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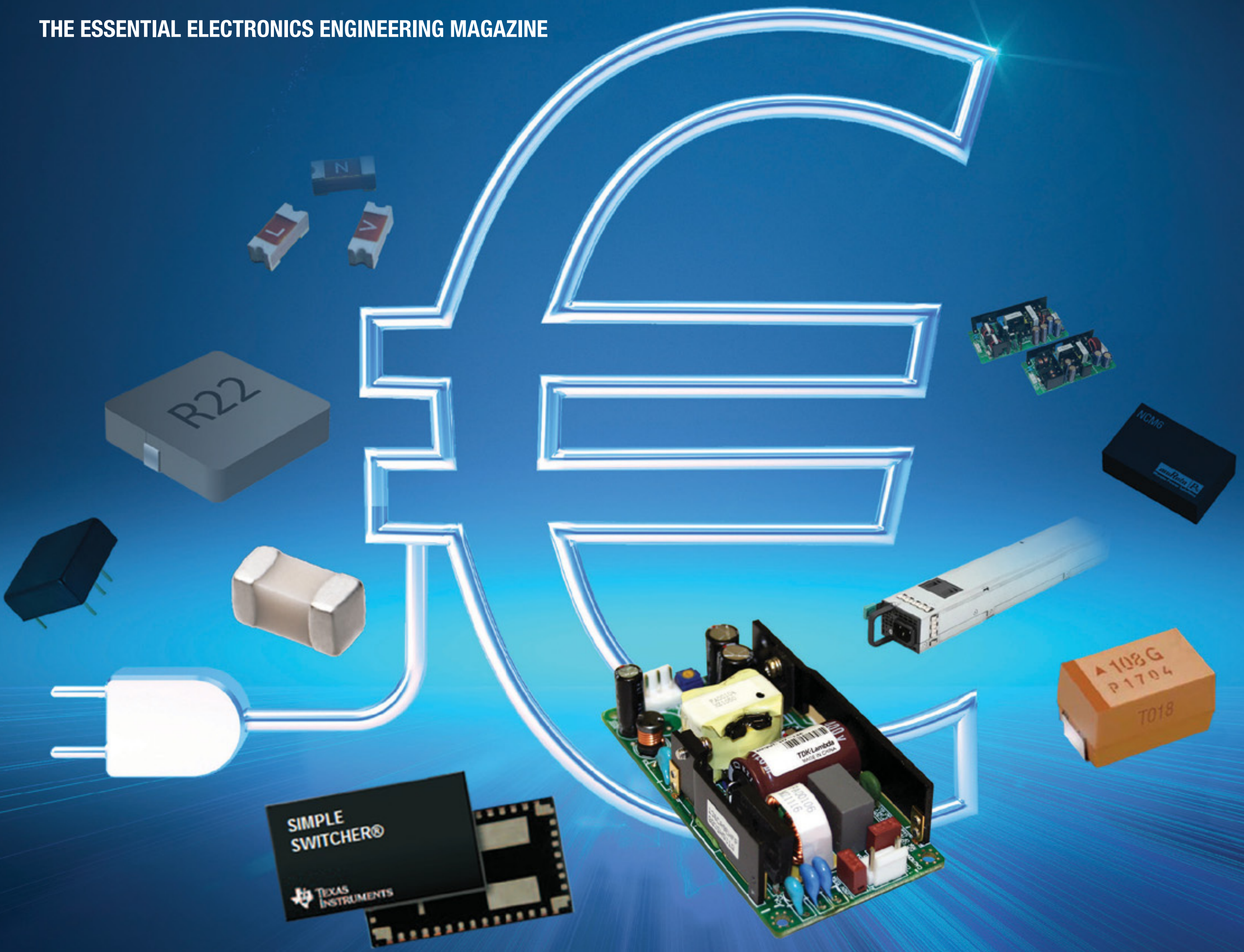
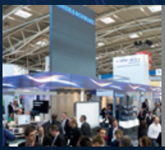
THE ESSENTIAL ELECTRONICS ENGINEERING MAGAZINE



Resources narrow the MAKE-OR-BUY DECISION

Special Report
Medical electronics

Special Report
Power matters



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'Electronica' and 'Strategies in Light Europe 2014' previews


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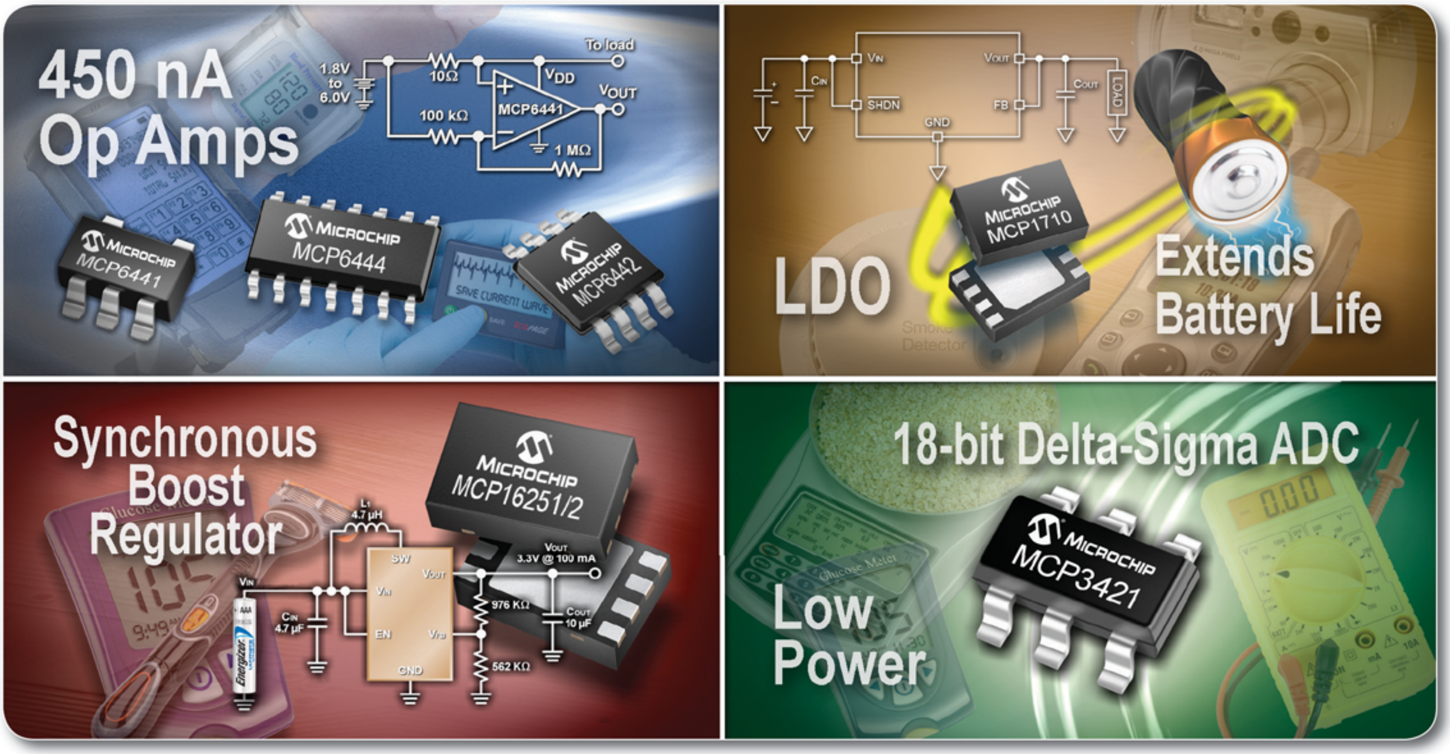
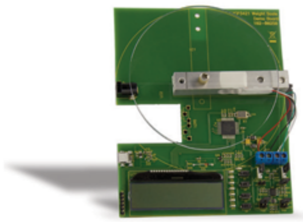

450 nA Op Amps
1.8V to 6.0V
10Ω
100 kΩ
MCP6441
VDD
VOUT
To load
1 MΩ
MICROCHIP MCP6441
MICROCHIP MCP6444
MICROCHIP MCP6442
LDO
VIN
CIN
SHDN
GND
VOUT
FB
COUT
LOAD
MICROCHIP MCP1710
Extends Battery Life
Synchronous Boost Regulator
L1 4.7 µH
VIN
CIN 4.7 µF
SW
VOUT
EN
VFB
GND
VOUT 3.3V @ 100 mA
976 KΩ
562 KΩ
COUT 10 µF
MICROCHIP MCP16251/2
18-bit Delta-Sigma ADC
MICROCHIP MCP3421
Low Power



SMALL DATA WILL CHANGE OUR WORLD

> The biggest impact of Small Data is expected to be on the semiconductor industry which can look forward to a new period of growth

Big Data is about the Internet of People (IoP): various devices are connected to the Internet and tracked to provide information regarding how, when and where they are used.

In comparison, Small Data is generated by the Internet of Things (IoT), which relies on sensors to collect it. Small Data will be processed by sophisticated algorithms; it'll be combined, analyzed, interpreted and sent back to the microcontrollers in that same environment for action determined by the algorithms.

The Small Data world is expected to be many times larger in complexity and number of devices than the Big Data world. Many are predicting that Small Data is the opportunity that will fuel the Information Technology (IT) industry for the coming two decades.

Sentrollers

Sentrollers (sensor, actuators and controllers) are the devices that monitor and control our environment, homes, cars, offices, cities and so on. There will be billions of them, continuously collecting, generating and distributing enormous amount of data.

Small Data – gathered from all aspects of your life – will help marketeers to better target you and your family with advertising and marketing pitches that are customized for your lifestyle. Even knowing what your house is 'doing' when you are not in it will help advertisers become more efficient with their campaigns.

Earlier this year, Small Data arrived with a bang when Google acquired a company called Nest and its sophisticated thermostats. The acquisition was strategic, as Google wants to gather Small Data in people's homes. It demonstrates that in our evolving and ever more connected world, there is not a single place that will not be touched by innovation and changing business models.

The Size Of Small Data

A home can easily have 100 or more Small Data sensor-based devices, ranging from temperature to motion sensors, lighting, remote monitoring and so on. This means in the coming years there is a potential hardware market of 60 billion Small Data devices. Each device will probably cost less than $10, and over time every home can become "smart" for less than $1,000, establishing a $600bn market for the hardware sentroller devices alone. For many, these devices will probably be subsidized by subscriptions – comparable with today's smartphone services. Operators across the world are currently testing various business models to offer such Smart Home services.

New concepts and horizons usually send shockwaves through any industry and the arrival of Big Data was no different. It has already extinguished many companies (who remembers 3Com?), seen the merging of others (i.e. Alcatel-Lucent) and has driven many to reinvent themselves (such as Microsoft, for example) as well as grow (like Google). So it is no surprise that the arrival of Small Data is both an opportunity and a threat, and is accelerating strategic activities in many large companies.

The impact of Small Data on the software and service industry will be mostly on pattern recognition, artificial intelligence and, from there, to predicting behaviour. At the same time, more demands will be placed on security and protecting privacy, while maintaining ease of installation and use.

Small Data's impact on the hardware industry may be even bigger. Both, the number of personal, wearable devices and smart-home devices required for providing Small Data information will balloon. The biggest impact is expected to be on the semiconductor industry which can look forward to a new period of growth, in particular around low-power embedded microcontrollers and radio communication devices, as well as sensor technologies. Each sentroller combines one or more of these technologies.

Over the next decade, the demand for these devices will grow exponentially, comparable to the growth of the laptop industry 15 years ago, or the smartphone industry in the last few years.

By Cees Links, Founder and CEO of GreenPeak, an RF communication technology provider (www.greenpeak.com)

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RECORD NUMBER OF STUDENTS ATTEND UK ELECTRONICS SKILLS FOUNDATION SUMMER SCHOOL

The fourth annual UK Electronics Skills Foundation (UKESF) summer school, hosted by the University of Southampton from the 7th to the 11th July, turned out to be the biggest ever.

Summer schools are trying to address the decline in UK electrical and electronic engineering (EEE) degree applications by offering prospective students first-hand electronics experience.

"The UK electronics industry is estimated to contribute £78bn to the economy with the potential to grow and generate 150,000 new and highly-skilled jobs by 2020," said Indro Mukerjee, chairman of the UKESF strategic advisory board. "To nourish this growth, we need more young people to aspire to careers in this sector, but of great concern at the moment is the decline in UK university applicants for electronics, [so] I am delighted that our summer schools are proving so popular and hope they will ignite the enthusiasm of future electronics engineers."

Record number of pupils are interested in engineering careers, says UKESF

Although there has been a significant rise in demand for engineering and technology courses since 2002, there's been a 26% drop in British applicants to EEE courses between 2002 and 2013. UKESF has responded by creating a programme of summer schools to introduce pupils to degrees and careers in electronics. The programme also includes a scholarship scheme, linking students with employers for sponsorship and work experience; since UKESF was launched in 2010, 174 students have been awarded UKESF scholarships by 21 companies.

This year some 80 students from 77 schools across the UK participated in the UKESF summer school, twice as many as the inaugural course in 2011.

The event was sponsored by well-known engineering companies such as ARM, CSR, Dialog Semiconductor, Imagination Technologies, Jaguar Land Rover and Thales.

"At Imagination [Technologies] we are committed to developing the electronics skills of UK youth. By sponsoring UKESF we get early access to the brightest and best students. The summer school is integral to this and gives us the opportunity to promote our company and the industry as a whole, while identifying and nurturing talent early, which is very important to us," said Tony King-Smith, EVP Marketing at Imagination Technologies.

LONDON CO-INVESTMENT FUND AIMS TO HELP TECH START-UPS

The London Co-Investment Fund (LCIF) is looking for venture capital (VC) firms and angel syndicates with experience of investing in early-stage digital, science and technology companies, preferably in London, to apply to the fund. It already has an initial £25m from the Mayor of London and the London Enterprise Panel's "Growing Places Fund" to address the funding gap in London faced by tech start-ups seeking to raise seed investment.

The businesses the fund is seeking to support will emerge from accelerators, incubators and support programmes and looking to raise between £250,000 and £1m, currently the largest gap in the market for investment. The fund plans to co-invest alongside up to eight competitively selected players in the early-stage investment community, into these new companies that are ready to accelerate growth and create jobs in the capital.

"The persistence of the funding gap at the very early stage of a business life is well documented, yet it is these businesses that represent the future of London's global economic potential," said Maggie Rodriguez-Piza, Chief Executive of Funding London, formerly known as SME Wholesale Finance (London) Limited, which leads and manages the fund.

The LCIF aims to incentivise and enable VC funds to invest in smaller funding rounds at an earlier stage of the business growth path than their business models presently, permitting business angels and other early-stage investors to join investments in larger funding rounds in businesses with demonstrable growth potential.

LCIF expects to begin investing toward the end of 2014, helping up to 210 early-stage businesses over the next three years.

EXCELLENT RESOURCES NARROW THE MAKE-OR-BUY DECISION FOR POWER SUPPLIES

by Landa Culbertson, Contributing Author, Mouser Electronics

In today's energy conscious, high tech environment - the performance of the power supply, historically disregarded as just a basic necessity, has arguably taken center stage. Consider for example, the U.S. Department of Energy's $37.7 Million USD investment in an ARPA-E program that seeks to increase energy efficiency of power conversion systems and enable high efficiency, high power density power electronics across all applications from consumer, mobile, and computing to wireless infrastructure, lighting, industrial, and automotive. The effort is driven by the department's assessment that by 2030, 80% of the country's electricity could flow through power converters, as compared to just 30% in 2005.

In the not too distant past, it was generally an automatic decision to choose to purchase a ready-made power supply over designing one at the component level when given the choice. However, as the importance of the power supply has risen in recent years, amazing tools and resources from semiconductor suppliers have become available to support component-level power supply designers seeking to differentiate their end product based on power technology. These same assets can aid the designer tasked with unique requirements that would not be met by off-the-shelf products. It is now more worthwhile than ever to spend the time to carefully evaluate the make versus buy decision for power supplies.

Why Buy?

Purchased power supplies provide the following great advantages:

- **Lower cost:** The component bill of materials (BOM) of a power supply is high compared with buying a complete off-the-shelf product due to volume manufacturing. For example, the BOM of a 30-amp 5-volt power supply is about 5 times the cost of purchasing a commercial power supply.
- **Time to market:** You can get to market faster by saving development time and applying resources to your core competencies instead.
- **Safety and regulatory compliance certifications:** Off-the-shelf power supplies remove the expense, time, and challenge associated with seeking agency approvals. Regulations are also subject to change, and a purchased power supply is guaranteed to meet standards at the time of purchase. Some approvals to consider are –
    - Worldwide Electrical Safety Standards
    - Worldwide EMC/EMI Standards
    - Global Power Consumption and Efficiency Regulations for External Power Supplies and Battery Chargers
    - Application-Specific Certifications such as Medical and ITE Certification
- **Quality and Reliability:** Commercial power supplies have been rigorously tested over line, load, temperature, shock, and vibration specifications. Some products are even backed by extended warranties.
- **Second sourcing:** By choosing products offered in industry-standard form factors such as quarter-brick, half-brick, and full-brick, you can realize the benefits of having alternate sources.

Commercial power supplies are readily available. TDK-Lambda, with 36 years of experience, is one notable provider. The company takes pride in offering an extensive collection of highly reliable products, including the ZWS-BP Series of 150W – 240W compact, lightweight, high efficiency, open frame, AC-DC power supplies. Offering 200% peak power capability (280W – 480W), this series meets global safety standards for a universal input (85-265VAC) and less than 0.5mA earth leakage current, meets EMC/EMI standards including power factor correction requirements, and comes with a 5 year warranty. The TDK-Lambda portfolio also includes the MWS65 Series of 55-67W AC-DC power supplies with Medical and ITE certifications including BF (Body Floating) rating for applications where the equipment may come in direct contact with the patient, such as blood pressure monitors and ultrasound equipment. For DC-DC applications, TDK-Lambda recently introduced the PH-A280 Series of converters for 50W, 75W, 100W, and 150W output power levels from a 200 to 425VDC input. These devices come in industry standard quarter-brick modules and are ideal for liquid, air cooled, and conduction cooled systems given their wide temperature range of -40 to 100°C. The series is also backed by a 5 year warranty.

For DC-DC, make sure to also take a look at Murata Power Solutions Murata Power Solutions, currently the world's largest supplier of DC-DC converter modules. The NCM6 Series of isolated 6W single and dual output DC-DC converters, the SPM15 Series of isolated 15W DC-DC converters, and the SPM25 Series of isolated 25W DC-DC converters are amongst the company's latest introductions. All of these products feature small footprints for board mounting. NCM6 is encapsulated for superior thermal performance, and SPM15/25 are potted in a metal can for low electromagnetic interference emission, protection from harsh environments such as high humidity, and resistance to mechanical stresses such as vibration and shock.

Making Your Own Power Supply is Easier than Ever Before

Here are some of the latest design tools and resources available to assist both expert and new power supply designers:

Texas Instruments

- **PowerLab™ Reference Design Library:** Use the online PowerLab™ Power Reference Designs Selection Tool to input your design criteria including AC or DC input, isolated or non-isolated, input and output voltage ranges, and output current, as well as other advanced search criteria such as application or topology to search TI's database of over 1200 reference designs. These are designs that have actually been built and tested by

TI, and have downloadable documentation including circuit schematic, printed circuit board (PCB) layout, BOM, test report, and gerber files.

- **Power Stage Designer™ 2.1:** This online tool helps you to design the power stage of the most commonly used switchmode power supplies. Choose the topology (buck, boost, flyback, etc) and input your design criteria, and the tool will show you the recommended values for the inductor/and or transformer as well as provide helpful insight on the duty cycle, input power, losses on the diodes, current ripple, and more.
- **WEBENCH® Power Designer:** End-to-end power supply design is really just a matter of clicks using this online design and simulation tool. Simply input your design requirements, select your optimization preference from high efficiency, small footprint, to low BOM cost, and the tool will return your design options for module, integrated, and controller-based solutions. From there, select one or more designs to electrically and thermally simulate, as well as optimize components. Finally, export your schematic and layout to popular CAD formats for hardware prototyping.

Maxim Integrated

- **EE-Sim Design Generation and Simulation Tool:** Maxim's online tool allows you to input your design requirements, change from default to preferred components, and simulate your design. Use the checkout feature to see the availability of components and pricing at your favorite distributor, including Mouser. Save or print your schematic and BOM.

International Rectifier

- **SupIRBuck® Design Tool:** IR's online DC-DC design tool takes basic parameters and any special requirements entered by the user and generates solution recommendations from which the user chooses the best fit for the application. The tool produces a detailed schematic and BOM, with the ability to fine tune. Features include a full AC analysis, modeling of key voltage and current waveforms, transient performance modeling, re-arranging of component layout, a detailed thermal analysis, and power dissipation analysis.

Fairchild Semiconductor

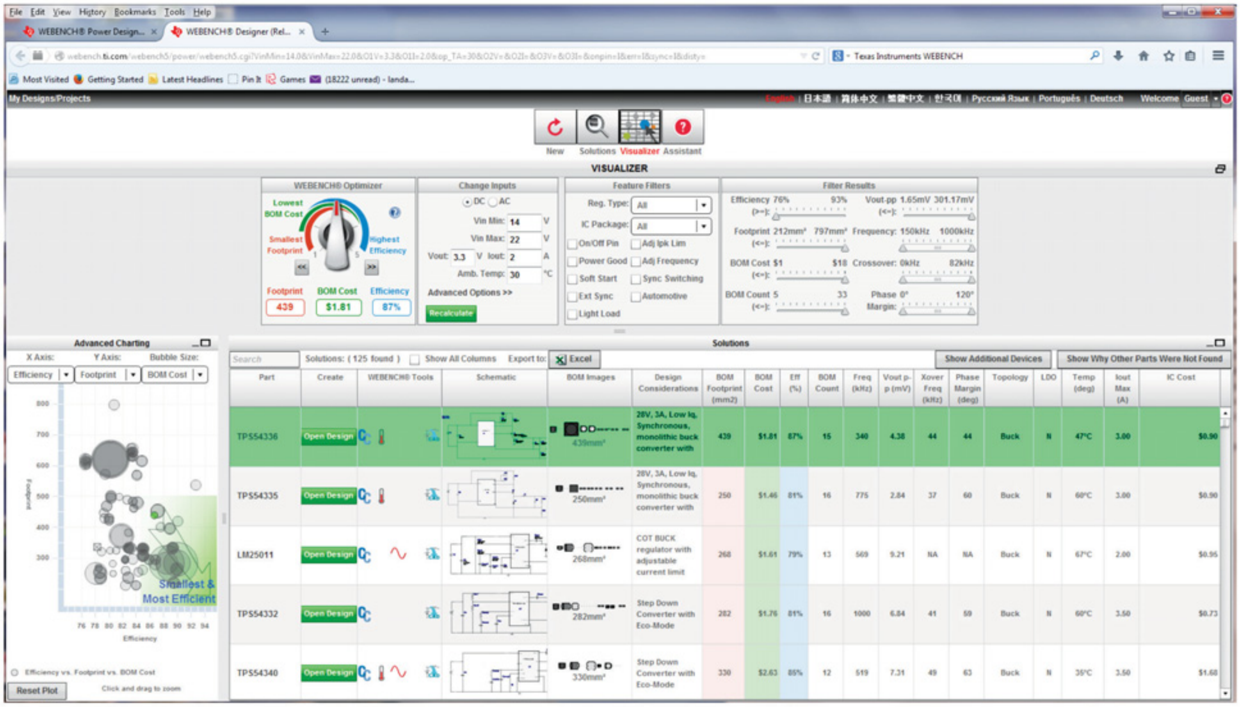
- **Power Supply WebDesigner:** Topologies supported by Fairchild's online power supply design tool include primary-side regulated flyback converters, secondary-side regulated flyback converters, switch-mode power supplies, AC-DC off-line power supplies, isolated buck-boost converters, forward isolated buck converters, and DC-DC isolated converters. Just enter basic design requirements or use the tool to optimize parameters. The tool enables you to analyze and simulate the design and then automatically generates a schematic and BOM.

