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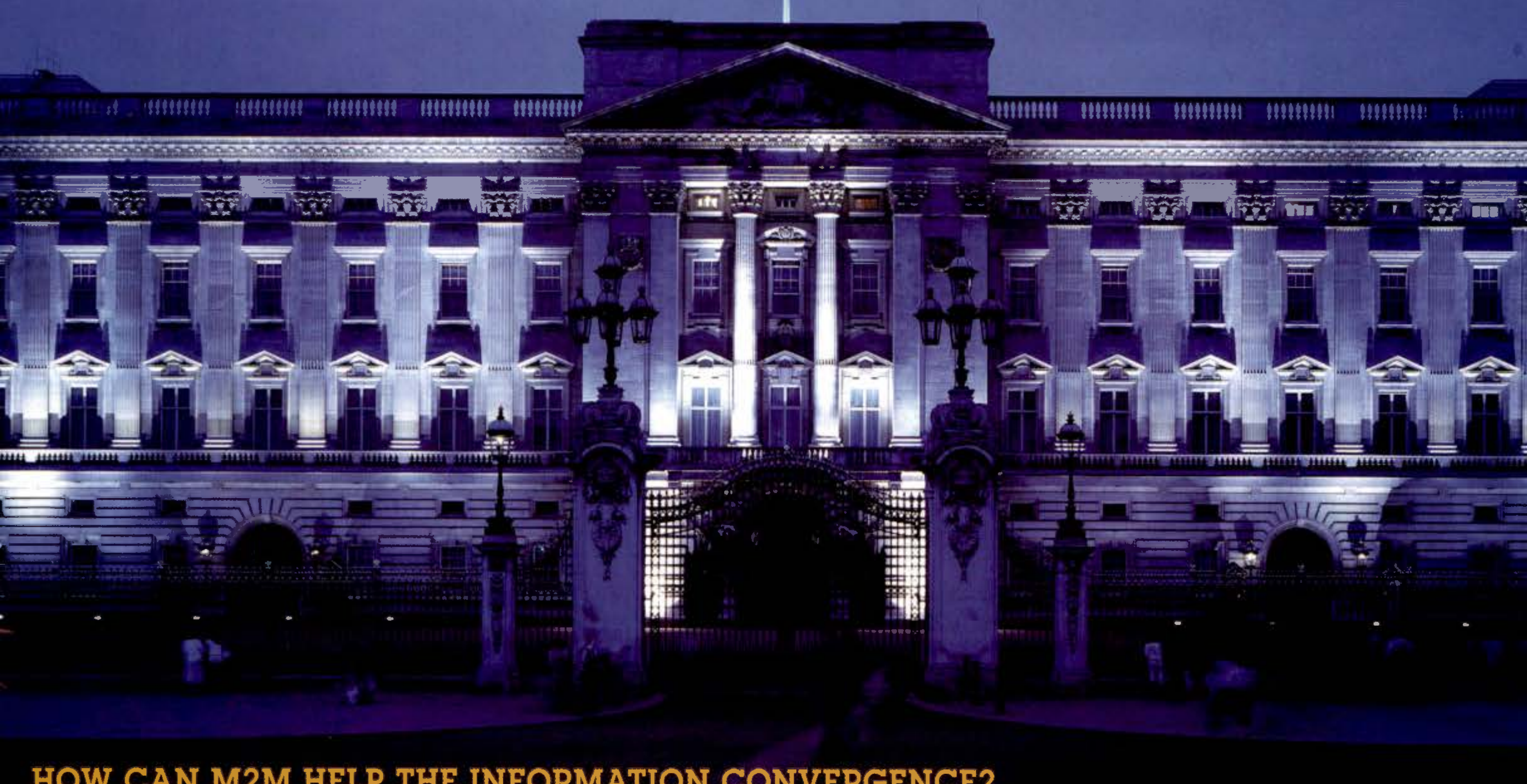

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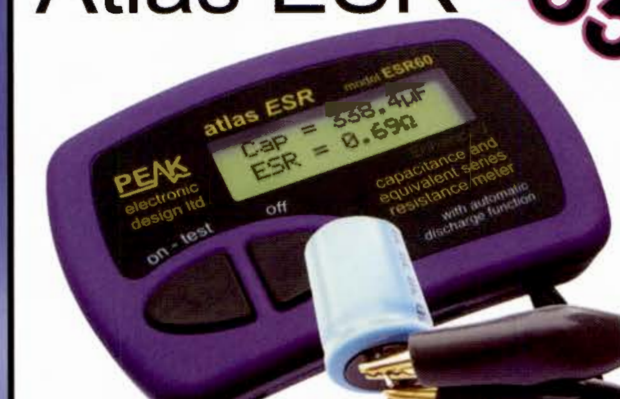

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THE BATTLE OF THE LIGHTING

Let there be light! But which one, ask many as different types of technologies try to battle it out in the homes and minds of people.

There are quite a few types of lighting technologies available at present. The incandescent light bulb is one of them. However, the old incandescent bulb is just that – old! It is old technology (actually very old technology, considering how things have moved on in other technology fields) and it seems to be a waste of energy and therefore money, even though it arguably offers the best quality of light.

Then there are the tungsten and halogen bulbs, which have been found not to have a "place at the energy-efficiency table", and high wattage bulbs are gradually being phased out.

Shall I mention the compact fluorescent bulb (CFL), which has prompted so many of our readers to write to us recently? Sadly, the CFL is not favoured by many due partly to its inefficiencies, as well as poor lighting quality and the fact that many people seem not to like them.

Then, there are the LEDs. Although LEDs are commonly found in backlighting applications in handheld battery-powered devices, they are now set to move into the field of general-purpose lighting. To date, LEDs have predominantly occupied small display backlighting; these applications represent some 50% of the total LED driver market. This is now set to change as this application has matured and does not have significant future compound annual growth rate (CAGR).

The three largest market segments with growth rates far greater than that of the handheld backlighting market segment for LED lighting applications are automotive headlamp illumination, followed by large LCD TV and, finally, general-purpose lighting.

Year 2007 has been named the "pivotal year" for the adoption of LEDs into what will become a mainstream business for many analogue IC suppliers. So, the future for LEDs looks bright.

But, there are those who'd say that this technology's adoption will not go without major snags. Among these are major manufacturers' investments into other technologies. John Allard, technical director at Gloucestershire-based LED lighting company Greenled says: "Major manufacturers have invested a great deal into developing the CFL and, up until now, it has suited them to ignore the problems they bring. They are able to produce CFLs cheaply thanks to continued government subsidies, so they're not offering consumers a viable alternative technology, which offers the same quality of light as the incandescent bulb, is energy-efficient and environmentally sound."

So, which type of light is going to win the day? Despite so much lighting being talked about, I, for one, cannot see clearly just yet.

Svetlana Josifovska
Editor

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WiMAX could ruin satellite communications, study warns

National governments worldwide have been urged to refrain from allocating spectrum to WiMAX applications in the 3.4GHz to 4.2GHz frequency band after a new study has reported major interference problems with existing satellite systems.

The 3.4GHz to 4.2GHz band is widely used in many countries for C-band satellite communications and plays a critical role in remote and tropical regions to provide universal access, disaster recovery and television services. Unlike the small dishes used for residential satellite TV reception, the much larger C-band earth stations are designed to receive a very low-power signal, which makes them extremely sensitive to interference.

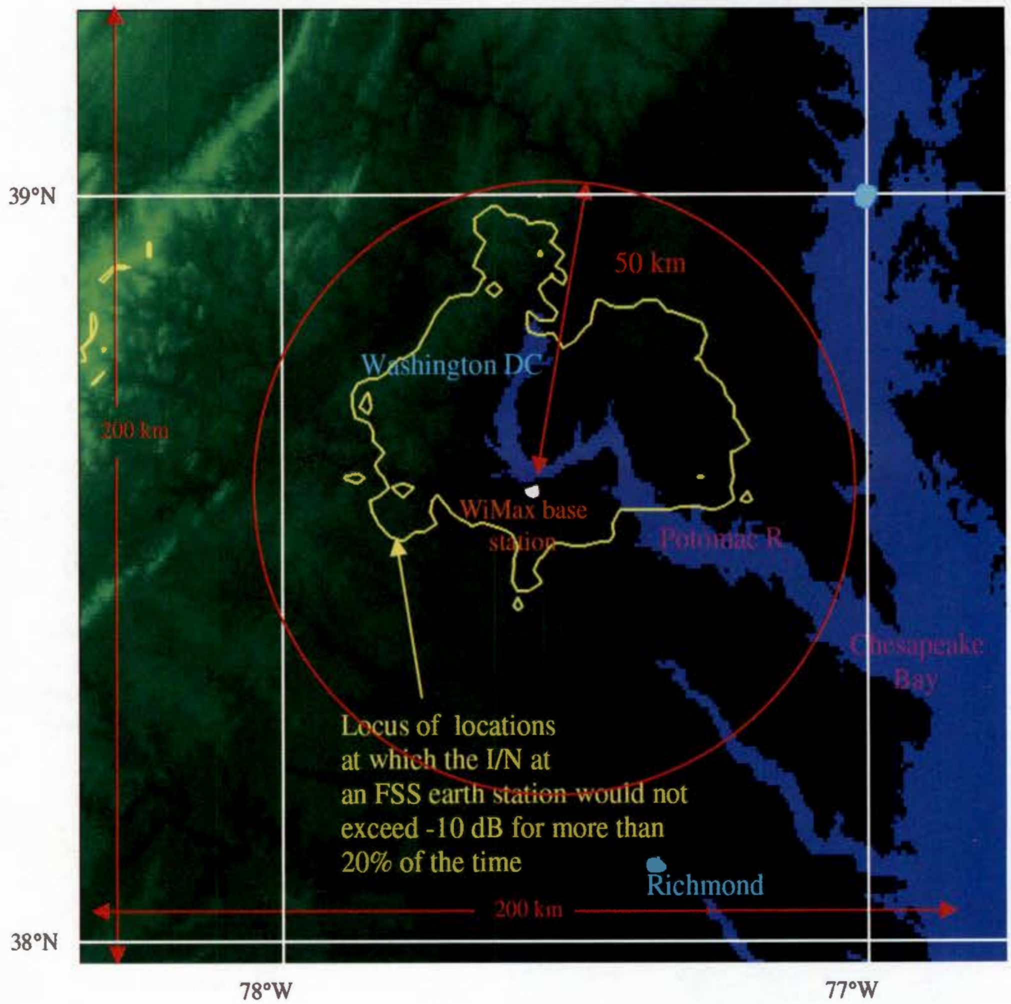
Worried by the proliferation of nations considering and, in some cases, already authorising the use of this band for WiMAX and other wireless broadband applications, a study was commissioned by the Global VSAT Forum, the WiMAX Forum and the Satellite Users Interference Reduction Group.

To measure the interference levels generated by fixed WiMAX base stations into a fixed satellite service (FSS) earth station, a WiMAX antenna was mounted on top of a water tower at a height of approximately 50m. Then, an FSS antenna was positioned at various angles and several different locations in a radius of up to 12km from the WiMAX base station.

The tests, carried out in Southern Maryland and Northern Virginia in the US, showed that the WiMAX transmit signal could cause significant problems to a digital signal well in excess of 12km away. At 12km, a baseline video signal that was transmitted by a C-band SES satellite was fully operational with the WiMAX carrier centred on the video carrier. However, the data BER (bit error rate) was degraded from a nominal 10-8 to a BER of 10-4, which the report says is an unacceptable quality of service in the digital telecommunications industry.

Subsequent calculations based on the measured data and scaling with International Telecommunication Union criteria for WiMAX output power and additional path loss led the scientists to conclude that FSS antennas and WiMAX systems should not co-exist in distances ranging from 50km to over 200km depending on local terrain and WiMAX output levels.

Interference from broadband wireless access services have been reported in many parts of the world where governments have opened portions of the C-band for WiMAX use, including Australia, Bolivia, Fiji, Hong Kong, Indonesia, Pakistan, Kazakhstan and Sub-Saharan African nations. "Other national administrations can, and should, avoid repeating this costly mistake," the report authors urged.



A grid of points was set up at 2.5km intervals over an area of 200 x 200km with the WiMAX base station at the centre. The value of path loss was computed between the base station and each point. The resulting locus is shown in this graph. For fixed satellite service earth stations sited outside the contour the long-term protection criterion would be met, but it would not be met for earth stations inside the contour

Strained Compound Semiconductors Should Improve on Silicon Speed

Collaborative work between Glasgow University in Scotland and the Semiconductor Research Corporation (SRC) in the US aims to identify the best p-channel material to minimise device feature sizes. It is expected that the size of MOSFET gate lengths will be reduced to some 8nm.

Research on compound semiconductor materials at the university shows promise that it will enable faster silicon devices to be produced and is expected to advance the previous projections of the roadmap in miniaturisation by four to six years.

Compound semiconductor materials, such as indium gallium arsenide, are expected to be strong competitors with silicon for use in the channel regions of MOSFET devices, as the rate of improvement in the speed of switching of silicon devices is likely to fall unless compound semiconductor are implemented. The Glasgow group plans to develop the use of strained p-type compound semiconductors in much the same way that the performance of silicon devices can be enhanced by the use of strained silicon.

Mobilities in the range 6,000 to 50,000cm^2/Vs are expected to be obtained in strained compound semiconductors, this being more than an order of magnitude greater than the values achieved in silicon. It therefore has the potential to considerably reduce device switching times.

Glasgow is collaborating with the SRC in a three year research programme that started in January, with a total investment of $2.5m. This programme will complement work by the global industry on the development of smaller n and p-type channels in compound semiconductor devices.

Jim Hutchby, a senior scientist at the Global Research Corporation (GRC), a part of the SRC, said: "Being able to utilise MOSFETs in compound semiconductors has been the elusive Holy Grail of scaling for 30 years. With what we expect to accomplish with the University of Glasgow, we may be only two to three years away from achieving that breakthrough. When the day comes that Moore's Law scaling of classical silicon CMOS slows, the benefits from our extending the silicon chip using compound semiconductors could be profound for the electronics industry. At that point, we'll have developed with compound semiconductors a new set of materials and devices to improve both the power dissipation and speed of the historically successful CMOS technology."

IN BRIEF

● The European semiconductor distribution market has declined 1.9% in 2007, says DMASS (Distributors' and Manufacturers' Association of Semiconductor Specialists). After record 2006, 2007 has been hit with a decline of 6% in the fourth quarter of 2007 averaging to 1.9% in the full year. This was partly influenced by the weakening of the US Dollar and partly by the large price difference between Europe and Asia, which has lead to pricing pressures. However, Ian Bass, Chairman of DMASS, played down the data: "I would call a decline of 1.9% percent a comparably soft landing."

● A survey commissioned by communications solutions provider TeleWare has highlighted the high uptake of VoIP in the UK organisations but also the lack of adoption and understanding of the value of 'Unified Communication'. The survey, conducted by analysts at PMP, uses a representative sample of senior IT decision makers from 100 UK companies, with almost half the respondents from firms with an annual turnover of over £250m. Although a key finding shows almost 80% have a clear VoIP strategy, having either deployed or currently evaluating deployment, only 5% have implemented rudimentary unified voice and data communications systems and only 16% have integrated voice with another data application.

● The Electronics Enabled Products Knowledge Transfer Network (EEP KTN) is changing its name to better reflect the focus of its members. As of 25 February this year, the organisation will be known as the Integrated Products Manufacturing KTN.
The role of the KTNs is to bring together academic and industry members to stimulate innovation in the UK economy through higher levels of research and development and knowledge transfer. The EEP KTN serves the needs of organisations and individuals involved with the development and manufacture of innovative products and processes that inevitably includes the close integration of electronics and mechanical functionality.

● Qimonda the German-based memory supplier announced its technology roadmap down to the 30nm generation and featuring cell sizes of $4F^2$. Qimonda's innovative Buried Wordline DRAM technology promises a combination of high performance, low power consumption and small chip sizes to further advance the company's diversified product portfolio. Qimonda is introducing this technology in 65nm and plans to begin production of a 1Gbit DDR2 later this year. Mass production of 46nm Buried Wordline DRAM technology is scheduled for the second half of 2009. This node will offer more than twice the bits per wafer over the company's 58nm trench technology.

● The University of Kent has joined the Continuing Education in Electronics Systems Integration (CEESI) Training consortium of 11 UK universities, contributing four new advanced modules in the area of biometrics and security.
Its four modules for CEESI are: Foundations of Biometrics and Secure Systems; Industrial Context of Biometrics; Practical Biometric Systems; and Advanced Biometrics.
The CEESI-Training programme, supported by the Engineering and Physical Sciences Research Council, aims to address industry's need for flexible training in electronics systems design and integration by establishing a 'pool' of training modules at postgraduate level, accessible mainly via the Internet.

● Freescale Semiconductor and STMicroelectronics have unveiled the first four automotive Power Architecture microcontroller (MCU) products resulting from their joint design program that started two years ago.
The two companies have achieved first silicon from their respective wafer fabs in Austin, Texas, and Agrate Brianza in Milan, Italy, for four automotive MCUs targeting powertrain, body, instrument cluster and safety/chassis applications. Manufactured on the two companies' aligned 90-nanometer (nm) embedded-flash technology, the four products are the industry's first 90-nm automotive MCUs built on the advanced microcontroller technology. Automotive customer interest is strong, and initial product samples are available to support customer demand in Asia-Pacific, Europe, Japan and the United States.

Nortel paves the way for tenfold bandwidth jump

Denmark's TDC will be one of the world's first carriers to offer 40Gbit/s connectivity

Telecom operators around the world have been offered the ability to immediately quadruple the capacity of their backhaul networks from current maximum speeds of 10Gbit/s to 40Gbit/s.

The new plug-and-play technology announced by Nortel Networks is actually ready to support up to 100Gbit/s, although such speeds will not be available to telecom operators and business users until Internet routers, which currently support 40Gbit/s interfaces, are upgraded in the future.

With worldwide Internet traffic now growing at over 40% a year triggered by an explosion in the consumption of bandwidth-hungry applications such as IPTV, high-definition video and VPN traffic, service providers are struggling to keep pace with surging demand.

Unlike alternative methods to upgrade to 40Gbit/s, which require new fibre optic cables to be buried across the carrier's service area, Nortel claims its new 40G/100G Adaptive Optical Engine platform only needs "minor upgrades" to existing 10Gbit/s infrastructure.

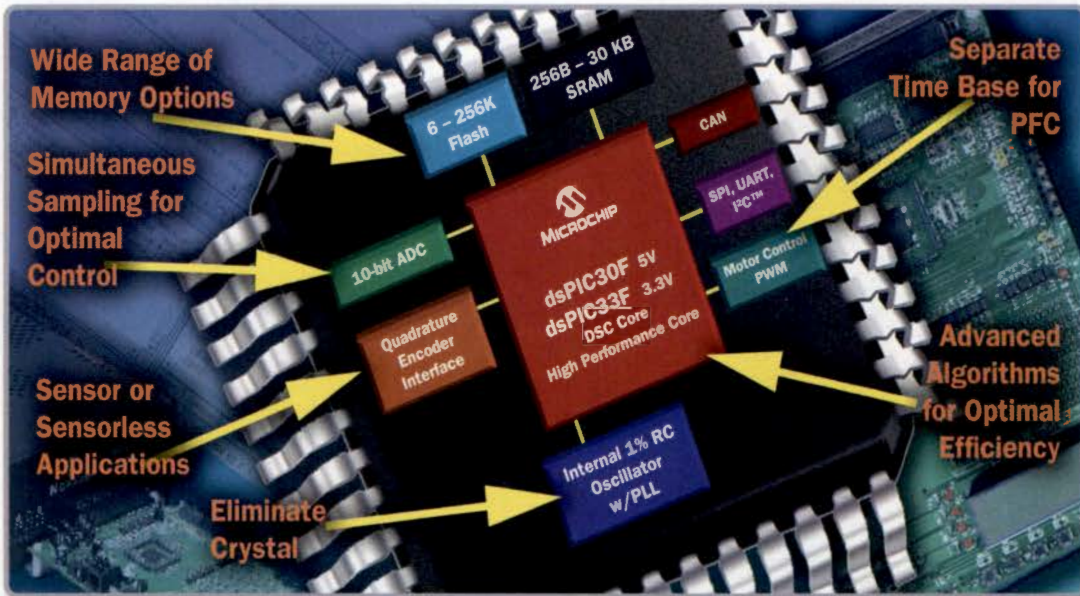
Behind the breakthrough is the use of an innovative modulation technique called Dual Polarisation Quadrature Phase Shift Keying with coherent detection, as well as advanced digital signal processing that removes all compensation requirements from the network.

The technology takes advantage of the full value of Reconfigurable Optical Add/Drop Multiplexing (ROADM). Its transponders allow data-carrying light waves to be transmitted beyond 2000 kilometres without breaking down, nearly twice as far as competing approaches according to the vendor.

Nortel has confirmed its first two customers for the platform: Denmark's TDC and Neos Networks in the UK. TDC will initially use the technology to carry its European network traffic across Germany, the UK and the Netherlands. Following a trial period, the operator plans to launch the new services in late 2008.

Meanwhile, Neos will be using the Nortel gear to support its Liquid Bandwidth product in the UK, which allows corporate clients the flexibility to increase or decrease bandwidth on a day-to-day basis as their own demands dictate.

More Efficient 3-Phase Motor Control



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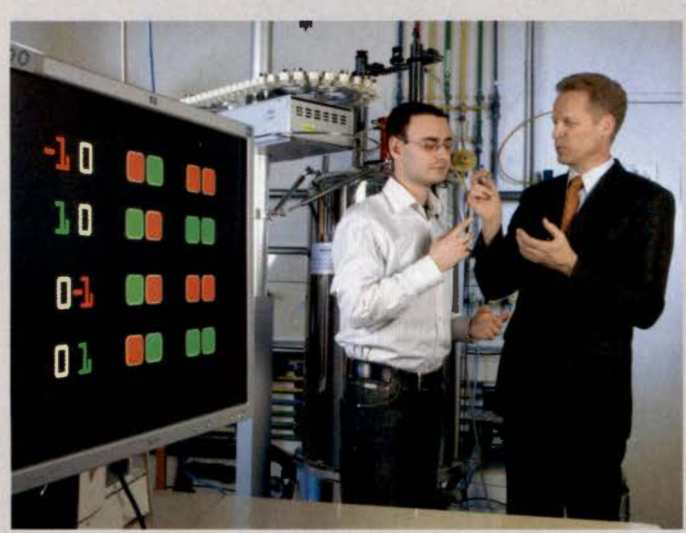
SIEMENS NEURONS THINK UP QUANTUM BREAKTHROUGH



A quantum bit can be a lot more than just a '0' or a '1'

Scientists in Germany have moved a step closer to developing a practical quantum computer. Working in conjunction with Munich Technical University, a group of researchers from Siemens Corporate Technology claim to have achieved the world's first experimental implementation of an artificial neural network on a simple quantum computer.

The team used a special type of artificial neural network that is capable of recognising patterns. For the experiment, a pattern made up of dots was used, with each dot assuming two colours and depicted by means of qubits.

Qubits (or "quantum bits") are expected to replace bits as the next unit of digital information once – some argue, if – quantum computing becomes a reality. While one bit can represent only 0 or 1, a qubit can be either 0, 1 or a superposition of both.

The system used in Siemens's tests featured just two qubits. Still, these two quibits proved enough to confirm all results from the simulation of pattern recognition carried out in a magnetic resonance spectrometer at the Munich Technical University.

The researchers have developed an algorithm that allows them to predict how a real quantum processor would behave if confronted with a new colour pattern. The simulation compares this pattern with patterns stored in the memory and indicates the degree of similarity.

Using a solution of sodium formiate at room temperature containing one carbon and one hydrogen atom, each of the two particles forms one qubit when subjected to a strong magnetic field. The measured signals of the actual quantum computer corresponded exactly to the signals that had previously been calculated.

The next goal of the project is to identify ways of speeding up pattern recognition time. Ultimately, the team hopes its research will lead to the development of a hybrid processor which would work with both conventional and quantum mechanical technologies.

Apart from making faster computers possible, the advent of quantum computers could one day bring significantly reduced energy consumption to today's power-hungry mainframe computers.

Ofcom approves mobile phone use on planes

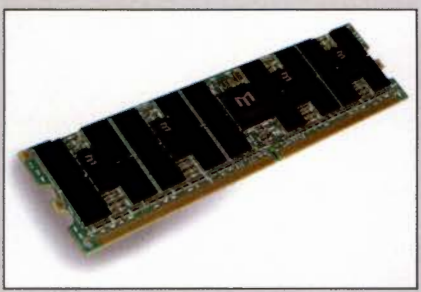
Once an aircraft reaches 3000m, flyers on all UK-registered planes flying in Europe can start using their mobile phones, says UK telecom regulator Ofcom.

This however, does mean that aircraft will need to have specialist hardware installed to enable calls and prevent any interference with other aircraft systems, which in turn means that the European Aviation Safety Agency will need to get involved to approve it.

The hardware is likely to consist of picocells, which will be "switched on" after take-off and switched off once the planes leave European airspace. The calls will normally be routed to terrestrial networks via satellite links, for which radio spectrum has already been allocated. Initially, the services will be 2G based with 3G to follow.

Ofcom's reached its decision to allow use of mobile phones on planes following a consultation that started late last year. Up until that point, the available research has shown that mobile phone use on airplanes can interfere with onboard communication and navigation systems. A 2003 Civil Aviation Authority research found that mobile phone signals skewed navigation bearing displays by up to five degrees.

