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ELECTRONICS WORLD

THE ESSENTIAL ELECTRONIC ENGINEERING MAGAZINE

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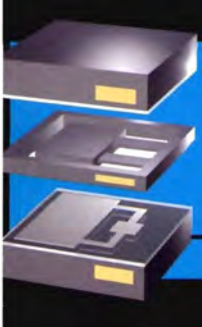

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Assembled Order Code: AS3166v2 - **£27.95**

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Assembled Order Code: AS3067 - **£21.95**

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Rolling Code 4-Channel UHF Remote

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NEW! USB & Serial Port PIC Programmer

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NEW! USB 'All-Flash' PIC Programmer

USB PIC programmer for all 'Flash' devices. No external power supply making it truly portable. Supplied with box and Windows Software. ZIF Socket and USB lead not included.
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WHAT CAN ENGINEERING COMPANIES DO NEXT TO HELP DESIGN ENGINEERS?

Like with the discipline of electronics itself, the life of the electronics engineering developer and the electronics engineer in general, is changing too. One major trend is that engineers are increasingly working all hours: either staying longer at work, or working from home in the evenings or weekends – sometimes even working whilst on holiday.

To be able to do their job well from anywhere at any time they need data sheets, design hints, components, simulation, software at their fingertips and most of the time they can find all of this online. But is that enough? It does not appear so. Not only do they need the information but they also need the support at any time too. This is precisely what they are looking for and asking companies to have: technical support from senior design engineers 24/7.

I hear from many engineering companies that they are aware of these needs and are trying to accommodate them, but they themselves are experiencing problems. After all such services need resources, especially when it comes to having senior engineering staff that can work shifts so they can immediately reply to queries coming from any geographical region.

A spokesperson from a large engineering firm recently told me that engineers are less likely to go to seminars, technical workshops or even trade fairs, and yet they do want the information coming out of those events available to them at any time. Her company has been looking into providing a comprehensive website to include this type of content as well as have the technical support to deal with related queries, but as usual, funding and the right staff have been the main problems.

Does this mean that companies should start looking into creating new departments and actively recruiting for these positions? Departments that will offer technical support to customers, which are highly needed, and yet which are not going to show direct return on

SUCH SERVICES NEED RESOURCES, ESPECIALLY WHEN IT COMES TO HAVING SENIOR ENGINEERING STAFF THAT CAN WORK SHIFTS SO THEY CAN IMMEDIATELY REPLY TO QUERIES COMING FROM ANY GEOGRAPHICAL REGION

investment for the companies that have them, since are not going to be really selling anything.

And there's the other side to it: would companies be more ready to spend on resources for dedicated technical support departments if they were to charge for their services?

It's a tough one, but the need is there and likely to become even more severe as engineers continue to be overloaded with projects and have less support available to them – be that external or internal support.

Svetlana Josifovska
Editor

Electronics World is published monthly by **Saint John Patrick Publishers Ltd**, 6 Laurence Pountney Hill, London, EC4R 0BL.

New robot ready to lift people out of trouble

A US R&D firm called Vecna Robotics is developing a robot which will help injured people out of dangerous environments.

The Battlefield Extraction Assist Robot (BEAR) uses hydraulics and runs on rechargeable batteries. It can lift weight of up to 180kg and carry it for anything between 30 minutes and six hours, depending on the terrain and whether there are stairs.

"The humanoid BEAR robot can do what humans can't: Lift heavy loads and carry them over long distances. Whether on a battlefield, in a nuclear reactor core, near a toxic chemical spill, or inside a structurally-compromised building after an earthquake, the BEAR can rescue those in need," says the company literature.

The BEAR employs Dynamic Balancing Behaviour (DBB), enabling it to balance on the bottom of its lower tracks or wheels. It is controlled remotely and has cameras and microphones through which an operator sees and hears. The robot will soon be equipped with more sophisticated controls and software for 'semi-autonomous' behaviour.

This year, the US Congress has allocated $1.1m for its development.

The robot has gone through several prototyping stages already and in the process undergone many improvements, which are likely to carry on. For example, it currently has 15 joints, which will be upgraded to 20; there will be a new upper body with more degrees of freedom for greater dexterity, as well as a new lower body with separate tracked leg sections.

Initially, the BEAR will be used by the US Army, however, following its release next year the company hopes to introduce it to the commercial sector too, for service and loading applications in various industries, or in the healthcare sector to perform patient transfers among other.

The BEAR will carry people out of hostile environments

ULTRA-SMALL PROCESSORS WILL EMPLOY SPINTRONICS

Researchers at the University of Wales in Swansea are developing a new generation of computer chips that will lead to processors with memories the size of a grain of sand. The devices rely on the orientation of an electron, called a 'spin' to indicate a one or a zero. This in turn is used to store data and to write instructions.

At Cardiff, a nanoneedle device is being developed to etch information onto spintronic processors by the nanotechnologist Dr Kar Seng Teng. He said: "The new processors will be smaller, more versatile and more robust than those currently making up silicon chips and circuit elements. The potential market is worth hundreds of billions of dollars per year."

Spintronic processors could find their way in mobile music players as small as a button, which will also capture human voice. Military applications will include miniature spy aircraft, as small as flies, that will collect and send back data and photographs some hundreds of miles. In the medical field, they are expected to be used in devices such as cardiac pace makers, almost too small to be seen and which can be injected into patients.

India plans a semiconductor industry ... with some help

The newly created Hindustan Semiconductor Manufacturing Company (HSMC) will use the help of Infineon and others to build ten fabs in India to form a so-called 'Fab City'. Infineon will provide much of the chip design capabilities and the process technologies plus an expertise in setting up the new facilities.

The first fab planned will use 130nm technology on 200mm wafers to produce relatively economical devices and is expected to be in operation by 2009 at a cost of some $800m. The second fab will employ more advanced 90mm technology on 300mm wafers. Details of the other eight fabs have not yet been released, but they are expected to produce leading edge devices.

The HSMC facilities will be located near the city of Hyderabad in the Indian state of Andhra Pradesh. The focus will be on System-on-Chip (SoC) for products like mobile phones, wired line telecom systems, SIM cards, ID cards, set-top boxes and automotive chipsets, but for the Indian market. India anticipates its domestic sales of electronic goods to increase by a factor of ten over the next decade to reach a value of some $360bn by 2015, about one tenth of which will be the value of the semiconductor content of these goods. The Indian government is therefore prepared to cover up to 20% of the cost of projects, as it would much prefer the semiconductor devices to be made in India than to be imported from overseas.

HSMC is governed by expatriates who are already involved in the semiconductor industry and California-based VCs of Indian origin.

EXPERIMENT CONFIRMS NO WIRES NEEDED TO POWER DEVICES

Researchers from the Massachusetts Institute of Technology (MIT) have successfully proven that cables are not necessary to power electronic devices.

The setup, consisting of two 60cm diameter copper coils, a transmitter connected to a power source and a receiver placed 2m away, made the attached 60W light bulb glow. Using self-resonant coils in a strongly coupled regime experimentally demonstrated efficient non-radiative power transfer over a distance of up to eight times the radius of the coils.

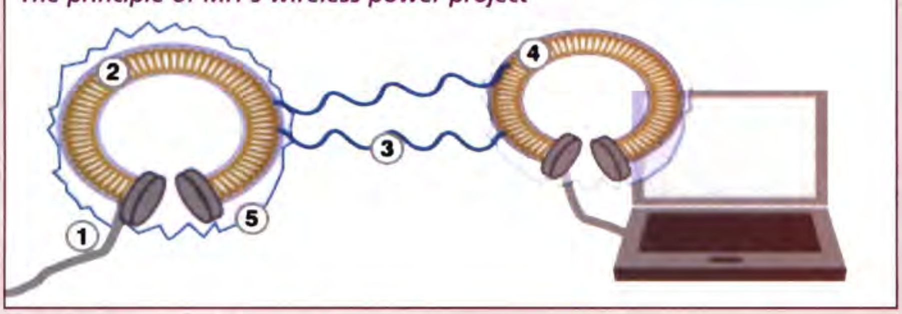
MIT's WiTricity technology exploits the resonance of electromagnetic waves. When two objects have the same resonance they exchange energy without having an effect on other surrounding objects. Here, the team explored a system of two electromagnetic resonators coupled mostly through their magnetic fields. When perfected, the technology will enable mobile and portable systems to be powered without the need for a cable.

To make the bulb work in their setup, the MIT team made the coils resonate at 10MHz and the bulb glowed even when obstructions such as wood, metal and other electronic devices were placed between them. According to the measurements, the transfer of 60W power was achieved with approximately 40% efficiency.

MIT's Professor Marin Soljacic and his team are now looking at refining their setup. "This was a rudimentary system that proves energy transfer is possible. You wouldn't use it to power your laptop. The goal now is to shrink the size of it, go over larger distances and improve the efficiencies," he said.

Wireless energy transfer was first publicly suggested by nineteenth-century Croatian physicist and engineer Nikola Tesla. Others have worked on highly directional mechanisms of energy transfer such as lasers. However, unlike the MIT work, these require an uninterrupted line of sight and are not as good for powering objects around the home.

The principle of MIT's wireless power project



Toshiba stacks memory arrays differently

A new three-dimensional memory cell array structure from Toshiba offers greater cell density and data capacity. The cell does not rely on advances in process technology but a novel way of stacking.

In the new structure, pillars of stacked memory elements pass vertically through multi-stacked layers of electrode material and use shared peripheral circuits. This is different to conventional methods, where stacking is done by placing two-dimensional memory arrays on top of each other.

Toshiba etches a through-hole down through a stacked substrate, i.e. a multi-layer sandwich of gate electrodes and insulator films. Pillars of silicon, lightly doped with impurities, are deposited to fill in the holes. The gate electrode wraps around the silicon pillar at even intervals and a pre-formed nitride film for data-retention, set in each joint, functions as a NAND cell.

IN BRIEF

- A new research from Liquavista, the firm developing mobile displays, shows that multimedia device users are not happy with their screens. Up to 83% of the British consumers interviewed for the research commented that they have problems seeing the screens of mobile phones, digital cameras, TVs and laptop or desktop computers in some light conditions. Around 75% further commented that they have had to block out natural daylight in some situations. Nearly all questioned said they were unable to view the screen when the backlight powers down, not allowing them to use the devices' full functionality. Up to 86% of respondents said they'd like a screen that is clearly visible in all light conditions.

- The Metro Ethernet Forum (MEF) announced the first group of providers to offer services certified for quality and performance. Until now, every program in the history of the industry has only certified correct functionality, but never the quality of service.
This confirms that Carrier Ethernet is ready for widespread use as the most stringent real-time communications applications including VoIP and HD quality videoconferencing can now be met.
AT&T, COLT, Embarq, Neon, NTL Telewest, Optimum Lightpath, RCN, Swisscom, Time Warner Cable, Verizon and VSNL International are now certified for Carrier Ethernet services compliant with MEF 14 – Abstract Test Suite for Traffic Management.

- Phihong USA proposed to the IEEE802.3 at task force to allow midspans used in Power-over-Ethernet (PoE) applications to have the power onto the data pair as required for Gigabit systems. Putting the power on the data pair is required for Gigabit systems as all wires used to carry data. If 4-pair powering gets ratified then it will also be required to carry power on all the wires that carry data as well.
The new standard is now in draft and a year away from being ratified. When implemented, IEEE 802.3at (PoEPlus) will not only allow PoE in Gigabit systems but will enable at least 30W of power and potentially up to 60W.

IN BRIEF

● Infineon researchers have unveiled details of a new transistor architecture that removes many of the barriers to the production of smaller, more powerful electronic devices and circuits. Known as multi-gate field-effect transistors these devices can offer at least a 10-fold reduction in 'off' current and a 50% reduction in transistor switching power compared to today's 65nm transistors.
The integrated multi-gate transistors have been constructed with enhanced high-k gate dielectrics and metal gates in highly complex digital circuits offering record switching speed, lower leakage power and higher switching power efficiency.
Unlike today's commonly used two-dimensional, planar standard technology, multi-gate field-effect transistors are three-dimensional.

● Chemical giant BASF and IBM have joined forces to develop electronic materials required in the production process of the most advanced ICs. Together, they will develop chemical solutions for the IC manufacturing process of new high-performance, energy-efficient chips based on 32nm technology.
"Chemistry will increasingly play an important role in the development of the next generation (32nm) IC products. BASF will provide an interdisciplinary background that only a major chemical company can offer," said Dr Ronald Goldblatt, Senior Manager at IBM Research.
The technology is expected to be commercialised by major companies in the semiconductor industry in North America, Asia and Europe by 2010.

● Saft will cooperate with European aircraft constructors to perfect its Li-ion battery technology for aviation applications.
In conjunction with partners within the framework of two cooperation programmes, ELISA and BATTLION, Saft is expected to develop a new battery system that will be able to connect directly to the DC bus, thanks to an integrated charge control and monitoring system. The system also features indication of state of health (SOH) and state of charge (SOC), as well as communicating with the aircraft system management. The control electronics and charger are integrated inside the battery system box. Saft's system is due to meet qualification requirements in 2009.

Laser beam lightning conductor

The French Alisé laser beamline has been used by a group of French and Swiss workers to direct extremely high power 32TW laser pulses into the atmosphere to effect a lightning conductor. The pulse duration was less than 1ps and the wavelength 1053nm.


Lasers can help channel lightning

The pulses reached heights of over 20km, going into the stratosphere and generating many filaments with a broad continuous spectrum of light over the 300 to 850nm region. These filaments produce plasma channels that conduct electricity, so they can channel and direct high voltage electrical discharges.

The workers said that the plasma channel remaining after one of their pulses was directed into the atmosphere could act as a lightning conductor to attract a discharge from any direction in the sky. However, the maximum pulse repetition frequency of these intense pulses using the present Alisé system is only about one per hour.

MEDICAL INSTRUMENT POWERED BY SHAKING

Two consultant anaesthetists of the Morriston Hospital in Swansea have developed the ShakerScope, a medical examination instrument powered by kinetic energy.

The device was a direct answer to battery-powered medical instruments, where batteries can run out, leak or corrode their contacts, which may create a serious problem in an emergency situation.

The ShakerScope does not need batteries but is powered simply by being shaken. The shaking motion activates a Faraday generator within the device, which produces a small electric current that is fed to a high intensity white LED in the handle of the instrument. Shaking the device for half a minute is said to produce enough energy to power its light for 10 minutes.

The light is conveyed by fibre optics into the head of the instrument. Unlike conventional filament bulbs, the LED produces very little heat and has a typical life of over 100,000 hours, while being very robust to withstand mechanical shocks and vibrations.

The instrument was initially developed for use in ophthalmoscopes for eye examinations in the developing countries. Interchangeable attachments have since been added to extend its use to any medical application where a bright light source is needed for a limited time, such as in ear, nose and throat examinations.

The ShakerScope has been redesigned to incorporate improved functionality, with the help of funding from the Welsh Assembly Government. Pre-production prototypes will be lent to potential users, including local doctors, anaesthetists and paramedics, before it is transferred into the next stage of production.

HI-MISSION PROJECT DEVELOPS SOC AND SIP MICROWAVE DEVICES

A European collaboration is designing a platform for system-on-a-chip (SOC) and system-in-a-package (SIP) microsystem applications for radar and microwave communications. These will enable shorter and more flexible development microwave designs and enable the reuse of existing devices in new applications.

High performance modules will be designed and demonstrated using multichip technology on a silicon substrate, with enhanced functionality optimised for high frequency and speed.

There is an increasing demand in the telecommunications and automotive fields for devices providing improved performance in smaller packages at lower cost. Some problems in the integration of functions not suitable for silicon technologies can be overcome by the use of multichip modules (MCMs) with specific functions, as separate devices that can be interconnected. MCM techniques are preferred if they are cheaper than integrating all functions in a single chip, but fully integrated devices may be considered if high volumes are required.

It is necessary to chose between SOC and SIP to achieve optimum performance against cost. SOCs are not generally very cost-effective for RF and microwave applications when much integration of passive microwave components is required, especially if gate lengths of less than 100nm are to be used. In the near future many microwave and mixed signal systems will be MCMs, with cost and performance balanced in each sub-circuit. Silicon is a good substrate for MCMs, as various components such as delay lines, tuneable filters etc can be fabricated on it.

MCM techniques are being developed that can integrate not only silicon and gallium arsenide chips, but also components such as high-Q passive devices.

This Medea+ Hi-Mission (Hi-frequency Microsystems on silicon) project, coded 2T401, began in October 2005 and will finish in December 2008. The project leader is Thomas Lewin of Ericsson, other partners being Acreo, Infineon Technologies, Signal Processing Devices Sweden, STMicroelectronics and United Monolithic Semiconductors. The project results should strengthen the competitive position of Europe in automotive and communications applications, boosting market share, exports and jobs.

New crystals improve on piezoelectric ceramic performance

Nexttechs Technologies from the US has developed a new type of single crystals with properties greatly superior to those of conventional piezoelectric ceramics.

Its so-called PMN-PT (lead-magnesium-niobate/lead titanate) crystals exhibit extremely high electromechanical coupling of over 90%, which enables over twice the ultrasound bandwidth to be produced for ultrasonic and sonar projection applications with increased acoustic power. As such, composite plates using them will provide a major advance in medical ultrasonic diagnostic equipment.

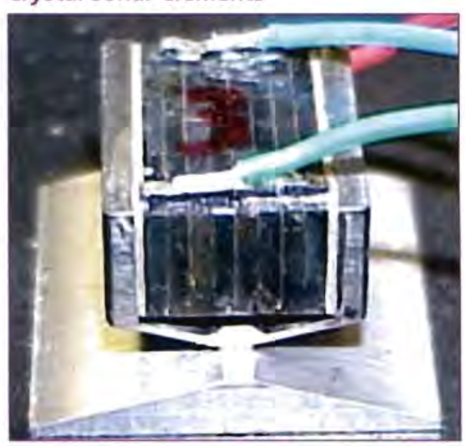
In addition, low strain hysteresis brings improved efficiency at high power and lower acoustic impedance than other piezoelectric ceramics, thus providing easier matching to air or water. The high coupling leads to a great improvement in passive vibration damping.

Also, with a usable strain of 0.5% at 35kV/cm, the PMN-PT crystals exhibit five times the strain energy density of conventional piezoelectric ceramics. Hence, single crystal actuators using them can provide higher strain levels than those actuators that employ strain magnification schemes, without sacrificing generative force.

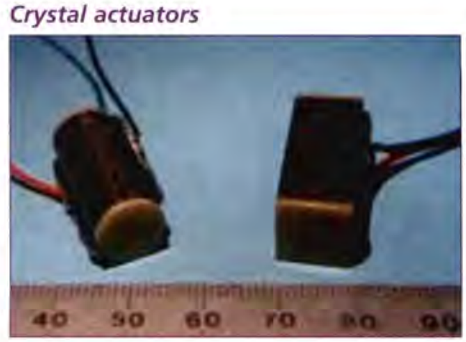
Single crystal PMN-PT wafers enable devices to be produced that were not previously possible, including custom shapes and sizes with unique possibilities based on the orientations of the crystal. Applications include adaptive optics and other adaptive structures, vibration control, nano-positioning and cryogenic actuators.

The increased compliance of the materials enables piezoelectric stack lengths to be reduced by up to 3%, thus making smaller platforms and devices possible. The extremely high piezoelectric effect increases the strain by some 5% above that in conventional piezoelectric ceramics and thereby reduces the system power needs. The PMN-PT materials are available now.

Crystal sonar elements



Crystal actuators



Stopping Sabotage of Sensitive Data

So it's official then. Men are more truthful than women and Scots are the most truthful social group in the UK. Now far be it from me to say I told you so, but this has been self evident for a long time. For example, when do you last hear a Scotsman claim that Scots could play football or cricket? Unlike your delusional "Sassenach" who simply can't come to terms with reality and continue to delude themselves – even the Dutch beat them at darts these days!

So where's all this going you might ask. Well, recent research by YouGov **www.yougov.com** and commissioned by Microsoft found that "22% of UK employees admit to having illegally accessed sensitive internal information such as salary details on their employer's IT systems and over half (54%) would do, given the opportunity".

What is of course interesting from the statistics is that 27% of men, compared to 16% of women, admitted to having stolen confidential information, and 25% of Scots admitted to doing it as opposed to only 18% in the Midlands.

But this is not simply a cause for some hilarity, but rather it is an indicator of a much more serious problem facing every organisation in the UK. There is a legal requirement to protect sensitive data, apart from the fact that the very survival of your business and reputation can rest on the protection of highly sensitive information. And to continue the alarmist message, recent studies by CERT have found that 90% of those that access this information and who are likely to abuse it are IT professionals. Of course, this doesn't prove that IT professionals are more dishonest – it's just that maybe they have a genetic predisposition to give in to temptation.

Today organisations – whether in the public or private sector – have a duty to safely store, process and exchange sensitive data inside and outside of their organisation in a way that is, preferably, transparent to the user.

There are essentially three broad areas that organisations should aim to address to counter the problem.

1 • Basic human errors and negligence

2 • Attacks by inquisitive but easily discouraged third parties with possible criminal intent targeting your organisation's data, whether it is being processed, transported or stored

3 • Attacks by focused, determined and resourceful employees and ex-employees, system managers and third parties with criminal intent specifically targeting secret data when processed, transported or stored.

The third category is the one that by far represents statistically the greatest risk and presents the biggest challenge since it is relatively easy to take steps to combat the first two cases. In the third case, statistically it has been proven that the most damage has been done by those who had the means to access data that did not pertain to them, and who accessed it using system resources that your normal user would normally possess.

It is therefore absolutely essential that adequate controls are put in place to ensure that sensitive data is protected from abuse. Many organisations are under the misapprehension that there is simply no effective method to secure digital assets from systems administrators and, therefore, simply live with the risk. But the reality is actually the opposite. Many organisations today have implemented solutions that guarantee that no matter how resourceful or determined someone may be, the organisation can remove this risk. At a minimum the following list can serve as a useful guideline on how to do this.

01. Create a secure repository – sensitive data can be stored in a manner that provides the owner with complete control over who has access and where they have to be to gain it. In other words, the organisation can immediately eliminate the risk of unauthorised users gaining access from the outside. It also ensures that system administrators are no longer able to access the data even though they may be responsible for managing the system that stores the data.

02. Use effective but manageable encryption – methods that do not require administrative intervention remove the risk of keys being managed by systems staff. Symmetric encryption of data offers a solution that removes the need for human intervention and eliminates the risk associated with recovering private keys. Data should be stored using the strongest algorithms available in the market, such as AES256 and RSA-2048.

03. Back up securely – Back up is a very critical component and something that can be abused. It is absolutely essential that any system that is used to back up data should do so in its encrypted form with no regards to the method of backup.

04. Segregation of duties – There needs to be segregation between system management and data management. Additionally, there should be hierarchies within data management, such as dual-control which can enforce checks and balances to ensure that highly sensitive data cannot be accessed unless authorisation has been given. If possible the access to, and responsibility for, data should be devolved to the relevant departments. For example, there is no reason why anyone outside of HR should have access to HR data. There needs to be a flexible policy within departments so that users can manage other users who are at the same level or lower than them.

05. Proactive alerting – By having automatic reporting of user activity, anytime anyone who is authorised accesses a sensitive file as the system cannot automatically report this activity. By having this at departmental level ensures that management can identify potential inappropriate behaviour at an early stage since they are aware of the sensitive data under their control and can thus identify misuse at an early stage.

So what's it to be? Doing nothing risks internal sabotage with the associated problems.

This month's top tips were supplied by Calum Macloed from Cyber-Ark. To find out more go to **www.cyber-ark.com**
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**

UNCHALLENGED Winner?

DVD SEEMS TO BE A CLEAR WINNER FOR ARCHIVING AND PERMANENT STORAGE, BUT RECORDING DEVICES HAVE BEEN CHALLENGING SAYS KENROY FRANCIS, DIRECTOR OF DIGITAL TV PRODUCTS MARKETING AT LSI LOGIC CORPORATION

Interesting dynamics will continue to drive the UK DVD recorder market over the next couple of years. With digital broadcasts set to completely replace the old analogue system in the UK in the next few years, the introduction of DVD optical recording products will increase dramatically as analogue VCRs become a thing of the past.

According to In-Stat, US-based market research firm, the worldwide DVD recorder market will grow from 20 million units in 2006 to 38 million units in 2008. A major part of that growth will depend on product pricing but more importantly, it will also depend on improving ease-of-use features and consumers' understanding of the benefits of DVD optical media and recording devices as we enter the digital age.

Today, the explosive growth of digital content continues to permeate through our daily lives. To store and manage the growing quantity of personal content, there are three primary storage media used in CE devices: hard-disk drives, flash memory and DVD optical media – all of which have their own unique advantages and disadvantages in different applications.

