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ELECTRONICS WORLD

THE ESSENTIAL ELECTRONIC ENGINEERING MAGAZINE

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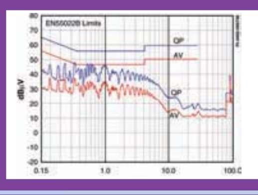
TECHNOLOGY
EAGLE FOR EUVL



REPORT
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Assembled Order Code: AS3166 - **£25.95**

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Assembled Order Code: AS3123 - **£34.95**

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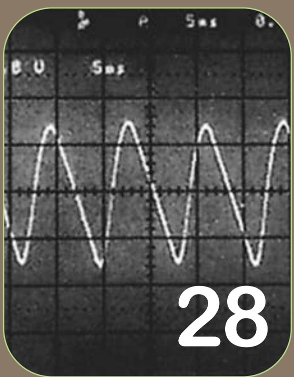


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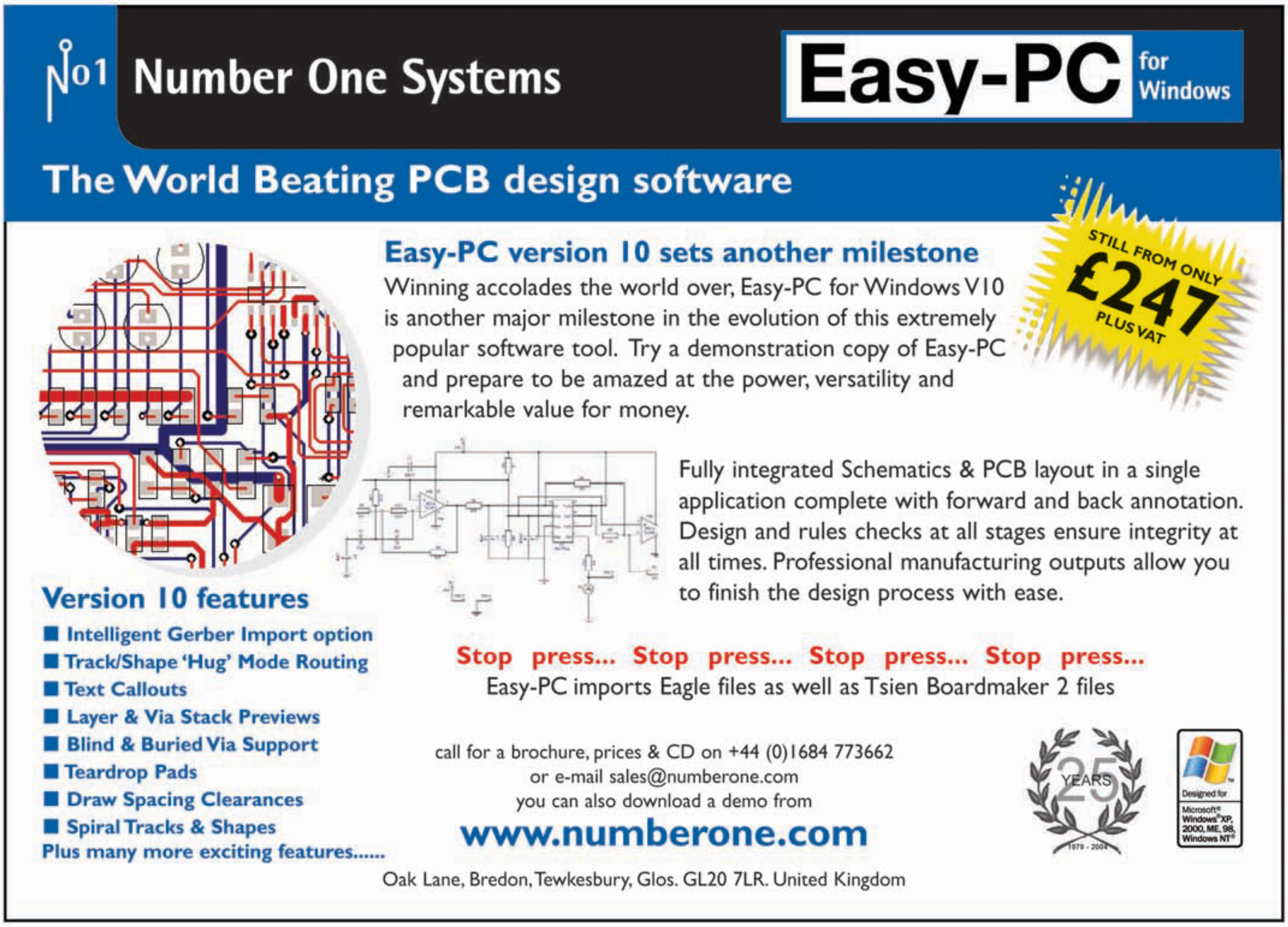
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Show schools the way

Whenever I speak to any UK firm (see Technology section, page 4), one thing that regularly crops up in the conversation is how great the local design skills are. Funnily enough, these very skills seem to be at risk of becoming a dying kind in the UK.

A recent research of UK engineering academics and students has painted an alarming picture of a skills crisis brewing in the UK engineering industry. The survey, conducted by Loudhouse on behalf of the UK-headquartered high-reliability electronic systems developer C-MAC, questioned some 100 engineering heads of department and 250 undergraduate engineering students, and resulted in a clear warning that the UK's engineering industry is in terminal decline and needs an urgent action to attract and recruit more students.

However, how do you entice pupils to study engineering when they claim it is boring, hard and too theoretical? Even those students who enrol on an engineering course either do not finish it or simply do not go into engineering jobs.

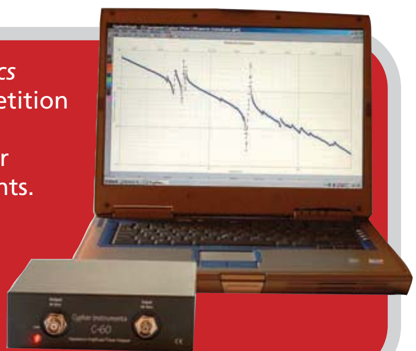
Among many other problems, such as lack of suitable jobs after graduation, clearly the engineering degree courses suffer from a poor image. But, I do wonder why. There isn't a pre-pubescent kid who does not have a mobile phone, or one that does not use a PC or indeed own a games console. They are the first generation to adopt technology and are highly adept to using it. Indeed, it is more intuitive to them than to an ageing grown-up. How can schools and universities fail to make that connection between these systems and engineering and explain how cool technology is and the future advances it could make?

So, maybe we should familiarise the teachers first with technology so they can fully understand the real role of engineering in our every day lives and, hopefully, this should help to try and bridge at least the image problem currently plaguing engineering courses. Maybe it's time we simplified the problem and started with small steps.

Svetlana Josifovska
Editor

In the October issue of *Electronics World* magazine we ran a competition where the prize was the C60 – Impedance & Frequency Analyzer from UK-based Cypher Instruments.

The winner is:
Pietro Cremonini, from Bologna in Italy.
Congratulations, Pietro!



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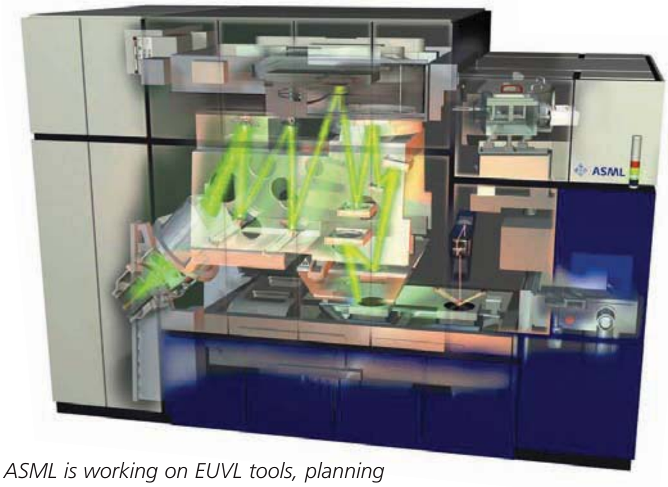
EAGLE for EUVL

A new MEDEA+ project named EAGLE aims to develop an Extreme Ultra Violet Lithography (EUVL) platform for volume manufacture, which is expected to serve for the next decade. It will enable industry to produce ICs for the 32nm node in 2009, as in the ITRS roadmap.

Lithography tool manufacturers have now decided that the source power for EUVL tools providing a throughput of 100 wafers per hour should be 180W at the Intermediate Focus (IF) for resists that require a 10mJ/cm^2 dose. MEDEA+ R&D results are now being used to develop EUVL tools towards the required power level. The latest research by ASML with Sn sources, in terms of power output, debris control and spectral purity, suggests that such sources are scalable to the required power level for production systems within about two years. However, continued work on source reliability will be needed. This time-frame also depends on many other factors, such as the readiness of EUV reticles and resists.

Relatively new Sn source technology limits current power to 20-50W at the IF. ASML has supplied two alpha demonstration tools to research partners which will be qualified on site with Sn-based sources in 2007. Sources in the past were based on Xe, which do not seem to be scalable to the 180W required at the IF. ASML plans to ship pre-production EUVL tools in 2009, followed about two years later by systems that can meet the desired 100 wafers per hour level. Laser plasma sources are potentially able to provide adequate power, but are not cost-effective, so research has concentrated on discharge plasma Sn sources. ASML says that it is too early to firmly predict the precise type of source that will be used in future systems, but work with laser triggered, multiplexed Sn sources is very promising in terms of the power produced, the heat load and electrode erosion.



ASML is working on EUVL tools, planning to start shipping the pre-production versions in 2009

Non-volatile on-chip re-programmable memory technology from Europe

A Non-volatile Embedded Memory for Systems-On-Silicon (NEMeSyS) project will develop embedded Non-Volatile Memory (NVM) technology for integration into standard baseline CMOS technologies. The emphasis will focus on NVM electrically erasable and programmable read-only memory, such as Flash and EEPROM, to create programmable product platforms for system-on-chip realisation.

This MEDEA+ 2T201 project will enable the industrial MEDEA+ partners to generate innovative techniques for rapidly expanding markets. They are expected to be especially useful in the previously unavailable field of sub-100nm CMOS, where feature density, performance, size/weight ratio and cost are vital factors that can be met only by higher levels of integration with embedded NVM.

Programmable on-chip NVM enables the same chip to be adapted to various applications, thus greatly reducing costs and addressing the paradox between low volume system-on-chip products and mass production. NVM tunnel oxide and programme/erase voltages do not scale satisfactorily, so they are posing increasing problems with each new generation of yet smaller devices. Stacked gate NVM is still considered the technology of choice down to 65nm and less, but is expected to become more and more difficult to realise with smaller features. Thus, the main challenge will be the scaling of stacked gate technology for new device generations. Hence, a decision has to be made about the possible implementation of other technologies, such as magnetic RAM that could be potentially useful. R&D on innovative cell options, such as Silicon Oxide/Nitride/Oxide/Silicon (SONOS), will bring these closer to industrialisation.

A reduction of the time needed to validate and industrialise novel NVM cell concepts and process options is required to ensure European companies are competitive in global telecommunications, wireless communications, smartcard, consumer and automotive electronics. Global competition comes from the US and Far East, especially for NVM applications in the smartcard, consumer and automotive sectors.

The project started in January 2005 and is scheduled to run until December 2008. It is led by Frans List of Philips, The Netherlands, with other partners being Atmel, CEA-LETI, IMEC, Infineon Technologies and STMicroelectronics. The technology options being developed will be transferred to the production sites used by the partners.

Bright future for phase-change memory

A new non-volatile memory could be the successor to the flash memory chips used in memory sticks, digital cameras and portable music players. Developed by scientists from IBM, Macronix and Qimonda collaborating at IBM Research Labs in the US, the new memory is far faster and much smaller than conventional flash memory. A prototype device switched over 500 times more rapidly than flash, while using less than half the power to write data to a cell. Even more remarkable is the miniscule cross-section of the device, just 3 x 20nm – far smaller than Flash can currently be made, and equivalent to the expectation of the chip making industry for 2015.

At the heart of the devices is a tiny piece of semiconductor alloy. It can be changed very rapidly between an ordered, crystalline phase having low electrical resistance and a disordered, amorphous phase with much higher electrical resistance. As no electrical power is required to maintain either phase of the material, this phase-change memory is non-volatile, retaining data when using no power.

The phase of the material is set by the amplitude and duration of an electrical pulse that heats it. When heated to a temperature just above its melting point, the alloy's energised atoms move around in random arrangements. When the electrical pulse suddenly ceases, the atoms are frozen into a random, amorphous phase. If the pulse is turned off more slowly, over about 10ns, this allows enough time for the atoms to rearrange themselves back into the well-ordered crystalline phase.

The new material is a germanium-antimony alloy to which small amounts of dopants have been added to enhance the properties. Simulation studies enabled the researchers to fine-tune and optimise the material's properties and to study details of its crystallisation behaviour.

"These results dramatically demonstrate that phase-change memory has a very bright future," said Dr T. C. Chen, VP of science and technology at IBM Research. "Many expect flash memory to encounter significant scaling limitations in the near future, but we have a new phase-change memory material with high performance, even in an extremely small volume. This should ultimately lead to phase-change memories that will be very attractive for many applications."

'Designed in the UK', but for how long?

A pioneering design-orientated distribution start-up from Hertfordshire, UK, says that this country should be proud of its design skills and advertise them directly on finished products.

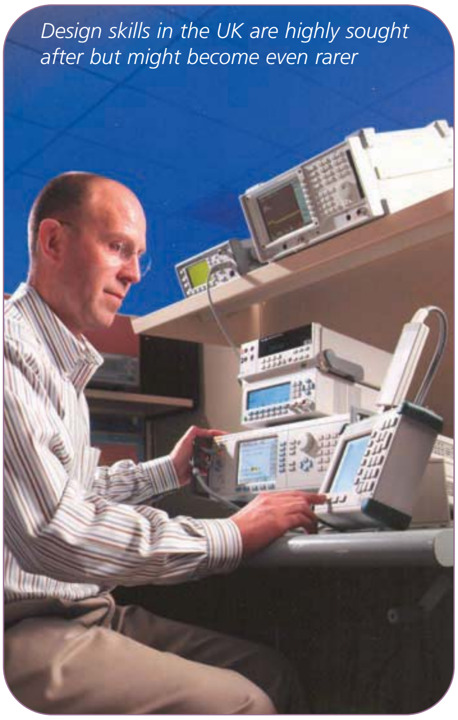
"We need to fly the British flag as there is a lot of design taking place in the UK. There's a great entrepreneurial spirit and a lot of brains here," said Trevor Cullen, managing director of Broadband Technology. "We need to carry the 'Designed in the UK' badge, like the Evoke DAB radio receiver – it carries the 'Made in China' and 'Designed in the UK' badges."

However, when asked how easy it is to recruit the right mix of skills in the UK, Cullen said: "It's hard. We are looking for eight people at the moment, with 75% digital skills and 25% analogue skills, but they should be able to sell well too."

Broadband sells and designs in electronic components.

John Walters, founder and chairman of UK electronics subcontracting firm with operations in the UK and abroad agrees: "The UK still has the best design engineers and the best imagination to create new designs. But, we've been facing daunting challenges including the lack of skills due to universities and colleges not focusing on attracting students to engineering."

Design talent in the UK may become a lost wealth if the government, the industry and academia do not do something imminently to attract more students in the engineering disciplines. A recent study commissioned by electronics contract manufacturer C-MAC highlighted that over the past three years there are 45% less students enrolling in UK engineering courses. To a great degree this has been blamed on schools, which do not do enough to promote the benefits of engineering to pupils; lower pay for UK qualified engineers; and lack of suitable jobs to get into straight after graduation.



Design skills in the UK are highly sought after but might become even rarer

Microsoft and Woking-based McLaren Electronic Systems (MES) have been selected as the official suppliers of electronic control units (ECUs) to the FIA Formula One World Championship for three years, from 2008 to 2010.

The systems will be developed jointly and then manufactured by MES and supplied to all competing Formula One teams for installation on their cars. The ECUs will monitor all aspects of the power train and gather data from over 100 sensors located on the vehicle. Each car's ECU can potentially gather over 1GB of information during a Grand Prix race from the sensors, at an average rate of between 100kB and 500kB of data per second.

* * *

Fujitsu has developed a new bio-based polymer from castor oil. The polymer will be used for small components of notebook PCs and mobile phones, such as connector covers for example, as the new bio-based polymer features superior flexibility and withstands repeated bending.

Fujitsu started using bio-based polymers in 2002, made from materials including corn in the chassis of the FMV-BIBLO notebook PC. However, in order for plant-based materials to be used more widely, what has been needed is a polymer with a higher bio-content that features superior flexibility and is suitable for mass-production.

* * *

Researchers at Infineon have tested the world's first complex circuit fabricated using a new 65nm multi-gate field effect transistor architecture. With an approximately 30% smaller footprint compared to current single-gate technology with the same functions and performance, the new transistors had quiescent current that measured a factor of 10 and less. This will increase the energy efficiency and battery life of portable devices up to two times compared to the 65nm technology going into production today. For future technology nodes (32nm and beyond), this figure will increase significantly.

SOI plus strained silicon will improve device performance

A pan-European collaborative project will create an industrial source of large diameter strained silicon-on-insulator (sSOI) wafers for producing high performance devices.

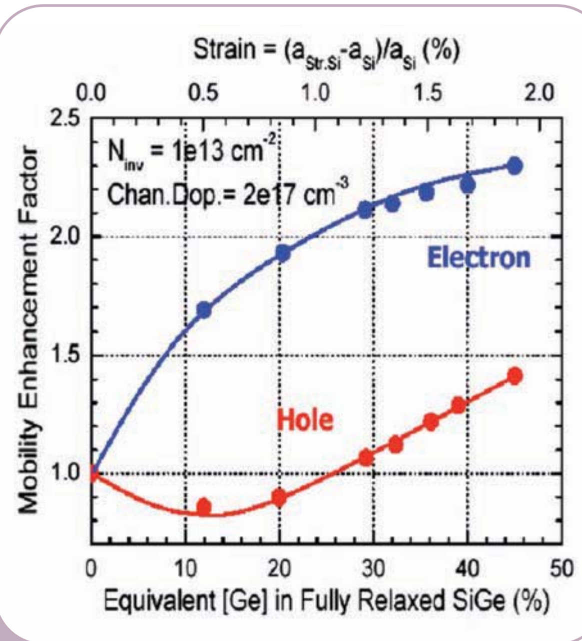
The MEDEA+ project, known as SilOnIS, aims to combine SOI architectures with advanced forms of strained silicon to produce transistors and ICs with improved performance by virtue of the greater charge carrier mobilities and better transistor I_{on}/I_{off} ratios among others. SilOnIS will not only combine SOI with high mobility global strained silicon, but will also use local or 'process-induced' strain at the device level. It is expected to anticipate the requirements of advanced SOI substrates for the next generation of devices using the nodes of 45nm and below.

Project leader Bruno Ghyselen of Soitec, France, explained that as the device dimensions shrink, the transistor scaling calls for more strain in the silicon, yet there is less space for external stressors to be used to create that strain. He said that current results include the demonstration and sampling of 300mm sSOI wafer substrates, including thin fully-depleted (FD SOI) wafers, thick partly-depleted (PD SOI) wafers and FINFET 3D structures.

The researchers have achieved significant sSOI material improvements, with a typical defect density of only 0.2 defects/cm^2. FD SOI devices with 25nm short, narrow gates and a Ti nitride/Hafnium oxide gate stack have been produced.

The partners involved in SilOnIs include Si-based substrate suppliers (Soitec and Siltronic), IC manufacturers (STMicroelectronics, Freescale Semiconductor, NXP), equipment suppliers (ASM and AIXIRON), specific metrology equipment suppliers (Horiba, Sopra, OMI, Accent) and public R&D labs with specialist material expertise (CEA-LETI, MPI Mikrostrukturphysik, Forschungszentrum Jülich).

The project is due to complete in December.



THE PHYSICS BEHIND STRAINED SEMICONDUCTORS

Global strain across a whole wafer level can be attained by the epitaxial growth of silicon onto a layer of relaxed silicon doped germanium (SiGe). Strain occurs because the atomic spacing is slightly larger in SiGe than in relaxed silicon and this stretches the inter-atomic separation of the silicon atoms so that it is similar to that in the SiGe layer.

As the germanium content of the SiGe rises, the strain in the silicon increases and this enhances electron mobility. The amount of strain required to achieve high enhancement of the hole mobility is considerably larger than that needed to similarly enhance the electron mobility.

Asian distributors will re-write Western distribution business

Asian distributors are likely to change the landscape of the European distribution market and fast. So says Adam Fletcher, chairman of the Association of Franchised Distributors of Electronic Components (AFDEC) Limited.

"The Asian distributors can't gain greater foothold in Asia any more, so they'll look west to Europe and the US. Europe is first so we'll see a lot more acquisitions in Europe over the next one to three years," he said. "These distributors are more stakeholder-based rather than family based and, so, they'll be more open to moving to Europe."

Out of Western-headquartered global distributors, Avnet and Arrow have some 50% of the business. They have already seen a dramatic growth mainly driven by the Asian tigers. According to Fletcher, the question for franchised distributors in two to five years' time is "what will the Asian distributors do in Europe?"

"In this business you can't organically grow fast so you'll have to acquire and they can pick by territory. Anybody is a potential target. There are opportunities in Germany and in the Eastern Europe market, where there are easier targets," said Fletcher.

Not only that the Asian distributors will start acquiring European and US businesses but they are also likely to change the business of distribution. "Asian distributors are looking at a different business model. One or two things can happen: they'll move their business model to our way of thinking or us to theirs. I suspect it'll be a bit of both. But, it'll be difficult for us to achieve the margins that they operate on in Asia. It's down to the very low cost of components there. In Asia, there's also a lot of inter-distributor trading going on, all of which [in the chain] are making between 3% and 5% on the components."

Semiconductor business trends, according to TSMC

Chuck Byers, director at the Taiwanese semiconductor fabrication giant TSMC, says that over the next three to five years there will be a greater consolidation in the IC manufacturing space. "In the 80s there were some 22 different outfits making ICs, now there are only five to seven companies that have 90nm products. There's a trend for consolidation in the [IC] manufacturing space." Byers also said that, at present, "consumerisation" is a driving trend in the semiconductor business, fuelled by products with shorter life-cycles. "Today the business is driven by some 40 applications. Statistically, it is driven by 15-year old girls [who shape the consumer space]," he said.

In turn, the future of the semiconductor industry, according to Byers, is in the "gigafabs", where monthly capacity exceeds 80,000 wafers. "With gigafabs you qualify one fab instead of three to quickly rump up to efficient volumes. It also means equipment for one fab instead of three."

Byers also said that Design-For-Manufacture (DUF) adopted in the EDA businesses is helping the semiconductor makers to bring out 'right first time' silicon at ever smaller geometry nodes. "Because of DUF, 65nm offers a lot more 'right first time' silicon. If you don't have DUF in place you're going to kill the node." Process-wise, Silicon-On-Insulator (SOI) will be made optimal at the 45nm node but will be standard at 32nm, added Byers.

India will become a major semiconductor manufacturing player, says industry research house In-Stat. It is recognised as one of the fastest growing semiconductor-consuming markets in the world. This market was valued at $1.18bn in 2005 and is forecast to supersede $3bn by 2010.

By then, the local semiconductor ecosystem, which is currently dominated by design services and embedded software, will be in place with a planned semiconductor manufacturing facilities. As such, by 2010, India will have the entire semiconductor value-chain in place and will be in the reckoning among other Asian semiconductor manufacturing countries.

* * *

Year 2006 has been a highly competitive year for the electronics manufacturing industry. This year, however, is likely to be even tougher says David Pattison, senior analyst with Plimsoll.

Last year, growth in this market was around 1.1% and nearly a half of the 880 companies monitored by Plimsoll saw a fall in sales. For 2007, Pattison predicts growth of just 1% with some companies enjoying a record 20% or more, whilst over a third of companies will lose money.

* * *

New research of UK engineering academics and students paints an alarming picture of a skills crisis brewing in the UK engineering industry. A survey of 100 engineering heads of department and 250 undergraduate engineering students highlights the very real dangers that the UK's engineering industry could be in terminal decline unless urgent action is taken to attract and recruit more students, as well as encourage more engineering jobs in the country. In turn, it is expected that this decline will have a negative impact on the UK economy.

In the past three years, some 45% of universities have reported a drop in course applications over the past three years.

TOP 10 TIPS

VIRTUALISATION

PC and server virtualisation software can potentially shake up the entire IT world. Virtualisation technology allows a single system to run multiple incompatible operating systems – and their applications, meaning that long-standing barriers to flexibility and compatibility can be broken down whilst dramatically improving hardware utilisation rate. Virtualisation software is something that every IT manager should be considering. All IT managers should also appreciate the necessity for companies to run multiple operating systems without the financial constraints that purchasing new hardware and software can bring. These ten tips are intended to help organisations transition to new software without huge time and financial implications.

1 **Understand your infrastructure:** Before making any decisions concerning virtualisation, it is important to understand your current infrastructure; this would include numbers and types of servers, operating systems, CPU and memory utilisation, application names and versions. Without a thorough understanding of these components, it would be difficult to understand how virtualisation technologies could best be used within your organisation.

2 **Not everything should be virtualised:** Although virtualisation brings many benefits and may be used in a variety of environments, it is not necessarily the answer to everything. Operating system virtualisation will provide most benefit when replacing a physical server which is being under-utilised. For example, a typical server running Active Directory may only use a small percentage of its processing power and is, therefore, ideal for virtualisation.

3 **Understand your administration model:** Virtualisation brings with it a new style of administration that may impact the existing processes in place within your organisation. For example, where there is a server team responsible for the provisioning of new servers they may have to adapt the administration model in order to have the ability to create servers in the new virtual environment.

4 **Understand what applications you have:** Before virtualising any applications, it is best practise to understand exactly what applications are included in the estate, what versions they are currently using and how they work. Having a full understanding of your application estate enables you to make the best decisions when considering virtualising those applications.

5 **Capacity planning:** Make sure you fully understand the infrastructure that will be used to virtualise your environment. You need to understand all components required to virtualise the proposed services, especially the specification and capacity of the chosen systems. If this is not done correctly then the solution may not provide the expected performance and service levels.

6 **Know the technologies:** There are a number of virtualisation opportunities (including server, operating system, storage and application) and many vendors offering products and solutions. Having a clear understanding of what vendors are offering and how their products and solutions compare, will enable you to choose the best solution for your environment. For example, in the application virtualisation space both Citrix and Softricity offer solutions, although they do this in different ways, using different methods.

7 **Make the best use of virtualisation tools:** Virtualisation is a complex and technical subject. Taking an environment from the physical to virtual can be a tricky task if administrators do not fully understand how to best design and implement virtualisation technologies. However, there are a number of tools available that will help with the implementation and migration from physical to virtual environments which will save time and money (with many of them offering 'drag & drop' style management interfaces).

8 **Use the vendor and consulting community to help you understand the various virtualisation technologies available in the marketplace today:** The solutions available are wide and can appear at first glance complex. Use the experts to enable you to confidently make informed decisions.

9 **Before implementing and virtualisation technologies it is important to understand the cost benefits that it brings with it:** For example, if the required hardware specification to support the infrastructure being virtualised costs more than the virtualisation hardware itself, why would you go ahead with the exercise, unless you had a clear idea how long the payback period would be? The tip is to complete a simple return on investment analysis, prior to submitting the business case for funding.

10 **Although virtualisation brings many benefits, make sure you fully understand that virtualising some applications can be a complex affair:** So make sure you prepare fully and use expert advice to understand how to make maximum use of the virtualising technologies.

These tips were supplied by Shane Colombo at IT Infrastructure coaching company, C&C Technology Consulting.

If you want to send us your top five or ten tips on any engineering and design subject, please write to the Editor at EWeditor@nexusmedia.com.

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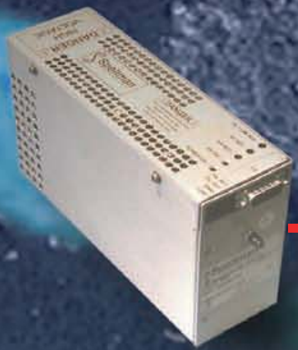

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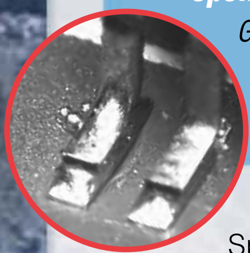

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The hard drive.... 50 Years on

On the 50th anniversary of the hard drive, its future still looks bright, says **John Fox**, EMEA Business Development Manager at Hitachi Global Storage Technologies

From time to time, we in the hard disk drive industry are faced with prognosticators' visions for the impending demise of the hard drive. But after 50 years, the industry remains healthy and growing.