MetaRAM aims to close the memory capacity gap



An 8GB MetaRAM R-DIMM

A Californian start-up led by former AMD CTO Fred Weber has caused a stir in the server market by introducing a technology that significantly boosts RAM memory capacity while reducing its cost by up to 90%.

Backed by Intel Capital among other investors, fabless semiconductor maker MetaRAM has launched a chipset that quadruples the capacity of a DIMM card without the need of migrating to more expensive DRAM chips.

Called MetaSDRAM and sitting between the memory controller and the DRAM, the DDR2-based solution tricks the CPU into thinking that multiple mainstream DRAMs are actually a larger capacity DRAM. The chipset combines four separate 1GB DDR2 SDRAMs into a single, virtual 4GB DDR2 SDRAM that emulates a monolithic 4GB DDR2 MetaSDRAM.

While a company looking to equip a high-performance server with 250GB of RAM memory today would have to spend in the order of half a million dollars for the privilege, the MetaRAM approach would only cost $50,000.

Already, two memory module makers – Smart Modular Technologies and Hynix Semiconductor – have agreed to use the chipset in a new family of R-DIMMs. Taiwan's TSMC foundry has been contracted to fabricate the devices.

High-density memory circuitry hasn't been able to keep up with exponential progress in the microprocessor space. While CPU clock speeds can reach over 4GHz on the latest multi-core architectures, DDR2 main memory can't run beyond 667MHz.

The way system designers have traditionally compensated for this gap has been by adding higher capacity – but not readily available – and exponentially more expensive DRAM to each DIMM module on the motherboard.

"I've spent my career focused on building balanced computer systems and providing compatible and evolutionary innovations," said Weber. "With the emergence of multi-core and multi-threaded 64-bit CPUs, I realised that the memory system is once again the biggest bottleneck in systems and so set out to address this problem."

By helping drastically reduce the memory capacity gap, the company claims that even entire high-end modelling databases could be hosted into main memory, which would significantly boost the performance of this type of demanding applications.

Servers and workstations from Appro, Colfax International, Rackable Systems and Verari Systems are expected in the first half of 2008.

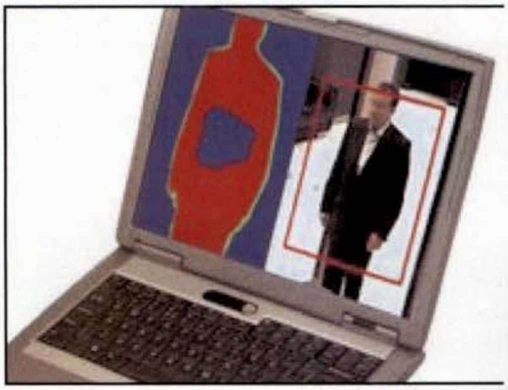
Terahertz technology used to combat crime

Teraherz technology has now being used in systems to detect explosives, drugs and weapons at airports, railway stations and other public places.

The so-called T5000 ThruVision system can 'see' under clothing from 25 meters away.

Teraherz images are normally used by astronomers, forest managers and even pharmaceutical scientists among others to check for decaying stars, trees or check the structure of chemical compounds. The electromagnetic radiation is a low level energy emitted by people and objects. The ThruVision system works by collecting these waves and processing them to form an image, which reveals concealed objects. Although the silhouettes are obvious, body details are not.

The system is based on a technology developed at the Rutherford Appleton Laboratory (RAL) in Oxfordshire. Now, the portable camera has already found a home at the Dubai Mercantile Exchange and Canary Wharf in London.



Portable camera can check for hidden weapons

ARE BURIED COMPONENTS THE FUTURE?

BY KEITH GURNETT AND TOM ADAMS

The idea of putting components, both active and passive, inside the printed wiring board has been simmering in the background for three decades or more. Now two organisations are working to make buried components a credible alternative to surface mount.

In Berlin, Germany, Fraunhofer IZM has been partnering with commercial partners and the Technical University of Berlin for nearly ten years in a project known as 'Hiding Dies' (**www.hidingdies.net**). The technology developed by the consortium is known as Chip In Polymer, and will shortly be used in commercial applications.

Chip In Polymer is intended for specific applications where burying the components conveys real advantages. It will be limited to boards with relatively low component counts, and is not seen as a broad-scale replacement for surface mount.

In the US, Verdant Electronics, a company formed in 2007, is proposing a somewhat different approach, named the Occam Process after William of Occam, a fourteenth-century English Franciscan friar and scholastic philosopher. Verdant Electronics is in the early stages of work with several commercial partners in the US and other countries, and expects to publicise significant prototypes of its technology shortly. Although a complete description of the Occam Process is not yet available, it is intended to be used on a massive scale, and to essentially replace surface mount.

Reduction in connection lengths, and as a result higher speed, is probably the most significant advantage to be gained from placing components inside the board instead of on top of the board. The advantage may be greater in Chip in Polymer where thinned chips are used than in the Occam Process where packaged chips are planned.

Another benefit is that neither approach needs to use solder for interconnections. The removal of solder of course also removes all of the concerns associated with both lead-free solder and the older tin-lead solder.

A third benefit is ruggedness. Conventional surface-mount boards should, broadly speaking, be able to withstand a "drop test" (being dropped on the floor), without suffering electrical damage. Boards with the components inside, it is thought, should be able to pass a "throw test", where the board is thrown at the floor.

There are disadvantages, of course. Perhaps the most important is that rework, once the components are sealed inside the cured board, is either elaborately difficult or impossible. If processes are so carefully controlled that yield is high, then rework is not much of an issue. If yield is lower, the difficulty or impossibility of rework will make costs creep upward.

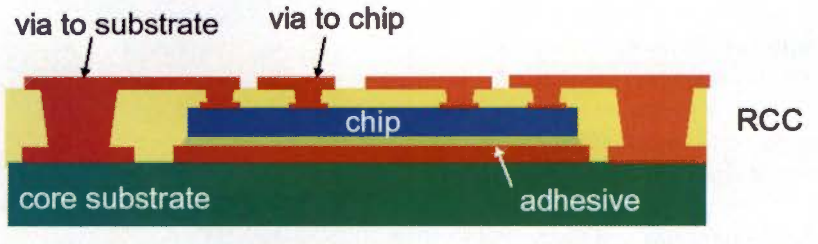


***Figure 1:** The Chip In Polymer method uses thinned chips, a very thin board core, and electrolessly plates the chip bond pads at the wafer level*

Chip In Polymer

In this method, the first stage in production is the thinning of silicon wafers to 50 microns, and sometimes even thinner. The bond pads on the die are then modified in preparation for later processing and the wafers are diced.

The "board", Fraunhofer IZM physicist Andreas Ostmann explains, is actually a board core that may be as thin as 150 microns. The bare die are adhesively bonded to the core. The 'Hiding Dies' project has used only currently available assembly equipment throughout its development, and a conventional die bonder is used in this step. Great care is taken to ensure that the bonding is uniform and that the die is perfectly flat.

Passive components can also be bonded to the core. Ceramic chip capacitors have continued to shrink in size in recent years. The smallest ones are still too thick to be used in Chip in Polymer, but modifications of the technology have already taken place to accommodate these capacitors and other somewhat thicker components.

One development project at Fraunhofer IZM successfully used specially made ultra-thin ceramic chip capacitors. After the components have been bonded to the core, a layer of resin-coated copper (RCC) is laid on top as a build-up layer. The resin itself is 70 microns thick, the copper only five microns.

During curing, the resin flows over and around the components on the board, permitting the copper surface to become flat. At this point a laser is used to drill microvias down to the connection points on the various components. The microvias are then plated with PCB-compatible copper. A patterned layer of resist is put on top of the copper surface and etching of the copper forms the traces at the surface. If needed, additional layers of RCC, microvias and traces can be put on.

The Occam Process

Verdant Electronics president Joe Fjelstad

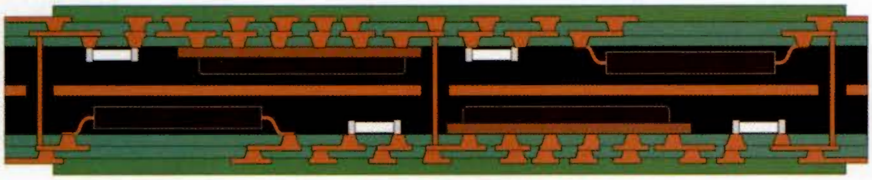


Figure 2: The Occam Process uses unthinned, packaged chips, and a variety of core and build-up materials. Both methods can bury active and passive components. Each chip shown here is several times thicker than the chip shown in Figure 1

explains that the Occam Process may use various types of packaged chips, although his own choice would be to use chip-scale packages, where the area of the package is at most 1.2 times the area of the chip. The thickness of the package for the unthinned chip is typically 600 microns or more, compared to the bare 50-micron chips used in Chip In Polymer. Whatever chips are used should be tested and burned in before assembly.

Fjelstad's plans do not include thinned chips; boards made with his technology will, therefore, be thicker than those made according to strict Fraunhofer guidelines.

In the Occam Process, the packaged chips are placed on a sticky substrate and, once in place, are overmolded with a suitable material. Fjelstad has no specific recommendations for materials for the substrate or the build-up material, but notes that numerous suitable materials are currently available or in development.

At this point the whole assembly is flipped over and microvias are laser-drilled down to the contact points on the components. The microvias are then electrolessly plated with a seed layer of copper (an electrolytic process won't work on an insulating material) and then electroplated with copper.

A patterned resist layer is laid on top and etching forms the traces. As in Chip In Polymer, additional build-up layers can be placed on top.

Current Status of The Two Methods

Bosch is using Chip In Polymer to develop a new 77GHz automotive radar system. The embedded design will add ruggedness to a system that will also incorporate high performance (from short interconnects) and low production costs. Other commercial applications are also in the works.

More than a year ago, Chip In Polymer test boards successfully endured 1000 hours of standard humidity testing and 6000 cycles of thermal cycling (-55° C to +125°C).

Adaptations of Chip In Polymer are also emerging. One German company uses a full-thickness (300-600 microns) flip-chip attached to an interposer. The joined pair is flipped over and the backside of flip-chip is attached to a substrate. A prepreg, with a cutout for the assembly, goes on top and vias are drilled down to the contact points on the interposer.

As mentioned above, the Occam Process is still at a much earlier stage of development. One Brazilian company is using the process to make demonstration boards for the Argentine Space Agency. To the delight of researchers, one of these boards recently passed the "throw test" without damage. Eventually, Fjelstad thinks that the evolving Occam Process could sharply reduce the number of package types needed. The two best candidates for long-term use would be QFNs (Quad Flat Pack, No Lead) and LGAs (Land Grid Arrays).

"REDUCTION IN CONNECTION LENGTHS – AND AS A RESULT HIGHER SPEED – IS PROBABLY THE MOST SIGNIFICANT ADVANTAGE TO BE GAINED FROM PLACING COMPONENTS INSIDE THE BOARD INSTEAD OF ON TOP OF THE BOARD"

Chip In Polymer, as Andreas Ostmann explains, is intended for small systems, preferably with not more than four ICs in a board. Joe Fjelstad, on the other hand, intends the Occam Process to be used for boards of any size or complexity. Because it will use tested and burned-in components, along with strict control of processing parameters, he thinks the Occam Process will permit a high level of yield, even when many components are embedded into a single board. Once solder and reflow are removed from the equation, Fjelstad anticipates that new failure mechanisms may emerge.

Andreas Ostmann doubts that rework of an embedded board will be feasible. Joe Fjelstad thinks that rework, although difficult, will "yield to effort", although it would likely still be a tricky business.

Both processes would make the reverse engineering of a system very difficult, although not impossible. Simply extracting the components without serious damage would likely be a delicate and time-consuming business. This aspect of embedding, along with the much greater protection from shock and vibration, should appeal to military users of electronics systems. It may also turn out that boards with embedded components can be held in storage for years with little or no deterioration. This quality too would appeal to military users.

The Occam Process is, of course, aiming much higher than Chip In Polymer; Joe Fjelstad foresees nothing less than the obsolescence of surface mount and the extermination of solder as a production material, while Chip In Polymer is focused only on specific suitable small-board applications. Fjelstad has come in for some criticism, chiefly because he seems to be promising too much from a technology that is not yet clearly defined.

The two methods described here could eventually reduce the electronics industry's dependence on solder and make solder reflow a relict of the past. They could also be a threat to the use of FR4 board material. None of this may happen on a large scale, of course, but it is hard to ignore an emerging technology that is being taken seriously by substantial numbers of people on both sides of the Atlantic.

The latest news: a slightly different European consortium will shortly begin work on moving Chip In Polymer into volume production. ■

Gary Nevison is chairman of the AFDEC RoHS team, and Customer Support Manager, Legislation and Environmental Affairs at Premier Farnell. As such he is our industry expert who will try and answer any questions that you might have relating to the issues of RoHS, WEEE and REACH. Your questions will be published together with Gary's answers in the following issues of Electronics World.

2008 – A BUSY YEAR FOR LEGISLATION

EU-RoHS Scope

A current review by the European Union (EU) is looking at scope, but no new product categories are likely to be implemented until around 2012. At that time, medical and monitoring and control instruments are expected to be included. Manufacturers of these products are expected to be making changes to their product ranges from 2008 onwards in readiness for the implementation date.

Other changes to scope are possible. The status of "fixed installations" for example, should be clarified and is likely to be included, although many EU Member States already consider them to be in scope. "Spare parts" should also be defined more clearly.

RoHS Worldwide

The first, limited, publication of the so called "*China RoHS catalogue*" *is* expected towards the end of the year. This will highlight the products that will have substance restrictions, their implementation dates and any exemptions. At this stage, product testing and certification will be required.

California-RoHS is now in force for displays only, but legislators are likely to try again in 2008 (vetoed in 2007) to broaden its scope to match that of EU-RoHS.

Korea-RoHS comes into force during 2008. At present this affects a limited range of products but the scope will be reviewed and is likely to broaden. Substance restrictions and exemptions are currently the same as EU-RoHS.

Thailand, Taiwan and Australia are considering new legislation and, in the case of the latter, voluntary agreements, but these are not likely to be implemented in 2008.

Additional Substance Restrictions

The restriction of additional substances is being considered in the EU as additions to RoHS6. These could come into force before 2012, but the phasing out and obsolescence process could be initiated as soon as suitable alternative substances are identified.

Under the Marketing and Use Directive, restrictions could be introduced during 2008 but are unlikely to affect equipment suppliers. More likely to be impacted are suppliers of materials such as solvent cleaners.

In certain US States mercury and two PBDEs are banned. Other substances could follow in 2008.

Norwegian PoHS that was originally planned to restrict 18 substances in consumer products from 1 January 2008 has been postponed and is subject to review, following a stakeholder consultation. Elsewhere most legislation seems to be encompassing the same restrictions as the EU covers with RoHS6.

REACH

REACH is now in force and pre-registration of chemicals, begins on 1 June 2008 and lasts for a period of six months. Failure to pre-register within this window means that a substance cannot be used until it is fully registered. Industry is already seeing some withdrawal of products and this is likely to continue through 2008.

Initially, the main focus of REACH is the registration of substances that are most frequently used, at levels of more than 1000 tonnes per annum, along with those that are highly toxic, carcinogenic and mutagenic or are reproductive toxins. It is likely that some manufacturers will begin to introduce substitutes during 2008 and withdraw products simultaneously to avoid the significant costs of REACH. However, these substitutes will not be identical and could potentially cause production difficulties.

It is also possible that some chemicals will become more expensive, although the EC believe that most will increase only slightly. Clearly, there will be variation but some significant price increases are probable due to the costs of registration and evaluation, and the implications of using substitutes, via the REACH process.

Material Safety Data Sheets (MSDS) are a requirement under REACH and should now follow the format specified in the regulations, although most currently do not. It is important that suppliers make these available for all substances and preparations that are being sold now. MSDS are required for all materials that meet the EC's definition of substances, which includes ink in inkjet cartridges and electrolytes in batteries. MSDS should be updated by suppliers when new data becomes available and when registration starts. Importantly, they will need to include "exposure scenarios" in an appendix.

Equipment suppliers are obliged to provide information on substances of very high concern (SVHCs) present within 45 days of request. At present there is no SVHC list but a "likely candidates list" will be published in late 2008 and the final list will be drawn from this by June 2009 at the latest.

Energy using Products (EuP)

Implementing measures will be introduced in 2008 that will affect:

- External power supplies and battery chargers;
- Standby and off-mode power – any equipment that uses these features (most products have off-mode power losses and many such as PCs, TVs and microwave ovens use standby);
- Lighting (office and street);
- Computers (possibly late 2008 or early 2009);
- Televisions (possibly late 2008 or early 2009).

These measures will affect the design of equipment. Linear power supplies will continue to be phased out and replaced by switch-mode alternatives. There will be an increasing demand for more energy-efficient versions of components such as microprocessors, lamps and electric motors.

Twenty broad product categories are currently under review and the EC has defined a further 34 categories to be considered over the next three years.

Waste Electrical and Electronic Equipment (WEEE) Review

All aspects of the EU-WEEE directive are being reviewed but any changes will not take effect until at least 2010, and more likely after 2012. Designing products for easier recycling at end-of-life is likely to become a requirement.

WEEE type legislation is also being introduced in other countries, most notably China and South Korea, where legislation is expected to come into force during 2008.

EU – Batteries Legislation

The new EU-Batteries directive comes into force in September 2008, although Member State legislation has not yet been formulated and so may be late. This legislation has requirements for:

- Substance restrictions – Cd and Hg;
- Labelling – not yet defined;
- Collection and recycling of discharged batteries;
- Registration by 'producers', which includes companies that import equipment into the EU that contains batteries;
- Ensuring that batteries are easy to remove from equipment. ■

Please email your questions to:
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marking them as RoHS or WEEE.

CHOICE OF FREQUENCY BAND CAN REALLY MAKE A DIFFERENCE

by Myk Dormer

When choosing a module, the typical user starts with the simple requirements at the interface (data rate, power supply); considers physical size limitations and price; worries about the claimed link range; and takes a random stab at the catalogue.

But there is another parameter which influences all the others and which might best be considered first: the *operating frequency band* of the module.

2.4GHZ IS DEFINITELY THE MOST "FASHIONABLE" BAND CURRENTLY IN THE ADVERTISING PRESS. THIS BAND IS DOMINATED BY "DEFINED PROTOCOL" SHORT-RANGE NETWORKS LIKE ZIGBEE, BLUETOOTH AND THEIR VARIOUS IMITATORS AND LOOKALIKES

There are a wide range of frequency bands where ISM band wireless modules are used. Some frequency allocations are available worldwide or across an entire continent, while others are specific to one particular country. Legal transmit power levels, operating modes and usage restrictions are depressingly non-uniform. However, a little examination of the physics of radio transmission reveals certain basic characteristics that should influence the selection of a particular operating band:

• 2.4GHz

This is definitely the most "fashionable" band currently in the advertising press. This band is dominated by "defined protocol" short-range networks like Zigbee, Bluetooth and their various imitators and lookalikes (Wibree, Zwave, Nanotron and others).

- *Merits:* Truly a worldwide allocation, with materially similar regulations for its use in almost every country (although fine details do vary). The allocation is wide (over 80MHz), which encourages wide bandwidth, high data-rate systems.

There is a great deal of heavily marketed available silicon, making the radio design easier. And, the aerials are tiny.

- *Problems:* Path loss per meter is high compared to lower frequencies, and penetration of building materials (and even rain!) is poor, so this is a short-ranged allocation, even ranges over 10m can be difficult to reliably achieve. Band congestion is serious, as this band is shared with WiFi radio-LANs.

• 915MHz

In the US (also Canada and limited usage in Australia/New Zealand). This is a fairly generous allocation (26MHz total) with tightly defined operating modes (compliant spread spectrum radios are allowed up to 1W transmit power, fixed frequency units are restricted to less than 1mW).

- *Merits:* High-end modules are capable of good range (up to 1km), while simple units can offer the size/cost benefits of "European" type modules. Aerials are small.

- *Problems*: Limited area of use, within which the FCC approval procedures can be difficult. Even well designed spread spectrum modules tend to have long set-up/sync periods and high power consumption. Little penetration of this band by "network" radios.

• 868MHz

A band harmonised throughout the European Union. To improve band useability, specific areas of the band are assigned to specific applications (fire alarms, security) and in certain sub-bands there are limits to transmit duty cycle or operating mode ("Listen Before Talk" or LBT operations). Transmit power varies from 5mW to 500mW.

- *Merits*: Small aerials, reasonable range. Relatively little band congestion (helped by the sub-band allocations). Wide range of modules available from long range 500mW units to very simple short ranged 1mW devices

- *Problems:* Complicated band plan. Zigbee units on 868MHz are limited to a single channel. Not as wide a range of modules as for the 433MHz band.

• 433MHz

Probably the widest used ISM band, the 433MHz band is used throughout Europe and much of the rest of the world also (excluding the US).

Both, simple wideband units and sophisticated longer ranged narrowband radios, are offered and in many regions there is simple band planning and duty cycle restrictions.

- *Merits:* Extremely wide choice of modules from a great many manufacturers. Integrated circuit solutions are also available, for even lower costs. Lower path loss than 868MHz band - so less transmit power for the same range.

- *Problems:* Low power (10mW, or 25mW

in Australia). Band is overcrowded in some areas and there's some very low quality hardware on offer, which can make selecting a device hazardous. Aerials tend to be bigger (a 1/4 wavelength monopole is 16cm long). Range rarely exceeds 500m.

• Other 400MHz

In addition to the 433MHz allocation, many nations retain other 400MHz band allocations, such as the 458MHz band in the UK, or 448MHz in the Czech Republic. Some nations specify licensed operation, for instance "part 90" operation in the US.

These allocations are usually intended for high reliability industrial telemetry and telecommand, so higher transmit powers (up to 500mW) are frequently permitted and only narrowband (25KHz or 12.5KHz) radios are usually permitted. Aerial sizes are similar to 433MHz.

- *Merits:* Long range of several km. High quality, reliable, equipment, some units even meet PMR standards. Uncrowded band allocations.

- *Problems:* Limited choice of expensive modules. Frequency allocations are specific to particular countries. Channel bandwidths limit data rates to 10kbit/s or less. Relatively few channels allocated.

• VHF bands

There are no worldwide (or even continent-wide) VHF allocations – although a 169MHz allocation is slowly being introduced across Europe.

Where they can be used, VHF telemetry radios are associated with long range applications. Typically, these modules are used for environmental monitoring, agricultural process control, remote meter reading and asset tracking. Almost all VHF modules are narrowband.

- *Merits:* 5-10km range is easily achievable (lower path loss than UHF bands). Modules tend to be cheaper than comparable performance UHF examples. Good penetration into buildings; low power consumption.

- *Problems:* Limited, country specific, frequency allocations; low data rates; large aerials. No "single chip radio" silicon has yet been released.

• HF bands

Typically the 27MHz (and 40MHz) bands have so far been limited to model/toy control and very low end short-range data link applications, such as wireless keyboards – although Bluetooth is encroaching on this market. A few operators use them for agricultural process control.

Owing to environmental variations, the propagation of these much lower frequency signals can occasionally be highly unpredictable.

- *Merits:* Very simple, very cheap hardware. Some countries permit high powers (4W in the US). Allocations exist in almost all countries

- *Problems:* Very large aerials are needed to achieve anything but short range operation. Highly overcrowded bands, especially the 27MHz allocation, shared with CB and model control. Low data rates.

What I have detailed here is far from exhaustive, but combined with a little investigation into available products it ought to make choosing a radio module a little more scientific and a little less dependant on extravagant advertising claims.

Good luck!

Note: Path loss is related to frequency, being proportional to 10log(1/f^2).

This means (aerial gain, transmit power and rx sensitivity being the same) that 10mW at VHF (173MHz), 80mW at 458MHz, 250mW at 869MHz and 2W at 2.4GHz would exhibit similar ranges.

Receiver sensitivity, hence range, is also related to channel bandwidth, and as such data rate. Higher speed links have shorter ranges for the same tx power.

For further information, refer to **http://www.ofcom.org.uk/radiocomms/ifi/licensing/classes/rlans/short/** **http://www.ofcom.org.uk/radiocomms/ifi/tech/interface_req/uk2030.pdf** (refer to table 3.1 especially).

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SMARTPHONE INDUSTRY SHOULD SOLVE TESTING, COLLABORATION AND DELIVERY PROBLEMS

ABHIJIT KABRA, SENIOR EXECUTIVE FOR PRODUCT ENGINEERING AND DEVELOPMENT BUSINESS PRACTICE AT ACCENTURE, SAYS THE EMBEDDED SOFTWARE INDUSTRY IS PLAGUED WITH SEVERAL TYPES OF PROBLEMS THAT NEED TO BE SOLVED PRETTY QUICKLY

The embedded software smartphone industry must face and work to solve three of its three most widespread and vexing problems: testing, collaboration and product delivery inefficiencies.

These deficiencies were discovered in an Accenture embedded software research study conducted near the end of last year. Working closely with executives throughout this industry, I have learned these deficiencies continue to be major problems today.

The industry should focus on more effective and accurate ways to test the embedded software within smartphones, and develop common product verification performance techniques.

The industry should also delve into innovative ways for embedded software companies to collaborate more. Accenture's research found collaboration with third party software suppliers to be the second biggest problem facing companies that design and market embedded software.

Companies in this industry are notorious for their inability to work well with other companies. This is not necessarily on purpose, or any person's or company's fault, but it is reality. The industry needs to admit this and change it.

The industry is too inter-dependent and complex for any one embedded software company to excel riding this journey alone.

Consider these realities: A mobile phone typically houses about one million lines of software code. Software platforms are becoming more diverse and multi-dimensional. Wireless service providers have different standards, quality and reliability requirements. Chipset manufacturers use different smartphone platforms.

