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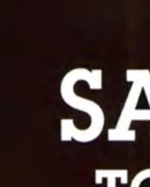

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ALSO IN THIS ISSUE: BOOK REVIEW @ THE TROUBLE WITH RF @ PRODUCTS

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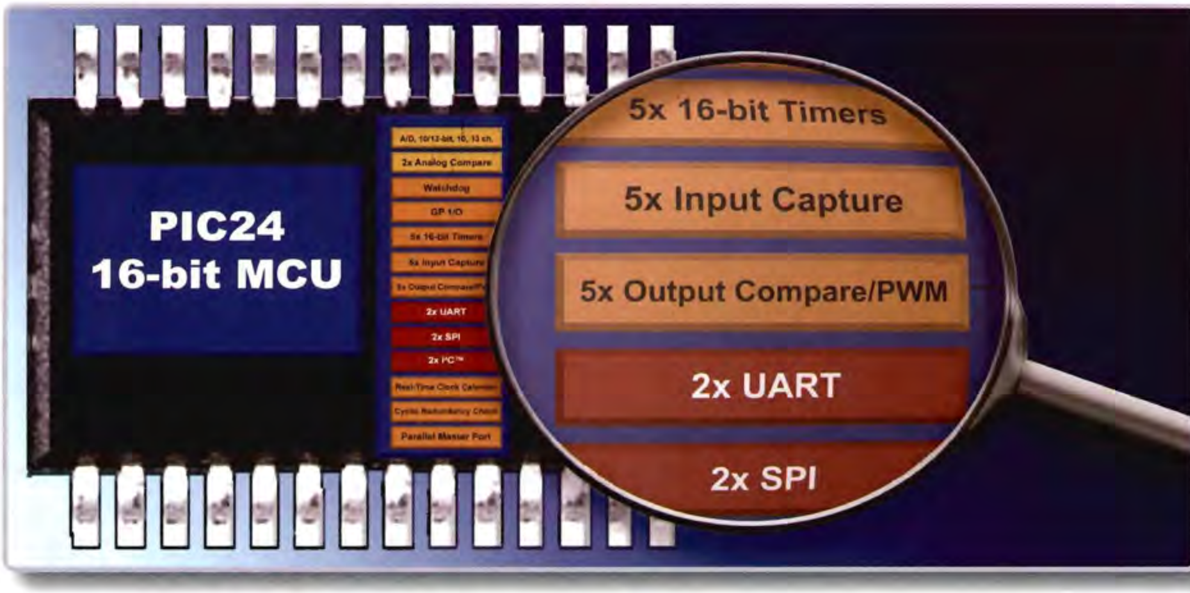

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RAT'S NEST

It's been just over a year since I wrote my last piece on the confusing state of all the digital networks that are trying to enter our homes ('*Networking gone crazy*', Electronics World, October 2006). A year later and the situation has not changed that much, even though the way we are accessing and using content – data, TV, film, music, photos, phone calls – is changing all the time.

So it is not surprising when one of the most challenging tasks facing the consumer electronics industry to date has been to set up standards to move various types of content around the home; make that content interoperable between different devices; as well as between devices from different vendors.

There are already several standards vying to "connect" our homes and "make life easier": wireless LAN, Ethernet, WiFi, Powerline Communications etc, all of which are developing fast but also each of them being better at one thing rather than everything. Nevertheless, although they can complement each other they cannot quite be harnessed to work together just yet to offer one seamless solution. For example, Bluetooth systems are incompatible with wireless USB systems, and both in turn are incompatible with the 802.11 variants.

Then, there are still the wired solutions which are not only competing with the wireless ones but also with each other: Ethernet and Powerline Communications (PLC). With PLC all the connectivity takes place over the electrical wires, which already exist in most homes – all that's necessary is a simple adapter that fits into the electrical socket. For the sake of argument, if we took the potential problems out of the equation (such as interference from certain wired systems, for example), this is potentially the simplest solution (and one of the tidiest wired ones!).

So, whichever systems we have in our homes (wired or wireless), we will need to have them work together. But, wait, there's yet another snag in all this and that's digital rights management (DRM). A lot of the content (music, films etc) will not be allowed for sharing, even though 'sharing' could mean content being moved from your PC to your TV or set-top box.

As I wrote at the beginning, the situation is complicated and there's just as much of success of the industry unravelling this one as I have in unravelling the 'rat's nest' of cables under my desk.

Svetlana Josifovska
Editor

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New computer architecture is built with mechanical parts

The scientists have used gold and silicon for the prototype

A group of scientists are developing a computing machine based on nanometre sized mechanical and piezoelectric components and not silicon.

"What we are proposing is a new type of computing architecture that is only based on nano mechanical elements," said Professor Robert Blick of the University of Wisconsin-Madison. "We are not going to compete with high-speed silicon, but where we are competitive is for all of those mundane applications where you need microprocessors which can be slow and cheap as well."

According to the scientists, these devices could be used in places where silicon is easily affected by the environment, such as in high-temperature automotive applications, domestic appliances but also toys. They suggest that the system could be constructed from diamond or piezoelectric materials.

So far, the researchers have demonstrated a working single element that is the building block of a circuit. Professor Blick believes that in a couple of years this work will lead to commercial applications.

Unlike silicon chips, the mechanical devices run much cooler and consume less power than silicon. Although they are unlikely to replace silicon chips, there's the possibility of a hybrid device that will combine both technologies.

BRITAIN TO KEEP ANALOGUE RADIO TRANSMISSION FOR NOW

Although Britain has made definite plans to discontinue analogue television broadcasting in favour of digital transmission within the next few years, it has been decided there will be no similar early end to analogue radio broadcasts. The communications regulator, Ofcom, has announced that there are currently no plans to switch off either AM or FM analogue radio broadcasting signals, but this does not mean that they will never be discontinued.

Ofcom said that it is seeking views on various changes that could free some of the radio spectrum currently used by the analogue radio services at an appropriate time in the future. It added that this part of the radio spectrum might be more sensibly allocated to other services, such as mobile television, more digital radio services, more community radio services or various other future new technologies. The present UK analogue commercial radio licences are due to expire between 2009 and 2027, but under the current licensing regulations they will be re-advertised.

Britain has led Europe in digital audio broadcasting, starting its first transmissions some 12 years ago. Most of the other European countries have put much less effort into the promotion of digital audio services, so British manufacturers want to ensure that their lead in this field is not lost. Some have proposed that broadcast radio networks are switched exclusively to digital transmission as early as 2009.

No short-term health danger from mobile phone masts, say researchers

A recent study by the University of Essex found no link between "electro-sensitivity" and mobile phone base stations.

Mobile phone masts have long been blamed for a range of ailments, ranging from headaches and tiredness to even the flu, by those living near them. Now, Esssex University researchers studied more than 150 people, a third of whom claimed to be highly sensitive, but only a few of the participants were able to tell when mobile signals were present.

The researchers carried out the experiments inside a Faraday cage. It blocked out all external electronic signals while a transmitter inside simulated the effects of a mobile phone mast 30 metres away. Signal intensities ranged from low to high, as in 3G transmissions.

Participants were asked to rank their discomfort and their vital statistics were monitored. The results indicated no link between changes in their vitals and mobile phone mast signals.

"In the short term at least, there are no health risks from mobile phone masts. There was no evidence people were even able to detect a signal," said Professor Elaine Fox, who led the study. "I do not doubt that people are genuinely ill, and suffering these symptoms. However, I think [we] should look elsewhere for the causes."

However, critics say that electro-sensitivity is a recognised condition. "The Swedish government calculates 3.1% of its population suffer from it, and [this number is] growing," said a Mast Sanity representative.

Hydrogen fuel research may open the way to carbon free cars

A UK group has produced a lithium boron nitrogen hydride compound, $Li_4BN_3H_{10}$, following the testing of thousands of chemicals in a search for light, cheap, readily available material that will permit adsorption and desorption of hydrogen to take place very rapidly and safely at typical fuel cell operating temperatures.

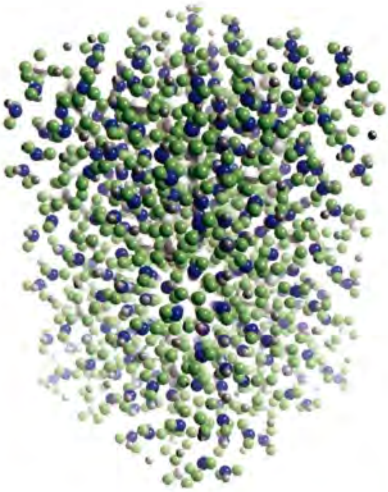
The breakthrough has been achieved by a team from the Universities of Birmingham and Oxford and the Rutherford Appleton Laboratory under the auspices of the UK Sustainable Hydrogen Energy Consortium (UK-SHEC), funded by the SUPERGEN (Sustainable Power Generation and Supply) initiative and managed by the Engineering and Physical Sciences Research Council (EPSRC).

When hydrogen is used as a fuel, it produces only pure water, so it is the ideal fuel for the environment. Unfortunately it is very difficult to carry this light explosive gas in adequate quantity to run a car for a distance of over 300 miles before refuelling, as the gas would occupy a large space. Equally, it is not practical to store in cylinders, owing to their weight. Therefore, the creation of this suitable solid chemical compounds, where a chemisorption process enables atoms of hydrogen to be absorbed into the crystal structure of the material and to be easily released when required, is greeted with optimism for the mass market adoption of fuel cells.

"This could be a major step towards the breakthrough that the fuel cell industry and transport sector have waited for," says UK-SHEC's Project Co-ordinator Professor Peter Edwards of the University of Oxford. "This work could make a key contribution to help fuel cell cars become viable for mass manufacture within some 10 years."

Separately, a major report in 2004 concluded that using hydrogen in vehicles could, on its own, enable the UK to meet its Kyoto targets for CO_2 reductions.

This white powder could store the hydrogen for powering future cars



The future in store: hydrogen atoms can be absorbed effectively into the new storage material. Hydrogen (H) atoms are shown in green, lithium (Li) atoms in dark grey, nitrogen (N) atoms in blue and boron (B) atoms are in grey and inside the pyramids

IN BRIEF

A new simulator developed by the University of Southampton is expected to facilitate smaller, more competitive handheld computing devices. NIRGAM (Network-on-Chip Interconnect RoutinG and Applications Modelling) simulator will allow to easier interconnect different cores on a System-on-Chip (SoC).
As the demand for more functionality from handheld devices increases, the current interconnection techniques will fail to support more powerful devices, due to limited bandwidth scalability. NIRGAM allows researchers to plug in and experiment with different applications and routing algorithms using different traffic and topologies, evaluating them quickly. Expectations are that by 2008 SoCs will contain over 50 processing and memory blocks, increasing to 100 cores four years later.

Researchers from the Optoelectronics Research Centre (ORC) in Southampton, UK, are developing an optical chemical sensor that can detect compounds with a sensitivity of one molecule in 10 million.
Based on an optical fibre that is 1000 times thinner than standard optical fibre used in telecommunications, the sensor has many advantages over other optical sensors currently used in biotechnology and chemistry applications.
In comparison, other optical sensors currently under investigation or on the market have detection limits of around 1 in 1 million. ORC's sensor can also easily be coupled to standard optical equipment and features an intrinsic fluidic channel for delivery of the analyte.

PicoChip has joined the Femto Forum – a new body to promote femtocell standardisation and deployment. The Forum brings together the foremost femtocell equipment vendors with the major global mobile operators assessing the technology. It plans to promote the uptake of femtocell technologies through open standards, market education and ecosystem development. The initial focus will be on pre-competitive standards-focused issues including radio planning and control, device provisioning and management and device to network standardisation. In addition, a marketing task force will promote the benefits of femtocell technology for both operators and subscribers.

Competing lithography techniques presented at Semicon West

Both EUVL (Extreme UV Lithography) and the competing nanoimprinting techniques were discussed at Semicon West in San Francisco, the world's largest semiconductor event. Cymer presented advances it has made in laser produced plasma (LPP) EUVL sources, with new power levels of up to 50W at the intermediate focus point and 100W promised by the end of this year. Cymer switched to its LPP technology from its use of discharge produced plasma techniques a few years ago. The largest EUVL toolmaker, ASML, is to use a Cymer EUVL source in its system.

Although 100W of EUV is typical of the level at which the industry has been aiming for use in production systems, Nigel Farrer of Cymer said estimates of the necessary level is rising owing to new requirements for a greater resist dose and an increase in the number of EUVL mirrors that will be needed in the EUVL optical systems. He suggested the required power may be two or three times greater than the previously anticipated needs. Cymer also showed it has made significant progress in the vital field of the reduction of debris formed by the source, which can ruin the EUVL reflective optics. The current anticipated lifetime of the optics is of the order of one year.

Although many people believe EUV radiation at the 13.5nm wavelength is set for adoption in future lithography tools that will produce features on chips down to 32nm in size, others have serious doubts about the viability of EUVL within the required time scale. Some support nanoimprint lithography for which Molecular Imprints presented its developments. However, nanoimprint lithography will require a great deal of R&D and huge investments before is ready to be considered for ultrafine chip patterning.

It will be a year or two before it becomes clear if one of these technologies will be the major one for ultrafine chip patterning.

Russia announces plans for a new nanotechnology centre

At the SEMI Expo CIS Semiconductor Executive Market Conference in Moscow, in June, Professor Michael Kovalchuk, head of the Russian State Nanotechnologies Program and director of the Kurchatov Centre for Nanotechnologies, presented plans for a project to form a Nanotechnologies Development Centre. It is to be opened in the first quarter of 2009 in the Kurchatov Institute and will be part of the Russian national program for nanotechnologies.

The government has nominated the Kurchatov Centre as the controlling and coordinating organisation of Russia's National Nanotechnological Network (NNN), based on President Putin's initiative to create a national nanotechnological complex. It will include a network of various Russian research centres that can handle the complex nature and wide variety of fields covered by nanotechnology.

The project aims to create a modern and effective infrastructure for nanotechnology development in the Russian Federation and to establish an experimental basis for the development and effective realisation of Russian innovation potential.

● **The first printed, low cost, organic tickets developed by the PRISMA (Printed smart RFID labels) Project have been field-tested at the Organic Electronics Conference held in Frankfurt, Germany, in September.**

The tickets were based on a first generation printed organic devices incorporating RF technology produced by BARTSCH and PolyIC. Four reader stations checked some 1,000 organic tickets which were also used to monitor the flow of attendees throughout the two day conference and exhibition as well as collect other statistical data.

It is expected that low-cost printed RFID tickets (pRFID) will generate new opportunities and benefits for applications in public transportation, exhibitions and logistics.

● **An NMI study of air conditioning energy efficiency at sixteen of its members' wafer fabrication plants has identified opportunities to reduce CO_2 emissions by more than 40,000 tonnes per year.** Supported by funding from The Carbon Trust, the study determined that almost half of the emissions reduction could be achieved through no-cost or low-cost measures.

Strict control of temperature, humidity and particulates in clean rooms means that air conditioning plant typically consumes about a third of all site energy usage. The study found that sites can continue operating at high levels of efficiency but still manage to save between 2 and 10% of the total energy consumed.

Many of the study's recommendations are expected to be implemented by the end of 2007.

● **LSI Corporation is moving its worldwide assembly and testing semiconductor and storage systems products operations over to contract manufacturers in an effort to cut costs and provide scalable capacity without additional capital investment.** The initiative is part of a previously announced three-phase business acceleration plan adopted by LSI following its merger with Agere Systems in April this year.

So far the firm has signed an agreement to sell its semiconductor assembly and test operations in Pathumthani, Thailand to STATS ChipPAC for approximately $100m. The storage products assembly and test operations transitions are expected to be completed in the first half of 2008.

Carbon Nanotubes Potenial For Use In Chips

Versatile system grows carbon nanotubes

The growth of carbon nanotubes will be greatly facilitated by a new tool from Surrey Nanosystems in the UK, which is said to be the most versatile of its type. This NanoGrowth 1000n tool is designed for nanomaterial fabrication to facilitate growth both in the 450-1000^{0}C range and at lower temperatures.

Ben Jensen, chief technical officer at Surrey Nanosystems, said it offers the technology to grow nanotubes even at temperatures within the typical CMOS device processing range of 200-400^{0}C. This is will make possible the commercialisation of the use of carbon nanotubes and other nanowires in silicon chips that are approaching their performance limits.

The tool offers both CVD (Chemical Vapour Deposition) and PECVD (Plasma-Enhanced CVD) capabilities, greatly enhancing its versatility. "This new type of tool addresses the needs of nanomaterial researchers for stable and repeatable results. The tool's intrinsic hardware modularity allows users to gain automated control over all aspects of nanomaterial synthesis from catalyst generation to final material processing" said Dr Guan You Chen, Chief Scientist, Surrey Nanosystems.

The process recipes and patented fabrication technology inside the tool are derived from work by the University of Surrey's Advanced Technology Institute (ATI). The IP Group provided funding to create the firm.

The excellent electrical properties of the nanotubes make them one of the very few materials that can exceed the current density of 1 x 107A/cm^2 that is thought to be required for the next generation of devices using 32nm technology. The nanotubes also seem to show ballistic conduction in which electron scattering from impurity defects is absent or very small. They can potentially be grown in via holes with high aspect ratios, without the problems associated with copper deposition.

Top Five Tips

Wireless module design

Beyond the usual good practice when using a wireless module, there are a few extra precautions to be taken at higher power levels:

01. Use a good aerial. Make sure the aerial chosen is properly set up for the frequency of operation and that sufficient ground plane, required by monopoles and whips, is present. Ensure the aerial is mounted away from metal structures, which will de-tune it, and as high up as possible. Use a VSWR meter to optimise the aerial tuning, if necessary. Avoid running other cables near the aerial.

02. Use adequate shielding. Mount your circuitry (and the transmitter) inside a metal, shielded enclosure, if at all possible. Use a bulkhead mounted RF connector to ensure the braid of the aerial cable is properly earthen to the enclosure wall. Use good RFI filtering on all wiring at the point of exit from the housing (feed through capacitors are effective, although somewhat old fashioned looking; filtered connectors, containing ferrite blocks or LC filter circuits, are especially useful).

03. Remember power and heat. Provide an adequately rated power supply for your transmitter, ideally separate from the analogue and logic rails in your design. The module will dissipate 1-3W of heat (at least) when in operation, so provide good ventilation, any necessary heat sinking and limit transmit duty cycle.

04. Test for known problems. Monitor the analogue baseband output of your receiver, or use a separate monitor receiver or 'scanner', and look for unexpected distortion in the transmitter's modulation. Test into a dummy load and into the chosen aerial, and look for differences.

05. Be careful. Half a watt doesn't sound like a great deal, but the field near to the aerial can interfere with the operation of unshielded electronics and can block other receivers. Locate your transmitter – and it's aerial – carefully.

This month's top tips were supplied by Myk Dormer, Senior RF Engineer at Radiometrix Ltd.

If you want to send us your top five or ten tips on any engineering and design subject, please write to the Editor:
svetlana.josifovska@stjohnpatrick.com


GLEVUM
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MANAGING INNOVATION through 'open innovation partnerships'

COULD BIG MANUFACTURING OR ELECTRONICS COMPANIES MAKE BETTER USE OF THEIR PRODUCT INNOVATION BUDGETS? ABSOLUTELY, SAYS **SIETE HAMMINGA**, FOUNDER AND CEO OF NETHERLANDS-BASED HIGH-TECH FIRM WALELI

You are asking how big manufacturing or electronics companies could make better use of product innovation budgets. The answer is by tapping into the complementary strengths of a new breed of smaller, nimbler, high-tech innovation specialists who have made a specialisation of applying the latest technologies in innovative products that really meet people's needs in simple ways.

I believe that 'open innovation partnerships' between big businesses and these smaller firms will become the key strategic ingredient of innovation management in future, helping big firms spot opportunities, then bring products and services to market at maximum speed and minimum cost.

Big businesses in the consumer electronics field have all the advantages of established brands, distribution channels, financial muscle, buying power, global reach and marketing weight. They can and do invest fortunes in product innovation to secure the future of the business with a horizon of the next five, ten or more years. But are these large groups best placed to identify and exploit all the potential ideas for new products and services? You'd think so, but in reality it's not that simple.

When firms concentrate on ideas that have the potential to shape the way people live and work ten years from now, it's easy to overlook new products and services that could fulfil a genuine market need tomorrow and which could also generate useful long-term income.

Supply chains in the electronics and telecoms industries have changed significantly in recent years and as a result many new types of business collaboration have emerged. Until now, though, this has not generally impacted upon innovation management.

We are now seeing a new breed of innovation specialists emerging, with a business model based on working in partnership with larger firms to identify new product opportunities, then turn them quickly and cost-effectively into marketable products or services.

The art of correlation: seeing and understanding a need and knowing how to apply products and services that fulfil that need in a simple way. As an example, we asked why a person's front door bell doesn't connect to his or her mobile phone. The Waleli GSM doorbell grew out of this thinking.

The art of limitation: resisting the temptation to stuff a product full of functions and features just because you can. Defining what a high-tech product should not do is a critical success factor in innovation. It's as important as defining what the product should do.

There are also emotional and cultural factors to overcome in new product innovation. The 'not invented here' syndrome is a good example. There may be a natural reluctance to accept innovations that come from outside the company. It's understandable. This may be reinforced by a business culture in which the manager may be asked to justify why he or she didn't use internal resources for the project.

However, there are signs of a shift within many large companies, as they begin to understand the benefits of combining internal and external innovation resources, and acknowledge the efficiency of working together with smaller enterprises through open innovation partnerships. And we are not talking about developing the technologies that will rock the world years from now, but rather about how to fast-track innovations that fulfil a need in a simple way tomorrow.

