interfaces for digital displays and other future-oriented features. The new revision defines, with EAPI, a uniform software interface for the board and module management.

**www.kontron.com**

## ENERGY MICRO TOOL INSTANTLY RESOLVES MCU PIN CONFLICTS

Energy Micro, the energy efficient microcontroller company, has introduced a free software tool designed to remove the traditionally time-consuming problem of debugging I/O pin conflicts. Supporting the complete EFM32 Gecko low power MCU family, energyAware Designer ensures correct pin configuration and automatically generates set-up code and documentation.

On creating a new project, designers select a target MCU and are presented with a default device configuration. Clicking on a peripheral function enables it and highlights respective pins in green on an intuitive pin-out diagram. Pin-conflicts induced by selecting another peripheral are highlighted in red. These are simply resolved by choosing an alternative peripheral location, automatically suggested by the software.

Configuration of GPIO resources and clocks are handled in a similar way.

Once happy with the overall MCU configuration, designers can then use the energyAware Designer tool to generate the corresponding C-code file, which can then be cut-and-pasted directly into the application code.

**www.energymicro.com**

## NEW ENHANCED AUDIO SCRAMBLER AND SUB-AUDIO SIGNALLING PROCESSOR IC

CML Microcircuits has announced the launch of a new audio scrambler and sub-audio signalling processor to its family of analogue two-way radio ICs.


The CMX138A, an upgrade based on the hugely successful CMX138 IC, is intended for use in half duplex analogue two-way radios or family radio equipment, particularly suited to enhanced MURS, GMRS, PMR446 and FRS designs. Highly integrated by design, the device provides a user programmable frequency inversion audio scrambler with signal processing functions, CTCSS, DCS and in-band tones, allowing comprehensive voice processing and tone control.

Key enhancements for the CMX138A include: improved limiter functions, enhanced CTCSS and DCS performance, a new input Automatic Gain Control (AGC) function, in-band tone operation enabled down to 288Hz and improved audio compandor, which enhances the performance of compressed signals. These developments are designed to provide even greater levels of tone control and voice processing, making the CMX138A the complete audio solution.

**www.cmlmicro.com**

## ETXEXPRESS-AI IS NOW AVAILABLE WITH THE NEW TYPE 6 PIN-OUT

Coinciding with the launch of the COM Express 2.0 specification by the PCI Industrial Manufacturers' Group (PICMG), Kontron presents an additional version of the Computer-on-Module ETXexpress-AI based on the new COM Express Type 6 pin-out definition.

As compared to the Type 2 pin-out definition for COM Express Basic form factor modules, the new Type 6 pin-out offers configurable Digital Display Interfaces (DDI) SDVO, DisplayPort and HDMI/DVI along with 23 PCI Express Gen 2 lanes. This provides more native display options and higher serial bandwidth than previously possible. Most noteworthy is that the native support for all the new display interfaces simplifies carrier board designs, reducing time-to-market and total cost of ownership for graphics-intensive applications. The extensive PCI Express support underscores the trend of moving away from legacy parallel interfaces towards pure serial embedded system designs for higher bandwidth and reduced latency. This represents a smooth transition path for application designers to enhancing designs with next generation technology.

**www.kontron.com**

## SMARTTM1 - NEW TELTONIKA TM1 DEVELOPMENT TOOL

mikroElektronikca has introduced SmartTM1 Board, which allows users to use Teltonika TM1 module in their GSM/GPRS application design.

The tool supports the Teltonika TM1 GSM/GPRS module and has on-board voltage regulation, so there is no need for an additional power supply circuit. All you need to do is to connect the power supply to the board, attach the GSM antenna and you are ready to begin the design of your device.

Each feature of the board is supported by example written in mikroC, mikroPascal and mikroBasic PRO compilers.

In addition, mikroElektronika has launched a new Atmel XMEGA based board called XMEGA-Ready. This tool is a full-featured prototype board that contains ATxmega128A1 device (it is connected to an 8MHz oscillator). It also features a USB support via FT232R.

This tool is ideal for exploring and designing devices using the new Atmel XMEGA A1 family.