While all three storage media will continue to co-exist in the consumer electronics marketplace, DVD optical media is the unchallenged winner for permanent storage of personal content. Why?

Hard-disk drive technology is the leader in capacity and is easy to rewrite but is overkill in many popular CE devices. Flash memory offers rewrite capabilities and is highly portable but can be higher cost per a given capacity. Both hard-disk drive and flash memory technologies are good solutions for temporary storage where rewriting is an important requirement.

DVD optical media, however, is the ideal solution for the permanent archiving and storage of digital content. It has the right balance of capacity (4.7GB to 9.4GB), it offers blank-media cost, portability, and a huge installed base of DVD players to be the best solution for general-purpose storage of valued personal content.

Technology has evolved since the days of early photography but people still keep permanent physical copies of pictures of family, friends and memorable events. The desire to keep a physical 'library' hasn't changed. Most people prefer to keep a hard copy of photos on a disc rather than keeping their precious memories on a server or less permanent storage device. DVD discs offer that physical reassurance.

When it comes to the devices that record and archive content, there's still significant room for improvement, particularly in the areas of simplicity, ease-of-use and automation

Now lets consider the situation if you couple that desire with an increasing amount of content. Today, there is an abundance of content, originating from different sources – digital camcorders and cameras, old home movies and photos, the Internet and broadcast video. A DVD recorder can permanently record over two hours of video on one layer of the disc. With that level of capacity, consumers are equipped to store content from virtually any source.

When it comes to the devices that record and archive content, there's still significant room for improvement, particularly in the areas of simplicity, ease-of-use and automation. Even in this digital age, many consumers are not tech savvy and, if they encounter difficulties using a new device they have just bought, many will simply give up and either not use the product or return it to the store.

PCs and some complicated DVD recorders today offer editing and play-listing features for the more tech savvy consumer. But quickly and easily getting content into a format that consumers are already familiar with has often been out of reach.

Some silicon providers are taking a step in the right direction by enabling ease-of-use features through highly integrated processors that also reduce product costs. With authoring software, DVD recorders can transfer personal content from any analogue source to a DVD disc while automatically creating Hollywood-style DVDs with easy-to-use menus, chapters and music videos at the push of a button. This is a powerful and beneficial feature which drives consumer understanding and acceptance.

However, this alone is not enough to develop the UK DVD recorder market; there is much more that can be done. Silicon providers and manufacturers must continue to drive ease-of-use features. Retailers and manufacturers should promote the benefits of the DVD recorder product category rather than reducing retail price points. A coordinated point-of-sale promotion combining DVD recorders with digital camcorders is an interesting possibility. Retailers and manufacturers can benefit from increased revenues through cross-sales, while families would get an easy way to archive and enjoy their camcorder memories.

Product pricing affects adoption rates. But the industry must also promote the ease-of-use and value propositions of consumer electronics. Doing so will help drive the market as a whole as well as categories like DVD recorders, with benefits for retailers, manufacturers, technology suppliers and ultimately consumers.■

JUAN PABLO CONTI PROFILES LG ELECTRONICS, THE OEM STRIVING TO LET EVERYBODY KNOW THERE'S MORE TO KOREAN CUTTING-EDGE GADGETRY THAN JUST SAMSUNG

LIFE'S GOOD?

It's 1995. Someone in a casual conversation that takes place somewhere in the West mentions the "consumer electronics manufacturer from Korea". There's no need to specify what the name of the company in question is. There's only one of them at the end of the day, isn't there? And everybody knows it's called Samsung.

It's 2005. Someone in a casual conversation that takes place somewhere in the West mentions the "consumer electronics manufacturer from Korea". But then someone else interrupts asking for clarification: "Which one of them do you actually mean?"

Building brand awareness is one of the most critical and difficult things to achieve for a company with mass-market ambitions. Doing it on a global scale adds a whole bunch of new challenges. And yet, in the space of just over ten years, LG Electronics has managed to overcome the feeling of constantly living under the shadow of its larger, more successful Korean rival to make a name for itself beyond its domestic market.

It could be argued that 1995 was the year this process of internationalisation started for the vendor. After all, this was the year when the original name of 'Lucky Goldstar' – which had remained in place since the foundation of the company's parent group in 1947 – was abbreviated, only the initials kept in a clear attempt to better position the brand for the global marketplace.

In reality, the process had already started a few years back. In 1991 the company opened a new design centre in Ireland, its first one outside Korea. Others followed in the US (1993), Japan (1993), China (1998), Italy (2002) and India (2002). Today, each of these facilities is used to design products that incorporate technology stemming from LG's 30 R&D labs worldwide, but that are individually adapted to meet local tastes.

SLIDING PHONES AND PHONE SALES SLIDING

LG Electronics is organised into four main business units, internally called Mobile Communications, Digital Appliance, Digital Display and Digital Media.

At a group level, the company has set itself the ambitious target of being among the top three electronics, information and telecommunications firms in the world by 2010. Judging by its current market share position at each of the segments where it operates, the goal seems achievable in some cases, but extremely difficult in others.

Mobile phone handsets are a good example of the latter. "Up until the first half of 2006, they were kind of neck-and-neck with Sony Ericsson," says Carolina Milanesi, research director for mobile devices and consumer services with industry analyst firm Gartner. "For a few years, the whole story every quarter was: is it going to be LG or is it going to be Sony Ericsson in number five?"

With fourth-placed Siemens Mobile starting to show some problems in 2004 and eventually going out of business in 2006 as BenQ-Siemens, the battle between LG and Sony Ericsson moved to the number four position (behind market leaders Nokia, Motorola and Samsung). But worryingly for LG, Sony Ericsson began to pull away with accelerated growth during the second half of 2006 and has relegated its Korean competitor to the fifth place.

"That's the story from a volume point of view," says Milanesi. "From a business point of view, the main problem that LG has been facing is the fact that they're not actually making much money. At the beginning it was a case of trying to get to some markets and trying to gain market share – especially

Twin Tower headquarters in Seoul

An MP3 player with a 60-hour battery life

The company's R&D team is growing

LG's KE800 Platinum handset

in places like North America – by offering a much more aggressive price point than competitors like Samsung. But then they got caught in having to offer operators that kind of aggressive pricing. That's why their margins are so poor. Low margins are something that everybody is suffering from at the moment, but for LG in particular is an issue."

Because margins in general are so low, mobile phone manufacturers would give anything to come up with a very hot product design that could help them balance their books by driving up volume instead. Motorola showed how this was done back in 2005 with the iconic RAZR V3 handset. And while perhaps not reaching the same sort of widespread success, the Chocolate released last year by LG was the closest any other handset has got to replicating the RAZR story so far.

But Milanesi thinks this won't be enough to improve LG fortunes in the cellular space: "They are suffering to some extent from what Sony Ericsson suffered a few years back, which is that they have one good product at a time. So they might have the Chocolate, but that is only one product, which is not enough to drive volumes. I think what is key for them is to come up with a stronger portfolio of products – having not one but at least two or three products at a time that are strong."

And then there's the challenge of keeping pace with innovation: "As far as technological vision is concerned, they seem to be a bit reactive to things instead of driving them forward. For example, there's a lot of push around smartphones at the moment and operators here in Europe are starting to look at the platform strategies to rationalise their offerings a little bit better. But LG is yet really to address the smartphone category as such.

"Here in Europe they were initially really strong on WCDMA [or 3G], working in partnership with Hutchison. But then they kind of lost their edge on people like Samsung and Nokia, which came in very strong and are now the leaders in WCDMA," says Milanesi.

3G FOR ALL

Earlier in February this year, while the 3GSM Congress was getting under way in Barcelona, LG received what in principle would seem like very good news. Twelve of the world's largest mobile operators chose the LG-KU250 designed by the Korean vendor as the winning handset for the "3G for All" campaign, which the GSM Association set up to accelerate take-up of 3G services.

LG beat competition from eight other vendors, which had submitted 19 different handsets. By agreeing on a common set of technical specifications, the 12 operators that will be buying the 3G phone will bring in major economies of scale to the equation, allowing LG to manufacture and distribute the device at a lower-than-usual cost.

However, the Gartner analyst feels the '3G for All' tender win might not necessarily be a good thing for LG. What's more, she says it might actually end up turning into a curse for the firm: "If you look back at Motorola when they won the emerging markets' ultra-low-cost [2G] initiative, for them that was the beginning of the end, really. You know, from a brand-value point of view, to go out and say 'we can do a phone for X amount of dollars' is not really a good thing, because suddenly you've got all the operators saying: 'well, if you do it for that, you can do it for this'. And they are going to start pushing you down more and more, which obviously is not going to help your margins."

The tricky mobile phone business aside, there are other areas of the electronics industry where LG is the undisputed world leader. Take optical storage devices, for example. Here, the Korean firm has occupied the top spot for nine consecutive years since 1998.

A big part of the reason behind this success derives from the fact that LG has consistently managed to be first-to-market with the latest generation of PC drives. In 1997, it became the world's first producer of CD-ROMs; one year later, it was the first one to sell CD-RW drives; in 2000 it was first-to-market again with DVD-R (readers); two years later it was the first vendor to have a combined CD-DVD product; and in 2004 it started to ship the first batch of DVD-W (writers).

Continuing with this strategy, in 2007 LG announced – and already started commer-

The Chocolate phone was one of LG's most successful designs

cialising in the US – the world's first high-definition (HD) optical disc drive for PCs. Mirroring its own approach adopted in standalone next-generation DVD players (see the panel 'The end of the war'), the device supports both standards currently fighting to establish themselves as the HD format of choice. But while it can both read and rewrite Blu-ray discs, DVDs and CDs, it can only read HD-DVD discs.

COOL

Another area where LG remains a world leader is in the market for residential air conditioners. No other company has been able to sell more air conditioners than the Korean OEM for the past seven years. In 2006 – for the third consecutive year – it shipped more than 10 million units worldwide. Japanese market research firm Fuji-Kezai estimates LG's global market share in 2006 totalled 19.5%.

This year the company has set itself a production target of 16 million units. A whopping 103 new models were introduced during 2007 alone, a figure that can only be explained by the fact that LG has six R&D centres located in four different continents dedicated exclusively to air conditioning technology. This has allowed the company to bring true innovation to the market, such as the introduction of its 2-in-1 and 3-in-1 space-saving systems, which make it possible for one external unit to be simultaneously linked with up to three internal units.

Washing machines are another area that the Digital Appliance business division of LG can proudly exhibit as the fruit of its R&D efforts. In 2005 the company patented a washing machine that uses steam to clean clothes, thereby saving both water and power consumption.

The product was invented by designer Kwang Soo Kim, who was asked by LG simply to develop an energy-efficient washing machine. The breakthrough idea came to him after he realised the same principle used in Korea to cook rice cakes via steam could be applied to washing machines.

In the audio/video industry, the Digital Display business unit has established the company as a leading force in both the plasma and LCD technology markets. Considered the world's largest maker of plasma panels, the vendor was able to produce 550,000 units per month as of the end of 2006.

The development of single-scan technology by LG researchers (which was successfully applied for the first time to 42-inch HD plasma TVs in 2004 and then to 50-inch models in 2005) reduced the required driving circuitry by 50% compared with dual-scan systems.

As for the LCD side of the flat-screen market, the company is also the world's largest vendor – although in this case courtesy of the 'LG.Philips' LCD joint venture that it formed with the Dutch giant in 1999. Last May LG opened a new LCD manufacturing centre in Wroclaw, Poland, its third such facility worldwide.

But just as it is happening with its mobile phones, the Korean firm is also suffering from very low margins in its flat-screen operations. In fact, its Q1 2007 financial results showed the Digital Display unit made a loss, which the company blamed mainly on overcapacity in its plasma panel operations and intensified price erosion.

LG ELECTRONICS IN BRIEF

Founded: 1958 (parent group in 1947)
Headquarters: Seoul, Korea
Vice chairman & CEO: Yong Nam
Employees: 82,772 (30,000 in Korea, the rest overseas)
Annual sales: $24bn (2006)
Net income: $223m (2006)
R&D expenditure: $1.5bn (2006)
Listed: Korea, London and Luxembourg

The Dual Core Express TX laptop

LG's new Shine GSM mobile phone

The company invented steam washing machines

THE END OF THE WAR

On 7 January 2007, when the doors of the Las Vegas Convention Centre had not even been officially opened to host this year's International Consumer Electronics Show, LG 'dropped a bomb'.

Its explosive power not only made most other company announcements look practically irrelevant during the four other days that the event lasted, but it was directly aimed at ending the biggest standards war the consumer electronics industry has witnessed since VHS versus Betamax.

We all know what caused the war by now. High-definition televisions – sold in their millions these days – are screaming out for HD content. But, when it comes to next-generation DVD players, there are two competing standards, backed by different hardware manufacturers and Hollywood studios. Both the Sony-developed Blu-ray Disc and Toshiba-led HD DVD formats have been finalised, with several movies released and standalone players supporting one or the other technology on sale.

Problem is: consumers aren't buying them. They're sensibly waiting for one of the two standards to finally win the war, just as VHS did in the eighties. So LG had a simple idea: let's build a high-definition player that can read both formats. The idea in itself wasn't groundbreaking. Indeed, if you happened to have read the company profile on Sony that *Electronics World* published last year, we anticipated then that most OEMs were hoping to come up with dual-format HD disc players at some point.

LG was simply the first one to be able to do it. The device was dubbed the 'Super Multi Blue Player' and is already shipping in the US for around $1300. The first independent product reviews complained that LG's claim of having a truly dual-format player were only half-true, as the device was unable to play back all the interactive features (such as trailers, director's comments, etc) found in HD-DVD discs. LG had actually warned about this deficiency in its initial product announcement, but this hasn't prevented this particular issue from constantly being raised in the all-important blogs that prospective new buyers invariably check nowadays before making an important purchase decision.

Meanwhile, Samsung has recently confirmed that it will have its own dual-format HD disc player ready in time for this Christmas season. And that – unlike its Korean rival's product – this one will support full menu interactivity. ■

DATA OVER A SIMPLE RADIO LINK

ISM band radio module manufacturers are offering higher and higher levels of user interface complexity; from elementary transparent RS232 'radio modems' up to the sophistication (and complexity) of Bluetooth or ZigBee protocol based radios. Many of these devices come with high-level software drivers to link seamlessly into an Ethernet or USB port.

But what if you are only trying to implement a simple remote control function – maybe a few user inputs controlling a handful of relays, without the need to transfer megabytes of data and without a powerful computer at either end of the link?

"THE METHOD DESCRIBED HERE DOES NOT OFFER THE BEST IN S/N PERFORMANCE BUT IT SHOWS A WORKABLE TECHNIQUE, WITH A MINIMUM OF SOFTWARE EFFORT AND PROCESSING OVERHEADS"

Despite what advertisers and industry pundits would have you believe, it is (still) possible to realise a reliable radio link with a pair of low-cost radio modules and a handful of parts, without megabytes of code running on power-hungry, complex systems. With only basic programming skills and a minimum of hardware or processing power it is very easy to design your own 'data over RF link protocol'.

Firstly, if we examine the baseband (or data) interface of any simple FM wireless link pair, we find what is effectively an audio path through the radios, usually with limiter or squarer on the transmitter input and an 'average and compare' comparator on the receiver output, to permit direct connection to digital logic devices.

From initial inspection of the data sheets it looks like it should be as simple as attaching the transmitter to a UART output and the receiver to a UART input, and sending a byte or two through the link. If you try that in most cases it will sort of work, but the raw radio path has a few unfortunate characteristics that need to be considered.

1. The channel is noisy. While this may not be evident during strong signal tests, as the range is increased the signal-to-noise of the received output degrades. (On the recovered digital output this manifests as increased jitter and mid-bit 'dropouts'.)

In the presence of interference, such as other transmitters or environmental noise (ignition, lighting, electromagnetic machines, or natural sources of noise like electrical storms), the wanted signal may be temporarily swamped entirely. In the complete absence of a signal, a simple FM receiver outputs bandwidth limited white noise, which appears at the data output as a completely random datastream.

2. The channel bandwidth is limited (by a baseband filter in the transmitter and by the receiver filters). The maker's data sheet will quote a maximum permitted data rate, but a non-time-critical application such as this one should be designed to operate at a much lower speed than that (to simplify the coding and to maximise range for given S/N ratio).

3. The channel is AC coupled (despite the apparent logic level input and outputs), so there is a minimum frequency limit as well as a maximum. This imposes the need to keep the aggregate mark-space ratio of the burst close to 1:1, or the signal to noise will further degrade. In the worst case, a long enough string of continuous 'one' or 'zero' will cause the receiver's comparator reference to drift off and output spurious bit inversions.

4. The link has a defined and sometimes quite long set-up time, required for the transmitter to reach full output and stabilise, and for the receiver to acquire an average for its data recovery circuit. During this time no valid data can be passed, but it is necessary to provide a 'preamble' (a square wave sequence of consecutive high and low) to condition the data recovery circuit.

From these characteristics it is possible to get an idea of what is required of the data format:

- Enough information (as framing, synchronising or addressing bits) needs to be sent in addition to the actual data or command sequence to allow the decoder to reliably discriminate between random noise in the absence of signal (or in the presence of interference) and the transmitted command burst.
- A bit level format is required, which prevents long streams of continuous

A PRACTICAL REALISATION

If a little care is taken, it is possible to still use a hardware UART (RS232 type asynchronous interface) and fulfill all the requirements of the link.

The data is sent in a burst, or packet, comprising of: [preamble] [uart 'start' byte] [framing bytes] [data 'payload'] [checksum].

Characters must be sent continuously, start bit to stop bit without gaps (or the mark:space ratio will become unpredictable)

Assuming 1+8+1 (one start, 8 data, 1 stop) format, a sequence of 55h (ASCII U) characters provides a square wave preamble. After the transmitter is turned on, a stream of these preamble bytes must be sent, until the 'tx-on' time spec of the radio module used has been met. (This will usually be between 3 and 50mS, depending on the module)

An FFh byte must immediately follow the preamble, so the UART can frame on an identifiable start bit. To maintain DC balance, a 00h byte must follow the FFh. Both these bytes can form part of the decoded 'framing' sequence of the burst.

Then, to maintain mark:space balance, data can be sent by using only those characters with an equal number of ones and zeros in them. Of the 256 possible 8 bit codes, 70 contain 4 ones and 4 zeros. Omitting 0Fh, F0h, 3Ch and C3h (worst case 'four ones in a row' bit sequences) still leaves 66 usable codes per byte, which allows six bits of actual data to be coded into each transmitted byte. A full explanation of this method can be found at:
http://www.radiometrix.co.uk/products/bimsheet.htm#rs232

'one' or 'zero' occurring and which maintains an equal balance between high and low states (i.e. has a high enough minimum frequency and no DC offset). This format should also allow for a reasonably noise-tolerant decode method.

- The chosen data rate must be as low as possible, within the system response time requirements. This will maximise the sensitivity of the link within.
- The burst format must have a sufficiently long preamble (settling time) sequence preceding any decoded data.

It is necessary to use a number of fixed value bytes preceding the actual data 'payload' as packet identification (or 'framing') to allow the decoder to tell a valid data burst from random channel noise. In my experience, to avoid false triggering of the decoder, at lease 3-4 bytes of framing data will be necessary.

Additionally, one or more 'address' bytes may be added (to allow co-located operation of multiple systems, or polled access of multiple receivers by a single transmitter) and, ideally, a checksum of some kind should be added to the data packet, as an extra precaution against spurious triggering.

I have described a very simple protocol here. There are many, far more sophisticated techniques in use throughout the industry. The method described does not even offer the best in S/N performance (as the edge triggered UART receiver is overly susceptible to data bit jitter and dropouts compared to a proper duration measuring biphase decoder), but it shows a workable technique, with a minimum of software effort and processing overheads.

Sometimes a simple approach is sufficient.

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THE RAPIDIO HIGH-SPEED INTERCONNECT: A TECHNICAL OVERVIEW

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

Today's high-speed embedded applications are like networks onto themselves. They possess tremendous processing resources capable of acquiring and analysing large amounts of data that require a complex internal fabric to facilitate the transfer of data throughout the system. Data often passes through many interconnect layers and protocols as it crosses the fabric, with each layer of interconnect introducing undesirable latency, complexity and cost (see **Figure 1**).

In order to achieve the performance required for these applications – many of which must produce results in real-time with the minimum latency – developers are seeking ways to consolidate interconnect layers across the system. Not only are they trying to more seamlessly connect chips, boards and chasses, ideally they'd like to collapse the data and control planes into a single fabric.

A system-level interconnect must perform efficiently and offer the mix of functionality appropriate for the data it is to transport. Developers aiming to achieve the highest performance and reliability understand that selecting the optimal interconnect for a system fabric involves a great many considerations beyond theoretical maximum throughput, including how efficiency is an inherent part of the physical, transport and logical layers, and features such as multiple PHY options, deadlock avoidance through priority mechanisms and buffer management, advanced quality of service with short and long-term flow control mechanisms and data plane capabilities that enable the interconnect to transport any protocol.

DESIGN BY INTENTION

While there are many interconnect technologies available for use as a system interconnect fabric, the RapidIO standard was designed specifically to address the needs of embedded developers. Originally conceived as a next-generation front-side bus for high-speed embedded processors, its designers had the foresight to widen its focus to include embedded in-the-box and chassis control plane applications. In this way, the standard provides reliability with minimal latency, avoids unnecessary software dependence, offers extensibility to maximise application applicability and simplifies switch design, all while achieving effective data rates from 667Mbps to 30Gbps.

The origins of the RapidIO interconnect standard date back to 1997 when Motorola began work on a next-generation bus for its Power and PowerPC-based processors. By 1999, Motorola and Mercury Computer had joined together to complete the initial RapidIO specification. In 2000, these two companies drove the formation of the RapidIO Trade Association, making the RapidIO specification an independent standard and, in 2004, the RapidIO specification become an international standard as ISO/IEC 18372:2004.

It is useful to contrast the development of the RapidIO standard to that of Ethernet. Many embedded developers are quite familiar with Ethernet and, because of their familiarity, attempt to carry Ethernet from the WAN and LAN down into the system-level fabric. Ethernet, however, was originally designed to connect large computers. Its creators assumed that every Ethernet node would have substantial processing resources available to it. Therefore, in order to provide Ethernet with the flexibility to support the widest range of applications, the base specification uses a simple, generalised header with a single transaction type and a large ID field (6 bytes for a MAC address). Best-effort service simplified packet delivery, and

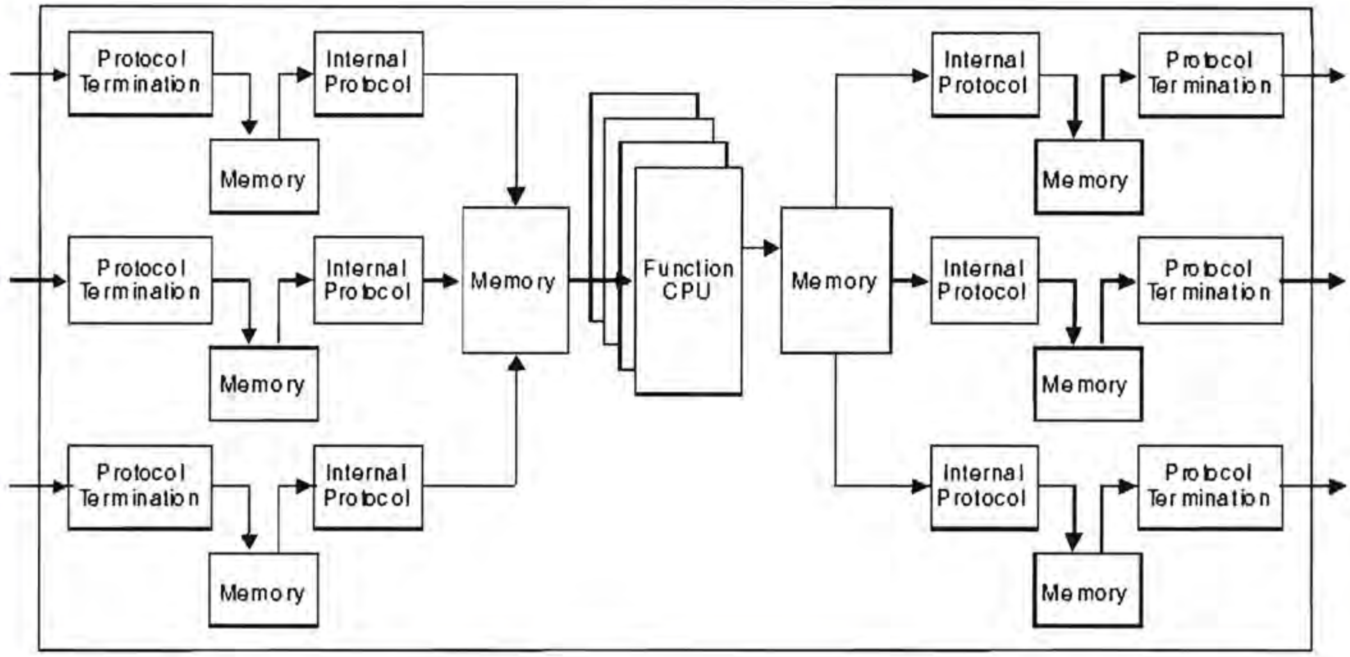


Figure 1: *Today's embedded applications require a complex internal fabric to facilitate the high-speed transfer of data throughout a system, often passing through many interconnect layers and protocols, with each layer of interconnect introducing undesirable latency, complexity and cost*

implementing most of the protocol in software kept pricing of early deployments down.

