Volume 116 • Issue 1895
November 2010 • £4.60

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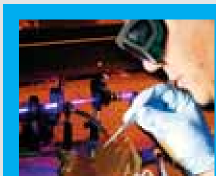

TECHNOLOGY NEW PIEZOTRONIC DEVICES MAKE AN ENTRANCE

ELECTRONICA 2010 COUNTDOWN TO THE LARGEST TRADE FAIR CONTINUES

PRODUCTS NEW SENSORS, CONNECTORS THERMISTORS

ALSO IN THIS ISSUE: THE TROUBLE WITH RF.... • AUDIO COLUMN • DESIGN

REGULARS

FEATURES

Cover supplied by TEXAS INSTRUMENTS
More about enabling power supplies for portable applications on pages 12 and 13

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


QUASAR electronics
Quasar Electronics Limited
PO Box 6935, Bishops Stortford
CM23 4WP, United Kingdom
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E-mail: sales@quasarelectronics.com
Web: www.quasarelectronics.com
All prices INCLUDE 17.5% VAT.
Postage & Packing Options (Up to 1Kg gross weight): UK Standard 3-7 Day Delivery - £4.95; UK Mainland Next Day Delivery - £11.95; Europe (EU) - £10.95; Rest of World - £12.95 (up to 0.5Kg).
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SOLVING THE MOBILE NETWORK SIGNALLING OVERLOAD

What this piece states is that mobile networks are experiencing signal traffic overloads created by increased use of smartphone type devices

BY JOSH ADELSON

Earlier this year, Cisco Systems predicted that mobile data traffic would double annually until 2014 at a compound annual growth rate of 108%. Greater distribution of smartphones such as iPhone, Android and Blackberry devices, increases the use of 'continuously on' content and data applications and, therefore, the level of network usage. As sales of smartphones and the number and the range of dedicated smartphone 'Apps' increase, their use will accelerate the growth of traffic far more than the mobile industry had anticipated. It has been widely acknowledged that the rapidly increasing data traffic is placing an increasing load on mobile networks, risking network overload during peak traffic periods, but the increase in signalling traffic has not received the same level of attention. In this context, signalling refers to the small messages that control call connections and other network functions.

Mobile operators that plan network capacity expansion to maintain sufficient network data quality generally consider the total and peak volumes of network traffic in their calculations. The messaging 'overhead' involved in signalling may appear trivial in these capacity load calculations. When compared to voice, or data content, signalling generates relatively few bits. Signalling performs the functions of initiating and terminating a connection, maintaining a connection while users move from cell to cell, and capturing user and session data for back-end BSS/OSS systems.

However, push-based smartphone applications like Twitter, Facebook, email and foursquare constantly poll the network for updates and remain running even when not actively in use. Whether or not a smartphone is in use is immaterial, the fact that it is 'left on' while travelling means that it constantly generates roaming signals. Analysis of signalling activity on a network revealed that for a given volume of data transmitted, one smartphone typically generates eight times the network-signalling load of a USB modem-equipped laptop. This has the potential to create a bottleneck in the signal-processing elements of the network such as radio network controllers (RNCs), which in turn can affect network performance, even if there is sufficient raw bandwidth available to handle the data volumes.

The discovery of the 'network load multiplier' was a result of an ongoing study of the capacity load of macro-cellular mobile broadband infrastructure to identify the sources of capacity bottlenecks. Monitoring initially focused only on networks' data throughput, extending also to signalling traffic as the smartphones grew in popularity. The study compared data use profiles for given volumes of transmitted data. The multiplier calculation refers to the fact that laptop users download a higher proportion of data in a single session, but smartphones generate considerably more signalling traffic for 'bite size' chunks of data on a continual basis.

This 'load multiplier effect' will only increase as more and more consumers continue to adopt smartphones and now tablet devices. The latest figures from Gartner suggest that smartphones sales are booming, with over 325.6 million handsets sold in the second quarter of the current financial year. A recent report by Morgan Stanley anticipates that smartphones will outsell PCs by 2012.

Mobile operators are deploying a new generation of RNC platforms that scale to as much as 10 times greater capacity than previous generations, to address the growth in signalling traffic. With high performance hardware architectures and faster processors, these new RNCs dramatically improve the capacity and performance of a macro-cellular network.

Updated network infrastructure, however, is only one tool to address the smartphone signalling explosion. Femtocells, perhaps best known for their ability to provide indoor mobile phone coverage, can also play a valuable role in addressing signalling overload because they divert mobile traffic from the radio access network altogether. According to Informa Telecoms and Media, approximately 80% of mobile data traffic originates indoors so it makes a lot of sense to offload the traffic to a high capacity fixed network at that point.

New-generation, high-performance RNCs, combined with femtocell technology applied to localised concentrations of heavy data users, provide a cost-effective strategy to relieve network signalling congestion arising from the increasing use of smartphones.

Josh Adelson, Director of Product Marketing, Airvana

> **"SMARTPHONE SIGNALLING GENERATES EIGHT TIMES MORE TRAFFIC THAN USB DONGLES"**

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SUBSCRIPTIONS:
Saint John Patrick Publishers
PO Box 6009, Thatcham,
Berkshire, RG19 4QB
Tel: 01635 879361 Fax: 01635 868594
Email: electronicsworld@circdata.com
SUBSCRIPTION RATES:
1 year: £46 (UK); £67.50 (worldwide)

MISSING ISSUES:
Email: electronicsworld@circdata.com
NEWSTRADE:
Distributed by Seymour Distribution Ltd,
2 East Poultry Avenue, London, EC1A 9PT
Tel: +44 (0) 20 7429 4000
PRINTER: William Gibbons Ltd
ISSN: 1365-4675

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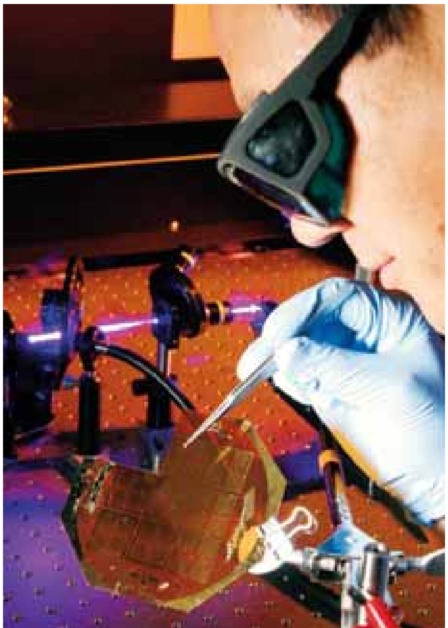
New Type of Logic Device Uses Piezoelectric Effect



Georgia Institute of Technology researcher works on piezotronic type logic devices

Researchers at the Georgia Institute of Technology have developed a new class of electronic logic device in which current is switched by an electric field generated by the application of mechanical strain to zinc oxide nanowires.

In traditional field-effect transistors (FETs), electrical field 'switches' the flow of electrical current through a semiconductor. Instead of using an electrical signal, the new logic devices create the switching field by mechanically deforming zinc oxide nanowires. The deformation creates strain in the nanowires, generating an electric field through the piezoelectric effect, which creates electrical charge in certain crystalline materials when they are subjected to mechanical strain.

"When we apply a strain to a nanowire placed across two metal electrodes, we create a field, which is strong enough to serve as the gating voltage," said Zhong Lin Wang, a Regents professor in the Georgia Tech School of Materials Science and Engineering. "This type of device would allow mechanical action to be interfaced with electronics, and could be the basis for a new form of logic device that uses the piezoelectric potential in place of a gate voltage."

Wang calls this new class of nanometer-scale device "piezotronics", as they use piezoelectric potential to tune and gate the charge transport process in semiconductors. The devices rely on the unique properties of zinc oxide nanostructures, which are both semiconducting and piezoelectric.

"The family of devices we have developed can be joined together to create self-powered, autonomous and intelligent nanoscale systems," said Wang. "We can create complex systems totally based on zinc oxide nanowires that have memory, processing and sensing capabilities, powered by electrical energy scavenged from the environment."

Using strain-gated transistors fabricated on a flexible polymer substrate, the researchers have demonstrated basic logic operations, including NOR, XOR and NAND gates and multiplexer/demultiplexer functions, by simply applying different types of strain to the zinc oxide nanowires. They have also created an inverter by placing strain-gated transistors on both sides of a flexible substrate.

A student at the University of Sheffield's clean room inspecting a semiconductor device

£10M BOOST FOR THE UNIVERSITY OF SHEFFIELD

A cutting-edge University of Sheffield research facility, which studies advances in semiconductors used for the Internet, solar cells, DVD players and gas detection systems, has received a £10m boost over a 5-year period.

The funds will be used to support research in III-V semiconductor materials and devices, which play a fundamental role in many types of applications, including fibre optics, communications, consumer electronics, security and solar cells among others.

"We are extremely pleased to receive this investment which will enable us to continue our long tradition of enabling very high quality UK academic research in this field. Much of the research will result in improvements in quality of life for everyone in the future," said Professor Peter Houston, Director of the EPSRC National Centre for III-V Technologies at the University of Sheffield's Department of Electronic and Electrical Engineering.

Research into these semiconductors has been taking place at the University's facility for 32 years, where current applied projects include studies of solar cells in conjunction with QuantaSol, a spin-out company from the Imperial College of London and the University of Sheffield.

KaiSemi Offers FPGA-to-ASIC Replacement with a "Zero NRE" Model

A breakthrough in automated FPGA-to-ASIC conversion allows fabless semiconductor company KaiSemi from Israel to provide customers with a seamless full turnkey ASIC solution, selling fully compatible replacement chips.

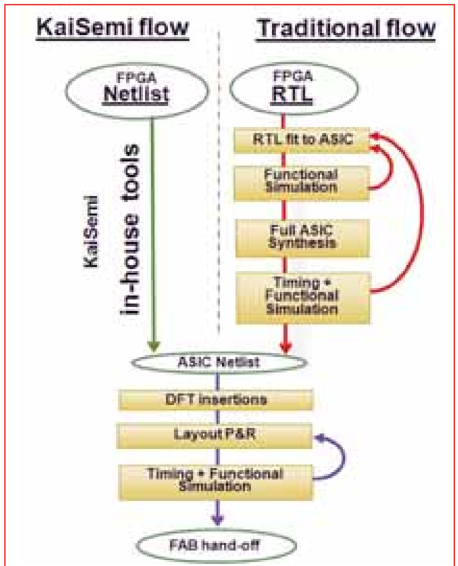
KaiSemi's proven process uses a unique in-house tool, which performs an automated conversion directly from the original FPGA netlist into a functionally-identical ASIC gate-level netlist.

KaiSemi's automated conversion utilizes a database of multiple proven standard-cell fab process libraries. The wide range of libraries enables the conversion of any type and size of FPGA from any FPGA vendor to ASIC. This approach is accompanied by cost optimization during the automated conversion and allows the use of third party standard hard cores, such as DDR interface, PCIe Phy, etc. The resulting ASICs – which are pin-compatible, timing-compatible and functionally-identical to the original FPGAs – consume less power and cost up to 70% less than their FPGA counterparts.

KaiSemi's executives claim the automated conversion and flow eliminates the need for customer involvement and resources, NRE costs, long lead times and the risks that are part of traditional FPGA-to-ASIC conversion flows. KaiSemi manages the whole FPGA-to-ASIC process for the customer, from the purchase order through conversion, the ASIC flow, manufacturing, all the way through to the shipment of the ASIC chips. This seamless conversion process – combined with the Zero NRE model – lets the customer order an ASIC chip as if it were an off-the-shelf second-source replacement chip with a relatively short lead-time.

"KaiSemi is focused on automating the process of converting any FPGA into an ASIC replacement chip while achieving the best cost solution in terms of price, power, area optimization and the most appropriate fab process," said Gal Gilat, KaiSemi CEO. "Using a proven automated conversion tool with no RTL touch means we can offer a fully functional guarantee; we will provide a functionally-identical chip at a dramatically lower price within a significantly shorter lead time."

KaiSemi's FPGA-to-ASIC conversion offering is complemented by additional capabilities. For example, the company can convert multiple FPGAs into a single ASIC die. KaiSemi can also add peripheral die (such as memory) stacked with the FPGA replacement die in a single package. KaiSemi also handles ASIC-to-ASIC conversions, mainly for End-of-Life purposes. Additional offerings include migrating DSP algorithms to ASIC implementations via FPGA evaluations and prototypes.



Difference between KaiSemi's flow and the traditional approach

Iwasaki Electric and Teijin Limited have jointly developed a completely plastic LED lamp based on a high thermal conductivity resin. The new lamp, named LED EYELAMP, will be released by the end of this year as the world's first LED lamp for outdoor illumination that uses plastic for the entire housing except for the bayonet cap.

It weighs only 300 grams and with only a tenth of the power consumption of a conventional mercury-vapour lamp. It is brighter and lasts 40,000 hours, seven times longer than a conventional lamp.

De Montfort University is undertaking groundbreaking research into the analysis of electroacoustic music. Electroacoustic music is composed and performed using electronic technology and composers work directly with sound, either performed, recorded or synthesised and rarely uses traditional music notation.

The three year research project will develop an analysis software package and create new, as well as collating existing, analytical work in order to facilitate systematic evaluation.

The Wireless Power Consortium launched the Qi 1.0 standard which enables consumer electronic brands and device manufacturers to bring interoperable wireless inductive charging devices to market. The Consortium also announced today the first products certified with Qi.

Qi ensures interoperability between Qi devices from different companies to power and charge on any Qi charging station. The Consortium views interoperability as a key growth driver for the wireless charging market. There are over 55 Consortium members.

Lead time

Myk Dormer

HOW LONG DOES it actually take to get a product delivered? In our ideal world the desired item is always in stock, on the shelf and the only delay is in the shipping.

In the low power wireless sector, however, this is far from the truth. The delivery times for radio modules are long and seem to be getting longer. What has gone wrong?

As with almost every downward trend recently, the root cause is the recession, accompanied with what seems to be a general shortage of basic components. The poor economic climate makes holding stock, either of the finished units or components, unacceptably costly, which then causes build-to-order delays in staff-depleted, run-down factories attempting to buy parts on extended lead-times.

