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ELECTRONICS WORLD

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THE ESSENTIAL ELECTRONICS ENGINEERING MAGAZINE

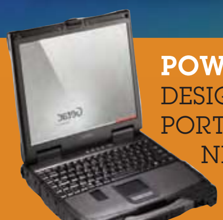
- OPTIMIZING DESIGN TRADE-OFFS FOR THE NEEDS OF TODAY'S PORTABLE AUDIO AMPLIFIERS

- **SPECIAL REPORT:** PORTABLE SYSTEMS DESIGN

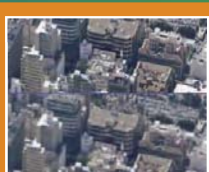
- TIPS ON HOW TO PROTECT BATTERIES

EXTENDING BATTERY RUN TIME

- SWITCHMODE POWERPATH PMIC WITH BUCK-BOOST



POWER DESIGN
DESIGNING FOR PORTABLE POWER NEEDS



CAMERA DESIGN
LOOKING AT THE LATEST ZOOM CAPABILITIES

FOCUS:
SCOPE ALLIANCE'S AIMS AND ACHIEVEMENTS

ALSO IN THIS ISSUE: THE TROUBLE WITH RF – WHAT DOES 'OBSOLETE' MEAN TO A DESIGNER?

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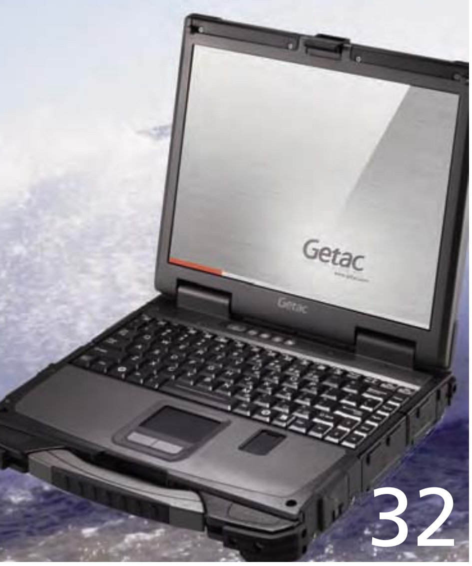

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REGULARS

FEATURES

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Going Green

Extending battery run-time – page 8

The march for more energy-efficient, environmentally-friendly home appliances is on and in full swing.

As most industrialized nations recognize the need to conserve energy, developers and manufacturers are cottoning on to the fact and beginning to provide energy-efficient products.

As the world population increases, so does the demand for energy to power new homes with heating/cooling systems, lighting and electrical appliances. It costs a great deal of money not only to build new power-generating facilities, but also to deliver this power to the users once it is generated. A simpler solution would be to make appliances less power-hungry.

Many suppliers or power management and conversion ICs are responding to the need for 'greener' solutions and have made a lot of progress in improving power efficiency across a wide load range. Others are resorting to the basics of physics and materials' chemistry to create devices that need less energy to function. Examples include BASF and Delta Electronics, two different type companies – one a chemical firm, the other electronics – who have recently announced a joint cooperation to develop new cooling systems. Their plans include technologies that are expected to revolutionize refrigerators and air conditioning by making them 'greener', less noisy, more compact and highly energy-efficient.

The cooperation partners are working on materials and prototypes for cooling systems and power generators intended to replace conventional compressor technology in refrigerators and air conditioning systems; theirs will use an environmentally-friendly magnetocaloric technology.

Cooling systems based on the magnetocaloric effect have the potential of significantly reducing energy consumption. The magnetic technology does away with gaseous refrigerants, it is quieter and it causes less vibration than conventional compressor type refrigerators. It is also compact enough to suit all conventional household refrigerators and commercial applications, including computer cooling systems and air conditioners.

Industry observers estimate that energy consumption can be cut by up to 50% by using a unit with magnetic refrigerating technology instead of a conventional refrigerator – a particularly significant figure as refrigerators account for about one-fifth of total domestic energy consumption.

Developing energy efficient, environmentally-friendly home appliances is well under way. Hopefully next in line for a complete and much-needed 'environmental' overhaul should surely be vehicles; to make them less 'gaseous', more fuel-efficient and – definitely – less noisy!

Editor
Svetlana Josifovska

PULSE RESISTORS WITHSTAND 200,000V LOADS THANKS TO A PROPRIETARY POLYMER TECHNOLOGY

German-based PCB developer Würth Elektronik has created printed pulse resistors for voltages up to 200,000V, a range that up until now was difficult to achieve with conventional power resistors.

Würth Elektronik has used its own developed smart-conductive polymer thick film technology to create the devices. Company researchers say that the polymer-coated pulse resistors "assimilate" energy loads in KW during periods of milliseconds.

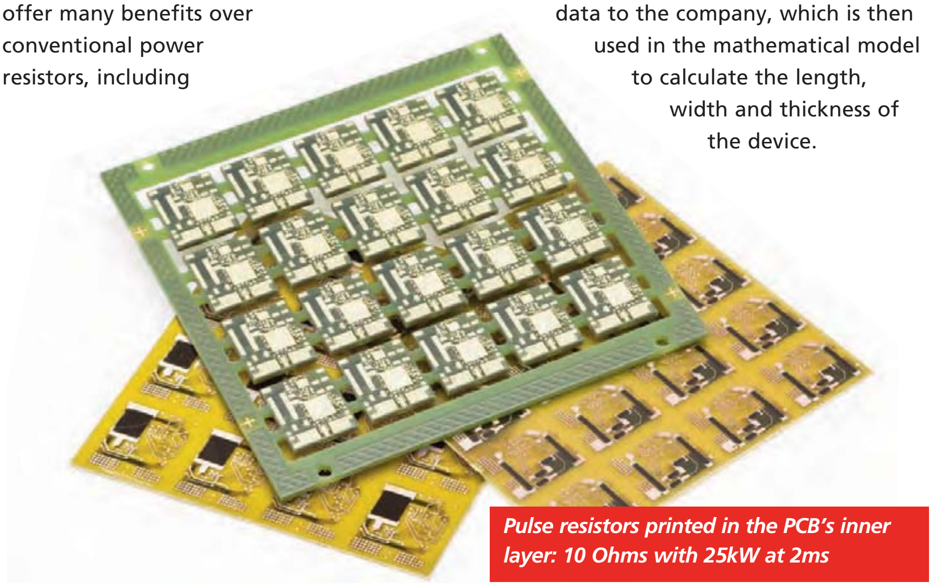
Frank Dietrich, developer of the special smart conductive polymer paste and head of the FLATcomp Systems division at Würth Elektronik, said: "Not too long ago [high-load pulse resistors] had been claimed impossible in the Giga-Ohms range. The reason is that a high voltage normally leads to such high field strengths – generating electrostatic forces – that a normal carbon resistor would just explode and be atomised in the first instance. However, our polymer thick film coating withstands such high field strengths."

"Additionally, this [the polymer coating] is supported by 'curved' geometry, avoiding sharp edges subject to sparks emissions, especially for voltages of 100,000V and above," he said.

Polymer coated resistors are seen to offer many benefits over conventional power resistors, including they need less board space (due to their nature they can even be integrated in the inner layers of the PCB); they offer better thermal management; and they do not need soldering (solder joints are susceptible to problems). In addition, polymer coated resistors do no seem to need heat sinks as conventional power resistors do. For example, it takes a heatsink of 10cm x 5cm to handle a conventional 10W resistor, but for a power resistor subjected to 25KW load even for the duration of only 2ms, an aluminium heatsink would not be sufficient. Luckily, says Dietrich, heatsinks are not needed for these devices.

To understand the real effects of 25KW on a thick film coating during a 2ms period, Würth Elektronik resorted to mathematics. The company says that large loads within a short time do not necessarily equate to too much energy, which means that the printed polymer resistors do not heat up quickly and remain at a nearly constant temperature across their surface.

Now Würth Elektronik is readying its technology for real applications. To get the perfectly matched pulse resistors to an application, customers can supply their data to the company, which is then used in the mathematical model to calculate the length, width and thickness of the device.



Pulse resistors printed in the PCB's inner layer: 10 Ohms with 25kW at 2ms

The University of Manchester and Murata of Japan have formed a nanotechnology research collaboration. The research will be financially aided by the Northwest Regional Development Agency (NWDA). Mark Hughes from the NWDA said: "I am pleased that work has now begun on the project, which may lead to further investment by Murata in future."

Japan is the second largest Asian supplier of Foreign Direct Investment (FDI) projects to the UK. In 2008/09, Japan contributed 81 new projects and created 1,405 new jobs, the sixth largest FDI source to the UK.

Prof Paul O'Brien from the University said: "I very much welcome this collaboration with Murata, which provides access to skills and equipment in Japan and training for a Japanese scientist in some leading edge aspects of nanotechnology in my laboratories."

Icelanders are increasingly turning to innovation to kick-start their struggling economy. Innovation centres have been formed in many towns and the low value of the Icelandic krona helps exporting companies.

Since last autumn when the banking business brought Iceland to a standstill, publicly run Innovation Center Iceland has overseen the opening of six new incubator centres which have led to the creation of many jobs.

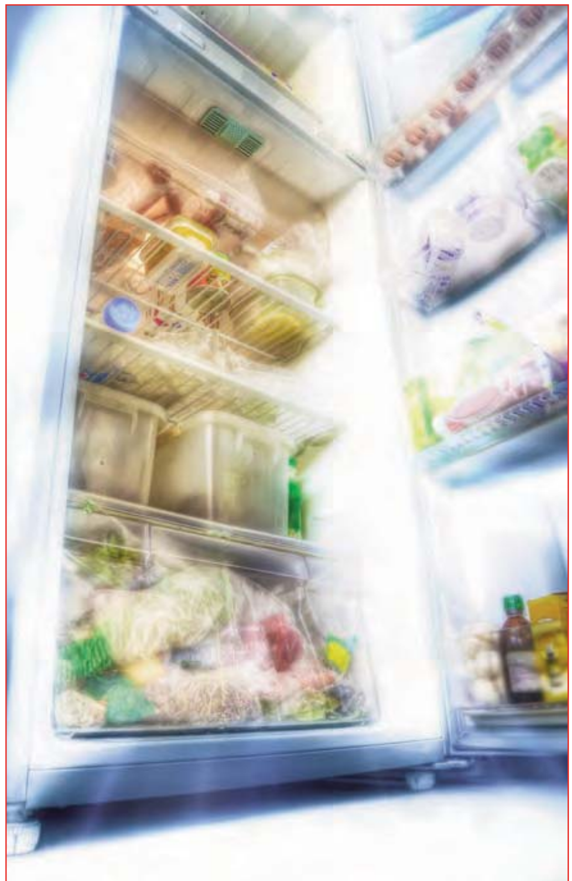
"We are seeing tremendous interest in innovation in Iceland. We have had that before, but now external circumstances drive people towards creating their own opportunities. They simply can't rely on the same things as before," says Andri Kristinsson, head of Innovit, a privately run entrepreneurial incubator in Reykjavik.

TSMC is the first foundry to achieve 28nm functional 64Mb SRAM yield across all three 28nm nodes.

"This achievement is striking," said Dr Jack Sun, VP of R&D at TSMC. "It is particularly noteworthy because it demonstrates the manufacturing benefits of the gate-last approach that we developed for the two TSMC 28nm high-k metal gate processes."

The 28nm HPL process features low power, low leakage and medium-high performance. It is aimed to support applications such as mobile phones, smart netbooks, wireless communication and portable consumer electronics that demand low leakage.

Joint Effort Promises to Lead to New Cooling Systems



Coolers are likely to get a complete overhaul thanks to a new technology

BASF and Delta Electronics have teamed up to develop new cooling systems that could revolutionize refrigerators and air conditioning.

The cooperation partners are working on materials and prototypes for cooling systems and power generators intended to replace conventional compressor technology in refrigerators and air conditioning systems; theirs will use an environmentally-friendly magnetocaloric technology.

"Our experts in material and process development work closely with scientists in fundamental research at internationally renowned universities such as the TU Delft," said Professor Rainer Diercks, President Chemicals Research and Engineering at BASF. "BASF has already started the scale-up for the production of special, economically feasible materials that already show a magnetocaloric effect at relatively low temperatures and, thus, offer a broad range of applications. This is a major contribution to the success of this project."

Cooling systems based on the magnetocaloric effect have the potential of significantly reducing energy consumption. The magnetic technology does away with gaseous refrigerants, it is quieter and it causes less vibration than conventional compressor type refrigerators. It is also compact enough to suit all conventional household refrigerators and commercial applications such as computer cooling systems or air conditioners. In addition, initial estimates by material researchers suggest that energy consumption can be cut by up to 50% by using a unit with magnetic refrigerating technology instead of a conventional refrigerator, a particularly significant figure as refrigerators account for about one fifth of total domestic energy consumption.

In 1880 the German physicist Emil Warburg observed that ferromagnetic materials heat up when introduced into a magnetic field and cool down again when removed. Magnetic field based cooling systems have been developed since, but stayed primarily in laboratories. Today, developments have led to even weak magnetic fields – and at normal ambient temperatures – to generate particularly large temperature differences that can be harnessed for cooling by means of heat exchange. Now Delta is ready to roll-out small coolers for household appliances.

"We're all ready to go," said Dr Thomas Weber, Managing Director of BASF Future Business GmbH. "What we need now are prototypes for cooling systems to demonstrate the energy-saving potential in everyday use."

Commercially viable applications for magnetocaloric cooling are only possible if there is an abundant supply of affordable raw materials. BASF is working, for example, on chemically stable manganese iron compounds that are characterized by low-volume expansion and a particularly large magnetocaloric effect. At the same time, they are cheaper to produce than materials based on the metal gadolinium and its salts that have been used to date.

Among other applications for magnetocalorics-based energy-saving systems are in cryoproduction in the process industry, automotive air-conditioners and miniaturized cooling systems for electronic components.

DNA shows promise for electronic and computing applications

Researchers are increasingly turning to DNA for computing and electronics applications.

Structures such as carbon nanotubes and nanowires show great promise but are difficult to manipulate, however it is found that the chemical groups hanging off DNA helices could be used as anchor points for them.

Researchers reporting in Nature Nanotechnology have now shown that DNA can self-organise on silicon, which can be used to create structures or 'scaffolds' for electronic components just six billionths of a metre apart.

In the meantime, scientists at the Weizmann Institute in Israel have created a basic computer with DNA as the principal information carrier. To bridge the gap between a computer programming language and DNA computing code the team had to create a specific software program.

The DNA 'computer' has been shown to successfully answer simple questions in a binary format (as a 'yes' or 'no') to questions that needed deduction. Molecules, fluorescent DNA strands and enzymes were used to indicate the 'answers'.

Switchmode PowerPath PMIC with Buck-Boost Extends Battery Run Time

BACKGROUND

The number of power rails in today's content- and feature-rich portable electronic devices has increased while decreasing in voltage, yet many of today's modern devices still require 3V or 3.3V rails for powering hard disk drives, memory, microcontroller core and I/O, and logic circuitry. Traditionally these voltage rails have been supplied by step-down (buck) switching regulators or low-dropout regulators (LDOs). Nevertheless, these types of ICs do not capitalize on the Lithium-ion/Polymer cell's full operating range, thus effectively shortening the device's potential battery run time. However, the advent of the buck-boost regulator—it may step voltages up or down—has allowed the battery's full operating range to be used, thus increasing operating margin and extending battery run time as more of the battery's useful capacity is utilized, especially at the lower end.

On the battery charging side, a USB port has been the preferred means for fast data transfer and is also becoming the preferred means for portable device battery charging, eliminating the need for a separate wall adapter. However, there are power limitations when the USB port is used for charging the device's battery. PowerPath charging system topologies in analog ICs offer numerous advantages to both the system designer and the end-product user, including the ability to autonomously and seamlessly manage multiple input power sources to preferentially supply power to the system load in addition to charging the battery. Furthermore, reduced heat, faster charging times and instant-ON operation with a depleted battery are all available with this IC topology.

DESIGN CHALLENGES

Lithium-ion/Polymer batteries are preferred in portable consumer products because of their relatively high energy density. They provide more capacity than other available chemistries within a given form factor. As portable products become more complex, they consume more power, so the need for higher capacity batteries increases. Larger batteries require either higher charging current or additional time to charge to their full capacity. Further, USB-capable battery charging in many cases means more convenience to the user; however USB compatibility has the constraints of USB current (500mA max) and power (2.5W max) limits. An advanced USB-based battery charger should extract as much power from the USB port as efficiently as possible, while simultaneously meeting the stringent thermal constraints of today's power-intensive applications.

The new Li-Iron Phosphate battery chemistries enable longer run times, but their voltage discharge profiles are extended, with significant energy available at battery voltages below 3V. This characteristic influences the related power conversion system, making synchronous buck-boost regulators necessary to generate outputs of 3V or above.

Autonomous management of the power flow between various power sources and the battery in addition to powering the load presents a significant technical obstacle. Traditionally, designers have tried to perform this function discretely by using a handful of MOSFETs, op amps and other components, but have faced tremendous problems with hot plugging, large inrush currents, and large voltage transients to the load, which can cause big system reliability problems.

An integrated, compact PowerPath™-based PMIC with buck-boost regulation capability solves these problems simply and easily.

A SIMPLE SOLUTION

Longer Battery Life and Run Times

Accurately charging the battery to its final float voltage has a significant influence on battery life. This is controllable by selecting a sophisticated battery charging IC with constant-current, constant-voltage topology, high charging current, tight float voltage accuracy and accurate termination algorithms. This helps to avoid overcharging the cell. Furthermore, low IC standby (quiescent) current and high switching regulator conversion efficiencies via synchronous rectification allow small system current consumption in portable electronic devices, thus preserving battery run time. ICs that automatically reduce quiescent current (Iq) at light loads also help reduce device current consumption.

Buck-Boost Capability and Flexibility

Many of today's modern feature-rich portable electronics still require voltage rails in the +3V range. Integrating synchronous buck-boost switching capability into the PMIC allows 3.3V regulation across the entire Li-ion/Polymer battery range, 2.7V to 4.2V, with high efficiency, resulting in increased operating margin. For example, at 3.3V a buck-boost regulator can "ride through" battery transients that would force a step-down buck to lose regulation. Further, high switching frequency reduces the size of external components, and ceramic capacitors reduce output ripple.

Attribute	Battery-Fed	Linear PowerPath	Switchmode PowerPath
Size	Small	Moderate	Larger
Complexity	Simple	Moderate	More complex
Solution Cost	Low	Moderate	Higher
USB Charge Current	Limited to 500mA	Limited to 500mA	NOT limited to 500mA (~2.3W)
Autonomous Control of Input Power Sources	No	Yes	Yes
Instant-ON Operation	No	Yes	Yes
System Load Efficiency (Ibus<USB limit)	Poor (VBAT/VBUS)	Excellent (>90%)	Very Good (~90%)
System Load Efficiency (Ibus=USB limit)	Poor (VBAT/VBUS)	Poor (VBAT/VBUS)	Very Good (~90%)
Battery Charger Efficiency	Poor (VBAT/VBUS)	Poor (VBAT/VBUS)	Very Good (~90%)
Thermal Dissipation	High	Moderate	Low
Bat-Track Adaptive Output Control/Interface to HV Buck	No	Yes	Yes

Table 1: *Comparison of USB Battery Charging System Topologies*

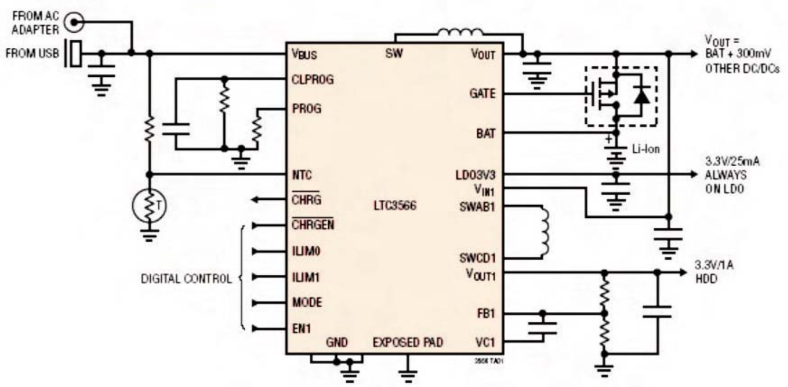


Figure 1: *LTC3566 Simplified Block Diagram*

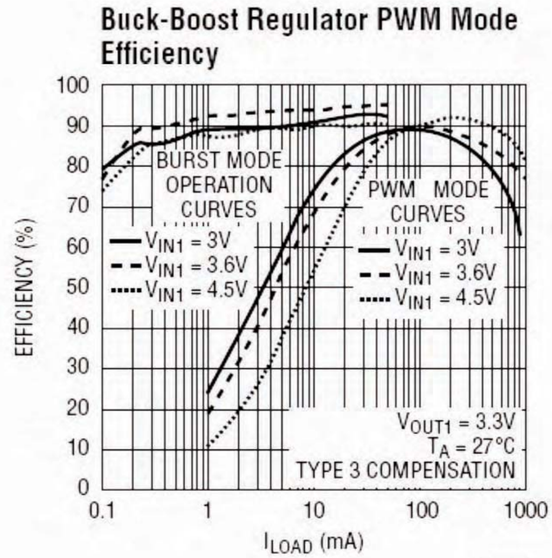


Figure 2: *LTC3566 Buck-Boost Regulator Efficiency*

Switchmode PowerPath Systems

Linear Technology's PowerPath Manager product family offers designers new choices in linear and breakthrough switchmode topologies to best fit their application. This key "hard to do" circuit block has recently been integrated into Linear's power management ICs (PMICs), resulting in autonomous, efficient and compact solutions to complex power management challenges, and resulting in significant benefits for the end-user of these portable products.