Next, consider integration challenges such as converging software and hardware platforms and subsystems from different vendors and figuring out to combine and leverage various system architectures.

Collaboration has proven to be possible. One prime and recent example of this collaboration manifesting itself has been the joint work of AT&T, as the wireless service provider, and Apple, as the device provider, in rolling out the iPhone.

It does not pay to travel alone in this industry because it involves too much complexity, too much intelligence, too many variables, too much market pressure and widespread convergence.

Product delivery inefficiencies – a third industry weakness – need to be addressed. Accelerating the speed at which smartphones are delivered to market, by focusing on the software problems causing much of this delay, should be a major embedded software industry thrust.

More than 50% percent of software designs are completed behind schedule and greater than 20% of projects are cancelled

No more excuses, such as one used too much: that this industry is so complicated because of the recent shift from standalone devices with limited functionality to complex, multifunctional networked devices

because of unrecoverable delays in product development schedules. Speeding the development process is a huge arena for competitive differentiation and customer satisfaction and retention. That spells dollars.

In addition to testing, collaboration and delayed product deliveries, other problems should be confronted too. For example, non-standardised technologies can frequently be tolerable. Everyone realises that these haphazard, 'bolted on' solutions are often an inefficient use of resources.

I believe there should be lots of buzz around the industrialisation of the smartphone embedded software businesses. This means standardising operating systems, employing re-usable code/modules and setting up repeatable processes to streamline embedded software testing and development.

Gains from industrialising will be immense. Rather than continuing to throw software "over the wall" and let someone else deal with it – a too-frequent industry practice – the embedded software industry should get together with an intense focus on providing solutions.

No more excuses, such as one used too much: that this industry is so complicated because of the recent shift from standalone devices with limited functionality to complex, multifunctional networked devices. Clearly a boost in complexity triggers the need for more intelligent, more versatile and more reliable embedded software. Yet customers demand that the software still has to cost less, perform more reliably and get to market faster.

These are all difficult problems. But they can be overcome using the experience and brain power of our industry's professionals.

Finally, because many companies in this industry lack in-house software expertise, companies should consider outsourcing such work, including testing, maintaining and developing embedded software. It pays to do what you excel at while letting others do the rest.

The next 12 months will be crucial to the future of the embedded software market. Make it a 'no excuses' time period for your company. Catapult it on a trajectory toward becoming a high-performance business. ■

ILLUMINATING EVIDENCE

The design benefits of using power LEDs to replace traditional incandescent light sources are undoubtedly powerful. Smaller, more efficient, longer-lasting, they can enable economic or functional improvements to existing lighting equipment, and enable types of lighting that were never before possible.

For all the obvious benefits, however, there are also hurdles for the user to overcome before completing a successful design with power LEDs. One of the most significant of these is determining the relationship between drive current, thermal management and effective lifetime of a luminaire or installation that uses power LEDs. It is this challenge that Philips Lumileds has sought to address with a new category of lifetime and reliability data.

This new data set improves on the industry-norm information on lumen maintenance that power LED manufacturers have presented to date. And designers who have used the new data give strong backing for claims that it is easier to work with, and provides a higher level of confidence in operational lifetime forecasts.

IN THIS ARTICLE **STEVE LANDAU** FROM PHILIPS LUMILEDS ANALYSES THE HURDLES FOR THE USER TO OVERCOME BEFORE COMPLETING A SUCCESSFUL DESIGN WITH POWER LEDS, ESPECIALLY WHEN IT COMES TO DETERMINING THE RELATIONSHIP BETWEEN DRIVE CURRENT, THERMAL MANAGEMENT AND EFFECTIVE LIFETIME

Conventional Data

Every lighting designer is familiar with the "mean time before failure" (MTBF) data commonly provided by conventional lamp manufacturers. Lighting designers use MTBF as a guideline to determine when re-lamping must occur. Such a simple rating is appropriate for conventional lamps, which tend to fail catastrophically after a relatively short period of time.

Power LEDs, however, behave differently; they rarely fail completely but, instead, their light output declines gradually over a long period as a function of drive current and temperature. Thus, the simple MTBF figure applied to conventional lamps is inapplicable to power LEDs.

Indeed, the complex relationship between drive current, temperature and light output makes it much more difficult for lighting companies to accurately model the behaviour of power LED systems than it is to model the behaviour of conventional lighting systems. To solve this

Buckingham Palace lit with Philips Lumileds Luxeon LEDs. The design provides maximum light output and directional control to stop 'spill' into the Palace problem, Philips Lumileds devised a new tool based in part on research by the Alliance for Solid State Illumination Systems and Technologies (ASSIST).

This new "graphical reliability data" model consists of two parts: a statement of failure "B" and a statement of lumen maintenance "L". Failure in the case of a power LED is defined as lumen maintenance below a specified level. (It should be noted that, unlike the conventional lamp model, even when an LED is considered a "failure" it is likely to still be providing useful light output.)

L is the minimum acceptable lumen maintenance figure as required by the application. So, if L = 70 (70% lumen maintenance) then an LED will be considered a failure if its lumen maintenance is 69% or lower.

Using these definitions, we can begin to describe the lifetime behaviour of power LEDs. For instance, if the LEDs are rated for B50/L70 at 50,000 hours, then we would expect that half of the LEDs in an array would have lumen maintenance below 70% at 50,000 hours.

Plotting the Results

While this B50/L70 measure has the benefit of being clear, on its own it is not sufficient to enable the designer to optimise an LED lighting design. This is because both the operational lifetime of power LEDs and their light output are dramatically affected by two factors: drive current – how much power you supply to the device; and temperature, ambient and internal to the LED.

Lighting engineers have to weigh up their system's costs and performance requirements and find a balance between the number of LEDs, drive current and temperature that provides the best commercial outcome.

In other words, for each luminaire design, a specified amount of light is required. This can be achieved by using fewer LEDs driven at a higher current, or more LEDs driven at a lower current.

But how much does a decrease in drive current extend the LEDs" lifetime? How much heat needs to be extracted from the light source in order to hit the designer's target lifetime?

It is these questions that Philips Lumileds's new graphical reliability data answers (see **Figure 1**). Presented as two-axis graphs, the lumen maintenance curves allow the lighting designer quickly and easily to plot the perfect combination of drive current and temperature in relation to lifetime for their application.

The plot of B/L data can be described for virtually any combination. Certain applications, such as wall washing, cannot tolerate as much as 30% degradation in light output, and can require 80% or 90% lumen maintenance typically. Others, such as decorative lighting, can sustain a degradation of as much as 50% of peak light output, so different representations are made for different combinations of B and L.

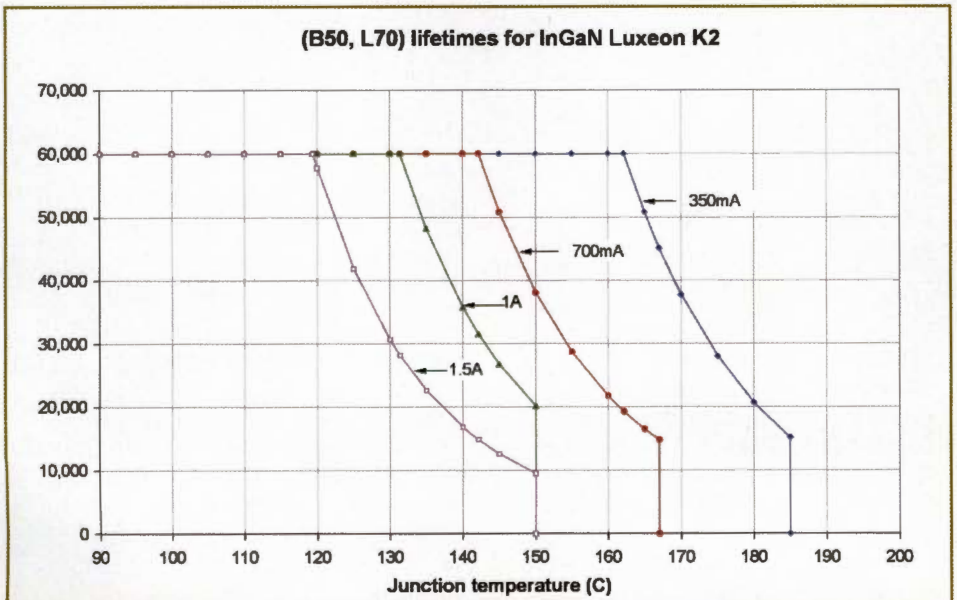


Figure 1: Lifetimes for InGaN Luxeon K2

Addressing Ligthing Professionally

One long-time power LED user that has used these new data sets is IST Ltd, a professional lighting company specialising in innovative architectural and entertainment lighting solutions. IST is on the verge of strengthening its commercial and domestic product offering with the launch of a range of downlighters which use LUXEON Rebel power LEDs.

Guaranteeing the level of light output for the lifetime of IST's products is essential because its downlighter is designed to be Part L compliant. This latest version of the regulatory document for new buildings in the UK came into effect in April 2006. This regulation includes provisions for the efficiency of light fittings and their absolute light output.

Matt Fitzpatrick, director of IST, said: "For commercial applications you need to reach 45 lumens/Watt; for domestic you need 40lm/W. The downlighter market is a high-volume, attractive market to play in, but to get adoption you need it as aggressively priced as possible while also meeting the requirements for Part L."

This presents a difficult design challenge: by driving fewer LEDs harder, IST could reduce the cost of the product, but this could put at risk Part L compliance if it meant lumen maintenance was compromised and total light output too quickly dropped below that specified by the regulations.

By the same token, if the company played safe (using many more LEDs at a greatly reduced drive current in order to greatly prolong peak lumen output), the cost of the product would go up beyond what the market could accept. It was essential to get the balance exactly right.

IST's Fitzpatrick says that the data from Philips Lumileds allowed product designers to do a comprehensive cost/performance comparison on designs using different numbers of LEDs at different drive currents, using temperature data that they were able to get from prototypes.

"Based on the information from Philips

Lumileds, I know what the light output is going to be and how many LEDs I need to put in to the product to get the light output I want, over the operational lifetime that I am guaranteeing to customers. It is exactly the kind of information that I believe the industry has been looking for," he said.

The ready availability of such data has given IST an important competitive edge, allowing it to get to market faster after a shorter research and development process. As Fitzpatrick explained: "Without this information we would have to do more development work and more practical experimentation with prototypes to understand exactly how the LED performed over time in our application."

Further Impact

The impact of comprehensive lifetime data is also imperative in applications where premature failure could be commercially damaging. Chromatica, an architectural lighting manufacturer, has been working with power LEDs for more than three years. It was recently responsible for what, at the time, was the largest installation utilising Rebel LEDs in the world - an architectural lighting installation for an office complex comprising in excess of 35,000 LEDs.

Kevin Clark, director of Chromatica, said: "It is critical to have factual information to predict the 'end of life', which for us means performance after 50,000 hours of operation. We guarantee our products for this duration, so we in turn have to be able to rely on our LED supplier's data."

Clark said that this is a key reason Chromatica primarily uses LUXEON LEDs. "In our experience, Philips Lumileds supplies the most comprehensive data sets for power LEDs in the industry," he added.

The Philips Lumileds reliability tools are distinguished by their ability to predict operational lifetimes in any combination of the two key variables: drive current and temperature. If Chromatica were to use different data sets that did not expose the effect of current and temperature differences, the company would risk making false assumptions about the operational lifetime of its light sources. This in turn could lead to costly in-warranty failures – a commercially disastrous consequence of poor rating data.

The alternative would be to withhold or limit the lifetime warranty. As Clark says, such installations are "not the type of application we want to target, as the price pressures in them are much tighter".

Indeed, cases such as Chromatica's highlight the importance for LED users of understanding the validity of the rating data that vendors supply.

Using the Weibull distribution function – a universally respected statistical technique – to extrapolate product performance, the data from Philips Lumileds shows an extremely low divergence between forecasted and actual performance. Based on the quantity of data it now holds, and using extremely prudent statistical principles, Philips Lumileds is able to accurately predict lumen maintenance for 60,000 hours with a 90% confidence rate. It is worth noting that data from fewer parts on test for fewer hours would support performance predictions that extended less far into the future.

Being Made Aware

The experiences of IST and Chromatica show that power LED customers should be aware of the parameters that affect device lifetimes, and demand that their suppliers provide comprehensive data showing the interactions of average lifetime, lumen maintenance, drive current and temperature.

Only by understanding and applying this crucial data can manufacturers and their customers continue to develop reliable lighting solutions that can be guaranteed for the whole of their intended lifetime.

UNDERSTANDING CLAIMS ABOUT EFFICACY

JAY SHULER OF PHILIPS LUMILEDS HELPS YOU CUT THROUGH THE HYPE AND HOW DISCERNING THE FACTS IS CRITICAL TO READING BETWEEN THE LINES OF LABORATORY ANNOUNCEMENTS

Have you ever been confused by conflicting information coming from different power LED vendors about new records for efficacy? You are certainly not alone. Depending on the application, efficacy can be an important technical consideration in the selection of LED components for a lighting solution. But how do you compare and interpret lab results, and what do they mean?

First of all, cutting-edge lab results are almost by definition based on new, prototype technology, under optimal conditions. While these kinds of results can be important indicators of future progress in actual products, they should not be a factor in your everyday product selection decisions.

Secondly, the results themselves can be misleading. Efficacy is a function of many different design and operating parameters that can be artificially manipulated for the sake of an impressive-sounding announcement.

Efficacy is defined in the industry as lumens per watt (lm/W). Lumen output is a complex function of the total optical power output of the LED across colour and the human eye response. Power in watts is simply current times voltage. Basic stuff, but important to remember when understanding efficacy claims.

The most commonly manipulated

parameter in efficacy claims is current density, computed by dividing the die area (e.g. in square millimeters) by the drive current. By this formula, a 1 x 1mm die has four times the current density as a 2 x 2mm die at the same drive current.

Lower current density can dramatically increase efficacy in nitride LEDs. A 4mm^2 die should *of course* produce more light at a given current than a 1mm^2 die. Similarly, a 1mm^2 die driven at a lower current should *of course* produce better efficacy (but less light) than the same one driven harder, assuming all other conditions are the same. Therefore, before you can understand efficacy, you must know both the die size *and* the drive current under which efficacy was measured in order to interpret the result. If the laboratory does not specify both, then a meaningful conclusion is not possible.

Additionally, different LED designs deliver different relationships between current density and efficacy as drive current changes. The phenomenon that all InGaN LEDs fall in efficiency at high current densities is called "droop". Droop is important in a practical sense because it forces tradeoffs between total lumen output, cost, LED count and efficiency. But some LED designs fall more quickly than others. So to understand how new lab results may ultimately impact the performance of a real product, the results must be reported at the drive current most likely to be used, if not multiple current levels.

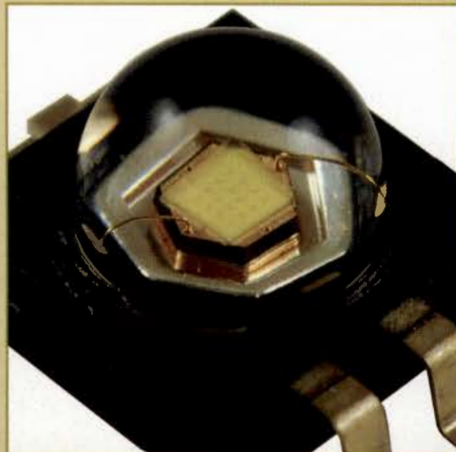


Figure 2: *Philips Lumileds Luxeon K2 with TFFC*

For white LEDs, probably the second most manipulated parameter is colour point – not just correlated colour temperature (CCT), but the exact (x,y) or (u', v') colour coordinates of the LED. Since lumens are a function of human eye sensitivity and efficacy is a function of lumens, as the colour of an LED drifts into spaces where the human eye is more sensitive, the efficacy can improve substantially. Even within "white", drifting off the blackbody radiation curve (the Planckian locus) toward a green tint can add 15% or more to the lumen value and, therefore, the efficacy of a tested LED. Of course, when you buy packaged LEDs from your vendor this is not an issue; the current, forward voltage and colour bin are specified along with typical or minimum lumens. But this is rarely the case with lab result announcements. Since record efficacy claims coming out of labs tend to be within a 15% margin from the previous record, you don't really know anything unless you know the colour point of both lamps.

There are many other factors that interact in complex ways to influence efficacy. For example, because the lumen output of nitride LEDs is affected by junction temperature (T_j) – the temperature at the point inside the die where the light is generated – T_j has a substantial impact on efficacy. Because power (watts) is the denominator of the efficacy equation, efficacy is affected by forward voltage. You can safely assume that vendors are doing their best to optimise these for the sake of technological leadership in areas that are important to their customers.

So, in order to interpret and make 'apples-to-apples' comparisons between lab statements about efficacy, you must know at least the following test conditions:

(1) Die size in square millimeters, or total area if multiple chips;

(2) Drive current, preferably multiple results at different, relevant currents;

(3) Colour point in (x,y) or (u',v').

Anything less is just hype.

IAN PETER MACDONALD, SALES AND MARKETING DIRECTOR AT GREENLED LOOKS AT THE RACE FOR ENERGY EFFICIENCY CURRENTLY PLAYING OUT BETWEEN MANY DIFFERENT LIGHTING TECHNOLOGIES, SOME OF WHICH SEMICONDUCTOR-BASED

WINNER TAKES IT ALL?

A paradox is currently playing out in the lighting industry. Tungsten and halogen bulbs have no place at the energy-efficiency table, as high wattage bulbs are gradually being phased out. With this in mind, there seems one clear contender – the compact fluorescent bulb (CFL).

However, the media is waking up to the dangers and inefficiencies of the CFL, but despite this - the inherent problems of poor lighting quality and the fact many people dislike them - the wide held belief is that regardless of its flaws this technology is the best on offer. Therefore, it seems increasingly evident that there is room for another technology and, up until recently, the case for the LED hasn't clearly been heard.

This is partly because major manufacturers are stalling LED development despite being aware of its advantages, leaving it to smaller lighting companies to push the development of high quality LEDs.

LEDs are becoming an increasingly good solution for aesthetic interior and exterior lighting. Here, Greenled's LEDs have been used at the Scandic Hotel in Oslo

Although the LED bulb looks a more attractive candidate for the energy conscious consumer longer-term, an additional lack of understanding of its potential blights the technology's overall appeal.

LEDs are an excellent energy-efficient alternative to halogen downlighters – perfect for task-orientated lighting

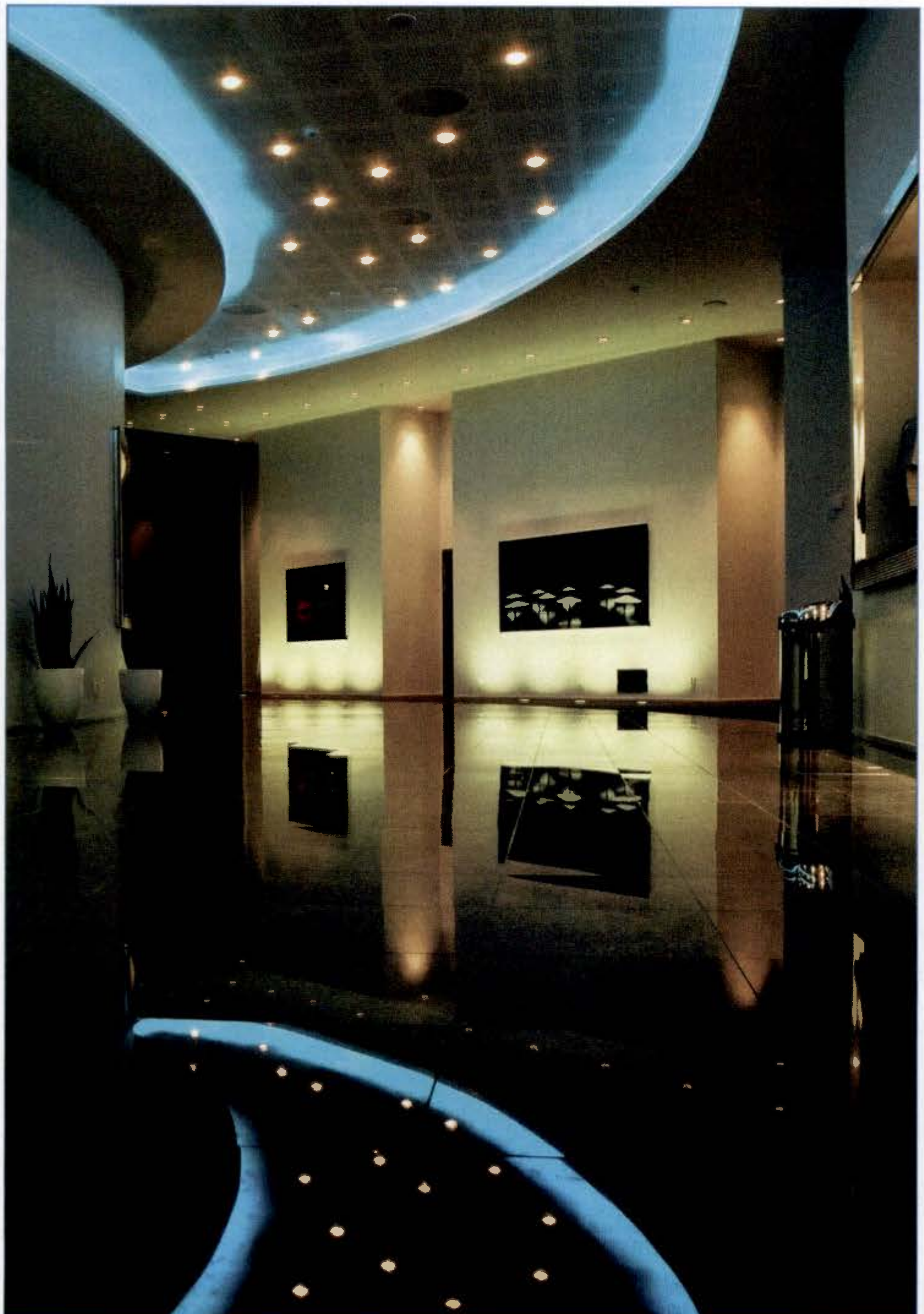
John Allard, technical director at Gloucestershire-based LED lighting company called Greenled is adamant that major lighting manufacturers are not fully exploring the latest advances LED technology has to offer, mainly because of ongoing vested interests in CFLs.

"Major manufacturers have invested a great deal into developing the CFL and, up until now, it has suited them to ignore the problems they bring," he says. "The main prohibitive factor is that manufacturers are able to produce CFLs cheaply thanks to continued government subsidies, so they're not offering consumers a viable alternative technology, which offers the same quality of light as the incandescent bulb, is energy-efficient and environmentally sound."

One only has to consider the vast investment the European Lamp Companies Federation (ELC) has put into CFLs to envisage just how detrimental an LED overhaul would be to the industry's financial balance. The ELC represents the leading European lamp manufacturers, their 50,000 employees, 95% of total European lighting production and an annual European turnover of €5bn.

According to the ELC's *'Strategy for Domestic Lighting'*, the organisation's members have promoted CFLs for 25 years and actively support the phase-out. However, there can be little doubt that this is based on the understanding that CFLs will prosper.

"The eight-year phase-out proposal is designed to ensure that supply of efficient cost-effective products can satisfy demand, development and innovation. We have a responsibility to ensure that consumers are not faced with empty shelves... It is



LEDs are becoming an increasingly good solution for aesthetic interior and exterior lighting. Here, Greenled's LEDs have been used at the Scandic Hotel in Stockholm

important to note that LED technology is still in the very early stages of development and, as such, there is a strong possibility that lamps will be made with a certain spectral composition in the future, hence alleviating some of these initial problems." The recent media backlash over the poisonous content of CFLs has raised general awareness of the long-term problems inherent in this technology. Despite the 'sudden' awareness of CFLs' hazardous content, they've always contained mercury and noxious gases, but there hasn't been as high a volume of CFLs in the marketplace before. Proper disposal is a complex process and is set to become a major problem.

Some Energy Statistics

According to 2006 records, in Europe there were 280 million halogen downlighters. Each emits 40 watts and is on average used for 3000 hours a year.

The mathematics of it is:

280,000,000 x 40 x 3000 = 3.36 x 1013

(280 x 40 x 3000 = 33,600,000 x 1,000,000 = 33, 600, 000, 000, 000) = 33 trillion 600 billion watt hours / 1000 = 33 billion 600 million kWhs = 34 billion kWh of energy are used per year in Europe – from halogen downlighters alone.

According to the Carbon Trust website these figures translate as follows:

34 billon kwH in Europe pa from halogen downlighters = 4 million carbon tonnes.

Greenled's equivalent bulbs are only 5 watts:

280,000,000 x 5 x 3000 = 4.2 trillion watt hours per year =

4.2 billion kWh per year = 0.5 million carbon tonnes

30bn kWh of energy saved = £2.5 billion saved in costs

– There are 1.4 billion CFLs in Europe, according to 2006 figures. Each has 4mg of mercury.

1.4 billion x 4 = 5.6 billion mg of mercury = 5,600,000,000 = 5,600,000g = 5600kg of mercury – the same as the annual carbon output of the average household per year, or the mass of the Eutelsat W7 communications satellite.

The addition of 1g of mercury into a 20-acre lake makes the entire lake's fish unsafe for human consumption. Exposure to very low doses of mercury during vulnerable periods of brain development can also prove harmful to memory, verbal learning, vocabulary and neuromotor function. According to the National Academy of Sciences (NAS), more than 60,000 US children are born each year at risk for adverse neurodevelopmental effects, including poorer school performance, due to in-utero exposure to mercury.

