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# The fluid state of semiconductors

It's tough being ST, NXP or Infineon today. Squeezed between tough margins and increasing development costs, these firms are facing the choice of spending an enormous amount of money on building new fabrication facilities or just managing the peaks and troughs of the current business climate without too high an expense (even though returns might be lower too).

One thing however seems clear and, if anything, these firms are moving in the opposite direction, where they are divesting facilities or restructuring. As we have already witnessed, until recently NXP was part of Philips; and ST is spinning off its memory division with some of the fabs going with it. All three European firms have said that they will go fab-lite, which means after a certain manufacturing node they will no longer fabricate semiconductors – to the greatest horror of some industry observers.

Even though over the last three decades the capex for building new fabs may have remained within the same range (18-21% of revenues), it is nevertheless an extremely expensive business. Development costs are rising at a tremendous rate, which in itself is hampering the seamless progress in this business.

For example, the International Technology Roadmap for Semiconductors (ITRS) outlined a move from 300 to 450mm wafer production by the year 2012, but this target seems impossible considering the extreme development costs. Tool costs used to roughly double in the switches from 125mm to 150mm and from 150mm to 200mm, but jumped by over a factor of ten with the move from 200mm to 300mm wafer sizes, at a cost of nearly $1.5bn. This cost is likely to top the $100bn mark when moving to the 450mm wafer size. In addition, equipment development spending is likely to reach $1 trillion.

These are frightening figures even to the bravest of business heads. Over the past decade, many companies turned to collaboration, but judging by recent developments, they are now turning away from the idea.

Although the future for diverse products spawned by different IC makers looks less certain now (as fabrication moves to one of the limited number of Far Eastern fabs), at least these companies can rest a little easier knowing that they don't need to spend billions on building new fabs. Instead (and hopefully), a lower but still sizeable figure could be used on developing future devices which may not even require fabrication facilities, but ones that could be built up, atom by atom, rather than etched down.

So, although the business model of each IC firm having its own fab held true for three decades, maybe the end of Moore's Law applies here too.

**Svetlana Josifovska**
**Editor**

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# Russia to invest heavily in advanced semiconductor fabs

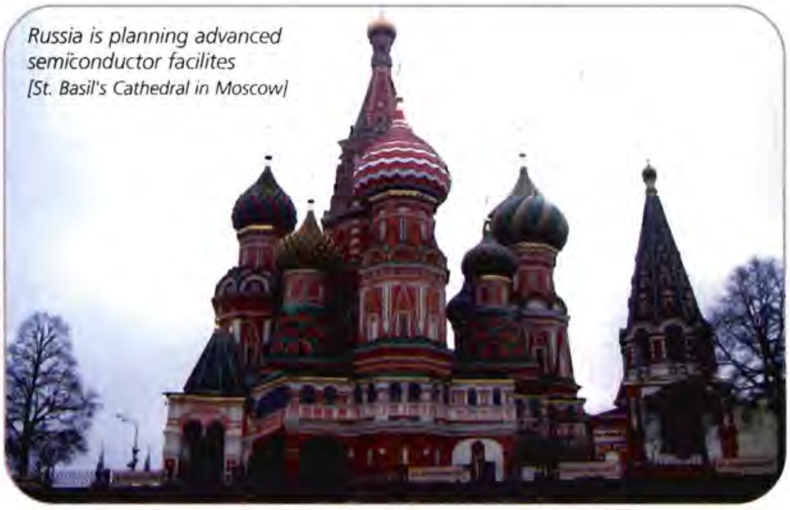
The Russian semiconductor industry represents only 0.01% of the country's economy, yet within the next three to five years it aims to be only one to two generations behind the International Technology Roadmap for Semiconductors (ITRS).

This bold statement was made by Alexander Kalinin, deputy chairman, Russian Federal Fund for Electronics Development, at the Industrial Strategy Symposium meeting in Zürich in March. He unveiled a $1bn government strategy for the period 2007 to 2011 to cover the design infrastructure and product development of the Russian semiconductor industry, with the upgrading of the existing facilities that use 200mm wafers with 180nm features and the construction of new 300mm facilities with 90nm features.

Kalinin said that semiconductors are fundamental to the world economy, but Russian semiconductors are not fundamental to the Russian economy. Problems arose because most of the Soviet industry was government orientated, with hardly any semiconductor commercial design and equipment that is 15 to 20 years old.

The government's $30m program is to develop ten centres like the Elvees Design Centre at Zelenograd, near Moscow, that has mass-produced multichip 0.25µm cores with some 25 million transistors on 12.5 x 12.4mm silicon chips. The national mask facility, which is now using 365nm lithography, plans to convert this to use 248nm and 193nm by 2009, incorporating phase shift masking and optical proximity correction.

Additional investments of $30m from the government and $200m from private sources will be made in the Mikron Corporation for 180nm tools.



*Russia is planning advanced semiconductor facilites [St. Basil's Cathedral in Moscow]*

# 450mm wafers production not dead just yet, but still too costly

It had been thought that a move to a new 450mm (18 inch) wafer size had been firmly put on ice for a long time, but SEMI's recent US Industry Strategy Symposium (ISS) in California indicated that it is still receiving much serious thought, with various diverging opinions.

Dan Hutcheson, CEO of VLSI Research, said he thought the subject had died, but it has not and is costing the industry a great deal of money. He said that the only agreement today is that serious cost issues will be involved in any move to 450mm wafers.

The International Technology Roadmap for Semiconductors (ITRS) planned a move from 300 to 450mm wafer production by the year 2012, but this target seems impossible to meet with its extreme development costs. There were some burned fingers after the last move from 200mm to 300mm wafers, with little return on some investments, which may make investors less inclined to speculate.

Tool costs roughly doubled in each of the switches from 125mm to 150mm and from 150mm to 200mm, but jumped by over a factor of ten with the move from 200mm to 300mm wafers, at a cost of nearly $1.5bn. Hutcheson explained that if this level of spending was extrapolated linearly, the cost of moving to 450mm would be about $100bn, which greatly exceeds the industry resources. Even more alarmingly, equipment development spending would reach nearly $1 trillion.

However, he said the industry could learn from experience and make the move to 450mm a fairly economic cycle. He said that the 2012 date must be dismissed as unrealistic. Instead of worrying about any timeline, the industry should focus on decreasing the cost per transistor by the use of new tools, technologies, wafer sizes and any other possible means.

NXP, formerly the semiconductor arm of Philips, announced a new generation of extremely power-efficient low-$VCE_{sat}$ transistors. Their power loss is reduced by 80% compared to general purpose transistors. The new BISS (Breakthrough in Small Signal) transistors enable ultra low saturation voltage – below 60mV at 1A, and provide high circuit-efficiency, lower energy consumption and reduced heat generation in battery-powered devices. With a maximum collector current of 5.8A, the third-generation BISS transistors use mesh-emitter technology to reduce $RCE_{sat}$ and to enable higher current capabilities, as well as an ultra-low $VCE_{sat}$ parameter.

* * *

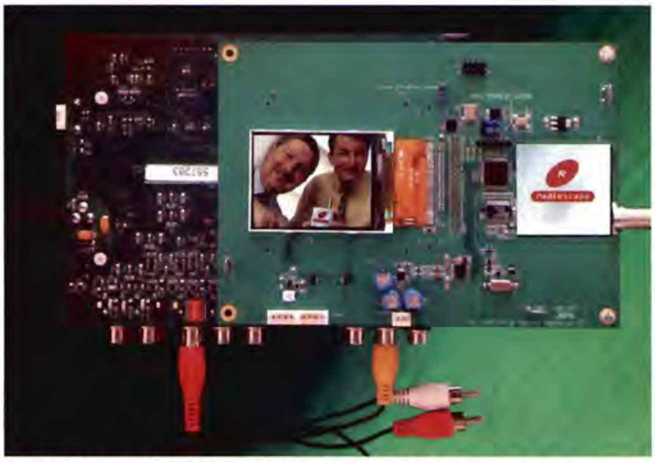
ACE Associated Compiler Experts, introduced the OpenCoSy compiler community initiative aimed to enable and encourage users of the development tool system CoSy to share advanced compiler technology components and to co-develop leading edge compilers. Providing a unique, modular and open compiler generator framework, CoSy offers the perfect environment for development of custom compiler components and exchange of compilation technology IP. Unlike other compiler frameworks, it lends itself to the re-use of components. Once an optimisation technique or data structure extension has been realised, it can readily be shared with other CoSy users. The OpenCoSy community website can be found at www.opencosy.org.

* * *

Austrian-based firm Nanoident Technologies announced the Nanoident Semiconductor 2.0 Platform, the core technology foundation for a wide array of application-specific printed semiconductor devices. The platform enables the realisation of a new class of printed semiconductor-based electronic devices with unique technical features for applications in a wide range of markets, including consumer, industrial, life science and security. The platform consists of four core intellectual property (IP) elements: liquid conductive and semiconducting materials IP, design and simulation IP, production processes and quality assurance IP, and functional component IP. It enables the design and mass production of printed components, such as photo detectors, light emitting diodes, transistors, photovoltaic cells, resistors, capacitors and interconnects.

# Choose a single mobile TV standard, or I'll choose one for you, says EC commissioner

A European Commission (EC) official has issued an ultimatum to those involved in mobile TV to agree on adopting a single technology standard. The EC telecoms commissioner Viviane Reding said that if the industry players did not agree on a standard, she is likely to choose one for them, as Europe is risking losing a chance to be a global player in the upcoming mobile TV market.



*RadioScape software-defined radio (SDR) platform for mobile TV and digital radio*

"The industry should agree on one standard. There's no more time to lose here," she said. "In the end, I could mandate the standard but I do not want to do that."

Although Reding did not want to "mandate" a standard, she did pick one which she thought was a winner – DVB-H, which swallowed some £27m of EC funding during its development.

However, for her bold comments Reding came under severe criticism from the WorldDMB Forum – an international, non-governmental organisation helping to promote worldwide the implementation of DAB/DMB which uses the Eureka 147 family of standards.

"It is ridiculous for the Commission to think that only one system can work everywhere," said Quentin Howard, president of WorldDMB. "Each country has its own unique requirements and market conditions, and the commissioner's preference for one solution suggests she has failed to grasp that mobile [TV] operators and broadcasters need flexibility to develop different business models."

The Digital Video Broadcasting – Handheld (DVB-H) standard is an extension of the DVB-T (Terrestrial) system designed for reception on handheld devices, whereas Digital Multimedia Broadcasting (DMB) is an extension of the Digital Audio Broadcasting (DAB) system based on the Eureka 147 development.

DVB-H is already in use in many EU countries, but the UK, Denmark, Norway, Belgium and Germany among others have already deployed mobile broadcasting using DMB. Still, there are differences even within a single standard. For example, mobile TV in the UK is delivered using DAB-IP, while in Germany the DMB variant is the platform for its national mobile TV network.

DMB is also adopted by countries in Asia; however, Japan has opted for its own standard – ISDB-T, Korea for T-DMB and China for T-MMB.

Solutions suppliers, such as RadioScape for example, are gearing up for all eventualities, developing software-heavy platforms that can work with many standards.

# IMEC shows NBTI is frequency independent

The Inter-University Microelectronics Centre (IMEC) in Belgium fabricated on-chip test circuits designed to accurately evaluate the shift in the threshold voltage $V_t$ in CMOS technologies resulting from Negative Bias Temperature Instability (NBTI) – the most important reliability problem.

Initial work concentrated on static or DC NBTI stress, but dynamic or AC data on NBTI was not clear, especially the frequency dependence of $V_t$ shift. Theoretical predictions covered only lower frequencies, yet current CMOS logic devices operate from low frequencies up to a few GHz in processors. Hence, reliable data was needed over a wide frequency range to enable NBTI degradation to be predicted in CMOS technologies.

IMEC's circuits consist of a ring oscillator, a frequency divider, a buffer, a pass-gate based multiplexer. The tested devices included a pFET and a CMOS inverter. The circuits were designed to allow measurements to be made in multiple modes on both devices under test, together with the testing of the charge pump characterisation of the stressed pFET. They were fabricated in a standard 130nm CMOS flow with silicon-oxynitride gate dielectrics, whose equivalent oxide thickness was only 1.4nm.

Low frequency measurements were made from 1Hz to 1MHz on identical circuits without the ring oscillator section using an external pulse generator. All measurements were performed at 125°C.

The results using both single pFETs and CMOS inverters indicated that dynamic NBTI is independent of frequency over the extremely wide 1Hz to 2GHz range. The NBTI shifts in $V_t$ due to dynamic stress are about half those of their static counterparts. The low value of $V_t$ shift at 1MHz is attributed to the loss of stress signal integrity caused by set up parasitic effects, which may explain the frequency dependence reported by other groups.

# US group claims first non-polar blue-violet laser diodes

The first non-polar blue-violet laser diodes have been developed by the Solid State Lighting and Display Center of the University of California, at Santa Barbara, US. These non-polar laser devices, based on gallium nitride, are expected to be used in high density optical data storage applications for high definition data displays and video, optical sensing and various medical applications.

The diodes displayed threshold current densities as low as 7.5kA per $cm^2$ and a lasing wavelength of 405nm, which is the wavelength that is required for high definition optical data storage applications, such as HD-DVD and Blue Ray DVD. Currently c-plane violet laser diodes, based on polar gallium nitride, are used for these applications. They could soon be replaced with non-polar diodes, which require lower power and have the longer lifetimes necessary for high performance operation.

The devices produced so far have been operated only under pulsed conditions, whereas continuous wave operation is required for commercial application.

Austrian firm Emporia has created a mobile phone especially for those aged 50 and above, and everybody else who finds existing handsets too fiddly and complicated to use. The Life phone has a built-in emergency button, a loudspeaker tuned for those who are either partially sighted or use a hearing aid, a big screen and big buttons. It only has the most basic functions on board such as allowing owners to make and take calls, send and receive text messages or manage their directory of numbers. The phone will go on sale around the world in May.

* * *

New Zealand firm Zephyr Technology has created a smart fabric that has various sensors woven into it. Once paired with electronics to store and broadcast data, this fabric can record vital statistics from the wearer. It gathers and gives information on heart beat, skin temperature, posture, activity and breathing rate.
At present, the company is preparing two patented products: a bio-harness and a shoe pod. The bio-harness is a type of a belt, and the shoe pod has a smart insole.
Initially, the fabric will be aimed at athletes and the Special Forces, but in due course its reach will widen to the health and medical sectors. The company is already in discussions with the US Department of Defense to provide its special forces with the bio-harness.

* * *

Digital Info Technology has launched the Nimzy Vibro Max speaker system (see below) which turns any flat surface into a speaker. No bigger than a Rubix cube, the Vibro Max is the ultimate portable speaker – all it needs is a flat, solid surface, and the patented electro-acoustic technology does the rest, transforming sonic signals into sonic mechanical vibrations to produce 20W of sound quality. Deemed a "great alternative to earphones or conventional portable speakers" by the company, the Vibro Max offers omni-directional surround sound that allows listening to music or sound from all directions.

# SECURING MOBILE DATA

**1 Don't just delete your data – encrypt it:**

Deleting data on your portable device rarely means that the data goes away forever. There are commercially available utilities that can undelete 'deleted' data in seconds. To be 100% secure, you should always encrypt data held on a mobile device. This ensures that the information is protected throughout the device's lifespan – and beyond.

**2 An unsecured wireless device can pose a serious security risk:**

Many organisations allow staff to access the company network using a wireless notebook, PDA or smartphone with network-based security software. It's worth noting that the latest exploits can use connection hijacking to give hackers access to the company network using the mobile device as a stepping stone, which poses a danger when the unit is passed on or falls into the wrong hands.

**3 Encrypt and authenticate at all points:**

The increasing use of portable devices and WiFi access to company IT resources means that truly personal control of data is a thing of the past. As a result, data on PCs, laptops, PDAs and smartphones – as well as back-up data on the network – needs to be encrypted. It's now possible to install encryption solutions on most mobile devices. You can also use authentication technology – tokens, biometrics and smartcards – to create a security system that is stronger than the sum of its parts.

**4 Factory reset cancels everything – or does it?**

Using a factory reset on your portable device may seem to be the easiest precaution before disposing of the unit, but factory resets are far from permanent, since they only delete the header information to your data. This allows file undelete software to be used. The best way to delete data forever is to use encryption as standard. That way, even if a hacker manages to undelete your portable device's files, it stays secure, since it is encrypted.

**5 Don't forget the back-ups:**

Even if your smartphone, PDA or laptop data is securely removed from the mobile device, it can continue to exist on a back-up somewhere on the company's IT network. Even deleting the data files on the back-up system is not full deletion, as network/PC restore functions can regenerate the back-up files.

The most secure approach to data deletion is to encrypt the data in the first place, as well as ensuring that the machine you are synchronising with is also protected with encryption.

**6 Implement a best practice policy for mobile devices:**

The optimum approach to mobile device security is to conduct a risk analysis and, from the results, formulate a best practice set of policies relating to the use of mobile devices across the entire organisation. Remember that good IT security is not just in the domain of the IT manager – it's a responsibility that needs to be shared across all disciplines.

**7 Effective data scrubbing can augment encryption:**

Data scrubbing – aka file shredding – is one option to delete sensitive information files. Most PDAs and laptops now have file scrubbing/shredding utilities available. When used in conjunction with on-device encryption technology, the security of the mobile device is raised by several factors.

**8** **IDs and passwords give the game away:**

There's more to ID/password security than avoiding writing them down. Always use a combination of letters plus numbers that only mean something to you personally. Avoid using the same ID/password on multiple systems. You can now replace your conventional password system with a single sign on solution or a picture-based system such as PicturePin, which uses pictures rather than words to act as an aide memoir.

**9** **Don't forget the cellular network back-ups:**

A growing number of cellular networks now support network-based data back-ups. Although designed to assist users in the event of a mobile phone loss or theft, the back-up poses a security risk if a third party obtains your network logon details, or if your old mobile number is re-assigned (as most are). If you must use cellular network-based back-ups, remember to delete the data when no longer needed. Consider building this strategy into your organisation's best practice security guidelines.

**10** **Are you at the end of your mobile contract? Upgrade your mobile, but don't forget about your old handset:**

Upgrade your mobile, but don't forget the data – including your contacts list – on your old handset. Many mobiles automatically back up data from the SIM card to the phone, so moving your SIM card can leave contact data behind on the old handset. The best way to delete contact data on a mobile is to copy data from a new SIM card to the old phone – and so overwrite the old contacts list.

**11** **Not all information needs to be downloaded:**

Just because a set of data is available on the company desktop resource doesn't mean it should be downloaded. A better option is to securely view that data on the mobile device using a 'window viewing' approach – when the connection disappears, the window-based data also disappears. You may also want to consider an information control system to supplement the company data downloading policy.

**12** **And finally...**

The Companies Act in the UK and the Sarbanes-Oxley Act in the US, which is a growing number of UK organisations, especially those that trade with the US, are implementing a mandate that high levels of security and compliance are introduced in companies both large and small.

Despite this, recent research has shown that 55% of mobile devices in active use by UK organisations are unprotected.

Three quarters of respondents in the DTI Information Security Breaches Survey of 2006 stated that the theft of a laptop or mobile devices had been their worst security incident – proving extremely problematic, not just in terms of reconfiguring their systems, but the unknown long-term use of the data and public perception of trust.

This month's Top Twelve Tips were supplied by Martin Allen, Managing Director of Pointsec Technologies.

*If you want to send us your top tips on any engineering and design subject, please write to the Editor at* ***svetlana.josifovske@stjohnpatrick.com***

# Electronic tooth in controlled drug release

Scientists in an EU consortium led by the German-based Fraunhofer Institute for Biomedical Engineering (IBMT) have developed a prosthesis that releases the necessary dose of required drugs continuously.

Unlike earlier drug donating prostheses and implants, this 'intellidrug' unit is small enough to fit into two artificial molar teeth inside the patient's mouth. It is easily accessible and can be readily maintained and refilled with a drug.

The prosthesis comprises a drug filled reservoir, a valve, two sensors and a number of electronic components. Saliva enters the reservoir via a membrane, dissolves part of the solid drug and flows via a small duct into the mouth to be absorbed by mucous membranes.

Two sensors in the duct measure the amount of the drug being released into the body. A flow sensor measures the volume of liquid entering the mouth through the duct and the other measures the concentration of the drug in the liquid. The electronic circuit controls a valve at the end of the duct to adjust the dosage.

If all the drug is used, the electronic system provides an alert via a remote control developed at IBMT. Dosage can be controlled using a wireless link operated by the patient or doctor. Typically, the prosthesis is refilled every few weeks, often by replacing the prosthesis. This system offers the advantage that no peak concentration occurs like that after taking a pill. Such peaks often magnify unwanted side effects of a drug.

Intellidrug will undergo clinical testing this year. The system is hoped to help chronically ill patients, especially the elderly, who often forget to take their medication at the right time and in the right dosages.


*Electronic tooth prosthesis developed by an EU consortium led by the Fraunhofer Institute*

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# 2007... the year of RFID?

**Teresa Jones**, Senior Research Analyst at the Butler Group says that many organisations have been put off from deploying RFID technology in the past, but no longer this has to be the case as the technology continues to improve

RFID technology is no longer new, yet it has seen relatively little take-up to date, in spite of some high profile trials. However, during 2006 there have been a number of successes, as some of the teething troubles start to be overcome. Might 2007 finally become the year that such technology becomes commonplace?

RFID tags are essentially a chip and an antenna that is spiralled around the chip providing a relatively flat label that can then be affixed to products or containers. The majority of chips are passive, in that data is stored on them which can then be read and compared to a database that matches the code on the tag. Active tags transmit information wirelessly and, therefore, need a power source, although this can be very small. Radio frequency is used to transfer data between the tag and an antenna and then onto a reader, which communicates with the tag. The reader can receive commands from application software and provide a power supply to tags where needed.

The advantage of RFID tags over barcodes is that more information can be stored on the tag and a line of sight to read or scan tags is not necessary. Several tags can be read in one scan and, with some tags, data can also be re-written (for example, saying where the item has been is very useful for traceability).

As well as scanners or readers, additional hardware and software will be needed, adding to project costs. To date, the scanning process has been somewhat inaccurate, with mis-scans being common, but accuracy is improving as organisations gain better understanding of the best positioning of readers and as devices evolve. So, although the cost of tags may be an issue (even though they are coming down in price as volumes grow), it is only a small part of overall costs of any project which needs additional hardware and applications to process the data and then do something value-added with it. This is likely to be what is putting many organisations off doing projects with RFID, even if they can see that there may be some benefits.

Until recently, mandates for the use of tags have come mostly from the US – with WalMart and the US Department of Defense both requesting that suppliers use tags. In Europe, the UK's Tesco and Germany's Metro supermarket giants are also involved. Newer projects include 2006's World Cup event, where RFID chips were incorporated in all 3.5 million of the tickets sold. The cost of tagging was some $700,000 but the benefit in this case was in improved risk management (the tags allowed the tickets to be checked against lists of known trouble-makers when combined with activating facial recognition cameras).

A Dutch bookstore chain, Boekhandels Groep Nederland (BGN), has been using tags and both fixed and portable scanners with significant benefits. In

2006, the chain launched two new fully-automated 'Smart Stores' that combine item-level RFID tagging and also used a Service Oriented Architecture (SOA) approach to deliver an integrated 'warehouse-to-consumer' supply chain. This improves stock control and also permits better services to be provided to customers, such as book ordering and specialist searching.

A point to note is that the RFID tags are 'killed' (de-activated) at the point of sale, which lays many potential privacy issues to rest. At the initial deployment the checkout process had not been automated, but this could be a second phase. Loss prevention could also be a future, as could automatic re-ordering, since inventory is already reduced at the point of sale. In this case, the tags are about 1% of the book cost (approximately €0.15), but the fully loaded cost is probably more like €0.25, including the cost of actually applying the tag.

RFID tagging can only be of real benefit if the data being transmitted is clean and of high quality. This is not a technology issue, but one that has been at the heart of many failed initiatives particularly relating to supply chains.

Undoubtedly RFID will become increasingly used in manufacturing and the supply chain, but there are some novel uses around as the technology improves, including solar-powered yet washable clothing that allows the wearer to be located easily using a combination of GPS positioning and Internet access – which could be useful for skiers in potential avalanche areas as well as military uses or even in tracking children.

Innovation in the use of RFID technology continues apace, but the real world problem of how best to then use the data that it can deliver in an appropriate manner is still likely to mean that it remains just another innovative idea for some time to come. Most organisations still have significant hurdles to overcome before they will be ready to reap the benefits that can accrue from it.