Identifying the issue is, however, easy. The salient question is, as ever: "What can we, as engineers, do about this?" I have some suggestions:

- Identify "critical" components, which are hard to find equivalents to, and which will adversely affect multiple product lines if they run short. Strongly advocate that extra stocks of these parts at least be maintained.
- Carefully examine your designs, looking for areas of circuitry where part parameters are non-critical, and re-specify these components as 'generic' devices, relating to a (long) list of alternatives. Unless the circuitry is doing something very clever, one NPN switching transistor is much like any other.
- Take time to talk to purchasing and production, so they will be more likely to share their concerns about any given supply issue before it gets to the 'official meeting' point.
- Widen component tolerances where you can. A pull-up resistor doesn't need to be a 1% part. It doesn't even need to be 10%. In many cases, a range of alternative values can be permitted. Much the same is true of decoupling capacitors.
- Remember that better performance parts can usually replace lower spec ones. A quarter watt resistor can be replaced by a half watt part, and a 50V capacitor will function where 25V was specified, assuming physical dimensions permit.

"ALWAYS REMEMBER THAT EVEN THE WELL-KNOWN CATALOGUE SUPPLIERS MAY UNEXPECTEDLY HAVE USEFUL STOCK OF A STRATEGIC COMPONENT"

- Go over the stock database or listings and look for parts which aren't being used; most stores have surplus parts, no-longer needed, rarely used, or bought in error. Find places where these parts can be used up, so stocks of the 'right' parts go further in those designs where they must be used.
- Help the purchasing clerk. When a part is running short and short lead-time supplies cannot be found, take a look yourself. You may have contacts (often from years past) that the purchasing departments do not, or you may be able to identify near (and acceptable) equivalents that they wouldn't know about.
- Don't ignore unexpected suppliers. Most companies have a few favorite distributors or suppliers. When they fail, panic frequently ensues. Always remember that even the well-known catalogue suppliers may unexpectedly have useful stock of a strategic component.

When working on new designs, even more can be done to alleviate component sourcing problems, if some subtle changes are made to the initial design:

- Identify critical parts as early as possible in the design process and be prepared to take a risk, by ordering stocks – or scheduling orders – early. This can, I understand, backfire at a very individual level. So can any design decision.
- Take the 'generic parts' idea further and specify a range of alternatives for all possible parts, right at the start.
- If unit size isn't an overwhelming issue and PCB area is available, then when you have identified a 'critical' part, allow for several different package types to increase the range of alternatives.
- When a particular section of a design is obviously dependent on the availability of one crucial part, take time out to at least consider alternative approaches. Then, if supplies fail, you will be further along the corrective redesign route. If you are lucky enough to be working on a modular product, consider preparing several different module designs, even if only one is fully realise.

Do not get carried away. In all this, it is still very important not to lose sight of the basic need for reliability. Make sure that every alternative is properly tested and that the implications of each change are properly considered. If a replacement part degrades a performance parameter, make sure that a customer isn't depending on it. Always err on the side of safety.

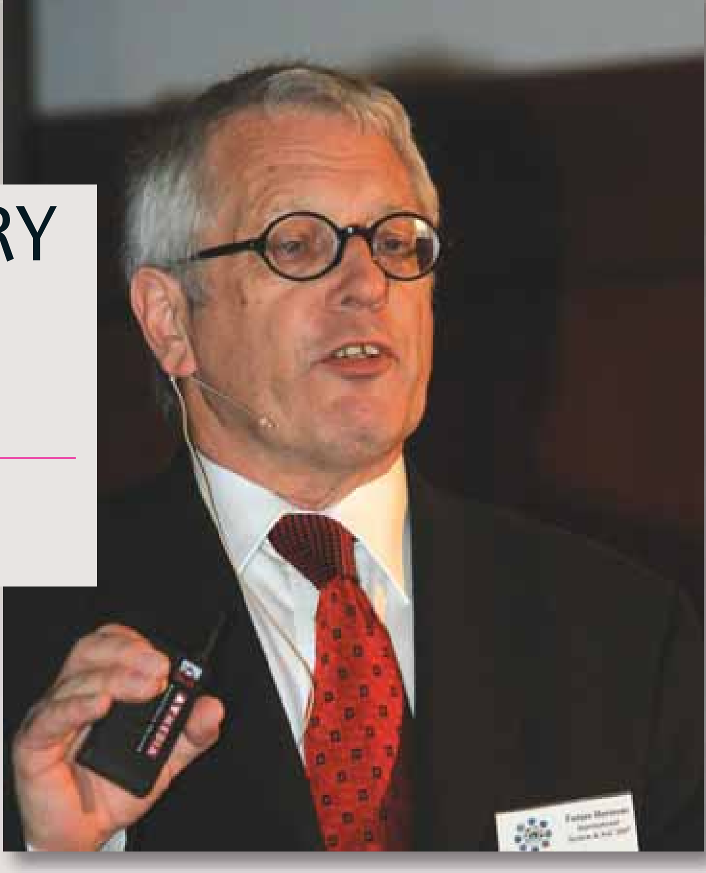
Sometimes, no matter what you do, supply will fail and a delivery will be delayed. Be honest with the customer. Suggest alternative products, even if made by a competitor, and keep them up to date with what is going on.

Who knows, they might have the part you need in their stores? ■

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

THE BROKEN INDUSTRY MODEL – BACK TO BUSINESS BASICS?

Malcolm Penn is CEO and chairman of market analyst firm Future Horizons, based in the UK



THE SEMICONDUCTOR LANDSCAPE has witnessed a sea change since the mid-1980s with an explosion in the number of fabless semiconductor firms and a (not unrelated) massive disaggregation of the traditional electronics food chain. In parallel, the global financial community has morphed from investor to trader, with the emphasis on short-term deals not long-term potential.

The first phenomenon was triggered by the founding of TSMC in 1987 as the world's first independent semiconductor wafer foundry, initially allowing firms to get to market much faster (by not having to wait the two years it took to build the fab), quickly followed by the realisation that no fab meant a significantly lower financial barrier to entry.

The second phenomenon was triggered by the advent of the electronic trading desk. Out went parochialism and long martini-fuelled lunches at the club; in came the dealing and cut-throat competitive ethos that overnight transformed the finance community's role.

Both phenomena were enabled and subsequently underpinned by ever cheaper, ever more powerful computers, which for the fabless firms brought IC design from the main frame to the desktop and for the investment community allowed transactions to be turned at picosecond speed.

Their combined infrastructure impact has been equally profound. The rise of the foundry delayed chip industry consolidation, encouraging lots of new players to enter the market. It also dramatically transformed the investment and cash flow dynamics, setting off a rethink on how OEMs built their products. If a foundry (i.e. sub-contractor) could be entrusted to build wafers for a chip firm, allowing the chip firm to focus on design, why can't a third-party (i.e. sub-contract equipment manufacturer) make the OEM's boxes, equally releasing them too from the factory investment handcuffs to focus on design?

With the traditional vertical integration model already discredited, the birth of the Contract Equipment Manufacturer was both logical and a marriage made in heaven. Needless to say the financial community and management loved it; overnight the cash that would have been spent on new fabs and factories would now be available for shareholders and investors. 'Something For Nothing' became the byword for success.

"ALL OF THE FACTORS POINT TO A BROKEN CHIP MARKET BUSINESS MODEL; IT'S TIME FOR A MAJOR RETHINK ON HOW BUSINESS IS DONE AND FINANCED"

Unfortunately, if something seems too good to be true, it usually always is, with the result that the now-evolved industry business models are starting to strain. The net result is what looks like a broken business model. Once sound business practices, discarded as old-fashioned or Neolithic are suddenly looking attractive; some of the evolved new models have a whiff of 'Emperor's new clothes'.

One clear example of this is the current 450mm wafer Mexican standoff. On the one hand Intel, TSMC and Samsung (i.e. the demand side) are pushing, whilst on the other hand the equipment industry players, led by SEMI (the supply side) are categorically saying 'No'.

Yet consortia around the world are blindly carrying on solving the technical and manufacturing problems, often with an element of government support or funding, despite the fact there is absolutely no path to market. Worse still, there is only a very clear path to non-market.

The bottom line? Nothing for nothing. Under the disaggregated model, the demand side expects the supply side to develop the equipment and technology entirely at their own cost and risk, with no time scale for orders or even a commitment to buy. Needless to say, the supply side, having suffered a three sales year famine and rapidly shrinking customer-base, is not willing to oblige. Yet the R&D muddles on presumably on the premise "It'll be alright on the night".

The OEM manufacturing model is also equally showing signs of strain. Now hugely disaggregated and batch production oriented, consider the following supply chain hypothetical reality.

OEM company 'A' places module/box order on CEM company 'B', who in turn places component order on chip company 'C'. Chip company 'C' places wafer requirements order on foundry company 'D'. The nominal lead-time from wafer start to module/box delivery? Four to six months, with few, if any, points for inventory buffers en route. Yet Company A runs a 'Just-In Time' procurement system, where 'just in time' means hours not months.

What if Foundry 'D' suddenly cannot supply chip company 'C' with enough ICs, who in turn is then forced to allocate what production is available, meaning CEM firm 'B' receives only part of his delivery, forcing him to allocate his available production across its customer base? OEM Company 'A' suffers a shortfall in supply, at best a missed quarterly sales target, at worst a full line stoppage.

With all points in the supply chain having fully leveraged their inventory and WIP, supply chain management, visibility (and risk) is significantly much higher than it was when done in house. Popular wisdom defaults to the position because the chain is more efficient 'What if' does not happen. Yet no one is responsible for overseeing the whole process; everyone simply hands off to the next link.

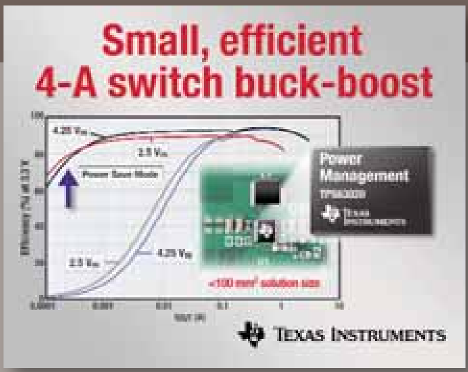
As Nissan recently found to its cost, 'What If'' did happen and the fact it stopped several factories demonstrates no one saw it coming. This is hardly surprising; there is no ball to keep an eye on any more. Just as the financial folks sliced and diced debt to the point no one knew who owed how much to whom, so too has the supply chain become so obfuscated it is now virtually impossible to track an OEM product back to a wafer.

Even the fabless sector is showing signs of systemic strain with the number of new start-ups falling as design costs, once low, replace the fab cost as the barrier to market. With the time (and cost) to exit now high and the traditional IPO exit route at least temporarily denied, the once freely available cash for financing semiconductor innovation has become much harder to find.

All of these factors point to a broken chip market business model; it's time for a major rethink on how business is done and financed. Industry currently talks the talk about "co-operation and the importance of customer-supplier relationships", but real commitment turns shallow when the out-sourcing risk-based business models come up front and centre. Industry must now learn how to walk to walk, not talk. ■

Malcolm Penn can be contacted at mail@futurehorizons.com. Future Horizon's website can be found at www.futurehorizons.com

Power supplies for portable applications – New challenges, new solutions



Carmen Gonzalez
Product Marketing Manager, Low Power DC/DC Converters
TEXAS INSTRUMENTS

Today's world is more 'portable' and interconnected than ever. You can take virtually anything you want with you, from your favourite songs or movies, to your social network! Portable equipment is transitioning from the 'nice to have' to the 'must have' category. New portable medical equipment like ultrasound systems or cardiovascular echographs, have progressed from in-built systems in the intensive care unit to small units that are easy to carry around the hospital and outside.

Portability implies smaller, which has market acceptance in smartphones and other consumer electronic devices. Extra features must be squeezed onto the existing board, making an optimized power supply essential. These new extra features are usually power hungry. Integral camera flash lights, torch light functionality, bigger displays all consume large amounts of energy from a limited energy source, typically a battery, or new alternative sources like solar cells,. Consequently, power management designers are obliged to pay great attention to the efficient use of available energy and how the application works.

The choice of batteries is diverse: Li-Ion, NiCd, NiMH, or alkalines to mention the most common. They are based on different chemistries, which translate into different amounts of energy. What chemistry we use, and whether the batteries are rechargeable will be dictated by the system requirements.

The chemistry also determines the discharge profile of the battery, giving the designer a starting point in understanding how much energy is available at a given time.

Figure 1 shows the discharge profile for a Li-Ion battery, dual Alkaline and dual NiMH based on a constant power discharge.

In general, regardless of the chemistry, for system voltages between 1.8V and 3.3V, which are the most common power rails, the input voltage can be above and below the desired output voltage.

This variation in the input voltage will affect directly the input of the power converter, which will have to cope with this delta. The system must, therefore, be capable of both buck (step-down) and boost (step-up) conversion. A topology only able to step down will regulate the output only as long as the input voltage is higher than the output voltage. However, we can see in the graphs

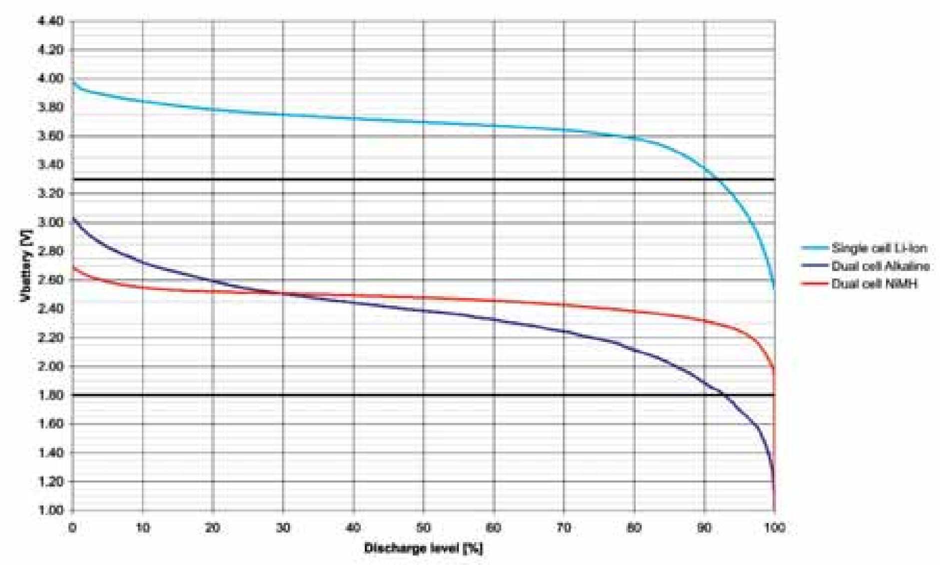


Figure 1: *The discharge profile for a Li-Ion battery, dual Alkaline and dual NiMH based on a constant power discharge*

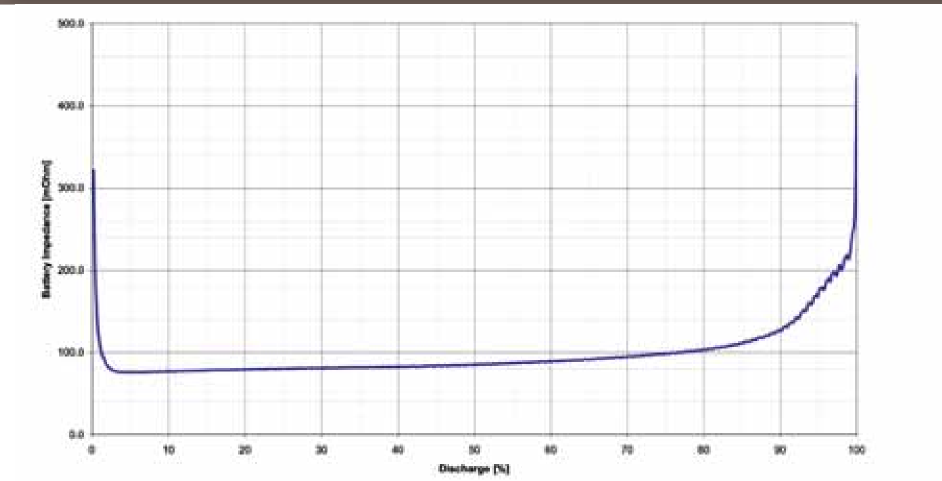


Figure 2: *Li-Ion Battery impedance variation*

that to get the best from the battery, we should also have the capability to step up. The most efficient solution with this profile is the buck – boost topology. The nature of buck-boost converters, which can keep a regulated output regardless of how the input voltage behaves, makes them the most suitable topology for such applications. This behaviour allows the flexible use of different battery types, maximizing the battery life with high levels of efficiency across the load range.