Greenled Easy Does It

Greenled is an LED lighting supplier based in the UK. Amongst its product range are halogen downlighters – a four watt LED designed to replace the popular 35 watt halogen bulb.

"Swapping a 50 watt halogen with a 5-watt LED will save a lot of money in the long run," says Allard. "At present, we're able to replace 35 watt downlighters with our 4 watt version. A room or a corridor with a dozen 35 watt downlighters is wasting nearly half a kilowatt of energy, as 90% of electricity is heat, not light. Five years ago electricity bills were not as high, but this has changed and with electricity prices soaring, running halogen lights now costs considerably more."

Greenled lights convert energy directly to light, in turn reducing energy wastage and costs. These savings means that properly engineered LEDs are expensive and, due to the investment needed, the financial benefits are more suitable for the commercial market in the short term. However, Allard is adamant that eventually individual consumers will form a growing part of Greenled's market.

"The biggest change for the LED, and consumer availability, will be government grants," he explains. "The government's continued subsidy of CFLs ends within the next year. This will free up money which we hope will pass on to LEDs, making them much more affordable."

For the meantime, Greenled realises that changing attitudes to high-tech energy-efficient technology requires influencing key decision makers at a corporate level. However, the company's products are already proving particularly attractive to facilities managers in the hospitality sector.

Steve Day, facilities manager at Best Western Blunsdon House Hotel in Swindon, has been using Greenled products for just over a year and is already reaping the benefits. He initially carried out an energy audit on a single floor of the hotel on normal power for a month. A month later, after installing Greenled lights he conducted another audit, revealing a 75% power output saving.

"Greenled lights appeal to both the pocket and the conscience," says Day. "We've already seen dramatic reductions in our costs and energy use. Greenled's Antares lights offer the same illumination quality as halogen and yet save over 30 watts of energy output per bulb."

These concerns are not encountered with LEDs. Essentially LEDs are electronic devices that emit light; they are not light bulbs *per se*. They are 80% aluminium and also contain silicon and a few other discreet electronic parts, so, not harmful as the components are in fluorescent light technologies. In addition, they are much more durable than glass bulbs and don't break easily. Because of their robust composition, LEDs are extremely resilient. However, because of the largely incompetent mass-produced LEDs, the quality stigma remains, affecting the LED's reputation as a viable light source.

"The electronics behind the LED can be their downfall and that's the area we've looked at in greatest detail, making sure that our technology is of the highest quality," Allard explains.

Driving Efficiently

To achieve optimum brightness, the chip inside the LED light has to be driven efficiently, particularly here in the UK where the mains voltage has frequent dips and surges, which inevitably causes poorly engineered LEDs to fail.

From a technical point of view, LEDs are designed to be current-dependent. This means that the higher the current, the harder the LED is driven. In other words, it may emit a brighter light output, but its lifespan will be correspondingly shortened and its overall efficiency lowered. The ideal solution is to design the LED in such a way that the driving technology adjusts the voltage to obtain the optimum current to make the LED work at its greatest level of efficiency.

LED lights can be powered at a variety of different forward currents – anything from 250mA to 2.5 Amps or even higher. A cool white 4A LED has been produced already, with a consequently high level of light output, however longevity was not the primary objective.

Long-life LEDs need to be driven at lower currents and require sophisticated heat-sink technology to dissipate the heat that is naturally created in the illumination process.

LEDs are sensitive to power fluctuations. In westernised countries, the electricity supply tends to run at between 110-230V A/C. In the US the mains electricity supply runs at the lower end of that spectrum at 110V A/C. In the UK, it is right up at the other end at 230V. This allows less room for manoeuvre when surges, dips and transient spikes occur across the electricity grid system. These are inevitable as they are usually caused by high energy-consumptive equipment (such as kettles, microwaves or fluorescents) being switched on nearby or by motorised equipment (such as lifts) being used, all of which draw significantly from the grid and cause the supply to suddenly alter from the norm.

To counteract these fluctuations and maintain smoothly operating LED lights, it is necessary to regulate the mains flow. Some products have switch mode power supply technology built in, which instantly protects the LED from being suddenly over or under-powered and thereby failing.

"The inherent problem is that the harder the LED is driven, the more heat is generated," explains Allard. "At Greenled we've aimed to resolve this by not driving the LED too hard and by putting very reliable electronics in at the back end."

IN THIS ARTICLE, BRIAN LAW, FIELD APPLICATION ENGINEER AT FAIRCHILD SEMICONDUCTOR, OVERVIEWS SOME OF THE PREVALENT APPROACHES TO DRIVING LEDS AND THEN TAKES A CLOSER LOOK AT SOME OF THE MORE EXOTIC WAYS

POWERING LEDS IN PORTABLE APPLICATIONS

Driving LEDs has quickly become an increasingly important application of power conversion techniques in modern battery-operated equipment. Along with the need for much high-efficiency and lower-quiescent current come somewhat more subtle requirements like LED matching, dimming, white colour balance and others.

There are some fundamental architectural questions too, like whether to connect the LEDs in series or in parallel and whether to do a high-side or a low-side disconnect. Their specific implementations take on various shades, like the well-known inductive boost solutions and charge pump doublers. Riding somewhat unnoticed alongside are fractional charge pumps, 4-switch buck-boost solutions and multiplexed inductor solutions. The latter, also called "SIMO", for single inductor multiple output, is expected to play an increasingly important role in the future as white LED backlights give way to more complex RGB counterparts.

The trend in portable products is bent toward increasingly more multi-media applications. This trend has mandated the use of higher resolution displays with millions of colours. The traditional methods used to light the display was the vacuum fluorescent bulb but, recently, the most widely adopted method of lighting these displays has been the use of LEDs.

LEDs are much smaller in size, which is beneficial for portable products, and they consume less power. They are also far more reliable compared to vacuum fluorescent. Maintaining a consistent light intensity and colour presents the biggest challenge associated with this lighting method. Understanding how white LEDs function will provide clues as to how to assure the intensity and colour are consistent.

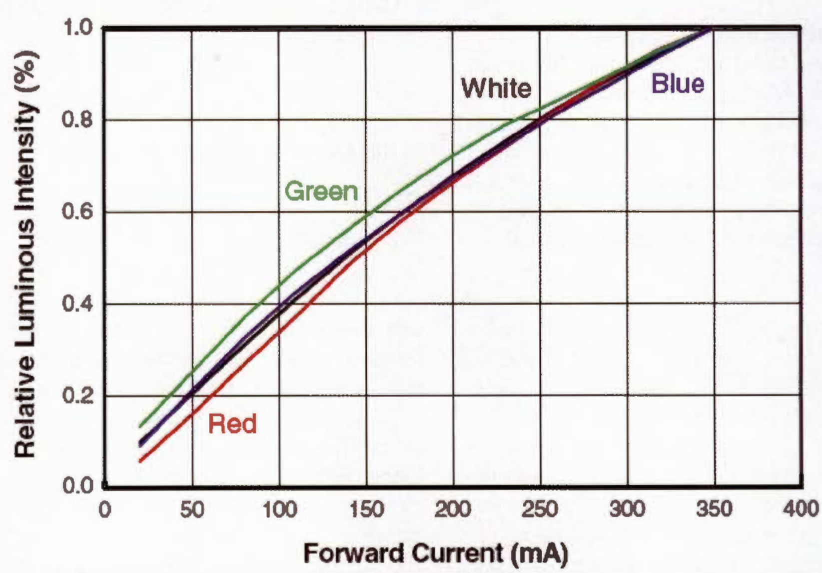


Figure 1: *Relative luminous intensity vs forward current*

LED Operation

Because an LED is a semiconductor it has unique characteristics when compared to other lighting sources. The most notable characteristic is the non-linear relationship between current and light intensity. **Figure 1** illustrates this relationship for some typical LEDs.

The second most notable characteristic is the forward voltage drop associated with an LED. Unlike an incandescent bulb, an LED is not a purely resistive load. The magnitude of the forward voltage varies with the colour of the LED. A typical red LED has a forward voltage of 2.2V and a typical green LED has a forward voltage of 3.1V. The white LEDs and the blue LEDs have the same forward voltage which typically is 3.3V.

Providing a consistent voltage and current to these LEDs in a portable device presents a challenge. The power supply needs to adapt to the decreasing battery voltage, otherwise the light intensity will vary with the battery voltage. These devices require a very specific power supply.

Driver Alternatives

There are three common architectures that are used to maintain both, a constant current and a constant voltage for LEDs. The first of these is an inductive boost regulator with the LEDs in a serial configuration. The second architecture is the same inductive boost with the LEDs in a parallel configuration. The last architecture is a capacitive charge pump. There are advantages to each of these architectures,

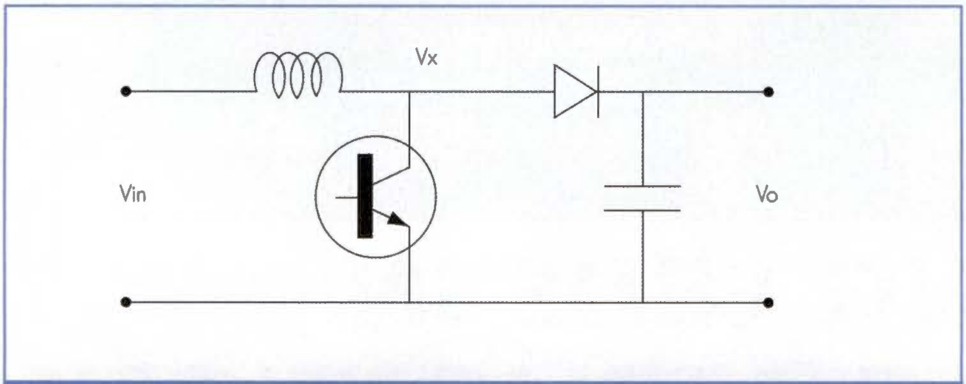


Figure 2: Inductive boost regulator

but only one of them will provide the most benefit to a given application.

**** Inductive Boost Regulator:***

The basic operation of the inductive boost, such as the FAN5608 from Fairchild, utilises the current storage capability of an inductor. An inductor resists changes in current flow, both negatively and positively. That resistance affects the voltage drop across the device. This is expressed as the following ratio:

$$V = L \cdot \frac{di}{dt}$$

The simple schematic provides an illustration of how the boost converter functions. The transistor turns on to start the current flowing in the inductor. Then the transistor is turned off. Since the current cannot instantaneously decrease to zero, it continues to flow through the diode. The current gradually decreases, so di/dt becomes negative resulting in a negative voltage across the inductor.

Using Kirchokff's Voltage Law, the output voltage can be calculated.

$$V_{IN} \cdot t_{ON} + (V_{IN} - V_{OUT}) \cdot t_{OFF} = 0$$

This can be rearranged as:

$$\frac{V_{OUT}}{V_{IN}} = \frac{1}{1-D}$$

where D is the on duty cycle. Since D can range from 0 to 1, the output voltage will always be higher than the input voltage.

The output voltage is directly proportional to the duty cycle, so in order to produce a higher voltage the duty cycle needs to increase. (The FAN5608 uses this method to increase the input voltage to as high as 18V. That allows for up to four to five LEDs in series. The FAN5608 can also produce up to 40mA for a parallel configuration.)

**** Capacitive Charge Pump***

A charge pump uses capacitors to store energy and boost the input voltage by a factor of 1, 1.5 or 2. Using an array of switches and a clock the capacitors are alternatively charged in parallel and discharged serially to produce a boost in the output voltage. This is better explained by **Figure 4**.

The maximum output voltage of this regulator is dependent upon the number of capacitors and the time allotted for charging and discharging. (The Fairchild FAN5607 utilises two capacitors and has three modes, 1X, 1.5X and 2X. This part can provide up to 30mA through each of four white LEDs over an input voltage range of 2.4V to 5.5V.)

LED Topology

With an inductive boost converter the LEDs can be either serially driven or parallel driven. The serial array assures that the current through all LEDs is identical which assures the same intensity. The unfortunate necessity associated with a serial array is the output voltage of the driver must equal or exceed the summation of the forward voltages of all the LEDs. In some applications that can be as much as 24V. That higher voltage requires the use of a silicon process that has a breakdown voltage in excess of 24V, which typically impacts the cost of the part.

Secondly, the efficiency of a boost converter suffers as the output voltage increases. **Figure 6** demonstrates the variation in power required by three different topologies to produce the same

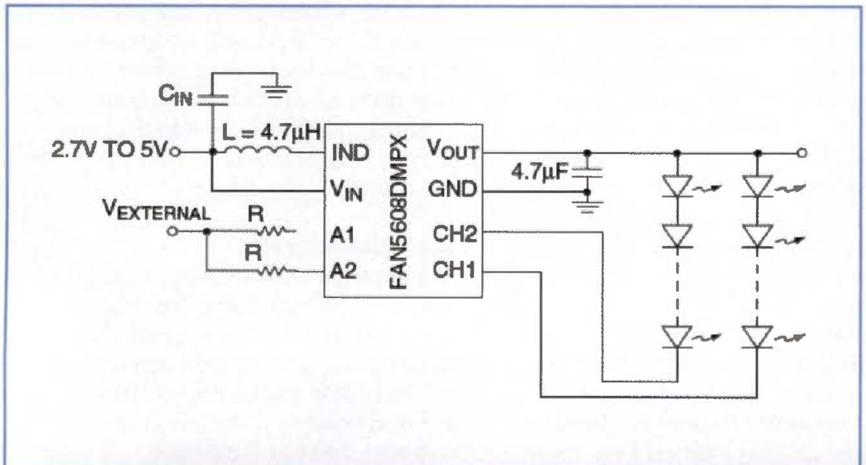


Figure 3: The FAN5608 uses the inductive boost regulator method

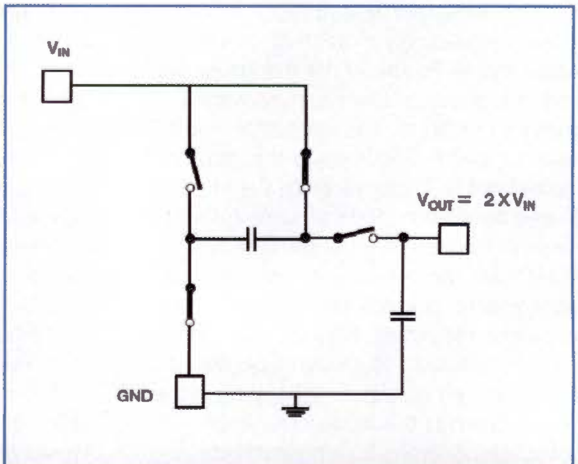


Figure 4: Capacitive charge pump

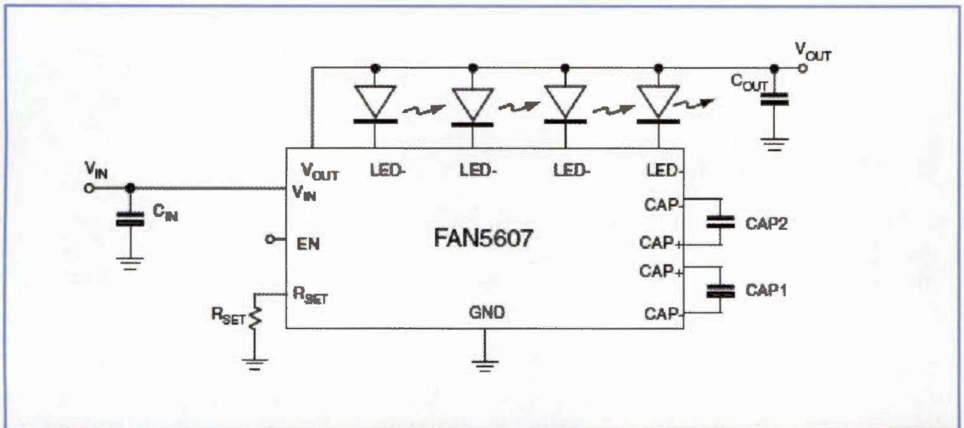


Figure 5: The FAN5607 uses two capacitors and has three modes, 1X, 1.5X and 2X

amount of light from four white LEDs. If efficiency is a primary concern, the serial topology is not the appropriate choice.

Power In (mW)			
Input Voltage	FAN5607 Charge Pump Input Power	FAN5608 in Parallel Mode Input Power	FAN5608 in Serial Mode Input Power
4.2	140.7	105	107.1
4.1	114.8	105.78	106.6
4.0	107.2	103.2	105.4
3.9	70.98	103.35	104.715
3.6	102.96	102.96	104.04
3.5	98.7	103.6	104.3
3.4	97.58	105.06	105.4
3.2	460.8	104.96	106.88
3.1	316.2	104.78	108.81
3.0	294	107.1	107.7
Average	180	105	106

Figure 6: Table of variation in power required by three different topologies to produce the same amount of light from four white LEDs

Although the converter doesn't need to boost the voltage very high (i.e. 3.3V) to drive a parallel array, a parallel topology requires current regulation for each LED. Since the intensity of an LED varies with current, the current in all of the LEDs needs to be matched in order to have consistent intensity from each LED. This adds complexity and cost to the system.

The advantage of the parallel topology is the efficiency. The data shown in Figure 6 on the FAN5608 in the parallel mode and serial mode indicates the efficiency is slightly better in the parallel mode.

Charge pumps are primarily restricted to driving a parallel array because the output voltage is dependent on the number of charge capacitors used. There are some benefits associated with charge pumps. Typically they require less board space because the capacitors can be a small as an 0402 package size. This can be a compelling feature, especially when the end product is a portable device.

The added benefit for portable radios is the lower EMI generated. Even with a shielded inductor, the inductive boost regulators generate more EMI noise than the typical charge pump. This is an important consideration in portable receivers such as a cellular phone. The FAN5607 generates very little EMI noise, which makes it ideal for driving the white LEDs in a mobile phone display. If board space and EMI are not a concern, a charge pump may not be the appropriate solution. The tradeoff for smaller size is efficiency. The charge pump is not the most efficient boost regulator, so it is important to consider this impact when calculating the power draw on the battery.

Dimming Methods

It can be beneficial to vary the intensity of the lighting for either power consumption or aesthetic value. There are two common methods for dimming LEDs. The first method is a simple regulation of the current. Small changes in current create small changes in the intensity of an LED. That makes this a very easy process to control.

The second method is to use a pulse width modulated clock to vary the ON duty cycle of the LEDs. The average current through the LEDs is lowered as the duty cycle is decreased. The key consideration with this method is the frequency of the clock. The frequency needs to be high enough that no flickering is perceived. Generally, 1kHz or higher is sufficient. Both linear regulation and pulse width modulation have an affect on the colour of a white LED, but they have an opposite affect.

The vast majority of white LEDs are simply a blue LED that has been coated with phosphor. The electrons in the phosphor are excited by the short wavelength light and they radiate a white light. The colour, or chromaticity, of a white LED will change as a result of a change in light amplitude, peak wavelength, or the shape of the spectrum. These will change as the junction temperature changes.

Employing a linear current regulation dimming method will cause the white LED to become more yellow, because the phosphor becomes more efficient as the current decreases. Employing a pulse width modulation dimming method will cause the LED to become bluer, because the phosphor becomes less efficient. This effect is due to a shift in the peak wavelength to a shorter wavelength.

Both, the FAN5607 and the FAN5608, allow for the implementation of either dimming method. They each allow for a varying analogue input that will linearly regulate the current. Both parts have an 'enable' that can be pulsed to turn the output on and off. The ideal dimming method would employ a combination of both methods to minimise the colour shift.

Efficient Lighting

The use of LEDs is an efficient method to light the display in portable devices. Since their essence is a semiconductor, they require unique means of regulation.

Charge pumps and inductive boost regulators provide the best source of power but there are advantages to each that should be considered for a specific application. The importance for efficiency, minimal EMI radiation and smaller size will indicate the appropriate driver to use.

Another important factor is the dimming method. The combination of pulse width modulation and linear regulation provides a consistent dimming method while minimising the shift in colour. Providing consistent light from LEDs is not a challenge, but the solution should be tailored to the application so the maximum benefit can be realised. ■

TONY ARMSTRONG, PRODUCT MARKETING MANAGER IN THE POWER PRODUCTS GROUP AT LINEAR TECHNOLOGY ADDRESSES THE DESIGNER'S DILEMMA OF THE BEST LIGHTING TO USE IN DISPLAYS AND HOW TO DRIVE THOSE

RGB VERSUS WHITE LEDS – THE TRADEOFFS

The LED driver ICs used to drive white LEDs commonly found in the backlighting of small displays in many handheld battery-powered portable products represent approximately 50% of the total LED driver market. However, this application has matured and does not have significant compounded annual growth rates (CAGRs) over the next five years.

The three largest market segments with growth rates far greater than that of the handheld backlighting market segment for LED lighting applications are automotive headlamp illumination, followed by large LCD TV and, finally, general-purpose lighting.

Nevertheless, calendar 2007 was a pivotal year for the adoption of LEDs into what will become a mainstream business for many analogue IC suppliers. During the course of the last twelve months, some key metrics were met by the LEDs themselves, which will translate into a significant increase in the demand for the LED driver ICs necessary to power them in all kinds of end applications.

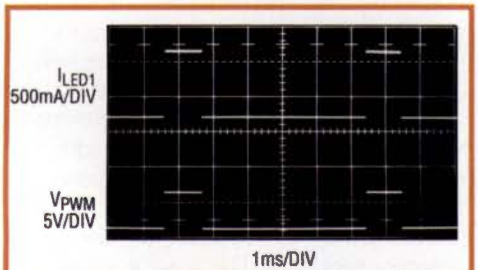


Figure 1: LT3476 PWM/LED current waveforms

But, despite these significant advances, more can be done in terms of the efficiency of energy conversion, thermal management and production costs. For example, LED efficiency has made dramatic gains. These improvements result from better light generation (> 100 lumens/Watt) within the chip and a better means of extracting the light from the chip and its package. Similarly, the selling price of 20mA white LEDs has made substantial reductions. When initially introduced, volume prices were a nominal $1. Today, it is possible to purchase these 20mA white LEDs for less than 20 cents in high volumes.

Some LED Light Output Basics

All of these advances have not only fueled the adoption of LEDs as a lighting source in different applications, but have also simultaneously driven the demand for LED driver ICs to power them. To understand the obstacles for the design and manufacture of these LED driver ICs, it is necessary to understand what a white LED requires in order to produce light.

A white LED must be driven by a constant current source so that the white point of the light does not shift, that is it must be uniform. Furthermore, since the white LED is a diode, its internal forward voltage (Vf) drop has to be overcome. This Vf varies with the current rating of the white LED and will also change with temperature. A typical 20mA white LED has a Vf that varies between 2.5V and 3.9V over the entire operating temperature range.

Most applications use more than one white LED and can also have these LEDs configured in parallel, in series, or a combination of both, for example, parallel strings of LEDs in series. This means that white LED driver ICs must be capable of delivering sufficient current and voltage for the specific configuration of LEDs, and in a conversion topology which satisfies both the input voltage range and required output voltage and current requirements.

The Designer's Dilemma

Cold Cathode Fluorescent Lights (CCFLs) used to backlight displays have a limited colour spectrum and also lack colour vividness; whereas an RGB LED actually expands the range of visible light.

Furthermore, CCFLs exhibit about 80% of the National Television System Committee (NTSC) defined colours, while RGB can reveal up to 110% of the NTSC colour spectrum, enabling a more accurate representation of images on the screen. The largest possible colour spectrum is achieved by using three monochromatic light sources such as red, blue and green lasers (RGB).

On the other hand, white LED backlighting is well-suited for handheld and mobile display panels since they have small form-factors, are simpler to drive, are less sensitive to mechanical stress and have twice the life expectancy when compared to CCFL. However, white LEDs share the same disadvantage in colour spectrum as CCFL because a white LED is equivalent to a broadband light source. A white LED is a blue diode covered with phosphor to convert a portion of the blue light to yellow light. This combined spectrum is perceived as white light.

Nevertheless, RGB LEDs come closer to delivering a narrow-band spectrum at a fraction of the cost of monochromatic light sources. Not only do RGB LEDs improve the colour spectrum, but they also improve efficiency as well because RGB LEDs only emit optical energy as needed – red, green and blue.