**RFID TAGGING CAN ONLY BE OF REAL BENEFIT IF THE DATA BEING TRANSMITTED IS CLEAN AND OF HIGH QUALITY. THIS IS NOT A TECHNOLOGY ISSUE, BUT ONE THAT HAS BEEN AT THE HEART OF MANY FAILED INITIATIVES PARTICULARLY RELATING TO SUPPLY CHAINS**

# ISRAELI FIRMS IN NEXT GENERATION DISPLAYS

Israeli high-tech companies typically are not in the peripheral end of the computer market but tend to concentrate more on the back end, chip-level or software core of consumer products. The technology is usually incorporated as an OEM component into a larger system.

When it comes to computer displays and screens, no Israeli company has made it on the world's stage, either by going public or being sold to large, multinational players. However, a small group of start-ups that are developing unique technologies will likely be at the forefront of the next generation of displays for every type of screen

***Figure 1:*** *Mirage LightVu*

## PEPTRONICS

Based on original research by Professor Nir Tessler of the Faculty of Electrical Engineering at the Technion-Israel Institute of Technology, Peptronics has succeeded in manufacturing new organic semiconductors using proteins designed from scratch in the lab and linking them together in precise chains to create electronic grade material. The company says the new semiconductors, called electronic peptides, will lead to lighter, cheaper and more flexible electronic devices within the next two years.

The electronic peptides will be used in full colour, foldable LED displays, with a sharper resolution than today's computer screens. It will also have an application in large, flexible solar cells that spread flat and roll up like a blanket. The peptides could be used in sensor devices that detect tiny amounts of disease molecules in the body or toxins in the environment.

"We can construct the electronic peptides one building block at a time, which gives us precise control over the semiconductor's properties, such as its ability to produce a particular colour on a flat screen monitor," said Professor Tessler. "The block-by-block approach allows us to prepare the material in the same way that electrical engineers at Intel or IBM prepare a circuit. We are seeking 100% control that will lead to close to zero errors."

To build the electronic peptides, Professor Tessler and his research team at The Technion began by imitating nature. In human cells and the rest of the biological world, peptides are created by linking together amino acids, the basic building blocks of proteins. In the lab, they used an automatic peptide synthesiser – a computerised machine – to link together artificial combinations of amino acids and create new peptides with semiconductor properties.

The precision manufacturing process creates 'electronic grade' material, which means that the material will not lose its response to electrical signals over time like some other organic semiconductors.

Tessler says the peptides could be integrated into existing electronic devices and are not intended as a replacement for the silicon based circuitry in today's computers. The most popular application for semiconductors like the peptides is in flat screen displays, since these semiconductors use less energy than the materials in current computer monitors. Laptop computers with peptide-powered flat screen displays, for instance, would need to have their batteries recharged less frequently.

# JOEL BAINERMAN GIVES DETAILS OF SOME OF THE CUTTING-EDGE WORK DONE ON DISPLAY TECHNOLOGIES IN ISRAEL

***Figure 2:*** *Citala's flexibile display*

## CITALA

Citala Ltd has developed the first mass-produced, plastic, character display. The displays are paper-thin, flexible, durable, power-efficient and overcome current display limitations.

The company calls its development Active Pixel Display (APD) technology which is based on the Onyx compound (to replace liquid crystals) and plastic substrates (which replace glass sheets).

The APD technology enables a made-to-order character displays that can be customised to fit application requirements. For example, size, form (i.e. paper-thin display applications), shape (i.e. curved and rounded display applications), and durability or colour format.

In addition to versatile mechanics, APD character displays offer outstanding optical properties such as contrast, brightness, wide-viewing angle and more.

The company claims the technology will enable the creation of displays that are free of fragile glass components, comprised of plastic substrates, flexible and paper-thin – offering display panel thickness of 300 microns. It will also allow mass production of smartcard display modules in a roll-to-roll manufacturing line.

Yaron Mazor, company spokesperson, said: "This new type of customisable, durable and flexible displays is a significant step forward, towards creating brand new applications (display smartcard), as well as enhancement of current products and applications, and will leave behind current display technologies that use rigid, fragile and limited glass."

## LUMUS

Lumus has developed a revolutionary optical imaging technology, enabling a wide range of ultra-compact personal displays for mobile applications.

The company's Light-guide Optical Element (LOE) enables personal screenless display by projecting images and data from computers, DVD players or VCRs into the viewer's eye, by displaying them in the visual field of the viewer.

Its first product is a Head Worn Display (HWD) which provides a range of light see-through personal displays attached to various headgears or worn like a pair of glasses, with different resolutions and corresponding fields-of-view. The HWD displays images generated by a computer (VGA interface) or from a video source (C-video interface).

The user can see through the virtual image, while the normal field of vision of the real world is unobstructed. The image source and the LED-based illuminator are mounted on top of the head, while the electronics are located in a small box attached to the headgear and connected by a cable to the head unit.

The company's second product line is a Wearable Smart Terminal (WST). The WST comprises an HWD combined with a pocket PC with wireless communication links (such as Wi-Fi, IR or WAP), to be used for a wide range of mobile and outdoor applications.

The displayed image can be acquired from any source, including a remote camera or remote PC which transmits the image via Wi-Fi, IR or cellular communications. There is an optional two-way audio system, used for communication, signalling and voice activation control of the application, enabling bi-directional audio and video streams, as well as Internet connection. Another optional element is a head location tracking system. This can be an independent tracking sensor or software-operated tracking using the visual signal from the camera.

Lumus is currently developing another application that projects an A5-size image but still fits inside a cellular phone. In this configuration the device is handheld and the image, which "materialises" at a distance behind the device, is viewed through a window similar in size to that of a common mobile phone display. It offers full colour performance, high resolution and an image that is not sensitive to the relative location of the viewer's eye, i.e. a 1.5" window projecting a 15" virtual image.

## OMS DISPLAYS

This company has developed a unique method of producing Optical Magnifying Sheets (OMS) to provide a solution for manufacturing low cost, slim, flat, large magnifying panels for the displays industry.

OMS's technology is a unique method in which an input pattern is optically magnified by guiding its content at the pixel level. The technology takes advantage of a unique integrated optic system the company's engineers have developed to magnify each pixel (from LCD/DLP/LCOS sources) by guiding its light to a large flat-panel display facet.

The technology will be used in the display industry in two main applications:

1) High end, low cost, slim, Large Format Panel Displays (LFPD), which have the performance of the high-end Micro-Display Rear Projection TV (MD-RPTV), but are slimmer and lighter than the current plasma and LCD displays, and more resistive than current available TV screens;
2) A revolutionary high efficiency backlighting panel for the high-end LCD LFPD TV sets backlit by Light Emitted Diodes (LEDs).

## MIRAGE INNOVATIONS

Mirage Innovations has developed an ultra-lightweight, compact and affordable personal video display device for use with portable media players, game consoles, cellular phones and PDAs.

The company claims its NanoPrism technology will substantially alter the price/performance of personal displays while solving the problems plaguing traditional personal displays, which include: unacceptably large weight and form-factor, binocular image misalignment causing nausea and headaches (cyber sickness), user discomfort due to lack of see-around capability and a lower consumer price.

The Israeli start-up's technology is based on the principle of transforming a thin transparent plate into a complete wearable personal display system. The unique diffractive planar optics is combined with a micro display source, such as micro LCD, LCOS or OLED, to provide the users with a colour video image equivalent to a 40" screen viewed from a distance of 2.1 meters.

Within the NanoPrism diffractive planar optics device, light emerging from the microdisplay source is collected by a lens and coupled into a thin transparent substrate via a nano-scale diffraction grating. The trapped light propagates within the substrate by total internal reflection toward the viewer's eyes. The result is a perfectly aligned image focused at infinity for strainless viewing.


***Figure 3:*** *Citala's flexible display*

"Our aim is to provide a solution to meet the need for future alternative portable display systems," said Tal Cohen, CEO of Mirage Innovations. "The demand for media-capable portable devices is being fuelled by the enormous increase in content for mobile TV and personal media players, which has become available only in the last couple of years."

***Figure 4:*** *Mock-up of Mirage LightVu control box*

***Figure 5:*** *Mock-up of Mirage LightVu group of products*

***Figure 6:*** *Mirage LightVu earphone*

## GENOA COLOUR TECHNOLOGIES

In cooperation with the Taiwanese company Chi Mei Optoelectronics (CMO), one of the world's leading manufacturers of large-size LCD TV panels, Genoa Color Technologies has unveiled its ColorPeak LCD system.

Conventional RGB technology using red, green and blue to recreate colour images has prevailed since the advent of colour television over fifty years ago. Current display technologies are capable of showing only 55% of the visible colour gamut at acceptable levels of brightness.

Genoa's technology will expand the gamut of visible colour beyond the limits of standard RGB (red, green, blue paradigm) devices. The ColorPeak technology will enable wide colour gambit, which means that colours will appear more natural, brighter and richer, such as the crystalline turquoise of tropical waters or the unique colour of true gold.

ColorPeak is revolutionary in that it adds from one to three colours to the current RGB mix – typically yellow, cyan and magenta – to significantly expand a display's visible colour gamut by approximately 35% while increasing its brightness by as much as 40%. Genoa has over 40 patents pending that apply to the concepts, processes, algorithms and implementation of its ColorPeak technology.

The company's engineers developed a unique set of algorithms that address both the creation of colour space and the requisite optimisation needed to support real-time video presentation. The combination of these algorithms translates video data into "Genoa colour", taking the existing coordinate values of RGB/YCbCr and converting them into multi-primary colour to recreate the 3D gamut of film.

Genoa's R&D team has also designed superior electro-optic colour filters to deliver the required colour gamut and performance of the system specified for the requirements of each device. The technology is compatible with digital media methods (DVD, DVB, MPEG2 compression). It will be incorporated into a line of four ASICs suitable for a broad range of displays. They perform the multi-primary colour conversion, taking in an RGB or YCbCr input signal and outputting up to six primary colours. The ASICs support resolutions of up to UXGA or 1080p.










# MORE POWER, please!

by Myk Dormer

As perceived by the general engineering community, ISM band radios are very innocuous things; robust little modules drawing a few tens of milliamps from the supply, to radiate a few milliwatts from a generally non-critical aerial.

In most cases, this is true, but like most rules there are exceptions: The wide category of 'low power radios' actually includes devices that emit up to half a watt of RF energy. These include units in the UK's 458MHz 'industrial telemetry' allocation, the European 869.4–869.69MHz sub-band and various other country specific bands (for example, the Czech Republic permits 500mW on certain 148, 156 and 448MHz frequencies).

Such units are most frequently used in long range or high-reliability applications, such as radio modems and industrial control apparatus, but still fall under the unlicensed band regulations EN300–220. Much higher power radios are used in licensed allocations – PMR bands, long range MPT1411 telemetry – but these are outside our scope.

Half a watt of RF energy is quite a lot of power to be dealing with. To give some sense of scale: across 50Ω this corresponds to 5Vrms (or 14V peak to peak). By comparison, 1mW is barely 220mVrms.

For the engineer planning to use such devices there is a whole new minefield of considerations:

**Mismatch:** In the ideal world, every aerial load presented to the transmitter would look like a perfect 50Ω resistor and, then, all the output power would be radiated usefully away.

But the real world isn't really like that. Aerial mismatch, due to poor tuning, incorrect specification or improper mounting (insufficient ground plane or too much adjacent metalwork) causes some of the power to be dissipated elsewhere, reflected back into the transmitter to be dissipated as heat, or radiated from the feeder coax. When a simple, 10mW ISM module is being used then, only a reduction in link range is likely to be seen.

At 500mW things are different. That energy that isn't being radiated out of the aerial goes somewhere. Some transmitters can suffer damage or faulty operation when driving a badly terminated load, from thermal overload, output device failure or, sometimes, instability (although other units are specified to survive such abuse; check your supplier's datasheets).

**Susceptibility:** The whole point of a transmitter is that it radiates RF energy. When this energy turns up in unwanted places, trouble follows. Any length of conductor is a potential receiving 'aerial' – all the more so if the conductor is a multiple of 1/4 wavelength, including all the internal wiring and PCB tracking of the design. And that results in induced RF voltages in places they should not be in.

Every PN junction acts as a rectifier for these interfering signals. In analogue circuitry this causes changes in bias and voltage errors; whilst in digital sections, spurious logic triggering, faulty program execution and even resets can result. When the RF signal itself switches on and off, then there is a further problem: an audio frequency interferer (at the switching rate) also appears, as the junctions act as AM demodulators. This is the 'bleeping and howling' heard when an active GSM phone is placed too close to the audio system.

As well as producing unwanted voltages, the non-linear nature of a semiconductor junction, when driven with a large RF voltage, gives rise to the generation of harmonics of the original frequency, which may then be re-radiated from the circuitry. In this way, a system can fail type approval harmonic and spurious emission limits, even when the transmitter is well within specification if tested separately.

**Recirculation:** Even when the transmitter appears to be operating normally, with a stable output spectrum and expected supply current drawn, there is still a possible failure mode in hiding. If excessive RF energy is allowed to leak back into the transmitter itself, then a phenomenon known as 'recirculation' manifests as unpredictable – and, sometimes, bizarre – distortion in the baseband signal. This distortion, as seen on the receiver AF output, is frequently worse during transmitter switch-on.

Multi-channel, synthesised designs

> “For the engineer planning to use such devices there is a whole new minefield of considerations”

suffer far more readily from this problem. What is happening is that the RF energy is leaking back into transmitter's local oscillator and upsetting the frequency synthesiser loop. In extreme cases, the disturbance is so severe that the unit loses phase lock and resets, giving rise to a low frequency power-up/shut-down oscillation known as 'motor boating'.

It is all too easy to blame non-existent receiver defects, or external interferers, for this problem, especially as the transmitter is unlikely to exhibit the effect when being bench-tested into a dummy load. The amount of RF leakage necessary to cause a re-circulation problem is far less than that necessary for 'real' RF instability.

**Power supplies:** Half-watt class radios draw considerably more current that their smaller, lower powered fellows. Few designs exceed 50% overall efficiency and a typical module is likely to draw 300mA to 500mA from a 5V supply, with even higher peak currents as the unit 'keys on'. This can cause a significant battery voltage 'droop', or cause regulator fold-back.

So what should you do?

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

- **Use a good aerial.** Make sure the aerial chosen is properly set up for the frequency of operation and that sufficient ground plane, required by monopoles and whips, is present. Ensure the aerial is mounted away from metal structures, which will de-tune it, and as high up as possible. Use a VSWR meter to optimise the aerial tuning, if necessary. Avoid running other cables near the aerial.
- **Use adequate shielding.** Mount your circuitry (and the transmitter) inside a metal, shielded enclosure, if at all possible. Use a bulkhead-mounted RF connector to ensure the braid of the aerial cable is properly earthen to the enclosure wall. Use good RFI filtering on all wiring at the point of exit from the housing (feed-through capacitors are effective, although somewhat old-fashioned looking; filtered connectors, containing ferrite blocks or LC filter circuits, are especially useful).
- **Remember power and heat.** Provide an adequately rated power supply for your transmitter, ideally separated from the analogue and logic rails in your design. The module will dissipate 1–3W of heat (at least) when in operation, so provide good ventilation, any necessary heat sinking and limit transmit duty cycle.

  Test for known problems. Monitor the analogue baseband output of your receiver, or use a separate monitor receiver or 'scanner', and look for unexpected distortion in the transmitter's modulation. Test into a dummy load and into the chosen aerial, and look for differences.
- **Be careful.** Half a watt doesn't sound like a great deal, but the field near to the aerial can interfere with the operation of unshielded electronics and can block other receivers. Locate your transmitter – and it's aerial – carefully.
- **And, as always, test everything!** A 500mW link should have a range in kilometers. If it doesn't, then something is wrong.

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

# RF/MW Simulation Techniques

IN THIS ARTICLE, **WILFREDO RIVAS-TORRES**, AN RF AND APPLICATIONS ENGINEER AT THE TECHNICAL SUPPORT GROUP AT AGILENT TECHNOLOGIES DISCUSSES THE TECHNIQUES INVOLVED IN SIMULATION IN RF AND MICROWAVE APPLICATIONS AND GIVES AN EXAMPLE OF THEIR USE

The rewards of simulation include more robust designs and decreased time to market. The cost of simulation typically includes the time spent to set up the software to perform meaningful analyses and access to appropriate component models. This article discusses the techniques involved in simulation.

### Component Modelling

Component modelling involves the acquisition of parameter values in order to reproduce the behaviour of a device. By comparing simulation results against data measured from the device it is possible to assess the model accuracy. When the simulated and measured data are close to each other, the model is said to have a good fit. A good model allows the designer to make accurate predictions about the component in any given application.

Models are generally a set of equations that are hard-coded into the simulator that emulate the component behaviour. The designer accesses the model through a set of predefined parameters (called model parameters). The process of adjusting the parameter values, so that the measured and simulated data are a good fit, is known as model parameter extraction.

The component models required for electronic design can be grouped into two areas:

- Discrete linear (for example, R, L, C) and non-linear (for example, BJT, MOSFET) components.
- High-frequency distributed components (for example, microstrip transmission lines).

In a perfect world the designer is expected to cover all interactions between components in the simulation. This type of simulation would only be possible by using EM (electromagnetic) solvers, due to the need to apply Maxwell's equations (including discrete components). Whilst this approach is the most rigorous and should be used wherever practical, for simulating complex circuits it is necessary to use a broader array of modelling techniques in order to achieve simulation times that are compatible with product development timelines.

The answer is to use circuit simulators with simplified models, sometimes called compact models. The SPICE (Simulation Program with Integrated Circuit Emphasis) circuit simulator is probably the most familiar to designers. After more than three decades since it was first introduced at the University of California at Berkeley, many consider SPICE the standard in circuit simulation. It requires a text file, known as a netlist, to describe the circuit and analyses to be performed.

### Model Classes

The component models used for circuit simulation can be divided into different classes:

- **Physical models**. The model equations of this class are based on the device physics. In a good physical model all parameters will have a physical meaning. Experience has shown that pure physical models may not be 100% practical (see Empirical Models).
- **Tabular models**. In this model the measured values are used without the use of model equations. Values are stored for, for example, the drain current at different bias or small signal parameters. The simulator then looks up the values and uses interpolation functions for computing values in between the measurements. The advantage of a tabular model is that it can provide a model when physical or empirical models are not defined or fail due to the complex nature of their equations.
- **Empirical models**. This model formulation is totally dependent on the alignment of parameters to measured data via curve fitting. The model parameters are the coefficients, exponents, etc, used in the curve fitting algorithm and have no

physical meaning. Empirical models are valid only in the physical area at which measurements were taken during parameter extraction. This is an important limitation when compared with physical models. Fully empirical models are hardly ever used. These empirical expressions are commonly used with table models to help with the interpolation, or in physical models, when the physics does not arrive at a closed form expression or the expression requires excessive computational resources.

- **Electromagnetic (EM) models**. As higher frequencies and smaller form-factors are used there is a need to include layout effects in the simulation. EM models are, therefore, used as computer speed and computing power increase. This type of model is actually the result of the EM analysis of the layout and the data, which is then imported into the simulation, is similar to a tabular model. A major advantage for the design engineer is that it includes the effects of the layout during the design process – before the first prototype is built and before the adverse effects of layout parasitics are discovered.

## Simulation Techniques

### *Time Domain Simulation*

Time domain simulation is used to solve a set of integro-differential equations that express the time dependence of the currents and voltages of the circuit. The result of this type of analysis is non-linear with respect to time and is similar to the measurements made by an oscilloscope. In order to obtain meaningful results from a time simulation, the user must understand the time settings. The simulation time step and time stop are the important parameters that need to be specified since, for commercial simulators, the other parameter default values will work in most cases.

In many applications the time stop needs to be set up so that the circuit being analysed reaches steady state. This setting can be frustrating to novice designers, especially for circuits that have a long settling time when compared to the time step being used.

The time step determines the sampling rate of the time domain simulation. In the strict sense, we want to use the Nyquist sampling criterion. The Nyquist rate (Fs) is in theory a sufficient condition for an analogue signal to be reconstructed from a set of uniformly spaced set of time samples. If the maximum frequency of interest is Fm then the Nyquist rate Fs is twice this frequency.

Suppose we fed a simple LCR circuit with a 10MHz square signal. It would be tempting to sample at twice the 10MHz signal frequency. However, the results would not be the square wave expected. The problem is that we would have misinterpreted what "maximum frequency of interest" means. Fourier analysis tells us that a square wave is represented by a series of sinusoidal components that are harmonically related. Let's say we are willing to accept up to the 5th harmonic in our simulation, if so, we need to sample at 100MHz (10ns time step). The results would represent the signal much better but still not as well as required; fortunately, circuit simulators have a more robust time step control method for this kind of problem.

Time domain simulator engines can use one of several Time Step Control methods. Hence, when setting up a time simulation, the Time Step Control method needs to be also known. The Time Step Control method discussed so far is the "Fixed" method. In a Fixed Time Step Control simulation, the time step is constant throughout the entire simulation and places all the responsibility on the user to select an appropriate time step value.

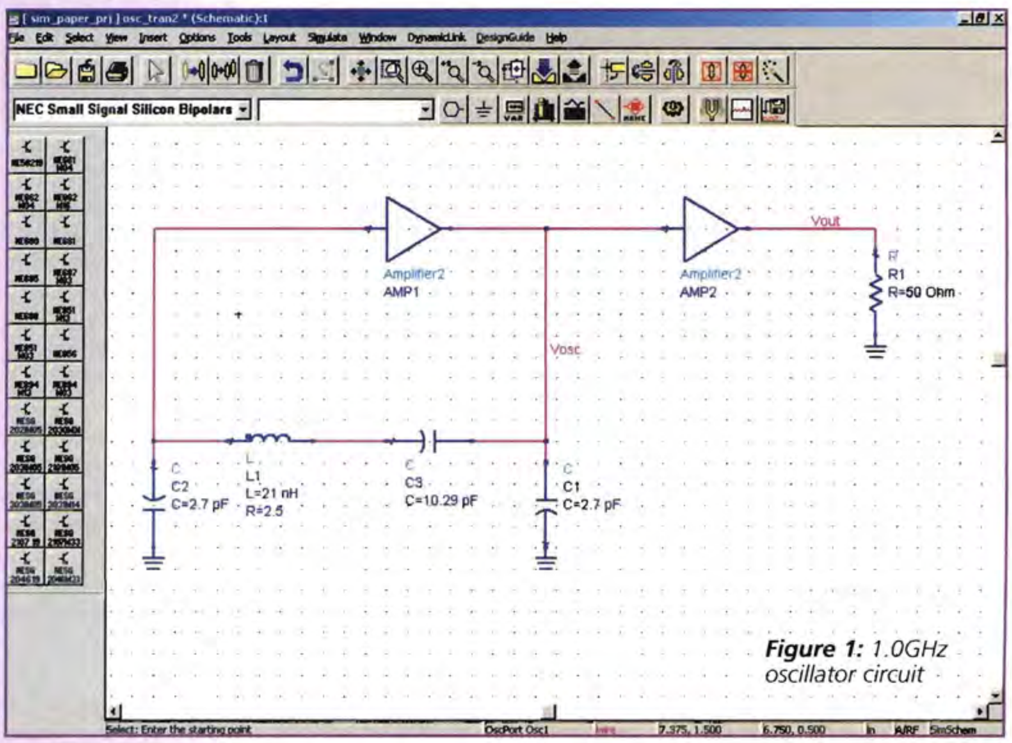



**Figure 1:** *1.0GHz oscillator circuit*

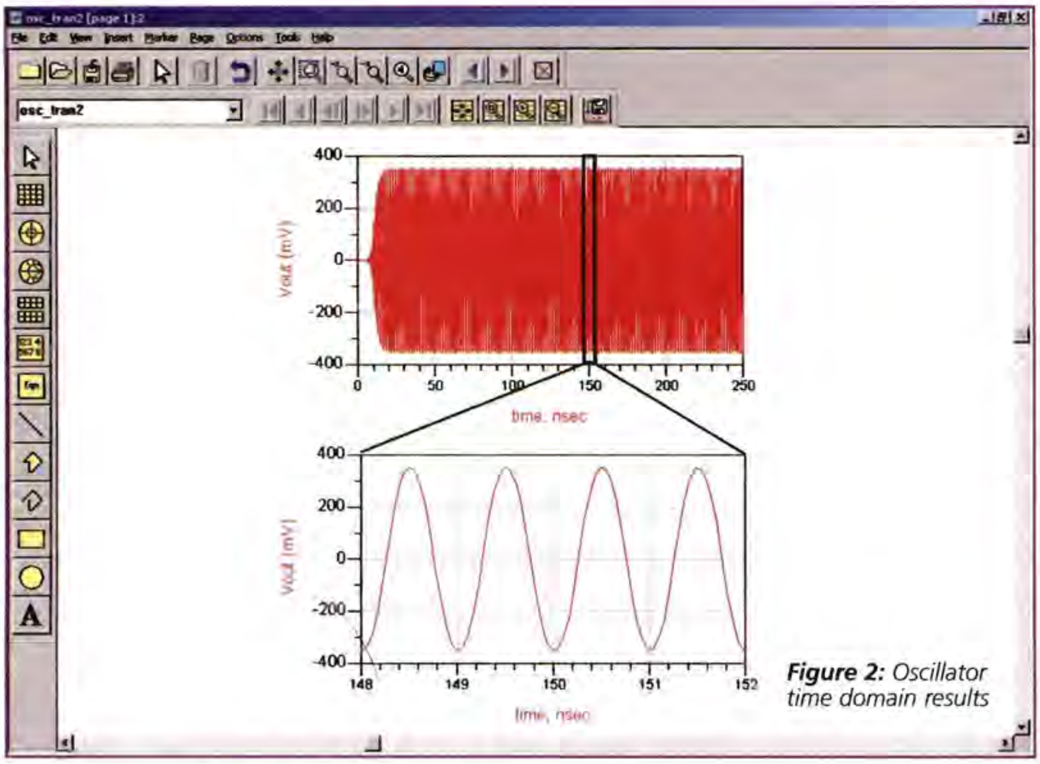



*Figure 2: Oscillator time domain results*

programs there is an AC analysis, which is a linear frequency domain simulation. The AC analysis will produce the amplitude and phase of the current or voltage response of the circuit being analysed. Also, many popular RF simulation programs will include S-parameter simulation analysis; typically any arbitrary n-port circuit can be analysed.