This switchmode technology preserves the advantages of linear PowerPath systems (i.e., instant-ON operation, autonomous power path control of inputs, system/load and battery) while improving power delivery efficiency to the load/system and to the battery. The technology reduces the power lost in the linear battery charger element, especially critical when the battery voltage is low and/or input power is limited (i.e., USB), providing excellent thermal properties. A second big advantage is the technology's ability to extract up to 700mA battery charge current from a standard USB port (~2.3W) by conservation of power. See Table 1 for a summary and comparison of the three different USB charging system topologies.

The LTC3566 is the latest in a family of compact next-generation, multifunction power management solutions for Li-ion/Polymer battery applications. The LTC3566 integrates a switchmode PowerPath manager, a stand-alone battery charger, a 1A high efficiency synchronous buck-boost regulator, an ideal diode and controller, plus an always-on LDO, all in a compact, low-profile 4mm x 4mm QFN package (see Figure 1 for details). The LTC3566's instant-ON operation ensures power to the system load even with a dead battery. For fast charging, the LTC3566's switching input stage converts nearly all of the 2.5W available from the USB port to charging current, enabling up to 700mA from a standard 500mA-limited USB supply and up to 1.5A when wall powered. An internal 180milliohm ideal diode plus optional external ideal diode controller provide a low loss power path from the battery to the system load, further minimizing heat generation and maximizing efficiency.

The LTC3566 contains a 1A, 2.25MHz constant-frequency voltage mode buck-boost switching regulator, allowing the use of tiny low cost capacitors and inductors less than 1mm in height. The regulator's internal low RDS(ON) switches enable efficiency as high as 94%, maximizing battery run time (see Figure 2 for details). Furthermore, the regulator is stable with ceramic output capacitors, achieving very low output voltage ripple. The buck-boost can be programmed to a minimum output voltage of 2.5V and can be used to power a microcontroller core or I/O, memory, disk drive, or other logic circuitry. To suit a variety of applications, a selectable mode function allows the user to trade off noise for efficiency. Two modes are available to control the operation of the LTC3566's buck-boost regulator. At moderate to heavy loads, the constant frequency PWM mode provides the lowest noise switching solution. At lighter loads Burst Mode operation may be selected, reducing quiescent current to increase battery run time. The regulator also includes self and system protection features such as soft-start to limit inrush current and voltage overshoot when powering on, short circuit current protection, and switch node slew limiting circuitry for reduced radiated EMI.

The LTC3566 features USB-compatible programmable current limiting to 100mA/500mA/1A, while its Bat-Track™ adaptive output control enables high efficiency battery charging and reduces power dissipation. Stand-alone autonomous operation simplifies design, eliminating the need for an external microprocessor for battery charge termination. To preserve battery energy, the LTC3566 draws only 38uA in suspend mode. The charger is compatible with inputs up to 5.5V (7V absolute maximum transient for added robustness). Finally, highly accurate charging current and float voltage, onboard charge termination, thermal regulation and temperature-controlled charging via an NTC thermistor increase battery life by reducing chances for overcharging the cell.

CONCLUSION

Designers of battery-powered products are challenged by demands for long battery life and long run times, small size, low power dissipation, USB compatibility, and input power convenience, along with needs for regulating output voltages across the entire Lithium-ion/Polymer battery operating range. At the same time, designs are being integrated to save board space, reduce manufacturing costs and increase product reliability. Linear Technology has addressed these needs with its growing family of "meaningfully integrated" PMICs, now featuring the combination of a switchmode-topology PowerPath manager and a buck-boost regulator, making the product designer's job much easier. These new ICs feature the ability to extract more power from a USB port, autonomously and seamlessly manage power flow between various input sources and the battery while preferentially powering the load to increase operating margin and regulate output voltages such as 3.3V across the entire Li-Ion/Polymer battery range.

Obsolete!

Myk Dormer

'OBSOLETE' – One word, but a nightmare to design- and production-engineers the world over.

A great deal of time, effort and cost is involved in bringing any design from initial specification to final delivered production item. In the case of an RF product, add to this the protracted testing, design iterations and the approval processes. Then consider advertising and customer support effort too, and the desire to keep a successful design in the market for as long as possible is very easy to understand.

Unfortunately, there is a limitation artificially placed on the lifetime of any product. Sooner or later the specter of component obsolescence will raise its head, as one or more important parts become, simply, unavailable.

"WHILE IT IS INTERESTING TO CONSIDER THE REASONS BEHIND A PART BECOMING OBSOLETE, TO THE ENGINEER, STRATEGIES TO COPE WITH THE INEVITABLE ARE MORE RELEVANT"

The reasons behind a component going obsolete are too many and varied to be covered in detail here (philosophically, it's actually a very wide issue: circumstances conspire to make entire technologies obsolete, while others persist unchanged for centuries), but identifying a few of the more common reasons can make insuring a design against them easier:

- Manufacturer driven obsolescence: Usually this will occur when a part is no longer selling in sufficient numbers to make it economically viable to produce anymore (unfortunately, some makers have made entirely abstract management decisions and withdrawn highly popular parts while 'rationalizing' their product catalogue). This example can be driven by changes in the market that most of the parts are sold into.
- Technology driven obsolescence: When newer techniques overtake an older part (such as the extreme examples of migrations from valve to transistor, or from germanium to silicon) then makers will chase the newer technologies. A less extreme (but still damaging) example is the constant down-scaling of integrated circuit line-widths, with associated increases in chip density. Earlier generation parts can become very hard to find, as production lines shift to the new geometry.
- Materials obsolescence: The raw materials used in the fabrication of a component become either unavailable (or prohibitively costly, as may yet occur with tantalum) or illegal (restrictions on the use of lead, among other materials, has led to the withdrawal of some components, where the manufacturer has not been able, or inclined, to execute a redesign).
- Financial obsolescence: Where the sole supplier of a part has ceased trading (usually bankruptcy, very occasionally natural or political disaster).

While it is interesting to consider the reasons behind a part becoming obsolete, to the engineer, strategies to cope with the inevitable are more relevant.

The phrase 'design for obsolescence' gets occasionally bandied about (usually when managers are blaming their designers for a third party withdrawing a favorite part) but realistically there are certain processes that we can use.

At the design stage a certain amount of care can prevent future trouble (although it must be remembered that a design must still compete. The most carefully 'proofed' product is still useless if it is under-featured or over-priced):

- Keep multiple sourcing in mind. Where possible (and, I know, it frequently isn't, especially where RF designs are considered), use components that are available from multiple manufacturers.
- Design with generous specification margins. In the event of a particular part vanishing, this can make designing in a new part much easier. Sometimes it is possible to design around several similar, but not identical, parts.
- Choose common package types and apparent 'industry standard' pin-outs. Avoid attractive parts in unusual packages, as the job of replacing them in the future will be much harder.
- Avoid manufacturers with a bad track record of design support. Without naming names, a few years of experience and discussions with other engineers will quickly bring up a short list of suppliers

with an apparent fondness for withdrawing parts, apparently at random.

Once in production the job is not over. During a product's production lifetime there are useful measures that can be taken. These can offset problems before a 'production stop' happens:

- Assign resources (in purchasing and in engineering) to actively and aggressively look for alternatives and equivalents to especially strategic parts in the design. (This is a good task for junior engineers, as it provides time to gain familiarity with existing successful designs and techniques).
- Be prepared to execute mid-life (minor) re-designs to remove particularly dated or hard to source parts. Plan this from the beginning of the project. These production iterations are also valuable to introduce cost reductions, improvements and to iron out problems discovered in bulk production.
- Watch the electronic markets and feed the information back into purchasing in good time, to allow them to re-source parts, or increase stock levels.

Finally, when a vital part does become obsolete, it need not (necessarily) mean the end of your product:

- Make use of manufacturer's announcements and 'final buy' notices to lay in stock of important parts. This gives valuable breathing space. Sometimes distributor stocks of older parts can last for years.
- Identify and test near-equivalent parts. Sometimes only minor (component value) changes will be necessary to use a new part in your circuit.
- Look for other suppliers stepping in with equivalents, alternatives or copies: There are companies whose only business is the manufacture of parts made obsolete by major suppliers. They acquire the rights to the design and keep the older processes running. This is especially useful in tightly regulated safety or military markets, where a substitution or redesign might be prohibited.
- As a last resort, consider a complete re-design, using new(er) parts to produce a compatible device.

Remember: in most cases obsolescence occurs through a human decision, not a change in the laws of the world. If you have a market for a product, there is no reason to let someone else's choice deprive you of it.

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

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PLACING CARRIER GRADE BASE PLATFORMS AT TOP OF THE AGENDA

Figure 1: The term 'carrier grade' covers a broad spectrum of characteristics, including high service availability

Magnus Buhrgard, Technical Co-Chair at Scope, and Tero Mustala, Marketing Co-Chair at Scope, disclose in details behind why the Scope Alliance was set up, its aims and achievements to date

THE COMMUNICATIONS landscape is always changing and, with evermore sophisticated applications/services being brought to market, service providers now have to make every effort to stand out from the rest of the telecoms crowd. In this day and age, a week doesn't pass without new offerings being launched and, to compete effectively, each service provider will have to guarantee that the right network foundations are in place to support new services and ensure what they offer is different but also meets market demand.

With this in mind, Network Equipment Providers (NEPs) have to provide network components that meet changing market requirements and allow the network to develop. Without this continued evolution, the network will not only become strained and obsolete, but the quality offered by service providers will be jeopardized. This highly competitive industry cannot afford to provide substandard services as this leads to customer dissatisfaction and, eventually, churn. Therefore, service providers need to stay ahead of the game by taking advantage of the current network ecosystem and having a good foundation to underpin their network to start with.

Having a network in place that is up and running almost 100% of the time and throughout any kind of circumstance is, therefore, essential. Over time there have been strict requirements for components within traditional network architectures which NEPs have to satisfy. This is to ensure high availability of voice services for end users and means that all solutions have to be carrier grade and provide a level of service availability that meets the telecommunications/networking carrier standards. The term 'carrier grade' covers a broad spectrum of characteristics including the following:

- High service availability: In the telecoms industry any network carrying voice has to have from 5 to 7 nines (99.999% – 99.99999%) of availability, depending on the application. This ranges from a few minutes to a few seconds of average planned and unplanned downtime per year. High service availability means that service providers have to guarantee their service availability in order to meet regulatory and end user requirements. Without this, they can guarantee their business will fail.
- High performance: The infrastructure needs to scale with the amount of hardware incorporated within it and support a large number of transactions and simultaneous sessions.
- Serviceability: Because of the non-stop nature of service provider environments, NEPs typically have constrained options for field support on the applications they provide. This functionality must also be available 24/7 and over a network to make off-site maintenance work possible. This places high demands on NEPs to ensure they can service their network components.
- Long life-time: All hardware and software must have a controlled and extended life cycle. The lifespan of products can range from five to more than ten years.
- Security: Standard host-based security

provisions including accounting and encryption are essential and so are capabilities such as secure boot, binary verification and access rights management. In addition, security should be configurable.

It is therefore important the carrier grade network components provide the foundations for the overall network and ensure that operators are able to concentrate their efforts on ever more sophisticated services and applications. However, the evolution of services will undoubtedly influence the way that individual network elements are being built, affecting the architecture and component ecosystem used in constructing network elements. The most prevalent trends in network architecture evolution today include:

- Backbone networks are collapsing and migrating from traditional circuit-based networks to IP-based networks.
- Convergence of mobile and fixed networks and the evolution away from circuit switched voice networks to VoIP.
- Convergence of IP/cable/fibre and phone/video networks.
- Carrier grade (metropolitan) Ethernet.
- Server/gateway separation and resource pooling.
- A shift from hierarchical networks to decentralization of control/intelligence (so-called 'flattened' architectures).

With relevant technologies evolving so quickly, there is always a degree of specialization needed to develop these components and it is virtually impossible for any single supplier to have all aspects in their product portfolio, let alone be best in class across all aspects of the Carrier-Grade Base Platform (CGBP). Thus, it is necessary to ensure that scalable and cost-effective network element implementations can be constructed with the ability to leverage a rich diversity of suppliers without requiring prohibitively high integration investments.

By using a CGBP based on open specifications such as 'Commercial-Off-The-Shelf' (COTS) hardware/software and Free/Open Source Software (FOSS) components, NEPs can avoid locking in to a proprietary solution or a single source supplier and enables the development of a vibrant supply chain for the operators. This provides operators with this underlying network foundation and allows them to free up the resources they need to roll-out new services. This also means NEPs can concentrate their efforts on the foundation components, developing CGBPs quickly and easily.

Working like this not only benefits the entire telecoms ecosystem but ensures that products,

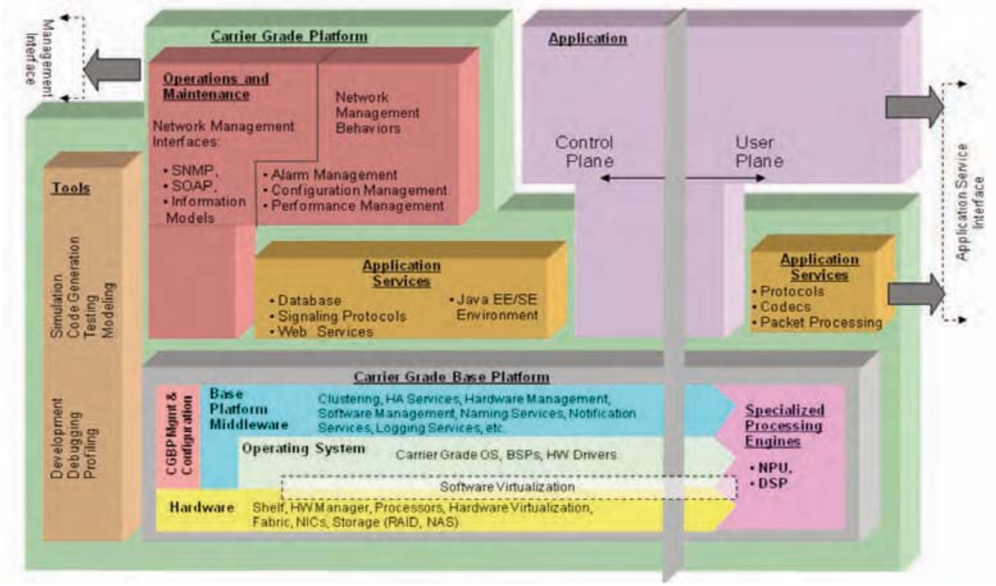

Figure 2: *Scope Alliance carrier grade platform reference architecture*

services and applications are brought to market faster. Much like a racing car driver who shouldn't have to care about the specific details of the car he is driving, but is safe in the knowledge that his team have provided him with the best possible vehicle, operators shouldn't have to worry about the foundation of their network. This system ensures that NEPs take on this responsibility of the network and can develop the best infrastructure from a vibrant ecosystem of suppliers who build products to specific standards and specifications.

Scope's Aims

Taking all this into account, the Scope Alliance was launched in January 2006 to actively support this process by encouraging and promoting the industry that produces the components that contribute to CGBPs. The aim of the Alliance is to enable a rich ecosystem of COTS hardware/software and FOSS building blocks best suited for CGBPs to help advance the telecoms ecosystem and the infrastructure it is based on.

"WITHOUT THIS CONTINUED EVOLUTION, THE NETWORK WILL NOT ONLY BECOME STRAINED AND OBSOLETE, BUT THE QUALITY OFFERED BY SERVICE PROVIDERS WILL BE JEOPARDIZED"

In its role, the Scope Alliance has committed to identifying, prioritising and making public lists of suggested open standards, specifications and associated contents that best enable NEPs to deliver solutions that fit their customers' requirements. Well-defined profiles will encourage the broadest possible ecosystem of suppliers from which to choose CGBP hardware and software – characterized by multiple vendors, full interchangeability, compatibility of components and application portability.

To date, the Scope Alliance has published profiles on PCI Industrial Computer Manufacturers Group (PICMG), ATCA, μTCA and AdvancedMC hardware, multiple profiles on the Linux Foundation's Carrier-Grade Linux specifications and profiles on Carrier-Grade Base Platform Middleware based on SA Forum Specifications.

In addition to profiles, the Scope Alliance also identifies gaps in existing specifications and/or implementations and publishes prioritized gap analysis descriptions to explain these gaps. So far, gap analysis descriptions have been published on ATCA hardware, Carrier-Grade Linux operating system and Carrier-Grade Base Platform Middleware.

The Scope Alliance strives to clarify definitions associated with carrier-grade engineering practices and to normalize methods used in qualifying and specifying COTS and FOSS components according to carrier-grade standards. To this end, the Scope Alliance has

> "DEVELOPERS OF SUCH APPLICATIONS NOW LOOK TO THE OPEN ECOSYSTEM FOR THEIR BASE TECHNOLOGY PLATFORMS, RATHER THAN BEGIN NEW INTERNAL PROPRIETARY PROJECTS"

published services and support profiles defining NEP standards for service availability, long life-cycle support and environmental conditions for central offices and network data centers.

The Scope Alliance works closely with all of the organizations mentioned above to help to speed the applicability of open standards and achieve a greater number of real world network components. Developers of such applications now look to the open ecosystem for their base technology platforms, rather than begin new internal proprietary projects; and the benefits are already being reaped.

This is an accelerating trend, and the technology and business model of open standards-based platforms will continue to evolve and succeed. As NEPs endeavor to engineer telecommunication systems by drawing upon the COTS ecosystem, they must have a way to define and verify the components that they leverage from this environment. The Scope Alliance, as well as other organizations such as the Computer Platforms Trade Association (CPTA), provides benchmarks to allow them do this and ensure that their products are meeting normalized building methods and are interoperable.

When launched, Scope's first accomplishment was defining its CGBP reference architecture, which is now well recognized within the industry. This architecture gives guidelines on how such platforms should be built using open specifications based on COTS/FOSS components. The diagram below show how the architecture should look from Scope's perspective.

The Carrier Grade Platform architecture is comprised of the following hardware and software components:

- Operations and Maintenance
- Tools (development, deployment and remote debugging or tracing)
- Application Services
- Carrier Grade Base Platform (of which Specialized Processing Engines are a part).

The focus areas of the Scope Alliance to date have been the Carrier Grade Base Platform and related tools. Specifically, these include Hardware, Operating System, Software Virtualization, Base Platform Middleware, Carrier Grade Base Platform Management and Configuration and low-level development, debugging and profiling tools. The reference architecture is purely a logical representation.

Hardware

An important part of Scope Alliance's work has been to describe the hardware profiles of these specifications and push for compatible modules. Several profiles for ATCA, µTCA and AMC's have been published by the Scope Alliance. The purpose of these documents is to provide guidelines to standardization bodies, vendors and end users who want to migrate from proprietary solutions to PICMG's open standard based platforms. These include hardware vendors; manufacturers of subcomponents, module and shelf building blocks and also base platform integrators; network equipment providers; telecommunications network operators; and standardization bodies and related trade associations among others.

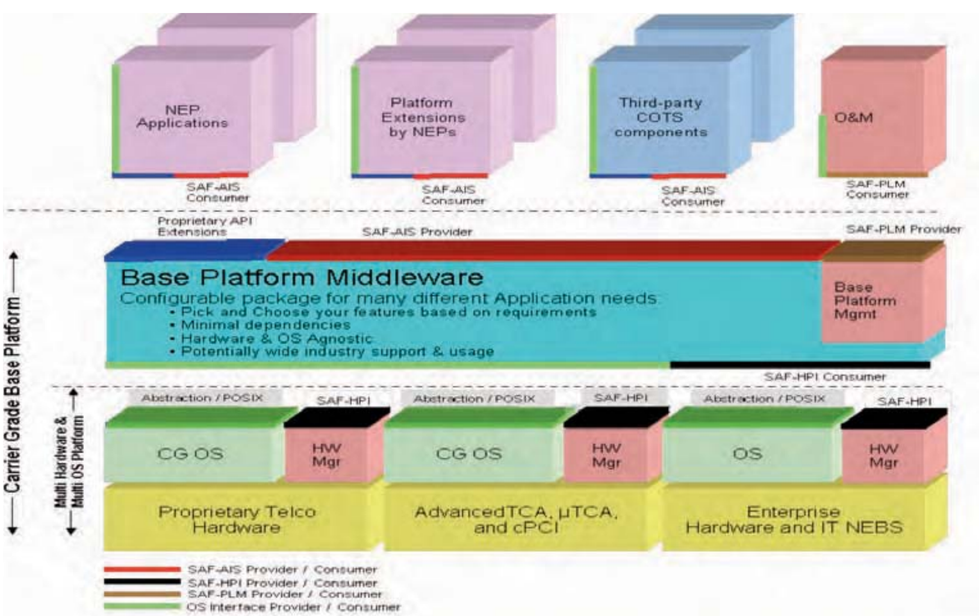

Figure 3: *Carrier grade base platform middleware consists of several functional areas on top of the operating system*

The Operating System

Within the operating system environment, the Scope Alliance has always focused its efforts on the carrier grade aspects of Linux (one of the most prominent examples of free software and open source development). In particular, the Scope Alliance has developed profiles around the results of the Linux Foundation (LF) Carrier Grade Linux (CGL) workgroup. The CGL project is dedicated to improving Linux so that it fits better with the telecommunications industry. To date, the Scope Alliance has published three profiles of CGL specifications and the Carrier Grade Operating Systems Gap Analysis. These documents are aimed at standardization bodies, Linux distribution providers, as well as other specification bodies, SIGs and related trade associations, board and module vendors.

Although Linux has been the focus, other operating system variants such as proprietary Real-Time Operating Systems can also satisfy the published profiles. For example, POSIX (Portable Operating System Interface) support and hardware support are not specific to Linux but are desirable on many OS alternatives. Since NEPs will undoubtedly continue to be heavy users of non-Linux solutions, the Scope Alliance will ensure that profiles are generally applicable for most operating systems.