On Semiconductor

- **GreenPoint® Design Tool:** The GreenPoint online design simulation tool from On is currently dedicated to LED Lighting drivers in AC-DC, DC-DC, or linear applications.

Though power supply design should always be undertaken with care and is still considered an art by many seasoned designers, given the new tools and resources available now, making your own supply is easier to achieve than ever before. Whether you ultimately decide to make or buy, Mouser is here to help. Mouser carries products from over 600 suppliers to enable you during the evaluation and development process.

www.mouser.com



Footprint 439 | BOM Cost $1.81 | Efficiency 87%

● DC ○ AC

Vin Min: 14 V

Vin Max: 22 V

Vout: 3.3 V Iout: 2 A

Amb. Temp: 30 °C

Reg. Type: All

IC Package: All

☐ On/Off Pin ☐ Adj Ipk Lim

☐ Power Good ☐ Adj Frequency

☐ Soft Start ☐ Sync Switching

☐ Ext Sync ☐ Automotive

☐ Light Load

Efficiency 76% 93% (>=):

Vout-pp 1.65mV 301.17mV (<=):

Footprint 212mm² 797mm² (<=):

Frequency: 150kHz 1000kHz

BOM Cost $1 $18 (<=):

Crossover: 0kHz 82kHz

BOM Count 5 33 (<=):

Phase Margin: 0° 120°

Search | Solutions: (125 found) ☐ Show All Columns | Export to: Excel

Part	Design Considerations	BOM Footprint (mm2)	BOM Cost	Eff (%)	BOM Count	Freq (kHz)	Vout p-p (mV)	Xover Freq (kHz)	Phase Margin (deg)	Topology	LDO	Temp (deg)	Iout Max (A)	IC Cost
TPS54336	28V, 3A, Low Iq, Synchronous, monolithic buck converter with	439	$1.81	87%	15	340	4.38	44	44	Buck	N	47°C	3.00	$0.90
TPS54335	28V, 3A, Low Iq, Synchronous, monolithic buck converter with	250	$1.46	81%	16	775	2.84	37	60	Buck	N	60°C	3.00	$0.90
LM25011	COT BUCK regulator with adjustable current limit	268	$1.61	79%	13	569	9.21	NA	NA	Buck	N	67°C	2.00	$0.95
TPS54332	Step Down Converter with Eco-Mode	282	$1.76	81%	16	1000	6.84	41	59	Buck	N	60°C	3.50	$0.73
TPS54340	Step Down Converter with Eco-Mode	330	$2.63	85%	12	519	7.31	49	63	Buck	N	35°C	3.50	$1.68

BOM Images: 439mm², 250mm², 268mm², 282mm², 330mm²

Screenshot of TI's WEBENCH Power Designer tool

Experiments With A UART

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

While low-power radio devices can be used to transmit a wide variety of signals – practically anything that you can express as a waveform – a large proportion of commonly seen applications are simple data links. A discrete packet of digital information, or a constant stream of serial data, is coded into a form compatible with the noisy, AC-coupled baseband path of the radio hardware, transmitted and then decoded again at the receive end. The available range of techniques to code a raw bit-stream into something “radio-friendly” is large. They vary from simple NRZ variants, through biphase codes, to multi-level bandwidth-efficient methods such as duobinary or 4FSK.

I’ve spent a great deal of time in my past implementing just such schemes. The one method I have always avoided however – and frequently argued against with some vigour – is asynchronous coding. Frequently this is the simplest technique of all, as it barely “codes” the data at the bit-level at all, consisting of simply connecting UART output and input to the transmitter and receiver digital ports respectively, and dealing with DC balance issues by coding the data at the byte level.

Asynchronous serial interfaces should be familiar to any engineer who has ever looked at data communications. This is the coding scheme used in the ubiquitous RS232 interface and which can claim ancestry back to the very earliest teletype installations.

It is a very simple system. Data is sent in NRZ form in discrete words (often 8-bit bytes, but not universally so). Each word is preceded with a start bit (a zero) and followed by one or more stop bits (ones, the same state as the idle condition for the signal medium). The method of decoding an individual byte is just as simple: the interface detects the leading (falling) edge of the start bit, uses this to set its bit clock and then samples-in the rest of the data word. The stop bit is frequently tested (to confirm that the correct “framing” of the word has been achieved), then the received data is outputted by the interface and the wait for the next start bit begins.

All very simple, but apparently useless for a radio link. The receiver is inherently edge-detecting (and so would be highly susceptible to poor S/N ratios, resulting in inferior range) and is unable to regain lost framing in a continuous stream of data words (where the stop bit of one word is immediately followed by the start bit of the next). Added to this, the data is simply NRZ and so can exhibit a high degree of DC imbalance (runs of up to nine continuous zeros or ones are possible), unsuitable to an AC-coupled baseband path. On the other hand, it is not unknown for customers to successfully use simple asynchronous data-streams over ISM-band radio links, so I resolved to investigate the performance of such a setup.

Before any meaningful experimentation can commence, it is necessary to somewhat “tame” the asynchronous data stream, to render it usable over a radio’s baseband link:

- **DC balance.** If an asynchronous data-stream is arranged to be continuous (no delay between stop bit and following start bit), then the effective “waveform” presented by the data can be controlled. The start (zero) and stop (one) bits are fixed but the data portion (which from now on I’ll assume will be 8 bits, as this is by far the most common arrangement) can be coded to ensure an equal number of ones and zeros. The easiest method is to follow each data bit with its inverse, but this reduces the data to a very inefficient four bits per word. A more sophisticated method (coding six bits into every byte and having a bandwidth efficiency equal to biphase) is detailed in the box on the next page.
- **Preamble.** It is essential at the start of a burst to allow the transmitter to key up and the receiver circuits to settle. To allow this, a simple sequence of ones and zeros is sent, before the data burst commences. This can be produced by sending multiple 0x55 bytes.
- **Framing.** In an asynchronous data stream, the UART uses the start bit to acquire timing for the rest of the word. In the preamble there is no way of determining where the start bit is in the uniform 010101 (etc) bit sequence. For this reason a pair of UART sync-up bytes (a 0xFF followed by a 0x00) are used to give the interface a clearly identifiable start-bit at the beginning of the burst. To provide the decoder with an identifiable bit-sequence to both identify start of burst and to discriminate between valid data and noise, a number of sync bytes (0xCC in the “6 in 8” coding scheme) are added at the start of the burst.
- **Data integrity.** It is never sufficient to rely on just the sync sequences in a data burst to identify it. At the very least a checksum (the numeric sum of the 6-bit data values making up the payload, address field and any supplementary status words) is needed, if not a more complex polynomial error detection sequence. In addition, if using the 6-in-8 coding, an error is detected if a data byte corresponds to any value other than those in the lookup table.

Real-World Testing

We can write as much opinion text as we like, but from real-engineering's point of view it is actual measurements on actual hardware that matter. To that end I've conducted a basic test of a bare-UART-based radio data link, to examine the fundamental performance in terms of poor S/N tolerance, and hence poor sensitivity and range.

RF hardware: A narrowband UHF receiver is used, with a 5kHz-bandwidth baseband path and a measured sensitivity of -118dBm in for 12dB SINAD (www.radiometrix.com/content/nrx2b). This is a typical performance level for an ISM band receiver of this type. The squared "digital" output (from the simple internal average-and-compare data extractor) is fed via a level shifter buffer into the RXD input of a desktop PC's serial port.

The transmitter end is simulated by using an RF signal generator (an IFR 2023A in this case) with an external (DC-coupled) modulation input fed (again, through a level shifter) from the TXD output on the same PC serial port.

Data burst: All coding and decoding of the data was conducted by a simple program running on the PC, communicating with the radio via a conventional COM port – a 16550 type device, set for a 1+8+1 (with no parity or handshaking) word format. A burst structure representative of a simple "remote control" application was used; although a longer data payload could be used with the same set-up, for telemetry or data logging:

Preamble: Six bytes	0x55	(approximately 50ms)
UART setup	0xFF, 0x00	
Framer	0xCC	
Address	three bytes	(coded by 6-in-8 method : 18 real bits)
Data	one byte	(ditto : 6 real bits)
Checksum two bytes		(ditto : 12 real bits)

The overall burst length (not including preamble) is nine bytes, or 75ms at 1200 baud.

A successful decode is recorded if the framer word and all three address words match predetermined values and if the checksum calculations match (the checksum value is calculated as the sum of the 6-bit data word and the three 6-bit address words).

Test method: In order to determine a sensitivity level with data, as opposed to analogue test tones, it is necessary to set a threshold condition. In this case I have used a venerable pager testing method, by which the threshold is set at the point where three or more of any given five bursts are successfully decoded. The transmitter software is configured to send (and decode) data bursts in groups of five; statistically this decoding rule is supposed to correspond to a 50% burst decode success rate.

Results: For comparison, from earlier tests it was determined that a production standard software-based (averaging method) biphase encoder/decoder could achieve a sensitivity threshold level of -120dBm with a radio of equivalent performance at this data rate. It was anticipated that the UART-based link with its edge-detecting decode method would be considerably inferior.

1. **First test: -96dBm** sensitivity. It seemed that my preconceptions were well-founded, but on further investigation of the decoder routine and the recovered data bursts, an error was identified. The initial version of the code not only detected the 0xCC sync character, but also the preceding 0xFF and 0x00 words. These are present to ensure the UART has a clean, unambiguous start-bit to frame onto, following the preamble. For that reason neither of these words are resolved correctly.
2. **Corrected decoder routine: -116dBm**. With the decoder detecting only the relevant framing information, sensitivity was markedly improved, although not to the levels achieved with biphase decoders. It was noticed that the edges in the recovered data were badly jittered and that considerable high-frequency noise was visible on the received AF data waveform.
3. **Narrower AF bandwidth: -119dBm**. On the receiver design used, it is easy to lower the roll-off of the post demodulator filter (a 10K/1nF RC low-pass) by adding capacitance to the raw AF output pin. Adding a 22nF capacitor drops the filter roll off to 690Hz (a near enough match to the 600Hz maximum frequency component of a 1200 baud NRZ stream). The data waveform is noticeably rounded off, but the noise component is reduced and sensitivity rises noticeably.

Conclusions: To my surprise, the eventual sensitivity performance of the simple UART-based link nearly equals that of a biphase system, for a similar burst length. The only significant difference seems to be that to achieve optimum sensitivity it is necessary to match the receiver AF bandwidth more closely to the data rate (the software low-pass functions of the biphase decoder being less sensitive to this effect).

Provided that the correct measures are implemented to ensure proper start-bit acquisition and equalization of DC imbalances in the bit stream, there is no reason why simple low-power wireless data links should not successfully use direct-UART connection, without the addition of additional "modem" hardware. ●

CODING 6-BIT DATA WORDS INTO DC-BALANCED 8-BIT BYTES

Of the 256 possible 8-bit codes, 70 contain four ones and four zeros. The 66 Hex codes below have a 50:50 mark:space and may either be sent/received from a standard serial port (UART) using one start, one stop and no parity. The use of this subset also allows simple byte-error checking on reception, since all received codes must contain exactly four ones and four zeros.

17 1B 1D 1E 27 2B 2D 2E 33 35 36 39 3A 47 4B 4D
4E 53 56 59 5A 5C 63 65 66 69 6A 6C 71 72 74 78
87 8B 8D 8E 93 95 96 99 9A 9C A3 A5 A6 A9 AA AC
B1 B2 B4 B8 C5 C6 C9 CA D1 D2 D4 D8 E1 E2 E4 E8

Note that 0Fh & F0h 3Ch and C3h have been omitted to minimise consecutive 0s or 1s, 0x55 because it corresponds to preamble, and 0xCC because it is used as a framing sequence.

SETTING THE STANDARD FOR MEDICAL DEVICE SOFTWARE

PAUL ANDERSON, VICE PRESIDENT OF ENGINEERING AT GRAMMATECH, EXPLAINS HOW DEVELOPERS OF MEDICAL DEVICES CAN DELIVER HIGH QUALITY SAFETY-CRITICAL CODE THAT WILL HELP SAVE LIVES

Developers of medical devices face the challenge of creating safety-critical software for applications where human lives are at risk. In other safety-critical industries there is a widespread acceptance that coding standards are a good way to reduce the risk of introducing life-threatening software defects. For example, the automotive industry has adopted the MISRA coding guidelines, even though there is no regulatory requirement to do so, and the use of those or similar guidelines is spreading into other industries too.

The Importance Of Software Standards

Although many medical device companies have now accepted that coding standards are best practice, software development is still treated by many as a low-risk activity that merits little attention, so programming standards are neglected.

It is a sad fact that patients can and do die from poorly-designed medical device software. In the 1980s, due to a software defect in the Therac-25 radiation therapy machine patients received 100 times the intended dose of radiation. With advances in software and technology, it is natural to assume that such disasters could never happen today. The reality, however, is that in the last decade the recalls of defective medical devices have nearly doubled, with a sharp increase in those where the defect carried a reasonable probability of death.

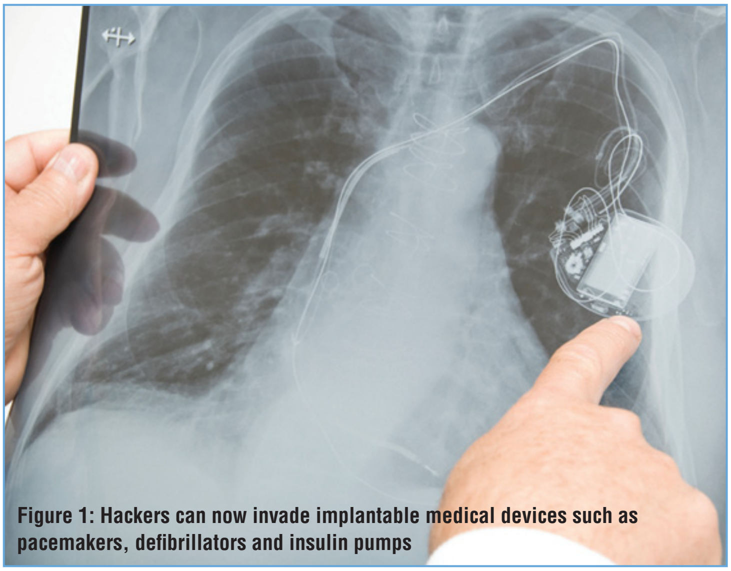


Figure 1: Hackers can now invade implantable medical devices such as pacemakers, defibrillators and insulin pumps

Over a five-year period, more than 56,000 adverse events and 710 deaths associated with infusion pumps were reported to the US FDA, more than for any other medical technology. During this period, there were 87 pump recalls. Although it is not known how many infusion pump failures were due to software defects, the FDA reports that such failures are very common in medical devices that rely on software; four out of every ten failures were due to a problem in the software itself.

To compound the challenge of developing safety-critical software, almost every medical device now includes some form of interconnectivity. Most medical devices are connected, often wirelessly, for the purposes of monitoring and reporting. As a result, a malicious hacker could invade medical devices implanted in a patient's body such as defibrillators, pacemakers and insulin pumps and cause grave harm. Furthermore, according to the MIT Technology Review, many medical devices are now riddled with the same malware and viruses that plague desktop computers. In many cases, equipment is running on older Windows operating systems that manufacturers will not modify or allow the hospital to change, even to add antivirus software, because of disagreements over regulatory requirements.

Further increasing the risk of software failures, medical devices have become more complex and now include a significant amount of third-party software. This is code that was not developed by the device manufacturer and therefore not under its direct control. Even if the manufacturer's code is bug-free, there is still the risk of lurking defects introduced by the third-party operating system, code libraries and open source or commercial software components that were included when the software was integrated and built.

The Perfect Storm

The confluence of decentralized coding practices, pervasive software defects and ubiquitous connectivity has created a perfect storm of opportunities. Even in cases where software defects do not lead to overt device failures, they still provide countless opportunities for hackers to exploit.

With patient lives at stake, developers of medical device software have a responsibility to adopt best practices, and the adoption of a safety-critical coding standard is one such low cost, high reward, practice. It is now well established that coding standards improve software quality. Both the FDA and EC require that medical device manufacturers have a documented


Figure 2: Infusion pumps, common in every hospital, have had more problems than any other medical technology

Figure 3: Many medical devices are now riddled with the same malware and viruses that plague desktop computers

software development process in place, such as the process presented in IEC 62304. However, the FDA does not specifically require adherence to a coding standard.

Historically, hardware was the driving force in devices and the primary focus of the FDA. As technology has advanced, software has become the driving force in complex medical devices and the FDA has not made the necessary changes to keep up with these advancements. Many medical device manufacturers recognize the importance of coding standards and have voluntarily implemented them as part of their software quality initiatives. However, many other companies still view software as an add-on and leave it to individual development teams to implement their own methodologies. This is unfortunate since excellent safety-critical standards are available and many of the best practices could be adopted with minimal effort or cost.

> Although many medical device companies have now accepted that coding standards are best practice, software development is still treated by many others as a low-risk activity that merits little attention, so programming standards are neglected

Safety-Critical Programming

One standard that has been successfully adapted for medical device software is *The "Power of 10" Rules for Safety-Critical Programming*. This was developed at the NASA Jet Propulsion Laboratory for software used in space vehicles. It includes a set of ten simple programming rules that are easy to remember and designed in a way that violations can be detected automatically by static analysis tools.

Once a coding standard is adopted, the most effective means to ensure it is properly implemented is to use advanced static source-code analysis. In addition to checking the code for standards compliance, static analysis can find serious semantic errors, such as buffer overruns, null pointer dereferences, race conditions and resource leaks. These types of defects are examples of violations of the fundamental rules of the language or of an API being used in an incorrect way.

Static analysis can also find inconsistencies in the code or statements that indicate contradictory assumptions. Although such occurrences are not bugs per se, they do correlate well with real bugs because they often indicate that some important property of the code is missing or has been misinterpreted.

Most medical device projects include either third-party or proprietary code for which source-code-level analysis is either unavailable or insufficient for the level of confidence needed in the software. Some of this is open-source, but in embedded applications such as medical devices nearly 30% of the code is third-party commercial software, typically delivered in binary format without the actual source-code. Such components include graphics and windowing toolkits, cryptography libraries, middleware, databases and others.

Systems comprised of code supplied by several different vendors are at particular risk. Research has shown that defects that give rise to security vulnerabilities proliferate at the boundaries between modules, often due to innocent disagreements in interpretation of the interface specifications. Therefore, when portions of the source code are unavailable, mixed-mode static analysis tools that combine source code analysis with binary code analysis can be extremely useful for ensuring code robustness and security.

Security Vulnerabilities

Despite best efforts, most deployed medical device software still has latent defects or security vulnerabilities. For this reason, developers need to defend against such defects by treating inputs from potentially risky channels as hazardous until the validity of the data has been checked. In the parlance of secure programming, unchecked input values are said to be tainted. It can be difficult to check that a program handles tainted data properly because doing so involves tracking its flow through the structure of the code. This can be tedious, even for relatively small programs, and is generally infeasible to do manually for most real-world applications.

The biggest risk of using values read from a risky channel is that an attacker can use the channel to trigger security vulnerability or to cause the program to crash. There are many

Figure 4: Best practices such as coding standards are a good way to reduce the risk of introducing life-threatening software defects in medical devices

different kinds of defects that can be triggered by hackers using tainted data such as buffer overruns, SQL injection, command injection, cross-site scripting, arithmetic overflow and path traversal. Many of the most damaging cyber-attacks in the last two decades have been caused by the infamous buffer overrun defect. As this is such a pervasive vulnerability and because it illustrates the importance of taint analysis, it is worth explaining in some detail.

There are several ways in which a buffer overrun can be exploited by an attacker, but here we describe the classic case that makes it possible for the attacker to hijack the process and force it to run arbitrary code. Consider the following code in which the buffer is on the stack:

```
void config(void)
{
 char buf[100];
 int count;
 ...
 strcpy(buf, getenv(“CONFIG”));
 ...
}
```

In this example, the input from the outside world is through a call to getenv that retrieves the value of the environment variable named “CONFIG”. The developer who wrote this code was expecting the value of the environment variable to fit in the buffer, but there is nothing that checks that this is so. If the attacker has control over the value of that environment variable, then assigning a value whose length exceeds 100 will cause a buffer overrun. Because buf is an automatic variable, which will be placed on the stack as part of the activation record for the procedure, any characters after the first 100 will be written to the parts of the program stack beyond the boundaries of buf. The variable named count may be overwritten (depending on how the compiler chose to allocate space on the stack). If so, then the value of that variable is under control of the attacker. This is bad enough, but the real prize for the attacker is that the stack contains the address to which the program will jump once it has finished executing the procedure.

To exploit this vulnerability, the attacker can set the value of the variable to a specially-crafted string that encodes a return address of their choosing. When the CPU gets to the end of the function, it will return to that address instead of the address of the function’s caller. The most risky input channels are those over which an attacker has control. If the code is executed in an environment where the attacker does not have control of the value of the environment variable, then it may be impossible to exploit this vulnerability. Nevertheless, the code is clearly very risky and remains a liability if left unfixed.