This year, the hard disk drive (HDD) industry is celebrating its 50th anniversary. And the march of time has been good. Over the last 50 years, the industry has experienced a phenomenal pace of technological advances that has led to a 70-million-fold increase in areal density, the measurement of how much data can be placed on a disk.

As we look into the future, the prospects for the health and longevity of the HDD industry continue to look bright. For most of the hard drive's lifespan, it has been targeted at large mainframe storage systems and, from the beginning of the 1980s, at the PC and notebook PC. Both of these applications clearly still exist today and continue to thrive. But beginning in the late 1990s, with the introduction of the first 1-inch Microdrive from IBM, now produced by Hitachi, we began to see the changing face of the application for hard disk drives.

Today, the industry is headed toward a huge period of growth, driven by the use of hard drives in consumer electronics devices, especially video applications. In fact, we believe digital video is the next "killer application" for hard disk drives. According to industry analyst firm, TrendFOCUS, digital video will be the next primary catalyst for the growth of hard-disk based storage in consumer electronics, with the predominant shift occurring in 2006. TrendFOCUS projects that video-based CE devices requiring hard drives will grow 80% this year. Apple Computer's announcement of its latest video iPod and new iTV are a testament to this trend.

This demand for capacity is what continues to make hard drives the ideal storage medium for a large set of applications, even though new forms of storage, like flash, are becoming more readily available. Flash can offer reasonable capacity levels at fixed price points. This, of course, is why lower capacity points, such as 1 and 2 gigabytes, are now primarily served by flash at relatively low prices. If we look not too far back in time, we recall that many of the applications that now use flash were pioneered by hard disk drives. The 1 or 2 gigabyte flash cards now found in many digital cameras followed Microdrives in the very same application. While flash will continue to make sense for low-capacity applications, hard disk drives remain the "work horse" for applications requiring high capacity and high performance.

To keep pace with the ever-increasing demand for more storage capacity, companies like Hitachi are engaged in research into advanced technologies that will extend the life of the hard drive, and allow the industry to continue to double capacity every two years, taking full advantage of the exponential growth in these consumer devices.

The first of these technologies, Perpendicular Magnetic Recording (PMR), began shipping in volume this year. Perpendicular recording aligns the magnetic direction of the bits on a disk vertically, or perpendicular to the disk. In contrast, its predecessor longitudinal recording aligns the magnetic direction of data bits horizontally, parallel to the surface of the disk. With a perpendicular orientation, the magnetic field used to write the information on the disk can be made much stronger. This allows the magnetic material storing the bits to be thicker and much more resistant to changing its magnetic direction. Because of these changes, perpendicular recording is much more stable and, thus, reliable as bits are made smaller for greater densities.

The first PMR based drives were delivered this year, including Hitachi's 2.5-inch Travelstar and CinemaStar products, targeted to notebook and "slim" DVR applications, respectively.

Looking out into the future, we expect to continue to see major breakthroughs in areal density, demonstrating the hard drive's resilience, with strong product roadmaps well into the next decade. Storage capacity will continue to double every two years with extensions to perpendicular recording like patterned media and thermally-assisted recording. We will continue to see even more reliable and secure hard drive technology that is also more power efficient, more rugged and increasingly tailored to CE devices. We'll see a proliferation of the numbers and types of applications that use hard drives – particularly in the high-growth consumer electronics market.

The march to keep pace with the growing hunger for storage capacity continues unabated, and the hard disk drive industry looks to develop new products that will manage the explosion of digital content – content that needs to be stored, searched, retrieved and shared. Analysts believe the industry will ship more hard drives in the next five years than it has in the last 50. I'd say the future indeed looks bright.

> **"While flash will continue to make sense for low-capacity applications, hard disk drives remain the "work horse" for applications requiring high capacity and high performance"**

THE KING OF BLUETOOTH

Being able to ship two million units every day is a luxury which, for most technology products today, would be closer to fantasy than anything else. Yet, for the Bluetooth community this is a reality that was worth waiting for after weathering a stormy start at the turn of the new millennium.

An explosive growth in demand for products featuring the short-range wireless communications technology has taken the total number of Bluetooth devices sold worldwide beyond the one billion mark. Annual sales have been consistently doubling since 2002, fuelled mainly by mobile phones and headsets. Computer peripherals such as wireless mice, keyboards and printers have also contributed to this growth, while a new breed of products from automotive to multimedia consumer applications is starting to gain traction.

The notion that such healthy figures actually belong to an industry that is formed by over 6000 companies – and, therefore, can't be directly linked to the fortunes of any single one of them – is only half true when the company in question is Cambridge Silicon Radio. Most commonly known by its initials, CSR owns today 50% of the market for Bluetooth ICs. In other words, of the two million Bluetooth-enabled products that will be sold today, half of them will be fitted with a CSR chip.

CSR supplied Nokia with its first chip for Bluetooth 2.0 + EDR headsets

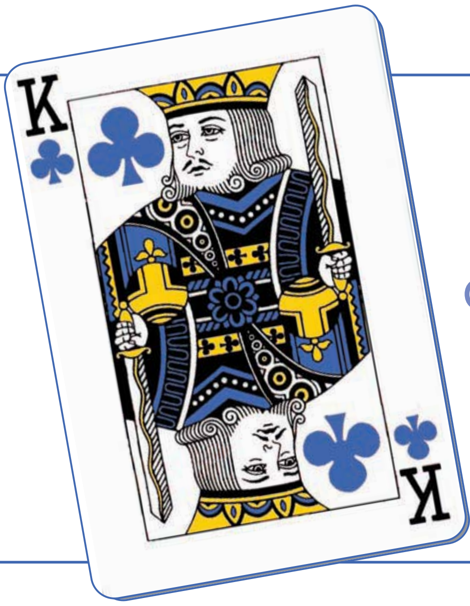
The Cambridge-based firm is not only the overall market leader, but it's also the number one supplier in every category of Bluetooth devices. In some of them it enjoys an almost ridiculous lead. Take wireless headsets, where 90% of all products currently manufactured incorporate Bluetooth silicon designed by CSR; or laptops with over 70% of all design wins, including at OEMs such as Apple, Dell, IBM, NEC and Sony.

The list of CSR customers includes practically all the big names as far as mobile phone vendors go. Nokia, Motorola, Samsung, BenQ and NEC are all included, while automotive manufacturers such as BMW, SAAB and Audi have also ordered CSR silicon for their in-car communication systems.

"It's interesting that they weren't necessarily the first people in Bluetooth, but they were the ones who clearly grew the fastest and took over the market," notes Will Strauss, principal analyst with DSP market research firm Forward Concepts. He recalls that a company called Silicon Wave (later acquired by another one called RFMD, which in turn was recently bought by Qualcomm) had actually managed to launch a product before CSR. "But for whatever reason they never really developed into a big market player. CSR was much more aggressive and obviously came out with good working silicon that the market really did like."

Blue Chip

CSR's dominance of the Bluetooth silicon market is not coincidental. Ten years before the company emerged as a spin-off from Cambridge Consultants in 1998, the team of engineers that eventually founded the company was already working on a series of research projects which demonstrated for the first time that low-cost RF CMOS ICs had the potential to bring unprecedented levels of size and cost efficiencies to the design of mobile phones.



JUAN PABLO CONTI LOOKS AT HOW CSR GREW FROM A SMALL BUNCH OF RESEARCHERS IN CAMBRIDGE TO BECOME EUROPE'S LARGEST FABLESS SEMICONDUCTOR COMPANY – AT ONE POINT, EVEN BIGGER THAN ARM HOLDINGS

A concept was then formulated that helped propel CSR to its current position as Europe's largest fabless semiconductor manufacturer – a concept that is still at the heart of its most advanced Bluetooth chipsets. Called BlueCore, it's an approach to single-device design that tightly integrates a radio modem, baseband DSP, micro-controller and software.

The inclusion of powerful and versatile DSPs have indeed characterised CSR ICs from the outset. The BlueCore platform – now in its fifth generation – includes a chipset targeting the headset market (BlueCore5 Multimedia) that features a 64 MIPS DSP named Kalimba. It provides enough power to load the device with a wide range of software applications that differentiate the product from those of competing vendors such as Broadcom or Texas Instruments (TI).

Eric Janson, CSR's senior vice president of worldwide sales, says the chip also integrates a Li-ion battery charger and power management circuit: "We've swept in more of what would be normally on the circuit board in the headset, which means lower bill of materials and, of course, a smaller physical package. So now, in order to build a headset, all the components you'd have to add really are a battery, a speaker, a microphone, an antenna and that's about it."

Janson confirmed that the company is targeting the first quarter of 2007 as the date when the first mass-produced mono and stereo headsets incorporating the chip will hit the market, adding that "there are a lot of designs in progress". The chip meets the latest, Enhanced Data Rate (EDR) version of Bluetooth, which means a throughput of up to 3Mbit/s is supported.

Beyond Bluetooth

The fact that CSR was able to strike gold with Bluetooth was never going to prevent it from exploring opportunities opened up by other standardised wireless technologies. Wi-Fi, Ultra Wideband (UWB), FM radio and even a new technology developed by Nokia researchers for button cell-powered devices called Wibree are all part of the company's future plans.

Its Wi-Fi silicon is, in fact, at an advanced stage of development and the company has already secured a design deal with a major mobile phone maker for its UniFi chip. Announced at the end of 2004, UniFi is not only CSR's first non-Bluetooth

Headsets continue to drive Bluetooth growth

hardware, but also the materialisation of the company's grand vision for the role that 802.11 technology will play in the cellular world.

While the company acknowledges that a significant number of smartphones already come equipped with Wi-Fi connectivity, it points out that these are mainly targeted at business users for applications such as broadband Internet access. CSR predicts it is only a matter of time before an alternative application area emerges from the marriage of Wi-Fi and cellular technologies: the 'converged wireless phone' – not to be confused with fixed/wireless convergence.

This vision encompasses conventional mobile phones (using 2G or 3G cellular infrastructure to route calls) that automatically switch to Wi-Fi mode (using Voice over IP – or VoIP) when they enter a hot-spot or are used in offices and homes fitted

Mobile phones are still CSR's biggest revenue generator

with 802.11 access points. Although this sounds sensible (it would allow users to save money) and simple, the complications of adding an increasing number of radios (cellular, Wi-Fi, Bluetooth, FM, each with their own antenna needs) in such a confined space are vast.

But CSR claims it has solved these challenges. Last May the company showed in London its UniFi-1 and BlueCore4 Bluetooth solutions operating on the same board and without interfering with each other or the host device. This was proved by staging application scenarios in which both radios were operating simultaneously, such as taking a VoIP call over a Wi-Fi link using a Bluetooth headset.

Looking further down the line, the move towards higher integration is only likely to intensify, as Janson anticipates: "We are working on a chip that will integrate Wi-Fi and Bluetooth. We are also working on another chip that will integrate Wi-Fi, Bluetooth and FM radio. And we are sampling a Bluetooth also FM radio in a single chip now. There will be other functions that will get added in as well, such as Near-Field Communications and Assisted GPS."

Ultra Hungry

At some point in mid-2007, the most radical new version of the Bluetooth spec will be released. It will integrate what many industry analysts had initially feared would be a competing short-range wireless technology to Bluetooth: UWB.

"In order for UWB to make sense for something like a cell phone or a camcorder, it basically has to be friendly to the battery," says Janson. "The problem with the current UWB standards (especially Wireless USB) is that they're extremely power-hungry. You might say 'hang on a minute – UWB is supposed to be very high-bandwidth and very low-power', right? In fact, UWB is very efficient at transmitting large amounts of data for a given current. But, the way the protocol stays connected is by looking for radio beacons and it's

"THEY WEREN'T NECESSARILY THE FIRST PEOPLE IN BLUETOOTH, BUT THEY WERE THE ONES WHO CLEARLY GREW THE FASTEST AND TOOK OVER THE MARKET," WILL STRAUSS, PRINCIPAL ANALYST, FORWARD CONCEPTS"

FM radio and Bluetooth, all in one chip

CSR IN BRIEF

Founded: 1998 (Cambridge Consultants spin-off)
Headquarters: Cambridge, UK
Chairman: John Whybrow
CEO: John Scarisbrick
Employees: 719 in 10 countries
R&D team: 454
Annual sales: $487m (2005)
Net income: $83m (2005)
Listed: London Stock Exchange

CSR's RoadRunner solution targets car manufacturers interested in Bluetooth

THREATS AHEAD

Whether CSR proves as successful in the new wireless technologies it looks to address as it has been in Bluetooth, it remains to be seen. But, according to Forward Concepts analyst Will Strauss, the chipmaker doesn't have much of an option: "Bluetooth is nice, but companies like Qualcomm (which just bought some Bluetooth IP) and Texas Instruments will ultimately take the IP and try to put it into a single-chip solution in a cell phone. That is not going to kill the market, but it will diminish it for separate chips. We are now probably three years off before we start seeing these big companies making noticeable inroads into the discrete Bluetooth chip market that is owned today by CSR. I don't think this is a near-term concern for them, but they certainly do have to expand their product portfolio."

So does CSR agree with this warning? "If we were doing nothing about integrating devices and radios, then I would agree," replies Janson. "But we are already doing that and we'll be sampling at about the same time as these other guys.

"Now, if he is talking about integrating these things into the baseband chip, then we disagree completely. Integrating radio functions in the baseband chip has never been a good idea, everyone who has tried it has failed completely and, going forward, it doesn't look like it's a good idea either. The reason is that all these radio standards – every single one of them – are changing rapidly. The amount of time and effort required to do these things and qualify a chip is huge. You don't want to take your baseband chip and 'requal' it time and time again."

"And, if you aren't willing to do that," he continues, "you only have one choice, which is what Qualcomm has chosen: you end up with something that is horrendously out-of-date. So you've got a Qualcomm chip today that's not even Bluetooth 2.0, let alone Bluetooth 2.0 and EDR... you know, it's silly."

Janson reveals that Qualcomm had to resort to signing an agreement with his company to equip the MSM7000 series with CSR's Bluetooth baseband. "CSR is their Bluetooth silicon partner of choice for the MSM7000 series. They'll probably try and replace that as quickly as they can with the RFMD acquisition, but they'll be sorely surprised at the outcome if they displace us," he warns.

been configured in a way such that it draws 20 times more standby power than Bluetooth."

Janson explains the time a typical Bluetooth application spends transmitting and receiving is only about 3% of the total time. "Standby power dominates battery drain in mobile wireless devices. And a technology like UWB is going to be used much less frequently than Bluetooth. It's just nonsense to try and use UWB for, say, a headset – far too much bandwidth is required, the range is terrible and it takes a heck of a lot more power."

This is not to say that UWB won't have a role to play in specific short-range applications. With mobile phones now being designed with six mega-pixel cameras and 40GB micro drives, users are demanding the chance to wirelessly sync their heavy music and photo files with their PCs, and they expect that to be a quick affair. Janson says the service discovery function of Bluetooth will be used in such cases to detect nearby devices featuring a Bluetooth and UWB radio. Then, "if there's a user-initiated command to do a file transfer to this device, it will look at the size of the file and go: 'Wow! That's a 3GB file! We're going to turn on the UWB radio to get a fat pipe for it'. That's what UWB is going to be used for: bursty transmissions. UWB will not be used in battery-powered devices to be on continuously like Bluetooth or Wi-Fi."

WHY SPECIFICATIONS really matter

by Myk Dormer

Look at the data sheet of any receiver module and you will find a list of (by now) familiar specifications: sensitivity, adjacent channel, other spurious responses, blocking, etc. Units with tighter specifications usually cost more and are often physically bigger and more power-hungry.

It's easy to convince yourself that these figures are no more than 'specmanship' amongst design engineers. This article attempts to show that this is not the case. They directly affect real-world performance and good specifications are vital for reliable system operation. Unfortunately, to show this, we'll need some maths.

Imagine a simple ISM band application: a wideband 433MHz FM transmitter/receiver pair using unity gain whip antennae. To keep things simple, these aerials are 1m from the ground – roughly, bench-top height. Typical radio characteristics will be: Tx power 1mW (0dBm), Rx sensitivity (including decoder) –100dBm; link margin for reliable operation 10dB.

So, good reliability will be achieved if the path loss between the aerials is –90dB or less.

Using the Egli model (see note 1)
$d = (1/(117 \times 10^{(0.1 \times L)}))^{0.25}$
for L (loss) = –90dB, then d (range) = 54m.

Now consider the addition of an interfering signal. To keep things simple once more, this will be an identical transmitter. Taking the simplest case, that the unwanted signal must equal the (wanted level + relevant receiver rejection spec) to jam the system, then taking the receiver adjacent channel rejection of a typical 'single chip' design: –35dB. Wanted transmitter is at maximum range (as above) from receiver (so wanted = –90dBm). Unwanted transmitter is on adjacent channel, so for unwanted signal = wanted, then the path loss from the interfering transmitter to the receiver must be –55dB.

From the same model, –55dB corresponds to a distance of 7.2m. In other words, if a similar transmitter comes within about 7m of the receiver, the system fails. This is a fundamental limit in how multiple links co-exist in the same area.

Note that in this case we've taken adjacent channel: for interferers located at greater frequency separations the alternate, or even blocking, figures can be used in the same calculation.

Now let us repeat these calculations, in abbreviated form, for a higher performance, narrowband link, employing the same frequency band and aerials:

Tx 10mW (10dBm), Rx sense –120dBm; (link margin again = 10dB).
therefore,
Path loss < –120dB, and for this loss,
d (range) = 304m

Adding in the adjacent channel interferer, assuming Rx adjacent rejection is still –35dB, unwanted path loss must be > –85dB, corresponding to a distance of 40m.

Re-calculating for adjacent channel rejection of –65dB (more typical of good quality narrowband SRD receivers): unwanted path loss > –55dB, critical distance = 7.2m.

Not surprisingly, if the rejection specifications are not improved in line with the increase in range and operating path loss, then the minimum distance between receiver and unwanted transmitter increases in direct proportion.

To retain, or improve the allowable separation between a receiver and interfering transmitters, as receiver sensitivity improves it is necessary to increase the receiver rejection performance proportionally.

Makers of supposed 'narrowband' single-chip radios should take heed: a rejection performance sufficient for a short-range wideband radio will not prove good enough for a long range, narrowband link.

Note 1: Path loss calculation.

The usable range of a radio system is defined by several basic factors: transmitter power, receiver sensitivity, effectiveness of the aerials (antenna gain) and, finally, the transmission path loss. Transmit power and antenna gain are simple constants set by the system components. Receiver sensitivity is a

> "Makers of supposed 'narrowband' single-chip radios should take heed: a rejection performance sufficient for a short range wideband radio will not prove good enough for a long range, narrowband link"

combination of the basic sensitivity of the circuitry (defined by noise factor and signal bandwidth) and the ability of the ‘decoder’ (which could be a modem chip, or the human ear) to recover meaningful information at a given signal-to-noise level.

Path loss is more interesting. It is the effective attenuation factor measured between transmitter and receiver. There are numerous different ways of calculating this value, from the basic (and for practical, UHF and VHF terrestrial radios, wildly optimistic) free space model:

Loss (dB) = 32.4 + 20log(F) +20log(D)
F = frequency in MHz
D = distance in km

In this case, I have chosen to use the rather traditional Egli propagation model, which attempts to simulate path loss over open, but irregular terrain. This model cannot take into account in-building propagation, fading, or multi path effects; but for simple ISM links in rural and suburban environments, I have found it tolerably effective.

Loss factor = $((40/F)^2 \times (Ht \times Hr)^2 \times Gt \times Gr)/d^4$
F = frequency in MHz
d = distance in meters
Gt, Gr = antenna gain
Ht, Hr = antenna elevation

For our 433MHz system, using unity gain aerials located 1m above ground the G and H terms cancel out and this equation simplifies to:

Loss factor = $1/(117 \times d^4)$, or in dB
$d = (1/(117 \times 10^{(0.1 \times L)}))^{0.25}$

For example, for a -90dB path loss, d = 96m.

For more information about the Egli path loss model, see J. J. Egli, “*Radio Propagation Above 40 Mc Over Irregular Terrain*,” Proc. IRE, Oct. 1957 **http://en.wikipedia.org/wiki/Egli_Model**

Note 2: Here is a more extreme worked example:

Consider our second example ISM link when operating in the proximity of a typical vehicle mounted 25W, 70cm band amateur transmitter, driving a +3dBi gain aerial. In this case, relevant is the ±1MHz blocking spec. Again, take a typical performance figure for ‘narrowband’ single-chip designs, at –45dB.

Unwanted transmitter power is +47dBm, interferer path loss > –122dB for the link maximum range to remain unaffected. The link range begins to degrade when the unwanted transmitter comes within 340m.

For a good, EN300-220 class 1, module design where blocking exceeds 86dB, this critical distance falls to 32m. This is difference between an interferer in your drive-way and an interferer somewhere in the same town.

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

Notes on RELIABLE EQUIPMENT DESIGN

Design engineers will be familiar with the classical failure rate curve for a piece of equipment over its lifetime. When the equipment enters the field there will be 'infant mortality' with an initial high failure rate, that should fall to a low fail rate for the useful life of the equipment, before old age takes over and the rate rises towards an end-of-life state.

The term 'useful life' may be a minimum of 20 years for the aircraft or railway industry, for example, and will be helped by a strict regime of maintenance and inspection to ensure that faulty equipment is detected and replaced. Useful life may well be longer if maintenance is difficult or hazardous – or it could be as short as 10 minutes for equipment on a satellite launch vehicle – the equipment simply has to be reliable and work on demand.

Modern electronic components, when chosen sensibly, used wisely and assembled to rigorous standards, can produce remarkably reliable pieces of equipment. The initial part of the equipment life is more likely to have failures that are not due to the internal electronic circuit, but rather to inter-face components like cables and connectors, or to fledgling manufacturing and test procedures that may have been involved. Sometimes failures arise from the unanticipated behaviour of the customer equipment to which it is connected.

As a general rule, electronic component assemblies are readily designed for a long life given the rules of sensible conservative design to suit a specified environment.

The following notes consider some aspects of electronic equipment design that are largely based on common sense and the author's experience in designing equipment for the aerospace and railway industries.

Predicting Mean Time Between Failures

The customer has agreed upon product performance specification based on industry standards for the type of equipment concerned, and there will usually be a section under the heading 'Reliability' requiring a minimum Mean Time Between Failure (MTBF) for the equipment. The given target may have been based on safety issues, level of demand and knowledge of older equipment in service.

The most widely used tool for prediction is MIL-STD HDBK 217 (Reliability Prediction for Electronic Equipment) and the first thing to realise when using it is that it is intended for guidance only, based on failure models for particular parts, and is not absolute truth. Whether one uses a simple parts count initially, or a more involved stress analysis later for each component, the resulting failure rate prediction is likely to be pessimistic for a number of reasons. Continuous improvement in manufacturing technology has produced components of quality and reliability such that the difference between 'best commercial quality' and 'military' grade is now rather less than would be suggested by the 'π_q' quality factors given in this handbook, other things being equal. One can improve this factor easily by subjecting a product to a burn-in testing after manufacture.

The 'π_e' environmental factor is difficult to justify for currently available small components – why should a surface-mounted metal film resistor or plastic encapsulated integrated circuit have a considerably worse environmental factor applied to it under 'ground mobile' conditions (e.g. on a vehicle) compared with a benign rest condition?

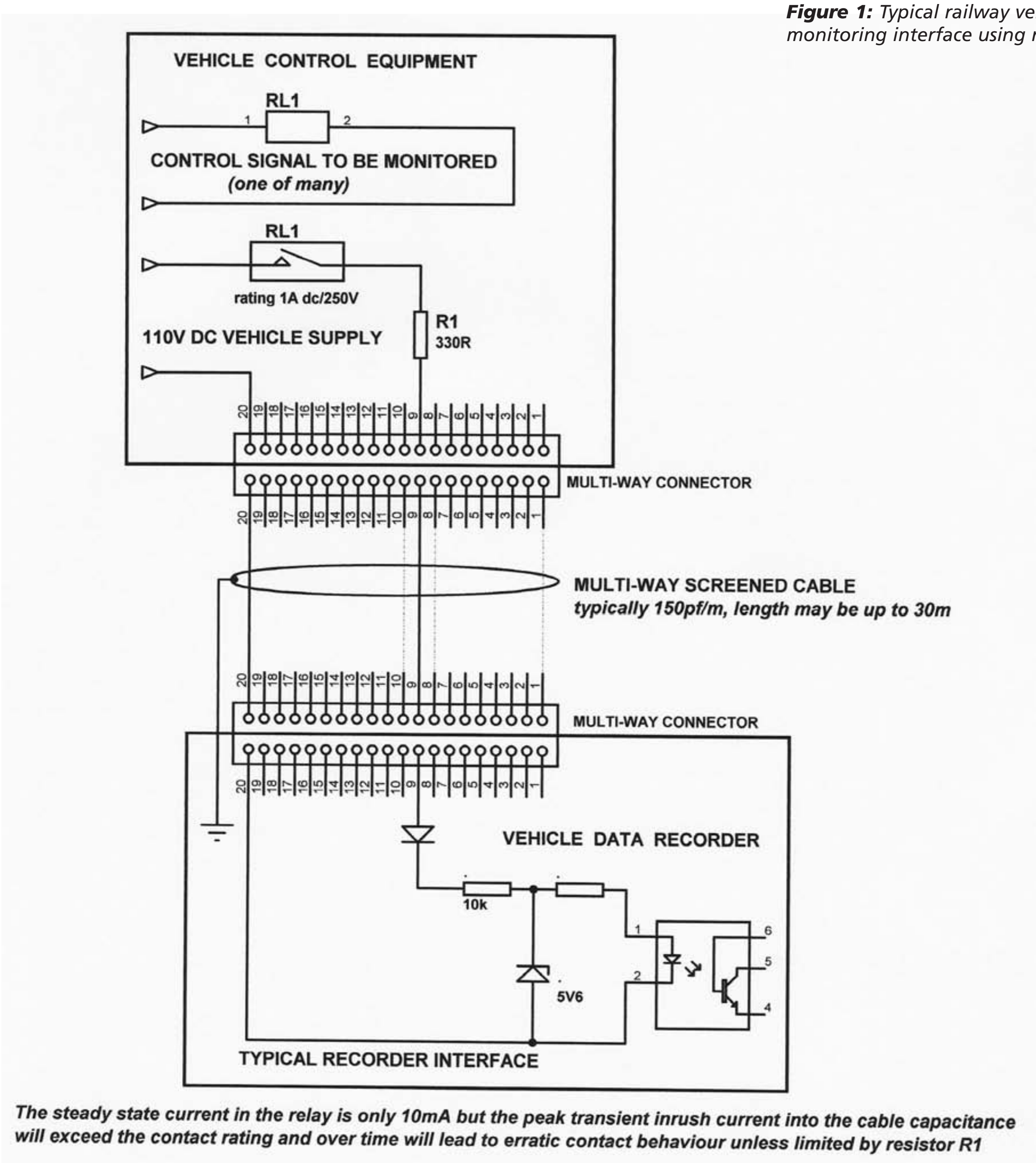
One should, however, apply such factors to components if they are mechanically more vulnerable: components like relays, for example, due to the nature of their construction since shock and vibration could obviously affect them.

Given the pessimistic qualifying factors of MIL-STD HDBK 217, it is reasonable to modify them on the basis of experience, conservative design and testing at all stages of product development. A database of failures logged by a competent QA department is of great value if fault analysis has been carefully carried out.