Major consumer electronics companies all have core areas of technology expertise, intellectual property and competence, and rightly regard these as assets that must be protected at all costs. Open innovation partnerships with smaller innovation specialists do not threaten these assets. On the contrary, the collaboration may well identify new areas in which these technologies can be applied, resulting in increased revenue streams.

This highlights another benefit of partnerships. The external company is not driven by, or tied to, any specific technology. It has access to efficient resources anywhere in the world and is, therefore, in a good position to select the optimum technology to solve a particular consumer need, rather than looking for products and services that play to the company's existing technology capabilities.

There are signs of a shift within many large companies as they begin to understand the benefits of combining innovation resources

Talking to big firms about why they are prepared to consider partnering with an external specialist on innovation projects, the answer is often along these lines: "If we do it ourselves, it costs three times as much, takes four times as long and, then, just before it's ready, the project is killed."

Cooperation allows everyone to do what they do best. ■

CISCO'S NEW SYSTEMS

JUAN PABLO CONTI PROFILES CISCO SYSTEMS AT A TIME WHEN NETWORKING IS HEADED INTO A NEW ERA, WHICH WILL TEST THE BEST OF THE COMMUNICATIONS AND SOFTWARE GIANTS

As I jump from one website to the next one while I begin to research the history of Cisco Systems, I am well aware that the Internet traffic I am generating is being handled by a collection of IP routers and switches inevitably built by Cisco.

After all, that sort of core networking equipment is what this giant technology company founded 23 years ago as a small start-up by a married couple from California has always specialised in. And, judging by the fact that 80% of all IP routers and switches deployed worldwide come from Cisco, there's no arguing the vendor's success in that particular market.

Less than two minutes into my web surfing, the wildly flashing green LEDs at the front panels of my cable modem and broadband router catch my attention. I look closely at both devices to confirm what brand they were – Scientific Atlanta the modem; Linksys the router – and straight away I realise that it's not just backbone IP traffic that Cisco equipment is routing for me, but also the traffic taking place at the very end of my last mile, just before it reaches my computer.

Cisco's decision to buy Linksys in 2003 and more recently Scientific Atlanta in 2006 is part of a larger vision that the company has about the future direction of the networking industry and the role it needs to play to remain competitive in it.

John Chambers, the vendor's Chairman and CEO, likes to refer to this vision as "the second phase of the Internet". "We believe that we are headed into a new era in networking that we define as the second phase of the Internet," said Chambers during Cisco's last earnings announcement in August. "We expect that this phase will be driven by collaboration and Web 2.0 technologies and will become an increasingly influential market trend for businesses. Collaboration has already transformed almost every area of our business internally, resulting in the potential for dramatic gains in productivity and efficiency. We believe this new model will help enable Cisco to identify, target and capture market opportunities more effectively than at any other time in our history."

The "new model" the CEO is trying to sell (and adopting internally first just to prove how it can radically transform the ICT infrastructure of a large business) is essentially 'unified communications', a new concept – and associated family of products, as you would expect – that Cisco has developed and is already marketing as the hot new must-have for the corporate world.

STAYING IN TOUCH

As its name partially suggests, unified communications is the coming together of disparate existing communications technologies to enable true convergence in the shape of anywhere, anytime, any device and any platform connectivity. The ultimate goal is to offer business users an unlimited combination of interactions between their fixed telephony, cellular, email, instant messaging, videoconferencing and remote web access systems.

Based on an all-IP network infrastructure, unified communications adopts the type of user interface commonly seen in instant messaging applications, and then takes it further to include all other communications tools. So, in the same way that a Windows Messenger user can, for example, indicate

A Scientific-Atlanta high-definition DVR to their buddy list whether he or she is online, busy or 'back-soon', unified communications systems allow corporate users to permanently update their communications status in order to let co-workers know not only if they are currently contactable or not but also what the best form of reaching them is at any particular time.

Then anybody can constantly check – on any device – the status of anybody else. Or do things like, for example, sending voice messages to an email account from a WiFi-enabled laptop.

The eye-catching TelePresence system that Cisco launched in December 2006 is an integral part of the wider unified communications and collaboration market that the company is targeting. Touted as the next generation of videoconferencing technology, telepresence systems are basically meeting rooms that were entirely designed and built by Cisco to create an immersive experience in which participants joining in from anywhere around the world appear as if they were sharing the same conference table.

Unlike conventional videoconferencing systems, telepresence technology lets participants see their virtual counterparts both in very high resolution (1080p) and in life-size, thanks to the use of 65-inch HD plasma screens that are strategically positioned at eye-level height. In TelePresence 3000 rooms (designed to seat up to six people, while the smaller, TelePresence 1000 version can accommodate one or two people), camera arrays generate multiple HD video streams in order to capture individual attendees. Its high-end microphones feature spatial audio, a technology that allows multi-channel sound to be heard at the remote site as coming from the left, right or centre of the table, depending on where it originates at the other end.

They don't come cheap, though. Each TelePresence 3000 room will set you back $299,000, and you will obviously need at least two of them to start building your corporate network of interconnected telepresence rooms, before you can begin to factor in the extra bandwidth you will need to handle the heavy multimedia traffic they generate.

However, Randy Harrell, the director of product marketing for the TelePresence System business unit at Cisco, says the hefty price tag is not preventing a high level of interest in the systems: "We've got a number of customers that have ordered, and that's growing very quickly. I came [to Cisco] from the videoconferencing industry. I never had this type of success in promoting videoconferencing the same way that we are having in telepresence."

"Interestingly, our first five orders for telepresence gear were both geographically and vertically dispersed," continues Harrell. "Literally: Asia, the Middle East, Europe and the US were the first five orders that we got. And they were from very different industries too: we had telephone companies buying it for internal use; public works for an airport in the Middle East; retail in Europe and then a number of financial services and pharmaceutical firms that are deploying it in the US right now."

FRIENDS OR FOES?

A new Cisco with a new line of products and services that go beyond the company's traditional networking turf and begins to experiment with end-user applications is not without its challenges. Applications call for software and trying to get into the software world means trying to get into Microsoft's turf.

Ever since the emergence of the global economy made it clear to large corporations that it was vital for them to invest heavily in their IT departments, both Cisco and Microsoft have grown to become two of the world's richest companies by selling their networking gear and client and server software to – essentially – the same customer base.

For over 20 years it was almost as if they were sharing a magical formula for success. But now, as the two vendors' own needs to grow are leading them to expand into new markets, they are increasingly finding they are competing head-on with each other in some areas. And unified communications is the area where industry watchers expect the first major battle will be decided. In fact, Microsoft is already marketing its own unified communications system, with the hardware pieces of the ecosystem being supplied by Cisco's rival Nortel Networks.

At the end of August 2007 both Cisco's and Microsoft's CEOs organised a joint event to announce that, although they were happy to compete with one another, they were also going to work together to ensure the various elements of their unified

Cisco's main campus in San Jose, California communications solutions would interoperate.

A cute public display of mutual affection? Not quite. This is more like a calculated effort to keep that mutual customer base affectionate. "Companies don't want issues of competition to cause them not to be able to interoperate effectively in their own environments," said Cisco's John Chambers during the event. "You don't want to catch the customer in the middle."

CISCO SYSTEMS IN BRIEF

Founded: 1984 by Len Bosack and Sandy Lerner
Headquarters: San Jose, California (US)
Chairman & CEO: John Chambers
Employees: 55,000
Annual sales: $34.9bn (Fiscal 2007)
Net income: $7.3bn (Fiscal 2007)
Listed: NASDAQ and Hong Kong Stock Exchange

Each TelePresence 3000 room can seat up to six

by Myk Dormer

ERRORS IN THE DATASTREAM?

We engineers are simple creatures and like to work in a world of absolutes. When a signal is applied to one end of a cable, it appears at the other. When a datastream is transmitted from one device, we anticipate that it will be received exactly as sent; any deviation from this and we look for faults, software errors and faulty connections. But most of all, we consider these to be exceptions from the normal.

"CERTAIN INCIDENCE OF DATA ERROR IS UNAVAILABLE"

Radio links aren't like that. When planning to use a wireless data link, the engineer must accept that a certain incidence of data error is unavoidable. For usable links this can vary from a few ppm, to a few percent, but it is never zero.

A radio path is:

... Noisy. As signal strength falls away with increasing range the signal to noise ratio of the baseband path falls (and so the error rate of the digital stream rises).

... Subject to interference. RF energy from interfering sources (from other radio systems and from the natural environment) can swamp the wanted signal, causing single errors, or whole bursts.

... Unpredictable. Even when well 'in range' the signal strength can fall radically (by 20dB or more) due to fading. (Nulling of the wanted, direct path signal by out-of-phase echoes reflected from obstructions, geographical features and even moving vehicles).

At this point it must seem like I'm implying that wireless links aren't usable at all (and most ISM band module manufacturers will gloss over what I'm describing and do frequently make some sort of 'seamless cable replacement' claim for their products) but I'm not. What is important to realise is that, while data errors are not frequent in a properly designed link operating within its specified range, they will occur and the design of the overall application must take this into account.

How to deal with data errors depends greatly on the amount of data being transmitted, and most importantly, what it is being used for. Techniques include:

1. Ignore the error. In applications using 'feedback-via-operator', where the user is observing the controlled device and continues to activate the control until the desired occurance, then a lost wireless instruction burst is at worst a mild annoyance.

Typical examples include remote controls and remote actuators, wireless keys and similar functions. In such cases, although no overt error correction is implemented, error detection is still important, as spurious operation of the controlled function is usually unacceptable (either during transmission of a command, or during idle). Sufficient burst identification data ('framing', 'synchronising' or 'addressing' words, combined with error detecting checksums, CRC or parity schemes) needs to be sent in addition to the actual command data to allow a decoder to reliably discriminate between random noise in the absence of signal (or in the presence of interference) and the wanted command burst.

2. Make the error statistically insignificant. Where the failure to receive a given piece of data has safety implications, such as in alarm systems, or where dangerous processes are controlled, then multiple redundant transmissions of the same command can be used to swamp the effects of a given error, either by sending a sufficient number of command data bursts that the likelihood of all of them suffering errors becomes small enough, or by simply sending the command continuously and relying on the majority of identical commands being received correctly. This is a method used in industrial machine and vehicle control.

In extreme cases, a fail-safe approach can be taken, where the cessation of reception of the datastream (after a given time-out period) is taken to indicate the alarm condition.

A significant sub-class of this approach is the provision of forward error correction (FEC), where a relatively small amount of extra data is added to the message, which allows a suitably sophisticated decoding algorithm to correct for the effects of a limited number of bit errors. These 'FEC' techniques have attracted a huge amount of effort in recent years and are now found in the Reed-Solomon coding schemes in CD recordings and in the Viterbi algorithms used in cellular telephony.

3. Send, acknowledge and re-transmit on error. This is effectively an automated version of our first example. The datastream is broken up into discrete packet bursts and after each packet the receiving unit transmits an 'acknowledge' back to the sender. If the sender fails to receive a valid acknowledge within a given time-out of sending the packet (due to an error in the packet or the 'ack' burst), it re-sends the same packet again.

This powerful technique is frequently used in high-end radio-modems and is a feature of file-transfer software, such as Z-modem. Where the data must be received entirely intact and error-free, such as when data logger files are downloaded or computer binary files are transferred, then this is a preferred method.

It is not problem-free, however, as it requires a bi-directional (transceive) link, combined with good error detection algorithms and, in the event of significant errors in the radio path, can deliver a very low overall data rate and require large data buffers at the transmitter.

There is no absolute 'correct' approach. Even the best error handling technique will fail when the radio environment is compromised, such as during electrical storms, or when the path loss is too high, i.e. out of range.

It is up to the engineer to understand the imperfect nature of the wireless link and design around it. Good luck

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

PRACTICAL DESIGN CONSIDERATIONS ETHERNET VERSUS RAPIDIO

Engineers can be thought of as negotiators between the ideal world and the real world. It is their task to apply the theoretical possibilities of technology in a practical manner that balances performance, reliability, cost and a number of other key considerations, depending upon the application.

Many times, engineers are so good at what they do that they are able to carry technology over to applications for which it was never intended. In some cases, the fit is "good enough", and the resulting economies of scale are sufficient to make the extended implementation of the technology successful. In other cases, however, the desire to make use of a technology that is already familiar leads engineers to "shoe-horn" it into new applications which then stretches it beyond its capabilities, unnecessarily complicating design by creating more problems that need to be solved.

Expanding the scope of a technology can yield significant system-wide savings. For example, consider the consolidation of the many interconnect levels of a system fabric (see **Figure 1**). Rather than having to support a new protocol at each level, substantial cost savings as well as simplified system development and management can be realised by collapsing levels into each other through the use a single protocol, thus reducing the number of protocols a system must support.

Given its ubiquitous presence throughout the LAN and WAN, Ethernet is a prime candidate as the convergence protocol for system-level fabrics. Its high volumes and extreme flexibility make it an especially attractive option for many applications and for these reasons engineers have begun to carry Ethernet from the LAN and WAN down into the chassis and board-level infrastructure.

Before committing to Ethernet in board and chassis-level applications, however, engineers will find it useful to first compare Ethernet to alternative technologies, such as the RapidIO specification that, rather than extending downward as Ethernet does, push up through the fabric.

IN THE JULY ISSUE WE STARTED A SERIES ON ETHERNET AND RAPID**IO** INTERCONNECT TECHNOLOGIES: TYPES, TECHNICAL COMPARISONS AND OVERVIEW, PRACTICALITIES AND DESIGN CONSIDERATIONS. IN THIS – FIFTH AND LAST – ARTICLE, GREG SHIPPEN, SYSTEM ARCHITECT FOR THE FREESCALE SEMICONDUCTOR DIGITAL SYSTEMS DIVISION AND A MEMBER OF THE RAPID**IO** TRADE ASSOCIATION'S TECHNICAL WORKING GROUP AND STEERING COMMITTEE, FOCUSES ON THE PRACTICAL DESIGN CONSIDERATIONS

ORIGINS

Ethernet was designed to serve in large networks with a great many endpoints, each of which was expected to have a processor available for protocol stack processing. Ethernet was also built to be extremely flexible, enabling it to serve in a great many applications beyond its original specification. However, as Ethernet was originally designed for the LAN, its applicability becomes increasingly strained as application requirements diverge from Ethernet's base capabilities (see **Figure 2**). Specifically, while the communications infrastructure of high-speed, embedded board-level and chassis-level applications resemble small networks unto themselves, data transfers at these levels differ in significant ways from the LAN.

RapidIO technology, on the other hand, was designed specifically for embedded in-the-box and chassis control plane applications. The RapidIO protocol emphasises reliability with minimal latency, limited software dependence, protocol extensibility and simplified switching providing effective data rates from 667Mbps to 30Gbps. Other differences from Ethernet include hardware-based protocol processing as well as support for read/write operations, messaging, data streaming, hardware QoS, data plane extensions and protocol encapsulation.

Both of these standards can serve in chassis and board-level applications. Depending upon the application, however, the difference between them is the difference between good and not good

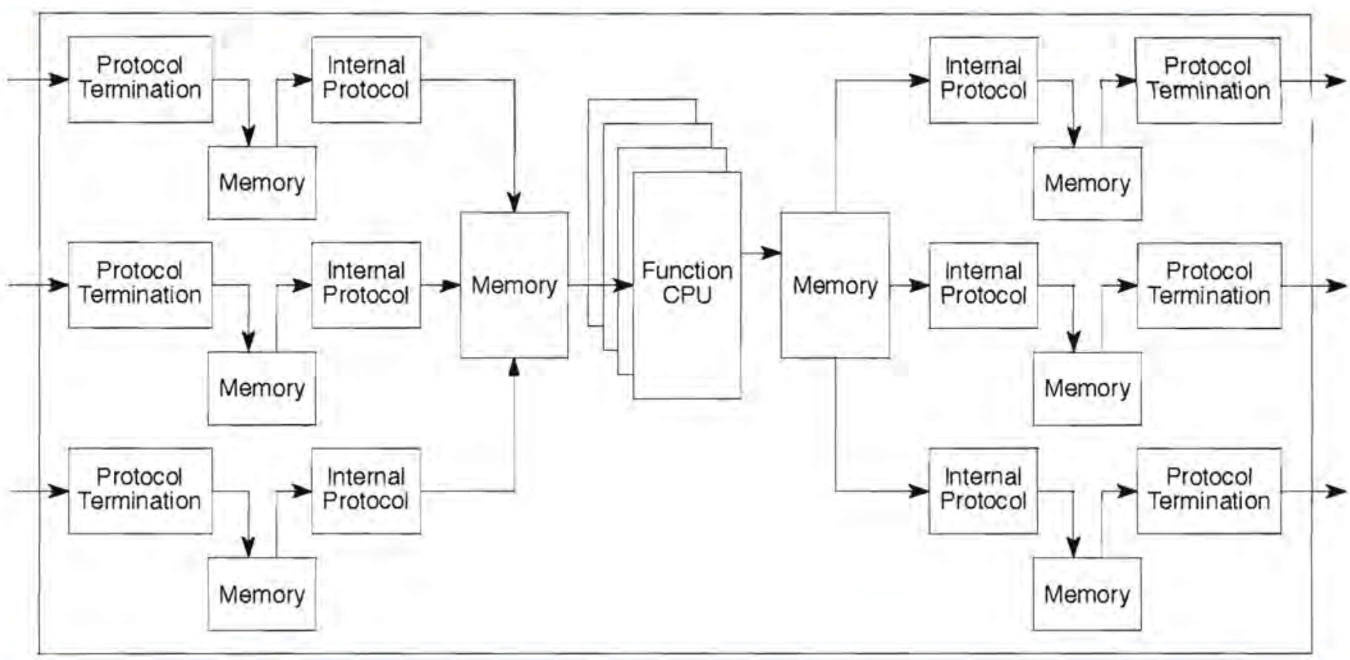


***Figure 1:** Consolidating protocols yields significant system-wide savings by eliminating processing and increasing efficiency, leading to improved system performance, throughput, reliability and cost-effectiveness*

enough. Determining which is which requires a deeper understanding of each technology, including the standards, interoperability issues, throughput, latency, power consumption, economies of scale, ecosystem support and, of course, cost.

STANDARDS

A key consideration in determining the viability of a technology for use in chassis and board-level applications is its status as an industry standard. Standards bring the engineering community together and focus efforts on directing innovation in a common direction. While proprietary standards may offer many promises, including superior performance, they tie manufacturers to a single source for parts and support. If the company that owns the proprietary standard decides to abandon it or focus innovation in a new direction, this can leave manufacturers facing a technological dead end.

As standards gain momentum, as both Ethernet and the RapidIO specification have, competition increases to lower system costs while encouraging the widest range of possible support for the standard. Even industry standards, however, can run into problems when they are not administered by the same standards body.

Ethernet, for example, is supported by a wide range of Layer 3 and higher protocols that implement optional and advanced functionality. While this flexibility expands Ethernet scope in the network, a direct result of having so many standard organisations and interests involved in the various derivative protocol definitions is that no single unified specification is available that can be uniformly implemented. This in turn results in significantly increased stack complexity for Ethernet to accommodate all of its variations and possibilities, leading to higher cost for processing resources, as well as higher packet latency.

For example, there have been occasional violations in compartmentalising the various protocol layers, including the fact that the TCP checksum includes elements of the previously-built IP header and how the IPSec security protocol inserts header skims between existing layers but only encrypts some of the header fields. Inconsistencies like these make it extremely difficult to process Ethernet in a pipelined fashion. In fact, they force interim pipeline stages to parse fields up and down the layer hierarchy, substantially increasing the complexity of implementing off-load hardware such as TCP/IP off-load engines (TOE), which are absolutely necessary for efficiency in 10G Ethernet applications.

Even if these issues are resolved, another challenge for Ethernet is how, and when, protocol off-load engines will be standardised. Within the embedded industry, there is no standard driver-level interface for hardware off-load. This means that every off-load implementation is essentially a proprietary implementation, each with a proprietary Ethernet stack that locks OEMs into using that stack in future designs, eliminating one of the key benefits of using an industry standard, that of choice in vendor and implementation selection. In effect, the wider Ethernet's derivatives spread, the more standardisation issues arise.

The RapidIO specification, on the other hand, has more consistent protocol layering and is completely governed by a single standards organisation, the RapidIO Trade Association. Rather than providing

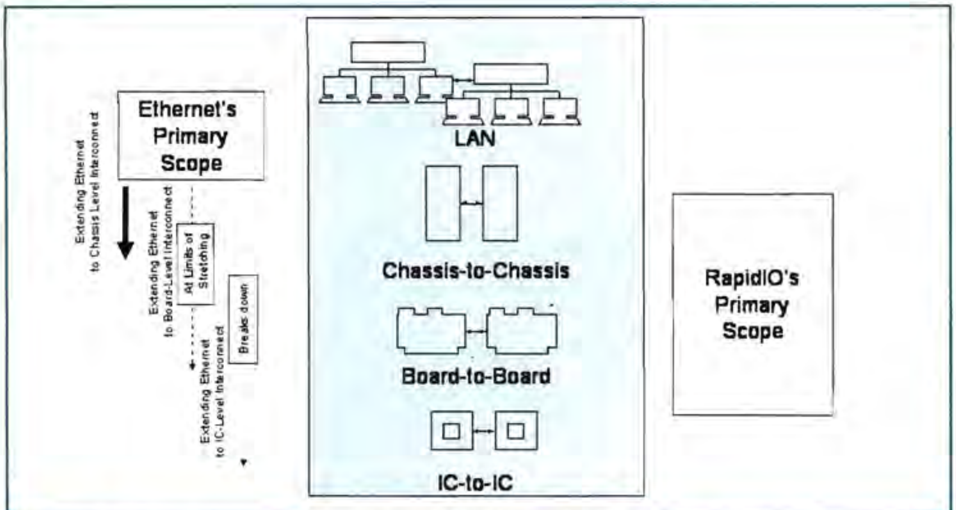


Figure 2: *a) Ethernet was originally designed to serve in large networks with a great many endpoints, each of which was expected to have a processor available for protocol stack processing. b) The RapidIO protocol, in contrast, was designed specifically for embedded in-the-box and chassis control plane applications.*

near unlimited flexibility with corresponding added complexity, the RapidIO specification outlines a more appropriate set of baseline functionality for chassis and board-level applications than Ethernet. The result is lower implementation cost with reduced overall complexity. And since most of the RapidIO protocol is implemented in hardware, its software drivers are far simpler than the typical Ethernet TCP/IP stack. Additionally, RapidIO stacks can depend upon the existence and consistency of standardised implementations.