In this type of simulation a small signal equivalent circuit will replace the active component. In essence, the circuit will not include large signal effects. Another result of using the small signal model for all active devices is that the circuit frequency response will not be sensitive to the excitation signal level.

The method more typically used is called "Truncation Error." Truncation Error is the default time step control method in SPICE and many commercial simulators. The Truncation Error method uses the current estimate of local truncation error to determine an appropriate time step. Truncation Error is an adaptive time step control method; the user needs to set the maximum time step to be used.

Unfortunately, the reality is that no method can cover all applications. Experienced designers will tell how frustrating the "time step too small" error message can be. When encountering this kind of convergence problem the solution is to try another time step control method (either fix or iteration count).

There are also other remedies that will depend on the type of application being analysed. For example, when analysing a bi-state circuit, an initial condition may need to be specified on the output nodes because the solution may not be clearly defined from the topology before it starts the simulation. The analysis of non-linear circuits, such as amplifiers, multipliers and others, can also lead to convergence issues, especially if driven into compression. Frequently, these circuits will successfully simulate if you do not start them at the full signal level but at a power level at which the circuit converges and then increase the power level with simulation time.

***Frequency Domain Simulation***

The frequency response of a circuit is also of great interest to designers and highlights the need for Frequency Domain simulation engines. Frequency domain simulations are undertaken under steady state conditions and can be divided into linear and non-linear frequency domain simulation engines.

***Linear Simulation***

In SPICE and many other popular simulation

***Non-Linear Simulation***

It was mentioned previously that the results of a time domain simulation are non-linear with respect to time. This means that if we want to know the frequency content (for example, harmonics) we just need to use a Fourier Transform on the time data. While this last statement is true it comes at the expense of simulation time and computer resources for many of the typical RF analyses.

Let us consider a mixer stage in which the local oscillator frequency and radio frequency are in the GHz range and the IF is 1.0MHz. For such an analysis we need a sampling rate of say 10GHz at least, which means we would have a sampling period of 100ps. Now the selection of the time stop not only has to consider the fact that we need to ensure steady state has been reached but that sufficient time samples have been collected to represent the much lower IF frequency. The period of the IF is 1μs, which at a sampling period of 100ps represent 10,000 points of a steady state signal for only one cycle of the IF signal to be sampled.

The use of a time-domain simulator on a discrete tone analysis like the preceding example is often considered inefficient, especially when you can use a simulator such as Harmonic Balance (HB) to solve this problem. In a Harmonic Balance simulation, as well as with other non-linear frequency simulators, the user specifies the frequency tones and the order (number of harmonics and intermodulation products) to be considered in the simulation. In a Harmonic Balance simulation what is taking place is a truncated Fourier analysis.

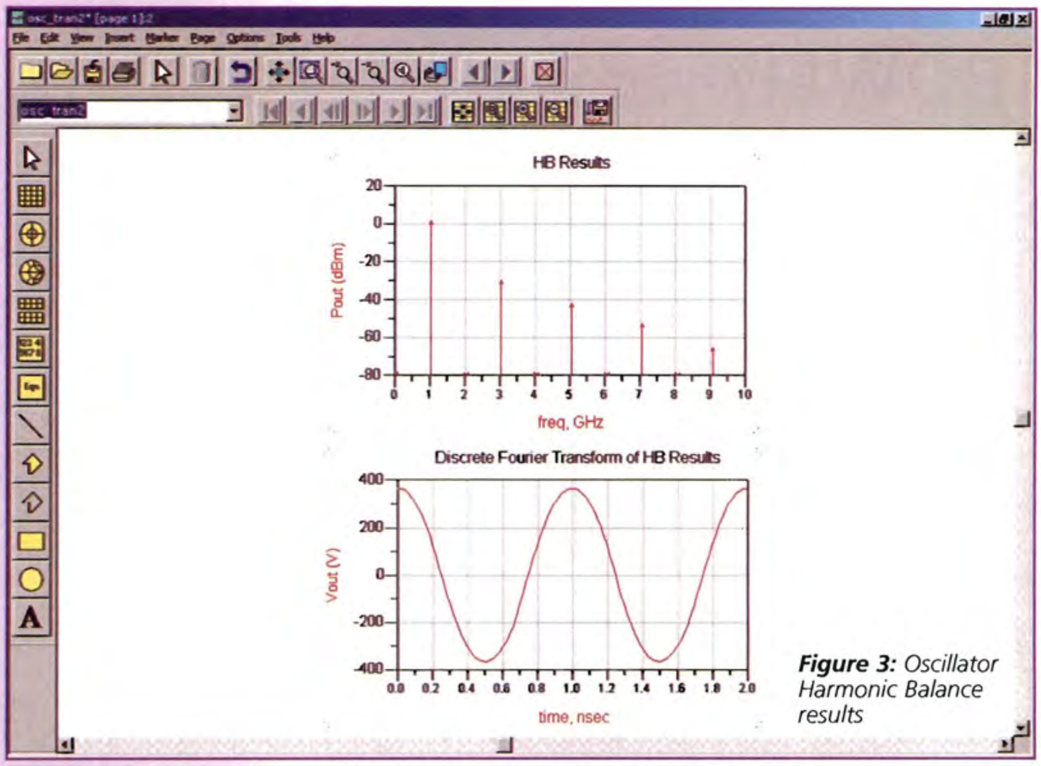



***Figure 3:*** *Oscillator Harmonic Balance results*

### Oscillator Example

The schematic in **Figure 1** shows a basic LC oscillator designed to work at 1GHz.

This circuit can be analysed using either Harmonic Balance or Time Domain analyses. If we are interested in performing a start-up analysis, then the proper simulator would be a time analysis engine (be prepared to wait for the results if you are simulating a high Q oscillator such as one using a crystal). The start-up results for this circuit are shown in **Figure 2.**

The same circuit when analysed with HB will produce the fundamental oscillating frequency components and the harmonics as specified in the analysis. The results of the HB analysis of this circuit are shown in **Figure 3.**

From the time analysis results we could determine the frequency spectrum by applying a Fourier Transform to the steady state part of the signal. If this is the case, then why would we want to bother with an HB simulation when a time domain simulation might give us all the information we need. There are several reasons, including: (1) computer resources needed for the analysis and (2) simulation time.

The time domain analysis requires more data to be saved in order to provide meaningful results, in this analysis the time domain saved 4501 points for the output data and the HB simulation only saved 10 points (times 2 since the results of HB are complex in nature, e.g. magnitude and angle). This shows the ability that HB can handle larger problems with the same limited amount of computer resources (e.g. available RAM).

The simulation duration for the time domain analysis is also an important consideration. The fact that a time analysis runs so many iterations can represent a total simulation time that can be many orders higher of a corresponding HB analysis (depending on the complexity and non-linear characteristics of the circuit).

### Dictating Design Requirements

This article has discussed simulation techniques and presented a simple example of their use. Ultimately, the design requirements will dictate the kind of analysis that needs to be performed.

Analysis set-up is the key to obtaining useful and accurate results from your simulations. Device models are simulation inputs and these need to be a good fit to the actual physical device performance they are trying to emulate.

## ADS Design Environment

The simulations discussed in this article were performed using the Advanced Design System (ADS) design environment from Agilent Technologies.

ADS is one of the leading development environments for high-frequency design. It is used in the development of all types of RF designs, from RF/microwave modules to integrated MMICs for communications and aerospace/defense applications. With a complete set of simulation technologies ranging from frequency and time domain circuit simulation to electromagnetic field simulation, ADS allows designers to characterise and optimise designs fully. The single, integrated design environment provides system and circuit simulators, along with schematic capture, layout and verification capability, eliminating the interruptions associated with changing design tools in mid-cycle.

# POWER AMPLIFIER ENHANCEMENTS ENABLING TOTAL RADIATED POWER COMPLIANCE

**JAMES VROBEL, APPLICATIONS ENGINEER AT THE RFMD COMPONENT BUSINESS UNIT, GIVES AN OVERVIEW OF TOTAL RADIATED POWER AND THE SYSTEM REQUIREMENTS NEEDED TO MEET COMPLIANCE**

Cellular network operators face numerous challenges to ensure reliable, high quality, cost-competitive voice and data services over widely varying geographical coverage areas without excessive investment in base station infrastructure equipment. A major contributor to cellular network quality of service (QoS) and connectivity is the mobile handset (UE or User Equipment) performance. The UE's ability to transmit and receive calls over a variety of conditions is fundamental to successful network implementation.

A key aspect of UE implementation focuses on the antenna and front-end design. Efficient radiated performance with maximum spatial coverage is mandatory for effective network operation. However, today's handsets are becoming smaller and operate over multiple frequency bands. Sufficient, but non-optimal, radiated performance is inherent due to tradeoffs in antenna performance versus size and form-factor. More importantly, antenna performance is heavily influenced by its surrounding operational environment, as a UE rarely functions under ideal freespace conditions.

Interaction with the human body or inanimate objects degrades the antenna radiation pattern, lowers efficiency and impacts performance of front-end transmit components, such as the power amplifier (PA). Antenna impedance mismatch (VSWR) effects are translated to the PA RF output and create large power and current variation due to load pulling. Under certain circumstances, these variations limit the total power transmitted to the surrounding environment. Reductions in UE Total Radiated Power (TRP) may result in dropped calls or poor network coverage. In combination with higher PA current, which reduces talk time, TRP degradation impairs QoS, potentially increasing customer dissatisfaction. Although not discussed herein, TIS, or Total Isotropic (Receive) Sensitivity, also plays an important role in network QoS, perhaps even more so than TRP.

TRP performance deviates significantly (~ 8dB) across many varieties of UE designs, therefore a more comprehensive characterisation, testing and certification methodology for Over-The-Air (OTA) performance was created. OTA testing measures the magnitude and direction of radiated energy to determine UE performance. The most familiar (North American) certification organisation is the Cellular Telecommunications and Internet Association (CTIA). Under such auspices, carriers and handset suppliers establish verifiable OTA compliance specifications within the constraints of an operator's specific network design. TRP and TIS are included within OTA certification testing to ensure compliance with operator specifications that fulfill its link budget requirements. In turn, UE manufacturers are turning to compo-nent vendors, namely antenna and PA suppliers, and requesting improved TRP performance.

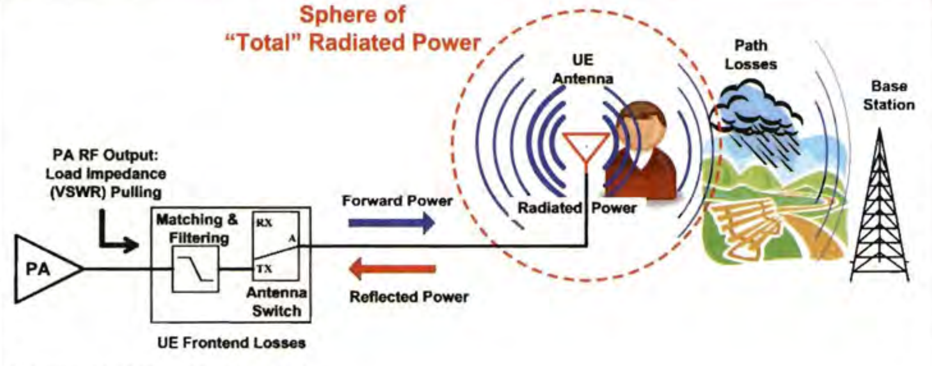



***Figure 1:*** *TRP system model*

TRP issues can be sectioned into three basic categories. The first is in-situ antenna design and its sensitivities to the external UE environment; the second is the VSWR interaction between the antenna and the PA; and the third is PA performance in response to the antenna VSWR stimulus. The primary focus for this article, therefore, deals with the VSWR interaction between the PA and antenna and the PA response.

required volume for an efficient quadband antenna is > $6cm^3$, but unfortunately this volume is not always available, so compromises are inevitable, especially in lowband.

As mentioned previously, the mobile users' body or inanimate objects affect the antennas efficiency, impedance and radiation pattern. Quadband terminals exhibit freespace antenna losses of approximately 2.5–5dB in GSM850/900 band and 2–4dB in GSM1800/1900 band. Freespace antenna impedance is nominally < 3:1 VSWR, but may approach 6:1 at the band edges. Unfortunately, freespace environments are not real-use conditions. When measured in the user talk position, antenna losses increase, up to between 5 and 9dB in the GSM850/900 band, and up to 4–6dB in the GSM1800/1900 band. The "loaded" antenna impedance can easily exhibit a VSWR of 8:1. The significant increase in antenna loss, approximately 2–4dB or more, directly subtracts from TRP versus the freespace condition, and is the primary contributor to TRP degradation. In combination with PA power mismatch effects, prediction of overall radiated power becomes very complex.

Owing to many possible UE configurations, user positions and radio operating environments, there does not exist a single, typical antenna design with typical performance, as the phone itself is a big part of the design. The antenna designer needs extensive hands-on experience working with various materials, metals and plastics across all form-factors of flip-phones, monoblocks or sliders. Effective TRP design and implementation of today's UE antenna systems, given the volumetric size constraints and intricacies, has become quite challenging indeed.

## UE Antenna Basics

The UE antenna transmit function is conversion of a guided RF electromagnetic signal into a propagating wave through excitation of an electrical or magnetic field within its surrounding environment using a radiating element. UE antenna design focuses on many key performance parameters relative to size and frequency, including efficiency, directivity, feedpoint impedance and bandwidth. The most important for TRP performance are efficiency, feedpoint impedance and bandwidth.

Mobile phone evolution to ultra-thin, compact designs has increased the need for the development of volumetrically small antennas, with emphasis on internal antenna elements as opposed to external. Only one single-fed antenna is normally allowed and it must operate effectively across multiple frequency bands. Additionally, it must be low cost and highly manufacturable. For effective antenna performance however, size reduction is not always better and cannot be reduced indefinitely without performance compromise.

There are fundamental limitations and tradeoffs of small antenna size versus efficiency and bandwidth. In general, as size decreases, bandwidth and efficiency decrease also. Within a mobile unit, antenna elements may not be implementable and accommodate all requirements without increasing size. The resonator requires certain volume (ground clearance and area) to provide sufficient bandwidth over a wide frequency range. To realise a physically small yet electrically efficient antenna, radiating elements are incorporated into the printed circuit boards or phone mechanics. Due to the antenna's physical proximities, design and performance are strongly dependent upon the phones' size, shape, materials and components, including ground plane and shielding.

The antenna couples energy into these items, which either dissipate it or radiate it as part of the "effective" antenna structure. Low-band resonators need more volume and ground plane sizing, therefore, longer PCB dimensions (~ 8cm) than highband (~ 4cm) to achieve equivalency. The

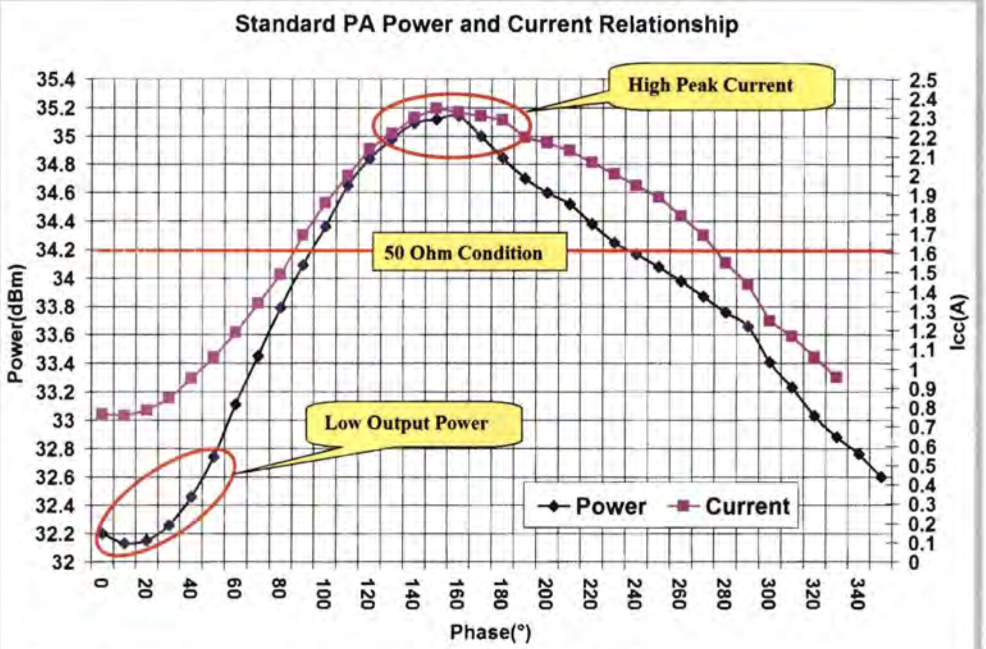



***Figure 2:*** *GSM 900MHz PA power and current vs 3:1 VSWR*

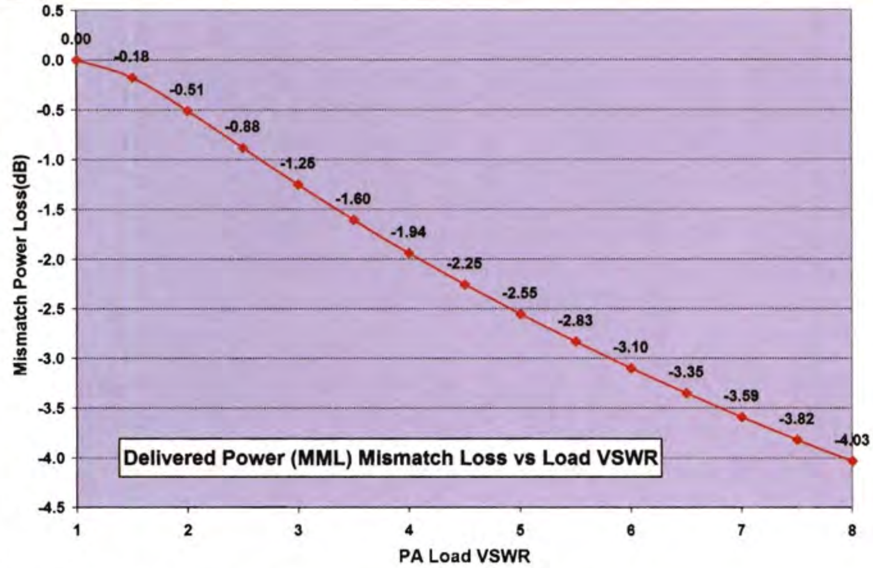



*Figure 3:* *Delivered power mismatch loss vs PA load VSWR*

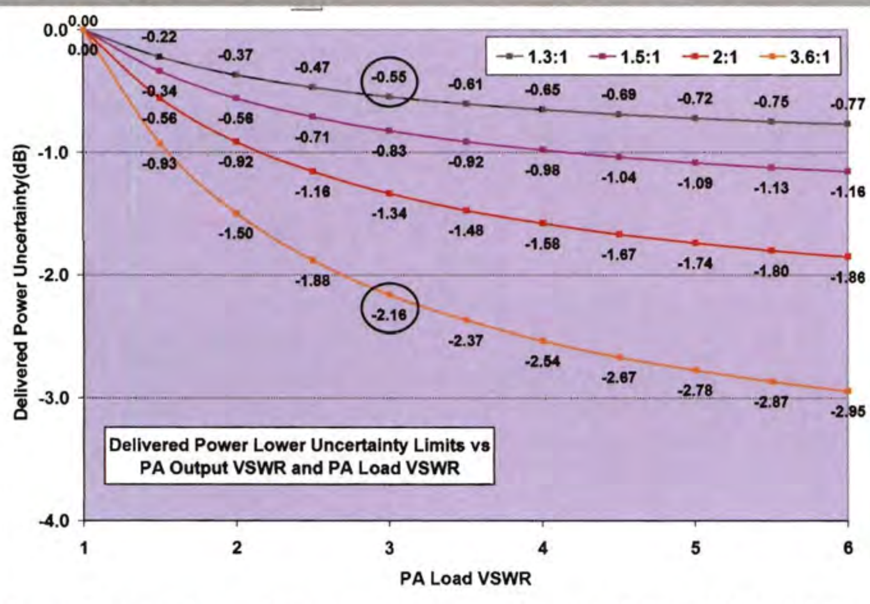



*Figure 4:* *Delivered power lower uncertainty limits vs PA output VSWR and PA load VSWR*

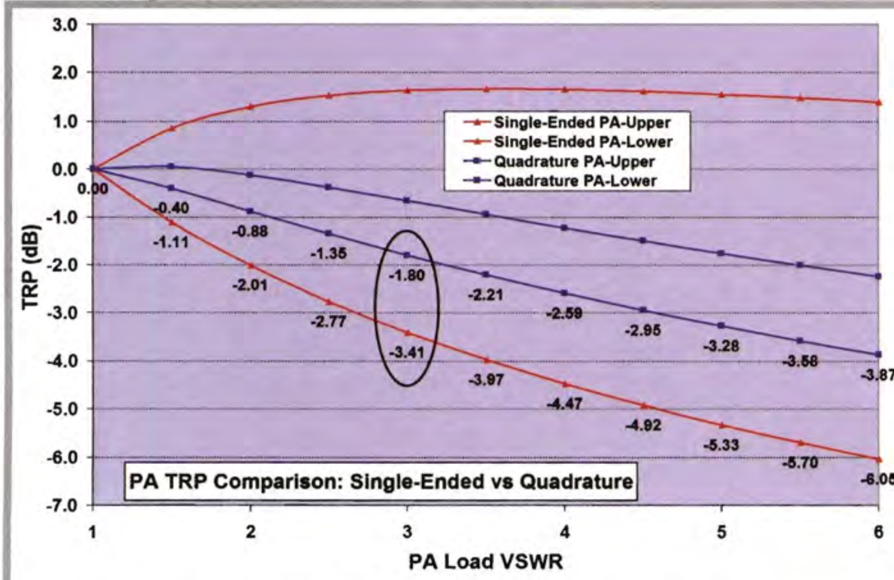



*Figure 5:* *PA TRP comparison for single-ended PA vs quadrature PA*

## TRP System Model

A basic GSM TRP system model in **Figure 1** depicts the interaction between the user, the UE antenna, the Tx front-end components and the surrounding propagation environment between the user and the base station receiver.

In an ideal world, the antenna is matched to free space and the UE forward power is equal to the radiated power. User proximity effects on the antenna are not present and the radiation pattern is quite uniform in magnitude and omni-directional like in a dipole radiation pattern. No power is lost due to PA loadpulling effects or absorption by the UE or user body, therefore, total radiated power equals radiated power.

In real world application, all the aforementioned effects are present. User proximity alters the antenna impedance and lowers efficiency, as it is no longer well matched to the free space or system impedance. Antenna directivity is modified such that the magnitude of radiated power is not spatially distributed in a uniform manner. Antenna VSWR magnitude or phase variation creates PA load impedance pulling, resulting in large power and current variation (**Figure 2**). A significant portion of forward power is lost as reflected power. Radiated power no longer equals forward power. Radiated power is also reduced by power absorption in the user head and hand, thereby reducing total radiated power. In addition, UE battery efficiency is degraded by high peak PA current resulting in reduced average talk time.

## PA-Antenna Interaction

PA-antenna VSWR interaction can be minimised through RF isolation. RF isolators substantially reduce PA power and current loadpull effects by masking antenna VSWR and presen-ting constant load impedance. Isolators, however, do not eliminate impedance mismatch loss between the antenna and UE system interface.