Reliability data is more widely available now for well-established semiconductor and small passive components but a few components like electrolytic capacitors, relays and board connectors are likely

IN THIS ARTICLE, **MICHAEL FORBES** DISCUSSES THE DOS AND DON'TS OF DESIGNING RELIABLE ELECTRONIC EQUIPMENT

Figure 1: *Typical railway vehicle monitoring interface using reed relays*



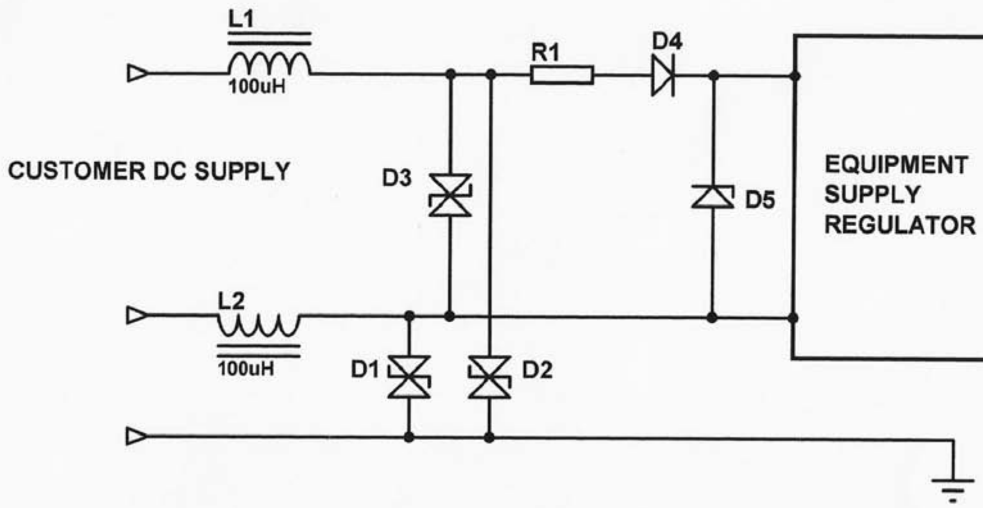


Figure 2: *Typical unregualted customer DC supply interface*

L1 AND L2 ATTENUATE FAST RISE TIME DIFFERENTIAL VOLTAGE TRANSIENTS (typical values shown)
D1 AND D2 LIMIT MAGNITUDE OF COMMON MODE VOLTAGE TRANSIENTS
(clamp voltages chosen to be greater than any supply voltage condition)
D3 LIMITS MAGNITUDE OF DIFFERENTIAL VOLTAGE TRANSIENTS
D4 PROTECTS EQUIPMENT AGAINST REVERSE POLARITY INPUT
D5 LIMITS VOLTAGE APPLIED TO EQUIPMENT (when less than the clamping voltage of D3)
(D4 and D5 are slow devices compared with suppressor diodes)
R1 LIMITS CURRENT IN D4 AND D5 UNDER FAULT CONDITION

to dominate the reliability of your equipment. Any data published by a manufacturer will be based on tests done under controlled conditions that may bear little resemblance to yours.

Consider a reed relay, for example – the data sheet may define a failure on the basis of contact resistance under rated load after 10 million operations – quite useless to the user if he has a load current of microamps for a relay that is only energised ten times a day.

If in doubt about a component that you intend to use by the thousand, then test some – find the limits for its use and whether some protection is needed, etc. A large sample size may be needed though and the effort is expensive, of course, but so will a redesign at a later stage in the project, or worse, a product replacement in the field.

Components To Be Careful About

- **Small tantalum capacitors:** ripple current is not likely to be an issue but absence of any series impedance to a voltage source might cause trouble. Manufacturers usually recommend about 3Ω/V. When these capacitors became common usage and were sprinkled all over logic boards, the author came across one alarming characteristic – they can get hot enough to burn a board due to a rising leakage current if they get inserted the wrong way round, dissipating power in the small epoxy case. Such an effect might take minutes or hundreds of hours to occur and is, therefore, not likely to be noticed during board testing. A factor of three in rated to working voltage lessens the risk. Consider high value ceramic or solid aluminium capacitors instead.
- **Electro-mechanical relays:** do not use them unless unavoidable. It is strange to look at modern, inherently reliable, electronic sub-assemblies comprising microprocessors, ADCs and FPGAs etc, communicating with the outside world via electromechanical relays. They will eventually fail and dominate the overall reliability of the unit. Modern solid state relays provide good isolation, have comparable voltage and current ratings, and can be bi-directional – they do not provide 'volt-free' contacts of course, which are so often specified by custo-mers when replacing older equipment, but nor do metallic contacts, strictly speaking. It is a rare application than cannot tolerate a volt or so across a 'contact'. They must be protected against transient voltages but so also must mechanical relay contacts.

  Some authorities, however, might insist on electromechanical relays for traditional and valid safety reasons.
- **Dry reed relay:** superficially, this a very simple device – two nickel-iron wires energised by an external magnetic field and sealed in a glass envelope with plated or sputtered precious metal contacts, usually overlaying gold. Some types can unexpectedly fail in the field and frustratingly, have no fault found when equip-

Notes on RELIABLE EQUIPMENT DESIGN

ment is returned, because the moment they have been jarred the 'sticky' contacts will have released themselves. This might have been due to contact wear produced by arcing (12V is enough for common contact metals), possibly accelerated by misaligned contacts or perhaps by contamination due to impurities included at manufacture.

However, for switching low-level signals there may be no practical alternative. Many modern types use sputtered ruthenium contacts which appear to have a much better contact life but the contacts still have to be protected. Current must be limited to well below the contact rating, paying attention to inrush current into any circuit capacitance (which may be just that of cables). See **Figure 1** for an example of use in a railway vehicle application.

Finally, be aware of their sensitivity to magnetic fields.

- **Capacitor voltage rating:** use a factor of at least two or more to allow for a derating at higher temperature and the fact that reliability worsens as the rated voltage is approached.
- **Resistor power dissipation:** again, use a derating factor of at least two; some authorities insist on a factor of three. The lower the power dissipated the better the stability. The dissipation under fault conditions must not be ignored since it may affect adjacent components.
- **Connectors:** use the best for the task and make sure that they are assembled correctly. Contamination and vibration will find the faulty ones.

Testing For The Unspecified

After design completion and the specification has been met with all the boxes ticked, the first units are manufactured, test procedures ironed out and a small number delivered for trial. It is never a good moment when that equipment is returned after failure or to be told that it does not perform in the way the customer had thought that it would.

Here are a few points to be aware of that are often not specified.

- Accidents can and will occur, especially during installation. Loads get short-circuited, output or signal lines get shorted to supplies – all too easy when probing a multi-pin circular connector, for example. It is necessary to have considered all this on the test bench – can the design withstand gross faults?
- You may have included polarised transient protection components – what happens when the power supply is connected with reverse polarity? See **Figure 2** for a typical DC supply interface.
- Bear in mind that equipment may well be installed and maintained by semi-skilled personnel.
- The equipment has undergone its dry heat test successfully – has allowance been made for additional temperature rise when it is located near to a hot motor casing, for example, or for the internal temperature rise due the encapsulation material you may have used in a sub unit?
- Your equipment may need some control signals supplied from the customer's equipment – what happens when the signals arrive out of sequence or have momentary interruptions? If not specified, does the equipment tolerate power supply interruptions of at 20ms duration?
- The resistive load presented by the customer's equipment is known – but will your equipment have to supply a substantial inrush current before normal steady state conditions are reached?
- Avoid placing a shunt capacitor directly across a customer's stabilised DC power supply; unless you have checked that the inrush current is not a problem.
- If the equipment has a single point failure potential where the loss of one connection renders it useless then use spare connector pins, if possible, to add some redundancy. It costs little.
- Are the track widths wide enough to carry fault currents without acting as fuses?
- A static cold and hot soak test may have been specified but you will have designed more reliable equipment if it can also survive several rapid limit temperature cycles without fault – always a good way to find potential problems in stressed joints.

Notes on RELIABLE EQUIPMENT DESIGN

Environmental Protection

Any equipment destined for an industrial environ-ment may be required to withstand specified levels of shock and vibration (even if only due to transport and handling), and if installed outside it may have be weatherproof also. If the equipment is vehicle mounted there may be other factors to consider such as contamination by fuel oils or hydraulic fluid and exposure to high-pressure steam cleaning.

The surest way to protect small items of equip-ment against mechanical damage and liquid ingress is to encapsulate them; however, beyond a certain volume (a few hundred ccs) this may be impractical and too expensive. One problem is geometry: circuit boards occupy area but terminals, transformers and connectors need volume. One could use closed cell foam encap-sulation but this is more costly than poured materials and requires careful proces-sing in a safe area.

Encapsulation of any kind usually places a unit into the irreparable category.

- If you have designed an encapsulated unit for resistance to shock, vibration and water ingress then model the process and cut it through to see if there are any significant voids present.
- Be aware of fire and smoke hazard specifi-cations – these will limit the materials that can be used although some relaxation may be permissible if the material mass does not exceed about 500g.
- Avoid the use of a rigid encapsulant, if possible. The lack of elasticity can cause faults after long term temperature cycling and it makes fault analysis all but impossible. There are a number of compounds available with varying degrees of adhesion and elasticity, but the more rigid ones tend to have the better fire hazard ratings.
- Where units are not encapsulated then circuit boards and radial-mounted components must obviously adequately supported to withstand shock and vibration. Consider adding support in the middle of a board and not just at the corners (preferably before the artwork has been completed). There are many coating compounds available that can offer support for small parts and add moisture-resistance to a circuit assembly. An endurance test on a vibration table will quickly show up vulnerable areas like the support of cabling.
- External cables should be contained in a conduit, which may be a mandatory safety requirement anyway, but obviously reduces risk of damage.

Meeting EMC Requirements

Without suitable in-house equipment and the skills to use them, an expensive day at a test house may be required – but only go when you are confident of a successful outcome. One might prefer to write a Technical Construction File and justify a case for acceptance as a paper exercise, especially if similar equipment has already been successfully accepted. Assembling such a file from scratch is an onerous task for most: it takes time to organise descriptions, parts lists, diagrams and so on for scrutiny.

It is quite possible that you will have to do this anyway if the customer requires an assessment by an independent body who may insist on certain tests being carried out in order to demonstrate compliance.

A mythology has formed around this subject but there are a few simple common sense design rules for equipment intended for an industrial environment, which should give some measure of confidence that tests will be successfully passed.

- Use a sealed metal enclosure ideally with no more openings than necessary to give an adequate level of screening.
- Keep signal and power lines separate and minimise the area between forward and return paths.
- Ensure that power lines are fitted with differential and common mode filtering as near to the equipment connectors as possible, even in a separate compartment. Include, where possible, a series choke (with a suitable fault current rating) and shunt capacitor across signal or control lines to attenuate conducted interference. For both power and signal lines fit suppression diodes across the line and from each line to ground to limit differential and common mode transient voltages to safe levels.
- In a test house, testing will be done according to the format laid out in the relevant standard with signals referenced to an artificial ground plane, usually in the form of a large copper sheet. When the equipment is installed, it is unlikely to be that simple and the return path for transient currents may be to ground via a cable screen, which assumes, of course, that the customer will continue the screen on his side. It is worth checking on test to see what happens if a cable screen is disconnected from ground.

DESIGNING WIDE-RANGE POWER SUPPLIES FOR THREE-PHASE INDUSTRIAL APPLICATIONS

Industrial equipment operating from a three-phase AC supply often requires an auxiliary power stage that supplies regulated, low-voltage DC to the control electronics. Specifications for these supplies are much more demanding than for the typical single-phase supply. The nominal input voltage is higher, and equipment designed for three-phase input has to tolerate larger input supply-voltage variations.

Line surges, extended sags and sub-cycle drop-outs often occur in an industrial environment as a result of large loads being switched off and on, or as a result of fuses being cleared for fault conditions elsewhere on the line. Three-phase applications can occasionally lose a phase or a neutral connection. Industrial equipment is expected to handle all of these conditions without malfunc-tioning. Applications such as energy meters must work reliably over these extreme conditions.

Design Goal

The goal is to create a three-phase input, off-line switching power supply that has wide input voltage range, high overall operating efficiency and good immunity to input voltage perturbations.

Most switching power supplies can operate over the universal input voltage range to provide worldwide coverage. For three-phase applications such as energy meters, the power supply must work from 57-580VAC, from all three phases and with the occasional loss of a phase or a neutral connection.

For auxiliary power supply designs, the flyback topology is best-suited and offers the following advantages:

- Use of a single active switch that simplifies circuit design;
- Use of a single-wound component in the topology (eliminates large filter chokes on the output);
- Easy-to-create multiple output voltages;
- Very low component count and cost.

A flyback converter typically requires a minimum MOSFET breakdown voltage of 1.6 times the rectified peak of the maximum AC input voltage. For 580VAC, a 1200V MOSFET would be required, adding cost and (normally) ruling out the use of an integrated switching IC that could dramatically simplify the solution (when compared to a discrete design).

An IC such as the LinkSwitch-TN from Power Integrations incorporates a 700V MOSFET and controller into a single device, and can eliminate 20 to 30 external components when compared to a circuit using a discrete MOSFET and external control IC. The 700V rating of this IC would normally limit use to single-phase applications. However, by adding an external MOSFET in a cascode or StackFET configuration, it is possible to distribute the voltage stress across two devices, resulting in an overall voltage rating equal to the sum of the individual MOSFET voltages.

Design Solution

The circuit in **Figure 1** is a 12V, 250mA wide-range flyback power supply that operates from a single-phase or a three-phase input. Using the StackFET technique with a low-cost 600V MOSFET results in an overall voltage rating of 1300V and allows supply operation over the desired wide input voltage range of 57-580VAC. The supply will work from 47-63Hz, single- or three-phase 110VAC, 220VAC or 440VAC. This supply comfortably handles the loss of one or more phases or the neutral, as well as extended sags and surges.

Circuit Operation

The circuit in Figure 1 is based on a LinkSwitch-TN IC, the LNK304P (U1) that is configured as a flyback, to leverage its 66kHz switching frequency. This reduces switching losses and improves efficiency. The IC's on/off control regulates the output by skipping switching cycles. As the load is reduced, the effective switching frequency decreases, hence scaling the switching losses and maximising the operating efficiency.

Note that a standard fixed-frequency PMW controller would suffer from poor efficiency under high-line and light-load conditions, due to the short duty cycle relative to the operating frequency. On/off control eliminates this problem.

The AC input is full-wave-rectified by diodes D1 through D8. Resistors R1 through R4 provide in rush current

RAHUL JOSHI OF POWER INTEGRATIONS LOOKS AT THE CHALLENGES OF DESIGNING SWITCHED-MODE POWER SUPPLIES FOR THREE-PHASE APPLICATIONS AND PRESENTS A COST-EFFECTIVE DESIGN THAT OPERATES OVER A WIDE INPUT VOLTAGE RANGE

limiting and protection against catastrophic circuit failure. Capacitors C5 through C8 are used to filter the rectified AC supply. To meet maximum bus voltage of 820VDC, 450V input capacitors C5, C7 and C6, C8 are connected in series with balancing resistors R13 to R16 to equalise the voltage. The C5/C7 and C6/C8 capacitor sets are used in conjunction with L1 to form a π filter for EMI reduction. Capacitor C9, which is placed very close to U1 and T1, shunts switching induced noise currents, to minimise differential mode EMI generation. Combining this EMI reduction technique with 1) the jittering of the switching frequency of U1, 2) E-Shield winding in the transformer, and 3) the safety Y-rated capacitor C1 across the isolation barrier, allows the design to easily meet conducted EMI limits (as specified in EN55022-B).

The high-voltage DC is applied to one end of the transformer primary, and the other end driven by MOSFET Q1. MOSFET Q1 and the MOSFET inside the LNK304P effectively form a cascode arrangement. When the internal MOSFET of U1 turns on, the source of Q1 is pulled low, which allows gate current to flow through the resistor string R6, R7 and R8 from the junction capacitance of VR1, VR2 and VR3, to turn on Q1. Zener VR4 limits the gate-source voltage applied to Q1.

When turned off, VR1 to VR3 (connected in series) form a 450V clamping network that ensures the drain voltage of U1 remains close to 450V; any input voltage above 450V will be dropped across Q1. This arrangement distributes the sum total of flyback voltage and DC bus voltage across Q1 and the internal MOSFET within U1. Resistor R9 limits high frequency ringing that occurs when VR1 to VR3 conduct. The clamping network, VR5, D9 and R10, limits the peak voltage that appears across Q1 and U1 (due to leakage inductance) during the flyback interval.

The circuit on the secondary of transformer T1 provides output rectification, filtering and feedback. Diode D10 rectifies the output. Capacitor C2 filters the rectified output. Inductor L2 and capacitor C3 form a second-stage filter, which helps to reduce the high-frequency switching ripple in the output. Zener diode VR6 conducts when the voltage at the output exceeds the total drop of VR6 and the optocoupler diode inside U2. A change in output

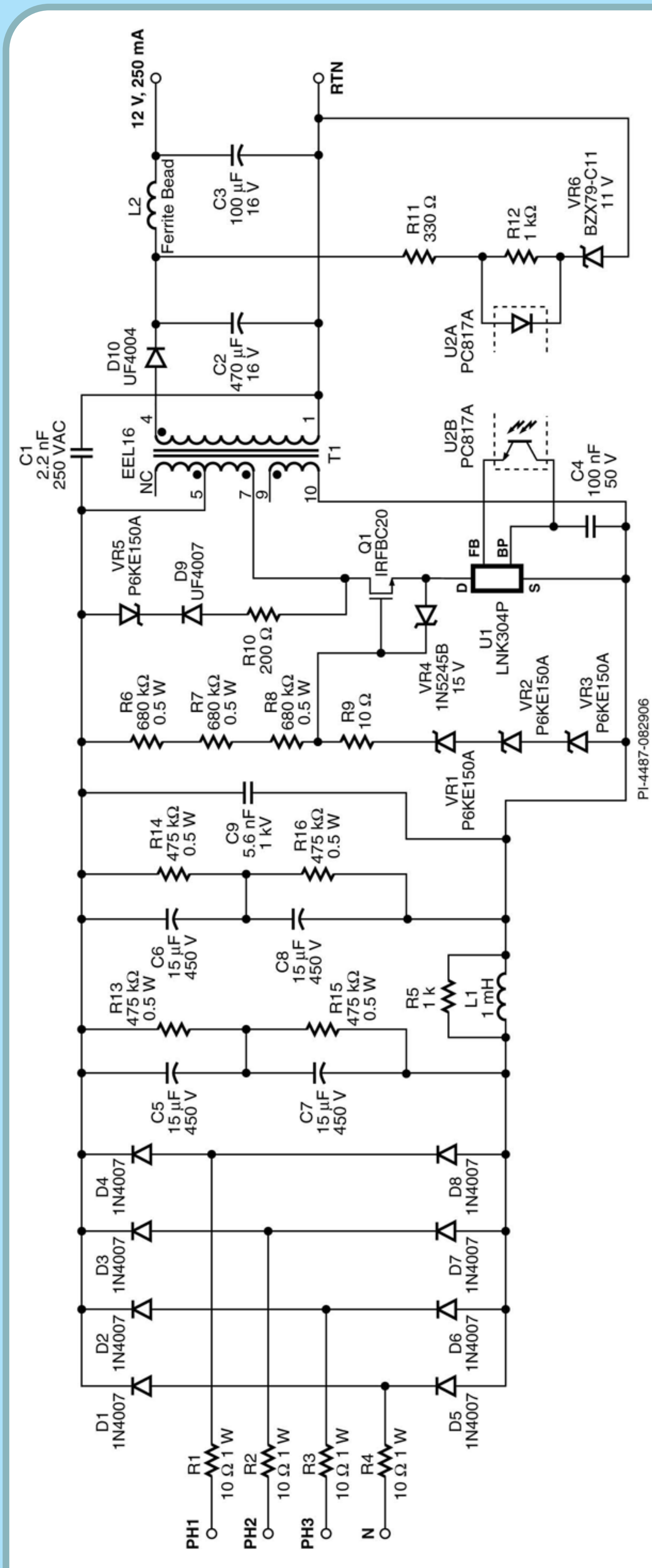


Figure 1: *Circuit schematic*

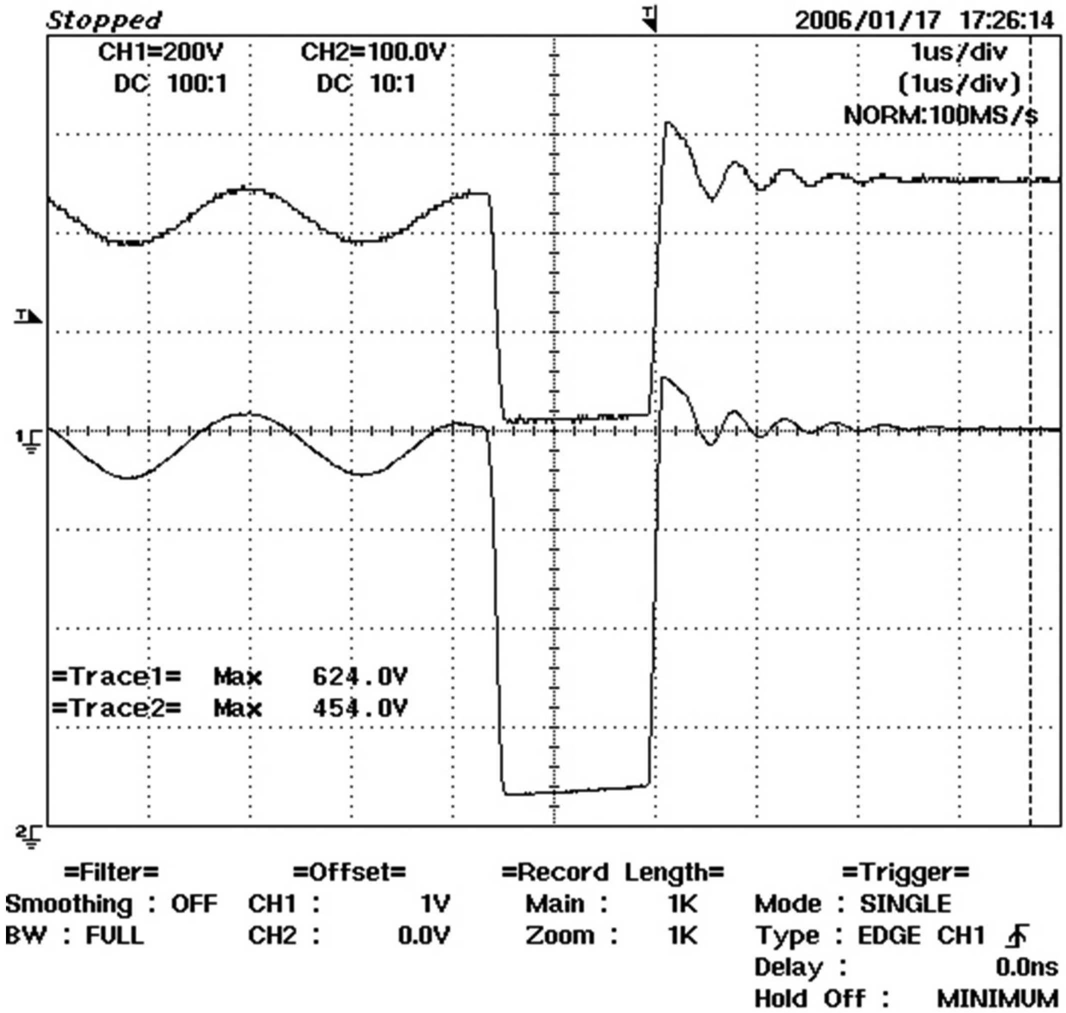


Figure 2: *Trace 1 – U1 drain voltage (200V/div) and Trace 2 – Q1 drain voltage (100 V/div)*

voltage results in a change in the current through the optocoupler diode. This, in turn, increases the current through the transistor inside U2B.

When this current exceeds the FEEDBACK (FB) pin threshold current, the next switching cycle is disabled. Output regulation is maintained by adjusting the number of enabled and disabled switching cycles. Once a switching cycle of U1 is enabled, the current ramps to the internal current limit of U1. Resistor R11 limits the optocoupler current during transient loads and sets the gain of the feedback loop. Resistor R12 provides bias current to the Zener diode, VR6.

If the FEEDBACK pin is not pulled high for a period of 50ms, the internal power MOSFET switch in U1 is disabled for 800ms. Alternately, enabling and disabling the switch protects the circuit against output overload, an output short circuit, or an open feedback loop.

No auxiliary winding or bias winding on the transformer is required to power U1, as it is self-powered from the DRAIN (D) pin. At start-up and during the off-time of the internal MOSFET, the local decoupling capacitor (C4) is kept charged via an internal high-voltage current source.

Circuit Test Results

The oscilloscope plot shown in **Figure 2** was captured at an input voltage of 312VAC (440VDC bus voltage). At turn-off, the drain voltage of U1 (trace 2) is clamped to a voltage of 450V, which is the total voltage across VR1, VR2 and VR3. This clamping ensures safe operation of U1. Trace 1 shows the voltage on the drain of Q1 referenced to primary ground (negative of C8). The actual voltage across the MOSFET Q1 in the OFF state (trace 1) is the difference between the two traces, in this case 170V.

As the AC input voltage is increased to 580VAC (820VDC), the voltage drop across the MOSFET Q1 in the off state is less than 550V, which allows the use of a low-cost 600V to 800V external MOSFET.

The efficiency characteristic of this design is shown in **Figure 3**. The curve reveals that the efficiency drops at higher input voltage, due to increased switching losses and dissipation in the cascade connected power stage (Q1 and the internal MOSFET within U1). However, this is still significantly higher than a regulated linear transformer supply.

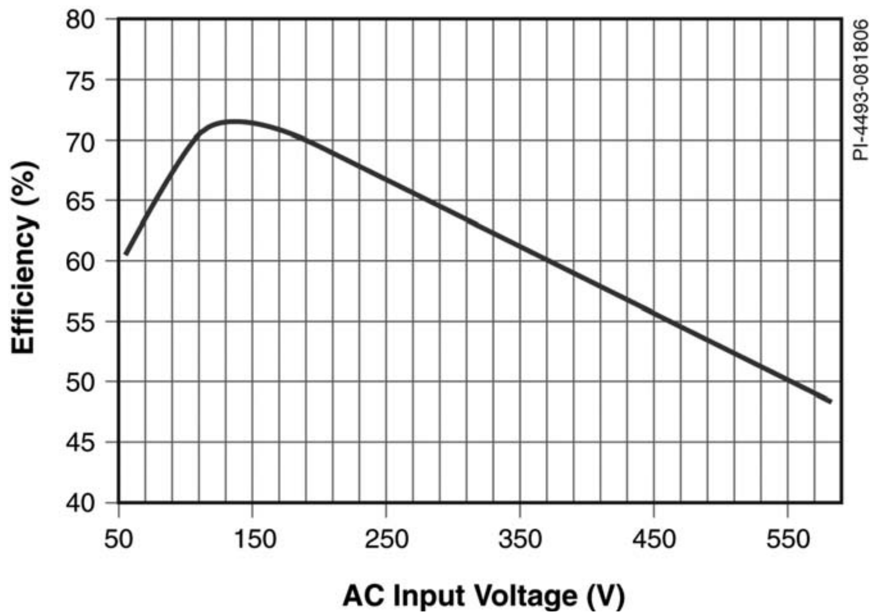


Figure 3: *Efficiency vs input Voltage*

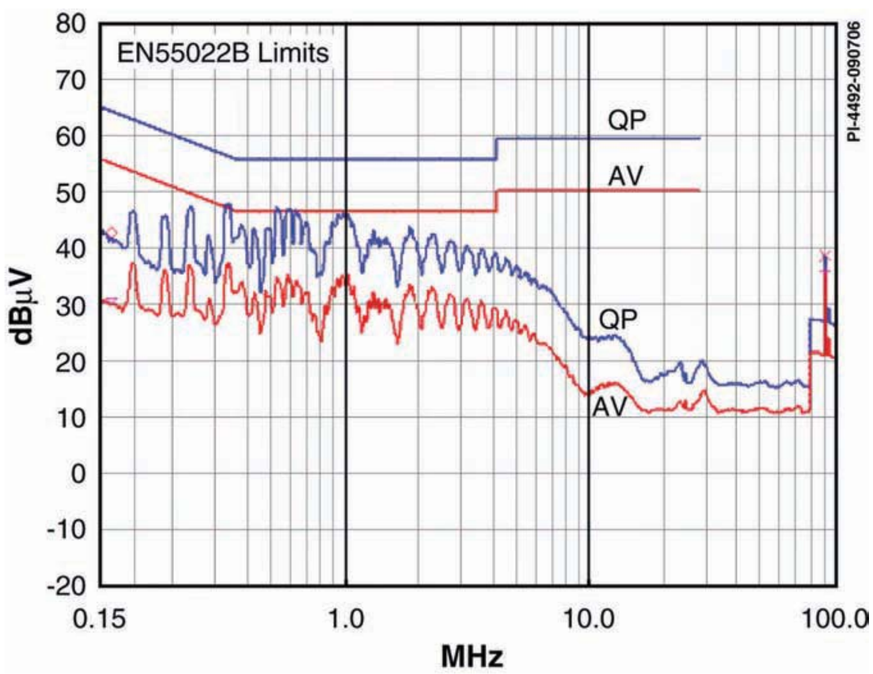


Figure 4: *Conducted EMI at 230V*

The circuit meets conducted EMI requirements with a comfortable margin when tested at 230VAC, as shown in **Figure 4**. The blue and red upper lines represent the quasi-peak and average limits, perEN55022 B. The lower lines represent the corresponding quasi-peak and average test results.