THROUGHPUT AND LATENCY

For LAN and WAN applications, Ethernet's high overhead can be compensated for by large packets. Limited flow control makes switches less complex throughout the network, and the ability to drop packets is a key element for efficient congestion management.

These same characteristics which are advantageous in the LAN, however, can be devastating in control plane applications at the chassis and board level. Control plane transactions tend to be limited in size, so high overhead (the TCP/IP header alone adds 40 bytes) directly results in reduced efficiency.

The RapidIO specification has optimised header size to maximise efficiency for the size of packets typically used in control plane applications. Additionally, the RapidIO protocol provides robust flow control and guaranteed delivery, both essential for maintaining the priority and reliability of control plane transactions, providing higher fabric usage in complex topologies well in excess of 50%. Furthermore, link-level error correction minimises latency jitter incurred as the result of soft errors. End-to-end latency is substantially lower as well, potentially much less than 500ns, depending on the particular implementation, since software stacks at endpoints can be minimised or even eliminated.

Ethernet can be implemented in a way that supports control plane applications that cannot tolerate packet loss, but the fabric must be significantly over-provisioned to achieve this. Such over-provisioning is typically within the range of 25 to 35% usage, depending on the expected sustained and peak traffic demands of a given system. While over-provisioning reduces end-to-end latency and latency jitter, it decimates throughput: at 25% usage, the sustainable effective throughput of Layer 2 traffic for Gigabit Ethernet is ~ 250Mbps and only 2.5Gbps for 10Gigabit Ethernet, depending upon average packet size (see **Figure 3**). Even with over-provisioning, however, end-to-end latency can still be in the milliseconds, since traffic must traverse software stacks at both the source and destination endpoints.

POWER CONSIDERATIONS

From a PHY perspective, both Ethernet and RapidIO interconnects can take advantage of the power efficiencies of a single-lane XAUI-like PHY interface which dissipates anywhere from 70-200mW at 3.125Gbaud. For Ethernet applications using 1000Base-T PHYs power dissipation rises to between 640-950mW.

In applications where power consumption must be managed carefully, Ethernet protocol processing can consume more power than is desirable, compared to a RapidIO-based endpoint. This is in large part due to the fact that most Ethernet implementations run a software stack on a high-frequency host processor. Applying the rule of thumb that a Hz of CPU clock rate is required per bit of terminated TCP/IP performance, the power to terminate a line-rate Gigabit Ethernet link includes a GHz-class processor (adding on the order of watts of power), in addition to that consumed by the Gigabit PHY.

ECONOMICS

In general, the economies of scale for any silicon-based device depends upon die size, volumes shipped and the competitive level of the technology's ecosystem. At first glance, it might appear that Ethernet's economies of scale dominate those of RapidIO devices on every count. In fact, the opposite is true.

For example, RapidIO protocol processing is implemented in hardware. However, one RapidIO endpoint – including messaging support – shipping today is only 25% larger than a Gigabit Ethernet controller on the same processor. Note that this example is slighted in favour of the Ethernet controller since it did not implement a full TCP/IP TOE. With a complete TOE, the Ethernet controller would be at least comparable to or larger in size than the RapidIO controller. When considering PHY cost/size, both Ethernet and RapidIO systems can utilise a XAUI-like PHY, suggesting comparable silicon complexity and areas between the two standards.

From a volume perspective, it would be erroneous to take into account the entire Ethernet market when comparing volumes to RapidIO applications. Ethernet covers a wide range of applications and industries which are similar to high-speed, embedded chassis and board-level applications but require significantly different hardware and software

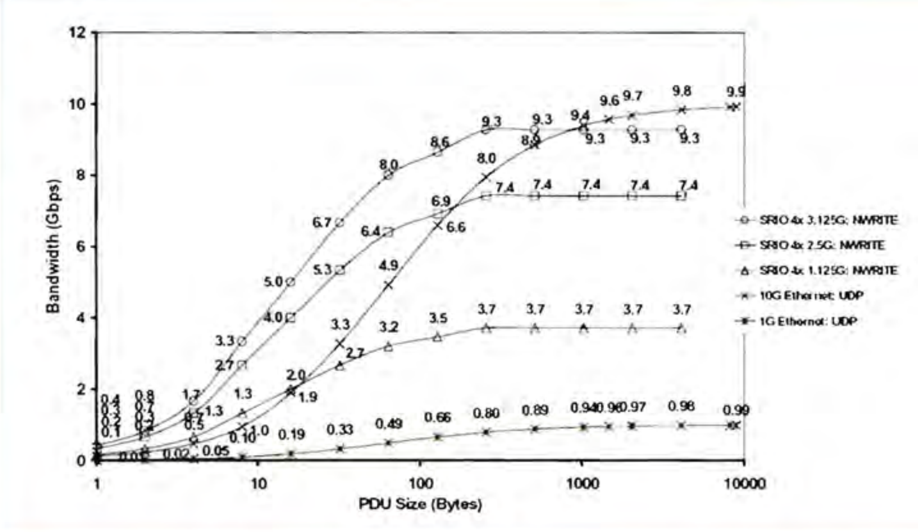


Figure 3: *Ethernet can support control plane applications that cannot tolerate packet loss but only through significant over-provisioning. Even with over-provisioning, Ethernet end-to-end latency can still be in the milliseconds since traffic must traverse complex software stacks at both the source and destination endpoints*

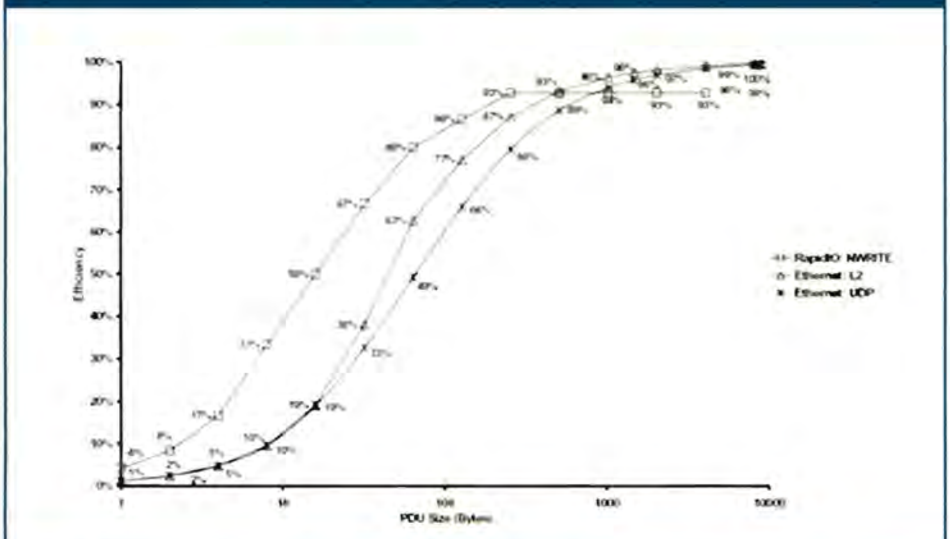


Figure 4: *Ethernet achieves its best efficiency with a maximum payload, although increases latency jitter significantly. By balancing small payload inefficiency against large payload jitter, the RapidIO specification achieves better overall efficiency at the payload sizes most commonly used in high-speed, embedded applications*

implementations. Consider that while an Ethernet endpoint targeted for LANs does hit an aggressive price point, Ethernet controllers for the LAN endpoint market offer only basic functionality and are effectively commodities.

Endpoints for backplane applications, on the other hand, require more specialised functionality such as VLAN QoS support, which significantly reduces the number of applicable applications and eliminates any high volume advantages. Additionally, Ethernet's best price economies today are for four to eight port switches, not the highly aggregated configurations required for efficient backplane configurations.

Finally, one must carefully consider the existing silicon and support ecosystem to understand its true impact on price. For an application such as a 12 to 24 port ATCA-like backplane, an Ethernet controller must support both VLAN QoS and Serdes PHYs. Such devices, however, are offered only by a relatively limited number of vendors in the Ethernet ecosystem. A comparable RapidIO device is offered by more vendors, given its standardised nature, making for a much more competitive marketplace.

EFFECTIVE THROUGHPUT

Given that the cost between Ethernet and RapidIO controllers is potentially comparable, developers need to turn to other considerations, such as throughput, to determine which technology is best-suited for an application. When all of the factors listed above are taken into account, RapidIO technology offers 2.5 times more bandwidth per link than Gigabit Ethernet.

The difference is even more pronounced when fabric bandwidth requirements exceed 1Gbps. In these cases, the only option for Ethernet is 10Gbps which, if an application doesn't need this much throughput, introduces undesirable over-provisioning cost without any corresponding performance or reliability benefits.

In addition, today RapidIO devices offer higher effective bandwidth for payloads less than 1024 bytes at a lower cost (see **Figure 4**). Note that this comparison overlooks the added cost and complexity associated with managing Ethernet stack processing at 10Gbps.

Ethernet is clearly the technology of choice for many LAN and WAN applications. While the ability to consolidate interconnect levels by bringing Ethernet down to the chassis and board level, the complexities arising from its derivatives, associated inefficiencies, lower throughput and smaller ecosystem make Ethernet less appealing for use as a backplane or control plane technology.

The RapidIO protocol, designed from its inception to serve in chassis and board-level applications, offers the efficiency of a hardware-based protocol processing architecture, superior throughput without extreme over-provisioning, lower overhead, more reliable flow control, more efficient power usage and a well-established ecosystem. As a result, RapidIO-based implementations can consolidate more levels of the system-level interconnect more efficiently and more reliability than Ethernet, making RapidIO the technology of choice for next-generation high-speed, embedded applications. ■

MICHAEL LOCH, MANAGER AT THE SYSTEMS APPLICATION GROUP IN THE AUTOMOTIVE BUSINESS UNIT FROM RENESAS EXAMINES THE TRENDS AND PERSPECTIVES OF MICROCONTROLLERS AND MEMORIES ADOPTED BY AUTOMOTIVE ELECTRONICS DEVELOPERS

STEERING TRENDS

The automotive electronics industry is celebrating its 25th birthday this year, marking two and a half decades of constant evolution.

This rapidly developing sector is rich with technology targeting automotive electronic control and its associated units, including sensors, microcontrollers, microprocessors, mixed signal ASICs and digital signal processors.

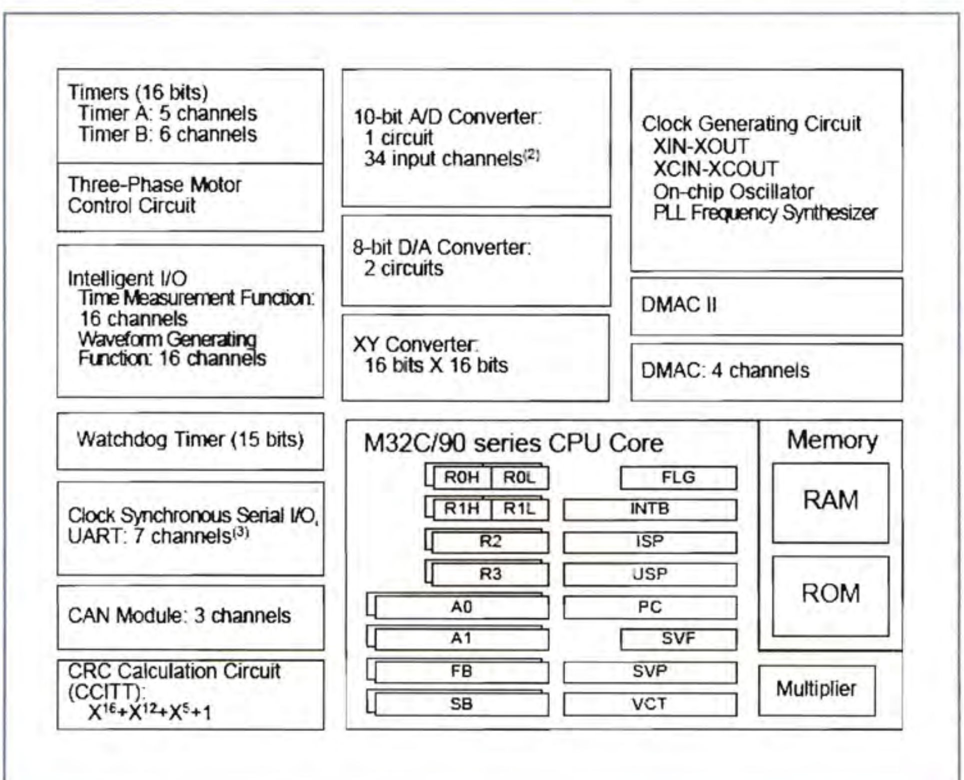
The semiconductor industry has been continuously improving its processes in response to the automotive sector's specific requirements – especially zero defect quality and high reliability – in order to meet and even exceed AEC Q100 specifications.

In the field of microcontrollers, for instance, this dedicated R&D effort has enabled the very large scale integration of 32-bit CPU cores with more than 2Mbyte of 80MHz single cycle random access embedded flash and application-specific peripherals such as multi-channel CAN, LIN, MOST and Flexray interfaces.

Applications such as navigation systems are now enabled by multichip solutions; where high-end superscalar processor cores like the SH4 are integrated alongside DDR RAM in one package, and mixed signal ASICs integrating power and logic in one chip are addressing the need for low end LIN slave devices.

Today, this combination of CPU performance, application specific peripherals, network interfaces and the integration of large embedded memory on chip is enabling economic single-chip solutions for complex applications, solutions which would not have been thought realistic until recently.

This article discusses some of the aspects driving the innovation in this field of embedded electronics.



Block diagram of M32C microcontroller

PROCESSOR PERFORMANCE AND MEMORY INTEGRATION

In Europe particularly, the evolution of microcontrollers has been driven by the automotive electronics sector. Their use in engine control units, ABS and navigation systems is now widespread, while new application areas including drive-by-wire or driver assistance systems is promoting further development. Even body and comfort applications, which in the past have utilised 8-bit micros, are changing in terms of integration and performance requirements. The humble fuse box, by way of example, now employs integrated electronics to provide protection against short circuit failure in central locking, immobilisation and alarm systems, as well as keyless entry/go, interior and exterior light control, wiper interval and numerous additional features. This application is now referred to as a 'smart junction box' or central body computer and is based on an embedded micro with 64-256kbyte flash, 4-10kbyte RAM and around 20MIPS processor performance.

The introduction of network architectures within automotive, using multiple CAN and LIN interfaces and promoting the standardisation of software layers is driving another change in body computer modules, towards a cluster/client server topology.

The demands of a body computer/cluster application will drive processing power requirements up, too, in to the region of 100MIPS with 1Mbyte flash and 64kbyte RAM. The need for multiple I/O channels operating across a range of frequencies will also require a flexible timer engine, as well as an A/D converter with a large number of analogue inputs. Typically 2-4 CAN and up to eight independent LIN network interfaces, with large message buffers and automatic transmission or gateway routing functions, are expected to be mandatory in future, as will a 10Mbaud Flexray connection.

By applying the latest process and CPU core technologies, this high level of integration can be realised today as monolithic single chip microcontroller designs, even within a high temperature environment of up to 125°C and single digit FIT rates for automotive reliability.

However, engine control units are under pressure for even more dramatic increases in performance and integration. Every 10 years, processing needs have risen here by a factor of 20 and they continue to increase. In 2008, a minimum of 400MIPS of CPU performance is anticipated, reaching 800MIPS by 2012 and which will by no means represent the upper limit. Application developments including navigation systems and driver assistance systems are demanding more than 1000MIPS calculation power; demands that can't be met with conventional single chip microcontroller concepts.

While some commercially available microprocessors achieve this performance, they are predominantly developed for the digital consumer or PC market, sectors without the same reliability demands as automotive. Additionally, in most cases their high power dissipation requires cooling. None of these attributes are acceptable in the automotive sector, so alternative solutions are needed.

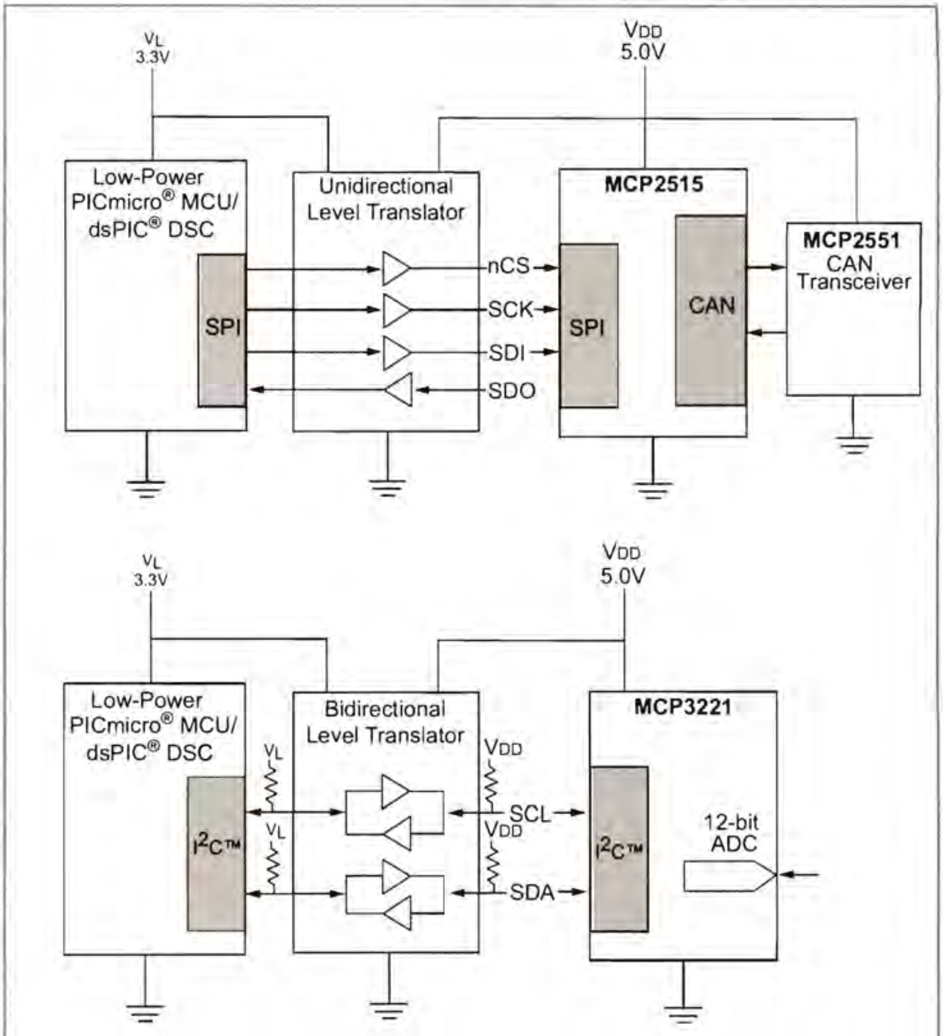


Figure 1: *SH7780 system in package (SiP) provides integration of processor and memory*

MEMORY REQUIREMENTS

Be it an airbag, a car's body computer or motor management electronics, hardly any control unit can do without non-volatile data storage. All these applications require permanent data storage for parameterisation, diagnostics or families of characteristics.

Users often try to emulate external EEPROM using the microcontroller's internal flash memory for commercial or technical reasons. This frequently fails due to the limited number of write/erase cycles, the restricted operating temperature range during the flashing procedure and due to inappropriate memory segmentation.

Most applications divide a microcontroller's flash memory into different data areas. The largest area is reserved for program code since its content must allow re-flashing. This re-flashing procedure is generally performed at the end of the control unit manufacturer's production line, on the car manufacturer's assembly line or in the garage for troubleshooting or simple software upgrading. Correspondingly, the estimated number of required flash cycles will be rather low with a value of less than 100.