One particular limitation batteries have is to deliver the required power when they are close to being discharged. Looking at figure 2 we can see how the impedance of a Li-Ion battery evolves as it discharges:

We can see that the impedance increases considerably towards the end of the discharge cycle. This graph does not include any impedance caused by a possible battery switch, protection circuit, if required, the battery connectors and the battery connection to the power management circuit, which would need to be added. Under the conditions shown in figure 2, for a given amount of current being delivered, the voltage at the terminals of the battery decreases. If a higher amount of current is drawn, the voltage at the terminals of the battery would be reduced, with the risk of collapsing if the current surge is too high. For example, a phone receives a call while taking a picture with a camera flash light active.

When the voltage at the terminals of the battery is reduced, so will be the input voltage of the DC to DC converter that is connected directly to the battery. Under normal circumstances, where the battery has enough energy to deliver, the DC to DC converter can cope with the change in input voltage by increasing the input current. The output voltage is fixed and determined by the application. However, when the battery is at low levels of charge, increasing the input current will not translate into higher levels of power being delivered.

To solve these challenges, monitoring circuits can be implemented to decide which section of the circuit to disable depending on available battery power. One example is switching off the communications modem (GSM or WCDMA) in smartphones when the battery is low to make sure we maximize the power available for other less demanding applications, like picture viewing or playing music. Another approach would be to have a dynamically controlled input current implemented in the DC to DC converter. This control would determine when lower input current is required to avoid a big voltage droop at the battery terminals. Having a smooth control over the input current prevents the DC to DC converter from switching off and on if an under-voltage lockout happens due to a sporadic current surge. If there is truly not enough energy available anymore to provide the required output power, the DC to DC converter will go smoothly into under-voltage lockout, switching off without a banging effect. Controlling the input current in such a way, also allows the converter to have the output voltage regulated and the power rail alive for the longest time.

A device supporting this design strategy is the TPS63020. This built-in capability allows for a more stable system, as the battery will be smoothly used throughout the complete load until the end time of the discharge period.

Fig 3 shows the results of a set up where the TPS63020 evaluation board has been pushed into input current limit operation. The TPS63020 has been supplied with a 1.5Ohm resistance power source and a small motor as load, typically drawing 1A current at 3.3V operating voltage. The purple curve shows the 3.3V input voltage as the motor starts. Once the device is enabled (green curve) it suffers a drop in the input voltage, down to approximately 2V. To avoid a further input voltage drop, the TPS63020 limits the input current to 750mA. By the law of energy conservation, we will not be able to deliver the power required at the output. The output voltage (pink curve) settles at about 1.5V. In this case, not having enough output power would mean a slower rotation of the motor, but the system powered from the same rail, (microcontroller, display, etc.) could still be operational.

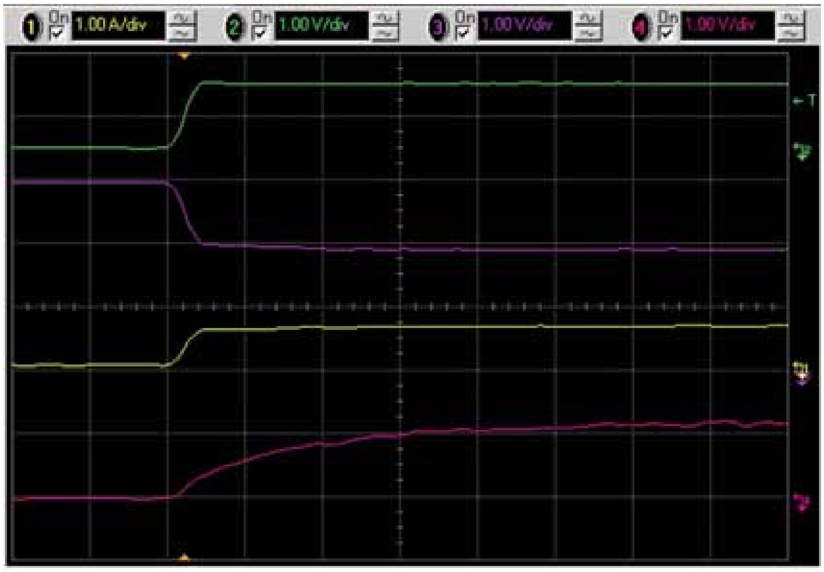


Figure 3: *TPS63020 behaviour*

The implementation of a smart Power Good feature improves communication between the TPS63020 and the load, providing notification as soon as the device triggers the input current limit, and there is a risk of losing the programmed output voltage. The smart Power Good, together with an optimized output capacitor, maximizes the time the programmed output voltage is regulated and minimizes communication time with the loads to take appropriate action (ex. data storage before shutting down)

Although portable applications design is becoming more challenging as new features are added, size constraints become harder and battery energy needs to be shared, new ICs like TPS63020, with innovative features like dynamic input current limit and smart Power Good ease the process.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REGENERATION – CAPTURING ENERGY BEFORE IT IS LOST

MOTOR MANUFACTURERS have been challenged in today's low carbon environment to target one of the holy grails of the motoring community – energy efficiency. Two significant approaches have found their way into mainstream motoring: automated stopping of the engine when idling at traffic lights, and conserving the energy generated in braking to optimise the fuel usage and reduce carbon emissions. In fact, the second approach even found its way into Formula 1 motor racing as a way to get a performance boost.

Until a few years ago, when drivers stopped at traffic lights or a level crossing, they simply left their engines running. But now there are many campaigns to encourage switching off; in California it's already a legal requirement for commercial vehicles. But restarting an engine, even a warm one, requires an extra squirt of fuel, leading to extra CO2 and NOX, so regenerative technologies are being used to capture braking energy that was previously dissipated through hot brake discs and provide a carbon neutral kick-start when the lights go green. A number of car manufacturers have automated this approach bringing clear energy reductions.

Historically in industry, an electric motor was started and left running throughout the shift. There was often a good reason for this as starting motors usually took a huge energy inrush until it got moving and built up its own resistance. This power inrush could be up to 12 times the working current of the motor and, therefore, motors are usually rated with a number of direct starts allowed per hour.

Leaving the motor running seemed quite a realistic approach. However, fitting a motor with an inverter offers a much softer starting regime and is far less restricted in terms of available starts. This really opens up the opportunity to only run the motor during operational requirements and to save significant energy by switching the motor on and off.

An inverter drive offers even more energy "bang for its buck" by optimising energy used in the electric motor whatever the load and, also, by running the process at lower speeds which can save significant energy and as such costs. The best savings can normally be made when running a fan or pump, as a slight reduction in speed can really impact the power consumption.

Maybe this isn't a realistic goal of Formula 1, and wouldn't attract much of an audience, but it is well known that a smooth driver uses far less petrol than a boy racer. Uncharacteristically, Jeremy Clarkson and his Top Gear colleagues demonstrated this some time ago by driving large cars from Paris to Liverpool on a single tank of petrol. By maintaining a steady, moderate speed, avoiding stop/start driving, rapid acceleration and hard braking, fuel consumption was kept in the optimum range and the total mileage proved to be way beyond what is normally achieved.

> "THERE ARE MANY MECHANICAL WAYS TO COLLECT SOME OF THIS ENERGY BUT MOST OF THEM ARE FAIRLY CRUDE AND ONLY PARTIALLY EFFECTIVE"

The savings gained by using inverters in real terms are both financial, affecting a business's bottom line and ecological in the

Jeff Whiting of Mitsubishi Electric looks how Inverter Drive technology, in the form of the regenerative drive, answers real issues in industrial environments and demonstrates a number of other operational benefits

reduction of CO_2 used. In fact, it has been calculated that the CO_2 savings made by the inverters sold in the UK each year relate to the CO_2 used by 100,000 business cars doing normal mileage.

An inverter doesn't just save energy or allow a process to be optimised for changing loads and requirements. There are many types of industrial processes driven by motors. Some of these applications bring a number of other challenges which are easily addressed by today's high performance inverter drives. Typical of these is where energy in the process overhauls the power of the motor.

To keep the process under control, this energy must be dealt with and, if possible, used to power other parts of the production cycle. This was the principle of the Kinetic Energy Recovery System used for a short period of time in Formula 1 racing, but finding a far more appreciative audience in today's high efficiency and hybrid cars.

Normally, under braking conditions, the weight of the car generates heat in the brake disks. With the latest technology, KERS uses this condition to capture the energy and release it during the driven part of the journey, thereby reducing fuel consumption.

Consider an escalator at a deep London Underground station at rush hour. The 'up' escalator will be working hard to lift maybe a hundred people over a considerable height. The 'down' escalator will be carrying just as many people and it will be creating energy as they descend. In power terms, the motor requires power to be fed into it to drive the loaded escalator upwards, whereas when descending, the motor has a load driving it, making the motor act as a generator.

Under these conditions the power has to be controlled for the passengers need to descend in a safe manner. This is generally done by using an inverter to ensure safe control and a measured stopping function. Without this, an uncontrolled stop could have huge repercussion with people thrown every which way, mainly downwards into a big heap of limbs and bodies. People could be hurt and the legal repercussions could last for years.

To achieve this continuous control under all load situations, an inverter has to shed this extra energy somewhere. There are many mechanical ways to collect some of this energy – counterweights, winding springs, etc – but most of them are fairly crude and only partially effective. As this generated energy is in the form of electricity, it is general to dissipate it in that form.

In the past, vast banks of braking resistors were used to dissipate the electricity into heat. This could become a considerable fire risk anywhere, but doubly so in a dusty, hot underground machine room. However, a specially designed regenerative drive, such as Mitsubishi's Regenerative A701 drive, controls the load under all conditions and sheds the excess power by converting the kinetic energy into electricity and pumping it safely down the mains or even sharing it with other drives by connecting their power reservoirs together.

The energy generated during the lowering stage can be dissipated and lost, or captured and reused. By contrast, a regenerative drive captures all of the energy and feeds it back into supply mains giving welcome savings in electricity bills.

The basic requirements of a soft start-up and stop can be programmed into a regenerative drive quite easily. Throughout a normal day's operation of the escalator, the drive will still be minimising the energy used. As you can imagine, during rush hour the escalators are fully loaded with people rushing to get to and from work, yet for most of the day there will only be a trickle of people using them.

A typical energy strategy would be to operate at full loading with optimum transfer speed to get the rush hour passengers through as quickly as possible, and then to slow the escalators slightly for the rest of the day where the speed requirements are not so prevalent. The use of a reduction in transfer speed will bring an immediate energy gain, which will be further enhanced by the inverter's innate capability to shed excess power when there are fewer people on the escalator.

The next stage in the developing strategy takes its lead from the stop-start strategies beginning to appear in today's high efficiency vehicles. As previously stated, using an inverter means the motor can start and stop the escalator quickly and safely when required. Maximum savings will occur when there are no passenger requirements and the escalator can be stopped. Implementing controls which sense approaching passengers means the inverters can start the escalators and bring them up to speed before a passenger arrives to step onto it.

Industrial electrical engineers have long known of the energy saving benefits of inverters and, although they might not be in a position to teach the likes of Button, Hamilton and Schumacher a thing or two about fast driving, regenerative drives show they know a lot about efficient recovery and use of kinetic energy in the real world. ■

Here COMes the future!

PICMG adopts new specification for COM Express modules. What is new and what does this mean for developers? Gerhard Szczuka, product marketing manager for Computer-on-Modules at Kontron, answers these questions

The Kontron COM Express COM.0 R 2.0 Type 6 ETXexpress-AI with Intel core i5/i7 processor

FIVE YEARS AFTER its debut, the PCI Industrial Computer Manufacturers Group (PICMG) has now released revision 2.0 of the COM Express COM.0 Computer-on-Module standard. COM.0 Rev. 2.0 addresses the new functionalities that Intel, AMD and other manufacturers are integrating in their upcoming processor families.

Rev 2.0 adds two new pin-outs that make space for possible future technologies by dropping a number of interfaces that are less useful. The growing significance of graphics and displays is evident in the changes made to the COM Express specification. These optimizations now make smaller COM Express form-factors possible. Even with the changes to the specification, the pin-out types produced to date will continue to be available with new generations of chips, thereby ensuring the scalability of existing applications.

In the COM Express COM.0 specification, the PICMG defines the standard for a Computer-on-Module (COM) as a bootable host computer in the form of a single large-scale integrated component. The vendor-independent specification of interfaces and form-factors for Computer-on-Modules gives designers and solution providers a firm basis on which to develop products for the market that are future-oriented and promise long-term availability.

PICMG continues along the right path with the Rev 2.0 of the COM Express specification. OEMs that set up their medical diagnostic apparatus, industrial robots and vending machines, test and measurement applications, POS and kiosk systems, surveillance cameras, or unmanned vehicles on COM Express modules have chosen a sustainable and innovative solution for the future.

When these designers elect to migrate to a more compact form-factor, COM Express COM.0 Rev. 2.0 will afford them a seamless transition, thanks to the newly specified compact form-factor (95 mm x 95 mm).

A change that is a little less apparent but that has a great impact is the addition of two new pin-outs to the five already defined pin-out types within the COM Express specification. Seven pin-out types are now defined in Rev. 2.0. These can be split into two groups differing initially in the number of connectors they utilize.

