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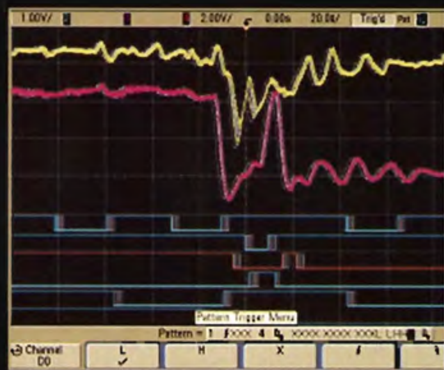

SPECIAL REPORT:

Displays and Solid State

Capturing Elusive Events

Cost Effective Vehicle Speed Measurement

• CIRCUIT IDEAS • CIRCUIT IDEAS • CIRCUIT IDEAS • CIRCUIT IDEAS • CIRCUIT IDEAS

- Novel BPSK Demodulator
- Point-Contact Audio Oscillators
- Auto Shut-Off Utility Light

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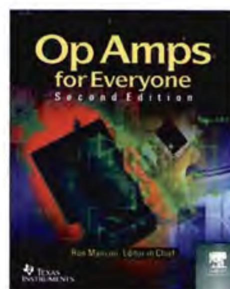

Left: Delivering TV to mobile phones – p12

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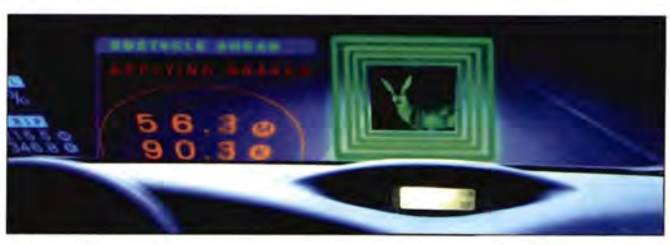

Video devices from the DaVinci platform – p6

Is a Nano a No-no?

Something is 'rotten' in the state of nano. There are some conflicting messages coming out of the nanotechnology sectors. Some nanotechnology observers claim that the economic cycles will see consumer interest in nanotechnology evaporate before we find new ways of integrating such devices in ICs in high densities. This is supported with evidence of some companies' recent decisions to cease investment in nanotechnology programmes, even though they have been at the forefront of such developments for some time.

On the other side of the argument, there are figures emerging predicting that by 2010, the global market for nano tools and equipment will be worth in excess of $3bn.

The question is, if we are going to hit a technology barrier within ten years, then why should anybody bother in spending money on nanotechnology developments now?

Over the past 50 or so years, the electronics industry's growth has been determined by, more or less, single drivers, such as the PC, then the mobile phone, for example. Therefore, they have been the main technology wave drivers. The third wave is a bit of a mystery, however. What is the application or device that will drive this one?

Recently, a lot of words are being spent on 'energy' and how to preserve, save and generate it in environmentally friendly ways. It is not just the generation and transmission companies that are now looking into renewable energies, but electronics and semiconductor firms too. One semiconductor executive told me recently: "We are starting to save energies from the IC upward. You don't want your device to draw too much power from the mains."

Hence, there's an implication that the third technology up-cycle will be driven by energy and the evidence is beginning to mount up. Photovoltaic systems (solar panel systems), for example, are in high demand at present. This is further strengthened by certain countries' legal requirements to have such systems installed in new builds; countries like Spain and Germany, for example. In turn, there is already a reported shortage of polysilicon, as both photovoltaics manufacturers and the semiconductor industry use it in their products.

So, going back to our nano riddle: If energy is truly going to fire up and drive the next technology up-wave, then where does the current research of nanotechnologies fit in?

SEMI, the association of semiconductor equipment and material manufacturers, has a way of describing the future of the nano state. SEMI categorises nanotechnologies into nanoelectronics – semiconductors that are scaled down to below 100nm, and the rest of nanotechnology, which emerges from the bio and pharmaceutical fields. Then, it further splits the nanoelectronics side into 'evolutionary' and 'revolutionary' veins.

According to its latest figures (submitted in December 2005), 23% of the $3.1bn of money spent in 2010 on nano tools and equipment will cover the 'revolutionary' side. SEMI says, the advent of nanoelectronics "has started and will not be stopped".

On the other hand, I am still not sure how all these figures tie in with the forecast of an uncertain nano future on the large scale. One thing that is certain, however, is that firms investing in nanotechnology will need to be pretty darn sure that they will see returns on their invested millions before getting in any deeper.

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Editor

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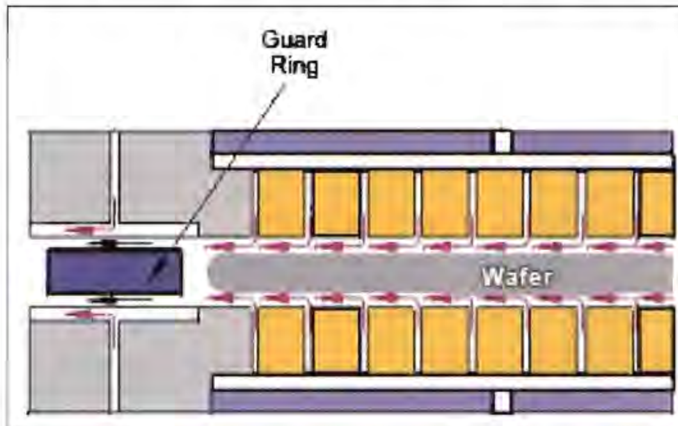
Novel Annealing System Developed for Chip Makers

Pan-European collaborative work led to the development of a revolutionary new annealing technique for wafer fabrication. After wafers have been implanted with high-energy ions, rapid thermal annealing (RTA) is required to repair the semiconductor crystal structure. RTA requires very rapid changes of temperature under accurately controlled conditions for satisfactory annealing. This annealing is conventionally accomplished by focusing the heat from a bank of tungsten filament lamps onto the wafer surface, as furnace heating involves long process times. However, rapid cooling is difficult to achieve.

In the new RTA system, the heat is supplied by conduction rather than by radiation. The semiconductor wafers are precisely floated between two hot graphite blocks, coated with silicon carbide and kept at the process temperature. A stream of hot nitrogen or helium gas emerges from narrow channels in the blocks to ensure that the wafers are heated and cooled very rapidly and very uniformly across their surfaces. Faster heating and cooling rates and better temperature control can be obtained than with conventional RTA systems. The system is also very suitable for rapid thermal oxidation, even though the oxidation application is not completely ready yet.

The new RTA system can be used at up to 1100°C with heating rates of up to 900°C per second with helium and a high wafer throughput. This 'Levitor' machine is available from ASM International (ASMI) for annealing silicon after ion implantation and for the very fast heating of conducting layers. Power consumption is only 6-20kW for a 300mm wafer system, whereas tungsten filament RTA requires 200-250kW. It has been qualified for 65nm chip technology and qualification for 45nm is commencing. A simpler, more economical, version is available for use at up to 400°C.



Principle of 'gas-bearing' between two high-mass blocks that act as a thermal flywheel

The results of this project should provide Europe with a global lead to boost employment in manufacturing equipment.

The partners who developed the new system are ASMI, ASM Belgium, CEA-LETI, IMEC, Schunk, STMicroelectronics and Xycarb Ceramics. This Medea+ project, dubbed T303 Contactless Anneal And Silicides System (CLASS), was carried out in Belgium, France, Germany, Italy and The Netherlands. It is one of 34 completed projects of the 70 projects under the Medea+ umbrella.

The Medea+ programme involves 350 partners from 21 European countries and the work of 14,000 person-years.

• Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch • Nanowatch •

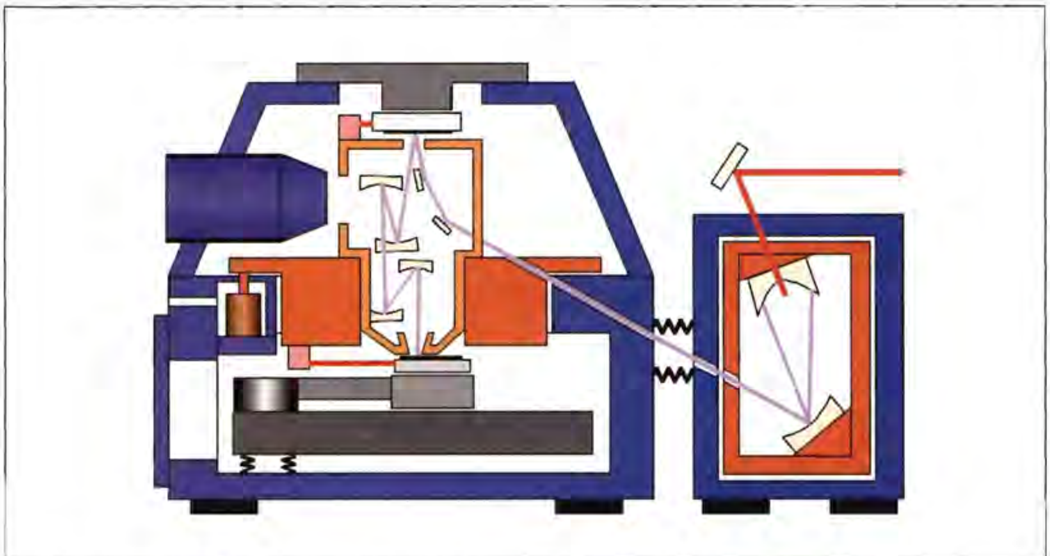
New market report by Nexus (the EC-backed Network of Excellence in Multifunctional Microsystems) forecasts the MEMS market to reach $25bn in 2009, which is more than double on 2004. The *"Nexus Market Analysis for MEMS and Microsystems III, 2005-2009"* report states that MST/MEMS sensors and actuators will still remain an important element of the IT peripheral market for read/write heads and inkjet heads, but also enter new areas such as microphones, memories, micro energy sources and chip coolers.

Seagate's nanotechnology facility in Springtown, Northern Ireland, has received a financial boost of £83m, which it will share with sister plant Limavady, also in Northern Ireland. Between the two, some 300 new jobs will be created. The investment includes backing of £24.8m from Invest Northern Ireland, the main economic development agency there.

University of Surrey's Advanced Technology Institute (ATI) and CEVP have started trials of the world's first tool for low temperature carbon nanotube growth.

The partners envisage releasing the technology – called NanoGrowth – for commercial use in March this year.

Europe Leads in Extreme UV Lithography



Schematic drawing of the EUV lithography tool
Right: Illuminator optics, **Left:** Six mirror demagnifying optics with mask at top and waferstage at bottom

Extreme UV Lithography (EUVL) will be the technique used to pattern ever more transistors of yet finer dimensions onto silicon chips towards the end of this decade. By then, chips will have feature sizes of 45nm and less, using patterns that cannot be produced by refractive optics. The vital importance of using the shorter EUVL wavelengths was demonstrated at the Medea+ Forum in Barcelona, Spain, in November.

Rob Hartman, of ASML, said Europe will dominate in EUVL by 2009 with an expected turnover of more than €1bn and about 18,000 employees, mainly at a higher technical level. Medea+ is a pan-European organisation that promotes research and development between companies and academics in projects taking place in at least two countries.

Until recently, a major problem has been that of generating adequate EUV power at the required 13.5nm wavelength to enable EUVL to be used for mass production. However, Hartman said, an EUV power level of 800W over 2-Pi steradians has been achieved at 4kHz. This is an increase of three orders of magnitude over three years, so power is no longer a major issue. The lifetime of the sources has also been increased by several orders of magnitude.

Aachen-based Philips has developed a source using gas discharge plasma containing xenon or tin. Göttingen-based Xtreme has produced both a gas discharge and a laser induced plasma source. However, collector lifetimes, masks and resists are still major problems in this work involving 13 collaborators in France, Germany, The Netherlands, Poland and Sweden. Critical issues include optics quality and life and reticle protection during storage, handling and use. Reflective optics using mirrors, coated with alternate layers of molybdenum and silicon are used, but it is vital to minimise losses at each mirror, as the EUV undergoes many reflections in the system.

Nevertheless, one full-field EUV tool will be shipped to research facility IMEC in Leuven, Belgium, and another to the University of Albany in the US, in the second quarter of 2006.

Another Medea+ project has led to the development of a mask for aligning and installing an EUV system. It can be fabricated in the AMTC (Advanced Mask Technology Centre) in Dresden and is already available.

MEDEA+ participants have already started a debate on a successor programme. The advanced co-operative R&D programme in microelectronics is coming to a close in 2008, but since it involves over 350 partners from 21 countries, it will take some time before the technical outline and funding for a similar programme are agreed. Prior to MEDEA+, MEDEA and before that JESSI helped advance Europe's capabilities in micro and nanoelectronics R&D and placed it firmly on the map in these fields. MEDEA+ started in January 2001 with the remit to focus on system innovation on silicon for the e-economy.

Ω

The Centre for Integrated Photonics (CIP) has developed a reflective semiconductor optical amplifier offering highly optimised performance for WDM passive optical network (PON) applications. Capable of delivering a gain of 20dB, the semiconductor optical amplifier (SOA) can be modulated at rates up to 1.5Gbit/s to provide wavelength-agile optical data transmission for fibre-to-the-home/premises (FTTH/FTTP) access network architectures – without the expense of a tunable wavelength source. Novel curved waveguide architecture inside the monolithic InP (indium phosphide) based SOA delivers smooth output characteristics with a ripple of just 0.5dB (typical) and a polarisation-dependent gain of 1.5dB. This performance is claimed to be unique on the market and it will boost the development of cost-effective WDM PONs.

Ω

Students at the De Montfort University in Leicester are learning about the next generation of television technology in a unique £300,000 high-definition TV lab, where academics are also conducting a multi-million pound research to develop 3-D TV. The new HDTV lab includes a £23,000 DVB/ATSC combined encoder and multiplexer for processing multiple data streams. The students are also using real-time high-definition editing facilities as well as high-definition cameras, which will soon be used by TV crews around the UK. The research for this project is funded by a 'Network of Excellence' grant from the European Union.

The Association of Franchised Distributors of Electronic Components (AFDEC) released a disappointing forecast for the state of the UK electronic components market for 2006 and 2007. The report found that the total available market (TAM) in the UK declined significantly over the last five years from a peak of £10.2bn in 2000. According to the AFDEC membership, this decline is due mainly to volume manufacturing moving off to Eastern Europe and Asia, and the shift in demand of components from lower volume, complex datacom/telecom type products, to high volume, lower complexity consumer products.

Ω

WiMax has enormous potential, but competing technologies are significant threats, reports In-Stat. The high-tech market research firm forecasts a WiMax chipset market as high as $950m in 2009, however, among the competing technologies, such as 3G on the cellular side (EV-DO Release 0, A, and B; HSDPA) and Wi-Fi (coupled with wireless mesh networking and MIMO enhancements within 802.11n) on the networking side, this figure may realistically reach only $450m. In-Stat also suggests that despite tremendous hype surrounding WiMax, the WiMax chipset market has a relatively small number of players, with Intel being the largest and most heavyweight to drive it.

Ω

British children have snubbed nuclear power as an energy source for the future in a recent survey commissioned by the IEE as part of the 2006 Faraday lecture *'Emission Impossible – Can Technology Save the Planet'*. The survey also revealed that children are also more likely than their parents to shoulder the blame for climate change and are most concerned about changes to wildlife. "We know that children are concerned about the environment," said Dorrie Giles, IEE's director of qualifications, but she added: "Only 19% of children are aware that engineers can make a difference when, in truth, all environmental technologies have their basis in engineering."

Potential automotive application for the DaVinci technology. A video image can be processed using a DSP camera providing a head-up display

Texas Instruments's DaVinci sees its first products

Texas Instruments (TI) announced the first two video devices based on its recently launched DaVinci platform.

The TMS320DM6443 and TMS320DM6446 act as a video decoder and video encoder/decoder, respectively. As the first generation of devices, they are aimed at IPTV set-top boxes, CCTV monitoring equipment and other video security products.

DaVinci consists of the hardware – an ARM9 core, TI's 64-bit 600MHz DSP and on-board memory; multimedia codecs implemented in software; MontaVista's Linux operating system; a host of device drivers, frameworks and APIs and the tools for product development.

According to TI, any development engineer will be able to pick up this platform and "run with it" without the need to possess knowledge and working understanding of DSPs. "On the DSP side, there are four major codec engines – for imaging, speech, video and audio – we are providing. If the customer wants, however, they can use the ARM to run the codecs. But, if the customer wanted to access the DSP 'under the hood' then CodeComposer [the development tool] will allow that. We offer a lot of flexibility with this platform," said Jean-Marc Charpentier, DSP business development manager at TI.

Among the video codecs included in this platform are H.264 and H.263, MPEG-2 and MPEG-4, MP3, WMV9/VC1, AAC/AAC+ and G.711.

"With all the frameworks, operating systems, hardware components and device drivers that we've included in DaVinci, you won't need 50 engineers working on a product for a year any more to get it rocking," said Charpentier. "Before, customers had to run around to get all of these separately. We've simplified that. For example, with our pre-wired software codecs, development time is cut down to less than a month, compared to up to 16 months."

Isreali start-up develops fibre optic technology for flexible screens

Israeli start-up Oree has developed a technology that promises to replace back light units in laptops, televisions and mobile phones. It is based on a flexible, flat, three-ply fibre optic system and uses a new way of dispersing and preserving light.

Currently, the back lighting in larger LCDs typically uses a cold cathode fluorescent lamp (CCFL), which generates a lot of heat, is expensive and, often, low quality. In recent years, CCFLs have been replaced by light emitting diodes (LEDs). However, according to Oree's CEO, Eran Fine: "Current screens have trouble uniformly transmitting light from LEDs to every part of the screen to create a uniform picture. LEDs also require considerable energy and their efficiency is low."

The inefficiency stems from the light losing energy as it travels between the layers of the screen. The loss of energy, in turn, requires a more powerful source of light, which means a bigger battery and a larger LED. In addition, the dispersal of light within the plastic sheet that separates the screen from the LED is not completely uniform.

A part of a mesh module enabling the easy fabrication of a large area backlight unit for LCD screens, as prepared by Oree

Oree offers a different structure for the sheet, a new location for the LED and a unique method of dispersing the light within the plastic of the screen. The sheet in which the light is dispersed is built in the form of a three-ply fibre optic made from flexible polymers. The LED is placed in parallel to the sheet, instead of behind it, and most importantly, it is placed within the sheet, rather than outside it. In this way, the light only passes through one layer to disperse within the sheet, cutting energy loss by 30-50%.

Oree plans to integrate the LED directly inside the sheet, further reducing energy loss. This method should also shorten production procedures of screens, cutting costs further.

Another advantage of fibre optics is their elasticity and flexibility. Since the LED will be placed inside the fibre optic sheet, the light will still disperse uniformly, regardless of the angle in which it is flexed.

The company is at the pilot stage, manufacturing the sheet at laboratory level. The initial applications will be for televisions and mobile phones. It has already signed an agreement with a leading television manufacturer to test how the system functions when attached to the screen.

Shortage of polysilicon continues to affect industry

BP Solar Showcase, Birmingham, UK

Demand for photovoltaic systems continues to cause shortages of silicon for the semiconductor industry – the traditional user of this material.

Photovoltaic systems (solar cells) are growing in demand, due to the recent energy saving policies in the face of a new energy crisis. Countries like Japan and Germany have subsidies and incentives in place that fuel demand for such systems. Spain, for example, has gone a step further and made it a legal requirement to have solar cells installed in new builds. "Now, focus is on sustainable systems; you'll be buying systems that'll save energies," said Heinz Kundert, president of SEMI Europe, the global association of semiconductor equipment and material suppliers.

Although silicon is readily available (it is basically sand), it is expensive to purify into high-grade polysilicon required in the semiconductor and solar industries. "There's a shortage of polysilicon as sales boom. A lot of materials that used to go into semiconductors are now going into photovoltaics. Polysilicon makers have started to increase capacity, but are trying to be careful how they go about it," said Kundert.

The solar market is currently valued at $7bn and this industry has shown a sustained growth of up to 40% per year for nearly a decade. Prices for polysilicon have increased ten-fold to reach $80 per kilo at the end of last year. Certain industry observers claim that even though polysilicon prices are going up, the semiconductor industry can still afford them, but not necessarily the younger solar panel industry, where polysilicon constitutes 80% of the total cell's production costs.

Patented technique provides improved EDLCs

By the use of a unique patented manufacturing process, Israeli firm Cellergy has developed a small footprint, high frequency electrochemical double layer capacitor or EDLC, capable of storing large amounts of energy.

The development is based on an innovative printing technology that allows the inexpensive production of EDLCs in many different sizes with varied dimensions and shapes. Device footprints start from 11 x 11mm, with capacitances of between 18mF and 1.2F and ESRs down to a mere 10mΩ.

Film capacitors store charge by means of two layers of conductive film that are separated by a dielectric material. The charge accumulates on both conductive film layers, yet remains separated due to the dielectric between the conductive films.

Electrolytic capacitors are composed of metal to which is added a thin layer of non-conductive metal oxide, which serves as the dielectric. These capacitors have an inherently larger capacitance than that of standard film capacitors. In both cases the capacitance is generated by electronic charge and, therefore, the power capability of these types of capacitors is relatively high while the energy density is much lower.

The EDLC or Super Capacitor is a form of hybrid between conventional capacitors and a battery. The capacitance, coined the "double layer capacitance", is the result of charge separation in the solution/solid interphase. On the solid electrode, electronic charge is accumulated with its counter charge gathering in the solution in the form of ionic charge.

The production process involves a printable aqueous electrode paste based on a high surface area carbon paste that is printed in an electrode matrix structure on an electronically conductive film. The electrodes are then encapsulated with a porous ionic conducting separator and another electrode matrix is then printed on the separator.

The finished wafer is then cut into individual EDLCs that are then packaged. The combination of the separator and carbon paste lead to the capability of very high power bursts within low millisecond pulse widths, as required in digital cameras, for example.

The technology will enable assimilation of the low ESR capacitor into a number of applications in which electrochemical capacitors have never before been integrated, such as laptop computers and mobile telephones.

TOP 10 TIPS

How to apply for a patent

- Patents are a crucial way of staking your claim on an innovation, but as with all tools, they are only useful if you take care over your application.

- If you think you have developed a new electronic device or process, a patent will give you the right to prevent anyone from making, using, selling or importing your invention for up to 20 years.

- During your research and development, search a patent database to make sure that someone else hasn't already patented something very similar to your idea. Repeated efforts can be very costly in terms of time and money. The Patent Office and the British Library offer commercial services, or you can use the services of a patent attorney.

- If you are satisfied that your idea is novel and want to file a patent, remember to keep your innovation a secret: non-confidential disclosures can harm a later application.

- In terms of cost, the Patent Office's fees to take an initial application to grant (typically 2-4 years) are just £200. The advice of a patent attorney will be several times this amount, but could prove invaluable in securing the strongest protection possible for your invention. Your application must describe your invention and its operation clearly and completely.

- If you want protection for your electronic innovation in overseas markets you will need to make patent applications for these within one year of your UK filing date. You may have to use patent attorneys for these countries as well.

- Your UK patent application is usually published by the Patent Office 18 months after your initial application, so everyone can read your invention's secrets. If the Patent Office believes your invention is novel and inventive, and grants a patent for it, your patent could become a useful tool for striking a licensing deal or attracting further investment.

- Last year, the UK Patent Office granted 10,541 patents of which 521 related to electric circuit elements and magnets, 287 to electric power, 178 to electronic circuits and radio receivers, and 1,700 to telecommunications.

- For more information about patenting, visit the Patent Office website at **www.patent.gov.uk**

- For more information about patent attorneys, visit the Chartered Institute of Patent Agents website **www.cipa.org.uk**

Miles Rees, Business Development Manager at The Patent Office, supplied this month's top ten tips.

If you'd like to send us your top five or ten tips on any subject, please write to the Editor at **EWadmin@nexusmedia.com**

Freescale manufactures 24Mbit nanocrystal memory

Freescale has manufactured the world's first 24Mbit memory array based on silicon nanocrystals. This type of non-volatile memory is denser, faster and more cost-effective than conventional flash memory and, as such, it's likely to replace conventional floating gate-based flash memories.

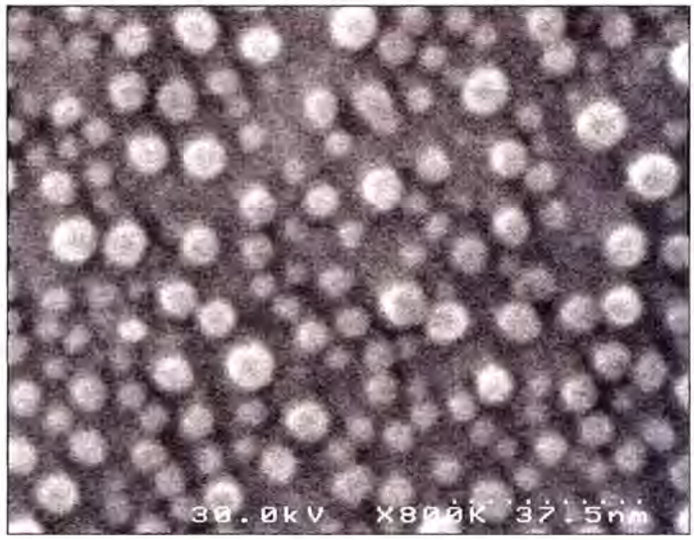
According to the company, silicon nanocrystal technology offers lower operating voltages, reduced memory module size, simpler process flow and lower manufacturing costs.

Additionally, it requires no new materials or wafer fabrication equipment, allowing for immediate compatibility with existing production wafer fabs.