Similar requirements apply to the flash

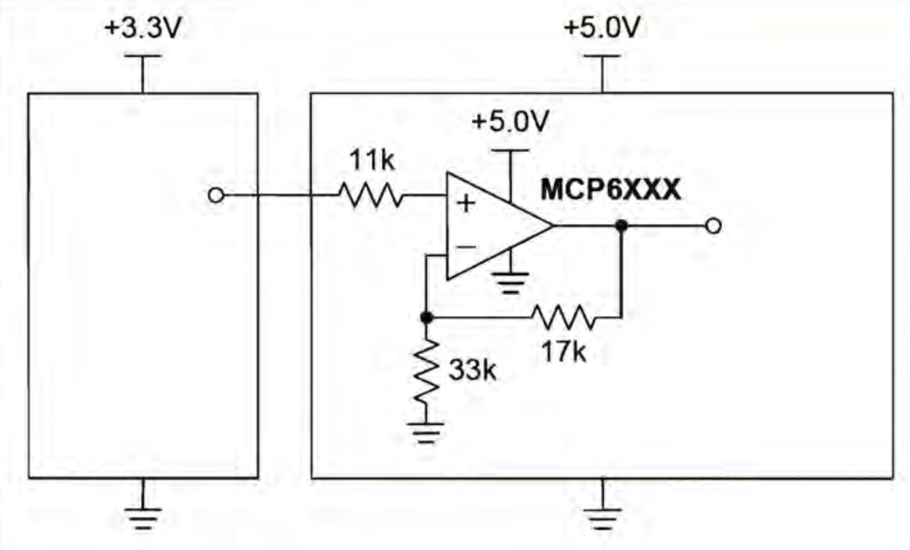


Figure 2: Example of multi-layer, stacked SiP construction

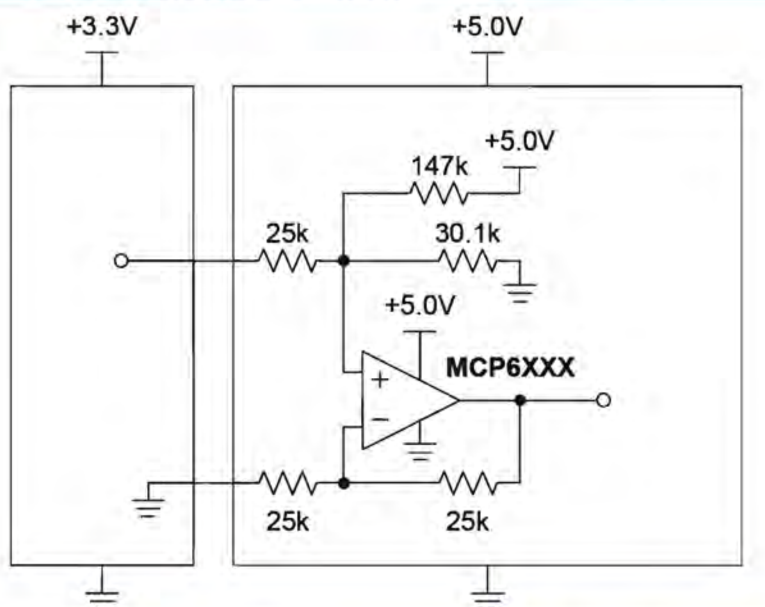


Figure 3: Construction of MONOS flash memory

boot loader program which is assigned to a dedicated, protected area, so that it cannot be overwritten during program code reloading. Protection of this memory area is vital because inadvertent or erroneous overwriting of the flash loader program would render another re-flashing operation impossible and thus make the control unit unusable.

Finally, another area is needed for data that are dynamically generated by the application, and which need to be stored in real time at regular time intervals or on certain events. This data could be a previously read switch position, hopping codes of the immobiliser system, error codes for diagnostic purposes or adaptive families of characteristics. High write/erase cycle counts are characteristic for this area. Data that are saved on ignition on/off can generally do with 250,000 storage cycles, whereas dynamically generated data often require up to 1 million write/erase cycles.

All flash memory areas must be capable of storing its content without any loss of data over a period of approximately 20 years. Reliable charge carrier retention for long periods of time is one of the main physical requirements for flash memory cells. High storage and operating temperatures and by stress due to high numbers of write/erase cycles are the main factors that impair data retention.

NEW MEMORY TECHNOLOGIES

In the automotive field, flash continues to be the predominant memory technology used in various applications, even though the access speed for conventional stacked-gate flash technology qualified for automotive is limited to around 80MHz, for single cycle access with ambient temperatures up to 125°C.

A flash technology which offers faster access is MONOS (Metal-Oxide-Nitrite-Oxide-Silicon). The advantage of this flash technology is in the addition of an isolating layer between the floating-gate and the drain-source area of the memory transistor. If a defect develops in the tunnel-oxide material during the operating life of the chip, only the charge centred locally near the defect will be lost. This robustness makes it possible to develop smaller cell architectures with smaller gate capacities, resulting in higher access speeds. These technical advantages and the reduced flash module size make MONOS an attractive memory technology, especially for large densities over 512kbyte.

Next generation of non-volatile memory technologies, such as MRAM (magneto-resistive RAM) and PCM (phase change memory) are already under development and will offer many advantages, such as nearly unlimited erase/write cycles and faster write times. This will make MRAM and PCM viable as not only EEPROM replacements, but even RAM in the long term. The magneto-resistive principal of MRAM is also resistant against transient or 'soft' errors, which are now beginning to impact the reliability of memory in smaller process structures. These technologies are planned to debut around 2010, while existing flash technologies will surely stay for many years.

MULTICORE CHIPS AND MULTI-CHIP PACKAGING

If one CPU doesn't offer enough power, why not run two or more in parallel on the same chip? In fact, the merits of this concept go beyond performance; it also offers redundancy, which increases safety integrity. Accordingly, multicore chips are becoming popular, especially for safety relevant applications like ABS. Since both CPUs are sharing the flash and RAM memory resources, ideally a double cache strategy for instruction and data cache should be applied in order to avoid too many wait cycles. In certain cases the combination of a CPU and a DSP core is favoured, as it meets the data processing requirements of the application. An example would be adaptive cruise control (ACC), where the radar sensor unit – or image processing in the case of a CMOS sensor-based unit – must perform excessive filter calculations.

Besides a monolithic implementation with dual cores, there is another approach to achieving higher performance; the integration of several chips on the same substrate, or multi chip packaging (MCP). The effort for simulating and verifying a MCP chip can compare well against a monolithic approach, since the individual chips can be tested more easily, becoming more a matter of thermal simulation and impedance matching of the address/data bus interconnection between the chips.

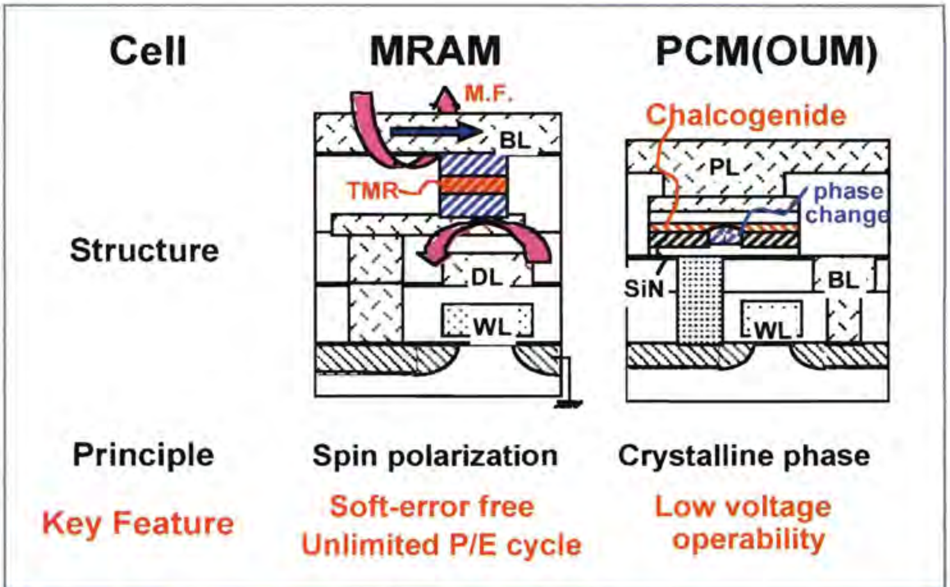


Figure 4: *Next generation non-volatile memory technology. Magneto resistive RAM (MRAM) and phase change memory (PCM)*

INNOVATION THROUGH STANDARDISED NETWORKS

Another force behind the evolution of automotive electronics is the need for a network, enabling efficient communication between the increasing numbers of electronic control units. CAN, LIN and MOST are dedicated automotive interface standards and have seen worldwide acceptance from all car makers. The latest addition is Flexray, a real-time deterministic high speed 10Mbaud network standard for safety relevant applications.

The key to establishing worldwide acceptance was the creation of standardisation committees, with contributions from all relevant parties within the car industry, including the car manufacturer, Tier 1 suppliers providing the electronic systems and Tier 2 suppliers, which include semiconductor vendors as well as the tool and middleware software providers, all of whom have joined the committees.

This means that as well as the physical and logical hardware protocol layers, the software layers have also been standardised, through common operating systems like OSEK and, recently, through the AUTOSAR consortium, which is working towards a common platform for low level drivers, as well as the upper layer software. The tremendous increase in software and the emerging complexity of the applications and gateway functionality continues to push the demand for more powerful 16 and 32-bit controllers.

While CAN, LIN, MOST and Flexray network systems are mainly intended for communications between different electronic control units in one car (excluding flash and diagnostic interfaces), it is predicted that in the near future new network systems will arise for inter-car and central traffic station/service communication. Data integrity and security will be one of the main issues for this type of network and will open a new application area.

INTERESTING TIMES AHEAD

Even though the automotive sector represents just 10% of the total worldwide semiconductor market, it remains an interesting segment for the industry. Its dynamic evolution benefits from and contributes to the leading edge in semiconductor technology, especially for microcontroller performance, integration and automotive specific solutions, while the sector's characteristic long-term production schedules ensure several years' continuous business. ■

Navigation Solution

Navigation is an example application that can be realised using an MCP solution, in the form of the Renesas's SH7780 processor integrated with 2 x 512Mbyte DDR SDRAM in a single package. The integration of processor and memory allows 320MHz memory accesses, avoiding the performance loss of discrete devices, with a moderately fast 50MHz bus interface to the I/O. The solution achieves 720MIPS CPU performance, while the next version will break the 1000MIPS barrier by increasing the clock frequency to 600MHz.

IN-VEHICLE NETWORKING – DESIGNING WITH SYSTEM BASED CHIP TECHNOLOGIES

JAN POLFLIET, PRODUCT MANAGER ASSP, EUROPEAN MIXED SIGNAL OPERATIONS AT AMI SEMICONDUCTOR, LOOKS AT IN-VEHICLE NETWORKING (IVN) AND EXPLAINS HOW THE LATEST MIXED-SIGNAL SYSTEM BASED CHIP (SBC) TECHNOLOGIES ARE HELPING DESIGNERS DEPLOY IVN-BASED DESIGNS

The evolution of the processes that allow semiconductor manufacturers to integrate digital, analogue and high power functionality on a single chip have led to the emergence of increasingly integrated IC technologies for automotive in-vehicle networking (IVN) applications. For the designer looking to make use of these technologies it is essential to understand how such system-based chips (SBC) operate and to take into account critical issues such as power consumption, electromagnetic compatibility (EMC) and protection functionality.

IVN REQUIREMENTS

The electronic and electrical content, including software, of vehicles has grown rapidly in recent years and, according to industry analyst Databeans Inc, now represents somewhere in the region of 20% of total vehicle cost. It is not uncommon for a modern vehicle to contain 70 or more control modules and more than 400 components, while the predicted 9% growth rate of the global automotive semiconductor market far outstrips the 2-3% annual increase in worldwide automotive production.

This growth in automotive electronics is fuelled by factors ranging from legislation in areas such as safety and emission standards to consumer requirements for cockpit 'infotainment' and comfort systems. To manage the increased electronic content automotive manufacturers are looking to decentralise systems around the vehicle through the deployment of multiple electronic control units (ECUs). This decentralised approach means that the role of the IVN is becoming more important in vehicles at all levels of the cost spectrum. Furthermore, to support the decentralised model, a range of automotive bus systems have emerged, each matched to the particular type of data communications required.

Networks on a modern vehicle can be

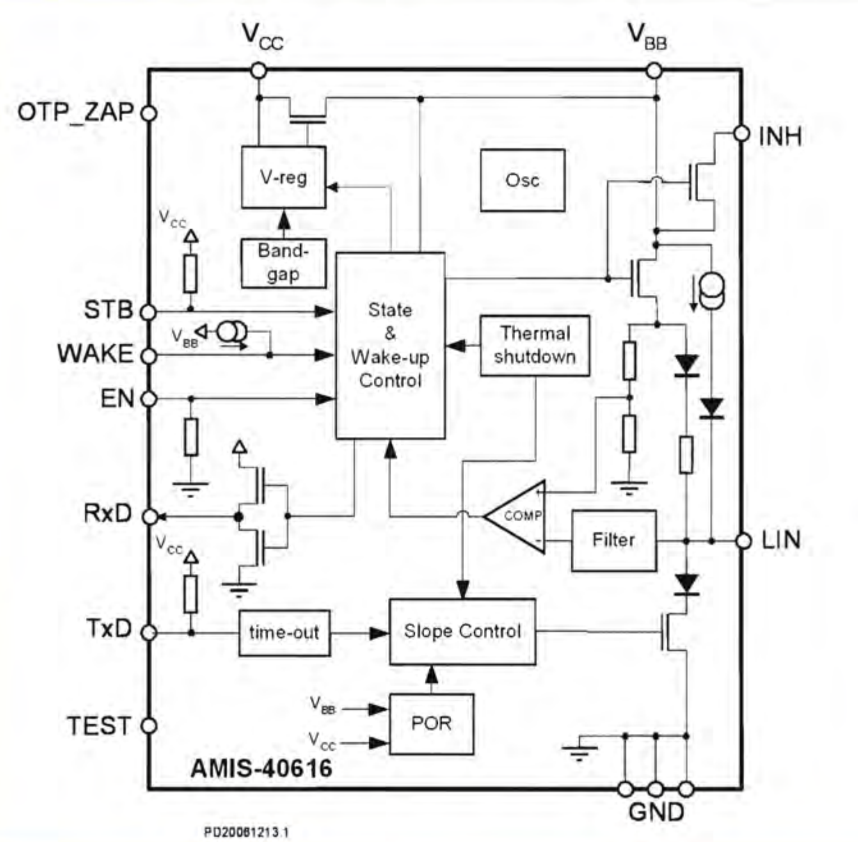


Figure 1: Block diagram of LIN transceiver IVN

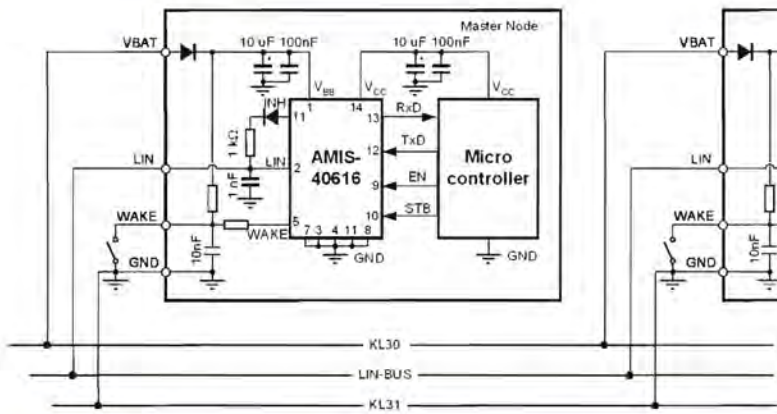


Figure 2: Typical application for LIN transceiver SBC

divided into clear application areas, each with different needs. Engine and transmission (power train) applications are high redundancy, low latency, closed loop control systems requiring a continuous high-volume flow of data, while active and passive safety systems require low latency coupled to very high redundancy and safety.

Chassis (suspension, steering and braking) applications are also low latency closed loop control systems that exchange data with other systems in the vehicle. Again safety is key so good network reliability and continuity is essential.

Body (comfort function) applications represent the greatest number of functions on the vehicle, but are the least demanding in terms of network performance. They transport short bursts of slower data, usually triggered by driver and passenger inputs to comfort function controls. The main demand on body control networks is that they have flexibility (to accommodate vehicle upgrades for example), have a high degree of compatibility and are low cost.

Finally 'infotainment' systems (wireless, navigation, entertainment, diagnostics) require data exchange with the outside world and, therefore, must be compatible with non-automotive standards. Whilst latency is not especially important, these networks have to be able to exchange large amounts of multimedia data, both inside and outside the vehicle and information integrity and confidentiality can both be important.

NETWORK PROTOCOLS

The primary 'open' network protocols that exist to meet the needs of the five application groups are: Local Interconnect Network (LIN), Controller Area Network (CAN), Media Orientated Systems Transport (MOST) and FlexRay.

Commonly used and with the lowest cost per node is single-wire (LIN). With a maximum data rate of 20kbps (over 40 metres cable) plus good flexibility and extendibility, LIN is well suited to body electronics functions.

Developed by Bosch in the early 1980s and first used in 1992, dual-wire CAN is currently the most dominant bus system in the automotive market. Although it has the potential to achieve a data rate of 1Mbps (over 40 metres of cable) most current CAN-based powertrain and chassis systems operate at 500kbps.

MOST uses fibre optics in a point-to-point network with ring, star or daisy chain topology. Specifically developed to serve rapidly evolving vehicle telematics, audio and multimedia applications, MOST

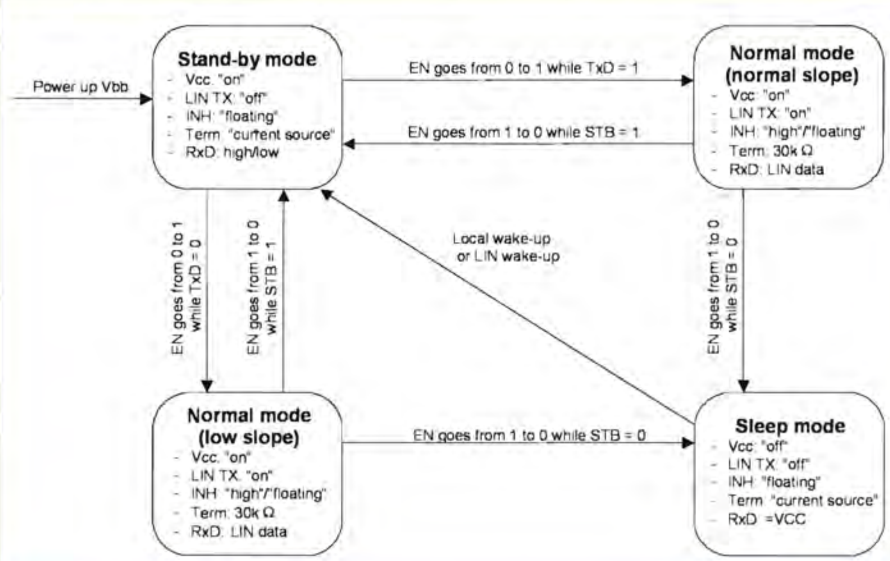


Figure 3: LIN transceiver operating modes

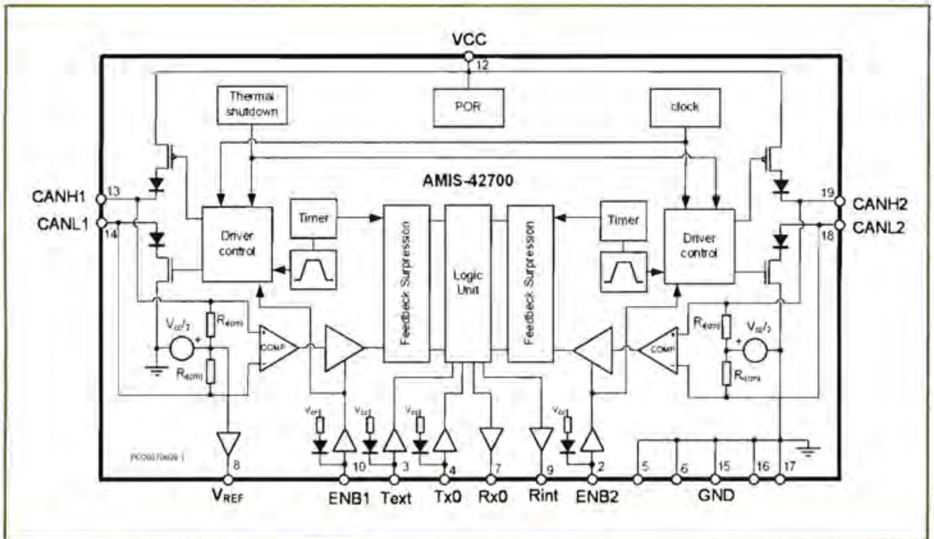


Figure 4: Block diagram of a CAN repeater

runs at 24Mbps on 64 nodes.

As steer-by-wire, brake-by-wire and active safety systems move closer to being adopted for mainstream vehicles, FlexRay is positioned as an ideal network for these types of safety critical powertrain and chassis applications. Using dual-wire optical fibre it is able to handle a gross data rate of 500kbps to 10Mbps – significantly higher than CAN, but also much more expensive.

SYSTEM BASIS CHIPS (SBC)

A system basis chip or SBC can be described as a single IC that integrates a variety of the functions that would typically have been implemented using discrete circuitry when building an IVN-based ECU. The emergence of these ICs has been made possible by the advent of mixed-signal semiconductor processes that allow high-voltage analogue circuitry to co-exist with digital functionality in the same compact device.

The most obvious example of an SBC is the single-chip transceiver. These devices are now available for all of the automotive bus standards outlined above, and combine the physical layer compliant bus connectivity circuitry with a number of other key functions such as voltage regulation and protection.

Figure 1 shows a block diagram of a typical LIN transceiver IC. Housed in a compact 14-pin SOIC package this IC is designed to interface between the LIN protocol controller and the physical LIN bus and integrates a LIN v2.0 physical transceiver, a voltage regulator, power on reset (POR) circuits, protection against thermal overload, short circuits, load dump (up to 45V) and ESD. The voltage regulator offers a 5V output and a current capability up to 50mA, allowing the device to power an external component such as a microcontroller.

Figure 2 shows a schematic of how this type of transceiver would be typically deployed in association with the relevant microcontrollers in a master node and a slave node configuration on the LIN bus.

IMPORTANT CONSIDERATIONS

While it is true to say that using an SBC simplifies much of the design work for the automotive engineer, there are still some important issues to consider. Two of the most important are EMC and power consumption.