Pin-out types 1 and the new pin-out type 10 utilize the single A-B connector that has 220 pins, which can also be found on all other pin-out types. But types 2, 3, 4, 5, as well as the new type 6 also use the second 220-pin connector – the C-D connector – so they possess a total of 440 pins.

Let's now look at the features of the individual pin-out types as specified in COM.0 Rev. 2.0.

Taking Stock

Pin-Out Types 1 Through 5

- Pin-out type 1: This has one 220-pin connector – the A-B connector – and supports up to eight USB 2.0 ports, up to four SATA or SAS ports and up to six PCI Express Gen1/Gen2 lanes. It supports dual 24-bit LVDS, an HDA digital audio interface, Gigabyte Ethernet and eight GPIO pins. SPI is added to all single pin-out types in Rev. 2.0 on previously reserved pins. (We will go into this issue in more detail later in this article; see the section on External BIOS-Boot). The primary input voltage is +12V and standby is +5V. Some solutions allow a variable input voltage.
- Pin-out type 2 has all the stated functionality of type 1, but adds a second 220-pin connector to it as well (C-D). In this case, type 2 features a 32-bit PCI interface plus IDE ports to support legacy PATA devices such as PATA HDD and CompactFlash memory cards. There are a total of 22 PCI Express lanes (six on the A-B connector and up to 16 on the C-D connector), 16 lanes on the second connector being intended for PCI Express Graphics (PEG). The maximum power consumption, previously defined as 188W, is now matched to 137W in Rev. 2.0, thanks to ever more energy-efficient processors.
- Comparing pin-out type 3 to type 2, only the IDE pins are used in favour of extra Gigabit Ethernet capability. Consequently, it has no legacy interfaces, but now supports up to three Gigabit Ethernet channels. In pin-out type 4, again compared to type 2, pins reserved for PCI are reallocated, creating space for ten additional PCI Express lanes. These can be used as PCIe lanes 0-15 or as second PEG port lanes 16-31.
- Pin-out type 5 fuses the changes in types 3 and 4 as compared to type 2.
- Pin-out type 6 opens up a new world of graphics.

PICMG has added a sixth type of pin-out to the COM Express standard especially to utilize the expanded graphics possibilities of new processor families. This pin-out type is essentially based on type 2, the most widely adopted COM Express COM.0 pin-out type to date.

Legacy PCI pins are now used to support the digital display interface and for additional PCI Express lanes. Furthermore, in pin-out type 6, the pins previously assigned to the IDE interface in pin-out type 2 are now reserved for future technologies still in development. One of these technologies could well be SuperSpeed USB, because the 16 free pins would offer sufficient lines to implement four of the eight USB 2.0 ports as USB 3.0 ports that each require an extra pair as compared to USB 2.0.

Extensive Support for Additional Display Interfaces

Although pin-outs type 2 and 6 are very similar, pin-out type 6 adds extensive support for additional display interfaces. The graphics options have always been one of the special strengths of COM Express through support of PEG that has been chosen by Intel to provide a high-speed bus for external graphics cards. But, these days, it is not only a matter of satisfying the growing need for performance, but of supporting different output devices as well. And these are precisely the kind of requirements for which pin-out type 6 has been scaled.

Like virtually all the other pin-out types (except type 10), pin-out type 6 continues to support the familiar analogue VGA, the standard interface for RGB/CRT devices used in many industrial applications. Because of the analogue transmission of the picture signal, VGA is not entirely suitable for modern TFT displays with resolutions of more than 1280×1024. LVDS (low-voltage differential signalling) devices can also be driven directly by all pin-out types. This is important for applications with LCD displays, for example, which mainly use this transmission standard.

It should be noted here that the dual 24-bit LVDS channels are designed for one display; the second channel serves solely to process the increasing data rates caused by higher resolution and frequency. The connected LVDS display defines how many channels are needed for each resolution.

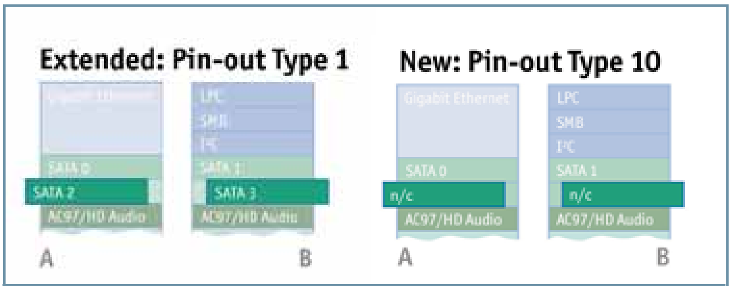


Figure 1: With Type 10, the SATA 2 and 3 pins are no longer occupied. They are now reserved for alternative purposes, such as USB 3.0

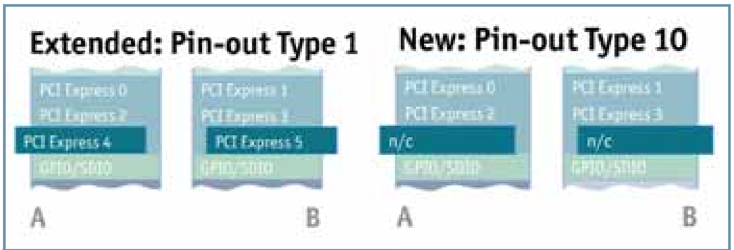


Figure 2: In Type 10, the pins for PCIe Lanes 4 and 5 remain free and can be used for future technologies

From SDVO to DisplayPort

Pin-out type 6 goes far beyond these graphics options. It offers three new ports that are dedicated to new digital display interfaces (DDI). The developer can configure these ports individually for HDMI (high-definition multimedia interface) respectively, the electrical compatible DVI (Digital Visual Interface) or DisplayPort (DP). DDI port 1 supports

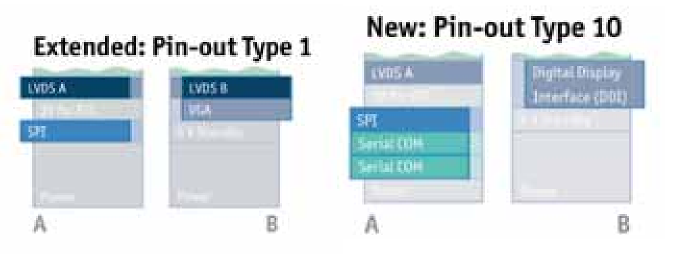


Figure 3: COM Express COM.0 R2 supports two independent displays via LVDS and DDI

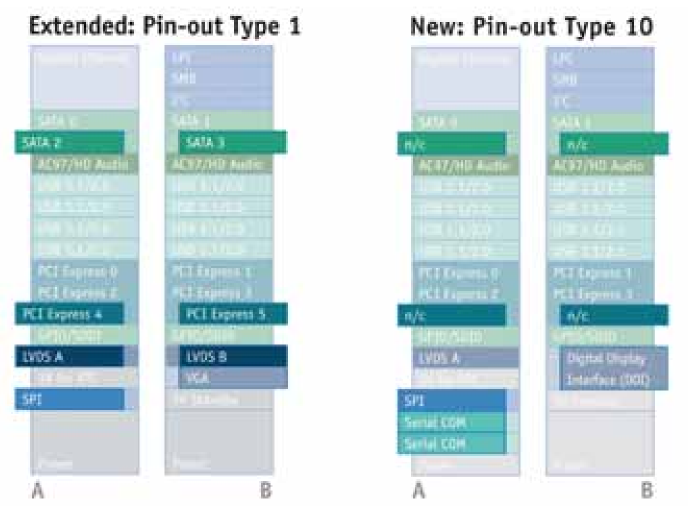


Figure 4: The changes from type 1 to type 10 at a glance

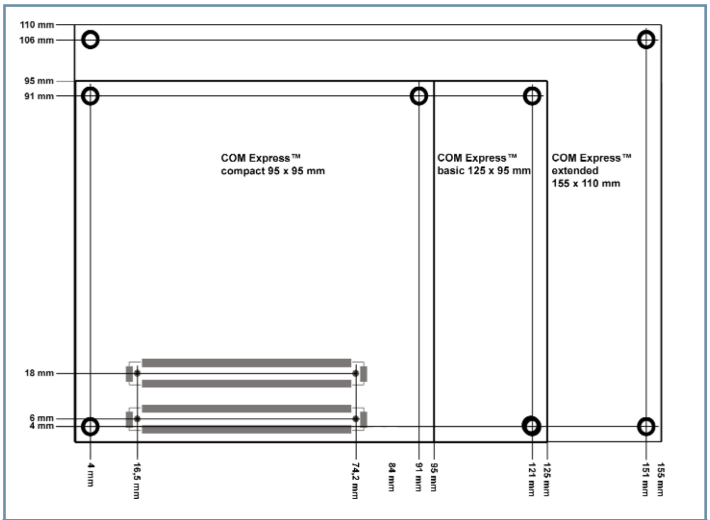


Figure 5: The new COM Express compact form-factor (95mm x 95mm) opens the way for compact designs within the COM Express specification

additionally SDVO (serial digital video output).

SDVO is not multiplexed on the PEG port in type 6, which has been possible under the pin-out type 2 definition. Thus, in parallel with embedded graphics, an external PEG graphics card can be used, for example, for multi-monitor applications with more than four screens or for data processing using general purpose GPUs (GPGPU).

With the SDVO interface supported by Intel chipsets, COM Express is flexible in supporting a wide variety of graphics signals. So the developer can now implement DVI (digital visual interface) for example and achieve relatively low cost integration of digital monitors and dual display solutions. COM Express previously did not officially support SDVO, but it has also become part of the COM Express standard in the new COM.0 Rev. 2.0.

Graphic Layout:

1. VGA
2. LVDS
3. DDI -> SDVO;DP;HDMI (TMDS)
4. DDI -> --------;DP;HDMI (TMDS)
5. DDI -> --------;DP;HDMI (TMDS)

The developer can also operate modern DisplayPort and HDMI/DVI graphical interfaces through the DDI. DisplayPort is a universal and – unlike HDMI – royalty-free interconnect standardized by VESA, which should ensure its widespread popularity.

DisplayPort not only has a much higher data transfer rate of 17.28Gbps (compared to 2.835Gbps with LVDS and 4.95Gbps with DVI), but also a micro-packet protocol, allowing simple expansion of the standard. Furthermore, DisplayPort supports an auxiliary channel that allows a bidirectional connect to control devices by VESA standards such as E-DDC, E-EDID, DDC/CI and MCCS. This enables genuine plug & play operation. The auxiliary channel can be used for peripherals such as touch-panel displays, USB connects, cameras, microphones and so on.

DisplayPort could eventually replace HDMI, popular on the consumer market, which as mentioned above is also supported by the COM Express standard on the DDI. HDMI is an ideal solution for AV and multimedia applications, such as home theater PCs or set-top boxes, due to its high data rate, its connector concept (audio and video on one cable) and its backward compatibility. However, this interface was not developed for the embedded market. Its implementation does not make for a particularly suitable solution, plus long-term availability could also be a problem as with drivers or mechanical requirements frequently change.

With this extensive support for the new graphics and display functionalities of upcoming chipsets, pin-out type 6 is a promising follow-on to pin-out types 2 and 3 and comes at the right time. Kontron already anticipated this development in a number of areas, so developers who want to make full use of the new graphics possibilities of COM Express are well served by the embedded specialists.

10 for 1

The major innovation that COM.0 Rev. 2.0 represents is the definition of the new pin-out type 10, a kind of twin brother to pin-out type 1. Type 10 addresses the requirements of newer and highly compact processors more explicitly. A close look at the pin assignments reveals the differences to watch out for when migrating from type 1 to this new type, although both pin-out types are compatible with each other.

In pin-out type 1, SATA ports 2 and 3 are assigned pins in rows A and B, but these are no longer reserved in pin-out type 10. The pins could still be used as SATA ports, but are now reserved for alternative purposes such as USB 3.0. So in designs for pin-out type 1 as for type 10, Kontron advises against wiring SATA 2 and 3 over the module connector. The modules then remain compatible and they are ready for USB 3.0 at the same time. **Figure 1** indicates the differences.

The Figure shows another difference in rows A and B, this time regarding the pinning of the PCIe lanes, where pin-out type 1 offers six lanes in total. In pin-out type 10, the pins for PCIe lanes 4 and 5 are no

DesignSpark PCB is the world's most powerful free PCB and schematic design tool. Martin Keenan from RS Components answers questions from users on PCB software and general PCB design regularly at www.designspark.com. Here's a selection of the latest questions and answers.

DESIGNSPARK

Can I get a 3D model of a PCB assembly?

You can use the IDF file format to export all the information needed by a mechanical CAD systems to create a 3D model. Many mechanical CAD tools will import IDF v3.0. The process requires two files that define the board's outline and thickness, the component positions, the component boundaries, heights, units and component name. In Designspark PCB the export-to-IDF options can be found on the Output menu.

I am working on a PCB design that uses an A/D converter to measure the current supplied to a motor using a voltage divider. I have used the power class for the tracks supplying current to the motor. But, when using autoroute, I also get thick power traces for the signal line that passes through the voltage divider to the A/D converter. How can I separate the nets into power and signal classes?

To ensure that the current measurement signal passed to the A/D converter is accurate, the traces should not carry any load current at any point. Ideally, you should use a layout in which the sense resistor is Kelvin-connected: the traces that carry the motor load current are separate from those used for the measurement traces and connect to the sense resistor directly at its pads. As it's unlikely an autorouter will do this, you are better off not trying to use autoroute to create these particular traces. Iain Mosely, Zone Electronics.

How many schematic sheets does DesignSpark PCB support?

DesignSpark PCB uses projects to hold schematic sheets together with a PCB layout. The advantage of using a project is that the schematic design can be split into separate sheets and there is no limit on the number in an individual project.

The autorouter is only routing a small number of my nets on a 100-pin LQFP package? Am I doing something wrong?

DesignSpark PCB uses a technology file to set many important parameters, such as track styles, spacings and design rules that your PCB manufacturer supports. For this design, you have specified tracks that are too large to be routed to this component and still conform to the design technology settings. Once the track styles have been changed to a smaller size the autorouter will complete the job successfully.

How do I generate and open Gerber files? I am not sure I have generated them correctly as I cannot open any of them to view on my computer.