**www.mikroe.com**

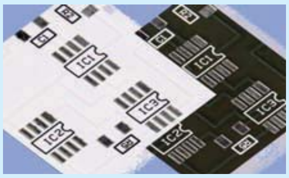
## NEW IMS PROTOTYPING SERVICE FROM PCB-POOL

PCB-POOL, manufacturer of prototype printed circuit boards, has announced the introduction of a new metal core (insulated metal substrate) PCB prototyping service.

Metal Core PCBs are designed to transmit heat away from operating areas on the PCB or components to less critical areas such as metal heat-sink backing and metallic core.

Designers of high intensity LEDS, power converters, automotive applications or any circuits requiring greater heat dissipation can now take advantage of reduced pricing and shorter lead-times offered within this new PCB-POOL service.

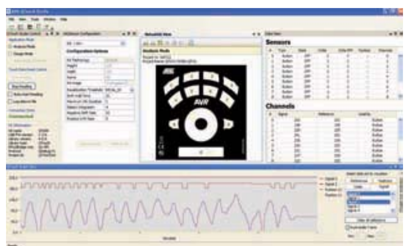
Various machining methods have been integrated in the IMS manufacturing process, including the ability to produce threaded drills holes, counter sinking and controlled depth milling using the latest CNC technology.



The offering includes 1 layer IMS PCBs, no minimum quantity, various soldermask and silkscreen colours, no tooling or set-up charges, lead-free HASL surface finish, 1.5mm thickness, 100µm isolation layer, 35µm copper and free laser SMT stencil with all prototype orders.

**www.pcb-pool.com**

## ATMEL QTOUCH STUDIO 4.3 SOFTWARE TOOL EASES TOUCH DESIGNS



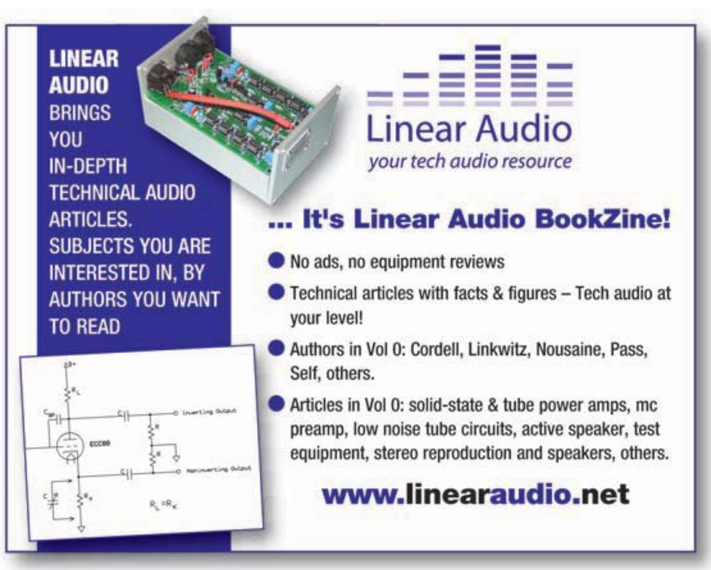
Atmel Corporation launched the Atmel QTouch Studio 4.3, the industry's first touch design software tool to support the complete touch design flow.

Another first is the Touch Validation Wizard, a feature in the Atmel QTouch Studio 4.3 to help assess design quality by reporting capacitance, noise and reference levels, as well as notifying the user of design marginalities. The software tool is so easy to use that design engineers do not need an expert level of understanding of touch technologies to quickly and effectively integrate touch functionality into their applications.

With Atmel QTouch Studio 4.3, designers can quickly enhance their designs with touch functionality while bringing their products to market faster, thereby reducing the overall engineering workload and accelerating their time to revenue. This software tool supports real-time tuning of the touch sensors, permanent storage of the tuned configuration data into the flash memory, design validation and debug of the touch interface.

**www.atmel.com**





# UNLICENSED WHITESPACE FREQUENCIES TO **REVOLUTIONIZE WIRELESS NETWORKS,** SAY EXPERTS

A new report released by Cambridge Consultants, called '*Whitespace: a revolution in wireless communications?*', looks at how the highly desirable TV band whitespace could fundamentally change today's wireless provider model while spotlighting technology hurdles that will limit immediate disruption. The new whitespace frequencies, recently authorized in the US by the Federal Communications Commission (FCC), greatly increase the global wireless bandwidth available to computers, set-top boxes, laptops, WiFi hot spots and other radio devices that currently use the unlicensed bands at 2.4 and 5GHz.