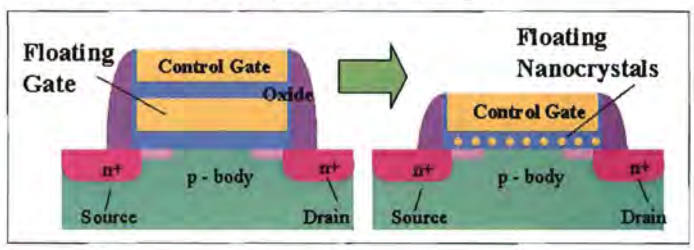
Embedding floating gate-based flash becomes more difficult to produce cost-effectively at geometries of 90nm and below. At those dimensions, the chip area consumed by the 9-12V high-voltage transistors required to write and erase the conventional flash module cannot be scaled down. Furthermore, engineers cannot reduce the high voltage in floating gate based flash without compromising reliability or risking memory failures and loss of data.

"The industry anticipates that conventional embedded flash memory technology will reach its scaling limit within the next four years due to high-operating voltages, fabrication process complexity and cost," said Dr. Claudine Simson, Freescale's chief technology officer.

Silicon nanocrystal memories are part of a new class of memories called thin-film storage. They are more scaleable than conventional floating gate-based flash technology, as their tunnel oxide thickness can be reduced without impacting data retention. The charge is stored on isolated nanocrystals and is lost only from those few nanocrystals that align with defects in the tunnel oxide – while the same defects would result in significant charge loss from a conventional floating gate. A thinner tunnel oxide permits lower-voltage operation, substantially reducing the memory module area needed to generate the bit-cell programming voltages and allowing for significant wafer processing simplifications and manufacturing cost reductions. The combination of higher bit density and reduced cost translates to lower cost per bit to embed silicon nanocrystal memories.



Freescale's new silicon nanocrystal memory structure; **Above:** under the microscope; **Below:** block diagram



Freescale has manufactured the 24Mbit memory array technology using 90nm CMOS bulk technology. During the fabrication process it had to overcome several major challenges, including a uniform depositing of the silicon nanocrystals and keeping the nanocrystal properties intact during subsequent processing.

SEE PAGE 62

A Call for New Wave PMR

Mike Norfield of Team Simoco analyses if the days of PMR are over

The digital revolution seemed to pass the private mobile radio (PMR) industry by. Instead of seizing the opportunities created by advances in silicon and software, PMR stood back and watched the computer boys eat our lunch. Analogue cellular came, then GSM. Then the Internet and voice over IP came and converged, offering rich media services on both, the PC and mobile cellular platforms. PMR continued to plough its lonely furrow, eschewing these newfangled technologies like they would never catch on.

Indeed, over the 1990s, a large chunk of the PMR potential user-base was lost to cellular, which in terms of technology sophistication had the edge. If it was a technology race, PMR would have disappeared without a trace. Fortunately, although it fell behind in technology, there are a number of compelling reasons why PMR survived and why it will continue to thrive in key market sectors.

Try telling an airport operator or a police chief constable that you are going to put all their communications on a public network. You will get a very short shrift, indeed. What if the network shuts down when everyone is calling to wish each other a happy new year? Public technologies like cellular simply cannot guarantee the same service levels and security as a private radio-based network.

With terrorism being on top of the public safety agenda and open networks like cellular getting more driven by revenue earners like ring tones and even streaming video, which make ever greater demands on bandwidth, it is unlikely that private radio networks will be replaced in the near future.

The introduction of the Tetra digital radio standard was to give customers some of the advanced features of cellular but with the security of a private network. So, you can stream video, you can send CCTV pictures, plus give better quality of voice. But, the shortage of licences and the relatively high cost means that Tetra currently only addresses the emergency services and transport markets.

The PMR sector has found its own niche by default. Demand for the advanced service has been driven by the public networks but people can now see the benefits of them on PMR. Plus, PMR has an overwhelming cost advantage over the longer term. Once you have installed the system, your calls, data and rich media content are all free. A public network would never be able to compete with this. They have to recover their capital and operating costs through service charges in one form or another.

So having secured its niche, PMR now needs to seize the opportunity presented by new technology to deliver advanced services. This doesn't mean offering ring tones and wallpaper on your handheld systems but, rather, delivering advanced services that will benefit the operator. Tetra addresses the higher end, such as public safety and emergency services, but what about the small to medium sized business end of the market? They too want advanced features.

Strangely, an opportunity to achieve this came about with the introduction of the RoHS and WEEE directives. PMR had to upgrade its technology in order to stay in business. We had a choice to spend millions of pounds to upgrade, just to stay compliant, and, effectively, stand still. Alternatively, we took the opportunity to make a quantum leap and upgrade the technology to take advantage of plug-and-play, IP compatible, software configurable, standard components. Just like the rest of the IT industry.

With various initiatives abound, this industry now has the low capital cost and flexibility advantages of analogue PMR, but with the system management and low cost of ownership benefits of digital. With our own Xfin technology, we can call up a base station over the Internet and reconfigure the controller, without having to send a technician to a remote, windswept hilltop. With digital technology, the PMR industry can offer standard services, such as call logging and teleconnect, which, not so long ago, used to be expensive extras. Such advances will help meet the expectations of a new generation of customers who are used to buying a home computer from PC World that comes already loaded with all the applications they could ever need and even gives them an Internet service thrown into the bargain.

The really exciting prospect for "new wave" PMR is the ability to deliver services to markets that have been completely left out by the cellular business. In Africa, for example, there's a PMR network for a national railway that will be using IP addressable base stations. These can now be connected via WiMax instead of microwave, with Wi-Fi at each location, delivering broadband Internet to the rural community. Only PMR could do this. Cellular is not cost-effective for remote parts of Africa, which are poor and sparsely populated.

There is a great future for PMR if the industry takes on board new technology to bring down costs and deliver the new services that customers will start demanding as standard. We have been paddling in the shallows for far too long. It's time we took heart and started surfing the new wave.

Mike Norfield is Team Simoco's Managing Director, based in the UK.

Nokia unveiled the N92, as part of the Nseries launch

Eyeing Up a Pot of Gold

By John Walko

Interest in delivering TV to mobile phones and other handheld media players exploded in 2005, first with streaming services over third generation networks, followed by numerous trials of dedicated mobile broadcast networks. Then, in November 2005, Nokia, with much fanfare, demonstrated a phone capable of receiving mobile broadcast TV, dubbed the N92, with an innovative design, using a hinged 2.8-inch display that lets the device sit on a table like a portable DVD player or twist into an LCD viewfinder like a handheld video camera.

Nokia's launch underscores a still uncertain rollout and future for the Digital Video Broadcast-Handheld (DVB-H) version of the mobile broadcast technology. DVB-H is being tested in about 20 pilots in Europe, the US and Korea, but, to date, no network operator has committed to a live service.

That has not stopped them enthusing about it, however. For instance, Sanjiv Ahuja, CEO of UK mobile operator Orange, said that trial results indicate "live TV is really capturing [our] customers' imagination".

While the market researchers are as enthusiastic as the operators and content providers, it is not a given that TV over mobile will turn out to be a workable consumer proposition, once the introductory offers are withdrawn and the novelty has faded. Just ask Sir Clive Sinclair!

One problem with this emerging – some suggest 'killer' – application for next generation mobile networks is that it is beset with protagonists pushing incompatible and, even, proprietary standards. Not surprisingly, there are also regional regulatory concerns, not least the fact that in Europe at least, the spectrum for delivering DVB-H is currently owned in the main by broadcasters rather than mobile network operators.

And while IC makers, mobile network operators and handset and PDA suppliers are eyeing a pot of gold, political intrigues could jolt the most optimistic forecasts about the impact of mobile TV. For it seems clear that the sector will, at least in the early days, remain fragmented.

Lining up against each other and backed by disparate groups, we have terrestrial and satellite delivered versions of South Korea's DMB (Digital Media Broadcast), which is based on the Eureka Project 147's digital audio broadcast (DAB) technology; the European developed DVB-H version of the DVB-T (terrestrial) specification; and MediaFlo, a proprietary format being pushed by American mobile chip maker Qualcomm. Qualcomm has secured licences in the US for (700MHz) UHF channels and plans a nationwide network of broadcast towers to deliver TV to mobile phones, quite separately from the cellular systems, relieving operators of the potentially huge congestion concerns.

> *"It is clear that no one company, however large, will dominate the silicon market for mobile TV"*
> Anthony Sethill, founder and CEO, Frontier Silicon

DMB has taken off in South Korea, but DVB-H is coming up fast on the outside, with small scale deployments planned for next year (with the World Cup starting in June in Germany – a target for many to showcase the technology) and massive rollouts to follow in 2008.

The major stumbling block is that while, in principle, DVB-H is designed for use in numerous UHF frequency bands, there is currently no consensus on which is the best option – Band III, IV or V. At least in the US, it is a given that the tuner for the commercial service Crown Castle plans to start this year will operate in the L-band (1670 to 1675MHz). Crown Castle has a massive trial running in Pittsburgh at the moment.

These differences and options are creating both an opportunity and a concern for all involved, not least the semiconductor makers targeting mobile TV. Well established chip suppliers include Texas Instruments (TI), Philips Semiconductors and

Samsung, but there are also a number of innovative, fast moving start-ups who plan to make their mark.

Perhaps, furthest down the road to delivering silicon is Palaiseau, France-based DiBcom, which at the 2005 3GSM Congress in Cannes demonstrated a demodulator chip complying with the DVB-H specification, functioning on a PDA. The company says that it is at least a year ahead of others with an IC suitable for demodulating DVB-H, as well as DVB-T transmission, and which can work with tuners from either Freescale Semiconductor or Microtune. The part represents a 'fourth generation' device for the company, which has been selling DVB-T only demodulators since 2004.

Success at the silicon level in this market is not straightforward, however. Mobile TV is based on complex technology with large amounts of signal processing required, coupled with computational demands that are not needed for normal TV reception. Systems and handset makers will be looking for total solutions that will require strategic partnerships. A turnkey design will typically comprise an antenna, RF interface, tuner, demodulator and channel decode processors.

DiBcom is lucky and astute as amongst its investors are potentially key-partners too, such as Intel and UMC, the latter being the main foundry for the devices. In addition to numerous venture capital groups, earlier rounds also included funding from Motorola's venture arm, whose interest has now passed to another partner, Freescale.

"We targeted mobile TV right from the start, which is one of our main strengths, building on experience gained from devices for the automotive sector with chips for DVB-T reception. This gave us an excellent insight into the technical and marketing expertise needed for, what we believe, will be the much bigger market of demodulators for use in mobile phones and a host of other mobile devices," said Yannick Levy, president and CEO of DiBcom.

Levy suggests even TI, with its proven RF and silicon expertise will have problems meeting the performance and low power characteristics of DiBcom's fourth generation processor, "and we are clearly ahead of them in terms of having the parts field tested". TI is planning to develop the Hollywood decoder/tuner combo device for this market.

"So far, we can only publicly discuss Siemens as a user of our DVB-H chips, which is supplying Vodafone for one of its trials, although there are many others looking at the part. The recent investment from Intel will work wonders for us in marketing the parts for use in PCs and laptops," added Levy.

TI announced its Hollywood single-chip device in late 2004. It will integrate a tuner, OFDM demodulator and the channel decoder processor. This is expected to be available in volume in late 2006. It is claimed that the device will deliver video at 24 to 30 frames per second with high quality audio.

Not surprisingly, Philips is also leveraging its RF expertise to develop a single-chip mobile TV tuner/receiver that initially will sample as a system-in-package. Philips claims its part will have a power consumption of less than 40 milliwatts when operating in DVB-H mode, while consuming less than 300mW in DVB-T mode.

Watford, England-based Frontier Silicon is challenging the mobile TV space from a slightly different perspective, that of an established and market leading supplier of silicon for DAB radios. Founded in 2001 and using basic technology licensed from Imagination Technologies, the company has already developed receiver chips for terrestrial DMB and is now readying a multi-standard and multiband integrated tuner and baseband SoC, dubbed Kino 3.

Anthony Sethill, founder and CEO of Frontier, says DMB is already a big money earner for the company, with "several tier 1 handset makers choosing our solution".

"DVB-H, because of regulatory issues regarding spectrum, could be a longer-term play, perhaps three to four years for real volume, but what is clear is that no one company, however large, will dominate the silicon market for mobile TV. There will be room for several players as handset makers will look to offer different platforms, but clearly, as we have seen in other markets such as Bluetooth, we can also expect some consolidation down the road," he added.

Israeli start-up Siano Mobile has already started sampling a CMOS integrated, multi-standard receiver chipset that, it is claimed by the firm, scores over competitors in low power consumption. The part combines a quad band zero-IF CMOS RF tuner and a demodulator supporting DVB-H, DVB-T, DAB, Enhanced Packet Mode DAB and T-DMB standards, and uses a processor core from ARC International on the demodulator side.

With all this innovation at the chip level, the debate now needs to shift from "Who would ever want to watch TV on their mobile phone?" to some equally important real-world implementation issues. At the top of that list must be frequency allocations and availabilities, network planning, infrastructure costs and, on the handset side, power consumption issues.

The Cause of Flicker in LCD Screens

Donald LaFontaine, **Mike Wong** and **Tamara A. Papalias** state that contrary to popular belief, LCD panels do exhibit flicker, but simple potentiometer adjustments can be made to minimise the effect

When comparing CRT to LCD screens, one of the most popular differences is the issue of flicker. It is a common assumption that CRT screens flicker while LCD screens do not. In truth, both screens have some amount of flicker. The mechanisms are different and methods for correction have varying amounts of success. This article presents the cause of flicker in LCD screens and offers a solution for avoiding flicker in LCD panels.

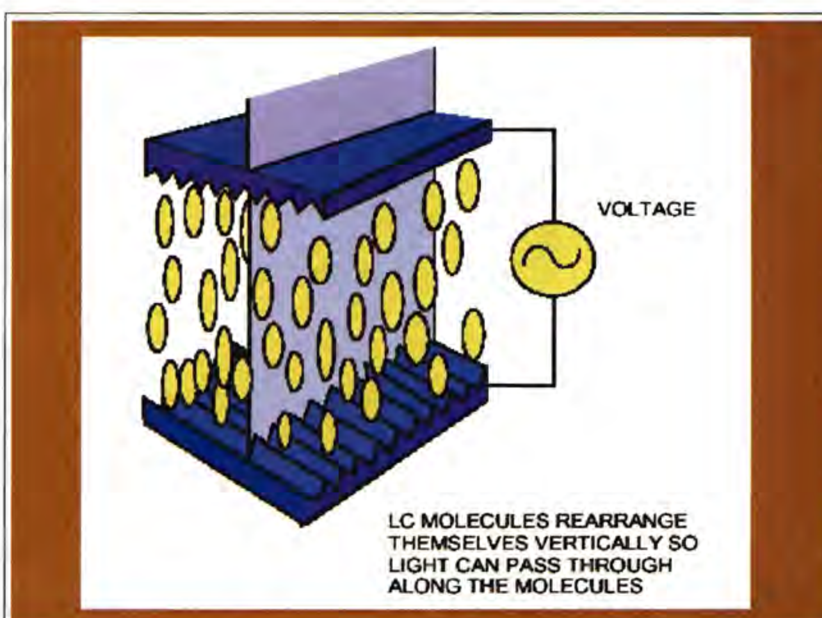
LCD technology

Liquid crystal displays (LCDs) appeared in 1973 in calculator displays. These first LCDs were screens embedded with 7-segment units, allowing numbers to be displayed. Each segment was driven by a separate control line. The next generation of LCDs appeared in 1980. They were dot-matrix displays, allowing characters and graphics in addition to numbers, like simple monochrome computer screens or the popular toy, "the electronic pet". These matrix designs allowed control of pixels by activating a row and column of the array, instead of a separate control line for each pixel. By the end of the 1980s, colour filters were being successfully and cost-effectively included within the LCD design. Since then, generations of products have focused on the growth of screen size, the weight of the monitor, power efficiency and viewing angle.

While improvements continue, the basic operation of an LCD screen remains the same. LCD screens have an array of pixels constantly illuminated by a backlight. The constancy of the light removes the type of flicker found in CRT screens (phosphors pulsing with each refresh cycle). Instead, an LCD pixel has upper and lower plates with grooves cut perpendicular to each other as in **Figure 1**. These grooves align the crystals to form channels for the backlight to pass through to the front of the panel. The amount of light emitted depends upon the orientation of the liquid crystals and is proportional to the applied voltage.

The upper and lower plates are polarised perpendicular to each other. The voltage between the plates aligns the liquid crystal in a twisted pattern to match the polarisation of each plate. Light from the backplane is delivered through the aligned liquid crystal elements. Conversely, light is scattered when the liquid crystals are not aligned. The amount of alignment is proportional to the applied voltage and serves to control the intensity.

The external plate is coated with a colour (RGB) filter. A red, green and blue area (each called a subpixel) is included within each pixel. The area associated with each colour is addressed separately, allowing a full range of colours and intensities to be displayed. The number of pixels determines the resolution. **Table 1** presents the pixel-array size for a variety of video formats. Note that the numbers for pixel-array size do not convert directly into aspect ratio for the screen since the pixels are not typically square.



Cause of LCD panel flicker

Flicker in an LCD panel is different from a CRT screen. LCD flicker exhibits itself as washed out colour rather than pulsating light, as shown in **Figure 2** (**a** and **b**). Figure 2a is an LCD panel that has been adjusted to reduce flicker and Figure 2b is an LCD panel with excessive flicker. This is because of higher refresh rate of the LCD panel up to 300Hz.

The circuit driving a single LCD pixel is shown in **Figure 3**. The gate voltage acts as a switch and is commonly amplified to become -5V to 20V. The video source, typically ranging from 0V and 10V, provides the intensity information that appears across the pixel. The bottom of the pixel is commonly connected to the backplane of the panel. The voltage at this node is Vcom.

While this set-up is functional, it reduces panel lifetime. Assuming the Vcom voltage is at ground, the voltage across the pixel varies from 0V to 10V. Assuming an average of 5V, there is substantial DC voltage across each pixel. This DC voltage causes charge storage, or memory. In the long term, it is a form of aging, degrading the pixels by electroplating ion impurities onto one of the electrodes of the pixel. This contributes to image retention, commonly seen as fading colour on older TFT-LCD panels.

The construction of the LCD panel is symmetrical (Figure 1) and either a positive or a negative voltage can be used to align the crystals. One can capitalise on this aspect by moving the common voltage (Figure 3) to the midpoint of the video signal, 5V. Now the video signal swings above and below the common voltage (Vcom), creating a net zero effect on the pixel. This net zero effect on the liquid crystal eliminates the aging and image retention issues. The trade-off for this technique is resolution, since the video signal travels 5V to full brightness instead of 10V.

To achieve a net zero effect on the display, different inversion patterns can be utilised across an LCD (**Figure 4**). The simplest type is frame inversion. With this driving method, every pixel on the screen is inverted in each subsequent frame. Frame inversion creates a net zero effect with respect to time on the pixels. Two additional methods include inversion within each frame. Line inversion alternates the phase on each horizontal line. An alternate form of line inversion, called line-paired inversion, applies a common phase to pairs of horizontal lines instead of single lines. Dot inversion inverts the phase to every adjacent pixel, like a checkerboard. These three methods also create a net zero effect with respect to time on the pixels. The inversion pattern is chosen by the manufacturer and embedded within the driving circuitry. In all cases, the inversions alternate with each frame displayed.

Table 1: Pixel-Array Size for Various Video Formats

Video format	*Pixel-array size*
VGA	640 x 480
SVGA	800 x 600
XGA	1024 x 768
WXGA	1365 x 768
HDTV – CIF (common-image format)	1920 x 1080
PAL	720 x 576
PAL – CIF (common-image format)	352 x 288
NTSC	720 x 480
NTSC – CIF (common-image format)	352 x 240

The Vcom voltage needs to be placed exactly at the midpoint of the video signal to avoid flicker. To illustrate why a panel will flicker, let's assume that due to manufacturing of the panel the Vcom is 5.5V. If the video signal swings between 0V and 10V, the full-scale voltage will be different on each field. On one field, the full-scale voltage will be 4.5V and on the other, the full-scale voltage will be 5.5V. This difference in full-scale voltage translates to a difference in intensity, experienced as flicker.

Figure 2: Visual example of flicker in an LCD panel
(a) (Left): LCD panel with optimised flicker
(b) (Right): LCD panel with excessive flicker

Figure 5 shows the difference in a panel's light intensity with and without flicker. The (black) trace with the larger DC level is the measurement of a panel without flicker. The measurement was made using an EL7900 light sensor. The light sensor converts light intensity to current. Larger current produces larger voltage deflection on the scope.

In order to understand these results you first need to know there are two types of LCD panels, 'white' panels and 'black' panels. White panels allow light to pass through the crystal in the relaxed (no voltage applied across the crystal) state and black panels block all the light in the relaxed state. As the voltage potential across the crystal is increased, the crystal rotates and either blocks more light (as in the white panel case) or allows more light to pass through (as in the black panel case). The panel tested was a white panel and, therefore, the more voltage you have across the crystal the darker the panel. If the Vcom voltage is set exactly in the middle (no flicker), then the average AC voltage is zero and the panel will be at its brightest. If the Vcom voltage is not in the middle, then the resulting AC voltage will be higher and the panel's luminance will be darker.

The washed-out colours in Figure 2b are the result of the error voltage across the crystal due to the imbalance of the Vcom voltage and not the over all intensity of the light.

Methods to eliminate LCD panel flicker

Due to the variations in construction of each panel, the optimal Vcom voltage can differ from panel to panel or across a single panel. Original equipment manufactures must, therefore, adjust each of the panels coming out of the factory to eliminate flicker. For small screens, where the backplane can be considered a low-impedance ground, a single potentiometer can be added for common voltage adjustment. Traditionally, this was achieved by using mechanical potentiometers that required additional man-hours. This is acceptable for small panels, even though it is big in size, has low precision and could easily break during assembly, requiring the replacement of the whole module. For panels exceeding 19", the backplane cannot be considered a single low-impedance node. Multiple corrections are needed in various locations of the screen. There may be up to five localised compensation networks, four in the corners and one in the center. In this case, Digitally Controlled Potentiometers (DCPs) allow the manufacturer to automate the process, a necessity for larger panels where a manual adjustment is not practical. **Figure 6** (**a** and **b**) illustrates the mechanical and digital controlled potentiometer solutions.