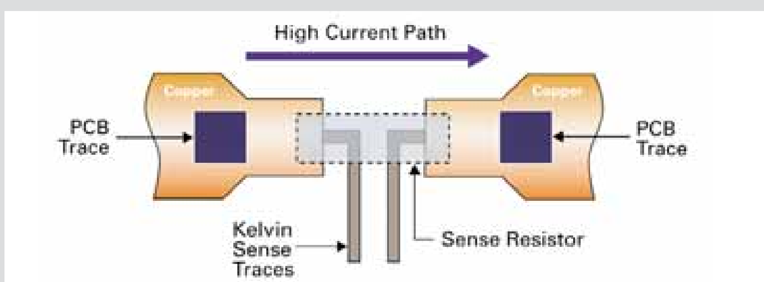
If you want to view Gerber files on a PC, you can download GC Prevue, an excellent free-of-charge viewer written by Graphicode, from the DesignSpark SparkStore. To generate a Gerber file from DesignSpark PCB, just go to the Output menu, from where you can pick Gerber, NC Drill, PDF and other export options.

Can I create custom parts and libraries in DesignSpark?

DesignSpark PCB provides a comprehensive library of standard parts but there will be occasions where you need to modify or create new part types. In DesignSpark PCB, there are wizards for creating new components. You can then use the library manager to manage where the program looks for components. Using this method you can let a design engineering team share a library on a network drive or access a library on a portable media device such as USB stick for easy portability.

How can I navigate around a large schematic or PCB design?

There are several ways to navigate around a design and the larger and more complex your design becomes, the more useful these shortcuts become. With DesignSpark PCB you can use the mousewheel and keyboard shortcuts to zoom in and out. You simply point at the area you wish to zoom in to and scroll the wheel until you are happy with the zoom level. Pressing the mouse wheel will let you drag the design about in a similar way to how the hand tool works in Acrobat when viewing PDF documents. To easily move around the PCB in very large designs, you can use the Goto Bar, from where you can find or select specific components, nets and connections and then move straight to them without having to hunt around the PCB layout manually.



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longer reserved and can also be used for upcoming technologies.

The background in both the above cases is as follows: Processors of a small form-factor, at which type 10 aims, support up to two SATA interfaces and four PCIe lanes. The vacated pins on the module connectors of the ultra standard can therefore be used efficiently for new purposes.

As of COM.0 Rev. 2.0, serial ports are again supported. The pins for this were previously used for VCC 12V.

What is new is that with COM.0 Rev 2.0 type 10 and type 6 support serial ports. The pins were formerly used for VCC 12V. However, dedicated manufacturers like Kontron ensure compatibility with existing carrierboards by a protective circuit on the module. Developers do not have to completely modify their existing carrier board layout, but can cost- and time-efficiently use the new possibilities.

A further difference is that type 10 uses the second LVDS channel, TV out and VGA to support the SDVO port (or alternatively DisplayPort or HDMI/DVI) via DDI. That is no real loss seeing as VGA will only play a minor role in future. But now type 10 ultra-compact modules (such as the nanoETXexpress-TT) provide native support not only for latest display interfaces but also for dual independent displays, since they will continue to support an LVDS channel. **Figure 3** shows the precise differences in pinning between types 1 and 10.

For customers that already use the ultra compact nanoETXexpress modules from Kontron these differences are not likely to be of much consequence. With foresight, Kontron has already reserved the appropriate pins for SDVO support, for instance, on the former VGA and second channel LVDS pins in its nanoETXexpress-SP modules.

Other Changes

Further changes affecting all the types of modules available are as follows: The COM Express connector in the present form is now also approved for PCI Express Gen2 signals. Technically speaking, that means no alteration to the connector or its pinning, but the developer must still adhere to new rules for PCIe Gen2 when routing the module and carrierboard. Additionally, the AC97 pins are now used to support AC97 and HD audio.

The following changes have additionally been made in the new version: COM modules type 10 and type 6 now also support SDIO, multiplexed on the existing GPIO signals. Optionally, two 3.3V TTL serial ports are added – as required by many legacy applications – and, here, the standard again shows its flexibility in responding to the needs of the market. Both ports can be used for different purposes such as RS232, RS485, the CAN bus, or other two-wire interfaces.

External BIOS Boot

One change shown in the new specifications affects all pin-outs. In addition to the previous firmware hub, there is a new BIOS firmware interface for an internal and external boot, implemented in the new generation of processors. This is a serial peripheral interface (SPI), the future interface for firmware flash on the module and carrier board. Ready reserved pins are used for this purpose.

Generally, PICMG allows a choice between two SPI chips, the new COM.0 Rev. 2.0 specifying external firmware support for all module types. The LPC interface was used for this purpose in the earlier version. The new modules must support SPI, but may still additionally flash firmware externally through LPC, i.e. if the chipset continues to support it. The reason for this change in firmware flash is that the new small form-factor processors only support SPI boot devices.

Compact Form-Factor Now Officially Standard

Inclusion of the smaller, compact, form-factor in the standard is a major innovation. It means that the most widely adopted pin-out type 2 can now also be used in applications with space constraints. COM.0 Rev. 2.0 defines its dimensions as 95mm x 95mm. Aside from the reduced footprint, the physical requirements, connector placement and pin-out are exactly the same as those of the successful basic form-factor.

This is another case where Kontron entered the scene early, because the company had already been producing modules with these specifications for more than two years under the brand name of microETXexpress and was the first one to market. Recently, Kontron introduced a new product in this module family: the microETXexpress-XL with an Intel Atom Z520PT processor and Intel US15WPT system controller hub. This is a COM Express COM.0 pin-out type-2 Computer-on-Module with a compact form-factor, specially developed for use in the E2 industrial temperature range from -40 to +85°C.

The Kontron microETXexpress-XL with a 1.33GHz Intel Atom Z520PT processor supports up to 2GB of soldered DDR2 RAM and also has space for an onboard solid-state drive. Additionally, it makes full use of the bandwidth of the COM Express pin-out type 2 connector with 1 x Gigabit Ethernet, 1 x serial ATA, 1 x PATA, 8 x USB 2.0 and 2 x PCI Express, plus PCI for custom additions. With the SDVO port, it is very simple to implement a DVI output and together with the 24-bit LVDS single channel the Kontron microETXexpress-XL presents possibilities for connecting a whole variety of displays and monitors. This extensive feature set makes the Kontron microETXexpress-XL one of the most flexible interface choices in Computer-on-Modules in the compact COM Express form-factor for extreme environments (-40 to +85°C).

Kontron nanoETXexpress modules also match the PICMG COM Express standard with respect to pin assignments and pin-outs type 1 and type 10 and are ideally suited for a new generation of mobile embedded applications with low power consumption and the latest interfaces no bigger than a credit card.

Appropriate Response

The updated specification for COM Express modules is an appropriate response to trends in the sector, because the standard can only be sustainable if it adapts flexibly to new demands such as miniaturization and graphics performance.

The PICMG COM Express COM.0 Rev. 2.0 standard is for embedded developers a good indicator of what the future holds. It will create further confidence if the current PICMG design guide is speedily matched to the new challenges.

COM Express is, other than the standard adopted in 1998 for DIMM-PC and the one published in 2000 for ETX, the only vendor-independent standard for Computer-on-Modules. Thus, it is extremely important in the embedded market. With Rev 2.0, it is extended by a new form-factor and new pin-outs to meet future needs. Thus, the strengths of the COM Express concept have been preserved in their entirety. With full compatibility for existing applications, the proven standards have been adapted to the new requirements and new features of the pin-out types 6 and 10 have been implemented. That is a basis for the next few years. ■

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If it's embedded, it's Kontron.

The Cathode Follower CF

Burkhard Vogel presents a series of short features with general remarks on triodes in audio applications

CATHODE FOLLOWERS are gain stages that offer gains G always <1, rather low output resistances R_o and, depending on the type, very high input resistances R_i. A typical circuit is shown in **Figure 1**.

It is the most complex one of the three simple CFs. A much more complex type of CF, the White Cathode Follower, will be in the next issue of *Electronics World*. The equivalent circuit of **Figure 2** allows deriving all equations for the three simple CFs.

I call $CF1_u$ the Figure 1 cathode follower without the R_{c1} bypassing capacitance $C_{c1} = (2\pi f_c R_{c1})^{-1}$, $f_c << 20Hz$. Hence, inclusion of C_{c1} leads to cathode follower $CF1_b$.

If we get rid of R_{c2} we will get another alternative called CF2. Replacing R_{c2} by an active current sink would create another two alternatives because that current sink could be formed by a second triode V2 plus bypassed or un-bypassed cathode resistor R_{c3}.

I do not dive deeper into these two solutions, however, replacing R_{c2} in the following equations by the total differential V2 resistance $R_{V2} = [r_{a2} + (1+\mu_2)R_{c3}]$ will make it.

Let' go back to CF1. According to Figure 2, the R_L dependent gain $G1_u(R_L)$ of the un-bypassed version $CF1_u$ can be derived – without 180° phase shift – as:

$$G1_u(R_L) = \mu \frac{R_{c1}+R_{c2}}{r_a + (1+\mu)(R_{c1}+R_{c2}) + \frac{r_a}{R_L}(R_{c1}+R_{c2})} \quad (1)$$

Setting $R_{c1} = 0\Omega$ in **Equation 1** leads to the gain $G1_b$ of the bypassed version $CF1_b$

$$G1_b(R_L) = \mu \frac{R_{c2}}{r_a + (1+\mu)R_{c2} + \frac{r_a R_{c2}}{R_L}} \quad (2)$$

Setting $R_{c2} = 0\Omega$ in Equation 1 leads to the gain G2 of CF2:

$$G2(R_L) = \mu \frac{R_{c1}}{r_a + (1+\mu)R_{c1} + \frac{r_a R_{c1}}{R_L}} \quad (3)$$

Figure 1: *Cathode Follower*

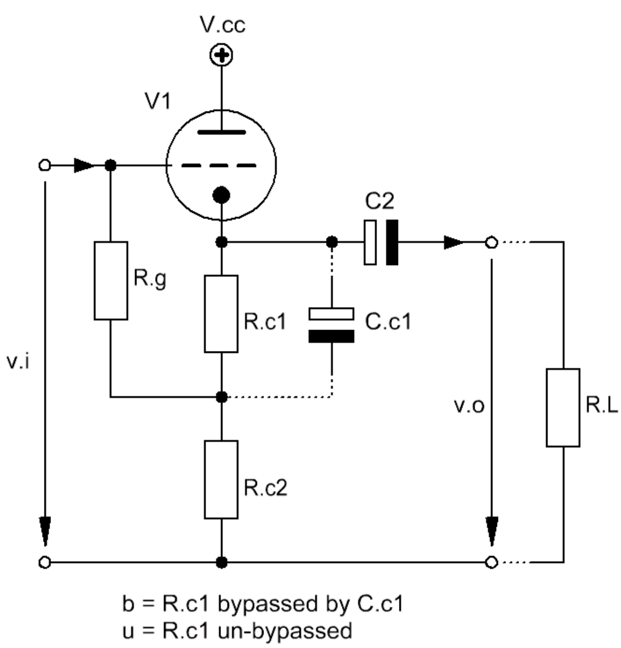


Figure 2: *Equivalent circuit of Figure 1*

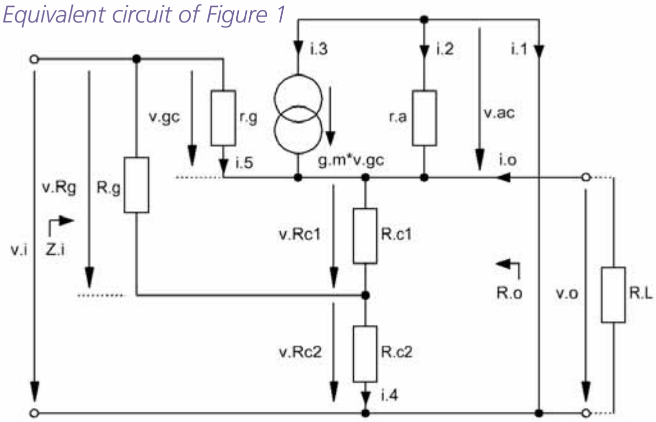
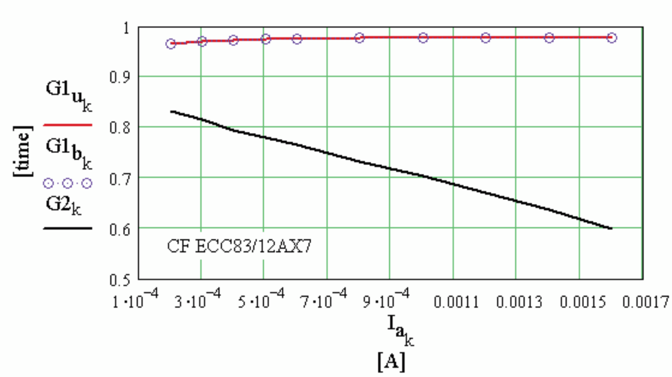


Figure 3: *CF gains G vs. anode current I_a (R_L = 100kΩ)*



The output resistances $R1_{o.u}$, $R1_{o.b}$ and $R2_o$ of the three different CF types look as follows:

$$R1_{o.u} = r_a \frac{R_{c1}+R_{c2}}{r_a+(1+\mu)(R_{c1}+R_{c2})} \quad (4)$$

$$R1_{o.b} = r_a \frac{R_{c2}}{r_a+(1+\mu)R_{c2}} \quad (5)$$

$$R2_o = r_a \frac{R_{c1}}{r_a+(1+\mu)R_{c1}} \quad (6)$$

The three input resistances $R1_{i.u}$, $R1_{i.b}$ and $R2_i$ look very much different. As function of R_L we obtain:

$$R1_{i.u}(R_L) = \frac{R_g}{1-G1_u(R_L)\dfrac{R_{c2}}{R_{c1}+R_{c2}}} \quad (7)$$

Setting $R_{c1} = 0\Omega$ in **Equation 7** leads to the bypassed version $R1_{i.b}$:

$$R1_{i.b}(R_L) = \frac{R_g}{1-G1_b(R_L)} \quad (8)$$

Setting $R_{c2} = 0\Omega$ in Equation 7 leads to the third version $R2_i$:

$$R2_i = R_g \quad (9)$$

Not taking into account the reducing R_{c1} effect on the calculation of the actual C_{gc} value, we can use **Equation 10** to calculate C_i (C_{stray} = 1pF … 10pF), hence, the calculation of the respective input impedances follows its general rules:

$$Z_i(f) = |C_i \| R_i| \qquad C_i = C_{ga}+C_{gc}+C_{stray} \quad (10)$$

Configured in all three CF versions the graphs show the most relevant traces of the example triode ½ECC83/12AX7 at a constant V_{cc} = 300V (202V for CF2), V_a = 200V, R_g = 100kΩ ("$_k$" indicates the number of the ten I_a values from 0.2mA to 1.6mA).