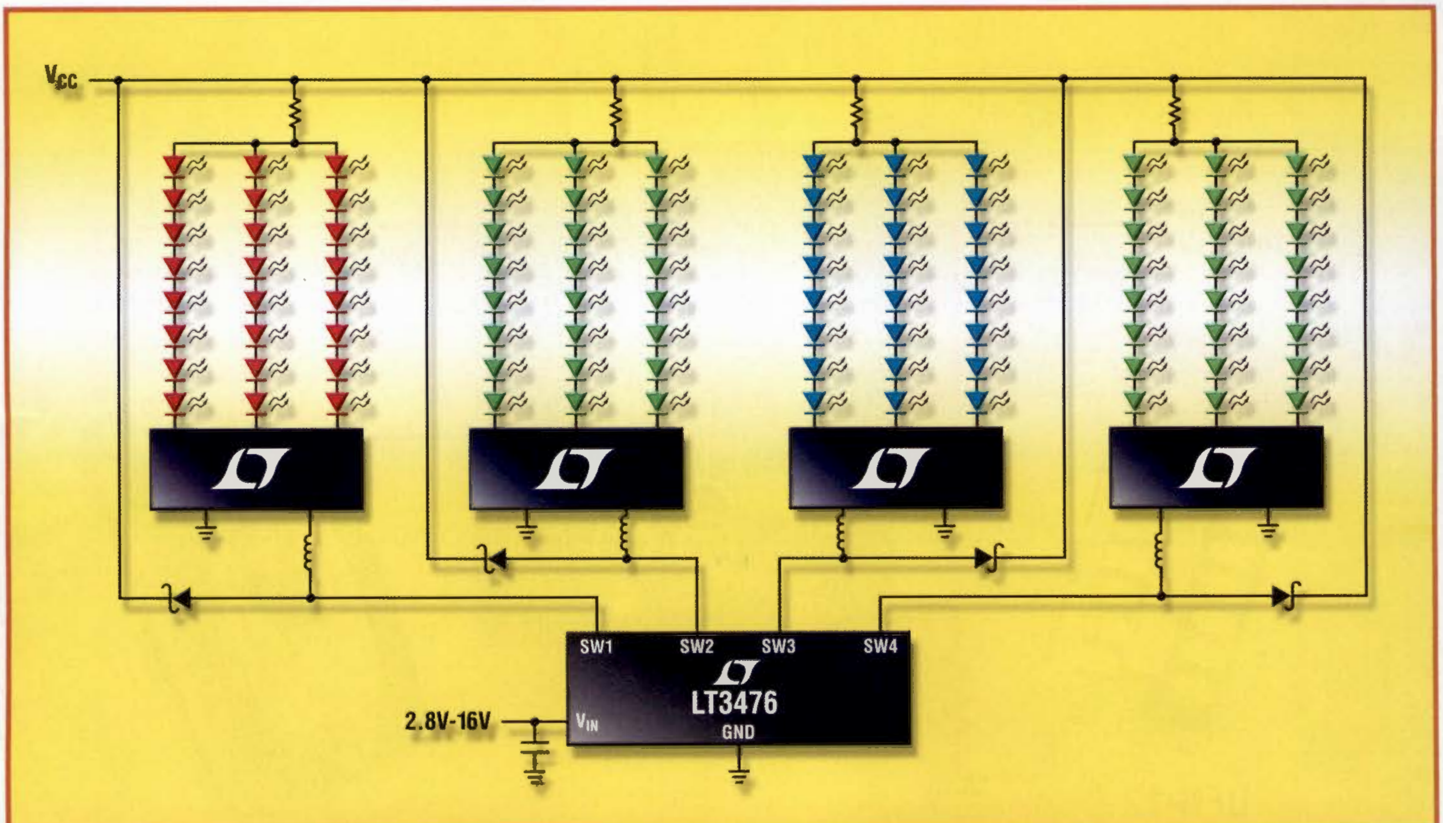


Figure 2: The LT3476

Broadband light sources such as white LEDs and CCFL have a relatively high presence of unwanted colours that deteriorate the colour spectrum and therefore cause a loss in efficiency. Since individual colours can be driven independently, the white point, or the colour temperature of an RGB LED, can be corrected – whereas both CCFLs and white LEDs have a fixed white point.

As a result, many designers face a dilemma when deciding on how to backlight their LCD panels. Should they use white LEDs or should they use an RGB light source which has a purer white light? Part of their answer to this question lies in yet another question: "What are the issues associated with driving either of these light sources?"

There is no doubt that white LED drivers and RGB drivers differ from each other. For example an inductorless low noise LED driver IC designed to drive low-profile RGB LEDs in portable electronic device displays or general backlighting applications has different performance criteria versus a standard white LED driver IC. This is due to the fact that an RGB LED has a different forward voltage than that of a white LED, thus requiring a different IC architecture.

Typically, an RGB LED driver will have a single-wire ON/OFF interface and three individual resistor-programmable LED current sources to control dimming and brightness. Furthermore, a "white" mode would be used to optimise the red, green and blue LED current ratios for optimal white colour when all three RGB LEDs are programmed ON.

Cost Implications of RGB versus White LEDs

The selection of either an RGB or white LED as a backlighting source may be applicable based upon specific end-products' requirements. Nevertheless, it is justified to use RGB LEDs instead of white LEDs due to the expanded colour spectrum that significantly improves picture quality, because consumers will pay a premium for colour vividness when deciding between LCD TV models, for example.

However, using RGB LEDs involves a larger, more complex and more costly solution. Thus, in applications where the expanded colour spectrum is not going to allow the end product to have a price premium, the white LED solution as the backlighting source is an acceptable one.

Dimming Considerations

Traditionally, dimming of LEDs has been done by adjusting the forward current flowing in the LEDs via a DC signal or a filtered PWM. Reducing the LED current adjusts the intensity of the LED light output; but a change in forward current also changes the colour of the LED as the chromaticity of the LED changes with the current.

Many applications, such as automotive and LCD TV backlighting cannot tolerate any shift in the colour of the LED. Wide dimming ranges are needed in these applications because of the different light variations in the ambient environment and the fact that the human eye is sensitive to minor changes in light intensity. Controlling the intensity of the LED via applying a PWM signal allows dimming of the LED without changing the colour.

There's a product called *"True Colour PWM dimming"* that dims an LED via a

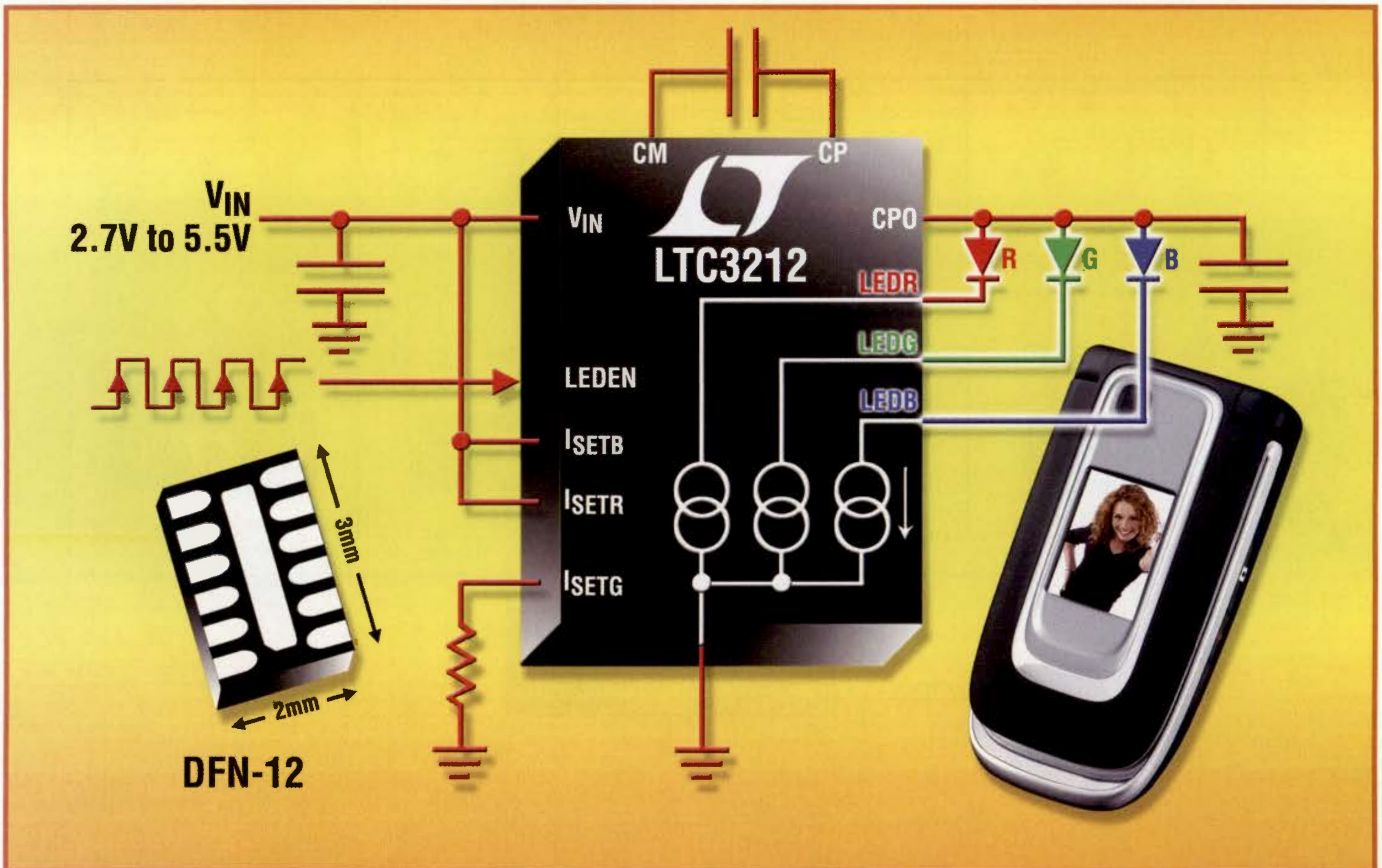


Figure 3: The LTC3212

PWM signal. It essentially involves turning the LED on and off at full current at the PWM frequency (see **Figure 1**). The human eye has a limit of 60 frames per second. By increasing the PWM frequency, 80Hz to 100Hz for example, the eye can be deceived into believing that the pulsed light source is continuously on.

Additionally, by modulating the duty cycle (amount of "on-time"), the intensity of the LED can be controlled. The colour of the LED remains unchanged in this scheme since the LED current value is either zero or a constant value. Many LCD TV designers are requiring dimming ratios of upward of 3,000:1 to adjust to a wide array of ambient lighting conditions.

Practical Driver Solutions

One example of an RGB LED driver would be Linear Technology's LT3476 Quad LED driver. Each channel of the LT3476 can drive up to 8 1A LEDs in series (red, green, blue or white), enabling the device to drive up to 32 x 1A LEDs while delivering efficiencies of up to 96% (see **Figure 2**).

Each of the four channels is separately operated by a True Colour PWM signal, enabling them to be dimmed independently to ratios as high as 1000:1.

The LT3476 senses output current at the high side of the LED enabling buck, buck-boost or boost configurations. With an external sense resistor, the user programs the output current range of each channel. Each of the four independent driver channels utilises an internal 1.5A, 36V NPN switch. In addition, its thermally-enhanced 5mm x 7mm QFN package offers a very compact solution footprint for 100w LED applications commonly found in large LCD TVs.

Another example is the inductorless low noise LED driver IC designed to drive low-profile RGB LEDs in portable electronic device displays and lighting applications. RGB LEDs have different forward voltages than white LEDs, thus requiring a different IC architecture. The LTC3212 is capable of driving three LEDs at up to 25mA each from a wide input voltage range of 2.7V to 5.5V and is optimised for single cell Li-Ion/Polymer battery applications (see **Figure 3**).

The LTC3212 has a single-wire ON/OFF interface and three individual resistor-programmable LED current sources to control dimming and brightness. White mode optimises the red, green and blue LED current ratios for optimal white colour when all three RGB LEDs are programmed ON. Quiescent current in standby mode current is only 400uA, maximising battery run-time.

Additional Design Complexity

Even though more RGB LEDs, and therefore RGB LED drivers, might be needed to backlight a display when compared to white LEDs, the colour spectrum and more accurate colour image are worth the additional design complexity.

Thus, the designers are left the classic 'cost versus performance' design trade-off when making the decision between RGB versus white LEDs for their backlighting needs. ■

CATCHING UP WITH CRYSTALS

KAZUTAKA HORI, PRODUCT MANAGER FOR PIEZOELECTRIC PRODUCTS AT MURATA CONSIDERS THE CASE FOR CERAMIC RESONATORS VERSUS CRYSTAL OSCILLATORS WITH PARTICULAR REFERENCE TO AUTOMOTIVE APPLICATIONS

Ceramic resonators have always been the more cost-effective alternative to quartz crystal oscillators. The latest technology and materials developments mean the performance of modern ceramics is gaining ground on crystals.

It used to be the case that in the automotive sector, ceramic resonators were thought of primarily as low-cost timing elements for microcontroller clocks, where tolerance could be overlooked in favour of size and price. But advances in materials and process technology have improved the performance of these devices, so they are now finding their way into automotive local area networks (LANs).

An automotive LAN is typically composed of a controller area network (CAN) bus joining together several electronic control units (ECUs). A CAN bus cannot tolerate high levels of jitter, and the wide temperature range experienced in automotive applications complicates things further.

Other applications for timing devices in cars include receivers for remote keyless entry (RKE) systems, which demand fast start-up to preserve battery life.

Piezoelectric Materials

Both crystals and ceramic materials exhibit the piezoelectric effect. This is a property of the material whereby applying an electric field results in its physical distortion. Conversely, when the field is removed, the material will return to its original shape, which generates a voltage. This vibration produces an electrical signal with precise amplitude and frequency, which can be used as stable clock signal.

A metric known as the electromechanical coupling factor indicates the efficiency of the piezoelectric material's conversion between electrical and mechanical energy. It is four or five times higher for ceramics than for crystals, that is, ceramic resonators can produce oscillations four or five times larger in magnitude for the same drive voltage. This means that ceramics can be mounted more rigidly and still produce adequate signal levels. As a result, they are less susceptible to external shock and vibration damage.

Start-Up Time

After initially applying the drive voltage, the time it takes for oscillations to reach full magnitude in the device is called the start-up time. This is an important factor for oscillators used in RF receivers for remote keyless entry systems. Powered by the car battery, these receivers poll for a transmission from the key fob intermittently to save power.

The car battery may seem huge compared to the power consumed by the receiver, but when you consider that it is polling frequently and that the car may be switched off for weeks at a time, this draw on the battery becomes significant. It's, therefore, important that each poll operation is completed as quickly as possible, which is where the fast start-up resonators come in. Most of the amplifiers in the receiver can come online in a relatively short time, but until recently the resonator start-up time has been a limiting factor.

Ceramic resonators have been developed that start up ten times faster than a crystal resonator. In recent tests, a typical crystal oscillator was found to have a start-up time of approximately 0.78ms. Compare this to the start-up time of a Murata Ceralock

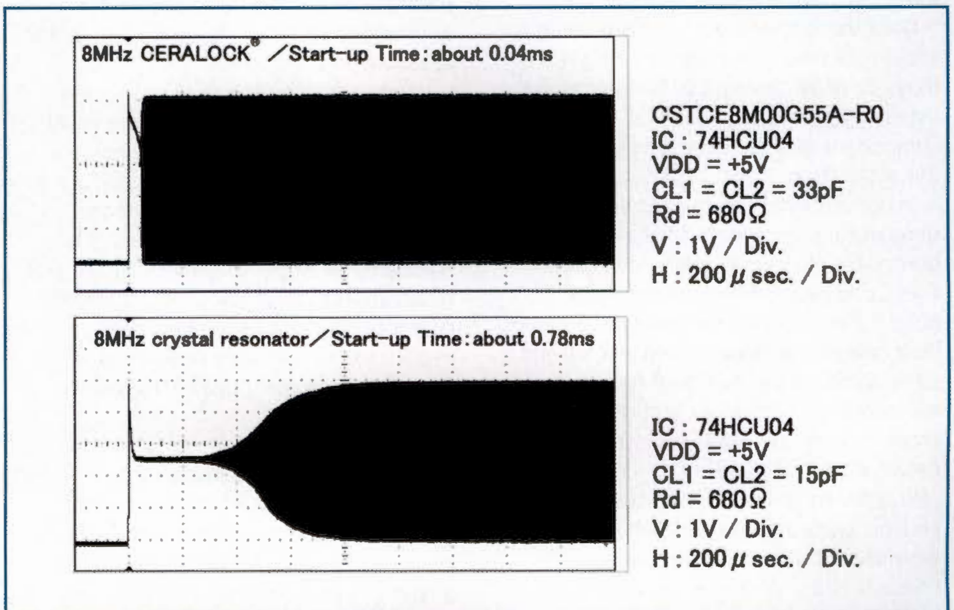


Figure 1: *Comparison of start-up time characteristics*

ceramic resonator oscillating at the same frequency, and the difference is substantial (see **Figure 1**). The ceramic part has a start-up time of just 0.04ms.

Size and BOM

Through improvements in processing methods and development of new materials, ceramic chip resonators are now available in packages as small as 0805 (3.2 x 1.2mm). Ceramic resonators are about half the size of their quartz counterparts.

It's also important to note that most ceramic resonators have built-in load capacitors – they incorporate the two capacitors needed for a Colpitts or Pierce oscillation circuit, saving space and reducing the system bill of materials (BOM).

In crystal oscillator circuits, an external resistor is often used to protect the crystal from extreme drive voltages, since they experience a breakdown of their piezoelectric properties under these circumstances. This isn't the case for ceramics, so the protective resistor can be eliminated, reducing component count further.

Tolerance

Resonator tolerance gives a measure of the accuracy of its output frequency. Tolerance can be defined as initial tolerance (the tolerance of the part dependent on material properties), temperature-dependent tolerance and aging effects. The part's overall tolerance is the sum of the three.

Data sheet tolerances usually refer to the initial tolerance; it is necessary to get a measure of all three parts to determine the overall frequency changes that the component may exhibit over the lifetime of the application.

In conventional ceramic resonators, temperature-dependent tolerance usually dominates the overall tolerance figures. These parts exhibited large swings in output frequency vs temperature, meaning their overall tolerance is between ±1 and ±2%. While this is sufficient for most microcontroller clock applications, it prevents their use in car communication networks.

In order to achieve tighter tolerances for ceramic parts, new materials have been developed that have better temperature characteristics. Where conventional products had a frequency shift of around ±0.4% over the range -40 to 125degC, using the new material this has been brought down to ±0.13% over the same range. Murata specifies operation of its parts up to 125degC as standard for automotive applications, with some parts available up to 150degC.

Figure 2: *Resonators offered by Murata*

Improvements in ceramic processing technology have also reduced the initial tolerance and the frequency aging substantially. The overall frequency tolerance of some of the most recent ceramic resonators is less than ±0.3%, compared to ±1% for earlier devices. This much improved accuracy means ceramic components are approaching quartz crystals in performance and are now a viable choice for timing in automotive LAN systems.

Jitter

Jitter is the unwanted fluctuation of a clock signal, typically caused by thermal noise, phase noise and spurious noise. Since crystal shave traditionally had tighter tolerances than their ceramic counterparts, it has often been assumed that ceramic parts exhibited higher jitter.

In fact, research has shown that this is not the case. In tests comparing ceramic and crystal parts, short-term jitter (period jitter) proved to be almost identical for both types, at around 10ppm at 8MHz. The CAN bus architecture is particularly intolerant of jitter; ±0.15 to ±0.5% is the maximum overall frequency tolerance allowable.

In the past, this limited designers to quartz crystals. More importantly for CAN bus applications, long-term jitter also proved to be very similar for both types of resonator.

Moving with the Times

Improvements in ceramic materials have made ceramic resonators viable in many applications where quartz crystals would previously have been specified. The smaller size, reduced external component count and greater ruggedness of ceramic resonators all contribute to their increased adoption in automotive and other applications requiring high accuracy clocks for microcontrollers. The lower cost of ceramic resonators is an added bonus. ■

AS THE WORLD OF DEVICE NETWORKING EVOLVES AND TECHNOLOGY ADVANCES, USERS AND MANUFACTURERS ALIKE ARE CALLING FOR MORE COMPLETE SOLUTIONS THAT OFFER UBIQUITOUS REACH, SAYS **MARK PROWTEN**, SENIOR PRODUCT MARKETING MANAGER AT LANTRONIX

PUTTING THE PIECES TOGETHER FOR TOTAL INFORMATION CONVERGENCE

There are several trends shaping the future of machine-to-machine (M2M) technology, including the move toward true autonomous control of networked equipment and a greater level of intelligence built into the machine infrastructure. But, what may have the greatest impact – actively propelling the M2M market toward substantial growth – will be the convergence of technologies that will enable an end-to-end solution for device control.

The Future of Machine Connectivity

For the past few years, analysts have touted M2M as a rapidly-growing market full of promise. Technologies such as web services, XML data schemas and RFID were expected to impact the market's growth, as is remote device server technology which effectively enables M2M communications and is the foundation for distributed device intelligence. The market for M2M is ripe with possibility due to the convergence of four major trends:

- The omnipotence of the Internet now connects everyone and everything quickly and easily.
- Users now expect continuous access to information.
- Users now recognise the need for and value of real-time information sharing.
- Technological advancements have lead to a reduction in both the size and cost of networking hardware and software.

But even with the huge expectations surrounding it, the M2M market has seen slower than expected growth. This is largely due to the fact that companies see the difficulties and risk of designing with disparate technologies needed to make M2M a reality. There is also uncertainty about the results and ROI (return on investment) of implementing these solutions.

There is no doubt that the technologies required to make M2M a reality is readily available, from hardware to software, user interface to server side applications. What has been missing is a single source to unify implementation. By putting all the pieces together, suppliers will inevitably create more advanced systems that make it easier to share information. For suppliers, this would mean finally demonstrating the significance of M2M. For users, it would mean having an "all-access pass" to access all the benefits of the M2M through connectivity.

The first step to moving toward total information convergence is the adoption of device networking technology within the market. While this has been achieved, the next step is for suppliers to provider the other piece of the puzzle. Once this has been achieved, vendors will be more likely to stick

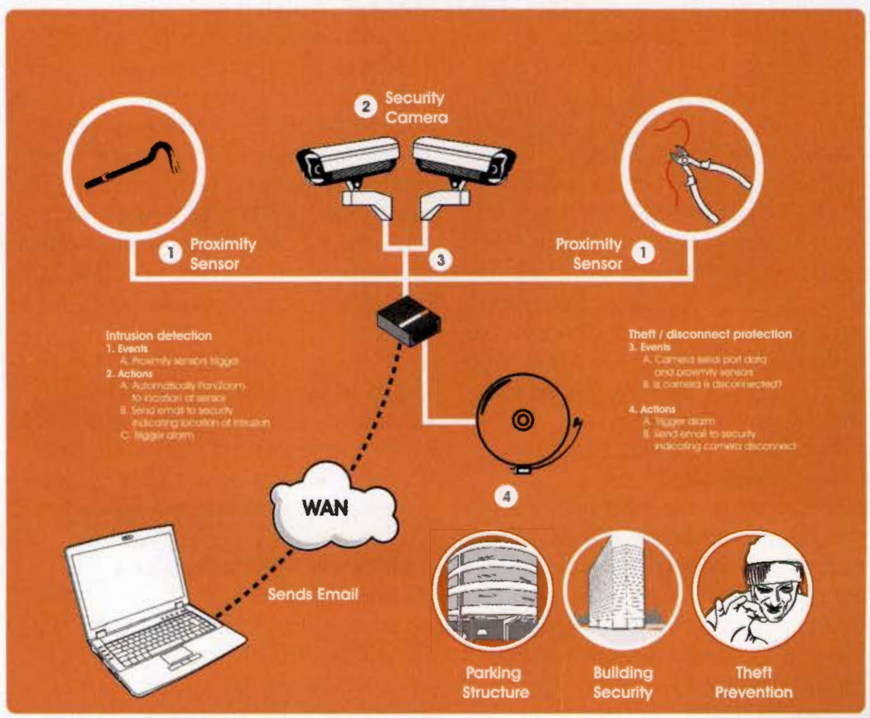


Figure 1: *Basic equivalent circuit of capacitor*

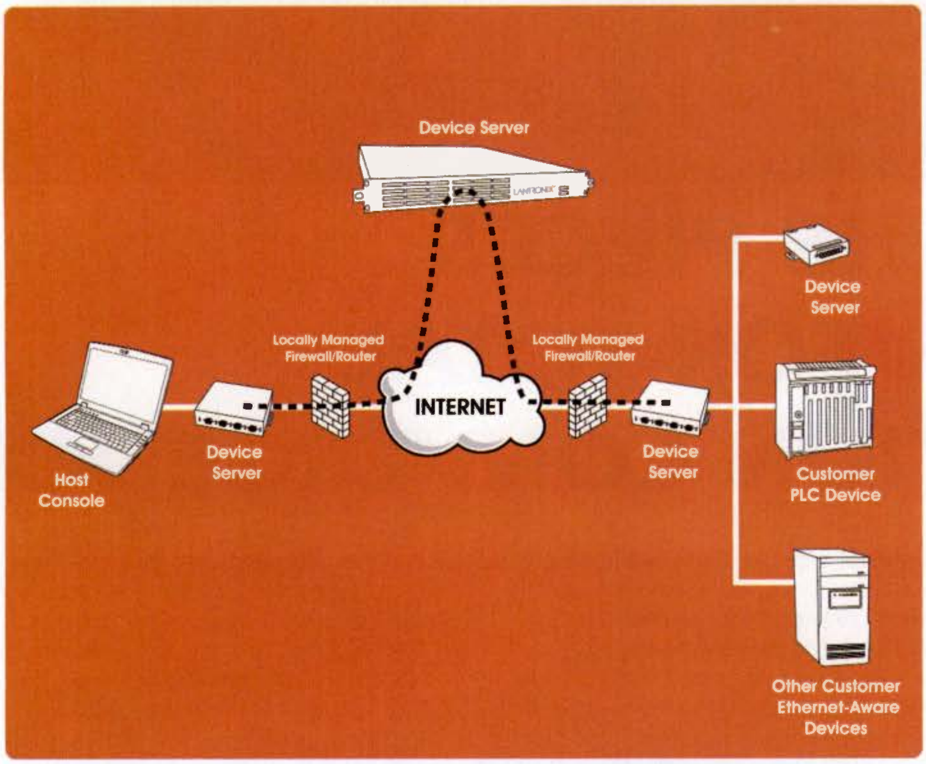


Figure 2: *Users must be able to easily establish two-way communication that works without weakening the firewalls*

with the same supplier, creating long-term partnerships that will drive the creation of complete solutions and grow confidence in M2M. Beyond that, suppliers can work together to create total solutions that will gain wider acceptance of the M2M promise.