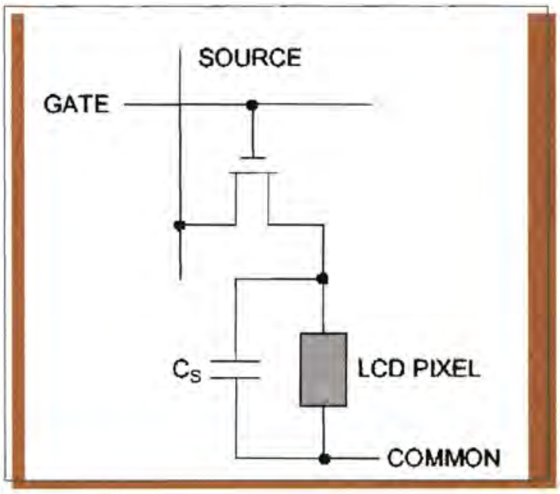
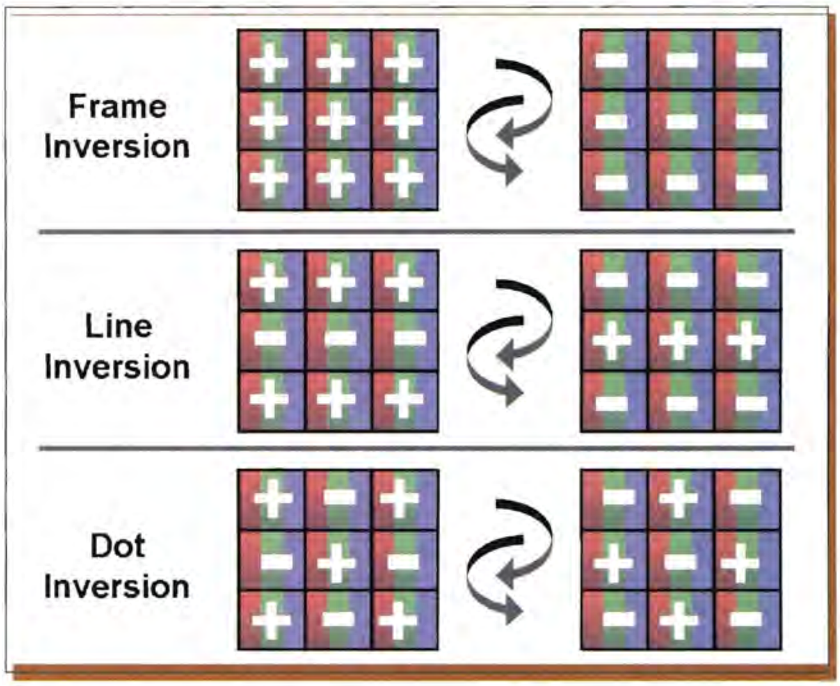
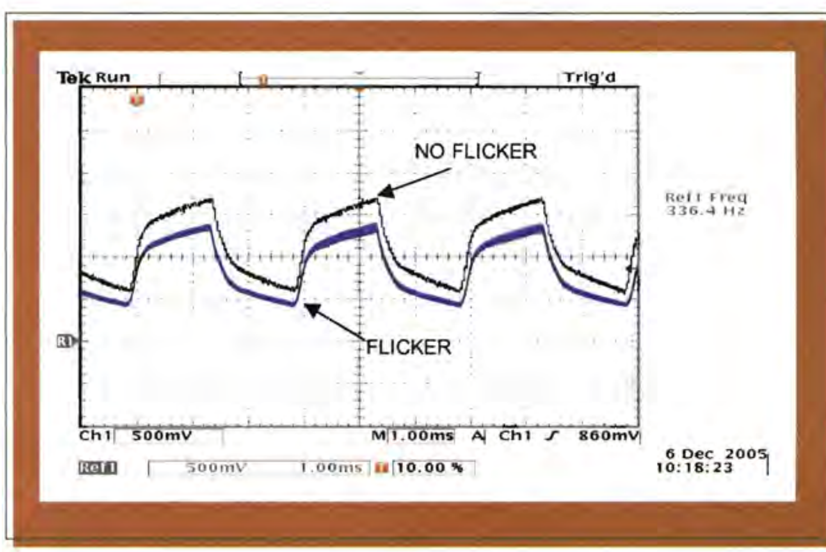


Figure 3 (Right): Circuit diagram for single LCD pixel

Figure 4 (Middle): Distribution of the phase of LCD pixels for the alternating frames for three types of inversion: frame inversion, line inversion and dot inversion

Figure 5 (Bottom): Measurement of a panel using EL7900 light sensor W/WO flicker





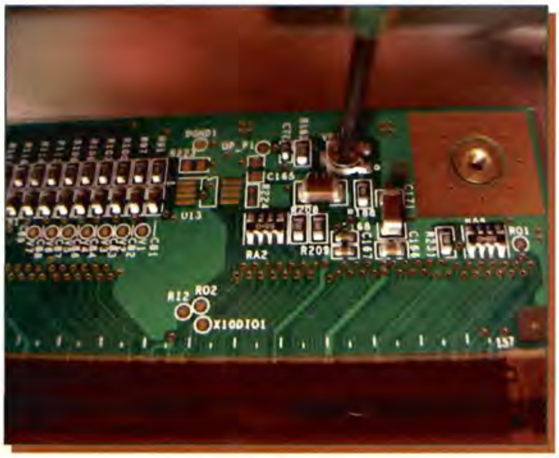


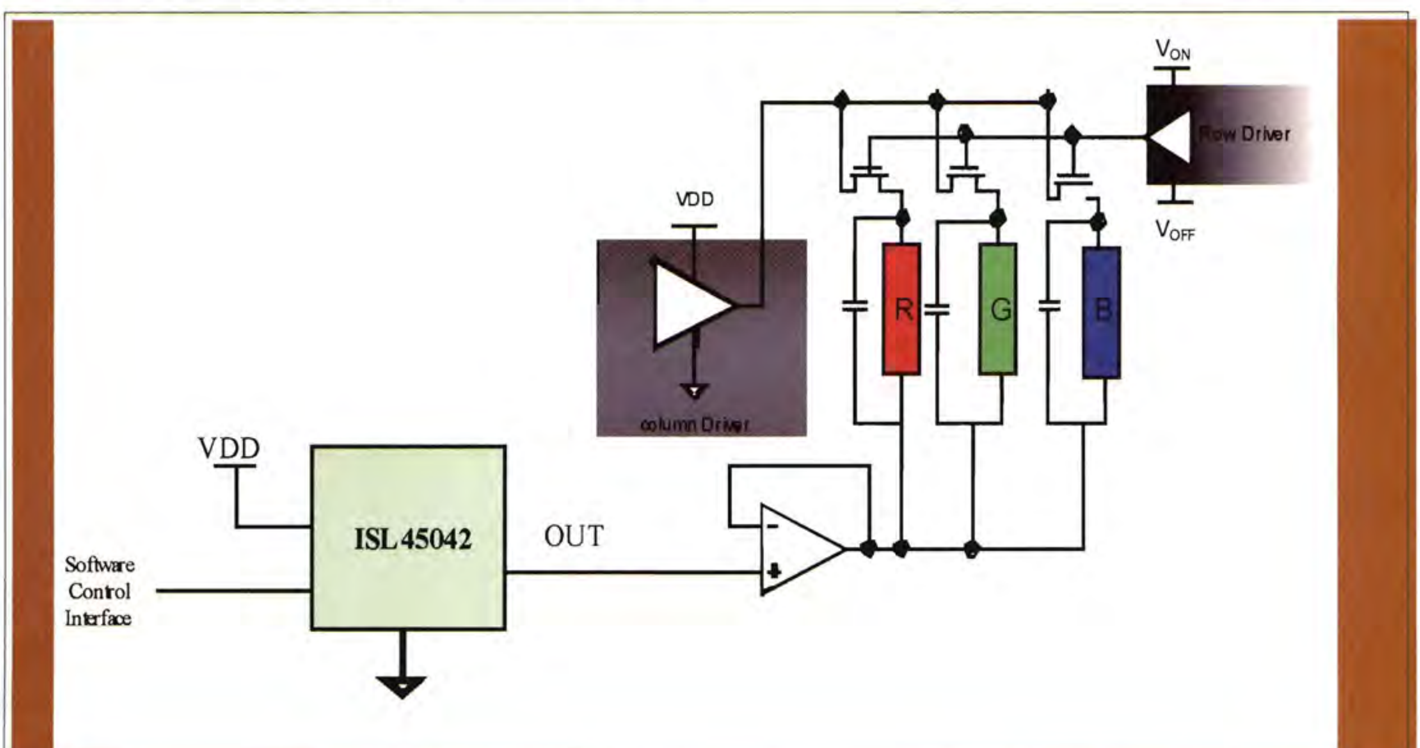
Figure 6: Vcom adjust using a potentiometer or digital controlled potentiometer
(a) (Left): Vcom adjust using a potentiometer
(b) (Right): Vcom adjust using a digital controlled potentiometer

The system implementation and conversion from a mechanical POT to a DCP is simple. **Figure 7** illustrates the system application implementation of a buffered DCP Vcom driver. The ISL45042 is a current output, non-volatile DCP that can operate with an AVDD of up to 20V. The ISL45042 uses a two-wire, up and down interface. It is an extremely accurate 7-bit device with a resolution of 128 steps. The desired Vcom value can be stored in an on-board EEPROM. The digital circuit voltage range is from 2.25V to 3.6V, this enables it to interface with many controllers used today. The analogue voltage supply, running the analogue resistor ladder of the device, can operate from 4.5V to 20V. This is an important characteristic for small panels that typically require less than 10V of analogue supply, as well as the large panels that may require supply greater than 15V. The DCP output voltage is buffered to the Vcom bus through the EL5111 (180mA output current) amplifier.

Contrary to popular belief, LCD panels do exhibit flicker. Simple potentiometer adjustments can be made to minimise the effect since LCD flicker arises from an offset of the common voltage, not a refresh signal.

As LCDs grow in popularity and in size, manual adjustment of a single point on the backplane is no longer possible. Using ISL45042 DCP and EL5111 Vcom buffer allow automatic correction of Vcom offsets at multiple sites on the backplane.

Figure 7: DCP software-programmable Vcom implementation



Plasma Displa

Much has to be done following reception of a conventional video signal, whether analogue or digital, to generate drives that are suitable for a plasma display panel. This also applies to baseband-video inputs. By Fawzi Ibrahim

Plasma display panels can accept video signals from various sources – tuners, scart sockets for external composite and RGB video inputs, and S video inputs. The video signal is then fed to an input switching arrangement that selects input(s) for further processing and switching. See **Figure 1** for the basic video processing system in a plasma TV receiver.

The colour decoder separates the luminance and chrominance components of the composite video signal using a comb filter, and produces RGB video outputs. These are fed to an analogue-to-digital converter (ADC) that encodes each primary colour signal as an 8-bit digital signal, ready for passing to the display formatting section.

The comb filter

For analogue TV transmission, the picture's colour content (the chrominance signal, C) modulates a 4.43MHz subcarrier whose sidebands fit neatly within those of the basic luminance signal (Y) (see **Figure 2**). Separation of the Y and C components of the demodulated video signal must be as clean as possible to avoid high-frequency luminance information being contaminated by colour information and, conversely, colour being contaminated by luminance, otherwise this gives rise to 'rainbow swirls'.

Traditionally, notch filters are used for Y and C signal separation. A much more effective method, however, is to use a digital comb filter. There are several types of comb filter, all of which use the fact that the chrominance signal is phase-shifted by 180° on alternate lines.

The two-line (2L) comb filter mixes two consecutive lines of video information and takes the average. The two lines are added to produce the chroma information and subtracted to produce the luminance information. It's assumed that the two lines are much the same.

This type improves the horizontal resolution and reduces rainbow swirls.

The three-line (3L) comb filter uses three consecutive lines, giving the first one half weight, the second one full weight and the third one half weight. Differences in line content are in this way reduced. If all three lines are identical, the result is perfect. It provides better resolution than the 2L type.

The two-dimensional three-line (2D-3L) comb filter uses three lines in the same way as the 3L type, but the weighting allocation to each line depends on how similar the lines are. If all three lines are identical, the 3L weighting is applied. Otherwise, the weighting is varied. It's called two-dimensional because the mixture is varied vertically.

The 3D (motion-adaptive) comb filter senses motion between one field and the next (hence three-dimensional) and adjusts the weighting given to the lines accordingly. If there is no motion, 2D filtering is used. This type of filter requires a large memory so that adjacent frames can be stored.

ay Technology

Signal manipulation

The luminance and chrominance signals are sampled and converted into 24-bit video, consisting of three separate 8-bit groups for each primary colour, R, G and B. Each colour has a grey scale of 256. The total number of colours is thus 256 x 256 x 256 = 16.78 million.

When it comes to video formatting (see its main elements in **Figure 3**), the received video is interlaced, so the first task is to de-interlace it, normally carried out by the I/P (interlaced/progressive) converter. The process involves the creation of new scan lines between the original successive ones of an interlaced frame. Several techniques can be used, from very simple line repetition to very complex variations of interpolation and motion adaptation. Some sort of filtering is desirable to smooth out high-frequency artefacts, caused by creating abrupt frame transitions.

With simple intra-field I/P conversion, data from the same field is used, e.g. by repeating the previous line or creating a new line that's an average of two successive odd lines in an odd field or two even lines in an even field. The disadvantages of these methods include horizontal line flicker, still area flicker and low resolution.

Inter-field conversion data from odd and even fields can be combined, which involves two or more fields. Referring to the current one and the one in the previous and/or next field creates new lines. This method doesn't take into account motion between fields. As a result, a 'tearing' effect may appear in areas with movement.

The motion-adaptive method uses either intra- or inter-field conversion depending on the motion between successive interlaced fields. By comparing successive fields, a 'motion value' is produced. This is used to determine the 'bias' toward an intra- or inter-field conversion. Motion detection and estimation are thus critical.

With the motion-compensation method the picture content of successive fields is analysed to find out whether there is motion from one field to the next. If motion is detected, a full frame is woven into the intervening scan lines.

Image scaling

Once the video has been de-interlaced, a scan-rate conversion process may be necessary to ensure that the input frame rate matches the output display-refresh rate. To equalise the two, fields may need to be dropped or duplicated. As with de-interlacing, some sort of filtering is desirable to smooth out high-frequency artefacts, caused by creating abrupt frame transitions.

The purpose of image scaling is to convert the incoming signals, which may be NTSC, PAL or computer-generated VGA, into a form suitable to feed the fixed-format display panel, which in turn may be standard- or high definition. Video scaling is very important, as it enables an output stream of different resolution to the input format to be generated. The only way to avoid image scaling is to crop the image to fit within the confines of a smaller panel. This is the cheapest approach, but is not very satisfactory.

Depending on the application, scaling can be either upwards or downwards. It's important for the scaler to be able to distinguish between purely video content and non-video elements such as text. Failure to do so would distort the non-video parts

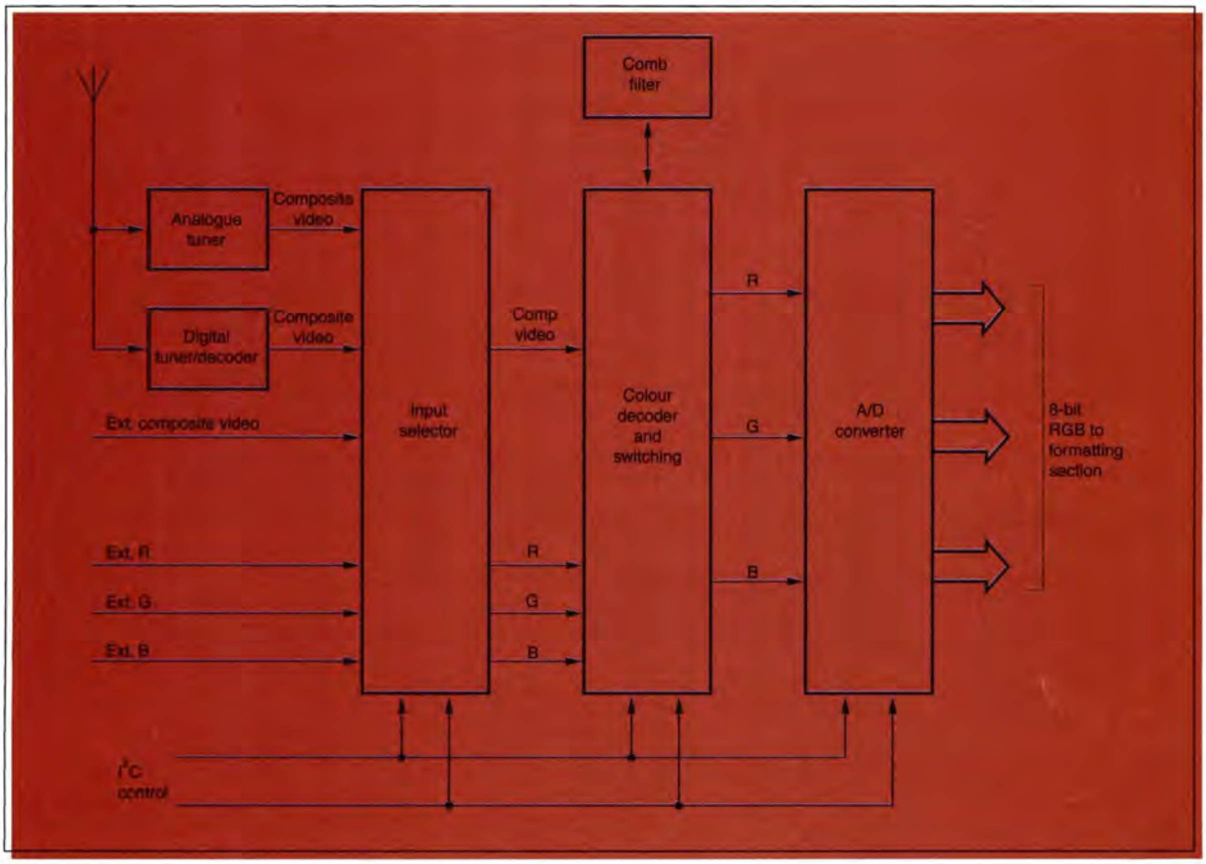


Figure 1 (Left): Basic video-processing arrangement in a plasma TV set

of the display, making text unreadable, or cause some horizontal lines in the scaled image to disappear.

The simplest scaling methods consist of either dropping or duplicating original pixels. For example, when scaling down to a lower resolution, a number of pixels along each line and/or a number of lines per frame are discarded. While this is a low processing load, the results will produce aliasing and visual artefacts.

A small step upwards in complexity uses linear interpolation to improve the image quality. For example, when scaling an image down, interpolation in either the horizontal or vertical direction produces new output pixels to replace initial ones. As with the previous technique, information is still lost so artefacts and aliasing will again be present.

If image quality is paramount, there are ways of carrying out scaling that avoid reduced quality. These methods endeavour to maintain the high-frequency content of the image, consistent with the horizontal and vertical scaling, while reducing the aliasing effects. For example, consider an image being scaled by a factor of Y x X. To accomplish this, the image could be up-sampled by interpolation by factor Y, filtered to eliminate aliasing, then down-sampled by decimation by factor X. These two sampling processes can in practice be combined within a single multi-rate filter.

Digital video interface (DVI)

One of the problems of transferring data at a high bit rate is the bandwidth required. For example 24-bit, 1280 x 1024 resolution video at a refresh rate of 50Hz requires:

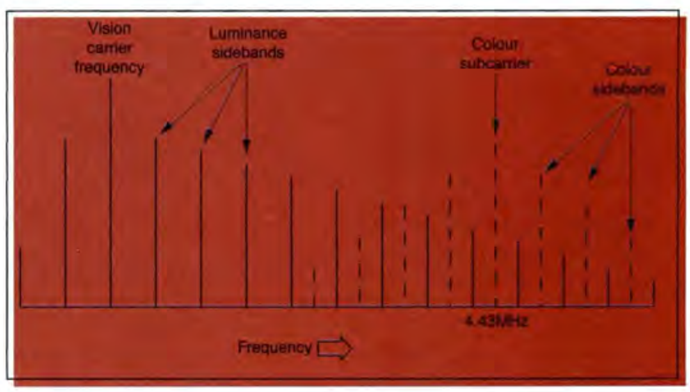


Figure 2: Interleaved luminance and chrominance sidebands with a PAL colour transmission. The side frequencies cluster around multiples of the line frequency

1280 x 1024 x 24 x 50 = 1.57Gbit/s

The normal RS-422, RS-485, SCSI and other interfaces have limitations, in terms of bandwidth and interference, which make them unsuitable for use as connectors to an LCD or a PDP screen. Hence, the need for an interface that's capable of handling such data rates, with low power consumption and low interference. This is what the DVI specifications provide. There are two main types of DVI: DVI-D for digital only and DVI-I for both digital and analogue signals.

Three main techniques are in use: LVDS (low-voltage differential signalling), PanelLink and TMDS (transition-minimised

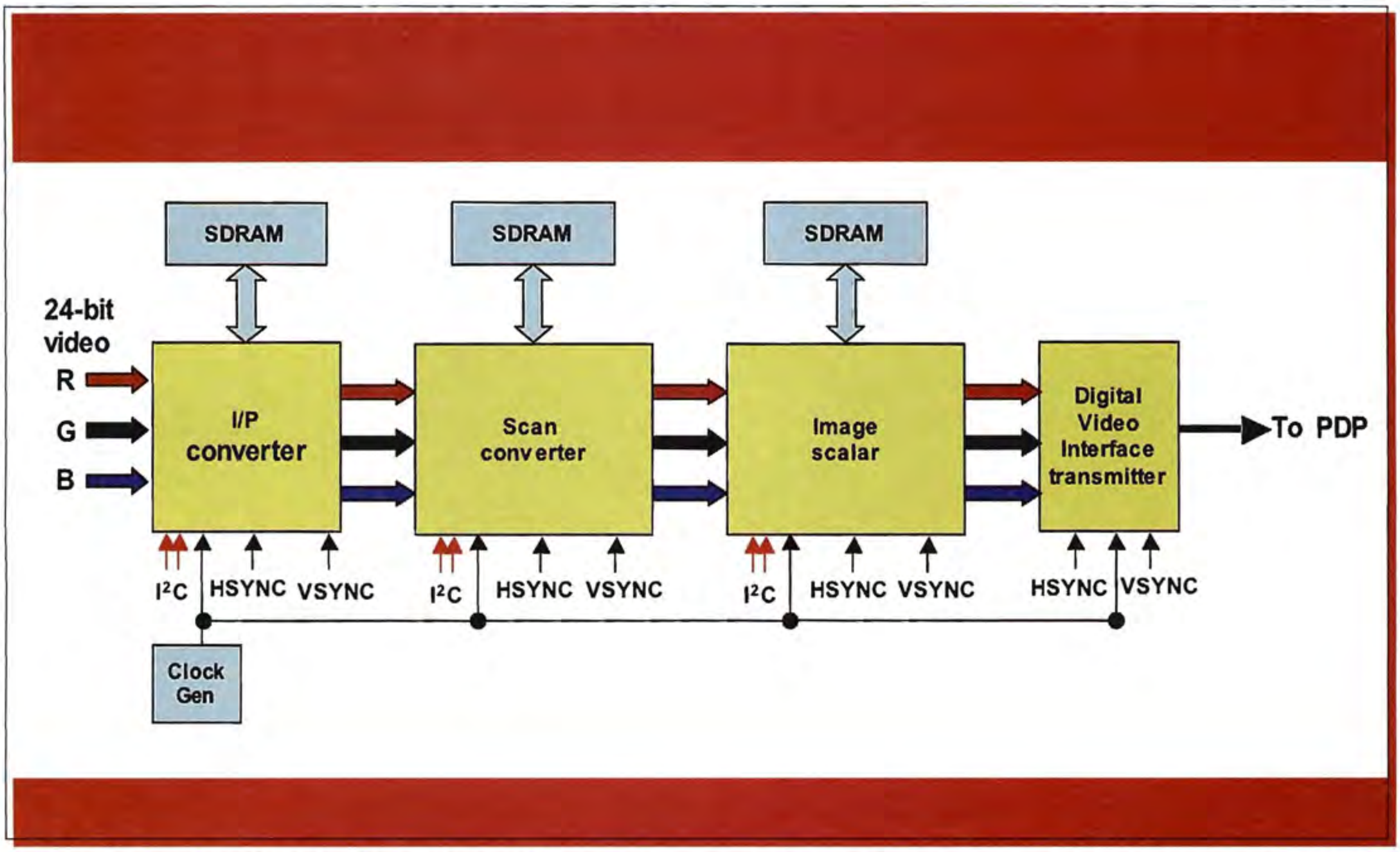


Figure 3: Main elements of a display-formatting system for plasma panel drive

differential signalling).

➢ LVDS

The LVDS interface (see **Figure 4**) is a unidirectional digital data connection that encodes 24 bits of data using four differential serial-data pairs (each pair consists of two twisted wires). The pixel clock is transmitted using a separate differential pair. The differential swing is low (355mV) and the nominal impedance is 100W, the speed being 500Mbit/s to 1.5Gbit/s.

Parallel input data is fed to a parallel-to-serial converter, then to an LVDS transmitter that encodes the incoming data into four serial channels, to be sent out via four separate data pairs of wires. As shown, the clock is sent via a separate output pair. At the other end, an LVDS receiver decodes the data back to its original format, or another one, as required.

The clock rate is seven times the original pixel rate. Thus, with

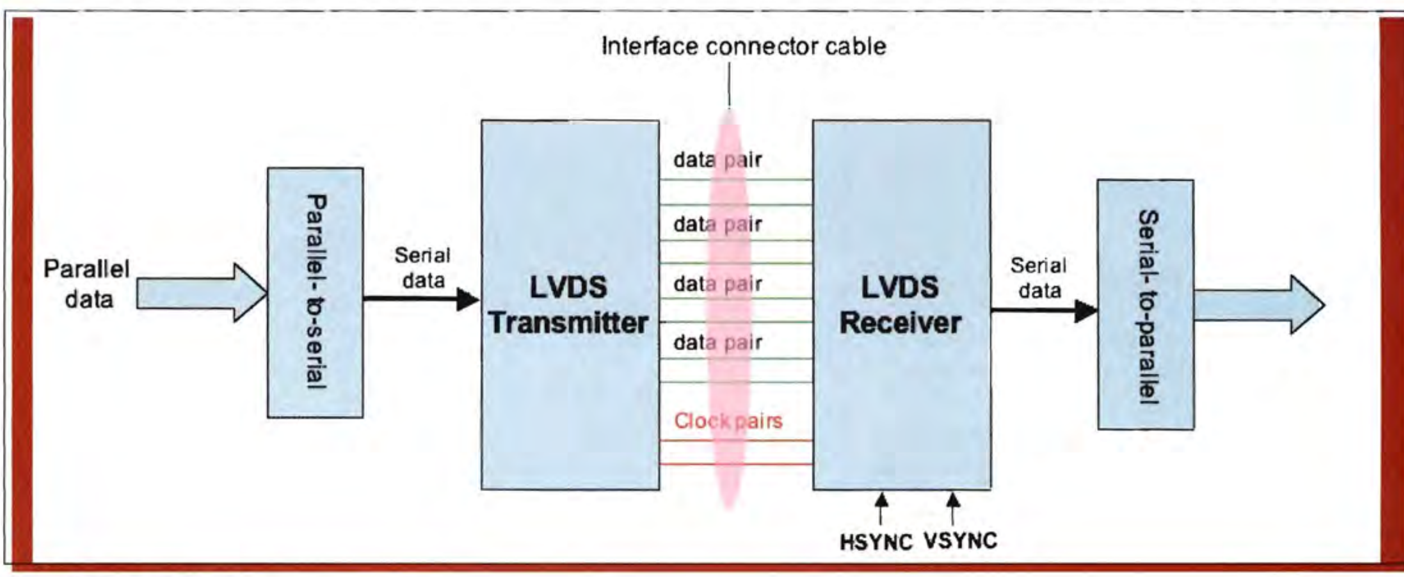


Figure 4: The LVDS interface

four pairs of data:

bits per original pixel clock = 7 x 4 = 28 bits per pixel clock

Of these, 24 are used for video. Three of the four remaining bits are allocated to frame sync, line sync and display enable (DE). The final bit is a 'custom bit' that can be used by the manufacturer as required for the application.

For 24-bit data a 65MHz connection will work with a panel that has a resolution of 1024 x 768.

By virtue of its low switching voltages, soft transition and true differential data transmission, LVDS achieves a high aggregated bandwidth, low power consumption and low EMI (electromagnetic interference).

➢ PanelLink

This interface is similar to LVDS. The difference is that three data pairs are used instead of four. It also isolates the three primary colours andallocates one to each data-pair. By increasing the data rate per channel to ten times the original pixel clock, instead of seven times as with LVDS, capacity can be retained. This is achieved by using an encoding technique known as Silicon Image.

The other basic difference is that PanelLink uses a fixed-current instead of a fixed-voltage transition. The advantage here is that, unlike LVDS, which is suitable for only short distances, PanelLink can be used for distances up to a few metres. The only disadvantage with a fixed current is that a return path has to be provided. The voltage swing for PanelLink is between 500mV and 1V.

➢ TMDS

Transition-minimised differential signalling is a derivative of PanelLink developed by VESA for computer LCD and PDP monitors. It has a speed of 165MHz, which in the future is expected to increase to 200MHz. Additional pairs may be used for increased capacity. **Figure 6** shows the basic connections to a TMDS transmitter IC.