Due to cost, size and insertion loss reasons, RF isolators are noticeably absent from UE designs, especially in GSM-EDGE applications. Absent isolators, PA performance will be subject to VSWR effects and to improve performance, the PA response to VSWR must be modified. PA power and current improvement in response to VSWR effects are classified as loadline adaptation techniques.

### PA TRP Specification

In order to understand the impact of TRP requirements on PAs, it is useful to examine how TRP is specified, and then determine how open-loop PA performance impacts achievable TRP performance.

UE manufacturers specify PA TRP requirements similar to:

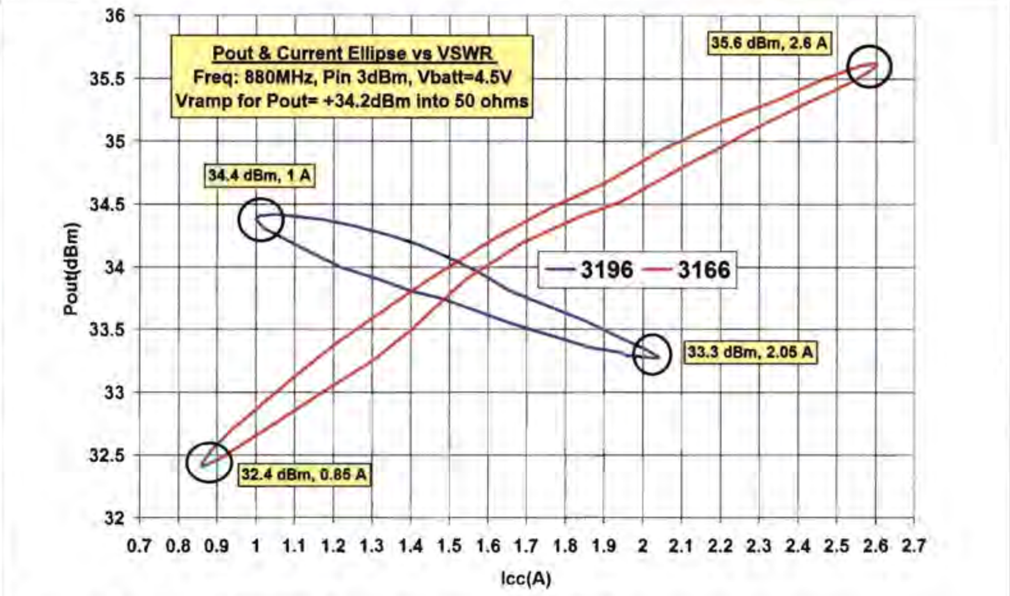



***Figure 6:*** *RF3166 vs RF3196; $P_{out}$ and $I_{cc}$ across 3:1 VSWR*

$$TRP(dBm) \geq P_{out}(dBm, 50\Omega) - MML(dB, VSWR) - X(dB) \quad (1)$$

where $P_{out}$(dBm, 50Ω) is the rated power assuming matched conditions, MML is the theoretical mismatch loss for a matched (50Ω) power source driving a specified load VSWR and X is an assigned loss factor based on how closely performance must adhere to the best case theoretical mismatch. **Equation 2** expresses theoretical mismatch loss as a function of load VSWR and **Figure 3** illustrates the results.

$$MML(dB,VSWR) = 10 \times Log\left[1-\left|\frac{VSWR-1}{VSWR+1}\right|^2\right]; \text{ where } \frac{VSWR-1}{VSWR+1} = \Gamma_L \quad (2)$$

A typical TRP specification is $P_{out}$ (dBm, 50Ω) – 1.25dB – 1dB for a 3:1 load VSWR, or for short, TRP = –2.25dB, where X = 1dB. Recent reference design specifications have tightened 3:1 TRP requirements to –1.75dB, i.e. X = 0.5dB.

The PA output large-signal reflection coefficient S22 is rarely 0, especially for single-ended PAs. Uncertainty in delivered output power is introduced due to interaction between the PA output (source) VSWR and PA load VSWR. This uncertainty appears as ripple in delivered power (Figure 2) due to arbitrary source and load phase angles. The uncertainty can be understood through examination of two-port network S-parameter theory. **Equation 3** describes unilateral transducer (delivered) power gain (GTU). This equation can be applied to TRP by recognising that power must be delivered to the antenna for it to be radiated.

$$GTU = \left[\frac{1-|\tilde{A}_s|^2}{|1-S_{11}{*}\tilde{A}_s|^2}\right] \times |S21|^2 \times \left[\frac{1-|\tilde{A}_L|^2}{|1-S_{22}{*}\tilde{A}_L|^2}\right] \quad (3)$$

When S22 is 0, the denomination of the last bracketed term becomes 1, and TRP into load VSWR is simply a function of mismatch loss described by Equation 2. When S22 is non-zero, through multiplication of phase-arbitrary vector quantities S22 and $\Gamma_L$, the denominator assumes maximum and minimum limits, which create uncertainty boundaries. These delivered power uncertainty boundaries are described by **Equation 4**.

$$\text{Delivered Power Uncertainty Limits(dB)} = 10 \times Log\left[\frac{1}{\left[1 \pm |S_{22}| \times |\Gamma_L|\right]^2}\right] \quad (4)$$

**Figure 4** illustrates the lower uncertainty boundaries as a function of PA output and PA load VSWR.

A typical single-ended PA can exhibit a 3.6:1 output VSWR, while a quadrature (balanced) PA demonstrates a 1.3:1 output VSWR. Given a 3:1 load VSWR, the lower uncertainty limit is –2.16dB for a 3.6:1 PA VSWR, but only –0.55dB for a 1.3:1 VSWR. When added to the 3:1 mismatch loss of –1.25dB, worst-case TRP for the single-ended PA is –3.41dB, but only –1.8dB for the quadrature PA, a difference of 1.6dB. For these two cases, **Figure 5** demonstrates the cumulative impact that PA output VSWR has on worst-case TRP.

Improving the PA source match increases TRP and reduces the amount of peak-peak ripple into mismatch. This design approach, however, is not generally practical for single-ended PAs. Achieving optimum source match while targeting output power, efficiency and/or linearity etc, compromises the desired performance. PA architectures, specifically quadrature designs, demonstrate good PA source match but lower performance, primarily gain and peak efficiency. Single-ended, open-loop PAs, therefore, require closed-loop correction methods to achieve improved TRP performance.

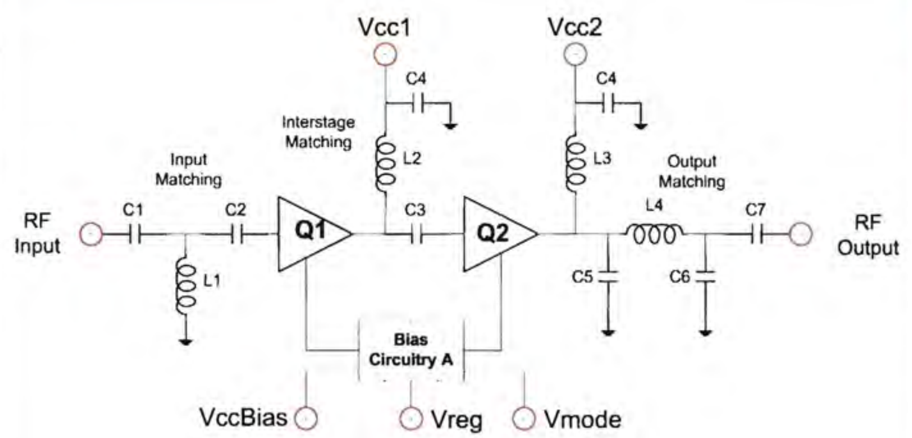



***Figure 7:*** *Single-ended PA*

## PA Loadline Adaptation

RFMD PA loadline adaptation techniques fall into two general categories: open-loop and closed-loop. For saturated, single-ended (GSM) PAs, closed-loop collector voltage and/or bias-current control versus VSWR is utilised to reduce power and current variation. VSWR monitoring is internal to the PA module and is realised indirectly using intelligent DC current monitoring techniques, or directly using RF monitoring.

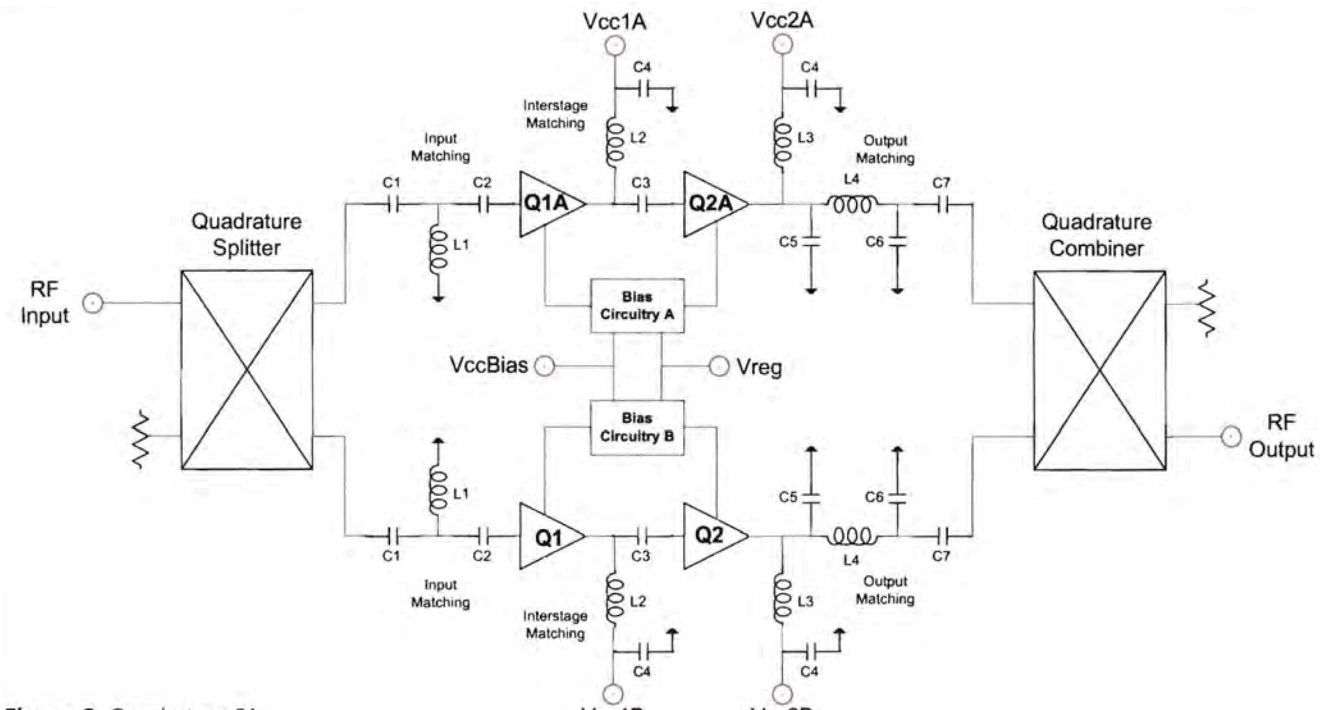



***Figure 8:*** *Quadrature PA*

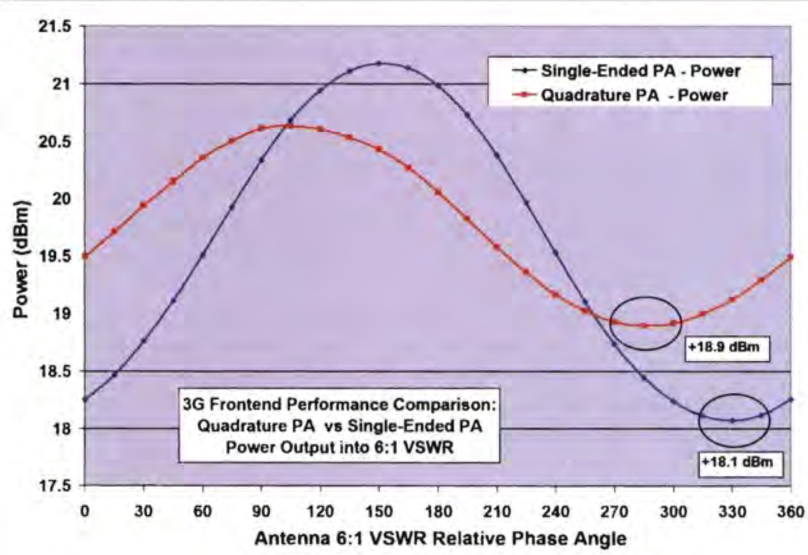



***Figure 9:*** *Quadrature PA vs single-ended PA power output into VSWR*

The direct RF monitoring method incorporates a high-directivity coupler and high dynamic range (DR), temperature-compensated power detector. No variable tuning to the output loadline matching is used.

Passive, open-loop loadline adaptation is accomplished using the "quadrature" PA architecture (**Figure 8**) mentioned previously. VSWR insensitivity is implemented by employing the unique properties of –3dB, 90° power splitters and combiners. Quadrature PAs compromise cost, size and nominal efficiency, but they exhibit low power variation into VSWR by providing good S22 source impedance match. They do not require VSWR monitoring, active loadline tuning or dynamic bias adjustment. Quadrature PAs are not yet considered commercially viable for GSM application due to cost, size and low efficiency, but are utilised extensively for WCDMA linear applications where performance tradeoffs are not as severe.

Although not a central topic for this article, handset manufacturers must also meet SAR, the so called Specific Absorption Rate government UE safety standard. SAR limits the maximum amount of RF power absorption by the user.

By reducing overall power variation, the UE supplier may balance a higher nominal operating power to achieve TRP performance, against a maxi-mum output power which does not exceed the SAR exposure limit.

### TRP Enhancements in WCDMA PAs

All conventional single-ended linear PAs, especially those tuned for highest efficiency, are sensitive to antenna VSWR effects. Isolators are utilised to minimise PA mismatch gain and current variation while maintaining linearity. The quadrature PA provides these benefits, but without the

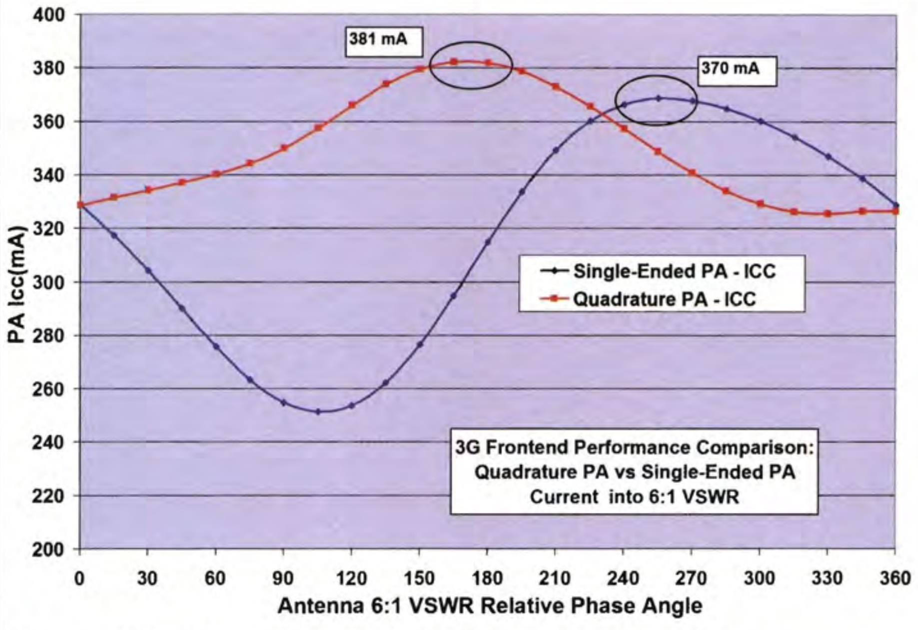



***Figure 10:*** *Quadrature PA vs single-ended PA current into 6:1 VSWR*

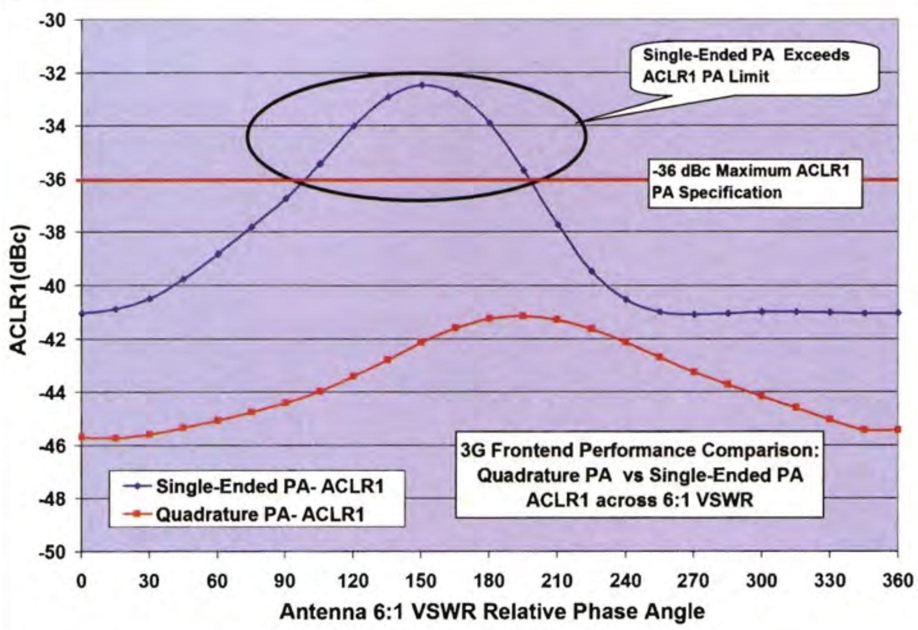



***Figure 11:*** *Quadrature PA vs single-ended PA ACLR1 into 6:1 VSWR*

**Table 1: Relative Performance Summary of RFMD GSM PA TRP Enhancement Methods**

| RFMD PA Architecture | VSWR Sensing / Loadline Adaptation | Power Variation into 3:1 VSWR | % Current Variation into 3:1 VSWR | Cost | Size | Comments |
|---|---|---|---|---|---|---|
| Powerstar® | None/None | High | High | Lowest | Lowest | High Efficiency / LDO Open-loop Collector Voltage Control |
| Powerstar® w/ Power Flattening | Closed-loop ICC Current Detection / Collector Voltage Control | Medium | Medium | Low | Lowest | High Efficiency / LDO Open-loop Collector Voltage Control |
| Powerstar® w/ RF Power Detection | Closed-loop Power Detection / Collector Voltage & Bias Control | Medium | Medium | Medium | Medium | Highest Efficiency / Integrates High Directivity Coupler & High D.R. Power Detector |
| Quadrature PA | None / 3 dB Quadrature Combiner | Lowest | Lowest | High | High | Low Efficiency |

additional cost and size of an isolator. Figure 8 compares quadrature PA power output versus single-ended when operating within a typical 3G UE front-end configuration using no isolator. In both cases, PA input power was adjusted for a nominal 50Ω antenna power output of +23dBm and held constant. The switch module's antenna port was then operated into a 6:1 VSWR and varied across all impedance phase angles.

The results illustrate that the quadrature PA delivers 0.8dB higher output power with less ripple vs a single-ended PA. Referenced to the 6:1 antenna port VSWR, the quadrature PA achieves TRP ≈ –4.1dB, or X = 1dB. **Figure 10** demons-trates current variation vs VSWR under the same operating conditions.

The quadrature PA exhibits less current variation (55mA vs 220mA) across VSWR and has roughly the same peak value (380mA). Although the quad-rature PA current is, on average higher across VSWR, without an isolator, the single-ended PA cannot meet the required system linearity into mismatch.

**Figure 11** depicts the 3GPP ACLR1 linearity performance comparison between the quadrature PA and the single-ended PA. The quadrature PA provides 5dB margin to the –36dBc ACLR1 limit and varies 5dB (min-max). The single-ended PA exceeds the limit (as much as 4dB) over a significant portion of the VSWR phase and varies 11dB (min-max). Overall, the quadrature PA provides a very good compromise between cost, size and performance.

## Vital to Success

UE TRP compliance is vital to the success of today's cellular network operators for quality and cost reasons. UE antenna sensitivity to the external environment – and its impact on front-end component performance – plays the key role in overall TRP performance.

Power amplifier output power and current variation due to antenna mismatch compromise the PA's ability to deliver sufficient power and impairs talk-time due to high peak currents.

# TRP ENHANCEMENTS

**GSM Enhancements:** For GSM PA applications, RFMD has introduced the RF3196 featuring its new TRP enhancement method called "Power Flattening". Power flattening can increase minimum output power into VSWR by ~1dB, while decreasing peak current by 0.5 A. In addition, peak power has been reduced by 1dB, thereby benefiting SAR compliance.

The power flattening circuitry is integrated into RFMD's Powerstar power control architecture. Powerstar power control circuitry uses a single feedback loop to adjust the Vcc collector voltage, proportional to the control voltage input. Power output is directly proportional to the collector voltage, but it is also a function of the load impedance ($R_{load}$). Predictable and stable output power occurs provided that the load impedance remains fixed. Since the PA load impedance varies due to antenna mismatch, adjustments to Vcc are made to correct power.

To account for the varying load impedance, a second feedback loop was added to the Vcc control circuitry. The additional loop monitors Icc current and intelligently compensates Vcc proportional to load VSWR. As expected, power flattening reduces current variation and lowers the peak current value, thereby improving talk time under mismatch conditions.

To best illustrate the benefits of power flattening, performance comparisons are made between the RF3166 and RF3196 Powerstar PAs. The RF3166 is a conventional Powerstar PA, while the RF3196 includes the power flattening circuitry. Figure 6 compares power and current ellipses for operation into a 3:1 load VSWR across all impedance phase angles. In both instances, nominal performance is +34.2dBm into 50Ω.

The RF3166 exhibits 3.5dB of power variation and 1.75A of current variation across a 3:1 VSWR. The RF3196 exhibits 2.25dB of power variation and 1.05A of current variation across 3:1 VSWR. Overall, power flattening reduces power variation by 1.25dB and current variation by 0.7A. In addition, the minimum power output into VSWR is increased from 32.4dBm to 33.3dBm, yielding a 0.9dB improvement. Peak current is reduced from 2.6A to 2.05A, for a net reduction of 0.55A. For a 3:1 VSWR, the RF3196 achieves TRP ≈ –2.25dB, or X = 1dB.

An added benefit of power flattening is reduction of peak power into VSWR. The RF3196 reduces peak power from 35.6dBm to 34.4dBm, a 1.2dB decrease.

**Table 1** summarises the relative performances of RFMD's TRP enhancement methods used in GSM PA applications.

**WCDMA Enhancements:** For WCDMA applications, RFMD has developed load insensitive quadrature PA technology. Quadrature PAs have also demonstrated ~ 1dB increase in minimum output power into VSWR while limiting peak current. Excellent compliance to the strict 3GPP linearity requirements is achieved without the use of isolators, thereby reducing system cost and size.

For WCDMA TRP enhancement, RFMD has developed quadrature PA technology in products such as the RF6281 and RF6285. Figures 7 and 8 illustrate the single-ended PA vs the quadrature PA architecture.

**Future Enhancements:** For the GSM-EDGE market, RFMD is developing the RF3203 GSM-EDGE PA. Using a closed-loop power detection method with Powerstar, RFMD has improved operating efficiency without degradation in TRP performance. Leveraging its WCDMA quadrature PA technology, RFMD is developing the RF6281 (Region 1) and the RF6285, which provides multiband coverage. Both PAs are DC-DC converter compatible for enhanced backed-off power efficiency.

# The design of SINGLE-ENDED AND DIFFERENTIAL MMIC VCOS

**ANDY DEARN AND LIAM DEVLIN FROM PLEXTEK LTD HERE DESCRIBE DESIGN TECHNIQUES FOR BOTH SINGLE-ENDED AND DIFFERENTIAL VCOs, WITH EXAMPLES SHOWN FABRICATED IN GAAS MMIC PROCESSES. POTENTIAL USES AND ADVANTAGES OF THE DIFFERENTIAL OVER THE CONVENTIONAL SINGLE-ENDED APPROACH ARE ALSO DISCUSSED**

Voltage Controlled Oscillators (VCOs) are widely used as signal sources in RF and microwave communication systems. Fully monolithic VCO ICs are rarely encountered as standalone components, mainly due to the low Q of the resonators and poor tuning performance of the available varactor technology. Their use in multi-function ICs is, however, now relatively common, as pressure to reduce the number of external components needed by the IC increases. This article aims to show that the use of monolithic differential. VCOs have several advantages in transceiver ICs over a conventional single-ended approach.

### VCO Advantages

In monolithic transceiver circuits, the use of double balanced mixers also offers important advantages [1]. These include:

- Rejection of the Local Oscillator (LO) signal;
- Suppression of even-order products of the LO and/or RF;
- Inherent isolation between all three ports;
- Improved linearity.