Firms such as Intel, Dell, Philips, Nokia, Microsoft and Google contributed to the report to discuss the potential $100bn US market for wireless technologies enabled by whitespace frequencies. The consensus is that new wireless devices will soon emerge taking advantage of the increased range and wall-penetrating ability of the newly allotted band. This could be in the form of supplementing traditional cellular networks or by creating low cost wireless broadband capabilities in some urban environments.

## Our panel of commentators says the following on this development:

**BURKHARD VOGEL, MANAGING DIRECTOR, GERMANY:**

Isn't it a shame? Europe slept well and the US (FCC) acts! Now, US's respective industry got a huge advantage over the competition of the rest of the world. And again, they will dictate which way to go. It was not unknown to the European wireless industry that a broad range of new business adventures could be passed in the whitespace frequency range. Why didn't they act? Why do we (the Europeans) always miss an opportunity instead of simply being faster?

Nevertheless, the use of the whitespace by data transmitting activities à la Internet should not be organized nor should it be pushed through at the expense of the wireless microphone manufacturers. On the other hand, if it's true that 80% of the spectrum capacity below 3G is unused and the demand for free spectrum space for long-range wireless data exchange will become the growing market challenge in the near future, the following question should be answered by the respective international organizations as soon as possible: Isn't it high time reorganizing the spectrum < 3G according to this growing demand? The 600MHz whitespace can only be a first step.

**BARRY MCKEOWN, RF AND MICROWAVE ENGINEER IN THE DEFENCE INDUSTRY, AND DIRECTOR OF DATOD LTD, UK:**

I note that CCL recognize that LTE is a short term proposition and that there is much misinformation placed in the public domain by incumbent vested interests over the past six years in the US where this technology initiative originates; which their report should hopefully sanities. I would disagree with CCL about the unlicensed whitespace technology rivalling licensed cellular networks though. This is to misunderstand the current regulatory framework and how it is evolving such that developments in future healthcare Body Area Networks shall be required to interface with both broadband fibre and cellular network operators on basic economic grounds.

**PROFESSOR DR DOGAN IBRAHIM FROM THE NEAR EAST UNIVERSITY IN NICOSIA, CYPRUS:**

One of the major problems with the existing wireless devices is the seriously limited range and the fact that the signals do not penetrate through walls. Many people find it difficult to connect to their access points even within their homes, when for example the access point is located upstairs and there may be no signal downstairs or in the garden. This is mainly as a result of the limitations of the existing 2.4 and 5GHz wireless frequency bands. In general, lower frequency bands, such as the whitespace radio bands offer several times longer range than the existing wireless bands.

Television whitespace bands will enable an access point to serve a much greater area, e.g. a single low-cost access point would be sufficient to service a public place such as a library, train station or an airport. Without a doubt, the use of whitespace radio frequencies will revolutionarise the wireless connectivity.

**MAURIZIO DI PAOLO EMILIO, TELECOMMUNICATIONS ENGINEER, INFN – LABORATORI NAZIONALI DEL GRAN SASSO, ITALY:**

Whitespace devices take advantage of wireless innovations and advances in computer processing power and automatically detect unoccupied TV frequencies. For consumers, they're very similar to the wireless devices we use today.

Whitespace devices will have a greater positive impact than wi-fi and spur far more innovation than mobile phones.

**HAFIDH MECHERGUI, ASSOCIATE PROFESSOR IN ELECTRICAL ENGINEERING AT THE UNIVERSITY OF TUNISIA:**

The spectacular innovations in the field of telecommunications represent a true scientific revolution. It is noted that with the numerical world, allotted to telecommunications, the transmission of the television programs is ensured by distributive firms and operators. Indeed, the transmission of the video signals and the data are digitized in a numerical flow. This operation made it possible to have whitespace frequencies. It is a new era in telecommunications. It constitutes a revolution of the wireless network. Thus whitespace frequencies will be used by titular companies and allotted to radio broadcast diffusion.

*If you'd like to comment on this subject or want to become a member of our panel, please write to the Editor at Svetlana.josifovska@stjohnpatrick.com*