Chip count

The chip count with flat-panel TV sets continues to decrease as more and more functions are performed by fewer ICs. Functions such as tuner and IF demodulation plus video and audio selection may be incorporated into one chip, with colour decoding, video processing, gamma correction and LVDS encoding carried out by a second chip.

The microcontroller may be embedded in one or both of the above chips, as well as memory stores, including flash memory.

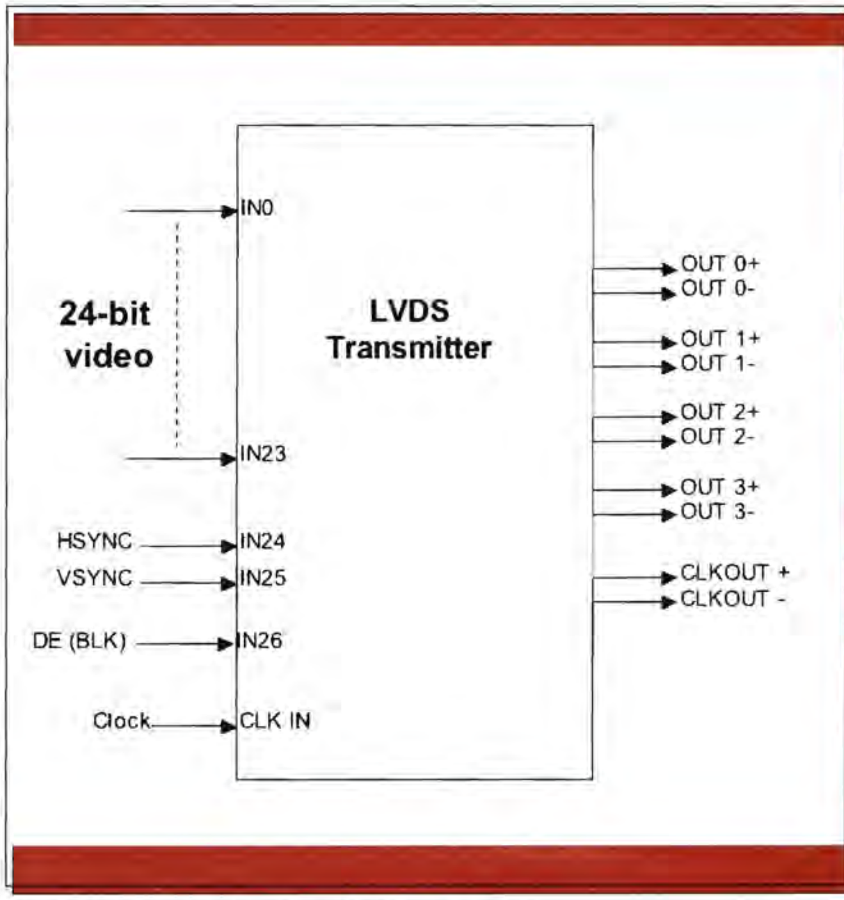


Figure 5: Basic connections to an LVDS transmitter IC.

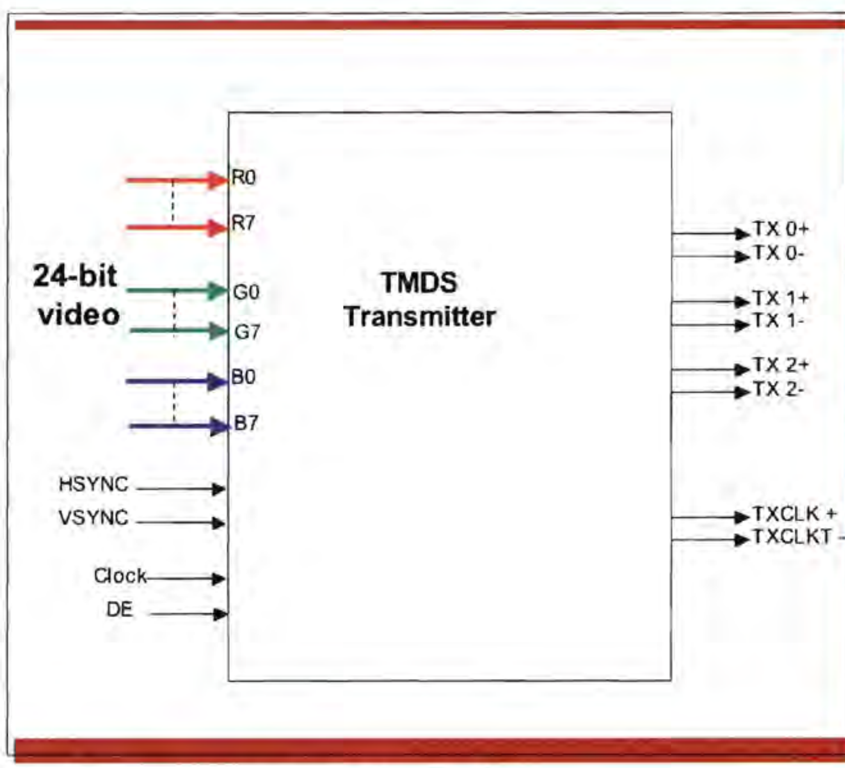


Figure 6: Basic connections to a TMDS transmitter IC

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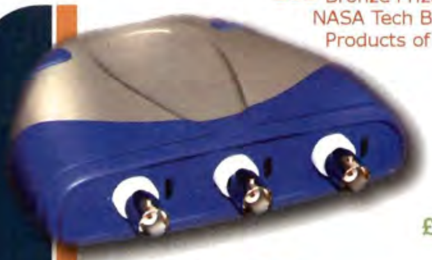

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The role of the transport properties of the interlayer in blue LEP's lifetime

Natasha Conway, Clare Foden, Matthew Roberts, Ilaria Grizzi of Cambridge Display Technology present a paper that yields a set of design rules for choosing interlayer properties to provide optimum lifetime for RGB materials in LEPs

It has been reported previously that efficiency and lifetime in RGB light-emitting polymer (LEP) diodes can be considerably improved by the incorporation of an interlayer between the hole transport layer (often formed from PEDOT) and the emission layer. We believe that the presence of the interlayer increases device efficiency in two ways: firstly, with an increased confinement of electrons in the region where the hole density is also high, and secondly, by blocking excitons, leading to a reduction in exciton quenching by PEDOT, as has been observed experimentally before. This is illustrated in **Figure 1**.

Previous work has linked the degradation of the polymer-LED to the growth of an insoluble layer from the PEDOT/LEP interface. Experimental data using electrical and optical models suggests that the exciton formation zone is peaked close to this interface, and that the inclusion of an interlayer moves the peak away from the LEP/PEDOT interface. It is found that the growth rate of the insoluble layer is considerably slowed and that the device's lifetime is increased by including an interlayer.

Other approaches to solving this problem, such as changing charge balance to move the exciton formation zone away from the anode, have resulted in very low device efficiencies, consistent with an increase in cathode quenching.

The work described above illustrates the importance of keeping the exciton formation zone away from both the anode (PEDOT) and cathode interfaces, in order to achieve high efficiency and long lifetime, and the role of the exciton and electron blocking properties of the interlayer in achieving this. However, the impact of the LEP and interlayer transport properties on the device performance has not been reported in detail. The work related here is a systematic study of the effects of varying the interlayer electron and hole currents on the efficiency and lifetime of a blue LED. The results are then related to our current understanding of device performance.

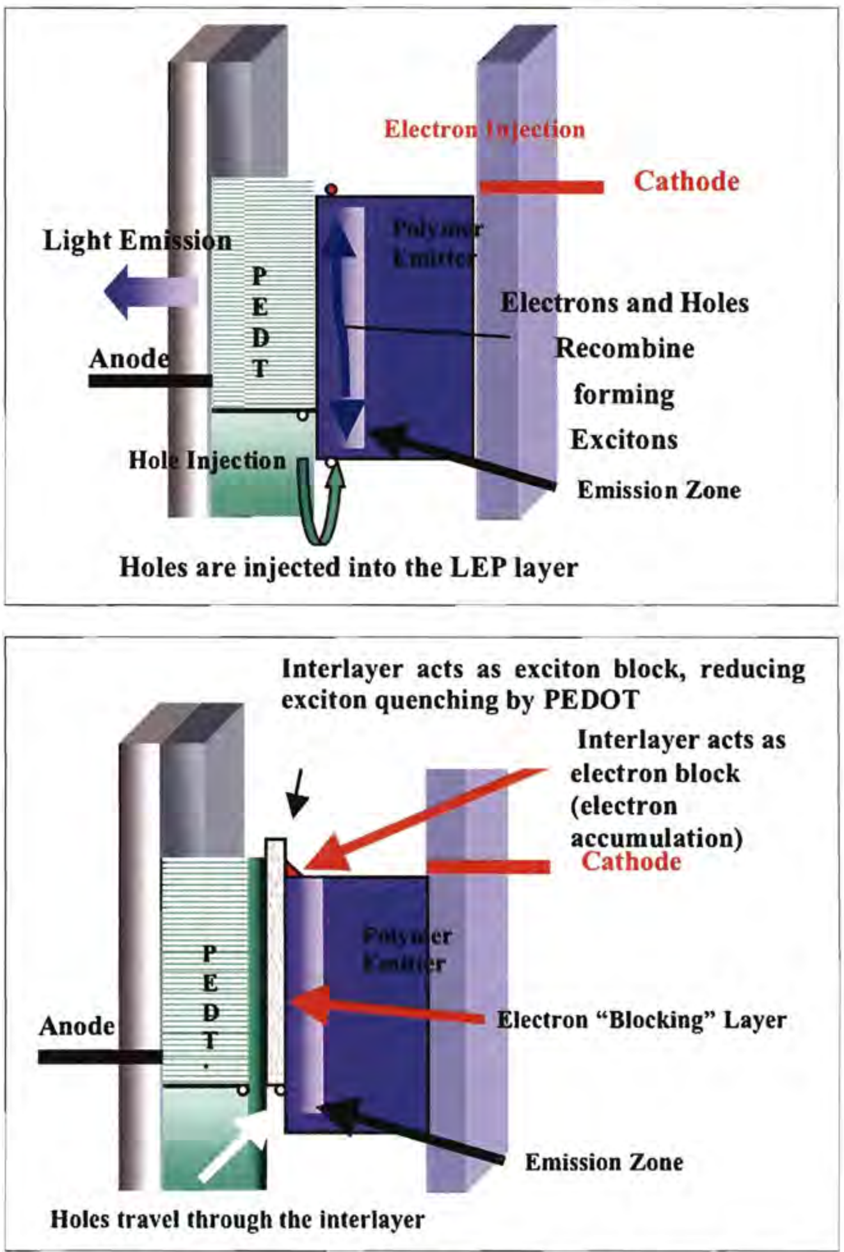


Figure 1: Schematic diagram of LEP structure **(a) Top:** without **(b) Bottom:** with interlayer

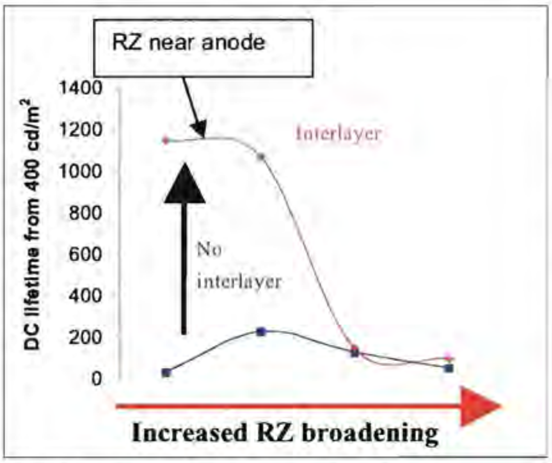


Figure 2: As the recombination zone broadens towards the cathode, the effect of the interlayer on the display lifetime is reduced. (The distribution of the recombination zone was inferred from EL spectra measurements fitted using an optical model).
Note: 'Lifetime' is defined as the time to half initial brightness from a defined start point

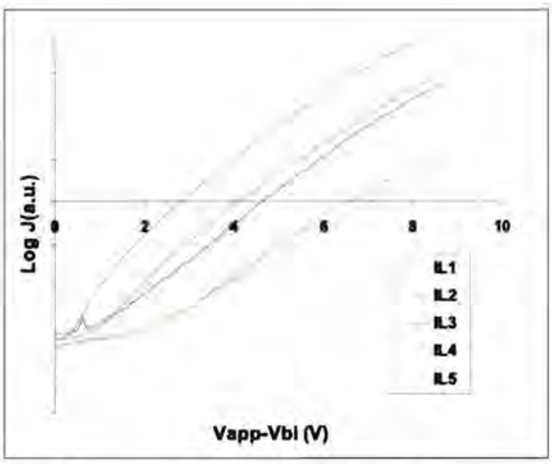


Figure 3: J-V characteristics of electron-only devices as a function of internal voltage

Discussion

The introduction of an interlayer does not benefit all LEP materials. **Figure 2** shows the variation in DC lifetime as we modify the structure of a blue LEP so that the recombination zone is broader and moved towards the cathode. When the recombination zone broadens and the exciton density at the interlayer interface is reduced, we do not observe a lifetime enhancement due to the interlayer.

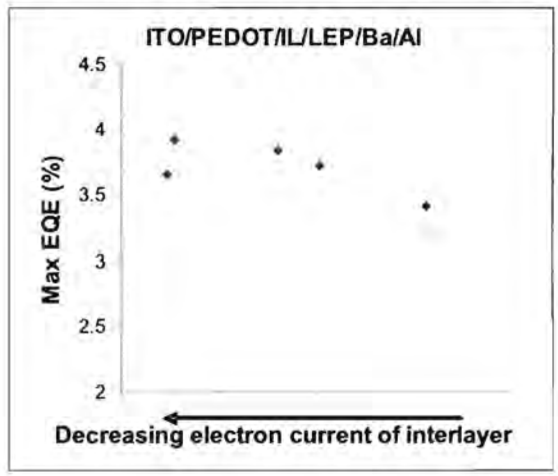
Note that, for broader emission zones away from the anode, the lifetime of the device is generally much lower. This is due to a combination of charge imbalance and increased cathode quenching, which reduces device efficiency and, as a result, the device has to be driven at very high current to achieve the desired brightness.

The interlayer was modified in order to vary its hole and electron currents and the magnitude of variation was measured in single carrier devices (with modified electrodes). The electron only J-V characteristics of the series of interlayer materials (coded IL1 to 5) are shown in **Figure 3**. It can be seen that the electron conductivity decreases from IL1 to IL5.

Each of these interlayer materials was tested in the following device structure: ITO/PEDOT (65nm)/ interlayer (10nm)/ CDTblue (65nm) /Ba (5nm) /Al.

The variation in the maximum external quantum efficiency (EQE) is shown in **Figure 4a**. As the electron current in the interlayer is decreased, the efficiency of the structure is improved up to IL4. **Figure 4b** shows that the behaviour with respect to lifetime roughly matches this trend, with IL4 giving the best lifetime.

As previously discussed, in the longest-lived blue PLED devices, the recombination zone is near the anode. By reducing the interlayer electron conductivity with respect to the LEP conductivity we expect that electrons will accumulate within the LEP layer



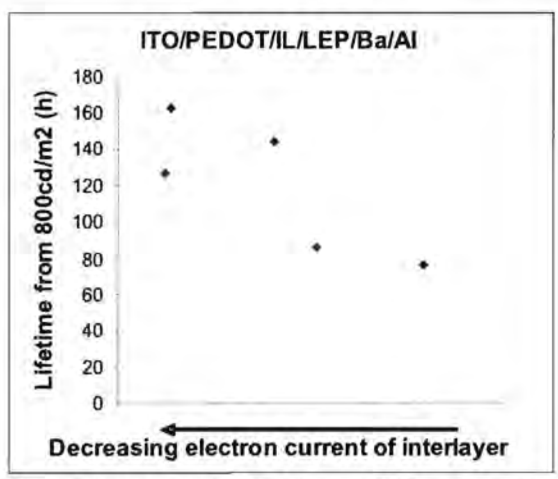


Figure 4: Variation of **(a) Top:** EQE and **(b) Bottom:** lifetime with respect to the electron-only current density of the interlayer at 3V. **Note:** EQE is defined as the proportion of electrons passing through the device which are converted to photons (light)

at the interlayer interface. The interlayer can further improve the device performance if, in addition to the electron accumulation, the hole currents in LEP and interlayer were such as to also promote hole accumulation at the interface. The increased accumulation of both electrons and holes would result in an improved exciton formation efficiency and increased confinement of recombination zone at the interlayer/LEP interface, giving the observed improvement in efficiency. The lifetime improvement could be related to this improvement in efficiency as it roughly follows the same trend.

The decrease in performance for IL5 cannot be explained by the small difference in electron current compared to IL4 (Figure 4b). A possible explanation for this result could be the larger hole current exhibited by IL5 compared to IL4 (i.e. approximately three times higher than in IL4). This suggests that there may be an optimum current for maximum lifetime.

Improving efficiency

The gathered data suggests that optimising the electron and hole currents in the interlayer is of key importance to achieve high efficiency and lifetime. However, the presence of the interlayer may also improve lifetime and efficiency by reducing the probability of excitons reaching the PEDOT layer. IL1 to IL5 all have a deeper HOMO and shallower LUMO than the LEP so that the electrochemical band gap of the interlayer is wider than the LEP's band gap (by more than 0.5eV). Therefore, a further interlayer, IL6, was examined in order to try and decouple the effects of exciton blocking from that of varying the transport properties.

IL6 has a similar optical band gap to the LEP layer and, therefore, will not act as an exciton block. However, the electron and hole currents are such that an accumulation of charges at the il-LEP interface would be expected.

Figure 5 shows that IL6 improves the device lifetime by a similar amount to that seen for other interlayer materials, which also act as an exciton block. There is however a decrease in efficiency observed with IL6 compared to IL3 (see **Table 2**), consistent with some of the generated excitons being able to diffuse through the interlayer and become quenched by the PEDOT. This demonstrates how both LEP and interlayer transport properties are key in determining device lifetime by confining the recombination zone at the interlayer-LEP interface. The exciton-blocking character of the interlayer can, however, add a further improvement to the device efficiency.

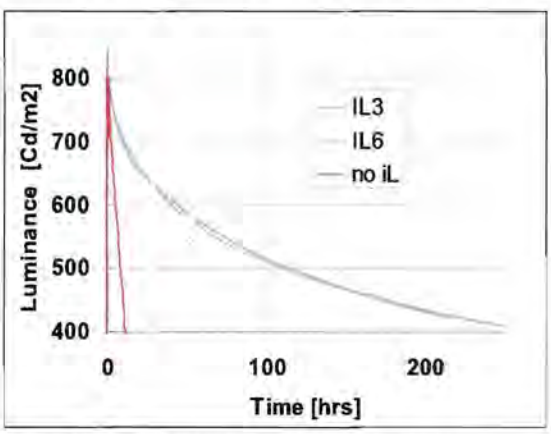


Figure 5: Lifetime from 800cd/m^2, DC at room temperature

Table 2: Efficiency data

Interlayer	*Max. EQE (%)*
None	2.3
IL3.	3.5
IL6	3.3

Balancing charges

This work identifies the importance of balancing charges in the interlayer and LEP layers. This ensures that the exciton formation zone is confined within the LEP at the interlayer/ LEP interface, and is neither near the interlayer/PEDOT interface nor close to the cathode.

Furthermore, the results with IL6 show that lifetime can still be improved when the interlayer is not exciton-blocking but the recombination zone is still at the interlayer/ LEP interface, due to tuning of the electron and hole currents of the interlayer such that electrons and holes accumulate at the interlayer/LEP interface. This is the first evidence to suggest that exciton quenching by PEDOT does not play a significant role in device degradation and, therefore, implies that the role of the interlayer transport properties is of key importance.

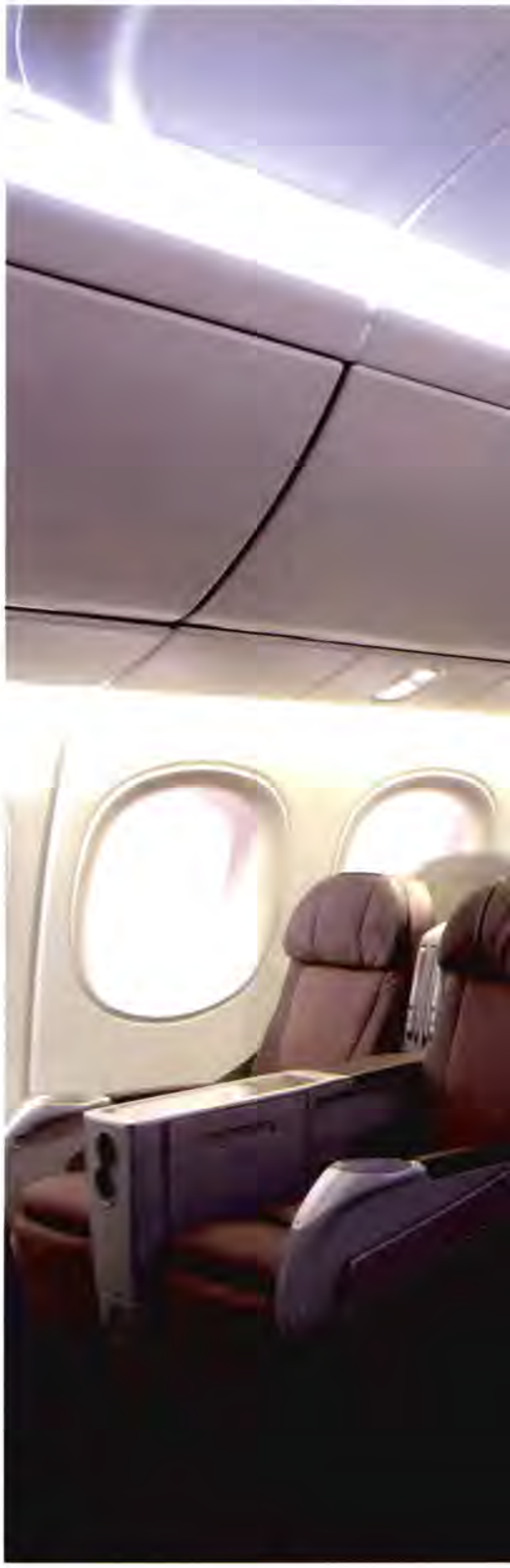
These results provide a set of design rules for choosing interlayer properties to provide optimum lifetime for RGB materials. It demonstrates that the transport properties of the LEP and interlayer need to be matched in a way that ensures the recombination zone is confined near the interlayer/LEP interface.

This understanding of the underlying parameters governing device performances should also enable the tailoring of the LEP to ensure that we can achieve best performances whilst keeping the manufacturing process as simple as possible (e.g. by using a single interlayer material for RGB).

In addition, the fact that improved lifetime can be achieved where the interlayer need not be exciton-blocking is of key significance to blue where it may not always be possible to use an interlayer with an increased band gap, particularly for deep blue LEP materials.

Solid-State Lighting

In this article, Faiz Rahman delves into the world of the latest light sources and helps you figure out what will be the best one for your application



Away from our homes and places of entertainment, a quite revolution is brewing that promises to fundamentally change the way in which we light up our surroundings. Artificial lighting has changed little since the inventions of the filament bulb and fluorescent lighting. These devices are cheap, widely available and easy to use but lack flexibility of illumination characteristic control and are also wasteful of energy. The new luminaries in development are fundamentally different, and with their light control and energy saving features, are extremely well suited for our modern lifestyles. Not only do they promise more pleasant forms of lighting but their low power consumption is a godsend in an increasingly energy-conscious world. Instead of generating light by heating a wire to white hot heat or producing an electrical discharge in a low-pressure gas mixture, these new light sources are completely solid-state devices that work on the same principles that make transistors and integrated circuits possible.

Solid principles

All solid-state light emitters work by allowing electrons to fall from a high-energy band to a low energy band. The difference in energy is radiated away as light particles or photons. There are now two distinct classes of devices that emit light in this way: the semiconductor light-emitting diode and the organic polymer light-emitting diode. The former are usually referred to simply as LEDs, whereas the latter are called OLEDs with the 'O' standing for organic.

Let's first take a look at the physical principles behind the operation of ordinary LEDs. Diodes are made from a combination of electron-rich (n-type) and electron-deficient (p-type) semiconductor materials. Where these two come together, a region devoid of electric charge carriers, called a depletion layer, is formed. On connecting the n-type material to the negative of a battery or power supply and the p-type material to the positive side of the battery or power supply, electrons are injected from the n-type material through the depletion layer into the p-type material. Similarly, electrons are extracted from the p-type material, which is the same as the injection of electron vacancies, called holes, into the p-type material. The flow of electrons and holes constitutes the diode current. As only holes travel in the p region of a diode and only electrons in the n region, at some point, one effectively changes into the other. This so-called electron-hole recombination takes place inside and close to the depletion region of the diode and results in the release of energy, because it essentially represents a sudden decrease in the electron's potential energy. The energy thus released gets converted into heat and causes the diode to get warm. Diodes capable of emitting light are made from materials where electron-hole recombination results in the emission of infrared, visible or ultraviolet radiation instead of generating heat. These are called compound semiconductors. The wavelength (colour) of the emitted radiation depends on the band gap of the semiconductor used for the LED, with the colour shifting from infrared through the colours of the rainbow to ultraviolet as the band gap of the semiconductor increases.

LEDs for light

LEDs made from compound semiconductors like aluminium indium gallium phosphide (AlInGaP) and indium gallium nitride (InGaN) have existed for many years now and come in several different colours

– A Bright Future

Interior of Boeing's Dreamliner cabin, lit by solid-state sources ranging from infrared (invisible) through red, orange, yellow, green, blue to ultraviolet. Their efficiencies have also improved over the years so that high power devices are now capable of putting out a decent amount of light.