A developer might also be tempted to re-use this code in a different program where it may not be safe to run. This example is taking its input from the environment, but the code would be just as risky if the string was being read from another input source, such as the file system or a network channel. As mentioned, manually finding program errors that are sensitive to tainted values is extremely time-consuming, so automation is the best approach.

Assessing Risk

Taint analysis is a technique that helps developers understand how risky data can flow from one part of the program to another. An advanced static-analysis tool can run a taint analysis and present the results to the user, making the task of understanding a program’s attack surface easier, and simplifying the work involved in finding and fixing serious defects. There are tools that do taint analysis dynamically. However, there are important advantages in doing it statically, which confirms that it holds for all possible executions, not just the ones with test cases.

Developers of medical device software are responsible for delivering the highest quality code possible; the health and safety of patients depend on it. Safety-critical coding standards are widely used in other industries where human lives are at risk, with excellent results. Based on the rate of medical device recalls, it is imperative that device makers adopt well-honed, safety-critical coding standards developed with the collective knowledge of the industry’s best minds.

Developers can easily get started with the NASA/JPL Power of Ten, which incorporates some of the best practices from several coding standards. Use of an advanced static analysis tool will ensure that coding standards have been properly implemented and should be used whenever new code is checked in and routinely at every software build. Using these practices, developers of medical devices can rest assured they are doing everything possible to deliver high quality safety-critical code that will help save lives. ●

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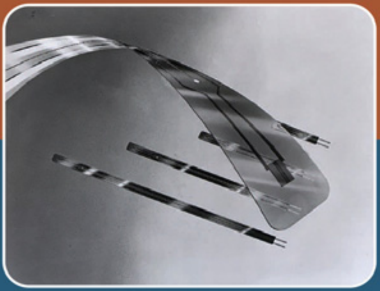

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Medical devices, monitoring and control instruments are now part of the RoHS 2 directive

BY **SEPPO VAHASALO**,
MEDICAL DEVICE PRODUCT LINE
MANAGER AT SGS FIMKO
IN FINLAND

MEDICAL DEVICES AND THE CHALLENGE OF ROHS 2 COMPLIANCE

The European Union adopted new legislation concerning the Restriction of Hazardous Substances in Electrical and Electronic Equipment, RoHS 2 (2011/65/EU) in May 2011; it replaces the previous RoHS Directive (2002/95/EC) and expands its scope to cover a larger number of businesses. Until now, medical devices have been exempt from complying with RoHS, however additional categories now include medical devices.

RoHS 2 Implementation

The new RoHS 2 had to be implemented by national legislations by 2 January 2013. It did not add any new restricted substances to the list but did expand the scope of products that must comply with RoHS requirements. The number of categories of products covered by RoHS 2 has now increased to 11, due to the inclusion of three new categories comprising medical devices, monitoring and control instruments, and "all other electrical and electronic equipment not covered by any other category". These categories thus include products that were initially excluded, such as in-vitro medical devices.

The list of RoHS 2 restricted hazardous substances with their respective maximum allowable concentrations in homogeneous materials includes lead (Pb, 0.1%), mercury (Hg, 0.1%), cadmium (Cd, 0.01%), hexavalent chromium (Cr VI, 0.1%), polybrominated biphenyls (PBB, 0.1%), and polybrominated diphenyl ethers (PBDE, 0.1%). The earlier RoHS directive put restrictions on hazardous substances in electrical and electronic equipment (EEE) but was somewhat ambiguous on what products were included in that category. According to the directive, a product was considered to be EEE when electricity was required for its primary function.

RoHS 2 states that "electrical and electronic or EEE means equipment which is dependent on electric currents or electromagnetic fields in order to work properly, and equipment for the generation, transfer and measurement of such currents and fields and designed for use with a voltage rating not exceeding 1000 Volts for alternating current and 1500 Volts for direct current". Additionally it defines items "dependent on electric currents or electromagnetic fields as needing electric currents or electromagnetic fields to fulfil at least one intended function".

The new definition for EEE now means that new products within an existing category will be required to comply. For example, generation of speech is not a primary function for a talking doll, so the doll is out of scope of the original RoHS. Because speech is one of the intended functions however, the doll now needs to comply with RoHS 2 as a category 7 product.

Possible Exemptions

Article 2 of the directive lists permanent exemptions, such as military and space equipment among others. Annex III of the directive lists exemptions for technical applications for each device category; additionally, Annex IV lists applications that are exempt from the restriction, specific to medical devices and monitoring and control instruments.

Most of the exemptions are self-evident. For example, it is difficult to build a shield for ionizing radiation without lead, or a helium-cadmium laser without the use of cadmium.

> “The number of categories of products covered by RoHS 2 has now increased to 11, due to the inclusion of three new categories comprising medical devices, monitoring and control instruments, and “all other electrical and electronic equipment not covered by any other category”

It is also possible to apply for new exemptions. A manufacturer, the authorised representative of a manufacturer, or any economic operator in the supply chain may submit an application for exemption, renewal of exemption or revocation of an exemption to the European Commission. Exemptions should be permitted if substitution is not possible from a scientific and technical point of view. According to the EU language, permission is given “taking specific account of the situation of SMEs or if the negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the environmental, health and consumer safety benefits of the substitution or the reliability of substitutes is not ensured”.

Interestingly, notified bodies will also be involved in the substitution decision. “If such a notified body certifies that the safety of the potential substitute for the intended use in medical devices or in-vitro diagnostic medical devices is not demonstrated, the use of that potential substitute will be deemed to have clear negative socioeconomic, health and consumer safety impacts”.

A commission is required to evaluate all requests. This is done by appointing independent technical experts and possibly requesting additional input from industry. Exemptions granted will be limited in their scope and duration. For medical devices the exemptions have a maximum validity of seven years.

A commission will review all current and new exemptions at least every four years to assess the situation. Are the exemptions still technically and scientifically justified? Do the negative environmental, health and consumer safety impacts of substitution still outweigh the environmental, health and safety impacts of the substances used?

Article 24 of the directive takes into account the need to review and develop the directive. “No later than 22 July 2014 the Commission shall examine the need to amend the scope of this directive in respect of the EEE referred to in Article 2, and shall present a report thereon to the European Parliament and the Council accompanied by a legislative proposal, if appropriate, with respect to any additional exclusions related to that EEE”. This means that it is possible to add devices currently exempt from RoHS into categories that need to comply.

In the longer scope, no later than 22 July 2021, the Commission will carry out a general review of the RoHS 2 Directive and present a report to the European Parliament and the Council accompanied, if appropriate, by a legislative proposal.

Other Regulations For Medical Devices

It should be noted that not only RoHS 2 regulates the substances allowed in medical devices. A recent vote in the EU Parliament requires the ban of substances that are classified or recognized as carcinogenic, mutagenic or toxic to reproduction 1A or 1B (CMR, in accordance with Regulation (EC) No 1272/2008); or endocrine disruptors (EDCs) in concentrations above 0.1% by mass of homogeneous material contained within medical devices that come into contact with the human body. The regulation states that such substances would be phased out within eight years should safer alternatives become available.

If specific medical devices are meant for the treatment of children, pregnant or nursing women, phthalates, which are classified as CMR, should be banned as of 1 January 2020. The only exceptions are the cases when the manufacturer has

For medical devices the exemptions have a maximum validity of seven years

Until now medical devices have been exempt from complying with RoHS, however additional categories now include medical devices

the ability to prove that no other safer substances are available, in which case the device's labelling and (or) packaging needs to clearly indicate the presence of substances that are classified CMRs 1A or 1B or as EDCs.

The proposed regulation also covers devices that contain or consist of nanomaterials that can be released in the human body. In accordance with the amendments, manufacturers are required to incorporate evidence as part of the device's technical documentation or instructions, which demonstrates that the use of nanomaterials is in compliance with safety and performance requirements and standards.

Some of the new medical devices now affected by RoHS 2 requirements include X-ray equipment, magnetic resonance imaging (MRI) equipment, portable emergency defibrillators and computerised tomography machines. MRI equipment and computerised tomography machines needed to demonstrate compliance with RoHS requirements starting 22 July 2014, whilst in-vitro medical devices such as polymerase chain reaction (PCR) equipment have more time, until 22 July 2017.

Active implantable medical devices are not included in RoHS 2. Only spare parts specifically manufactured for the repair, reuse and updating of functionalities or upgrading of capacity, and already available on the market before the above-mentioned dates, are exempt from compliance with RoHS 2.

Manufacturers' Responsibilities

In addition to the impact of this new product category, RoHS 2 brings about a few other significant changes related to the broader scope of the directive, which has implications on the legal responsibilities of businesses.

Some of these changes affect manufacturers directly, since before placing a medical device on the European market they are required to:

- Issue a signed Declaration of Conformity (DoC);
- Create a Technical Documentation File per the EN 50581:2012 or equivalent that meets requirements of module A of Annex II to decision 768/2008/EC;
- Accept analytical, material, test results per the IEC 62321 Standard;
- Keep the DoC and Technical Documentation File for a period of 10 years after the product has been placed on the market;
- Obtain the CE marking to prove RoHS 2 compliance.

Since the CE marking now has a double function, manufacturers are required to comply with RoHS requirements not only in their technical documentation, but also on the EU DoC. In other words, the CE marking cannot be applied to the product until RoHS 2 compliance is demonstrated. In addition, the technical documentation must include, among other things, a conformity assessment, the use of standards, supplier declaration(s) of compliance, materials declarations and results of any supplier audits, as well as possible test results.

Within the EU, anyone who is placing a product on the market has a responsibility to ensure that it complies with legislation. While an importer does not need to generate technical files and material declarations, it has to take care that the manufacturer does. In short, importers need to ensure that the manufacturer has drawn up technical documents and implemented the procedures in module A of Annex II of directive 768/2008/EC. The product has to be labelled with a CE mark, manufacturer name and contact address and type, batch or serial number, together with the importer's name or trade mark and contact address. Additionally, the importer has to keep copies of DoCs for 10 years after the product has been placed on the market and ensure that the technical documents can be made available upon request.

> "Some of the new medical devices now affected by RoHS 2 requirements include X-ray equipment, magnetic resonance imaging (MRI) equipment, portable emergency defibrillators and computerised tomography machines

Impacts of RoHS 2

Because most other electrical product categories already need to meet the requirements of RoHS, electrical equipment subcontractors do not find lead-less manufacturing or ban of other substances a problem – they have learned to comply. Businesses that were not part of the scope of the original directive will now be faced with considerable burdens in creating and gathering the required documentation. On the other hand, manufacturers that are already in compliance with RoHS are affected by the application of the CE marking, which may involve additional testing and documentation.

RoHS 2 conformity is not a one-time task. After 22 July 2014 it is not possible to place a non-compliant product onto the European market without consequences. The EU Commission re-evaluated the list of restricted substances by the same date. An enlightened manufacturer will monitor the situation carefully. ●

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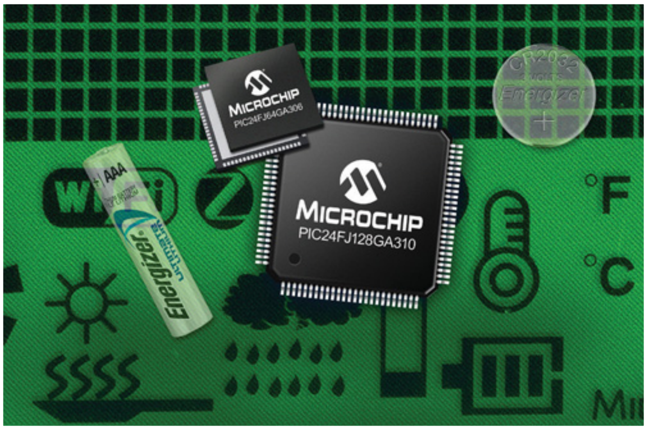
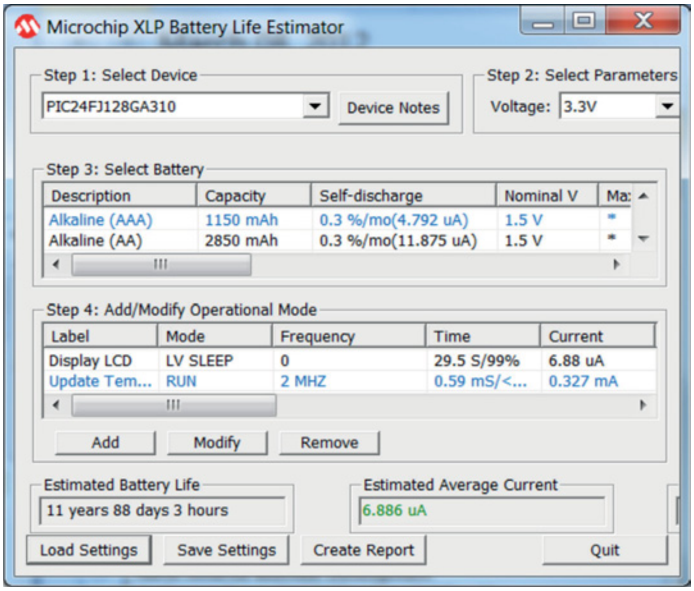


NEW POWER MODES, SUCH AS LOW-VOLTAGE SLEEP AND VBAT, ARE ALLOWING GENERAL-PURPOSE MCUS TO OPERATE IN A WIDER VARIETY OF APPLICATIONS. BY **DONALD SCHNEIDER**, PRODUCT MARKETING MANAGER FOR THE ADVANCED MICROCONTROLLER ARCHITECTURE DIVISION AT MICROCHIP TECHNOLOGY

Low power is often considered a central tenet of a green product, but the nature of the low power is rarely clarified or quantified.

Depending on the application and how the microcontroller (MCU) will be used, the requirements for a low-power MCU will vary. The uses can be classified into three main areas:

- **Minimum power mode** – Typically used in applications such as a battery-operated thermostat, for example. The minimum power mode defines the lowest level of power available to drive the LCD display. This reduction in power leads to extended battery life.
- **Active current consumed** – For applications such as an electricity meter for example; the level and nature of low power refers to the active current consumed by the system during operation.
- **Time-specific applications** – These are systems that require date and time be maintained, regardless of the presence of the system's primary power supply, such as an electricity meter during a power failure.



Microchip XLP Battery Life Estimator

Step 1: Select Device: PIC24FJ128GA310

Step 2: Select Parameters — Voltage: 3.3V

Step 3: Select Battery

Description	Capacity	Self-discharge	Nominal V	Ma:
Alkaline (AAA)	1150 mAh	0.3 %/mo(4.792 uA)	1.5 V	*
Alkaline (AA)	2850 mAh	0.3 %/mo(11.875 uA)	1.5 V	*

Step 4: Add/Modify Operational Mode

Label	Mode	Frequency	Time	Current
Display LCD	LV SLEEP	0	29.5 S/99%	6.88 uA
Update Tem...	RUN	2 MHZ	0.59 mS/<...	0.327 mA

Estimated Battery Life: 11 years 88 days 3 hours

Estimated Average Current: 6.886 uA

Figure 1: The Battery Life Estimator tool's main screen

Perfect Fit

As the requirements of applications diversify, designers look for MCUs with even more flexible power modes to further tailor system operation.

In the past, MCUs had an active mode to allow for device operation; Idle and Doze modes to reduce or eliminate CPU switching power while allowing peripherals to operate; and Sleep modes that allowed limited peripheral operation with minimal power consumption. In a move to minimise costs and reduce active current, a number of new low-power modes are being added to increase the flexibility of advanced MCUs. To demonstrate some of these new low-power operating modes available on today's advanced MCUs, this article will examine how they might be used in a variety of applications.

Each example will be created using a software Battery Life Estimator (BLE) tool and 16-bit MCUs to provide a comparison of the various power modes, when implemented in different applications. The BLE from Microchip is a free software tool that enables a designer to estimate the battery life of their system and determine which available operating mode is best suited to their application.

Advanced Processes

Thermostats have become more complex, having to display more information and be usable in multiple regions. As a result, significant amounts of on-chip Flash program memory are often required to store complex menus in multiple languages.

In general, advanced processes are required to produce MCUs with large memories at competitive prices. As semiconductor processes advance, there tends to be a reduction in operating (active) current and an increase in the transistor leakage current.

The increase in leakage current is most visible in the current specifications for low-power modes, such as Sleep. The Sleep currents on advanced MCUs are typically in the 3-5µA range, while the typical thermostat application does little more than drive a segmented LCD display most of the time. The segmented LCD display is typically driven in Sleep mode that allows the peripherals to operate while the CPU and most peripherals are powered down. The thermostat will wake up periodically and enter an active mode to read the temperature, update the display and perhaps signal the furnace, fan or AC units to turn on. Because 99% of the time only Sleep mode is required, Sleep current is an area where improvements can greatly benefit the battery life of the system.

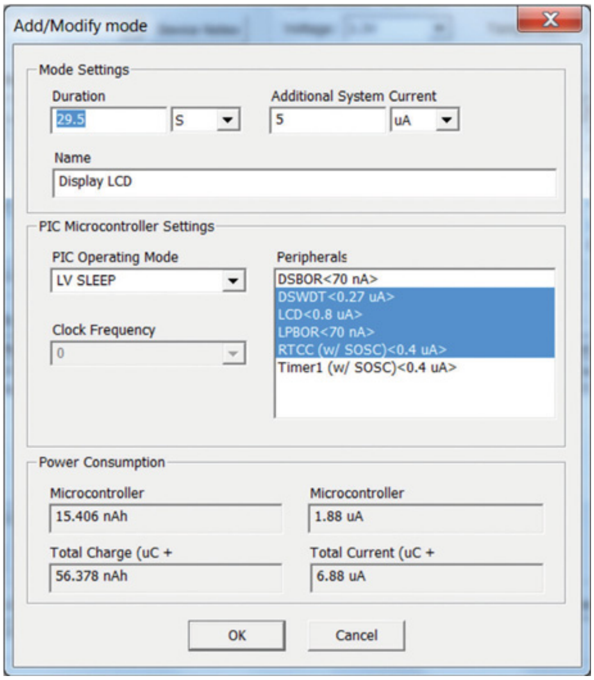
To provide MCUs with a sub-µA power mode, many suppliers have introduced low-power Deep Sleep modes. Typical Deep Sleep currents are in the 10-50nA range, and these devices can run a Real-Time Clock Calendar (RTCC) with an additional 400nA current. One option is to shut down the entire device – with the exception of a small amount of memory, a real-time clock and, perhaps, a watchdog timer – to achieve extremely low currents. However, these Deep Sleep modes do not allow peripheral operation or maintain RAM data on the device. Loss of RAM contents requires the device to execute a restart routine prior to resuming program execution, when waking up from Deep Sleep.

An alternative can be found with new low-power modes, such as the Low-Voltage Sleep mode which maintains the device's data RAM at a typical base current of 330nA and allows the operation of additional low-power peripherals. This Low-Voltage Sleep mode maintains the device's RAM and lowers sleep current by reducing the output of the device's on-chip regulator. By reducing the supply voltage to the device logic and limiting the active peripherals, the MCU's Sleep current can be reduced from 3.7µA to 330nA. As a subset of this mode, peripherals such as LCD drivers, timers and the RTCC can operate with minimal additional current.

Low-Voltage Sleep mode allows the device to return to an active state in less than half the time of a wake-up from Deep Sleep. The device then begins execution at the next instruction, rather than beginning with the restart sequence typically required by a wake from Deep Sleep.

Thermostat Example

As shown in Figure 1, the main screen of the Battery Life Estimator tool shows the MCU and its operating voltage, battery and operating modes. The result of the thermostat model is an 11-year, 88-day estimated life.



Duration: 29.5 S
Additional System Current: 5 uA
Name: Display LCD
PIC Operating Mode: LV SLEEP
Clock Frequency: 0
Peripherals:
DSBOR<70 nA>
DSWDT<0.27 uA>
LCD<0.8 uA>
LPBOR<70 nA>
RTCC (w/ SOSC)<0.4 uA>
Timer1 (w/ SOSC)<0.4 uA>
Microcontroller: 15.406 nAh
Microcontroller: 1.88 uA
Total Charge (uC +: 56.378 nAh
Total Current (uC +: 6.88 uA

Figure 2: Battery Life Estimator tool mode-edit screen

The BLE tool models the time a microcontroller will spend in each operating mode and how much power the device will consume in each mode.

Figure 1 shows the output display of the BLE, which is used to set several key parameters of the system and to provide the resulting life estimate and average system current. First, the MCU and operating voltage of the system are selected. This allows the Battery Life Estimator to access the appropriate specification parameters. A battery or battery pair is then selected – in this case, two AAA alkaline batteries.

The expected operating voltage of the system and the operating temperature can also be selected, to access the most appropriate specification for use in the BLE model. Finally, the operating modes that will be used in the system are defined. In the case of our thermostat, two modes will be used.

To model the time when the thermostat is only displaying the LCD screen, an operational mode called "Display LCD" is created. This uses the Low-Voltage Sleep mode to provide the lowest power mode from which the LCD can be driven. The BLE tool is set to model the Low-Voltage Sleep mode for 29.5s out of the 30s-loop used to model the operational life of the device. A second Update Temp and LCD operational mode is used to model the time the MCU will take to monitor the temperature, update the LCD screen and communicate with the HVAC units.

Settings Adjustment

The new Low-Voltage Sleep mode and implementation of an operational mode in the BLE tool are shown in Figure 2 – the Add/Modify Mode screen. From this screen, a designer can adjust the settings for the duration, which is set to 29.5s. By using the Additional System Current entry box, designers can add an estimated current consumption for the components that surround the MCU. In this case, 4µA system current has been added to represent the current consumed by the LCD display, and an additional 1µA current has been added to represent the current required for the internal LCD bias resistors.

Next, the power mode is selected, in this case Low-Voltage Sleep, and the required peripherals. To provide an accurate model of the system current, the LCD Drive, BOR, WDT and RTCC have been selected. The total current consumed by the MCU itself is 1.88µA, which is added to our 5µA system current to arrive at the 6.88µA required by the system while in Low-Voltage Sleep mode.