Emission of and susceptibility to electromagnetic interference is a critical issue in most electronic designs but it takes on even more importance in the electrically noisy automotive arena. As a result, some SBC manufacturers have taken to offering built-in functionality that can help to minimise EMI. In the case of the device illustrated in Figure 1, for example, the integrated slope control function control can be used to control the slew rate of the LIN output for minimum EME. Despite this, external protection may still required for optimum

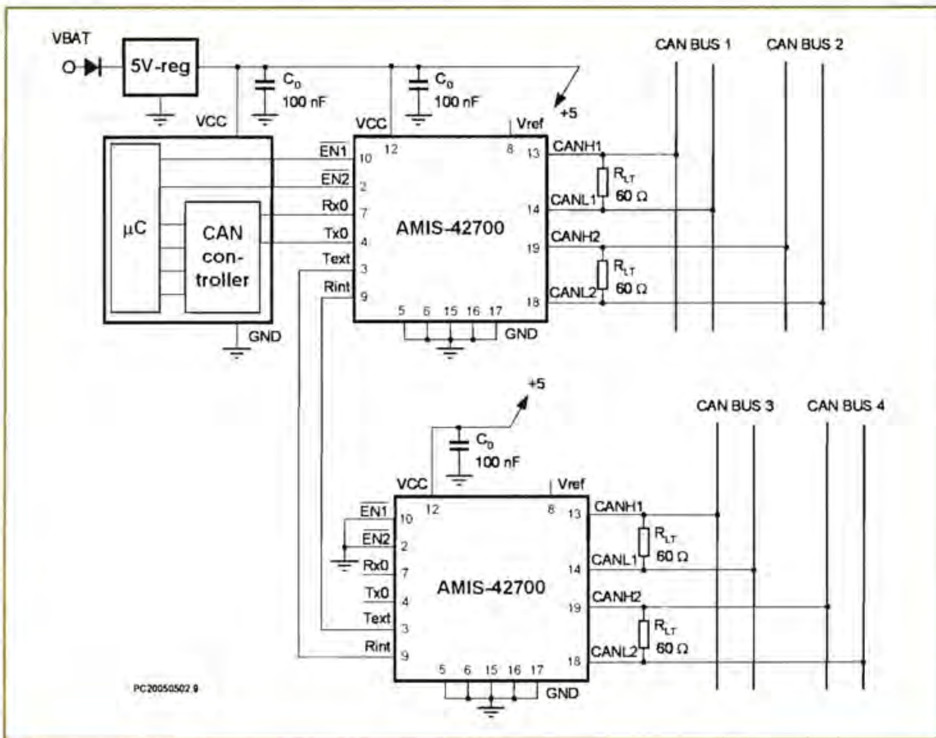


Figure 5: CAN repeater used as bus extender

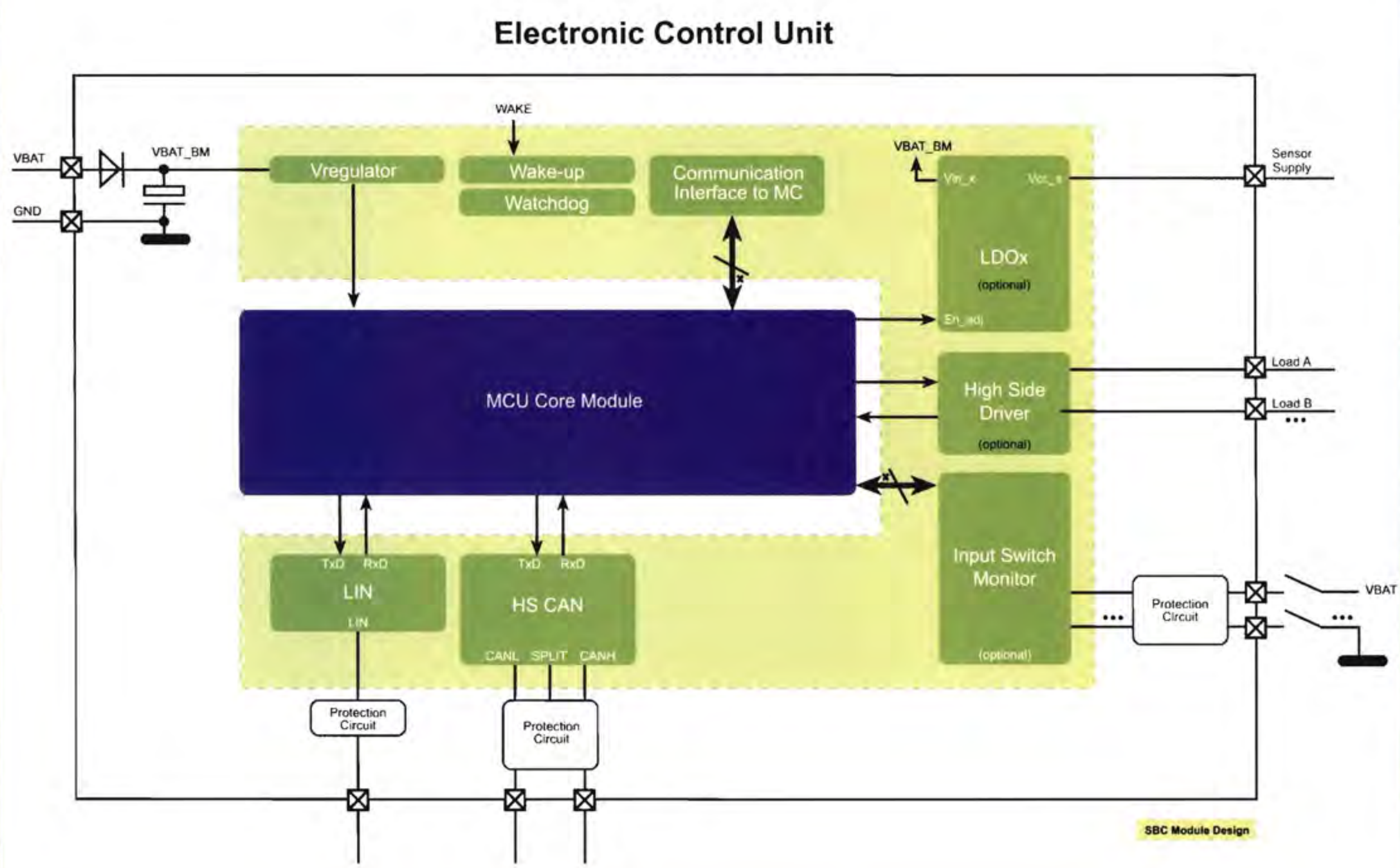


***Figure 6:** Next generation SBC functionality*

EMC design. In the case of the master node shown in **Figure 2**, for example, EMC immunity can be enhanced by adding a capacitor between the LIN output and ground. The optimum value of this capacitor will be determined by the length and the capacitance of the LIN bus itself, the number and capacitance of the slave devices, the pull-up resistance of all devices (master and slave) and the required time constant.

Because all vehicles have a limited power budget, power consumption is an issue that becomes more challenging as electronic content increases. Choosing an SBC that offers options to automatically enter standby and sleep modes can go a long way to minimising power consumption. Furthermore, some SBC manufacturers are now creating devices with operating modes that allow designers to address the issues of both EMC and power consumption.

Figure 3 illustrates the operating states offered by the device outlined in Figure 1. In normal slope mode the transceiver can transmit and receive data via LIN bus with speeds up to 20kbaud. The transmit data stream of the LIN protocol is present on the TxD pin and converted by the transmitter into a LIN bus signal with controlled slew rate to minimise EMC emission.

GOING WITH LIN

The receiver consists of the comparator that has a threshold with hysteresis in respect to the supply voltage and an input filter to remove bus noise. The LIN output is pulled high via an internal pull-up resistor. For master applications the designer will need to put an external resistor with a serial diode between LIN and Vbb (see Figure 2). The mode selection is done by EN=HIGH when the TxD pin is high. If the STB pin is high during the stand-by-to-normal slope mode transition, the INH pin is pulled high. Otherwise, it stays floating.

In low slope mode the slew rate of the signal on the LIN bus is reduced (i.e. the rising and falling edges of the LIN bus signal are longer). This further reduces the EMC emission but, as a consequence, the maximum speed on the LIN bus is reduced to a maximum of 10kbaud. This mode, therefore, is suited for applications where the communication speed is not critical. The mode selection is done by making EN=HIGH when the TxD pin is low.

In order not to transmit immediately a dominant state on the bus (because TxD=LOW), the LIN transmitter is enabled only after TxD returns to high. If the STB pin is high during the standby-to-low slope mode transition, INH pin is pulled high. Otherwise, it stays floating.

The stand-by mode is the first mode entered after power-up, although it can also be entered from normal mode when the EN pin is low and the stand-by pin is high. From sleep mode it can be entered after either a local wake-up or a LIN wakeup signal. In stand-by mode the Vcc voltage regulator for supplying external components (e.g. a microcontroller) stays active, while the LIN receiver stays active in order to be able to detect a remote wake-up via the bus. The LIN transmitter, however, is disabled and the slave internal termination resistor between LIN and Vbb is disconnected in order to minimise current consumption. Only a pull-up current source between Vbb and LIN is active.

The sleep mode is designed to provide extremely low current consumption. This mode is entered from normal mode when both the EN and STB pins are low. The internal termination resistor between LIN and Vbb is disconnected and the Vcc regulator is switched off to minimise current consumption.

CAN REPEATER

A recent addition to the SBC offering has been the dual transceiver that provides an interface between the protocol controller and up to two physical bus lines. An example of a dual high-speed CAN transceiver is shown in **Figure 4**. In addition to allowing engineers to implement dual CAN systems, this type of device can also be used as a CAN bus repeater or, as shown in **Figure 5**, a CAN bus extender.

Let's consider some of the key functions provided by such a device. The transceiver element includes transmitters for each bus line and a driver control circuit. Each transmitter is implemented as a push pull driver, which become active if transmission of a dominant bit is required. During transmission of a recessive bit all drivers are passive. As with the LIN transceiver described earlier, the driver control circuit ensures that the drivers are switched on and off with a controlled slope to limit EME. The driver control circuit will be controlled itself by the thermal protection circuit, the timer circuit, the ENBx inputs and the logic unit.

The dominant time-out timer circuit prevents the output drivers from driving a permanent dominant state, which would block all network communication (a situation that can occur due to hardware or software failure). The enable signal ENBx allows the transmitter to be switched off by a third device such as the microcontroller.

Two bus receiving sections sense the states of the bus lines. Each receiver section consists of an input filter and a fast and accurate comparator. The aim of the input filter is to improve the immunity against high-frequency disturbances and also to convert the voltage at the bus lines CANHx and CANLx, which can vary from –12V to +12V, to voltages in the range 0V to 5V, which can be applied to the comparators.

The output signal of the comparators is gated by the ENBx signal. In the disabled state (ENBX = high) the output signal of the comparator will be replaced by a permanently recessive state and does not depend on the bus voltage. In the enabled state the receiver signal sent to the logic unit is identical to the comparator output signal.

The central logic unit provides data transfer from/to the digital interface to/from the two busses and from one bus to the other bus. Digital input stages convert the input voltage at Tx0 and TEXT into a logical value for the logic unit. All digital inputs, including ENBx, have an internal pull up resistor to ensure a recessive state when the input is not connected or is accidentally interrupted. Output stages convert the logical value provided by the logic unit into voltages corresponding to the input signal specification of the CAN controller at Rx0 and RINT. A dominant state on the bus line is represented by a low-level at the digital interface, a recessive state is represented by a high-level. Input and output signals of the logic unit are related in such a way that a dominant state on any bus or Tx0 causes a dominant state on both buses, RINT and Rx0. An internal logic connection ensures that the output signal at Rx0 corresponds to the inputs Tx0 and TEXT, independent of the state of the two enable inputs.

The pins TEXT and RINT are used for connecting the internal logic of several ICs for applications requiring more than two bus outputs.

The IC provides a number of protection functions including a thermal protection circuit that prevents transceiver damage if the junction temperature exceeds the thermal shutdown level. A fault such as a short circuit is limited to that bus line where it occurs, ensuring that data interchange from the protocol IC to the other bus system is unaffected, while reverse polarity protection eliminates the possibility of damage if the ECU connections for ground and supply voltage are accidentally reversed.

NEXT GENERATION SBC

A new generation of SBCs is now emerging that integrate even more of the ECU functionality onto a single chip, as illustrated in **Figure 6**.

Among the key features of many of these new SBCs is the integration of transceiver functionality for different bus types, programmable window watchdogs and the option of multiple voltage regulators.

Many of the latest devices also offer fail-safe, diagnostic and fault tolerant capabilities that are increasingly demanded by automotive manufacturers for operationally critical applications. ■

SÜHA N. BAYINDIR, HASAN DEMIREL AND HÜSEYIN KUSETOGULLARI FROM THE DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING AT THE EASTERN MEDITERRANEAN UNIVERSITY, DISCLOSE THE DETAILS OF A SENSORLESS RED LIGHT VIOLATION DETECTION SYSTEM USING IMAGE PROCESSING TECHNIQUES, WHERE ADVERSE EFFECTS OF MAGNETIC LOOP, FIBRE-OPTIC OR MICROWAVE DETECTORS ARE AVOIDED

A SENSORLESS RED LIGHT VIOLATION DETECTION SYSTEM USING IMAGE PROCESSING

Red light violation is one of the major causes of fatal accidents in urban areas. Various sensors are used in practice to detect the vehicles which violate the red light rule. Microwave and optical sensors may cause false triggering of the camera due to non-vehicle objects which may pass on the pedestrian crossing. Magnetic loop and fibre-optic sensors are more reliable in detecting vehicles, however, they are also avoided because of destruction caused on the asphalt and interruption of traffic during their installation.

In order to eliminate the adverse effects of vehicle sensors, image processing techniques are used in this new system, to detect vehicles and also take the pictures of vehicles violating the red light rule using only a single camera. Vehicle detection using image processing is based on comparison of the current picture frame to the previous one, known as frame differencing. There are mainly two basic frame differencing methods referred to literature, such as D. Koller, J. Weber and J.Malik's *"Towards realtime visual based tracking in cluttered traffic scenes"* from the CS Division at the University of California:.

- Background removal method
- Inter-frame difference method

In the background removal method a sequence of empty road scene is used to form a reference frame. Consequently, each following frame is subtracted from the reference frame to determine the difference frame, which is then converted into a binary form by using the thresholding method.

The background removal method is susceptible to changes in daylight and climate, which may cause false detection with reference to a fixed reference frame. In this project, inter-frame difference method is used in the detection of vehicles where each frame is subtracted from the previous frame to determine the changed regions (i.e. moving objects). This technique helps us to avoid false detection due to changes in daylight and climate conditions by updating the reference frame at each refresh cycle.

The camera is adjusted such that it takes the picture of the vehicle together with the signal head where turning on of the red light is detected by observing the changes in pixels at the red light location.

VIOLATION DETECTION WITH IMAGE PROCESSING

The key point in the operation of the new system as illustrated in **Figure 1** is to detect the presence of a vehicle that crosses the violation line while the red light is on, by applying image processing techniques on the picture frames which are received continuously from a camera observing the violation region. Once the vehicle is detected it can be tracked through the video frames for taking the picture of its license plate.

There are two major problems associated with vehicle detection using image processing which may result in false triggering of the camera. One of these problems arises when a non-vehicle object such as a bird or a pedestrian who may cross the border line while the vehicle is waiting at the red light. The other problem arises due to changes in daylight and climate conditions. In order to avoid false triggering due to changes in daylight, the interframe difference technique is used, where each frame is subtracted from the previous one to determine the changed regions. Moreover, the number of changing pixels along the violation line is compared with a critical value to differentiate between the vehicles and other objects.

The system setup is illustrated in Figure 1, where a video camera is mounted on top of a pole located at one side of the road, where the violation line is designated at a location just after the signal headpost.

Frame differencing in temporal domain

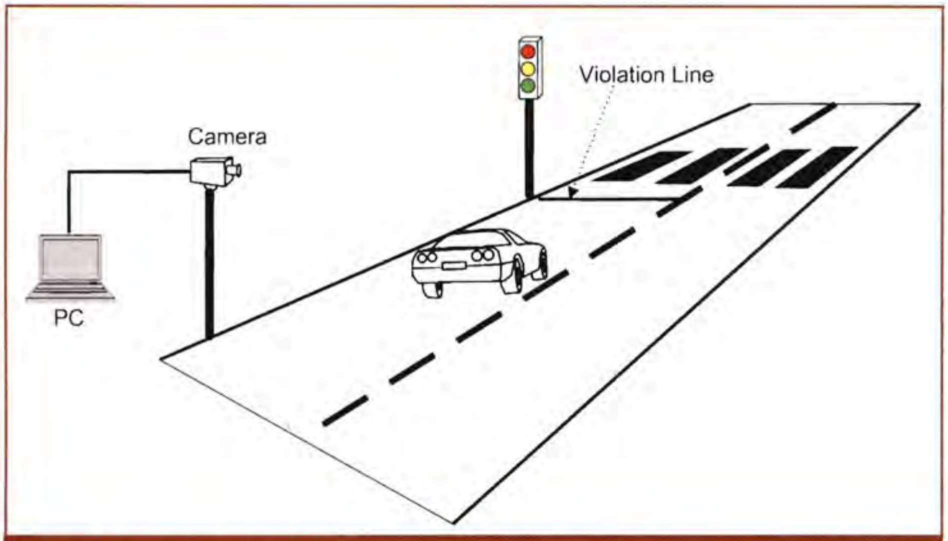


Figure 1: Red light violation detection system setup

and thresholding techniques are used to detect the existence of a vehicle. A difference frame is obtained by subtracting the previous frame from the current frame and a binary image of the difference frame is obtained by using thresholding method, as in G. Leedham, C. Yan, K. Takru, J. H. N. Tan and L. Mian's *"Comparison of Some Thresholding Algorithms for Text/Background Segmentation in Difficult Document Images"*, in the IEEE Proceedings of the Seventh International Conference on Document Analysis and Recognition (2003).

The number of changing pixels along the violation line on the binary image is calculated at each refresh cycle and compared with a critical value, which allows the program to differentiate between the vehicles and the other objects. When the number of pixel sum along the violation line exceeds the critical value, while the red light is on, it is assumed that a vehicle is violating the red light rule. A triggering pulse is thus produced to trigger the camera and capture the picture of the vehicle on which its licence plate can be seen clearly.

Figure 2: The current frame (a), previous frame (b), resulting difference image (c), binary image (d), obtained by thresholding the difference frame

INTERFRAME DIFFERENCE TECHNIQUE

The proposed system uses a number of image processing techniques including RGB to grayscale conversion, image subtraction and thresholding. After converting the image into grayscale, the previous frame is subtracted from the current frame as shown in Equation 1:

$$I_d = I_c - I_p$$

where I_p and I_c are the previous and the current frames respectively. The subtraction gives the difference frame I_d. Once the difference image is obtained, an adoptive threshold level is applied to differentiate the changing pixels from the static ones. This process generates a binary image I_τ for further processing. The threshold value, τ, is obtained statistically as given in Equation 2, where, μ and τ are the mean value and standard deviation of all of the difference pixels in a given frame, and $I_\tau(x,y)$ corresponds to the value of each pixel in 2D representation.

$$\tau = \mu + \sigma$$

$$I_\tau(x,y) = \begin{cases} 255, & if\ I_d(x,y) > \tau \\ 0, & if\ I_d(x,y) \le \tau \end{cases}$$

Figure 2 illustrates the current and previous frames in (a) and (b) respectively, followed by the difference image in (c) and the binary image (d) obtained through the thresholding process.

The flowchart in **Figure 3** illustrates the details of the algorithm used in the detection process. After the generation of the binary image, the amount of white pixels indicates the level of change between the current and previous frames due to moving objects.