Initially, for many years, LED applications were restricted to light indicators on electronic equipment. Only as their luminosities increased did they begin to be seriously considered for ambient lighting applications. Hewlett-Packard (HP) was the first to realise the potential of these devices for outdoor commercial applications and, in the late nineties, it brought out new traffic light signals that were built entirely with red, amber and green emitting LEDs. Whereas conventional traffic signal units based on colour-filtered filament light bulbs consume about 150 watts, the new LED-based units consume only one-tenth as much power. What's more, the new traffic lights also proved to be much less maintenance-intensive than the units that they had replaced.

Not surprisingly, most old traffic lights were replaced by these better performing units and, now, LEDs are the standard light sources in almost all new traffic signals. We also see them in service on temporary and permanent highway signs and, again, it is the energy efficiency and long life characteristics of LEDs that make them suitable for such applications.

Even before the widespread adoption of semiconductor light emitters by public sector agencies, LED-based displays had started to be used for commercial sign display and advertisement purposes. The lead, in this case, was taken by Japan, where large format LED dot-matrix graphic displays have been a familiar sight in city centres. This application received a big boost when in 1993 Shuji Nakamura at the Nichia Chemicals Corporation developed the blue-emitting LED. Finally, it was possible to deploy full colour solid-state displays. We are now seeing an increasing use of such displays for commercial applications and all indications are that this sector will continue to grow briskly for the foreseeable future.

Manipulating light

While it is possible to produce white light by combining emissions from red, blue and green LEDs, a more convenient way is by using blue-excited phosphors in conjunction with a blue LED. The phosphor converts some of the original blue radiation to red and yellow light such that the combination appears white to human eyes. All 'white LEDs' on the market are of this type.

The white light produced by these devices is not particularly pleasant and because it doesn't contain all the colours so it is also bad for rendering coloured objects. Manufacturers are working on overcoming this problem by employing customised phosphor mixes that could produce broadband radiation, which matches the spectrum of natural daylight more closely. Such 'warm' white light LEDs are now becoming available and are being put to use in black-and-white dot matrix displays and spot lights for retail exhibit illumination.

Another area where LED illumination has made considerable inroads is that of automobile lights. Brake lights were the first to switch to LEDs and now headlights are next on the cards. Interior lights have also gone solid-state in several makes and in doing so have opened up the possibilities of large-scale space lighting with LEDs. The first to take the lead in this area are aircraft manufacturers, both civil and military.

Most famously, Boeing revealed last year that it intends to use LED-based lighting in its new 787 Dreamliner. According to the company, travellers will be able to control the intensity and tint of lighting in their seating areas to suit their preferences. This should reduce the effects of jetlag due to crossing time zones.

The images on these pages show the flight deck of the new Boeing plane with cockpit lighting provided by solid-state lighting fixtures, and also the interior of the same aircraft with ceiling and window-side lighting provided by diode-based lamps.

Several other manufacturers of executive and regional jets are also implementing similar schemes for interior cabin lighting. This kind of application brings out the advantages offered by LEDs for space lighting.

Controlling light

Unlike filament lamps that can only be controlled in intensity, diode-based light sources enable the control of light colour as well. For this, however, LEDs of more than one colour need to be combined in lighting fixtures and electronic circuitry provided to control the different coloured devices independently.


Solid-state lighting in the Boeing 787 cockpit

Two approaches are possible here: either separate red, green and blue LEDs could be applied, or multichip devices, each containing red, green and blue chips in the same housing could be used. Generating any desired colour then is a matter of combining different intensities from the three LEDs or chips. This is almost always accomplished by running each colour element with a Pulse Width Modulated (PWM) current drive waveform. Varying the duty cycle of the waveform effectively controls the average current fed to the individual diodes and thus their output intensities.

Three channels are needed for complete RGB control. The PWM waveform could be easily generated either by a microcontroller or by a dedicated PWM generator chip. Several manufacturers, including Freescale Semiconductor, are bringing out optimised microcontrollers for this kind of RGB lamp control.

For greater light output, all that is needed is to interface a larger number of LEDs to the control chip through the use of appropriate power transistors.

Sizing potential

As the size and efficiency of LEDs have increased so has their potential for space lighting applications. Several companies are hard at work developing the high current devices that would, one day, begin to replace conventional tungsten filament-based light bulbs. These companies include GTE, Osram, Philips and several others. At the present time, LED clusters have become available for spotlighting and low ambient illumination purposes.

These units are rated in the range of five to ten watts, feature screw, bayonet and other standard bases and are available for operation with both low voltages (12V DC) and mains supplies. These come in red, green, yellow, blue and white colours with each unit assembled from sixteen standard 5mm diameter LEDs. High brightness surface mount LEDs are also available and can be used for making lighting modules.

The example from Lumileds, shown on the next page, is capable of 1W power output but other units in this family can deliver up to 5W of power. These LEDs have a special multi-pronged wire bond connection to the chip for ensuring uniform current flow. Multiple chip arrays are also available where a number of Luxeon LEDs are mounted on a metal core PCB that is capable of removing heat much more efficiently than ordinary glass fibre laminate material.

In addition to producing cold light, LEDs require much less power than existing lighting solutions, are small in size, resistant to vibration and shock, immune to ambient humidity, have a very fast "on-time" (less than 1ms compared to 250ms for incandescent lamps), have good colour resolution producing pure colours and present low or no shock hazard. Their directional characteristics, however, make it difficult to incorporate them in omnidirectional lighting units. Westinghouse is attempting to overcome this problem and is marketing LED bulbs that provide all around lighting.

Light extraction

In conventional LEDs it is difficult to extract all the light that is internally generated. Large difference between the refractive index of the semiconductor and air results in low extraction efficiency. However, if the light source is placed inside a microcavity then the emitted light is coupled to the cavity modes and, if proper design is applied, then it can be completely extracted. In recent years, due to the development of nano-scale semiconductor technologies, a number of optoelectronic devices employing micro-cavity structures have been proposed.

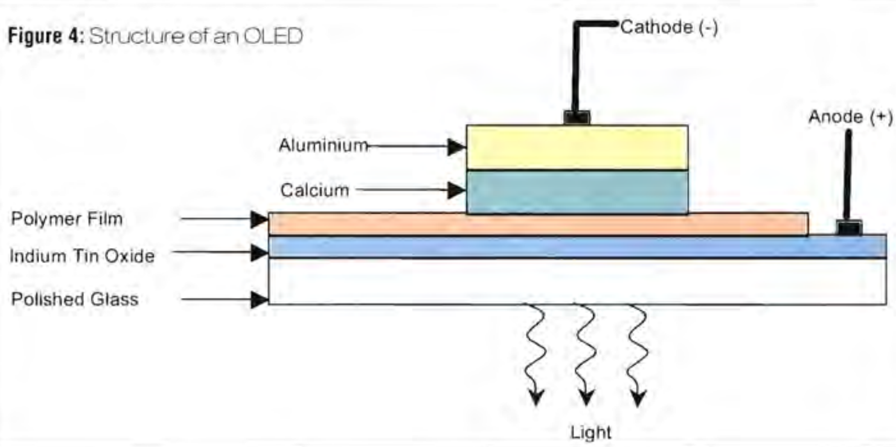
The most notable examples of such devices are Resonant Cavity Light Emitting Diodes (RC LED), realised in the early nineties. The main advantages of resonant cavity LEDs over conventional devices are their higher emission intensities, higher spectral purity and more directional emission patterns. Yet another technique is to integrate LED chips with synthetic opal crystals, which can also be used to improve light extraction efficiency. These and other approaches are helping raise the electricity-to-light conversion efficiency of LEDs to levels where they will start to pose a challenge to existing lighting technologies.

Organic vs inorganic

The LEDs discussed so far are all made from inorganic semiconductors, derived from elements in groups III and V of the periodic table. A quite different type has been under development lately, derived from carbon compounds. These organic light emitters represent one of the most vibrant areas of research and development today. Organic LEDs are built from conducting and light emitting polymers such as poly-para aniline vinylene (abbreviated as PPV). These materials are plastics but with a structure that is capable of conducting current. Although their conductivities are usually lower than that of metals, they have found several applications in electronics.

Intrinsically, conducting polymers often behave like p-type semiconductors and are thus better conductors of holes than electrons. One approach to building light emitting diodes from organic materials is to sandwich them between a glass sub-

Figure 4: Structure of an OLED



strate coated with a transparent conducting layer e.g. Indium Tin Oxide (ITO) and a low work function metal like calcium, which is capable of emitting electrons into the polymer. When such a device is biased as shown in the illustration (**Figure 4**), holes from the polymer combine with electrons injected by the calcium electrode and light is released.

There are several possible variations based on this structure, designed to increase the efficiency and lifetime of these devices. Depending on the detailed structure of the polymer used, OLEDs can emit any colour in the range from infrared to blue, so it is quite possible to build full-colour displays from these devices. The revolutionary advantage offered by polymeric light emitting materials is that these could be coated on very large area substrates such as plastic sheets. This opens up the possibility of extended area luminaries, which may well make incandescent light bulbs obsolete in the not too-distant future. These emit a diffuse white glow that is very pleasant to the eyes. Prototype units have already been made and several companies, including General Electric, are at work perfecting the processes required to produce polymer-based light emitters at price levels that would be attractive to consumers. These sources will provide shadow-free diffuse light in several different 'tones' like warm white, cool white and daylight replica white.

With ongoing developments in the material, design and fabrication of both inorganic and organic LEDs, we are getting close to seeing their widespread use in space illumination applications. This will probably not happen for another few years but, when it does happen, then our surroundings will be changed forever as light plays such a crucial role in human life.

The lead in this transformation is being taken by many companies and research labs around the world that are busy developing ever better solid-state lighting products. In turn, consumers have begun to respond by buying LED-based lighting products.

Centre: Lumileds's LEDs have a multi-pronged wire bond connection to the chip for ensuring uniform current flow

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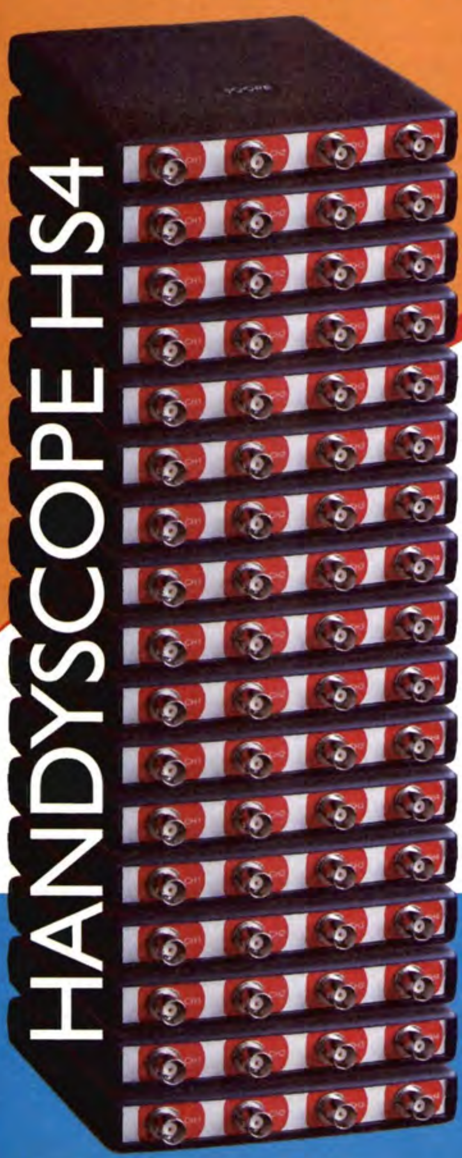

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N. S. Bayindir, H.Ö. Bayindir, H. Demirel, M. Yakup, V. Alsancak and **T. Kabakli** of the Department of Electrical and Electronic Engineering and Technology Development Center in Turkey present an applicable vehicle speed measurement system

The automatic vehicle speed measurement, classification and license plate detection systems are becoming the vital components of Intelligent Transportation Systems (ITS) as the traffic load increases and, hence, the traffic violations become a serious threat to the transportation safety. Several systems on vehicle speed measurement and classification have already been introduced. The design development and production costs of such systems are so high that the under-developed and the developing countries cannot afford them. On the other hand, these systems consist of several disciplines of Electrical and Computer Engineering, which makes them an attractive project for researchers in the fields of computer software, pattern recognition, electronic circuits and digital signal processing.

In this paper, a cost-effective vehicle speed measurement, classification and license plate detection system has been developed using very low cost equipment, including magnetic loop detectors, an industrial PC, a PIC microcontroller and a digital surveillance camera. The system has been implemented successfully on a motorway in North Cyprus where the speeds of vehicles were measured with an error of less than 3%. Pictures of the vehicles violating the speed limit were captured always at the same spot with excellent zoom and focus conditions, regardless of the vehicle speed, and the license plate could be clearly read. The system also provides statistical information regarding traffic flow on the motorways, which can be used to design efficient traffic control systems and road network.

System workings

An object-oriented Java program was developed to control the operation of the system, which can process data from four successive vehicle channels in parallel, so that the system does not miss any vehicles during the speed detection, image capturing and storing process. As the vehicle passes over the detectors, the time delay between the pulses produced by two magnetic loop detectors is measured by a microcontroller based system, and the speed of the vehicle is then calculated in km/h using this time delay. The picture of the vehicle exceeding the local traffic speed limit is captured using a digital video camera, which is connected to the industrial PC via a low-cost video capture card. The camera is focused at a pre-specified distance beyond the second loop detector and, in order to capture the picture always at the same precise focused location, an adaptive delay which is inversely proportional to the vehicle speed is applied after the vehicle passes over the second detector. This delay ensures the capture of the vehicle picture always at the same location with the best zoom and focus adjustments, independent of the vehicle speed. The pictures taken by the camera are directly saved into the hard disc of the industrial PC via the video card with a distinctive file name, which contains the date, time, location and the vehicle speed. This picture file is then transmitted to a traffic-monitoring and control center via the wireless data transmission system. In addition to the measurement of the speed, the length of each vehicle is also calculated by multiplying the speed by the time duration elapsed while the vehicle passes over the second loop detector. This information is used for the classification of the vehicles into six categories, whereby important statistical data regarding the traffic flow can be obtained. This statistical data can be used by the research staff at the Traffic Research Center to analyse the characteristics of the traffic flow on various roads and design efficient traffic control systems and optimal road networks.

Hardware and software

The system is operated with an industrial PC, where the main parts of the system shown in **Figure 1** are specified as follows:

- Magnetic loop detectors: Two magnetic loop detectors are used to trigger the capture inputs of the microcontroller when the car passes over the magnetic loops.
- PIC 16F877 microcontroller: A low-cost PIC 16F877 microcontroller is used where the capture 1 input of the microcontroller is connected to both loop detectors, and capture 2 input is connected only to detector 2.
- Microcontroller program: An operating program whose algorithm is presented in **Figure 2** is developed for the microcontroller such that capture 1 is set to detect the rising edges from both detectors (which yield the period Δt_1) elapsed while the vehicle passes between the entries of the two loops. In order to prevent miscalculations due to possible entries in the opposite direction, the program checks whether the rising edge from detector 2 comes before or after that of detector 1. If a rising edge arrives from detector 2 before that of detector

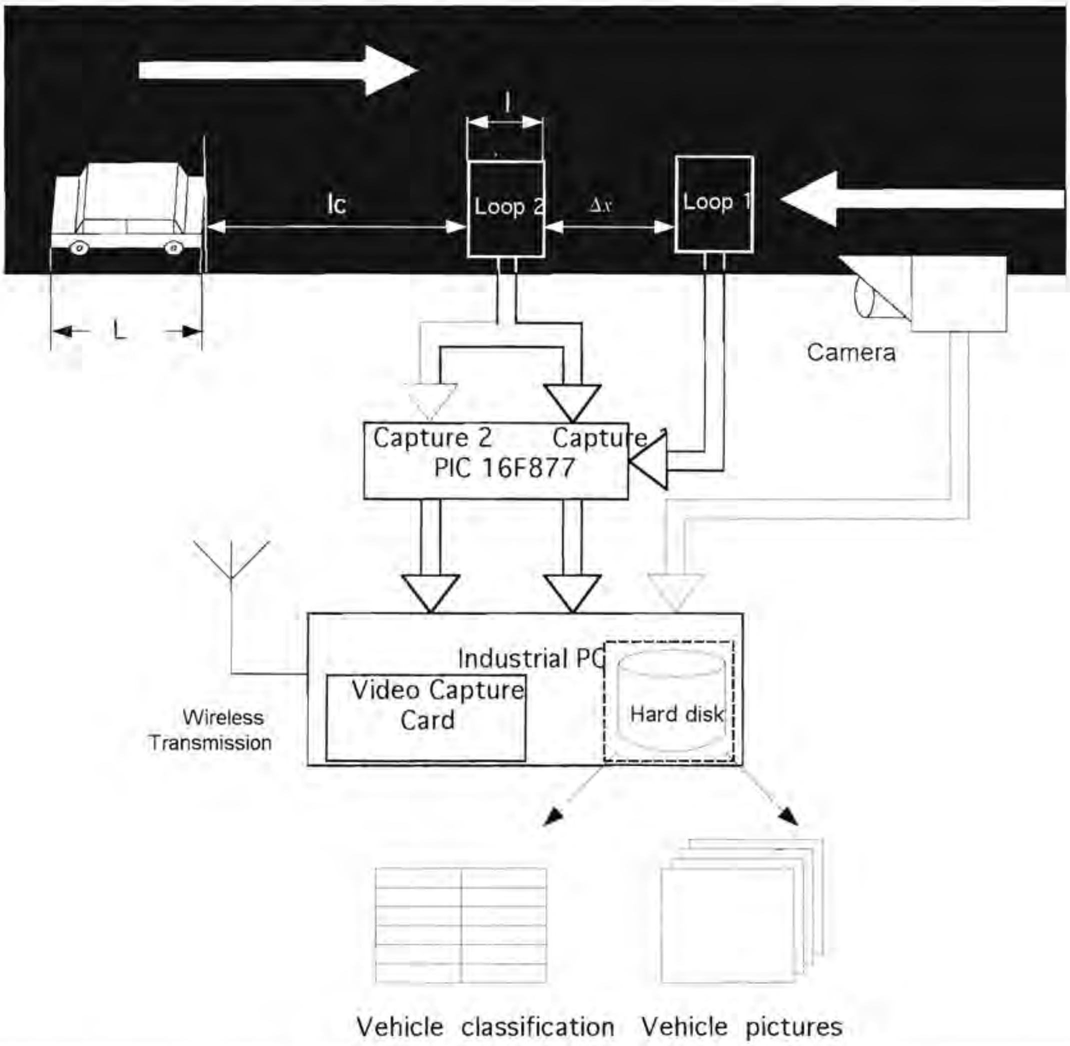

Figure 1: Block diagram of the complete system

1, the program returns to the start to wait for a rising edge from detector 1.

Once the car enters the second loop and the rising edge is detected by capture 2, the current value of the timer (TMR), which yields Δt_1, is automatically recorded into the capture register CCPR2 and the timer is reset for the measurement of Δt_2. The control register of capture 2 is then set to detect a falling edge to measure the time elapsed during the vehicle passes over the second loop. The time difference Δt_2 between the rising and falling edges of the pulse coming from detector 2 is equal to the time elapsed while the vehicle passes over the second loop. Δt_2 is then used to calculate the length of the vehicle.

- Industrial PC: A low cost Pentium III 500MHz industrial PC with the Windows 98 operating system was used, where the RS232 serial port of the industrial PC is used to receive the time delays Δt_1 and Δt_2 for calculating the speed of the vehicle, as well as determining the class. Furthermore, an extensive object-oriented program developed using Java software, is designed to control various parts of the system.
- Digital surveillance camera: A standard auto-focus, auto-exposure surveillance camera, which continuously generates video frames at 24fps and transfers to the industrial PC via the video capture card, is used in this application.
- Wireless data transmission: The measured data and the vehicle pictures stored in the industrial PC are transmitted to the traffic monitoring and control centre by using a 2.4GHz wireless radio link with a bandwidth of 8Mbps, which can communicate over a range of 35km.

Speed measurement

In order to measure the speed of a vehicle, several types of vehicle detectors may be used. Non-destructive infrared detectors can be mounted by the side of the road, however these detectors have high error of around 10% in the measurement of speed and need regular maintenance to keep them clean. Pressure tube technology has also been used in order to detect the presence of a passing vehicle, where the pressure tubes are subjected to wearing, hence, in our application magnetic loop detectors buried into the asphalt has been the preferred option. Two magnetic loops, which are displaced by a fixed distance

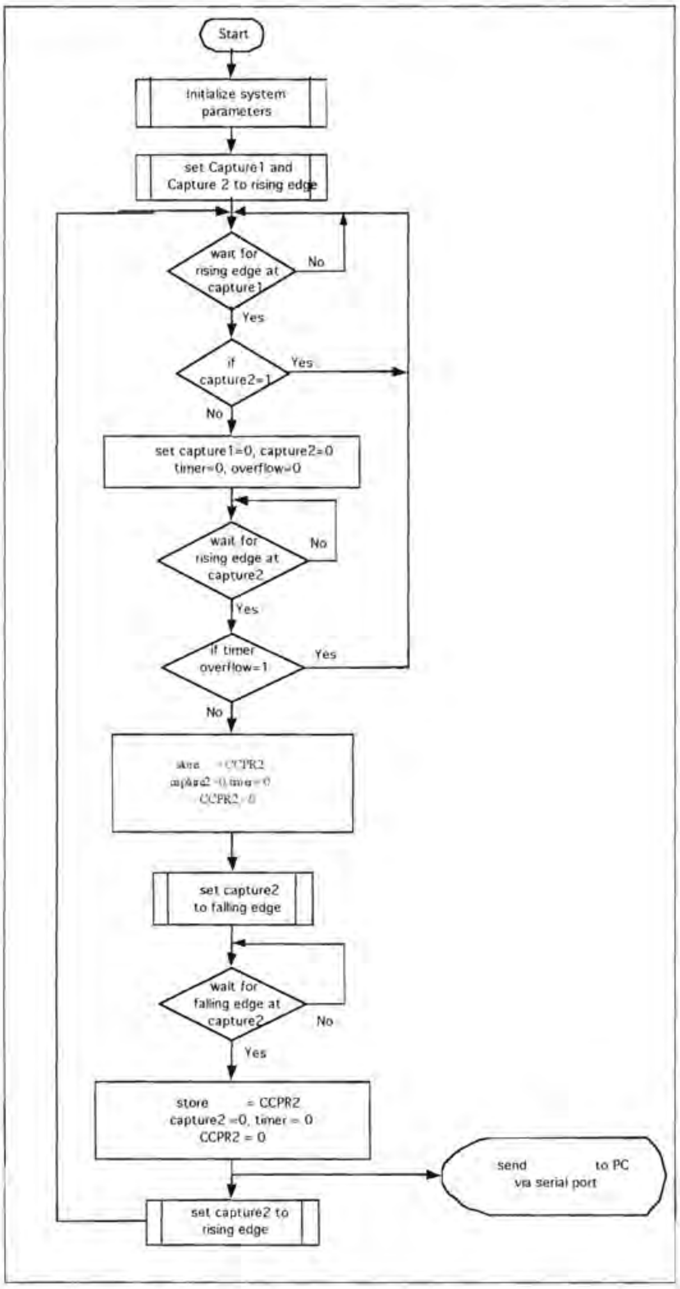

Figure 2: The flowchart of the program developed for the PIC MCU

($\Delta\chi$), are used to detect the presence of the car at two different locations as shown in **Figure 1**. The detectors connected to these loops produce TTL pulses which are applied to the capture inputs of a PIC 16F877 type microcontroller. The software on the PIC microcontroller initialises a timer when a rising edge is received at the capture 1 input from the detector 1 and the measured time delay (Δt_1) is recorded when a rising edge is received at capture 2 input from detector 2, as soon as the vehicle enters the second loop. This time delay is then transmitted to the industrial PC through the serial port for the calculation of vehicle speed.

The measurement of vehicle speed, classification of vehicles and the capturing and saving the video frames are managed by the Java program. Algorithmic details of the program code are given in the flowchart as shown in **Figure 3**. At the start, the program creates four vehicle objects which can process the data obtained from the microcontroller via the serial port. The program receives the data related to the time differences Δt_1 and Δt_2 from the PIC microcontroller. The transmitted data consists of two parts, the speed data (Δt_1) and the length data (Δt_2), which are received via the serial port in a single pack. When the reception of one pack is completed successfully, it is recorded to a string variable. String data is sent to one of the vehicle objects that is not processing at that instant. By the use of four vehicle objects, the program is capable of processing up to four successive vehicles during the delay time before the capture of the license plate of the first vehicle. Experimental work on the system has shown that four parallel objects are sufficient for the fastest traffic flow conditions.

The vehicle speed is directly calculated using

$$v = \frac{\Delta x}{\Delta t_1} \qquad (1)$$

where $\Delta\chi$ is the distance between two loops and Δt_1 is the time elapsed while the vehicle passes between these loops.