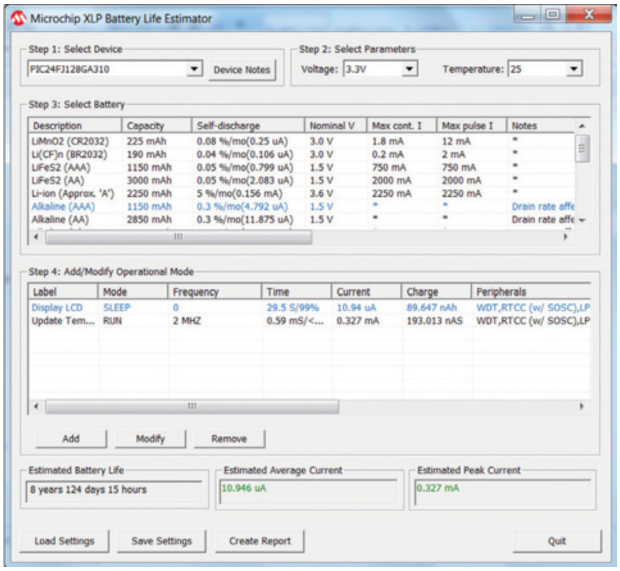
As shown in Figure 2, the BLE tool's mode-edit screen allows a designer to name and specify the conditions of each power mode used.

The BLE main screen shows that an average 6.88µA is consumed while the device is in Low-Voltage Sleep mode and just over 327µA is consumed during the short time the device is in an active state, for an average current of less than 6.9µA. The estimated battery life for the system is almost 12 years, nearly five years beyond the shelf life of the batteries.

A similar analysis using Sleep mode rather than Low-Voltage Sleep mode is shown in Figure 3, and results in an average current of approximately 10.5µA and a three-year reduction in battery life.

Electricity Meter Needs

A contrasting application for an MCU is a system that would spend most of the time in active mode, such as an electricity meter. Today's electricity meters are in one of two states. The normal operating mode occurs when electric power is available, so the MCU is active and is constantly measuring the voltage and current, and calculating the power being sourced through the meter. The meter may also be monitoring for potential tampering, driving an LCD display and potentially communicating with the meter-reading infrastructure.


Microchip XLP Battery Life Estimator

Step 1: Select Device
PIC24FJ128GA310

Step 2: Select Parameters
Voltage: 3.3V
Temperature: 25

Step 3: Select Battery

Description	Capacity	Self-discharge	Nominal V	Max cont. I	Max pulse I	Notes
LiMnO2 (CR2032)	225 mAh	0.08 %/mo(0.25 uA)	3.0 V	1.8 mA	12 mA	*
Li(CF)n (BR2032)	190 mAh	0.04 %/mo(0.106 uA)	3.0 V	0.2 mA	2 mA	*
LiFeS2 (AAA)	1150 mAh	0.05 %/mo(0.799 uA)	1.5 V	750 mA	750 mA	*
LiFeS2 (AA)	3000 mAh	0.05 %/mo(2.083 uA)	1.5 V	2000 mA	2000 mA	*
Li-ion (Approx. 'A')	2250 mAh	5 %/mo(0.156 mA)	3.6 V	2250 mA	2250 mA	*
Alkaline (AAA)	1150 mAh	0.3 %/mo(4.792 uA)	1.5 V	*	*	Drain rate affe
Alkaline (AA)	2850 mAh	0.3 %/mo(11.875 uA)	1.5 V	*	*	Drain rate affe

Step 4: Add/Modify Operational Mode

Label	Mode	Frequency	Time	Current	Charge	Peripherals
Display LCD	SLEEP	0	29.5 S/99%	10.94 uA	89.647 nAh	WDT,RTCC (w/ SOSC),LP
Update Tem...	RUN	2 MHZ	0.59 mS/<...	0.327 mA	193.013 nAS	WDT,RTCC (w/ SOSC),LP

Estimated Battery Life: 8 years 124 days 15 hours
Estimated Average Current: 10.946 uA
Estimated Peak Current: 0.327 mA

Figure 3: Battery Life Estimator tool

While the electricity meter is running, it may seem that power is abundant. In reality, the power is the product being supplied by the electric utility – the end customer of the meter manufacturer.

The electric utility company supplies millions of customers with power, and even a small power drain is costly to a power company's business. In fact, most meters must operate under a 10VA power budget, established by the IEC. When possible line variations, component tolerances and system-design margins are taken into consideration, the end result is a current budget of about 10mA for the system MCU, when a capacitive power supply is being used.

Some of today's low-cost electricity meters utilize 8-bit MCUs that typically consume over 10mA, when operating at their full speed in active mode. In order to stay within the system power budget, designers are often required to operate the MCU at reduced frequency. Many of today's 16-bit MCUs benefit from advanced processes and design techniques to provide typical operating currents as low as 150µA/MHz, and can operate at a full 16MIPS while consuming a maximum of 6.9mA. The reduced operating current provides the designer with the choice of either lowering the MCU operating speed to minimise the system's power consumption, or adding additional functions while keeping the system within the allotted power budget.

Lowest-Power Modes

As electricity meters are in an active state most of the time, they are also an example of an application that can take advantage of one of the lowest-power modes – Vbat. This functionality provides a dedicated pin that is supplied with a back-up power source, such as an LTC battery or a supercapacitor. When primary power to the system fails, as it would during a power failure, power for the RTCC automatically transitions to the backup Vbat pin. The RTCC is important in a power meter during a power outage, as time-of-use billing becomes increasingly popular.

While operating through Vbat, the RTCC allows an LTC battery to last for tens of years, allowing an almost indefinite power backup. The use of the Vbat functionality with RTCC is not limited to power meters. Many applications, including the thermostat discussed earlier, can employ an RTCC to maintain the time during a power failure or battery change. Vbat, with a capacitor or battery, can go a long way toward eliminating the annoying blinking lights that result from a power failure.

The evolution of low-power MCUs in a power-conscious world has led to highly flexible general-purpose MCUs. Advances in process technology and design techniques have resulted in 16-bit MCUs with active currents as low as 150µA/MHz. Flexibility has been added to the power-management chain through new low-power modes, such as Low-Voltage Sleep and Vbat, which permit general-purpose MCUs to operate in a wider variety of applications. The outcome means designers have access to powerful and adaptable microcontrollers that allow more energy-efficient and customer-friendly end applications. ●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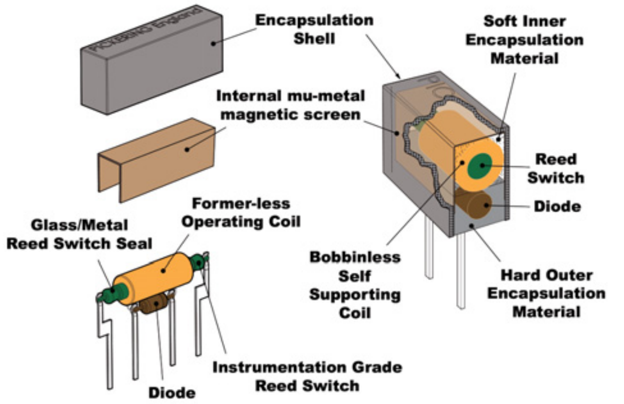
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DRIVING SIC MOSFETS EFFICIENTLY

USING THE NEW GENERATION OF OPTOCOUPLERS

NICK BOURN, FIELD APPLICATIONS ENGINEER AT ANGLIA COMPONENTS, DISCUSSES HOW THE NEXT GENERATION OF GATE DRIVE OPTOCOUPLERS CAN BE USED FOR PROTECTING AND DRIVING SILICON CARBIDE (SIC) MOSFETS

Silicon Carbide (SiC) power semiconductors are rapidly emerging in the commercial market, delivering several benefits over conventional silicon-based power semiconductors. SiC MOSFETs can improve overall system efficiency by more than 10%, and the faster switching can reduce overall system size and cost. The technical benefits, coupled with lower costs, have accelerated the adoption of SiC power semiconductors in applications like industrial motor control, induction heating, industrial power supplies and renewable energy.

Gate drive optocouplers are used extensively in driving silicon-based semiconductors like IGBTs and power MOSFETs. Optocouplers are used to provide reinforced insulation between control circuits and high voltages and power semiconductors. The ability to reject high common mode noise will prevent erroneous turn on of power semiconductors during high-frequency switching.

This article discusses how the next generation of gate drive optocouplers can be used to protect and drive SiC MOSFETs. Avago Technologies's gate drive optocouplers have been used extensively in driving silicon-based semiconductors like IGBTs, and we will use tests carried out with Cree devices to show how the new generation of these gate drive optocouplers can be used to drive and protect SiC MOSFETs.

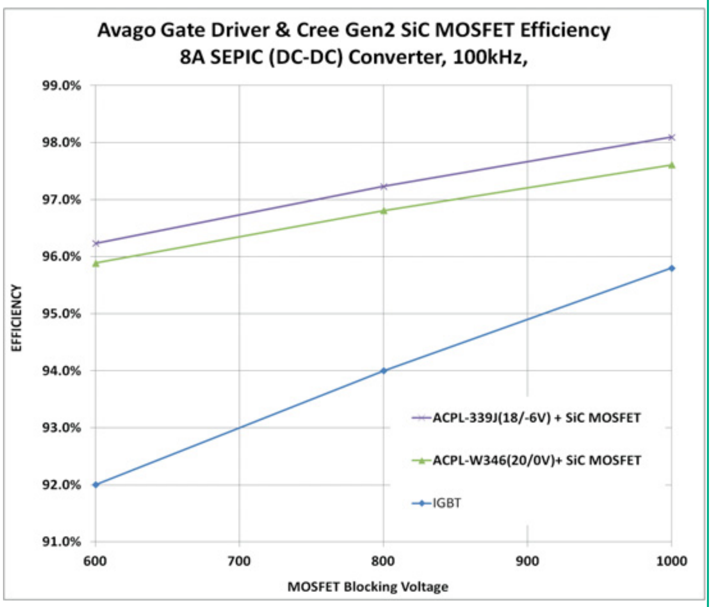

Figure 1: Achieving high efficiency with Avago gate drive optocouplers and Cree C2M0080120D SiC MOSFET

Advantages of SiC MOSFETs

Silicon Carbide is a wide bandgap (3.2eV) compound made of silicon and carbon. Besides being able to operate at high voltage, frequency and temperature, SiC exhibits on-resistance [Rds (on)] and gate charge an order of magnitude lower than silicon.

Cree conducted an evaluation to compare a second-generation 1200V/20A SiC MOSFET with a silicon high-speed 1200V/40A H3 IGBT, using a 10kW, hard-switching, interleaved, boost DC/DC converter. Results showed that even at five times the switching frequency, the SiC solution achieved a maximum efficiency of 99.3% at 100kHz, reducing losses by 18% from the best efficiency of the IGBT at 20kHz.

> "The lower conduction and switching losses allow engineers to reduce the size of the heat sink or potentially remove fans and move to passive cooling solutions

New devices, like the recently-released Cree C2M family of MOSFETs, provide engineers with 1200V and 1700V SiC MOSFETs for a wide range of applications. Cree has been able to bring the costs down significantly while providing improved switching performance and lower Rds (on).

Increasing the switching frequency can significantly reduce the size of the inductor. The lower conduction and switching losses allow engineers to reduce the size of the heat sink or potentially remove fans and move to passive cooling solutions. Smaller inductor and heat sink can reduce system size significantly. Although a SiC semiconductor costs more than silicon, the overall system bill-of-materials (BOM) costs can be up 20% lower than with silicon technology.

SiC MOSFET Gate Drive Optocouplers

Avago Technologies has been working closely with SiC maker Cree to develop suitable gate drive optocouplers to fit SiC MOSFET operations. Evaluation was made of the gate drive optocouplers ACPL-W346 and ACPL-339J with a Cree C2M SiC MOSFET using an 8A SEPIC DC-DC converter at 100kHz. The gate driving capability of these two optocouplers met Cree's efficiency requirement of 98%, as shown in Figure 1.

To match the low switching loss of the Cree SiC MOSFET, the gate driver must be able to deliver high output current and voltage with fast slew rate to overcome the gate capacitance of the SiC MOSFET. The scope capture in Figure 2 shows ACPL-W346 with a 20V, fast rise and fall times signal profile at the gate of the SiC MOSFET, which is necessary for efficient switching of the MOSFET.

The ACPL-W346 is a basic gate driver optocoupler used to isolate and drive the SiC MOSFET operating at high DC-bus voltage. It has a maximum rail-to-rail output of 2.5A. The unique feature of ACPL-W346 is its speed – the industry's fastest in its class. The maximum propagation delay is 120ns and typical rise and fall times are around 10ns.

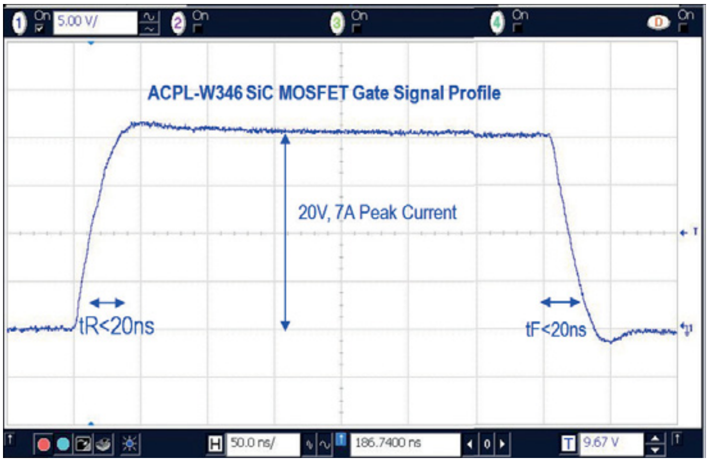

Figure 2: ACPL-W346 SiC MOSFET gate signal profile

The very high common mode rejection (CMR) of 50kV/µs is required to prevent transient noise during the high frequency operation from causing erroneous outputs. When coupled with a bipolar current buffer stage, ACPL-W346 provides fast switching, high voltage and high driving current to turn on and off the SiC MOSFET efficiently and reliably. Compared to the older reference

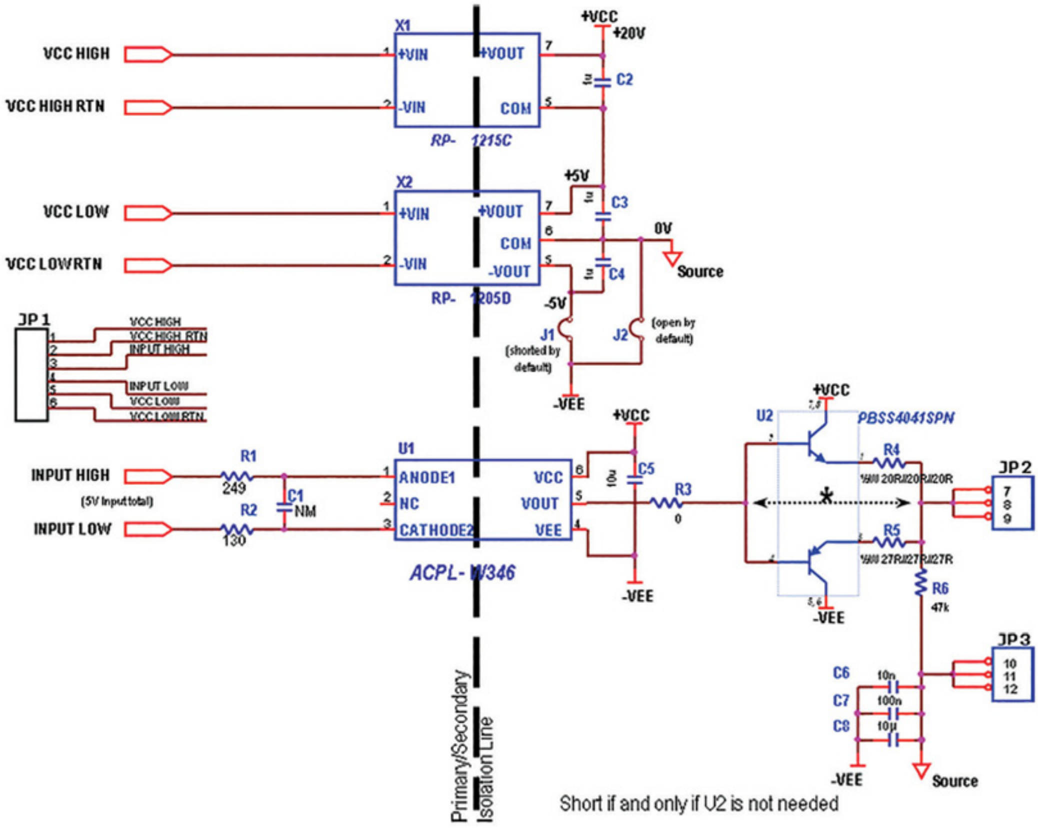

Figure 3: ACPL-W346 and Cree SiC MOSFET reference design

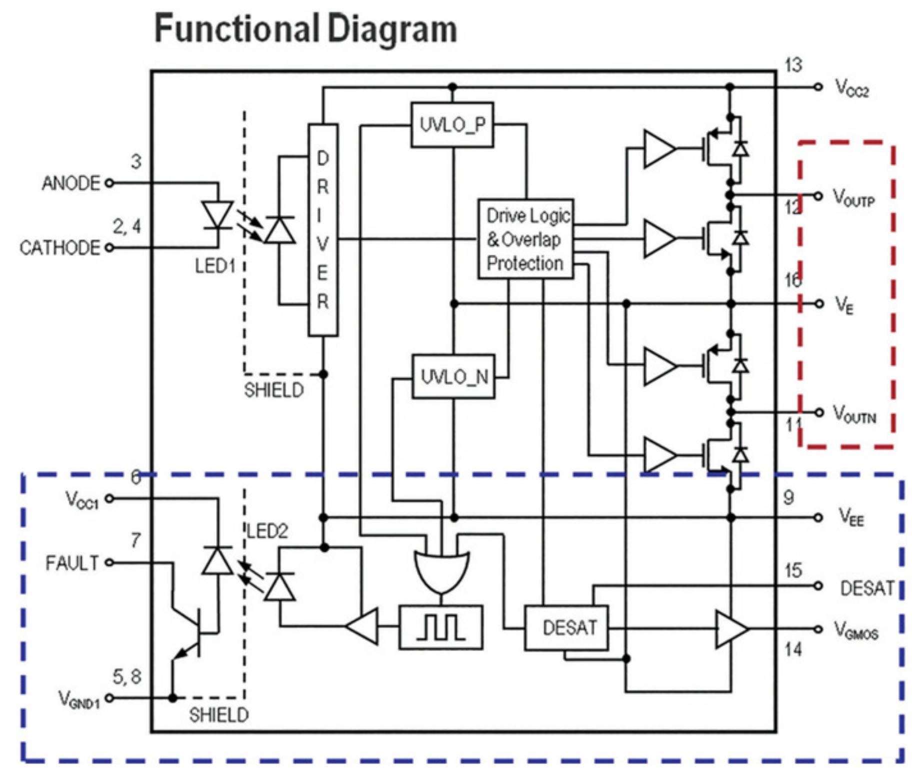

Figure 4: Functional diagram of the ACPL-339J

designs that used dedicated MOSFET drivers with proprietary circuits, the ACPL-W346 and the generic off-the-shelf bipolar current buffer offer a cheaper and easy to implement gate drive solution.

Driving and Protecting SiC MOSFETs

The ACPL-339J is a “smart” gate drive optocoupler that can isolate, drive and protect SiC MOSFETs in a single-chip solution. In the functional diagram of Figure 4, the integrated SiC MOSFET short-circuit-detection and faults-feedback features are enclosed in blue. It has the industry’s first dual-output gate drive optocoupler uniquely designed to support the MOSFET buffer in the area enclosed in red. The device has a minimum output peak current of 1A, optimized for driving both high-side and low-side MOSFET buffer-stages. It features internal active-timing control circuitry, preventing cross-conduction and minimizing switching losses in the MOSFET buffer stage.

The main reason for using MOSFET buffers, which are made off PMOS and NMOS transistors, is that they are voltage-controlled devices. The output of the MOSFET is able to switch very fast once its input threshold voltage (typically 1V) is crossed. In this way, the MOSFET buffer’s level switching speed is independent of the previous gate-drive-optocoupler stage’s level switching speed, as shown in Figure 5.

The scope capture in Figure 6 shows ACPL-339J with a bi-directional, fast rise and fall times signal profile at the gate of the SiC MOSFET, which is necessary to switch the SiC MOSFET efficiently.