However, double balanced mixers also require differential rather than single-ended drives. **Figure 1** shows a block level schematic of a double balanced quad-ring resistive FET mixer, driven with a single-ended LO (VCO). A balun (or differential amplifier) is required at all three ports.

**Figure 2** shows how the LO balun can be eliminated by the use of a differential oscillator. This can have very positive implications for MMIC size (as well as performance) and, therefore, cost. In monolithic implementation, the quad-ring and single-ended VCO are relatively small in area compared to the baluns.

### Single-Ended and Differential VCO Design

A typical single-ended VCO topology, this one using a FET as the active device, is illustrated in **Figure 3**. The topology is essentially a Colpitts (or Clapp) arrangement, with the capacitive divider formed by the source capacitor and the internal Cgs of the device. The performance of this VCO topology, especially at high frequencies, can be degraded by the presence of the induct-ance of the grounding via holes. However, potentially more serious performance degradation arises from the grounding inductance of the package and, when lower cost via-free processes are used, the inductance of grounding bondwires. In addition to VCO performance degradation, the fact that LO signal is flowing through bondwires and package pins to

*Figure 1: Conventional schematic of quad-FET ring mixer with single-ended VCO*

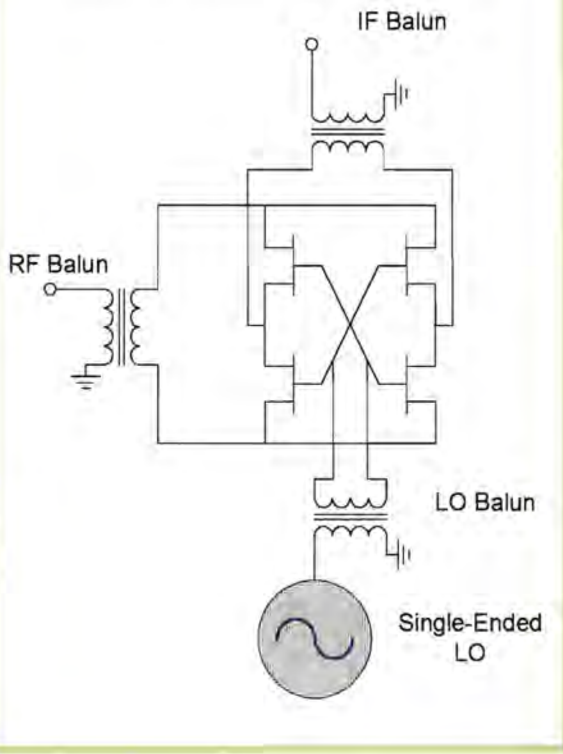


*Figure 2:* Schematic of quad-FET ring mixer with differential VCO

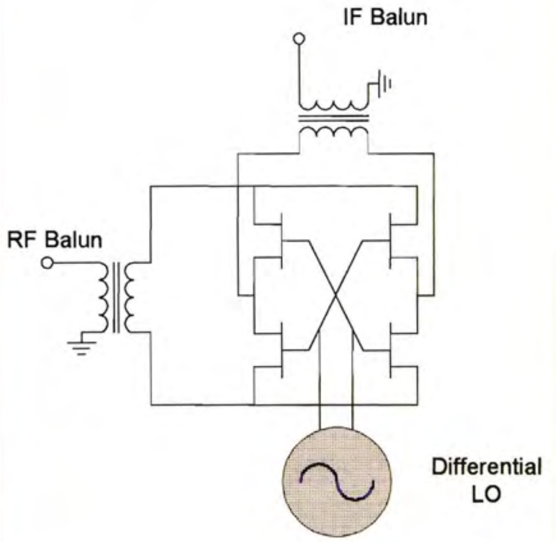



*Figure 3:* Simple schematic of single-ended FET-based VCO

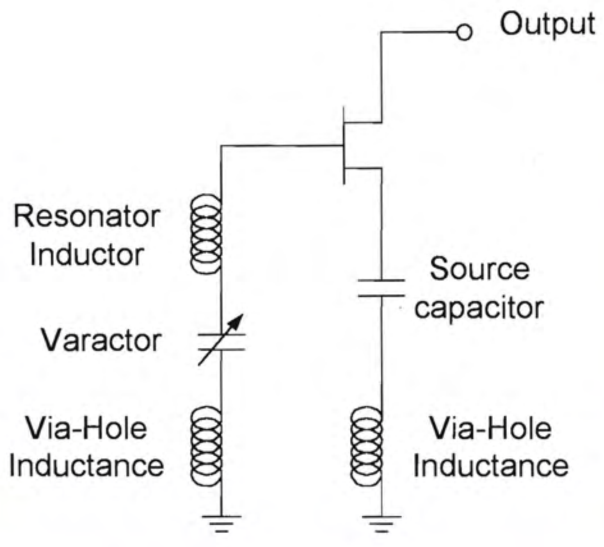
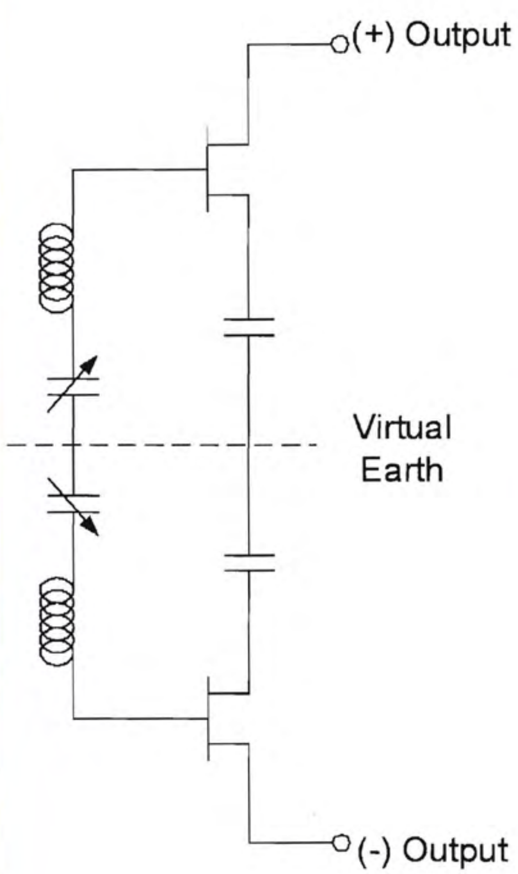



*Figure 4:* Equivalent schematic of differential FET-based VCO



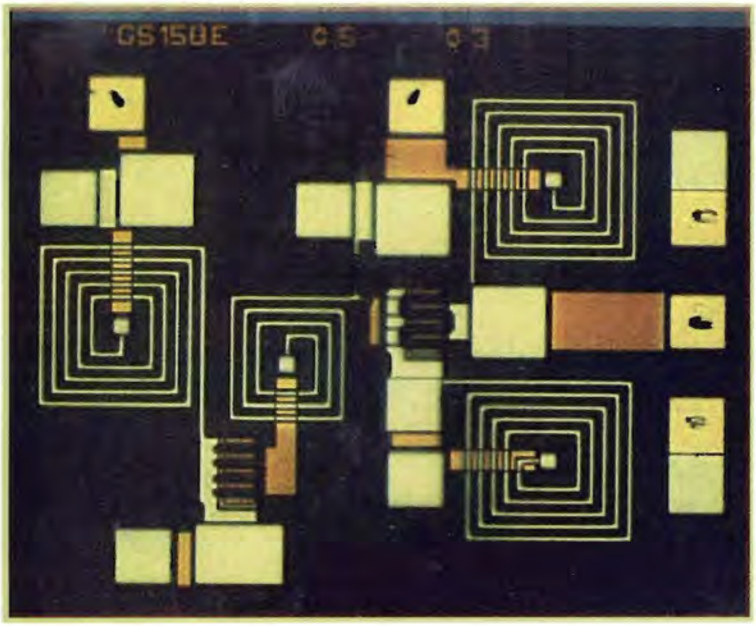

ground can result in increased LO leakage and an increased risk of interfer-ence with surrounding circuitry.

The equivalent schematic of a differential version of this oscillator is shown in **Figure 4**. Two identical versions of the core oscillator are essentially used in a "push-pull" mode. When correctly symmetrical, the two outputs can be shown to be locked in frequency, but 180° out of phase. Differential circuitry relies on "virtual earths" and does not require low inductance RF paths to ground. This gives rise to a number of important advantages for the differential VCO:

- High frequency performance is no longer degraded by via-hole/bondwire inductance;
- Fabrication on a simple, cheap via-free process can be considered;
- Rejection of common mode interference;
- The differential signals required to drive balanced mixers are directly generated by the VCO, dispensing with the need for a potentially large LO balun;
- LO signal does not flow through the bondwires and package pins to ground, resulting in less LO leakage and reduced risk of interference;
- Bias de-coupling is easier.

The simplest approach to designing a differential VCO is to design a single ended oscillator (using either a small-signal approximation or full non-linear analysis [2]), using ideal grounds and then simply combining two circuits symmetrically at the layout stage. The ideal grounds in the single-ended simulation become virtual earths in the differential implementation. A full harmonic balance of the complete differential oscillator can of course be performed, if desired.

*Figure 5: MMIC FET-based VCO [Courtesy of GEC-Marconi]*



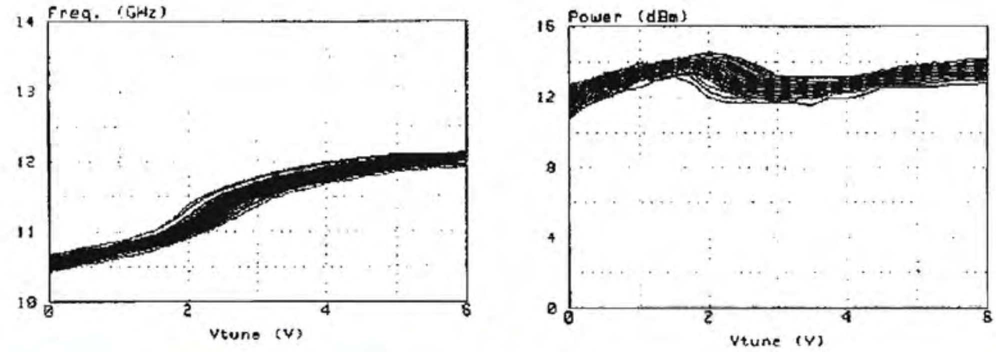
## Single-Ended VCO Examples

An example of a single-ended FET-based MMIC VCO with a RF schematic identical to that shown in Figure 3 is illustrated in **Figure 5**. Additional components on the IC are for DC bias of the FET and the application of the tuning voltage to the varactor. This particular example tunes 10.5 to 11.9GHz, as shown in **Figure 6**. The measured phase noise is –75dBc/Hz at 100kHz offset.

A similar VCO, but utilising a bipolar rather than a field-effect transistor, is shown in **Figure 7** [3]. This particular MMIC uses an InGaP HBT process from GCS Semiconductors, based in the US. This example operates at approximately half the frequency of the previous example. The measured tuning range is given in **Figure 8**.

The percentage tuning range of the HBT VCO is much less than that of the FET version and is also less linear. This is due to the poor varactors on the HBT process, which are derived from a

*Figure 6: Measured tuning range and output power of single-ended FET VCO*



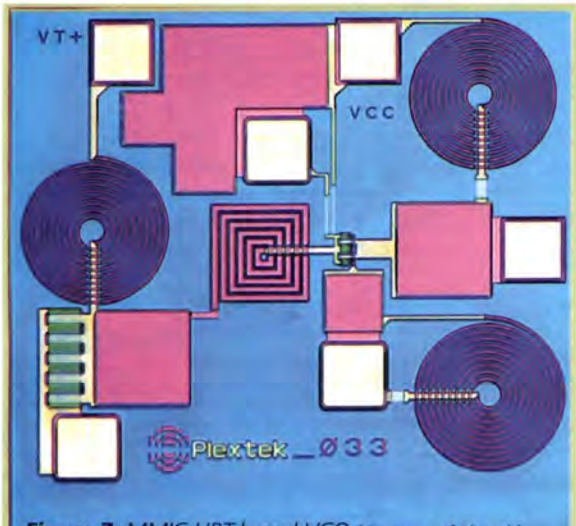




*Figure 7: MMIC HBT-based VCO [Courtesy of Plextek]*

*Figure 8: Measured tuning range of MMIC HBT-based VCO*

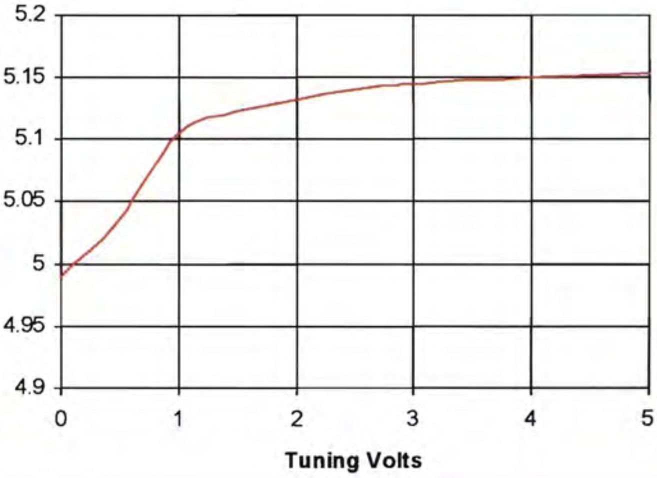
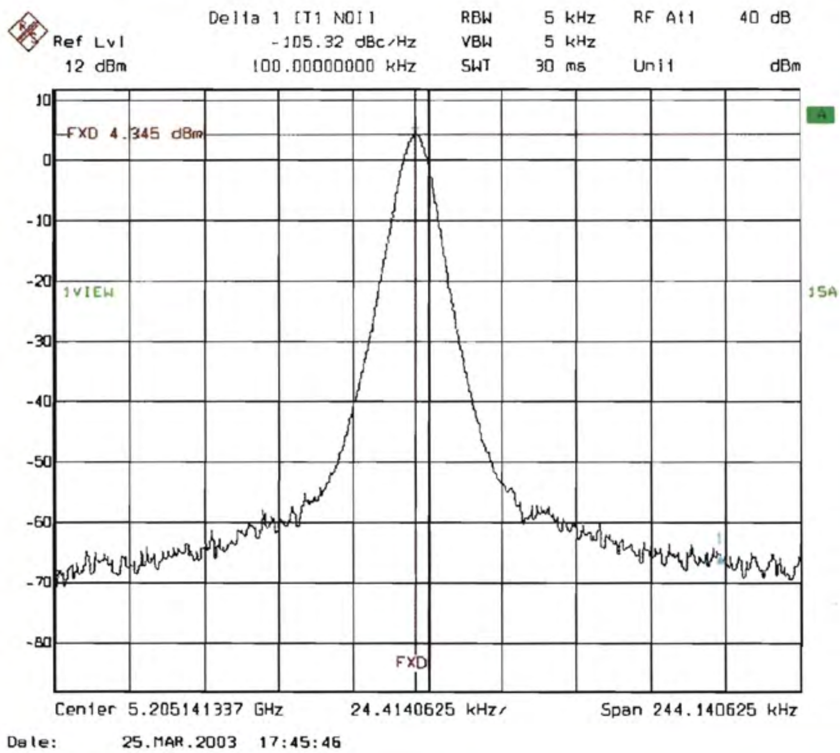


*Figure 9: Output spectrum of HBT MMIC VCO showing measured phase noise*




transistor's base-collector capacitance. The phase noise of the bipolar circuit, however, is far superior to the FET version and was measured as –105dBc/Hz at the same offset frequency of 100kHz. This is shown in **Figure 9**. Adjusting for the frequency difference this is an improvement of approximately 24dB.

### Differential VCO Examples

A differential VCO, used as the LO within a complete 2.4GHz transceiver IC, is shown in **Figure 10** [4]. This circuit was fabricated at the GEC Marconi GaAs MMIC fab at Caswell. The circuit is 0.5μm MESFET-based, through-GaAs via-free, and plastic packaged.

The exploitation of virtual earths in the VCO circuit meant that low inductance RF grounding of the VCO through the package leads was not necessary. A single-ended VCO does not benefit from virtual earths and would need to be grounded through bondwires and the package ground. This would almost certainly have killed oscillation or, at the very least, significantly degraded the performance.

The tuning range is illustrated in **Figure 11**. The measured phase noise was –87dBc/Hz at 100kHz offset. This is equivalent to that of the aforementioned FET single-ended VCO, when compensating for the different output frequencies (–75dBc/Hz at a frequency of 10GHz is equivalent to –87dBc/Hz at 2.5GHz, allowing 6dB/octave).

**Figure 12** illustrates a similar differential VCO used within a 5GHz transceiver MMIC, again fabricated by GEC Marconi [5]. This particular transceiver MMIC is neither via-free nor plastic

*Figure 10: MMIC FET-based differential 2.4GHz VCO*
*[Courtesy of GEC-Marconi]*

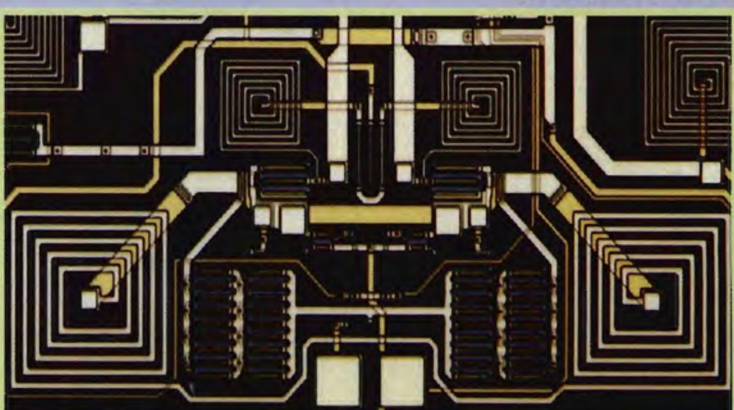
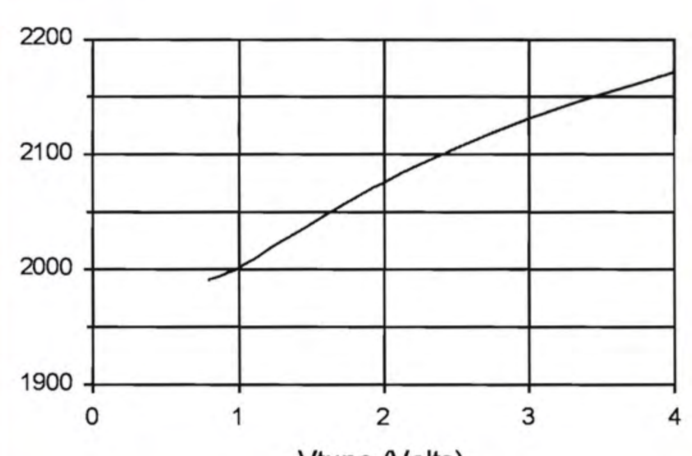


*Figure 11: Tuning range of MMIC FET-based differential LO*
*[Courtesy of GEC-Marconi]*



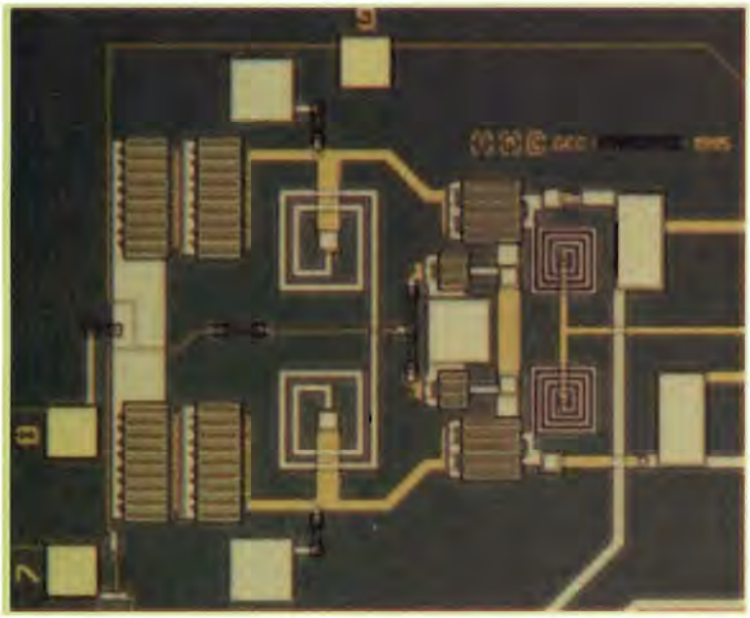


***Figure 12:*** *Photograph of MMIC FET-based differential 5GHz VCO [Courtesy of GEC-Marconi]*

packaged due to its higher frequency of operation. The differential VCO, however, does exploit the use of virtual earths throughout. This ensures that the oscillation is not degraded by parasitic inductance and removes the need for on-chip bias de-coupling capacitors. The measured tuning range and buffered output power of several of the VCOs (measured on-wafer) is presented in **Figure 13**.

## Comparisons

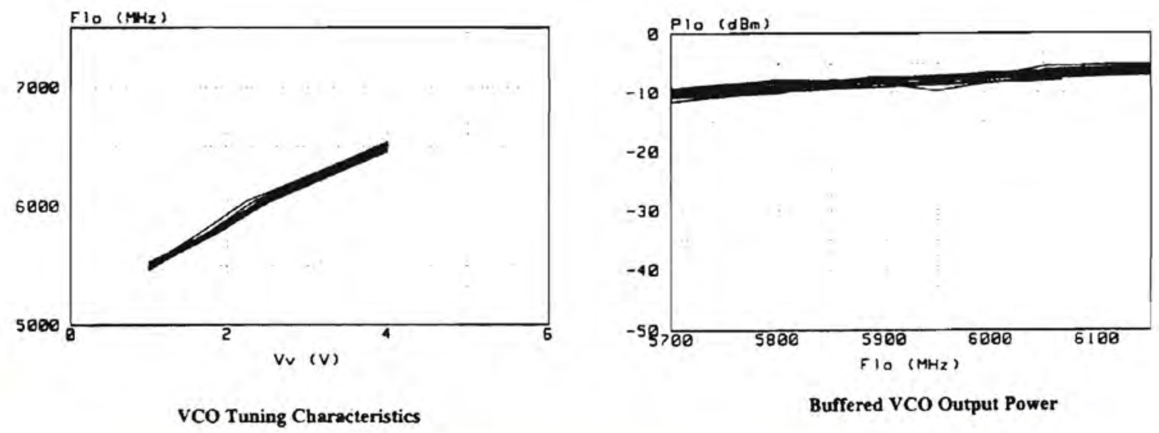
The design and measured results of several MMIC single-ended and differential VCOs have been presented. All of the VCOs are fully monolithic and require no external resonators or bias components. When utilised in monolithic, multi-function transceiver circuits, the differential VCO approach holds several advantages over a single-ended LO/balun approach. These include:

- The chip area occupied by a dual-output VCO exploiting virtual earths is (generally) less than that of a similar VCO using via-holes in combination with a balun structure;
- The via-free design is smaller, cheaper and higher yield, and less parasitic inductance means higher possible frequencies of oscillation;
- Symmetrical oscillator design guarantees outputs with 180° phase difference for driving balanced mixers;
- Rejection of common mode interference;
- LO signal does not flow through the bondwires and package pins to ground resulting in less LO leakage and reduced risk of interference.

## References:


1. "RF Mixer Design"
   *L. M. Devlin, IEE Training Event "How to Design RF Circuits", April 2000*
2. "Oscillator Design"
   *A. W. Dearn, IEE Colloquium on "The Design of RFICs and MMICs", November 1999*
3. "InGaP HBT MMIC Development"
   *Andy Dearn; Liam Devlin; Wing Yau; Owen Wu; ARMMS Conf. Nov. 2003*
4. "A High Volume, Low Cost, Plastic Packaged 2.4GHz Transceiver MMIC"
   *L. M. Devlin; B. J. Buck; A. W. Dearn; J. C. Clifton; A. A. G. Frier; M. Geen Proc. 3rd Annual Wireless Symposium, Santa Clara, CA, 1995, pp 121-125*
5. "GaAs Application Specific MMICs for a HIPERLAN MCM"
   *L. M. Devlin; B. J. Buck; J. C. Clifton; A. W. Dearn; M. Geen; A. P. Long; S. P. Melvin GAAS IC Symposium, Paris, 1996*


***Figure 13:*** *Measured performance of MMIC FET-based differential 5GHz VCO [Courtesy of GEC-Marconi]*



# CAPACITIVE-INDUCTIVE ELECTRONIC IGNITION SYSTEM

**H. MECHERGUI AND N. KOUNEV FROM THE UNIVERSITY OF TUNIS HERE PRESENT AN ELECTRONIC IGNITION SYSTEM WHICH JOINS THE ADVANTAGES OF CAPACITIVE AND INDUCTIVE IGNITIONS**

The electronic ignition system suggested here combines the advantages of two ignitions: capacitive and inductive. Indeed, a spark of long duration is created which has sufficient ignition energy; but also a very high secondary voltage to make easier the spark creation by the ionisation effect; and a very short rise time which makes it possible to overcome the electric leakages. These advantages give a sure ignition spark to burn the mixture of air and fuel in the combustion chamber.