Coming in the next issue is *Part 6: 'The White Cathode Follower'*

If you missed any of the previous parts, you can order them online by going to Electronics World's website at www.electronicsworld.co.uk

Figure 4: *CF gains G vs. load resistance R_L (I_a = 1.2mA, R_{c2} = 82.5kΩ)*

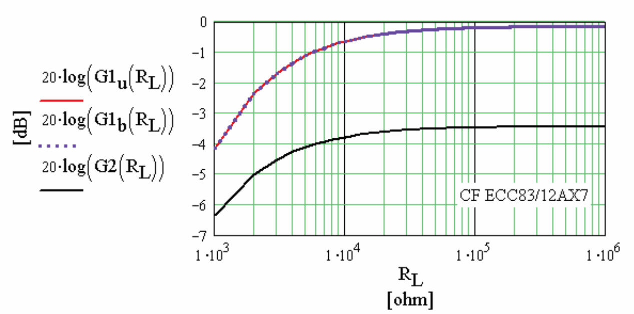


Figure 5: *CF output resistances R_o vs. anode current I_a (R_L = 100kΩ)*

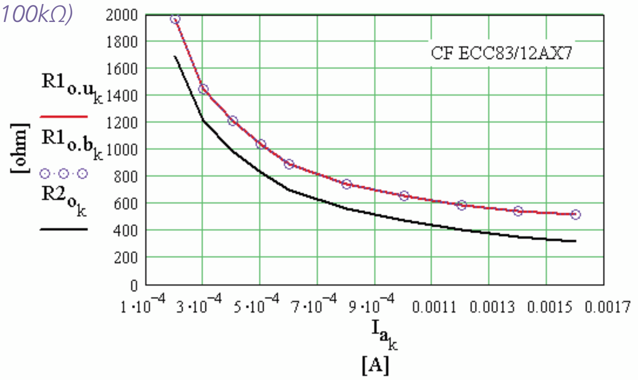


Figure 6: *CF input resistances R_i vs. anode current I_a (R_L = 100kΩ)*

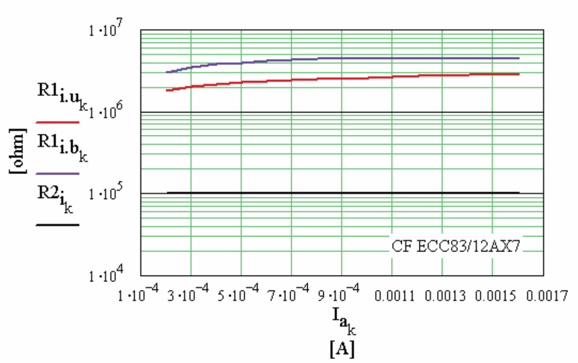
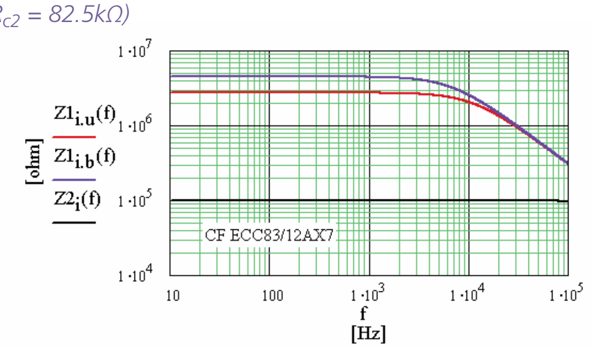


Figure 7: *CF input impedances Z_i vs. frequency f (I_a = 1.2mA, R_{c2} = 82.5kΩ)*



RS AT ELECTRONICA 2010

At Electronica this November, RS Components will be presenting its package of unique design resources developed by engineers for engineers.

With over 500,000 products available from 2,800 suppliers, serving customers in over 80 countries, RS has set the standard for high-service level distribution. This year, their market-leading range and services to engineers across the globe has been boosted by the launch of new online design resources called DesignSpark (**www.designspark.com**). It provides engineers with a gateway to design tools, information and reviews, including DesignSpark PCB, the world's most powerful free PCB design software package.

rswww.com/electronica
Hall A4, Stand 117

APACER CFAST CARDS

Apacer's storage device CFast card shares the same advantages as today's industrial CF cards: compact profile, anti-shock and low power consumption. It also embraces the up-to-date technology announced by the Compact Flash Association and increases the transfer speed by using SATA II framework to as high as 115/100MB/sec of continuous read/write speed. Traditional IDE interface-based CF cards can meet users' demand for capacity, yet often fail to achieve their desired read/write speed. Apacer CFast card has broken the speed limit and offers guaranteed high operating stability against harsh working environment (e.g. resistance to a wide temperature range). Apacer CFast card has a built-in HW ECC and SMART function, advanced wear-leveling and flash management, power failure recovery, shock resistant's, low vibration sensitivity and low power consumption. Apacer CFast provides solid traceability to ensure all BOM HW/FW are the same as you qualified.

http://emea.apacer.com
Hall A6, Stand 148

NEW FILTER CAP FOR THE WORLD'S SMALLEST DIGITAL HUMIDITY SENSORS

Sensirion has just launched a filter cap for its latest generation of humidity sensors. The SF2 filter cap is made of PBT, has an integrated filter membrane and protects Sensirion's SHT2x humidity and temperature sensor from water, dust, dirt and various contaminants.

The filter cap features a filtration efficiency of 99.99% of all particles > 0.1µm and is designed to keep response time low. Thanks to the optimal protection, the highly stable DFN sensors of the SHT2x series can be used in even the harshest environments and still offer excellent long-term stability and performance.

The SF2 fits exactly to the external dimensions of the SHT21 and soon be launched SHT25 (SOP Q4 2010), and is easily mountable after reflow soldering. The SF2 is fixed by plugging the four pins into corresponding holes in the PCB. It can be glued for additional adhesion, if desired. The SF2 filter cap also serves as an adaptor for mounting the humidity sensor directly into the wall of housing. Using a sealing ring results in a waterproof mounting solution that allows protection according to IP67.

www.sensirion.com
Hall A2, Stand 206

LECROY ESTABLISHES CLEAR OSCILLOSCOPE LEADERSHIP

LeCroy Corporation's new line of WaveMaster 8Zi-A digital oscilloscopes – the 8 Zi-A Series – now provides up to 45GHz of bandwidth and 120GS/s of sample rate, the world's highest bandwidth and fastest sample rate real-time oscilloscope, combined with 768 Megapoints of analysis memory. Additionally, the introduction of a model with 20GHz of true analogue bandwidth on four channels provides the highest performance and signal fidelity available on four measurement channels. On all models, acquisition capability can be doubled with the use of the Zi-8CH-SYNCH Oscilloscope Synchronization Kit, with all acquired channels displayed on a single display grid.

The standard sample rate is 120GS/s for 45GHz bandwidth, 80GS/s for 25 to 30GHz bandwidths and 40GS/s on all 4 channels at 20GHz bandwidth. For 4 to 20GHz bandwidths, the standard sample rate is 40GS/s on all four channels with an option to increase the sampling rate to 80GS/s on two channels. All memory is available at full record lengths for analysis processing, 20Mpts/ch is provided standard, with memory options up to 256Mpts/ch available. In 120 and 80GS/s mode, memory can be interleaved to 768 and 512Mpts/ch.

www.lecroy.com
Hall A1, Stand 449

EUROPEAN LAUNCH OF BIRST ON LXI DEVICES, FULLY COMPLIANT TO THE LATEST 1.3 SPECIFICATION

Pickering Interfaces has continued in 2010 to regularly release a steady flow of new products in both the LXI and the PXI platforms. Amongst a variety of products, these latest models deserve attention and will be shown at Electronica 2010 are BIRST Modules (Built-In Relay Self Test) and new PXI products.

Verification and diagnosis of complex switching operation in a test system has always been an issue, especially in the PXI platform. For this reason, Pickering Interfaces has developed a range of PXI modules with built in self-test This feature is called BIRST, or Built In Relay Self Test.

The first PXI modules with built in self-test have been released a year ago and new launches continue to include BIRST in PXI matrix modules. At electronica 2010 BIRST on LXI Devices will be shown for the first time in Europe – and demonstrated on a 60-555 LXI matrix.

www.pickeringtest.com
Hall A1, Stand 530

CHOMERICS TO SHOWCASE LATEST THERMAL AND SHIELDING PRODUCT INNOVATIONS AT ELECTRONICA 2010

Chomerics Europe, a division of Parker Hannifin, will be exhibiting its latest innovations in thermal management and EMI shielding products, including shielded windows, at this year's Electronica exhibition to be held in Munich in November. The focus application areas covered in four main displays on the booth will be automotive, medical, telecoms and military.

As electronics technology has evolved, specialists such as Chomerics have developed materials to meet the new challenges including those caused by smaller form-factors, closer proximity of analogue and power components to sensitive integrated circuits, and the difficulties of shielding the growing number of battery powered portable products from spurious EMI.

New materials that visitors to the Chomerics booth at Electronica can see and discuss with experts include the company's THERM-A-GAPTM T652 thermally conductive dispensable gap filler that combines compliance under low assembly pressures with thermal performance of 3W/m-k and an operating temperature range of -50ºC to +150ºC, and EMI shielding materials that use low transfer impedance Nickel/aluminium (Ni/Al) particle filled elastomers to give industry-leading levels of shielding effectiveness.

www.chomerics.com
Hall A2, Stand 475

SEAWARD DEBUTS NEW CLARE HAL 104 MULTI-FUNCTION TESTER AT ELECTRONICA

The new Clare HAL 104 from Seaward will be launched at Electronica 2010 as the first multi-function hipot electrical safety tester capable of undertaking all the important electrical safety tests required in the manufacturing and production environments.

The HAL 104 has been developed for multiple standards, production line and type testing applications in the avionics, appliance, lighting, defence and similar electronics manufacturing sectors. It combines the performance of a multi-function production line safety tester with load and power factor measurement for product energy consumption and rating assessments. As well as incorporating key functional checks, the new HAL104 meets the end of line electrical safety compliance tests required by the majority of national and international product safety standards.

A new range of HAL electrical safety test enclosures will be displaying at Electronica 2010. These feature a modern ergonomic design to enable production personnel to carry out the safe and controlled electrical testing of a wide range of products in compliance with EN50191, which specifies safe working conditions for electrical testing.

www.seaward.co.uk
Hall A1, Stand 270

SHARP SUPPORTS PARTNER AT ELECTRONICA 2010

Sharp is showcasing its latest innovations from display technology and LED technology for general lighting at Electronica 2010 at the Data Modul (Hall A3, stand 207) and Rutronik (Hall A5, stand 159 & 260) stands.

"The close cooperation at Electronica should enable us to support our partners, particularly in generating more business with our components, something both of us will reap the benefits from," said Franco Morotti, General Manager Business Unit Consumer Industrial Distribution of Sharp Microelectronics Europe.

Via the direct presence at the partners' stands visitors will get first-hand detailed technical information on Sharp products, while commercial aspects can be discussed directly with the distribution partners.

At the Rutronik stand the focus of Sharp's presentation is on LED technology whilst at Data Modul on displays.

www.sharp.eu
Sharp @ Rutronik: Hall A5, Stands 159 & 260 Sharp @ Data Modul: Hall A3, Stand 207

EUROQUARTZ TO SHOW WIDE RANGE OF FREQUENCY MANAGEMENT PRODUCTS AT ELECTRONICA 2010

Frequency control specialist Euroquartz is exhibiting its wide range of frequency management products at the forthcoming Electronica 2010 exhibition. The company's will have examples of CMOS clock oscillators with wide supply voltage range, miniature package voltage-controlled crystal oscillators (VCXOs) and a wide range of temperature-compensated crystal oscillators (TCXOs) from frequency 20kHz.

CMOS clock oscillators are available in several ranges – X022, X032, X053 and X091 – offering supply voltages from 0.9 to 5.0V. Package sizes range from ultra-miniature 2.5 x 2.0 x 0.9mm for X022 series up to miniature 7 x 5 x 1.4mm for X091 series.

New G534 series VCXOs are housed in miniature 5 x 3.2 x 1.2mm SMD packages and are available in the frequency range 625kHz to 50MHz. The small package size makes these oscillators ideal for use in a wide range of applications including phase-locked loop, SONET/ATM, set-top boxes, MPEG, audio/video modulation, video games consoles and HDTV.

www.euroquartz.co.uk
Hall B5, Stand 531

LATEST RANGE OF TECHNOLOGIES FROM ROHM SEMICONDUCTOR

In dedicated booth areas, ROHM will demonstrate latest technology and products (MCUs, sensors, power management ICs, drivers, opto electronics, audio & video, as well as R&D achievements) resulting from the intensive work of its European and Asian design centres. The exhibits will prove to meet today's markets demands for energy-efficiency, while maintaining optimum performance; they also allow for miniaturization, component save and easier designs based on ROHM's leading packaging experience, as well as provide beneficial features with new materials like SiC. In addition, ROHM will invite visitors to take part in a raffle. The lucky winners of high level prizes such as Apple iPads will be drawn on site at 16.00 hrs during the first three days of the show.

www.rohmeurope.com
Hall A5, Stand 542

System on Chip in Portable MEDICAL Electronics

Sanjeev Kumar, application engineer at Cypress Semiconductor compares directly the traditional, individual component-based design of portable medical electronics devices versus system-on-a-chip type design

PORTABLE MEDICAL ELECTRONICS has seen a tremendous growth and adoption in the recent years. More new variants are being introduced in the market increasingly by newer companies. The need of the hour is better mass-producible designs which are low in complexity and provide acceptable performance so as to keep the cost of the device low. In designing medical devices, selection of right components to meet needed specification, power efficiency, cost, form factor and FDA certification of the components are some important factors to be considered.

A typical portable medical electronic system comprises components like analogue front-end for data acquisition and signal conditioning such as amplifiers and filters, A to D converter, buttons to take user feedback, MCU for algorithms and various interfaces like an LCD display, USB port etc.

The traditional way of designing is to put together all the needed components in a PCB. This method increases the overall BOM (bill of materials), PCB complexity, design cycle etc. These individual analogue components will reduce analogue IP protection as the solution can be reverse-engineered easily.

Portable medical equipment's design and manufacture is regulated by the Food and Drug Administration (FDA). This means that their design and construction must follow precisely documented processes, and their performance must meet stringent documentation, development testing, production testing and field maintenance requirements.

One such FDA regulation is that the components used in medical device have to be in production for the next five years. This puts the developer to reduce the bill of materials to make the FDA certification simpler.

Blood pressure monitor, non-contact digital thermometer, glucose meters, pulse oximeter etc are some portable medical electronics devices in home care and clinical space. **Figures 1** and **2** show a typical blood pressure monitor (BPM) and a non-contact digital thermometer built using the traditional approach.