To execute short-circuit protection, the drain-source voltage of the SiC MOSFET is monitored by ACPL-339J during normal operation. When a short circuit occurs, high current flows through the SiC MOSFET and causes the drain-source voltage to increase rapidly. Once it crosses the ACPL-339J’s threshold of 8V, a short-circuit fault is registered and soft shutdown triggered. The ACPL-

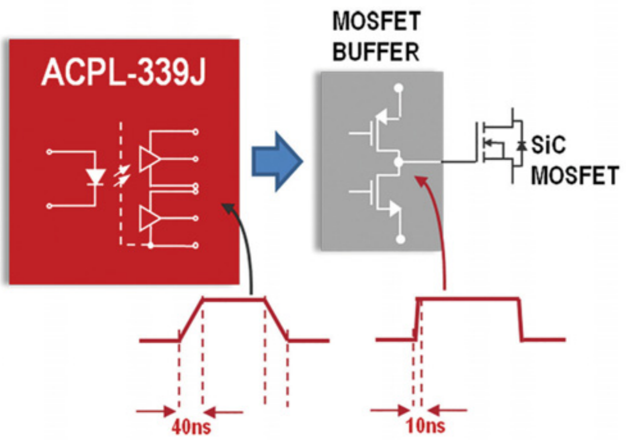

Figure 5: Achieving fast switching time with MOSFET buffer

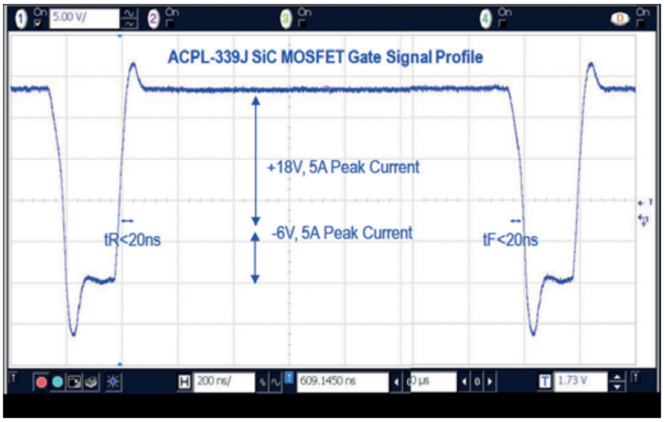

Figure 6: ACPL-339J and MOSFET buffer SiC MOSFET gate signal profile

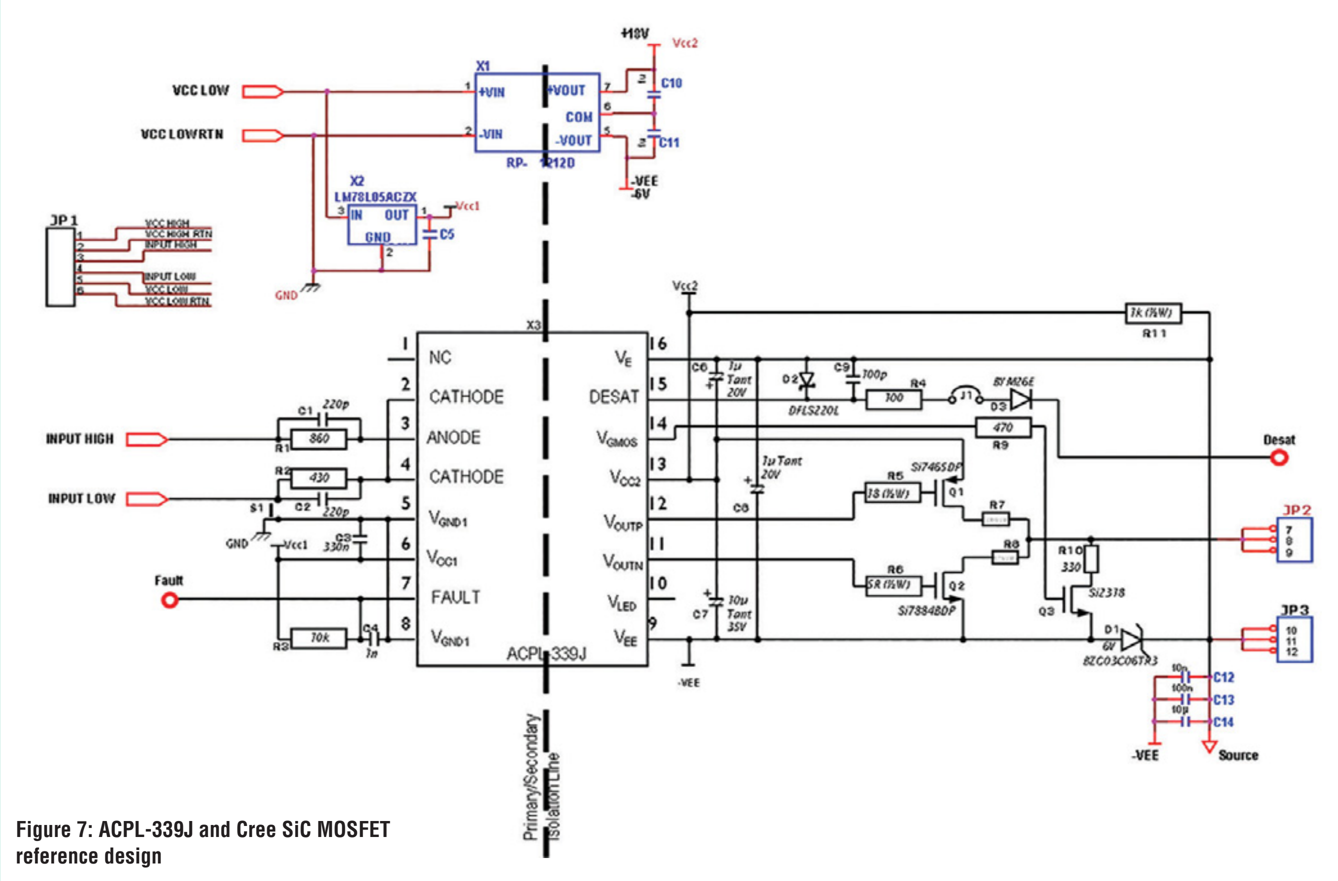

Figure 7: ACPL-339J and Cree SiC MOSFET reference design


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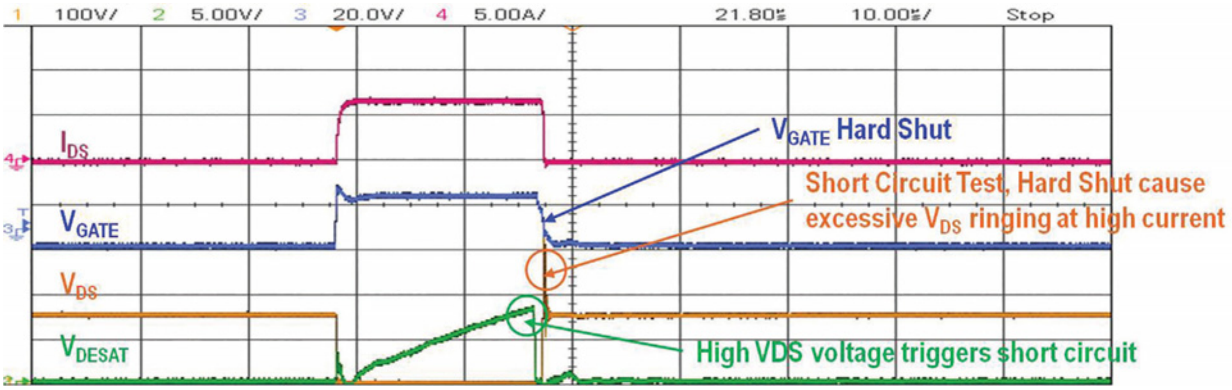

Figure 8: Hard shutdown causing excessive VDS ringing during high-current short circuit

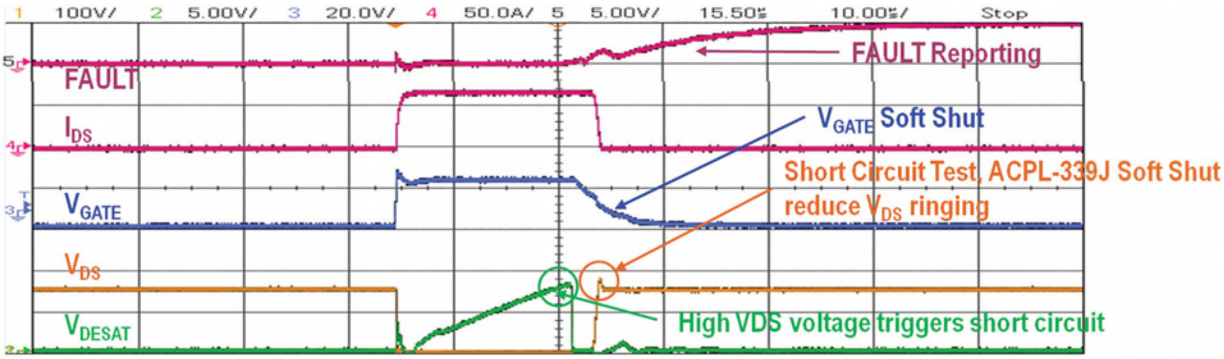

Figure 9: Soft shutdown reduces VDS ringing during high-current short circuit

339J's VGMOS pin will switch on an external transistor to slowly discharge the gate of the SiC MOSFET to achieve soft shutdown. The entire short-circuit protection sequence is completed by reporting the fault through the isolated feedback path to the controller.

During the short circuit, a high overload current, together with any parasitic induced current, can result in a high overshoot voltage if the SiC MOSFET is shut down abruptly, which may exceed the SiC MOSFET breakdown voltage. To minimize such damaging overshoot voltage, ACPL-339J does a soft shutdown when a short circuit is detected. The SiC MOSFET gate voltage is slowly reduced to low-level off state. The rate of soft shutdown can be adjusted through an external MOSFET and resistance (Q3 and R10 respectively, in Figure 7) to reduce the overshoot voltage level.

Figure 8 shows high overshoot and ringing across the drain-source of the SiC MOSFET when doing a hard (or abrupt) shutdown during short circuit. (During the experiment, a low BUS voltage was used to prevent excessive damage to the SiC MOSFET.) Figure 9 shows how the high overshoot can be suppressed when short-circuit detection is triggered and the gate is shut down "softly".

SiC MOSFET Market and Adoption

SiC technology is now widely recognized as a reliable alternative to silicon. More than 30 companies worldwide have established SiC manufacturing capabilities. Many power-module and power-inverter manufacturers include SiC devices in their future-products roadmaps.

Solar inverter manufacturers and server power suppliers are the earliest adopters of SiC semiconductors, as efficiency is critical in their technological ranking. In 2013, Europe's top solar-inverter makers, REFU, SMA and Delta each announced new models that include SiC devices. Evaluations of SMA SiC inverters show their efficiency has increased from 98% to 99%, with physical weight reduced by 30% compared to equivalent IGBT inverters.

With increased availability, higher voltage variety and lower costs, SiC semiconductor production volumes will ramp up, resulting in greater adoption in applications such as motor drives, railway traction, industrial UPSs and even hybrid vehicles. ●

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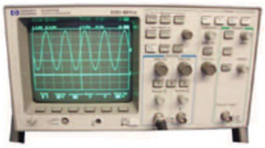

HP 54600B Oscilloscope Analogue/Digital Dual Trace 100MHZ £125

AGILENT E4402B Spectrum Analyser 100HZ – 3GHZ with options £2950

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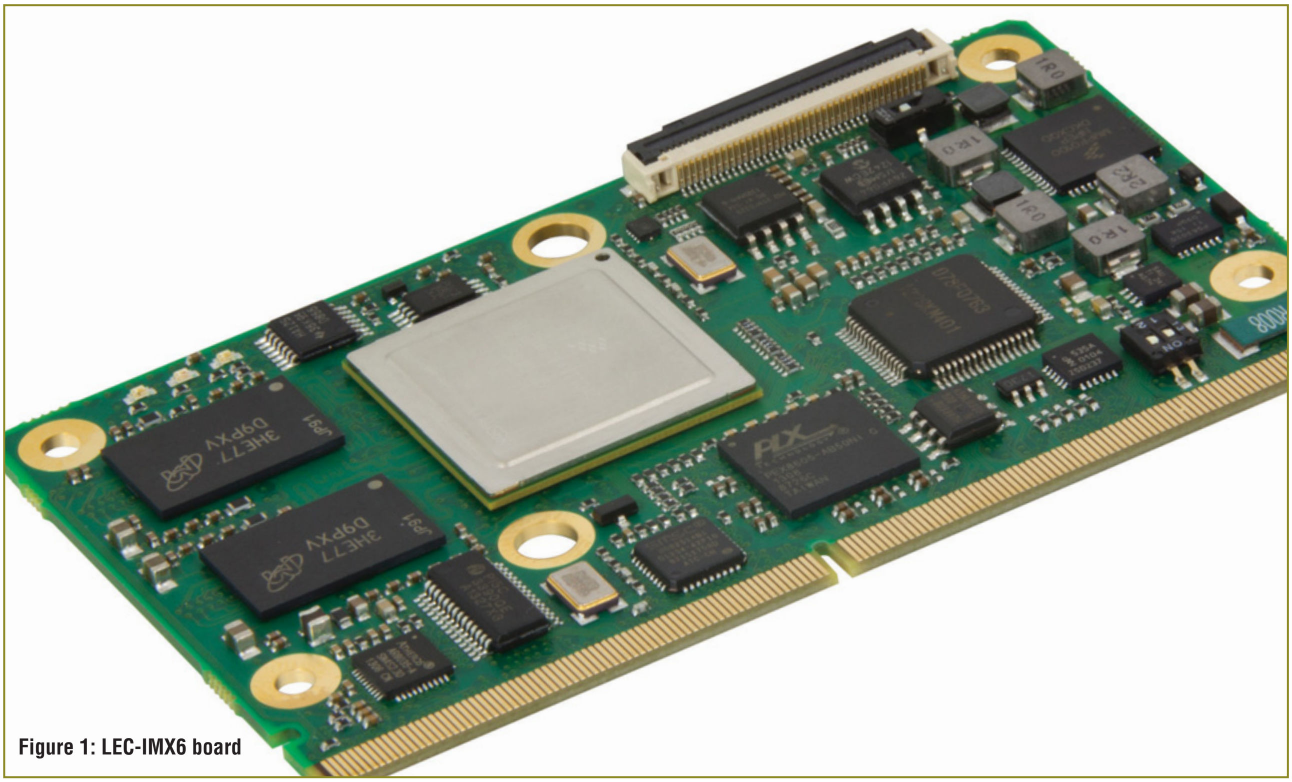


Figure 1: LEC-IMX6 board

THE SMART CHOICE FOR LOW-POWER EMBEDDED COMPUTING

BY ADLINK TECHNOLOGY, MANNHEIM

Thirty years after mainstream adoption of the personal computer (PC), the industry faces another major trend in IT. The technology behind the IBM PC and similar machines not only revolutionized desktop computing, it changed the world of embedded computing too, which was previously restricted to using expensive minicomputers or custom digital logic with an often prohibitively high cost of non-recurrent engineering.

Embedded PC form-factors have enabled the implementation of a wide variety of systems for many different applications. The most successful PC platforms were designed for power envelopes that run from tens of watts to over a hundred watts. This, however, puts some portable and low-energy applications out of reach. Using non-PC architectures can extend the benefits of off-the-shelf computing platforms even further.

The ARM Architecture

The rise of architectures designed for mobile phones and tablets has introduced a new trend, which promises to propel embedded computing into new markets, providing users with not just energy-efficient systems, but intuitive user interfaces incorporating touchscreens and voice recognition. These interfaces will revolutionize many applications by introducing sophisticated controls, as well as providing access for the Internet in remote and inaccessible locations.

Optimized for the mobile phone and tablet markets, the ARM architecture offers an effective alternative for low-energy applications that have previously found it difficult to adopt standard form-factors, and so had to absorb the high upfront costs of custom board- and module-design. At the same time, ARM enables scalability into high-performance computing and 64-bit platforms at the heart of advanced, highly energy-efficient server platforms. It can be said that ARM underpins this new, third generation of embedded computing.

There are strong historical contrasts between the Intel x86 and ARM market environments. Intel has been instrumental in defining not just the core microprocessor and instruction-set architecture, but also the architecture of peripherals. Companies that provide embedded-computing products based on the x86 architecture have been able to leverage that expertise at chip level by providing either proprietary or open-standard products with common I/O interfaces. Through the use of common connector pinouts, customers can select from a wide range of hardware- and software-compatible peripherals to customize their end products.

Successful Embedded Computing I/O Standard

COM Express is an example of a successful embedded-computing I/O standard. It is a computer-on-module (COM) form-factor that offers very high integration, enabling a complete, compact PC to be used in an end application as though it was a discrete integrated circuit component.

The COM Express module itself typically comprises the core processor and memory, with the standard I/O of a typical PC, including USB ports, audio, graphics and Ethernet networking. The PCI Express lanes and all other I/O signals that provide support for custom I/O expansion are mapped to two high-density, low-profile connectors on the COM.

With COM Express the emphasis is on high-speed I/O expansion. A pair of high-density connectors provide up to 32 PCI Express lanes or multiple storage, networking and graphics channels. In addition to providing a connector with a high degree of signal integrity and robustness, COM Express provides standardization, which is instrumental in building up a large portfolio of CPU modules and carrier boards from many different vendors. The road to a standard I/O pinout was assisted by the manner in which the PC form-factor is itself built on a commonly accepted set of standard I/O functions.

The ARM Environment

The ARM environment is more complex and differentiated. In contrast to the PC environment, in which the core module consists of a processor and Northbridge and Southbridge device, the focus with ARM is on system-on-chip (SoC) products, each usually optimized for a particular application.

Historically, there has been far less focus on building standard I/O definitions; each SoC would be used on a custom board design. There is also a wider range of I/O options that ARM platforms provide, depending on their target market, with less emphasis on standard buses such as PCI Express, for example. The result has been the introduction of a number of proprietary form-factors and connector definitions that lock the customer into a vendor's offering and which may not have support for more than a generation of silicon as they move to different SoCs.

Some vendors claim the use of a standard form-factor – sometimes piggybacking ARM support on an existing x86-focused specification – but with additional, custom connectors to provide support for I/O lines that cannot be supported by the primary connectors.

> “Supported by a number of embedded computing module vendors, the Smart Mobility ARChitecture (SMARC) provides an open-standard definition for ARM-based embedded computing solutions, optimized for low power, cost efficiency and high performance

Smart Mobility Architecture (SMARC)

Supported by a number of embedded computing module vendors, the Smart Mobility ARChitecture (SMARC) provides an open-standard definition for ARM-based embedded computing solutions, optimized for low power, cost efficiency and high performance. SMARC also provides support for systems that need more compact solutions than are offered by the PC-orientated form-factors.

Since ARM SoCs don't need the support chips of a PC platform and draw less power, the amount of board space needed for power converters and power supply lines is greatly reduced. This permits a smaller footprint, facilitating the use of SMARC-based modules in low-power portable equipment.

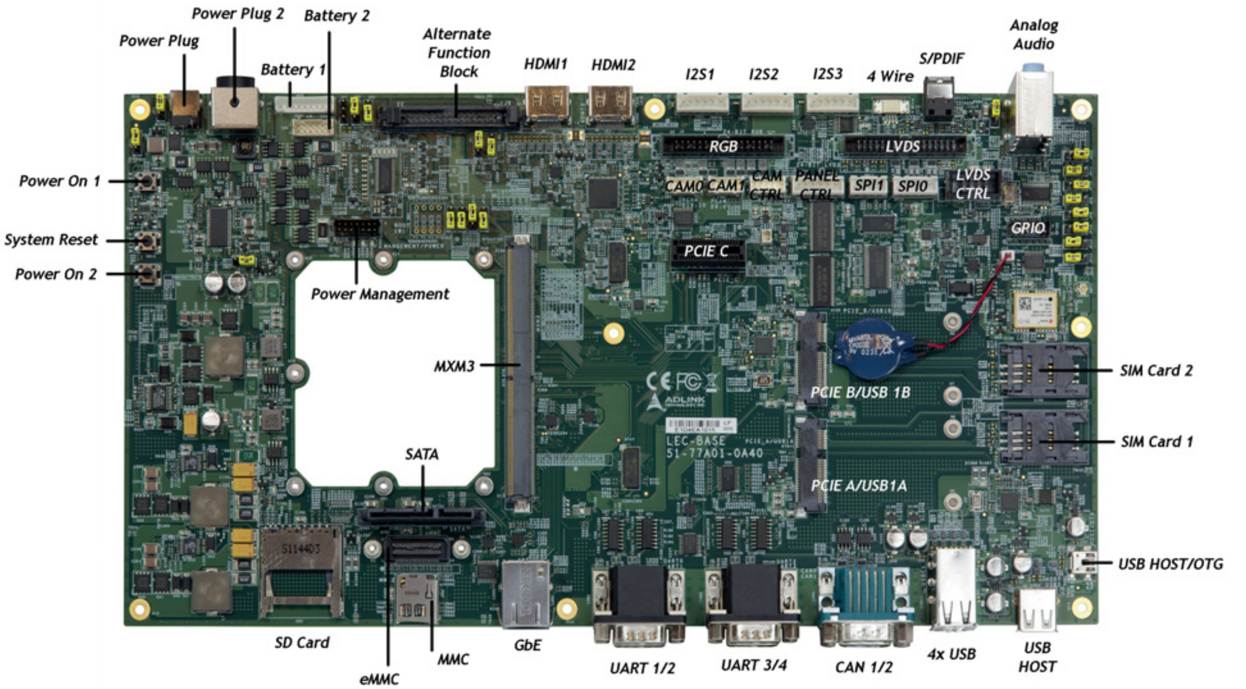


Figure 2: LEC-BASE SMARC reference carrier

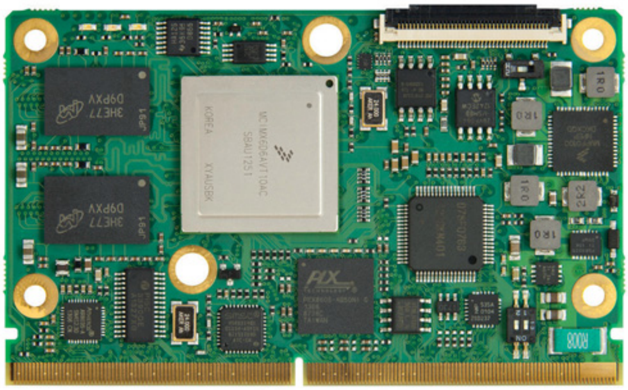


Figure 3: LEC-IMX6 board

SMARC CPU modules are expected to have an actual power requirement of between 2W to 6W, allowing for passive cooling and further reducing subsequent design effort and overall costs. The standard allows a continuous power-draw of up to 9W, for the more demanding applications.

Based on the proven connector as it is employed by MXM video modules, SMARC defines two sizes of modules: a full-size one that measures 82mm x 80mm and a short module for more compact systems, measuring 82mm x 50mm. The edge connector supports 314 electrical contacts. For harsh-environment systems, shock- and vibration-proof versions of connectors are readily available. The connectors' temperature range is from -55°C to +85°C. Competing systems such as Q7 – which also lacks the ecosystem advantages of SMARC due to the proprietary extensions used by its restricted group of supporters – are not specified over this temperature range.

The connection system employed by SMARC offers a number of benefits over competing systems beyond its support of multiple vendors, which promise to form the basis of a successful commercial ecosystem. The MXM connector guarantees a high level of signal integrity, required by the high-frequency serial interfaces commonly supported by ARM SoCs. For example, on 2.5GHz signals (as employed by PCI Express Gen 2) the insertion loss of the connector is just 0.5dB. In comparison, the insertion loss of previous generation MXM connectors was significantly higher at 3dB.

A further advantage of SMARC over other small module formats is its support for a wider input voltage range, reducing the need to use additional DC/DC converters on the core module and lowering the overall power dissipation. A SMARC module can support input voltages from 3V to 5.25V. Originally designed to support PC-class hardware, the many other formats are restricted to a nominal 5V input.

The SMARC module is designed to support a combined height above the carrier of less than 7mm. The PC heritage of most computer-on-modules has led to the assumption that all COM boards will be used with a heat spreader, which adds to the overall height of the package. The typical combined height of processor board and heat spreader is greater than the height of a package that includes both the SMARC COM and carrier board. Many ARM SoCs do not require a dedicated heat spreader because of their lower overall power consumption. The SMARC format allows for this, making it more suitable for use in systems where space is at a premium, such as tablet computers.

I/O Diversity

To take advantage of the greater I/O diversity of the core ARM-based SoCs, SMARC uses a different mix of connection options from those offered by COM Express or Q7. In contrast to the PCI Express focus of COM Express, SMARC provides options for different types of video and graphics output, serial buses such as I2C, I2S, both client and host forms of USB, serial and parallel camera interfaces and support for standard flash-memory card formats such as SD and eMMC. Future SMARC modules will also support field buses such as EtherCat, ProfiBus and Sercos.