Simplicity

The StackFET technique provides a cost-effective solution for auxiliary power supplies in industrial applications. This technique allows the designer to benefit from the simplicity afforded by an integrated switching IC when used for high input voltages required by three-phase AC input.

Simplified EMI Solutions DC-DC Converters

PHILIP LIOIO, SENIOR FIELD APPLICATIONS ENGINEER, AND CHESTER FIREK, MARKETING MANAGER AT VICOR DISCUSS EMI SOLUTIONS FOR SWITCHED-MODE DC-DC CONVERTERS

All switched-mode DC-DC converters generate potentially interfering signals as a result of the high-frequency, high-power switching. Conducted noise on the input power lines can occur as either differential-mode or common-mode noise currents. Differential-mode noise, largely at low frequencies, appears across the input conductors at the fundamental switching frequency and its harmonics. Common-mode noise, having mostly high-frequency content, is measured between the converter's input conductors and ground. Similarly, switching DC-DC converters will contain some noise, as well as ripple, on the output. Properly designed and implemented EMI filtering will reduce noise to acceptable limits.

In Europe and the US, for example, conducted noise emissions are governed by the Class A and Class B limits of both FCC and VDE standards. In Europe, all countries require that equipment for both home and factory use meets the VDE Class B standard. In the US, the FCC requires compliance with Class A for equipment operating in factory settings and Class B – the stricter standard – for equipment destined for home use.

EMI Filter Solutions For Input Noise Reduction

Most switching power supplies today operate in the frequency range between 100kHz and 1MHz. Usually, the dominant peaks in the conducted noise spectrum reflected back to the power line correspond to the fundamental switching frequency and its harmonic components. Conducted emissions standards such as EN55011 and EN55022 set quasi-peak and average limits on conducted noise reflected from the input of converters or power supply systems back to the source over the frequency range of 150kHz to 30MHz. In order to comply, all of the conducted noise – the peaks in the spectrum – must fall below the specified limits.

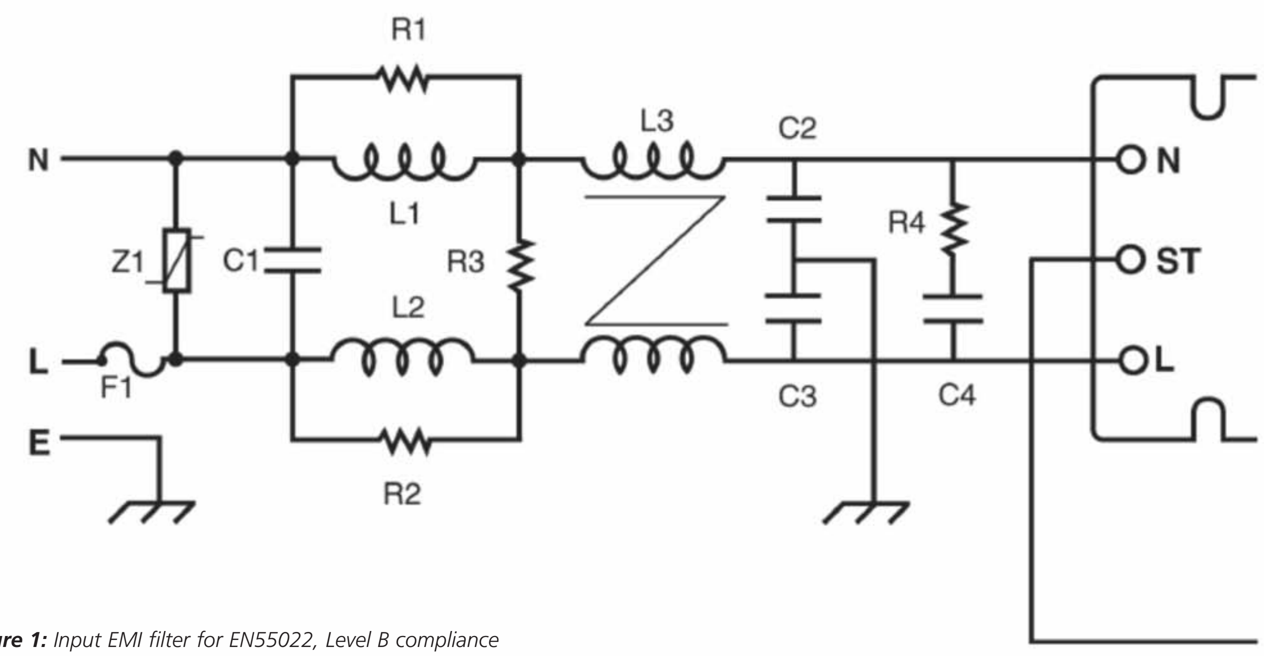


Figure 1: *Input EMI filter for EN55022, Level B compliance*

for Switched-Mode

Component And Packaged Filter Solutions

EMI filters are often constructed in a single package (with configurations similar to that shown in **Figure 1**). The EMI filter is a through-hole filter with a common mode choke and Y-capacitors (line-ground), plus two additional inductors and an X-capacitor (line-line). Transient protection is provided by Z1. This filter configuration provides sufficient insertion loss to comply with the Level-B conducted emissions limit.

Nevertheless, capacitors, inductors and filters are commonly used in power supply designs to reduce or attenuate the amount of conducted noise, both common mode and normal mode. First, the effects on the noise spectrum of adding individual components or filters are shown leading up to the result with a full common mode filter.

The 48V input DC-DC converter shown on the left in **Figure 2a** has a differential mode capacitor, C1, on the input. This single-mode electrolytic capacitor – 120μF, 100V – is used to ensure low input impedance, stability and good transient response. It's an energy reservoir for the converter. To reap the most benefit, the capacitor must be as close to the input pins of the module as possible.

The module alone and that one capacitor provide a baseline from which to start. The spectra in Figure 2a on the right shows the harmonic content of the noise and the EMI limits, A and B levels, for this converter and differential mode capacitor combination. These measurements were made at 100% load nominal line for a 48V, 150W DC-DC converter. With this differential mode capacitor only, the converter is clearly not meeting the limits, but the power component is not designed to meet any specific EMI limits.

The effect of adding bypass caps to the converter and differential mode capacitor combination, shown in **Figure 2b**, is rather dramatic. Notice the bypass cap on each input pin to the base plate, which is ground, and each output pin to the base plate. These electrolytic capacitors are 4700pF, 100V, Y caps that are commonly used in the industry. The Y caps are very effective in attenuating the type of noise that the power component generates.

The 48V design with 100% load generates a little higher noise than, for example, a 3.3V design with a 50% load would, but, nevertheless, the spectrum in Figure 2b shows some significant improvement.

Even with the addition of a 27μH differential inductor, L1, **Figure 2c** shows that the 48V design is still not compliant at the lower frequencies, where noise is still present above the B limits.

Figure 2d shows the next stage where we're adding a common-mode choke. The differential-mode choke is eliminated because the common-mode choke does have differential-mode inductance. The common-mode inductor accentuates the capabilities of the Y capacitor. That's because it provides high impedance to common-mode noise that's being conducted out of the converter, therefore, the noise follows the path of least resistance to ground which would be through these Y caps.

The spectrum of the 48V converter is just peeking over the top of the B limit, so, a little more filtering would be needed on a 48V converter design. The noise spectrum of a 3.3V converter with a common mode filter would be below the B limit both at 50% and full load.

Active EMI Input Filter Solutions

Conducted EMI compliance in telecom has emerged as an important application for active filters for DC-DC converters. In the past, conducted EMI testing and confirmation of compliance to conducted EMI standards has been focused in off-line AC input supplies. This changed in 2003 when PICMG ratified a new specification for telecom blades, PICMG 3.0, more commonly known as Advanced Telecom Computing Architecture (AdvancedTCA, or ATCA). The specification requires DC-powered blades to meet the EN 55022B limits for conducted EMI. Filtering at the blade level ensures interoperability between different blades and reduces the amount of bulk DC filtering required on each equipment rack.

Furthermore, the trend for smaller devices with more functionality in smaller spaces continues unabated in the electronics industry. As spaces shrink, the potential interference between devices increases as systems pack more functions in densely packed blades and racks. As frequencies rise and voltage levels fall, the control of conducted EMI becomes an even more important design task. Telecom blades are not exempt from the trend toward denser packaging coupled with higher performance. The ATCA, PICMG 3.0 specification supports a 2.5Tb backplane bandwidth in a standard 19" rack. A fully populated ATCA rack can have 14 blades in a 19 x 21 x 15inches volume.

To support higher functionality, each blade can use as much as 200W of DC power. EMI compliance is made more difficult because each blade is required to supply its own power from a -48Vdc redundant input. On-board DC-DC conversion, in the form of bricks or discrete converters, generates conducted and radiated EMI on each blade. Compared to compact PCI, where the bulk of the DC power was converted off the blade, EMI control becomes a nightmare under these circumstances.

To minimise blade-to-blade and rack-to-rack interference, ATCA blades are required to provide on-board filtering for conducted EMI. PICMG 3.0 states that

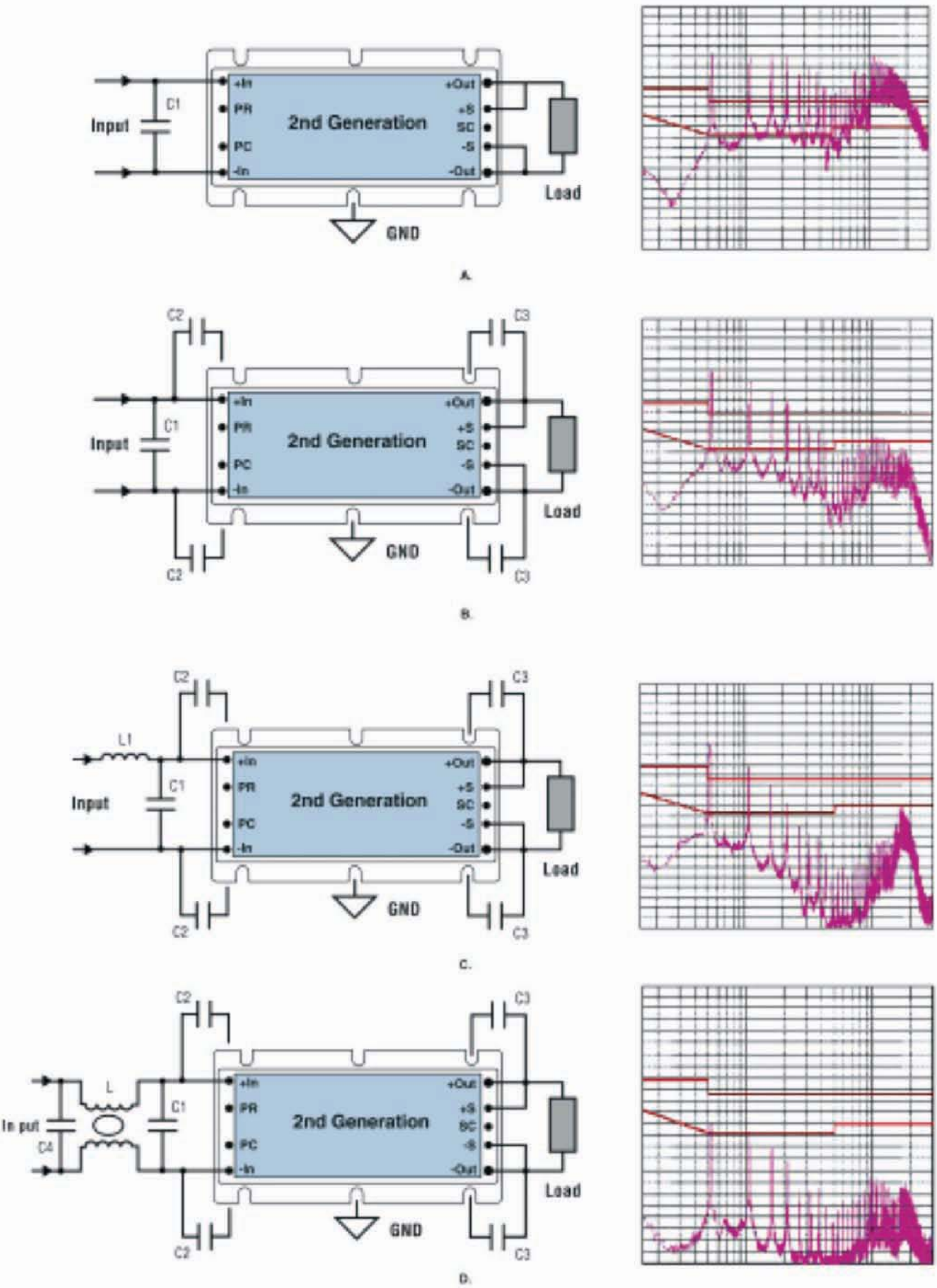


Figure 2: *48V, 150W DC-DC converter with associated noise spectrum with the use of:* ***(a)*** *differential-mode capacitor,* ***(b)*** *bypass capacitors,* ***(c)*** *differential-mode inductor,* ***(d)*** *common-mode filter (with differential mode choke eliminated)*

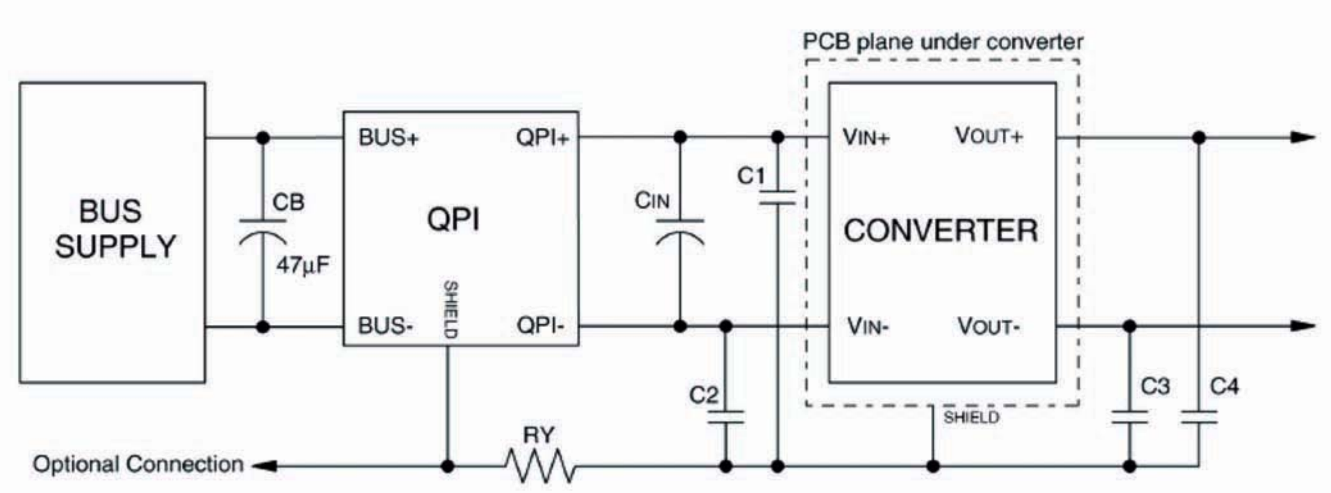


Figure 3: *Typical diagram for an active EMI filter (labelled QP1) for a DC-DC converter. Values of Cin and C1, C2, C3 and C4 are those normally recommended by the converter manufacturer*

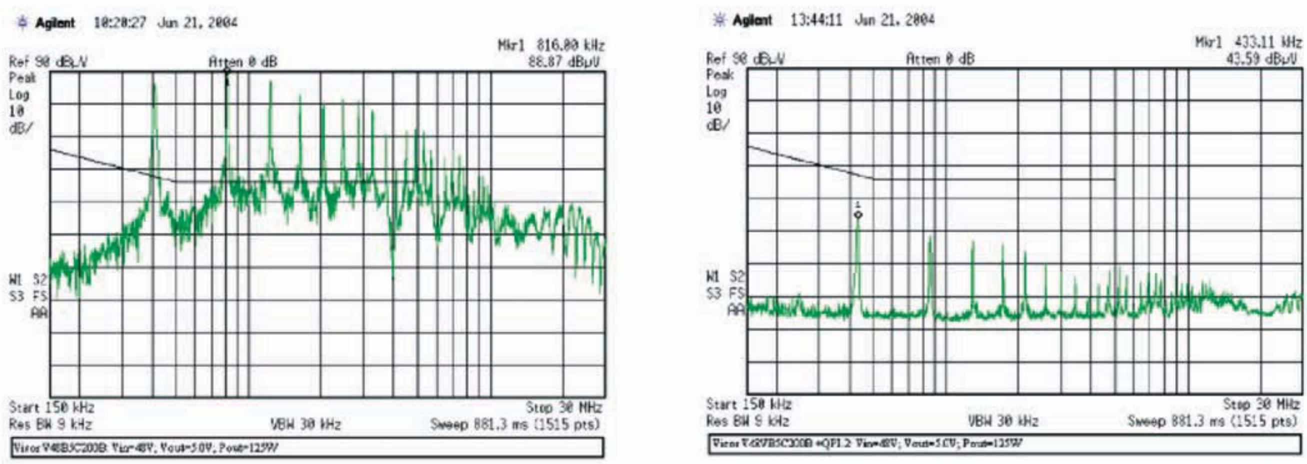


Figure 4: *: Conducted EMI profiles of a DC-DC converter with no filter (left) and with an active EMI filter (right)*

each blade must meet the conducted noise specification of EN5022B. By taking a blade-level approach to filtering, interference between cards is minimised. At the same time, PICMG 3.0 also requires the rack to meet an overall conducted EMI standard. By controlling EMI on card with "distributed" filters, the filter required for the rack can be smaller. The filter for a fully populated ATCA rack needs to support almost 60A of DC current. Inductors to support this current are large enough, controlling EMI on board, helps to keep these inductors as small as possible.

Active EMI filters (see **Figure 3**) are available that attenuate conducted-mode and differential-mode noise over the frequency range of 150kHz to 30MHz required by the conducted emissions standard EN55022 (CISPR22). Designed for use on a 48Vdc bus (36-76Vdc), their 7A rating supports multiple DC-DC converter loads up to a PCB temperature of 60µF.

In comparison to passive solutions, the use of active filtering reduces the volume of the common-mode choke, providing a low profile, surface mount device. Specifically, active EMI filters also reduce the size of the inductive elements, allowing an EMI filter to be packaged in a 1 x 1 x 0.2inch package. Smaller size saves valuable board real-estate and the reduced height enhances airflow in blade applications, helping blade designers recover some of the lost space required for EMI control. The 7A rating of active filters easily handles the current required for a 200W ATCA blade.

Figure 4 shows the before and after plots of a DC-DC converter noise profile, to demonstrate the performance of an active filter. The plots were taken using the standard measurement technique and set up as defined in CISPR22. The results show the total noise spectrum for a standard DC-DC converter under load compared to the EN55022 Class B quasi-peak detection limit. The plot shows that an active filter is effective in reducing the total conducted noise spectrum to well below the required limits.

Multi-Function Input Filter Modules

Some DC-DC converter suppliers also offer AC-DC modular front ends. Some of these devices contain multiple functions, including EMI filtering. One such multi-function module, for example, is a filter/auto-ranging rectifier that provides EMI filtering, auto-ranging line rectification and inrush current limiting. It enables designers to meet the EMI requirements of Telcordia, FCC, ETSI and European Norms.

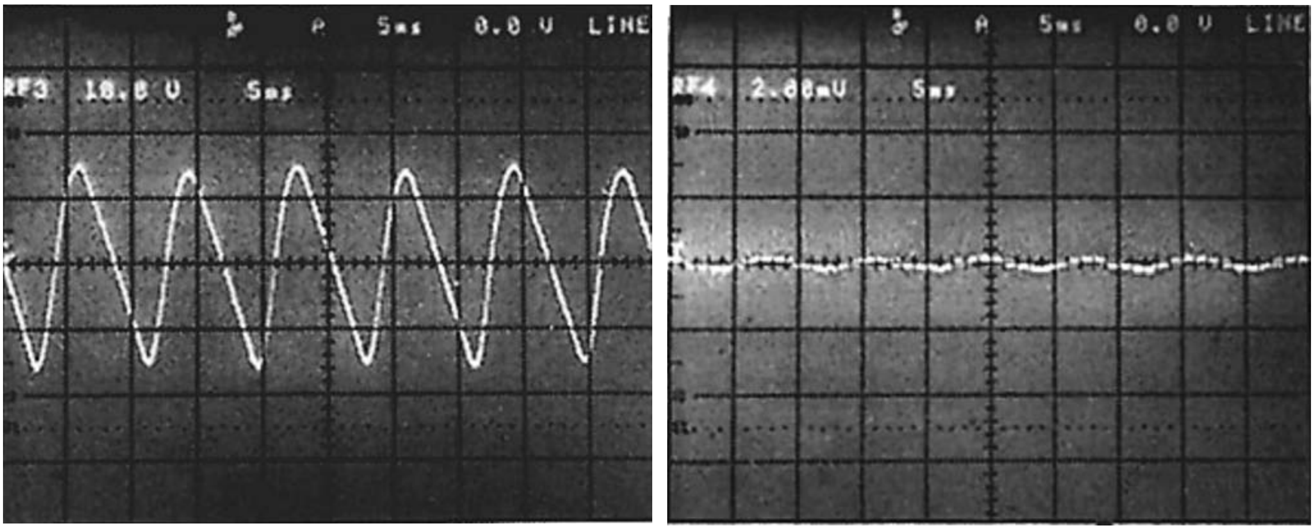


Figure 5: : *Input to the converter, 10V/cms (left) and the output of the ripple attenuator module, 20mV/cm*

EMI Filter Solutions For Output Noise Reduction

Switching DC-DC converters also exhibit ripple and noise on the output. This output noise, usually referred to as Periodic And Random Deviation (PARD), is the sum of all ripple and noise components superimposed on the DC output of a power supply, regardless of nature or source. Switching DC-DC converters often exhibit ripple and noise levels in the tens of mV.

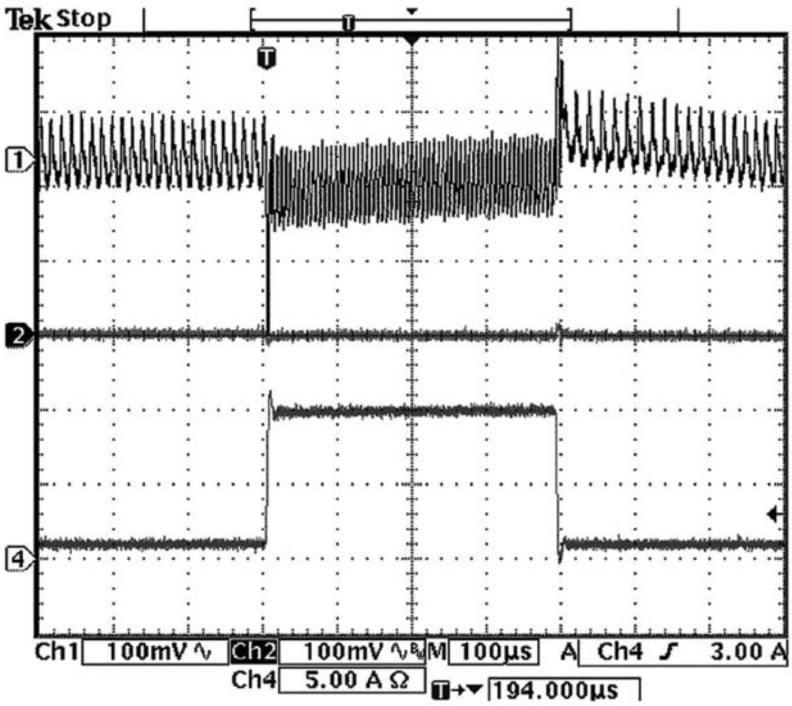


Figure 6: *Typical performance of an output ripple attenuator using active filtering*

An output ripple attenuator module that combines both active and passive filtering can limit output noise to less than 3mV peak-to-peak at loads up to 20A (**Figure 5**). These modules, which measure 2.28 x 2.4 x 0.5inches attenuate both low frequency input power source fundamental and harmonics in the frequency range of DC to 20MHz, while exhibiting efficiencies of 93-99%.

Another output ripple attenuator (**Figure 6**) in a System-in-a-Package (SiP) configuration uses active filtering to reduce supply output ripple and noise (PARD, periodic and random deviation) by over 30dB from 1kHz to 500kHz. This architecture improves transient response and ensures quiet point-of-load regulation when used with most switching power supplies. It regulates the load by using either the remote sensing feature of a converter or the adjust pin of the device.

The adjust feature will correct the converter's output voltage to compensate for the headroom voltage drop of the filter, if remote sensing is not available or not preferred. The headroom setting of the filter dramatically reduces the capacitance needed at the converter output to provide the equivalent transient performance and ripple reduction.

It is targeted to applications such as test and measurement, distributed point-of-load power systems, sensors requiring low-noise power and medical instrumentation.

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No need for subsidies says British Energy

Nuclear plants can be built without subsidy British Energy (BE) insisted this month.

The company has indicated it would be interested in building and operating a new generation of nuclear power stations provided it had long-term contracts for their output at guaranteed prices.

Bill Coley, British Energy's CEO, said potential investors would need "price certainty" before committing to funding. Coley was speaking as, only a year after receiving a £5bn rescue package from the government, the company announced full-year profits of £599m for the year ending March 2006 – a performance driven by soaring electricity prices.

Coley said: "British Energy has made significant progress over the past year. Largely due to higher realised prices, the group has shown significant improvement in profitability and cash flow. We continue to be focused on delivering world class nuclear operations, improving our financial stability and pursuing life extensions for our stations. We expect to invest £250m to £300m in our plant this year to enable us to meet those objectives."

The company intends to upgrade its ageing plants, including Hunterston on the west coat of Scotland and Torness in East Lothian. The extension of the Dungeness plant (pictured) by ten years has already been announced.

Coley also welcomed the news, disclosed in the Budget earlier this year, that the government intended to sell part of its current 65% stake in the nuclear generator, acquired at the time of the bailout. He said the company would like to see the government "sell down as much of the stake as possible", giving British Energy more flexibility.

Dungeness B power station in Kent

Excess energy sales made easier

Royal assent has been given for a Government supported Private Member's Bill that will make it easier for householders who produce electricity from microgeneration technologies at their homes to sell unused power back to their supplier.

Mark Lazarowicz's Climate Change and Sustainable Energy Bill aims to reduce carbon emissions and fuel poverty through a series of measures designed to increase installation of micro-wind turbines, solar panels and other localised energy production technologies.

The Act will make it easier for excess energy to be sold back to the utilities by encouraging energy companies to establish schemes that reward smaller scale generators for their exported power. This is a key plank of the DTI's recently published microgeneration strategy and is now legally underpinned by the bill's passage through the house.

Opening up the ability to earn money for the sale of electricity produced by these technologies will help to offset the cost of installation and play a part in the expansion of the sector, bringing both environmental and economic benefits.

The 40 Eastbourne Terrace offices of engineering contractor CB&I have been refurbished by architect Fletcher Priest.

A major part of the project was installing a lighting control system that was fully flexible. The Philips LightMaster control system is designed to accommodate future upgrades and additions, crucial to many new office developments where clients may wish to take whole or part floors or even a mix of the two. The fact that offices may be fully or partially occupied has a major implication on energy consumption costs. When lighting controls are correctly applied, energy costs can be reduced by up to 30% in comparison with conventional switched lighting. The light control system installed ensures light is always adequate for efficient work performance, but not excessive.

The project took advantage of the natural daylight that pours in to the full height atrium around which the office space is arranged. Multiple light sensors were installed around the periphery of the building measuring the amount of natural light coming in. The system automatically dims the luminaires within the area, so a constant level of light is maintained in the working space. The luminaires can also be programmed to switch off as daylight takes over altogether.

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The Next Great INNOVATION

WHAT OFFERS A UNIQUE COMBINATION OF HIGH POWER DENSITY, LOW OPERATING COSTS AND LOW ACQUISITION COSTS THAT IS NOT AVAILABLE IN ANY OTHER CONVERSION TECHNOLOGY CURRENTLY OFFERED IN COMMERCIAL PRODUCTS? TO FIND OUT, READ ON, SAYS TRISTAN LEWINSOHN OF ENECO INC

Year 2007 looks set to be a great year for alternative energy. Whether it is governments looking to reduce the oil and gas imports, or manufacturers hoping to give their latest product a commercial edge, everyone is on the lookout for the next great innovation that will change the way we work and make the world a greener place.