M2M Application Possibilities

Remote device management via device servers allows users to proactively monitor usage and performance of equipment from anywhere, anytime. The ideal solution is one that is fully-automated, programmable and ubiquitously available to users. It should also be an effective end-to-end system that is capable of managing the complexities and inherent risks of implementing a comprehensive M2M solution based on otherwise incompatible devices.

With autonomous device control, users have the ability to anticipate and even prevent problems before they occur. When a problem does exist, they can remotely identify and diagnose it before deploying technicians, making repairs more efficient. In some cases, problems or actions that would typically be addressed by a technician or require human intervention could actually be handled automatically by networked equipment in real time.

The ability to utilise existing web tools to automate reporting and centralise device management leads to more efficient processes. Beyond internal operations, the application of remote autonomous device control can result in improved service for customers, thereby enhancing customer relations. Results are generated more quickly due to remote access to controls for problem detection, streamlining of diagnosis and repair, and the ability to partner with others to troubleshoot issues more efficiently.

Service management can also be improved through reporting tools, dashboards and metrics. Having access to usage and equipment monitoring data enables preventative maintenance, saving organisations from unnecessary downtime.

Real-World Applications and Technologies

As the promise of M2M states, the better technology gets, the more machines will begin to interact directly with each other and the network requiring less human intervention. Virtually everything that has anything to do with information management and control is now becoming Internet or Ethernet connected, meaning that machines are already working together. The efficiency this provides is phenomenal – a huge leap from the way businesses worked even a few years ago. Consider the following example, which illustrates the use of device servers for maintaining security in a facility.

Most large facilities have a number of security cameras placed in critical areas throughout their premises, which are generally connected to the network or Internet via device server technology. With the use of these device servers and networking technology, security guards can monitor all cameras remotely.

If an incident occurs, the security guards are notified, at which time they have the opportunity to manually locate the specific camera recording the incident and zoom in for more information. When a programmable device server is connected to the cameras, the security system can incorporate programs that will automatically pan and zoom the camera if a person walks by the camera, and, as defined by the user, not only trigger an alarm but initiate other associated events such as turning on the lights or reporting the identity based on a proximity reader or other identification systems.

Users can also program the device server to react to more than one event simultaneously. For example, if a wire is cut, or the door is not shut within the allotted time, the device server can trigger an alarm or notify security. The graphic in **Figure 1** shows how this might work.

With convergence comes end-to-end networking and communication. This means that an alarm can trigger other actions unrelated to the door to take place. For example, it can send an email to employees of a high security facility to lock down their workstations. It can also signal security to look for authorised personnel who should be walking through the doors at a given time and those who tend to prop the door open, then send an email to any violator's management to assure the event does not repeat itself.

Technology for Total Convergence

Device networking provides the ability to perform real-time diagnostics and repair, automate the capturing of data and the ability for the end user to be automatically and immediately notified of a problem. This can translate into improved efficiency,

Figure 3: The IntelliBox – I/O 2100 from Lantronix

reduced operating and maintenance costs and maximise uptime. In addition, networking can provide new service opportunities which can result in additional revenue streams.

This technology can effectively provide a gateway to a total convergence of information, providing a vehicle to connect nearly any piece of equipment to be managed from the desktop. In fact, device servers are already making convergence a reality today. With advanced technologies, incoming data from an attached device can be gathered and sent via email or RSS feed, allowing hundreds of devices to be simultaneously monitored from a single RSS-enabled browser. In order to maximise the potential for device server technology, the following elements must be assured:

❑ ***Cost-effectiveness*** – In order to make M2M cost-effective for users, basic embedded Internet/Ethernet connectivity must be achievable at less than $15 per node.

❑ ***Easy configuration*** – End users must be able to easily configure a programmable device server to monitor events and respond with pre-determined, user-defined actions. The majority of companies that design and use embedded devices are not networking specialists. Therefore, all hardware and software incorporated into a solution must be as plug-and-play as possible. Quick integration with the enterprise is also essential.

❑ ***Security*** – The device server must provide full product connectivity and offer a highly-secure connection via enterprise-grade networking security. This assures complete confidence on all ends of the network, from the end-user to their partners, customers and anyone else with approved access.

❑ ***Two-way communication*** – Users must be able to easily establish two-way communication that works without weakening the firewalls (see **Figure 2**).

❑ ***Scalability*** – Because connected devices will continue to evolve or be added to the network, scalability to support future applications and equipment is crucial. Embedded Internet/Ethernet connectivity should support a wide range of system performance and power consumption needs, and be operational in power hungry machines and portable battery-powered devices alike.

❑ ***Reliability and stability*** – Access to information is only as good as its connectivity. Reliability, stability and self recovery become as important as data provided.

❑ ***Intelligence*** – Intelligence at the edge allows for monitoring and initiating complex events and autonomous interaction between nodes or device servers.

Putting it All Together

As stated previously, the only way to take M2M to the next level is for suppliers to partner together to create comprehensive end-to-end solutions. For example, a patient bedside monitoring system may include the following devices: device server, local appliance for data storage, nurses station display system, patient room display system, remote server for offsite storage and record keeping, diagnostic application, remote user interface for doctors and tie in with hospital's ILM system. In addition, knowledge of hospital networks, firewalls, software as service and managing secure remote user are required to complete such a solution.

This demonstrates how quickly a complete solution becomes very complex and beyond a single vendor today (note this is a relatively simple solution example). This can be overcome by collaboration and partnership between different vendors specialising in a subset of technologies required. These include, but are not limited to, connectivity hardware, device server application, Graphical User Interfaces (GUI), aggregating application, specialised storage devices, local appliances for storage and user interface, and interfaces to local network including routers and firewalls.

When these elements are in place, device server technology becomes the means to connect the user to just about anything he needs access to, and to share these resources with others in his collective but secured "community".

Total information convergence is both necessary and technologically possible today if suppliers can partner together to make M2M a common goal. End-users now understand and appreciate the value of sharing information in real time, thanks to the advancements in networking hardware and software, and the vast ubiquity of the Internet.

Much like the convergence of features and services that catapulted the Smartphone market, M2M total convergence will take on considerable importance as those suppliers who support it provide OEMs with full end-to-end solutions that give users the freedom, flexibility and immediate remote access to the intelligence they need. Once that happens, M2M will go from being a novelty that sets users apart from their competition to becoming a necessity for providing customers with the services they require. And it won't take long. Remember when the now-mandatory cell phone was merely a luxury enjoyed by only a few or only used for phone calls? iM2M anyone? ■

Example of Autonomous Network

One example of autonomous network control is EventTrak technology from Lantronix. EventTrak is scripting language which enables the ability to monitor events and take appropriate action(s). When an event occurs, automatic pre-determined, user-defined commands are sent to the equipment causing it to take appropriate and/or corrective actions – all without any user intervention. Notification can be sent via email when an event is detected and handled accordingly.

EventTrak allows users to specify "chain definitions" (series of events/ actions) that can be not only be saved, stored and transferred from one device server to another but also allow interaction between multiple device servers, providing a great deal of flexibility for large-scale deployment (see Figure 2).

EM Radiation from Bulbs

I read the *'Looking at Light Bulbs'* article in the March issue of Electronics World (p43) with great interest. It should be made compulsory reading for many of our do-gooders.

Just two comments though: There should be more stress on the low light from the low energy bulbs. There are some texts that I can only read with the old tungsten bulbs.

You do not mention electro-magnetic radiation from the 'new' bulbs. You can test this yourself. Hold a portable radio near a bulb and listen to the buzzing.

I'd just like to add: keep up the good work!

Dennis Kaye

Chris Williams from the UK Displays & Lighting (UKDL) Knowledge Transfer Network replies:

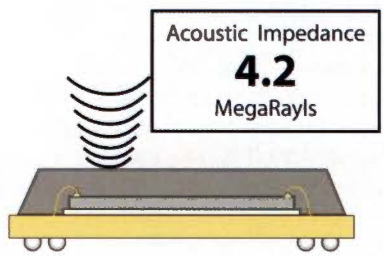
Thank you for your letter about my article on compact fluorescent lamps. Your comments about the low light levels are absolutely correct: when measuring the number of lumens that you get out from a Compact Fluorescent Lamp (CFL), and which can then be delivered for the user to perform a task, such as reading, it is very often the case that the old incandescent bulbs would perform better. What this means in terms of compromise for the average user is that if you are replacing a 40 watt incandescent bulb with a CFL lamp for use in a reading lamp, actually you would be better off getting "the next size up" CFL that is equivalent to a 60 watts or even 75 watt incandescent bulbs.

Your other comment about the electromagnetic radiation emitted from the CFL bulbs is also completely correct. The problem is caused by the need for the lamp itself to be driven at a frequency of several kilohertz, at a voltage of several hundred volts to achieve a stable plasma channel.

The power supply circuit designs that are used to create this high switching frequency are very clever, but are also built very cheaply, with next to no attempt to cut down or eliminate these unwanted emissions, resulting in these low power lamps having a power factor of around 0.5. This rotten power factor, coupled with the cheap circuit design, means that harmonics are fed back into the mains supply of the house itself and the lamp will also radiate electromagnetic interference.

It's interesting to note that if you buy a higher power bulb of any technology (more than 25 watts), it will have a guaranteed power factor of better than 0.9 – imposed by law – and that is you haven't seen the problem before.

It is frustrating that the "new" technology of CFLs that are supposed to be "environmentally friendly" can actually be implemented so poorly that it causes electrical interference and doesn't allow you to read properly.



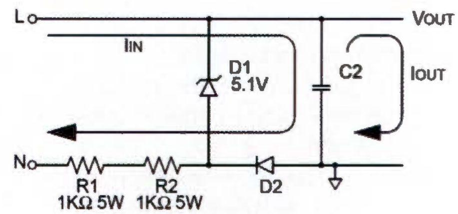
Checking for Lead

I was interested to read in the February issue of Electronics World (*'Steering Clear of Hybrid-Technology Boards'* on page 11) that measuring the acoustic properties of the moulding compound of a component can give a clue as to if it is lead-free. The writer admits that the method is not totally certain.

However, in looking through the Rapid Electronics catalogue for 2007, I found listed Lead Check swabs. These can be 'rubbed' on the surface in question and by a chemical reaction turn pink if lead is present. This gives a direct test, which must be more certain.

I have not tried them myself, but as they come from a reputable supplier, I am sure they perform as stated.

Sebastian Linfoot



Checking the Circuits

I looked at Figures 3 and 4 on pages 48 and 49 in the Microchip Tips and Tricks section in the April issue of Electronics World magazine and was appalled.

There should have been a prominent warning about the use of circuits that connect to mains voltages without the use of an isolating transformer. Such a warning was always given in EW in times past.

The lightweight comment under 'disadvantages' that the 'circuit is not isolated from the AC line voltage which introduces safety issues' is both irresponsible and unprofessional.

Isolating transformers exist for a very good reason – they protect the user, especially if the circuit gets connected to ground accidentally through test equipment or worse, through the user.

Furthermore, the circuit of Figure 4 will destroy itself by getting extremely hot – the resistors R1 and R2 will dissipate nearly 30W each, which exceeds the 5W rating shown by rather a large amount. It seems rather a waste to dissipate 60W to supply the few mA at 5V required by a PIC controller!

A small isolating transformer will dissipate very little power; it will probably use less space than two 30W resistors. It might cost a couple of pounds more but it is safe.

Doesn't anyone review these contributions before publication?

M Forbes MIET

Editor Svetlana Josifovska replies:
Resources on Electronics World or on any other technical title are so minimal these days (very much similar to what we see in our industry) that we cannot check every circuit in detail.

However, in each issue of the magazine, at the very front, usually on page 5, we do carry a disclaimer: *"We work hard to ensure that the information presented in Electronics World is accurate. However, the publisher will not take responsibility for any injury or loss of earnings that may result from applying information presented in the magazine. It is your responsibility to familiarise yourself with the laws relating to dealing with your customers and suppliers, and with safety practices relating to working with electrical/ electronic circuitry – particularly as regards electric shock, fire hazards and explosions."*

Standing the Test of Time
I like Myk's column (*'The trouble with RF…'*). He would be a very interesting fellow to talk to. He's very informative.

Your editorials (*'Editor's Comment'*) bring to light current 'thinking/problems' in the English electronics fields. I have been retired many years now and I wasn't going to renew my subscriptions to *Electronics World*, but I can't let go … Keep up the good work!

I'm not confident that Gary Nevison's columns will stand the test of time (I don't mean Gary's column itself, but the RoHS articles). Some materials like lead and mercury may not be able to be completely replaced by other materials.

I was designing/building experimental (one off) devices and equipment that was tested in aircraft, with physical size and weight being just some of the constraints. So, I started making experimental boards to accept gull-winged components (bending the through-hole legs). This was the time when any surface mount component had to be glued onto the PCB before it was soldered. I would not have that confidence with lead free solder.

Have lead-free soldered components been put into space and survived? (I have used tin lead solder, and cold weld bonding that survives harsh treatment.)

Also with Gary's column on the WEEE directive: There should be some place that electronic equipment can be recycled (reclaim materials) that is not attached to manufactures' outlets i.e. shops. I have many items that should be 'recycled' but the shops/manufacturers have gone out of business, so where do we take it to? There should be a depot in each town to take these items. (I live in Australia.)

John Ingram

Gary Nevison from Farnell and author of our RoHS column replies:
It is true that there is limited test data on lead-free solder and it is clear that it has different properties to lead-based solder. However, the general feeling is that it is no better or worse, just different.

As aircraft, trains, boats and space craft etc do not fall within the scope of RoHS, then there has been no real need to put lead-free 'into space'. Having said that, there are examples of satellites that have used lead-free with no resultant problems.

It was assumed by the European authorities – but never documented – that categories 8 and 9 (medical and monitoring and control instruments) were originally left out of scope because the equipment needed total reliability and solder was a key element of assuring that. However, there is now sufficient confidence for the recommendation to include these categories as part of the review of scope that is currently taking place.

In terms of WEEE, it is not a single market directive, so implementation differs in each European Member State.

Regarding shops and businesses going out of business, the approach in the UK would be that in the case of B2B (business-to-business) WEEE, the last user would be responsible for recycling; the view could be different in other EU countries. If B2C (business-to-consumer) then the local civic amenity facility, which is basically the "depot in each town", referred to in the letter, would be the responsible party.

As a final point, the current RoHS review is likely to result in more restricted substances with 46 plus a number of flame retardants currently part of a stakeholder consultation. While only one or two are likely to be added to the scope, further substance restrictions are inevitable over the coming months and years.

HARMONIC PHASE ANGLE AND POWER FACTOR MEASUREMENT

In several power system installations the loading conditions vary from time to time resulting in changing of reactive power and power factor. To increase the efficiency of utilisation of power and energy, power factor correction schemes are employed and followed in practice. For this requirement the actual power factor has to be determined and then corrected accordingly.

The variations in the loading systems, especially the reactive elements, cause the original sine wave to deviate from its shape, resulting in additional harmonics. Under such circumstances determining the power factor of the fundamental frequency alone may not be sufficient for the system analysis and power factor correction scheme. It will also need the power factor contributed by the first few significant harmonics to be determined and applied accordingly.

In several other applications the phase shifts encountered by a signal and its respective harmonics after passing through the system need to be studied under varying system parameters. Therefore, measuring harmonics phase angle becomes important under these circumstances. This article describes the circuits for measuring the phase angles of harmonics of a signal, and their digital display in degrees. Also, with minor changes, a circuit measuring and displaying harmonic power factor is reported.

Consider two sine wave signals of frequency 'f' differing in phase given below:

$$A = X. \sin(2\pi f\, t + K1) \quad (1)$$

$$B = Y. \sin(2\pi f\, t + K2) \quad (2)$$

The phase shift between the two in radians is: $\theta r = K1 - K2$ (3)

The phase shift in degrees is:

$$\theta d = \theta r\,(180/\pi) \quad (4)$$

In most practical situations, the first few harmonics are significant, so we describe here the measurement of the phase shift of the fundamental, 2nd harmonic and the 3rd harmonic. **Figure 1** shows the schematic of the circuit for measurement and display. The signals denoted as A and B are fed to an array of high Q band pass filters having centre frequency at the fundamental, 2nd harmonic and 3rd harmonic respectively.

Active filters performing these tasks are quite popular and they are not discussed here. Digital filters can also be employed for improved frequency response characteristics of the filter and in this case each filter should be preceded and succeeded by an ADC (Analogue-to-Digital Converter) and a DAC (Digital-to-Analogue Converter) respectively. The

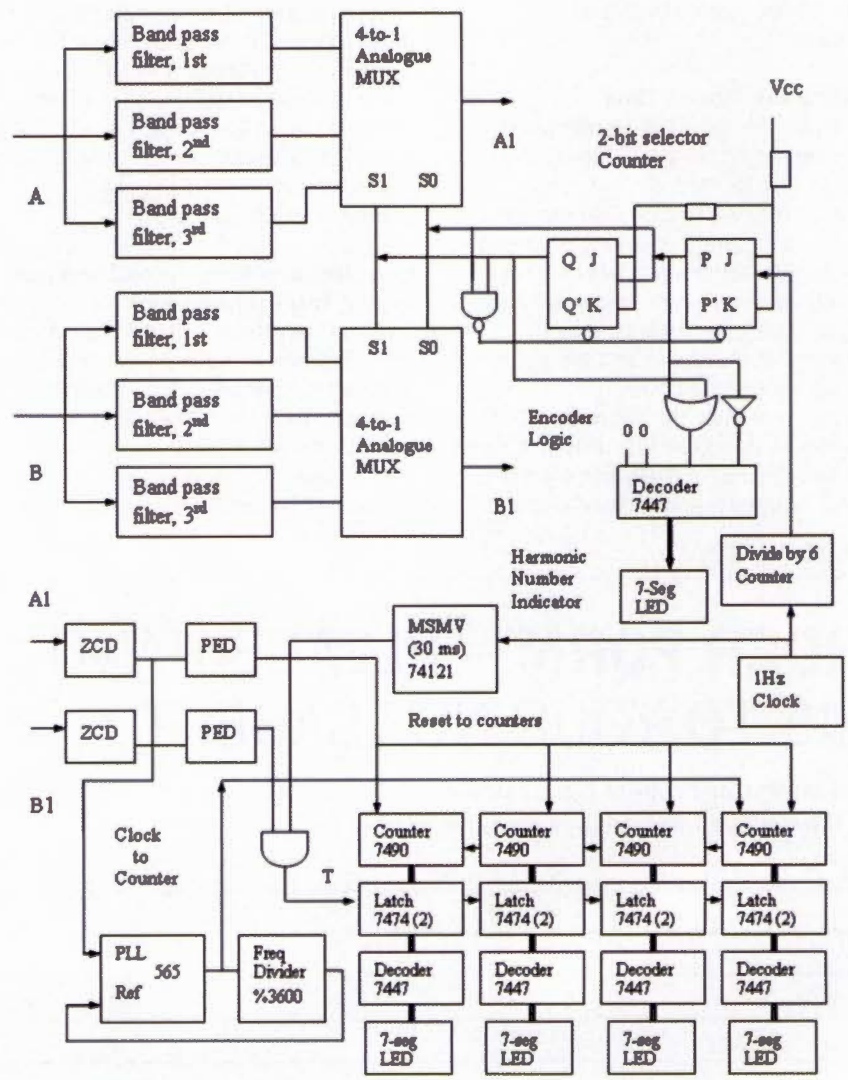


Figure 1

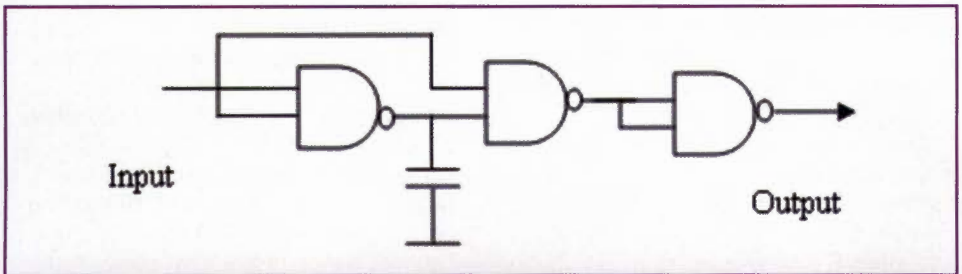


Figure 2

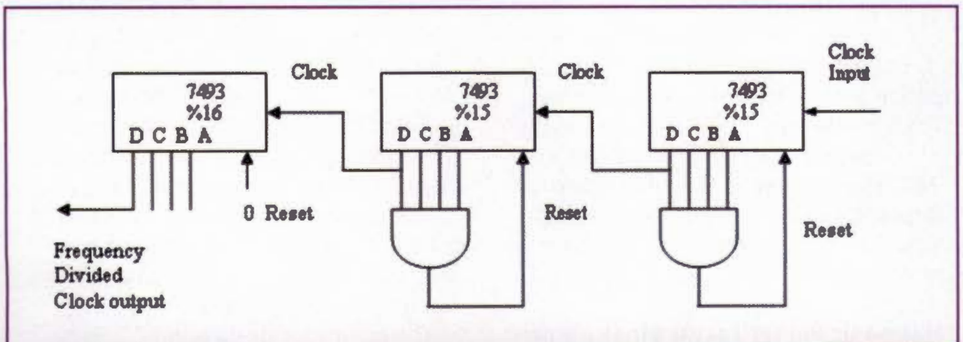


Figure 3

phase shifts of these three signals are sequentially measured and displayed.

Analogue multiplexers select one component (indicated as A1 and B1) at a time for measurement and display. The selector inputs to these multiplexers are driven by a 2-bit binary counter realised by JK flip flops (7476) and run by a low frequency (1/6 Hz) clock. The sequence created by the counter on Q and P (00, 01 and 10) is converted into another sequence (01,10 and 11) by an encoder logic, and after decoding this (BCD-to-Decimal Decoder, 7447) it is given to 7-segment LED for indicating the present harmonic status being tested and displayed. This makes each phase angle to be displayed for a 2-second period. When Q and P become '1' they are cleared by the NAND gate.

The selected harmonic signals A1 and B1 are zero-cross detected (ZCD, an analogue comparator, or op-amp, having reference input at 0V level) and their positive edges are identified (PED) for use

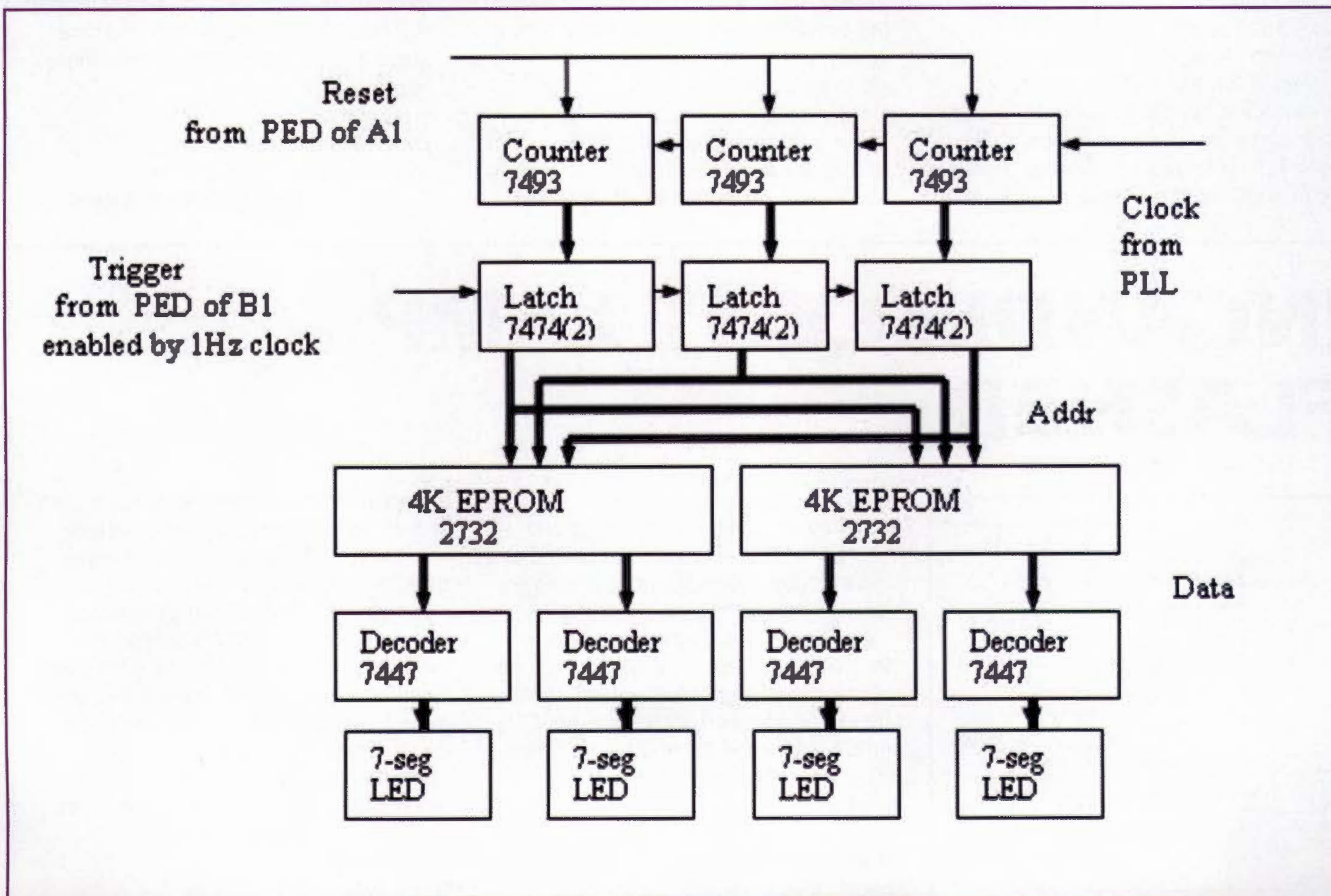


Figure 4

in a counter and display unit. A chain of four BCD counters (7490), each accompanied by latch (7474, 2 numbers), BCD-to-Decimal Decoder (7447) and a Common Anode LED (FND507) counts the clock for the time period corresponding to the phase shift between A1 and B1 and displays it as a four decimal digit in LEDs with an accuracy of one decimal; for example 115.4 degrees.