Using SMARC, system integrators can take full advantage of the user interface options available to mobile device OEMs – options not usually found in x86-based embedded computing systems. For example, SMARC does not just support a direct parallel display bus for low-cost connection to a wide variety of thin-film transistor LCDs, but also supports a display interface compatible with the MIPI specification. This provides access to the smaller, low-cost display modules employed in smartphones or tablets as they find their way into the embedded market.

Because of its I/O flexibility and focus on ARM solutions, SMARC provides the support needed to build scalable solutions. Integrators can choose from a wide variety of processing options, from low-power single-core devices such as the Adlink's LEC-3517 Cortex A8 processor, to dual- and quad-core processor platforms like the LEC-iMX6, LEC-BT and LEC-BTS.

Key Building Block

Thanks to its focused support for the ARM architecture and backing from multiple vendors, SMARC is the key building block for a new generation of embedded computing applications, providing system integrators with the ability to build their own tablet and other advanced human-machine interfaces. Among the vendors supporting the SMARC standard are Kontron, Advantech and Adlink, held by a vendor-independent group SGET (Standardisation Group for Embedded Technologies) to ensure a healthy and unbiased ecosystem.

Thanks to the introduction of the SMARC platform, system integrators can now take full advantage of the ARM SoC ecosystem without being forced to compromise on I/O options or be tied to a single-vendor standard with limited options for future growth. Through SMARC, integrators and OEMs can be sure of having access to new generations of ARM processors, including the upcoming 64-bit and advanced multi-core products.

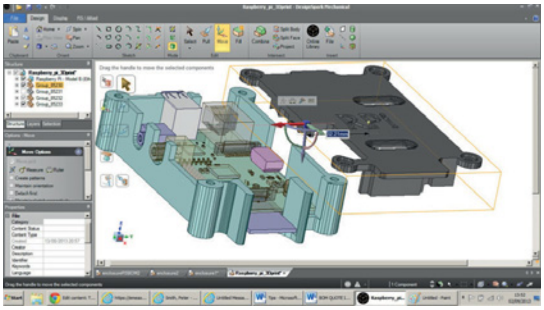
As Intel works to improve the power efficiency of its own processors and develops more Atom-based SoCs, x86 architecture products could also benefit in the future from the SMARC format. As those products appear, designers will have more choice and access to backward-compatible, low-energy products. As the third generation of embedding computing develops, SMARC is a smart choice. ●

RS COMPONENTS AT ELECTRONICA 2014 – ENABLING TECHNOLOGY DEMOCRATISATION

Glenn Jarrett, Global Head of Product Marketing at RS Components, talks about an increasing accessibility to technology and expertise, how it is influencing the way products can be developed, and why a global distributor like RS has a significant role to play.

Electronics technology and know-how has never been as accessible or affordable to professional engineers, hobbyists or students. Rich repositories of electronics design and development content and knowledge exist online now in growing quantity and increasing quality. The web has also allowed developers to be involved in design communities and forums to seek advice or to collaborate with others. In addition, major system technology platforms and their associated development materials such as Raspberry Pi or Arduino are enabling learning and innovation that seemed most unlikely only a few years ago – and it is innovation from all corners, not just from major OEMs. Certainly the open source movement – for both software and hardware – has accelerated the trend. And increasingly available connectivity via wireless modules implementing cellular, Wi-Fi or Bluetooth technologies among others is also playing a major role allowing individuals or small collectives of designers and creators to engage with the Internet of Things, for example.

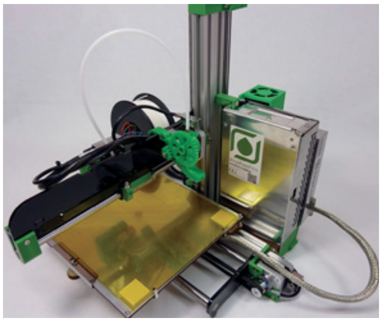
More and more resources and tools are becoming available to enable the democratisation of electronics design. But not only for the individual or student; it is also pervading product development in industry. Along with open source, two more important developments are enabling this change and introducing a more agile approach to product design. Firstly, there is the availability of free and powerful design tools such as DesignSpark PCB and DesignSpark Mechanical. DesignSpark PCB has removed the bottleneck of having to use specialist PCB layout engineers and allows all engineers to rapidly design new concepts; and DesignSpark Mechanical has enabled many more people to use a powerful 3D design tool and quickly create mechanical concepts and designs. The other element is, via RS among others, increasing access to: rapid prototyping via PCB board manufacturers that can deliver low-cost prototype boards in a matter of days; and increasingly affordable 3D printing machines, which allow engineers to quickly realise mechanical design concepts in just a few hours.



All these components enable a more agile 'rapid concept and prototyping' approach to design that can open up the product design process to entire engineering departments, as well as loosening up requirements with must-have functionality identified at a much higher level. This means that multiple concepts can be created digitally and developed in parallel with the strongest concepts progressed and physical prototypes quickly produced. This new approach can deliver the ability to rapidly react to market demands, reduce time-to-market and encourage innovation across a wider base of people including electronics and mechanical engineers.

As a major global player that is committed to empowering engineers to reach greater heights of innovation in companies of all sizes, RS has recognised these trends and is further enabling a democratisation of technology with system-level technology and products and free design tools and resources.

This brave new world of electronics democratisation will be in evidence at Electronica 2014. RS (Hall A4, Stand 246) will be using the show to demonstrate many of the tools and technologies mentioned above including DesignSpark PCB Version 7, DesignSpark Mechanical Version 2 and advanced 3D printers such as the RepRapPro Ormerod and the CubePro from 3D Systems. RS will also be showing many popular board-level computing and development platforms including the Raspberry Pi Model B+ and Compute Module, Arduino, SparqEE, Red Pitaya and Adapteva's energy-efficient open-source Parallella board. The stand will also feature the growing collection of open source designs from the DesignShare portal, especially focusing on the Internet of Things.



IMPROVING THE POWER FACTOR
OF SWITCHING MODE POWER SUPPLIES WITH CORRECTION

STOJCE DIMOV ILCEV AND **IVAN SKORYK** FROM DURBAN UNIVERSITY OF TECHNOLOGY IN SOUTH AFRICA CONSIDER THE POWER FACTOR OF SWITCHING MODE POWER SUPPLIES AND HOW TO IMPROVE IT WITH POWER FACTOR CORRECTION

In a power system, a load with low power-factor draws more current than a load with high power-factor, which may cause grid overload and lead to increased power consumption.

Loads can be divided into two types: linear and non-linear, with linear loads further categorized as resistive or reactive. Circuits containing pure resistive heating elements such as cooking stoves, irons and filament bulbs have a power factor of 1. Circuits containing reactive elements (inductance or capacitors), such as solenoids, electric motors, lamp ballasts and others have a power factor of less than 1.

The main characteristic of a linear load is that it doesn't distort the power distribution system or, in other words, it doesn't change the waveform of the current in the grid, but may only change the relative phase-shift between voltage and current. Such phase shifting can be compensated for simply by connecting the appropriate compensating reactive elements in parallel with the load.

Non-linear loads are usually rectifiers, widely used in industrial Switching Mode Power Supplies (SMPSs). Their power factor is significantly lower than 1 and can be increased with the help of Power Factor Correction (PFC).

SMPS Power Factor Without PFC

Today, a lot of systems, such as desktop computers, laptops, monitors, TV sets and others, have an SMPS to provide the needed voltage and current conditions. These SPMSs produce output power that may range from a few watts to more than a kilowatt.

The main part of an SMPS, which creates reactive power, is the input circuit comprising a diode rectifier and capacitor, as shown in Figure 1. The higher the produced reactive power, the lower the power factor of the SMPS.

Figure 1 shows the input circuit of an SMPS with the waveforms in the AC line 'a' before the rectifier and on the DC bus 'b' after the rectifier. It can easily be seen why there's a power factor decrease.

The waveforms of the fully rectified voltages $U(t)_{rect}$ and $U(t)_{cap}$, and current $I(t)_{cap}$ across the input capacitor C are shown in Figure 2. The rectified voltage pulses $U(t)_{rect}$ following the input capacitor C become a smoother waveform $U(t)_{cap}$, and eventually a DC voltage. The current $I(t)_{cap}$ flows through the rectifier during the input capacitor's charging period $t_{chrg.}$ The phase of that current pulse ($\Delta\varphi_i$) is shorter than the phase of the rectified voltage pulse ($\Delta\varphi_u$) and this difference produces a phase shift ($\Delta\varphi$) between input voltage and current in the input AC line, as shown in Figure 3. This phase shift $\Delta\varphi$ determines the power factor of the SMPS, so a bigger value gives a lower power-factor. To remove the phase shift and increase the power factor of the SMPS, either an active or passive PFC circuit can be used.

> "An active PFC is an electronic system that changes the phase of the current drawn by the load to improve the power

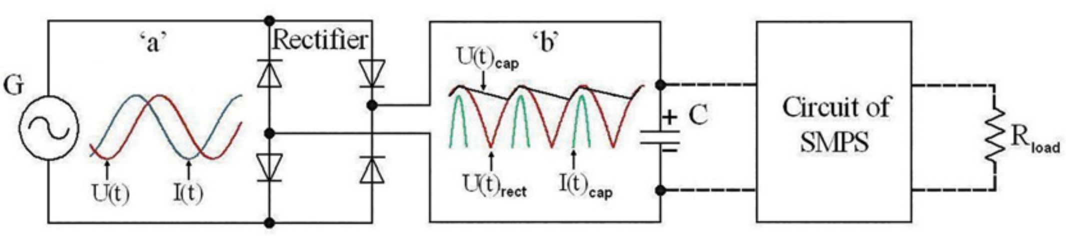


Figure 1: Input circuit of an SMPS

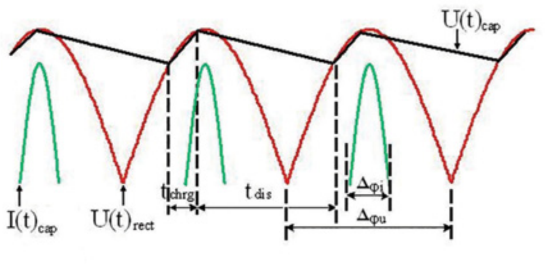


Figure 2: Waveform of a fully rectified voltage $U(t)_{rect}$ and current $I(t)_{cap}$ and voltage $U(t)_{cap}$ across the input capacitor (C)

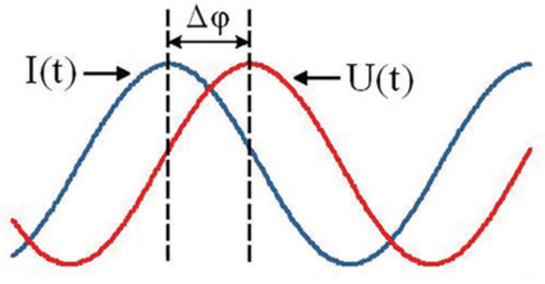


Figure 3: Phase shift between current I(t) and voltages U(t) in the AC line before the rectifier

PFC Characteristics

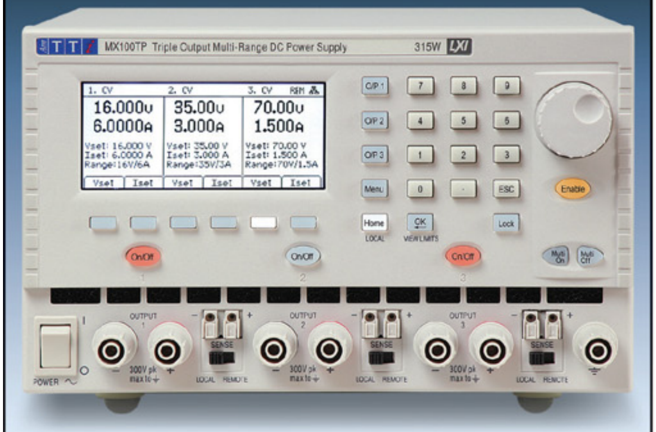
A passive PFC is usually a low-pass filter consisting of a capacitor and an inductor, which can slightly suppress distortions. However, this type is not as useful as an active PFC because of its low efficiency and, as such, it is not widely used for industrial SMPSs.

An active PFC is an electronic system that changes the phase of the current drawn by the load to improve the power factor. An active PFC makes the SMPS circuit act purely resistive, improving its power factor. Typically, an SMPS without any PFC has a power factor of only 0.55-0.65, but with an active PFC this is much higher – between 0.90 and 0.95.

An active PFC produces current $I(t)_{load}$ in phase with the rectified voltage $U(t)_{rect,}$ as seen in Figure 4. This characteristic enables the most efficient delivery of electrical power from the grid to the load.

The circuit of an active PFC as part of a boost topology is shown in Figure 5. It consists of a diode rectifier, choke coil (L), current sensor (CS) in series with the negative bus, an active element (VT), diode (D0) required for the boost, output capacitor (C), resistive voltage divider as a voltage sensor (VS) of the output voltage, and a PFC controller.

The rectified voltage, current and output voltage flow into the PFC controller, which then processes them to determine the driving parameter for the active element VT, or in



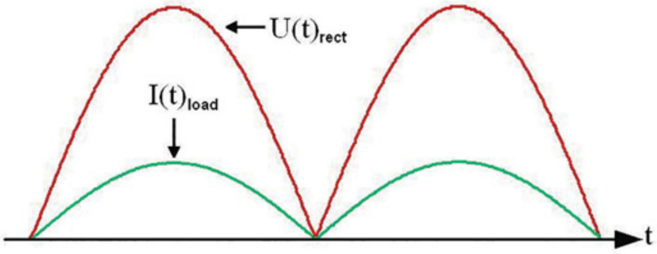


Figure 4: Phase of the current $I(t)_{load}$ and voltage $U(t)_{rect}$

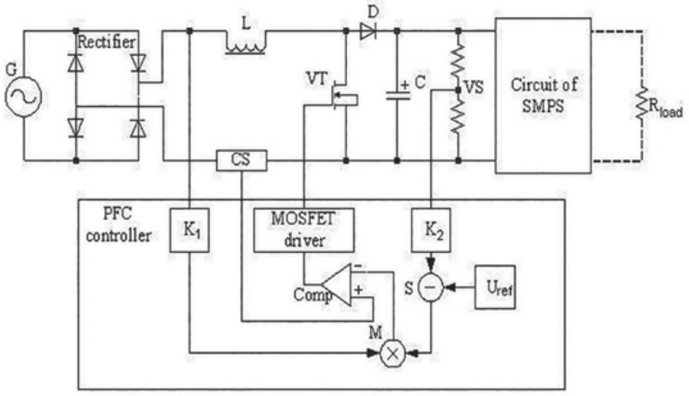


Figure 5: Simplified electronic power circuit of active PFC

other words, it determines the active element's turn-on and turn-off times. The accuracy of the PFC controller defines the maximum possible efficiency of the entire PFC circuit.

Circuit Operation

In some instances, the standard structure of the PFC controller is as shown in Figure 5. However, here it is important to protect the PFC controller by not allowing any current to flow through the choke coil. This is ensured by the following: the rectified voltage flows into the multiplier (M) through the attenuator K1 and at same time supports the constant value of the output voltage. Then, the voltage divider's output voltage flows into M through the subtractor (S) and attenuator K2. The result of the multiplying is fed into the inverting input of a comparator (Comp), with current going into its non-inverting input. The result of the comparison is handled by the MOSFET driver unit, which then provides the driving PWM signal for the MOSFET. It will also work for other types of transistors, but in our case this is a MOSFET.

The PWM transistor-driving signal is determined by two factors: the rectified voltage amplitude value and the current across the choke coil (see Figure 6). The PWM signal is a sequence of pulses with different duty-cycle values or different pulse widths. Every pulse of the PWM sequence drives the MOSFET: the rising edge is the turn-on point, whereas the falling edge is the turn-off.

It can be seen that the PWM pulse begins when the rectified voltage $U(t)_{rect}$ and current across the choke coil are zero. The MOSFET turns off when the value of the linearly-increasing current $I(t)_L$ across the choke coil becomes equal to a certain level of the rectified voltage $U(t)_{rect}$. After the transistor goes off, the current across the choke coil begins to decrease linearly and, when its value reaches zero, the transistor turns on. The process repeats, controlled by the PFC controller with relatively high frequency, which is an active correction of the power factor.

The current across the choke coil $I(t)_L$ can be represented as an integrated average current $I(t)_{average}$, the same as the one drawn by the load. The choke coil is a component that determines the total power of the active PFC circuit.

Advantages

Advantages of the active PFC include:

- High efficiency, with a power factor correction of between 0.90 and 0.95, which means that an active PFC produces almost no reactive power in the AC line and minimizes the level of non-linear distortions;
- The electrical efficiency of an active PFC is around 95%;
- An active PFC can be used with any size SMPS;
- Active PFCs become more cost-effective with increasing SMPS output power.

However, the main disadvantage of the active PFC is the power circuit's complicated design. ●

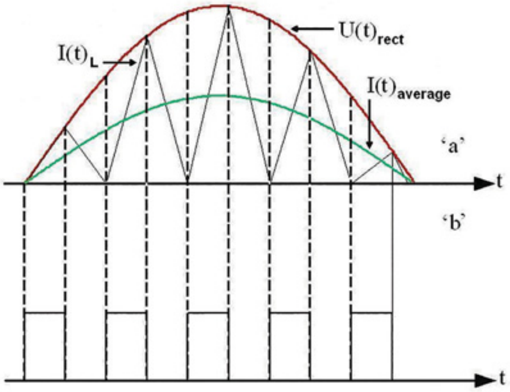


Figure 6: Timing diagram of the PWM signal 'b' that drives the MOSFET according to the amplitude of the rectified voltage U(t) rect and current across the choke coil I(t)L 'a'

Voltage Regulators

MAURIZIO DI PAOLO EMILIO, PHD IN PHYSICS AND A TELECOMMUNICATIONS ENGINEER, PRESENTS THIS SERIES OF ARTICLES ON THE FUNDAMENTALS OF MICROELECTRONICS

A voltage regulator (Figure 1) is designed to automatically maintain a constant voltage level, and it can be a simple "feed-forward" design or a negative feedback control loop used in electromechanical mechanisms.

Electric or electronic components can be badly damaged by power surges; on the other hand, low voltages might not provide enough power for them to function; regulators keep the voltage within safe and usable operating range to function properly.

Cars also use voltage regulators to maintain the battery's charge. Regulators are usually part of the car's alternator, although many cars – particularly older cars and modern American models – have separate voltage regulators. Alternators or generators are used to generate power, which is fed into the car's battery to maintain a full charge. The power generated by the car's charging system is also used to run the car's electrical systems, such as headlights, stereo, power windows and ventilation systems.

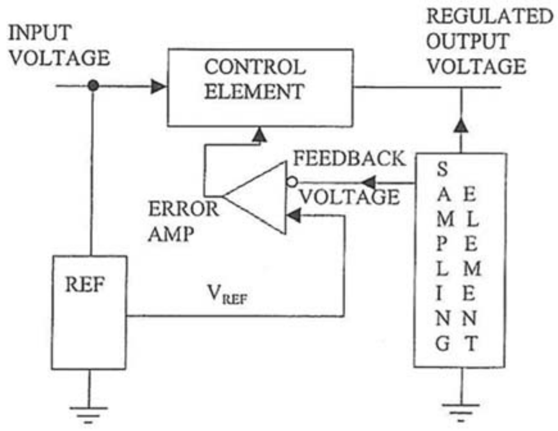


Figure 1: Typical voltage regulator

Voltage Regulator Modules

A voltage regulator module (VRM) is a standalone module that senses a computer's microprocessor voltage requirements and ensures correct voltage is maintained. If you are changing your computer's microprocessor (for example from a Pentium to a Pentium Pro, or a Pentium with MMX), you need to add a VRM to the existing voltage regulator on the motherboard so the new voltage requirements can be detected and maintained.

For example, in the case of the Pentium, the original processor has the same voltage requirement for its core or basic operation as for its I/O operation, at 2.8V. However, Pentium Pro and Pentium with MMX have different voltage requirements for the core (2.8V) and I/O (3.3V). Adding a VRM allows regulating the voltage for the I/O while the original regulator built into the motherboard continues to regulate the core voltage.

Types of Regulator ICs

There are three types of IC voltage regulators: linear, IC switching and DC/DC converters. IC linear voltage regulators use an active pass element to reduce the input voltage to a regulated output voltage. By contrast, switching regulators store energy in an inductor, transformer, or capacitor and then use this storage device to transfer energy from the input to the output in discrete packets over a low-resistance switch.

DC/DC converter chips, the third type of IC voltage regulators, also provide a regulated DC voltage output from a different, unregulated input voltage.

Performance specifications for IC voltage regulators include the following:

- The regulated output voltage (V_{out}) can be fixed or adjustable.
- The output current (I_{out}) is measured under specified conditions.
- Dropout voltage (V_D) is the minimum voltage drop across

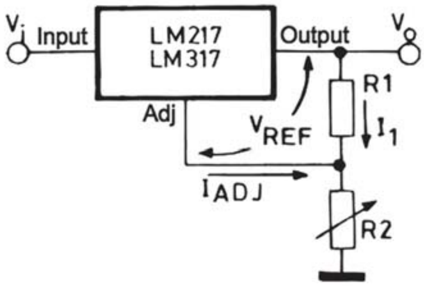


Figure 2: LM217/317

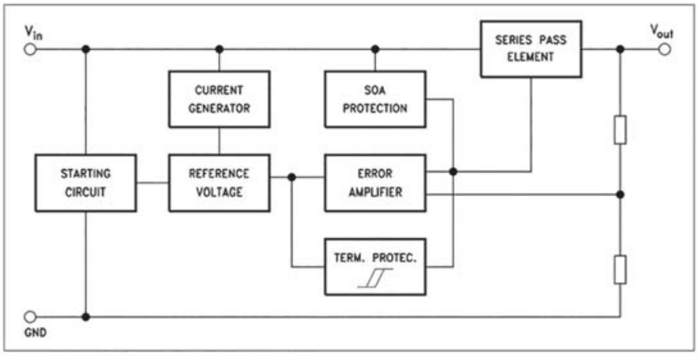


Figure 3: Block diagram of PB137

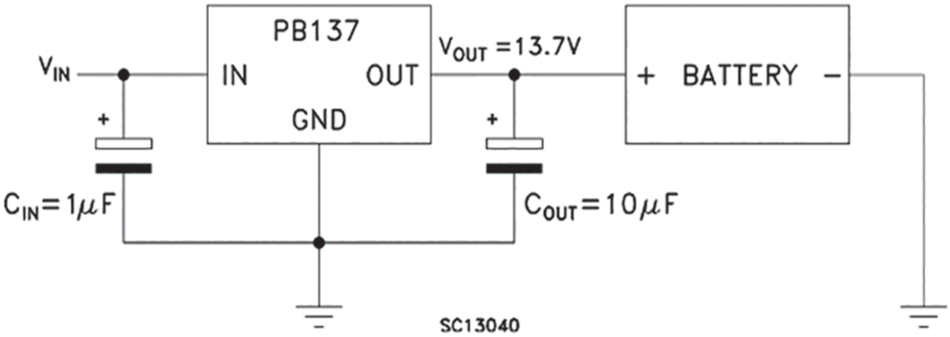


Figure 4: PB317 application

the regulator that maintains the output voltage. Voltage regulators with small dropout voltages dissipate less internal power and have relatively high efficiencies.