Vehicle classification

Classification of vehicles based on their lengths provides very important statistical information for the design of transportation networks and traffic flow management. In order to determine the length of a vehicle, the time taken for the vehicle to pass over a single loop detector is measured by the PIC microcontroller. The timer of the microcontroller is triggered with the rising edge of the pulse produced by the second detector arriving at capture 1, when the front of the car enters the second loop. The timer value is recorded when the falling edge of the pulse arrives at capture 2 as the vehicle exits the second loop. This time delay (Δt_2), together with the measured speed (v), is used to calculate the length of the vehicle (L) as

$$L = v \cdot \Delta t_2 - l \qquad (2)$$

Table 1: Classification of vehicles with length

Class	*Vehicle length (m)*
Cycles	$L \leq 3.00$
Cars	$3.00 < L \leq 5.00$
Pick-up	$5.00 < L \leq 6.00$
Lorry	$6.00 < L \leq 8.00$
Bus	$8.00 < L \leq 9.00$
Long vehicle	$9.00 < L$

Table 2: Statistical speed violation results

Vehicle type	*Motor cycle*	*Car*	*Pick-up*	*Lorry*	*Bus*	*Long vehicle*
Vehicles Passed	136	2310	257	568	379	342
Speed Violations	23	396	96	42	17	58
Speed Violations (%)	16.9	17.1	37.4	14.2	7.4	17.0

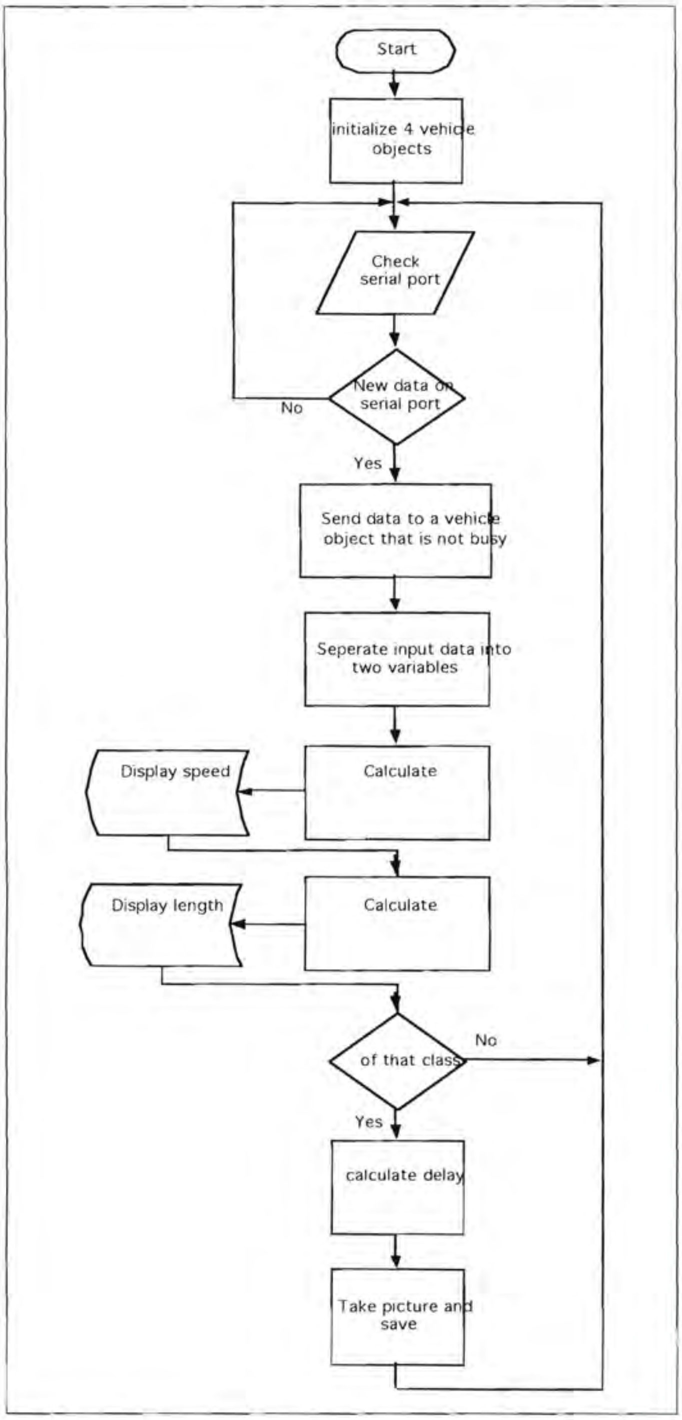

Figure 3: Flowchart of the speed measurement and video capture program

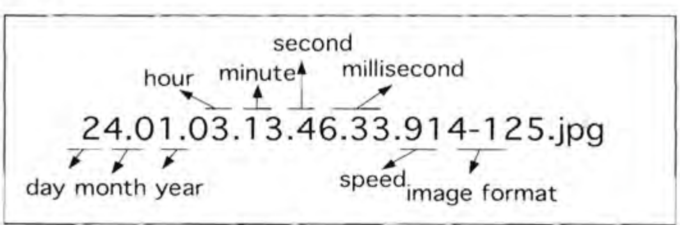

Figure 4: A filename example of the captured images

where l is the length of the second magnetic loop. The vehicles are classified by the industrial PC into six categories according to **Table 1**.

Table 2 presents the statistical average values of the recordings for one day of the vehicles on the main road from Nicosia to Famagusta in North Cyprus. According to these results, on the average, 16% of the vehicles passing on the main road violate the local speed limit.

Image capturing

A low-cost video capture card installed in an industrial PC is used to capture the images of the license plates of the vehicles violating the speed limit. After determining the speed of the vehicle, if the speed exceeds the local speed limit, the picture of the vehicle is taken after a time delay of t_3, such that the camera will be focused at a specific spot at which the picture will always be captured clearly, independent of the speed of the vehicle. The focus and zoom of the camera is set to produce a picture on which the license plate can be detected clearly as shown in **Figure 5**. The industrial PC applies a delay of t_3 , calculated by

$$\Delta t_3 = \frac{l_c}{v} \qquad (3)$$

before it captures the picture of the vehicle, where lc is the distance allocated between the camera and the second loop to take a picture with least deformation of the license plate. Once the picture of the vehicle is captured, the current time, date, location and speed of the vehicle are printed, the picture is saved into the hard disk for further evaluation.

Figure 5: Picture of the vehicle violating the speed limit

Picture storing and transmitting

The captured picture, which is shown in Figure 5 is the image of a vehicle, which has exceeded the speed limit, on which the license plate is clearly visible. The pictures must be stored for further visual inspection, in order to determine the license plate number. Not only the picture but also the measured speed, the time, location and the date of the measurement are required for the traffic authorities to have complete information in hand. This is achieved by incorporating the time, date and speed information of the vehicle into a filename. The format of a typical picture filename is given in **Figure 4**. The information regarding the speed, date and the exact time of the event is printed on the picture. A 2.4GHz wireless radio link with a bandwidth of 8Mbps, which can communicate over a 35km range, is used to transmit the picture and the measured data from the site to the traffic centre. This range can be extended up to 500km by using active or passive repeaters.

Creating efficient road networks

A vehicle speed measurement and classification system has been developed as part of an Intelligent Transportation System project, and implemented successfully on a highway where severe accidents due to speed limit violations take place. The speed of the vehicles were measured with an error of less than 3% and the pictures of the vehicles that violate the speed limit were captured always at the same spot, so that the license plate can be read clearly, independent of the vehicle speed. The speed, date and time information is recorded into the filename of the picture, which can be helpful for the authorities to locate if necessary. Valuable statistical data can be collected regarding the speed violations, vehicle classes and traffic density. The data can be processed by the Traffic Research Centre, to design more efficient road networks with a better traffic flow, free from congestion.

Acknowledgement:
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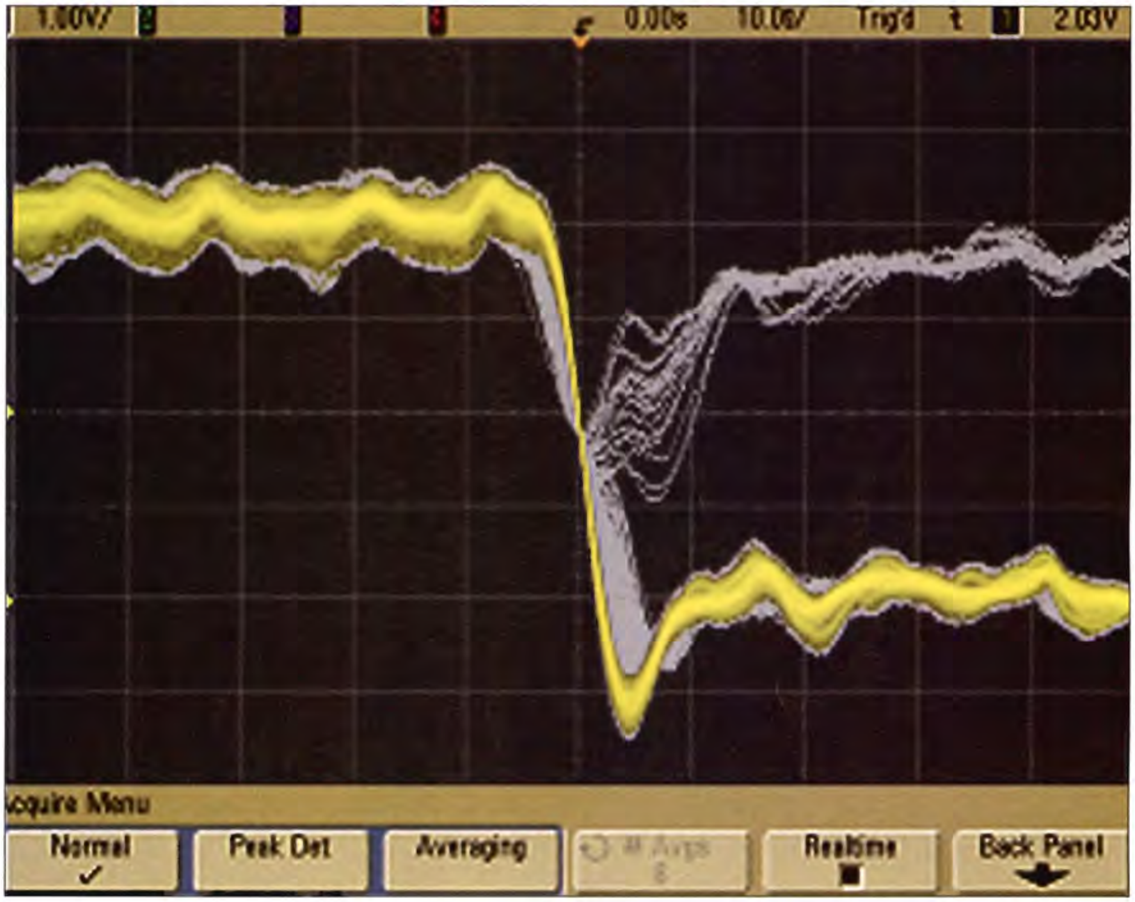


Figure 1: Infrequent metastable state captured on Agilent's 6000 series oscilloscope using real-time sampling

Easier Capturing

Johnnie Hancock of Agilent Technologies explains that oscilloscope waveform update rates determine the probability of capturing elusive events, especially when debugging high-speed digital circuitry

Bandwidth, sample rate and memory depth are the most common specifications engineers evaluate when they select a digitising oscilloscope. However, waveform update rate is another important factor to consider. The rate at which an oscilloscope acquires waveforms and updates the display determines the probability of capturing random and infrequent events such as glitches. This article uses a debugging application – an attempt to capture a random and infrequently occurring metastable state – to illustrate the importance of waveform update rates. There's also a discussion on the use of special repetitive fast acquisition modes and their possible tradeoffs.

Choosing your tools

When you evaluate an oscilloscope, its responsiveness can influence your decision. To get a good feel for whether a scope is responsive, simply probe a relatively fast repetitive signal and view the response. If the scope's display updates too slowly, the sluggishness can make using the scope a frustrating experience. This is especially true with some of today's deeper-memory oscilloscopes, as processing deep-memory records can slow the update rate. In general, if a scope's display is updated at least twenty times per second, the displayed waveform will appear "live" and the scope will feel responsive. But the importance of waveform update rates extends far beyond responsive-

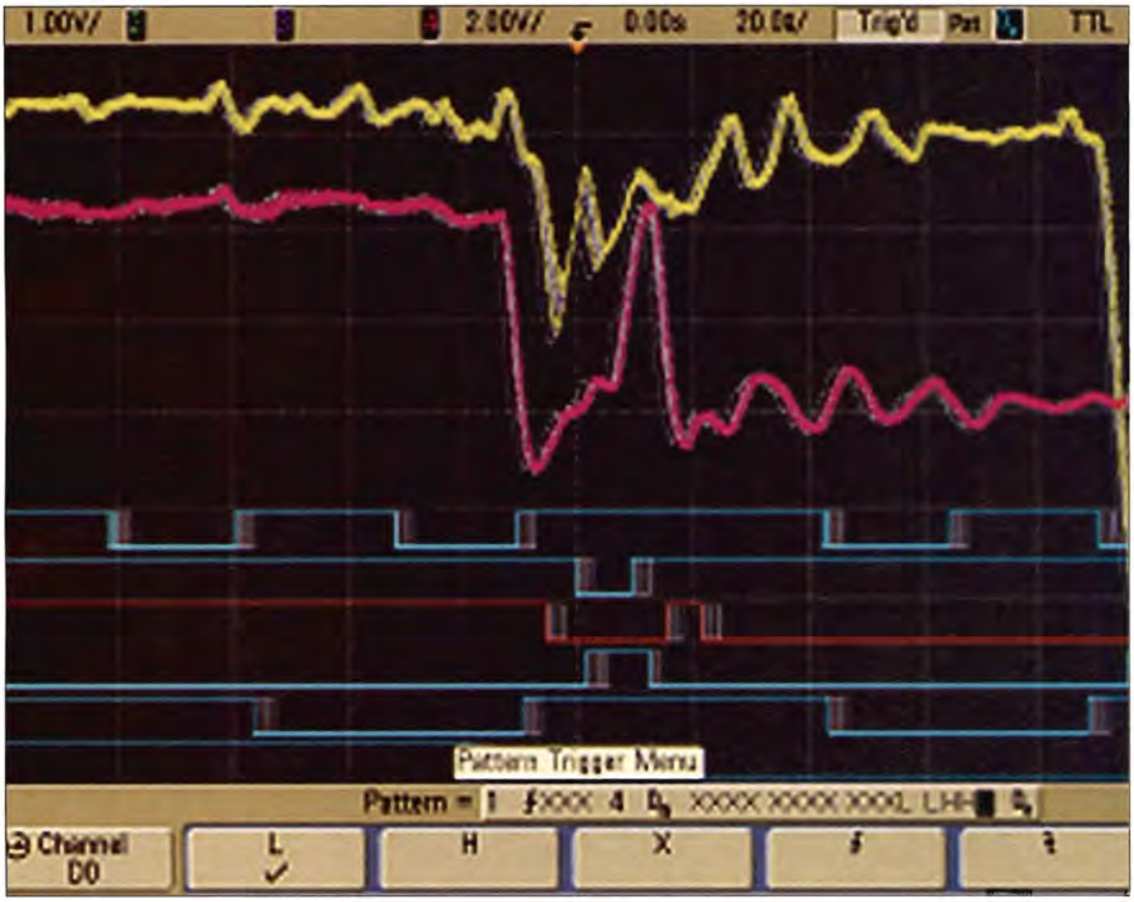


Figure 2: Pattern triggering reveals a setup-and-hold-time violation

# of Elusive Events

ness issues. A "live" feel gives no indication of a scope's probability of capturing infrequent and random events.

Some of today's scope vendors advertise update rates in the hundreds-of-thousands of waveforms-per-second range, but the human eye cannot discern differences in performance at this level. However, when you are debugging high-speed digital circuitry, scope update rates in these ranges are critical because they increase the probability of capturing infrequent events. If the signals you need to observe on a scope's display were always exactly repetitive (no anomalies), extremely fast update rates would not be very important. But when the signals are not exactly repetitive – when anomalies do occur – the random and infrequently occurring events are likely to cause you the most headaches. Faster update rates enhance the probability of capturing elusive events and, thereby, alleviate debugging headaches.

Capturing a metastable state using real-time sampling

Figure 1 shows a random metastable state (glitch) that occurs on average just one time every 50,000 cycles of the data signal. If you knew in advance that this event occurs randomly, you could set up most scopes to trigger on the glitch condition – based on a minimum pulse-width setting – to reliably capture the glitch on each acquisition of the scope. But if you were unaware of the glitch's existence, you might simply probe various signals in your design to verify proper signal fidelity with the scope set up to trigger on standard rising or falling edge conditions.

Because of their relatively slow update rates, most scopes need to acquire data for more than just a few seconds in order to capture infrequent events. If you plan to use the typical debugging model, where you probe each test point for just a few seconds, and you want to capture the infrequently occurring events that may occur at each node, you need a scope with an extremely fast update rate.

The glitch shown in Figure 1 was captured using Agilent's 6000 series oscilloscope, which can update waveforms as fast as 100,000 times per second using real-time sampling, even with sin(x)/x reconstruction. At this update rate, the scope has a statistical probability of capturing this particular errant signal approximately two times per second. Such high real-time update rates are achieved through the use of Agilent's proprietary third generation MegaZoom III technology.

Once we discover that our circuitry exhibits unexpected behaviour, we can begin to further debug our system. Using the logic channels of our mixed-signal oscilloscope (MSO), we are able set up a combinational logic pattern trigger condition across multiple analogue and digital channels. This process reveals that our system occasionally violates a critical setup-and-hold-time specification due to clock jitter, as shown in **Figure 2**.

Typically on the market today, using other digitising oscilloscope's default real-time sampling modes, waveform update rates range from approximately 60 to 700 waveforms per second. Although 60 waveforms per second is more than fast enough to give an oscilloscope a "live" feel, capturing this particular metastable state that occurs just one time every 50,000 cycles will require maintaining probe contact with the test point for an average of nearly 14 minutes to capture just one glitch. Even at 700 waveforms per second, which sounds pretty impressive, probe contact must be maintained for over one minute to capture a single glitch, on average.

If you were using the typical debugging method of quickly moving your scope probe from test point to test point every few seconds, you would probably miss this event using any other DSO's default real-time sampling mode. To capture this particular errant event within a few seconds, you will need an oscilloscope that updates in the tens-of-thousands of waveforms per seconds, or faster.

Using special acquisition modes

Some scopes on the market today claim to have waveform update rates in the thousands-of-waveforms-per-second range. But this usually requires the selection of a special fast acquisition mode. However, there is usually a tradeoff when it comes to "special" modes of operation in an oscilloscope.

Special fast acquisition modes often tradeoff sample rate and acquisition memory depth – and sometimes require the use of repetitive/equivalent-time sampling modes, as opposed to real-time sampling. In addition, there can also be tradeoffs concerning measurement functionality of the oscilloscope including measurements, waveform math, and post-acquisition panning and zooming on stored waveforms.

Although special fast acquisition modes of operation may sometimes be the right selection to choose in order to capture infrequently occurring events, you must know when to use and when not to use these "special" modes due to their possible tradeoffs. In addition, even though a particular scope may claim to achieve waveform update rates in the hundreds-of-thousands of waveforms-per-second range using these special modes, these updates rates may only apply for a narrow set of conditions and they may only produce a scattering of dots and not "complete" waveforms for each acquisition cycle.

Defining complete waveforms

Not all waveforms are created equal. How do you define a complete waveform? By definition, when you use real-time sampling with sin(x)/x reconstruction, each acquisition will produce a complete waveform consisting of a minimum of 500 to 1000 points. But when you use equivalent-time/repetitive sampling, most scopes with "special" fast acquisition modes will produce incomplete waveforms with samples widely spaced on the faster time base ranges. For example, at 200ps/div, one particular scope on the market today produces just 2.5 points (on average) during each acquisition cycle, since the scope limits the maximum sample rate to 1.25GS/s when the special fast acquisition mode is selected. This is clearly an insufficient number of points to define a complete waveform.

Even though this scope may be able to attain an acquisition rate of more than 100,000 acquisitions per second at these faster time base ranges, it does not produce 100,000 complete waveforms per second at these settings. Therefore, to compare waveforms per second between the various oscilloscopes using special equivalent-time sampling techniques, your should normalise the actual acquisition rate on the faster time base ranges in order to compute "complete" waveforms-per-second update rates.

Agilent suggests that a minimum of 500 digitised points should be used as a normalisation factor. So, if a particular scope is able to update at 100,000 acquisitions per second, but only produces 2.5 points per acquisition, it will require approximately 200 acquisition cycles to produce a "complete" waveform consisting of 500 points. This means that the effective waveform update rate is not 100,000 waveforms per second (using special fast acquisition repetitive sampling), but actually just 500 "complete" waveforms per second.

Additional factors

In addition to being cautioned about the truth about special fast acquisition modes, you should also be aware that there are many other setup variables that come into play that can affect waveform update rates. Some of these variables include time base range, measurements, number of active channels, memory, complexity of displayed waveform, etc. **Figure 3** shows a chart of waveforms per second as a function of time base setting for Agilent's new 6000 series oscilloscopes.

Although engineers often overlook waveform update rate performance, when they select a digitising oscilloscope, waveform update rate can have a huge impact on your ability to find and fix intermittent circuit problems. The trick is to use technology that can provide the fastest real-time waveform update rates and one that does not require users to select special operating modes that may entail tradeoffs in performance and functionality.

The number of logic-timing channels is also of great importance to find the root cause of intermittent failures. The more channels there are, the easier the task becomes.

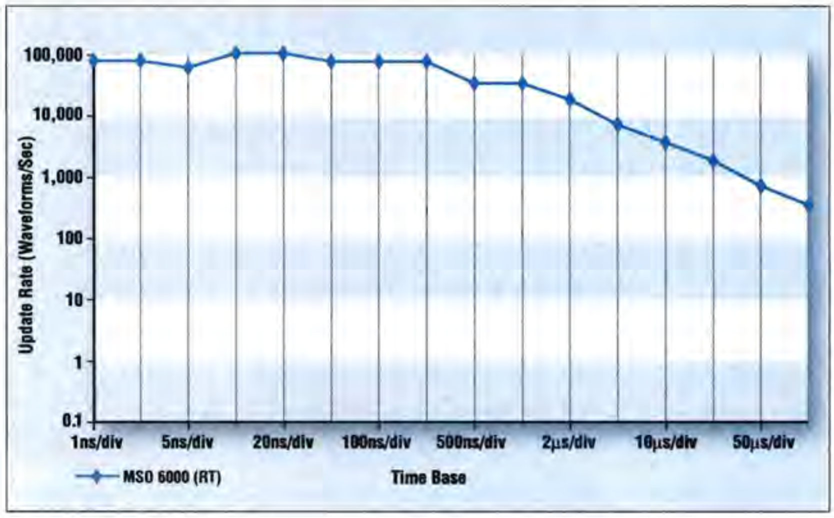


Figure 3: Agilent 6000 series scopes waveform update rates as a function of timebase setting

PICmicro Microcontroller DC Motor Control

Every motor control circuit can be divided into the drive electronics and the controlling software. These two pieces can be fairly simple or extremely complicated depending upon the motor type, the system requirements and the hardware/software complexity trade-off. Generally, higher performance systems require more complicated hardware. The tips below describe some basic circuits and software building blocks commonly used to control motors.

TIP 1: Brushed DC motor drive circuits

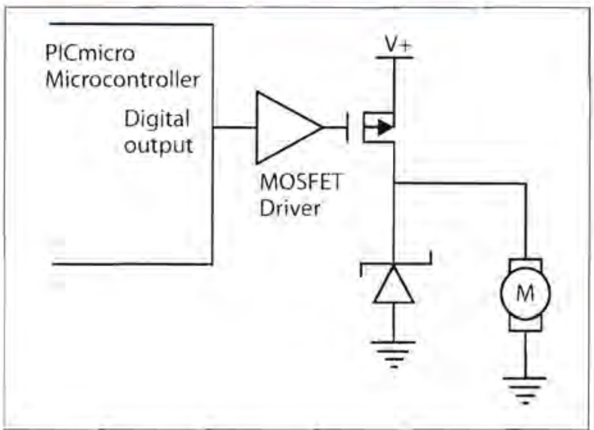


Figure 1: High side drive

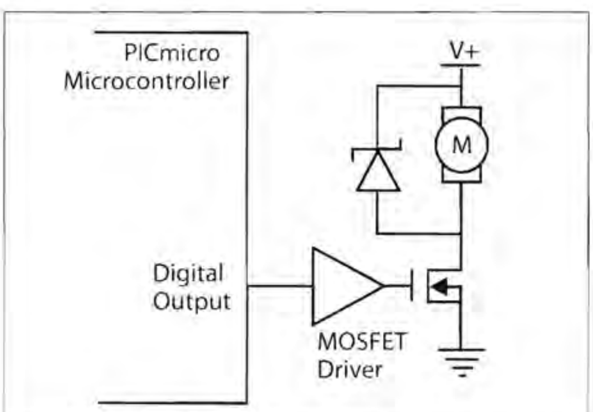
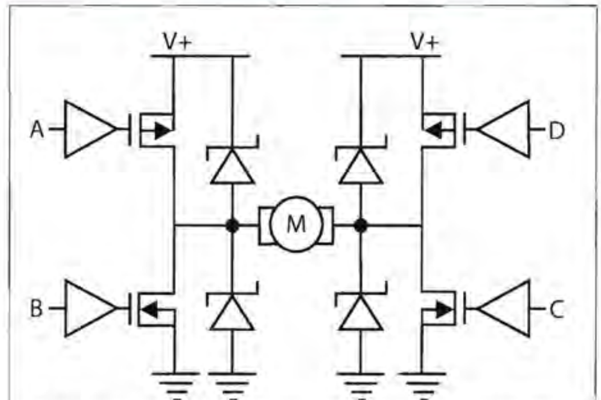


Figure 2: Low side drive

All motors require drive circuitry that controls the current flow through the motor windings. This includes the direction and magnitude of the current flow. The simplest type of motor to drive is the brushed DC motor. Drive circuits for this type of motor are shown in the figures.

This is the lowest cost drive technique because of the Mosfet drive simplicity. Most applications can simply use an output pin from the PICmicro microcontroller to turn the Mosfet on.