While the PED of A1 resets the counter chain, the PED of B1 takes the counted decimal value from the counters to the latches as enabled by the 1Hz clock, for static display until next trigger arrives. **Figure 2** shows a typical PED circuit realised using NANDs (7400) producing a rising edge.

As the fundamental and harmonic frequencies are different their counting time periods allowed by the signals corresponding to the same phase angle would be different. Therefore, it needs the clock frequency to the counter be adjusted in accordance with the frequency of the input. In one complete cycle we make 3600 counts such that the maximum phase angle display is 359.9 degrees. Each harmonic signal (or fundamental) is multiplied by 3600 and used as the clock to the counter chain. Using PLL (565) and a frequency divider of factor 3600, this frequency multiplication is achieved. While ZCD output of A1 is one input for PLL, the other input is taken from the frequency divider. The frequency of fundamental being 50Hz, the PLL output supplying clock to counter would have its frequency at 180KHz. **Figure 3** shows the schematic of the frequency divider realised by three 4-bit binary counters (7493) producing division factors of 15 and 16 in cascade. Resetting of divide-by-15 counters are achieved through ANDs (7408).

The trigger signal (T) to latches are combined with 1Hz pulse train with ON period greater than the period of the fundamental, say 30ms, realised through a monostable multivibrator (MSMV, 74121) as to update the information in display by every second. The display would be static within the latched period of one second.

Harmonic Power Factor Measurement and Display

As known, Power Factor of a power system is related to the phase difference (θr) between the voltage applied to the system and the current drawn by it and is given by $\text{Cos}(\theta r)$.

For measuring the harmonic power factor we use a major part of the circuit shown in Figure 1 with only the counting and display stage being different (as shown in **Figure 4**).

A 12-bit binary counter realised using three 4-bit binary counters (7493) addresses two 4K EPROMs (2732), where a table of two bytes of data corresponding to each possible power factor in BCD form is stored. Depending on the phase shift count made by the counter, the corresponding power factor from the EPROM is accessed and displayed.

Referring to Figure 1, for measuring the power factor we apply voltage input as A and current input (in voltage form) as B. As before, the harmonic is filtered and selected to get A1 and B1. Also, the selected harmonic number is displayed in the LED. Again the PED of A1 resets the 12-bit counter (Figure 4) and the PED of B1 enabled by 1Hz pulse triggers the latches to take the counter data to the address input of the EPROM.

The power factor data in BCD form given by data lines of the EPROM is decoded and displayed as 4 digits. Under demanding instances it is easy to extend the circuit for measurement of phase angle and power factor of some more harmonics, if needed.

Dr. K. Balasubramanian
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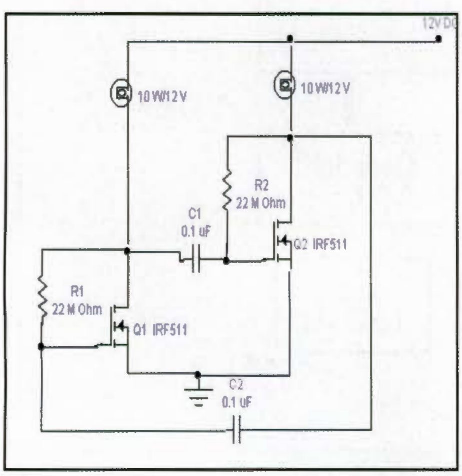
INCANDESCENT LAMP FLASHER



The given circuit (left) is for an 'Incandescent Lamp Flasher' using two IRF511 MOSFETs which are configured as a simple astable multivibrator to alternately switch the two lamps on and off.

The R and C values given set the flash rate to about 1/3Hz. By varying either the resistor or capacitor values almost any flash rate can be obtained. Increase either C1 and C2, or R1 and R2, and the flash rate slows. Decrease them and the rate increases.

Unlike most semiconductor devices, the power MOSFET can be paralleled, without special current-sharing components, to control larger load currents. This can be an important feature when the device is used to turn on incandescent lamps, because the lamp's cold resistance is much lower than the normal operating resistance.

A typical 12-14V volt lamp measures 6 ohms cold. When 12V is applied, the initial current drawn is 2A. The same lamp, when operating at 12V, requires only about 200mA. The hot resistance figures out to be ten times its cold resistance, or 60 ohms. That concept should be considered when selecting any semiconductor device to control an incandescent lamp.

D. Prabakaran
India

NICE TECHNOLOGY, SHAME ABOUT THE BOX

By Chris Williams, UKDL

It is a real shame that excellent examples of modern display technology are designed with the aim of making our lives easier and yet they are let down by the box they are mounted in.

I am specifically talking here about the use of Flat Panel Displays to provide travel information to the public at railways, airports and bus stations. If you go back several decades the choice was simple: if you wanted to create a multiple-line alphanumeric display to show text that can be easily seen from a distance of several metres, you would use the electro-mechanical "flip dot".

This simple device was based on matrices of small plastic discs, each coated on one side with a fluorescent paint and on the other coated black. The disc was attached to a miniature metal rod axle at its centre. Mounted on the disc was a small magnet and mounted behind the disc was an electromagnet that would change polarity depending on a received pulse from a remote electrical controller. Depending on which a positive going or negative going electrical pulse was sent to the electromagnet, it attracted or repelled the magnet on the disc, and this controlled which face of the disc was presented to the viewer.

The perceived information could be changed by simply sending a series of electrical pulses to the display board (many will remember the "clackety clack" of the rotating discs as all of the information on the boards was changed).

These simple display devices had excellent chrominance contrast that was maintained across a wide dynamic luminance range, or in other words, they were equally viewable in direct sunlight and in dim night-time illumination from lamps directed onto them. Unfortunately for us the passengers, these devices were electromechanical, and although the optical performance was superb, the mechanical reliability could be suspect: axles got damaged, plastic mountings (for low cost) would wear out and, when individual display elements failed, the cost of in-service maintenance was high.

This picture shows the old plasma screen installation at Waterloo station before it was ripped out and replaced with LEDs. The glare off the front face of the boxes is very clear, as is the lack of brightness of the plasma panel itself.

Enter high-technology! The first wave of high-tech display devices used in public information systems in the 1980s were signs assembled using multiple LED lamps. These used the commercially available coloured LED lamps and quickly exhibited unacceptable failure modes: the lamps, when driven at high brightness levels for extended periods of time, would exhibit differential aging characteristics with many of the lamps having different brightness levels. This was very unattractive and was quickly removed by various operators.

The next generation of display devices, again trying to replace flip-dot displays with higher-tech solutions, were plasma displays, introduced to the transport market in the 90s. Two problems here was that the plasma displays of that generation used CRT phosphors and not photoluminescent-specific phosphors. These phosphors were not suited to continual use whereby the same pixels are "on" for much of the time. Since this is exactly what is required in a public information display, the inevitable result was phosphor burn-in, with every display showing ghostly images of every previous line of information shown. Remember the horrible plasma displays at Paddington station before they were thrown out?

The second problem of course is one of brightness. No matter how much you turn

This picture shows very clearly the reflections off the front face of the box within which the FPD displays are mounted. It wouldn't matter whether the display was plasma or LCD, the reflections off this front surface would be just as bad

up the brightness control on a plasma panel, you won't get it to be bright enough to be seen in direct sunlight. And that is exactly what was asked of the plasma panels at Waterloo station, resulting in an installation that could never be "fit for purpose".

Enter the Liquid Crystal Display! Is this the answer to all of the problems? After all, it is (relatively) easy to engineer a super-bright backlight to allow the perceived brightness of the displayed image at the front of the display to be seen in direct sunlight.

Unfortunately, no. In spite of superb technology within the Liquid Crystal Panel itself, the panel has to be protected from the real world, things like dust, grease, rain, poking fingers, etc. So, this superb example of modern display technology is mounted in a well-sealed protective box with a transparent front cover, made of bulletproof glass (so it doesn't shatter when punched) or polycarbonate (for the same reason, often used because it is cheaper). The LCD displays can't display rows of characters as large as the old flip dot displays, which would be mounted high up above the heads of passengers. This physically smaller display unit (even though a 42-inch LCD panel mounted in portrait mode isn't exactly tiny) has to be mounted much closer to the viewing public in order for the display text to be read properly. To avoid prospective vandalism, as well as giving protection against the elements, it has to be in a box.

LCD panels are mounted in boxes with protective front panels in military and civil aircraft. These displays are perfectly readable by the pilot at 30,000 feet, even with direct sunlight streaming in from the window over his shoulder and onto the display. These displays use complex antiglare/antireflection filters to protect the glass of the LCD. Typically, less than 0.05% of the light that falls onto the surface of this filter glass will be reflected back towards the pilot. This allows LCD displays with modest front surface brightness (about 1000-1500 nits) to be perfectly viewable in the sunlight, with no possibility of misreading the information on the display. Pretty important, since we don't want pilots to misread 38,000 feet for 33,000 feet because he couldn't read the display properly!

Why don't public information displays use these same front panel filters? This is where cost hits us again. The problem is the filters cost about £5 (and above) per square inch in production volumes. In an aerospace display unit, the front panel filter will cost as much, or more, than the display itself. For a typical public information display (42", 16:9 aspect ratio), the cost would be around £1700 or above – more than the display + driver + rest of box. Although this would result in a display that would be viewable in direct sunlight, the cost increase would be staggering and totally unacceptable to the typical site manager's accountant.

To sum up the problem: an LCD display can be made sunlight-viewable if it needs to be mounted in a box for "protection", but the cost of the front panel filter is excessive. An LCD panel can be used "as supplied" in direct sunlight with a powerful enough backlight, but it will not be protected against the elements or against vandalism, and is likely to suffer a drastically reduced lifetime as a result.

What we need is for someone to invent a new low-cost process for making anti-reflection films that will reduce front panel reflections to around 0.5% or less, and which costs about £5 per square metre.

So, what did the technology companies supplying the public information displays do? Revert back to LEDs of course – assuming that "making it brighter" will solve the problem. Where this is done using best practice engineering, as in the video displays shown in the picture, this solution works at a high cost, but when it is implemented at a much lower cost, and

WHAT WE NEED IS FOR SOMEONE TO INVENT A NEW LOW-COST PROCESS FOR MAKING ANTI-REFLECTION FILMS THAT WILL REDUCE FRONT PANEL REFLECTIONS TO AROUND 0.5% OR LESS, AND WHICH COST ABOUT £5 PER SQUARE METRE

This picture, taken at Euston station, shows that a well-designed LED video wall can overcome the problem of reflections off the front surface. Sadly, the lower cost LED displays mounted adjacent to the video wall are mounted inside protective boxes and, again, ambient light reflecting off the surface of these displays reduces the legibility of the text

high brightness LEDs are simply mounted inside a box, all the normal problems with front panel reflections return.

The only conclusion to draw is that unless public information displays revert to the good old Flip Dot, or all displays are based on (high-cost) LED video walls, we will be forced to suffer readability problems in these displays for the foreseeable future.

Displays mounted in boxes intended for public viewing in bright light or sunlight conditions – regardless of display technology – just don't work!

(You'll recognise me at any station or airport – I'll be the guy squinting in the sunlight to try and read what the information on the display is.)

Chris Williams is Network Director at the UK Display & Lighting Knowledge Transfer Network (UKDL KTN)

PIC microcontrollers (MCUs) are used in a wide range of everyday products from washing machines, garage door openers and television remotes to industrial, automotive and medical products. While some designs such as Switch Mode Power Supplies (SMPS) are traditionally implemented using a purely analogue control scheme, these designs can benefit from the configurability and intelligence that can only be realised by adding a microcontroller.
intelligence that can only be realised by adding a microcontroller.

NOTE: The tips 'n' tricks presented here assume a 3.3V supply. However, the techniques work equally well for other supply voltages with the appropriate modifications.

TIP 1: GENERATING A TWO-PHASE CONTROL SIGNAL

Power supplies using a push-pull topology or with multiple switching components require a two-phase control signal as shown in **Figure 1**.

It is possible to produce this type of control signal with two out-of-phase square waves using a PIC MCU with an ECCP module.

In order to configure the ECCP to produce this type of output:

1. Configure the ECCP in half H-bridge configuration PWM pulse with both outputs active-high.
2. Set the duty cycle register (CCPR1L) with the maximum duty cycle of 50%.
3. Change the programmable dead-time generator to reduce the pulse width to the desired value.

The programmable dead-time generator has a 7-bit resolution and, therefore, the resulting pulses will only have a 7-bit resolution. Each pulse will have a 50% duty cycle, less the dead time.

Using an internal 4MHz clock produces 31kHz output pulses, and using a 20MHz crystal would produce 156kHz output. The frequency of the output could be increased with a loss in resolution.

Example software is provided for the PIC16F684, but this tip is applicable to all PIC MCUs with ECCP modules.

The software and referenced documents can be found on the Microchip Technology web site at **www.microchip.com.**

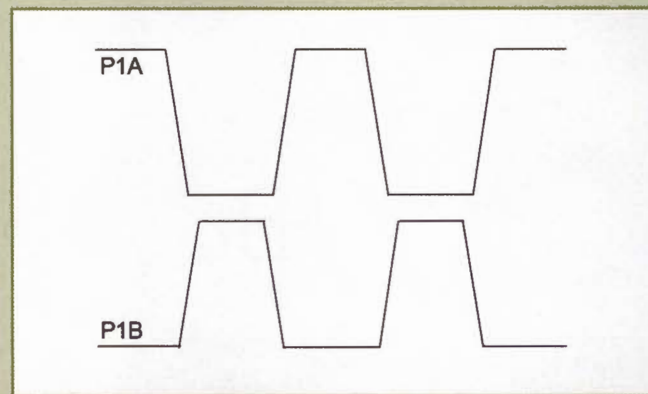


Figure 1: *Two-phase control signal*

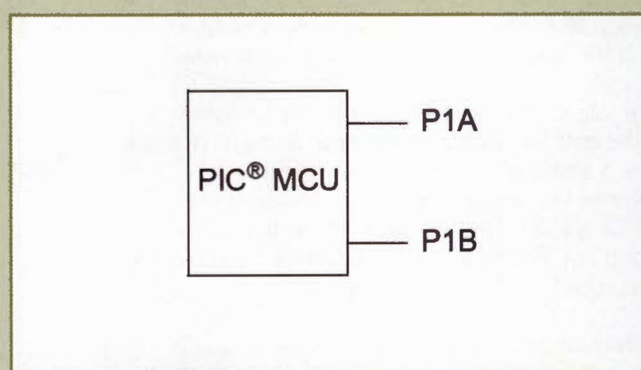


Figure 2: *Two-phase control signal schematic*

TIP 2: BRUSHLESS DC FAN SPEED CONTROL

Brushless DC Fan Speed Control

There are several methods to control the speed of a DC brushless fan. The type of fan, allowable power consumption and the type of control desired are all factors in choosing the appropriate type.

* **Method 1:** Pulse-Width Modulation

As shown in **Figures 3** and **4**, a simple PWM drive may be used to switch a two-wire fan on and off. While it is possible to use the circuit in Figure 3 without a high-side MOSFET driver, some manufacturers state that switching on the low side of the fan will void the warranty.

Because of this, it is necessary to switch the high side of the fan in order to control the speed. The simplest type of speed control is 'on' or 'off'. However, if a higher degree of control is desired, PWM can be used to vary the speed of the fan.

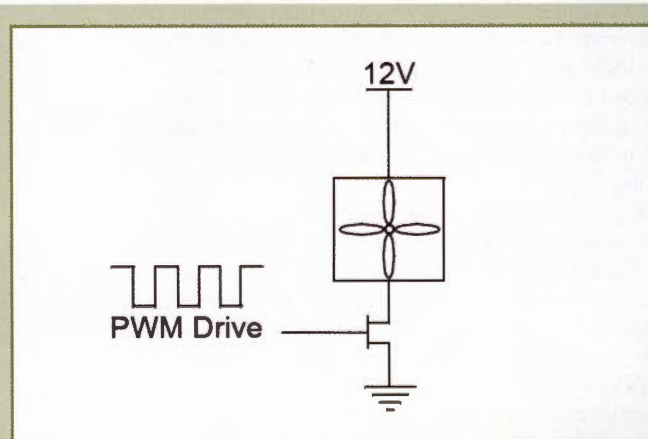


Figure 3: *Low-side PWM drive*

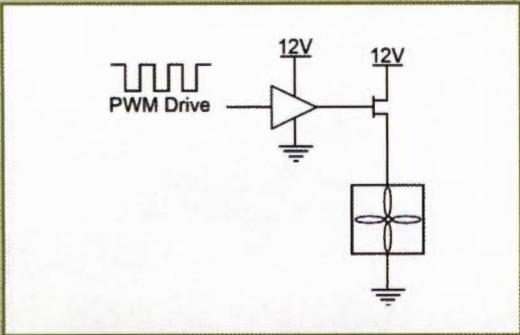


Figure 4: High-side PWM drive

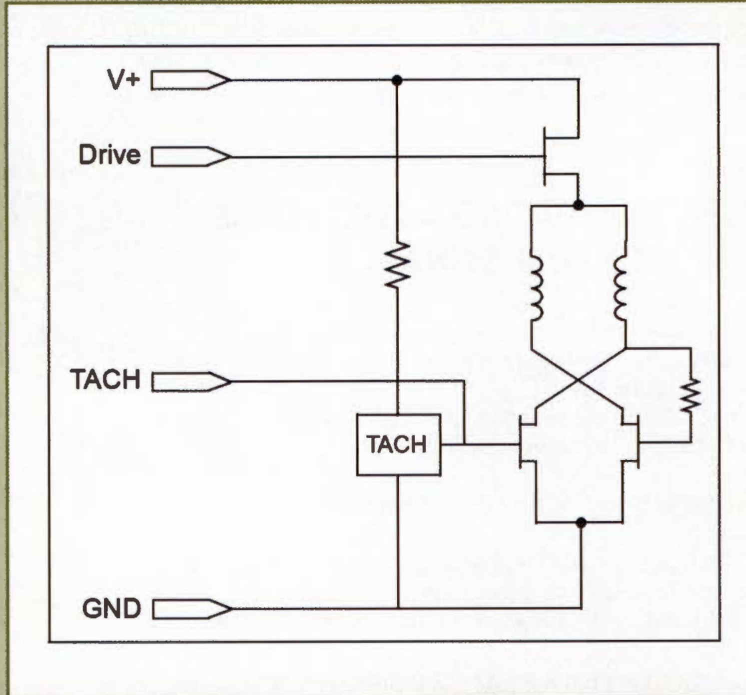


Figure 5: Typical 4-wire fan

For 3-wire fans, the tachometer output will not be accurate if PWM is used. The sensor providing the tachometer output on 3-wire fans is powered from the same supply as the fan coils, thus using a PWM to control fan speed will render the fan's tachometer inaccurate.

One solution to this is to use a 4-wire fan which includes both the tachometer output and a drive input. **Figure 5** shows a diagram of a 4-wire fan.

A 4-wire fan allows speed to be controlled using PWM via the Drive line. Since power to the tachometer sensor is not interrupted, it will continue to output the correct speed.

* **Method 2:** Linear Control

When using PWM, the voltage will vary between a maximum and a minimum, however, is it also possible to use a linear method to control fan speed, as shown in **Figure 6**.

The voltage applied at the non-inverting terminal of the op-amp is used to vary the voltage across the op-amp. The non-inverting terminal voltage can be produced by a Digital-to-Analogue Converter (DAC). When using this method, care must be taken to ensure that the fan voltage is not too low or the fan will stop spinning.

One advantage this method has over PWM is that the tachometer output will function properly on 3-wire fans. The disadvantage, however, is that it often offers less speed control. For example, a 12V fan will not spin below 8V, so a range of only 4V is available for speed control. A 5V fan will not spin below 4V and, so, the control range is only 1V, which is often unacceptable.

Another disadvantage is the power consumption of the circuit. The transistor will dissipate more power than the PWM method.

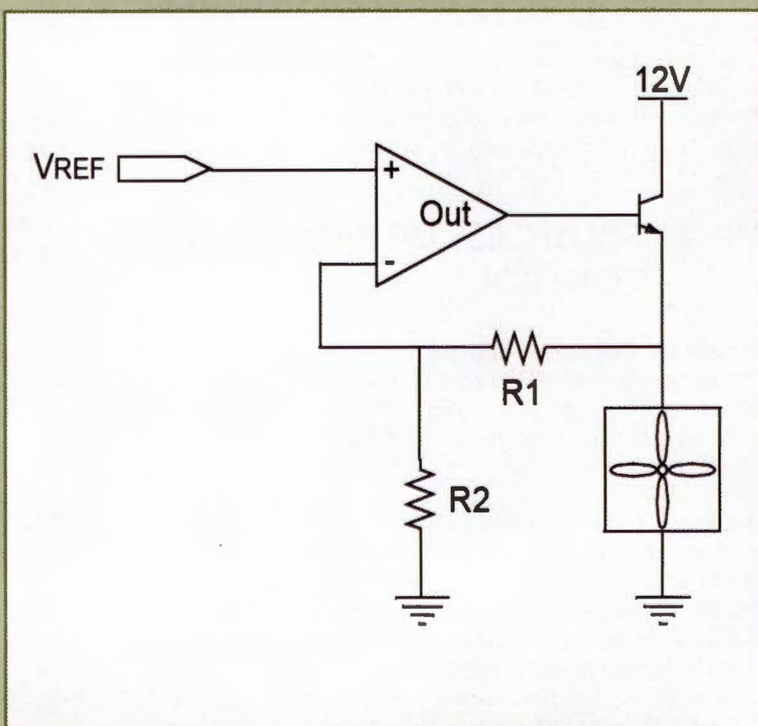


Figure 6: Linear control drive

TIP 3: HIGH CURRENT DELTA-SIGMA BASED CURRENT MEASUREMENT USING A SLOTTED FERRITE AND HALL EFFECT DEVICE

Many current sensors rely on ferrite cores. Nonlinearity in the ferrite can lead to inaccurate results, especially at high currents. One way to avoid the nonlinearities is to keep the net flux in the ferrite near zero.

Consider the circuit in **Figure 7**. The Hall Effect sensor output is proportional to the current being measured. When $I_{IN} = 0$ amps, the output of the sensor will be $V_{DD}/2$. A current passing through the sensor in one direction will increase the output of the sensor, and a current in the other direction will decrease the output of the sensor.

The output of the comparator is used to drive a coil of wire wound around the ferrite core. This coil of wire will be used to create flux in the opposite direction as the flux imposed in the core (see **Figure 8**).

The net flux in the core should be approximately zero. Because the flux will always be very near zero, the core will be very linear over the small operating range.

When $I_{IN} = 0$, the output of the comparator will have an approximate 50% duty cycle. As the current moves one direction, the duty cycle will increase. As the current moves the other direction, the duty cycle will decrease. By measuring the duty cycle of the resulting comparator output, we can determine the value of I_{IN}.

Finally, a Delta-Sigma ADC can be used to perform the actual measurement. Features such as comparator sync and Timer1 gate allow the Delta-Sigma conversion to be taken care of entirely in hardware. By taking 65,536 (2^16) samples and counting the number of samples that the comparator output is low or high, we can obtain a 16-bit A/D result.

Example schematic and software are provided for the PIC12F683 in both C and Assembly.