If the total white pixel count (P_c) on the binary image is less than a threshold value, then the amount of change is not enough to indicate the presence of a moving vehicle. This threshold value (i.e. 40) is heuristically determined. When there is an insufficient change in the current frame, the threshold, τ, is updated for the next frame. When a vehicle is detected entering the current frame while the red light location on the image is activated, the system assumes that a violation is initiated and waits until the vehicle crosses the violation line completely. This is determined by checking the variation of before total number of white pixels along the

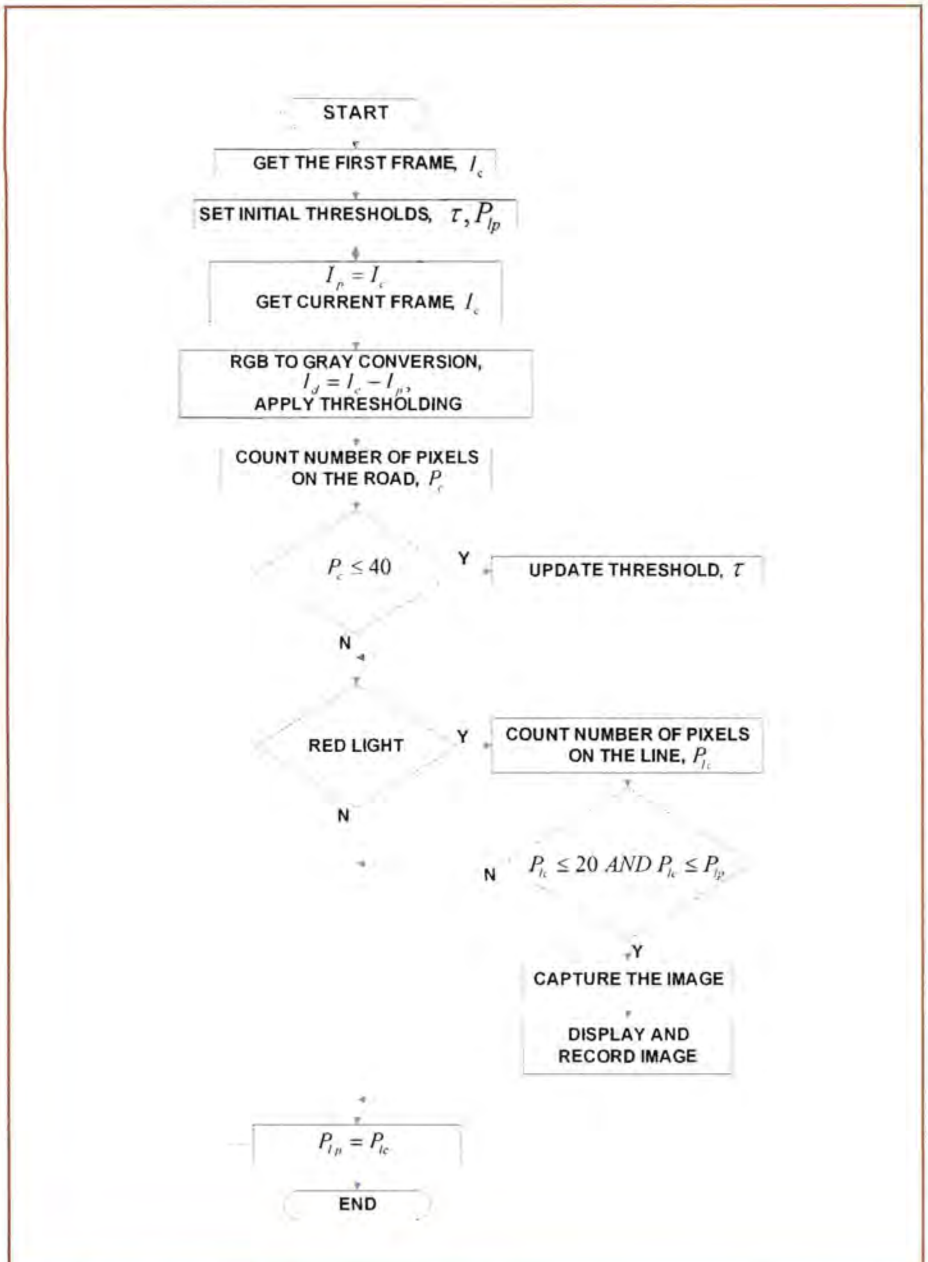


Figure 3: *Flowchart of the detection software*

Figure 4: *Pictures of a vehicle just before (a) and after (b) red light violation (red light violation system in Basmane-Izmir, Turkey)*

violation line as shown in **Figure 4a**.

P_{lc} and P_{lp} show the number of white pixels (i.e. changed pixels) falling onto the violation line in the current and previous frames respectively. The vehicle is assumed to be moved out of the violation line when P_{lc} falls below a critical value. This critical value is obtained heuristically to be 20.

IMAGE CAPTURING

When the program detects a vehicle violating the red light zone while the red light is on, the image of the vehicle, together with that of the signal head, is captured and saved in a JPEG file with a unique name composed of the date and place of the incidence. This picture is then scanned by an Automatic Number Plate Recognition (ANPR) program to determine the licence plate number. In the final step, the date, licence plate number and the place of incidence are printed on the picture as shown in **Figure 4b**.

The recorded pictures are transmitted to a Traffic Centre by using fibre-optic, GPRS or other wireless communication means. Pictures are certified after they are processed to secure the contents until it is printed so that it can be used as a legal document in court.

STOP – RED LIGHT!

In order to avoid the destructive nature of vehicle detectors, such as magnetic loop and fibre optics, and the false triggering nature of microwave and optical sensors, a novel sensorless red Light Violation Detection System is designed, constructed and implemented at an urban junction in Izmir. The existence of a vehicle passing the red light violation line is detected by continuously checking whether there is a change in pixels along the violation line. The on state of red traffic light is also detected by checking the changes in pixels at the location of the red light.

False detection due to variations in environmental conditions or due to non-vehicle objects is avoided by using the interframe difference technique and comparing the number of changing pixels along the violation line using a threshold value to differentiate between the vehicles and the other objects.

Performance of the proposed system is compared with reference to a magnetic-loop-detector based Red Light Detection System, where it is observed that the rate of false triggering was below 1%, which proves the validity of the proposed system.

As this system uses nothing more than a single camera, its cost is much lower than those which utilise specialised vehicle detectors. ■

JEFF GRUETTER, PRODUCT MARKETING ENGINEER AT LINEAR TECHNOLOGY, INVESTIGATES HOW NEW AUTOMOTIVE-SPECIFIC POWER ICs CAN MEET THE TOUGH NEW DEMANDS REQUIRED BY AN ENVIRONMENT THAT IS ELECTRICALLY AND THERMALLY CAUSTIC

AUTOMOTIVE POWER ICs FIND NEW APPLICATIONS AND CHALLENGES

Each year cars continue to incorporate increasingly complex electronic systems to maximise comfort, safety and performance while minimising harmful emissions.

US-based market research firm IC Insights predicts the automotive semiconductor market will grow to more than $18.1bn in 2008, up from $14bn in 2006. Strategy Analytics, another research firm, offers an equally positive view: "Today, electronic systems account for more than 22% of a typical car's cost, but that figure will jump to more than 30% by 2008." Examples of these electronic systems are infotainment systems (i.e. telematics), safety systems, engine management, satellite radio and TV, LED lighting, hands-free cellular phones and other wireless connectivity. Five years ago, these systems were only found in "high-end" European luxury cars but now they are being integrated into mid-range automobiles from every manufacturer, accelerating automotive IC growth even faster.

One of the driving electronics applications is engine control management. Each year, worldwide emissions standards get stricter while gas mileage requirements increase, yet customers demand even higher performance. Once mutually exclusive requirements, the adoption of "smart" engine control systems, a myriad of sensors and several DSPs enable car manufactures to attain higher levels of engine efficiency with cleaner running engines. Electronics is making a similar revolution in safety, climate control, lighting, navigation and wireless connectivity, as well as chassis control systems. Collectively, these new systems improve safety, performance and comfort for the driver and create a cleaner environment for everyone else.

As the electronic component count in these automotive systems increases, the available space requirements continue to shrink, greatly increasing the electronic density of each system. All of these systems require power conversion ICs, usually with multiple voltage rails for each subsystem. Once, linear regulators provided the majority of power conversion, as efficiency and small size were not of primary importance. But as the power density has increased by an order of magnitude and many applications require relatively high ambient temperatures, any practical heat sinking is too large to be accommodated. Thus, power conversion efficiency becomes critical due to space limitations and operating temperature-range requirements.

At low output voltages and even with moderate current levels above a few hundred milliamps, it is no longer practical to simply use a linear regulator to generate these system voltages because they generate too much heat. As a result of these constraints, switching regulators are replacing linear regulators. The benefits of a switching regulator, including the increased efficiency and smaller footprint, outweigh the additional design

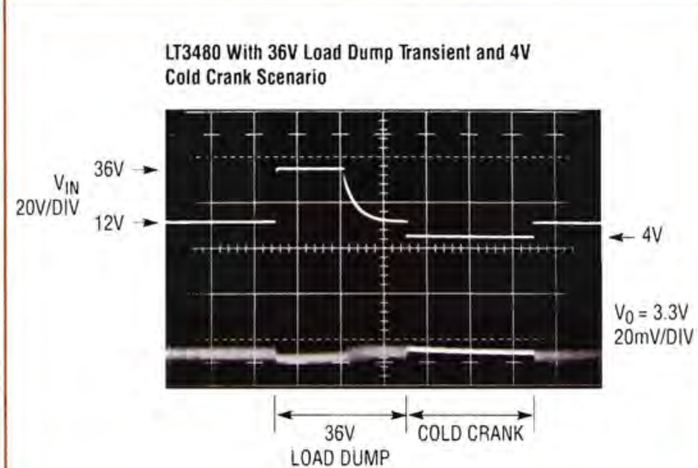


Figure 1: 36V load dump condition and cold crank conditions

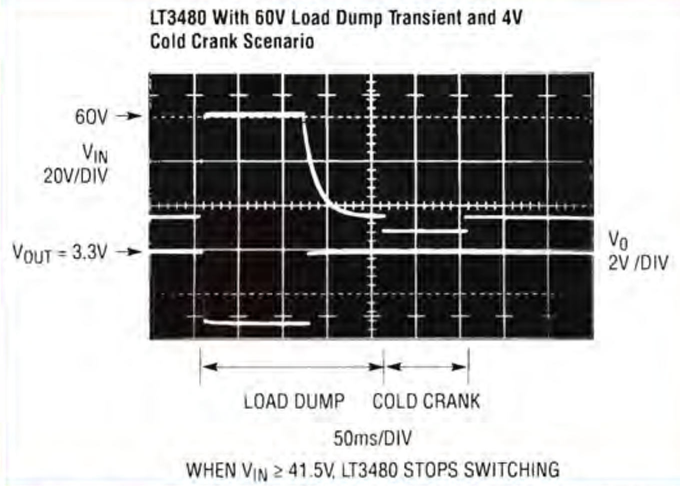


***Figure 2:** 60V load dump condition and cold crank conditions*

complexity and EMI considerations.

The primary objective of this article will be to investigate how these new automotive-specific power ICs can meet all of these new demands required by an environment that is electrically and thermally caustic.

LOW SUPPLY CURRENTS FOR 'ALWAYS ON' SYSTEMS

In addition to the aforementioned load dump and cold crank requirements, many electronic subsystems are also required to operate in standby mode drawing minimal quiescent current. These circuits are found in most navigation, safety, security and engine management electronic power systems. Each subsystem can use several microprocessors and microcontrollers. In fact, most luxury cars have between 60 and 100 of these DSPs on board.

Most operate in two different modes. First, when the car is running they generally operate at full current, fed by the battery and charging system. However, when the car ignition is turned off, many of these microprocessors must remain "alive", thereby drawing current from the battery. As there can be upwards of 30 of these always-on processors required for the navigation, security, climate control and engine management systems, there is an ever-increasing power demand on the battery even when the ignition is turned off.

Collectively, several hundreds of milliamps (mA) of supply current can be required to power these always-on processor voltages that could completely drain a battery in a matter of days. For example, after an extended two to three-week business trip, a luxury automobile's battery would be unable to crank over the engine. Quiescent currents of these power supplies need to be drastically reduced in order to preserve battery life without greatly increasing the size or complexity of the electronic systems.

Until recently, the requirement of high input voltage capability and low quiescent currents were mutually exclusive parameters for a DC/DC converter. If a car's high voltage step-down converters require 2-10mA of supply current each, combining several of these with other mandatory always-on systems such as ABS brakes, leakage current from electronically actuated windows and a host of other always-on systems can create a significant drain on the battery.

MANAGING 'ALWAYS ON' IN-VEHICLE SYSTEMS

In order to better manage the drain on the battery by several always-on systems in the car, several automotive manufacturers created a low quiescent current target of 100uA for each always-on DC/DC converter. Until recently, systems manufacturers were required to connect a low quiescent current LDO in parallel with a step-down converter and switch from this converter to a much lower current LDO each time the car was turned off. This created expensive, bulky and relatively inefficient solutions. Linear Technology's 36V to 60V input capable, < 100uA step-down DC/DC converter family, is shown in Table 1. Switching regulators with Burst Mode operation provide a much more compact and efficient solution to the always-on problem.

LOAD DUMP AND COLD CRANK CONDITIONS

Load dump is a condition where the battery cables are disconnected while the alternator is charging the battery. This can occur whether a battery cable is loose while the car is operating, or a battery cable breaks while the car is running. An abrupt disconnection of a battery cable can produce transient voltage spikes up to 60V as the alternator is attempting a full-charge of an absent battery (see **Figure 1** and **Figure 2** for graphical representations of a 36V and 60V transient).

Transorbs on the alternator usually clamp the bus voltage somewhere between 36V and 60V and absorb the majority of the surge current; however, DC/DC converters down stream of the alternator are subjected to these 36V to 60V transient spikes. As these converters, and the subsystems they power, are expected to survive, and in some instances regulate an output voltage through this transient event, it is critical that these DC/DC converters are capable of dealing with these high voltage transients. There are various protection circuits, usually transorbs, which can be implemented externally, but they add cost and take up valuable space.

Cold crank is a condition that occurs when a car's engine is subjected to cold or freezing temperatures for a period of time. The engine oil becomes very viscous and requires the starter motor to deliver more torque, which in turn needs more current from the battery. This large current load can pull the battery/primary bus voltage below 4.0V upon ignition, after which it typically returns to a nominal 12V to 13.8V (see Figure 1). It is imperative for some applications such as engine control, safety and navigation systems to require a

LOAD DUMP AND COLD CRANK – TACKLED

Depending on output current and the level of transient protection required, Linear Technology has several switching regulators that can operate through both cold crank and load dump scenarios and require less than 100uA of quiescent current (see Table 1). The LT3480, a 2A, 38V step-down switching regulator with input transient protection up to 60V, is a good example. Its Burst Mode operation keeps quiescent current under 70uA in no load standby conditions.

The device has an input voltage range of between 3.6V and 38V, and a transient protection of 60V, making it suitable for these conditions. In Figure 1, the LT3480 will regulate a 3.3V output through the 36V transient. In Figure 2, the LT3480 actually shuts itself down above 41.5V, to protect itself and circuitry down stream. When the transient drops below 38V, the LT3480 will go back into regulation.

Its 3A internal switch can deliver up to 2A of continuous output current to voltages as low as 0.79V. The LT3480's Burst Mode operation offers no load quiescent current of only 70uA (see Figure 3). Switching frequency is user programmable from 200kHz to 2.4MHz, enabling the designer to optimise efficiency while avoiding critical noise-sensitive frequency bands.

The LT3480 utilises a high efficiency 3A, 0.25Ω switch, with the necessary boost diode, oscillator, control and logic circuitry integrated into a single die. Low ripple Burst Mode operation maintains high efficiency at low output currents, while keeping output ripple below 15mV$_{PK-PK}$. Special design techniques and a new high voltage process enable high efficiency over a wide input voltage range, while its current mode topology enables fast transient response and excellent loop stability.

Part No	Device Architecture	V_{IN} Range	I_{OUT} (A)	Frequency	I_Q	Package
LT3437/8	Step-Down Regulator	3.3V to 80V	0.40	200/500kHZ	100μA	DFN-10
LT3433	Buck-Boost Regulator	4V to 60V	0.40	200kHZ	100μA	TSSOP-16E
LT1976/7	Step-Down Regulator	3.3V to 60V	1.25	200/500kHZ	100μA	TSSOP-16E
LT3480	Step-Down Regulator	3.6 to 38V, 60V_{MAX}	2.00	200kHz to 2.4MHz	70μA	3x3 DFN-10, MSOP-10E
LT3481	Step-Down Regulator	3.6 to 34V, 36V_{MAX}	2.00	300kHz to 2.8MHz	50μA	3x3 DFN-10, MSOP-10E
LT3681	Step-Down Regulator	3.6 to 34V, 36V_{MAX}	2.00	300kHz to 2.8MHz	50μA	3x4 DFN-14
LT3434/5	Step-Down Regulator	3.3V to 60V	2.50	200/500kHZ	100μA	TSSOP-16E

Table 1: *100uA step-down DC/DC converters*

Part Number	V_{IN} Range	Output Current	Topology	$T_{J(MAX)}$ °C	Package
LT3010H/-5	3V to 80V	50mA	LDO	140	MSOP-8E
LT3012/3H	4V to 80V	250mA	LDO	150	DFN-12
LT3470H	**4V to 40V**	**300mA**	**Buck Converter**	**150**	**2x3 DFN-8**
LT3437H	**3.3V to 60V, 80V Transients**	**500mA**	**Buck Converter**	**140**	**3x3 DFN-10, TSSOP-16E**
LT1933H	**3.6V to 36V**	**600mA**	**Buck Converter**	**150**	**2x3 DFN-6**
LT1766H	**5.5V to 60V**	**1.25A**	**Buck Converter**	**140**	**TSSOP-16E**
LT1976H	**3.3V to 60V**	**1.25A**	**Buck Converter**	**140**	**TSSOP-16E**
LT1936H	**3.6V to 36V**	**1.4A**	**Buck Converter**	**150**	**MSOP-8E**
LTC3803H-5	6V to 72V	3A	FlyBack Controller	150	ThinSOT
LTC1772H	2.5V to 9.8V	5A	Buck Controller	140	ThinSOT
LTC1871H	2.5V to 36V	10A	FlyBack Controller	150	MSOP-10
LTC3731H	4.5V to 36V	60A	Sync Buck Controller	140	SSOP-36

Table 2: *A family of H-Grade converters*

well regulated output voltage (usually 3.3V) through cold crank to operate seamlessly through this scenario.

THERMAL CONSTRAINTS IN AN AUTOMOTIVE ENVIRONMENT

In addition to the caustic electrical environment in automotive applications, the thermal environment can be equally challenging. As more electronics share the same prime real estate in cars, thermal management becomes critical. Under-the-hood applications typically require ambient temperatures of 125°C, or higher, while prime electronics real estate such as the navigation/infotainment system, gauges experience thermal challenges as they are both close to the cars firewall with high ambient temperatures and have a very high density of electronics. All electronics dissipate some amount of electrical power through heat. The key in managing heat in power converters starts with maximising each converter's efficiency thereby minimising the power lost to heat. This has been one of the driving forces in replacing LDOs with switching regulators in the past few years.

In addition to the particular devices efficiency, it is also important that each power conversion device has a very thermally efficient package to better conduct heat away from the IC. Leadless packages, such as DFNs as well as MSOP and TSSOP packages all use a thermally enhanced design which incorporates a thermal pad at the bottom of the package to reduce thermal resistance by more than a factor of two.

In order to meet the most demanding high temperature applications, such as under-the-hood applications, Linear Technology offers a family of H-Grade converters, which can operate with junction temperatures of either 140°C or 150°C, depending on the part. A comprehensive list of these can be found in **Table 2**. Conversion topologies include LDOs, high voltage monolithic switching

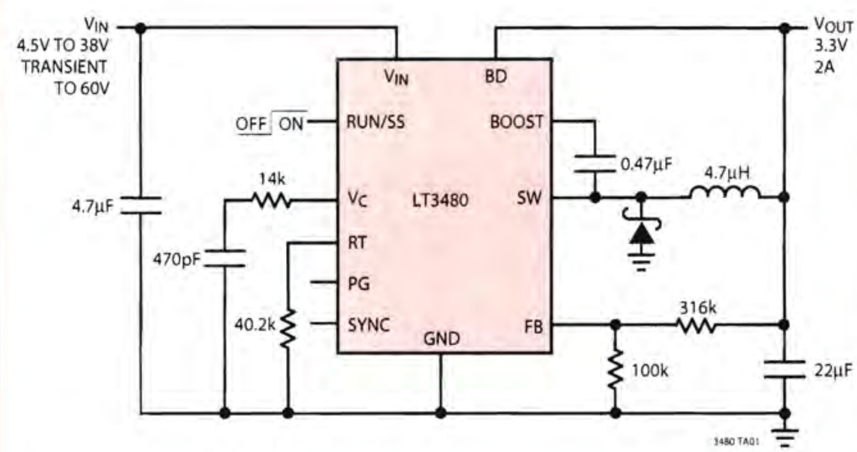


Figure 3a: *A 3.3V step-down converter based IC*

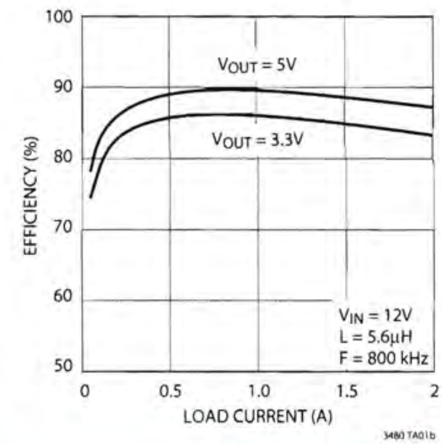


Figure 3b: *The efficiency graph of the IC in Figure 3a*

regulators and controllers.

For example, an application running from 12V and regulating to 5V while delivering 1A of output current, an LDO offers only 41% efficiency, dissipating 7W of wasted power which requires a substantial heat sinking to prevent thermal failure at even 80°C. Conversely, a switching regulator would operate at 90% efficiency dissipating only 0.5W externally. With a $ø_{JA}$ of 45°C/W of its TSSOP-16E package, this would represent a 22.5°C temperature rise, enabling a 102.5°C ambient temperature for an industrial grade device (125°C) and a 137.5°C ambient temperature for an H-Grade rated device.

CONCLUSION

The rapid growth of very specialised electronic subsystems in automobiles has created stringent performance requirements for power ICs in automotive applications. Depending on where the power supplies operate on the automotive power bus, they may be subjected to load dump and cold crank conditions as well as high ambient temperatures. Additionally, some of these systems will operate in an always on standby mode, requiring minimal supply current.