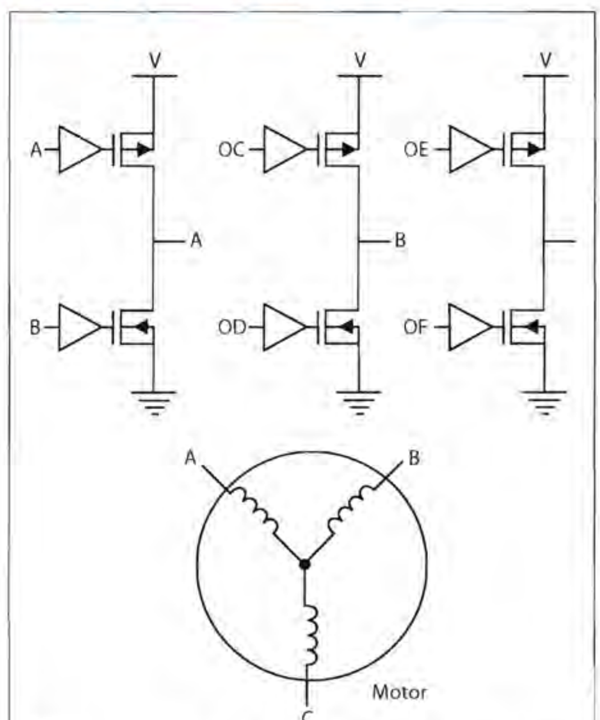


A-D are digital outputs from a PICmicro Microcontroller

Figure 3: H-bridge drive

The H-bridge derived its name from the common way the circuit is drawn. This is the only solid-state way to operate a motor in both directions.

TIP 2: Brushed DC motor control circuits



OA-OF are digital outputs from a PICmicro Microcontroller.

Figure 4: 3-phase brushless DC motor control

A brushless DC motor is a good example of simplified hardware increasing the control complexity. The motor cannot commutate the windings (switch the current

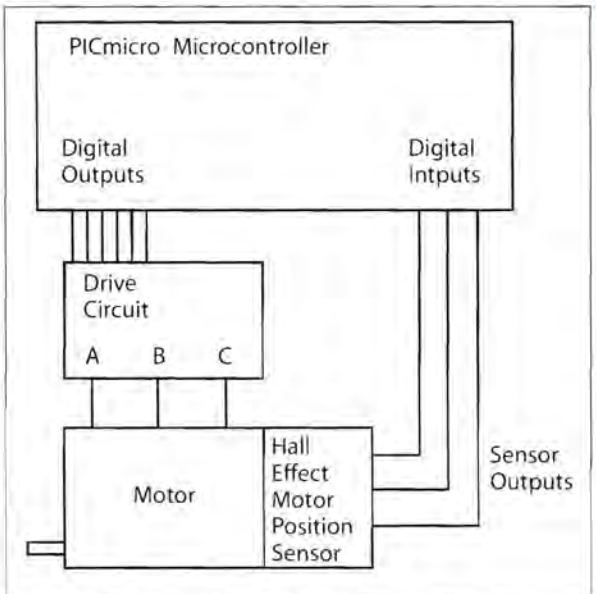


Figure 5a: Quadrature decoder (sensor motor)

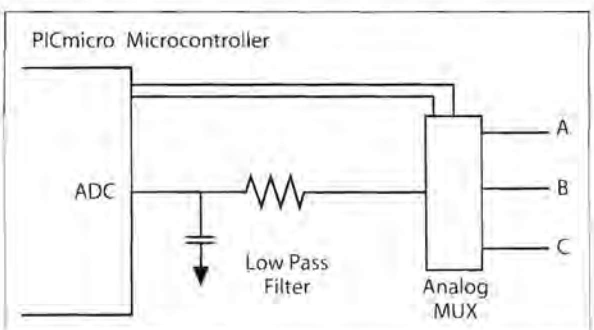


Figure 5b: Back EMF sensing (sensorless motor)

flow), so the control circuit and software must control the current flow correctly to keep the motor turning smoothly. The circuit is a simple half-bridge on each of the three motor windings. There are two basic types of brushless DC motors: sensor and sensorless. Because it is critical to know the position of the motor, so the correct winding can be energised, some method of detecting the motor position is required. A sensor motor will directly report to the controller, the current position of the motor.

Driving a sensor motor requires a look-up table. The current sensor position directly correlates to a commutation pattern for the bridge circuits. A sensorless motor requires that the induced voltage in the un-driven winding be sensed and used to determine the current speed of the motor. Then, the next commutation pattern can be determined by a time delay from the previous pattern.

Sensorless motors are simpler to build due to the lack of sensors, but they are more complicated to drive. A sensorless motor performs very well in applications that don't require the motor to start and stop. A sensor motor would be a better choice in applications that must periodically stop the motor..

TIP 3: Stepper motor drive circuits

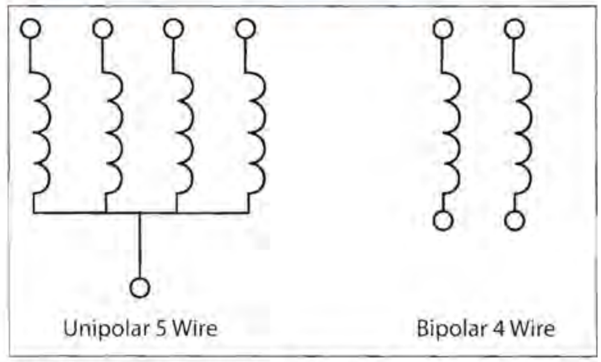


Figure 6: 4- and 5-wire stepper motors

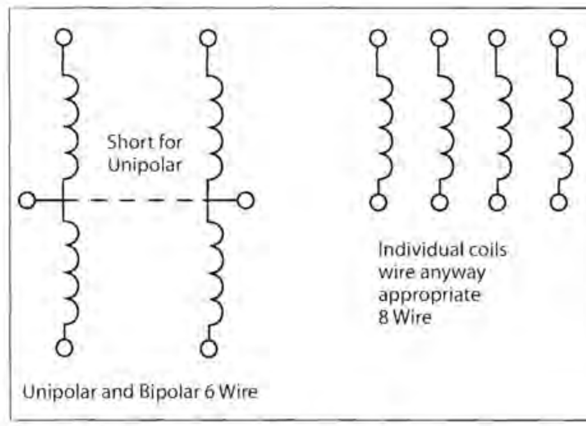


Figure 7: 6- and 8-wire stepper

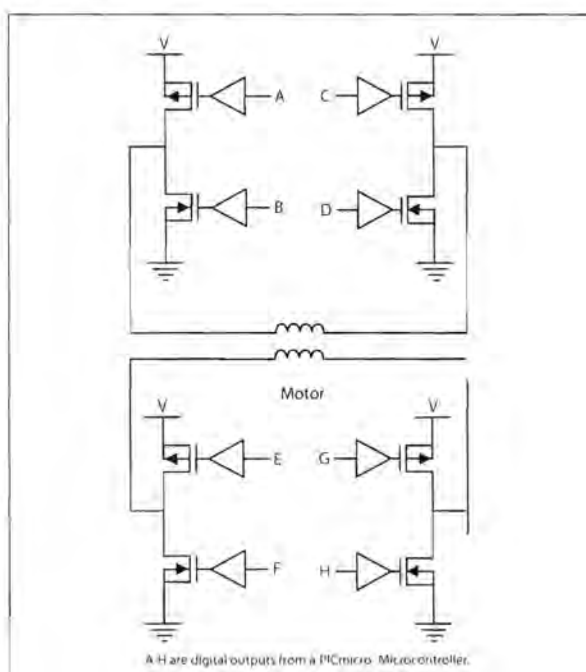


Figure 8: Unipolar motor (four low-side switches)

Stepper motors are similar to brushless DC motors in that the control system must commutate the motor through the entire rotation cycle. Unlike the brushless motor, the position and speed of a stepping motor is predictable and does not require the use of sensors. There are two basic types of stepper motors, although some motors can be used in either mode.

The simplest stepper motor is the unipolar motor. This motor has four drive connections and one or two center tap wires that are tied to ground or VSUPPLY, depending on the implementation. Other motor types are the bipolar stepper and various combinations of unipolar and bipolar, as shown in **Figure 6** and **Figure 7**. When each drive connection is energised, one coil is driven and the motor rotates one step. The process is repeated until all the windings have been energised. To increase the step rate, often the voltage is increased beyond the motor's rated voltage. If the voltage is increased, some method of preventing an overcurrent situation is required.

There are many ways to control the winding current, but the most popular is a chopper system that turns off current when it reaches an upper limit and enables the current flow a short time later. Some systems are built with a current chopper, but they do not detect the current, rather, the system is designed to begin a fixed period chopping cycle after the motor has stepped to the next position. These are simpler systems to build, as they only require a change in the software.

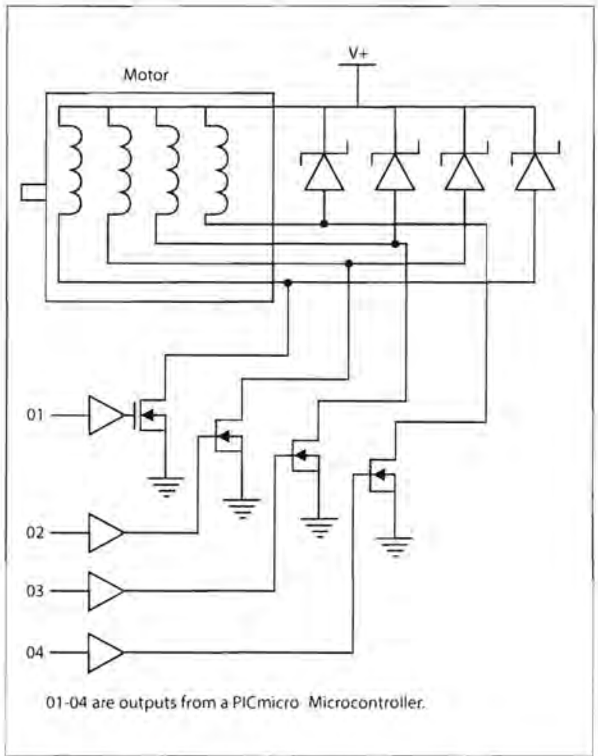


Figure 9: Bipolar motor (four half-bridges)

Win a Microchip PICDEM MC Development Board for Motor Control Design

Microchip's PICDEM MC Development Board makes it easy for engineers of all experience levels to cost-effectively add the efficiency and reliability of electronic motor control to their embedded designs.

The new PICDEM MC supports creation of both AC induction motor (ACIM) and brushless DC (BLDC) advanced motor control applications with the PIC18FXX31 family of MCUs. These devices feature three advanced motion control modules, including a built-in quadrature encoder interface. The PICDEM MC board is also constructed with complete electrical isolation from the power circuitry, allowing users to plug in the MPLAB In-Circuit Emulator (ICE 2000) or MPLAB In-Circuit Debugger (ICD 2) for full programming, debugging and emulation while high power is connected to the board. In addition, the PICDEM MC board's isolated serial-port PC interface to the MC-GUI software enables users to modify their application parameters on the fly. The PICDEM MC combines the above features with included hex, assembler and C source files to provide a complete reference design for ACIM and BLDC motor control applications.

Supported by Microchip's Motor Control Design Centre (www.microchip.com/motor) and the free to download MCGUI, engineers will easily be able to add electronic control to their motor-driven products, reduce development time and costs.

For the chance to win one of these boards, log onto
www.microchip-comp.com/elecworld-picdemmc

RoHS
WHAT'S ALL THE FUSS ABOUT?

RoHS (the Restriction of the use of certain Hazardous Substances) and WEEE (Waste Electrical and Electronic Equipment) is the equivalent of Y2K for the electronics industry. The upcoming EU environmental directives are the most significant developments in electronics legislation to happen in many years and will completely revolutionise the way electrical and electronic products are designed, sold, recovered and recycled. Worryingly, many design engineers are still not fully aware that the upcoming legislation will affect them. For those who are, many questions remain unanswered. Complicated exemption rules, uncertainty about how the directives will be enforced, obsolescence and component availability has left engineers unsure of what they need to do and when. The clock is ticking. With only several months to go, there's no time to lose in the transition to RoHS. If compliant components aren't already part of the design cycle it could well be too late.

Q: What's the update on the latest delays to the WEEE Directive?

A: *The Department of Trade and Industry (DTI) announced a further delay to the implementation of the WEEE Directive in December 2005. The WEEE Directive is now not likely to come into force until around January 2007, 17 months behind schedule of the original date of August 2005.*

Q: What do I need to consider when deciding to upgrade my solder tools to cope with the introduction of lead-free solders?

A: *There are three key areas to consider when upgrading or changing your solder tools: ● Lead-free alloys do not flow (wet) as readily to form the join and will therefore take slightly longer to form the solder joint ● Lead-free alloys currently being specified melt approximately 400C higher than current tin/lead alloys ● Solder iron tip temperature is only one measure of the available energy to solder. Power and thermal recovery (speed to reach optimum temperature) are equally important.*

Q: How do I know if my current solder tips are lead-free compatible?

A: *Solder tips have little or no lead content, however, tinning the tip with lead-free solder prior to soldering will eliminate the risk of lead-free contamination during the soldering process.*

Q: Would a car radio be within the scope of the RoHS Directive?

A: *This is an example of the ruling in respect of equipment that is part of another type of (larger) equipment not covered by the RoHS Directive – a car does not fall within RoHS so, therefore, nor does the car radio.*

Q: I understand that a slow-responding iron can be a problem when working with lead-free solders. What is considered slow?

A: *A slow responding iron will not recover heat quickly enough to solder lead-free joints repeatedly. As a guide, if the iron reaches operating temperature from switch-on within 10-15 seconds this would be considered good. If the heat-up time approaches one minute, this would be considered poor.*

Q: What are the benefits of joining a WEEE compliance scheme?

A: *It is anticipated that most producers will use compliance schemes to meet WEEE obligations of which the benefits include: ● Reduced administration processes for the producers ● Pay the same regardless of the amount of waste ● Competitive service provision such as recycling, transportation etc. ● Producers do not become involved in WEEE collection ● Obligations are catered for in a cost-effective and environmentally-compliant way ● Legal liabilities transfer to the compliance scheme ● A choice of business-to-business or business-to-consumer schemes.*

Q: Should the wheelie bin sticker be put on a printed circuit board?

A: *No, PCBs are considered to be a 'component' and there is no legal requirement to label components.*

Q: I manufacture test equipment; do I have to worry about RoHS?

A: *Not at the moment, as test equipment is category 9 and does not fall within the scope of RoHS. However, ERA Technology are now reviewing categories 8 and 9 for the EC and are expected to report back on their recommendations in the next few months. If it is decided that these categories should be added to the scope of the RoHS Directive, implementation is not expected before 2010. It is also important to note that test equipment is within the scope of the WEEE Directive and should, therefore, be recycled at end-of-life.*

Q: What are the benefits of working with an approved recycling company to meet the requirements of the WEEE Directive?

A: *The benefits of working with a recycler include: ● Potential of cost effectiveness for small quantities of WEEE ● Payment only for recycling what the user returns to the recycler ● Advice on design for disassembly ● Help with collection/treatment ● Information on various treatment facilities ● Practical advice on reuse/salvage ● Knowledge of end markets/raw materials*

Q: What is the definition of 'homogeneous' material?

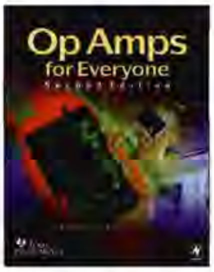
A: *Homogeneous material means a unit that cannot be mechanically disjointed (by cutting, grinding etc.) in single materials such as plastic, ceramic, glass, metals etc.*

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

Op Amps for Everyone (2nd edition)

Ron Mancini

Newnes (Elsevier)



This book takes a different approach from the traditional textbook. It starts with a review of the physics behind op-amps then discusses idealised op-amp models. It is a comprehensive guide to design using op-amps. It gives the readers the basic design and theory of these circuits.

This is an excellent starting reference book. It covers a wide range of circuit and system op-amp based design: feedback theory; ideal and non-ideal op-amps; feedback and stability factors; a comprehensive comparison between voltage op-amps and current feedback op-amps, instrumentation and wireless communication design; ADCs/DACs and active filters. However, probably the most important coverage is in chapter 11, "Understanding Op Amp Parameters", and chapter17, "Circuit Board Layout Techniques".

Few books show useful op-amp design, without bothering to explain anything about how they work. This one does. Each chapter stands alone, with good background, and without the necessity of looking at other chapters of the book. Despite the good features there are some shortcomings in the presentation, however.

The circuit equations in Chapter 2 and the calculations relating to them only involve resistors. A general review of circuit equations should have them expressed in terms of impedance instead of resistance.

In Chapter 3 there is a sign error in Equation (3.4), and (Equation 3.21) is incorrect.

In Chapter 4, plots of input voltage versus output voltage are called transfer curves as shown in Figure 7. It is normal to plot the output (the dependent variable) against the input (the independent variable).

We found the title of the book somewhat misleading, though, as not "everyone" is conversant with the complex frequency variables or with plots and zeros, dealt with, for example in Chapter 7.

Khaled Hayatleh and Bryan Hart

PC-based Instrumentation and Control (3rd edition)

Mike Tooley

Newnes (Elsevier)

Mike Tooley's book is a good practical introduction on how to use a computer to control and monitor external transducers and sensors. I wish I had only known of its existence a couple of years ago when I was commissioned to provide a design for a PC-controlled IC tester, it might have saved my client some of the time and cost it took to investigate the various options.

The first two chapters give in-depth detail on PC hardware architecture, complete with an interesting history of PCs and their growth over the past two decades. Most of the different x86-type CPUs are listed, with a description of their associated chipsets. There is also useful information on PC BIOS data addresses. The ISA, EISA and PCI buses are described in some detail with brief explanations of the AGP and PC104 buses. The features of the USB bus have been comprehensively covered. The second chapter concludes with descriptions of some of the proprietary I/O cards that can be connected to these buses.

The next five chapters are concerned with how to write programmes to access external hardware. There is a full description on the origins of DOS and its command line interface, together with an explanation on how DOS batch commands are created and implemented. A chapter on programming, giving the basics of software engineering, is followed by a description of assembly language programming. The BASIC and C/C++ languages are also covered in some detail.

There is a very informative chapter explaining the details of the IEEE bus and a chapter on hardware interfacing, where a variety of sensors and transducers are described, complete with circuit arrangements. Following that is a chapter on several commercial software packages.

A chapter on virtual instruments deals, mainly, with digital storage oscilloscopes. Together with descriptions of a proprietary DSOs, it describes how to create an oscilloscope using the computer's sound card as an input and the PC monitor as the oscilloscope screen. A working application program, WinScope, is available free as a download from the companion website.

The chapter on applications gets down to the main object of the book namely "PC Based Instrumentation and Control". Several working examples of real projects, complete with detailed information on hardware and software, give the reader a solid introduction on how to employ a PC as a controller or an instrument.

In the last chapter, Mike Tooley provides an introduction to software quality control and covers, in some depth, software reliability and fault-finding. For me, the revelation of the existence of the Microsoft utility "DrWatson" is, alone, worth the price of the book. A set of appendices covering all manner of physical and computer data completes the volume.

The content of the book fully justifies the author's claim that it provides sufficient information to make an informed decision on which hardware and software is needed to implement a range of instrumentation and control systems. It is an ideal introduction to PC controlled instrumentation for students and engineers who have some knowledge of PCs and is a useful reference for professional control and instrumentation specialists.

I was disappointed that there was very little information on the Windows API command interfaces pertaining to hardware input/output ports. The PC serial (COM) ports were only mentioned in passing and, to complete the information on programming, it might have been useful to make a brief mention of Delphi ("Visual Pascal").

The requirement for "stand alone" instruments having turnkey operation has given rise for a large demand for "small board computers", where the use of assembly language to access external hardware is almost a necessity. The chapter on assembly language programming shows how an experienced engineer may fiddle with the guts of the x86 family of processors. However, I do think that Tooley should have given would be experimenters the warning "Dabbling in assembly language can seriously damage your PC's hardware".

I liked the part in the chapter on visual BASIC, where the means of communicating with the PC's parallel (LPT) port is described. The address of web sites of several companies or organisations providing parallel port DLLs and ActiveX programs is given.

Mike Tooley states that his book is the end result of several thousand hours of research and development. Anybody reading through the book would find this very evident, considering the variety of different but related subjects covered in five hundred pages. The author's web site is valuable and has available for download a complete set of source codes for the programs in the book, plus extra documentation and information about the author. I consider this book to be a useful addition to my technical book shelf.

Mike Button

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EWeditor@nexusmedia.com

Siemens's new Sinteso fire detector is intelligent enough to differentiate between a real fire and the causes of common false alarms, such as cooking fumes, insects, steam and dust, bringing an end to false alarms. It can detect changes in temperature and see smoke particles in the air using fuzzy logic, allowing it to recognise smoke from non-threatening causes such as cooking fumes, burnt toast and cigarettes.
Available early 2006, costing £25-£40 from most electrical outlets

The Plantronics Discovery 640 is the smallest Bluetooth headset on the market, weighing only nine grams. Ideal for gadget lovers who are always on the move between car, office and home, it offers multi-point connectivity and incoming call vibrate alert for seamless switching between Bluetooth enabled devices. A huge benefit to users is the innovative cradle charging system that gives up to 15 hours talk-time and multiple charge adapters for compatibility with any mobile device. It is compatible with both Bluetooth v1.1 and v1.2 and supports handsfree and headset profiles of all major mobile devices, including Nokia, Sony Ericsson, Motorola and Siemens.

Available now from under £70
www.plantronics.com
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BT's Trackit is a vehicle anti-theft device. It pinpoints a stolen vehicle's location using global positioning satellite (GPS) technology to within a few feet. The latest in tracking technology is combined with wireless technology, advanced in-car electronics and satellite navigation, so the system can monitor and track a vehicle in order to identify when it is moved without authorisation. The Secure Operating Centre then informs the owner that the car has moved and can liaise with the police to arrange for the vehicle's ignition to be disabled when parked, to help ensure its fast recovery. With this system, a car can be tracked across 27 EU countries and customers can also benefit from police immediate response. **Available now from around £299, with installation at £149 and an annual subscription fee of £149.**

www.trackit.bt.com

Fusing style and technology, Intempo Digital's iDS-01 iPod speaker system and docking station now comes in black, a perfect complement if you can get your hands on the black iPod Nano, which is currently flying off the shelves. Lightweight and portable, this is a powerful speaker system that also allows you to charge your iPod through the built-in dock, while downloading new tracks or listening to hi-fi quality sounds at home, work or at play. It is also compatible with many other audio devices such as a Walkman, MP3 and MiniDisc players and includes powerful 2 x 6 watt RMS with neodymium speakers and 3D Super Bass design. It is mains operated and comes with external AC adaptor and 3.5mm stereo line in jack with a stereo cable for connecting other audio devices.

Available now from around £29.99
Comet, Carphone Warehouse, Amazon.co.uk, dabs.com, misco.co.uk and empire direct

Novel BPSK Demodulator

Digital modulation techniques play a prominent role in modern communication systems and Binary Phase Shift Keying (BPSK) is widely being employed in many such systems. This circuit idea presents a novel demodulator for detecting the BPSK signal faithfully.

In BPSK communication systems, in order to synchronise the sine wave oscillator in the transmitter and in the receiver, a sine wave sync signal is normally transmitted with the BPSK signal. This can be in the form of a burst signal for a short duration (like a colour burst in the video signal), transmitted along with the BPSK signal. Part of the BPSK receiver is shown in **Figure 1** as a block diagram.

The BPSK signal is received and its signal level raised and conditioned by the usual AGC (Automatic Gain Control) circuit, so to meet the level corresponding to that of the sub-carrier oscillator producing the sine wave for BPSK detection. The precision BPSK demodulator, in turn, would recover the bit stream b(k) used in the transmitter. The proposed BPSK demodulator consists of three stages: an analogue adder, a precision full wave rectifier with envelope detector and a threshold comparator as shown in **Figure 2**.

The received BPSK signal (va) and the sub-carrier sine wave oscillator (vb) are added in the op-amp Q1 to get the sum (vc). The sum signal vc is given to the precision full-wave rectifier consisting of op-amps Q2 and Q3 and a PNP transistor T1. The op-amp Q3 functions as a controlled inverter, which would either buffer its input to the output or would invert it in accordance with the conducting conditions of the non-inverting terminal (+). The op-amp Q2 is functioning as a zero-cross detector, as it develops a control voltage to the transistor from the received BPSK signal. When vc is +ve, vc1 is also +ve at its saturating voltage, causing the transistor to go into cut-off state. This, in turn, allows the vc to appear to both the input terminals of Q3. Since equal resistances are chosen at the input and feedback paths of the inverting input (-) terminal, the inverting gain and the non-inverting gain would be -1 and +2 respectively, resulting in an overall voltage gain of +1. Therefore, the voltage vd at the output of Q3 is of the same amplitude and polarity as vc. When vc becomes -ve, the transistor conducts, producing a virtual earth at the non-inverting input terminal (+) of Q3, causing inversion to take place. Therefore, the output vd of Q3 is always +ve, irrespective of the polarity of the input, thus functioning as full-wave rectifier. The presence of the capacitor C and the resistor R at the output of Q3 makes the envelope detected at vd. This is threshold compared at the op-amp Q4 to get the bit stream b(k). The threshold reference voltage VT for the comparator Q4 is preset to a desired value from Vcc through a zener diode and a potential divider. **Figure 3** shows the timing diagram for a typical input.

The circuit of BPSK demodulator presented has a simplified architecture compared to the existing circuits and yields precision results.