Middleware

Carrier Grade Base Platform Middleware consists of several functional areas on top of the Operating System. These areas serve to complete the functionality of the CGBP, which goes beyond the capabilities of the Operating System and can be outlined in the **Figure 2**.

CGBP middleware includes areas such as High Availability (HA) Services, Hardware Management, Software Management (including software lifecycle management and live software upgrade) and Basic Security. Having open specifications for these is essential to make the CGBP a standalone entity which can be handled separately in the architecture as a concept and as a product as well. The initial focus of the Scope Alliance in the CGBP middleware space is in HA Services and closely related functionality.

Applications and their architecture contribute to the overall system availability with the help of HA middleware services. High availability services in the platform will help in achieving availability targets of service providers.

The main Scope Alliance activities for HA Services are based upon the SA Forum specifications Application Interface Specification (AIS) and Hardware Platform Interface (HPI). First level profile of the AIS services and a gap analysis have already been published.

In addition, today NEP applications are increasingly written in Java to leverage the promised shorter development times by the language, tools and wide support functionality. This development has started in the service and content centric parts of the network but there is no inherent reason for it to be limited to this area only. Java usage has been focused on using the J2EE environment. Scope has developed a white paper outlining current gaps and how they should be bridged through joint effort of SAF and the JCP (Java Community Process).

In addition to the profiles and gap analysis Scope has created for the hardware, middleware and operating system elements of the CGBP, it has also developed profiles on service and support, suggesting standard terminology and methods that NEPs may converge around portions of the engineering process and the requirements of components for service availability and long lifecycles of products.

Environmental

Network equipment is subject to strict environmental requirements, which include physical construction practices, climatic conditions, acoustics, safety, vibration and earthquake power, EMC (electromagnetic compatibility), quality, reliability and availability, and ecological compatibility. In today's networking environment the trends in network design are continually changing to accommodate the increase in bandwidth required to deliver data-rich services. This has meant that service providers now have to deploy high performance network elements in different locations across their infrastructure to support these services.

While these high performance network elements are needed to allow the network to evolve, they are all pushing the environmental limits of service providers' facilities, which are loosely environmentally controlled and which have been designed to handle only moderate equipment heat loads.

To address these issues, the Scope environmental specification defines the Network Data Center environment (area for data servers), along with the traditional Central Office environment (area for classic telecom equipment such as switches) to cover the more tightly controlled environments applicable in such locations, as well as other key differences. It is intended to supplement the already published hardware work items, and is agnostic to specific equipment specifications, like AdvancedTCA or µTCA.

***Figure 4:** The on-going evolution of the telecoms industry means that players are constantly faced with developing carrier grade solutions*

Virtualization

Virtualization is an emerging technology enabling significant improvements in building network components, such as porting legacy software on new platforms technology, optimizing hardware resource usage and using multi-core processors. However, there is not enough standardization effort in this area and Scope aims at identifying the gaps and encourages appropriate activities.

Today, the importance, prevalence and visibility of virtualization have increased, due in large to technology evolution and significant reductions in virtualization performance overhead. One main reason for this is that CPU (central processing unit) manufacturers have started to include virtualization support into multi-core chips.

Virtualization enables a multitude of interesting technology solutions that previously had not been resource effective to implement. When deploying solutions with embedded virtualization, there are some areas of particular sensitivity in the NEP space:

- Quality of Service (QoS)
- Cache management
- Security
- Power Management.

In support of the use of virtualization technology by its members, the Scope Alliance has authored three virtualization documents which aim to provide clarity and direction to virtualization suppliers for the role this technology plays within CGBPs.

The ongoing evolution of the telecoms industry means that players in this space are constantly faced with the hurdle of developing carrier grade solutions that have longevity and interoperate with other elements of the network infrastructure. With organizations such as Scope making recommendations on how COTS and FOSS standards and specifications should be developed, organizations and solution providers can ensure their own standards, specifications and products are designed to meet these recommendations fitting with industry requirements, ultimately evolving the entire telecoms market. ■

Rob Kratsas, Product Marketing Manager in the Cirrus Logic Mixed-Signal Audio Division, ventures into the understanding of why the Class AB amplifier has become the preferred standard in portable headphone amplifier designs and examines the latest portable amplifier architectures

Optimizing Design Trade-offs to Meet the Needs of Today's PORTABLE AUDIO AMPLIFIERS

ENGINEERING is usually an exercise in trade-offs. This fact holds true in the world of portable audio, where the goals of increasing audio performance and decreasing system power consumption are frequently at odds. Specifically, when it comes to the headphone amplifiers used in media players and mobile handsets, performance variables such as lowering distortion introduced by the amplifier and improving the frequency response (linearity) of the amplifier are indirectly related to the efficiency of the amplifier itself. This article is a study of the incremental decisions that engineers have made in recent years in portable amplifier design to optimize performance, while simultaneously trying to lower power consumption.

This article will venture into the understanding of why the Class AB amplifier has become the de facto standard in portable headphone amplifier designs over more efficient Class D amplifiers. Then it will examine the recent additions to portable amplifier architectures that have increased performance and efficiency simultaneously. Specifically, it will focus on the trade-offs of a ground centered amplifier architecture, the addition of features such as an analogue volume control to help lower the overall system noise floor at the expense of silicon die area, and the advantages of using a Class H controller to increase the efficiency of a standard Class AB amplifier.

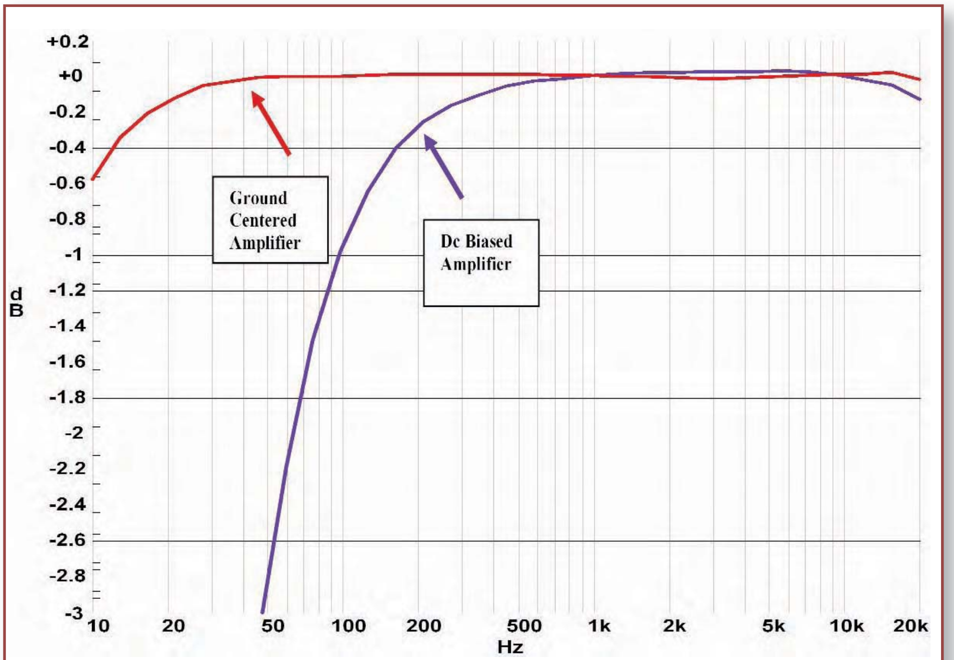

Figure 1: Performance advantages of a ground-centered architecture over its predecessor

Class AB vs Class D

On the surface, the efficiency of a Class D amplifier at 90% plus is quite alluring, especially for portable products in which saving every possible milliwatt of power consumption to extend battery life is considered the highest priority. Unfortunately, there is a very big trade-off to be had with this almost perfect efficiency number that Class D offers. The inherent strength of this type of amplifier, using high speed switching of the transistors to achieve 90% efficiency, is also its Achilles heel. While switching at thousands or even millions of times a second to increase efficiency, the amplifier is degrading its performance by adding a considerable amount of noise and distortion into the amplified signal. A switching amplifier has higher "dead-band" time when it is not supplying a voltage to the load or speaker.

Dead-band time is defined as the "off" time that a switching amplifier is not supplying voltage to the load or speaker in order to prevent shorting the power supply through the output devices. This time-off is at the root of why these amplifiers are considered non-linear.

This "dead-band" time contributes to a considerable distortion increase and makes the Class D amplifier considerably less linear than the Class AB amplifier. A Class AB amplifier virtually eliminates "dead-band" time with its architecture, by using N and P channel high-voltage transistors that can supply the load simultaneously, or independently, but almost always constantly. This architecture virtually eliminates cross-over distortion, or distortion that is caused at the moment when there's no load. Of course, a Class AB amplifier can only theoretically achieve a maximum of 78% efficiency when operating just below the power supply rail, or just before the clipping region. Since operating in the region is unrealistic, the normal operating efficiency of a Class AB amplifier is much less, at about 20 or 30%.

If Class D is so efficient, then why is it not taking over every possible portable headphone amplifier opportunity? Besides the increased noise and distortion, which incidentally is audible in a headphone application, electromagnetic interference (EMI) is also a credible threat to overall performance. Interestingly enough, EMI becomes more of a factor as switching frequencies increase.

In a Class D amplifier, to increase efficiency you have to increase the frequency that you turn on and off your transistors in the amplifier. This switching frequency increase of the amplifier is a threat, not only to the performance of the amplifier itself but also to other system components and can create a situation that requires cost prohibitive shielding to be added.

According to **Equation 1**, increased switching frequency also increases your electromagnetic interference to the system. This increased interference potential is further compounded by the fact that the output of the amplifier is connected to a headphone wire that acts as antenna for EMI.

E = 12.6 x 10-7
(Freq * Common Mode Current * Antenna Length) /Antenna R **(1)**
(This equation assumes the orientation of emission to be maximized at 90º)

Or **EMI = Freq**

To attenuate or even eliminate the threat of EMI to a portable system, it is necessary to add filters to the output of the amplifier, which will increase system costs. When considering that the threat of EMI could hinder the functionality of products such as mobile phones and that an audible difference can be heard between a Class D amplifier and a Class AB amplifier, it is no wonder that Class AB amplifiers still dominate the headphone amplifier space.

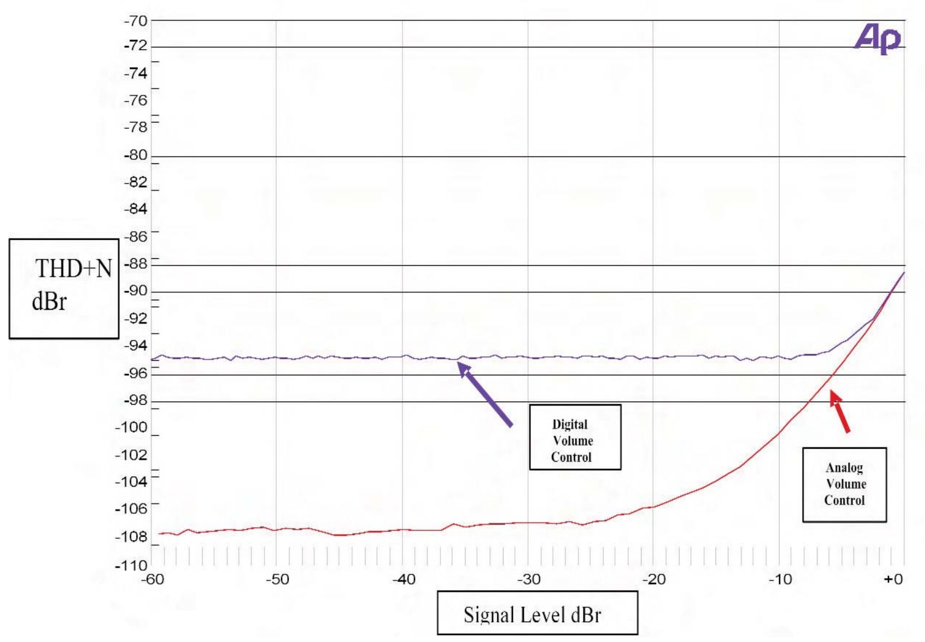

Figure 2: *Noise floor – advantages of analogue volume control*

Ground Centered Architecture

There are very few moments in engineering that are watershed events, forever changing the course of things to come. Instead, most events are smaller incremental changes that improve the performance, size, or cost of the previous generation of ideas.

Amplifier design is no different. First generation Class AB amplifiers typically had access to only commonly available low noise, positive power supply rails. In a portable system, the positive power supply rails can range from 0.9V up to 5V for SOCs, DSP or audio CODECs. This availability of only positive rails did not allow the output of the amplifier to be ground centered and required the addition of DC blocking capacitors to the output of the amplifier. These DC blocking caps, while solving the problem of biasing within an amplifier, unfortunately hindered the frequency response of that amplifier.

The frequency response of an amplifier is defined as its ability to accurately reproduce at its output the signals which appear at its input. To eliminate or significantly reduce the DC bias of a headphone amplifier, a DC voltage blocking cap is placed downstream of the output of the amplifier, prior to the headphone load. These DC blocking caps, while eliminating the bias voltage from the amplifier, also can act as a high pass filter, effectively blocking low frequency "bass" tones in the sub-500Hz range. This effect hinders the ability of the amplifier's frequency response in the sub-500Hz range.

To authentically reproduce the input signal to the amplifier, it was necessary to eliminate the DC blocking caps downstream of the amplifier. It should be mentioned that DC blocking capacitors also add unwanted audible pops and clicks when charging the capacitor up during start-up and discharging during shut-down.

The best way to authentically reproduce the amplified signal and eliminate unwanted artifacts is to make the output of the amplifier ground-centered. Since most systems do not have a positive and negative high-quality power supply rail, it was necessary for amplifier designers to create their own rails internally. To do this, a charge pump was added to the amplifier designs. While this addition did increase die area to integrate the

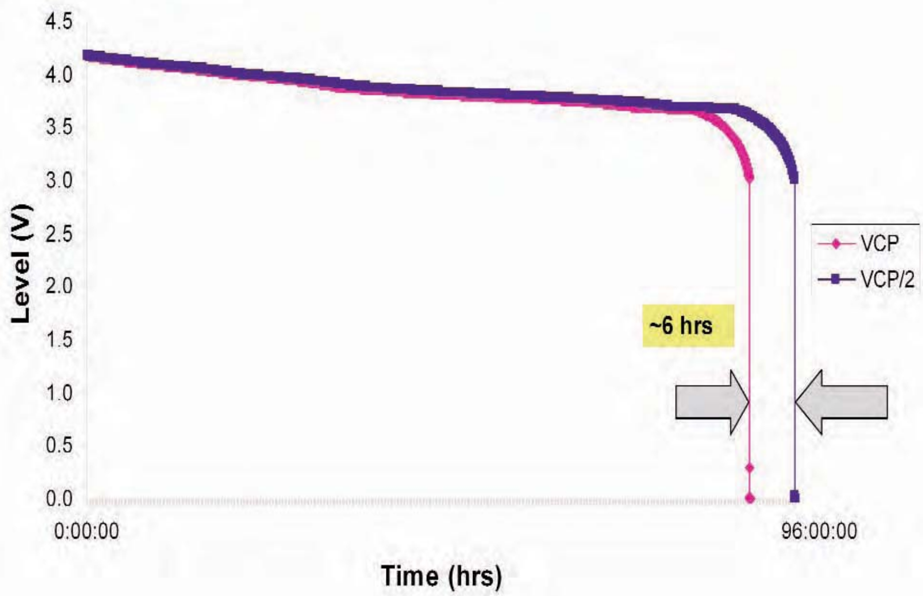

***Figure 3:** Battery life plots of standard Li-Ion battery when using a Class H controller*

charge pump, it was more than offset by the board area savings when eliminating DC blocking capacitors.

A graphical representation of the performance advantages of a ground-centered architecture has over its predecessor can be seen in **Figure 1**. The ground-centered amplifier (in red) clearly does not attenuate the signal as much as a DC-biased amplifier (in blue) at the lower frequencies.

Several other advantages can be realized with this architecture over DC-biased designs, such as decreased implementation area and elimination of unwanted audio artifacts. For a more detailed study of the advantages of ground centered amplifier architectures, please review the Cirrus Logic Applications Note AN293: "*Optimizing Portable System Designs, Part 1 – The GND-Centered Amplifier*" (**www.cirrus.com**).

Incrementally Improving the Performance of a Portable System

An understanding of the playback signal chain path is necessary when comparing the performance of a digital volume control (DVC) versus that of an analogue volume control (AVC). Digital volume control attenuates the signal upstream of the DAC by shifting bits. For instance, shifting a 16-bit word one bit to the right attenuates the volume 6dB. This process effectively makes the signal now 15 bits.

Theoretically, a 16-bit signal can obtain 98dB of dynamic range, while a 15-bit obtains 92dB of dynamic range and a 14-bit 86dB of dynamic range. This is a very accurate and exacting way of attenuating the volume of a signal. However, because this process is achieved upstream of the DAC, we are not attenuating any noise introduced into the system by the DAC or amplifier. An analogue volume control attenuates the analogue signal downstream of the DAC, in the amplifier. The advantage of this architecture is that the analogue volume control preserves the dynamic range of the system. This preservation of the dynamic range is accomplished by simultaneously attenuating the noise floor by equal amounts as the signal itself. The trade-off to this technology is that analogue volume control has a higher cost in silicon area over digital volume control and it is somewhat less accurate.

As can be seen in **Figure 2**, which plots THD+N versus signal level output from the amplifier, the noise floor of the system with analogue volume control (red line) is much less then that of the one using digital volume control (blue line) to attenuate the signal. The 16-bit signals are on equal ground when at the full amplifier output level. But once the volume of the signal starts to decrease, the non-attenuated noise floor and distortion components of the system using digital volume control become more pronounced.

As the system approaches the volume minimum of -60dB from full scale, the AVC system has a 13dB performance increase over the DVC. In this example it is possible that the user, if using a decent set of headphones, could actually hear an audible hiss of the noise floor of the DVC system from the DAC when not playing back music.

Note: dBr – THD+N measurement taken relative to the full scale output voltage level at 0dB.

DVC can be useful when trying to minimize area at the expense of performance. Digital volume control also adds more granularity and accuracy to the volume control, but as stated earlier, attenuates the signal without attenuating the noise.

Efficiency – Addition of the Class H Controller

In keeping with the theme of this article, small feature additions to the amplifier should result in incremental performance or efficiency gains over time. With that in mind, a recent advance in portable amplifier technology has allowed a further increase in efficiency over standard Class AB amplifiers. As stated, a realistic efficiency expectation for a Class AB amplifier is around 20 to 30%. If a Class AB amplifier can operate in a region just below the power supply rail, the amplifier can get closer to its theoretical efficiency region of 78%.

The best way to achieve this amplifier operation is to adjust the power supply rails that feed the amplifier to track just above the amplified signal output from the amplifier. In this way, the Class AB amplifier can now increase efficiency while still maintaining the usual performance advantages associated with its architecture.

As mentioned previously, to best replicate the input signal, a Class AB amplifier should be ground centered. To create a ground-centered output, the amplifier must create a charge-pump-generated negative supply rail. Thus, in order to make the amplifier as efficient as possible, it is necessary to adjust both the positive and negative power supplies to operate just above the signal. To make this adjustment, a Class H controller had to be overlaid onto the amplifier, with a feed forward mechanism to adjust the rails to the appropriate level just before the incoming signal adjusts. This configuration can increase the efficiency of a Class AB amplifier to about 45% under normal operating conditions. Under these types of conditions, the normal operating efficiency of a standard Class AB headphone amplifier can be doubled.

This efficiency increase can have a dramatic effect on the battery life of a portable product. A recent test running a state of the art portable audio CODEC in playback mode that has an integrated Class AB headphone amplifier with an overlaid Class H controller can add as much as 6% back to playback time when connected to a Li-Ion battery. **Figure 3** shows the battery life plots of the portable audio CODEC running a Class H controller seen in pink and with that same Class H controller turned off and running in standard class AB mode seen in blue.

Interestingly enough, another advantage, besides extending the battery life of this configuration, is that a charge pump driven Class AB amplifier with an integrated Class H controller should theoretically reduce EMI over a standard ground-centered Class AB amplifier. EMI is also directly related to the square of the voltage. Therefore, by lowering the amplitude of the voltage in the charge pump, all other things being equal, you should also lower your electromagnetic interference.

For a more thorough understanding of Class H controllers and their contribution to portable amplifier technology, please refer to the Cirrus Logic Application Note AN294: "*Optimizing Portable System Designs, Part 2 – The Class H GND-Centered Amplifier and Battery Life*".

Tackling the Challenges at Hand

Engineering is always an exercise in pragmatism. There is hardly ever a moment where a clear and easy path is obvious. Instead, usually several good options are presented and the decision as to what is the best solution for the application has to be made.

In the portable headphone amplifier case, performance and efficiency are at odds. Class D efficiency is far superior to Class AB efficiency, but Class AB amplifiers have the advantage of lower distortion and better EMI performance. Since headphone amplifiers can provide the listener considerable dynamic range with very little amplification overhead, authentic audio reproduction is actually more important than the efficiency of the amplifier.

The other unique component about portable players is their headphone wires can act as an antenna which broadcasts unwanted emissions that interfere with other features on a player, such as radios, and even decrease the performance of the DACs or the ADCs on the audio codec. Again, Class AB amplifiers have the edge by not switching at high frequencies and adding noise back into the system as do Class D amplifiers.

Class AB amplifiers are a superior option for portable headphone amplifiers; however their deficiencies do need to be addressed. The additions of a Class H controller to increase efficiency and a charge pump to create a ground-centered output that can help accurately reproduce the amplified signal and help to offset these deficiencies.