In addition, the secondary voltage, the energy and the duration of the spark are practically constant until a maximum speed of the engine is reached. Indeed, the studied system presents excellent design features and the enormous improvements in solving the problems caused by ordinary inductive ignition systems, where the current across the spark coil doesn't reach a sufficient value to give the necessary spark energy: $W_e={}^1/_2L_1I^2$. For the capacitive ignition, the spark energy $W_e={}^1/_2CV^2$ reaches its maximum in a short time via a DC converter.

For environmental and energy-saving purposes it is necessary to avoid the air pollution caused by car engines as not all fuel burns in the combustion chamber. The requirements will be satisfied as soon as the automotive ignition systems provide a powerful spark with energy over 60mJ and a duration of between 1.5ms and 2ms.

Indeed, the increase in the new vehicles' engine speed cannot be adapted to the classical ignition circuit using a mechanical switch. That's why the manufacturers look for modern electronic ignitions to overcome the following problems:

- At high speed, the contact point that causes the ignition wears out;
- At high speed, the inductive charge cannot store enough electromagnetic energy to create a strong ignition spark to burn off the air-fuel mixture.

### Inductive Ignition System

The basic structure of an ignition circuit lies in the RLC circuit which works at a normal rate of damped oscillation during the opening of the contact point (see **Figure 1**) [1]. The circuit must provide sufficient energy to have a secondary voltage in the coil to be able to create a spark, which makes it possible to ignite the air-fuel mixture.

Moreover, the terminal voltage of the capacitor must be limited to avoid the wear of the contact point. In addition, the current through the primary coil must reach a maximum value in order to have a magnetic energy ($W_e={}^1/_2L_1I^2$) which will spark off with strong power.

The analysis of the circuit in **Figure 1** makes it possible to write the analytical expressions that describe the operation of the system.

Initially we assume that the current through the primary coil at the point of open contact is:

$$I_f = \frac{E}{r_\Sigma}$$

with $r_\Sigma$ being the total resistance of the primary coil. At time $t = 0$, the system is ordered by the following equation:

$$E = r_\Sigma i + L_1\frac{di}{dt} + v_c \quad (1)$$

where $$i = c\frac{dv_c}{dt}$$

After developing **Equation 1** we obtain the primary coil current equation:

$$i(t) = \frac{E}{r_\Sigma}e^{-\alpha t}(\cos\omega_0 t + \frac{\alpha}{\omega_0}\sin\omega_0 t) \quad (2)$$

where $E$ is the battery voltage ($E_{bat}$).
For the primary coil, the voltage is:

$$v_1 = L_1\frac{di}{dt} = \frac{-E}{\omega_0 RC}e^{-\alpha t}\sin\omega_0 t$$

If we put $m = \frac{v_2}{v_1}$

(the ratio between the primary and secondary coil turns), then the secondary voltage creating the spark is:

$$v_2(t) = -m\frac{E}{RC\omega_0}e^{-\alpha t}\sin\omega_0 t \quad (3)$$

For the capacitor the terminal voltage is:

$$v_c = \frac{1}{C}\int_0^t idt + v_{c(0)} \text{ or } v_c = E - r_\Sigma i - L_1\frac{di}{dt};$$

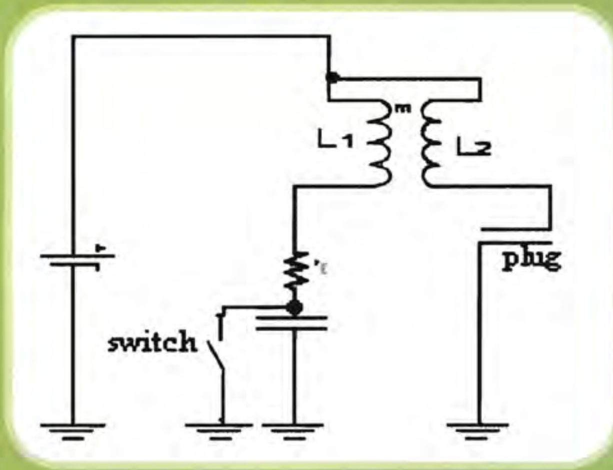



***Figure 1:*** *The basic schematic diagram of an automotive ignition system*

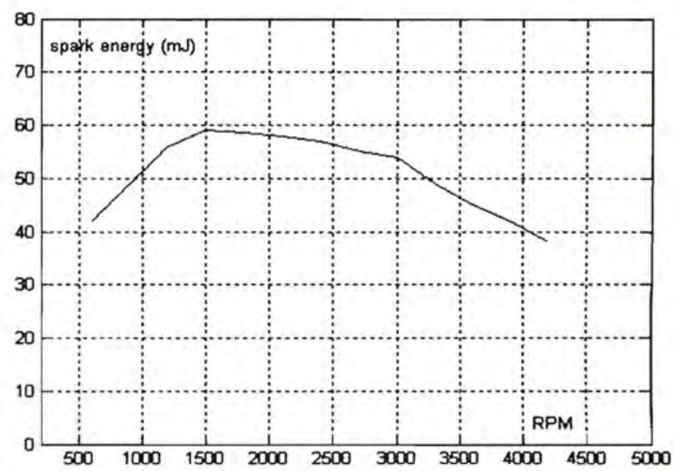



***Figure 2:*** *Ignition energy created by the coil*

which means:

$$v_c = E(1 - e^{-\alpha t}\cos\omega_0 t + ke^{-\alpha t}\sin\omega_0 t) \quad (4)$$

where $k = \frac{1}{\omega_0}(\frac{1}{RC} - \alpha)$

Thus, the voltage creating the spark is:

$$v_{spark} = E + v_2 = E(1 - \frac{m}{RC\omega_0}e^{-\alpha t}\sin\omega_0 t) \quad (5)$$

To find the maximum value of $V_{spark}$ we look for the derivative of $\frac{dv_{spark}}{dt} = 0$

The value of $V_{spark}$ is obtained for the time

$$t_{max} = \frac{1}{\omega_0} tg^{-1}(\frac{\omega_0}{\alpha})$$

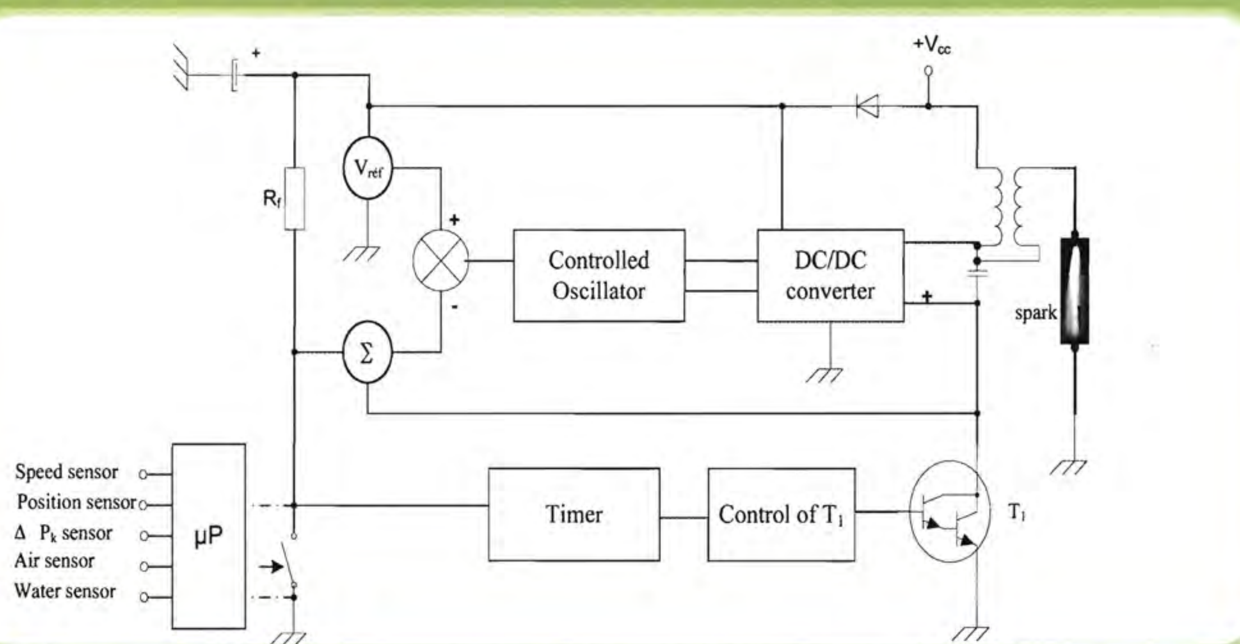
The validation and the interpretation of these calculations are illustrated in the following example:
If $E=12V$, $r_\Sigma=4\Omega$, $C=0.4\mu F$ and $m=100$ we obtain $a = 666.67 rad/s$, $\omega_0 = 285859 rad/s$ and the time $t_{max} = 53.63\mu s$ which corresponds to ignition voltage of $v_{spark} = 26kV$ and a voltage at the terminals of the capacitor of $v_C = 262V$.

In practice, the inductive character of the circuit limits the current through the primary coil to [2]:

$$I = \frac{E}{r_\Sigma} \text{ (1- exp. (} \frac{r_\Sigma}{L_1} \cdot \frac{\theta_{of}}{\theta_{on}+\theta_{of}} \cdot \frac{120}{N.n} \text{ )} \quad (6)$$

where $L_1$ is the inductance of the primary coil, $0_{off}$ and $0_{on}$ are respectively the opening and closing angle of the point contact; $n$ is the number of revolutions of the

***Figure 3:*** *Basic schematic diagram of the capacitive-inductive ignition system*



crankshaft and $N$ is the number of cylinders. For the most traditional automotive ignition system the time constant is

$$\tau = \frac{L_1}{r_\Sigma}$$

and it is between 3ms and 3.5ms long [3].
A simple calculation shows that to have a value of current $I_0 = 95\%I_f$ (with $I_L$ final current) we need a time constant $\tau_l = 3\tau$.

If we want to preserve a sufficient value at all speeds, the current $I_0$ should be guaranteed. **Figure 2** shows that this value is not guaranteed any more beyond a speed of 1800rpm (taking into account the relation

$$W_e = \frac{1}{2} L_1 I^2 \text{)}$$

and the secondary voltage falls off. Thus, we amend that with the circuit suggested in **Figure 3**.

This energy provides a rather strong spark, created by a capacitive circuit during a time $t_l$. The longer length of the ignition spark is ensured after that by the inductive circuit.

## Proposed Electronic System

Figure 3 represents the synoptic diagram of the suggested electronic system. The designed ignition circuit works respectively with capacitive discharge and after that with inductive discharge.

In this circuit, the capacitor C is being charged by a chopper booster that is controlled by an oscillator, which is ordered according to an instruction signal voltage coming from the terminals of the capacitor C.
The energy

$$\left( W_c = \frac{1}{2} C V^2 \right)$$

stored in the capacitor is transferred to the secondary ignition coil from where an ignition spark is created during a time $t = 0.6ms$, which is controlled by a timer ensuring the cut-off of the power transistor $t_l$.

The continuity of the spark is carried out by the inductive circuit of the igniter coil and which is prolonged until time $t = 1.3ms$. **Figure 4** represents the operation cycle of the studied electronic ignition.

Indeed, this new process joins together the advantages of the two systems: capacitive and inductive ignition.

We are looking for a long duration spark and which is adapted to the needs for the new economic engines that work with a relatively weak mixture.

Capacitive ignition systems are characterised with very high energies, high secondary voltage and a very short rise time, which allows the overcoming of the electric leakages to cause the ionisation between the plug contacts.

Hence, a complete burning of the air-fuel mixture is achieved.

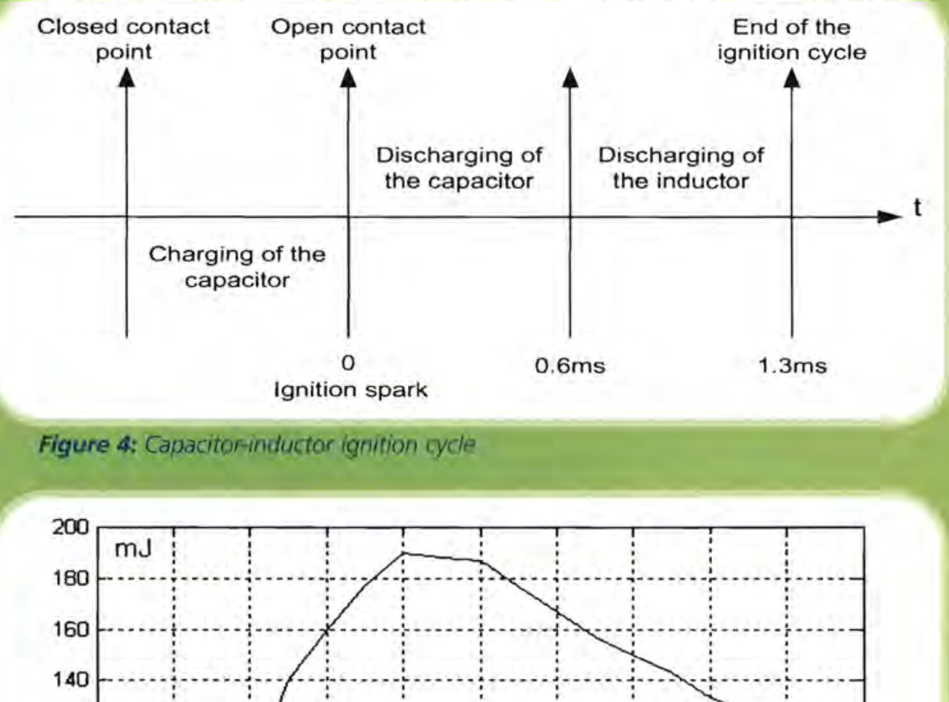



*Figure 4: Capacitor-inductor ignition cycle*


*Figure 5: The ignition energy versus battery voltage*

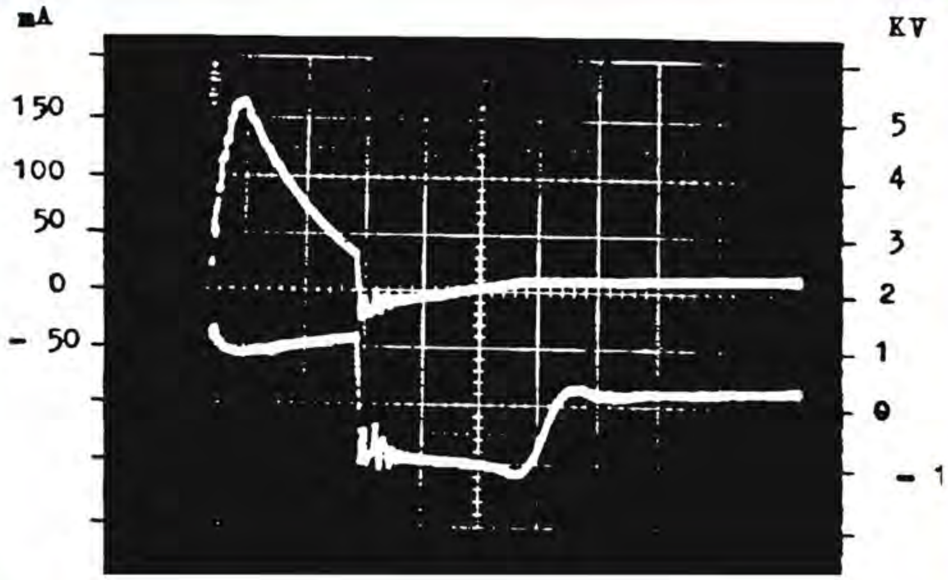



**Figure 6:** Spark ignition for current and voltage with CIIS–SS (Bosch coil 0221123007 12V with contact point of 0.7mm and a 1MΩ load)

The secondary voltage and the duration of the spark are practically constant until a maximum speed of 7500rpm.

### Looking Out For The Power Transistor

The experiment has showed that in an ordinary automotive ignition system (with inductive discharge), it is the power Darlington transistor which is generally damaged. If the energy stored in the magnetic field of the igniter coil (ignition system with inductive discharge) is: $W_L = \frac{1}{2} LI_{no} = 135mJ$

it is likely to deteriorate the power transistor of the electronic ignition system. The energy supported by a power transistor in an electronic ignition does not exceed *200mJ*.

Examples of a power transistor used in the electronic ignition system include the BU 322A (Motorola) with $W_L = 200mJ$; the BUV37 (Thomson) with $W_L = 200mJ$; the BUX 37 (Telefunken) with $W_L = 200mJ$; and the BUX50 (Telefunken) with $W_L = 200mJ$ [4].

It is noticed that the energy supported by the transistors is not enough to overcome their damage.

For our proposed electronic ignition, CIIS-SS (Capacitor Inductor Ignition System – Super Spark), the current cut-off through the primary coil is $I_I = 0.41_{nom}$, which means:

$$W_{L_1} = \frac{1}{2} L_1 (0.41 I_{nom})^2 = 0.16 \frac{1}{2} L_1 I_{Inom}^2$$

Thus the residual energy, due to the stored magnetic field in the coil at the cut-off point of the current through the primary coil, is at least six times lower than the energy corresponding to the inductive discharge of ordinary ignition.

The greatest part of this energy is being exhausted during the capacitive discharge. The voltage and current parameters of the ignition spark are represented in **Figures 5** and **6**. The figures show the variation of spark energy versus the battery voltage.

Figure 6 illustrates current amplitude of 150mA corresponding to a capacitive discharge and current amplitude of 30mA given by an inductive discharge during a time of 1.2ms.

**Figure 7** shows the proposed electronic diagram of the capacitive-inductive ignition system. **Figure 8** illustrates the experimental results which show the features of the CIIS-SS system.

### Advantages

The advantages of the proposed automotive ignition systems are:

- The facility to start the engine in all circumstances (winter conditions, low charge battery, old plugs, etc);
- Increased battery life;
- Improved engine efficiency and economy of fuel;
- Improved $CO_2$ emissions rate;
- Increased operational life of the spark plugs;
- The error caused by the spark plug is less than 1.5°;
- Decreased maintenance costs and frequency of adjustments;

  The CIIS-SS can be used as a simple electronic ignition in ordinary, old, vehicles. In new cars, it can be managed by a Hall sensor or a micro-processor.

### Design Features

- Supply voltage from 8.5V to 15V
- Maximum speed: 7500rpm
- Stored energy more than 140mJ
- Total duration of the spark is around 1.3ms

### References:


[1] *James W, Susan A Ridiel, Electric Circuit Fifth Edition, Addison - 1996 Wesley Publishing Company, ISBN20140100-2.*

[2] *H Mechergui, N Kounev, Electronic Ignition System with stabilization of the Spark Energy (Patent - May 1986).*

[3] *H Mechergui, N Kounev, Controlled Electronic ignition with JTEA 1986.*

[4] www.eetimes.fr/semi/news/showArticle.jhtml?articleID=19504722

***Figure 7:*** *Schematic diagram of the capacitive-inductive electronic ignition system*

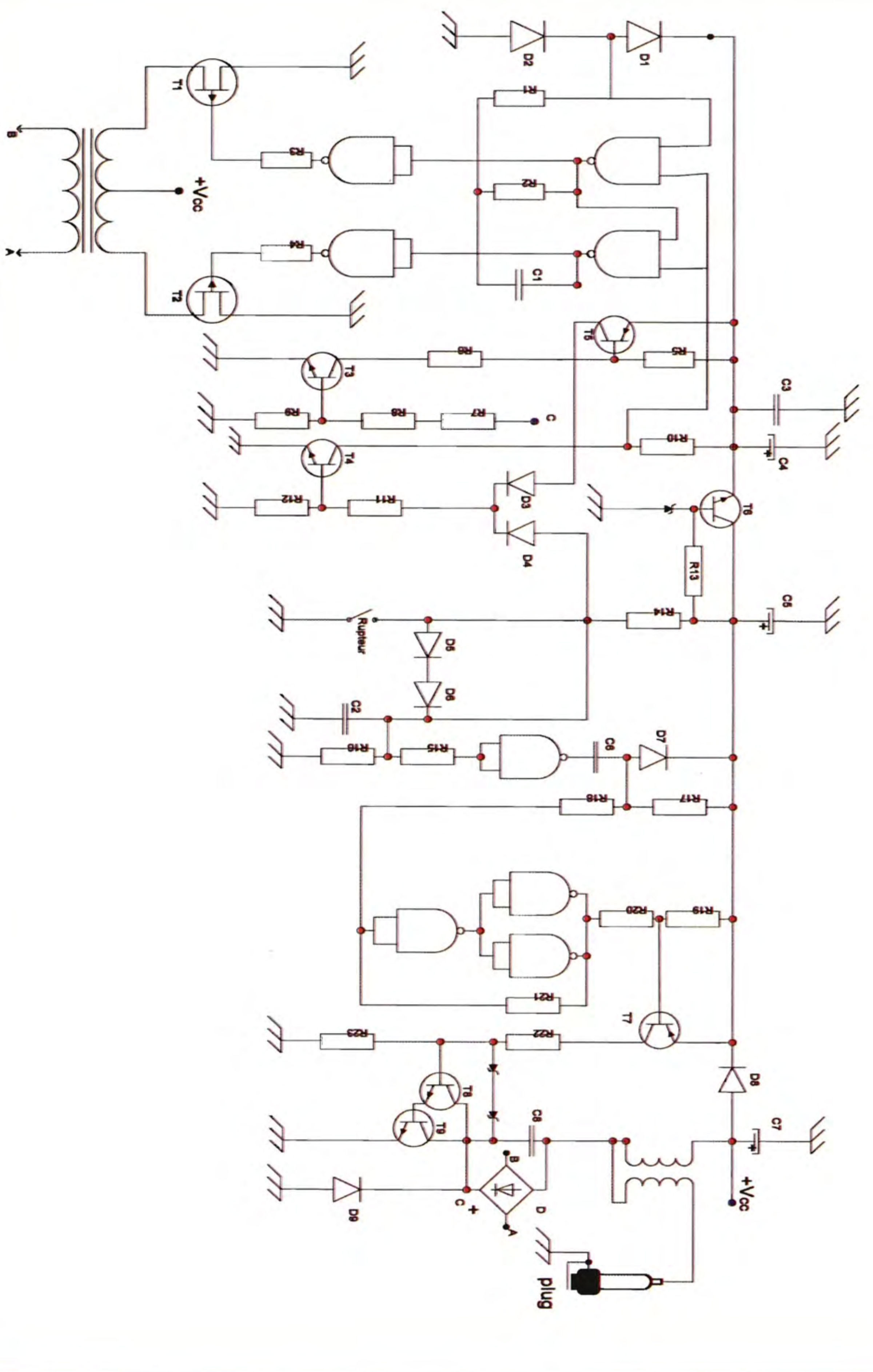


***Figure 8:*** *Illustration of electronic ignition sparks for different speeds and different distances between the plug points*

***Figure 9:*** *Electronic ignition system*

# Living with RoHS – Tougher Laws on Batteries

The EU has revised its 15-year old directive on batteries and accumulators, to harmonise disposal at end-of-life, throughout member states. This has become necessary because member states have responded to the original directive in such a variety of ways that performance in preventing batteries – and in particular the heavy metals they contain, such as lead, cadmium and mercury – from harming the environment varies widely across the EU. The new directive sets out clearer requirements on the use of substances, labelling, collection at end-of-life and recycling.

Another objective of harmonisation is to ensure the smooth functioning of the internal market and avoid distortion of competition within the EU. The scope of the new directive will have an impact on manufacturers and vendors of batteries and battery-powered equipment. Gary Nevison of Farnell explains the content and the enforcement deadlines of the new directive.

**Q: What is the new directive called?**

**A:** The new directive is referred to as Directive 2006/66/EC, on Batteries and Accumulators and Waste Batteries and Accumulators. This directive was passed in September 2006 and replaces the first Directive 91/157/EEC from 1991.

**Q: When does it come into force?**

**A:** Directive 2006/66/EC comes into force in September 2008.

**Q: Why is a new directive necessary?**

**A:** The 1991 directive had been implemented in a variety of ways, throughout all member states. The new directive aims to ensure that all states now reach the highest practicable standards for preventing high concentrations of heavy metals from returning to the environment.

**Q: Are all batteries covered?**

**A:** In practice all consumer or industrial batteries are in scope, including NiCad batteries, car batteries, button cells (watches etc) as well as back-up power supplies.