While many of these characteristics are advantageous in LAN and WAN environments – there's a reason Ethernet is as ubiquitous as it is in the network – they actually introduce significant inefficiencies when used in a system fabric. Given the high speeds and minimal latency requirements of backplane and box-to-box applications, these inefficiencies are unacceptable.

By being focused on chip-to-chip, board-to-board and chassis-to-chassis interconnect, the RapidIO standard is optimised for the types of transactions typical in these applications. For example, while the inefficiencies introduced by large headers are minimised when typical transactions utilise the maximised packet size, most control plane transactions, as well as chip-to-chip transactions, are relatively small. The efficient and minimal header size of RapidIO packets, therefore, has a substantial impact on effective throughput and efficiency in these applications.

Additionally, most of the RapidIO protocol is implemented in hardware. This minimises the burden placed on a host processor to process packets. This is especially important in high-speed applications where software protocol processing can actually limit effective throughput. For example, a 1Gbps or 10Gbps Ethernet can overwhelm a host processor, requiring the use of TCP/IP offload engine (TOE) technology. As there is no set TOE standard, such implementations are proprietary and vary significantly from vendor to vendor. By implementing protocol processing in hardware, implementation of RapidIO links is consistent across the industry.

The RapidIO physical layer is defined to move packets reliably and efficiently across individual links while the transport layer defines how packets are identified within a fabric and how they are routed to a particular destination. Specifically, the protocol guarantees packet delivery while managing link utilisation, packet transmission and error recovery. Individual packets participate in the link protocol through physical layer packet header fields, and packet loss is detected because the receiver must positively acknowledge each packet received. Through the use of control symbols, which can be embedded within packets, link operation can be coordinated between links while minimising loop latency. Except for certain rare error scenarios, hardware automatically recovers most link errors without software intervention since an error acknowledgement triggers a packet resend.

The logical layer is the highest layer of the RapidIO protocol and defines many operations common to interconnect protocols with additional operations helpful to embedded applications. The base protocol supports messaging and guarantees packet delivery. Ethernet, in contrast, must support these functions as higher layer protocols (RDMA and TCP/IP respectively) which increase both the latency and software processing required. Other supported functions include data streaming, globally shared memory, flow control and user-defined operations.

	Aggregate Data Rate[1]	Encoding	Symbol Rate	Number of Differential Pairs	Channel
8-bit LP-LVDS	4–16 Gbps	Source Synchronous DDR LVDS electricals	4–16 Gbaud	20	~50–80 cm of FR4 2 connectors
16-bit LP-LVDS	8–32 Gbps	Source Synchronous DDR LVDS electricals	8–32 Gbaud	38	~50–80 cm of FR4 2 connectors
1x LP-Serial	1, 2, 2.5 Gbps	8B10B + XAUI electricals (short reach level added)	1.25, 2.5, 3.125 Gbaud	4	~80–100 cm of FR4 2 connectors
4x LP-Serial	4, 8, 10 Gbps	8B10B + XAUI electricals (short reach level added)	1.25, 2.5, 3.125 Gbaud	16	~80–100 cm of FR4 2 connectors
[1]Does not include header and protocol overhead					

Table 1: *The RapidIO protocol defines both serial and parallel PHY interfaces with multiple lane widths, giving developers the ability to trade off between latency, data rate, physical channel length and number of differential pairs used based on the needs of a particular application*

PHYSICAL LAYER OPTIONS

The RapidIO protocol supports both a serialised embedded clock signalling interface (SerDes) and a parallel source synchronous interface, which provide developers with the ability to trade off between latency, data rate, physical channel length and number of differential pairs used based on the needs of a particular application (see **Table 1**). While the control symbol formats between the two PHYs are relatively different, packet formats are the same but for a few physical layer-specific bits. Additionally, the RapidIO protocol was intentionally designed to match existing PHY standards, where possible, so as to leverage existing ecosystems and economies of scale. For example, the Serial RapidIO specification follows XAUI electricals.

The 1x/4x LP-serial specification offers the lowest pin count and longest channel lengths, making this XAUI-based PHY well-suited for backplane fabric applications. The PHY further extends the capabilities of the XAUI specification by defining a reduced voltage swing short-haul specification to accommodate varying channel lengths and limit power dissipation and radiated EMI. Developers also have the option of increasing the overall data rate per port by using either one or four differential pairs/lanes per port.

The 8/16 LP-LVDS specification defines a parallel source-synchronous signalling interface passing either 8 or 16 bits at a time together with a framing bit and clock. Compared to the serial PHY, the parallel PHY requires more signals but offers inherently less latency per clock by eliminating the need for serialisation and deserialisation of the data stream. This makes the parallel PHY ideal for applications such as processor front-side buses and board-level designs that require very high bandwidth and the lowest possible latency.

As both the serial and parallel PHYs support two width options, the RapidIO specification also automatically allows interoperability between them by detecting when a narrow PHY is connected to a wider one.

DEADLOCK AVOIDANCE

Read transactions introduce the possibility of dependency loops which can lead to deadlock. In a RapidIO system, these loops can arise when the entire loop between two endpoints is filled with read requests, and deadlock avoidance measures are required that ensure that responses to outstanding reads can complete and, therefore, release their resources.

The RapidIO protocol uses priority mechanisms to avoid deadlock. Since switches and endpoints are required to handle higher-priority packets first, assigning responses a higher priority than the associated request ensures that responses are able to make forward progress through the fabric. By assigning each packet physical layer priorities, logical flows can be identified, ordering rules enforced, and deadlocks avoided. Additionally, defining priority at the physical layer greatly simplifies switch operation and design as there is no need to know a packet's transaction type or its interdependency with other packets when making switching decisions.

For priority mechanisms to be effective, switches must manage their buffers to prevent lower-priority packets from filling a buffer and blocking acceptance of higher-priority packets. This can be achieved in a number of ways, including assigning at least one buffer to each priority. RapidIO systems can also implement virtual channels requiring completely separate buffer pools by dedicating buffers to particular flows. A more common approach is to allow buffers to hold packets of a set priority or higher. In effect, this gives higher-priority packets access to the entire buffer pool.

QUALITY OF SERVICE

Quality of Service (QoS) is an inherent part of the RapidIO specification, implemented directly in hardware and enabling traffic to be classified into as many as six prioritised logical flows. While the mechanism for forward progress in the fabric relies upon ordering rules at the physical layer to give responses higher priority, the degree to which prioritisation results in lower average latency or jitter for a particular flow is specific to the actual implementation. For example, more aggressive switches might make ordering decisions based upon a flow's priority, source and destination ID fields while less aggressive designs might only utilise the priority field.

QoS is also affected by specific fabric arbitration policies. While the specification explicitly defines prioritised flows, developers are free to choose the particular arbitration policies to put into place to prevent starvation of lower-priority flows, such as the well-known leaky-bucket scheme. As even the least aggressive design must support these mechanisms, higher-priority flows are guaranteed to demonstrate better lower-average latency.

For applications requiring even more aggressive and effective QoS, advanced flow control and data plane capabilities are available. The RapidIO protocol defines multiple flow control mechanisms at the physical and logical layers. By managing physical layer flow control at the link layer, short-term congestion events are effectively managed for serial and parallel applications using both receiver and transmitter controlled flow. Longer-term congestion is controlled at the logical layer using XOFF and XON messages, which enable the receiver to stop the flow of packets when congestion is detected along a particular flow.

Receiver-only flow control, where the transmitter does not know the state of receiver buffers and the receiver alone determines whether packets are accepted or rejected based on receiver buffer availability, results in packets being resent, creating wasted link bandwidth. Additionally, ordering rules require a switch to send higher-priority packets before resending any packets associated with a retry, aggravating worst-case latency for lower priority packets.

Transmitter-based flow control avoids bandwidth wasting retries by enabling the transmitter to decide whether to transmit a packet based on receiver buffer status. Through receiver buffer status messages sent to the transmitter using normal control symbols, the transmitter is able to limit transmissions within the maximum number of buffers available at the receiver. In general, priority watermarks at the various buffer levels are used to determine when the transmitter can transfer packets with a given priority.

A third link-level mechanism is available within the parallel PHY specification, which enables the receiver to throttle the packet transmission rate by requesting that the transmitter insert a selectable number of idle control symbols before resuming transmission of packets.

Revision 1.3 of the RapidIO specification achieves further efficiency and higher throughput through the introduction of data plane extensions. Since data plane fabrics can carry multiple data protocols, these extensions enable the encapsulation of virtually any protocol using a data streaming transaction type with a payload up to 64kbytes. Hardware-based SAR support is expected for most implementations, with up to 256 classes of service and 64K streams.

The upcoming 2.0 revision of the specification builds on revision 1.3 capabilities, introducing a new 5.0 Gbaud and 6.25 Gbaud PHY, lane widths up to 16x, 8 virtual channels with either reliable or best-effort delivery policies, enhanced link-layer flow control and end-to-end traffic management with up to 16 million unique virtual streams between any two endpoints.

The RapidIO protocol is a simple and efficient interconnect designed specifically for high-speed embedded applications and appropriate to serve as a system-level fabric. By implementing protocol processing in hardware, many QoS and flow control mechanisms are an inherent part of the PHY, maximising efficiency and throughput while minimising latency and switch complexity. Backed by new data plane extensions which enable RapidIO switches to encapsulate virtually any data protocol, the RapidIO specification is an ideal interconnect technology, enabling developers to consolidate interconnect layers, as well as both control and data planes, into a single fabric, reducing cost while increasing overall system reliability. ■

K. FAWZI IBRAHIM, A SENIOR LECTURER AT THE COLLEGE OF NORTH WEST LONDON AND DIRECTOR OF KFI TRAINING AND CONSULTANCY, HERE PRESENTS A SERIES OF ARTICLES BASED ON THE FORTHCOMING 4TH EDITION OF NEWNES GUIDE TO TELEVISION AND VIDEO TECHNOLOGY. IN THE THIRD ARTICLE SEEN HERE, HE DESCRIBES THE PRINCIPLES AND RESONANT CONVERTERS USED TO SUPPLY POWER TO PLASMA DISPLAY PANELS

PLASMA PANEL POWER GENERATION

A plasma panel display (PDP) is a flat panel display and as such it consists of a number of pixels arranged in a matrix of rows and columns. While the columns are driven by the video data, the rows in a PDP are driven by two high-voltage, fast-switching pulses known as the scan and sustain pulses.

The scan and sustain pulses consume a large amount of power (about 80% of the total) and can generate a large amount of heat. It is thus essential for a PDP power supply to reduce the amount of heat generated and improve efficiency. In addition to high efficiency, PDP power supplies have to have fast transient response, low noise and low electromagnetic interference (EMI).

A PDP requires the following DC power supplies:

- Multi-power for processing chips, audio amplifiers and other semiconductors devices of 3.3V, 3.6V, +15V, -15V and 5V.
- Address electrode power supply (70V)
- Sustain and scan power supply (200V).

A PDP power distribution system is shown in **Figure 1**. It consists of the following elements:

- Main full-wave bridge rectifier
- Main line filter
- Power Factor Correction (PFC)
- Multi-power supply for ICs, audio, etc.
- Sustain power supply VSUS
- Protection circuits (not shown)

Power factor correction reduces reactive power and introduces pre-regulation. The sustain power supply provides over 75% of the entire power requirement of the PDP. To ensure high efficiency, low noise and EMI, soft-switching resonant converters are used.

POWER FACTOR CORRECTION

The purpose of the PFC is to reduce the reactive load current which is of no real value to the device. Only resistive power consumption is of any value as far as the device is concerned.

A fully resistive load when fed with a sinusoidal voltage is said to have a power factor of one. Power factor is defined as: Mean power/$V_{rms}I_{rms}$

If the voltage and current are pure sine waves, the power factor is given as k = Cos θ, where θ is the phase difference between the current and voltage waveforms. Since for a resistive load the current is in phase

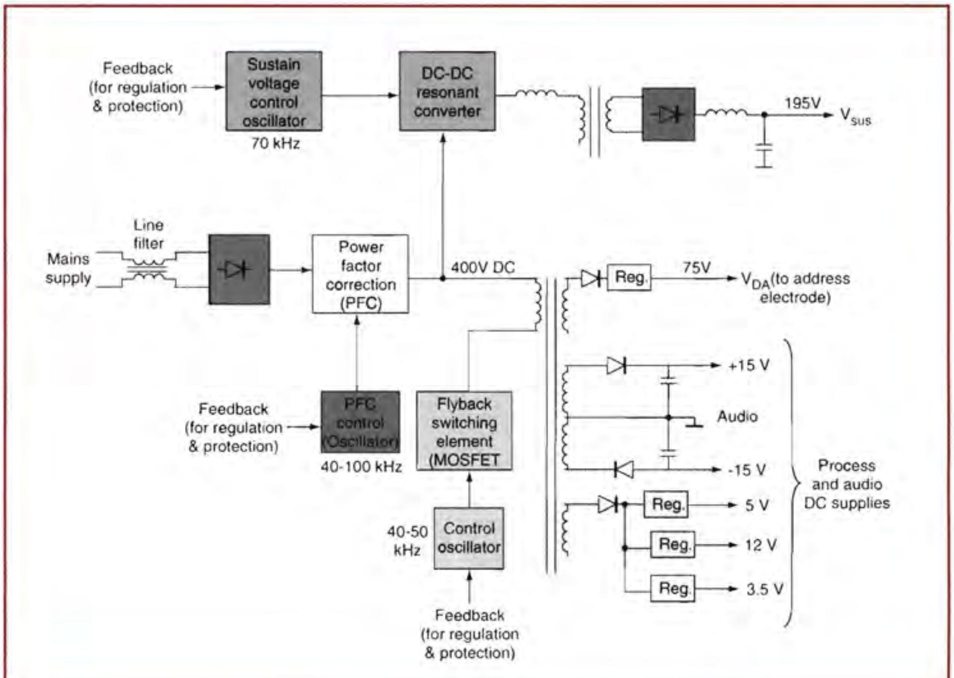


Figure 1: Power generation and distribution for a plasma television receiver

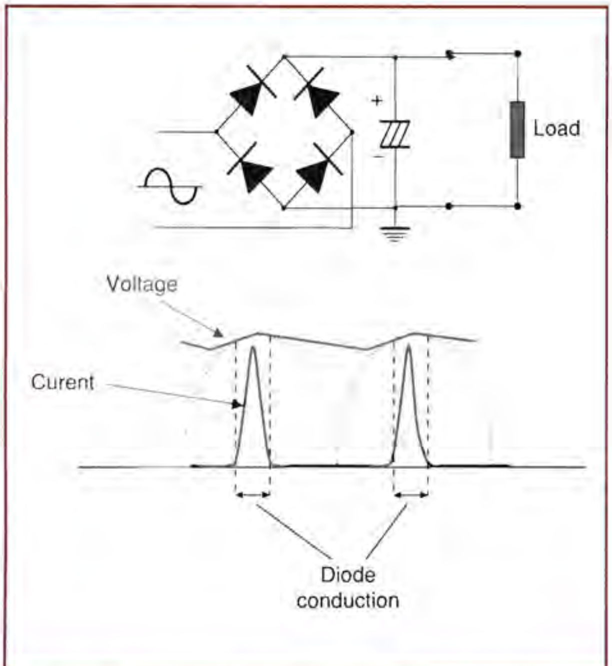


Figure 2: *The diodes in a traditional rectifier act as switches conducting for a short period of time*

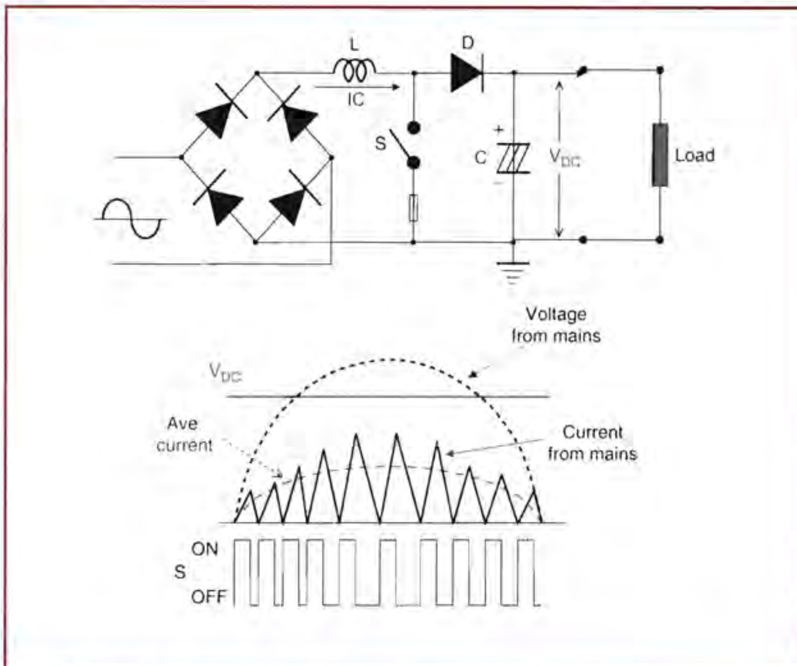


Figure 3: *The principles of the power factor correction circuit*

with the voltage, it follows that θ = 0 and Cos θ = 1. Hence, the power factor k = 1.

For a purely resistive load, the power $P = V_{rms} \times I_{rms}$. However, for a reactive load, the power factor has to be taken into account and power is given as:

$$P = V \times I \cos\theta$$

Thus, with a power factor (Cos θ) of 0.5, only halve of the power is useful power and the other halve is completely wasted power.

A power factor of one is the highest power factor possible in which all power consumed by the device is useful power. On the other extreme, a purely reactive load, e.g. a pure inductor or a pure capacitor, has a power factor of zero since $\theta = 90^0$ and $\cos 90^0 = 0$. A power factor less than one can also be obtained if the voltage and/or current waveforms are not pure sinusoidal, if they containing harmonics, even though the load is resistive. This is the case with all types of rectification including controlled rectification. For this reason, the power rectification and supply circuits look reactive to the mains supply with a power factor of between 0.5 and 0.7.

To rectify this situation, PFC is employed to ensure that as little power as possible is wasted. Furthermore, under European law, mains harmonics are restricted for devices of 75W and over. A power factor correction is therefore needed to ensure that these harmonics do not exceed the permitted level.

A further reason for using PFC is to reduce the amount of imbalance on the three-phase mains power supply caused by low power factors. Such interference becomes noticeable with high power requirements for equipment such as electric motors and PDPs. With PFC, a power factor of 0.9 is possible.

With the simple rectifier circuit illustrated in **Figure 2**, the diodes act as switches which conduct for a short period of time depending on the load current even if the load was fully resistive.

The current flows only when a pair of diodes conduct naturally, i.e. when they are forward biased during the period when the instantaneous value of mains voltages on their anodes exceeds the capacitor voltage on the cathode side. The current waveform is therefore a relatively narrow pulse as illustrated in Figure 2.

While the fundamental of the current waveform is in phase with the incoming voltage, its harmonics are not resulting in a low power factor. This may be tolerated where power requirements are low (10s of Watts). However, when power consumption is high, in the region of 100s of Watts, then the losses due to low power factors are high and must be avoided. This is carried out by a PFC circuitry. Instead of the capacitor receiving a charging current once every half cycle, PFC ensures that the charging current is small but more frequent; 100s of times every half cycle.

Refer to **Figure 3**. When the switch S is closed the current flows through inductor L in a linear manner, storing energy in the inductor. When S is open, the current is abruptly cut and back EMF across the inductor provides a forward bias to diode D, inductor L and capacitor C form a resonant circuit and a charging current (I_C) flows to charge the capacitor C. Energy stored in the inductor is now transferred to the capacitor.

When the capacitor is fully charged and I_C is zero, diode D is reverse biased. At this moment, S is closed and

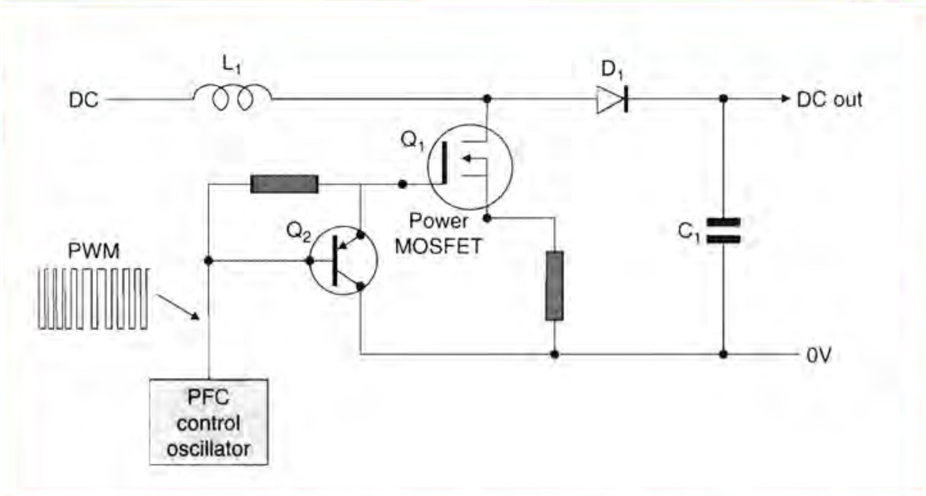


Figure 4: Main elements of a PFC circuit with Q1 acting as the main switching element

current begins to flow through L and so on. The average current taken from the mains now follows the shape of the voltage as shown in Figure 3, resulting in a power factor as high as 0.85 or even 0.9. The switching waveform for S is the pulse modulated waveform shown with a frequency of 40-100kHz. Note that the mark-to-space ratio of the PMW changes with the sine wave input. The off period increases gradually as the input goes up to peak and decreases as it goes down to zero while the ON period remains the same throughout.

The main elements of a PFC circuit is shown in **Figure 4**. A power MOSFET (Q1) is used as the switching element. Q1 is driven by bipolar transistor Q2. The PWM pulses are produced by the PFC control oscillator. The duty cycle is determined by the shape and amplitude of the mains sine wave, as well as the output voltage and current levels. In this respect, PFC acts as a voltage pre-regulator.

Figure 5 shows the main elements of a practical PFC circuit used by Panasonic employing two balanced MOSFETs for improved power factor correction. Sine wave, current and DC output sensors are used to ensure that the current waveform follows as closely as possible the mains voltage.

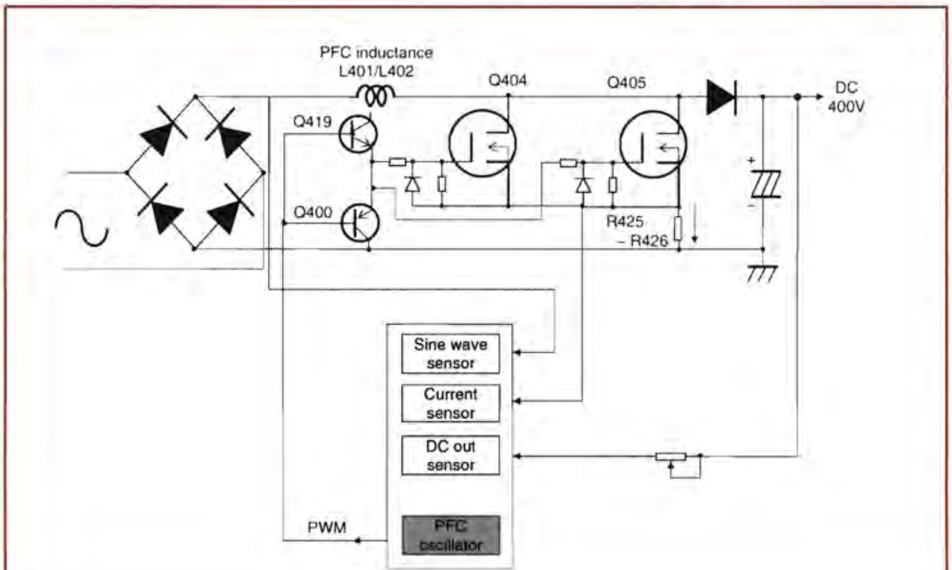


Figure 5: A practical PFC circuit employing two MOSFET transistors Q404 and Q405

SOFT-SWITCHING RESONANT DC-DC CONVERTERS

The power supply of a PDP TV employs three types of DC-to-DC converters:

- Linear regulated converter
- Switched Mode Power Supply (SMPS)
- Soft-switching resonant converter

The type of linear regulators and SMPSs used here is normally the flyback DC-DC converter. SMPSs suffer from a number of limitations: high electromagnetic interference (EMI), high stress levels on the switching devices and limited switching speeds to less than 100kHz. These limitations are mainly a result of the switching taking place at a high current and/or voltage levels. Hence, these converters came to be known as hard-switching converters. When switching at high frequencies, these converters are associated with high power dissipation and high EM interference caused by high frequency harmonic components associated with their quasi-square switching current and/or voltage waveforms.