In the coming years, it will be interesting to see what engineers can add to the amplifier to further increase efficiency without decreasing performance. One thing is for certain, the Class H controller concept is an excellent choice for increasing efficiency. The industry will eventually see changes to the Class H architecture such that the power supply rails adjust to just above and below the output signal to increase efficiency, eventually pushing the Class AB amplifier to its theoretical limits. ■

Tony Armstrong, Director of Product Marketing in Power Products at Linear Technology Corporation, gives ideas of how to implement the "Green Policy" to portable systems powered by batteries

Green Opportunities in PORTABLE Products

SEVERAL CHANGES in the power electronics industry are converging to create a growing problem. The complexity and performance requirements of power systems continue to increase and time-to-market pressures intensify. But at the same time, the number of competent power system designers in the industry is diminishing.

During the last couple of decades, universities have churned out graduates skilled in digital design, but very few of these graduates are capable of complex analogue design. These factors combine to produce an "experience gap" in power electronics. Because of this gap, many systems will go to market late and with poorly designed power systems.

Designing for Portable Power

Designers of today's portable electronic products are faced with unprecedented challenges. Among these are the demands for high performance power management systems to accommodate growing system complexity and varying power budgets. These systems strive for an optimum balance among competing objectives including long battery runtime, compatibility with multiple power sources, high power density, small size and effective thermal management.

While new lithium-based battery technologies promise incremental gains in energy density, these gains are now being offset by increased safety concerns which are driving charging strategies that include lower charge (float) voltages, thermal regulation and temperature qualified charging. New battery chemistries will enable longer runtimes, but their voltage discharge profiles are extended, with significant energy available at battery voltages below 3V. This characteristic will influence the related power conversion system, making synchronous buck-boost regulators necessary to generate outputs as low as 3V.

The demand for higher power solutions is largely driven by the increased computational power required in today's advanced handheld products. At the same time, the number of power supply rails continues to grow. This trend increasingly dictates the use of multi-output switching regulator solutions to meet size and efficiency goals and to keep thermals in check. Further, DC/DC converters with high efficiency over a wide range of load current and low standby (quiescent) current are a must to manage battery runtimes.

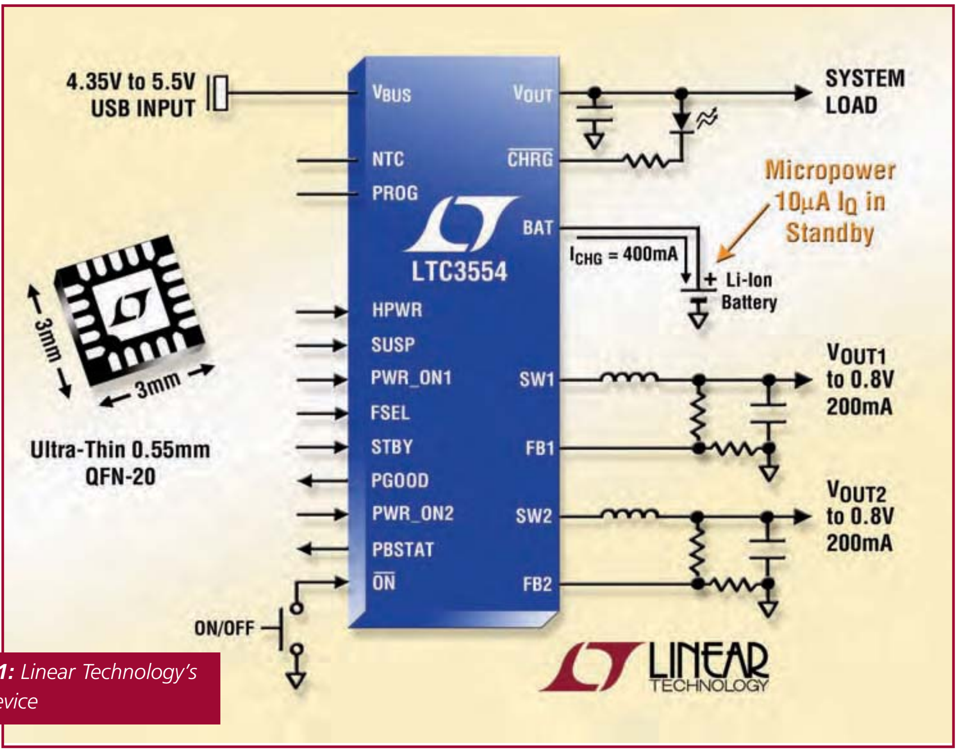

Figure 1: *Linear Technology's 3554 device*

Linear Technology has an extensive portfolio of PMICs

On the other end of the spectrum, there are still a wide variety of mobile handheld devices which are powered from either two AA or two AAA cell form-factor batteries (in NiMH, Alkaline or new Lithium-cylindrical chemistries), non-rechargeable and rechargeable, for convenience, availability and cost reasons. However, managing the flow of power into a handheld device is also a complex task because of the presence of multiple power sources, multiple supply voltages within the product, demands for optimum efficiency and very limited space. It has been common for these factors to drive the development of highly integrated power management ICs (PMICs) for battery-powered applications such as PNDs, DSCs, ultra-mobile PCs, MP3/MP4 players, ultra-small video recorders and portable medical devices.

One of the biggest obstacles when using a handheld device powered by either 2 AA or AAA cells and a 5V AC adapter or a 5V USB port, is being able to deliver both a fixed 3V or 3.3V output for the main power rail and a 1.xV output to power a microprocessor or DSP core voltage. When the device is powered from either a 5V wall adapter or a 5V USB port, then only a step-down (buck) DC/DC converter is needed. However, when the device is battery-powered, a buck-boost DC/DC converter is usually required to deliver the 3V or 3.3V for the main power rail, whereas a step-down DC/DC converter is needed to supply the 1.xV for the large-scale digital processor core voltage. This is due to the fact that the discharge profile of 2 AA cells (nickel or alkaline) is 3.2V down to 1.8V; however, this range has shifted approximately 0.4V higher with "new" Lithium cylindrical AA and AAA cells, thereby requiring a buck-boost to more efficiently regulate either a 3.0V or 3.3V rail across the entire battery discharge range. Additionally, a second buck channel is usually needed to power memory at a nominal 1.8V.

Green Power Is Needed in Portables, Too

The popularization of the concept of "Green Environment Protection" was in the news a great deal during the course of last year and we will continue to see more in 2009. As a result, many suppliers or power management and conversion ICs have made a lot of progress in improving power efficiency across a wide load range.

Furthermore, it is generally accepted that most industrialized nations recognize the need to conserve energy, regardless of whether the product is plugged into a wall socket or operated by battery power. This is due to the fact that as a nation's population increases, so does the demand for energy to power new homes with heating/cooling systems, lighting and electrical appliances. It costs a great deal of money not only to build new power-generating facilities, but also to deliver this power to the users once it is generated. It has been observed that it is more cost-effective to cut the current energy consumption of most electrical appliances by 15% to 20% than it is to build new power facilities.

For portable products powered by batteries, a similar concept also applies; however, in the case of multiple AA or AAA form-factor batteries, it is the disposal aspects of these batteries, with their hazardous chemical content, that has a negative impact on our environment. Clearly, anything that can be done to extend their useful life within an end product will minimize the frequency of replacement and thereby reduce the level of harmful contaminants needing to be recycled.

As a result of the high costs associated with the building of either new power-generating facilities or hazardous chemical recycling facilities, many countries have adopted a "Green Policy", whereby they encourage manufacturers to incorporate energy saving techniques into their end products. Thus, for a power management and conversion ICs to be used in any type of energy-saving device, any DC/DC converters used internally must have two main attributes. Firstly, they must possess very high efficiency of conversion properties across a wide range of load currents. And secondly, they must have very low quiescent current in both standby and shutdown modes. As a result, many types of battery-powered portable products are incorporating power management and conversion products with both of these key attributes.

Challenges

The most challenging issue facing a system designer of portable battery-powered products today is how to best architect his power management system to optimize overall performance and maximize battery run time.

Until recently, designers of portable power systems have had two basic approaches for addressing these challenges. One choice is to architect the system using individual components, each optimized for a single function. This approach yields maximum flexibility in design, layout and thermal management, while achieving the appropriate level of performance for each function. But this choice has the major disadvantage of being relatively costly and taken together; these components require substantial board space to address the growing list of functional requirements.

At the other extreme, designers may choose from a variety of very highly integrated power management ICs (PMICs). These devices typically support a superset of the functionality needed for most applications, including unwieldy combinations of switching DC/DC controllers, monolithic switchers and numerous LDOs along with unrelated mixed signal functions, like touch screen controllers, audio CODECs and more. As a result, they can be cumbersome to use and most require a substantial investment in firmware just to turn them on. These products tend to favour integration over performance and often complicate thermal management by concentrating heat in a single "hot spot" within the product.

Ironically, these highly integrated solutions also require relatively large board area. This is because they are housed in large, high pin-count packages, and because they force board layout heroics in order to accommodate all the related external components (MOSFETs, inductors, diodes and assorted passive components), as well as all the routing needed to get from the PMIC to the various loads across the system.

Green Conversion Products for Portables

Linear Technology's products developed for portable power management applications have many strengths, including high switching frequencies (as high as 8MHz), high efficiency conversion to minimize thermal issues, high efficiencies at light loads also, very low quiescent currents in standby modes (as low as 9μA) and high levels of integration, including integrated MOSFETs and Schottky diodes.

Recently Linear Technology introduced a new family of PMICs that provide a meaningful level of integration, with no performance compromises and without all the complexity that can get in the way. These products offer functions such as USB OTG, automotive-compatible power path control, autonomous battery charging and high efficiency monolithic DC/DC power conversion. Other features include high charge currents, high switching frequencies and independent I/O or I2C control.

The family is offered in packages that take just a fraction of the board space of traditional PMICs – from just 9mm^2 to 20mm^2, while requiring few external components and no tantalum capacitors.

Synchronous step-down converters have offered a substantial improvement in battery runtime over traditional linear regulators due to their increased conversion efficiencies. These converters have efficiencies of between 90% and 95% and virtually eliminate the need for any heat sinking. This higher efficiency comes at a cost of extra circuit board space for an additional inductor for each channel, so it is paramount to keep the total solution footprint to a minimum. By combining multiple channels in a synchronous step-down solution, they can all operate from a single input capacitor keeping the solution footprint minimal.

Going 'Green'

It is clear what is expected in terms of power management IC features and functions for an end product utilizing them to be qualified as Energy Star efficient when they are plugged into a wall outlet. However, it is not as clear when the device is a battery-powered handheld product. Nevertheless, some of the more recent power management and conversion product introductions targeted at portable products for a wide variety of battery configurations bring feature and performance benefits that enable the end product to be 'green'. ■

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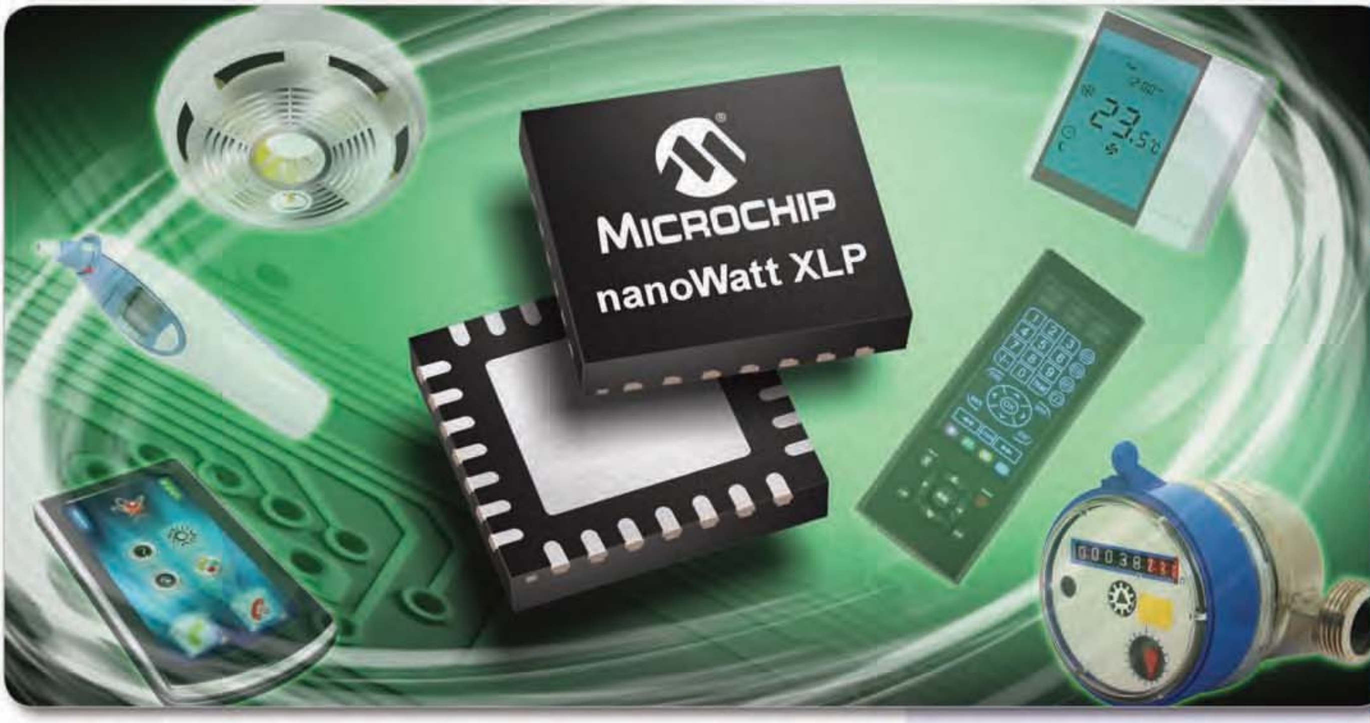

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Camera Phones Zoom-In on FIXED LENSES

DESPITE CONSUMER demand, few camera phones and budget digital-still-cameras provide optical zoom capabilities, instead relying on the more technologically inferior digital zoom. Traditional optical zoom involves either changing the position of lenses on the optical axis of a camera or altering the shape of fixed-position lenses.

While both approaches are perfectly acceptable, they tend to be quite large, slow, power-hungry if motorized, and not particularly robust. Therefore, they are both incompatible with mobile phone cameras, where the current trend is toward a thinner footprint, more durable cases and a longer battery life. But there's a potential solution in the form of a specially designed lens combined with a simple algorithm.

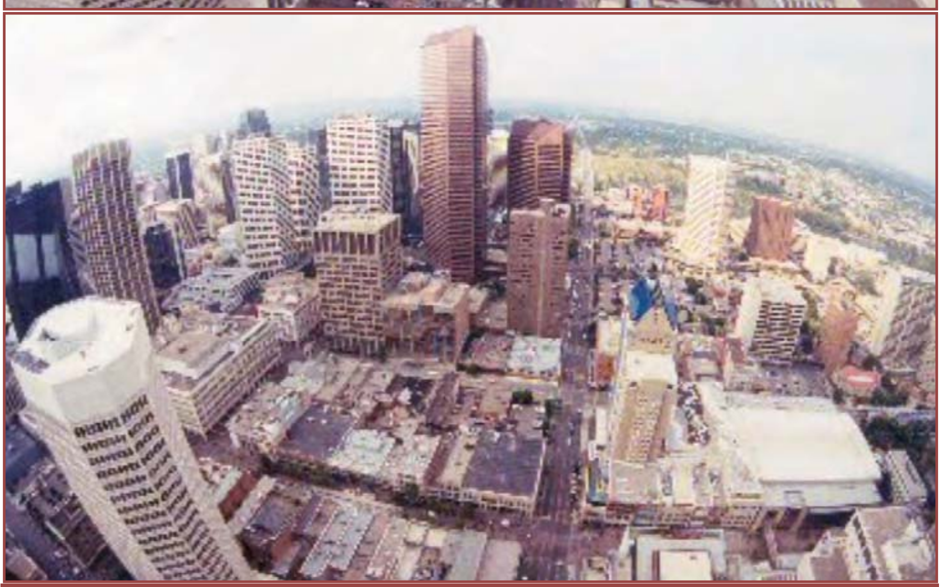

Figure 1: (above): *Image taken with traditional optical zoom capabilities* ***(below)*** *The same image after correction with Tessera's software-enhanced OptiML Zoom technology*

Before looking into this solution however, it's important to understand camera zoom and why it is such a desirable feature. Zoom permits the photographer to get closer to the subject in a much more convenient manner than moving the camera. The traditional use of zoom is to convert a distant body to a face and, for this reason, is sometimes referred to as "portraits of strangers".

Another way of thinking of zoom is as a macro mode for the camera, permitting close-ups of objects, like flowers. For professional photographers zoom makes the process of picture taking more creative, because it permits the scene to be composed, the perspective changed and selection of the particular objects in focus. For sports photography, provided the camera has focus tracking or continuous auto-focusing in addition to zoom, it is possible to obtain a sharp picture of a subject as it moves along the optical axis of the camera. Given these possibilities, it is not surprising that consumers rate zoom high on the list of "must have" features when purchasing a digital still camera or camera phone.

Camera manufacturers have responded to this demand. Quality and professional grade digital still cameras come standard with optical zoom, while camera phones and budget digital still cameras have digital zoom.

Traditional Zoom

The traditional means of obtaining the zoom function is by optical zoom. In this process the position along the optical axis of the camera of two or more of lenses is altered, changing the field of view. The result is to alter the size of the scene presented to the image capture device, be it film or a solid state sensor. Because the image capture device has fixed dimensions

A software-enhanced lens provides 3x optical zoom with no moving parts. By **Eran Kali** and **Giles Humpston** of Tessera Technologies

Figure 2: *Modern electronics make digital zoom easy to implement, but cannot overcome the fundamental limitation that picture quality degrades rapidly as the zoom increases* *[Source: Tessera]*

the captured image is magnified. Provided the degree of magnification is kept within a sensible limit, the resolution of the magnified image is not degraded by the zoom action. Optical zoom has two main drawbacks. The first is that it is a mechanical system, with all the attendant disadvantages of size, fragility, reliability, speed of change, power consumption if motorized and cost. The second drawback of optical zoom is that the F# changes with magnification so optical zoom systems tend to have poor low light performance in the zoom state.

Digital zoom is a relatively recent innovation, only becoming possible once digital computers had developed the power and speed to handle the large amounts of data present in electronic image files. However, it is radically inferior to optical zoom. A 3x optical zoom magnifies an area of the scene, increasing the optical resolution in the zoomed frame by three. With optical zoom, information quantity is preserved as the magnification varies. In contrast, digital zoom includes the process of cropping an image and expanding the remaining portion to fill the original pixel count so the image appears magnified.

With digital zoom, the optical resolution is fixed at image capture and the information quantity in the zoomed image degrades with the square of the magnification. As a result, a digitally-zoomed photograph quickly becomes visually unacceptable. For a 3x digital zoom, 91% of the information quantity in the captured image is decimated. Nevertheless, digital zoom has the singular advantage of being based on software and is, therefore, physically compact, rugged, virtually instantaneous, consumes negligible power and can be implemented at relatively low cost.

Software-Enhanced Lens

The sole purpose of conventional camera optics is to replicate a scene onto the imager as closely as possible. Extreme effort is invested in achieving the best possible chromatic and illumination uniformity, frequency-contrast response and other optical metrics so that the scene presented to the image sensor pixels has the highest possible optical fidelity. However, this approach requires that much information in the scene is discarded. An example is depth. A photograph is a flat piece of paper and contains no information about the distance between objects in the scene and the camera. As humans we can infer this data from experience, but it is not actually present on the paper.

It is possible to design a camera system to capture information from a scene. It requires a speciality lens and an algorithm to process the images. The lens manipulates the optical rays to provide an intensity distribution on the camera sensor with desired features. Examples include predefined compensation distortion or robust point-spread function behaviour for an extended depth of field. In most cases, the manipulated image is not used as is because it appears as though the camera has major problems with aberrations, distortion and other defects. However, because the image was manipulated in a known manner by the lens, it can be digitally restored by software so high-quality output can be extracted. So-called 'software enhanced lens' technologies provide access to some very desirable functions, of which optical zoom from fixed lenses is one example.

Fixed-Lens Optical Zoom

Fixed-lens optical zoom is a new solution that overcomes the issues in optical and digital zoom. It requires one or fewer additional in the optical train and some digital code. The special lens is permanently fixed in position, while the algorithm is small and time-efficient. The complexity of the lens is in its dimensions, profile and difficulty of manufacture are comparable to any other aspheric lens; it is only the design process that is unique and specialized.

The speciality lens can be manufactured and fixed in the lens barrel just like the other lenses and components of the optical train. Indeed, its presence is agnostic to the camera module manufacturer. The distortion correction is a fixed mathematical transformation. It can be implemented at the end of the image processing chain before JPEG compression and is sufficiently small to be compatible with video frame rate images. This technology can achieve 3x optical zoom that is much smaller than mechanical zoom, consumes negligible power, has no moving parts and can be produced affordably, making it a very compelling solution for camera phones.

Software-enhanced lenses function by exploiting a 'disconnect' between the laws of refractive optics and man-made image capture devices. Optical manipulations like refraction are analogue functions, whereas digital image sensors are quantized devices, each pixel being of identical size to its neighbours and arranged in a uniform 2D array. In a conventional digital camera there is, hence, an inherent mismatch between these two components that restricts the system performance. A software-enhanced lens designed to provide optical zoom does so by means of a specially-designed fixed lens that provides intentionally non-uniform optical information density over the image area, to match the quantized format of the

Figure 3a and 3b: *A software enhanced zoom solution combines a fixed lens of unique design with a compact but sophisticated algorithm. At negligible incremental size the core can provide additional image enhancement functions, the net effect being superior image quality to optical zoom over the entire zoom range increases* [Source: Tessera]

solid-state imager. This is, in effect, the converse of the approach taken by nature.