As more electronic systems are added to each vehicle, minimising the solution footprint, while maximising thermal efficiency, is also critical. Fortunately, some power IC designers have created solutions to meet these requirements, paving the way for even higher electronic content in future cars. ■

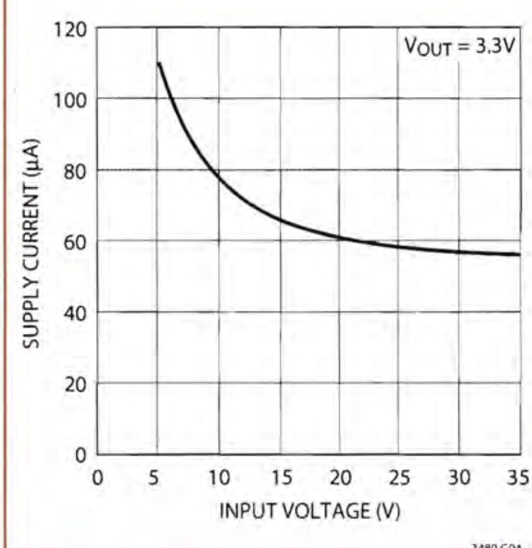


Figure 4: *LT3480 no-load quiescent current vs input voltage*

GRAND CHALLENGES

By Chris Williams, UKDL

It is a well-known and utterly reliable fact of life that throughout Europe August is the month when our national and local newspapers are full of light-weight stories that trend towards the moronic. Ignore the wars, pestilence, natural and man-made disasters happening around us – when the politicians are on holiday, the journalists and editors lose the collective will to be focused and let their sensibilities wander.

If they can do it, so can we.

Here is the theme for this month's UKDL column – a Grand Challenge is issued to all readers of this magazine. Solve the global problem I am about to outline and you will not only achieve instant fame, you may also become rich beyond your wildest dreams – you will certainly have contributed a societal benefit equivalent to saving billions of tons of carbon emissions each year.

THE GRAND CHALLENGE

Can you invent a way to directly collect photons, store them safely and then discharge them in a controllable and reliable process? Such an invention could then be used to harvest photons from sunlight, store them and then deliver them back when needed for illuminating rooms at night or for backlighting light modulating displays.

Doesn't sound like much of a grand challenge does it? After all, we already store

SOLVE THE GLOBAL PROBLEM I AM ABOUT TO OUTLINE AND YOU WILL NOT ONLY ACHIEVE INSTANT FAME, YOU MAY ALSO BECOME RICH BEYOND YOUR WILDEST DREAMS

Store water. Since the dawn of civilisation, mankind has created storage vessels for water for personal use and built larger installations for use as reservoirs to serve larger clusters of people.

water, gas and energy (see image captions)

So, we can store most of the fundamentals of life – air, water, gas, electricity – and we have been doing so for thousands of years in some cases, but we can't and never have been able to store massive quantities of light. Yes, we can store limited amounts by exposing certain phosphorescent materials to sunlight; they will retain part of the incident energy and release it as an afterglow. This gentle release has been at the centre of many a romantic walk along a beach at night, but it is sadly useless when looking at the demands for light control and release on a massive industrial scale.

Don't cheat; we are talking about direct

We store gas. The sight of large Gasometers may be a dwindling sight throughout the UK following the improved distribution and storage of natural gas, but the availability of small gas bottles for domestic and industrial use are a very common sight.

We store air. Compressed air supplies in pressurised metal canisters are a common sight in industrial and marine applications.

photon harvesting and storage here! Suggestions based on photovoltaic cells to harvest light by converting it into electrons and storing them in batteries simply won't count.

Suggestions to the Editor please – the best ideas will be represented to the UK's Photonics Leadership Group as part of our desire to find topics for research and development funding. The most amusing idea will qualify for a free ticket to any UKDL event that takes your interest.

ALL CHANGE AT THE TOP

With a change in Prime Minister and a shuffling of Ministers around the Cabinet table, we have seen big changes in our sector of industry. The Department of Trade & Industry (DTI) has been split into two entities: Business, Enterprise and Regulatory Reform (BERR) and the Department of Innovation, Universities and Skills (DIUS). In addition, where the former DTI was solely responsible for implementing the Innovation programme, a new non-departmental public body has now been set up, based in Swindon, explicitly to handle all aspects of innovation for the government.

This new body, the Technology Strategy Board (TSB), will control the content and delivery of the government's innovation strategy and, as such, it will control all aspects of the Technology Programme, including the collaborative research and development competitions, the Knowledge Transfer Networks (of which UKDL is one of twenty-two networks) and the Knowledge Transfer Partnerships.

These changes at the top are occurring at a time when innovation in industry is becoming ever more essential. We can't stand still, because competition in every developing market from overseas will inevitably be cheaper. We must drive technology forward to develop better materials, processes and systems to allow our companies to differentiate themselves from their competition.

We at UKDL are already working closely with the new TSB to promote the opportunities and challenges that we see within the displays and lighting communities that we work with. If you have ideas, suggestions, or a comment to make on how UK business in this sector can be improved, please e-mail or write to us.

Finally, please do spend a few minutes thinking about the Grand Challenge – a good solution to this problem would reduce the power consumption of the whole world. Up to 20% of our electricity generation is created just to power the lighting we use. Reduce the need for that and we reduce the generation need, cut CO_2 emissions and cut the demand for new power stations.

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

A CAPACITANCE METER

This simple circuit can be used to measure large capacitances of between 100 μF and 10000 μF. When the switch is turned to the left position, the voltage across the reference capacitor C becomes equal to the supply voltage V_1. The charge of the capacitor C becomes equal to $q = V_1 C$. At the same time, the voltage across the measured capacitor becomes equal to zero (the preliminary discharge of the measured capacitor is necessary because the electrolytic capacitors have the ability to charge themselves a little due to the chemical reactions inside of them).

After turning the switch to the right position, the charge becomes distributed between the capacitances C and C_X, however, the total value of the charge remains unchanged: $q = V_1 C = V_2 (C + C_X)$, where V_2 is the voltage across the capacitor C after turning the switch to the right position. Consequently, the value of the capacitance C_X can be calculated as

$$C_X = (\frac{V_1}{V_2} - 1)C$$

The voltages V_1 and V_2 across the reference capacitor can be measured by the means of an ordinary, digital multimeter.

Sergey Chekcheyev
Moldova

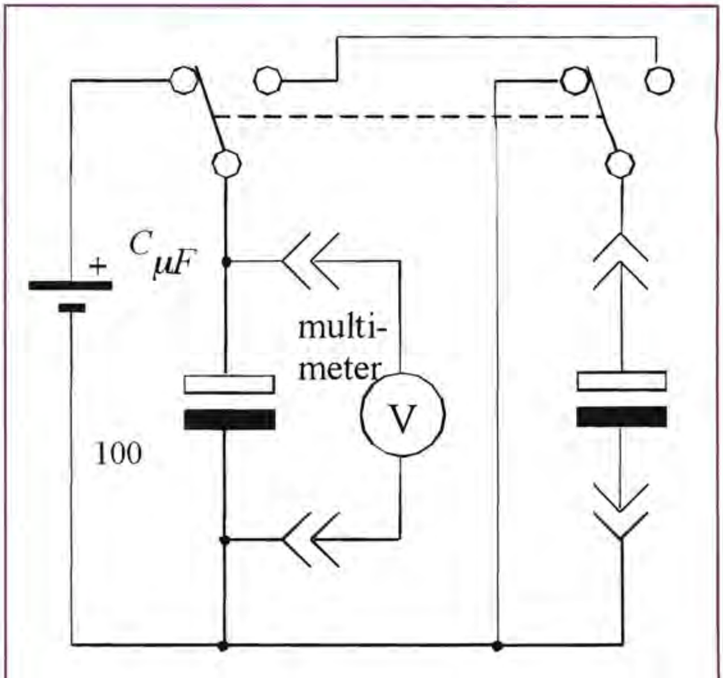


Figure 1: *Capacitence meter*

DRIVING MOBILE HEADPHONES FROM A BRIDGE CIRCUIT

There are several design factors in battery-powered headphones amplifier design (such as described by Yan Goh in "*Driving mobile headphones require attention to new details*" in Planet Analog, 16 February 2006:

a) Adequate output power with low supply voltage;

b) Ample sound quality – low distortion, high signal to noise ratio and flat frequency response.

The higher output voltage swing can be obtained with a bridge amplifier circuit, low distortion and high signal-to-noise ratio; by proper selection of the amplifier chip and for controlled low-frequency response it is better to eliminate DC-blocking capacitor from the output circuit. Unfortunately, the headphone left and right transducers share the same common wire and that common wire is an obstacle to employ a bridge amplifier connection.

The circuit shown in **Figure 1** allows driving DC-coupled stereo headphones with common wire from the bridge circuit. The circuit is based on TI TPA152 amplifiers ("*TPA152, 75-mW Stereo Audio Power Amplifier*," Texas Instruments, 2000).

Very simple equations can be written for the circuit in Figure 1:

$$V_{O1} = V_{O3} = \frac{R_F}{R_I}(R + L)$$

$$V_{O2} = 2\frac{R_F}{R_I}R - \frac{R_F}{R_I}(R + L) = \frac{R_F}{R_I}(R - L)$$

$$V_{O4} = 2\frac{R_F}{R_I}L - \frac{R_F}{R_I}(R + L) = \frac{R_F}{R_I}(L - R)$$

where R is the input voltage for the right and L for the left channel. The headphones operating voltage corresponds to the difference between V_{02} and V_{01}, between V_4 and V_3 :

$$V_{O2} - V_{O1} = 2\frac{R_F}{R_I}R$$

$$V_{O4} - V_{O3} = 2\frac{R_F}{R_I}L$$

For the component selection and values please address TPA152 datasheet, $R_0 = 0.1R_L$ Any others headphone drivers with the access to internal summing point can be used in the proposed topology.

Dimitri Danyuk
US

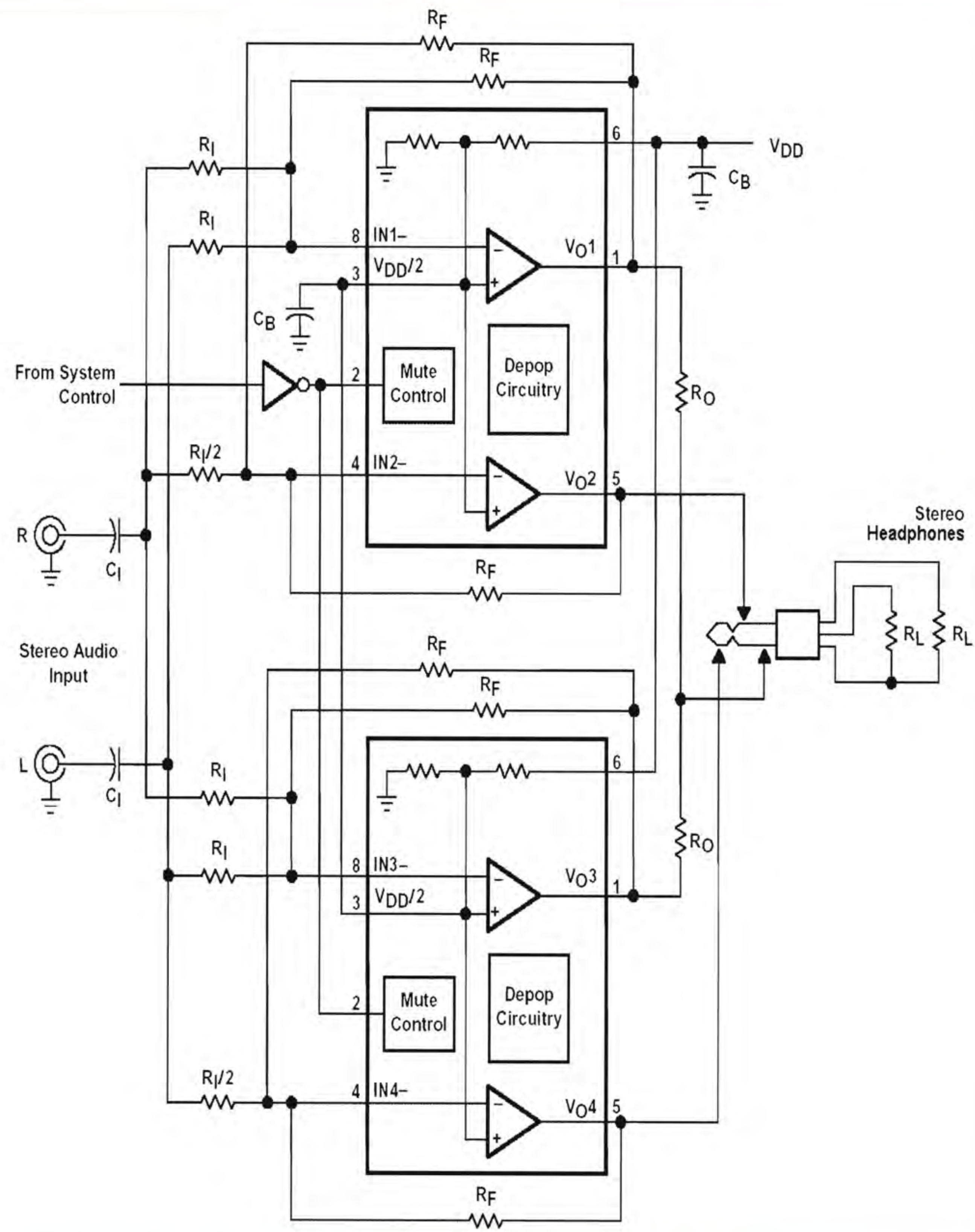


Figure 1: *Two headphones chips and a handful of passive parts drive DC-coupled stereo headphones with common wire from the bridge circuit*

This series of Tips 'n' Tricks addresses the challenges with a collection of power supply building blocks, digital level translation blocks and even analogue translation blocks. Throughout the series, multiple options are presented for each of the transitions, spanning the range from all-in-one interface devices, to low-cost discrete solutions. In short, all the blocks a designer is likely to need for handling the 3.3V challenge, whether the driving force is complexity, cost or size.

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: 3.3V → 5V LEVEL TRANSLATORS

While level translation can be done discretely, it is often preferred to use an integrated solution. Level translators are available in a wide range of capabilities. There are unidirectional and bidirectional configurations, different voltage translations and different speeds, all giving the user the ability to select the best solution.

Board-level communication between devices (e.g. MCU to peripheral) is most often done by either SPI or I2C. For SPI, it may be appropriate to use a unidirectional level translator, and for I2C it is necessary to use a bidirectional solution. **Figure 1** illustrates both solutions.

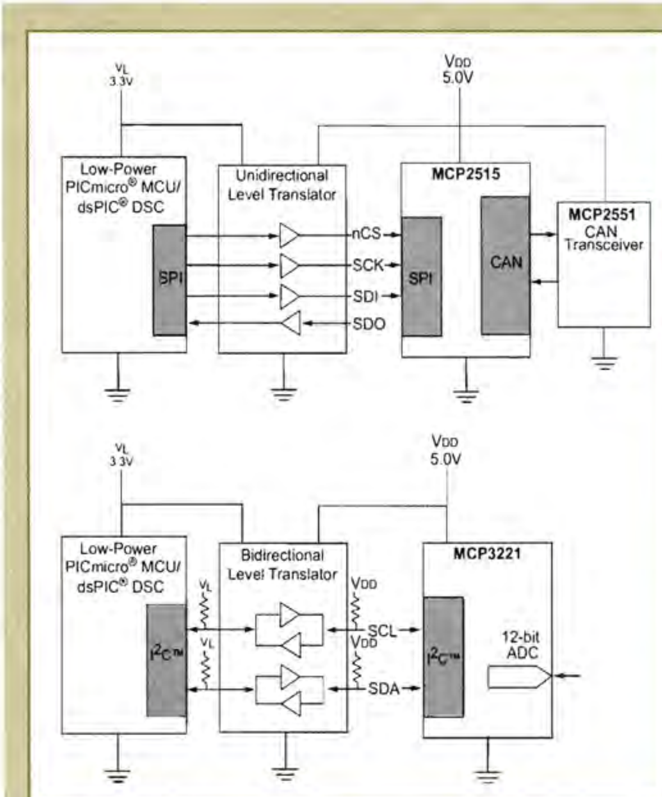


Figure 1: Level translator

Analogue

The final 3.3V to 5V interface challenge is the translation of analogue signals across the power supply barrier. While low level signals will probably not require external circuitry, signals moving between 3.3V and 5V systems will be affected by the change in supply. For example, a 1V peak analogue signal converted by an ADC in a 3.3V system will have greater resolution than an ADC in a 5V system, simply because more of the ADCs range is used to convert the signal in the 3.3V ADC.

Alternately, the relatively higher signal amplitude in a 3.3V system may have problems with the system's lower common mode voltage limitations. Therefore, some interface circuitry, to compensate for the differences, may be needed. This section will discuss interface circuitry to help alleviate these problems when the signal makes the transition between the different supply voltages.

TIP 2: 3.3V → 5V ANALOGUE GAIN BLOCK

This case is to scale analogue voltage up when going from 3.3V supply to 5V supply. The 33kΩ and 17kΩ set the op-amp gain so that the full scale range is used in both sides. The 11kΩ resistor limits current back to the 3.3V circuitry.

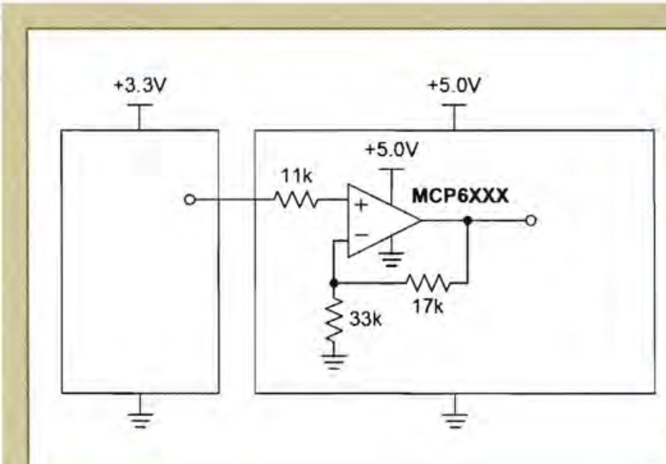


Figure 2: Analogue gain block

TIP 3: 3.3V → 5V ANALOGUE OFFSET BLOCK

This case covers offsetting an analogue voltage for translation between 3.3V and 5V.

Shift an analogue voltage from 3.3V supply to 5V supply. The 147kΩ and 30.1kΩ resistors and the +5V supply voltage are equivalent to a 0.85V voltage source in series with a 25kΩ resistor. The equivalent 25kΩ resistance, the three 25kΩ resistors and the op-amp form a difference amplifier with a gain of 1V/V. The 0.85V equivalent voltage source shifts any signal seen at the input up by the same amount; signals centered at 3.3V/2 = 1.65V will also be centered at 5.0V/2 = 2.50V.

The top left resistor limits current from the 5V circuitry (see **Figure 3**).

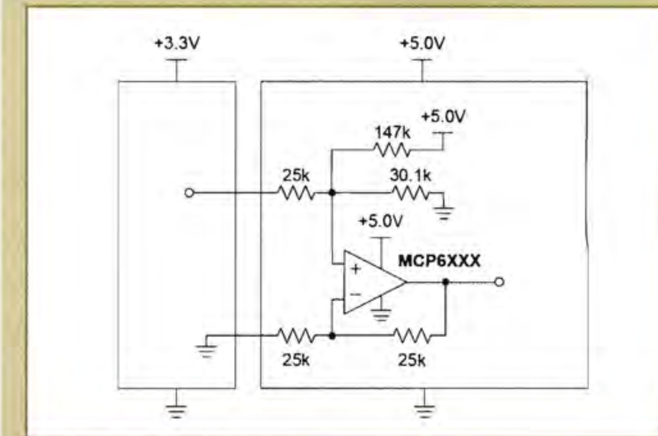


Figure 3: *Analogue offset block*

TIP: DUAL-PHASE INVERTING BUCK/BOOST SUPPLY PROVIDES –5.2V/15A FROM A 12V INPUT

By Mike Shrivers, Linear Technology

The most common use for a synchronous buck controller is the high efficiency conversion of a positive voltage to a lower positive voltage, but it can also produce a negative voltage from a positive voltage. In negative output applications, a buck controller can be configured as an inverting buck/boost, where the negative output voltage has an absolute value either higher or lower than its positive input.