To overcome the limitations of the traditional SMPS, a third generation power converters known as soft-switching (resonant) converters were introduced in the late eighties.

Like switched-mode power supplies, soft-switching power units are DC-DC converters. DC from a rectifier is first converter to AC through a switching element. This AC is fed into the primary of a transformer with a number of secondary windings for multi-outputs. The secondary outputs are then rectified in the normal way to produce the various DC voltage levels.

The new element that resonant converters bring is switching takes place when the voltage across the switching element is zero, known as Zero Voltage Switching (ZVS) or when the current through the switching element is zero, known as Zero Current Switching (ZCS). ZVS and ZCS are produced by using

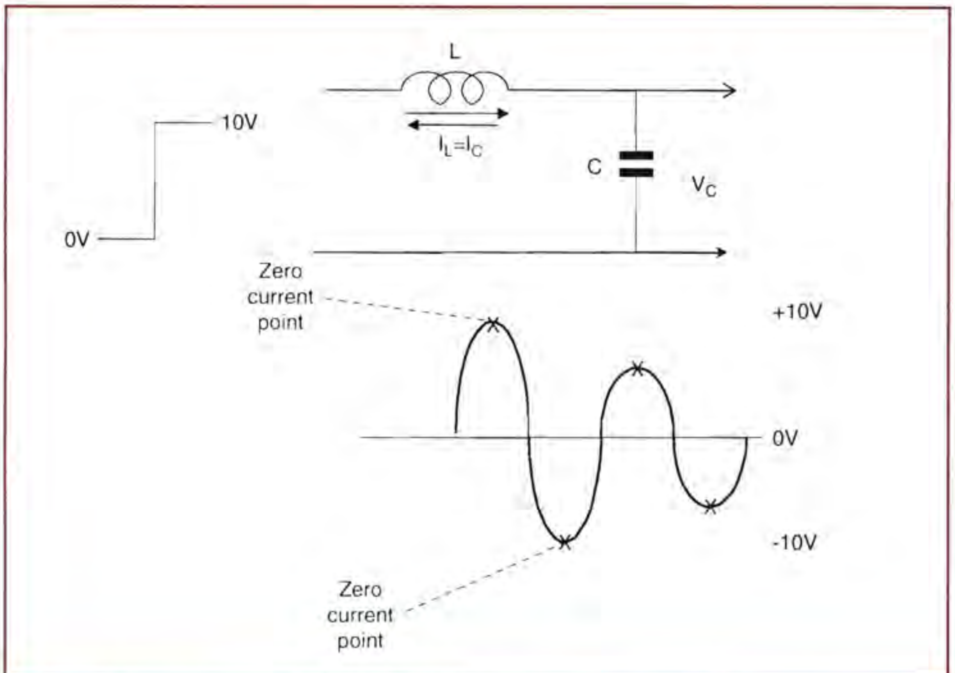


Figure 6: *Zero-current and zero-voltage points on a resonant waveform*

resonant circuits; hence these converters are also known as resonant or quasi-resonant converters. The result is low switching power dissipation and reduced component stress. These, in turn, result in increased power efficiency, reduced size and weight, faster responses and reduced EMI problems.

The reduction in losses due to zero voltage or zero current switching makes it possible to utilise much higher switching frequencies in 100s kHz or even few MHz. And since the size and weight of the magnetic components (inductors and transformers) and capacitors are inversely proportional to the switching frequency, the higher the latter, the smaller the size and weight of the power supply improving its power density. A further advantage of soft-switching resonant converters due to their switching frequencies is they can utilise transformer and switching elements' leakage inductance and capacitance respectively as part of the resonant circuit.

PRINCIPLE OF OPERATION OF RESONANT CONVERTERS

When a resonant circuit is fed with a +10V step voltage it oscillates, resulting in what is known as ringing. The capacitor charges up to 10V, at which point current ceases and the capacitor begins to discharge, causing current to flow in the opposite direction transferring energy from the capacitor to the inductor. The current continues to flow in that direction until the capacitor is fully charged to –10V, at which point current ceases and swings back in the opposite direction and so on, as illustrated in **Figure 6**.

As can be seen, the resonant waveform has zero current when the voltage is at a peak and zero voltage when it crosses the 0V line. Resonant converters use this fact to ensure that switching takes place at one of these points.

Steady state analysis of a basic ZCS resonant converter is shown in **Figures 7** and **8**.

In the steady state, load current I_{L2} is constant. The cycle starts when the MOSFET Q1 is turned ON by a control pulse while D1 is also ON. With capacitor C1 short-circuited by D1, I_{L1} flows through inductor L_1 and the diode D1. I_{L1} increases in a linear fashion and energy is stored in the inductor. When $I_{L1} = I_{L2}$, diode current drops to zero and the diode turns OFF naturally (ZCS).

With D1 open circuit, L_1 and C1 form a resonant circuit. I_{L1} increases to a peak in a sinusoidal manner and energy is transferred to the capacitor as I_{C1} charges capacitor C1. Once I_{L1} reaches its peak (at which point the voltage across C1 is equal to the input voltage V_{IN}), it begins to drop and when $I_{L1} = I_{L2}$, C1 is fully charges and I_{C1} drops to zero.

When I_{L1} drops further below I_{L2}, I_{C1} is reversed and the capacitor begins to discharge transferring energy to inductor L2. When I_{L1} drops to zero, MOSFET Q1 switches OFF naturally (ZCS), keeping I_{L1} at zero. The capacitor continues to discharge and when its voltage falls to zero and $I_{C1} = I_{L2}$, diode D1 switches ON naturally (ZCS) to short circuit C1 and break the resonant circuit. This state continues until Q1 is switched on by a control pulse to commence the next cycle, and so on.

As can be seen, the period Q1 remains ON is fixed by the resonant frequency of L1 and C1 while the time it is OFF is determined by the control pulse, which is varied as necessary to regulate the voltage. This type of resonant converter is known as 'fixed on-time, varied off-time'.

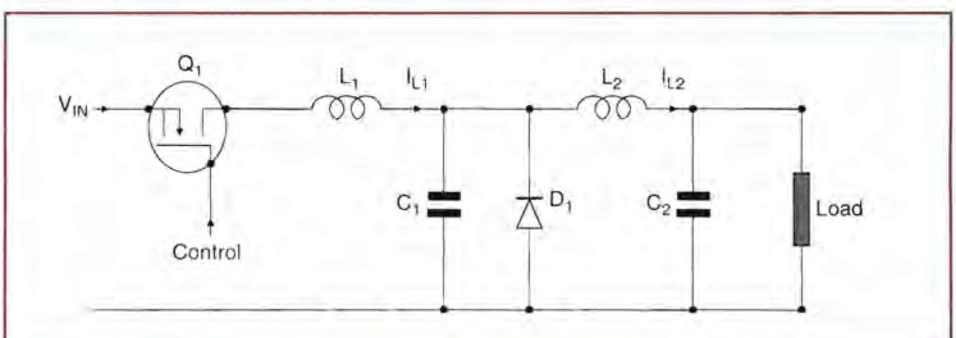


Figure 7: *Zero Current Switching (ZCS) resonant converter*

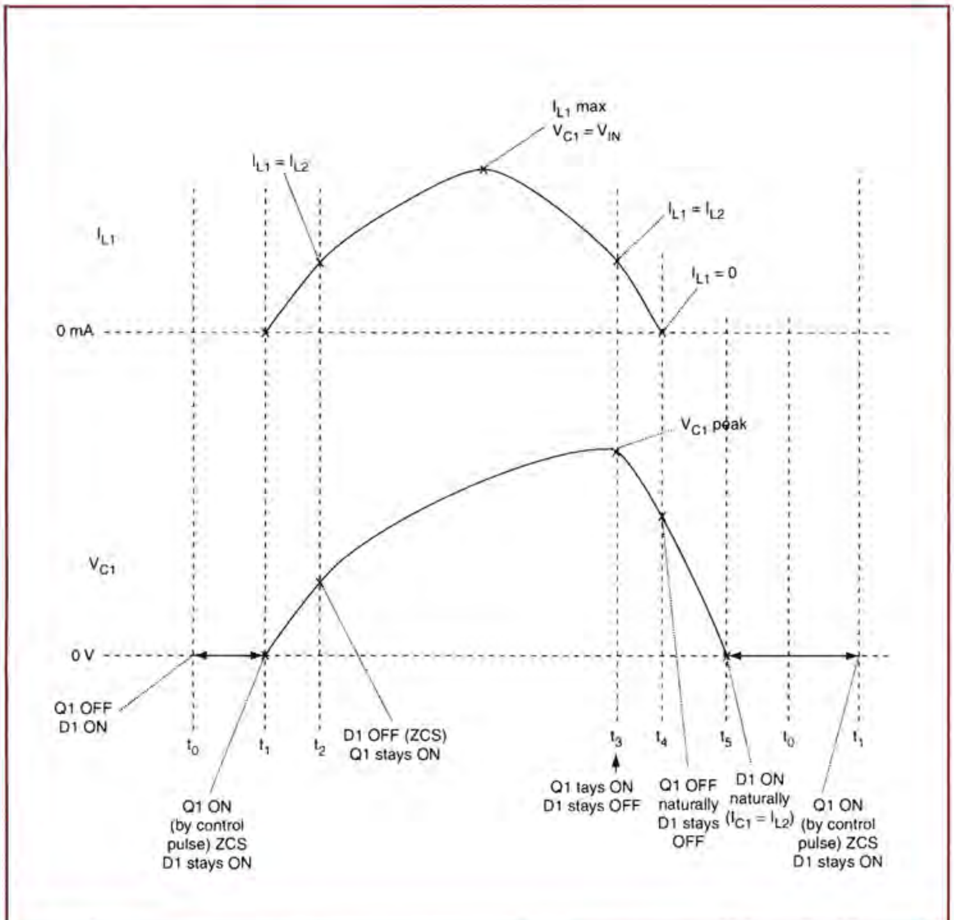


Figure 8: *Waveforms for Zero Current Switching (ZCS) resonant converter*

The ON period of the power MOSFET switch is the resonant period of L1/C1, known as the tank. For heavy loads, the resonant off-time is made shorter.

ZERO VOLTAGE SWITCHING

A resonant converter which uses Zero Voltage Switching (ZVS) is illustrated in **Figure 9** with L2/C2 forming a low-pass filter. In the steady state condition, load current I_0 is equal to the current through L2. Starting with the MOSFET on, its current I_T and I_{L1} are equal to I_{L2} and diode D_2 is reverse biased. The voltage across the MOSFET is zero.

When the transistor is turned off by a control pulse to its gate, current is diverted into C_1. Capacitor C_1 charges up until, when fully charged, diode D_2 becomes forward biased and conducts and C_1 and L_1 begin to oscillate going up to a peak after which, the voltage across C_1 attempts to reverse and diode D_1 starts conducting. During this time, the MOSFET is triggered to conduct, but remains off while D_1 is on. As soon as D_1 turns off when I_{L1} drops to zero and begins to reverse, the transistor turns on (ZVS) and remains on until it is turned off by a pulse and so on. The MOSFET turns off naturally and is turned on by a pulse, i.e. 'fixed off-time, varied on-time'.

In a circuit diagram for a resonant converter used to supply the sustain voltage for a 42-inch plasma panel, two pairs of back-to-back power MOSFETs Q12/Q15 and Q13/Q14 are used as the switching transistors driven by Q10 and Q11. They are fed with 400VDC from a flyback converter. Two anti-phase PMW control pulses arrive from the control panel to Q2 and Q3 to control the switching of each pair. The output for the sustain and the scan electrodes of the plasma panel are provided full-wave rectifiers connected to the secondary of the output transformer. Feedback to the control panel is obtained via Q6 and Q7. Although power MOSFETs have been used almost universally, current-driven Insulated Gate Bipolar Transistors, IGBT may also be used. ■

In the first article of this series, entitled "In Light We Believe" published in the July issue, on page 25, fraction '1/2n-1' should read '1/2ⁿ-1' and '28 = 256' should be '2⁸ = 256'

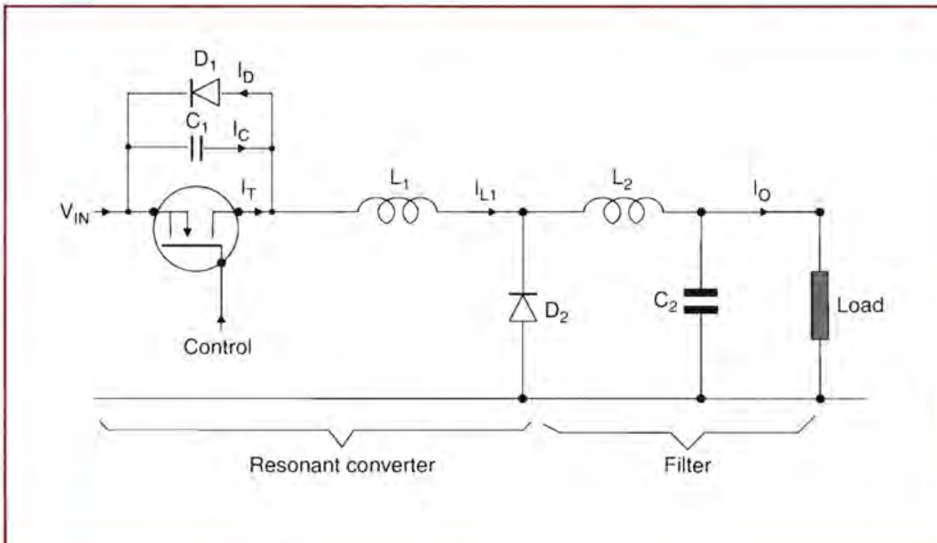
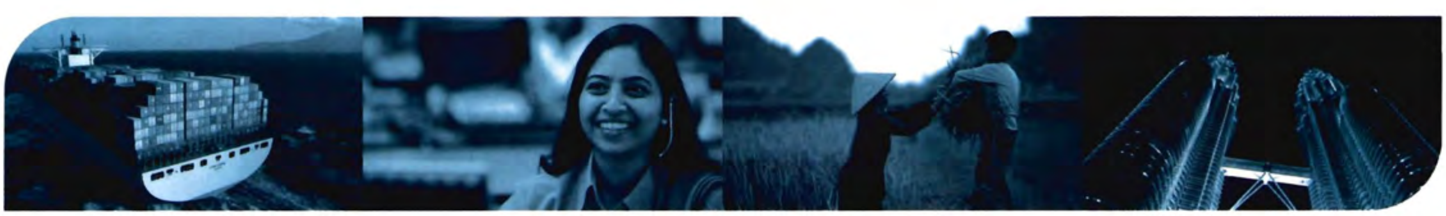


Figure 9: *Zero Voltage Switching (ZVS) resonant converter*



HEIKKI TIMONEN, PRODUCT MANAGER AT VTI TECHNOLOGIES IN FINLAND, EXPLAINS THE KEY PRINCIPLES SELECTED BY THE COMPANY TO PREPARE ONE OF THE MOST ADVANCED MEMS PRESSURE DEVICES TODAY

MEMS PRESSURE SENSORS

MEMS sensors are becoming increasingly important in fitness applications

There are basically two measuring principles used in MEMS pressure sensors: piezoresistive and capacitive. Piezoresistive sensors (where pressure changes the value of typically four resistors connected into a bridge) suffer from high temperature sensitivity, high sensitivity to mechanical stress, large noise, drift over time, very limited over-range capability and high current consumption.

Due to this VTI Technologies has selected the capacitive measuring principle, where pressure changes the distance between the electrodes in a capacitor. With VTI's technology, a robust, very small sized, high resolution and high accuracy, ultra low power sensing elements can be produced, which are relatively easy to package and assemble.

3D MEMS TECHNOLOGY

3D MEMS, used in both accelerometers and pressure sensors, are an optimised combination of technologies to achieve best performance at smallest size and lowest power. The technologies include wet and dry etching, capping with wafer bonding and glass insulation, electrode feed through structures and contacting for wire bonding and soldering.

Unlike some other MEMS (Micro Electro Mechanical System) technologies the company has real 3-dimensional structures, not just thin films on top of a silicon wafer. This gives flexibility in optimising electrode insulation, stress minimisation and capacitance dynamics for performance.

The relative capacitive change over the measuring range is typically 30-50%. This makes it relatively easy to measure and enables high signal-to-noise ratio and accuracy, even at low current levels, unlike piezoresistive sensors of the main competing pressure and acceleration sensor technology.

The glass insulation in use is relatively thick and gives high isolation resistance (low leakage current) and low stray capacitance. The two silicon wafers are anodically bonded together resulting in a hermetically sealed structure, where no chemicals or particles can intrude into the space between the capacitive electrodes.

The mechanical material in use is single crystal silicon giving hysteresis-free operation (no plastic deformation) and excellent over-range and shock performance. These are important features and advantages over the surface micromachined sensors.

The principles of operation of both capacitive acceleration and pressure sensors are shown in **Figures 1** and **2**.

The capacitive sensing of acceleration is a direct measurement of proof mass deflection. It is based on the large variation of gap between two planar surfaces. The capacitance or charge storage capacity of a pair of plates depends on gap width (d) and plate area (A): $C = e_0A/d$. Due to microns size gap the stored charge is relatively high and acceleration can be measured with high accuracy.

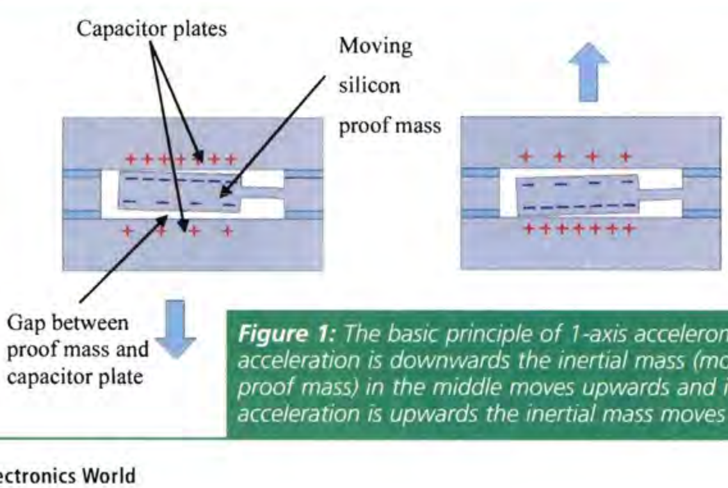


***Figure 1:** The basic principle of 1-axis accelerometer. If acceleration is downwards the inertial mass (moving silicon proof mass) in the middle moves upwards and if the acceleration is upwards the inertial mass moves downwards*

The outer pressure relative to the reference pressure inside the cavity between the silicon wafers causes a force on the membrane of the top wafer, bending it towards the bottom electrode (Figure 2). The elastic membrane acts as a force gauge. The displacement of the membrane is detected as a change in the value of the capacitor (C) between the membrane and the counter electrode. The capacitance can be modelled as a function of pressure with the following equation:

$$C_{model}(p) = C_{00} + \frac{C_0}{1-\frac{C_0}{k}p} + \frac{aC_0}{1-\frac{C_0}{bk}p}$$

where the function 1/C(p) is a fairly linear measure of the force acting on the membrane and it can be linearised with a simple polynomial functions to fulfill the required linearity demands.

The calibration complexity on the other hand depends on the linearity requirement and resources for calibration and computation. In other words, VTI's capacitive pressure elements can be used in many applications from lower accuracy applications with simple calculation to very high accuracy applications, where higher polynomial functions are utilised in calculations.

Electrical schematics of VTI's pressure sensor are shown in **Figure 3**. In the measuring range and in its proximity the element functions according to normal pressure sensing model and output can be calculated as presented before. When the input pressure exceeds the normal mode, the output behaves according to overpressure sensing element model. In the element this means that the diagram touches the capacitor plate and the output is no longer a function of pressure. After the pressure comes back to the measuring range it again works according to the normal pressure sensing model with as good a performance as before. As stated before, the element can withstand pressures 10 times the full-scale without degraded performance.

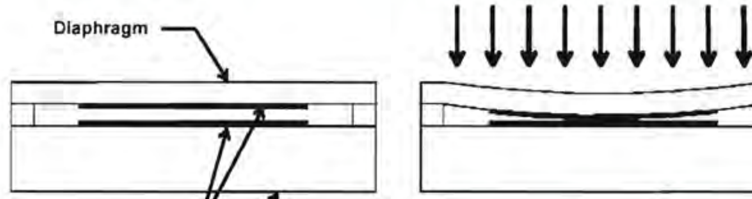


***Figure 2:** The basic principle of VTI's pressure element. The pressure bends the diaphragm and changes the capacitance between the diaphragm and the capacitor plate*

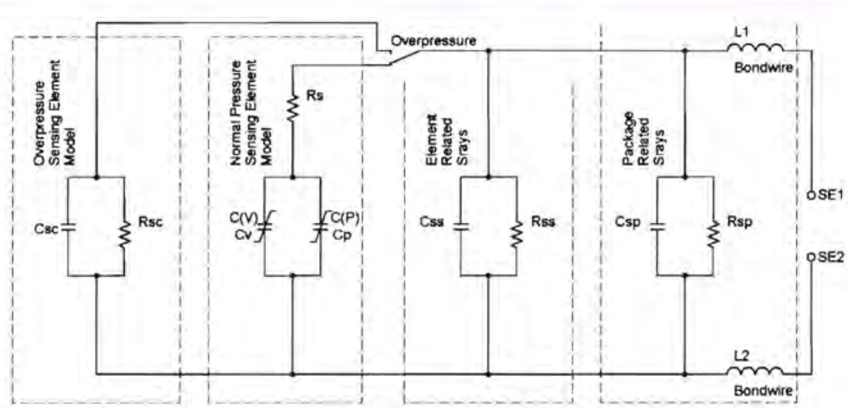


***Figure 3:** The electrical schematics of VTI's pressure sensor*

THE PRESSURE SENSOR AS ALTIMETER

The altitude measurement based on pressure is a relative measurement, i.e. based on a comparison of pressures at different places. This can be done with one pressure sensor, in which case it is sensitive to barometric pressure changes. Where accurate altitude information is needed over longer times, barometric reference pressure is often used.

Assuming a constant temperature gradient of dT/dH in accordance with the 1976 US Standard Atmosphere one gets for the altitude H as a function of pressure P:

***Figure 4:** VTI's low power pressure sensor component SCP1000 (φ = 6.1mm, h = 1.7mm)*

Standard			Model @ 4200m		Model @ g = 9.83217m/s² North Pole		Model @ g = 9.78039m/s² Equator		3rd order polynom P0 @ 0m		6th order polynom P0 @ 0m	
Pressure [Pa]	Altitude [m]	Temp. [°C]	Altitude [m]	Error [m]	Altitude [m]	Error [m]	Altitude [m]	Error [m]	Altitude [m]	Error [m]	Altitude [m]	Error [m]
101325	0	15	0	0,00	0	0	0	0	0	0	0	0
91193	880	9	880	0,00	878	2	882	-2	880	0	880	0
82073	1742	4	1742	0,00	1738	4	1747	-5	1740	-2	1742	0
73866	2587	-2	2587	0,00	2581	7	2594	-7	2578	-10	2587	0
66479	3416	-7	3416	0,00	3407	9	3425	-9	3388	-28	3415	-1
59831	4228	-12	4228	0,00	4217	10	4239	-11	4168	-60	4226	-2
53848	5024	-18	5024	0,00	5012	12	5036	-13	4914	-110	5018	-6
48463	5804	-23	5804	0,00	5790	14	5818	-15	5622	-182	5790	-14
43617	6569	-28	6569	0,00	6553	16	6585	-16	6292	-277	6540	-28
39255	7318	-33	7318	0,00	7301	17	7336	-18	6922	-396	7267	-51
35330	8053	-37	8053	0,00	8034	19	8072	-20	7511	-541	7969	-84
31797	8773	-42	8773	0,00	8752	20	8794	-21	8061	-711	8642	-131

***Table 1:** Models and altitude errors*

Figure 5: VTI's acceleration sensing element structure

$$H = T_0/(-dT/dH) * [1 - (P/P_0)^{(-dT/dH)*R/g}] \quad (1)$$

Inserting $dT/dH = -6.5°C/km$, $T_0 = 288.15K$ (+15°C), $P_0 = 101325Pa$, $g = 9.82m/s^2$ and $R = 287.052m^2/s^2/K$ one gets:

$$H = 44.33km * [1 - (P/101325Pa)^{0.19}] \quad (2)$$

This basic formula (1) still applies in cases where the temperature T_0 or/and reference pressure P_0 differ from those of the standard. This means that the relative change in pressure ($\Delta P/P_0 = (P - P_0)/P_0$) and the actual temperature determine the change in altitude regardless of altitude (Table 1: Model @ 4200m). The variation of the g value at different altitudes causes a maximum error of about 30m from sea level to 9000m. This error can be minimised to about 20m by selecting $g = 9.80665m/s^2$ (**Table 1**: Model @ g = #). **Equation 1** can be approximated with a Taylorian polynom of selected order of $\Delta P/P_0$ (Table 1: nth order polynom).