Much of this search has centred on renewable energies and, more recently, on fuel cells, bio-fuels and the viability of a hydrogen economy. However, a technology developed by Salt Lake City based Eneco may well provide more immediate solutions to our current challenges and revolutionise the way electricity may be generated.

Eneco's Thermal Chip is a new type of semiconductor which directly converts heat from any source into electricity, delivering energy and power conversion three to five times more efficiently than present alternatives, and producing commercial products that are likely to be up to ten times cheaper than the competition.

The company has been perfecting the technology quietly since 1999.

Performance Breakthrough

The Thermal Chip technology has two operating modes:

* **Power mode** – in which the Thermal Chip can be used to convert heat directly into electricity, and
* **Cooling mode** – in which the Thermal Chip converts electricity directly into cooling and refrigeration.

Its efficiency and ability to convert heat from any fuel source is what sets it apart from other energy conversion technology and adds a degree of flexibility not inherent in fuel cell technologies. It is environmentally friendly, virtually weightless, has no moving parts, does not deteriorate and instantly recharges – just add fuel. It is also more efficient and has greater power and energy density than alternative products.

The Power Mode offers small scale and portable power solutions for such products which combine high efficiency and low cost because it is extremely light and takes up a tiny space for the amount of power it can deliver. This makes it particularly useful where compact power is needed for portable applications. In addition, its efficiency is high, constant and independent of scale and it has a very long projected service life as there are no moving parts to wear out. The device is silent and does not cause electrical inter-

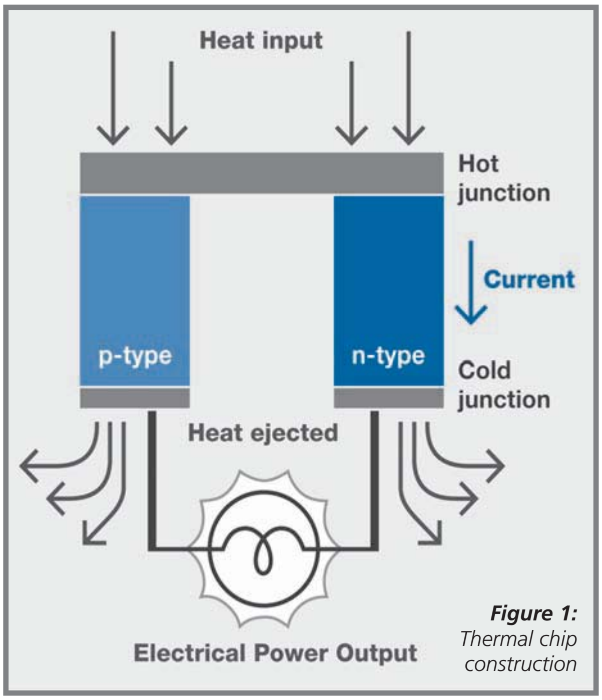


Figure 1: Thermal chip construction

ference. Having configuration flexibility, the Thermal Chip systems can be varied in size – from a square millimetre to an array of hundreds or thousands of Thermal Chips covering many square meters, depending on the amount of power required. It equally can vary in shape, as the array can be made to conform to the geometry of the heat source. This is particularly important for conversion of waste heat to electricity.

In the Cooling Mode, Thermal Chips operate in reverse – the application of electrical power transports thermal energy from one side of the chip to the other, thus providing effective cooling. The design elements required to assemble Thermal Chips – Cooling Mode and Power Mode – are common to both, so in that sense the design elements have been co-developed and tested. Eneco's current models project higher conversion efficiencies for the Cooling Mode than for the Power Mode, and laboratory tests for cooling, at least in some cases, have already yielded cryogenic temperatures (temperatures below –150°C).

For refrigeration applications smaller than about 200W, Thermal Chips are seen as more efficient than any other known technology.

The Science Behind The Thermal Chip

Eneco's technology is based on a combination of solid-state thermoelectric and thermionic principles.

In conventional thermoelectric technology, two dissimilar metallic or semiconducting plates are joined together and heat is added to one plate to produce a low-voltage, direct current. The weakness of thermoelectric technology is its low efficiency – typically, well below 10% at a hot-side temperature of 250–700°C. Consequently, thermoelectric conversion technology is only economically viable where the heat source is of little or no value, as is the case with waste heat, and is easily and cheaply harnessed.

The other technology which Eneco uses is called thermionics. The typical thermionic system consists of two parallel conductive surfaces, an emitter and a collector, separated by a vacuum gap. Heating the emitter causes electrons to boil off, cross the gap and be absorbed into the colder collector, where the electrons can be connected to an external load. Although vacuum thermionic devices achieve absolute conversion efficiencies exceeding 20%, the key limitations include prohibitively high manufacturing costs and intimidating operating temperatures (above 1100°C), thus confining the use of thermionic systems to limited special purposes, such as nuclear-powered converters in space probes, satellites and special military applications.

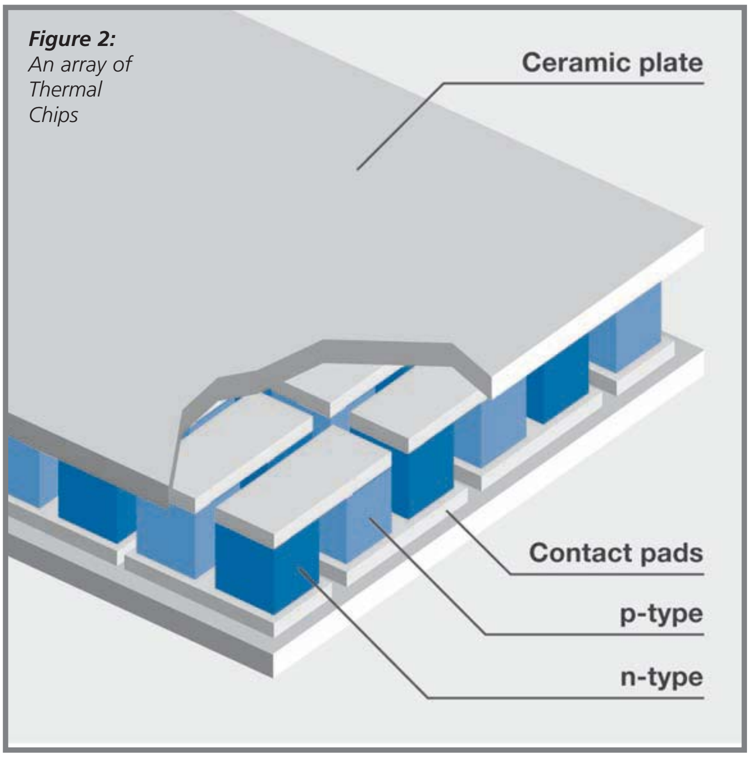


Figure 2: *An array of Thermal Chips*

Eneco's technology combines the best aspects of thermoelectrics and thermionics. Operating at 275°C and with a temperature differential of 250°C, Eneco's semiconductor technology has demonstrated conversion efficiencies approaching 40% of ideal Carnot cycle with absolute efficiencies close to 20%, that is thermionics efficiency at the relatively low temperatures associated with thermoelectrics. The National Institute of Standards and Technology (NIST), formerly known as the National Bureau of Standards, has independently verified Eneco's test methods and conversion results.

Physically, Thermal Chips consist of a solid-state "emitter" structure formed on the heated side of a "gap" material that also has a "collector" structure formed on its cold side. The layers of the Thermal Chip resemble the structure of a junction transistor combined with that of a field effect transistor. The emitter uses an energy barrier to separate hot carriers (electrons or holes) that are injected into the gap material. The gap is a properly selected semiconductor thermoelectric that is thick enough to support a significant temperature differential between the emitter and the collector in order to achieve efficiencies of practical interest.

Excess carriers in the gap near the collector can create a potential, which, during an open circuit, could result in a back flow of carriers and would decrease

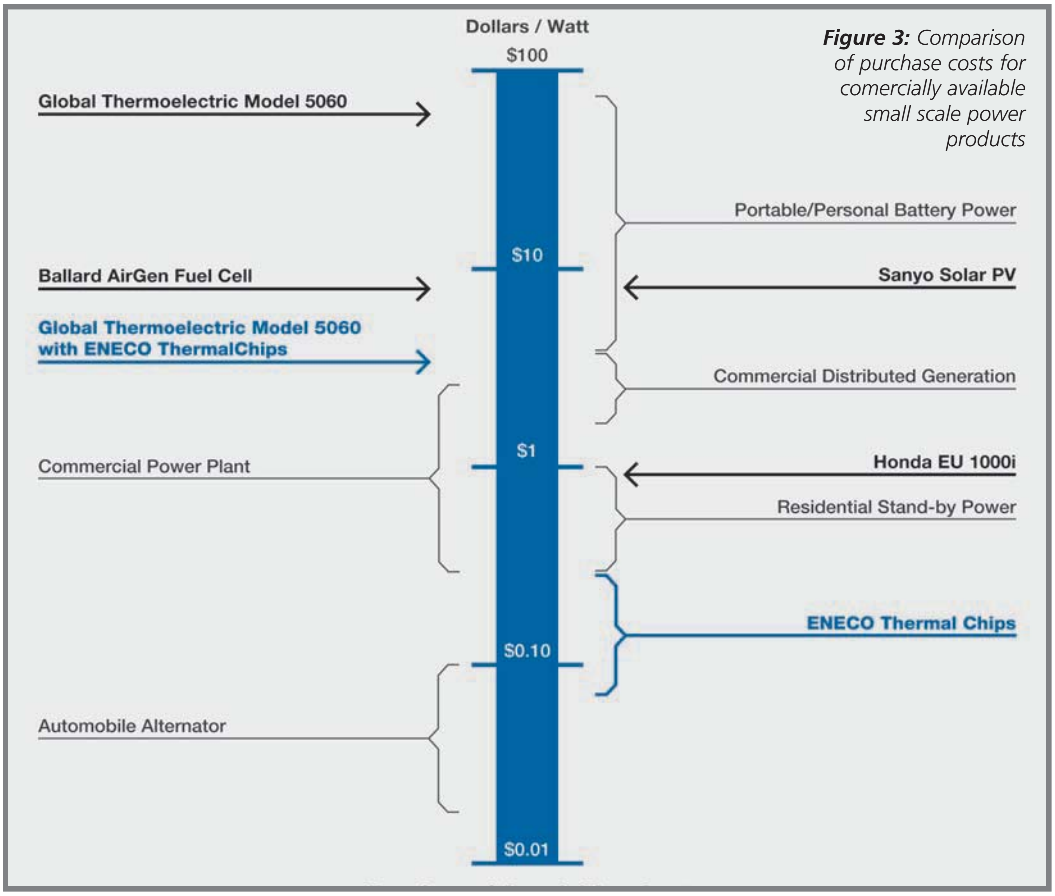


Figure 3: *Comparison of purchase costs for comercially available small scale power products*

output voltage. Construction of an additional barrier at the collector blocks this back-flow and maintains output voltage, which further increases the open circuit output voltage. Both the emitter and collector structures are thin enough not to change bulk material properties of the gap, so, thermally and mechanically, the Thermal Chip behaves similar to a thermoelectric device but with intensified open circuit voltage and closed circuit current significantly increasing the conversion efficiency.

Modules are constructed in sizes matched to the application and arrays or groups of modules can also be formed. For example, an array of four 20W modules could provide 80W for laptop power. In practice, two individual chips, each about one square millimetre, designated n-type and p-type, are arranged side-by-side and electrically and mechanically connected to form a "couple" as shown in **Figure 1**. These fundamental building blocks are grouped into "modules", as shown in **Figure 2**.

A Power Mode module's ceramic top plate is interfaced to a heat source from which heat flows through the chips to the cooled bottom plate, producing electricity through an efficient, solid-state conversion process.

The Cooling Mode is just the reverse, being electricity applied to the module pumps heat from the cool side to the hot side, making the cool side colder and providing effective refrigeration.

Potential Applications

There are many possible uses of the Thermal Chip technology. One opportunity is to licence or sell replacement conversion technology products to manufacturers of thermoelectric generators (TEGs)

Table1

	Conventional Thermoelectrics	Conventional Thermionics	Solar Photovoltaic	Fuel Cells	Eneco Inc. Power Mode Converter (Projected)
Watts/sq.cm	0.1 – 5	1 – 10	0.01	0.1 – 5	15
Watts/cu.cm	0.2 – 10	1 – 10	0.1	0.1 – 1	100
Watts/gram	0.1 – 10	1 – 10	0.1	1 – 10	20
Operating Temperature Range (C)	Up to 250	700 – 1700	N/A	200 – 800	Up to 600
Overall Conversion Efficiency (%)	5 – 10	20 – 40	10 – 30	25 – 60	20 – 30
Cost/Watts($)	1 – 5	5 – 15	6 – 12	1 – 5	<<1
Scalability	Good	Fair	Fair	Fair	Excellent

and coolers (TECs), a market estimated at approximately $250m in 2004.

TEGs are utilised in off-grid, special applications, such as powering remote pipeline process monitoring stations, remotely located navigational aids and spacecraft.

Some of the positive features of potential Eneco products also offered by TEGs and TECs in this market include extended periods (years to decades) of operation without maintenance or service, absence of sound and electrical interference, scalability from millimetre-sized devices to metre-sized arrays, low maintenance cost and the ability to use virtually any source of heat available.

Negative features of existing products and systems are their high system cost and low conversion efficiency. Due to their high purchase cost, TEGs predominately sell into applications for which there are no technical alternatives.

There are, of course, other examples of potential applications as well, such as in industrial market/industrial waste heat recovery joint ventures and industrial market/industrial waste heat recovery applications where they can take advantage of the scalability of Eneco's Thermal Chips to cover and convert heat to electricity from large and complex areas. In general, the applications fall into two categories:

∗ **Bottoming cycle for geothermal power plants**

Geothermal power plants cannot presently produce additional electricity from the heat of the 200°C "brine" that is normally pumped back into the earth. This temperature is too low for conversion by other recuperative technologies but can be converted with about 20% efficiency by Thermal Chip technology. For negligible additional operating cost, a power plant can increase its electrical output by using the Thermal Chip. A case study on a 25MW plant in Hawaii determined that 8MW of available energy is simply returned to the injection wells for lack of suitable energy extraction technology. Converting this to electricity using Thermal Chip technology would increase the plant output by over 6% with a negligible increase in operating cost, contributing more than $1.25m revenue annually for a capital cost estimated at about $2.5m.

∗ **Industrial waste heat recovery**

Electric arc furnaces, aluminium smelt pots and magnesium smelting cells are examples of industrial processes which require vast amounts of electricity. However, these processes also produce large quantities of waste heat that is lost into the environment. For no additional operating cost, a portion of this waste heat can be recovered and converted into electricity by using the Thermal Chip, thereby offsetting a plant's current power consumption. The double benefit is reduction of heat load and production of electricity without increasing operating costs.

∗ **Personal power market – battery replacement**

Eneco power packs made by combining microburner technology with Thermal Chip converters could replace batteries used to power personal products, such as power tools, games, laptop computers and emergency radios. This solution avoids the low power-density and disposal problem of batteries and is more efficient than even the most advanced small-scale fuel cells.

The Thermal Chip is a new type of semiconductor which directly converts heat from any source into electricity, delivering energy and power conversion three to five times more efficiently than present alternatives and producing commercial products that are likely to be up to ten times cheaper than other devices

∗ **Transportation market – alternator replacement**

Thermal Chips may be used to convert exhaust gas heat to electricity. Waste heat recovery allows elimination of the belt driven alternator, which reduces engine load and, therefore, increases overall efficiency. Present projects discussed included a 1kW alternator replacement. Car companies estimate that fuel efficiency would increase by about 10% if the alternator and air conditioning compressor were removed.

∗ **Interior cooling**

Thermal Chips may be used with electricity applied to pump heat for spot cooling and passenger compartment air conditioning. This all-electric solution eliminates the belt driven compressor, which in turn reduces engine load and, therefore, increases overall efficiency. At present, heated and cooled seats based on thermo-electric technology are available in some luxury cars. Cooled steering wheels are rumoured to be next. Ultimately, it is expected that all interior cooling tech-nology will be provided by an all-electric solution. Taken with the alternator replacement product, the comfort and efficiency of the entire car will increase.

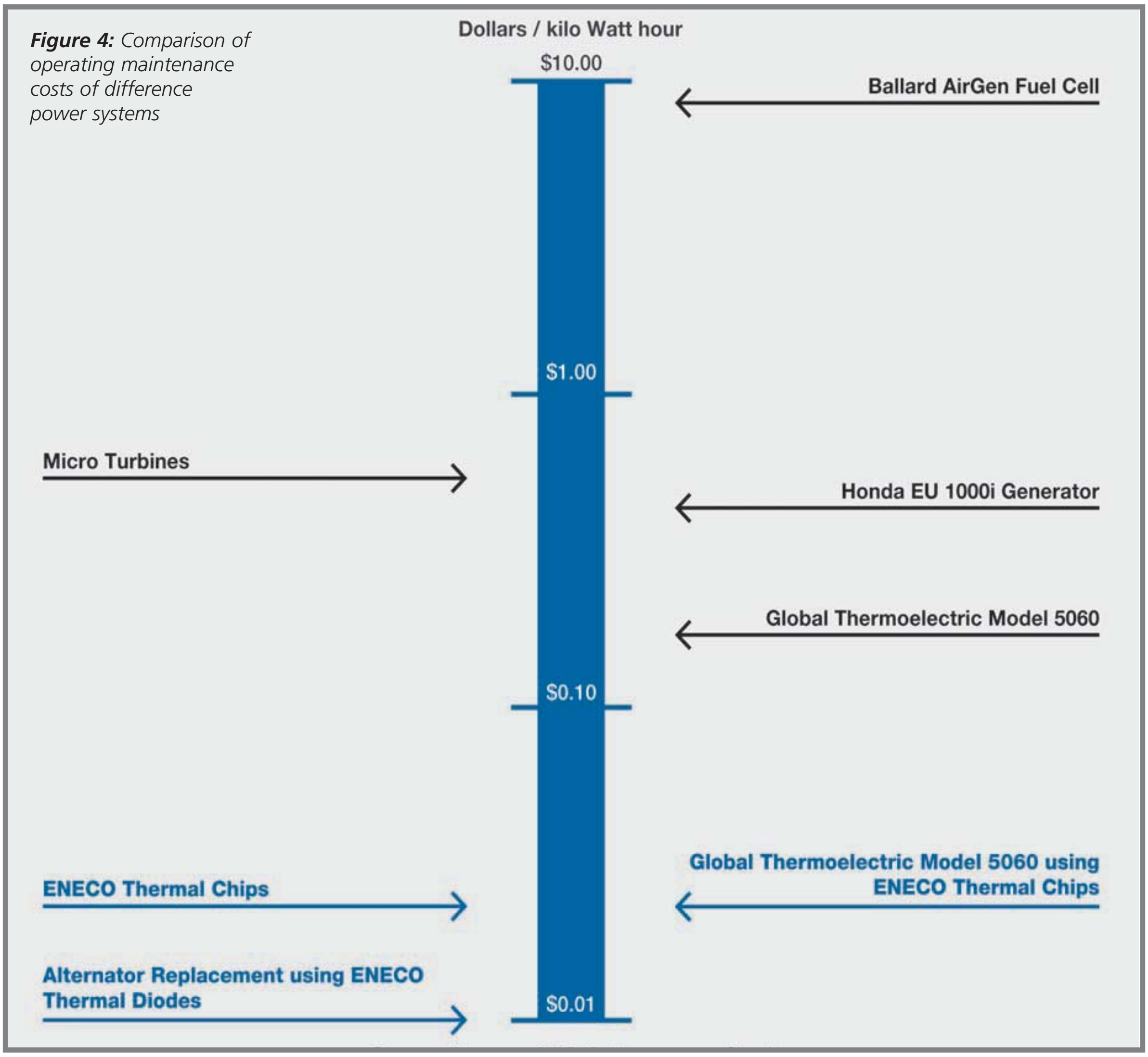


Figure 4: *Comparison of operating maintenance costs of difference power systems*

∗ **Military market – palm power**
The US military seeks a 20W power supply to replace rechargeable batteries carried by individual soldiers and specifically desires the use of JP-8 fuel. Thermal Chips can be combined with a catalytic micro-burner and management and control electronics into a highly integrated package to fill this need. This is the same approach as for the civilian battery replacement market so product development has considerable overlap. The principal differences are modifications for the fuel used and military specification product packaging.

∗ **Shipboard distributed power generation**
The US Navy aspires to be all-electric in order to allow stealth designs, which are free from the noise and vibration of present day propulsion systems, and in order to allow complete control of all the ship's power for flight or stand-and-fight. The US Navy requires direct conversion of thermal energy to electricity with generation distributed throughout the vessel.

A Fight Is Afoot

On a cost per Watt basis, it is more expensive to purchase and operate present-day, small scale, primary power products than it is to use grid power and the cost difference increases as the scale and size of the product decreases.

This cost/size trend holds true for power storage products (i.e. batteries) as well as primary power generators; the retail price of power from an average laptop computer battery (spread over 500 recharging cycles) is about $6-$10 per kilowatt hour, a premium of 70 to 120 times the cost of grid power.

Figure 3 shows how purchase costs for commercially available, small-scale power products compare with "grid power" plants and "grid connected" distributed generating equipment. Shown also is the cost for Eneco's Thermal Chip technology and a hypothetical Global Thermoelectric Model 5060 system, modified only by simple substitution of Eneco's Thermal Chips for Global's thermoelectric converters. This is an established modelling system which assesses thermoelectric efficiency. In practice, the cost of this hypothetical product would be further reduced through redesign to take full advantage of the higher efficiency of Thermal Chips compared with thermoelectric elements.

The operating and maintenance costs for the same power sources as referred to in Figure 3 are shown in **Figure 4**. Of note is the operating and maintenance cost advantage produced in the case of the hypothetical Global Thermoelectric system where Thermal Chips are substituted for thermoelectric elements.

Without moving parts to wear down or require service, the operating cost of thermoelectric systems derives from the cost of the fuel consumed, which in turn depends on the cost per unit of energy produced by combustion of the fuel and the conversion technology efficiency. As a result, the operating cost of the hypothetical system is close to the operating cost of the Thermal Chips themselves.

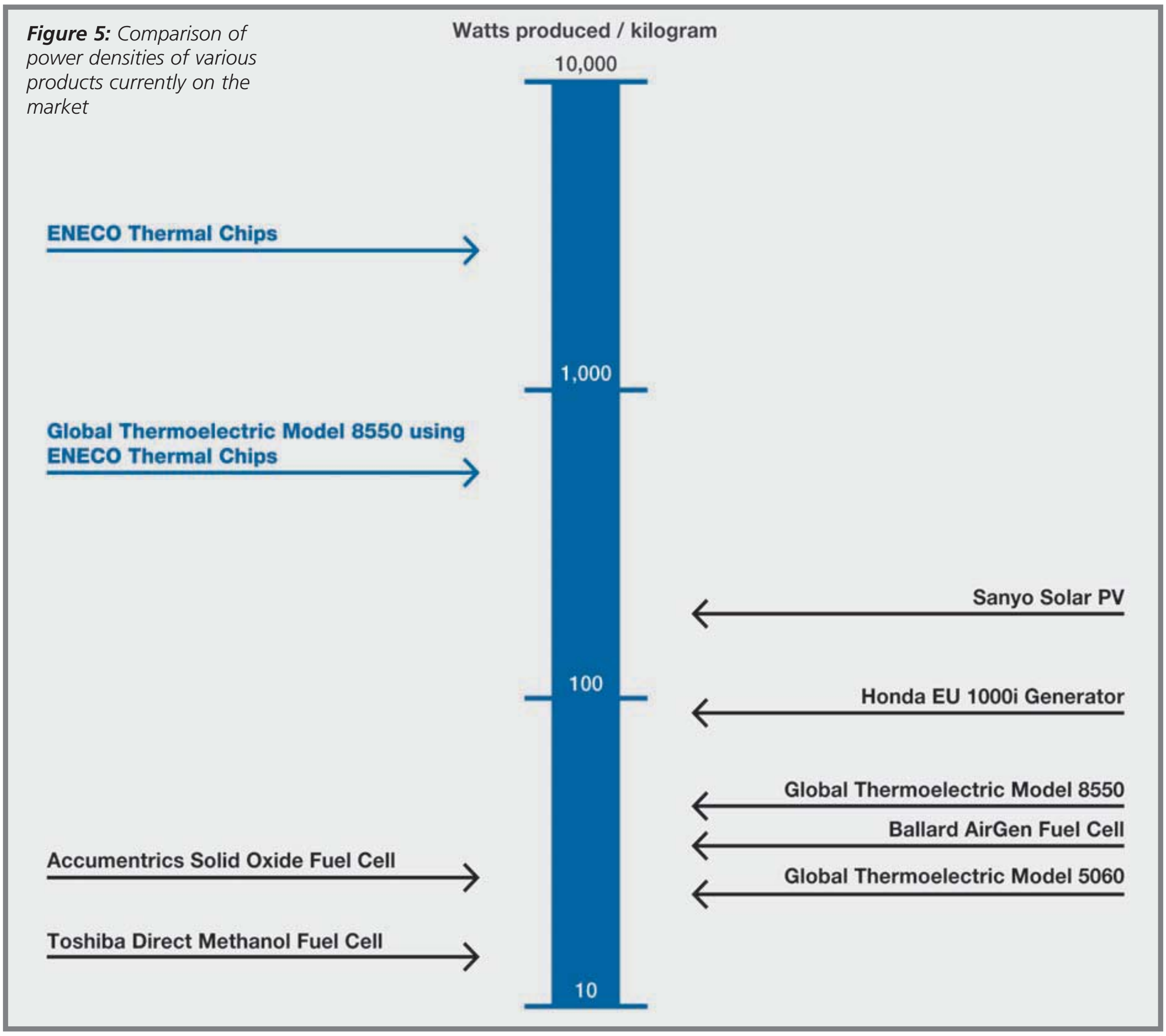
Thermal Chips can operate as the primary power source using a dedicated heat source or as a secondary power source by using the waste heat from another, primary power source. In the case of waste heat conversion, no additional fuel is consumed so the operating cost is comparable to that of solar photovoltaics, as illustrated by the car alternator replacement product with the Thermal Chip indicated in the lower left of Figure 4.

A further advantage is that Thermal Chips can be designed to work from heat sources over a wide temperature range from approximately 80°C to approximately 800°C, therefore, a wide variety of waste heat sources can be used to generate useful electricity with no substantial operating cost.

A highly important attribute for portable power sources is power density, that is, the amount of power produced for a given weight or physical size. This becomes progressively more important as the size of a product designed for portablity decreases.

Figure 5 compares the power density of products presently in the market with that of Eneco's Thermal Chip. Note again the hypothetical Global Thermoelectric product and, for further comparison, the fuel cell power source for mobile phones announced by Toshiba is included. In this figure, higher numbers indicate greater merit.