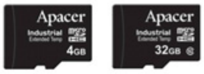
- Measured in Amperes (A) during the idling state, the quiescent current never makes it to the load. Instead, it flows from the battery to power the regulator itself.
- The operating temperature is a full required range.
- Transient response is the reaction of the regulator when a (sudden) change of the load current (load transient) or input voltage (line transient) occurs.

Regulator Packages

IC voltage regulators are available in a variety of packages. Dual in-line packages (DIP) can be made of ceramic (CIP) or plastic (PDIP). Quad flat packages (QFPs) contain a large number of fine, flexible, gull wing shaped leads. SC-70, one of the smallest available IC packages, is well-suited for applications where space is extremely limited. Small outline (SO) packages are available with 8, 14 or 20 pins.

The LM217 and LM317 (Figure 2) are monolithic integrated circuits in TO-220, TO-220FP and D²PAK packages, intended for use as positive adjustable voltage regulators. They are designed to supply load current of over 1.5A, with an output voltage adjustable over a range of between 1.2V and 37V.

The PB137 (Figure 3 and 4) is a positive voltage regulator able to provide 1.5A at 13.7V, intended as a charger for lead-acid batteries. An important feature is the very low reverse leakage current, as well as it's available in TO-220 and employs internal current limiting, thermal shut-down and safe area protection, making it essentially indestructible. If adequate heat-sinking is provided, it can deliver output current of over 1A. ●



ELECTRONICA 2014

Messe München, Germany

11-14 November 2014

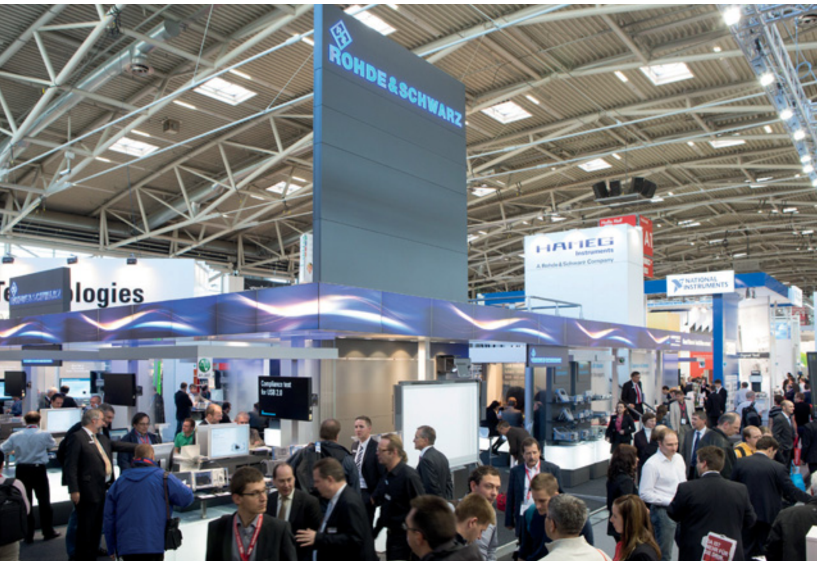
www.electronica.de

Top-Class Program For 50th Anniversary

Electronica, the largest European electronics event, is celebrating its fiftieth anniversary this year. From November 11-14, Messe München visitors can learn about the latest products: from components and systems to electronic applications and services.

This year's international trade fair revolves around automotive, embedded systems, medical electronics and lighting applications, as well as the overarching themes of security and energy efficiency; the program of conferences and forums will explore these exhibition topics in greater depth.

According to analysis by the German Electrical and Electronics Manufacturers' Industry Association (ZVEI, www.zvei.org), the global market for electrical and electronic products grew by 3% last year to around 3.7 trillion euros, a growth driven mainly by the Asian and American markets. However, this has also benefited the German electrical industry, which in the first quarter of 2014 saw new orders rise by 3% over the previous year.



International Exhibitors And Trade Visitors

In 2012, almost half of the 73,051 visitors and 63% of the 2,669 exhibitors came from abroad. With its three-pillar concept of exhibition, conference and forum program, this year's Electronica will again provide the latest information on technologies, products, services and trends in the industry. A highlight of the show is the CEO roundtable, which this year will be devoted to "*Internet of Things: Possibilities, Challenges and the Question of Security*". Whereas the Electronica Forum, with its panel discussions and lectures, will focus on automotive, embedded systems, medical electronics, lighting, security and energy efficiency topics among others.

Comprehensive Conference And Forums Program

In the exhibition halls, there will be several other forums that will help with the exchange of ideas and opening up of dialogues. In addition, the PCB and Components Market Place with its application-orientated approach will help visitors learn about current and future issues. These topics will be explored in greater depth within the conference program.

Electronica Automotive Conference

The Electronica automotive conference, supported by ZVEI, will take place on November 10 at the ICM – Internationales Congress Center München. The conference will investigate the major technology trends and strategies of the international automotive industry. Among the conference speakers are representatives from Audi, BMW, Daimler, Freescale, Infineon, Intel, Osram, Renesas and Visteon. This year, the focus is on lighting, sensor fusion and connectivity.

Embedded Platforms Conference

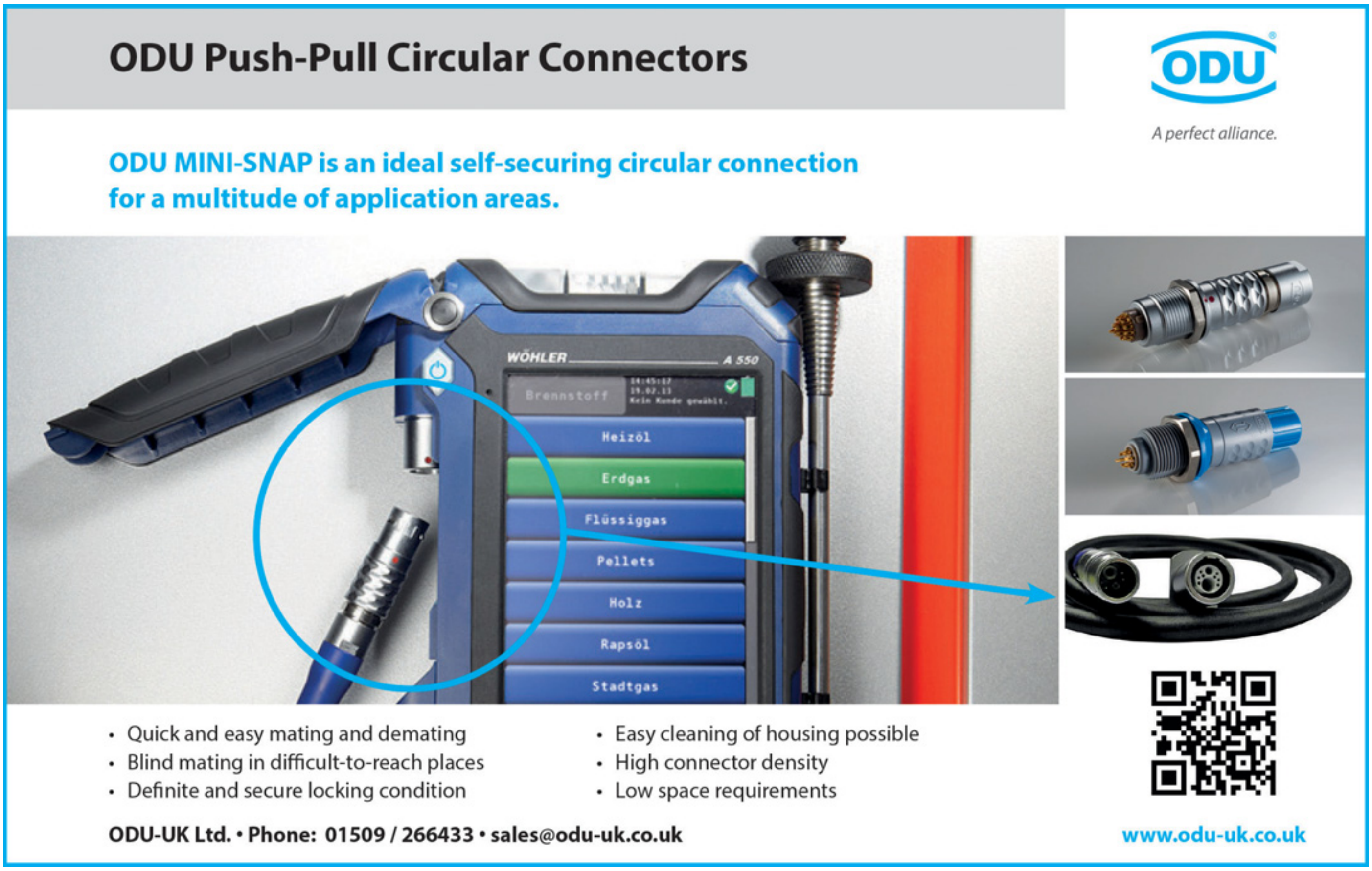
For the second time, the embedded platforms conference will be looking at new technologies, concrete solution approaches and services for the development of embedded systems. The conference will take place on November 12 and 13, in parallel with Electronica, at the Press Centre East of the Messe München.

Wireless Congress

At the Wireless Congress '*Systems & Application*', organized by "*Elektronik*" magazine, ZVEI and Electronica at the ICM – Internationales Congress Center Munich on November 12 and 13, industry experts will discuss the technical aspects of present and future wireless technologies, primarily for industrial use.

Registration

To find out more about all these events, to register as well learn how to get there, go to **www.electronica.de**



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New Nanopower Series From Honeywell At Electronica 2014

Honeywell will present a variety of products at Electronica in Munich in November, in Hall 13, Booth 325. Among those will be new products including Anisotropic Magnetoresistive (AMR) Sensor ICs and the Basic Compensated, Unamplified Board Mount Pressure Sensors.

Being demonstrated for the first time in Europe, Honeywell's AMR Sensor ICs, Nanopower Series are an industry first and provide the highest level of magnetic sensitivity. The new Basic Board Mount Pressure Sensors, Compensated, Unamplified, TBP Series are designed for customers who require simple, high quality, cost-effective, basic performance.

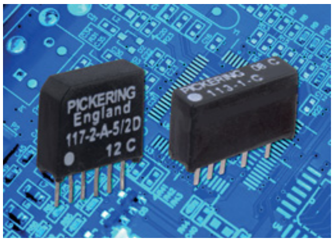
Hall 13, Stand 325
www.honeywellnow.com

Pickering Electronics Will Show Latest Reed Relays at Electronica 2014

Pickering Electronics manufactures high-quality reed relays for instrumentation and Automatic Test Equipment (ATE), high voltage switching, low thermal EMF, direct drive from CMOS, RF switching and other specialist applications. Relays are available in surface mount, Single-in-Line (SIL), Dual-in-Line (DIL) and many other popular package options.

Pickering manufactures reed relays for instrumentation applications using only the highest quality materials, certified to ISO 9001-2008 and audited by the British Standards Institution.

Hall A1, Stand 530
www.pickeringrelay.com



Shielding, Thermal Management and Optical Window Challenges Addressed by Chomerics

Designed to address complex and challenging electronics equipment applications, the Chomerics Europe division of Parker Hannifin will use the forthcoming Electronica 2014 exhibition to demonstrate what are considered to be the industry's most advanced shielding, thermal management and optical window technologies.

In particular vehicle electronic systems must deliver long-term reliability in harsh electrical and physical environments. Chomerics's materials enable these challenges to be addressed successfully.

Hall B1, Stand 370
www.parker.com/chomerics

A Sensor Pro In Every Discipline

Sensirion is taking sensor technology to a new level this year, presenting the most advanced platform for humidity and temperature sensors – the Platform3x with the powerful SHT3x sensor series – at Electronica. Sensirion is launching an innovation that excel across the board and a sensor that outperforms all previous models.

The versatile Platform3x consists of a group of humidity and temperature sensors with different precision levels and features. The Platform3x is thus optimally designed for individual applications on the market.

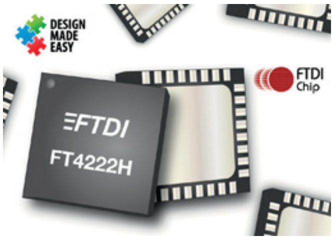
Hall B1, Stand 206
www.sensirion.com

Highly Advanced, IO-Packed And Power Efficient USB 2.0 to SPI/I2C Bridge Chip

The FT4222H is the latest addition to FTDI Chip's expansive USB offering. Compliant with the USB 2.0 hi-speed standard, this is a feature-rich single-chip bridging solution with I2C and multi-channel SPI interface capabilities.

With regard to SPI the device serves as a SPI Master/Slave interface controller and supports all four SPI modes (0, 1, 2, 3). It allows single, dual and quad data-width transfer, so that total data rates of up to 27Mbit/s are possible. The integrated configurable I2C master/slave interface controller conforms with both I2C v2.1 and v3.0 specifications.

Hall A5, Stand 261
www.ftdichip.com



Omron Launches Efficient, High-Power DC Relay

To address the growing market for high voltage DC battery powered systems and renewable energy applications, Omron Electronic Components Europe (OCB-EU) has added an efficient new DC power relay suitable for bicycle and scooter charging stations, UPSs, battery management systems, elevators, industrial robots, solar/wind generation systems and other applications.

The new Omron G9EJ-1-E is capable of interrupting 15A at 400VDC yet draws only 1.2W while switching. In order to allow the relay to interrupt high currents without the contacts deteriorating, the device features a proprietary high efficiency magnetic circuit that suppresses arcing.

Hall A5, Stand 163
http://components.omron.eu

THIS SERIES PRESENTS SOME SIMPLE ARDUINO PROJECTS. ARDUINO IS AN OPEN-SOURCE ELECTRONICS PROTOTYPING PLATFORM, BASED ON FLEXIBLE, EASY-TO-USE HARDWARE AND SOFTWARE

How to Add an Alarm to Your Arduino Clock Project

BY **BROCK CRAFT**

Adding an alarm is the easiest hardware modification for the Arduino Clock project. All that's needed is to attach the piezoelectric sounder. With that added, simply create a function to play the alarm. Add the following code to the bottom of your Arduino sketch:

```
void soundAlarm() {
float alarmFrequency=1400; // The value for the alarm tone
in Hz
float period = (1.0 / alarmFrequency) * 1000000;
long beepDuration=250000; // the time in microseconds
0.25 seconds)
long elapsedTime = 0;
while (elapsedTime < beepDuration) {
digitalWrite(piezoPin,HIGH);
delayMicroseconds(period / 2);
digitalWrite(piezoPin, LOW);
delayMicroseconds(period / 2);
elapsedTime += (period);
}
digitalWrite(piezoPin, LOW);
delayMicroseconds(beepDuration);
// Listen for either button to be pressed and if so, turn off
the alarm
int hrs=digitalRead(incrementAlarmHrsPin);
int mins=digitalRead(incrementAlarmMinsPin);
if (hrs==HIGH || mins==HIGH){
alarm=false;
}
}
```

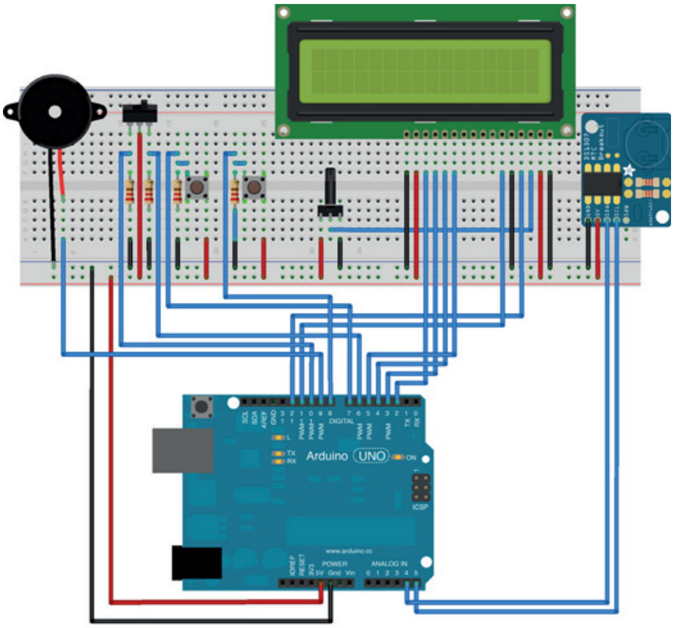


Figure 1: Connecting the alarm for Arduino

The code uses a standard formula to obtain the period of a frequency; the period is the duration of a single cycle in a repeating event and is reciprocal to frequency. The frequency of the alarm tone needs to be specified in Hertz (Hz) and assigned to the float variable alarmFrequency. The alarm will then play a tone at this frequency.

Two long integers, beepDuration and elapsedTime, reflect the tone's duration and the elapsed time of the played tone, respectively. The while loop uses these to limit the time the note is played to 0.25s (beep duration).

With the period calculated, this value is then used to rapidly write HIGH and LOW values to the piezoPin. One cycle includes both on and off times, so the amount of time to write the pin HIGH and LOW is half the total period. This is written to the digital pins using:

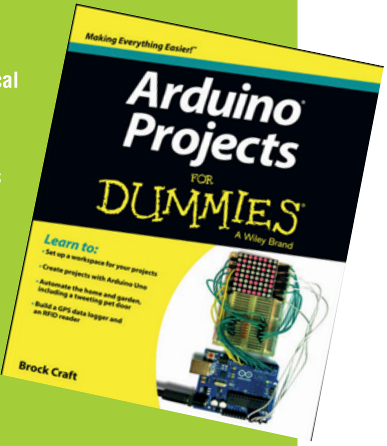
```
digitalWrite(piezoPin,HIGH);
delayMicroseconds(period / 2);
digitalWrite(piezoPin,LOW);
delayMicroseconds(period / 2);
```

The delayMicroseconds() function is the shortest amount of time you can delay the Arduino, and is needed for generating a tone. After the tone has been played, the following two lines create silence for the same duration (0.25s) by holding the piezoPin LOW:

```
digitalWrite(piezoPin, LOW);
delayMicroseconds(beepDuration);
```

WIN THE 'ARDUINO PROJECTS FOR DUMMIES' BOOK

Brock Craft is a Lecturer in the Department of Computing at Goldsmiths, University of London. He drew extensively on his practical experience with Arduino to write 'Arduino Projects For Dummies'. We have a couple of copies of this book to give away. To enter please supply your name, address and email to the Editor at svetlanaj@sjpbusinessmedia.com The winner will be drawn at random and announced at the end of the series.



The last thing to do is provide a way to silence the alarm when either button is pressed. The local integers, hours and minutes, store the value of the buttons used to program the alarm. If either the hours or minutes button goes HIGH because it's been pressed, the alarm condition is set to false. The vertical bars | | indicate a logical OR evaluation:

```
int hrs=digitalRead(incrementAlarmHrsPin);
int mins=digitalRead(incrementAlarmMinsPin);
if (hrs==HIGH || mins==HIGH){
alarm=false;
}
}
```

The clock is then ready for a trial run. In the code, set the alarm time to be some time in the next minute or so; then send it to the Arduino. Make sure the slide switch is in the armed position and that the asterisk is displayed. Pretty soon there will be the rewarding sound of the alarm.

If you have any trouble, check the connections and code to make sure all is correct. ●

More on this project, as well as other Arduino-related projects, can be found in the book 'Arduino Projects For Dummies' by Brock Craft.

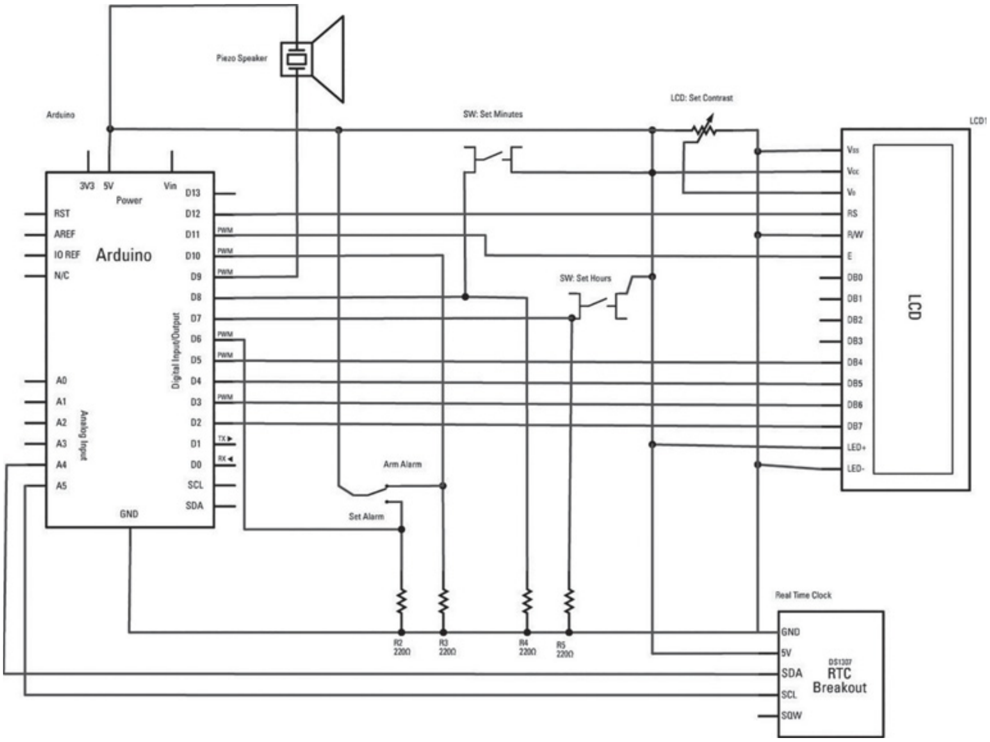


Figure 2: Connections for the project

STRATEGIES IN LIGHT EUROPE 2014

M.O.C. Event Centre, Munich, Germany

October 21-23, 2014

www.sileurope.com

The fifth annual Strategies in Light Europe Conference and Exhibition will be held at the M.O.C. Event Centre in Munich on October 21-23, 2014. The theme of the event this year is Lighting for the 21st Century, and the focus will be on recent developments in LED lighting technologies, markets and applications.