A slight modification of the coefficients in the polynom would probably improve the result. In most cases altitude changes to be measured are relatively small and the errors of the polynom approximation negligible.

Table 1 presents an altitude error calculation for altitude caused errors and polynom approximations. ■

PRESSURE SENSOR CONCEPT

VTI has introduced a low-power absolute pressure sensor concept mainly intended for battery operated handheld devices. Measuring ranges extend from barometric (120kPa) to 25 bar (2500kPa).

The output is digital over SPI (Serial Peripheral Interface) or I2C (Inter-Integrated Circuit) bus. The SMD (Surface Mount Device) component SCP1000 is as such intended for non-corrosive environments, but being only 6.1mm in diameter and 1.7mm in height (**Figure 4**) is easy to protect from aggressive media.

The sensor component has a circular vertical wall for O-ring sealing, a feature important in a humid environment and when measuring in liquids like water. The component includes the capacitive sensing element, a dedicated low power CMOS interface ASIC with on-chip calibration memory and an MID (Molded Interconnect Device) LCP (Liquid Crystal Plastic) package.

SCP1000 has different measurement modes for optimum performance in different applications, for different resolution, speed and power consumption requirements. All modes operate with at least 2.4-3.3V power supply. In the high-resolution mode the barometric sensor has a resolution of better than 2Pa, corresponding to about 16cm in an altimeter application at sea level. This resolution can be achieved with a twice-per-second update rate and at less than 30µA power consumption in continuous operation. In the high-speed mode the resolution is about four times worse and the speed four times higher.

To save power there are two options. One of them is to use the low power mode, where after each measurement the sensor goes into stand-by and typically consumes 3-4µA. In this mode the sensor stays ready for the next measurement command over its digital SPI (I2C) interface. Switching off power between measurements can even save more power. Hereby the wake-up time being around 10ms is important.

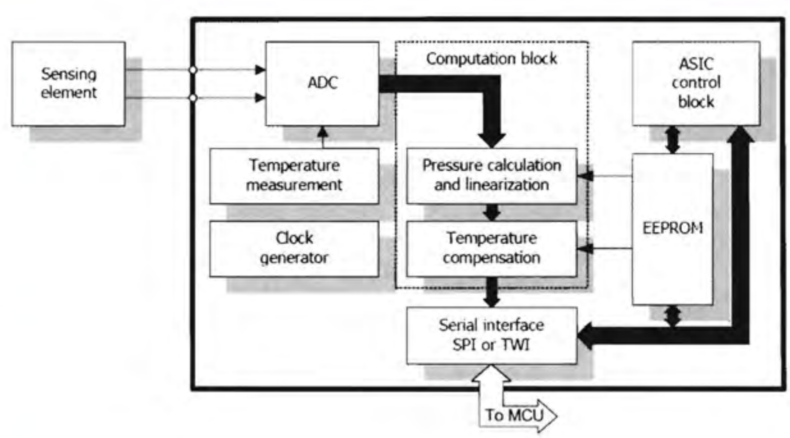


Figure 6: Block diagram of the SCP1000 pressure sensor

The SCP1000 includes a temperature sensor with typically a resolution of 0.1°C and an accuracy of about ±1°C.

The main intended application areas for the SCP1000 product family are wellbeing, sports and outdoor applications. SCP1000 products are particularly intriguing in handheld devices such as sports and outdoor watches, diving computers, where a combination of small and cost effective designs, low power and reasonable resolution and accuracy are important.

In navigation, the SCP1000 as altimeter serves as a perfect compliment to the GPS (Global Positioning System) signal.

The high resolution mode of SCP1000 gives the possibility for the first time to accurately measure cumulated rise, which is an important parameter for calculating training effect and energy consumption in heart rate monitors, sports watches and wrist top computers. This can be done with a rate of 2 times per second, a resolution better than 0.2m (2Pa) and a continuous power consumption of 20-30μA.

The sub-meter altimeter resolution and 1m accuracy level under normal conditions enable in sports and fitness a precise calculation of the accumulated risen height and through that energy consumption and training effect.

When increasing the update interval to 2 seconds, one can reduce the current consumption to below 10μA. SCP1000 has a typical temperature dependence smaller than 1.5m and linearity better than 0.1m, when going from sea level to 3000m. This is much better than fluctuations caused by local temperature gradients.

HAL PHILIPP, CEO OF QUANTUM RESEARCH GROUP LTD, LOOKS AT THE EVOLUTION OF CONTROL PANEL TECHNOLOGIES AND STATES THAT CHARGE-TRANSFER SENSING HOLDS THE KEY TO FUTURE LOW-COST, ROBUST USER INTERFACES FOR CONSUMER PRODUCTS

TRENDS IN KEYBOARD, KEYPAD AND CONTROL PANEL TECHNOLOGIES

Wherever one or more switching actions are required at a man-machine interface (MMI) the system designer is faced with a bewildering choice of technologies with which to accomplish the task. In many applications, particularly those in cost-sensitive consumer products, flat (or nearly flat) switches and keypads/keyboards have replaced conventional mechanical switches.

The technologies employed include resistive membrane switch panels, piezoelectric switch panels and touch panels based on capacitive sensing. This article briefly discusses the typical construction, advantages and drawbacks of each type and goes on to look at a relatively new and emerging technology, charge-transfer sensing, that promises to overcome many of the problems associated with other technologies – and at a cost that is attractive enough for high-volume consumer applications.

MEMBRANE SWITCHES

At their simplest – and cheapest – resistive membrane switches consist of a top flexible layer, an insulating spacer and a lower substrate layer. The top layer has graphics on the upper surface, and a conductive pattern, usually of silver or carbon conductive ink, on the lower surface. The lower substrate carries a matching conductive pattern. When you press the conductive layers together through holes in the spacer you create the contact action. The whole assembly is glued together. When users need tactile feedback, metal or plastic domes placed beneath the overlay can be used to provide a 'click' feel to the switching action and various types of embossing can be used to guide users' fingers to the 'sweet spot' of each switch.

However, even though cheaper than mechanical switches, being capable of being tightly sealed and being versatile in the graphic design options that can be used for the top of the overlay, membrane switches suffer from a number of disadvantages. Firstly, they normally require significant physical force to make each contact. For a simple flat-panel membrane this is typically between 0.5N (Newton) and 3N and for a tactile type between 1.5N and 5N is commonplace. Then, there is the degree of physical travel required to make a contact – 0.1 to 0.5mm for a flat panel keypad or 0.5 to 1.2mm for a tactile type. This combination of factors limits the rigidity and thickness of overlays that can be used. It also limits the speed at which a keypad can be operated and the ease with which users can cause a switching action to take place.

Furthermore, the feel of the keys which are most frequently depressed changes with time as they wear due to mechanical movement. This results in variations in the degree and angle of force needed to achieve reliable contact across the various keys.

PIEZOELECTRIC SWITCHES

Piezoelectric switches offer some advantages over their resistive counterparts. Piezoelectricity is a property of certain classes of crystalline materials, including natural crystals of quartz, Rochelle salt, tourmaline and manufactured ceramics such as Barium Titanate and Lead Zirconate Titanates (PZT). When mechanical pressure is applied to one of these materials, the crystalline structure produces a voltage and electrical charge proportional to the pressure. Conversely, when an electric field is applied, the structure changes shape producing dimensional changes in the material.

Negligible physical movement is needed, typically somewhere between 1μm and 10μm, to produce a usable switching voltage or charge. In fact, it is simply applied force, rather than any physical movement that generates an output from the switch element. The switching element uses a piezoelectric 'pill'. The overlay – the part that the user sees – is printed, stamped or embossed with the required information. A punched insulating layer, into which the piezoelectric pills are inserted, is then sandwiched between two layers of conductive foil that constitute the switch contacts. A carrier plate supports the whole assembly. See **Figure 1**.

Fast control keyboards need to be able to operate with an applied force of less than 1N. Industrial switches will typically be subjected to a force of between 3N

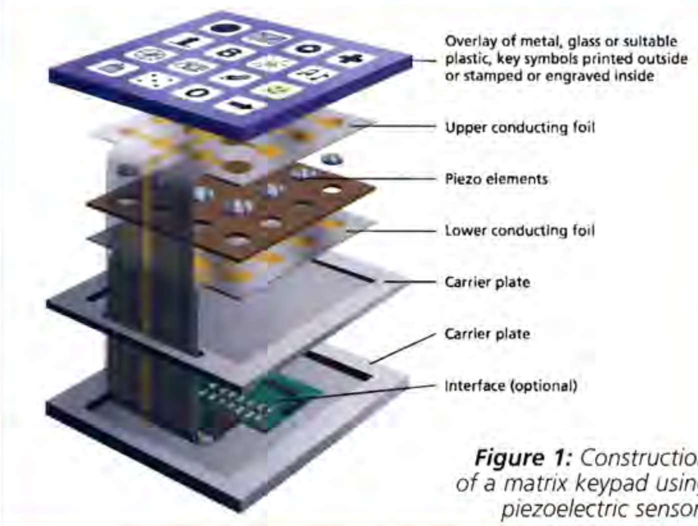


Figure 1: *Construction of a matrix keypad using piezoelectric sensors*

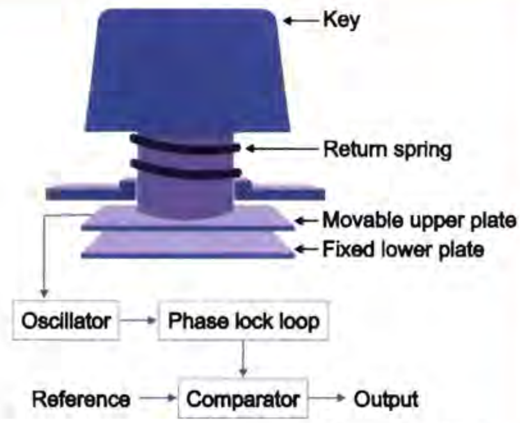


Figure 2: *Key switch using capacitive sensing and a mechanical action*

and 5N. The pills used in piezoelectric keyboards are typical around 200 microns thick and generate about 1VDC with an applied force of 1N. Within the last few years piezoelectric inks have replaced the pills in some designs, primarily to reduce assembly costs, but at the expense of an increase in applied pressure needed to produce sufficient voltage so that a switching action can be detected.

The voltage output from a piezoelectric element increases with pressure in a linear fashion. The exact output voltage is dependent upon ambient temperature, operating force and speed, and both the thickness and the type of material used for the overlay. This host of variables requires relatively complex electronics to take account of wide variations in both physical operation and environmental conditions under which the switches may be required to function. The complex construction is expensive when compared with other keyboard technologies but piezoelectric switches do offer a distinct advantage where a metal overlay is preferred for either aesthetic or security reasons.

CAPACITIVE SENSORS

Capacitive buttons and keys come in two basic types: those that use a mechanical key to activate them, as shown in **Figure 2**, and those that rely on proximity or touch. Key-operated switches are of relatively complex construction, involve mechanical movement and present challenges in making them mechanically robust. Despite this, they are commonly used in PC keyboards. The upper plate consists of plastic membrane onto which a conductive film has been printed to create the upper electrodes. The lower plate is a printed circuit board with conductive tracks that form the lower electrodes of the capacitive elements.

Touch, or proximity keypads, eliminate mechanical movement and rely instead on the operator's finger to affect the charge level on an electrode or capacitor. The sense electrode can be placed behind any insulating layer, typically glass or plastic, and it's very easy to achieve an environmentally sealed touch pad. The adoption of this apparently attractive technology has, however, been plagued by a number of technical challenges.

Firstly, touch sensing involves measuring or detecting changes in capacitance or charge levels. The degree of change that indicates a touch has taken place has to be programmed into a microcontroller. In other words, the system has to be calibrated. The problem is that changes in charge levels can occur due to a variety of external influences. Electrostatic discharge and electromagnetic interference can cause false triggering, and temperature changes affect calibration. Moisture, or a build-up of other contaminants on the surface of the keypad, is detrimental to accurate, repeatable operation.

Finally, it is very difficult to produce keypads with keys of differing shapes and sizes. This is often desirable when electronic equipment makers seek to make their products more aesthetically attractive as a source of marketing advantage. Overcoming these issues through a variety of mechanical and electronic compensation techniques makes the cost of traditional capacitive sensing prohibitive in many applications, particularly in cost-sensitive consumer appliances. An emerging technology, charge-transfer sensing, promises to overcome the technical challenges described above and at a cost that will make it attractive to companies producing high-volume products.

CHARGE TRANSFER SENSING

Charge-transfer sensing, also referred to as switched-capacitance or QT ('Q' for charge, 'T' for transfer) sensing, is a technique based on an elementary principle of physics, the conservation of charge. The QT sensor is essentially a microcontroller that is programmed to charge a sense plate of unknown capacitance to a known potential.

The sense plate can be anything conductive, from a printed circuit board pad to an area of optically-clear indium tin oxide (ITO) laid underneath or on top of a display screen. The resulting charge is then transferred into a measurement circuit. By measuring the charge after one or more charge-and-transfer cycles, the capacitance of the sense plate can be determined. The charge-transfer-acquisition process is carried out in burst

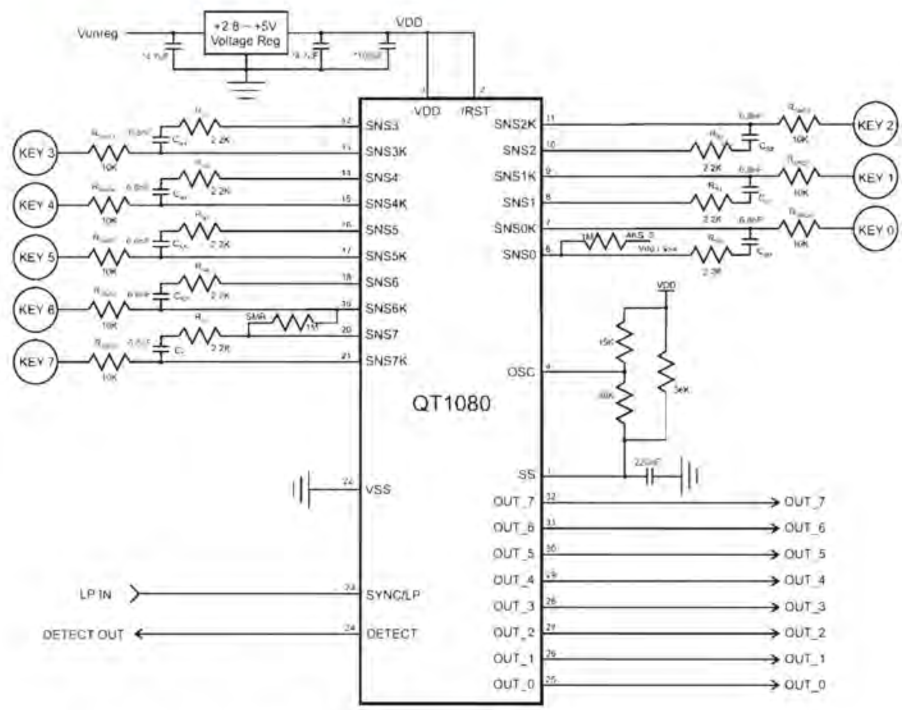


Figure 3: *Example application of a matrix keyboard using charge-transfer sensing*

mode using microcontroller-driven switching of MOSFET transistors. The presence of external capacitance caused by an object such as a finger affects the flow of charge to permit sensing.

Through the use of intelligent signal processing the decision logic is made very reliable. For example, voting filters that require a number of successful samples to be detected before a touch is registered are used. This eliminates false triggering due to electrostatic spikes or momentary unintentional touch or proximity.

Another feature, adjacent key suppression (AKS), uses an iterative technique that repeatedly measures a detected signal strength associated with each key, compares all the measured signal strengths from other keys to find a maximum signal change, then determines that the maximum signal change comes from the user-selected key. AKS then suppresses or ignores signals from all other keys, as long as the signal from the selected key signal change remains above a nominal threshold value. This prevents false triggering of adjacent keys, a particularly valuable feature in small control panels such as those found on handheld remote controls.

QT sensing ICs are available for use single or multiple keys, matrix keyboards, touch sliders, touch wheels (like the iPod), touch screens and combinations of these. Where multiple keys are used each key can be set for an individual sensitivity level. This facilitates keys of different sizes and shapes being used to meet both functional and aesthetic requirements. The physical design of electronic and electrical products is becoming increasingly important as a means of differentiation, particularly in consumer goods, and QT sensing techniques offer great flexibility in this respect.

Electromagnetic compatibility issues that plague traditional capacitive sensors have been overcome too. QT sensors use spread-spectrum modulation and sparse, randomised charging pulses with long delays between bursts. Individual pulses can be as short as 5% or less of the intra-burst pulse spacing. The benefits of this spread-spectrum approach include lower cross-sensor interference, reduced RF emissions and susceptibility, and low power consumption.

A further benefit of charge-transfer sensing is that QT devices are programmed with automatic drift compensation to account for slow changes due to ageing or changing environmental conditions. This again overcomes a common problem with traditional capacitive sensors.

QT technology has a dynamic range of several decades and, unlike traditional capacitive sensors, QT sensors do not require coils, oscillators, RF components, special cable, RC networks, or a lot of discrete parts. As an engineering solution it is simple, robust, elegant and affordable. A typical application circuit for a matrix keyboard is shown in **Figure 3**. As shown, the external component count is minimal.

CHARGE-TRANSFER SENSING APPLICATIONS

The existing and potential applications for charge-transfer sensing are growing daily. A few examples are shown in **Figure 4**. The technology is already widely used in domestic appliances such as cookers and food blenders. It is also found on the control panels of MP3 players, LCD monitors and personal computers. New applications are being developed in cellular phones, hand-held remote controls and pointing devices and new classes of touch screen. ■

Figure 4: *Charge-transfer sensing is now used in a wide variety of domestic appliances and personal electronic devices*

Figure 5: *Hal Philipp, CEO of Quantum Research Group with a new technology*

DONALD LYON, MANAGING DIRECTOR OF MONITRAN EXPLAINS THE NEEDS OF TWO INDUSTRIES FOR HIGHLY ACCURATE VIBRATIONS SENSORS

GOOD VIBRATIONS

Accelerometers (or vibration sensors) have for many years been used within scientific and research establishments to measure absolute acceleration values. This research was, and remains, an aid in the design of components, systems and engineering structures within, amongst other industries, automotive, aerospace and construction.

However, vibration monitoring is playing an increasingly important role in industries including water treatment, petrochemical and paper making. This role is largely to protect against the untimely failure of expensive plant machinery, unscheduled maintenance and plant shut-down.

For example, before vibration monitoring was employed, machinery (including motors, drives, gearboxes and pumps) in many industrial plants was either left to run until failure or it was replaced at regular intervals – irrespective of its use. In the former case, plants experiencing machinery failure were also running the risk of injury to personnel. In the latter case, in replacing equipment at set intervals companies were often removing and disposing of machinery unnecessarily.

Today though "predictive maintenance" is the buzz-phrase and accelerometers are playing a crucial role in detecting the vibrations and 'noise patterns' which are the earliest indicators that maintenance is required. Implementing vibration-based condition monitoring is now generally regarded as an essential part of any predictive maintenance routine.

TRANSDUCERS

There are essentially two types of accelerometer, namely piezoelectric and piezoresistive. Whilst other types do exist, these two equate for about 90% of the market.

The piezoelectric accelerometer is perhaps the most popular type for making vibration measurements. It is a robust device with no moving parts, as it consists of a crystal of piezoelectric material to which is attached a seismic mass (see **Figure 1**). When the crystal is stressed in tension or compression, it generates an electrical charge which is proportional to the acceleration level it is experiencing. Internal circuitry converts the charge into a voltage or current which is used for vibration analysis, machine control projection or projects. It offers long-term stability and reliability, it has wide frequency range (typically from less than 1Hz to more than 10kHz) and its signals can be integrated to produce velocity and displacement values.

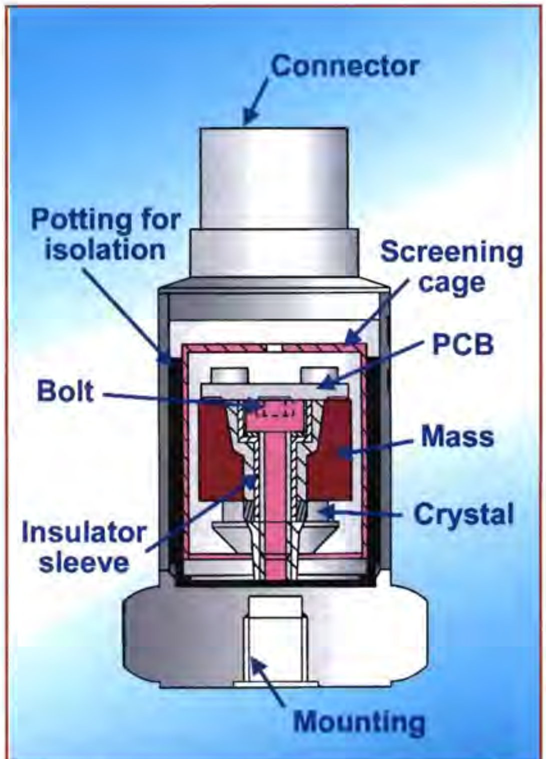


***Figure 1:** The mass (for a typical sensor) is bonded to a piezoelectric crystal which, when placed under tension or compression, generates an electric charge proportional to the acceleration of the mass*

Piezoresistive accelerometers on the other hand consist of a seismic mass that is attached to a cantilever beam. The beam is deflected when the transducer experiences g forces, and this movement is converted to an electrical signal by resistance changes in a semiconductor sensing element. Internal electronics provide amplification of the signal and temperature compensation. Its frequency range (which is typically from 0Hz to about 750Hz) is lower than that of a piezoelectric device, but this is an advantage if you wish to monitor static or DC acceleration levels.

Most accelerometer casings are made from stainless steel but other materials can be used, for example aluminium where weight-saving is important. They are typically sealed to IP65 but, increasingly, applications are calling for higher standards such as IP68 (for submersible use). Further, most accelerometers are welded during their construction so, if hunting around for sensors, it is worth checking that the manufacturer is certified to EN287/288.

As for electrical connection, most accelerometers are supplied with integral, screened cables, with cable entry either through the top or the side of the casing. However, sensors can also be supplied with connectors (for example BNC) on the body or, in some cases, just solder pins.

Installation of an accelerometer is achieved through one of three fixing methods: mechanical (i.e. some sensors have a threaded base), adhesive or magnetic.

The type of sensor, fixing method, electrical connection type, sensor casing material and sealing standard will typically all be driven by the application. However, a word of warning: incorrect selection of an accelerometer, or incorrect installation of a correct sensor, will most likely lead to unreliable performance and erroneous data.

Figure 2: *Underground engineers keep a keen eye on vibration levels*

If in doubt, contact the manufacturer to establish: a) their manufacturing standards and b) their experiences in your industry.

SHARED ACCESS

When installing any transducer it is important to consider the information (derived from the sensor's outputs) that needs to be presented and, possibly, stored. For process monitoring purposes, simple readings may suffice – with predefined alarm limits, if applicable. For maintenance purposes, data trending will certainly be required. And for fault-finding it may be necessary to view the raw data.

Accordingly, during installation it is important to consider the intended use of the data, by answering the traditional questions of Who, What, Where, When and Why. Within a factory for example, it is common-place to employ numerous accelerometers located around the site and have the data present in one location, for example a control room. However, it is often impractical to route all of the sensors' outputs into the control room.