Traditional Approach

A typical BPM uses a differential pressure sensor to measure the cuff or arm pressure, the output of this sensor lies within a few micro volts (30-50μV). The output pressure signal has to be amplified using a high-gain instrumentation amplifier with good CMRR. Usually the gain and CMRR needed would be around 150 and 100dB respectively.

The frequency of oscillatory pulses in pressure signal lies between 0.3-11Hz with amplitude of a few hundreds microvolts. These oscillations are extracted using band-pass filters with gain around 200 and cutoff at 0.3-11Hz. A 10-bit ADC with a speed of 50Hz is used to digitize the pressure sensor and oscillatory signal. Two timers are used to calculate the heart and implement safety timer functionality.

The safety timer regulates the pressure kept on subjects arm for certain period of time. This safety timer is a part safety regulation in AAMI standards. A microcontroller core calculates the systolic and diastolic pressures values using an Oscillometric Algorithm. The cuff is inflated and deflated using motors driven by PWMs.

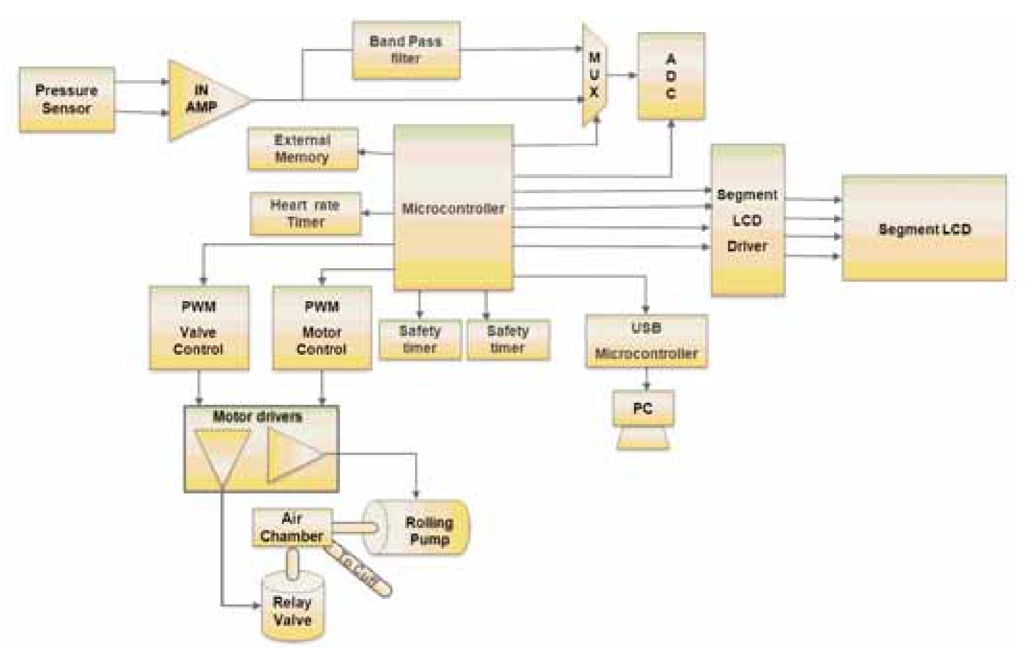


Figure 1: Blood pressure monitor in traditional design approach

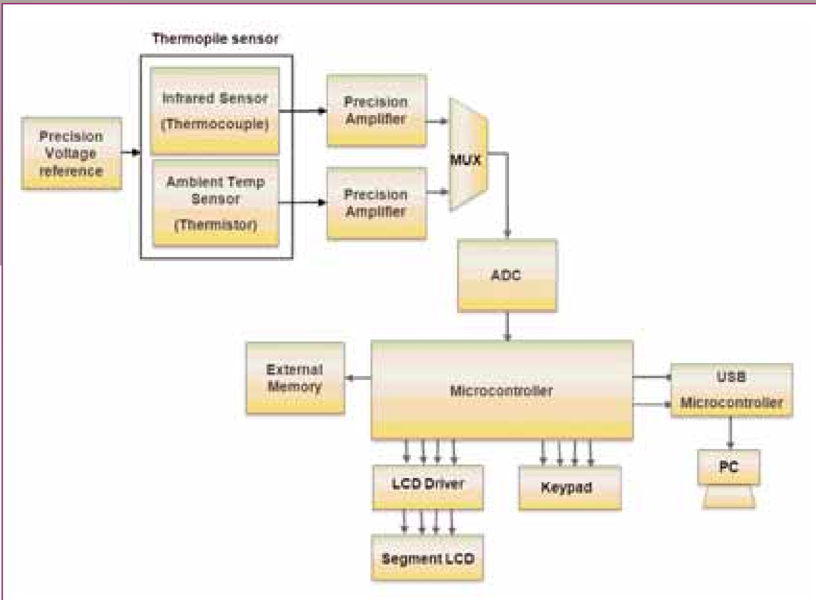


Figure 2: *Non-contact digital thermometer in traditional design approach*

A typical non-contact digital thermometer uses a transducer called thermopile, which comprises of a micro-machine embedded membrane with thermocouples, to measure thermocouple temperature and a thermistor to measure ambient temperature.

The thermocouple generates a DC voltage corresponding to the temperature difference in its junctions. The output of thermocouple is in order of a few μV. The signal from the thermocouple is amplified using low noise precision amplifier. A voltage divider is constructed with the thermistor and external precision voltage reference. This voltages divider converts change in thermistor resistance with respect to temperature to change in voltage.

Voltages from the thermocouple and thermistor are used to calculate thermocouple and ambient temperatures. The temperature is obtained from voltages using the polynomial function given by the sensor manufacturer or through a Look Up table with pre-stored readings. The ambient temperature is added to the thermocouple temperature to get the final temperature measurement.

Segment LCD driver, RTC, push buttons, EEPROM and USB are the other peripherals needed in both of the above applications.

The components external to microcontroller like the transducer, ADC, LCD driver/controller, USB controller, filter, amplifiers etc are the peripheral components. These components interface to the microcontroller through either a GPIO or a dedicated pin. With the use of these many peripheral components come several limitations and constraints like bill of materials, complexity of PCB, FDA certification for each and every component, increased design/development time, reduced analogue IP protection and others.

System on Chip Based Approach

System on a chip (SoC) provides a new way of designing portable medical electronic devices. Designing with these devices bring in numerous value additions. **Figures 3** and **4** depict the designs of a blood pressure monitor and non-contact digital thermometer using system on a chip.

Using SoC in blood pressure monitor simplifies the design to a great extent. An SoC can integrate high gain instrumentation amplifier needed for the design. Oscillatory pulses can be extracted using integrated analogue/digital filters.

The configurable ADC inside SoC can be used to digitize data. The integrated CPU core provides required processing power to handle bigger algorithms. This device also integrates segment LCD driver for display, EEPROM for data logging, real-time clock for time stamping, full speed USB for PC interface, DMA to offload CPU and touch sense to replace buttons. Timers inside SoC can be used to calculate heart rate and to handle safety functionality. SoCs also feature wide operating voltage and lesser current consumption, which is more suitable for battery-operated devices. Pulse-width modulators inside SoCs can be used to control the motors.

SoCs integrate amplifiers and ADCs needed to detect microvolt variation in an infra-red thermometer. SoC has internal precision voltage reference to provide a stable and accurate reference to the sensor. The other functionalities SoCs integrate include segment LCD driver, EEPROM, RTC, USB interface, touch sense etc.

As discussed above, SoCs integrate most of the peripheral components. This brings in immediate reduction of number of components used. Using these chips protects analogue IP as all the analogue components are integrated into the chip. Lesser number of components means simpler PCB, shorter design time and shorter time-to-market.

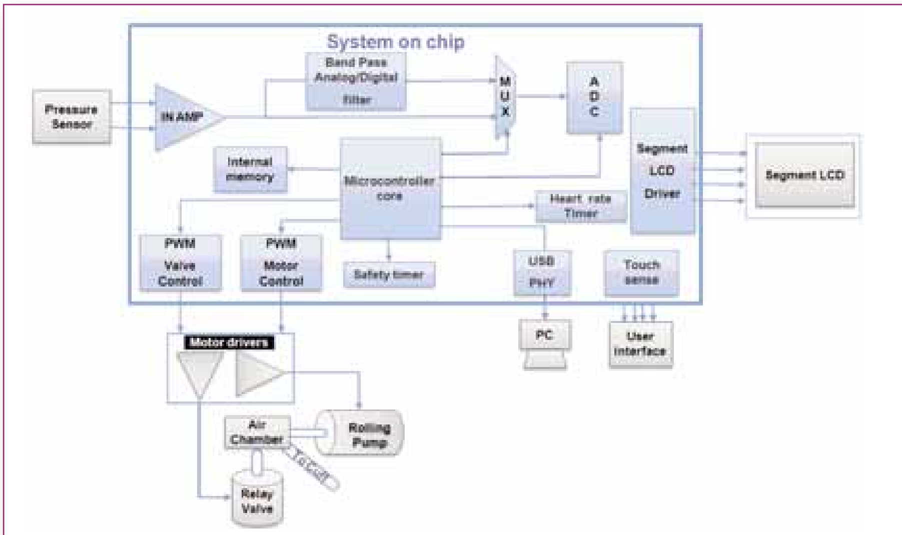


Figure 3: *Blood pressure monitor using SoC*

The power of different peripherals inside the chip can be managed individually in different modes so power management is made simpler and efficient. Reconfigurability of these chips reduces the cost and time of redesigning or changing the solution. More than anything, using SoC makes FDA certification simpler by reducing the bill of materials. Glucose meters, pulse oximeters, portable ECG devices etc are some other portable medical electronics equipments which can be implemented using SoCs.

As an example, Cypress's PSoC 3/5 products (Programmable System on Chip) are tailor-made for portable handheld applications like blood pressure monitors, blood glucose meters and pulse oximeters. PSoC3/5 integrates 8051/ARM cortex M3 core running at 33 MIPS and 100 DMIPS, amplifiers, dedicated digital filter blocks, configurable delta sigma ADC, integrated LCD driver that can drive a maximum of 736 segments, capacitive sensing for touch buttons/proximity detection, 2KB of EEPROM, full speed USB 2.0 and various other functions, thereby enabling true single-chip solutions. This combined with the PSoC Creator IDE, which has preprogrammed configurable IP modules for each function, gives a product designer all the tools necessary for a small form-factor, highly programmable end product with a very short design cycle. Low power operation of PSoC3/5 is better suitable for handheld medical/life style electronics applications.

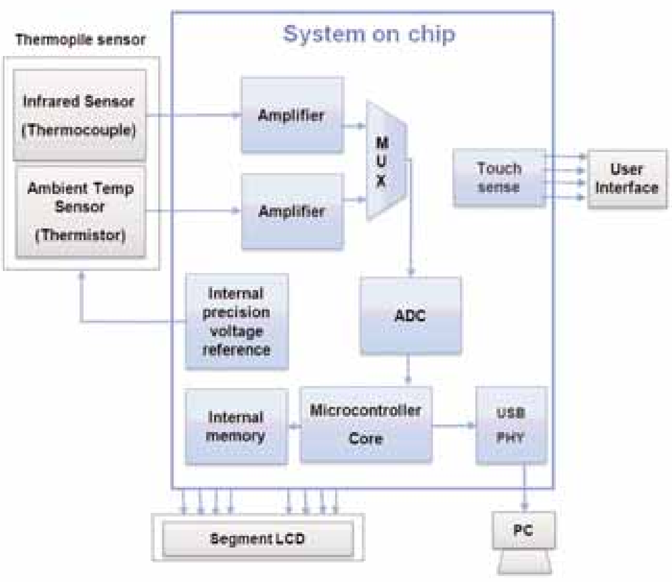


Figure 4: Non-contact digital thermometer using system-on-a-chip

Simpler Design and FDA Certification

Overall, using SoCs portable medical electronics make the design simpler, protect IP and provide novel and unique methods to solve problems, and makes FDA certification simpler. The example solutions stated above shows how system-on-a-chip simplifies the design. Given the advantages, SoC-based design is more compelling and a better alternative for many of the portable medical applications. ■

Bringing MEDICAL ELECTRONICS Up To Scratch

While the transition period for the Third Edition of the medical electrical equipment standard (IEC 60601-1:2005) doesn't end until 2012, there are many changes and 'firsts' with which design engineers must become familiar now, says **Jean-Louis Evans**, Managing Director at TÜV Product Service

WHILE THE TRANSITION period for the Third Edition of the medical electrical equipment standard (IEC 60601-1:2005) doesn't end until 2012, there are many changes and 'firsts' of which design engineers must become familiar now. This will ensure that they design electronic products and components that will come up to scratch and can be sold on the European market.

For many, the Third Edition is a much needed update as our use of medical equipment, in both work and within the home, has changed significantly. Electronic medical equipment is more omnipresent than ever in all of our lives and a new standard was needed to reflect that change.

While the transition period is still two years off, it makes commercial sense to start using this new, complex and greatly expanded standard now. Making sure this is incorporated into the design process now will help to avoid costly re-designs and the potential of increased time to market for products further down the line.

Health Aware

Previously, the standard only covered products intended for use 'under medical supervision'. However, we have never been

Figure 1: *Many changes are afoot when it comes to designing new medical equipment*

more aware of the state of our health and, consequently, there has been a boom in health-related electronic products industry. With an increase in popularity for medical products amongst consumers, the use and location of medical equipment has changed and it has, therefore, become necessary to 'upscale' the standard in terms of the types of products it covers. As a result, an increased number of health-related electronic devices that were not covered by previous standards could now be covered by the requirements of the new Third Edition.

This means that manufacturers of active devices, such as SAD lamps or fitness and depilation equipment etc, must now be careful of the claims they make, as the wording used when marketing a product could render it a medical device. If such a product is classed as a medical device it must meet the complex requirements of IEC 60601-1, and this could cost extra money and a delay in getting the product to market.

As there is now an increased chance of manufacturers that sell health-related products falling foul of the law, it is essential that how a product will be used and who it is marketed to are taken into account during the design phase. This will help to ensure that products meet the more robust standards and can be legally sold post-2012.

The Third Edition of this standard also includes a further range of products that were not covered by the previous standard. Medical equipment for household use is now clearly within the scope of the Third Edition of the standard.

Introducing Subjectivity Into Testing?

One of the many other 'firsts' as a harmonised standard, under the Medical Devices Directives, is the incorporation of the 'risk management' concept. This includes an obligation to keep a detailed Risk Management File (RMF) and it is essential to do so, as many of the tests that are required to demonstrate compliance with the standard make reference to the RMF.

This also introduces an increased level of flexibility, as it means that the testing process – required to ensure compliance with the standard – may be modified, depending on how the device must comply with some aspects of the standard. A good example of this is that some medical equipment may need to be robust enough to be used in the battlefield as the intended use of the product requires it to withstand extreme conditions.