**Q: Are there any exemptions?**

**A:** The new directive does not apply to equipment specifically intended for military purposes or equipment designed to be sent into space. Member states may also exempt producers that place very small quantities of batteries or accumulators on the market, relative to the total national market.

**Q: Who will be affected?**

**A:** The new batteries directive will affect producers, importers and distributors of all types of batteries that are put onto the EU market either as individual batteries or incorporated within electrical equipment. The directive also requires member states to register each producer.

**Q: What are the restrictions on use of materials?**

**A:** Batteries containing mercury were banned in 2000 under the previous directive, but button cells remain exempted. A restriction on cadmium will also be imposed from September 2008, other than in emergency and alarm systems (including lighting) medical equipment and cordless power tools. The latter is subject to review by the European Commission.

**Q: What labelling requirements are in place?**

**A:** All batteries must be labelled with the crossed wheelie bin symbol (with certain exceptions) and with the chemical symbol for lead, cadmium or mercury if any of these are present. Where batteries are incorporated into products, instructions showing how to remove them must be provided with the equipment.

**Q: What does the directive say about collection?**

**A:** Batteries must be collected at end of life and recycled. The directive requires vendors to provide disposal schemes that are free of charge and convenient for end users, in order to meet this objective.

**Q: Have targets for collection been established?**

**A:** Collection targets for Member States are set at 25% of annual sales by 2012 and 45% by 2016.

**Q: What are the requirements for recycling?**

**A:** As much lead and cadmium must be recovered as is technically possible while avoiding excessive costs. Targets are at least 65% for lead-acid batteries and 75% for nickel-cadmium batteries. For other battery technologies the recycling target is 50%.

**Q: How does this relate to the WEEE directive?**

**A:** Collection schemes may be run in conjunction with schemes inspired by the WEEE directive, for example where the collected equipment contains batteries. However, the batteries must be removed from the equipment and thereafter are covered by the new batteries and accumulators Directive 2006/66/EC.

**Q: Are there any further restrictions on disposal of batteries?**

*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 svetlana.josifovska@stjohnpatrick.com, marking them as RoHS or WEEE.*

**A:** The directive prohibits disposal of industrial or automotive batteries in landfill sites or by incineration.

**Q: How does the directive define an industrial or automotive battery?**

**A:** Basically, this refers to non-sealed batteries but also includes batteries designed exclusively for certain types of hand-held equipment such as payment terminals, barcode readers or divers' lamps. The Official Journal of the European Union presented a non-exhaustive set of examples in its September 26, 2006 publication.

**Q: Does the directive call for technical advancement of batteries to reduce environmental impact?**

**A:** Member states are required to encourage manufacturers established in their territories to improve the environmental performance of batteries and accumulators throughout their entire lifecycle, including participating in an Eco Management and Audit Scheme (EMAS). Preferred developments include reducing quantities of dangerous substances included in batteries and replacing mercury, cadmium and lead with less polluting alternatives.

**Q: What are the penalties for not meeting the directive?**

**A:** Member states are required to implement penalties that are both proportionate and dissuasive. The member states are also allowed to introduce measures to promote collection and recycling of batteries, for example by using economic tools such as differential tax rates.

**Q: How will performance against these targets be monitored?**

**A:** A common methodology for calculating annual sales of batteries and accumulators will be established by September 2007. The industry may be required to submit data or contribute towards maintaining a suitable scheme. As far as collection is concerned, member states will be required to monitor collection rates on a yearly basis.

# Book Review

## Software Design for Engineers and Scientists
### John Robinson
### Newnes (an imprint of Elsevier)

It is not unusual as a hardware engineer to find oneself having to dabble with software such as embedded code on a microcontroller or programmable logic design in a hardware description language. Indeed, it seems inevitable that, at some point, a hardware engineer will have to get involved with software. The aim of this book is to familiarise the engineer (or scientist) with the fundamentals of software design, the back cover claiming it will "[take] the reader from small-scale programming to competence in large software projects, all within one volume".

The author is currently a member of the Intelligent Systems Group in the Department of Electronics at the University of York and the book is based in a large part on course material developed over the last fifteen years, both at York and at the University of Waterloo but, also, Memorial University in Canada.

The book can be loosely split into four key parts: an analysis of software design; an introduction to C/C++ programming; a look at data structures and algorithms; and, finally, a breakdown of the design process. Once Chapter One has introduced the structure, notation and definition of terms used in the book, the first of these parts really kicks off with Chapter Two, which examines software and software design from nine different perspectives, for example from an engineering view ("A program is an artefact, designed systematically, applying science and mathematics") and a literature view ("A program is a document, expressing thought verbally").

**THE BOOK CAN BE LOOSELY SPLIT INTO FOUR KEY PARTS: AN ANALYSIS OF SOFTWARE DESIGN; AN INTRODUCTION TO C/C++ PROGRAMMING; A LOOK AT DATA STRUCTURES AND ALGORITHMS; AND, FINALLY, A BREAKDOWN OF THE DESIGN PROCESS**

From the discussion of these viewpoints, the book derives principles ("statements of the nature of things") and, consequently, rules ("advice") of software design. These are then referenced throughout the book as the process of software design is expounded. There is a risk that these may be seen as trivial, anecdotal aphorisms, but the author has taken care with his choice and argues well for their inclusion in each case.

I found the material in this chapter a particularly good read, possibly due to the extent to which it was also applicable to engineering as a whole. Chapter Three continues the theme, examining software design as a craft and offering six further pieces of advice for engineering best practice (such as the use of logbooks).

Having discussed the foundations of software design, Chapters Four and Five of the book aim to give an overview of procedural and object-oriented programming using C/C++. Whilst you cannot hope to equip someone with a comprehensive knowledge of C/C++ programming within the bounds of 121 pages (let alone delve into operating system APIs), this introduction is a thorough overview, adequate to support the material that is to come for people unfamiliar with the language and to illustrate the differences between linear, procedural programming and the more abstract object-oriented approach.

It may be tempting for readers familiar with C/C++ to skip these chapters but, ultimately, this would be counter-productive as the explanation and scope of the presented material matches up with the way later material is presented.

To complement this brief introduction to programming language, the next three chapters give an equally whirlwind introduction to some of the building blocks of programming, namely programming style (for example clarity and structure), data structures (arrays, linked lists and combinations thereof) and the implementation of algorithms (using various search and sort algorithms as examples). As with the C/C++ chapters, the purpose of this section is not to be a definitive guide to style, structures and algorithms, but to demonstrate the principles of good programming practice and the application of standard solutions to design problems.

The final major section of the book looks at the design process, splitting it into five key steps: understanding the problem (creating a problem statement, public domain research, understanding users); researching the solution (including prototyping and simulation, using state charts); modularisation (top-down design versus information hiding); design and implementation (design of data structures and algorithms and coding them); and, finally, testing (including static analysis, black box and white box testing).

These chapters are particularly effective when read in conjunction with the final three chapters of the book, which take three case studies and work them through using the principles discussed in the main body of the text. These worked examples – covering median filtering, multi-dimensional minimisation and the development of a string table class – are an excellent way of underpinning the discussion of the design process.

Considering the breadth of its subject, this is not a thick tome and this is largely indicative of the skill of the author whose style combines wit, example and anecdote with clear,

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succinct explanations, and the avoidance of rambling details that are so often the stock and trade of software books. In particular, the use of sidebars to give historical, supple-mentary and anecdotal information prevents the main text from becoming congested.

At the end of the bibliographies chapter is a comprehensive set of references and is responsible for the swelling of my Amazon wish-list. Also included in this chapter are code samples, links and other material available for download from the author's website. If I had a gripe about the book, it would be the use of the proportionally spaced Rockwell font for the program listings (instead of a monospaced font like Courier), which detracts from their readability by making them blend into the main text.

In conclusion, the easiest way to sum up my opinion is to ask if it weren't a freebie would I buy it. With the benefit of having read it, I would have to say not only would I hand over my hard earned cash, I would recommend others to do the same.

As to the back cover claim of delivering "competence all within one volume", well, this may well be the map book but I still have the drive ahead.

**Douglas Taylor**

# UKDL COLUMN

# If you can't join them

*By Chris Williams, UKDL*

During the last three decades we have seen the general implosion of the conventional electronics manufacturing base in the UK. There were two primary causes of this: the peace dividend from the collapse of the Soviet Union, which drastically reduced defence spending, and the migration of consumer electronics manufacturing to disparate parts of the globe to exploit the benefits of low-cost labour areas.

Only now have we been able to identify two key areas where a domestic (and Europe-wide) manufacturing base could be significantly rebuilt. The first of these and probably the most important in the long term is Plastic Electronics. This is a regular topic for this column, but today the theme is set around another buzzword that will become irritatingly more familiar to everyone – SSL or Solid State Lighting.

SSL is already being adopted by sections of the media as a tool with which to bash the government and other organisations, as it is quite clear that many of the (probably) well-meaning dignitaries don't have a clue what they are talking about or what the issues involved really are.

Solid state lighting is a descriptor for any type of lighting device that does not use liquid or gas in its operation cycle. Typically, but inaccurately, SSL is taken to be limited to the use of inorganic light emitting diodes (LEDs) as light sources, but it should also encompass phosphor-based electroluminescent devices (EL) and organic light emitting diodes (OLEDs). This larger definition of SSL encompasses much of the research activity that is taking place in and around the UK today.

The perceived benefit of using solid state lighting as a primary light source to replace conventional light sources, such as filament and tungsten halogen bulbs, and perhaps even fluorescent tubes, is that SSL appears to have much higher electrical efficiency. The argument runs that by using SSL we will save many watts of power per electrical lamp. This turns into Gigawatts of power savings nationally – a target that has great societal attractions. The principle is established: if we could implement solid state lighting for domestic and commercial lighting, probably using inorganic LEDs in the first instance, then there will be the opportunity to reduce considerably the amount of power that would need to be generated just to provide lighting to the UK (and Europe, and everywhere else!).

The use of inorganic LEDs for domestic lighting requires that LEDs be able to generate white light. Unfortunately, white is not a colour that LEDs can generate directly and, so, one of two approaches must be taken:

1. **Trichroic white light.** Here, a device will be constructed by mounting a minimum of three LED chips (1 x red, 1 x green, 1 x blue) that will then be viewed as a single source. The eye will integrate the three colours and will "see" white light.
2. **Dichroic white light.** Here, the device will be constructed from a single blue-emitting LED chip that is then overcoated with yellow-emitting phosphor. The blue light transmits into the phosphor. Some of the light is absorbed directly by the phosphor atoms and the rest is transmitted through to the outside world. The light that is absorbed by the phosphor will then stimulate the phosphor causing photoluminescence and, on relaxation, the phosphor will emit its characteristic yellow light. The eye will integrate the two colours (blue + yellow) and will "see" white light.

Both of these techniques are being used to create "white light" devices for use in SSL assemblies. The problem is that the general public has been exposed to the idea of SSL before it is fully ready.

**Table 1** shows the current state of play for the electrical efficiencies of most lamp technologies that you can buy by walking into a retail store today.

| Light source | Luminous efficiency |
|---|---|
| Edison's first light bulb | 1.4 lumens/Watt (lm/W) |
| Tungsten filament light bulb | 15 – 20lm/W |
| Quartz halogen light bulbs | 20 – 25 lm/W |
| Fluorescent light tubes & compact bulbs | 50 – 120 lm/W |
| Mercury vapour light bulbs | 50 – 60 lm/W |
| Metal halide light bulbs | 80 – 125 lm/W |
| High pressure sodium vapour light bulbs | 130 – 140 lm/W |
| White LEDs (best on market) | 100lm/W at 350mA (Seoul) |
| White LEDs (best in lab) | 150lm/W at 20mA (Nichia) |
| White LEDs (target efficiency) | 150 – 250lm/W |

***Table 1:*** *Comparison of typical efficiency of commercially available lamp products [Data courtesy of Professor Colin Humphreys of the University of Cambridge]*

# BEAT THEM

| | | |
|---|---|---|
| 2-inch wafer substrates | Sapphire | $40.0 |
| | Silicon Carbide | $1,000.0 |
| | Gallium Nitride | > $1,000.0 |
| | Silicon | $5.0 |
| 6-inch wafer substrates | Silicon | $8.0 |

***Table 2:*** *Typical costs of substrate materials [Data courtesy of Professor Colin Humphreys of the University of Cambridge]*

White LEDs that are commercially available today appear at first glance to be pretty competitive in efficiency – not as good as the best fluorescent tubes or sodium vapour lamps, but much better than filament bulbs and tungsten halogen. So, is this a no-brainer argument to change over to LED technology? Not necessarily. The problem lies with the total amount of light that can be created from a single device. The vast bulk of commercially available LEDs, which are made at more than one billion devices per month, are for relatively low-power chips. Running an LED that has a drive voltage of (say) 3V at a current level of 50mA will consume 150mW. At around 50 lumens per Watt (or less) for the vast bulk of LEDs made, this would yield just 7.5 lumens of light output. A 40W filament bulb, even at 20 lumens per Watt, would yield 800 lumens. So, to match like for like, I would need more than 100 of these low-grade LED chips to match the light output level of a cheap and cheerful filament lamp.

The creation of clusters of LED lamps is already well known and many of the Far Eastern manufacturers of LED devices offer a wide range of cluster devices targeted at specific applications. Examples include traffic lights, automobile brake lamps and bicycle front and rear lights.

Of course, in the real world, there are advantages to be gained – LED chips can be packaged such that the light is collected, collimated and directed in a specified direction. This allows the perceived brightness to be higher in the preferred direction, but the brightness then falls off rapidly when the lamp is viewed from any other direction.

Also, the recent emergence of high-brightness LEDs, with individual LED chips designed to handle power levels of 1W or higher, are another step towards the realisation of practical designs for SSL devices. But, they are not there yet and the cost difference is still huge.

The current costs for a white LED chip based on gallium nitride/yellow phosphor technology ranges from $0.10 for the cheapest to over $2.00 for the brightest. Putting this into practical terms as a strategy for domestic lighting – the current cost for 1000 lumens of white light using LEDs is around $100. Given that the current cost of a comparable "standard" light bulb is about $1, then we can reasonably expect that the market price of one kilo-lumen LED lamps must fall to $5 or less before they can be accepted into the mass market.

This is where UK expertise in innovation is coming up with a possible world-beating solution.

The UK gave up making LED chips in any volume years ago. The cost of manufacturing low-cost "standard" devices in the UK became prohibitively expensive and production moved to the Far East, where today the production volumes of LED chips of all colours and sizes are measured in up to 100s of billions of devices per month. The cheapest of these standard chips may be as little as $0.05 each. The price structure changes when moving away from red, green and yellow chips; blue chips have always required more sophisticated processing and more expensive materials.

As an example of the materials' cost-structure, blue LED devices will have their epitaxial layers grown on sapphire, silicon carbide or gallium nitride substrates. These materials are chosen because of their compatibility with the gallium nitride epitaxial layers, but they are in themselves expensive (see **Table 2** for details).


*LED traffic lights*

It would be great to be able to build blue-emitting gallium nitride epitaxial layers onto a basic silicon substrate, as that would significantly reduce costs. All things being equal, this single move would help progress towards the target of moving from $100 to $1 per kilo-lumen. This route is fraught with difficulty, as the relative atomic size of the different materials used is quite different, which causes great stress at the interfacial layers where the different materials are matched together.

Enter the experts at Cambridge University: Professor Colin Humphreys and his colleagues have perfected techniques for growing gallium nitride epitaxial layers onto silicon substrates. This pilot work has been done using 2-inch diameter wafers and with industrial partners supported by a DTI grant under the Technology Programme. This work is now being extended to developing a technique to grow devices on a 6-inch wafer. The successful outcome of this project is likely to be the lowest cost process for making high-brightness LEDs in the world. Accepting that the UK cannot compete in making commodity LEDs, it does seem that the UK may become a major supplier of specialist high-brightness LED chips for the emerging world of SSL lighting.

Let us hope that this can be done in time. I mentioned above that SSL lighting is in danger of being promoted to a market before it is ready. Today, devices that are bright enough to be used are too expensive to compete against all incumbent technologies. All attempts by lighting fixture manufacturers to try and reduce costs in the short-term by moving to cheaper LED lamp sources are probably doomed

*Front bike light*

to failure. The greatest weakness of all LED devices is that they are critically dependent on operating temperature. If they get too hot, their performance drops, light output falls and their operating lifetime plummets downwards.

LED lights for commercial use that are badly designed by using inappropriate chips and exhibiting insufficient thermal management will certainly fail well ahead of consumer expectations. Sadly, this can already be seen in the DIY sheds around the UK – wall mounted exhibits of low-cost LED lighting will commonly include lamps with at least one LED chip that has failed prematurely. This is not what the consumer wants to see, and time and time again we have witnessed public rejection of technology that is bought to market too early. Even real-world examples are seen; LED traffic lights and road signs with failed lamps are also a too-common sight in the UK.

SSL has a bright future for the UK and for Europe – but only when the technology and the price are right.

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

*UKDL is holding a series of events on LED technology for SSL applications. See* **www.ukdisplaylighting.net** *for details*


*The largest LED screen in the world, in Arkansas – a replay screen with 2.5 million LEDs*

# ELECTRONICALLY TUNABLE TRANSADMITTANCE BP FILTER

Numerous circuits realising voltage mode (VM) or current mode (CM) filters using active devices such as operational amplifiers, Operational Transconductance Amplifiers (OTA), Current Conveyor (CC), Current Feedback Amplifier (CFA), Four Terminal Floating Nullor (FTFN) and the recently introduced active device Current Differencing Transconductance Amplifier (CDTA)[1-4] have been reported in literature.

However, the available literature shows that much attention has not been paid towards the development of mixed-mode active filters as only a few circuits are available and none using the recently introduced active device CDTA.

Mixed-mode circuits find their application as an interface between a VM and CM circuit. The main purpose of this paper is to present a transadmittance (TA) band-pass (BP) filter using the active device CDTA. The circuit employs bare minimum number of active and passive components, i.e. one CDTA and only two capacitors. The filter response is available at high impedance thereby enabling cascadibility to CM circuits. The pole frequency $\omega_o$ is electronically tunable through the transconductance gain g. The filter has low sensitivity figures. The workability of the filter has been carried out using PSPICE.

The terminal relationships of the recently introduced building block CDTA of which the schematic symbol and behavioural model is shown in **Figure 1** are given by:

$V_p = V_n = 0, \; I_z = I_p - I_n, \; I_x = \pm gV_z$

A routine analysis of the circuit shown in **Figure 2** yields the following transadmittance transfer function:

$$\frac{I_o}{V_{in}} = \frac{s\dfrac{g}{C_2R_p}}{s^2 + s\left[\dfrac{1}{C_1R_p} + \dfrac{g}{C_2}\right] + \dfrac{g}{C_1C_2R_p}} \qquad (1)$$

$R_p = \dfrac{V_T}{2I_b}$ is the input resistance at port p[14], where $V_T$ is the thermal voltage and $I_b$ is the bias current.

$g = \dfrac{2I_b}{V_T}$ is the transconductance gain of the OTA.

If the output is taken at the w-terminal, then the circuit yields the following voltage transfer function:

$$\frac{V_w}{V_{in}} = \frac{s\dfrac{1}{C_2R_p}}{s^2 + s\left[\dfrac{1}{C_1R_p} + \dfrac{g}{C_2}\right] + \dfrac{g}{C_1C_2R_p}} \qquad (2)$$

The natural frequency $\omega_o$ and bandwidth $\omega_o/Q$ are given by:

$$\omega_o = \sqrt{\frac{g}{C_1C_2R_p}} \qquad (3)$$

$$\frac{\omega_o}{Q} = \frac{1}{C_1R_p} + \frac{g}{C_2} \qquad (4)$$

From Equations 3 and 4 it is clear that $\omega_o$ is electronically tunable through the transconductance gain g, whereas $\omega_o/Q$ can be tuned by the input resistance $R_p$ of port p, which is also electronically tunable.

The active and passive sensitivities are given by:

$$S_g^{\omega_o} = -S_{C_1}^{\omega_o} = -S_{C_2}^{\omega_o} = -S_{R_p}^{\omega_o} = \frac{1}{2}$$

$$S_g^{\frac{\omega_o}{Q}} = -S_{C_2}^{\frac{\omega_o}{Q}} = \frac{gC_1R_p}{C_2 + gC_1R_p}$$

$$S_{C_1}^{\frac{\omega_o}{Q}} = S_{R_p}^{\frac{\omega_o}{Q}} = -\frac{C_2}{C_2 + gC_1R_p}$$

The band-pass response of the proposed circuit with pole frequency of 159kHz was simulated using PSPICE. The design parameters were $C_1$ = 1nF, $C_2$ = 1nF and g = 1mS. The CDTA block was implemented using CDBA and OTA as shown in **Figure 3**. The simulated results are shown in **Figure 4**, confirming the workability of the proposed filter.

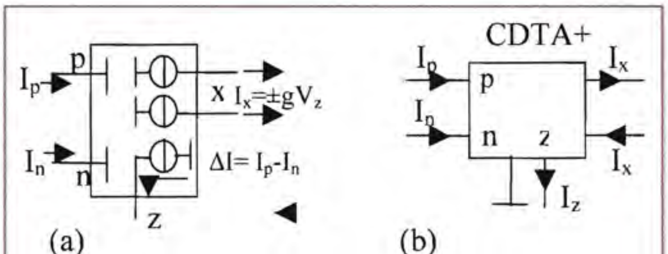


***Figure 1:** (a) Behavioural model, (b) symbol of CDTA element*

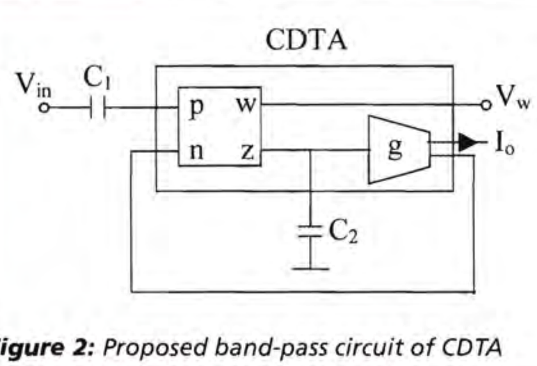


***Figure 2:** Proposed band-pass circuit of CDTA*

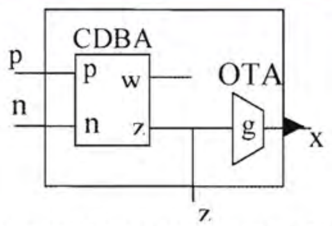


***Figure 3:*** *Implementation using CDBA and OTA*

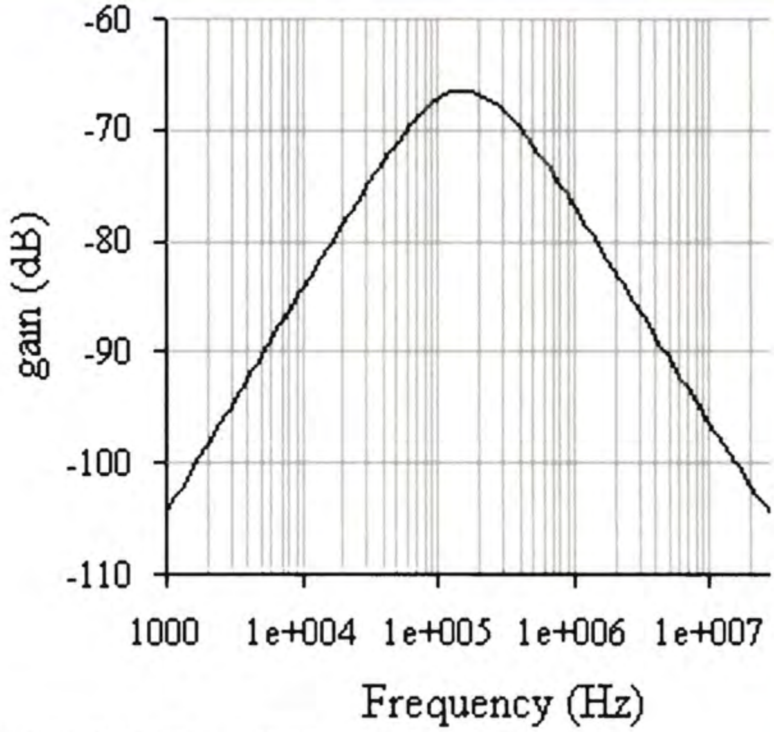


***Figure 4:*** *Magnitude response of the band-pass filter*

***N. A. Shah, Munazah Quadri** and **S.Z. Iqbal***
*Department of Electronics and Instrumentation Technology,*
*University of Kashmir*
*India*

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# HIGH-EFFICIENCY, BATTERY-POWERED, FLUORESCENT LAMP

The amount of light possible per watt for the modern low consumption fluorescent lamps is still about double that for white LEDs at present easily available.