For this reason signal conditioning is best performed on a group of sensors, as close to the sensors as is practicably possible and then communicate the readings over a data bus. Whilst sensible, until recently, the engineering difficulties and costs proved prohibitive, as it was often necessary to call in third parties. Now though, things are much easier.

The last few years have seen a number of low-cost solutions come to market. For example, Monitran's MultiSelect units can give manual access to up to 256 accelerometers and remote access to considerably more. A self-contained MultiSelect unit has a control panel and switching circuitry. It has inputs for up to 16 standard accelerometers, a control knob to select one of the 16 inputs, an industry standard 4-20mA output, an AC + bias output (available via the unit's connector pins and a BNC on the control panel), an RS-485 interface connection and a digital display.

Units like the self-contained MultiSelect can either poll the sensors to which they are connected or they can access a specific accelerometer. Units can be daisy-chained to create a network of sensors (here up to 256) and data can easily be presented in a single location. Further, via a PC and using the RS-485 bus (which is multi-drop) it is possible to create even larger networks. It is also possible to access the data from off-site, via the Internet.

GOING WITH THE FLOW

Accelerometers are fulfilling vital roles in enabling plant managers to implement predictive maintenance routines. One sector implementing such routines is the water treatment industry.

For example, Bedford Pumps, one of the UK's largest manufacturers of medium and large sewage and water pumps, at its end-users' requests is supplying many of its products with accelerometers already fitted. Some of the manufacturers' pumps have flow rates of up to 6,000 litres per second, although the company has experience of pumping at up to 21,000 litres per second.

When pumping clean water, vibration levels are unlikely to vary from one day to another. As such, reading the levels may not require the use of permanently fixed accelerometers, and weekly or even monthly site visits using hand-held equipment will probably suffice.

However, in an unscreened sewage pumping station, everything that flows down a sewer pipe will get pumped. In theory this is just sewage and waste water but in practice it can be anything from bits of wood to shopping trolleys. Consequently all pumps going into this environment must be sufficiently robust to withstand shock loading and even blockages.

Here, continuous vibration monitoring is a must. But there is a snag. The pumps are operating in particularly hazardous environments because methane and other potentially explosive gases are sometimes present. As such, any machinery operating in this environment has to be rated EExD (flameproof) and the risk of failure of equipment (causing fire) in this environment must be minimised. Accordingly, any vibration sensors used must be intrinsically safe (see box 'Protecting Pumps').

As for vibration levels, in Bedford Pumps's experience clean water pumps will vibrate at less than 3mm/s during normal operation. For sewage applications though, normal levels will fluctuate around this figure. If there is a blockage the levels will rise significantly – and they can be used to initiate a local shut-down and, if suitable communications are in place, flag the fact to a central control.

UNDERGROUND

Another application for accelerometers is in the coal mining industry, where the importance of vibration-based monitoring has been well understood for decades – and one of the UK's keenest advocates of the technology is UK COAL, Britain's biggest producer. The company has four ongoing deep mines located in Yorkshire and the Midlands. It employs about 3,300 people and supplies around 7% of the country's energy needs for electricity generation.

The depths of the company's mines vary from 800m to 1km and all have at least two shafts. Further, all operate 24/7 and, at any

IN 3D

Whilst traditional accelerometers measure displacement in one axis, a number of applications require measurement in three. For example, 3D measurements are often required in aerospace and automotive applications.

Until recently it was necessary to mount three accelerometers at 90 degrees to each other on a bracket. Now though, manufacturers like Monitran are producing tri-axial sensors.

The MTN/1310 weighs only 35g and incorporates three piezoelectric accelerometers mounted in the X, Y and Z planes, all within a hermetically sealed stainless steel enclosure.

Figure 3: *The MTN/1310 incorporates three piezoelectric accelerometers in one package*

one time, there will be up to 200 miners underground at each colliery. As you'd expect, there is much equipment underground for not only the transportation of men and minerals but also for the removal of water and the circulation of air. This equipment, along with lighting, gives rise to one of the industry's biggest threats to mine safety – fire, as a result of machinery failure igniting coal dust.

Some of the work faces in UK COAL's mines are up to 10km away from the shafts and extensive conveyor belt systems are employed to transport minerals. These systems are driven by electric motors which, even under normal operating conditions, produce heat. They have typical power ratings of between 500 and 750kW and all produce heat as a consequence of their operation.

However, if conveyor drive motors develop misalignment faults (offset or angular) then they will produce additional heat. Heat is also produced by the conveyors' roller bearings, as the balls and runners wear and excessive wear can easily result from overloading the system or as a result of inadequate servicing.

Whilst monitoring the temperature of the conveyors' motors and bearings is a common practice in mines, it does not always provide the earliest indication of wear and tear. However, vibration levels can not only provide the earliest indication of wear and misalignment issues, but they can also indicate the nature and location of faults. This is because each type of machine part (such as a motor or bearing) produces a specific vibration pattern, the frequency and amplitude of which is determined by the machine's geometry, load and operating speed.

Interestingly, a single vibration measurement provides information about multiple components. For example, four different frequencies are present in the vibration profile of a roller bearing, namely: ball spin frequency, fundamental train frequency, ball pass frequency (inner race) and ball pass frequency (outer race). This is therefore a great aid to in-situ diagnostics, as the nature of a specific fault can be determined with the component in place and without disrupting its operation.

In UK COAL's case, its maintenance strategy includes a strict policy of measuring the vibration levels of all major conveyor drums at regular intervals. The data is collected using handheld instruments and then downloaded to a PC (one per colliery) for a low-level analysis, which provides an early indication of motor and bearing health. Whilst 'low-level' the analysis of the data is sufficient to determine:

- Are vibration levels as per expected?
- If there's a deviation from expected is any immediate action required?
- Should the next scheduled service be brought forward?
- Should an additional inspection be conducted in the near future?

PREDICTIVE ROUTINES

The use of permanently installed vibration sensors is enabling the implementation of predictive maintenance routines in an ever-growing range of industry sectors. This provides users with an extremely cost-effective method of reducing or even eliminating unscheduled and costly down-time.

In addition, industry is experiencing the added benefits of the improved safety that early warning of possible machine failure is able to afford. The result is that for all sorts of reasons, both social and economic, a well-planned programme of vibration monitoring has become an almost essential ingredient of predictive maintenance in a wide range of industries. ■

PROTECTING PUMPS

The Bedford Pumps's DV.90.23.10 Volute pump was installed by Bedford Pumps in November 2006 at Thames Water's Datchet Pumping Station, near Windsor. Driven by a 6.6kV variable speed 730kW (6.6kV) motor, this pump has a rated flow of between 50 and 225 million litres per day, and the assembly is fitted with four accelerometers and seven temperature sensors – all feeding into a Monitran MTN/6000 monitoring unit.

Figure 4: *Bedford Pumps DV.90.23.10 Volute pump*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• Supply: 3.1 - 15V @ 34mA
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MIND YOUR BACKS – THE FUTURE MAY BE BIGGER THAN YOU THINK

By Chris Williams, UKDL

I am writing this column sat in the Virgin Atlantic lounge at San Francisco airport, writing on my Apple 17" laptop with its glass-based LCD 'direct view' screen, where the picture I see is just slightly smaller than the actual size of the glass display itself. This is not a lightweight laptop, but it works superbly well and meets my needs. However, my use of such a system may be in doubt for the future, if the industrial speakers who gave talks at the Projection Summit conference in Anaheim are to be believed.

The future, they predict, lies in Personal Projectors. These little devices will be built into just about every form of mobile phone, PDA, computer and other consumer appliance, and will project the image to be displayed onto any convenient surface that can be used as a screen. So, if a personal projector is built into my mobile phone, I can browse the web, read e-mails and write future versions of this column by using the built-in projector element to create a screen size as large as I need to do the job. There'll be no glass display needed or a flexible paper display, just my pocket-sized phone and a suitable surface to use as a screen.

Sounds good? Maybe, but I forecast that the problems of using this device will be much greater than any of the inventors working in this area are willing to acknowledge. Since I have plenty of time on my hands (my plane is delayed by at least 2.5 hours) I can do an imaginary case study on the use of such a 'personal projector' built into a mobile phone.

1. Any projector needs a suitable screen surface on to which the image can be projected. The technology that goes into any commercially available screen to make it suitable for use with front or rear projectors can vary from very little (just paint a wall white and project onto it) to very much (screens with positive gain to accentuate projected light and attenuate ambient light). If a projector projects its image onto an unsuitable screen, the image quality (readability, brightness, colour rendition and resolution) can be seriously degraded. Here is a simple test for anyone who has access to a projector at home – next time you have it set up to project the image onto the projection screen, just swing the projector around and see how the image quality dives down when you project on to wallpaper, the floor, curtains and so on. Try reading a text document with the image projected onto the curtains – you won't be able to do it. The real world has very few surfaces that are naturally suitable to have an image projected onto them without some form of surface treatment.

2. Every projector uses power when it creates the light to form an image. If the image is to be seen in bright ambient light (outside during the day) then the image has to be much brighter than it would need to be inside, at night. The efficiency of light sources for personal projectors is still way too low. As well as creating light, every big or small projection system creates heat, and within a small device such as a mobile phone it is likely to be impractical to dissipate the heat created, so the phone might easily get uncomfortably hot to handle. This is discussed more in the text box below.

3. Using power requires energy to be stored. This blindingly obvious statement is also a critical limitation to the likely market acceptance of personal projectors. Speakers at the conference suggested that a "mobile phone projector" capable of projecting 100 lumens to create an image of 24 inch diagonal or so within a darkened room would have a battery life of around 90 minutes. Come on guys! Everyone in the world wants mobile phones with

Plastic Logic flexible electronic display

PolymerVision's Readius

batteries that last longer and longer, and here you are saying that projecting an image would drain the battery in 90 minutes. Not good news for the consumer and unlikely to attract customers in droves. Plus, a 100 lumen projector cannot even be used in a bright office, let alone outside, so what happens to battery life if you did create, say, a 300 or 500 lumen projector?

4. Projection systems are not efficient. In a typical, well-engineered projection system, the projection optics only transfer 25% of the optical energy created at the bulb for projection onto the screen. The rest of the energy is 'lost' in the system. For a 100 lumen personal projector, it is possible that the light source itself might need to make up to four times this level to deliver the light to an external screen.

So, what is the bottom line? Projection systems offer a superb way of creating large images from relatively small equipment, but it seems most sensible that the world should concentrate on projection systems that are powered from mains electricity and not from small portable batteries. The component suppliers would love to see personal projectors take off as they would sell hundreds of millions of devices, but how do you even begin to address the simple problems outlined above?

I know I have grossly oversimplified the application of personal projectors in the information above, but the point I want to make is that just because we can do something does not necessarily mean that we should do something.

I FORECAST THAT THE PROBLEMS OF USING THIS DEVICE WILL BE MUCH GREATER THAN ANY OF THE INVENTORS WORKING IN THIS AREA ARE WILLING TO ACKNOWLEDGE

When a bandwagon starts rolling and receives considerable hype, it can be very difficult for companies to slow down or stop their involvement with it. All I am suggesting is that companies in this space run multiple reality checks to make sure they are not simply being carried away with their own enthusiasm and, perhaps, believing their own publicity departments information rather than their own proper systems analysis.

And what's my own prediction? Personal projectors built as head mounted systems have a good chance of success, but built into mobile phones... I really don't think so. The stunning appearance of flexible display devices such as the forthcoming PolymerVision "Readius" accessory for mobile phones and the Plastic Logic e-paper modules will, to my mind, eliminate much of the market opportunity that phone-based projectors are targeting.

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

A NEW MIXED-MODE OTA-C FILTER/OSCILLATOR CIRCUIT

Email your circuit ideas to:
svetlana.josifovska@stjohnpatrick.com

A new mixed-mode biquad circuit is presented here. The circuit uses eight Operational Transconductance Amplifiers (OTAs), two grounded capacitors and can realise inverting or non-inverting lowpass, highpass, bandpass, notch, lowpass notch, highpass notch and allpass responses from the same topology.

The circuit can be driven by voltage or current and its output can be voltage or current. In addition to the single-ended-input/single-ended-output voltage-mode realisations, the circuit can also realise differential-input/single-ended-output responses. The parameters ω_o and ω_o / Q_o enjoy independent electronic tunability.

The circuit can also realise a sinusoidal oscillator. The frequency and the condition of oscillation are electronically tunable and are totally uncoupled.

OTA AND GROUNDED CAPACITOR CIRCUITS

Because of their structural simplicity, electronic tunability, high frequency capability and monolithic integratability, active filters using OTAs and grounded capacitors, widely known as OTA-C filters, are attracting the attention of many researchers. While using multiple-output OTAs paves the way to realise current-mode filter functions, the use of single-output OTAs yields voltage-mode filter functions.

In analogue signal processing applications it may be desirable to have active filters with input currents and/or voltages and output currents and/or voltages; these are mixed-mode filters. Moreover, active filters with inverted and/or non-inverted outputs would be attractive. Careful inspection of available literature shows that while inverting/non-inverting voltage-mode realisations are available as well as mixed-mode realisations with input current and output voltage, no circuit realisation is available for realising a generalised inverting/non-inverting mixed mode active filter with input current or voltage and output current or voltage. It is the major intention of this paper to present such a generalised mixed mode circuit using OTAs.

PROPOSED CIRCUIT

The proposed circuit is shown in **Figure 1**. With switch S opened, routine analysis yields the transfer functions given by:

$$V_{out} = \frac{g_{m6}}{g_{m3} g_{m8}} \frac{N(s)}{D(s)} \tag{1}$$

and:

$$I_{out} = \frac{g_{m6}}{g_{m3}} \frac{N(s)}{D(s)} \tag{2}$$

where:

$$N(s) = s^2((g_{m3}V_{in3} - g_{m2}V_{in5}) + I_{in3}) + s(g_{m2}(g_{m5}V_{in6} - g_{m1}V_{in2}) - g_{m2}I_{in2})/C_2$$

$$+ \frac{g_{m1}g_{m2}g_{m7}}{C_1C_2}(V_{in1} - V_{in4}) + \frac{g_{m1}g_{m2}}{C_1C_2}I_{in1} \quad (3)$$

and:

$$D(s) = s^2 + s\frac{g_{m2}g_{m5}}{g_{m3}C_2} + \frac{g_{m1}g_{m2}g_{m4}}{g_{m3}C_1C_2} \quad (4)$$

Inspection of **Equations 3** and **4** shows that various inverted and non-inverted mixed-mode filter functions, with input voltage or current and output voltage or current, can be realised. For example:

1. With $I_{in1} = I_{in2} = I_{in3} = 0$, the following voltage-mode responses, with input voltages and output voltage, and mixed-mode responses, with input voltages and output current are obtained:
   a. an inverted highpass-filter (HPF) with $V_{in1} = V_{in2} = V_{in3} = V_{in4} = V_{in6} = 0$
   b. a non-inverted HPF with $V_{in1} = V_{in2} = V_{in4} = V_{in5} = V_{in6} = 0$
   c. a differential input/single-ended output HPF with $V_{in1} = V_{in2} = V_{in4} = V_{in6} = 0$
   d. an inverted lowpass-filter (LPF) with $V_{in1} = V_{in2} = V_{in3} = V_{in5} = V_{in6} = 0$
   e. a non-inverted LPF with $V_{in2} = V_{in3} = V_{in4} = V_{in5} = V_{in6} = 0$
   f. a differential input/single-ended output LPF with $V_{in2} = V_{in3} = V_{in5} = V_{in6} = 0$
   g. an inverted bandpass-filter (BPF) with $V_{in1} = V_{in3} = V_{in4} = V_{in5} = V_{in6} = 0$
   h. a non-inverted BPF with $V_{in1} = V_{in2} = V_{in3} = V_{in4} = V_{in5} = 0$
   i. a differential input/single-ended-output BPF with $V_{in1} = V_{in3} = V_{in4} = V_{in5} = 0$
   j. an inverted notch-filter (NF) with $V_{in4} = V_{in5}$ and $V_{in1} = V_{in2} = V_{in3} = V_{in6} = 0$
   k. a non-inverted NF with $V_{in1} = V_{in3}$ and $V_{in2} = V_{in4} = V_{in5} = V_{in6} = 0$
   l. a differential input/single-ended-output NF with $V_{in1} = V_{in3}$, $V_{in4} = V_{in5}$, and $V_{in2} = V_{in6} = 0$
   m. in cases j ,k and l, a lowpass-notch and a highpass-notch can be obtained by adjusting the transconductances g_{m4} and g_{m7}
   n. an inverted allpass-filter (APF) with $g_{m2} = g_{m3}$, $g_{m4} = g_{m7}$, $V_{in4} = V_{in5} = V_{in6}$ and $V_{in1} = V_{in2} = V_{in3} = 0$
   o. a non-inverted allpass-filter (APF) with $g_{m1} = g_{m5}$, $g_{m4} = g_{m7}$, $V_{in1} = V_{in2} = V_{in3}$ and $V_{in4} = V_{in5} = V_{in6} = 0$.
2. With $V_{in1} = V_{in2} = V_{in3} = V_{in4} = V_{in5} = V_{in6} = 0$, the following current-mode responses, with input currents and output current, and mixed-mode responses, with input currents and output voltage are obtained:
   a. a non-inverted HPF with $I_{in1} = I_{in2} = 0$

b. a non-inverting LPF with $I_{in2} = I_{in3} = 0$

c. an inverting BPF with $I_{in1} = I_{in3} = 0$

d. an NF with $I_{in2} = 0$ and $I_{in1} = I_{in3}$

e. In case d, a lowpass-notch and a highpass-notch can be obtained by adjusting the transconductances g_{m3} and g_{m4}

f. an APF with $I_{in1} = I_{in2} = I_{in3}$, and $g_{m3} = g_{m4} = g_{m5}$.

Inspection of Equation 4 shows that in all cases the parameters ω_o^2 and ω_o / Q_o are given by:

$$\omega_o^2 = \frac{g_{m1} g_{m2} g_{m4}}{g_{m3} C_1 C_2} \tag{5}$$

and:

$$\frac{\omega_o}{Q_o} = \frac{g_{m2} g_{m5}}{g_{m3} C_2} \tag{6}$$

Thus the parameter ω_o^2 can be controlled by adjusting the transconductances g_{m1} and/or g_{m4} without disturbing the parameters ω_o / Q_o, and the parameter ω_o / Q_o can be controlled by adjusting transconductance g_{m5} without disturbing the parameter ω_o^2.

Also, inspections of **Equations 1** and **2** show that the gain associated with any transfer function can be controlled without disturbing the parameters ω_o^2 and ω_o / Q_o by adjusting g_{m6} and/or g_{m8} for output voltage, or by adjusting the transconductance g_{m6} for output current. Thus, the proposed circuit enjoys the attractive feature of independent electronic tunability of the transfer gain and the parameters ω_o^2 and ω_o / Q_o.

Using **Equations 5** and **6** it is easy to show that all the passive sensitivities of the parameters ω_o and ω_o / Q_o are less than unity. Thus, the circuit parameters enjoy low passive sensitivities.

In addition to the realisation of the mixed-mode filter responses, the proposed circuit can realise a sinusoidal oscillator circuit. With switch S closed, all the input voltages and input currents set to zero, the characteristic equation of the resulting circuit is given by:

$$\frac{g_{m1} g_{m2} g_{m4}}{s^2 C_1 C_2} - \frac{g_{m2} g_{m6}}{s C_2} + \frac{g_{m2} g_{m5}}{s C_2} + g_{m3} = 0 \tag{7}$$

Equating the real and imaginary parts of **Equation 7** to zero, the frequency and condition of oscillation can be expressed as:

$$\omega_o^2 = \frac{g_{m1} g_{m2} g_{m4}}{g_{m3} C_1 C_2} \tag{8}$$

and:

$$g_{m5} = g_{m6} \tag{9}$$

Inspection of **Equations 8** and **9** shows that the frequency of oscillation ω_o can be adjusted by controlling the transconductances g_{m1}, g_{m2}, g_{m3} and g_{m4} without disturbing the condition of oscillation, and the condition of oscillation can be controlled by adjusting the transconductances g_{m5} and g_{m6} without disturbing the frequency of oscillation ω_o. The frequency and the condition of oscillation can, therefore, be adjusted by two completely different sets of transconductances. Thus, the proposed oscillator circuit enjoys the attractive feature of totally uncoupled control of the frequency and condition of oscillation.

Using Equation 8 it is easy to show that all the passive sensitivities of the parameter ω_o are less than unity. Thus, the oscillator enjoys low passive sensitivities.

A VERSATILE CIRCUIT

In this paper a new mixed-mode biquad circuit has been presented. The circuit is versatile as it can realise a wide variety of inverted or non-inverted responses in addition to a sinusoidal oscillator.

It was simulated using PSPICE circuit simulation program. The OTAs were modelled using the model reported by J. Wu, "*Current-mode high-order OTA-C filters*" in the International Journal of Electronics, Vol. 76, 1994, pp.1115-1120.

While the parameters of the filter responses enjoy independent electronic tunability, the frequency and the condition of oscillation of the oscillator version are totally uncoupled. That is, while the frequency of oscillation can be controlled by adjusting a set of transconductances, the condition of oscillation can be adjusted by a totally different set of transconductances.

All the parameters of the filter realisations and the oscillator enjoy low passive sensitivities. The circuit can also realise mixed mode filter responses. Thus, a voltage input may result in either a current or a voltage output. Also, a current input may result in either a current or a voltage output. Moreover, the circuit can realise voltage-mode filter responses with differential input voltage and single-ended output. While the simulation results confirm the theory presented in this paper, the discrepancies between the calculated and simulated results are attributed to the simplified model used in the analysis.

Muhammad Taher Abuelma'atti *and*
Abdulwahab Bentrcia
Saudi Arabia

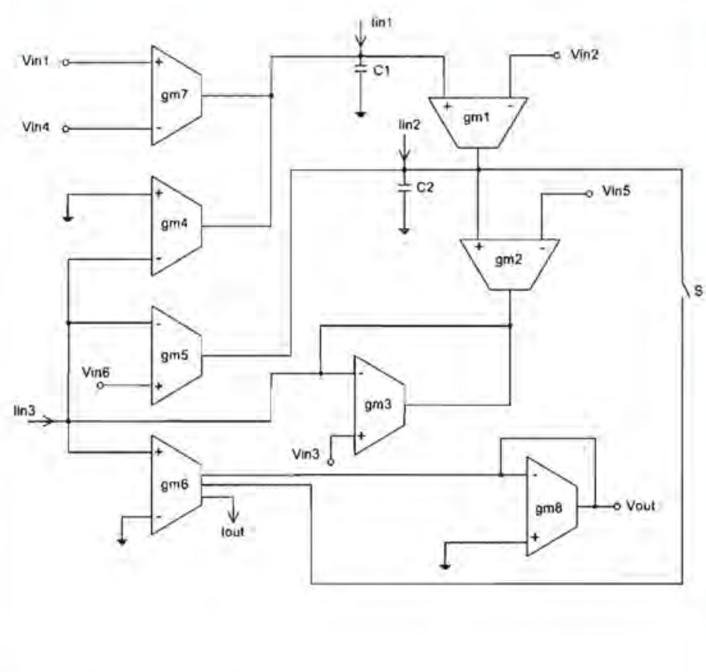


Figure 1: Proposed circuit

REALISATION OF VARIOUS ACTIVE DEVICES USING COMMERCIALLY AVAILABLE AD844s AND EXTERNAL RESISTORS

It is well known that the operational amplifiers (op-amps) without active or passive compensations suffer from the finite gain-bandwidth product which limits accuracy and reduces the frequency range of operation. Therefore, many active circuits such as oscillators, current-mode and voltage-mode filters, simulated inductors, immittance function simulators, transfer function simulators, rectifiers, etc, are constructed employing different types of current conveyors (CC) such as second-generation positive-type current conveyor (CCII+), second-generation negative-type current conveyor (CCII-), dual-output second-generation current conveyor (DOCCII), first-generation current conveyor (CCI), third-generation current conveyor (CCIII), differential voltage current conveyor (DVCC), dual X current conveyor (DXCC), and/or other active building blocks such as current differencing buffered amplifier (CDBA), four terminal floating nullor (FTFN).

Unlike voltage feedback op-amps, CCs do not have their bandwidth restricted by feedback. However, only CCII+ is a commercially available active device that can be found as AD844 the IC of Analog Devices. In fact, the AD844 is a current feedback operational amplifier (CFOA) which can be used also as a CCII+. For practical experiments, it is very important to realise different types of CCs and other active devices using AD844s or CCII+s. In this paper, we summarised the realisation of some of these active devices using CCII+s and external resistors.