To transform a buck converter to a buck/boost, simply reference the circuit to the negative rail instead of ground, tie the (+) end of COUT to ground instead of VOUT and connect the

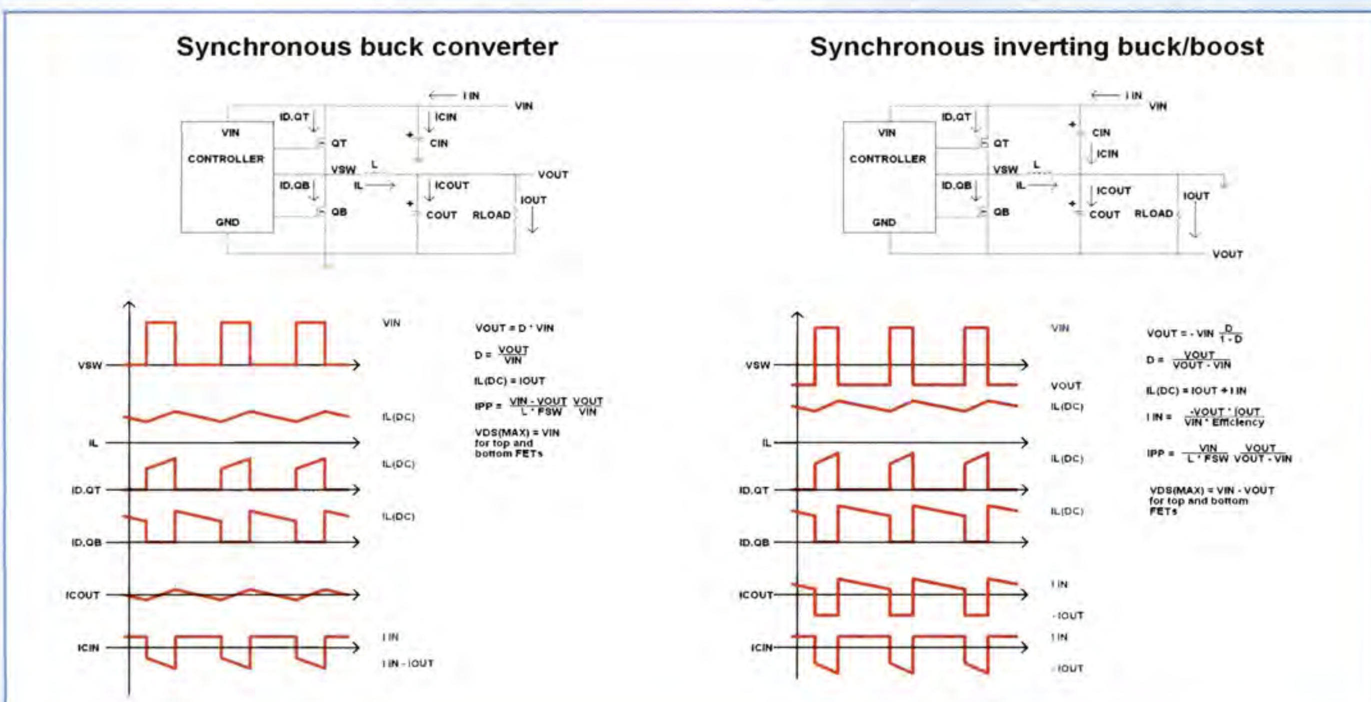
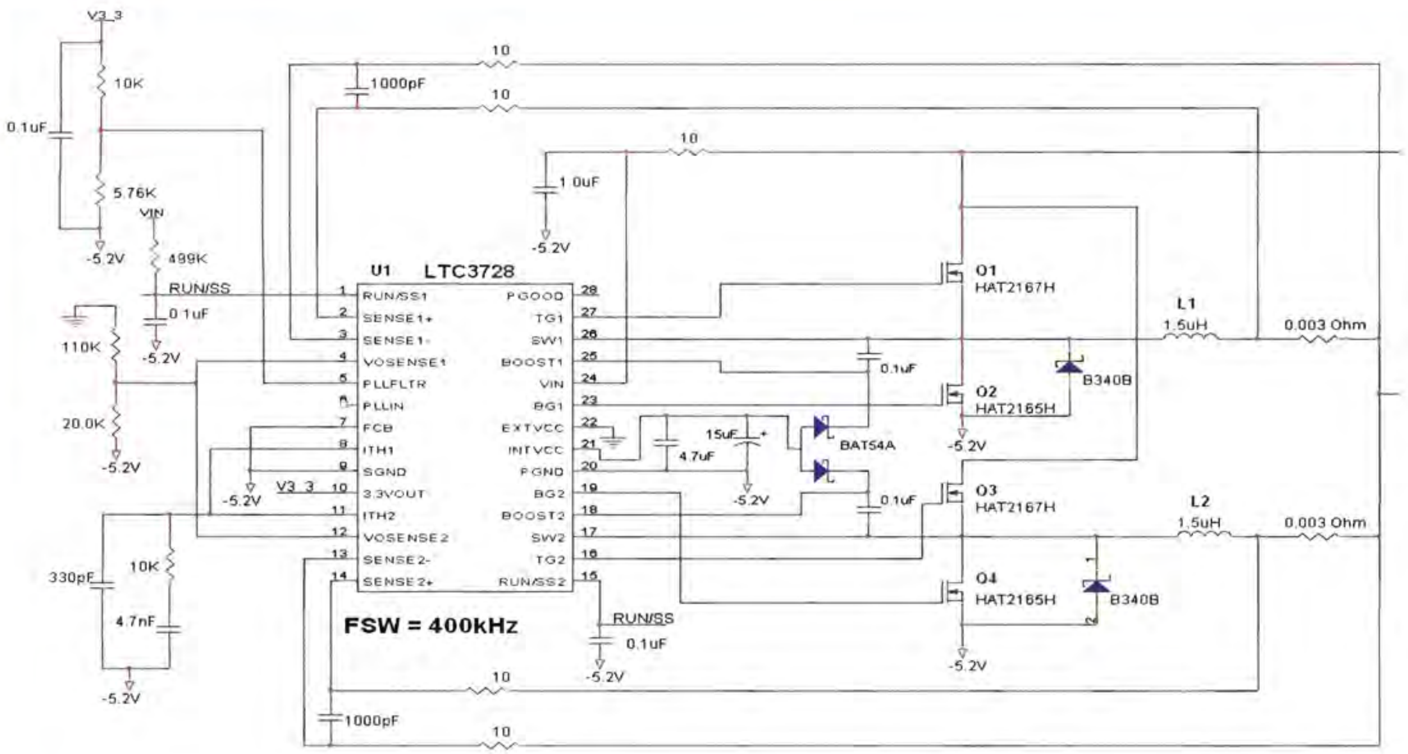


Figure 4: *Comparison of a buck versus an inverting buck/boost*



U1:	**Linear Technology LTC3728**	**COUT(BULK):**	**Sanyo 6TPE220MI 2X**
L1.2:	**Sumida CEP125-1R5MC**	**COUT(CER):**	**TDK C3216X5R1C106M 10X**
Q1.3:	**Renesas HAT2167H**	**CIN(BULK):**	**Sanyo 16SVP180MX**
Q2.4:	**Renesas HAT2165H**	**CIN(CER):**	**TDK C3216X5R1E475M 4X**

Figure 5: *An LTC3728 +12V to -5.2V/15A dual phase inverting buck/boost supply*

input voltage from the drain of the top MOSFET to the new ground (see **Figure 4**). The hook-up is otherwise the same as a standard positive buck configuration and the top MOSFET is still the control MOSFET.

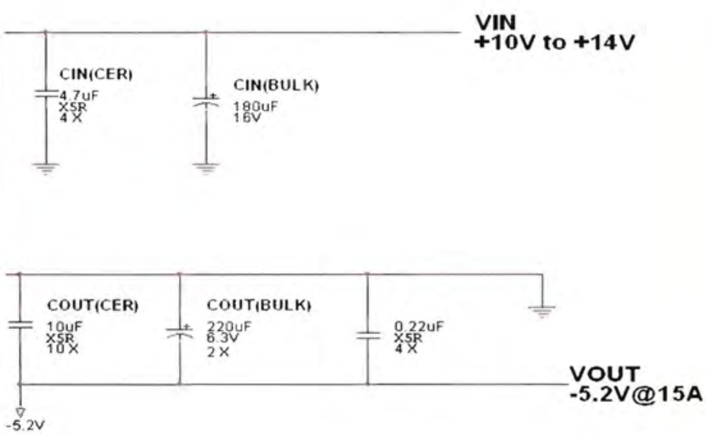
The design requirements for a buck/boost are, however, more demanding. For instance, the off-state voltage stress of the MOSFETs for a buck/boost is higher for a given input voltage since it is now equal to the difference between VIN and VOUT, which is below ground. The DC inductor current is higher for a given load since the DC inductor current is now equal to the sum of the load current and input current. As a result, the inductor must have a higher saturation current rating and lower DCR than required for a standard buck.

Due to the higher voltage stress and DC inductor current, the transition and conduction losses of the MOSFETs are higher. Since the output capacitor for a buck/boost is only recharged when the bottom MOSFET is on, the output capacitor has pulsed current flowing through it, where the peak-to-peak magnitude is equal to the DC inductor current (assuming a very large inductor is used).

On the other hand, the output capacitor ripple current for a buck is only equal to the inductor ripple current. As a result, the output capacitors used for a buck/boost need to have much lower ESR and ESL to maintain low output voltage ripple.

Figure 5 shows an example of an inverting buck/boost that meets the above challenges. This circuit is a +12V to –5.2V/15A dual phase dual output converter controlled by the LTC3728 from Linear Technology. Both phases of the converter are tied together and separated by 180°, which provides ripple current cancellation for both the output and input capacitors. The combination of dual phase operation, 400kHz switching frequency and the use of low ESR and low ESL ceramics in parallel with POSCAPs at the output provides an output voltage ripple of only 39mV_{P-P} as shown in **Figure 6**. The low output voltage ripple makes it suitable for the bias of negative ECL circuits.

Despite the higher losses of a buck/boost, this circuit does have high efficiency (see **Figure 7**). At full load, the efficiency is 91.4% and the peak efficiency is 92.9%. The high efficiency is the result of using low RDS (ON) and low QG MOSFETs, using two phases instead of one and the strong gate drivers of the LTC3728. The switch node pin and VIN pin of the LTC3728 are both rated at 36V and the MOSFETs are rated at 30V, which allows them to easily handle the stress created by converting +12V to –5V.



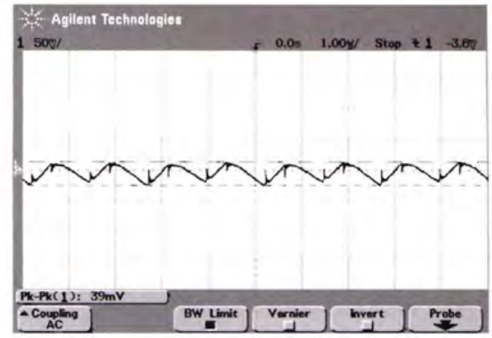


Figure 6: *Output voltage ripple of the LTC3728 inverting buck/boost supply.* $V_{IN} = +12V$, $I_{OUT} = 15A$

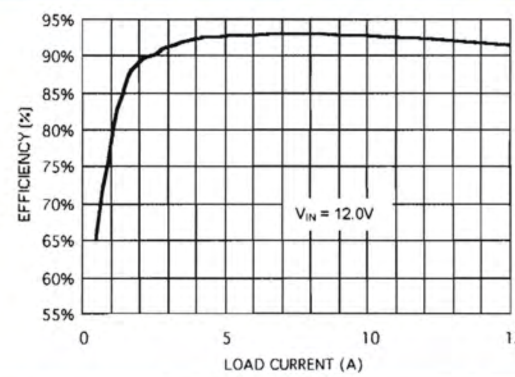


Figure 7: *Efficiency of the LTC3728 inverting buck/boost supply*

Win a Microchip PICDEM 4 Demo Board!

Electronics World is offering its readers the chance to win a Microchip PICDEM 4 Demonstration Board. The Demo Board helps engineers to evaluate and demonstrate the advanced capabilities of Microchip's low pin-count PICmicro Flash microcontrollers. PICDEM 4 offers multiple socket options for immediate programming and debugging of 8-, 14-, and 18-pin PIC12F, PIC16F and PIC18F microcontrollers. The board demonstrates many of the features of low pin-count parts, including Local Interconnect Network and motor control capability using the enhanced capture/compare/PWM module. Low-power operation is achieved with a supercapacitor circuit and jumpers allow the on-board hardware to be disabled to eliminate current draw. It also includes provision for crystal, RC or canned oscillator modes and a 5-volt regulator for use with a 9-volt supply, or hooks for a 5-volt, 100mA regulated DC supply. Additional features include an RS-232 interface, an EEPROM footprint, 2 x 16 liquid crystal display, PCB footprints for an H-Bridge motor driver, LIN transceiver, and a connector for programming via In-Circuit Serial Programming technology and developing with the MPLAB ICD 2 in-circuit debugger.

The PICDEM 4 Demonstration Board includes two PICmicro Flash microcontrollers and a CD-ROM containing sample programs, application notes and user guide. The MPLAB ICD 2 is available as a stand-alone unit and Microchip's MPLAB IDE (interactive development environment) software can be downloaded for free from Microchip web site.

For the chance to win a PICDEM 4, log onto **www.microchip-comp.com/ew-picdem4** and enter your details into the online entry form.

ADVANCED MANUFACTURING TECHNOLOGY

For Medical Applications

IAN GIBSON

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The book is written for medical technicians and those directly involved in medical engineering. It is a compilation of detailed chapters from a number of contributing world experts and it may not be a book for the casual reader.

Acronyms and abstruse medical terms, although defined, appear in great abundance and the text is presented in what I would regard as 'research paper style'. That said, it offers a detailed specialist resource for those who require it and usefully includes extensive bibliographies. To those on the fringe of this industry with just a casual interest, it can give a fascinating insight into the world of medical reconstruction. There are several case studies, from dentistry to human joint replacement, which help the casual reader identify with the topics, and especially those who may have already benefited from medical technology without knowing or understanding the processes that were used.

THERE ARE EXCITING TECHNIQUES DESCRIBED HERE FOR BUILDING 3D MODELS

I have always been fascinated by the idea of the Roddenbury-inspired 'Star Trek' 'replicator' that produces real objects from a voice command. While this is still very fanciful, there are exciting techniques described in this book for building three-dimensional models directly from digital data files, which might be bringing the science-fiction 'replicator' just a little closer to science reality. The current limitation is more in the clarity of the imaging data rather than the rapid prototyping processes themselves, but as digital camera resolution improvement in recent years has demonstrated, there is no doubt that this situation will improve dramatically in the coming years and, particularly, if the commercial demand is there. Systems for building scale models are covered in detail. Some readers may already be familiar with the idea of building complex three-dimensional shapes from individually shaped and bonded layers of sheet material, and it is perhaps not hard to imagine models being built from layer-by-layer deposition of softer materials by computer numerically controlled (CNC) extrusion of soft gels for instance, to produce a 'space' model. This could be for a pattern for further conventional manufacture, e.g. creation of high accuracy casting moulds, or perhaps as a three-dimensional map for delicate surgery.

I found the 'tissue engineering' section particularly interesting. As you might imagine from the terminology this refers to techniques for regenerating living tissue using a 'scaffold' or matrix of some compatible material around which new cells and living structures can develop. This technology is very young, although the underlying techniques have been around for quite a few years. However, making this viable requires input from a whole range of engineering disciplines such as material science, polymer processing and biomechanics. The structures that need to be created are very fine and dimensions are measured in microns.

One technique uses a raster-scanned laser to sinter (or fuse) successive layers of powdered material to build a three-dimensional matrix. Calcium phosphate implants, compatible with bone, have been built in this way. Another method uses liquid crystal display technology to make a dynamic mask for selective UV curing of successive layers of suitable polymers.

The techniques for creating three-dimensional models may be rather exotic and expensive, but they are already much more than a laboratory curiosity. The potential for future development and applications is huge. The imaging techniques of CT (computerised tomography), MRI (magnetic resonance imaging) and ultrasound scans are commonplace in medical diagnosis. Developing the concept of using such scan data to create a replacement knee joint, say, through a single rapid prototyping process is a challenging, yet logical step, but this technology is available now using electron beam melting (EBM). Those who are familiar with scanning electron microscopes (SEM) might recognise some of the equipment.

I would encourage non-medical engineers to persevere and read this book while thinking laterally and not just see it as a specialist medical tome. While the intended focus of the book is on medical technology, I am sure that most engineers will find it interesting simply because such a broad range of technologies are involved. Flexible engineers who are able to apply their skills across a range of disciplines could find a rewarding career here, as some already have.

Clearly, there is a need for considerable commercial investment in these technologies to establish them as a routine mainstream engineering approach, and most engineers simply won't have access to the high-cost equipment even for training purposes, so it may only be of academic interest.

Whether the finance will become available in the UK National Health Service to fund this technology may be doubtful in the short term and it probably needs massive investment from a few wealthy benefactors to get the ball really rolling, but the seeds are sown. I hope that when it's time for my new hip that I might benefit.

John Wood

Continuing on from last month's general look at the China RoHS directive, this month the more detailed questions that may arise for companies in the electronics sector wishing to do business in China are considered.

Q What should I do if my product type is listed in the catalogue of priority products?

A The as yet unpublished catalogue that represents a key element of the China RoHS directive will specify all product groups covered with implementation dates, plus details of any exemptions. If a product type is listed, then it cannot be imported after the specified date until an authorised Chinese laboratory has tested it and it has China Compulsory Certification (CCC) accreditation.

If the product meets the requirements, has a disclosure table printed in the manual as appropriate and has other compulsory marking for presence/no-presence of China RoHS substances and its environmentally-friendly use period (EFUP), it may be labelled with the CCC mark and sold in China.

It will be necessary to provide a test unit to the laboratory for destructive analysis although, to date, no guidance has been published that describes the procedure the laboratory will use.

Q How do I determine EFUP?

A A draft standard describing several methods for determining the EFUP of a product has been published. The options include by an experimental method, from the safe-use period (if known), from the products 'technical life', or based on the EFUP of other similar products.

Currently, the last of these options seems the most useful, accurate and cost-effective. This is helped by a number of examples given in the draft standard. It is likely that the final version of the standard will include a much longer list that will reinforce this approach as a reasonable method.

Q Why and how do I produce a disclosure table?

A Disclosure tables are required if the product you are exporting to China contains substances that are listed as being restricted under the China RoHS directive. Disclosure tables are needed in addition to product labelling that indicates RoHS substances are present and the product's EFUP.

If a disclosure table is required, the first step is to determine which controlled substances exist within each of the main parts of the finished product. Some may be known, but for most it may be best to ask the individual part or component supplier. If there is a PCB assembly, as is likely in electronics equipment, then the presence of restricted substances in each component on the board must be assessed until a substance is found (see next question) and the substance be marked with an "X" (or a "0" if none found) against PCB in the disclosure table.

Because under China RoHS there are no exemptions, it is not safe to assume that an EU RoHS compliant product meets requirements; it may contain China RoHS substances above the maximum concentration values (MCVs).

Once all the information for a product has been ascertained, the producer is required to print a table in the product manual. This provides a simple cross-reference of the six restricted substances and their presence in the primary assemblies that come together to make the finished product. As an example, in the case of a mobile phone handset these might be the PCB, a case, a display module and a battery pack. The table must be written in Chinese with a clear explanation of any symbols used.

Q How do I find out if an individual electronic component contains a restricted substance?

A Again, the easiest way is to ask the component supplier. Beware of suppliers who respond by saying that their component is RoHS-compliant; they are likely to be only referring to EU-RoHS, which will have been a major area of focus for them in the run-up of that directive coming into force in 2006.

Q Where can I find details on China RoHS label specifications?

A The Chinese government has provided details on dimensions, colours, where to use and so on in the official standard SJ/T11364-2006.

Q Do I need to label spare parts or components?

A The Chinese RoHS standard states that marking of components is not necessary if they are to be sold to OEMs for use in products that will be marked. However, information on any RoHS substances that are present in such components will need to be provided to the OEM. Components, including spare parts that are sold individually direct to end-users in China should be marked as they are classified as Electronic Information Products, or EIPs.

Please email your questions to:
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The new ACS760 from Allegro MicroSystems Europe is a hot-swap protection IC designed for 12V high-side applications.

The new device combines Allegro's Hall-effect current sensing technology with hot-swap control circuitry, resulting in a highly efficient integrated controller. No external sense resistor is required, resulting in greatly reduced I2R losses in the power path.

The ACS760 incorporates an external high-side FET gate drive and produces an analogue output voltage (factory trimmed for gain and offset), which is proportional to the current sensed in the device lead-frame. The soft-start/hot-swap function is accessed via the logic 'enable' input pin and an optional user-defined soft-start capacitor.

When the ACS760 is externally enabled and the voltage rail is above the internal undervoltage lockout threshold, the internal charge pump drives the gate of the external FET. When a fault is detected, the gate is disabled while simultaneously alerting the application that a fault has occurred.

There are three levels of fault protection within the ACS760: 240VA power fault protection with user-programmable delay; user-programmable overcurrent fault threshold with programmable delay; and short-circuit protection, which disables the gate in less then 2μs.
www.allegromicro.com

Rugged Convertible Notebook and Tablet PC with Intel Processor

Kontron announced its new, fully rugged, Kontron NotePAC Duo equipped with a flip-and-rotate display to instantly convert the notebook into a tablet PC.

With the 1.2GHz Intel Core Duo U2500 processor, Intel 945 GMS chipset and up to 2GB DDR-RAM, the dual-core and dual-use convertible rugged PC, Kontron NotePAC Duo, offers operation time of up to nine hours with only one lightweight battery pack.

The 2.2kg lightweight Kontron NotePAC Duo with magnesium alloy chassis is fully MIL-STD810-F compliant and IP54 dust and rain protected. Graphics provided by the directX 9.0c compliant Intel GMA 950 are displayed on a 10.4-inch XGA (1024x768) or wide 12.1-inch WXGA (1280x800) resistive touch-screen. Optionally, an extremely rugged display with protective digitiser screen and stylus pen offers extreme dirt resistance for hard-core outdoor usage.

Its feature set includes embedded GSM, GPRS, UMTS (HSDPA/EVDO), WLAN 802.11a/b/g and Bluetooth V2.0 class 2, 1x 10/100/1000 Ethernet-T, analogue 56k modem, 2x Cardbus, 2x USB 2.0, 1 x COM and VGA.
www.kontron.com

Optical Switch Connects up to 16 Ports

The new Yokogawa AQ2200-412 is a 1 x 16 low insertion loss optical switch for use in automated test systems.

The new unit contains 16 ports in a two-slot size module, and allows from one to 16 devices under test to be connected to test instrument modules in Yokogawa's AQ2200 Series modular optical instrumentation system.

As a result, different automated test configurations can be developed for the testing of active and passive optical components.

The AQ2200-641 expands the flexibility of the AQ200 Series multi-application test system and reduces the total measurement time for both active and passive multiport component tests. It features a low insertion loss of typically 1.0 dB and a very low polarisation-dependent loss of 0.08dBp-p.

As a result, the switch passes most of the light power through the device under test, ensuring that polarisation-dependent loss has virtually no influence on the measurement's accuracy.

Other key features of the unit include excellent reproducibility (within 0.01dB) to support high-accuracy measurements without the need for frequent reference measurements, and low crosstalk (-60dB or less) between neighbouring channels.
www.yokogawa.com

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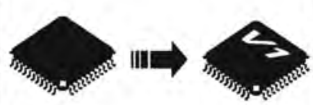

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