Figure 5: *Comparison of power densities of various products currently on the market*

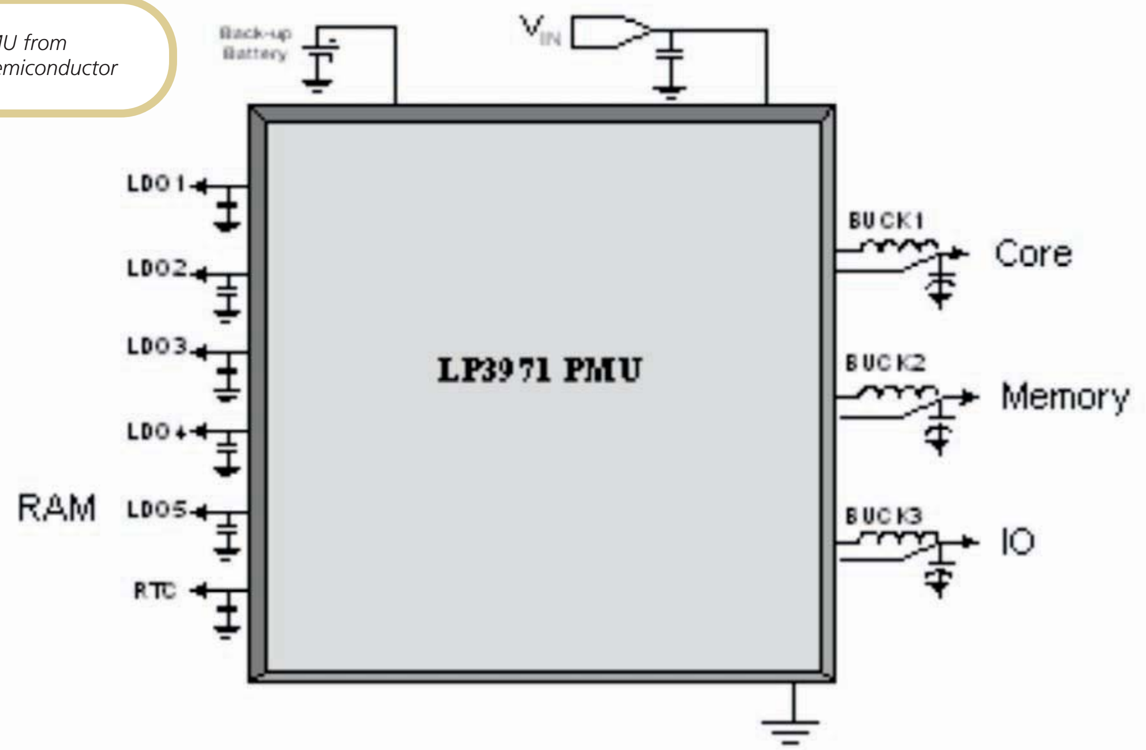


Optimising the Power Management Solutions for Applications Processors

SHELDON MAH, SENIOR APPLICATIONS ENGINEER FROM THE POWER MANAGEMENT GROUP AT NATIONAL SEMICONDUCTOR ANALYSES THE POWER MANAGEMENT OPTIONS AVAILABLE TODAY FOR PORTABLE APPLICATION PROCESSORS

Power management solutions for today's portable applications processors are becoming highly integrated. Total power consumption, standby and deep sleep current consumption effects battery size, bill of material cost and product acceptance. System designers have to consider many variations of power supplies when designing portable devices such as smart phones or PDAs. Smart phones are becoming more power hungry and require highly integrated power management solutions to meet the overall design requirements of maximum battery life in the smallest PCB area possible. Today's applications processors require separate power domains for the core, IOs, memory and peripherals. Applications processors require multiple power-supply voltages which can be optimised as demanded by the core power manager and system architecture. Flexible

LP3971 PMU from National Semiconductor



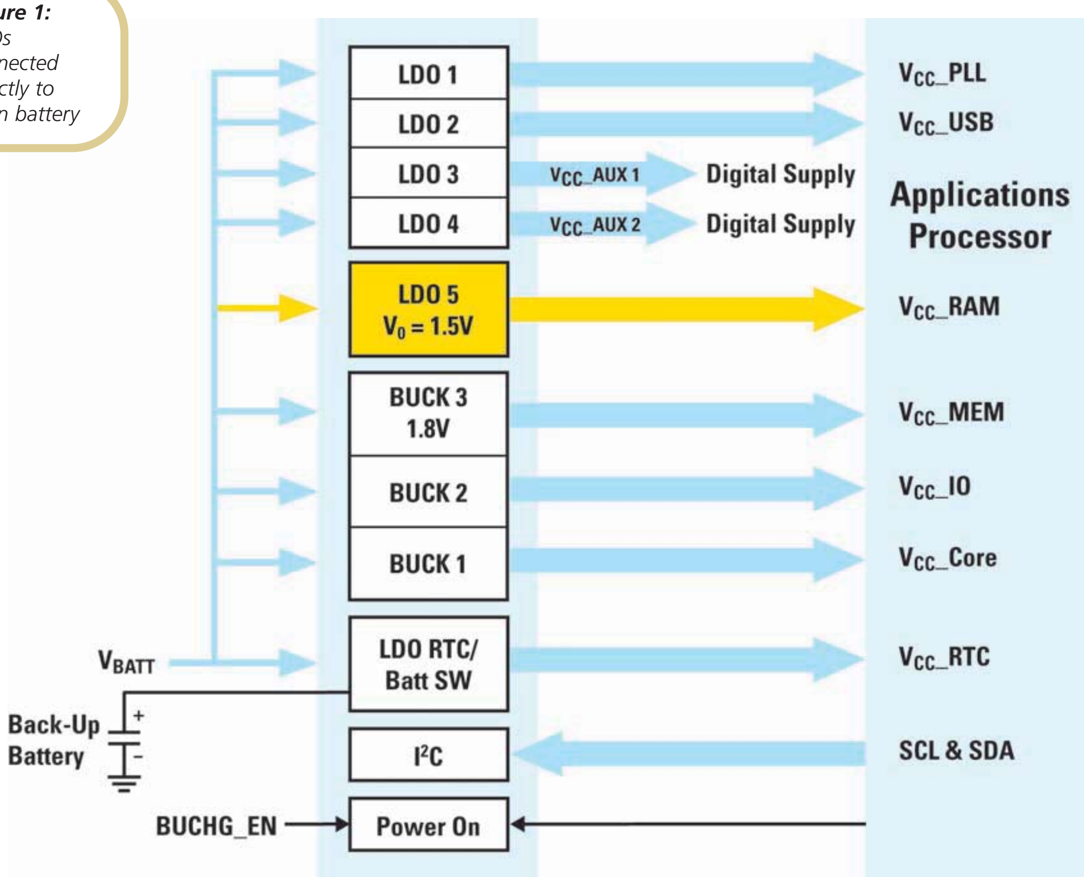


Figure 1: *LDOs connected directly to main battery*

Power-Management Units (PMUs) normally meet a wide range of system requirements, including factory configurable power-on sequencing and default output voltages.

This article will focus on powering a microprocessors low voltage rail using the LP3971 buck converter and LDO for a PDA or smart phone application.

Designing The System

When designing a system, the architect must balance many requirements such as cost, PCB area, component size, talk time, standby time, battery capacity and schedule. The microprocessor RAM requires a 1.5V supply with a maximum current of 400mA.

Let's start with the simplest lowest cost solution, an LDO (low dropout regulator) connected directly to the lithium ion battery as shown in **Figure 1**. The battery voltage will start at 4.2V and decrease to 3.2V where the system enters into deep sleep until the battery is recharged or replaced. **Figure 2** shows a typical Li-ion battery discharge cycle.

For the configuration shown in Figure 1 the efficiency of LDO 5 will be:

% Efficiency = $((V_{out} * I_{out}) / V_{in} * (I_{out} + I_q))*100$

For this and all other examples here, note I_q is removed because it is very low (40uA) compared with I_{out} (400mA). The efficiency equation then becomes:

% Efficiency = $((V_{out})/(V_{in}))*100$
For V_{in} = 4.2 volts and V_{out} = 1.5V the LDO efficiency is 1.5/4.2 = 36%.

Total power is Pt = 4.2*.400 = 1.70W

All power that is not delivered to the output load is dissipated as heat within the LDO. Dissipated power is estimated as:

Pd = $(V_{in} - V_{out}) * I_{out}$ = (4.2–1.5)*.400 = 1.1W

This will be dissipated as heat. We have just calculated the maximum continuous power (Pt) and the RAM will not operate at this level for very long. If we look at a 10% duty cycle the average power consumption will be:

Pt = 0.10*1.7 = 0.17W

The amount of time the RAM operates at I_{max} is dependent upon the application, power management firmware and the operating system.

As shown in Figure 2, the battery voltage does not stay at 4.2V for long. Let's recalculate the power consumption for the nominal battery voltage of 3.6V. V_{out} is still at 1.5V, the LDO efficiency is then 42%.

Figure 2: *Typical discharge characteristics*

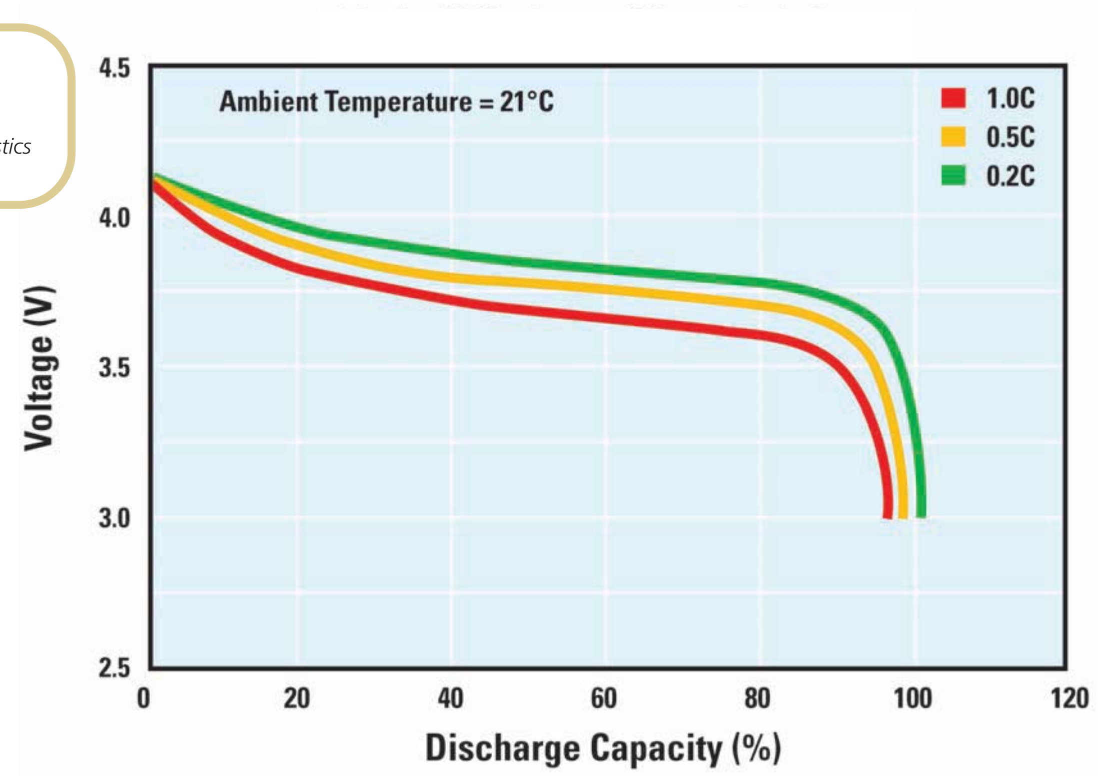


Figure 3: *LDOs connected to VCC_MEM*

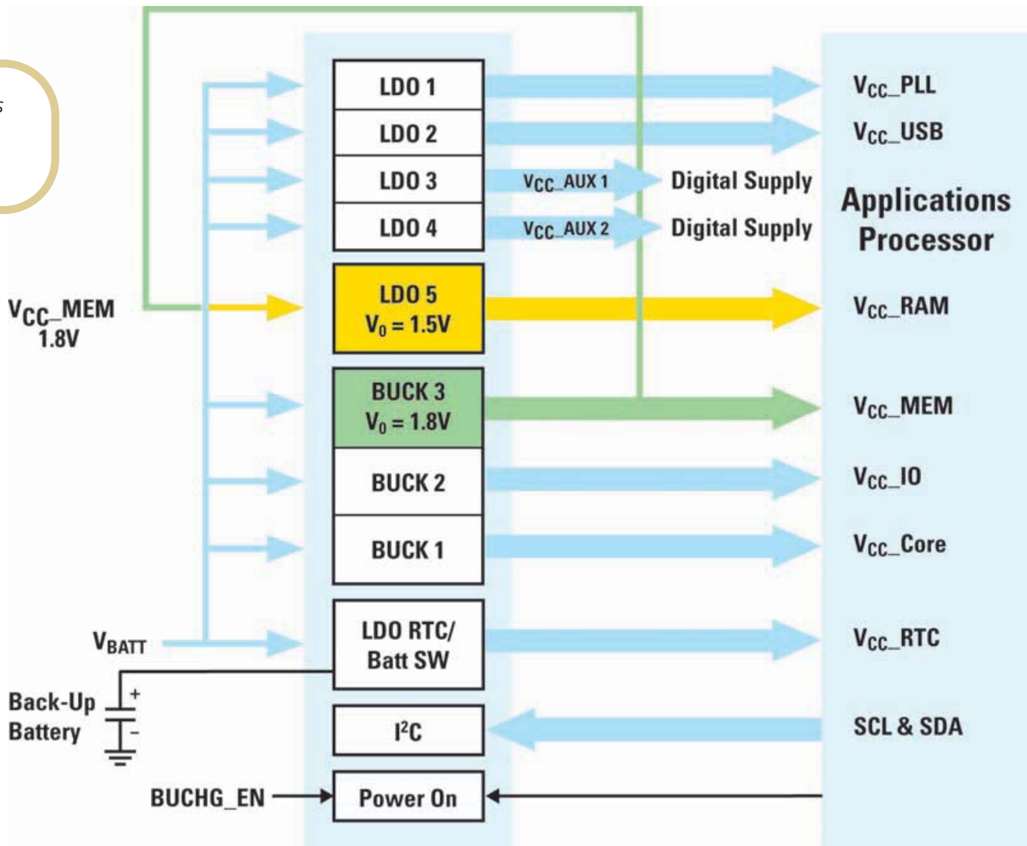
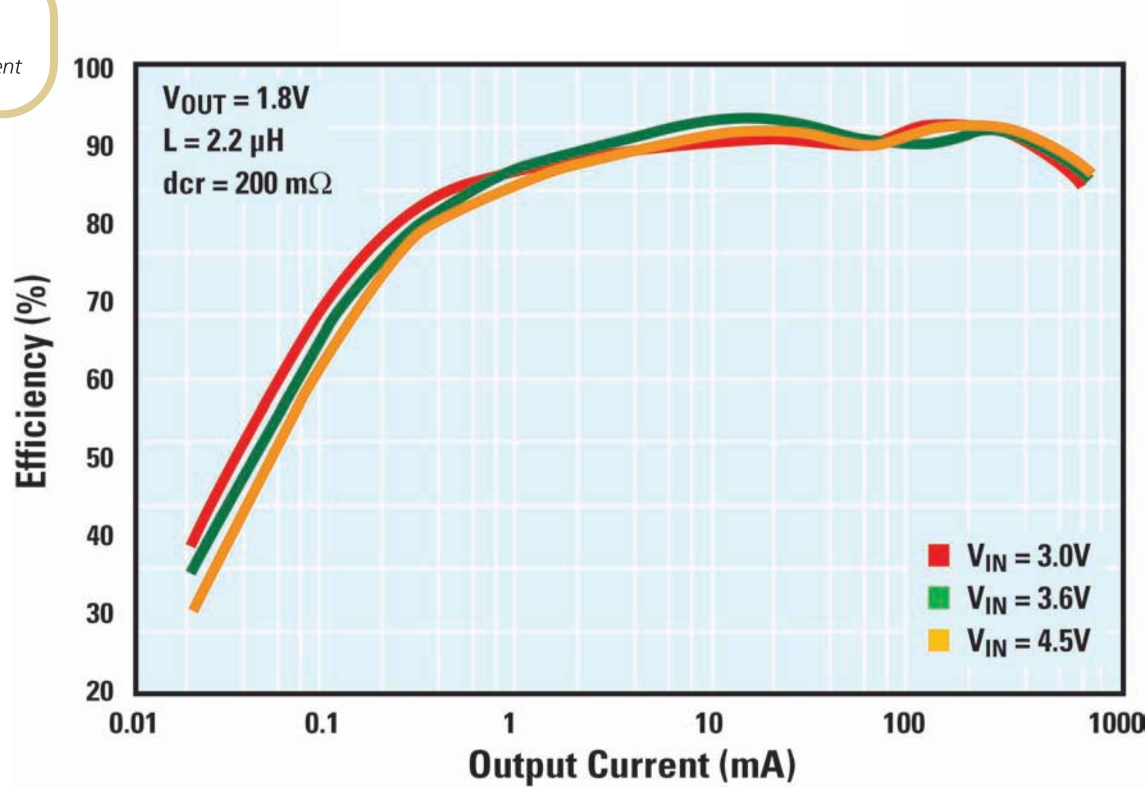


Figure 4: Efficiency vs output current



If the system requires lower power consumption and the above configuration is not acceptable, consider the solution shown in **Figure 3**, where the input of LDO 5 is connected to the output of Buck 3 which is set to 1.8V to power memory. For the configuration shown earlier the efficiency of LDO 5 will be:

% Efficiency = $((V_{out})/(V_{in}))*100$

For this example the input of LDO 5 is connected to a 1.8V rail, so the efficiency is now:

Efficiency = V_{out}/V_{in} = (1.5V/1.8V)∗100 = 83%

Dissipated power is estimated as:

Pd = $(V_{in}–V_{out})*I_{out}$ = (1.8–1.5)∗.400 = 0.12W

This will be dissipated as heat. The LDO 5 efficiency is 83%. Note if we were to use a switching supply instead of LDO 5, the efficiency could be as low as 85%, an improvement of just 2% for this block. However, the overall efficiency depends on the type of converter used. Using the efficiency curves from National Semiconductor's LP3971 buck converter datasheet (see **Figure 4**), the overall system loss due to this double conversion DC/DC + LDO will be 78%. An LDO is the lowest cost, smallest size and lowest noise solution.

Adding another DC/DC converter to power the RAM will increase the PCB area due to the addition of a very large external inductor (3 x 3mm) by $10mm^2$ and increase the overall noise of your system. If a 1.8V supply is not available, any buck converter voltage rail which is lower then V_{batt} can be used. The lower the LDO input voltage the higher the efficiency, as long as the input voltage is above $V_{out} + V_{dropout}$.

Simplest And Lowest Noise

Unlike Chicken Little who lived in fear of the sky falling, there is no reason to worry when using an LDO to power low voltage microprocessors as shown in this application note. Ask yourself this question: "It is your system and you can use any power solution, do you really want to use an extra buck converter and inductor to improve system efficiency by a few percent?" After all, the simplest form of a voltage converter is a linear regulator: it is cheap, small and easy to use. Using a buck converter to power the low voltage rails will increase the size of the PMIC add another 3 x 3mm inductor, increase the BOM cost and PCB area.

After all, an LDO is the simplest, lowest noise solution and can be optimised for your application.

Book Review

Military Avionics Systems

Ian Moir, Allan Seabridge, Malcolm Jukes (Contributions by)

Wiley

The term 'avionics' originated in the 1930s; it was a simplification of AVIation electrONICS.

World War II gave the impetus for the simple radio set which only some aircraft carried up to that time, to every aircraft having a radio and many "IFF" (Intercept Friend or Foe) that helped you work out which aircraft were on your side, so you could attack the rest.

Times have changed, however. Since my first foray as an Aviation Student in that late 60s, military aircraft had avionics purely as a supplement to aid the pilot in his task. Today, we have aircraft that are really flying avionics platforms, and the pilot is there to supplement the avionics in their task.

As the a potential next step, aircraft like the Global Hawk, have no on-board pilot and is a sensor and weapons delivery platform – all run by "avionics".

For all of us, whether practitioners of the "black art" of aviation electronics or students, technicians or just interested parties, this book gives an amazing insight into avionics history and the evolution of modern and future systems. The authors openly admit this book has taken a long time to prepare, with the assistance of companies that read like a "Whose Who" of the military aviation world. It also takes quite some time to read it too.

The first thing that struck home was the immense effort the authors have made to cover every aspect of just about everything. I believe many projects in the military (and civilian) world would benefit immensely from having the often isolated specialists given a "world view". This comes from increasing complexity and specialisation and, no-doubt, from "need to know" security issues. One of the design concepts of the book is to give the reader a "wholistic" overview of all the various systems that have been integrated into a platform, and how they are used. For example, Crew Escape systems are discussed, including details of what the pilot wears.

The book is well researched and organised in an easy to read style – even though it is 550 pages long, which makes the comprehension of sometimes difficult subjects relatively easy. Every section lists a comprehensive source of follow-up references.

> *It took me two months to read it whilst maintaining a very busy work schedule and, yet, I still find it a fascinating read and, especially, as an emergency back-up brain reference*

One of the joys of reading this book was the fact that throughout it there are actual case studies and real world examples from current projects.

Here is a summary of the contents:

1. Aircraft roles include air superiority, ground attack, strategic bomber, maritime patrol, battlefield surveillance, airborne early warning, electronic warfare, photographic reconnaissance, air-to-air refuelling, troop/material transport, unmanned air vehicles and training.
2. Technology and architectures includes JIAWG and COTS, teal-time operating systems, RF integration and Pave Pace/F-35 shared aperture architecture.
3. Basic radar systems include basic principles and antennas, major modes, pulsed and Doppler, other uses and target tracking.
4. Advanced radar systems include pulse compression, pulsed Doppler, advanced antennas and synthetic aperture radar.
5. The electro-optics chapter includes television, night-vision goggles, IR imaging and tracking and lasers.
6. Electronic warfare includes signals intelligence (SIGINT), electronic support measures and countermeasures and defensive aids.
7. Communications and identification includes CNI, RF propagation, transponders, data links and network-centric operations.
8. Navigation includes radio, inertial and satellite, integrated navigation GPS and Global Air Transport Management (GATM).
9. Weapons carriage and guidance include the F16, AH-64, Eurofighter Typhoon, F/A-22 Raptor, Nimrod MRA4, F-35 JSF and, also, covers the MIL-STD-1760 standard stores interface and air-to-air missiles and air-to-ground ordnance.
10. The Vehicle Management Systems chapter includes summary and control of utility systems, sub-system descriptions and design considerations.
11. Displays includes crew station, head-up, helmet-mounted and head-down displays, emerging display technologies and visibility requirements.

What then follows is a very comprehensive 15-page glossary.

I agree with the publishers that Moir and Seabridge's book will appeal to practitioners in the aerospace industry across many disciplines, such as aerospace engineers, designers, pilots, aircrew, maintenance engineers, ground crew, navigation experts, weapons developers and instrumentation developers. It also provides a valuable reference source to students in the fields of systems and aerospace engineering and avionics.

It took me two months to read it whilst maintaining a very busy work schedule and, yet, I still find it a fascinating read and, especially, as an “emergency back up brain reference”.

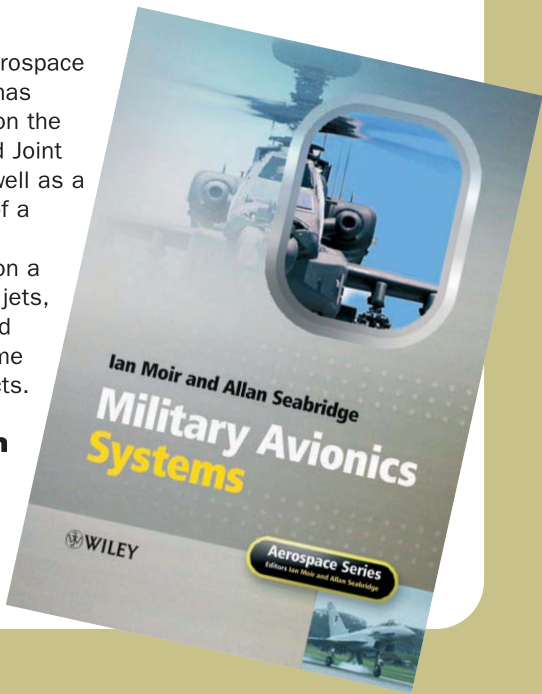
Military Avionic Systems follows on from Moir and Seabridge’s previous book, ‘Civil Avionics Systems’, which has become a standard reference.

Information about the authors:

After 20 years in the Royal Air Force, Ian Moir went on to Smiths Industries in the UK where he was involved in a number of advanced projects. Ian has a broad and detailed experience working in aircraft avionics systems in both military and civil aircraft, such as the RAF Tornado, Apache helicopter and Boeing 777. Since retiring from Smiths Industries he is now in demand as a highly respected consultant.

Allan Seabridge is the Chief Flight Systems Engineer at BAE Systems at Warton in Lancashire in the UK. In over 30 years in the aerospace industry his work has included avionics on the Nimrod MRA 4 and Joint Strike Fighter, as well as a the development of a range of flight and avionics systems on a wide range of fast jets, training aircraft and ground and maritime surveillance projects.

Carl Holden



8-pin FLASH PICmicro Microcontrollers

Microchip continues to innovative products that are smaller, faster, easier to use and more reliable. The Flash-based PICmicro microcontrollers (MCUs) are used in a wide range of everyday products from smoke detectors to industrial, automotive and medical products. The PIC12F/16F family of devices with on-chip voltage comparators merges all the advantages of the PICmicro MCU architecture and the flexibility of Flash program memory with the mixed signal nature of a voltage comparator. Together they form a low-cost hybrid digital/analogue building block with the power and flexibility to work in an analogue world. The flexibility of Flash and an excellent development tool suite, including a low cost In-Circuit Debugger, In-Circuit Serial Programming (ICSP) and MPLAB ICE 2000 emulation, make these devices ideal for just about any embedded control application. The following series of Tips 'n' Tricks can be applied to a variety of applications to help make the most of discrete voltage comparators or microcontrollers with on-chip voltage.

TIP 1: MAKING AN OP-AMP OUT OF A COMPARATOR

When interfacing to a sensor, some gain is typically required to match the full range of the sensor to the full range of an ADC. Usually this is done with an operational amplifier. However, in cost-sensitive applications an additional active component may exceed the budget. This tip shows how an on-chip comparator can be used as an op-amp-like gain stage for slow sensor signals. Both an inverting and non-inverting topologies are shown (see **Figure 1** and **Figure 2**).

To design a non-inverting amplifier, choose resistors R1 and R2 using the gain formula for an op-amp non-inverting amplifier (see **Equation 1**).

$$\text{Gain} = \frac{R1 + R2}{R2} \qquad (1)$$

Once the gain has been determined, values for R3 and C2 can be determined also. R3 and C2 form a low-pass filter on the output of the amplifier. The corner frequency of the low pass should be two to three times the maximum frequency of the signal being amplified to prevent attenuation of the signal and R3 should be kept small to minimise the output impedance of the amplifier. **Equation 2** shows the relation-ship between R3, C2 and the corner frequency of the low pass filter.

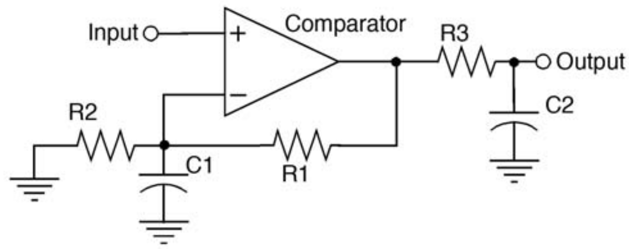


Figure 1: Non-inverting amplifier

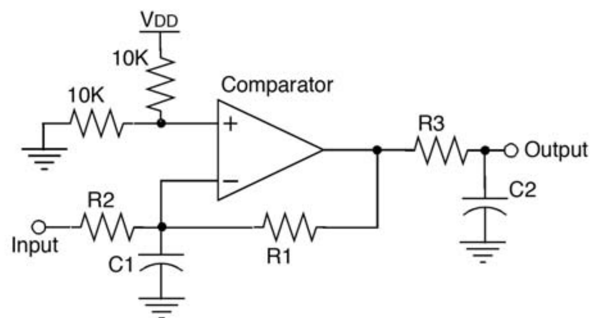


Figure 2: Inverting amplifier

$$F_{CORNER} = \frac{1}{2 * \pi * R3 * C2} \qquad (2)$$

A value for C1 can then be determined using **Equation 3**. The corner frequency should be the same as Equation 3.

$$F_{CORNER} = \frac{1}{2 * \pi * (R1 \parallel R2) * C2} \qquad (3)$$

To design an inverting amp, choose resistors R1 and R2 using the gain formula for an op-amp inverting amplifier (see **Equation 4**).

$$\text{Gain} = \frac{R_1}{R_2} \qquad (4)$$

Then choose values for the resistor divider formed by R4 and R5. Finally choose C1 and C2 as shown in the non-inverting amplifier design.

Example:

- For C2 will set the corner F
- Gain = 6.156, R1 = R3 = 19.8k
- R2 = 3.84k, C1 = .047µF, FCORNER = 171Hz
- C2 = .22µF

TIP 2: PWM HIGH-CURRENT DRIVER

This tip combines a comparator with a Mosfet transistor and an inductor to create a switch mode high-current driver circuit (see **Figure 3**). The operation of the circuit begins with the Mosfet off and no current flowing in the inductor and load. With the sense voltage across R1 equal to zero and a DC voltage present at the drive level input, the output of the comparator goes low. The low output turns on the Mosfet and a ramping current builds through the Mosfet, inductor, load and R1.