However, the typical self-oscillating circuit used to power battery-operated lamps is very short on circuit elements which can be readily adjusted to optimise performance. The result is a unit which is easy to get some sort of results from, mainly because of the very simplicity of the circuit, but very difficult to get the maximum efficiency and, therefore, satisfactory lighting from.

The difficulty is compounded by the fact that the narrow folded tubes of low consumption fluorescents need a much higher starting potential than that needed to keep the lamp running, even with the tube ends energised properly. It is often found, even in some commercial units, that the transformer is wound to provide this higher potential in order to give reliable starting. This results in weak performance as the amount of current available (which is what governs the light you get from any fluorescent tube) is reduced in proportion to the turns ratio of the transformer. Low consumption tubes should be run warm to operate efficiently, and this is difficult to achieve repeatedly with a simple inverter with exactly the battery voltage to be employed.

The resonant circuit used to do this in the standard mains-powered lamp is difficult to emulate at the higher currents and lower voltages of battery-powered circuitry and, since the circuitry needs to be arranged very differently anyway, a different approach has been used in this design.

Initially, the transformer is driven by a standard Schmidt oscillator at around a megahertz. At this frequency the capacitors in the heater circuits have low impedance and allow sufficient current from their respective transformer secondaries to heat them. The main secondary, connected directly across the tube, does not actually supply a boosted voltage like its mains-powered counterpart, instead relying on the higher ionising power of RF energy at this frequency, which has the same effect.

After a pre-determined time (after the tube has lit), the capacitive timing element of the driving oscillator is increased and the frequency of drive reduces to a more normal 300kHz or so. The capacitors in series with the end filaments now have much higher impedance, so very little power is now used here and the impedance of the main transformer secondary is much lower, allowing much more drive current to be delivered. The change in brightness (and colour) of the tube is very obvious when this happens.

After the usual warm-up period has elapsed, brightness equal to a mains-powered 'twin' which has not been cannibalised for its tube (they usually 'pop' apart very easily from their control unit – with care) is easily achieved at exactly the same power (6V at 0.5A).

This unit is very tolerant of supply voltage, light is only drooping slightly at 5V, which is the minimum level a 6V NiMH battery should be run down to.

The circuit was designed around the tube cannibalised from one of the small decorative substitute 'candle' bulbs available from larger stores, which come in a range of powers. Unfortunately, 3W seems less common now, but 4 to 7 watt versions are still easily available.

Adjusting the circuit for the power of the tube is simply a matter of adjusting the size of the extra capacitance which the timing circuit switches in, lowering the frequency of drive increases the current through the transformer so allowing higher power tubes to be fully driven.

Use is made here of switching mosfets' excellent performance at unusually high frequencies for an inverter – a little bit of bootstrapping around their gates boosts peak drive to 8V. This being ample at these frequencies, the 20mA drive capability of the five spare paralleled gates of the 74HC14 copes well at this low level of drive for switching mosfets – remember that the absolute maximum supply is 7V.

The decoupling of the 'earthy' end of the transformer primary has been made a bridge to make less demand on the main electrolytic decoupling capacitor with high currents of these frequencies flying about. A restart can be forced (if, for instance, there is a short interruption in supply because of weak springs in the battery holder) with a pushbutton across the starter timing capacitor.

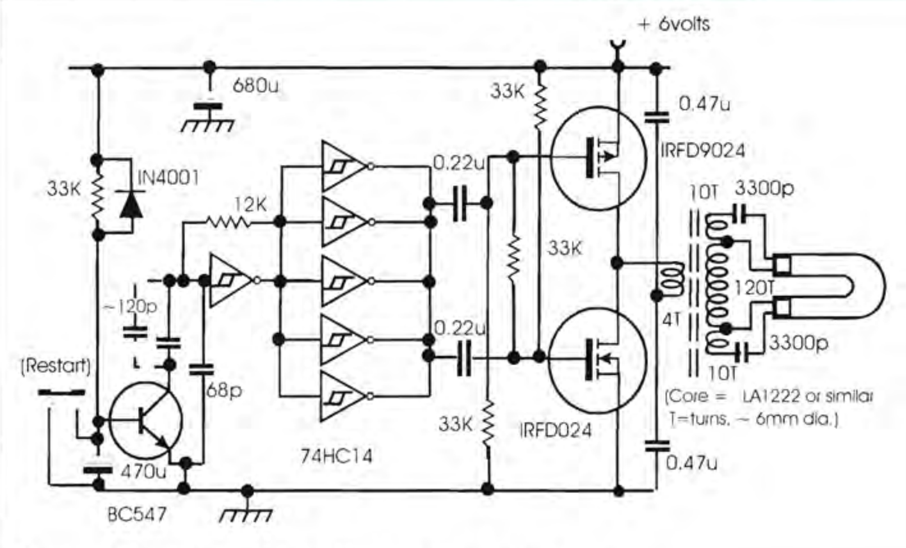



***Figure 1:** Inverter for high efficiency flourescent lamps*

Email your circuit ideas to:

**svetlana.josifovska@stjohnpatrick.com**

# Power Managed Family featuring

Microchip continues to provide innovative products that are smaller, faster, easier to use and more reliable. The Flash-based PICmicro microcontrollers (MCUs) are used in a wide range of everyday products, from smoke detectors, hospital ID tags and pet containment systems, to industrial, automotive and medical products.

The PIC16F/18F power managed family featuring nanoWatt Technology merge all of the advantages of the PICmicro MCU architecture and the flexibility of Flash program memory with several new power management features. The devices become a logical solution for

## TIP 1: HOW TO USE A COMPARATOR TO BUILD AN INVERTER

This is the easiest logic function to produce (see **Figure 1**). R1 and R2 should be equal in value and large enough to not draw excessive current. A value in the range of 1K to 10K works well in a 5V system.

The only restriction is that R1 and R2 should put the non-inverting input between the $V_{IL}$ and $V_{IH}$ limits for the incoming logic signal.

If the part has an internal $CV_{REF}$, this saves two resistors and an extra pin.

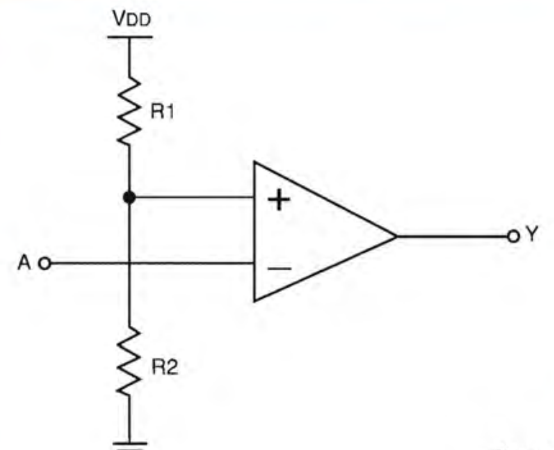



*Figure 1*

## TIP 2: HOW TO USE A COMPARATOR TO BUILD AN (N)AND OR (N)OR GATE

Both of these gates use the same schematic (see **Figure 2**). R3 and R4 should be the same value and chosen to limit the current when one input is high and the other is low. The differentiation between the AND and OR functions is the choice of values of R1 and R2. If R1 is half the value of R2, the gate is an AND gate, because the trip voltage on the input of the comparator is now two-thirds of VDD. If A is high and B is low, the resulting input to the non-inverting input is only one half of VDD. To set the output high, both A and B must be high, which puts the non-inverting input above the inverting input and sets the output.

If R1 is twice the value of R2, the gate acts as an OR gate. This is because the trip voltage on the inverting input of the comparator is now one-third VDD, so if either A, B, or both are high, the non-inverting input is at one-half VDD or greater, driving the output high. To turn either gate into its inverting version, swap the inverting and non-inverting inputs (see **Figure 3**).

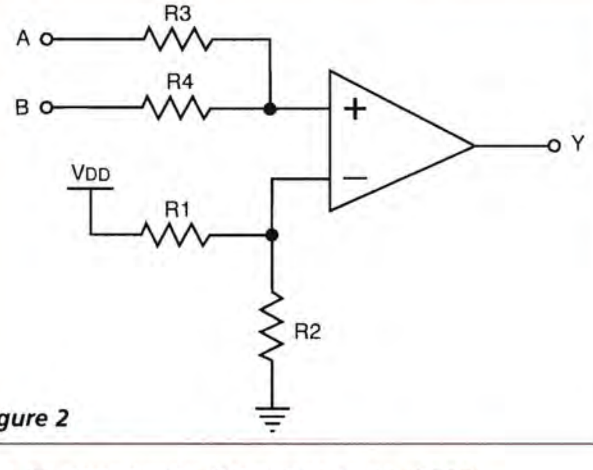



*Figure 2*

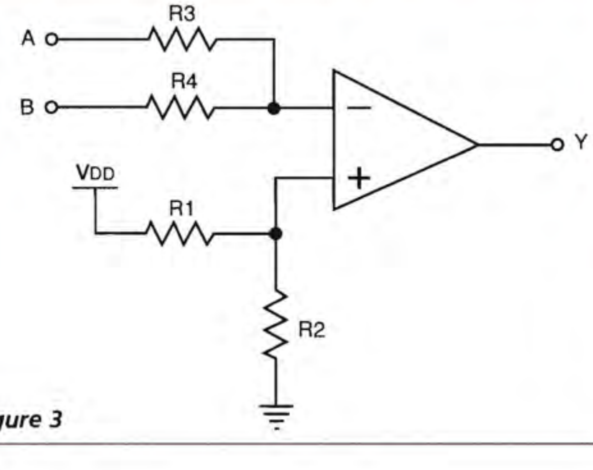



*Figure 3*

# nanoWatt Technology

intelligent small systems, or complex systems that require extended battery life and energy-efficient operation.

The flexibility of Flash and a suitable development tool suite, including a low cost In-Circuit Debugger, In-Circuit Serial Programming and MPLAB ICE 2000 emulation, make these devices ideal for just about any embedded control application.

The following series of Tips 'n' Tricks can be applied to a variety of applications to help make the most of the PIC16F/18F power managed family featuring nanoWatt Technology.

## TIP 3: HOW TO USE A COMPARATOR TO BUILD AN EXCLUSIVE 'OR' GATE

This requires a few more components, but can still be done with one comparator (see **Figure 4**). First, set R4 to a reasonable pull-up resistor value, such as 1K or 10K. R1, R2 and R3 are all equal and chosen to limit the current when either or both inputs are high. Again, a 1K or 10K works for a 5V system.

If A is high and B is low, the inverting input is held at 0.7V above ground by D2. The resistor divider formed by R1, R2 and R3 puts the voltage at the non-inverting input at about one-third VDD. This puts the non-inverting input at 1.6V, which is above the inverting input, so the output is high. The same is true if A is low and B is high. However, if both, A and B, are high, the inverting input is pulled to VDD and the resistor divider only generates two-thirds VDD on the non-inverting input, so the output remains low. As before, swapping the inverting and non-inverting inputs creates the inverting version.

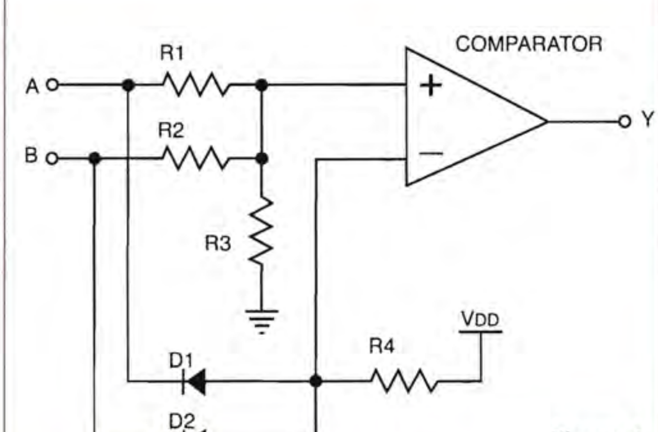



*Figure 4*

## TIP 4: HOW TO USE A COMPARATOR TO BUILD A SET-RESET FLIP-FLOP

A JK flip-flop is beyond the capabilities of a single comparator, but we can make a set-reset flip-flop (see **Figure 5**). All five resistors should be the same value, again typically 1K to 10K for a 5V system. The circuit assumes that both the set and reset inputs are active low, meaning that a zero on the set input sets the output and a zero on the reset clears the output.

The circuit uses positive feedback from the output to the non-inverting input. If both inputs are high and the output is already high, the non-inverting input would be at two-thirds VDD and the inverting input would be at half VDD – holding the output high. With both inputs high and the output already low, the non-inverting input would be at one-third VDD and the inverting input at half VDD, which holds the output low. So, with no inputs, the circuit is stable in either state.

If the output is low and the set input is pulled low, the output will go high. If the output is high and the reset is pulled low, the output will go low. If the output is high and the set input is pulled low, the output will stay high. Finally, if the output is low and the reset input is pulled low, the output will remain low. The only problem will occur when both set and reset inputs are pulled low simultaneously, when the output will be unknown. However, this problem will also be encountered with an SR flip-flop configured from cross-connected NAND gates.

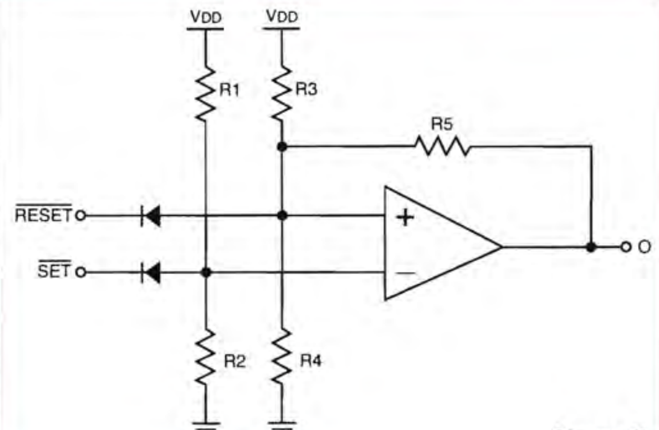



*Figure 5*

# The NP266 and NP366 Series of Slim Kiosk Printers

Printing 220mm/s, the NP266 and NP366 series of thermal printers from Nippon Primex are now available from DED. Developed with flexibility in mind, the NP266 and NP366 series printers are also available in 'slim' configuration models for kiosks where space is at a premium.

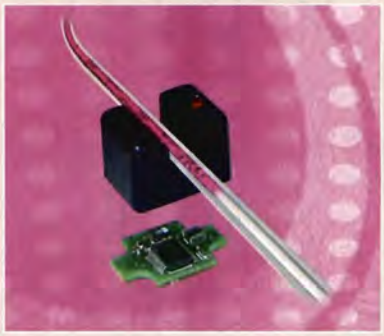
Perfect for printing applications such as information kiosks, fuel pumps, ATMs and parking meters, the NP266 and NP366 series feature drop in and print easy loading paper on widths of 60mm or 80mm, full or partial cutter and paper retraction presenter options.

Starting at just 103.5mm x 97.8mm x 131.3mm for the slim models and 103.5mm x 106.7mm x 161.3mm for the standard models, integration couldn't be simpler with interfaces for USB and RS232C serial and drivers for Windows 2000 and XP.

An optional presenter unit is available which loops and holds the paper until it is completely printed. Only then does it cut and eject it preventing the paper from being pulled whilst still printing.

www.ded.co.uk

# Sensors for Critical Applications



Sensortechnics introduces the AD8/AD9 series of non-invasive ultrasonic fluid monitoring sensors. These highly reliable sensors are ideal for critical applications to detect air or gas bubbles as well as 'end of sample' flowing through small tubing.

The AD8/AD9 series are based on a special pulsed ultrasonic technology which permits highly accurate and repeatable detection with excellent electrical noise immunity.

This non-invasive design, with no contact between the sensor and the fluid, eliminates all media compatibility and sterility issues. Detection can be carried out in a large variety of soft or rigid tubing with diameters from 1.6mm to 25.4mm.

The sensors are very compact and feature an integral programmable microcontroller to allow for custom sensor functionality or specific algorithms. This enables the AD8/AD9 standard sensor to be optimised to meet application specific requirements.

Typical applications can be found in many patient-connected medical devices such as transfusion systems, blood processing equipment, dialysis machines and infusion pumps. The air bubble and air-in-line detectors can also be applied in chromatographs, analytical instruments and dispensing or liquid filling machines.

www.sensortechnics.com

# PolyZen Micro-Assemblies Help Protect DC Power Ports

Now available from Avnet Time is Tyco Raychem's new PolyZen polymer-enhanced, precision Zener diode micro-assembly. Designed to meet the growing need for overcurrent and overvoltage protection on portable equipment that utilises barrel jacks for DC power input, the PolyZen device helps protect sensitive electronics from damage caused by inductive voltage spikes, voltage transients, incorrect power supplies and reverse bias.

The new PolyZen device helps provide coordinated protection with a component that protects like a Zener diode, but is capable of withstanding very high power fault conditions. The PolyZen micro-assembly incorporates a stable Zener diode for precise voltage clamping


and a resistively non-linear, polymer positive temperature coefficient (PPTC) layer that responds to either diode heating or overcurrent events by transitioning from a low to high resistance state.

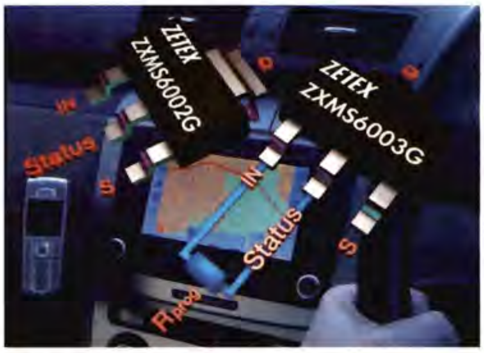
The RoHS-compliant device offers power handling on an order of 100W in a 4mm package and helps provide DC power port protection for portable electronics and systems using barrel jacks for power input, as well as internal overvoltage protection and transient suppression.

www.avnet.com

# Self-Protecting MOSFETs Add Diagnostics

Zetex Semiconductors has introduced the first low side self-protecting MOSFETs in a SOT223 package to provide diagnostic feedback via a separate status pin. The facility aims to further increase the reliability of high-voltage automotive and industrial systems.

The latest additions to the IntelliFET product range, the ZXMS6002G and ZXMS6003G are 60V, 500mΩ rated N-channel devices, particularly well suited to switching loads subject to high in-rush currents, such as lamps, motors and solenoids.




Providing protection against over-temperature, overcurrent and overvoltage fault conditions, the ZXMS6002G provides analogue indication of normal, current limiting and thermal shutdown modes without the need for additional external components. The availability of such diagnostics enables the development of intelligent automatic fault responses.

The ZXMS6002/3 devices have been specifically designed to be tolerant of 60V load-dump transients in automotive applications and unprotected 28V rail transients in industrial systems. Both can be driven directly from 5V microcontroller outputs.

Pricing is $0.667 for the ZXMS6002G and $0.75 for the ZXMS6003G in 1000 piece quantities.

**www.zetex.com**

# Low-Cost Spartan-DSP Series


Xilinx introduced the low-cost Spartan-DSP series with development boards and enhanced design software and establishing a new price-performance-power triad for digital signal processing (DSP). The new series provides high DSP performance at the lowest cost points in the industry, delivering over 20GMACS for under $30, while consuming up to 50% less dynamic power than other high-performance reconfigurable devices for DSP functions at this performance point.

The Spartan-3A DSP platform features the 3SD3400A device delivering over 30GMACS and 2200Gbps memory bandwidth and the 3SD1800A device with over 20GMACS and 1500Gbps memory. At the architecture is the new cost-optimised XtremeDSP slice (DSP48A) that enables designers to implement many independent arithmetic functions. The architecture also supports connecting multiple DSP48A slices to form wide math functions, DSP filters and complex arithmetic functions without the use of general logic fabric, thereby reducing power consumption while delivering very high performance and efficient silicon utilisation. The new DSP48A slice reduces power in common FIR filters by 50% compared to other high-performance reconfigurable devices.

**www.xilinx.com**

# JAE Industrial PC Card and Express Card Connectors

Two new connectors from JAE, supporting PC Card and Express Card formats, suitable for use in harsh environments are now available from Rutronik.

The new connectors allow users to transfer open-standard removable media conveniently between industrial or ruggedised PCs and office IT equipment. The PX20 and PX10 connectors are the latest additions to JAE's robust connector range supporting the latest desktop standards for industrial and embedded PC applications.

Available PX20 configurations include a combined PC Card and Express Card two-slot connector, as well as a single-slot PC Card connector, all with button-eject mechanisms. The products are available at Rutronik now.

Rutronik Elektronische Bauelemente GmbH is a European broadline distributor for semiconductors, passive and electromechanical components in addition to wireless products, displays as well as embedded boards. To round off the product portfolio, Rutronik also offers storage technologies from its subsidiary company Discomp.

**www.rutronik.com**

# LF RF IDIC with Unique ID and Read/Write Performance

Atmel announced the availability of the ATA5577 330-bit read/write transponder IDIC. The device features a unique ID and extended read/write distance and has been optimised for next-generation access control applications including hotel rooms, engineering departments, offices, time recording systems, parking lots and customer loyalty and membership cards.

Since the ATA5577 is a low frequency (LF) device, it can be used worldwide. It is not sensitive to rugged environments and can also be used under conditions that normally complicate the application of RFID devices such as water, metal or dirt, out-of-sight, or being worn on the body. The transponder IC supports different modulations and codings and is designed for passive identification systems with a 100 to 150kHz magnetic field.


The ATA5577 measures approximately 1.1mm$^2$, including the optional trimmed 330pF on-chip capacitors, which reduce the number of external components required.

The IDIC provides a manufacturer-programmed unique ID which is vital to guaranteeing access to secured areas. The unique ID also enables the traceability of the product, thus preventing easy cloning or counterfeiting of the tag IC.
**www.atmel.com**

# Broadband Version of Intermodulation Analyser

Summitek Instruments has upgraded the hardware design of its PIM analysers to provide added flexibility for broadband testing of RF components used in the high power path of basestations. The new architecture is comprised of three major building blocks: RF module for frequency generation and signal reception; power amplifier module for generating the required high-power signals and for power detection and control; and a front-end module for combining the two high power signals onto a single RF path and duplexing the transmit and receive signals to achieve the required PIM test capability.

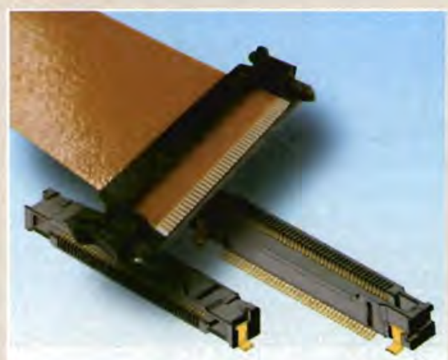
The Summitek PIM analysers are available for every major wireless band worldwide from 150MHz to 3600MHz. The analysers achieve a –168Bc PIM noise floor at 43dBm carrier powers for most of the available frequency ranges. Summitek Instruments also offers a complete line of spectrum monitoring and interference mitigation tools for wireless providers and spectrum users alike with its Oasis family of products. The Spartan Automated Test and Data Management solution provides manufacturers of RF components an automated test solution to reduce costs, improve operational efficiencies and create a positive impact on their bottom line.
**www.summitekinstruments.com**

# High-Speed Connectors from Yamaichi

Yamaichi Electronics presents a new generation of high-speed connectors and cables for data transmission rates of up to 5Gbps. Internal connections according to LVDS data transmission standard, HDMI, DVI, PCI-Express or S-ATA standard can be realised with this new connector system.

Like the proven HF503 series (for data transmission rates of up to 1.1Gbps), the new HF507 series is also an integrated connector and FPC cable concept. The FPC cable uses LCP insulation material and is based on the established YFLEX technology from Yamaichi thus guaranteeing excellent high speed data transmission characteristics. Elaborate and cost-intensive cable assembly is no longer required – the high speed cable is delivered customised, pre-assembled and 100% tested.

A secure connection between connector and cable is ensured using a side-lock mechanism. The SMT connectors are designed for reflow soldering and pick-and-place mounting from the tape and reel packaging. They are also suitable for EMI sensitive environments, available with an additional metal shield.



HF507 is a new addition to Yamaichi's product families for high speed applications. HF503 offers transmission speeds of up to 1.1Gbps, 32, 38 and 60 pol/0.5mm pitch, and HF507 up to 5Gbps 21, 31, 41 and 51 pol/0.5mm pitch.
**www.yamaichi.eu**

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| ENI 2100L 10kHz-12MHz 100W Power Amplifier | 5250 | 210 |
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| Tek TDS3054/3FFT/3TRG/3GM 4 Ch 500MHz 5GS/s Scope | 4500 | 135 |
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| Kikusui PCR500L 500VA Voltage/Frequency Converter | 2350 | 71 |
| Kikusui PLZ-300W 300W Electronic Load | 995 | 35 |
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