Many animals with single aperture eyes, particularly birds of prey, have a standard lens, but a non-linear distribution of rods and cones in the retina. In both cases the resulting image is distorted, but can be corrected my mathematical transformation because both the lens design and pixel distribution of the imager (or retina) are known.

The image distortion produced by a software-enhanced optical zoom lens superficially resembles a fish-eye lens. However, the software-enhanced optical zoom lens offers advantages across the zoom range. For a zoom magnification of x1, the algorithm has to compress details in the central portion of the field of view, where magnification and resolution are increased by the software-enhanced lens. Thus, the compression does not noticeably degrade image quality.

The software-enhanced lens and its coupled algorithms are designed so that, in this mode, the picture quality is almost as good as in a conventional camera. Indeed, as will be explained, by exploiting the necessity for the algorithm the final image quality can actually be made to be superior to a conventional camera with a standard lens and no special image processing. As such, it is greatly superior to centre-zoom in a fish-eye lens, which suffers from excessive border loss on image restoration at low magnification.

For operation of the software-enhanced zoom lens at higher magnifications, the image borders are cropped off and the already magnified centre is retained. The image is then corrected for distortion. This is fundamentally different than digital zoom because the magnification is the result of the lens action, so that the zoomed image retains its high resolution. The typical requirement from a zoom system in digital photography is to allow a 3x magnification. The software-enhanced zoom lens technique described here, when fortified with additional cost-effective solution components, can be used to achieve 3x magnification.

Because the speciality lens is fixed in refraction and location the magnification available from this novel zoom system is continuous between its limits. Intermediate zoom values are simply accessed by changing register settings used by the algorithm. By embedding the algorithm early in the image processing pipeline it is fully compatible with digital zoom where greater range is required. It is possible to engineer a continuum of zoom between the optical and digital domains, facilitating a single button user interface.

Beneficial System

A consequential benefit of a software-enhanced lens solution for optical zoom is that the F# of the optics does not vary with magnification. This is because the focal length of the optical train is fixed. This avoids a serious deficiency of mechanical optical zoom systems that have poor low-light performance in the zoom state. Another important benefit of this approach is that the height of the lens stack is dramatically smaller than the height required for achieving the same magnification with a mechanically moving zoom apparatus. This leads to a much shorter camera module and thinner camera phone.

Because software-enhanced lens solutions require the algorithm for functionality, it is possible to exploit the core and provide additional coding benefits at essentially zero incremental cost. Examples include noise reduction, dynamic range correction and distortion correction. The later is particularly powerful since by relaxing the distortion constraint the optics train can be designed to achieve better performance in other areas, such as reduced F# or decrease the module height. The fixed and known distortion can be corrected by a simple adjunct to the zoom algorithm. By these means it is actually possible for a software-enhanced zoom lens to deliver superior quality images to optical zoom throughout the entire zoom range.

The software-enhanced lens presents a distorted image with boosted magnification and resolution in the central region. A simple algorithm removes the distortion and allows the field of view to vary continuously between the wide and narrow limits of the zoom range. The zoom can achieve up to 3x without loss of information quantity. This approach provides a unique, inexpensive and novel solution to providing the optical zoom feature, while meeting the price, size and reliability constraints of cell phone camera. ■

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Accidental short circuits can happen when a metal object bridges the exposed terminals of the battery pack. Such a scenario might occur when a spare battery pack is carried in a briefcase or purse, where the terminals may come into contact with keys or some other metal object.

Battery cell overcharge can result from either an overcurrent or overvoltage condition, or a combination of both. In either case, if current or voltage is allowed to exceed prescribed values, a significant rise in cell temperature may result in venting, smoke or flame.

Overcharge can be caused by a runaway charging condition, in which the charger fails to stop supplying current after the pack has been fully charged. This is typically caused by a charger fault, i.e. using an aftermarket or non-compatible charger.

Designing Redundant Protection with PPTC Devices

Li-ion battery packs typically include protection schemes where MOSFETs and a control IC provide overvoltage, undervoltage and overcurrent protection, and a resettable polymeric positive temperature coefficient (PPTC) device provides overtemperature protection on charge and discharge, as well as redundant overcurrent protection.

PPTC devices are employed as series elements in a circuit and help protect the circuit by going from a low-resistance to a high-resistance state in response to an overcurrent or overtemperature event. **Figure 1** shows a typical single-cell Li-ion battery pack circuit employing a PolySwitch PPTC device.

The PPTC device's low resistance helps overcome the additional series resistance introduced by the MOSFETs, and the device's low trip temperature helps provide protection against thermal runaway in the case of an abusive overcharge.

During a short circuit fault, the PPTC device rapidly produces heat due to the excess current. As it nears trip temperature, the device increases in resistance by several orders of magnitude and limits the fault current to a low level. When the fault condition is removed and the power is cycled, the device cools and returns to a low resistance state. If the fault is not cleared and the power is not cycled, the device will remain latched in the high resistance state.

During a typical overcharge fault, cell temperature rises when excessive voltage across the fully charged cell causes chemical degradation of cell components. When a PPTC device is included in the circuit, as the cell temperature rises, the ambient temperature of the PPTC device increases accordingly and less current is required to trip the device.

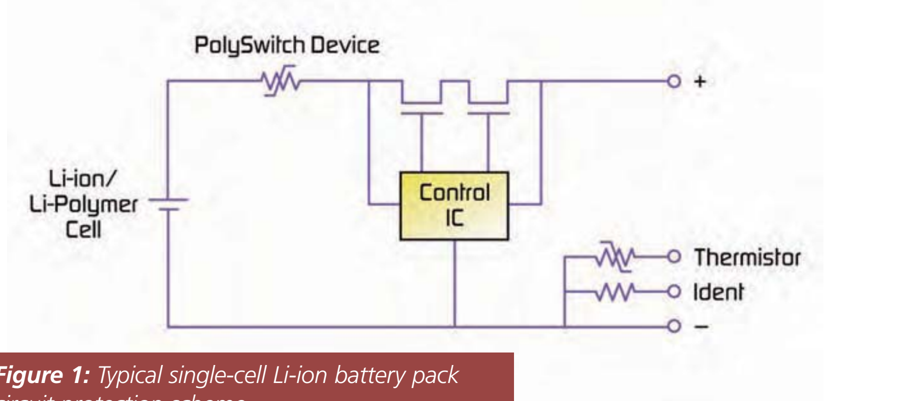


***Figure 1:** Typical single-cell Li-ion battery pack circuit protection scheme*

Technology Comparison

PPTC devices are often used to replace bimetal or thermal fuse protectors. Bimetals are typically bulky, higher cost protectors, which frequently do not latch in the protected position during a fault condition. This may result in a cycling battery pack fault and battery cell damage.

One-shot secondary overcurrent protectors, such as thermal fuses, are difficult to set at the low temperatures required for charge protection, and may trip in high ambient temperatures, disabling an otherwise functional pack. Low temperature PPTC devices are uniquely suited to limiting the charge current close to the functional pack's operating temperature.

The device's resettable functionality ensures that nuisance tripping, which can be caused by exposure to high storage temperatures such as leaving the phone inside a vehicle on a hot day, does not permanently disable the pack. Also, because the majority of fault conditions that a battery pack encounters are relatively infrequent or intermittent events, resettable protection is generally the preferred method.

PPTC devices are available in a variety of form-factors and current ratings and are designed for specific battery chemistries or usage profiles. The evolution of PPTC devices has been in the direction of lower resistance, smaller form-factors and better thermal protection. Clearly, the trend toward more space-efficient packs requires smaller protection devices. Also, locating protection circuitry in close proximity to the cell helps eliminate the need for long metal interconnects and helps improve thermal sensing.

Annular Disc Devices Help Protect Lithium Cells

Lithium cells are sensitive to faults caused by overcurrent and overtemperature conditions and generally require individual protection. The industry standard for protecting individual lithium

Ty Bowman, Global Battery Market Manager at Tyco Electronics, Raychem Circuit Protection Products, explains why PPTC devices have been such a success in applications where batteries need to be protected

cylindrical cells from overcurrent conditions is the PPTC device, in the form of an annular disc located inside the lid assembly of each cell.

As shown in **Figure 2**, the PPTC device works in conjunction with other safety devices, such as separators and pressure vents. Because the design of top cap assemblies in lithium cells varies from manufacturer to manufacturer, the PolySwitch annular disc devices are typically customized for each application.

PolySwitch circuit protection devices are made from a conductive polymer blend of specially formulated plastics and conductive particles that are sandwiched between metal foils. At normal temperature, the conductive particles form low-resistance chains in the polymer. However, if the temperature rises above the device's switching temperature, the crystallites in the polymer melt and become amorphous.

The increase in volume during the crystalline melting phase causes separation of the conductive particles and results in a non-linear increase in the resistance of the device. The heating can take place due to an increase in ambient or cell temperature, or can be generated by resistive heating, as in the case of an overcurrent condition.

Strap Devices Help Protect Battery Packs

The principal electrical hazards faced by battery packs are the result of external short circuits during discharge, or an overcharge situation caused by using a faulty or incorrect charger. Internal pack faults are less common, but a failure in any of the complex electronics that support features, such as fuel gauging or charge control, can increase the risk. Such conditions can result in a significant overtemperature event either inside or outside the pack.

An unprotected battery pack can typically deliver up to 100A of short-circuit current when "hard" shorted by a low resistance element. Power dissipated in the battery cell's internal impedance leads to a rise in cell temperature. The severity will depend on the pack's thermal characteristics and the battery cell chemistry.

If an unprotected pack is "soft" shorted by an element with some resistance, for example a few hundred milliohms, the hazard changes from being power-dissipated in the cell to power-dissipated in the shorting element. Tests have shown that the resistive shorting element can reach temperatures in excess of 600°C in this type of situation and may result in ignition of adjacent combustible materials.

Unlike surface-mount devices, strap devices are welded to the cell body, which helps improve heat transfer from an overheating cell to the PPTC device for faster thermal sensing. Also, locating protection circuitry in close proximity to the cell helps eliminate the need for long metal interconnects and helps improve thermal sensing.

PPTC devices for cell phone applications are designed for placement under the PCB. The PolySwitch MXP strap device, shown in **Figure 3**, incorporates conductive metal particles to achieve lower resistance than traditional carbon black filled PPTC devices. In comparison with the prior generation VTP strap device, shown in **Figure 4**, having approximately the same hold current at 60°C, the MXP device is 88% smaller in size and 68% lower in resistance.

Regardless of the pack chemistry, the PPTC device's hold current is selected on the basis of the maximum average charge or discharge current and takes into account the maximum operating temperature. The form-factor will depend on the available space within the pack.

Moving Forward

The use of PPTC devices for overcurrent and overtemperature fault protection is well established. The latest generation of PPTC devices provides pack designers with another level of design flexibility in the form of very low resistance devices in much smaller form-factors.

Ultimately, battery pack designers must decide what level of protection is required for their application and only a system test can determine whether or not a specific protection device is appropriate. Recommendations from device manufacturers are useful in narrowing protection options and benchmarking other pack protection schemes may provide a good lead for further investigation. However, specific testing of each protection option is the best way to evaluate its effectiveness. ■

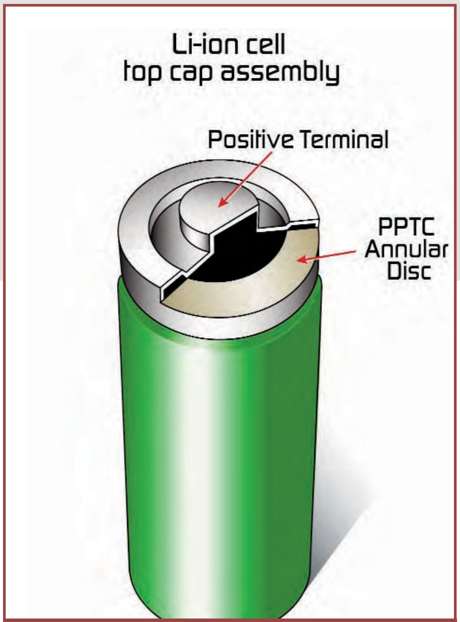


Figure 2: *PPTC annular disc devices work in conjunction with other safety devices*

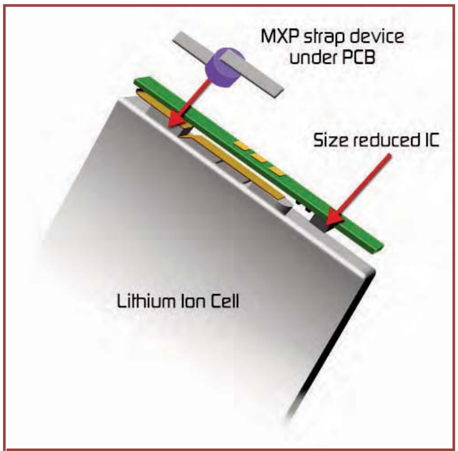


Figure 3: *PolySwitch MXP strap device is designed for use under the PCB*

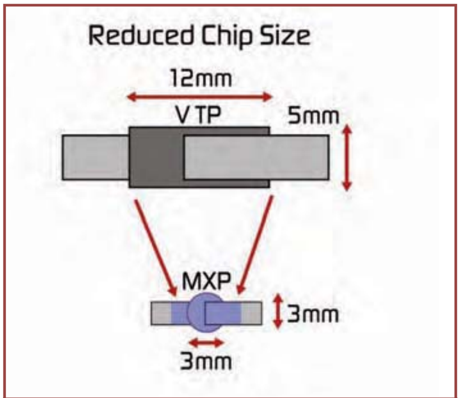


Figure 4: *PolySwitch MXP device provides lower resistance in a smaller form-factor*

MAXIMISING Battery Life in Rugged PCs

ALL NOTEBOOK PC owners are interested in maximising the battery life of their machines, but to the rugged-computing community this can be a mission critical issue that demands practical and effective techniques.

Rugged notebook PCs are designed for use in diverse yet harsh environments, particularly outdoors, on industrial sites, or on the move. They are designed to withstand hazards such as shock and vibration, water, dust and extremes of temperature.

Available machines can be broadly separated into two groups; semi-rugged PCs are typically rated to MIL-STD810F, and feature a metal-alloy enclosure and limited protection against dust or water ingress. Fully rugged PCs, on the other hand, have extra features such as sealed ports allowing certification to the international protection standard IP54, or higher. Both types tend to be visibly different from their home or office counterparts. Typical features include a robust enclosure design, shock-resistant mountings for display and hard disk and fanless operation, using the enclosure as a heatsink to eliminate air vents that would otherwise collect dust and dirt and provide an entry point for moisture.

Users who need the extra flexibility and mobility that come with this enhanced resilience frequently also need to operate their machines for long periods without recharging. They may need to move quickly from one site to another, for example, or operate in areas without ready access to mains electricity to recharge. In these situations, the typical notebook battery life of around two hours can be inadequate. Owners of ruggedised notebooks therefore expect effective power-saving design features – as well as reliable usage guidelines – to fulfil important mission objectives.

The Getac rugged computer

Design to Save Power

Power-saving design at the core of a rugged notebook can extend useful operation well beyond the typical battery life of a conventional machine. Solid-state hard drives, for example, not only achieve high resistance to shock and vibration but increase battery life significantly by saving the energy required to spin the disc and move the reading head.

For PCs featuring a conventional hard disk drive (HDD), proper system maintenance such as regularly defragmenting the disk can help to maximise the HDD's efficiency and thereby reduce demand on the battery. Specifying a large RAM capacity also helps to save power otherwise consumed by the HDD, by reducing the load on virtual memory, which resides on the hard disk by default avoiding access to the drive. The extra power demand imposed by the RAM is relatively small.

The LCD screen can also be a major power-consuming component of any notebook PC, as conventional CCFL backlights impose a considerable drain on the battery. More recently, displays featuring LED backlights have become available for rugged PCs as well as home/office products. These may comprise individual white high-power LEDs or strings of RGB LEDs, and deliver performance benefits including a brighter image and improved contrast. At the same time, LEDs use approximately 43% less power than LCDs at their maximum brightness setting; an energy saving that can, in some cases, double battery life. LEDs also enhance the 'green credentials' of the PC manufacturer, not only through their energy saving capabilities, but also due to the fact that they are mercury free.

As an example, the Getac B300 rugged notebook, which uses the efficient Intel Core 2 Duo processor and has an LED-backlit TFT screen delivering sunlight-readable performance at low

Russell Cartwright, Business Manager in the Rugged Mobile Division at Steatite Limited, outlines the main guidelines for specifiers and users when it comes to maximising battery life in rugged PCs

power, will operate for up to 12 hours between recharging. When using any PC, whether fitted with CCFL or LED backlights, the user can maximise battery life by adjusting the screen brightness. Dimming the screen to the lowest practicable level is an effective and widely recognised technique to maximise battery life.

Some producers of rugged notebooks offer a choice of operating systems, which can have a significant impact on the power consumption of the machine. As an example, Steatite is able to develop custom operating systems, such as Windows Embedded Standard, allowing unused features of the conventional Windows desktop system to be eliminated. In this way, operators of rugged PCs are able to take advantage of an operating system tailored to their needs, while at the same time maintaining hardware and software support. Benefits can include a smaller OS footprint, as well as the improvements in operating efficiency and boot-up time that enable lower overall power consumption and longer battery life. On average, a custom Windows XP Embedded OS can add around 30 minutes to the battery-recharge interval in a rugged-PC application.

Action to Save Power

Of course, while it is essential to choose a specification capable of achieving a suitable recharge interval for the intended application, end users can also significantly influence the performance their machines will deliver in the field. Since background processes that begin automatically on boot-up, for example, can consume significant resources, these should be terminated using the Windows Task Manager. Some of these, such as antivirus and firewall protection, are known to consume heavy resources and can be safely disabled provided the computer is not connected to the Internet.

Users should also pay careful attention to the number and type of programs in use. Applications with heavy graphics content tend to increase processor load, leading to higher overall power consumption. Running multiple programs concurrently also imposes a significant drain on battery energy, and should be avoided as far as possible.

In addition, unneeded features connected, such as an external mouse, PC cards or wireless interfaces such as Wi-Fi or Bluetooth, should be disconnected. Sound effects and the screensaver can also be turned off to maximise battery life. In addition, any time the PC’s optical drive is used the disc should be removed immediately afterwards. This saves valuable battery power, which is otherwise wasted as the PC periodically attempts to re-read the disc. Some rugged PCs currently on the market have smart battery capabilities that can automatically disable unused features when idle. If the optical disc contains information that must be referred to frequently, it is more power-efficient to copy this to the PC’s local drive and so avoid using the optical drive.

Another valuable tip for notebook users is to use the PC’s hibernate-mode in preference to standby. Compared to standby, which allows the user’s session to be resumed instantly, hibernating a PC saves significantly more power by completely shutting down the machine but saves the PC’s state allowing the session to resume after wake up.

Optimising the notebook power-management settings using the PC’s power-options controls is also essential. A selection of standard or custom settings prioritising power saving or high-performance operation determine the time that will elapse before the PC automatically turns off the display, powers down the hard drive and subsequently enters hibernate or shutdown mode.

Finally, as a general rule, battery-powered PCs should be kept cool to preserve the battery capacity. Sustained high temperatures will quickly reduce a battery’s operating capabilities and hasten replacement. Although users of rugged PCs may not always have the luxury of finding a cool area to work, the computer should not be stored or left in hot areas such as close to a heat source or inside a vehicle.

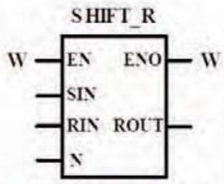
If More is Needed…

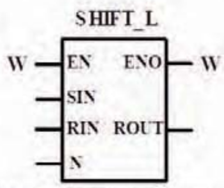
In summary, careful selection of PC features, combined with attentive management of battery resources, can enable users of rugged notebooks to increase the computer’s battery-recharge interval to meet a given set of mission objectives; modern machines will operate independently in the field for periods of around 12 hours.