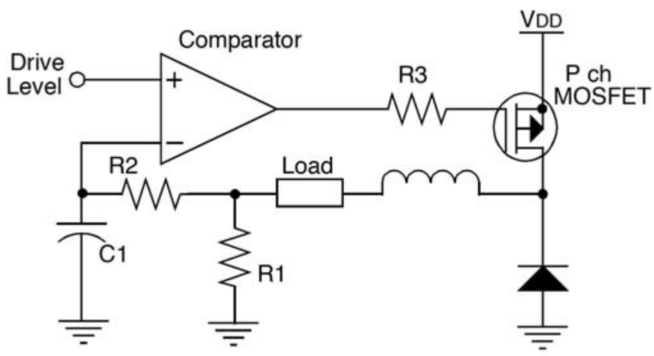


Figure 3: *High current driver*

When the current ramps high enough to generate a voltage across R1 equal to the drive level, the comparator output goes high turning off the Mosfet. The voltage at the junction of the Mosfet and the inductor then drops until D1 forward biases. The current continues ramping down from its peak level toward zero. When the voltage across the sense resistor R1 drops below the drive level, the comparator output goes low, the Mosfet turns on and the cycle starts over.

R2 and C1 form a time delay network that limits the switching speed of the driver and causes it to slightly overshoot and undershoot the drive level when operating. The limit is necessary to keep the switching speed low, so the Mosfet switches efficiently. If R2 and C1 were not present, the system would run at a speed set by the comparator propagation delay and the switching speed of the Mosfet. At that speed, the switching time

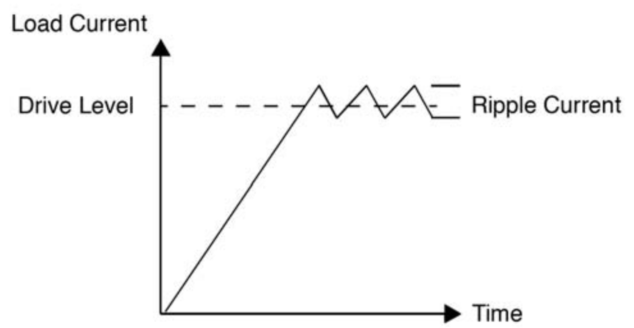


Figure 4: *Current through the load*

of the Mosfet would be a significant portion of the switching time and the switching efficiency of the Mosfet would be too low.

To design a PWM high current driver, first determine a switching speed (F_{SWX}) that is appropriate for the system. Next, choose a Mosfet and D1 capable of handling the load current requirements. Then choose values for R2 and C1 using **Equation 5**.

$$F_{SWX} = \frac{2}{R2 * C1} \qquad (5)$$

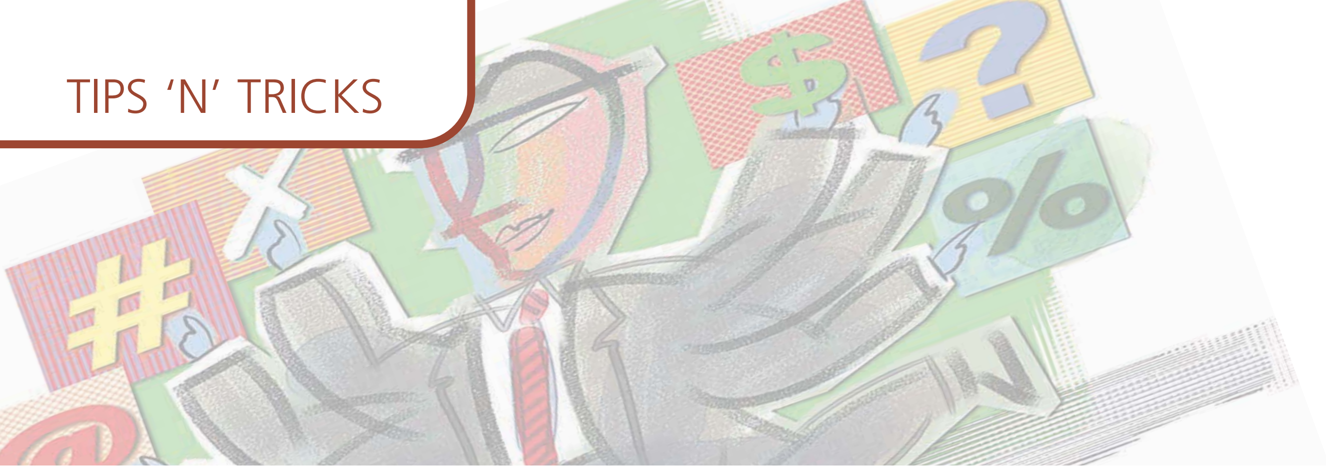
Next, determine the maximum ripple current that the load will tolerate and calculate the required inductance value for L1 using **Equation 6**.

$$L = \frac{V_{DD} - V_{LOAD}}{I_{RIPPLE} * F_{SWX} * 2} \qquad (6)$$

Finally, choose a value for R1 that will produce a feedback ripple voltage of 100mV for the maximum ripple current I_{RIPPLE}.

Example:

- F_{SWX} = 10kHz, R2 = 22k, C1 = .01µF
- I_{RIPPLE} = 100mA, VDD = 12V, VL = 3.5V
- L = 4.25mH



TiP 3: DELTA SIGMA ADC

This tip describes the creation of a hardware/software-based delta sigma ADC. A delta sigma ADC is based on a delta sigma modulator composed of an integrator, a comparator, a clock sampler and a 1-bit DAC output. In this example, the integrator is formed by R1 and C1. The comparator is an on-chip voltage comparator. The clock sampler is implemented in software and the 1-bit DAC output is a single I/O pin. The DAC output feeds back into the integrator through R2. Resistors R3 and R4 form a VDD/2 reference for the circuit (see **Figure 5**).

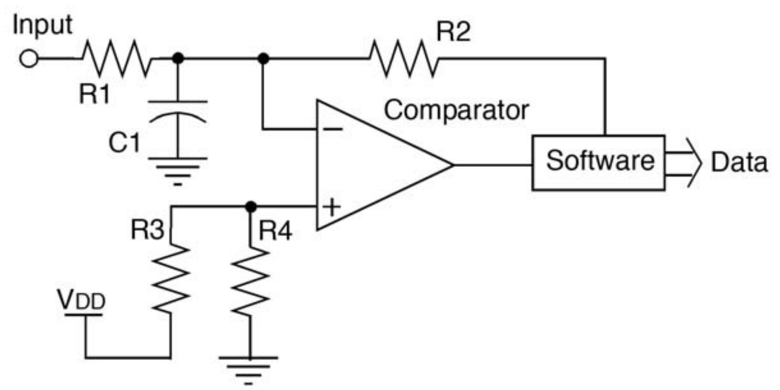


***Figure 5:** Delta sigma modulator*

In operation, the feedback output from the software is a time sampled copy of the comparator output. In normal operation, the modulator output generates a PWM signal which is inversely proportional to the input voltage. As the input voltage increases, the PWM signal will drop in duty cycle to compensate. As the input decreases, the duty cycle rises.

To perform an A-to-D conversion, the duty cycle must be integrated over time, digitally, to integrate the duty cycle to a binary value. The software starts two counters. The first counts the total number of samples in the conversion and the second counts the number of samples that were low. The ratio of the two counts is equal to the ratio of the input voltage over V_{DD}.

Note: This assumes that R1 and R2 are equal and R3 is equal to R4. If R1 and R2 are not equal, then the input voltage is also scaled by the ratio of R2 over R1, and R3 must still be equal to R4.

Example:

- R3 = R4 = 10kHz
- R1 = R2 = 5.1k
- C1 = 1000pF

TiP 4: LEVEL SHIFTER

This tip shows the use of the comparator as a digital logic level shifter. The inverting input is biased to the centre of the input voltage range ($V_{IN}/2$). The non-inverting input is then used for the circuit input. When the input is below the $V_{IN}/2$ threshold, the output is low. When the input is above $V_{IN}/2$, then the output is high.

Values for R1 and R2 are not critical, though their ratio should result in a threshold voltage $V_{IN}/2$ at the mid-point of the input signal voltage range. Some microcontrollers have the option to connect the inverting input to an internal voltage reference. To use the reference in place of R1 and R2 simply select the internal reference and configure it for one half the input voltage range.

Note: Typical propagation delay for the circuit is 250-350ns using the typical on-chip comparator peripheral of a microcontroller.

Example:

- V_{IN} = 0 – 2V, $V_{IN}/2$ = 1V, V_{DD} = 5V
- R2 = 10k, R3 = 3.9k

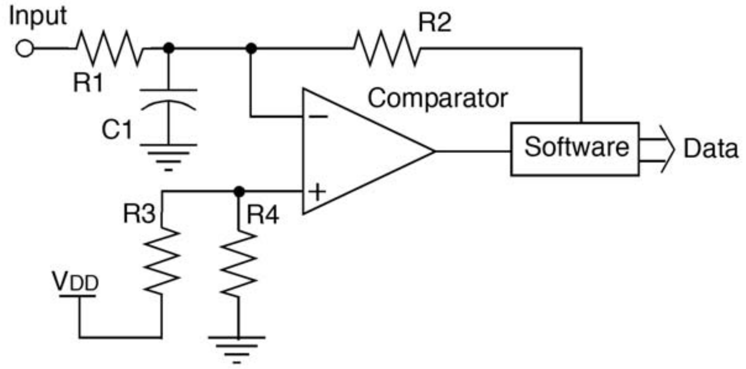


***Figure 6:** Level shifter*

Win a Microchip PICDEM.net Lite Internet/Ethernet Demonstration Board

Electronics World is offering its readers the chance to win a Microchip PICDEM.net Lite Demo Board and MPLAB ICD 2 Debugger.

The PICDEM.net Lite demonstration board is an Internet/Ethernet demonstration board using the PIC18F452 microcontroller and TCP/IP firmware. The board supports any 40-pin DIP device that conforms to the standard pin-out used by the PIC16F877 or PIC18F452.

The PICDEM.net board is used to experiment with Microchip's various TCP/IP solutions. The user has immediate network access after the initial set up of the IP address. The Flash microcontroller allows modifications to the demonstration program to add application software.

The breadboard area includes a regulated 5V power supply for the addition of sensors or custom circuits for testing. Other standard or custom stack control software can be loaded for evaluation.

The board now uses the free Microchip TCP/IP stack, which is available in Application Note AN833 (DS00833). Please refer to this document for code samples.

The Microchip TCP/IP stack is a suite of programs that can either provide services to standard TCP/IP-based applications (HTTP server, Mail Client, etc) or be used in a custom TCP/IP-based application. Potential users do not need to know all of the intricacies of the TCP/IP specifications to use it, and those interested only in the accompanying HTTP server application need not have specific knowledge of TCP/IP.

The TCP/IP stack is implemented in a modular fashion, with all of its services creating highly abstracted layers, each layer accessing services from one or more layers directly below it. The stack is written in the C program-ming language, intended for both Microchip C18 and HI-TECH PICC 18 compilers, and is designed to run on Microchip's PIC18 family of microcontrollers only.

Although, this particular implementation is specifically targeted to run on Microchip's PICDEM.net Internet/ Ethernet demo board, it can be easily retargeted to any hardware equipped with a PIC18 microcontroller. The PICDEM.net supports Ethernet and RS-232 interfaces. With a standard web browser such as Microsoft Explorer, HTML web pages generated by the PICmicro MCU can be viewed. The initial board configuration is performed via the RS-232 port using a standard terminal program to configure the IP, Ethernet, addresses etc for the board. The demo board is also equipped with a 6-pin modular connector to interface directly with the MPLAB ICD 2 In-Circuit Debugger. With MPLAB ICD 2, the developer can now modify or re-program the onboard Flash-based PICmicro device to meet the specific needs.

A generous breadboarding area is also available to add special circuits for experimentation. The area is large enough to add an embedded modem to provide for dial-up capability. Several status indicators and user interface devices are provided, including a 16 x 2 LCD indicator and LEDs.

For the chance to win a these development kits, please log onto **www.microchip-comp.com/ew-picdem**

Letters

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Somebody has it wrong with DAB

I noticed with great interest the headline on the front cover of the Electronics World December issue, with the words *"What's wrong with DAB*?" [the full article is on page 18, titled *"A new approach to demodulation"*].

My interest is not only academic – and not in any way polemic, but it is related to the recent talk of DAB being obsolete and that while the 'Danmarks Radio' (the Danish equivalent of the BBC) is heavily investing in this technology and promoting it intensely, the Swedish government has declared it a "dead technology".

Ole Christensen
Denmark

DAB – the right choice?

Understanding the link between the ear and the brain has been vital to the development of audio compression. In practice, only 10% of sounds reaching the human ear can actually be used in compression. Data or sound carried this way should be capable of being broadcast without loss of quality.

But sound quality has inevitably been lost in an attempt to reduce costs. The UK DAB system has been overloaded, so the sound information carried by DAB is spreads too thinly. It's being used on twice as many stations as the system was intended to carry. The result is that the UK DAB system frequently sounds like old medium wave radio.

A newer standard, called DRM, is much more efficient and already in use on the short, medium and long-wave bands. DRM is being tuned as a replacement for DAB on FM bands and will be known as DRM Plus.

DRM Plus can be carried on existing radio masts and less expensive. For small stations, DRM Plus should allow the flexibility of FM, so that individual stations can target their niche audience using their existing masts.

DAB, on the other hand, prevents small stations from targeting niche audiences, compelling them at extra cost to cover wider geographical areas. It also requires these stations to send their programmes to a remote central point (hub) where their content is digitally interwoven with that of other stations. The combined programmes are then transmitted from a common mast. This means stations will be carried from a single hub, ignoring the needs of the minority audiences.

To celebrate the 80th anniversary of Irish radio, RTE plans to launch a national digital radio service, using the DAB standards. The system is now being tested along the east coast between Dublin and Dundalk. DAB was first launched by the BBC in 1995 and introduced then as CD radio.

The founding ethos of RTE was supposed to encourage diversity and plurality, but DAB encourages monopolies, through the centralisation of broadcasting infrastructure.

The government is supposed to be encouraging decentralisation, yet, in the DAB system smaller stations are likely to be bought out by powerful media groups with deep pockets. The low cost and flexibility of FM allowed the birth of Radio na Gaeltachta in Rosmuc in 1970-1971. It was an unlicensed pirate station then.

Germany, France, Sweden, Holland, Canada and Australia have stalled further development of DAB and Finland has switched it off. RTE's attempt to introduce DAB in 1999 failed to make an impact. Local and ethnic stations couldn't afford DAB. ComReg, Independent Broadcasters Ireland, Communicorp, UTV and Community Radios do not support DAB.

Many stations are adopting the 'wait and see' approach.

Enda O'Kane
Ireland

THD nonsense

This letter concerns the inappropriate use of THD, since this problem is highlighted in the November article by Douglas Self *"A new type of power amplifier"* [page 20].

The square-law mode amplifiers are still unknown to most engineers. For audio, the square-law mode allows the bias current for pure class-A to be half that of conventional class-A, which equates to roughly half the size and weight of standard class-A. It also benefits class-AB.

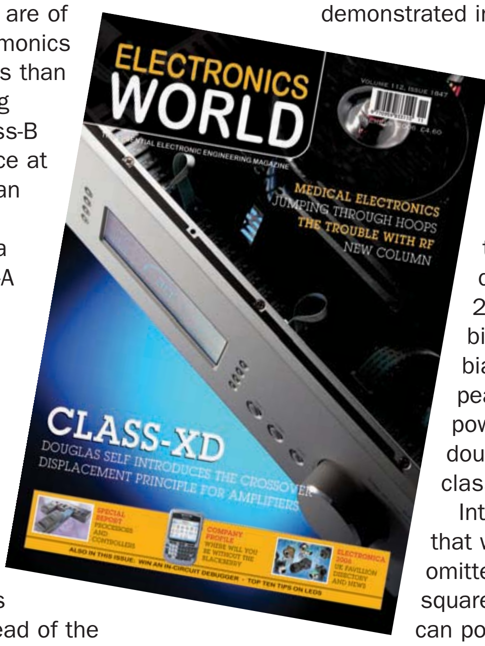
Since my square-law article was published 1995 I have searched the journals and have read over 50 articles that use the square-law principle, which is based on the 'quarter-square' mathematical identity. A 1996 Kluwer book '*Analog Circuit Design*', by Hauser, Klumperink and Meyer, has a chapter reviewing these articles from 1988 up to 1993. Philips published an IEEE 2002 paper by M van der Heijden (et al) for a 30W CDMA GHz power amplifier using Mosfets an approximated square-law mode with higher efficiency and lower distortion than conventional class-AB techniques. The technique is a significant technological advance and is not a hoax. (The Heijden article is free from a .de university; to find it search for: ultra-linear square-law). It provides a method for obtaining inherent linearity without negative feedback and that's great for GHz amps since negative feedback is not an option at that frequency.

I was pleased to read an audio power amp article again in Electronics World [1] [1 Self Nov 2006] after a long break. I would like to see more of the old style WW and EW articles on audio design. I would also like to see THD measurements replaced by weighted distortion measurements or some similar compatible scheme.

Why do we still use THD as a measure of audio quality when most know that it does not provide a measure of audio quality? It is nonsense and its use has brought the work of designers into disrepute.

THD as a flawed metric has been known since 1932 [2] [2 Masa], so Shorter [3] [3 Shorter] in 1950 proposed a harmonic weighting method to replace THD, and Fielder's [4] [4 Fielder] in 1988 provided the threshold curves for weighting distortion to take account of masking. But all have been largely ignored. Incidentally, Fielder established that distortion with high order harmonics of 0.0003% (-110dB) were audible. Even though distortion artefacts at these level are usually buried in thermal noise, our hearing system amazingly filters most of this out (if it is a steady noise level) [5,6] [5 Neve, 6 Philips 2005]. Several articles on distortion weighting have appeared in Hi-Fi News recently [7,8,9] [7 Howard 2001, 8 2004, 9 2005] and some on the Internet [5, 10,11] [5 Neve again, 10 Wiki 468, 11 Lindos, 12 Klippel].

Robin Froud's letter [13] [13 Froud] is an example where the use of THD leads to another misleading conclusion. His article seems to suggest why bother designing better amplifiers until we get better speakers, since, "surely any distortion is additive"? But speaker nonlinear distortion is not additive to class-B crossover distortion because speaker driver nonlinearities are of low order, which means low order harmonics and so can exist at much higher levels than high order harmonics before becoming audible. This is not the case with class-B crossover distortion, it does not reduce at lower power levels, and our hearing can be amazingly sensitive to this type of distortion [14] [14 SC]. Nonlinearity in a speaker is like nonlinearity in a class-A amplifier – both are of low order and when the signal level is reduced the distortion level falls away below audibility very rapidly, so in practice nonlinear distortion is not a problem with speakers and class-A amplifiers even though they may present high THD figures at full power.



A simple promising approach for weighting distortion that can be used by anyone on a limited budget is to place a passive weighting filter ahead of the harmonic analyser to simulate the approximate shape of the average listener's auditory threshold curve. Although this technique assumes no masking, it is a condition that can occur with high order class-B crossover distortion. The weighting filter boosts higher order harmonics such that the threshold value as viewed on a meter or graph is the same for any harmonic. When weighting is used the audibility threshold is around 1% for the average listener. A weighted figure of 0.1% has been suggested as a design target for power amplifiers [15] [15 Stuart 1973].

I performed simulations by placing a passive weighting filter prior to FFT to magnify class-B's high order distortion to demonstrate what we can expect with a weighting filter. With a typical emitter follower class-B stage with 0.22Ω emitter resistors and optimal bias the weighted figure is around 30 times higher. This pushes typical 0.003% THD class-B distortion figures into the just audible region.

These simulations were also able to answer a long-standing question of mine. Does crossover distortion become more audible at lower power levels? For class-B THD rises with reducing power, while the levels of high order harmonics fall with reducing power. It turns out that these two effects cancel and weighted crossover distortion stays roughly the same from near full power down to the crossover region, typically around 50mW for 25mA-50mA class-B biasing.

I also simulated weighted distortion for conventional class-AB and square-law mode class-AB, where the square-law mode provides two useful advantages over conventional class-AB in that the bias point is halved for the same class-A power band, giving a 6dB power advantage, as well as a smoother transition from the class-A region at high power, since an abrupt gm-doubling step does not occur in square-law mode AB [16,17] [16 Olsson's 1994, 17 Hegglun Sep 1995].

What's the best bias for class-AB? Simulations show when the bias is reduced to 1/3rd that required for pure class-A then the heatsink rating in square-law mode can be the rating as for class-B, and with this bias the class-A power band is -10dB relative to full power (eg 12W for a 125W amplifier). For 125W into 8R peak current is 5.6A, and for 1/3rd bias square-law-AB you need 1/12th of the peak current, hence a bias current of 466mA. This was demonstrated in my article with 300mA optimum bias for 50W, which corresponds to 470mA for 125W. I note XD used 1A for 125W and appears to provide a 5W class-A band.

Essentially, the difference between implementing square-law mode class-AB and conventional class-AB is the omission of source (or emitter) degeneration resistors [1] [1 Self Nov 2006] and then biasing FETs (or bipolar transistors) at a relatively high bias current (around 1/12th of the peak current), permitting a wide class-A power band and also lowering the gm-doubling distortion of conventional class-AB.

Interestingly, simulations also showed that when external emitter resistors are omitted a modified form of bipolar derived square-law class-AB is obtained, and this can potentially provide even lower distortion than Mosfets in square-law mode. It seems to the best solution to high order class-B crossover distortion since weighted distor-tion is reduced by a factor of 100 or more.

The problem without emitter resistors is thermal runaway, but there are circuit options that can prevent this, such as cascoding or devices like the Sanken

SAP15/16's with integral sensor diodes. Power Mosfets have an inherently lower temperature sensitivity than bipolar transistors and are therefore easier to stabilise without degeneration resistors [17] [17 Cordell 1984] and a number of simple error correction techniques can are available if desired.

I wish Cambridge Audio all the best with the Azur 840A amplifier, which overcomes the dreaded class-B crossover distortion problem at a good price.

References:

1. Douglas Self, A new kind of power amplifier, EW Nov 2006 p20-25.
2. D. Masa, Combination tones in Non-linear Systems, Electronics Sept 1938 p20. Quoted in Langford Smith in the 1940 edition of The Radio Designer's Handbook. Masa says, "The total harmonic distortion (THD) is not a measure of the degree of distastefulness to the listener and it is recommended that its use should be discontinued".
3. D.E.L. Shorter , Influence of High-order Products in Non-Linear Distortion, Electronic Engineering Vol. 22 April 1950 p152-3. Higher than N^2 weighting appears to be needed.
4. L. Fielder, E. Benjamin, Subwoofer performance for accurate reproduction of music, JAES Vol. 36, No. 6, Jun 1988, p443-456.
5. Steve Albini, Rupert Neve interview. www.poonshead.com/articles.html#article1 "THD took a wrong turn. Crossover distortion can be perceived even well below the noise floor and beyond the accepted hearing limits".
6. Alasdair Philips, Do we have an EMF problem?, Electronics World Sep 2005 p16-19, "The ear suppresses the vastly larger noise of its thermal atomic and molecular collisions by an as yet unknown mechanism, functioning as an almost perfect amplifier close to 0°K".
7. Keith Howard, The Weighting Game, Hi-Fi News & Record Review Dec 2001 p78-83. Reviewers who have FFT are not evaluating PA distortion using weighting techniques to give meaningful comparisons – Why not!?
8. Keith Howard, Bias assessment, Hi-Fi News Oct 2004 p84-9. Shorter's 1950 n^2/4 distortion weighting is applied to two class-B amplifiers during warm-up.
9. Keith Howard, 'Weighing up', Hi-Fi News, Mar 2005 p78-81. GedLee metric vs. Shorter's n^2/4. www.GedLee.com/downloads//Perception.htm
10. Wikipedia, Distortion measurement, and ITU-R 468 noise weighting. "468 – Weighting in Detail" www.lindos.co.uk
11. W. Klippel, Measurement of Weighted Harmonic Distortion HI-2, AN7. www.klippel.de
12. J.R. Stuart, An approach to audio amplifier design, Pt 1 WW Aug 1973 p387-391. Pt 2 Sep 1973 p439-447. Pt 3 Oct 1973 p491-4. Pt 3 includes a subjective test report and weighted distortion.
13. Robin Froud, Perfect Amplifier? So what?, Letters, Electronics World May 1997 p413.
14. Silicon Chip, Amplifier design philosophy questioned, Letters Mar 2004 p6. "Yes, the distortion in speakers is going to be much higher but that will not necessarily mask the distortion from amplifiers. Indeed, high order harmonic products from amplifiers can be heard at extremely low levels in quite ordinary loudspeakers. ... we feel justified in always striving for the very best THD performance."
15. Bengt Olsson, Better Audio from non-complements?, EW+WW, Dec 1994 p988-992. Open loop distortion 0.015% – unbelievably low! Although it was not stated in this article that square-law modeAB is used, it was stated in his Oct 1995 letter p886-7. Anthony Holton is one person exploiting this topology, see www.ausieamplifiers.com.
16. Ian Hegglun, Square law rules in audio power, EW+WW Sep 1995 p751-6. Minimising Mosfet square-law-AB "batwing" distortion and demonstrating an order of magnitude better linearity than conventional Mosfet designs. Erratum: The efficiency derived for square-law mode class-A was incorrectly stated as 75% (3/4), it should read 66.7% (2/3) – this fractional error occurred in the last line of the derivation. My apology. Note the conclusions given about heatsink size and power supply capacity still hold true, and nothing else is invalidated by my mistake.
17. Robert Cordell, A Mosfet power amplifier with error correction, JAES Jan/Feb 1984 p2-16.

Ian Hegglun
New Zealand

Is the Cambridge amp suffering from cross-over?

In the article '*A new kind of amplifier*' by Doug Self, an audio output stage is described with a 'displacement' current source added to it, which shifts up (displaces) the output voltage level at which the main amplifier leaves class-A operation.

In the case of the push-pull displacement current source (refer to Figures 7 and 8 in the article), which yields lowest THD, the control of this current is solely based on the actual output voltage and not on monitoring of the current flowing through the load. So the generation of the displacement current (which should be equal, roughly, to the actual load CURRENT) is based on the load VOLTAGE.

This approach assumes a linear (resistive) relation between the output voltage and output current of the amplifier. Or at least a fixed phase relation and fixed amplitude ratio. This reminded me of the articles by Graham Maynard: "*Class-A imagineering (part 1-6)*" in *Electronics World*, June to November 2004. His objection against common practice was that measurements of amplifiers were taken with a resistor as the load. His message was that for a real speaker, voltage and current could have an awful phase relation.

If true this could mean that a class-XD amp showing low THD and high efficiency if resistor loaded, suffers from cross-over once loaded by a real-life speaker.

This cross-over occurring could be solved by an increase of the margin of the displacement current (margin w.r.t. the amplitude of current demanded by a resistor), but then efficiency would drop. By the way: is the amplifier tuned to 8Ω and 6Ω, or 4Ω would disturb operation in class-XD.

Bram Melse
The Netherlands

Doug Self replies:

You can be certain that the Azur 840A class-XD amplifier is designed to handle a very wide range of real-life loud-speakers, including those with highly reactive phase characteristics. The fact is that the voltage/current phase relationship in a real loudspeaker – while very variable with frequency – varies within fairly well defined limits, and so can be allowed for in the design process. The operating parameters of the 840A XD system are set so there is ample displacement current available for any reactive load the amplifier is likely to encounter.

On your second point, you are quite wrong in assuming that the AB amplifier was a simpler or cruder design. It was exactly the same amplifier with the XD circuitry removed and the bias suitably increased to give AB operation. This is clearly the only way to make a mean-ingful comparison between conventional operation and the improved performance of the XD system.

Douglas Self
UK

Rejection Filter With An Impedance Inverter

An impedance inverter is the main part of the rejection filter shown in **Figure 1**. The circuit of the impedance inverter is shown in **Figure 2**. The total impedance of the impedance inverter can be described by the following equation:

$$Z_{\Sigma} \approx 4\frac{k(273+T°C)}{eI} - Z \approx 160\Omega - Z$$

where k is the Boltzmann's constant:

$$k = 1.38 \cdot 10^{-23} J/K$$

e is the electron charge:

$$e = 1.6 \cdot 10^{-19} coulomb$$

I is the current of the circuit (i.e. the DC current of R4), and T is the temperature in Celsius.
$Z \approx R2$ at the resonance frequency:

$$f = \frac{1}{2\pi\sqrt{C1L1}}$$

(it is assumed that the resonance resistance of the circuit C1L1 is many times larger than R2).
The frequency response of the rejection filter is equal to zero at that frequency when $R4 + Z_{\Sigma} = 0$ (the adjustment of the resistor R4 is necessary to satisfy this condition) – i.e. the output impedance of the rejection filter is equal to zero at that frequency. As a result the frequency response of the rejection filter is equal to zero at the frequency $1/2\pi\sqrt{LC}$, regardless of the input impedance of the filter load and the output impedance of the signal source.
The frequency response of the rejection filter is shown in **Figure 3**. The stopband width of the filter can be changed by means of the change of R2 value, if necessary.