1) The CCII+ and AD844

The commercially available current conveyor, AD844, comprises a positive-type second-generation current conveyor (CCII+) and a voltage buffer as shown in **Figure 1**. This integrated circuit has a low impedance at its inverting input (X) and high impedance at its non-inverting input (Y). From Figure 1 it is obvious that AD844 can also be used as a CCII+. The port relation of AD844 can be described as: $I_y = 0$, $I_z = I_x$, $V_w = V_z$ and $V_x = V_y$. The AD844 can be used in the realisation of different types of current conveyors as well as other active devices.

2) Second-generation negative-type current conveyor (CCII-)

A CCII- is characterised by $I_y = 0$, $I_z = -I_x$ and $V_x = V_y$. The CCII- can be realised using two CCII+s as shown in **Figure 2**.

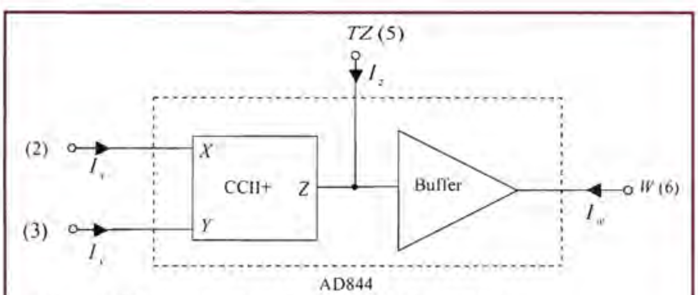


***Figure 1:** Equivalent schematic of the AD844*

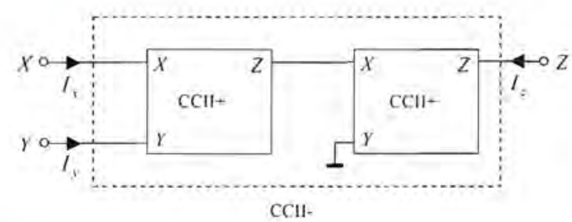


***Figure 2:** Realisation of a CCII- using two CCII+s*

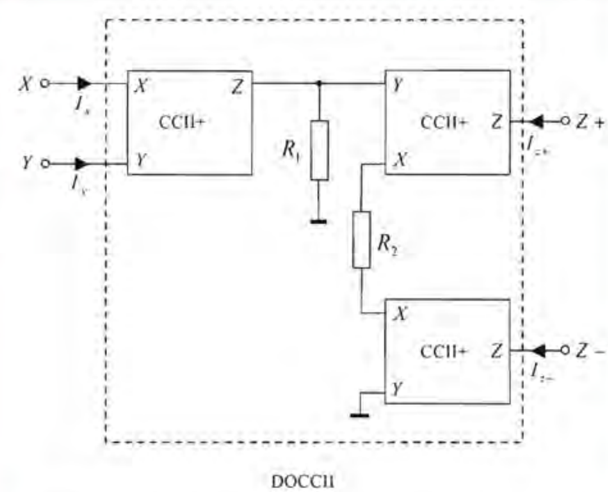


***Figure 3:** Realisation of a DOCCII using three CCII+s and two resistors*

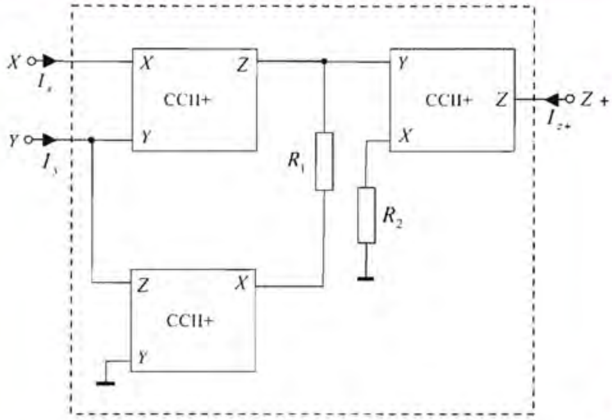


Figure 4: *Realisation of a CCIII+ using three CCII+s and two resistors*

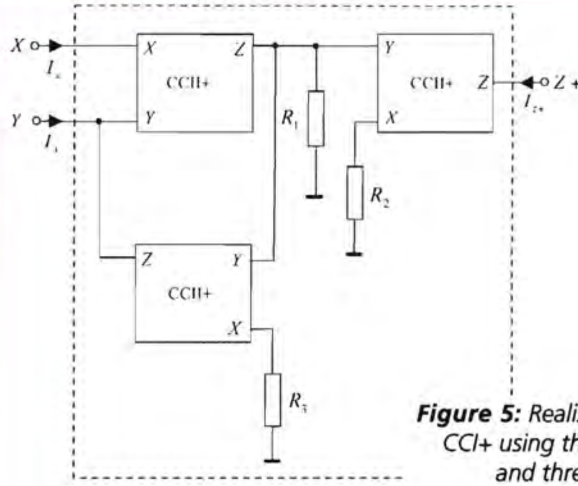


Figure 5: *Realisation of a CCI+ using three CCII+s and three resistors*

3) Dual output second-generation current conveyor (DOCCII)

A DOCCII, which is described by the equations $I_y = 0$, $I_{z+} = \alpha I_x$, $I_{z-} = -\alpha I_x$ and $V_x = V_y$, can be obtained using three CCII+s and two resistors as shown in **Figure 3**. The current gains of the Z+ and Z- terminals are equal to $\alpha = R_1 / R_2$.

4) Positive-type third-generation current conveyor (CCIII+)

The port relations of a CCIII+ is given by $I_y = -I_x$, $I_{z+} = \alpha I_x$ and $V_x = V_y$. The CCIII+ can be implemented with three CCII+s and two resistors as shown in **Figure 4**. The current gain of the Z+ terminal equals to $\alpha = R_1 / R_2$.

5) Positive-type first-generation current conveyor (CCI+)

A CCI+ is characterised by $I_y = \gamma I_x$, $I_{z+} = \alpha I_x$ and $V_x = V_y$. It can be realised with three CCII+s and three resistors as shown in **Figure 5**. The current gains of the Z+ and Y terminals are equal to $\alpha = R_1 / R_2$ and $\gamma = R_1 / R_3$, respectively.

6) Positive-type differential voltage current conveyor (DVCC+)

The DVCC+ is a four port active element described by $I_{y1} = 0$, $I_{y2} = 0$, $I_{z+} = I_x$ and $V_x = \beta(V_{y1} - V_{y2})$. It can be realised with three CCII+s and two resistors as shown in **Figure 6**. In this realisation, the voltage gain of the DVCC+ is found as $\beta = R_2 / R_1$.

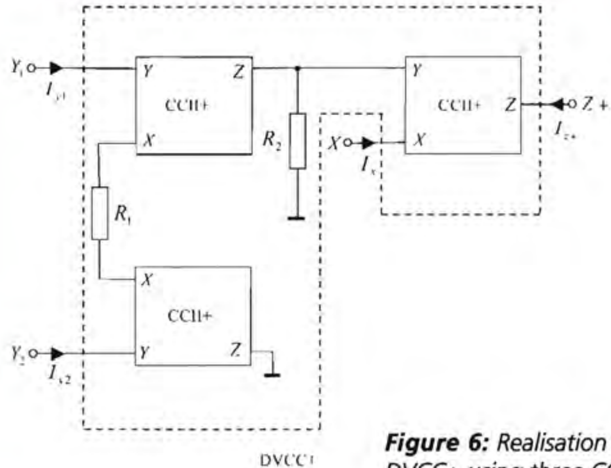


Figure 6: *Realisation of a DVCC+ using three CCII+s and two resistors*

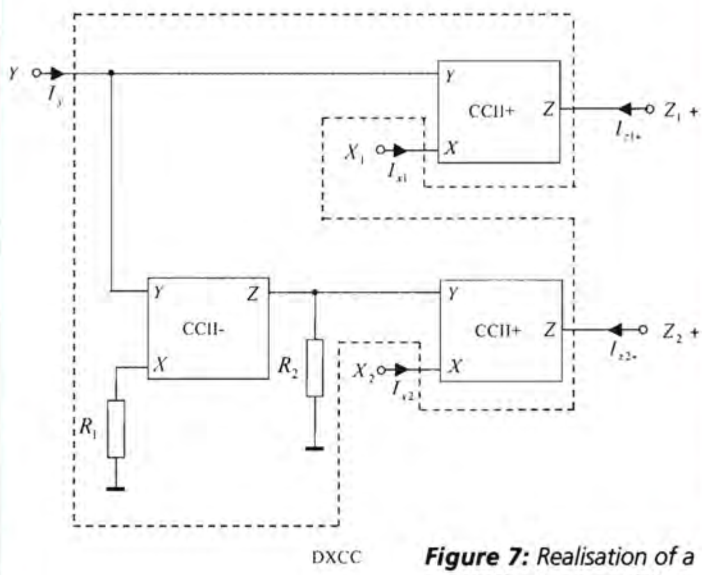


Figure 7: *Realisation of a DXCC using two CCII+s, one CCII- and two resistors*

7) Dual X current conveyor (DXCC)

The DXCC is an active device with two X ports, two Z ports and single Y port whose port relations are given as $I_y = 0$, $I_{z1+} = I_{x1}$, $I_{z2+} = I_{x2}$, $V_{x1} = V_y$ and $V_{x2} = -\beta_2 V_y$.

A DXCC can be implemented with two CCII+s, one CCII- and two resistors as depicted in **Figure 7**. In this implementation, the voltage gain at port X_2 of the device is found as $\beta_2 = R_2 / R_1$.

Note that the CCII- employed in this circuit should also be realised using two CCII+s (see Figure 2).

8) Dual output CCII+ (DOCCII+)

A DOCCII+ is a CCII+ with two Z+ terminals namely Z_1 + and Z_2+. The port relations of a DOCCII+ are given by $I_y = 0$, $I_{z1+} = \alpha I_x$, $I_{z2+} = \gamma I_x$ and $V_x = V_y$. It can be realised using three CCII+s and three resistors as shown in **Figure 8**. The current gains of the DOCCII+ in Figure 8 are found as $\alpha = R_1 / R_2$ and $\gamma = R_1 / R_3$.

9) Positive-type current gain variable CCII (CGVCCII+)

The CGVCCII+ is described by the following port relations: $I_y = 0$, $I_{z+} = \alpha I_x$ and $V_x = V_y$. The realisation of CGVCCII+ using two CCII+s and two resistors is depicted in **Figure 9**, where the current gain is found as $\alpha = R_1 / R_2$.

10) Positive-type voltage gain variable CCII (VGVCCII+)

The VGVCCII+ is an active device with the following port relations: $I_y = 0$, $I_{z+} = I_x$ and $V_x = \beta V_y$. It can be realised using two CCII+s and two resistors as shown in **Figure 10**. For this realisation, the voltage gain is found as $\beta = R_1 / R_2$.

11) Current differencing buffered amplifier (CDBA)

A CDBA is an active device with port relations $V_p = 0$, $V_n = 0$, $V_w = V_z$ and $I_z = I_p - I_n$. It can be realised with a CCII+ and a CFOA (AD844) as depicted in **Figure 11**.

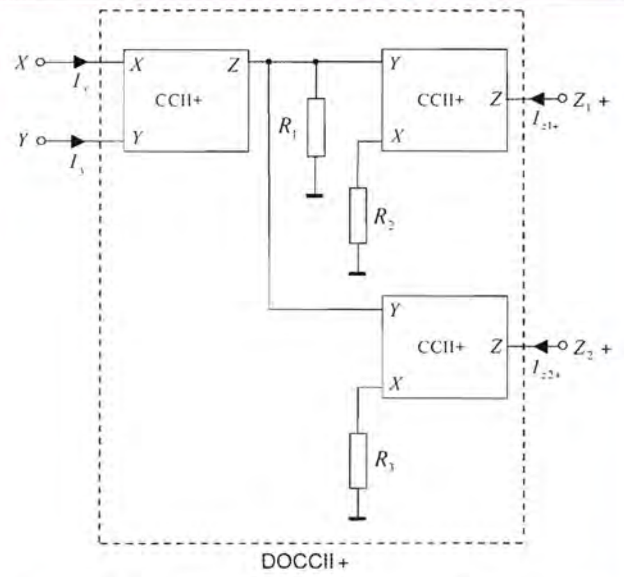


Figure 8: *Realisation of a DOCCII+ using three CCII+s and three resistors*

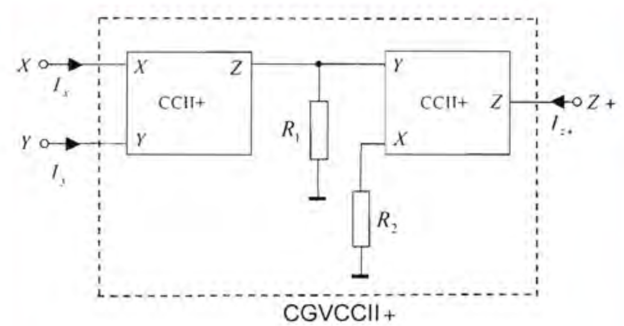


Figure 9: *Realisation of a CGVCCII+ using two CCII+s and two resistors*

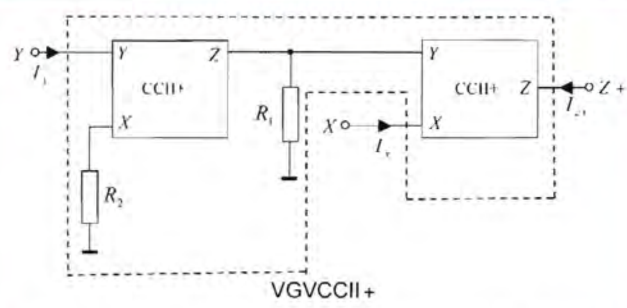


Figure 10: *Realisation of a VGVCCII+ using two CCII+s and two resistors*

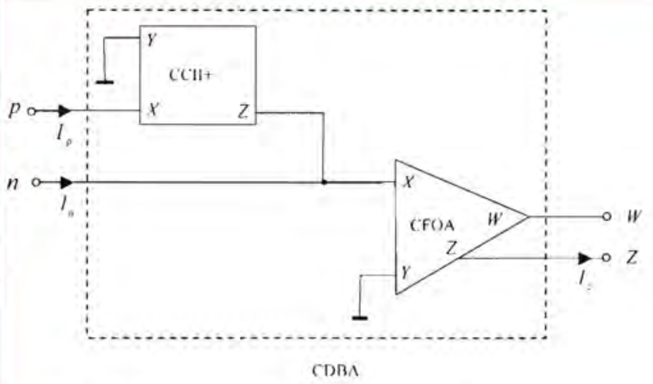


***Figure 11:** Realisation of a CDBA using a CCII+ and a CFOA (AD844)*

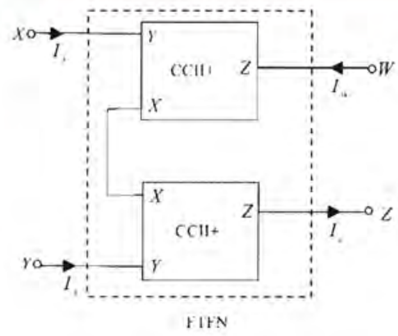


***Figure 12:** Realisation of an FTFN using two CCII+s*

12) Four terminal floating nullor (FTFN)

An FTFN also called an operational floating amplifier is characterised by $I_x = I_y = 0$, $V_x = V_y$ and $I_w = I_z$. It can be realised using only two CCII+s as shown in **Figure 12**.

Erkan Yuce** and **Shahram Minaei
Turkey

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.

Please note that the tips 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 DIRECT CONNECT

The simplest and most desired way to connect a 3.3V output to a 5V input is by a direct connection. This can be done only if the following two requirements are met:

- The VOH of the 3.3V output is greater than the VIH of the 5V input;
- The VOL of the 3.3V output is less than the VIL of the 5V input.

An example of when this technique can be used is interfacing a 3.3V LVCMOS output to a 5V TTL input.

3.3V LVCMOS VOH of 3.0V is greater than 5V TTL VIH of 2V, and 3.3V LVCMOS VOL of 0.5V is less than 5V TTL VIL of 0.8V.

When both of these requirements are not met, some additional circuitry will be needed to interface the two parts. See Tips 2, 3 and 4 for possible solutions.

TIP 2: 3.3V → 5V USING A MOSFET TRANSLATOR

In order to drive any 5V input that has a higher VIH than the VOH of a 3.3V CMOS part, some additional circuitry is needed. A low-cost two component solution is shown in **Figure 1**.

When selecting the value for R1, there are two parameters that need to be considered; the switching speed of the input and the current consumption through R1. When switching the input from a '0' to a '1', you will have to account for the time the input takes to rise because of the RC time constant formed by R1 and the input capacitance of the 5V input, plus any stray capacitance on the board. The speed at which you can switch the input is given by the following:

$$T_{SW} = 3 \times R_1 \times (C_{IN} + C_S)$$

Since the input and stray capacitance of the board are fixed, the only way to speed up the switching of the input is to lower the resistance of R1. The trade-off of lowering the resistance of R1 to get faster switching times is the increase in current draw when the 5V input remains low. The switching to a '0' will typically be much faster than switching to a '1' because the ON resistance of the N-channel MOSFET will be much smaller than R1. Also, when selecting the N-channel FET, select a FET that has a lower VGS threshold voltage than the VOH of 3.3V output.

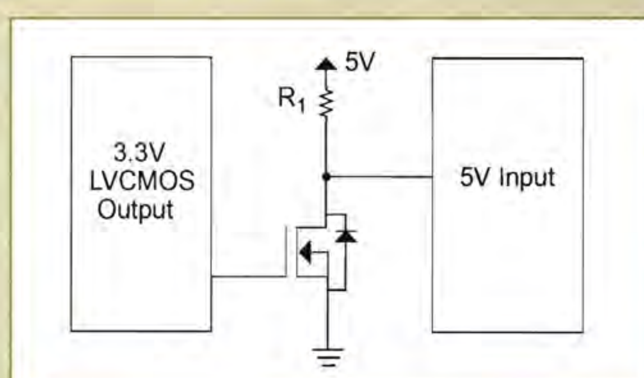


***Figure 1:** MOSFET translator*

TIP 3: 3.3V → 5V USING A DIODE OFFSET

The inputs voltage thresholds for 5V CMOS and the output drive voltage for 3.3V LVTTL and LVCMOS are listed in **Table 1**.

Note that both the high and low threshold input voltages for the 5V CMOS inputs are about a volt higher than the 3.3V outputs. So, even if the output from the 3.3V system could be offset, there would be little or no margin for noise or component tolerance. What is needed is a circuit that offsets the outputs and increases the difference between the high and low output voltages.

When output voltage specifications are determined, it is done assuming that the output is driving a load between the output and ground for the high output, and a load between 3.3V and the output for the low output. If the load for the high threshold is actually between the output and 3.3V, then the output voltage is actually much higher as the load resistor is the mechanism that is pulling the output up, instead of the output transistor.

	5V CMOS Input	3.3V LVTTL Output	3.3V LVCMOS Output
High Threshold	> 3.5V	> 2.4V	> 3.0V
Low Threshold	< 1.5V	< 0.4V	< 0.5V

Table 1: *: Input/output thresholds*

If we create a diode offset circuit (see **Figure 2**), the output low voltage is increased by the forward voltage of the diode D1, typically 0.7V, creating a low voltage at the 5V CMOS input of 1.1V to 1.2V. This is well within the low threshold input voltage for the 5V CMOS input. The output high voltage is set by the pull-up resistor and diode D2, tied to the 3.3V supply. This puts the output high voltage at approximately 0.7V above the 3.3V supply, or 4.0 to 4.1V, which is well above the 3.5V threshold for the 5V CMOS input.

NOTE: For the circuit to work properly, the pull-up resistor must be significantly smaller than the input resistance of the 5V CMOS input, to prevent a reduction in the output voltage due to a resistor divider effect at the input. The pull-up resistor must also be large enough to keep the output current loading on the 3.3V output within the specification of the device.

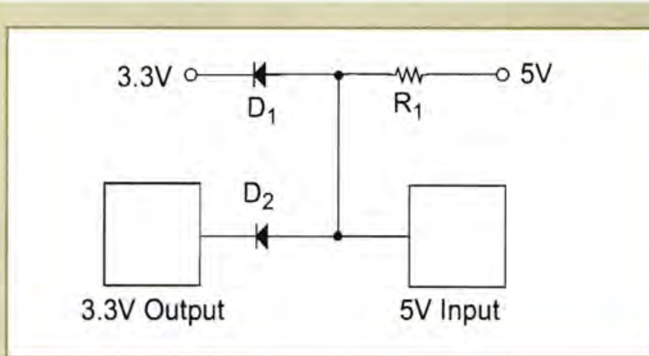


Figure 2: *Diode offset*

TIP 4: 3.3V → 5V USING A VOLTAGE COMPARATOR

The basic operation of the comparator is as follows:

- When the voltage at the inverting (-) input is greater than that at the non-inverting (+) input, the output of the comparator swings to Vss.
- When the voltage at the non-inverting (+) input is greater than that at the inverting (-) input, the output of the comparator is in a high state.

To preserve the polarity of the 3.3V output, the 3.3V output must be connected to the non-inverting input of the comparator. The inverting input of the comparator is connected to a reference voltage determined by R1 and R2, as shown in **Figure 3**.

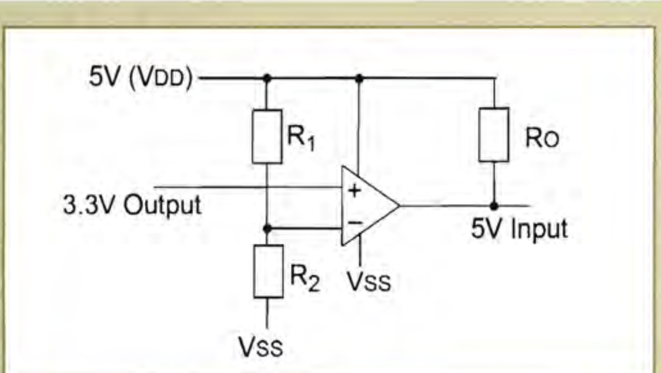


Figure 3: *Comparator translator*

CALCULATING R1 AND R2

The ratio of R1 and R2 depends on the logic levels of the input signal. The inverting input should be set to a voltage halfway between VOL and VOH for the 3.3V output. For an LVCMOS output, this voltage is:

$$1.75V = \frac{(3.0V + .5V)}{2}$$

Given that R1 and R2 are related by the logic levels,

$$R_1 = R_2 \left(\frac{5V}{1.75V} - 1\right)$$

assuming a value of 1K for R2,
R1 is 1.8K.

An op-amp wired up as a comparator can be used to convert a 3.3V input signal to a 5V output signal. This is done using the property of the comparator that forces the output to swing high (VDD) or low (Vss), depending on the magnitude of difference in voltage between its 'inverting' input and 'non-inverting' input.
NOTE: For the op-amp to work properly when powered by 5V,

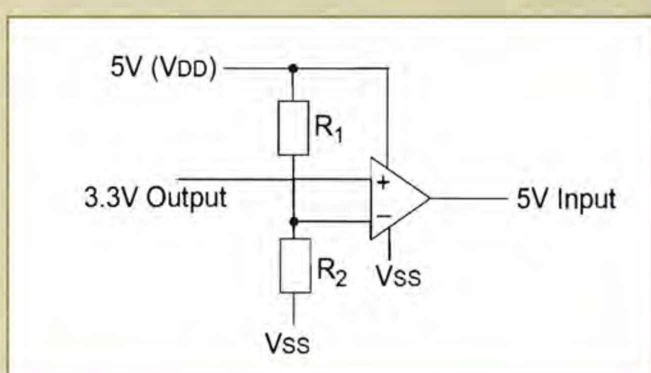


Figure 4: *Op-amp as a comparator*

TIP: SWITCHED CAPACITOR FILTER-BASED SINE WAVE OSCILLATOR WITH TRACKING FILTER

By James Mahoney and Philip Karantzalis, Linear Technology

This bus-controlled oscillator generates a low distortion 10Hz to 10kHz sine wave output. Typical low cost function generators use a diode shaping technique to transform a square wave into a sine wave, and have typical 2nd and 3rd order harmonics -35dBm and -25.5dBm respectively down from the fundamental.

This circuit generates sinusoidal outputs with typical 2nd and 3rd harmonics -76.1dBm and -74.2dBm across its full output range, a 40dB plus improvement.