However, for extreme applications requiring even longer battery life, some are also offered with an optional second battery installed in an expansion port. This is a straightforward and effective way of doubling the operating range of the computer. ■

PLC with PIC16F648A Microcontroller – Part 12

Algorithm	Macro	Symbol

if EN = 1 then
ROUT = N times shift right(RIN) and take the serial data_in from SIN;
ENO = 1;
else ENO = 0;
end if;
	shift_R macro n,reg,bit,Rin,Rout
	local L1,L2
	movwf Temp_1
	btfss Temp_1,0
	goto L1
	movlw n
	xorlw 00h
	skpnz
	goto L1
	movlw .9
	sublw n
	skpnc
	goto L1
	movfw Rin
	movwf Rout
	movlw n
	movwf Temp_1
	L2 bcf STATUS,C
	btfsc reg,bit
	bsf STATUS,C
	rrf Rout,f
	decfsz Temp_1,f
	goto L2
	bsf Temp_1,0
	movfw Temp_1
	L1
	endm
		
		
		RIN, ROUT (8 bit register)
		SIN (reg.bit) = 0 or 1
		N (number of shift) = 1.... 8
		EN (through W) = 0 or 1
		EN0 (through W) = 0 or 1

if EN = 1 then
ROUT = N times shift left(RIN) and take the serial data_in from SIN;
ENO = 1;
else ENO = 0;
end if;
	shift_L macro n,reg,bit,Rin,Rout
	local L1,L2
	movwf Temp_1
	btfss Temp_1,0
	goto L1
	movlw n
	xorlw 00h
	skpnz
	goto L1
	movlw .9
	sublw n
	skpnc
	goto L1
	movfw Rin
	movwf Rout
	movlw n
	movwf Temp_1
	L2 bcf STATUS,C
	btfsc reg,bit
	bsf STATUS,C
	rlf Rout,f
	decfsz Temp_1,f
	goto L2
	bsf Temp_1,0
	movfw Temp_1
	L1
	endm
		
		
		RIN, ROUT (8 bit register)
		SIN (reg.bit) = 0 or 1
		N (number of shift) = 1.... 8
		EN (through W) = 0 or 1
		EN0 (through W) = 0 or 1

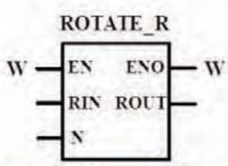
if EN = 1 then
ROUT = N times rotate right(RIN);
ENO = 1;
else ENO = 0;
end if;
	rotate_R macro n,Rin,Rout
	local L1,L2
	movwf Temp_1
	btfss Temp_1,0
	goto L1
	movlw n
	xorlw 00h
	skpnz
	goto L1
	movlw .8
	sublw n
	skpnc
	goto L1
	movfw Rin
	movwf Rout
	movlw n
	movwf Temp_1
	L2 bcf STATUS,C
	btfsc Rout,0
	bsf STATUS,C
	rrf Rout,f
	decfsz Temp_1,f
	goto L2
	bsf Temp_1,0
	movfw Temp_1
	L1
	endm
		
		
		RIN, ROUT (8 bit register)
		N (number of rotate) = 1.... 7
		EN (through W) = 0 or 1
		EN0 (through W) = 0 or 1

***Table 1:** The shift&rotate macros, together with their algorithms and symbols (continued on the next page)*

THE FOLLOWING SHIFT & Rotate macros are described in this article: SHIFT_R (shift right the content of register R), SHIFT_L (shift left the content of register R), ROTATE_R (rotate right the content of register R), ROTATE_L (rotate left the content of register R), SWAP (swap the nibbles of the register).

A shift function (SHIFT) moves the bits in a register to the right or to the left. As an example, **Figure 1** shows a shift right function that will retrieve the input data from the source register A and shifts the bits of source register A towards right as many number as specified by the number of shift, while the serial data is taken from left through the Boolean input variable "shift in bit". The result of the shift operation will be stored in a destination register B.

In this case, the least significant bit (LSB) is shifted out as many numbers as specified by the number of shift. A shift left function is identical, except that the shift in bit, taken from the right, is moved in the opposite direction towards left, shifting out the most significant bit (MSB) by as many a number as specified by the number of 'shift'.

A rotate function (ROTATE), like a shift function, shifts data to the right or left; but instead of losing the shift-out bit, this bit becomes the shift-in bit at the other end of the register (rotated bit). The number of 'rotate' defines how many bits will be rotated to the right or left. Similar to the shift function, the result of the rotate operation will be stored in a destination register B.

In this article, there are two shift (shift right and shift left) macros, two rotate (rotate right and rotate left) macros and a swap macro described for UZAM_PLC as shown in **Table 1**. In these macros, EN is a Boolean input variable taken into the macro through W and ENO is a Boolean output variable sent out from the macro through W. Output ENO follows the input EN. This means that when EN=0, ENO is forced to be 0 and when EN=1, ENO is forced to be 1. This is especially useful if we want to carry out more than one operation based on a single input condition.

"IN" and "RIN" refer to 8-bit source variables from where the source values are taken into the

Associate Professor **Dr Murat Uzam** from Nigde University in Turkey presents a series of articles on a project that focuses on a microcontroller-based PLC. This is the twelfth article in the series describing the Shift & Rotate macros

<table>
<tr><th>Algorithm</th><th>Macro</th><th>Symbol</th></tr>
<tr><td>if EN = 1 then
ROUT = N times rotate left(RIN);
ENO = 1;
else ENO = 0;
end if;</td><td><pre>rotate_L macro n,Rin,Rout
      local   L1,L2
      movwf   Temp_1
      btfss   Temp_1,0
      goto   L1
      movlw   n
      xorlw   00h
      skpnz
      goto   L1
      movlw   .8
      sublw   n
      skpnc
      goto   L1
      movfw   Rin
      movwf   Rout
      movlw   n
      movwf   Temp_1
L2   bcf   STATUS,C
      btfsc   Rout,7
      bsf   STATUS,C
      rlf   Rout,f
      decfsz Temp_1,f
      goto   L2
      bsf   Temp_1,0
      movfw   Temp_1
L1
      endm</pre></td><td>ROTATE_L

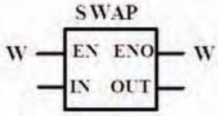
RIN, ROUT (8 bit register)
N (number of rotate) = 1.... 7
EN (through W) = 0 or 1
EN0 (through W) = 0 or 1</td></tr>
<tr><td>if EN = 1 then
OUT = SWAP(IN);
ENO = 1;
else ENO = 0;
end if;</td><td><pre>Swap macro   in,out
      local   L1
      movwf   Temp_1
      btfss   Temp_1,0
      goto   L1
      swapf   in,W
      movwf   out
      movfw   Temp_1
L1
      endm</pre></td><td>SWAP

IN, OUT (8 bit register)
EN (through W) = 0 or 1
EN0 (through W) = 0 or 1</td></tr>
</table>

Table 1: *Continued from the previous page*

related macro, while "OUT" and "ROUT" refers to 8-bit destination variables to which the results of the related macros are stored. In shift macros, namely "SHIFT_R" and "SHIFT_L", N represents the number of shift, which can be any number in 1, 2...8. Again in shift macros, SIN is the Boolean input variable "shift in bit". In rotate macros, namely "ROTATE_R" and "ROTATE_L", N represents the number of 'rotate', which can be any number in 1, 2...7.

When EN=1, the macro "SHIFT_R" will retrieve the 8-bit input data from RIN and shifts the bits of RIN towards right as many a number as specified by N, while the serial data is taken from left through SIN. The result of the shift right operation will be stored in 8-bit output register ROUT.

When EN=1, the macro "SHIFT_L" will retrieve the 8-bit input data from RIN and shifts the bits of RIN towards left as many times as specified by N, while the serial data is taken from right through SIN. The result of the shift right operation will be stored in 8-bit output register ROUT.

When EN=1, the macro "ROTATE_R", will retrieve the 8-bit input data from RIN and rotates the bits of RIN towards right as many a number as specified by N. The result of the shift right operation will be stored in 8-bit output register ROUT. When EN=1, the macro "ROTATE_L", will retrieve the 8-bit input data from RIN and rotates the bits of RIN towards left as many a number as specified by N. The result of the shift left operation will be stored in 8-bit output register ROUT.

In addition to these shift and rotate macros, here we define a "swap" macro. When EN=1, the macro "SWAP", will retrieve the 8-bit input data from IN and swaps (exchanges the upper and lower nibbles – 4 bits) the nibbles of RIN. The result of the swap operation will be stored in 8-bit output register ROUT. The file "shift_mcr_def.inc" including the 7 shift&rotate macros shown in Table 1 can be downloaded from http://host.nigde.edu.tr/muzam/.

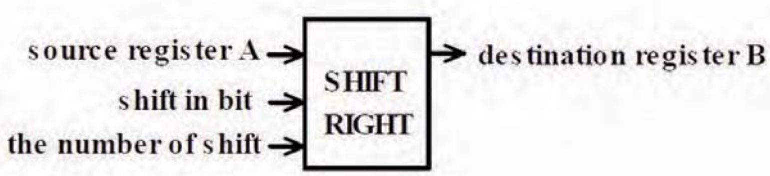


Figure 1: *The SHIFT RIGHT function*

Examples of the Shift & Rotate Macros

Here we will consider two examples of the UZAM_plc_8i8o_exN.asm with N = 19, 20 to show the usage of the shift&rotate macros. In order to test this example, you should download the files from http://host.nigde.edu.tr/muzam/ and then open the program UZAM_plc_8i8o_exN.asm, N = 19, 20 by MPLAB IDE and compile it. After that, by using the PIC programmer software, take the compiled file "UZAM_PLC_8i8o_exN.hex" and with a PIC programming hardware send it to the program memory of PIC16F648A microcontroller within the UZAM_PLC. After loading the "UZAM_PLC_8i8o_exN.hex", switch the 4PDT in "RUN" and the power switch in "ON" position. The example program is ready for test.

To check the correctness of each program you are referred to the related information for each shift&rotate macro provided in Table 1. When studying these three examples, note that the output register Q0 is made up of the 8-bits: Q0.7, Q0.6...Q0.0 and that Q0.7 is the most significant bit (MSB), while Q0.0 is the least significant bit (LSB).

Similarly, note that the input register I0 is made up of the 8-bits: I0.7, I0.6...I0.0 and that I0.7 is the MSB while I0.0 is the LSB. The two examples considered here make use of the

I0.4	I0.3	I0.2	I0.1	I0.0	Selected process
0	0	×	×	×	No process is selected.
1	1	×	×	×	No process is selected.
0	1	0	0	0	Shift right REG (F0h) once: shift in bit = I0.5
0	1	0	0	1	Shift right REG (F0h) twice: shift in bit = I0.5
0	1	0	1	0	Shift right REG (F0h) 3 times: shift in bit = I0.5
0	1	0	1	1	Shift right REG (F0h) 4 times: shift in bit = I0.5
0	1	1	0	0	Shift right REG (F0h) 5 times: shift in bit = I0.5
0	1	1	0	1	Shift right REG (F0h) 6 times: shift in bit = I0.5
0	1	1	1	0	Shift right REG (F0h) 7 times: shift in bit = I0.5
0	1	1	1	1	Shift right REG (F0h) 8 times: shift in bit = I0.5
1	0	0	0	0	Shift left REG (F0h) once: shift in bit = I0.6
1	0	0	0	1	Shift left REG (F0h) twice: shift in bit = I0.6
1	0	0	1	0	Shift left REG (F0h) 3 times: shift in bit = I0.6
1	0	0	1	1	Shift left REG (F0h) 4 times: shift in bit = I0.6
1	0	1	0	0	Shift left REG (F0h) 5 times: shift in bit = I0.6
1	0	1	0	1	Shift left REG (F0h) 6 times: shift in bit = I0.6
1	0	1	1	0	Shift left REG (F0h) 7 times: shift in bit = I0.6
1	0	1	1	1	Shift left REG (F0h) 8 times: shift in bit = I0.6

×: Don't care. Note that the resut of the shift operations will be stored in Q0.

***Table 2:** The truth table of the user program "UZAM_plc_8i8o_ex19.asm"*
×: Don't care. Note that the resut of the shift operations will be stored in Q0

I0.4	I0.3	I0.2	I0.1	I0.0	Selected process
0	0	×	×	×	No process is selected.
1	1	×	×	×	No process is selected.
0	1	0	0	0	Shift right REG (F0h) once: shift in bit = I0.5
0	1	0	0	1	Shift right REG (F0h) twice: shift in bit = I0.5
0	1	0	1	0	Shift right REG (F0h) 3 times: shift in bit = I0.5
0	1	0	1	1	Shift right REG (F0h) 4 times: shift in bit = I0.5
0	1	1	0	0	Shift right REG (F0h) 5 times: shift in bit = I0.5
0	1	1	0	1	Shift right REG (F0h) 6 times: shift in bit = I0.5
0	1	1	1	0	Shift right REG (F0h) 7 times: shift in bit = I0.5
0	1	1	1	1	Shift right REG (F0h) 8 times: shift in bit = I0.5
1	0	0	0	0	Shift left REG (F0h) once: shift in bit = I0.6
1	0	0	0	1	Shift left REG (F0h) twice: shift in bit = I0.6
1	0	0	1	0	Shift left REG (F0h) 3 times: shift in bit = I0.6
1	0	0	1	1	Shift left REG (F0h) 4 times: shift in bit = I0.6
1	0	1	0	0	Shift left REG (F0h) 5 times: shift in bit = I0.6
1	0	1	0	1	Shift left REG (F0h) 6 times: shift in bit = I0.6
1	0	1	1	0	Shift left REG (F0h) 7 times: shift in bit = I0.6
1	0	1	1	1	Shift left REG (F0h) 8 times: shift in bit = I0.6

×: Don't care. Note that the resut of the shift operations will be stored in Q0.

***Table 3:** The truth table of the user program "UZAM_plc_8i8o_ex20.asm"*
×: Don't care. Note that the resut of the rotate operations will be stored in Q0.
In addition, when I0 = 10h, "Swap REG (F0h) and store the result in Q0" process is selected

previously described macros "load_R" and "r_edge" and, so, the files "mv_ld_mcr_def.inc" and "ff_mcr_def.inc" are included too.

Example One

The first example program, "UZAM_plc_8i8o_ex19.asm" is shown in **Figure 2**. It shows the usage of two shift macros "SHIFT_R" and "SHIFT_L". The ladder diagram of the user program of "UZAM_plc_8i8o_ex19.asm" shown in Figure 2 is depicted in **Figure 3**.

As can be seen from Figure 2, we define and use an additional 8-bit variable called REG. In the first rung, 8-bit numerical data "F0h" is loaded to 8-bit variable REG, by using the macro "load_R".

This process is carried out once at the first program scan by using the "FRSTSCN" NO contact. In the 8 PLC rungs between 2 and 9, a "3 to 8 decoder" is implemented, whose inputs are I0.2, I0.1 and I0.0, and whose outputs are M0.0, M0.1...M0.7. This arrangement is made to choose the number of shift for the selected shift right or shift left operation based on the input information given through the input bits I0.2, I0.1 and I0.0. When these bits are 001, 010, 100, 100, 101, 110, 111 and 000, we define the number of shift for the selected shift right or shift left operation as 1, 2, 3, 4, 5, 6, 7 and 8, respectively.

In the 8 PLC rungs between 10 and 17, we define 8 different shift right operations according to the 3 to 8 decoder outputs represented by the marker bits M0.0, M0.1...M0.7. Shift right operations defined in these rungs are applied to the 8-bit input variable REG, holding the 8-bit value "F0h" throughout the PLC operation. The result of the shift right operations defined in these rungs will be stored in Q0. The "shift in bit" for these shift right operations defined in these rungs is I0.5.

The only difference for these eight shift right operations is the number of shift. It can be seen that for each rung one "rising edge detector" is used. This is to make sure that when the related shift right operation is chosen, it will be carried out only once. In order to choose one of these 8 shift right operations the input bits I0.4 and I0.3 must be as follows: I0.4=0, I0.3=1.

In the 8 PLC rungs between 18 and 25, we define 8 different shift left operations according to the 3 to 8 decoder outputs represented by the marker bits M0.0, M0.1...M0.7. Shift left operations defined in these rungs are applied to the 8-bit input variable REG, holding the 8-bit value "F0h" throughout the PLC operation. The result of the shift left operations defined in these rungs will be stored in Q0. The "shift in bit" for these shift left operations defined in these rungs is I0.6.

The only difference for these eight shift left operations is the number of shift. It can be seen that for each rung one "rising edge detector" is used. This is to make sure that when the related shift left operation is chosen, it will be carried out only once. In order to choose one of these 8 shift left operations, the input bits I0.4 and I0.3 must be set as follows: I0.4=1, I0.3=0. **Table 2** shows the truth table of the user program"UZAM_plc_8i8o_ex19.asm".

Example Two

The second example program, "UZAM_plc_8i8o_ex20.asm", is shown in **Figure 4**. It shows the usage of three shift&rotate macros "ROTATE_R", "ROTATE_L" and "SWAP".

The ladder diagram of the user program of "UZAM_plc_8i8o_ex20.asm" shown in Figure 4 is depicted in **Figure 5**. As can be seen from Figure 4, we define and use an additional 8-bit variable called, REG.

In the first rung, 8-bit numerical data "F0h" is loaded to 8-bit variable REG, by using the macro "load_R". This process is carried out once at the

```
.
    #include <definitions.inc>    ;basic PLC definitions, macros, etc.
    #include <cntct_mcr_def.inc>  ;Contact & Relay based macros
    #include <mv_ld_mcr_def.inc>  ;move_R, load_R macros
    #include <shift_mcr_def.inc>  ;Shift&Rotate macros
    #include <ff_mcr_def.inc>     ;flip-flop macros
.
    #define    REG   7Ch
.
;--------------- user program starts here --------
    ld         FRSTSCN    ;rung 1
    load_R     0F0h,REG

    ld_not     I0.2       ;rung 2
    and_not    I0.1
    and_not    I0.0
    out        M0.0

    ld_not     I0.2       ;rung 3
    and_not    I0.1
    and        I0.0
    out        M0.1

    ld_not     I0.2       ;rung 4
    and        I0.1
    and_not    I0.0
    out        M0.2

    ld_not     I0.2       ;rung 5
    and        I0.1
    and        I0.0
    out        M0.3

    ld         I0.2       ;rung 6
    and_not    I0.1
    and_not    I0.0
    out        M0.4

    ld         I0.2       ;rung 7
    and_not    I0.1
    and        I0.0
    out        M0.5

    ld         I0.2       ;rung 8
    and        I0.1
    and_not    I0.0
    out        M0.6

    ld         I0.2       ;rung 9
    and        I0.1
    and        I0.0
    out        M0.7

    ld         I0.3       ;rung 10
    and_not    I0.4
    and        M0.1
    r_edge     1
    shift_R    1,I0.5,REG,Q0

    ld         I0.3       ;rung 11
    and_not    I0.4
    and        M0.2
    r_edge     2
    shift_R    2,I0.5,REG,Q0

    ld         I0.3       ;rung 12
    and_not    I0.4
    and        M0.3
    r_edge     3
    shift_R    3,I0.5,REG,Q0

    ld         I0.3       ;rung 13
    and_not    I0.4
    and        M0.4
    r_edge     4
    shift_R    4,I0.5,REG,Q0

    ld         I0.3       ;rung 14
    and_not    I0.4
    and        M0.5
    r_edge     5
    shift_R    5,I0.5,REG,Q0

    ld         I0.3       ;rung 15
    and_not    I0.4
    and        M0.6
    r_edge     6
    shift_R    6,I0.5,REG,Q0

    ld         I0.3       ;rung 16
    and_not    I0.4
    and        M0.7
    r_edge     7
    shift_R    7,I0.5,REG,Q0

    ld         I0.3       ;rung 17
    and_not    I0.4
    and        M0.0
    r_edge     0
    shift_R    8,I0.5,REG,Q0

    ld         I0.4       ;rung 18
    and_not    I0.3
    and        M0.1
    r_edge     1
    shift_L    1,I0.6,REG,Q0

    ld         I0.4       ;rung 19
    and_not    I0.3
    and        M0.2
    r_edge     2
    shift_L    2,I0.6,REG,Q0

    ld         I0.4       ;rung 20
    and_not    I0.3
    and        M0.3
    r_edge     3
    shift_L    3,I0.6,REG,Q0

    ld         I0.4       ;rung 21
    and_not    I0.3
    and        M0.4
    r_edge     4
    shift_L    4,I0.6,REG,Q0

    ld         I0.4       ;rung 22
    and_not    I0.3
    and        M0.5
    r_edge     5
    shift_L    5,I0.6,REG,Q0

    ld         I0.4       ;rung 23
    and_not    I0.3
    and        M0.6
    r_edge     6
    shift_L    6,I0.6,REG,Q0

    ld         I0.4       ;rung 24
    and_not    I0.3
    and        M0.7
    r_edge     7
    shift_L    7,I0.6,REG,Q0

    ld         I0.4       ;rung 25
    and_not    I0.3
    and        M0.0
    r_edge     0
    shift_L    8,I0.6,REG,Q0
------------ user program ends here
```

Figure 2: *The user program UZAM_plc_8i8o_ex19.asm*

first program scan by using the "FRSTSCN" NO contact. In the 7 PLC rungs between 2 and 8, a "3 to 8 decoder" is implemented with inputs that are I0.2, I0.1 and I0.0, and whose outputs are M0.1, M0.2...M0.7.

Note that the first combination of 3 to 8 decoder, namely (I0.2, I0.1, I0.0) = 000 is not implemented. Therefore, for this combination the program will not produce any meaningful output. This arrangement is made to choose the number of rotate for the selected rotate right or rotate left operation based on the input information given through the input bits I0.2, I0.1 and I0.0. When these bits are 001, 010, 100, 100, 101, 110 and 111, we define the number of rotate for the selected rotate right or rotate left operation as 1, 2, 3, 4, 5, 6 and 7, respectively.

In the 7 PLC rungs between 9 and 15 we define 7 different rotate right operations according to the 3 to 8 decoder outputs represented by the marker bits M0.1, M0.2...M0.7. Rotate right operations defined in these rungs are applied to the 8-bit input variable REG, holding the 8-bit value "F0h" throughout the PLC operation. The result of the rotate right operations defined in these rungs will be stored in Q0.

The only difference for these seven rotate right operations is the number of rotate. It can be seen that for each rung one "rising edge detector" is used. This is to make sure that when the related rotate right operation is chosen, it will be carried out only once. In order to choose one of these 7 rotate right operations, the input bits I0.4 and I0.3 must be as follows: I0.4=0, I0.3=1. In the 7 PLC rungs between 16 and 22 we define 7 different rotate left operations according to the 3 to 8 decoder outputs represented by the marker bits M0.1, M0.2...M0.7. Rotate left operations defined in these rungs are applied to the 8-bit input variable REG, holding the 8-bit value "F0h" throughout the PLC operation. The result of the rotate left operations defined in these rungs will be stored in Q0.

The only difference for these seven rotate left operations is the number of rotate. It can be seen that for each rung one "rising edge detector" is used. This is to make sure that when the related rotate left operation is chosen, it will be carried out only once. In order to choose one of these 7 rotate left operations, the input bits I0.4 and I0.3 must be set as follows: I0.4=1, I0.3=0. In the last rung 23, an example is used to show the use of swap function.