For more information on using a PIC MCU to implement a Delta-Sigma converter, please refer to AN700, *"Make a Delta-Sigma Converter Using a Microcontroller's Analogue Comparator Module"* (DS00700), which includes example software. The software and referenced documents can be found on the Microchip Technology web site at **www.microchip.com.**

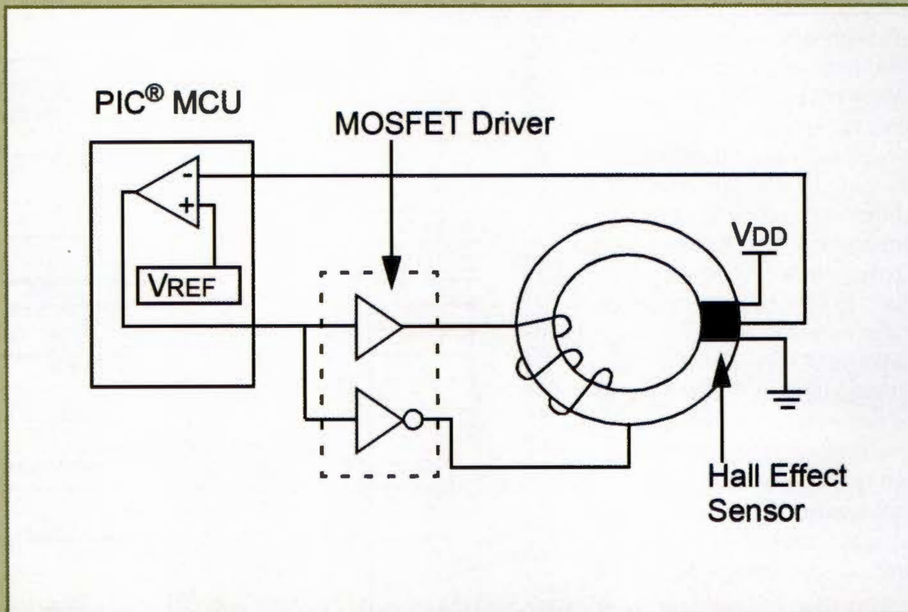


***Figure 7:** Hall-effect current measurement schematic*

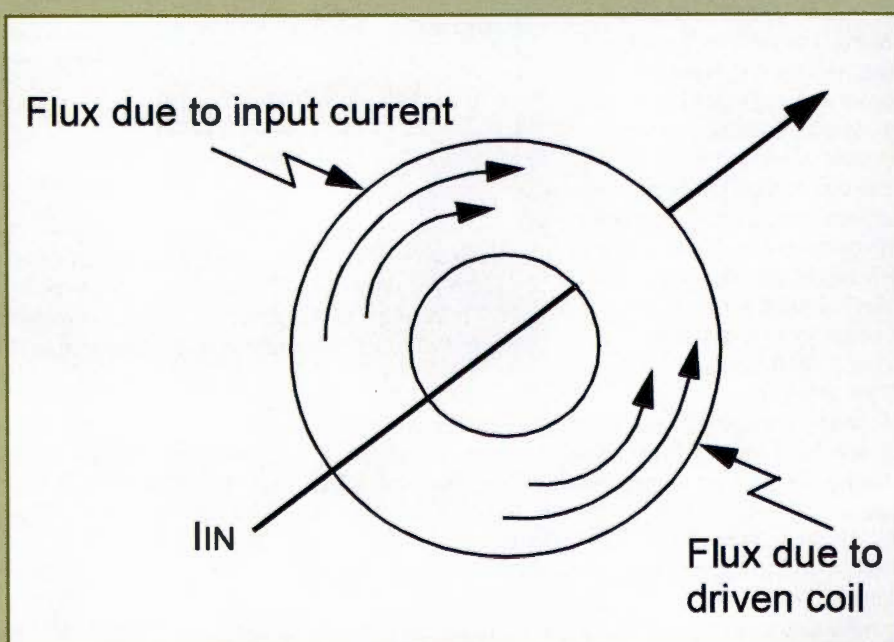


***Figure 8:** Hall-effect current measurement schematic*

TIP: FOUR-CHANNEL LED DRIVER LIGHTS THREE LED STRINGS AND PROVIDES CONSTANT VOLTAGE SUPPLY

By Hua (Walker) Bai, Applications Engineer at Linear Technology

The number of applications for LEDs is booming: backlighting for LCD TVs, LCD projectors and computer displays, camera torches and flashes, and automotive brake lights and taillights to name a few.

All require constant current LED drivers that offer high dimming ratio, high efficiency, precise adjustable current and low cost. Furthermore, to save space, some LED drivers are designed to light multiple strings of LEDs. For instance, Linear Technology's LT3476 can drive four LED strings, totaling 100W. If not all of the driver channels are needed for LEDs, leftover channels can be applied to the task of producing regulated power supplies, thus reducing the additional circuitry required by a separate power supply ICs.

This design idea shows how to do just that: use a single 4-channel LED driver to drive three constant current RGB led strings and use the fourth channel as a constant voltage source.

As an application example, an LCD projector requires three colour LED strings: red, blue and green. There are six 1A LEDs in each string, and each string is driven in a buck mode topology as shown in **Figure 9**. The LCD panel also requires a bias voltage source. The fourth channel provides the bias.

To use one of the LT3476 channels as a voltage source, the CAP and the LED pin of the channel need to be properly tied to the top voltage sense resistor. Channel 4 in Figure 9 is a boost circuit that generates a 15.5V output at 700mA from a 9V supply with 90% efficiency.

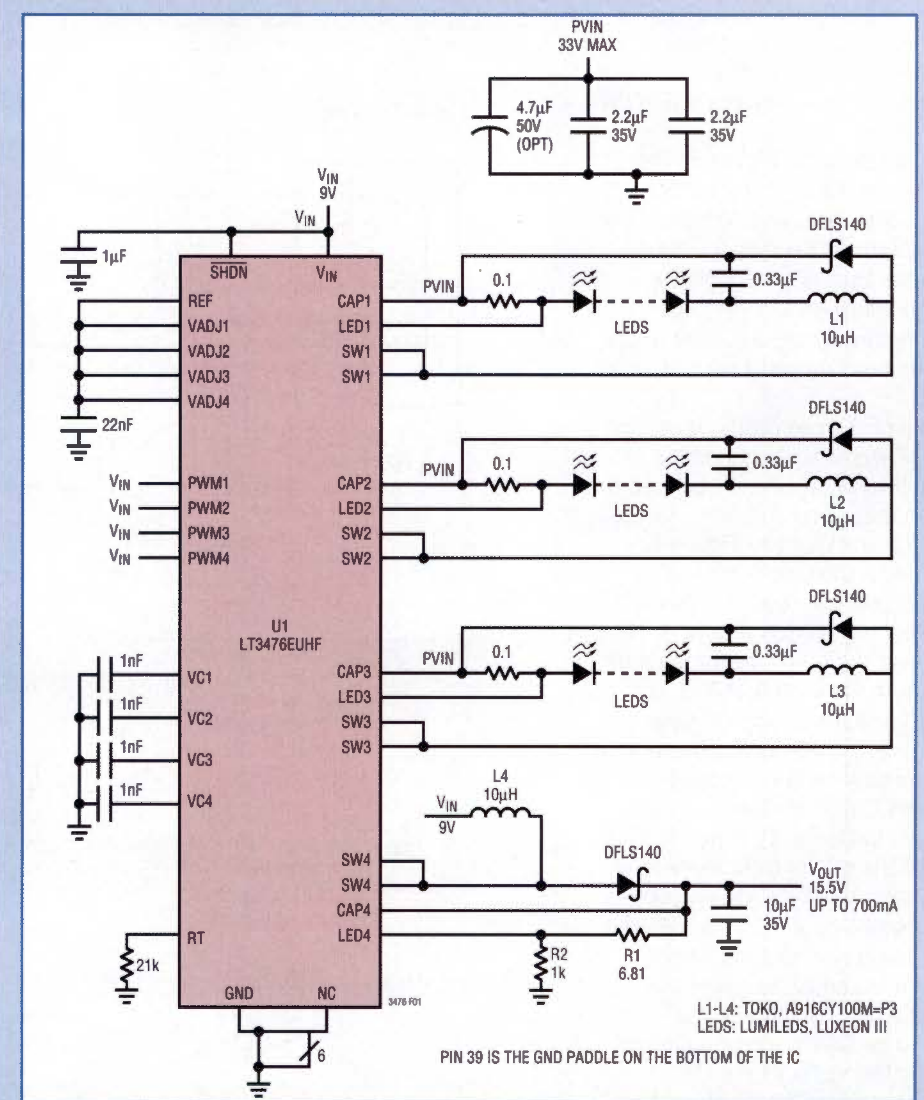


Figure 9: Here is a simple way to save BOM cost and reduce solution size in an LCD. A single-quad LED driver IC provides power for the LED backlight and the LCD bias of an LCD projector. Three of the channels drive R, G and B LED strings, while the fourth provides a voltage source in boost mode

In a classical voltage regulator design, it is safe to assume the voltage feedback error amplifier draws no current (10nA range) from the output. This assumption is not valid in the circuit shown in Figure 9.

The CAP pin and the LED pin bias current of the LT3476 are in the order of 70µA. This current level is necessary for the high side current sensing required to properly drive the LEDs. As a result, the values of the sense resistor R1 has to be low enough to limit the error caused by the bias current. The recommendation is setting R1 to less than 15Ω. Given V_{OUT} and R2, R1 can be calculated using the equation:

$R1 = R2 / (V_{OUT}/0.105V-1)$

In this equation, 0.105V is the regulated sense voltage between CAP and LED when the V_{ADJ} pin is tied to the Ref pin directly.

Here is a simple way to save BOM cost and reduce solution size in an LCD. A single-quad LED driver IC provides power for the LED backlight *and* the LCD bias of an LCD projector. Three of the channels drive R, G and B LED strings, while the fourth provides a voltage source in boost mode.

Win a Microchip PICDEM FS-USB Demonstration and Evaluation Board plus an MPLAB ICD2!

Electronics World is offering its readers the chance to win a PICDEM FS-USB demonstration and evaluation board and an MPLAB ICD2.

The PICDEM FS-USB is a demonstration and evaluation board for the PIC18F4550 family of Flash microcontrollers with full speed USB 2.0 interface. The board contains a PIC18F4550 microcontroller in a 44-pin TQFP package, representing the superset of the entire family of devices offering the following features:

48MHz maximum operating speed (12 MIPS), 32Kbytes of Enhanced Flash memory, 2Kbytes of RAM (of which 1 Kbyte dual port), 256bytes of data EEPROM, Full Speed USB 2.0 interface (capable of 12Mbit/s data tranfers), including FS-USB transceiver and voltage regulator.

The demonstration board provides the following functions:

20MHz crystal, serial port connector/interface (for demonstration of migration from legacy applications), connection to the MPLAB ICD 2 In Circuit Debugger, voltage regulation, with the ability to switch from external power supply to USB bus supply, expansion connector, compatible with the PICtail daughter boards standard, temperature sensor TC77 (connected to the SPI bus), potentiometer (connected to RA0 input) for A/D conversion demonstrations, 2 LEDs for status display, 2 input switches, reset button

The board comes pre-loaded with a USB bootloader that demonstrates the Enhanced Flash memory capabilities of the device. The PIC18F4550 can be re-programmed in circuit without an external programmer.

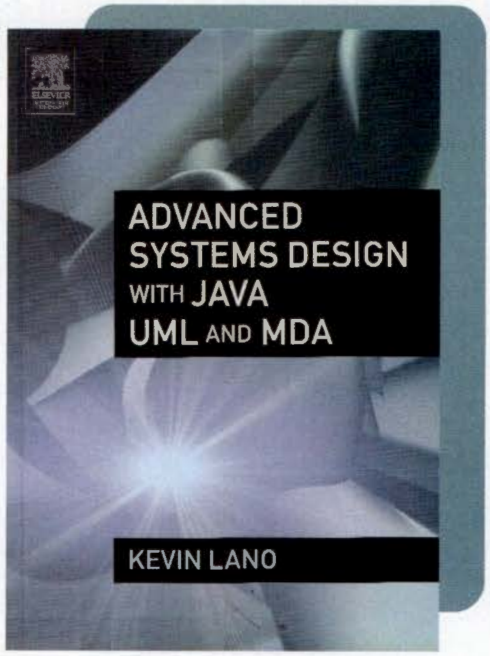
A CD-ROM is also included in the kit which contains full documentation about the board, application notes and software libraries for support of the HID, CDC and custom classes. Microchip is also giving away a MPLAB ICD2 to use with the PICDEM FS-USB Demo Board.

For the chance to win these development kits, please log onto **www.microchip-comp.com/ew-fsusb08**

ADVANCED SYSTEMS DESIGN WITH JAVA UML AND MDA

KEVIN LANO

ELSEVIER BUTTERWORTH-HEINEMANN



The increasing complexity of electronic systems and the relentless pressure to bring products to market in ever shorter timescales pose a major challenge for system designers. Traditional methods of system design can no longer be relied upon to deliver working products economically under these conditions therefore new techniques and improved tools are required to meet the challenge.

There is of course already a wide range of tools available that address specific aspects of system implementation such as electronic circuit, software and mechanical design. However, the initial stages of systems design – specification and abstract modelling – are not well served at present. The system level design tools that do exist tend to be orientated towards either hardware or software implementations and are generally poor at handling a mixture of both. Some do not support executable system models, which means that designs cannot be verified prior to the implementation stage and most have a limited ability to share information with other tools.

To overcome these deficiencies and facilitate the development of improved system level design tools, standard methodologies and modelling notations need to be adopted. The Unified Modelling Language (UML), which originates from the software development community, has recently attracted considerable interest as a possible basis for defining such standards. Indeed the Object Modelling Group, the software industry body which has oversight for UML, is in the process of extending the UML specifications so as to encompass the requirements of systems engineering more generally. Therefore, any publication that addresses systems design issues in the context of UML ought to be of topical interest to systems engineers.

Unfortunately, from an electronic systems engineering point of view, Kevin Lano is writing principally for advanced students of computer science and application software developers. As such, his book deals specifically with software systems design and object-orientated software construction techniques. His main theme is not UML or systems engineering issues in general but, rather, an exploration of platform independent software system design with particular reference to Java and the comparatively recent concept of the Model-Driven Architecture (MDA).

By way of an introduction to his book Lano does offer a useful, albeit brief, summary of the current challenges facing software systems designers, along with an overview of existing software development models and methods. He also explains, in relatively simple terms, the role of UML in the software design process and the principles of the MDA approach, which he sees as being a continuation in the trend towards greater abstraction in programming languages. However, it has to be said from the outset that electronics engineers, who are unfamiliar with object-orientated software construction and the terminology used by computer scientists, may find much of the rest of the book somewhat inaccessible.

IT HAS TO BE SAID FROM THE OUTSET THAT ELECTRONICS ENGINEERS, WHO ARE UNFAMILIAR WITH OBJECT-ORIENTATED SOFTWARE CONSTRUCTION AND THE TERMINOLOGY USED BY COMPUTER SCIENTISTS, MAY FIND MUCH OF THE REST OF THE BOOK SOMEWHAT INACCESSIBLE

Lano follows his introduction with a concise description of the main concepts, notations and practical usage of UML. He mentions 'use case diagrams', which in UML encapsulate system requirements, however he focuses mainly on only two notations, 'class diagrams' and 'statecharts', because he considers these to be the most generally useful.

By way of explanation, 'class diagrams' are used to represent the various types of object in a system and the relationships between them while 'statecharts', which may be more familiar to electronics engineers as 'state machines', capture the dynamic behaviour of objects and how they intercommunicate. He goes on to illustrate, with the aid of a system for playing the game of Scabble as an example, how these UML notations can be used in practice to create detailed but platform independent models.

Having introduced UML, Lano expands on his main theme of platform independent software design. He begins by outlining various methods of refining the design process including model transformations and structured software design techniques, such as module specification and patterns (a term borrowed from building architecture and subsequently applied to objected-orientated programming languages). This, then, leads him to consider how to map a platform independent design into a platform specific

BY WAY OF AN INTRODUCTION TO HIS BOOK LANO DOES OFFER A USEFUL, ALBEIT BRIEF, SUMMARY OF THE CURRENT CHALLENGES FACING SOFTWARE SYSTEMS DESIGNERS, ALONG WITH AN OVERVIEW OF EXISTING SOFTWARE DEVELOPMENT MODELS AND METHODS

design, both of which can be expressed as models in UML notation.

From there, Lano explores the transformation of a UML Platform Specific Model (PSM) into executable code using a Java implementation as an example. He makes good use of several case studies to illustrate the method of mapping of UML elements to Java program constructs and the automated synthesis of Java code.

Lano continues by examining the synthesis of implementation components derived from UML models in the context of Internet system design and distributed applications based on web services. In particular, he describes various techniques whereby an online version of a system can be constructed from a UML Platform Independent Model (PIM) and offers guidelines for improving the portability of web interfaces. Additionally, but in a later chapter, he presents a case study of a complete web system development using the UML2Web synthesis tool.

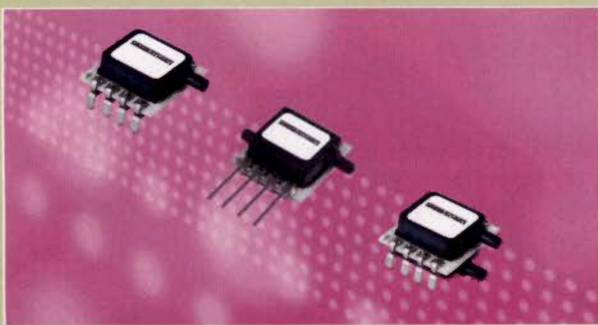
Finally, Lano turns his attention to describing the MDA approach to software systems design and draws together the various platform-independent design threads he introduced earlier. He begins by summarising the key concepts and terminology of the MDA approach which include PIM, PSM, model transformation and the notion of a 'computation independent model' (which is similar to an application domain model). Since model transformations are fundamental to the MDA approach, Lano refines these into three distinct categories: quality improvements of models, for example simplifying and removing duplicate features from a 'class diagram' by introducing a superclass; refinements, such as removing many-to-many associations; and abstractions, for instance substituting PIM types for PSM types. He explains the purpose of the various transformations and how they can be expressed formally. For ease of reference, he provides a catalogue of commonly used model transformations as the final chapter of the book.

Lastly, Lano considers various techniques for specifying and implementing model transformations and lists several commercially available tools that claim to support the MDA approach. Needless to say, in view of the fact that development of the MDA approach is still very much a work in progress, the list of tools is short.

Lano's book is well presented and would make an excellent introduction to platform-independent software system design for students of computer science. It might also be of interest to some software engineers and tool designers who want to keep abreast of current developments in system design methodologies. However, the book's emphasis on object-orientated software construction is unlikely to make it appealing to the majority of electronics engineers.

Douglas Taylor

Ultra Stable HCL Miniature Low Pressure Sensors



Sensortechnics's new HCL pressure sensors measure low gage or differential pressures from 5-75mbar. These devices are precision calibrated and temperature compensated and offer ratiometric millivolt output signals.

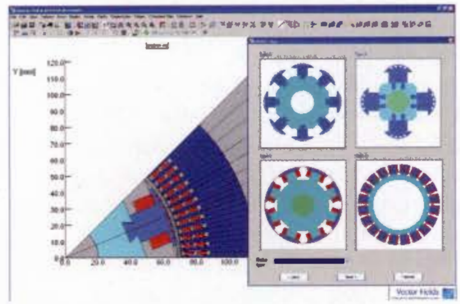
They use a special compensation technology to achieve a very high offset stability and virtually no position sensitivity in comparison to conventional sensors.

The HCL pressure sensors feature a high input resistance and are ideal for portable device applications. A wide range of miniature SMT, single inline (SIP) and dual inline (DIP) housing options allow for space-saving PCB-mounting and maximum OEM design flexibility. Sensortechnics can provide very fast and flexible HCL sensor modifications based on customer specific requirements.

Typical applications include medical devices as well as environmental controls and HVAC applications.

www.sensortechnics.com

Innovative Electromagnetic Design Tool Extended



Vector Fields is launching new capabilities for its design software for rotating electrical machinery. The software combines the extreme accuracy of finite-element analysis (FEA) modelling with a design entry system that allows users to create models of electric motors or generators in minutes. It allows users to achieve radical new levels of design productivity and efficiency.

Since launching it a year ago, Vector Fields is adding numerous new modelling elements requested by users to speed design.

The software is an application-specific version of the Opera package, and provides a front-end to the electromagnetic simulator that speeds design entry by means of 'fill in the blanks' dialogue boxes. Among dozens of new model features added with this release is a much extended range of cage geometries for induction motors. Users can now choose from six different starting points including circular, bullet and square, plus numerous potential variations and combinations of these shape elements.

The choice of geometries for wound rotor synchronous motors has also been expanded. These new options give users the means to quickly arrive at a model, even for manufacturers who have their own proprietary design techniques.

www.vectorfields.com

Axiohm Asteron Panel Mount Printer

With built-in mechanism, interface board and paper holder all in one compact unit, the Axiohm Asteron panel mount printer has been designed with instant integration in mind. Developed for control, test and measurement, as well as analysis and diagnosis applications, the Asteron delivers a print speed of 50mm per second onto a 58mm wide paper roll.

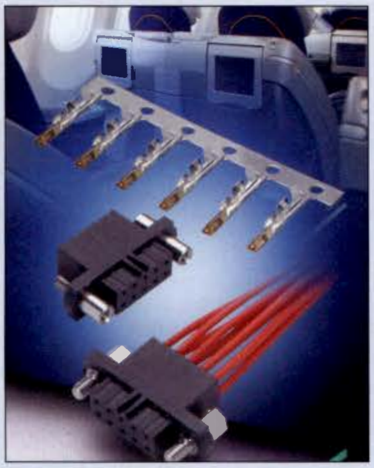
Performance has not been compromised with size; the Asteron offers robustness, large paper-roll capacity and a clamshell design, whilst also benefiting from the latest in enhanced integration techniques. Thanks to multiple mounting points and a fast and innovative attachment system, the Asteron is simple to integrate onto any panel, regardless of thickness.

The Asteron features an ergonomic door opening system with improved protection against spills and an advanced locking mechanism to prevent the door from opening unexpectedly.

Supporting dual RS232 and TTL connections, the Asteron is a 5V device, with dimensions of 78 x 85.7 x 57mm. The Asteron is available with or without the interface board should the user wish to integrate the controller into their own equipment.

www.ded.co.uk

Open Barrel Crimp Contact



Performing to the same high-reliability standards as conventional Datamate contacts, the Datamate Trio-Tek open barrel crimp contact from Harwin automates the crimp process to significantly save on assembly time and reduce process costs. The new crimp design, which features a latching feature, simplifies the insertion of contacts into the housing.

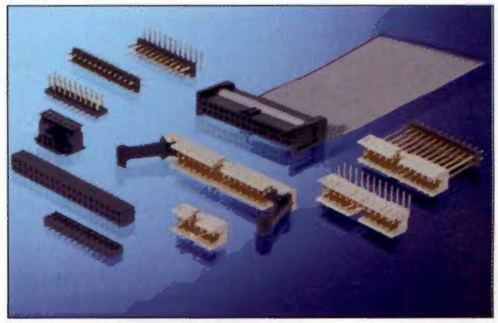
The high reliability contact of the Datamate Trio-Tek is tested in accordance with BS 9525-F0033. A crimp inspection window in the housing aids quality control, while the insulation crimp barrel provides improved strain relief. The contacts come with jackscrews (J-Tek) and are available both loose and on reels.

The Datamate Trio-Tek auto-crimp contact features a triangular form which allows a simplified crimping process, while at the same time enabling the customers to fully automate crimping in medium and high-volume applications.

Typical applications include high-reliability, high volume markets such as commercial aerospace, data communications, medical devices, engine management and high-end industrial equipment, including pumps, heavy machinery and drilling rigs.

www.harwin.com

Improved Minitek 2mm PCB Connector System



TTI is introducing FCI's new, improved Minitek, now their most complete 2mm PCB connection system. This 2.00mm PCB connection system is one of the fastest growing product lines in the industrial, instrumentation, medical, telecom and datacom segments, which are realising the benefits of using smaller pitch systems.

Minitek is part of FCI's Basics+ program. Recent improvements made to the range include introducing the lowest available profile eject latch header and the optional availability of Pin-in-Paste versions which eliminate costly secondary soldering operations. Carefully-controlled selective plating reduces cost while maintaining performance and co-planarity of surface mount parts is maintained at 0.1mm. Normal operating temperature has also been increased to 125°C.

The Minitek system is fully intermateable. Even the new active latch wire housing is unique in that it is not part of a separate system, but mates with the standard headers. This means that customer requirements for all types of 2.00mm board-to-board and wire-to-board interconnect solutions can be easily met.

www.ttieurope.com

COM Express Compact Module

Congatec AG enhances its successful COM Express product family with the introduction of the extremely low power consuming conga-CA. It features the brand new Intel Atom processor Z5xx series and the Intel System Controller Hub US15W.

The complete design of this compact (95 x 95mm) sized COM Express module is geared around low power consumption. Typical power requirements for this module will be less than 5W.

The conga-CA supports up to two PCI Express Lanes, eight USB 2.0, two Serial ATA, one IDE Interface and Intel High Definition Audio. Two onboard SDIO sockets allow for flexible expansion. Additionally, it features PCI bus, multi master I^2C bus, LPC bus, fan control and Gigabit Ethernet.

The conga-CA is available in two different CPU variants. The conga-CA eco version is powered by the Intel Atom processor Z510 with 1.1GHz and 400MHz front side and memory bus. The high-end version is powered by the 1.6GHz Intel Atom processor Z530 with 533MHz front side and memory bus. Both versions are equipped with 512k L2 cache and can access up to 1GByte onboard DDR2 memory.

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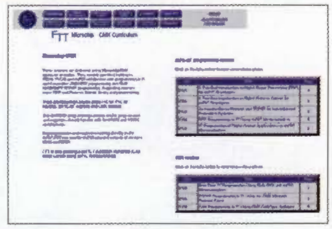

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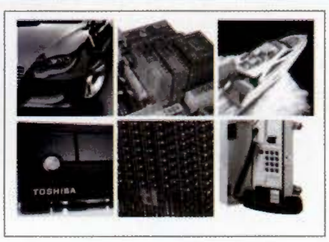

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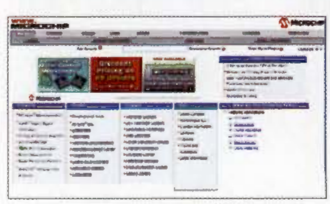

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AWS Group Strengthens Management Team

AWS Group, a UK specialist Electronic Manufacturing Services (EMS) provider, has announced additions to its senior management team, designed to support growth and improve the service the company delivers to its customer base. In the last few months, Mike Fairclough has joined as Group Sales Manager and Adrian Keane has been appointed Group Financial Director. Mike Berridge has also been given a board level position with responsibility to oversee Continuous Improvement and Strategic Development.

AWS Group has grown under the direction of CEO, Paul Deehan, and now operates from four sites in the UK and one in Slovakia. Currently the group turnover is around £40m. This enables the group to invest in the latest manufacturing technologies, yet still remain customer-focus.

Deehan said: "We are investing in new businesses and in top line management. We plan further acquisitions of successful businesses that will strengthen our Group capabilities. We are also looking to open up facilities in the Far East and South America to support UK businesses wherever they choose to manufacture. To do this we need a strong management team."

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