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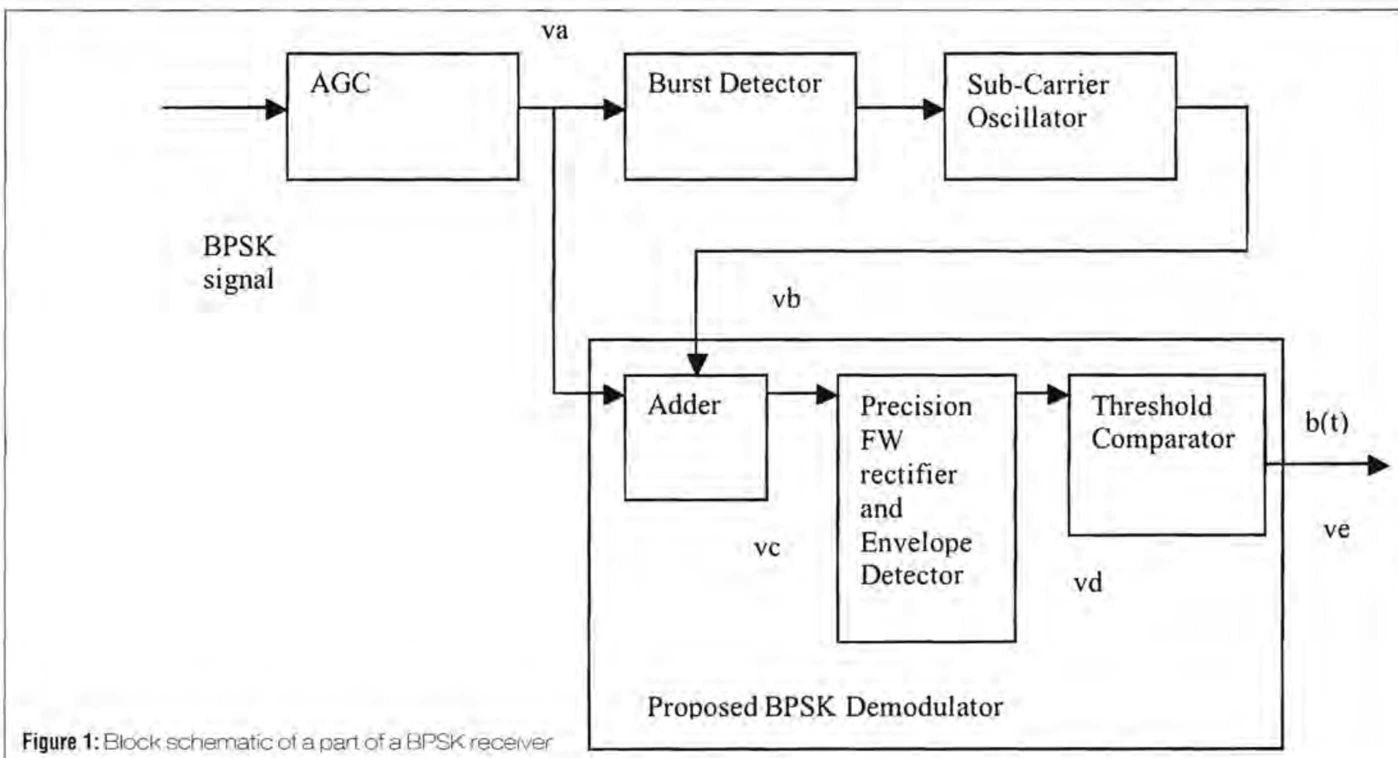
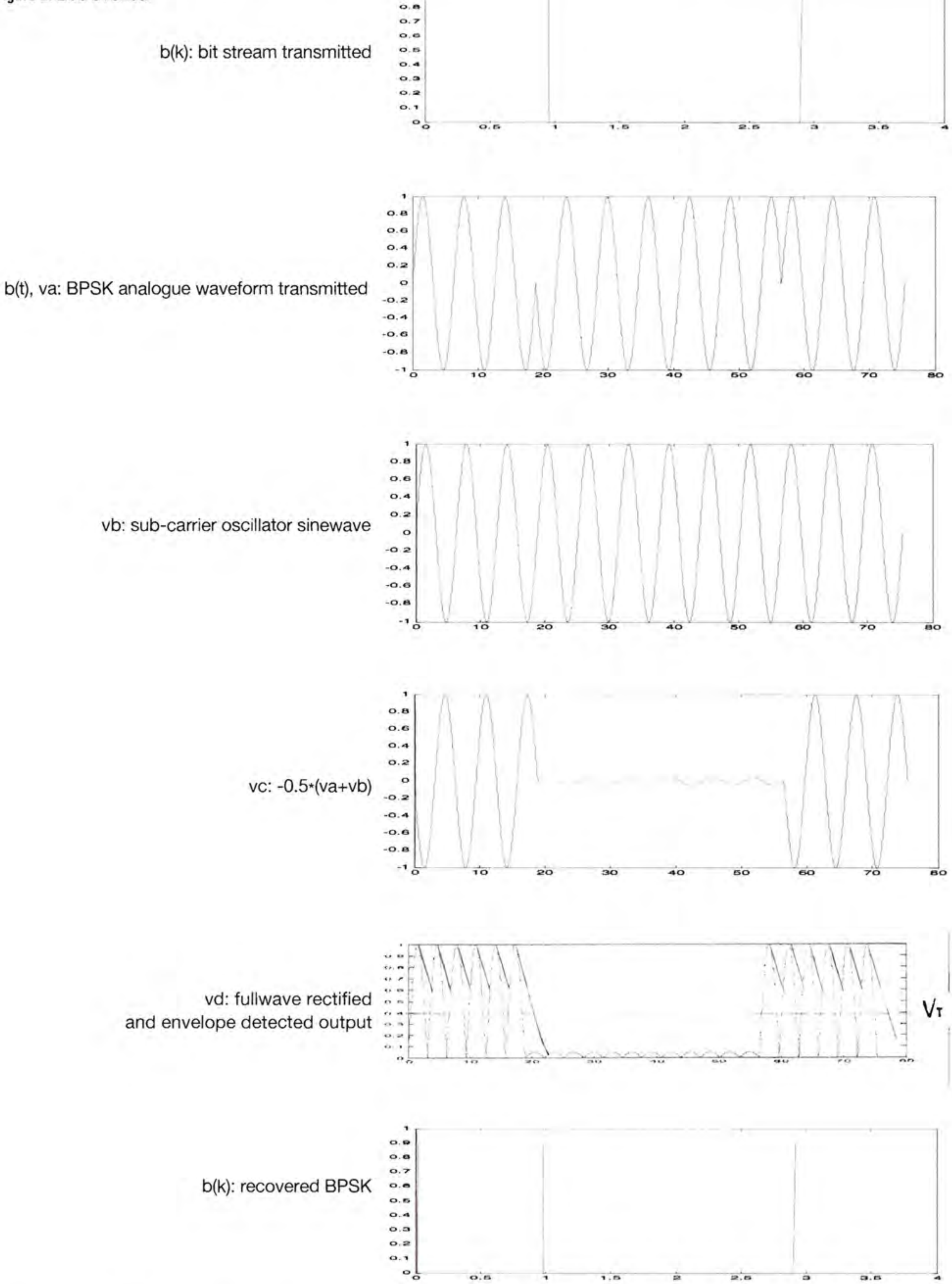


Figure 1: Block schematic of a part of a BPSK receiver

Figure 3: Timing diagram for typical BPSK reception and detection
Figure 2: See overleaf



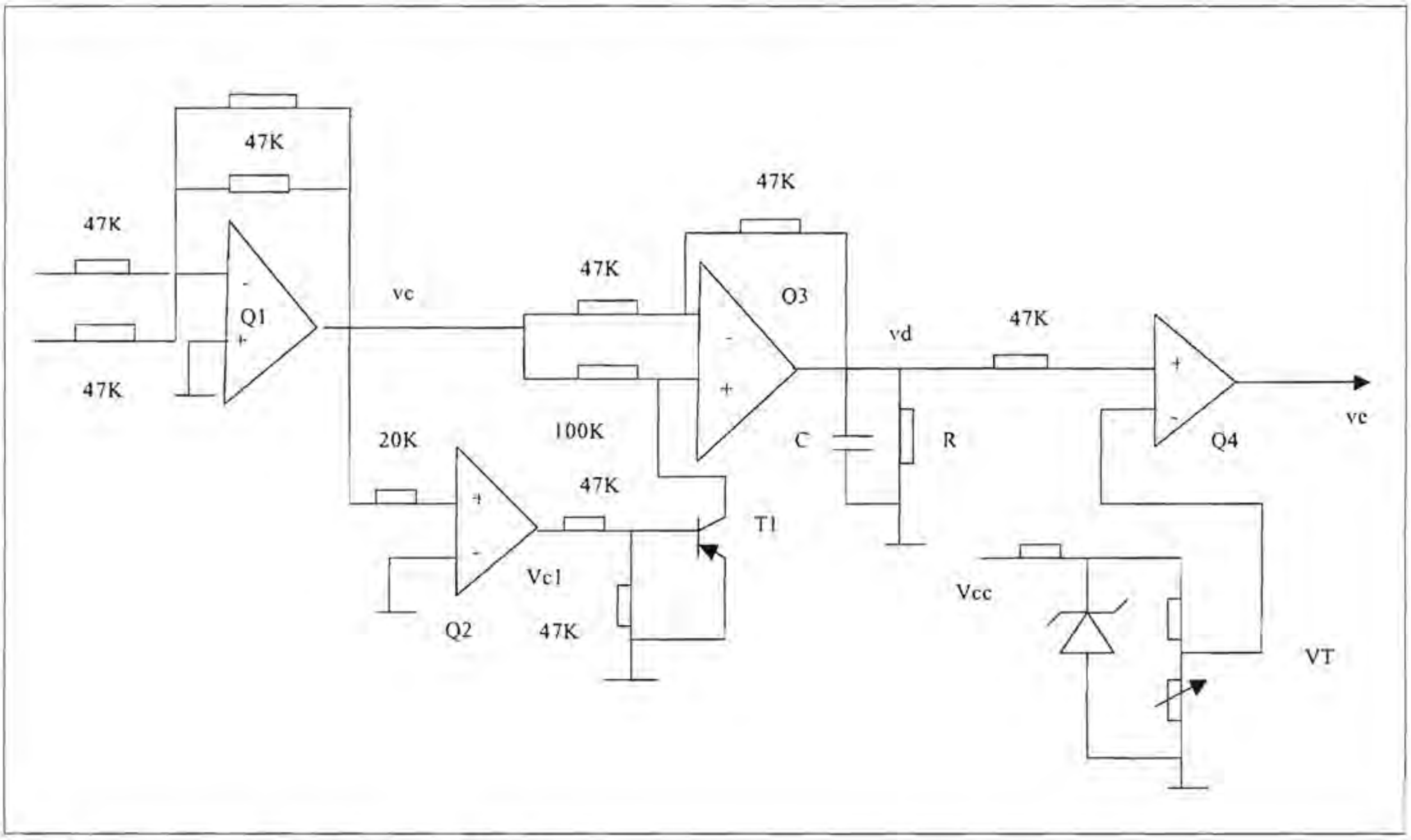


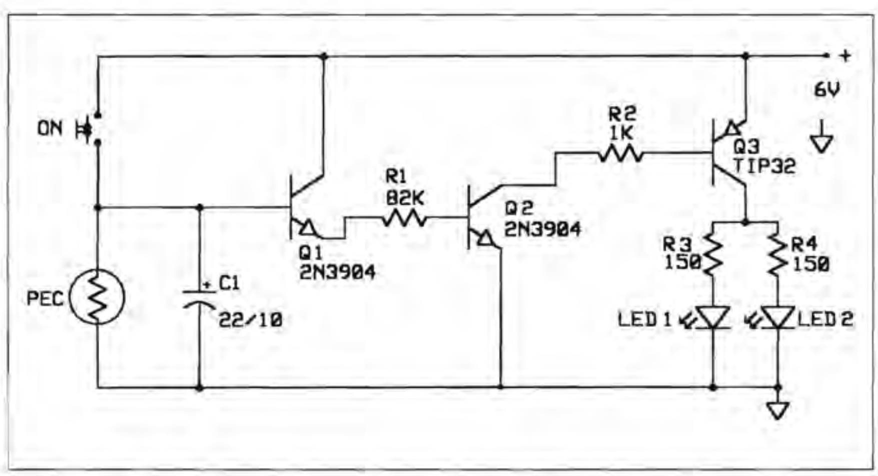
Figure 2: Circuit diagram of the precision BPSK demodulator

Auto-off Utility Light

Here is a circuit idea that shows how to make a simple, practical utility light. You do not have to remember to turn it off as it does that by itself.

This simple but handy circuit has helped feed horses and prevented bruised shins. It turns on when you push the ON button and turns off 15-20 minutes later in a dark room or within several seconds if it sees light, even if its own, reflected light.

Pushing the ON button charges C1 to the battery voltage, 6V. Q1, an emitter-follower, sees enough base voltage and current to turn on Q2. That turns on Q3 the second half of a complementary pair. The LEDs get essentially the full battery voltage as Q3 saturates. It has about 20mV, 0.02V across it when the light first turns on.



As C1 slowly discharges, the base current into Q1 will finally drop enough to cause Q3 to start showing a moderate voltage loss across it. Eventually, all three transistors will turn off, which turns off the lights.

The timing capacitor, C1 sees an impedance approximately equal to the HFE of Q1 times the emitter resistance. Here, that amounts to ~200 × 82000 or about 16,400,000 ohms. As they like to say in the ads, individual results may vary. The spec sheets list the dc current gain as 100-300. The input impedance of Q2 adds to the resistance of R1. For practical considerations, R1 times Beta gives a working figure.

With the values given, the lights will stay on for at least two-three RC time constants: 10-15 minutes. Of course, if the CdS photocell sees light, it will discharge the capacitor sooner, thereby turning off the light in as little as several seconds.

If you need the light longer, make C1 larger or hold down the ON button. If you need more light, add LEDs.

With the values shown, the circuit will drive up to seven or eight more LEDs. With the high-brightness LEDs now available, that will light up a large area.

In the standby mode, the circuit draws no current. Expect good battery life. Size D alkaline cells run the lights for several years of intermittent service. You can make a more compact light with C cells or even AA cells.

Thanks to this idea, a friend does not have to remember to turn off the light after feeding his horses. The one that I have makes a great automatic night-light when staying at a motel or other unfamiliar location or just to use around the house.

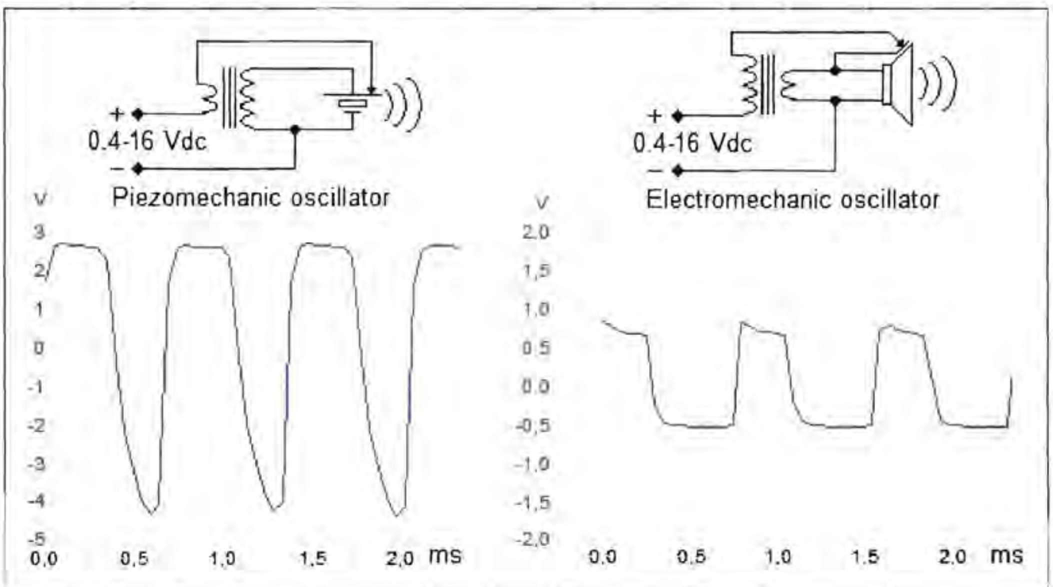
Parts list:

R1 82K 1/4W
R2 1K
R3 120-150 ohms
R4 120-150 ohms
C1 22-47uF 10V low leakage; tantalums preferred but not essential.
PEC CdS resistive photocell or phototransistor with collector going to the switch.
ON switch, momentary contact push-button.
Q1 2N3904 small-signal, high gain NPN.
Q2 2N3904 same.
Q3 TIP32 PNP plastic, TO220 power transistor. A small-signal transistor with a current rating of 200mA would work but would have higher saturation voltage, giving a dimmer light at the start and fading out sooner.
LED1, white or your favourite colour.
LED2, white or any other colour.
Battery 6V. For a 12V operation, such as in a car, make R3 and R4 470 ohms.

Evert Fruitman
Phoenix
USA

Point-Contact Audio Oscillators

The principle of operation of a car horn has been applied to both a ceramic sounder and a loudspeaker. The vibration of the ceramic sounder plate or the speaker membrane causes a break in the supply current. You could implement similar circuits even without a transformer but the voltage range will be limited, there will be too much sparking at the contact point, and pressure and position of the contact become critical. The transformer introduces a feedback mechanism thus eliminating or drastically reducing all mentioned negative effects. An output transformer is used in both circuits: one of the winding is normally 4W or 8W, while the other is at higher impedance. The larger plate of the piezomechanical oscillator goes to positive through the contact, typically an adjustable screw, and the transformer low impedance winding. To get the correct phase relationship you may need to reverse one of the windings for proper operation.



A similar transformer is used for the electromechanical oscillator with the low impedance winding connected to the speaker. Also, in this case, you may need to reverse one of the windings but, first, you must make sure that the speaker cone goes forward when the voltage is applied: reverse the speaker connections if necessary. A small copper strip is glued on the back of the speaker membrane with a screw placed in the speaker casing, so that it just touches the copper strip.

Frequency of operation depends on the position of the screw on the sounder plate: a higher frequency is given with the contact in the middle of the plate. The frequency for the electromechanical oscillator depends mainly on the speaker-damping factor: best results are obtained with the speaker laid against a flat surface or sealing the front side with a wooden panel.

The reported waveforms were measured directly across the transducers at a 2.4V supply voltage.

Operation below 0.4-0.6V depends on the careful adjustment of the screw and mechanical precision of the assembly.

Domenico Di Mario
Milan
Italy

LED driver with 3000:1 PWM dimming range

Linear Technology has introduced a current-mode multi-topology converter with constant-current PWM dimming for driving high-power LED strings and clusters. The device – the LTC3783 – is based on proprietary techniques to provide a fast PWM load switching with no transient undervoltage or overvoltage issues. Ratios of 3000:1 can be achieved digitally as True Color PWM dimming ensures colour integrity of white and RGB LEDs.

The LTC3783 allows an additional 100:1 dimming ratio using analogue control. The controller can be used as a boost, buck, buck-boost, SEPIC, or flyback converter, and as a constant-current/constant-voltage regulator. No RSENSE operation uses the on-resistance of a MOSFET to eliminate the current-sense resistor, increasing efficiency. Applications for the LTC3783 include high-voltage LED arrays and backlighting, as well as voltage regulators in telecom, automotive and industrial control systems.

www.linear.com

Mixed signal MCUs in Versa

Ramtron's Versa Mix 8051 family (VMX51C1xxx) of mixed-signal microcontrollers is a single-chip solutions for a diverse range of signal conditioning, data acquisition, processing and control applications in the industrial, medical, consumer, instrumentation and automotive markets. In addition, Ramtron has also added its Versa 8051 family of low-cost, industry standard, 8051-based drop-in MCUs with up to128kB ISP/IAP flash, designed to simplify device migration.

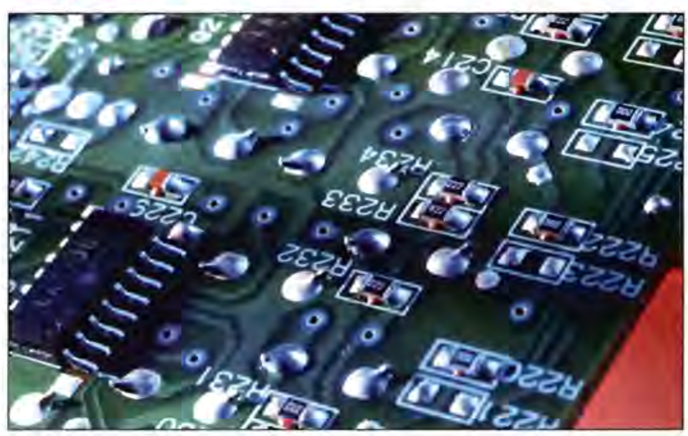
The Versa Mix (VMX51C1020/1016) offers mixed-signal 8051 microcontrollers with DSP capabilities, featuring a comprehensive set of on-chip peripherals for a complete data acquisition SoC. The VMX51C1xxx features a single-cycle 8051 processor that provides an average of eight times more processing power than standard 8051s for increased MIPS and efficiency. The device integrates an enhanced MULT/ACCU unit with 32-bit barrel shifter, 56KB of flash memory and 1280 bytes of RAM.

Peripherals include up to 28 general purpose I/O, three timers/counters, an SPI, two UARTs and an RS-485/RS-422/J1708 compatible transceiver, which enables data transmission over long distances via a twisted pair cable. The VMX51C1xxx operates at 5V and is available in QFP-64 (VMX51C1020) and QFP-44 (VMX51C1016) packages.

Lead-free proof for Henkel

Following a period of extensive lead-free evaluation trials, the electronics group of Henkel has revealed that selected Loctite Chipbonders are not only capable of running lead-free, but are designed to optimise lead-free processes, eliminating chip loss and saving components by low temperature curing systems. The trials involved were testing a range of Loctite Chipbonder adhesives on 'difficult to bond' components. Using Loctite Chipbonder test boards, the trials employed both lead-free and tin-lead dual wave solder machines using a range of Multicore fluxes. The results proved that Chipbonders 3609, 3616, 3621, 3627 and 3629 are optimised for lead-free compatibility.

www.henkel.com



Automotive industry's MOST Straight Junction Box

Molex has recently introduced its MOST (Media Oriented System Transport) Straight Junction Box that offers a lead-free solution for a vast range of multimedia networking car entertainment and accessory systems. Molex's new junction box has been designed as the interface connector between the car media electronics and the harness that connects many types of devices from speakers to amplifiers.

Molex played a pivotal role in bringing about a common standard for such applications. The MOST Junction Box has also been developed as a drop-in replacement for competitor parts, so can also be used with competitor harnesses. The MOST Straight Junction Box provides the transport industry with one of the only straight versions available on the market. Molex has also designed many custom right-angle versions to fit applications where the straight option wasn't suitable.

The junction box can interface consumer automotive devices, such as car stereos and navigation systems, but also transport non-automotive units such as audio systems for lorries or agricultural equipment, as well as entertainment systems for the marine sector.

www.molex.com

Universal input 30/60W switching PSU

Astec Power's new series of external switching power supplies – the DPS50 – is now in production. The new models deliver 30W of total power at 5VDC or 60W at 12V, 15V, 24V or 48VDC. Accepting universal input of 90 to 264VAC or 127 to 300VDC, these power supplies are ideal for external applications requiring flexible implementation worldwide.

The DPS50 series features high efficiency operation (typically >80%), as well as overload, over-voltage, short-circuit and thermal protection. They include built-in Class B EMI filtering, along with a 2.5mm ID barrel jack for the output and a convenient IEC 320 C inlet that can accept input line cords with virtually any appropriate plug configuration.

The conformity of the Astec DPS50 series to key safety, performance and environmental standards from leading agencies worldwide including UL, CUL, CSA, VDE, NEMKO, CB and CE is another major benefit for designers of electronic systems requiring a universal pre-approved power solution.

All models demonstrate a mean time between failures (MTBF) greater than 550,000 hours at full load in 25 degree C ambient conditions and are designed to meet EN1000-X susceptibility requirements.

www.astecpower.com

Software customisable AC/DC PSU

New generation of software-customisable switching power supplies is now available from Emerson Network Power and features digital management capabilities from Astec Power.

The microprocessor-controlled design is the industry's first AC/DC power supply to offer a fully software customisable power solution with the low cost and immediate availability expected from a standard "off-the-shelf" unit.

Astec's new iMP series allows designers complete software control over every major aspect of the PSU configuration. Custom power solutions from 400W to 1500W can be tailored in software to the specific and individual needs of an application, using standard units comprising single, dual and triple output modules in power ratings from 400W to 750W. These modules can be configured in a selection of three customisable MP cases accepting input voltages from 85VAC to 264VAC or 120VDC to 350VDC. Cases can accommodate up to seven individual modules with a choice of outputs ranging from 2VDC to 60VDC.

www.astecpower.com

Picoboard controller board

The Picoboard controller board from DED is specifically designed for use with the Axiohm Electron thermal printer mechanism. The board is small and easy to use; it is cost-effective and suitable for portable applications such as electronic cash registers, electronic fund transfer and test and measurement environments.

The Picoboard is supplied with drivers for Windows 98, 2000 and XP, and an RS232 interface. The board is only 58mm wide, 30mm deep and 13mm high. For integrating a printer driver circuit onto a different PCB, a separate chipset is also available for use with the Axiohm Electron.

In addition, the micro thermal printer mechanism offers simple integration, high printing speed of up to 70mm/s and an easy paper-loading facility. Its footprint is 68.6mm x 26.3mm and height 30mm. With its low weight of 32g and low power voltage of 3.3 to 5V, it is also suitable for battery-powered devices.

www.ded.co.uk

www.electronicsworld.co.uk

To reserve your web site space phone Reuben Gurunlian 01322 611261 reuben.gurunlian@nexusmedia.com

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MCES are a specialist electronics company providing a high quality repair, rework and re-manufacturing service to electronic modules and sub assemblies, including handling both large and small volume production and rework for major manufacturers.

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Working voltage	600V DC or pk-pk AC

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Bandwidth	DC to 150MHz
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Input resistance	10MΩ ±1% if oscilloscope i/p is 1MΩ
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all prices include UK Delivery and VAT

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