Sergei Chekcheyev
Tiraspol
Moldova

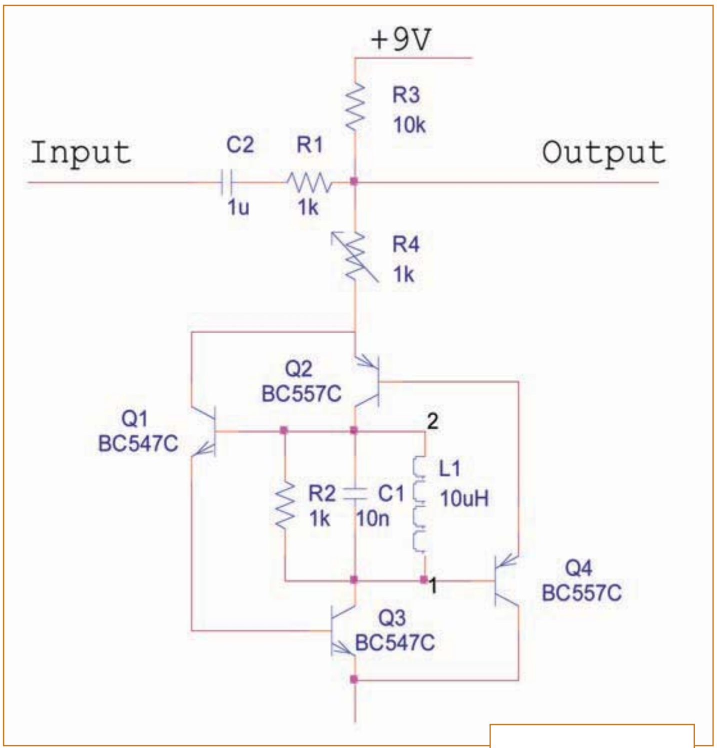


Figure 1: *Rejection filter*

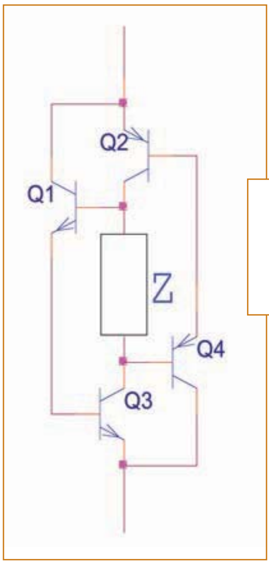
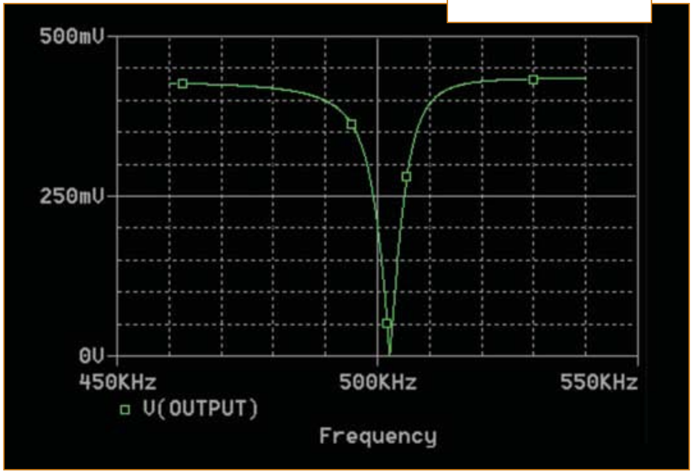
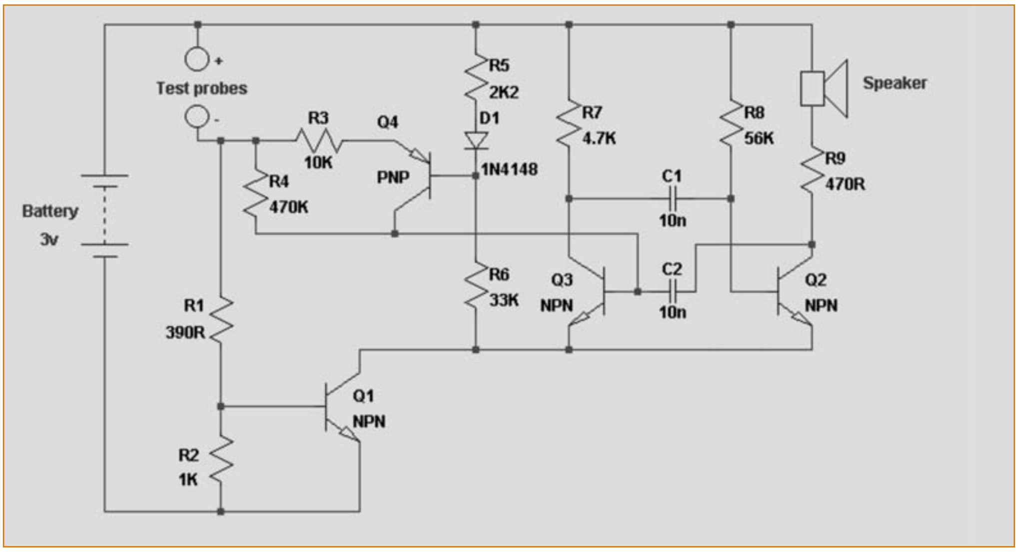


Figure 2: *Impedance inverter*

Figure 3: *Frequency response of the rejection filter*



Wide Range Continuity Tester



This tester does not need an on/off switch and produces a tone varying smoothly in frequency with resistance. It starts to produce a tone at a resistance of about 3K and, yet, 4Ω can be easily distinguished from a short circuit.

With nothing connected to the probes, TR1 is off and the circuit is not powered. At about 3K, TR1 turns on and TR3/4 oscillates. The frequency depends on the current through R4, which varies with the resistance between the probes. Once the voltage across the probes reduces below about 0.25V, TR2 starts to turn on progressively and gives a further increase in frequency, giving improved resolution at the low resistance end.

The voltage and current at the probes are enough to test diodes and light up LEDs (not blue), but should not damage sensitive devices.

The prototype uses an 8Ω loudspeaker and is fairly quiet. A higher impedance speaker would give more volume.

The prototype used 2N3704 for the NPNs, BC327 for the PNP and a 1N4148 diode, but any general purpose silicon devices should work. It will run off two AA batteries or a single lithium coin cell.

Alex Hiley
Woking
_UK_

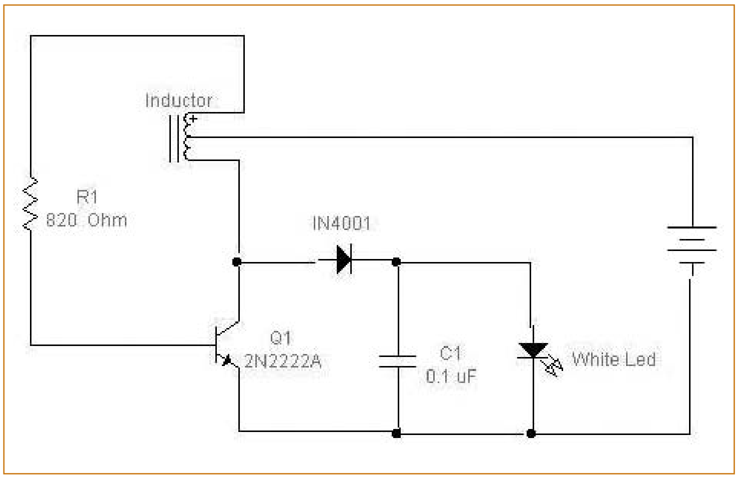
Email your circuit ideas to:
ewcircuit@nexusmedia.com

White LED Torch

This low-cost circuit is suitable for powering flashlights, emergency lighting and other applications in which it is desirable to power white LEDs from one or two primary cell batteries.

The transistor, 1k resistor [R1] and the tapped inductor form a blocking oscillator. When the power button is pressed, the transistor is biased on through the 1k resistor. Voltage that appears from the tap on the inductor to the collector causes the voltage on this resistor to be even higher than the battery voltage, thereby providing positive feedback. Also because there is voltage across the inductance between the tap and the collector of the transistor, collector current increases with time (this is in addition to a starting value that relates to the current supplied to the base, but this part of the collector current is rather small). Because of the positive feedback, the transistor stays saturated until something happens to change its base current.

At some point, the IR drop across the inductor from the tap to the collector approaches the battery voltage (actually battery voltage – VCEsat). As this happens, voltage is no longer induced in the winding from the tap to the 1k resistor and the base voltage starts to drop. This forces the base voltage to go negative, thereby accelerating the switching off of the transistor. Now, the transistor is off but the inductor continues to source current and the collector voltage rises.



Quickly, the collector voltage gets high enough for the LED to conduct current and it does for a little while, until the inductor runs out of current, then the collector voltage starts to ring toward ground base voltage swings positive again, turning the transistor on again for another cycle.

To obtain brighter LED for a given peak current, a diode [IN4001] and capacitor [C1] are added in the circuit.

For tapped inductor, wind 30 turns of 28 swg wire on a ferrite transformer core and make a tap at 15 turns.

This circuit draws approximately 20mA from the AA cell.

D. Prabakaran
Head of Department-mechanical engg
N L Polytechnic college
Tamilnadu, India

Living with RoHS – the big questions

Now that RoHS is law (as of 1st of July this year), there are more questions than ever about how to cope with it. Recent research showed that the UK wasn't prepared for the deadline. Only 12% of design engineers, buyers and MRO engineers were fully compliant in readiness, ahead of RoHS officially coming into force. Whilst 37% of respondents revealed that they were "close to becoming compliant", a further 28% confessed that they had only just "started to become compliant".

There's still clearly a lot that needs to be done by the design engineering community but the main thing for engineers to realise is that they aren't alone in their quest to become compliant. Wide ranges of support services exist to help people along the way, such as those on offer at www.rohs.info. The fact that the deadline has passed means that it is even more important to access the help that exists.

The research – which was conducted amongst 263 UK design engineers, buyers and MRO engineers – shows that distributors are playing a vital role in ensuring compliance is achieved. Around 46% of those surveyed had chosen to approach a distributor for reliable RoHS support, followed by 22% who preferred to directly approach the manufacturer. Interestingly, only 9% have been relying on the government for RoHS support.

By its nature, online support is the fastest way to find out about the latest RoHS complaint products. Signing up to automatic email notification or online 'Bill of Materials' conversion services are effective ways to get new part numbers for old non-compliant components and upgrade to the latest RoHS offerings. But being able to speak to experts is also proving key for engineers who have achieved compliance.

Whilst 53% of respondents from the research considered online technical help and support services to be either "extremely" or "very" important, 39% also considered telephone technical help and support services to be "extremely/very important". There are still many grey areas around the new legislation that people are unsure about – exemptions and due diligence are just two of the 'hot potatoes'. Being able to access expert opinion over the coming months on these issues will be hugely important as the real effects of RoHS start to take place.

There are still many questions that need answering about the scope of the legislation and it will be essential to keep on top of the products that are under review for exemption. A recent example of this is semiconductor evaluation boards. Distributors and manufacturers alike believed these to be out of scope but the National Weights and Measures Laboratory, the body responsible for policing RoHS, has decided they're in.

It often isn't clear if a product is within the scope of RoHS or not. The situation for many types of industrial product will depend on how they are used. Equipment that is not dependent on electricity is also excluded such as gas boilers and petrol lawnmowers.

Q: Do three-pin mains plugs have to be RoHS compliant?

A: If a three-pin mains plug is attached to equipment that is within the scope of RoHS then the plug has to comply. In the plug there are plastics that could well include PBB or PBDE brominated compounds. If PVC is present, then Pb and Cd also need to be considered. The metal components of a plug are usually brass so should contain less than 4% lead but the mains fuse should not be forgotten either. Usually, the end caps are silver-plated which is fine. Tey should not be SnPb, however, some fuses do use solder to attach the fuse wire. Thirteen-amp fuses are M-effect fuses so they will have a blob of solder on the wire and this can be SnCd or SnPb but should be lead-free. Also, remember that screws may be galvanised so hexavalent chromium is possible, although less likely.

Q: Can you give me an idea of the scope and requirements for RoHS in China?

A: Chinese legislation will cover all Electronic Information Products (EIP). An extensive list has been published which includes many products not covered by EU RoHS, such as radar attached to aircraft or ships, medical equipment, measurement instruments, some production equipment, batteries and most types of components. There are two levels of requirements. Firstly, all EIPs must be marked to indicate where any of the six substances are present, although no substance restrictions apply. Secondly, products that will be specified in a catalogue also need to be taken into consideration – substance restrictions will be specified and these may be some or all of the six EU-RoHS substances and possibly others. For more information visit **www.rohs.info**

Q: I understand that batteries are excluded from RoHS and are subject to a new battery directive. Do you know what this will cover?

A: The EU has adopted Directive 2006/66/EC "on batteries and accumulators and waste batteries and accumulators" which was published on 26th September 2006. This directive repeals the old battery directive 91/157/EEC and comes into force on 2nd September 2008.

The new batteries directive will affect producers, importers and distributors of all types of batteries that are put onto the EU market, either as individual batteries or incorporated within electrical equipment. It does not apply to applications in equipment for national security and specifically military purposes or equipment designed to be sent into space.

The approach used for the new batteries directive has many similarities to the WEEE and RoHS directives as it requires spent batteries to be collected and recycled. This will also be financed by producers who will need to register, and there are substance restrictions and labelling requirements.

Q: Do you know what the take is on Semiconductor Evaluation Boards?

A: There has been a lot of discussion about these without a clear satisfactory answer. However, NWML has stated that, in their opinion, they are finished products, although experts do not agree with this in all cases. Their status depends on their function. If this is to write software then they should be regarded as Category 3 (within scope), but if their function is designing equipment and they have no IT function, then they are not in the 10 WEEE categories. There will be boards that are somewhere between these two extremes; deciding on their status can be very difficult.

Gary Nevison is chairman of the AFDEC RoHS team, board director at Electronics Yorkshire and head of product market strategy at Farnell InOne. As such he is our industry expert who will try and answer any questions that you might have relating to the issues of RoHS and WEEE. Your questions will be published together with Gary's answers in the following issues of Electronics World. Please email your questions to EWeditor@nexusmedia.com, marking them as RoHS or WEEE.

Another stunning DISPLAY INVENTION

By Chris Williams, UKDL

During anyone's working lifetime in electronics, one might expect to see one or two spectacular inventions that can prove to be truly disruptive. I have been lucky – I witnessed the birth of colour LED lamps and display devices in the 70s, the emergence of TN and STN LCDs in the 80s and active matrix LCDs in the 90s.

Supplementing this was the continuing developments in plasma technology and the invention in the late 80s and early 90s of both small molecule OLED and polymer OLED, the latter being invented at Cambridge University and resulting in the spin out of a new company – Cambridge Display Technology (CDT).

The 90s and early years of the 21st century have seen active matrix LCDs become the dominant force in the display industry with, by far, the highest market value of any display technology, and the unexpectedly rapid demise of the CRT from major force to insignificantly minor player in most markets. Pundits will say that LCDs will simply steamroller over all opposition and that they will remain at the forefront of sales and technology for the foreseeable future.

All of this may now be set to change, courtesy of an extremely clever invention by CDT called Total Matrix Addressing. Launched to the market on November 9th 2006, this date will be memorable in the future as the turning point when the apparent domination of LCDs was stopped in its tracks. The whole industry of display manufacturers now have the opportunity to revisit technologies that had previously been written off as technically or commercially impossible to use for many large area consumer electronic applications.

The early promise of OLED technology (small molecule and polymer) was demonstrated using passive matrix displays. Here, the image is created from a continuous array of rows and columns, and an image would typically be "written" to the display by addressing a row at a time and illuminating the required pixels by activating the necessary columns, then moving on to the next row and activating a different set of columns. This 'row at a time' addressing is called multiplexing and OLED manufacturers quickly became aware of constraints to the system. As the number of rows increases, so the capacitive loading of the system increases and the power requirements increase non-linearly. It was guesstimated that to drive an OLED passive matrix TV might take a ridiculous 9kW of power.

Indeed, most commercial applications of passive matrix OLEDs has a rule of thumb that the maximum number of lines that can be multiplexed will be about 64 or 128. Applications requiring more lines than this, such as domestic TV, where a standard flat panel analogue TV requires 480 lines and a HDTV requires up to 1080 lines, require an active matrix backplane where the individual OLED pixels are driven by two or more transistors to ensure that the power consumption is minimised. Designing and developing reliable active matrix backplanes for OLED displays is taking longer than many product designers had wanted. There are fundamental technology hurdles to overcome – to have a cheap system, it would be better to use amorphous silicon thin-film transistors, but when these are used as current drive transistors their operating characteristics can drift widely over time. So, for a given operating condition, the amount of power that an amorphous silicon OLED drive circuit will supply at the beginning may be hugely different to that it will supply later on, which would lead to display variances in brightness and colour that would be quite unacceptable. To mitigate this, designers are looking to implement complex control systems and to create "higher quality" TFT transistors at the manufacturing stage. All of this is moving the cost of manufacture in the wrong direction.

Enter CDT with Total Matrix Addressing (TAM). Here, a picture or frame to be shown on a passive matrix display is broken down into a whole series of sub-pictures or sub-frames, and to display each sub-frame, every row and every column is driven at the same time. The variables between each sub-frame are the amount of power supplied to individual columns and the amount of time for which each row is enabled. In other words, each picture is built up from a sequential series of sub-frames that will present data in digital form sufficiently quickly so that when viewed by the human eye, which is and will always be an analogue system, the human visual system integrates the individual sub-frames and "sees" the original picture.

To display real-time video requires that pictures (frames) be presented to the eye at the rate of at least 24 frames per second, so depending on the number of sub-frames required for each frame, the actual data rate can be quite high. Using a digital signal processor (DSP) will allow this iterative frame building to take place using low-cost silicon chips.

The mathematical principles of TAM are well understood and the prototype has been successfully built and demonstrated using discrete components. The race is now on to implement a solution in just one or two ICs.

What's the likely result? Passive matrix displays with more lines of pixels will now be enabled. Speculating wildly: it might well be possible to design passive matrix OLED displays with many more lines – perhaps even to TV or HDTV standards. Let the imagination go free and you can envisage a future where we print massive, large area polymer OLED passive matrix displays on glass or plastic substrates using ink jet printers, or some similar type of system, and then simply attach a small PCB with the silicon-based DSP and row/column drivers on board.

Such a future will allow manufacturing of customised displays by small and medium companies, and will revitalise the electronics manufacturing economies of many of the countries where production of conventional electronics has been "lost" to the offshore countries where low labour costs or very high cost manufacturing centres have been established.

This really is a great time to be working in the displays industry.

Chris Williams is Network Director at UK Displays & Lighting KTN (Knowledge Transfer Network)

Helping Hand For Inter-Vehicle Space Problems

Leading connector manufacturer AB Connectors, part of TT Electronics, is launching a new in-line adaptor to help solve the space issues frequently encountered in today's military environment.

The ABORD 1062 slave start adaptor is designed to limit the amount of space required for carrying long inter-vehicle harnesses by allowing the standard NATO 'slave start' harnesses to be coupled together quickly and effectively. The rugged single piece rubber body features a sealing lip and protective caps and is shock-proof, dirt-proof and impervious to engine fuel and lubricants.

The ABORD 1062 inter-vehicle in-line adaptor will reduce the space needed for harnesses is essential for the modern military, which needs to be highly mobile and capable of deploying forces very quickly. The adaptor also withstands the harsh conditions experienced in military applications and through heavy use in the field."

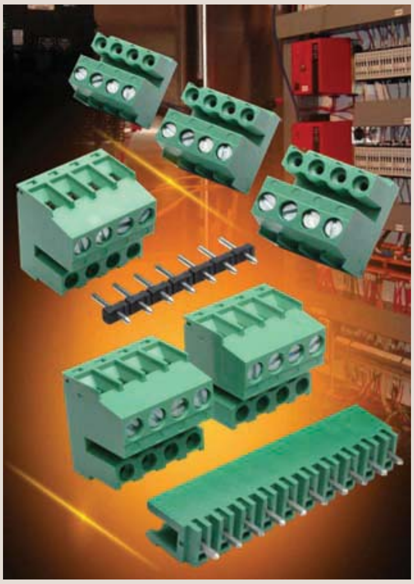
The ABORD 1062 adaptor is fully compatible with STANAG 4074 type 1 plug connectors. It has copper alloy tin-plated contacts and nylon caps, with coupling being achieved via 'push pull' friction. It is able to withstand temperatures ranging from -55ºC to 100ºC and has a maximum current rating on 1000A for six minutes.

www.ttabconnectors.com

Vertical Reversed Connector Block

Available from specialist distributor Switchtec, Euroclamp's SVR vertical reversed connector block enables quick, efficient isolation of equipments and circuitry via the connector's design that utilises push-in female connections for power and signal terminations.

The Euroclamp SVR connector blocks are available in lengths from two to 24 poles, in a standard flangeless design, or with a flange at each end for surface mounting. When mounted in the base part of an electronic housing, the SVR connector block takes all incoming power and signal wires, so that when the top half of the equip-ment (the electro-nics) is lifted off, the male connec-ting strip is totally isolated. The SVR connector blocks accept standard 5mm pitch male connecting strips, either the vertical or horizontal PCB connector PV/H** -5.00, or the vertical pin strip PVS** -5.00.



With an insulation resistance of 100MΩ, a test voltage of 2kVrms/60s, the connectors are rated at 16A/250V according to EN60998, or 12A/250V to EN61984.

Euroclamp's SVR series are CE marked and are fully RoHS compliant, while UL CSA and VDE approvals are pending. Along with all Euroclamp products, Switchtec is able to offer the SVR connectors ex stock.

www.switchtec.co.uk

Solid State Lighting Technology Solutions

RS, a distributor of electronic components, has introduced solid state lighting (SSL) technology to its electronic product portfolio, adding over 460 new products to its range.

Among the new lines are Dialight-Lumidrives's Colour Engine, Philips Lumileds's LUXEON K2 and OSRAM's LINEARlight Flex ranges.

Dialight-Lumidrives's Colour Engines are modular red, green and blue light based, which enable OEMs to easily construct dynamic full colour change applications using LED technology. The simple modular approach is ideal for OEMs with limited electronics capability.

Philips Lumileds's LUXEON K2 combines advances in LED die and packaging technologies to deliver LEDs with sigificant increases in temperature capability and luminous flux. At 1000mA, LUXEON K2 delivers more than twice the light than at 350mA while maintaining lifetime, quality and robustness. Further features include 1500mA drive current capability; 185° junction temperature; 9°C/W thermal resistance; 70% lumen maintenance at 50,000 hours etc.

OSRAM's LINEARlight Flex is an LED module on a flexible PCB with light emitted either at the top or at the side. Features include: dimmable by pulse width modulation (PWM); can be divided into units or their multiples with no loss of function in the parts; flexible installation on curved surfaces is possible; minimum bending radius of 2cm; wide beam angle of 120° and others.

www.rswww.com

Qualification For 16kbit SPI FRAM

Non-volatile ferroelectric random access memory (FRAM) supplier Ramtron has announced that its FM25C160 – a 16kbit, 5V, SPI FRAM memory device – has been qualified to AEC-Q100 (Automotive Electronic Council's Stress Test Qualification for Integrated Circuits) standards. The FM25C160 is the third FRAM device to be AEC-Q100-qualified as part of its automotive qualification programme. Ramtron is also developing various FRAM configurations specified for the Grade 1 (-40^{0}C to 125^{0}C) operating range.

The device is a direct hardware replacement for equivalent EEPROMs, yet it reads and writes at bus speeds up to 20MHz with virtually unlimited endurance (1 trillion writes), 45-year data retention and low power. It operates at 5V and is available in a "green" 8-pin SOIC package.

The AEC-Q100 qualification standard was established in 1994 by the Automotive Electronics Council (AEC). The standard is recognised worldwide as a benchmark for automotive systems. Electronic components that meet AEC-Q100 standards are deemed reliable, high-quality components suitable for use in the harsh automotive environment without additional component-level qualification testing. For more details, visit **www.aecouncil.com**

www.ramtron.com

Launch Of The Smallest ATCA Dual-Input Bus Converter

Emerson Network Power recently announced the availability of the industry's smallest front-end power solution to date for use on latest-generation telecoms cards.

The majority of existing Advanced Telecom Computing Architecture (ATCA) bus converters use a combination of front-end interface and conversion module, consuming valuable board space. The new Artesyn dual-input ATC210 bus converter is a fully integrated solution that occupies 20-40% less space than competitive solutions. It combines an exceptionally small footprint, high power-density isolated dc-dc converter with advanced digitally programmable power management functions. The converter has a 5.9 x 4.6cm footprint and a typical full load efficiency of 89%, yielding a power density in excess of 4W/cm^3.

The ATC210 bus converter is rated at 210W. It has dual inputs, each capable of accommodating a very wide input voltage range of -36V to 72V, and generates two independent, isolated dc outputs. The main 12V output can deliver up to 17.5A and is intended for powering an on-card intermediate bus. The secondary output is for supplying peripheral power management circuitry; it is rated at 1.8A and is resistor-programmable over the range 3.13V to 3.47V. The converter is equipped with I2C serial bus and direct high-speed interfaces for monitoring, reporting and digital programming of fault thresholds. Built-in power management functions include input ORing, inrush control and transient protection.

www.emersonnetworkpower.com

75W Power Resistor With Maximum Power Handling

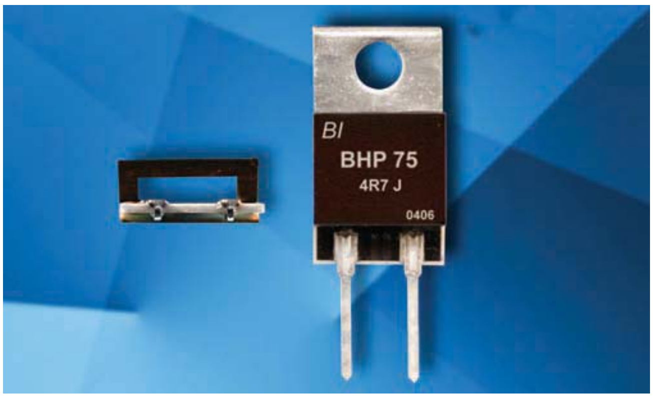
Providing design engineers with an open screened substrate device for applications requiring superior thermal performance, TT electronics BI Technologies SMT division has developed a non-moulded power resistor rated up to 75W. Designated the BHP75 series, the resistor is housed in a TO-220 opened screened substrate package and features an insulated tapered venturi bonded to the substrate for maximum heat dissipation. The design of the BHP75 series resistor allows utilises all three methods of heat dissipation, including conduction through the heat sink tab, radiation from the resistor surface and convection through the venturi element.

Typical applications for the BHP75 resistor include higher wattage switch-mode power supply circuits, motor control and drive circuits, inverters and industrial power equipment.

The BHP75 series resistors are rated for 75W power dissipation at tab temperature maintained at 25°C or less than 75W. Resistance ranges from 1Ω to 100kΩ, with tolerances of ±1% and ±5%. TCRs range less than 100ppm/°C, with maximum DC operating voltage of 250V and dielectric-withstanding voltage of 1kV. Thermal resistance is 1.3°C/W from the resistor's "hot spot" to the package's metal flange and operating temperature range is -55°C to +155°C.

The BHP75 device complements BI Technologies's MHP 50W TO-220 and MHP 100W TO-247 power resistors.

www.atmel.com



Website Directory

To reserve your website space phone Matthew Dawe 01322 611261 or email matthew.dawe@nexusmedia.com

Alpha Wire

www.xtraguard.com

Leading supplier of advance solutions and service in wire, cabling and tubing, Alpha Wire International, has announced the launch of a new website dedicated solely to its range of hazard-matched cables, XTRA•GUARD® that provide extreme performance for extreme environments. The new website www.xtraguard.com represents an industry first for a website dedicated solely to a single brand of cable. The site offers an intuitive selection aid to help engineers correctly specify cable for their application's extreme environment.

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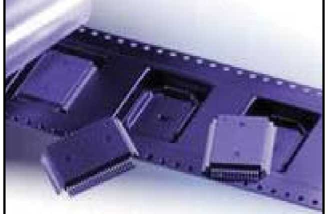

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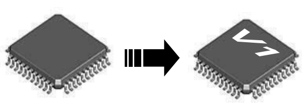

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