If the 8-bit input register I0 is set to be "10h", then the "Swap REG (F0h) and store the result in

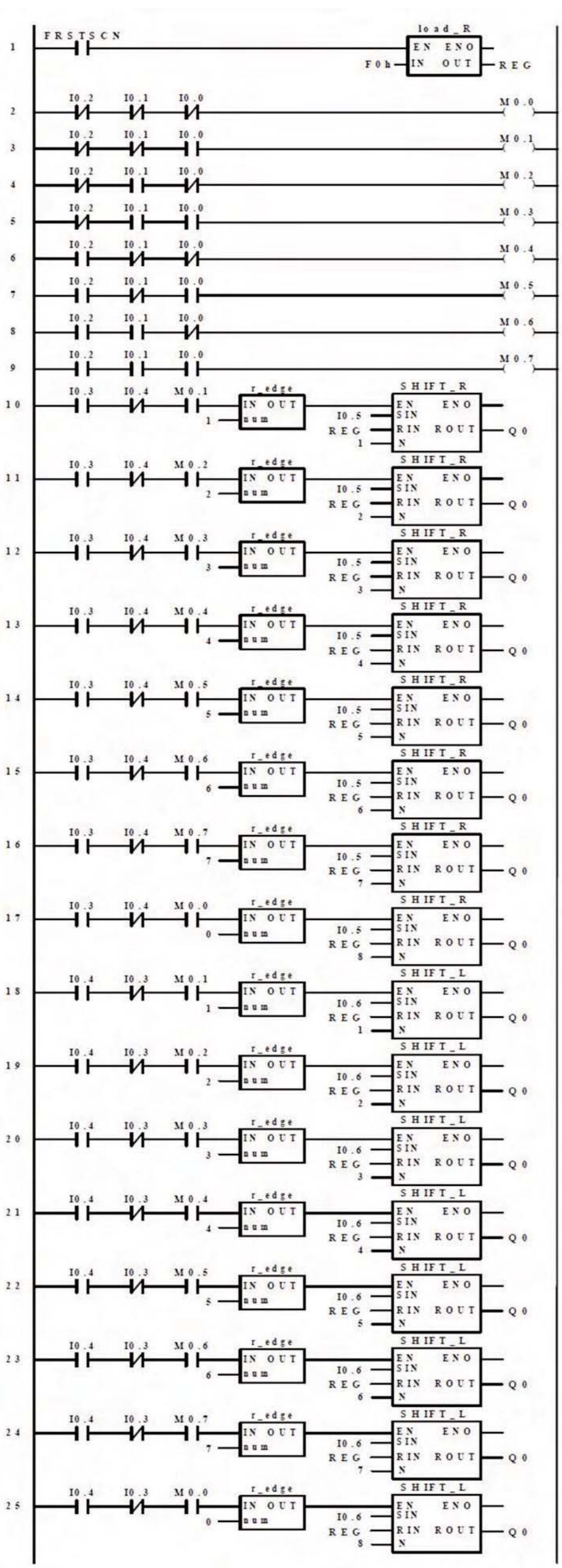


Figure 3: *Ladder diagram for the user program UZAM_plc_8i8o_ex19.asm*

Q0" process is selected. In this case we shall observe the 8-bit output register Q0 to be "0Fh". **Table 3** shows the truth table of the user program"UZAM_plc_8i8o_ex20.asm". ■

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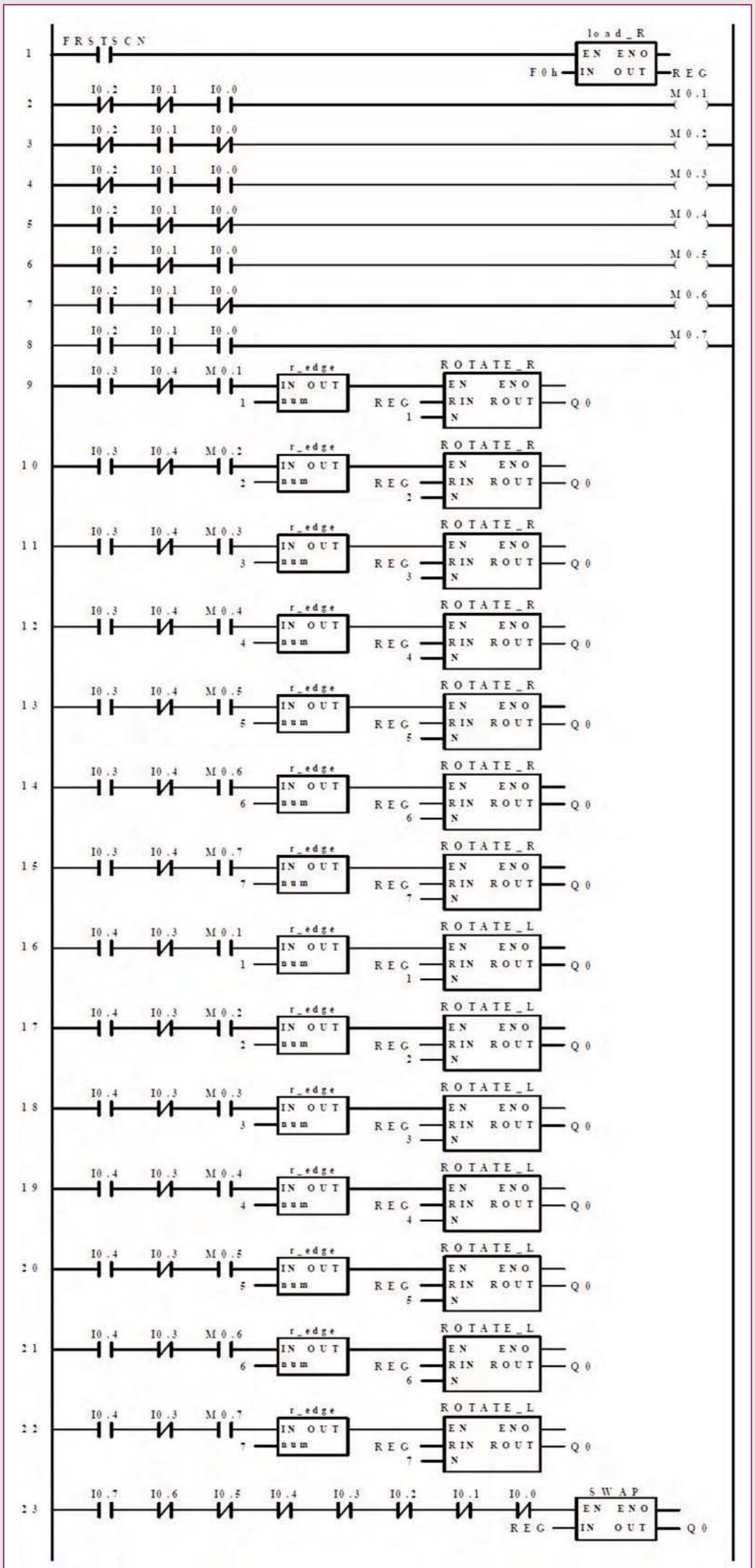

Figure 5: *Ladder diagram for the user program UZAM_plc_8i8o_ex20.asm*

```
.
        #include <definitions.inc>     ;basic PLC definitions, macros, etc.
        #include <cntct_mcr_def.inc>   ;Contact & Relay based macros
        #include <mv_ld_mcr_def.inc>   ;move_R, load_R macros
        #include <shift_mcr_def.inc>   ;Shift&Rotate macros
        #include <ff_mcr_def.inc>      ;flip-flop macros
.
        #define     REG    7Ch
.
;--------------- user program starts here ----------------------
        ld          FRSTSCN     ;rung 1
        load_R      0F0h,REG

        ld_not      I0.2        ;rung 2
        and_not     I0.1
        and         I0.0
        out         M0.1

        ld_not      I0.2        ;rung 3
        and         I0.1
        and_not     I0.0
        out         M0.2

        ld_not      I0.2        ;rung 4
        and         I0.1
        and         I0.0
        out         M0.3

        ld          I0.2        ;rung 5
        and_not     I0.1
        and_not     I0.0
        out         M0.4

        ld          I0.2        ;rung 6
        and_not     I0.1
        and         I0.0
        out         M0.5

        ld          I0.2        ;rung 7
        and         I0.1
        and_not     I0.0
        out         M0.6

        ld          I0.2        ;rung 8
        and         I0.1
        and         I0.0
        out         M0.7

        ld          I0.3        ;rung 9
        and_not     I0.4
        and         M0.1
        r_edge      1
        rotate_R    1,REG,Q0

        ld          I0.3        ;rung 10
        and_not     I0.4
        and         M0.2
        r_edge      2
        rotate_R    2,REG,Q0

        ld          I0.3        ;rung 11
        and_not     I0.4
        and         M0.3
        r_edge      3
        rotate_R    3,REG,Q0

        ld          I0.3        ;rung 12
        and_not     I0.4
        and         M0.4
        r_edge      4
        rotate_R    4,REG,Q0

        ld          I0.3        ;rung 13
        and_not     I0.4
        and         M0.5
        r_edge      5
        rotate_R    5,REG,Q0

        ld          I0.3        ;rung 14
        and_not     I0.4
        and         M0.6
        r_edge      6
        rotate_R    6,REG,Q0

        ld          I0.3        ;rung 15
        and_not     I0.4
        and         M0.7
        r_edge      7
        rotate_R    7,REG,Q0

        ld          I0.4        ;rung 16
        and_not     I0.3
        and         M0.1
        r_edge      1
        rotate_L    1,REG,Q0

        ld          I0.4        ;rung 17
        and_not     I0.3
        and         M0.2
        r_edge      2
        rotate_L    2,REG,Q0

        ld          I0.4        ;rung 18
        and_not     I0.3
        and         M0.3
        r_edge      3
        rotate_L    3,REG,Q0

        ld          I0.4        ;rung 19
        and_not     I0.3
        and         M0.4
        r_edge      4
        rotate_L    4,REG,Q0

        ld          I0.4        ;rung 20
        and_not     I0.3
        and         M0.5
        r_edge      5
        rotate_L    5,REG,Q0

        ld          I0.4        ;rung 21
        and_not     I0.3
        and         M0.6
        r_edge      6
        rotate_L    6,REG,Q0

        ld          I0.4        ;rung 22
        and_not     I0.3
        and         M0.7
        r_edge      7
        rotate_L    7,REG,Q0

        ld          I0.7        ;rung 23
        and_not     I0.6
        and_not     I0.5
        and_not     I0.4
        and_not     I0.3
        and_not     I0.2
        and_not     I0.1
        and_not     I0.0
        Swap        REG,Q0
;--------------- user program ends here
```

Figure 4: *The user program UZAM_plc_8i8o_ex20.asm*

FLOATING POSITIVE AND NEGATIVE INDUCTOR SIMULATORS WITH REDUCED COMPONENT COUNT

THE REALIZATIONS of grounded and floating inductors using active building blocks (ABBs) have been receiving considerable attention. This is because although conventional spiral inductors could be realized in an integrated circuit, it has some drawbacks in the usage of space, weight, cost and tunability, and hence active simulation of inductances is desired.

A number of active realizations of a floating inductor simulator have been reported in the past using a variety of ABBs and different component count. The motivation of this article is to propose designs of current-tunable and "resistorless" floating inductor simulators with the focus on reducing the number of employed components.

Although much emphasis has been given on active realization of positive inductors, only a few circuit realizations for negative inductor simulators are available. Negative inductor simulator is an important circuit and finds many applications such as in active filter design, oscillator design, analogue phase shifters, impedance matching in microwave circuits, to minimize reflection at the input of antenna, to compensate bond wire inductance and cancellation of undesirable inductance and others. In this article, circuits realizing both positive and inductor simulators are reported using an electronically-controlled ABB, namely the complimentary output, current-controlled, current conveyor transconductance amplifier.

The proposed circuit offers the following benefits:

- Minimum component count, compared to any of the previously reported floating inductor type circuits;
- Current tunability of the inductance by the means of the two bias currents of the ABB;
- The use of grounded capacitors makes the circuit suitable for monolithic integration, as grounded capacitor circuits can compensate for the stray capacitances at their nodes;
- There is no requirement for any component matching and cancellation constraints.

Proposed Circuits

The current-controlled current conveyor transconductance amplifier (CCCCTA) is the most recent addition to the list of current-controlled ABBs and has been proposed by Siripruchyanun et al (M. Siripruchyanun and W. Jaikla, *"Current Controlled Current Conveyor Transconductance Amplifier (CCCCTA): A Building Block for Analog Signal Processing"*, Electrical Engineering, vol. 90, pp. 443-453, 2008). In this article, a CCCCTA variant namely the complimentary-output CCCCTA or CO-CCCCTA has been used and it is ideally characterized by the following equations:

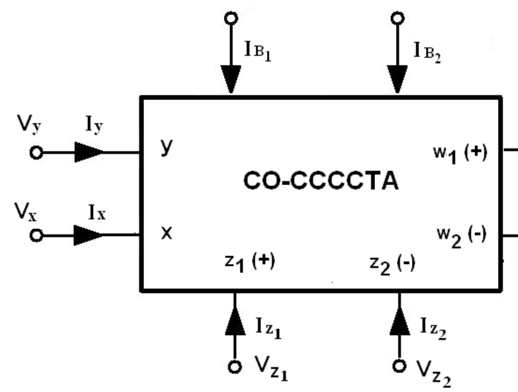

Figure 1a: *The circuit symbol of CO-CCCCTA*

$$I_y=0,\ V_x=V_y+I_xR_x,\ I_{z1}=-I_{z2}=I_x,\ I_{w1}=-I_{w2}=g_mV_{z1} \text{ and } I_w=-I_y \qquad \textbf{(1)}$$

In the above equation *Rx* represents the parasitic resistance at terminal x and is given by $R_x = \dfrac{V_T}{2I_{B1}}$, where V_T is the thermal voltage whose value is 26mV at 27°C and I_{B1} is a bias current. g_m represents the transconductance and is given as $g_m = \dfrac{I_{B2}}{2V_T}$ and I_{B2} is another bias current. The circuit symbol of CO-CCCCTA is shown in **Figure 1a** and its possible bipolar implementation is given in **Figure 1b**.

The ABB described here is used along with a grounded capacitor to create the floating positive and negative inductor simulators, as shown in **Figure 2a** and **2b**, respectively.

Using **Equation 1**, the short-circuit admittance matrix for the proposed floating positive inductor simulator can be obtained by:

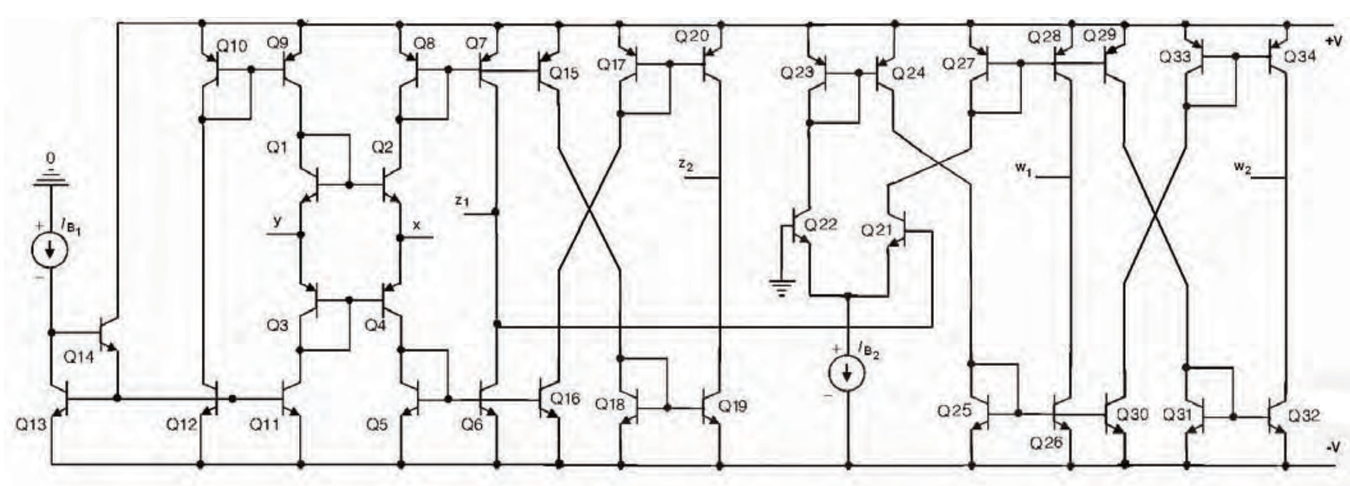

Figure 1b: *The CO-CCCCTA's possible bipolar implementation*

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = \frac{g_m}{sCR_x} \begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} \qquad (2)$$

For the floating negative inductor simulator the short-circuit admittance matrix is given by:

$$\begin{pmatrix} I_1 \\ I_2 \end{pmatrix} = -\frac{g_m}{sCR_x} \begin{pmatrix} 1 & -1 \\ -1 & 1 \end{pmatrix} \begin{pmatrix} V_1 \\ V_2 \end{pmatrix} \qquad (3)$$

Thus, the equivalent positive or negative inductance is given by: $L_{eq} = \pm \frac{sCR_x}{g_m} = \pm \frac{sCV_T^2}{I_{B1} I_{B2}}$, which is current-tunable by two bias currents. It should be pointed out that the equivalent inductance would vary with change in temperature. However, this should not be seen as a drawback, since the designer can control the inductance by means of the bias currents.

Also, when one of the voltages V_1 or V_2 is set to zero (grounded) and the other one is non-zero, the circuits in Figures 2a and 2b simulate a grounded positive and grounded negative inductor, respectively.

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Division of Electronics and Communications
University of Delhi
India

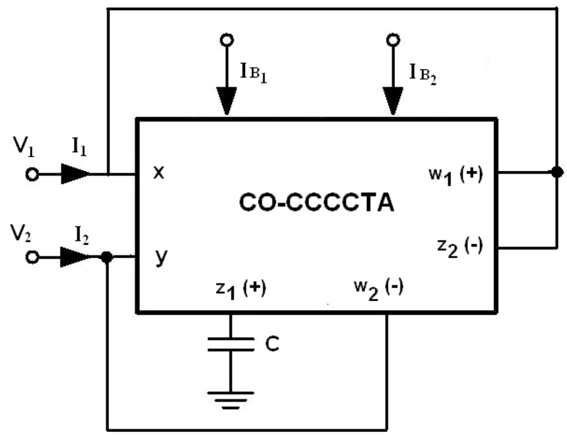

Figure 2a: *Floating positive inductor simulator*

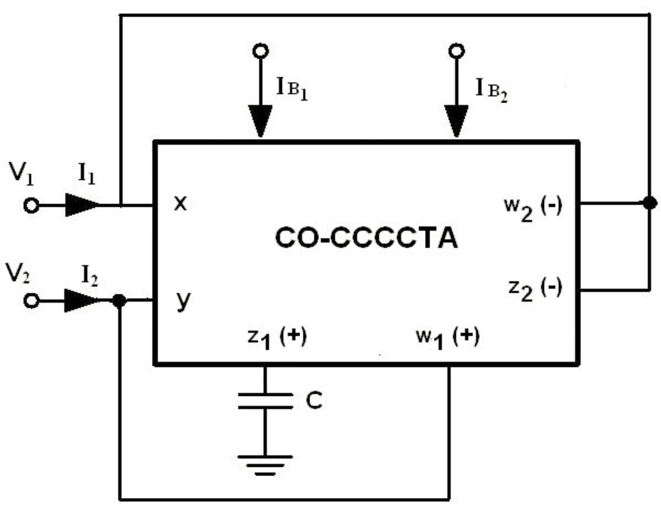

Figure 2b: *Floating negative inductor simulator*

TIP 1: MULTIFUNCTION WITH A SINGLE PUSH BUTTON

By Chris Gobok, Product Marketing Engineer, Linear Technology

IF YOU OWN a smart phone, including BlackBerry, Palm etc, personal digital assistant (PDA), laptop or PC, then you are probably already familiar with the multiple power functions that can be harnessed from a single button. These are just some examples where the main push button used to power on and off a device often incorporates additional functionality, usually a "standby" or "hibernation" mode, which puts the device in a power saving mode.

In a laptop, the standby mode cuts power to your hard drive and screen and stores your data in memory, keeping on the laptop essentials while you are temporarily away. In hibernation mode, your laptop completely shuts down, saving data to the hard drive instead of memory and makes for a safer but slower shutdown and resume process.

This Design Idea demonstrates how to use single channel push button controllers to design in power on/off functionality and secondary functions, like hibernation, into practically any electronic device where power conservation is crucial.

Figure 1 shows the typical application for a basic push-button controller. In a nutshell, the push button toggles an open drain Enable pin which, in turn, drives the system's DC/DC converter shutdown pin. The push button only needs to be pushed for 128ms in order to turn on the system, after which the Kill pin from the microprocessor is ignored for a 512ms blanking period to give the system sufficient time to power up.

To turn off the system, the push button needs to be pushed for at least a 32ms debounce time or the time set by the delay capacitor, COFFT, at which point the interrupt signals the microprocessor to perform any system housekeeping operations prior to shutdown. The microprocessor is given 128ms or the time set by the time-out capacitor, CKILLT, to perform its operations, but can pull the Kill pin early if it finishes its shutdown procedures sooner than the allotted time. As a failsafe feature, the Enable output will automatically release the DC/DC converter when the timer expires, thus forcing a system shutdown in the event of system fault conditions.