CIRCUIT DESCRIPTION

This circuit consists of four sections. The first section – the heart of the circuit – is the oscillator comprised of U1A, a second order clocked filter topology section whose bandpass

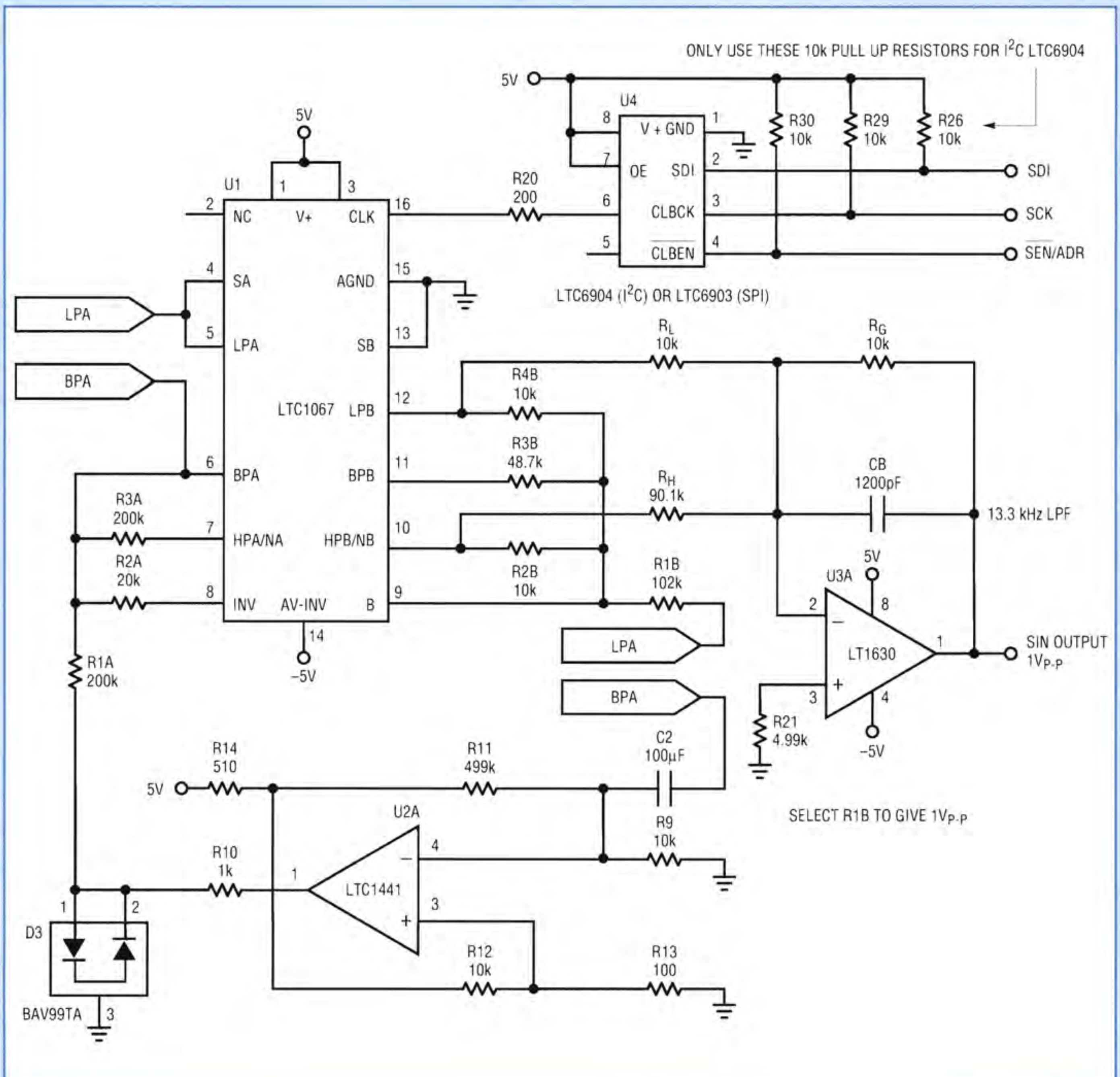


Figure 5

filter section sets the frequency of the oscillator, and comparator U2A. The bandpass only allows frequencies around its centre frequency to pass and this sets the oscillator's frequency, **Equation 1** gives the frequency. The filter Q is given by **Equation 2**.

$$F_O = F_{CLK}/100 \qquad (1)$$

$$Q = R3_A/R2_A \qquad (2)$$

The second section is the tracking-notch filter which is set to and tracks the third harmonic of the oscillator. The third harmonic was found to be the higher amplitude harmonic. The tracking filter is synchronously-clocked with the oscillator frequency setting filter to give lock step oscillator-tracking filter response characteristics.

Equation 3 gives the tracking filter –3dBm cutoff point and **Equation 4** gives the notch filter frequency.

$$F_O = (F_{CLK}/100)(\sqrt{(R2_B/R4_B)}) \qquad (3)$$

$$F_N = (F_{CLK}/100)(\sqrt{(R_H/R_L)}) \qquad (4)$$

The third section consist of a gain of –1 buffer amplifier with 13.3kHz lowpass filtering built in to reduce the high frequency component generated by the clocking steps in the output wave form.

The forth section is the SPI or I2C controlled clock generator, Linear Techology's LTC6903 or LTC6904 respectively. Some pull-up resistors, a decoupling cap and a resistor in series with the output are the only external components (see **Figure 5**).

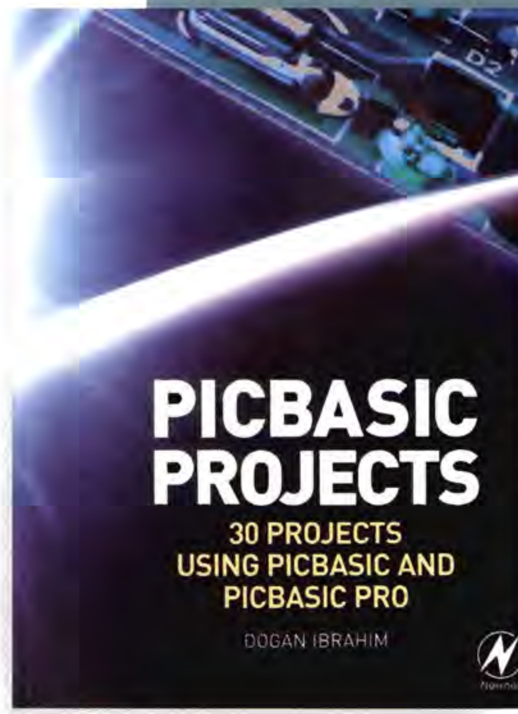
CONCLUSION

The result is a microprocessor controlled sine wave output generator with significantly lower distortion than the common diode-shaped sine wave generators. In addition a quadrature, sine/cosine, wave output can be realised by adding a second output op-amp whose input is taken from the band pass output of U1B pin 11. Quadrature signals are used in the design, testing and operation of encoders, modulators, demodulators and other measurement instruments.

PICBASIC PROJECTS – 30 projects using Picbasic and Picbasic Pro

DOGAN IBRAHIM

NEWNES (an imprint of Elsevier)



More and more electronics these days is based on programmable devices, and microcontrollers turn up in many of these. This book introduces programming of the Microchip PIC chip range of microcontrollers using PICBASIC and PICBASIC PRO compilers. These are two variants of BASIC both written by micro-Engineering Labs Inc. According to the book, PICBASIC is aimed at the hobbyist whereas PICBASIC PRO is more for professional engineers, but more about this later.

The preface gives a brief overview of microcontrollers and the structure of the book. Chapters 1 to 4 are the first 130 pages of the book and include a set of questions at the end of each chapter, in a manner typical of college course books. This is to help reinforce the ideas and concepts introduced, although I didn't find this style particularly helpful.

Chapter 5 is the projects section and covers page 131 to 358 – nearly twice as many pages, but with a lot of repeated text. Again, here's the concept of reinforcing learning with repetition.

Looking in more detail at the book, Chapter 1 provides a review of the basic architecture of microcontrollers. Having started with a paragraph giving some historical background of early microprocessors, various microcontroller concepts are described including I/O, RAM, ROM, EEPROM, Timers and A/D.

THE BOOK SHOULD WHET THE APPETITE OF ANYONE WANTING TO TRY USING PIC MICROCONTROLLERS AND, IN CONJUNCTION WITH THE RESOURCES ON THE WEBSITES LISTED, WILL PROVIDE THE MEANS TO DO SO RELATIVELY EASILY

Chapter 2 gives a detailed description of the PIC microcontroller family detailing the common architecture and some of the differences. To say that my mind was boggling by the end of this chapter would be an understatement. It is a very concentrated chapter and would probably need to be read several times by a beginner. Many of the details presented here very concisely can be explored in more depth by using on-line resources from Microchip.

Chapter 3 looks into what hardware and software tools are required in order to develop a PIC project. I was a bit surprised that for a modern, thoroughly revised book it still gave detailed instructions on how to use DOS EDIT as a text editing package for writing the PICBASIC source files. It also described other editing software, the various types of programming hardware and concludes with an example project (actually Project 1 from Chapter 5). The list of websites at the end of the chapter is a useful resource.

Chapter 4 introduces PICBASIC and PICBASIC PRO and has a table comparing them. It goes on to give details of the keywords for both variants and the chapter concludes with sections on LCD modules, stepping motors and servo motors. The last few sections seemed tacked on and did not generally seem to belong with a section on programming (but were probably insufficient for a chapter on their own). The author referred to the servo motors used as modified servo motors, but nowhere gave any explanation of how they were modified, or from which supplier they came. If I were a hobbyist starting out I would find the lack of information frustrating.

Chapter 5 then goes through 30 projects programming in PICBASIC and PICBASIC PRO. The hardware is the same for quite a number of the projects, the only difference being the program. They are purportedly arranged in order of increasing complexity, although the last three actually have much shorter programs than the preceding ones.

Each project had a hardware diagram, a flow diagram, a listing in PICBASIC followed by a listing in PICBASIC PRO. There were often short descriptive sections in between. Several of the projects only had PICBASIC PRO listings as they contained functions that are not supported by PICBASIC. There is a lot of repetition in this part of the book and I felt the point was laboured at times.

The chapter concludes abruptly with one project on robotic control using servo motors (the modified ones). I felt somewhat left in the air, looking for a few brief concluding words, but it simply went from the last program listing to a page about the CDROM and then straight into the index.

The book comes with a CDROM which has all the listings, all the tables and illustrations, and a demo version of PICBASIC PRO and Micro Code Studio editor. The demo version is limited to 31 lines of code, excluding comment lines, where may not sound much, but is sufficient for quite a lot of projects.

Overall the book is a reasonable introduction to programming PIC microcontrollers in high level language, but there were a number of things which caused me confusion, where a short paragraph of explanation would have helped.

I also felt that a lot of the projects were too similar to warrant being counted as separate projects.

One area that concerns me for a book introducing programming for people who may have no experience is the editorial and typographical errors. In several of the listings it is obvious that copy/paste has been used. Some comments relate to a different listing, but have not been deleted, and at least one of the PICBASIC PRO listings has declared variables that are not used. The errors are the identical on the CDROM versions of the listings. One of the flow diagrams has a logical error, which has been corrected in the BASIC by doing things in a different order. These are things that let this book down.

In the past I have done quite a bit of programming in BBC Basic, but PICBASIC and PICBASIC PRO, although similar in some areas, are quite distinct. I found the reading through the two listings for each project a little confusing, because of the differences. What I discovered from the microEngineering Labs website helped remove some of the confusion. It has PDF user guides for PICBASIC and PICBASIC PRO, which explains the philosophy behind each and details all the instructions. Nowhere does this book refer to them, which are ideal reference tools for anyone considering using these compilers.

According to the PDF user guides PICBASIC was written to be largely compatible with the BASIC STAMP, and predefines a lot of the PIC variables, so they don't need explicit define statements. PICBASIC PRO on the other hand does not predefine any variables so they all need to be declared.

The PICBASIC PRO user guide also details how interrupts are handled, giving details of its inner workings, explaining that interrupts are not serviced as they occur but only between instructions. For time-critical functions this is an important point. Although it is mentioned briefly in the book that interrupts are only handled between instructions, the reason and how this is achieved is not given. For anyone like me who has any experience of ISRs in assembler, this could cause confusion without the information from the user guide. If this information had been included in the book a lot of confusion would have been saved.

In conclusion, with the reservations given above, I feel it is a useful book if used in conjunction with other resources. The projects really provide a starting point and can be developed further. Some quite complex things can be coded in just a few lines of BASIC, which would be a major task if using assembler. The book should whet the appetite of anyone wanting to try using PIC microcontrollers and, in conjunction with the resources on the websites listed, will provide the means to do so relatively easily.

Ray Lee

WEEE – The big questions

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

Q What is the WEEE directive?

A The Waste Electrical and Electronic Equipment (WEEE) regulations were laid before parliament on 12th December 2006 and came into force on 2nd January 2007. Under the legislation, Producers* have to take financial responsibility for products at the end of their useful life. The primary purpose of the Directive is to reduce the level of disposal to landfill by encouraging the re-use, repair/upgrade, efficient recycling and recovery of WEEE.

The Directive lays a duty upon EU Member States and is issued under Article 175 of the Treaty of Rome allowing each Member State to transpose the Directive into its own regulations which vary from State to State.

*Producers are defined as a party who:

- Manufactures and sells Electrical and Electronic Equipment (EEE) in an EU Member State under their own brand
- Sells under their own brand equipment produced by another manufacturer
- Imports or exports EEE on a professional basis into an EU Member State

Anyone who manufactures, brands, imports, sells, stores, treats or dismantles EEE will be affected by the legislation.

Q Why is it needed?

A Currently over one million tonnes of WEEE goes to landfill per year in the UK alone. This is unsustainable and aside from the fact that landfill sites are being created and filled at an alarming rate, this method of WEEE disposal is causing the loss of around 400,000 tonnes of ferrous metal, 200,000 tonnes of plastic, 100,000 tonnes of copper and 50,000 tonnes each of aluminium and glass. Most of that is recoverable and recyclable.

The WEEE directive will encourage the separate collection of WEEE and the treatment, re-use, recovery, recycling and sound environmental disposal of electrical and electronic equipment.

Q Are any product types exempt from the WEEE directive?

A Certain types of EEE are exempt from the regulations, these include:

- Equipment that doesn't need electricity to work;
- Equipment that is part of another type of equipment which is outside the scope of the WEEE regulations, such as aircraft and vehicles;
- Equipment designed to protect the UK's national security or that is used for a military purpose;
- Household lighting;
- Large stationary industrial tools – permanently fixed at a given place in industrial machinery or an industrial location;
- Medical implants and infected medical equipment.

Q How does the WEEE directive impact electronic product design?

A Designers will be encouraged to consider the product lifecycle and ease of recycling at end of life right at the beginning of their new product design process. The starting point for this is to understand what causes the user to discard a product at end-of-life and then what happens to it.

It is fair to say that the recent introduction of numerous directives including WEEE has added a whole new dimension to the role of the electronics/electromechanical design engineer.

Q How will it be enforced?

A The Environment Agency will enforce and monitor compliance with the WEE directive. Their role will include:

- Approval of producer compliance schemes;
- Management of data on market share, WEEE collection, treatment and reprocessing;
- Registration of producers of EEE and maintenance of a public register;
- Identification of 'free-riders' and bringing them into compliance;
- Regulation of sites that will store and treat WEEE;
- Approval of treatment facilities and exporters of WEEE so that they are able to issue evidence of treatment and recovery.

Q What are the responsibilities on electronic equipment producers?

A All producers of electrical and electronic equipment (except those that fall into the categories described earlier) are required to register and join a compliance scheme.

They have to provide information on 'new' EEE to assist in its treatment, recycling and re-use. This will include information on the various components and materials in the product and the location of any hazardous substances.

All goods should be marked with the crossed out 'wheelie bin' symbol to identify and separate them from other waste streams. All equipment covered by the directive should also carry a producer identification mark indicating that is was placed on the market after 13th August 2005. A thick bar underneath the wheelie bin symbol can be used to show this.

Producers are financially responsible for collecting, treating, recovering, recycling and disposing in a sound environmental way an equivalent amount of WEEE to that which they produce. In order to do this they are obliged to put an appropriate compliance scheme in place or, less likely, set one up themselves.

Finally, producers will need to clearly understand the differences and implications of household and non-household WEEE.

Please email your questions to:
svetlana.josifovska@stjohnpatrick.com
marking them as RoHS or WEEE

USB Stick For Industrial Applications

A USB stick is now available as an accessory to the Y-ConUSB series from Yamaichi, meeting the highest protection requirements in the industrial sector.

The memory stick Y-ConUSB-Stick-1 has a USB 2.0 high-speed interface. It has a storage capacity of 512MB (up to 2GB on request) and, like the whole Y-Con series, meets the requirements of IP67/68/69K. This means it can also be used under extreme conditions, such as storing measurement data on construction machinery which easily soils, or for data exchange on industrial facilities, as well as the updating of programmes or the recording of error messages.

The main advantage is that the USB stick can collect data over longer periods of time. When the stick is full, data can be read off on every conventional USB interface and immediately used again. Transferred data is additionally displayed too, by way of a flashing blue LED.

The recommended operating temperature ranges from -25°C to +80°C and the life expectancy caters for up to 1500 connector mating cycles.

www.yamaichi.eu

68-pin MDR I/O Connector For SCSI-2 Applications

Technology firm 3M has introduced a 68-position MDR I/O board-mount connector that conforms to the standard contact pattern of popular SCSI-2 pin-and-socket interfaces. The new configuration allows use of 3M's robust MDR wiper-on-wiper connector system in applications that previously used traditional pin-and-socket SCSI-2 connectors. The 3M MDR SCSI-3 footprint version is available in a 68-pin count configuration and mates to all 3M MDR 68 position wire-mount plugs.

The MDR connector is suitable for use in a broad array of box-to-box applications, including telecommunications, networking, enterprise computing and factory automation. The connector's ribbon-style contact eliminates 'pin stubbing' failures that can occur in pin-and-socket I/O connectors and is reliable in repetitive plug-unplug applications. The connector's 360 degree shielding contributes to improved signal integrity.

Available options include a thumbscrew for secure attachment in challenging environments and a quick-release latch for fast, easy installation. A board-lock retention feature helps to ensure a reliable connection.

For further information, contact the 3M Customer Service Centre on **+44 (0)1234 229463**

New Shortform Catalogue From Link Microtek

Link Microtek has brought out a new shortform catalogue detailing the extensive range of microwave and RF components, assemblies and sub-systems manufactured in-house by its Engineering Division in Basingstoke.

Concentrating mainly on waveguide products, this 36-page A4 full-colour catalogue covers adapters, attenuators, couplers, filters, horn antennas, ortho-mode transducers, rotary joints, subsystems, TEM cells, terminations and waveguide hardware in both rectangular and double-ridge styles.

Each product entry consists of a colour photograph, a list of features and a summary of the standard models available, including key technical specifications such as frequency range and physical dimensions.

The catalogue can be obtained in printed format by e-mailing sales@linkmicrotek.com or downloaded as a PDF file via the link on the 'Engineering' page at:
www.linkmicrotek.com

Precision Measurement Solutions From Cropico

Cropico has published a new 52-page colour catalogue providing full information on the company's range of advanced technology precision measurement instruments.

Cropico's high quality reputation goes back over 50 years and the company's portfolio includes a wide range of resistance and temperature measurement solutions.

Cropico micro ohmmeters are designed for highly accurate measurement of low resistance values across a wide variety of production, safety and design engineering applications. They are supported by specialist temperature measurement instrumentation with accuracies of 0.01°C and which are designed for use with many different thermocouple types.

In addition, Cropico also supplies resistance decade boxes from 0.001 Ohm to 1 Tera Ohm and a range of high performance resistance standards which are noted for their long term stability.

Copies of the new Cropico brochure are available free of charge from the Cropico sales office by email at sales@cropico.com or download direct from:
www.cropico.com

Electron d'Or Award For 20GHz Oscilloscope

Tektronix has won a prestigious 'Electron d'Or' award. Tektronix's ultra-high performance oscilloscope with 20GHz real-time bandwidth and 50GS/s simultaneous sampling rate was selected as the most innovative product of the previous twelve months in the category of test and measurement.

The Electron d'Or awards recognise innovation in technology and in particular products that are likely to have a significant impact on the market and future applications.

Ultra-high performance oscilloscopes are required to capture the frequency harmonics of high-speed serial signals to make accurate and repeatable measurements. The DPO/DSA72004 oscilloscope provides support on all channels for ultra-high bandwidth, deep memory, fast sample rate and fast waveform capture rate. This is especially valuable for high speed multi-lane serial data architectures where multi-channel analysis is needed for lane skew timing violations. The model is ideal for design engineers developing and testing state-of-the-art serial data applications, including PCI-Express 2, SATA 3, FB-DIMM II, HDMI 1.3 and 10Gbit/s Ethernet.

www.tektronix.com

IP68 Rated USB Flash Drive Cover

Bulgin's waterproof USB Buccaneer connectors are being employed in many different areas and applications, with one of the most prominent as a data 'downloading' port.

In this application the panel connector is not always used with a mating connector, instead a USB Flash drive is connected to input or extract data from the equipment.

Some applications warrant the Flash drive being left in-situ, but this can compromise the integrity of the equipment's environmental sealing characteristics.

To overcome this Bulgin has developed an extended cover that will maintain the IP68 sealing of this interface whilst the Flash drive remains connected. The cover is suitable for use on all Buccaneer USB 'A' type connectors: PX0842/A, PX0843/A, PX0845/A and PX0849/A.

Designed to accommodate a wide variety of USB Flash drives this simple accessory will find many uses where transportation of data and sealing integrity of the equipment are important considerations.

www.bulgin.co.uk

Storage Interface Solutions With Compact Flash Host Controller

QuickLogic launched an addition to its integrated programmable connectivity solution portfolio targeting mobile devices. The company has released a full Compact Flash host controller to provide designers with simple access to this common memory technology.

Compact Flash is a high pin-count interface and, as a result, many of the latest application processors no longer

support it, in order to reduce costs. QuickLogic's Compact Flash host controller acts as a companion device to the application processor, enabling connectivity to a host of Compact Flash devices on the market.

QuickLogic's Compact Flash host controller solution supports the CF+ specification including memory, data storage, I/O and True IDE mode. It can be configured to work with Compact Flash memory cards, micro hard disk drives and a broad range of I/O peripherals.

The processor interface implemented in the programmable fabric allows seamless connection to a variety of applications processors, enabling developers to quickly add Compact Flash to their mobile designs.

www.quicklogic.com

Axiohm MGTA Series Of Printers At DED

DED introduced its MGTA series of printer mechanisms from Axiohm. One of the fastest printers in its class, printing at a speed of 180mm per second, the MGTA features a heavy duty guillotine cutter and works within a wide range of operating temperatures, enabling its improved paper feeding function to be taken advantage of in banking, gaming, transportation, ticketing and vending applications.

The MGTA has an improved lifespan of up to 1 million cuts, it is quicker, quieter and less likely to overheat than other, similar printers. The MGTA operates in a temperature range of between -20°C and +60°C. It prints receipts of between 80mm and 82.5mm wide.

With simple 'clamshell' paper loading, a range of boards in RS232 and USB interfaces to drive the mechanism and options to facilitate integration, the weight and dimensions of the MGTA only serve to strengthen its flexibility. The device weighs 370g and has the dimensions of 112.75mm x 66.71mm x 41.7mm.

www.ded.co.uk

GTK 3mm Signal/Power Connector Series

Now available from GTK is a series of 3mm pitch connectors for high current/high density applications for wire-to-wire and wire-to-board configurations. Capable of carrying currents of up to 5A max and with a 10mΩ contact resistance, the MPC series is suitable for power and signal applications.

Snap-in pegs, locking clamps and polarised devices guarantee the connectors will have isolated terminals to prevent contacts from damage. Connectors are available for circuit sizes 2–24 for single and dual row applications.

www.gtk.co.uk

Cherry and Devlin – Customisation Partners

Cherry Electrical has appointed Devlin Electronics as its customisation partner, where Cherry keyboards can be fully customised with layouts and graphics, increasing productivity, reducing errors and potentially enhancing customers' branding.

Devlin has invested in tooling so that it can produce customised keytops that fit the Cherry keyswitches – especially on the SPOS retail keyboard range. This means that system builders can have exactly the layout and graphical look they want. Devlin will also undertake any individual requests for firmware or software programming.

www.cherry.de

To reserve your website space phone Matthew Dawe 020 7933 8980 or email matthew.dawe@stjohnpatrick.com

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www.xtraguard.com

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

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Infratec AG, a supplier of Rack Monitoring Systems for the control and management of EDP and telecommunication systems, has launched a new SpeedUp Partnerprogramme. The programme offers potentially lucrative conditions and services, but above all it offers the SMS Alarm System which controls both PCs and servers; for instance, in case of damage, an alarm is sent via SMS or via email.

The SpeedUp Partnerprogramme has three categories: Partner, Silver Partner and Gold Partner. Certification depends essentially on training courses relating to the products. In order to achieve the Silver Partner status, training on the Remote Monitoring System and on Power Monitoring Products is required. The Gold Partner status can be obtained once training on NMS 1000 software for general control is undertaken.

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