Conference presentations will run in two parallel tracks, and there will be pre-conference workshops and the SSL Investor Forum. The Forum will explore key topics for the entire solid-state lighting (SSL) value chain, from components to systems and applications. Many of the conference sessions will feature panel discussions and allow in-depth interaction with the speakers. This year, the conference and its associated trade show are expected to attract over 1,000 delegates from Europe as well as other world regions.

Pre-Conference Events

Two workshops will be held on Tuesday, October 21, the day before the main conference. The aim of the first workshop, *LED Performance Marks – Are they on the Right Track?*, will be an open discussion on the impact of LED performance marks such as DEKKRA and ENEC and how useful they are for the market. Speakers will include representatives from MCA Baschnagel, DEKKRA Certification, EEPCA, LIA Laboratories and Andorfer Consulting among others.

The second workshop, Smart Lighting, will explore how the rapid evolution of lighting design concepts enabled by LED technology, ubiquitous networking of all things and long lifetimes of properly designed SSL systems will gradually change the fundamental structure of the lighting markets. Speakers will include representatives from Helvar, Tridonic, Mackwell Electronics, Harvard Engineering, Schneider Electric and Trilux.

Also on October 21, the SSL Investor Forum will be held for the fourth year. Sponsored by investment bank Canaccord Genuity, the Forum aims to address some of the principal questions being asked, as well as issues such as the pace of adoption of LEDs in lighting, the longer-term growth potential of the market, profitability analysis and the opportunities to invest in different levels of the lighting value-chain. Speakers from publicly-quoted companies, as well as private European and global firms that have successfully brought LED lighting products to European and international markets, will share their expertise and insight.

Market and Applications Track

Market and application-related presentations will range from case studies of high-end and challenging LED lighting projects to the concept of lighting as a service, from human-centric lighting to the impact of LEDs on luminaire design. This year's program has a particular focus on lighting design and will feature speakers from several leading European lighting design firms, including KSLD, Speirs + Major, DHA Design, KSLD, Lichtvision and AECOM Lighting Design. These speakers will discuss how LEDs have been used to address major design challenges across a wide variety of lighting applications.

Plenary Session

The opening plenary session will kick off the conference with high-level speakers from the LED and lighting industries who will address the important issues that affect the future growth of the SSL market in Europe as well as worldwide. A key feature of the plenary session will continue to be a review and forecast of the LED lighting market by Philip Smallwood, Strategies Unlimited's Director of LED and Lighting Market Research. Keynote speakers this year include world-renowned lighting designer Rogier van der Heide and Norbert Hiller, Executive Vice President of Lighting, Cree, Inc. Plenary speakers include Christian Schraft, President, Havells-Sylvania; Ruben Kubiak, Policy Officer, European Commission, DG Energy; and Gary Hua, President and Founder, Inventronics, Inc.

For more information on Strategies in Light Europe 2014, including the complete conference agenda and online registration, visit **www.sileurope.com.**

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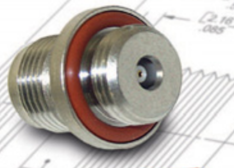

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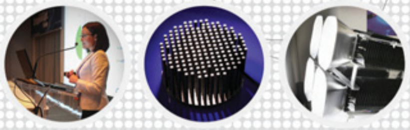

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NEW HEAVY-DUTY CONNECTOR SERIES FROM AMPHENOL

Amphenol Industrial Products Group now offers a heavy-duty connector series for size 8 and size 12 power contacts. The new ATHD series is a single pole, rugged, in-line connection system designed to replace splices and provide power wherever it's needed.

Using Amphenol's exclusive Radsok technology, the connector reaches higher amperages than other connectors in its class. Ideal for rugged, high-vibration applications found in the heavy equipment and mining markets, the sealed, thermoplastic connectors can be installed and repaired in the field eliminating the need for costly, non-repairable splices. They also feature clip slots for a variety of harness mounting solutions.

The size 8 system is rated to 70A continuous with the Radsok terminals and has contact retention of 156N. The size 12 system is rated to 35A continuous with the Radsok terminals and has contact retention of 133N. The ATHD series is RoHS compliant and has an IP67 rating.

www.amphenol-industrial.com

SMITHS CONNECTORS UNVEILS HIGH-SPEED FIBRE CHANNEL D-SUB SERIES

Smiths Connectors has introduced hand-tooled high-speed rugged D-Sub series. This range of high-impedance connectors has been designed to ground the outer shield quadrax and twinax contacts directly to the shell of the connector. A compelling differentiator in the D-Sub connector is minimal RF noise and high durability of up to 1,000 mating cycles.

To ensure that the correct high-speed connectors are mated to address specific wiring requirements and keying functions, a keyed jack post has been incorporated into the design. The six-positioned keyed jack post allows for 36 possible keying combinations, ensuring that the correct high-speed rugged D-Sub plug is mated to the correct high-speed receptacle. Non-keyed jack post versions are also available.

In addition to meeting and exceeding all requirements of MIL-STD-202 for shock and vibration, the size 10 contacts are 30% smaller than the standard size 9 for tight-space-constraint applications while delivering the same performance in a significantly smaller package size.

www.smithsconnectors.com

AC CURRENT SENSOR IC WITH DIFFERENTIAL OUTPUT AND GALVANIC ISOLATION

The new ACS726 from Allegro MicroSystems Europe is a current sensor IC designed to provide an economical and precise solution for AC current sensing in industrial, commercial and communications applications. In addition to featuring galvanic isolation, it is the first current sensor IC to include a fully differential back-end amplifier that can be used to adjust gain and bandwidth via external RC networks. The back-end amplifier is fully independent and, when unused, can be powered down to reduce power consumption. The fully differential output of this device gives better immunity to output offset drift as well as common-mode noise.

The low-profile device package makes it easy to incorporate into customers' applications. Typical uses for the ACS726 include motor control, load detection and management, switched-mode power supplies and overcurrent fault protection.

The device consists of a precise, low offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die.

www.allegromicro.com

NEW TOOLS FOR SAFE AND SIMPLE ASSEMBLY OF INDUSTRIAL CONNECTORS

Harting has introduced a new range of tools for easy assembly of the company's family of industrial connectors.

The tools include a new slimline screwdriver, tightening torque tools for guiding pins and bushes, panel cutout punch tools for industrial connectors, a new 4-indent crimp tool and crimping tools for wire gauges up to 70mm^2.

The tightening torque tool offers the simplest operation and reproducible quality with a fixed torque (0.5Nm), which makes over- or under-tightening impossible. The new slimline screwdrivers are ideal for lean assembly with the integration of the insulation at blade diameter.

The implementation of the Harting panel cutout punch tools represents a further addition in the area of processing technology. For crimp assembly technology, battery- and hand-powered crimp tools for high-current contacts are available, with a press force of 60kN in combination with 9mm-wide DIN 46235 press dies for all HC contacts up to 70mm^2.

www.harting.com

SCHURTER T9 NOW AVAILABLE FOR PCB MOUNTING

Schurter's T9 fuseholder style circuit breaker series will also include Model T9-818 for PCB mounting, providing a complete range of mounting styles equivalent to closed fuseholders.

The T9 series feature dimensions comparable to those of traditional fuse holders, and are similarly designed for direct placement on circuit boards. Schurter's existing T9 series features quick-connect terminal types for front and rear snap in panel mounting, as well as thread neck mounting.

As with all PCB mounted components, assembly costs are considerably lower because fewer materials are used and wires are eliminated to fully automate assembly. In addition, the T9-818 is more compact than quick-connect terminal types and thus requires less space. Furthermore, its slim design means the reset button protrudes only minimally from the front panel. Two mounting pins provide additional mechanical support on the circuit board and protect the solder connections from additional pressure when the reset button is activated.

www.schurter.co.uk

SPECIALIST HIGH-SHOCK OSCILLATOR ALSO DELIVERS HIGH-TEMPERATURE PERFORMANCE

The new SQXO-2ATHG range of very high shock survivability oscillators launched by IQD are housed in a TO-39 package and can withstand shock levels of up to 8,000g for 0.5ms, ½ sine. They are designed primarily for applications such as underground boring tools, down hole instrumentation and avionics applications, including flight recorder equipment and on board computers.

Frequencies are available from 32.768kHz up to 50MHz and can be specified to operate from either a 3.3V or 5V supply, providing CMOS output and a start-up time of under 5ms. High temperature is catered for with variants being available which operate up to 200 degrees C.

Current consumption is down to 3.0mA, which also lends itself to applications in remote locations where easy access is not always possible. Standard packaging is in a tray and the devices are fully RoHS compliant.

Further information is available from all IQD's worldwide sales offices with full applications support.

www.iqdfrequencyproducts.com

TTI EUROPE STOCKS INDUSTRIAL MINI I/O CONNECTORS FROM TE CONNECTIVITY

TTI Inc is stocking TE Connectivity's (TE's) mini I/O industrial connector system. This compact, latching, wire-to-board I/O interface measures one-quarter the size of a conventional RJ45 plug and features two points of contact for increased reliability in high-vibration industrial applications.

Mini I/O connectors are available in two coding options to help prevent mismating. Each connector contains eight individual contacts that accommodate I/O signals or industrial Ethernet, and are available in angled and vertical configurations and surface-mount and through-hole options. The unique latching system protects the plug from pull-out in high vibration environments.

The latest addition to the mini I/O product family is a field-installable version with an innovative and time-saving wire termination and an easy to use hand tool that allows for field assembly in virtually any environment.

The Mini I/O connectors are much smaller than RJ45 types and they can withstand much higher vibration acceleration (25G vs 10G for RJ45), crucial in the industrial environment.

www.ttieurope.com

POWER INTEGRATIONS'S CAPZERO X-CAPACITOR DISCHARGE DEVICES CERTIFIED

Power Integrations announced that its CAPZero family of innovative, two-terminal, automatic X-capacitor discharge ICs has been certified to meet IEC 62368, the new over-arching safety standard covering TVs and IT equipment. The CAPZero family eliminates power losses while allowing power supplies to comply with safety standards. The new standard replaces IEC 60950 and IEC 60065 and will become mandatory.

CAPZero ICs are smart, high-voltage switches that are placed in series with the resistors used to provide a safe discharge path for a power supply's X capacitor. Without this switching mechanism, these discharge resistors cause a constant power drain while AC is connected and, therefore, contribute significantly to no-load and standby input power consumption. CAPZero X-capacitor discharge ICs block current flow to the discharge resistors when AC voltage is applied, cutting the power wasted in these components to zero. When the AC voltage is disconnected, CAPZero automatically and safely discharges the X capacitor.

www.powerint.com

EZ-BOARDWARE PCB CONTACT FROM HARWIN IS SECURE AND COST-EFFECTIVE

Harwin has expanded its popular EZ-BoardWare PCB socket portfolio with a new contact which can accommodate mating pins ranging from 0.8-1.5mm in diameter. These new products complement an existing range, enabling Harwin to offers parts with pin diameters from 0.8-1.8mm.

A cost-effective alternative to turned PCB sockets, EZ-Board sockets are designed for SMT assembly and are ideally suited for high volume applications. The components come in industry standard tape-and-reel packaging, allowing them to be automatically placed, which minimises installed cost.

The new contacts are stackable on 2.54mm pitch spacing. The design features a two-point contact system which ensures secure retention whilst facilitating easy removal and replacement of the socketed component.

Ideal for contact pins, discrete components, sensors etc, these new EZ-Board sockets will suit applications in mid to high volume markets, ranging from consumer electronics through to the industrial, instrumentation and control systems environments. Examples include wireless security systems, ventilation fan stators, fire detectors, electronic switches and others.

www.harwin.co.uk

NEW USB 3.1 TYPE-C POWER DELIVERY SOLUTION SPEEDS USB CONNECTORS DEVELOPMENT

Lattice Semiconductor launched a USB 3.1 Type-C power delivery solution that enables manufacturers to immediately develop USB 3.1 Type-C connectors and quickly get them to market.

The Lattice power delivery solution comprehensively addresses all the critical power-related functions required by the recently finalized USB 3.1 Type-C specification, which defines very small jacks well suited to smartphones, tablets and other mobile devices.

"The considerable advantages of USB 3.1 Type-C connectors make them a lucrative market opportunity for manufacturers and our solution enables them to get a 'first mover' advantage," said Keith Bladen, Marketing Vice President at Lattice. "Manufacturers can immediately take advantage of our solution and its proven silicon to begin developing their connectors, rather than lose precious time waiting for ASSPs to fully implement the specification."

The core of Lattice's solution is the company's highly successful iCE40 devices, which are ideal for this application with an industry-leading combination of programmability, low power and small size.

www.latticesemi.com

GAN SYSTEMS SIGNS EXCLUSIVE DEAL WITH MOUSER ELECTRONICS

GaN Systems has signed an exclusive worldwide distribution agreement with Mouser Electronics. GaN Systems's gallium nitride power transistors are based on its proprietary Island Technology and offer significant advantages over traditional silicon MOSFETs and IGBTs to bring smaller, lighter and more efficient power electronics to numerous applications, including consumer appliances, data center server racks, heavy-duty battery-operated power tools, notebook travel adaptors and many others.

GaN Systems's Island Technology IP incorporates the wide-bandgap and superior switching speed, temperature, voltage and current performance of gallium nitride into a unique structure that maximizes wafer yields and produces highly efficient transistors, up to four times smaller and at lower cost than tradition design approaches. In order to take advantage of the Island Technology devices' intrinsic fast switching and dense current carrying capability, GaN Systems also designed GaNPX packaging, which has no wire bonds, minimizing inductance and thermal resistance and increasing reliability.

www.mouser.com/gan-systems

GaN Systems

AVX LAUNCHES NEW DC-LINK FILM CAPACITOR SERIES

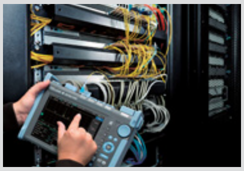
AVX has launched a new FRC series of medium power DC-link film capacitors, which feature a wide range of capacitance and voltage values in addition to self-healing properties. Designed for use in DC filter circuits, power supplies, industrial inverters, UPS systems, motor drives, power converters and solar inverters, FRC series capacitors are comprised of dry, wound, metalized polypropylene film dielectric encased in a size A, self-extinguishing, cylindrical plastic case sealed with thermosetting resin and featuring four snap-in terminals that facilitate easy mounting to PCBs.

The FRC series capacitors are available in nine voltages spanning 400-1500V, two tolerances (±5% and ±10%), two lead lengths (4mm and 8mm) and with capacitance values, spanning 4.7-35µF. Housed in size A cylindrical cases measuring 54mm (L) x 36mm (OD) x 5.1mm (P1), the RoHS-compliant series is rated for operating temperatures spanning -40°C to +105°C and exhibits long lifetime performance of 100,000 hours at rated voltage and 70°C.

www.avx.com

PORTABLE OTDR COMBINES AUTOMATION, USER-FRIENDLY OPERATION AND RELIABLE PERFORMANCE

The new Yokogawa AQ7280 portable OTDR (optical time-domain reflectometer) delivers the ideal combination of measurement automation, user-friendly operation and reliable performance to enable fast, precise optical-fibre characterisation in the field.



The AQ7280 is based on a plug-in modular design that allows configuration for a wide range of network environments and topologies, from FTTH to metro and core networks. Measurement speed and ease of use are guaranteed by a capacitive multi-touch touchscreen, automated measurement software and a highly stable operating system that enables rapid start-up, while field use is boosted by a battery pack providing more than ten hours of continuous operation.

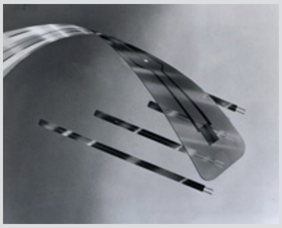
The AQ7280 hardware is designed to provide robustness and reliability in field use under harsh conditions. It has no cooling fans on its chassis and hence no apertures to allow dust or water ingress. The software also contributes to the reliability, with an operating system that is much more stable than those originally designed for PC use.

tmi.yokogawa.com

SEMITEC'S JT THERMISTOR IS THE THINNEST AVAILABLE WORLDWIDE

Semitec's JT thermistor is one of the thinnest thermistors around, with a thickness of only 0.5mm at its sensing tip, and yet with a very fast thermal response. It is laminated between two polymer layers to ensure a flexible yet resilient sensor.

Available with varying lengths and R25 values, the JT thermistor is often used for applications where other thermistors are too big, too inflexible or too slow. The JT thermistor offers very fast thermal response, it is flexible and durable, has 1% R25 tolerances as standard, R25 values of 10kΩ and 100kΩ, and various lengths from 25mm to 100mm.

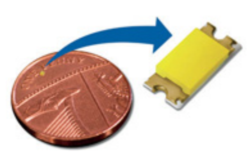


ATC Semitec is a UK distributor of thermal components, working with some of the major suppliers in the thermistor and thermostat industry. The company has over 25 years experience in the thermal controls industry and ISO 9001:2008 accreditation. ATC Semitec NTC thermistors and thermistor sensors provide high accuracy temperature sensing and control for electronic and programmable thermostats.

www.atcsemitec.co.uk

SOLID STATE SUPPLIES MAKES AVAILABILE DOTLED 01005 CHIP-SIZE LEDS

Solid State Supplies is now stocking Plessey dotLED 01005 chip-size surface-mount LEDs, which combine ultra-small dimensions with high optical output for use in mobile and wearable electronics.



The Plessey dotLED family, in blue and white colour options, joins the Solid State Supplies's portfolio as part of the new distribution agreement between the two companies announced in August 2014. The LEDs have a 1.0mm x 0.5mm outline, an extremely low profile of 0.2mm, and minimal weight of just 0.2mg. These are Plessey's smallest packaged LEDs and are compatible with automated surface-mount assembly.

The white dotLED, PLW138003, and blue dotLED, PLB138003, can be driven at up to 10mA and generate luminous intensity of up to 190mcd in the white version and 70mcd in the blue version. The devices produce highly collimated light and have a 130° viewing angle.

These are the latest devices to be produced using Plessey's proprietary MaGIC (Manufactured on GaN-on-Si I/C) technology.

www.sssplc.com

GCT IS A TRUSTED SUPPLIER OF CUSTOM BOARD-TO-BOARD CONNECTORS

Global Connector Technology (GCT) offers a full package of connectors to the smart metering market, including SIM cards, board-to-board and Flat Flexible cable and connectors.

A huge range of standard board-to-board products is complemented by custom product expertise, which allows simple modifications to the connectors all the way up to complete bespoke connector design.

GCT also offers an extensive range of FFC and SIM connectors, a perfect one-stop shop for those customers wishing to rationalise their supply base. SIM connectors are offered for three standard card sizes: Nano (4ff), Micro (3ff) and Mini (2ff). Choose between hinged, push-pull or push-push connector types, with options for SIM card detection switches and locating pegs. In addition, custom solutions can also be ordered from the company. One such bespoke product is a connector designed to meet SMETS (Smart Metering Equipment Technical Specifications).

To speed up design downloadable drawings, 3D models and specifications are available from the GCT website.

www.gct.co

CSR DUAL-MODE BLUETOOTH PLATFORMS ENABLE FASTER DEVELOPMENT

CSR has launched a new series of dual-mode Bluetooth 4.1 compliant platforms, designed to give greater flexibility to developers looking to create low latency and ultra low-power wireless gaming controllers. The CSRB5341 and CSRB5342, part of the CSR BlueCore range, will provide developers with turnkey solutions for wireless gaming controllers and HID applications from a single device.

The first of the new series, the CSRB5341 and CSRB5342, gaming system-on-chips are Bluetooth Smart v4.1 qualified, allowing developers to create next generation gaming accessories with optimal battery life. The new CSR platforms make use of a highly efficient baseband, ensuring that system level power consumption is minimized, giving optimized performance with minimum development effort.

The new gaming controller platforms come with an extensive list of fully configurable digital or analogue I/O and physical interfaces for design flexibility including direct LED drive. The CSRB5342 offers further standalone features such as embedded USB battery charging for lithium cells and digital microphone support.

www.csr.com

ACTIVE OPTICAL CONNECTOR: THE EASY WAY OF HIGH-SPEED DATA TRANSMISSION

Panasonic's latest released product is the Active Optical Connector, able to transmit data in devices through an optical fibre with speeds of up to 10Gbps. The electro-optic conversion function is installed in a small compact plug (13 x 9 x 6mm), which allows the same connectivity as standard electric connectors with a high connection reliability and easy handling.

Industry trends show that the amount of data that needs to be transmitted between devices is increasing steadily. One example is the transfer of high-definition pictures, commonly used in the medical and industrial equipment sector, which need to be transmitted between camera units and image-processing boards.

Another field of application for the Active Optical Connector is the next generation of high-performance measuring instruments and FA equipment. As the optical data transmission creates electric isolation between boards and units, it is more effective in medical equipment and measuring instruments than traditional data transmission methods.

www.panasonic-electric-works.co.uk

PROTEUS 25

1989-2014

Pioneering Electronics Design Software

1989 Autorouter added to PCB for DOS
1990 Schematic capture added

1991 World 1st schematic capture for Windows®
1992 Topological route editing
1993 Fully integrated circuit simulation
1994 Rip up and retry autorouter
1995 Shape based power plane support

True mixed mode SPICE simulation 1996
Interactive simulation 1997
PIC® microcontroller simulation 1998
8051 microcontroller simulation 1999
World 1st MCU co-simulation 2000

2001 Language support for MCU simulation
2002 Electra adaptive shape based router
2003 World 1st 32 bit MCU support with ARM®-7
2004 Integrated Proteus VSM and MPLAB™
2005 Redesigned GUI across Proteus Suite

3D visualisation engine 2006
World 1st USB simulation 2007
HDL support in simulation 2008
Shape based autorouter included 2009
VSM Studio IDE introduced 2010

2011 Design rule aware manual routing
2012 ARM® Cortex™-M3 MCU simulation
2013 New application framework

2014

NEW Project clips enable re-use of blocks of circuitry inside a project across multiple projects
NEW Dynamic teardrop control including per pad override
NEW Integrated Arduino™ toolchain with VSM Studio and common Arduino™ shields
NEW Library import tools (BSDL,PADS ASCII)
NEW New Project notes module for generic entry of notes and reports
NEW Major upgrade to BOM module to improve physical output and simplify styling
NEW Improved support for paste, solder, fanout and stitching vias during footprint creation

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