Figure 2 shows how to implement power on/off and hibernation functionality using a single push button and two push button controllers. The LTC2951 controls the on/off function as previously described by Figure 1. The LTC2954 is also an on/off

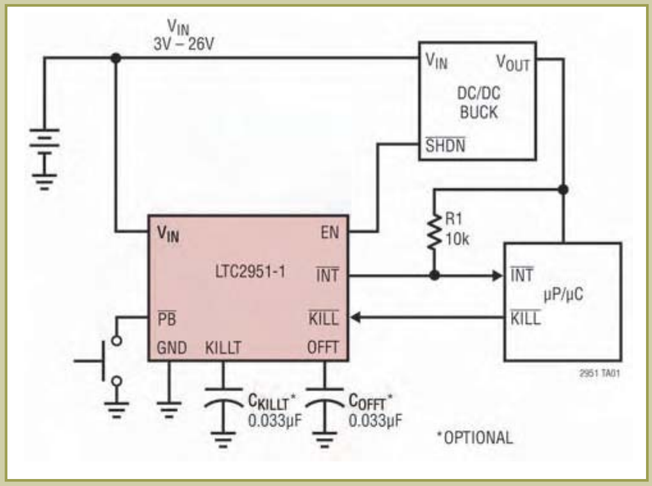

Figure 1: Typical push button controller application

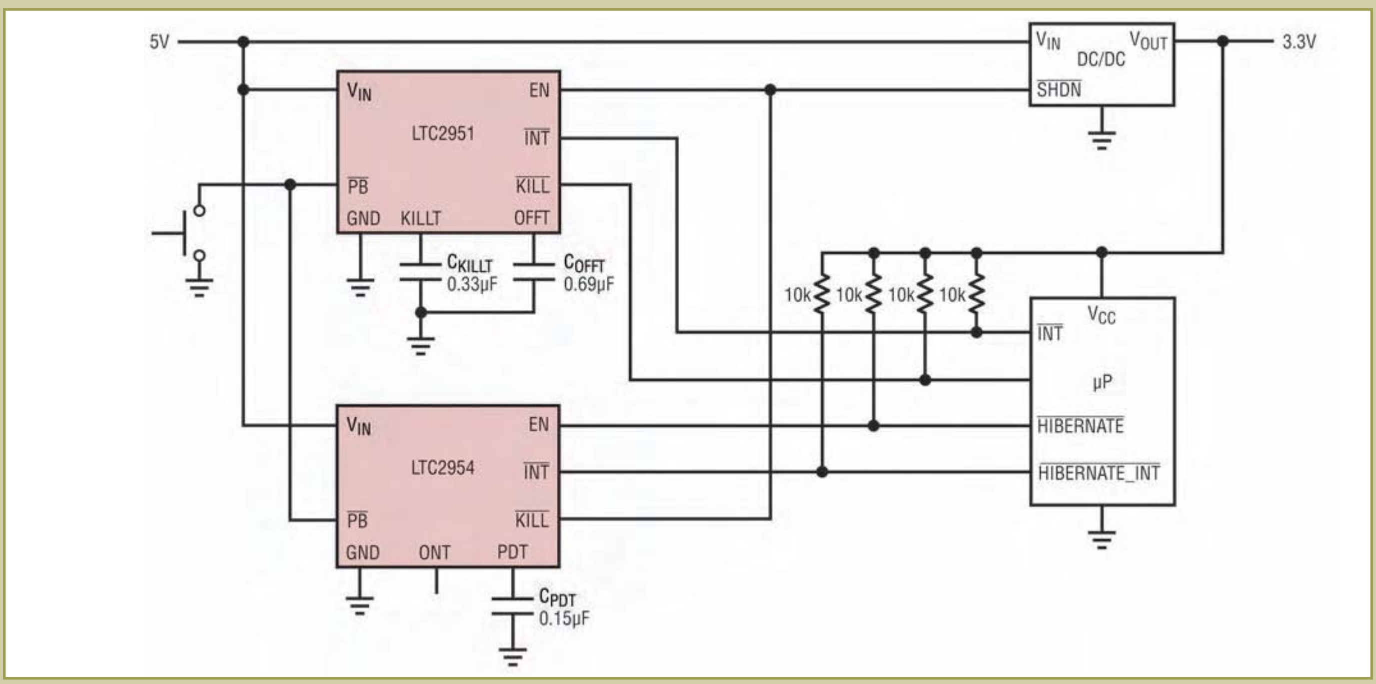

***Figure 2:** Two push-button controllers provide power on/off and hibernation functionality using a single push button*

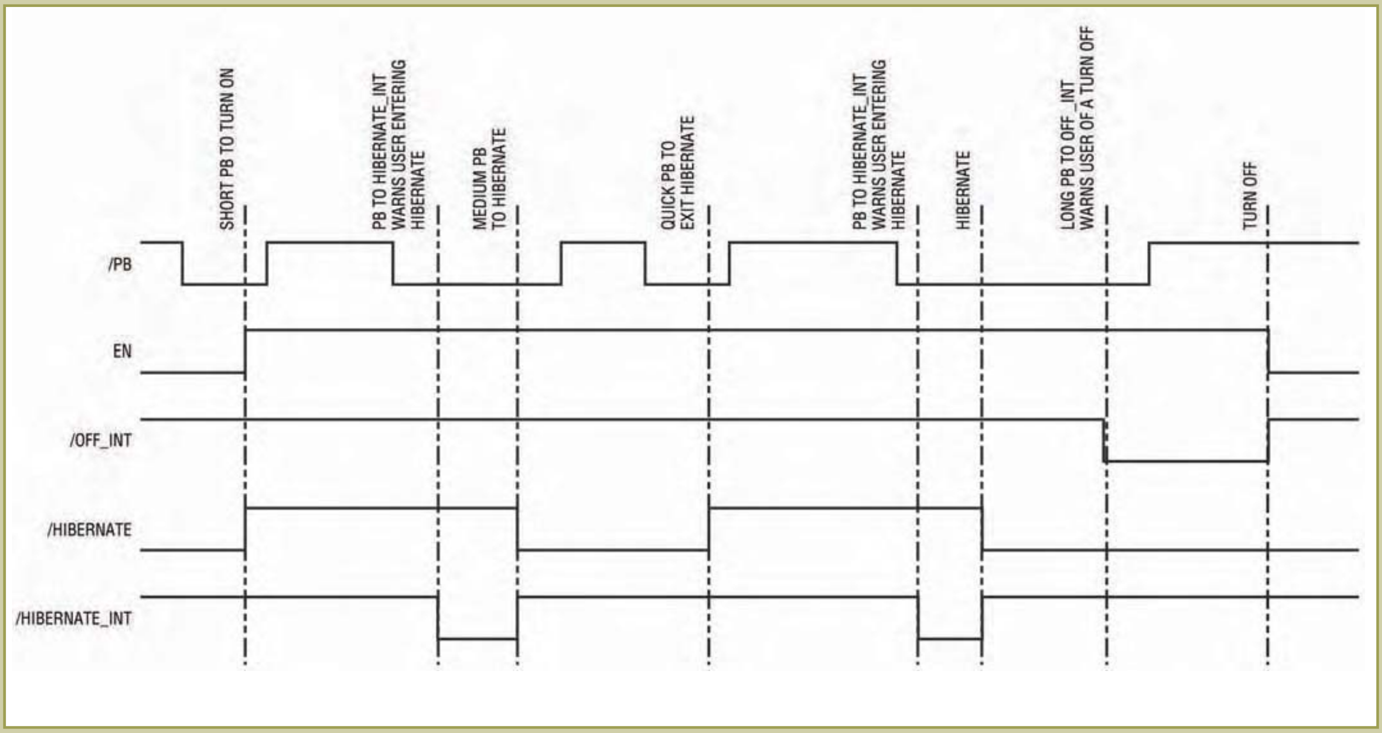

Figure 3: *Sample timing diagram for Figure 2*

Part	Function	Time	Set By
LTC2951	PB Turn On	128ms	Default
	PB Turn Off	4.4s	COFFT = 0.69µF
	Failsafe KILL	2.1s	CKILLT = 0.33µF
LTC2954	PB Turn On	128ms	Default
	PB Enter Hibernation	1s	CPDT = 0.15µF
	PB Exit Hibernation	32ms	Default

Table 1: *Functionality and push button specified timing for Figure 2*

controller, but is used here to generate a hibernation signal.

Although any of Linear Technology's push button controllers can be used to implement a second function, the LTC2954 was specifically chosen for its unique interrupt generation capabilities. Unlike the LTC2951 where a valid 32ms pulse, user-defined pulse or 128ms timer all inevitably result in system shutdown, the LTC2954 generates an interrupt after the 32ms debounce time but does not force a system shutdown, unless the push button is continuously held for an additional 32ms or a time set by the capacitor, CPDT. Otherwise, releasing the push button any time after the initial 32ms releases the interrupt pin and allows the microprocessor to continue its operations. This allows for the interrupt signal to request user intervention instead of forcing a system shutdown in menu driven applications, an especially handy feature in the case of accidental push button pushes.

In this particular application, after the LTC2951 turns on the system, the LTC2954 will determine whether a quick push of the push button generates a hibernation request or a longer pulse puts the system in hibernation.

The timing diagram in **Figure 3** exemplifies the following system events when using the circuit shown in Figure 2: Turn On → Enter Hibernation → Exit Hibernation → Enter Hibernation → Turn Off.

Note that external capacitor values were carefully chosen to define practical push button depression and delay times; see **Table 1** for summary. First, a "short" 128ms pulse sets the LTC2951 and LTC2954 Enable high, which would be used to turn on the system DC/DC converter and disable the hibernation signal respectively. Then, a "medium" 1s pulse triggers the LTC2954 to generate a hibernation interrupt request and a hibernate signal intended for the microcontroller to put the system into hibernation; a "quick" 32ms pulse exits this mode. Finally, to turn off the system, a "long" 4.4s pulse causes the LTC2951 to issue a 2.1s interrupt signal, followed by the enable pin pulling low; because the LTC2951 long pulse overlaps the LTC2954 medium pulse, the system goes into hibernation on its way to shutting down. ■


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Just to name a few!
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RS 666-4928
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KEITHLEY EXPANDS RANGE OF DC SOURCE-MEASURE INSTRUMENTS

Keithley Instruments has enhanced its popular ACS Basic Edition software, adding support for a broader line of source-measure (SMU) instrumentation. This broader choice of compatible instruments should prove especially useful in expanding the software's voltage and current limits available for testing solar cells, photovoltaic panels and discrete power semiconductors. ACS Basic Edition combines high-speed hardware control, device connectivity and data management into an easy-to-use tool optimized for part verification, debugging and analysis.

With the introduction of Version 1.1, ACS Basic Edition, a member of Keithley's Automated Characterization Suite (ACS) family, now the support is for a far broader range of DC voltage and current test capabilities. It's compatible with the company's full SMU offering, the broadest array of choices in the industry.

Depending on the SMU selected, ACS Basic Edition supports sourcing and measuring up to 5A or 1100V DC on individual channels. The newly expanded source and measure ranges are especially useful for tests on evolving photovoltaic panels/solar cells and high power electronics in research, failure analysis and inspection applications. ACS Basic Edition now also supports combining different SMU models into a single test, allowing easier configuration, test creation and test execution – with no need to write code.

www.keithley.com

LECROY ANNOUNCES INDUSTRY-FIRST SINGLE-SOURCE COMPREHENSIVE SUPERSPEED USB TEST SUITE

LeCroy has announced the launch of the industry's first single-source line-up of test instruments to comprehensively support the USB (Universal Serial Bus) 3.0 standard, also known as SuperSpeed USB. The LeCroy USB 3.0 Test Suite is an integrated selection of test instruments that addresses all transmitter, receiver, TDR and protocol tests currently defined in the Universal Serial Bus 3.0 specification.

This product line includes: the SDA 813Zi oscilloscope for physical layer transmitter verification, compliance and debug; the protocol-enabled receiver and transmitter tolerance tester, PeRT for receiver testing; the WaveExpert sampling oscilloscope for critical characterization and TDR measurements; and the world's first USB 3.0 protocol analyzer exerciser platform, the Voyager verification system, addresses the protocol layer. Automated easy-to-use QualiPHY physical layer compliance software and USB 3.0 test fixtures are included for rapid debugging and unmatched accuracy as well as full compliance testing.

The LeCroy's PeRT tool that can manage issues such as the insertion or deletion of SKP symbols without losing lock during automated testing programs and correctly measure BER (bit error rate). Because the PeRT combines the functions and features of a signal generator, bit error rate tester (BERT), protocol editor and serial data analysis system into one instrument, it is able to fully characterize the receiver tolerance envelope through the controlled introduction of various types and levels of signal stress (e.g. increased jitter) while monitoring signal integrity.

www.lecroy.co.uk

DSP UNIT DELIVERS REAL-TIME TURBINE BLADE TIP CONDITION MONITORING

Monitran Technology, the R&D arm of vibration and displacement sensor OEM Monitran, has developed a digital signal processing (DSP) unit for the real-time monitoring of turbine blade conditions.

The unit reflects 'live' blade health by providing traffic-light-type indicators: green for safe, amber for advisory and red for danger. Also, for each condition, there is a programmable output capable of switching up to 30V at 5A, which means the unit can be easily integrated into control circuitry and to provide an automatic shut-down of the turbine if necessary.

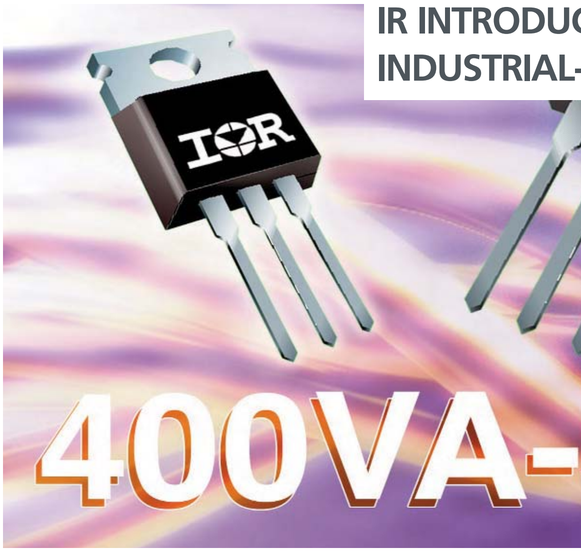
Up until now, turbine blade health monitoring has required the capture of data, often with the turbine off-line, and then extensive and time-consuming data analysis. The Monitran DSP unit affords real-time, in situ data analysis, allowing plant owners and other users of turbines to adopt predictive maintenance strategies, and to operate more cost-effectively.

The unit has four channels, each intended for use with an eddy current probe and suitable trigger circuitry, and processes data relating to blade-tip-to-casing clearance and by recognising any blade-to-blade lead or lag issues.

The use of all four channels supports the placement of sensors at approximately 90 degree intervals around the turbine's casing.

www.monitrantechnology.com

IR INTRODUCES BENCHMARK INDUSTRIAL-GRADE 30V MOSFETS



International Rectifier has released a series of industrial-qualified 30V TO-220 HEXFET power MOSFETs with extremely low gate charge (Qg) for applications, including Uninterruptable Power Supply (UPS) inverters, low voltage power tools, ORing applications and netcom and server power supplies.

The robust MOSFETs feature IR's latest generation Trench technology and offer very low on-state resistance, RDS(on), to reduce thermal dissipation. In addition, the new devices' ultra low gate charge helps extend battery life of UPS inverters or power tools.

Featuring fully characterized avalanche voltage and current, these MOSFETs are direct replacements and upgrades to existing 30V TO-220 devices as IR continues to develop benchmark MOSFETs.

The devices are qualified to industrial grade and moisture sensitivity level 1 (MSL1). The 30V MOSFETs are available in a TO-220 package, are offered lead free and are RoHS compliant.

www.irf.com

SCHROFF DEVELOPS NEW RETENTION DEVICE TO MEET RUGGED MICROTCA REQUIREMENTS

Electronics packaging specialist Schroff has developed a new retention device for securely fastening AdvancedMC modules into a MicroTCA subrack to enable such systems to withstand the extreme shock and vibration conditions laid down in the recently issued MicroTCA.1 specification.

The MicroTCA open computing architecture was originally conceived by the PICMG consortium for use in telecoms applications. To make it viable for other sectors such as defence, transportation and industrial automation, PICMG is now in the process of drawing up three 'Rugged MicroTCA' sub-specifications.

The first of these, MicroTCA.1 (Air Cooled Rugged MicroTCA), was adopted in the spring of 2009 and increases the shock and vibration performance requirements for MicroTCA systems from IEC 61587-1 level DL1 to level DL3.

In practice, this means that systems must now be able to withstand peak acceleration rates of 25g in shock testing and 3g in vibration testing – figures that are several times higher than those in the original MicroTCA.0 specification.

Schroff has achieved the required performance by extending the AdvancedMC module faceplate to provide flanges at the top and bottom and by using the new retention device to fasten the module to the MicroTCA subrack.

In essence, the retention device is a screw locking mechanism that has been specially designed to be tightened without transferring any force to the connector on the MicroTCA backplane.

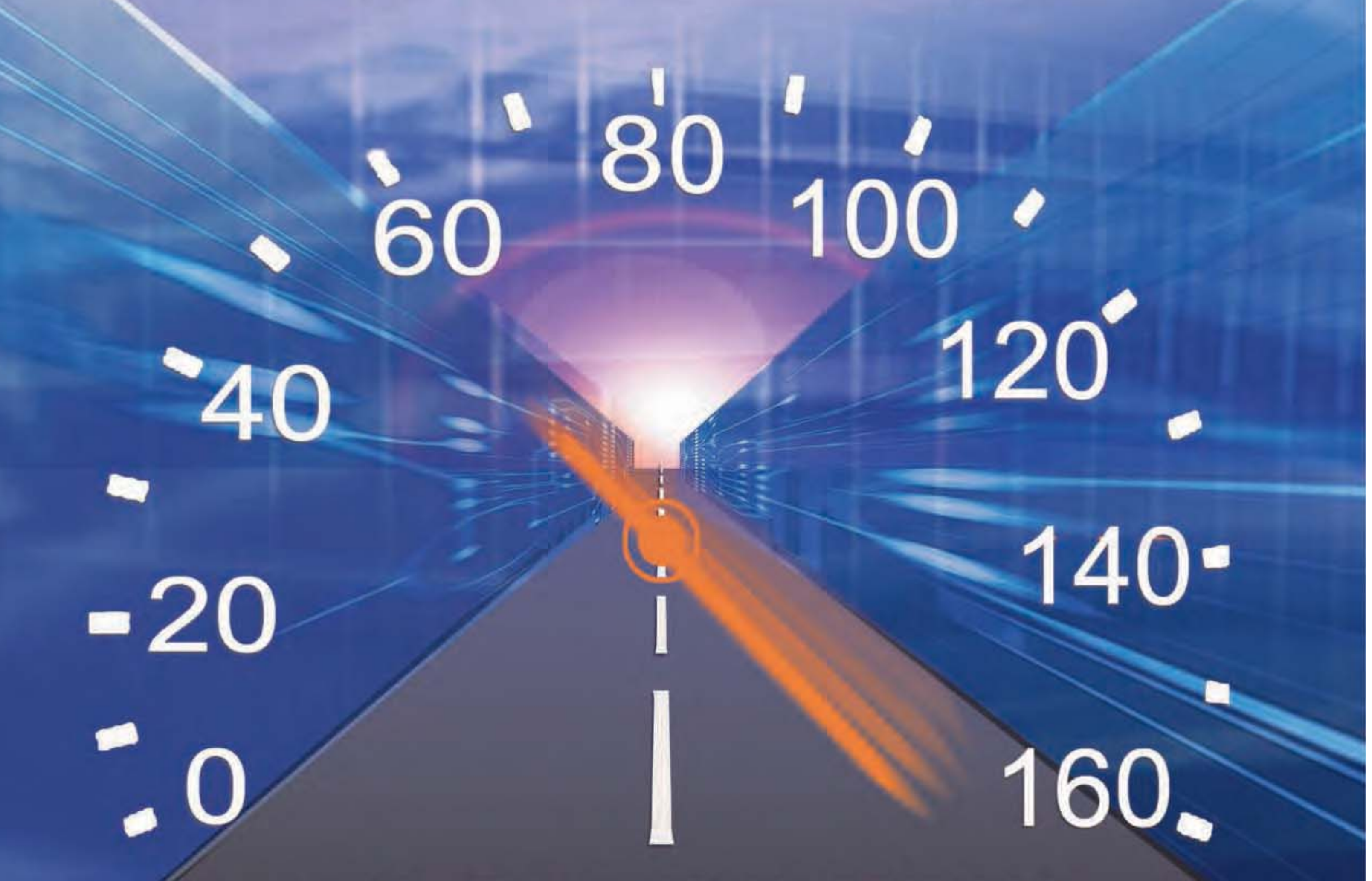
www.schroff.co.uk

LED ILLUMINATION FOR SWITCH/ CIRCUIT BREAKER OFFERS POWER SAVING

E-T-A Circuit Breakers, quality designer and manufacturer of a broad range of electro-mechanical and electronic products for circuit protection, has introduced a new variant of its extremely versatile and reliable 3120 Series of rocker-actuated, combined switch/circuit breakers. The optional integral LED illumination in a range of colours, is now available on the Type 3120 and offers power saving and improved endurance compared to earlier versions with filament bulbs. The well-proven 3120 is used widely for applications which include electrical machinery, power tools, household appliances and garden machinery, as well as for marine control panels, medical equipment and communications systems.

The versatile S-type E-T-A 3120 thermal circuit breaker range is designed for frequent ON/OFF switching under normal load conditions, at the same time providing accurate overcurrent protection with a trip-free mechanism. The illumination is offered in a choice of red, yellow, green and blue. The 3120 is suitable for switching applications up to 50V DC or 240/415V AC with a choice of current ratings from 0.1A up to 20A for single or double-pole applications. Designed for snap-in frame mounting, it can be specified with a water splash protection cover for rugged environments, and an actuator guard that protects against inadvertent resets.

www.e-t-a.co.uk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