The test house can, therefore, 'toughen' the standards relating to use and its associated risk, such as shock, heat, etc. However, the new element of 'risk management' has raised some concerns that it is open to interpretation and could introduce a degree of subjectivity, moving away from objective test/fail criteria; what one test-house passes could be failed by another.

What may surprise many, especially those purchasing equipment, is that for the first time the term 'essential performance' has also been introduced. This has expanded the scope of the standard beyond basic safety requirements, to ensure that the product does the job from the end-user's perspective.

There is now also a new requirement that is causing some ripples in the medical device world as, for the first time, the lifetime of the equipment must be planned and documented. This means that a manufacturer must estimate lifetime and, by implication, mean time between failures, availability of spare parts and for how long they will support that equipment. While this is a reassuring addition for those purchasers making a significant investment in expensive medical equipment, it has significant implications for marketing and selling products going forward.

The new requirements mean that users can now get a better idea of what the return on their investment will be when comparing equipment to purchase from different manufacturers. They will now have more knowledge of how long a particular product is predicted to last, for how long they will be able to repair it and, therefore, assess its long-term potential and cost-effectiveness compared to competitive products.

Reduced Exposure

The standard also includes new concepts for Means of Patient Protection and Means of Operator Protection.

In the past, a current was allowed to appear on the conductive enclosure of the medical equipment in question, exposing the user or patient to a small level of current. While there are greatly increased figures for earth leakage current in the new standard, this additional current is now confined to the earth continuity conductor of the product. This, of course, has significant implications for the design of many active medical devices that have been used for years – representing a massive re-design investment for manufacturers that want to keep selling their product. On the positive side, this increased earth leakage current allowance allows the use of more substantial mains interference filters.

Mechanical hazard protection has also been expanded significantly. This now covers 'trapping points', which had not been taken into consideration before. However, this makes perfect sense when you consider that equipment is used to manage patients, rather than directly treat them. If they are not thoroughly tested for hazards beyond electric shock, they may still cause harm to the patient. This means that when designing equipment such as dentist chairs and patient hoists, more detailed mechanical safety checks must now be conducted.

For the first time there is also a requirement for batteries and battery charging circuits.

Best advice would be to use one within the product that already carries a certificate that proves that it complies with 60601. If you don't use such battery components then they will require additional testing under this new standard. This can be a lengthy and expensive process as the batteries must be proved safe under all possible environmental considerations in which the device may be used across its expected working life. Such tests must also cover the full range of safety tests such as misuse, temperature, orientation, ingress of fluids etc.

The risk management file may indicate that batteries may be left idle for long periods of time. If so, this must be taken into account during the design. This would apply to systems such as Automatic External Defibrillation units that are stored in shopping centres, where users need assurance that it will work on the rare occasion it is needed. The same might apply to a battery operated relief kit for asthmatics.

More Hoops

While the new standard may be viewed by designers of medical equipment as yet another hoop to jump through, it is intended to keep pace with a rapidly changing technological world. Applying standards created more than thirty years ago would be pointless and not protect the manufacturers, end-user or patient.

The good news for those people tasked with designing such equipment is that the Third Edition of the standard includes extremely extensive explanatory material. This will of course give designers and testers an increased insight into the rationale behind clauses and, therefore, a more comprehensive understanding of the requirements.

Where Do You Stand?

As with the older standards, the Third Edition of the medical electrical equipment standard (IEC 60601-1:2005) has a number of 'Part 2's. This creates more complexity as Part 1 is published, but there are a number of Part 2 standards which have not yet been updated to relate to the Third Edition of Part 1.

Part 1 covers all medical electrical products and their electronic components. The Part 2 standards consist of 50 plus categories of specific products and their intended use e.g. operating tables, electro-surgical equipment and incubators. This will allow the general requirements under Part 1 to be varied according to the specific use of a product, e.g. Part 1 states that a product must not apply heat directly to a patient, but for some products this will be part of their intended use, so the Part 1 standard is varied accordingly.

Part 1 of the Third Edition is complete and harmonised now, but many Part 2 standards still need to be brought into line with the Third Edition and this will take some time. If a Third Edition Part 2 standard is currently unavailable for your product, best advice would be to continue with compliance to the current standards (Second Edition Parts 1 and 2), becoming familiar with the Third Edition of Part 1. Then start designing products to the Part 2 specification of the Third Edition as soon as it is available.

While getting to grips with these significant changes when designing active medical devices may take some effort now, it will prove to be a good return on investment. For those who leave it too close to 2012 to have their products tested against the new standard, they will find that test houses will be booked solid as the deadline approaches. If your product isn't approved in time, it will have to be withdrawn from the market until tests are completed. Invest in appropriate re-designs now and have them tested against the new standard to reap rewards further down the line. ■

SECURITY – Paramount Importance for Medical Systems

Figure 1: *Security risks are only now being recognised as a key part of system performance in medical equipment*

SECURITY IS BECOMING an increasingly vital part of the design of medical equipment. Engineers have long been expert in providing highly reliable, mission-critical and even life-critical real-time systems for use in hospitals. However, changes in regulations, pressure on design time and cost, and the increasing use of networking are creating a fundamental change in the industry.

As more systems are networked, intrusion and malware are exponentially increasing. This will only get worse as more emphasis is placed on the vision for connected health, driven by the Continua Health Alliance, an international nonprofit coalition of more than 200 health-care and technology companies aiming to improve home health care.

Under pressure from global competition, communication among remote medical devices using standard communication services is the new reality. This is partly accompanied by the move to commercial off-the-shelf (COTS) hardware and software, to reduce the time and cost of development, coupled with the need to protect the significant investment in legacy software. However, security risks are only now being recognised as a key part of system performance.

This has huge liability issues for doctors, hospitals, equipment providers and insurers. Remote monitoring and external access to systems will greatly increase the opportunity for attack and therefore risk the safety of all kinds of medical equipment.

While devices may be certified to medical equipment standards for reliability, these standards do not take security into account enough. Once a system is compromised, it is no longer safe, which creates a huge issue for hardware and software developers and their managers.

Intrusion and Malware

In addition to the rise in networking, one of the main reasons for added security risks is the increasing use of personal computing technology, not just in back-office systems

Changes in regulations, pressure on design time and cost, and an increasing use of networking are placing greater pressure on medical system development engineers. By **Alexander Damisch**, Business Development for Industrial & Medical at Wind River

but also in front-line medical systems. While this provides lower-cost hardware and software components and a wealth of developer skills, it increasingly opens up equipment to attack.

For example, health care companies in the United States saw an average of 13,400 attacks per day at the end of 2009, according to SecureWorks, a provider of managed security services. This is more than double the average of 6,500 during the first nine months of the year.

Some of these attacks are aimed at billing systems to get credit card information, names and social security information, while others are automated attacks from malware, such as the Butterfly or Mariposa bots that infect computers via a network and from USB sticks. It can be used to harvest data from victims' browsers, such as passwords, and to launch denial-of-service attacks that easily spread throughout the network.

To prevent the stealing and potential tampering of data, the US Food and Drug Administration (FDA) recommends using the FIPS 140 encryption requirements standard to strongly encrypt sensitive information. This standard requires a combination of encrypted communication, with implications to both the operating system and, depending on the security level required, hardware.

Malware attacks are costly. For example, in late 2009, three London hospitals were forced to shut down their computer networks and re-route ambulances, risking lives, because of malware known as the Mytob worm. It infected 4,700 computers, forcing some doctors to revert to pencil and paper, and took three days to restore and another two weeks to eradicate.

Furthermore, attacks do not just affect administration systems. A UK hospital in the Sheffield Teaching Hospitals NHS Trust found that the computers in its operating theatre – those that ran the camera and imaging systems – rebooted in the middle of a surgery after becoming infected with the Conficker B self-replicating worm. Information technology managers turned off the antivirus software to deal with the problem and then another 800 PCs in the Trust became infected.

Attacks are not the only problem. In April 2010, a flawed update from antivirus software provider McAfee caused machines running Windows XP to reboot every 60 seconds, creating havoc in hospitals and police stations around the UK.

Embedded Issues

While security may appear to be an enterprise issue, solved with firewalls and antivirus software, it is in fact a safety issue to be considered as part of the certification and approval of medical systems. If a system is not secure, it can be compromised; and if it is compromised it is not safe. This has huge implications for managing any liability for failure of the equipment.

The plain and unfortunate fact is that the majority of FDA-approved devices that fail in the aftermarket mainly fail through faults in the software, even without considering security issues. This is a difficult situation for both engineering and management.

For management in the UK, there are now heavy personal, financial and even custodial penalties of corporate manslaughter if medical devices fail in the field, not to mention cost to the company through liability and reputation. Engineering departments can find it difficult to "prove" there are no faults to the satisfaction of

Figure 2: *Emphasis is placed on the vision for connected health, driven by the Continua Health Alliance, an international non-profit coalition of more than 200 health care and technology companies aiming to improve home health care*

executives facing these potential penalties.

There are also new standards to follow, such as IEC 62304, a subset of the IEC 61508 standards. While 61508 makes reference to security, there are no specified standards, so designers do not know how to "prove" that the equipment is safe and secure. In the meantime, there are other standards from other areas such as ISA99 or FIPS 140-2/3 encryption that provide a good framework to make any system, not just medical equipment, more secure.

Time and Space Separation

One way to tackle this problem is from an architectural level. Time and space separation is a technique that has become widely established in safety-critical aerospace applications. Fortunately the advent of a new generation of multi-core processors in the embedded space means that it is also becoming practical and cost-effective for the medical market.

By using a lightweight, secure separation kernel, applications can be kept in separate partitions that do not interfere. This means if one application is compromised, it does not infect other applications in the same system or others in other systems. The beauty of this approach is that these applications can be anything: blocks in the operating system, drivers and system utilities, whole operating systems, or user applications.

This allows vulnerable operating systems such as Windows to run on processors – either single or multi-core – at the heart of the medical equipment in a secure partition away from other parts of the system. This protects the substantial existing investment in legacy code while at the same time limiting the opportunities for and consequences of an attack.

If the Windows operating system is compromised, it does not then affect the operation of the device, nor does it infect other equipment on the network. The kernel is small and light and as secure as possible, controlling access to each of the partitions. Each of these can have its own "mini-firewall", controlling access, plus there can even be partitions that monitor other partitions for infections.

This means containing one key vulnerability, in particular, the network stack. With a separation kernel, the stack can be kept in a separate partition with careful access control to prevent unauthorised access. This prevents any infection from spreading regardless of the source.

But there are other vulnerabilities, such as the memory subsystem. Using a scheduler to keep tasks separate is not enough because it can share memory space and even cache lines. Newer processors with direct memory access (DMA) engines can also move data around the memory space without the processor knowing, potentially allowing malware to break through partition boundaries and making the system vulnerable.

However, one of the issues is demonstrating that such designs comply with required standards and, perhaps more difficult still, that they can achieve approval through the regulatory body.

Process

The best approach to this problem is to follow a set of established standards and a proven procedure. With the right software framework, this can be coupled with certification artefacts that provide substantial resources to exhaustively test.

These certification artefacts are the documentation for well-proven, thoroughly tested software components such as Wind River VxWorks, according to a well-defined and adopted standard, such as the IEC 61508, or the derived ISO 62304 for medical device software. No software can be certified "out of the box" because it depends on the system's environment, hardware and connectivity. Therefore, the certification artefacts are generated in the context of a real hardware. Using these artefacts dramatically reduces the time to test and certify the system and provides reassurance that the code is fully covered.

This framework is costly and time-consuming to set up from scratch but is a key reason for adopting some commercial off-the-shelf software. This is often based around real-time operating systems and provides many man-years of experience in both safety and security across a wide range of industry sectors, including demanding markets such as military and aerospace.

This brings high levels of security expertise to bear for medical designs, while also providing assurance to the regulator that an established procedure has been followed to minimise risk.

The move to COTS hardware and software is a benefit for engineers in both safety and security, provided system-level issues are taken into account at the architectural level. As more and more medical equipment is networked, security threats will become more prevalent. With networked PCs now used in the operating theatre, protecting these systems and ensuring their safe operation is more vital than ever.

This can be tackled in several ways:

- Leverage time and space partitioning to provide multiple levels of security. Keeping secure portions of the system separate from non-secure partitions ensures the correct, secure and safe operations of safety critical components.
- The operating system has to be based on a full analysis of the complexity of the application, including both safety and security issues.
- If the application is mission-critical, there is the choice of using a previously certified OS or insuring the certifiability of the software through formal development methods.
- For a non-certified operating system, making use of field-proven software that has been successful in millions of devices reduces the risk.
- The operating system should be compatible with development tools that provide audit trails and documentation for requirements management and software control management tools.
- Ensure any product that is transmitting patient data in any way uses encryption, even over an internal network.

Without clear guidance on specific requirements, the best ways to avoid problems in certification is to follow the best practices for software development, ensuring that the design will fall within the requirements of the Drug and Medical Device Accountability Act and the FDA in the United States and IEC 62304 in Europe. In this way, medical devices can be developed and deployed with confidence for the manufacturer, the hospital, the regulator and the patient. ■

The Design of E-band MMIC AMPLIFIERS

Liam Devlin, Stuart Glynn, Graham Pearson and **Andy Dearn** from Essex-based Plextek in this article address the design and implementation of E-band MMIC amplifiers and consider the process selection, design challenges and practical approaches, as well as present the measured and modelled performance of a single-stage E-band gain block

THE WORLDWIDE availability of a large amount of spectrum at 71-76GHz and 81-86GHz – commonly known as "E-band" – for high data-rate wireless links has led to substantial interest. The open access to such large amounts of spectrum directly leads to high demand for point-to-point links, providing they can be realised at a suitable cost.

The availability of E-band components is currently very limited and the unit cost is far higher than that required to allow the realisation of low cost, commercial E-band links. However, the development of custom E-band GaAs MMICs offers a route to significantly reducing component costs and allowing the production of large quantities of E-band electronics at an adequately low cost.

This article discusses the challenges of designing E-band MMICs. It covers process selection, design techniques and practical approaches and presents the measured and modelled performance of a demonstrator circuit, a single-stage E-band gain block.

Process Selection

The first consideration when choosing a process is to find a commercially available, qualified process that can offer useful gain across the E-band frequency range. Three categories of process have been identified that meet this initial requirement:

- 0.15µm or 0.13µm gate length Pseudomorphic High Electron Mobility Transistor (PHEMT).
- 0.15µm gate length Metamorphic HEMT (MHEMT).
- 0.1µm gate length PHEMT.

Although CMOS and SiGe processes with transistors having high enough Ft to provide gain at E-band are also available, the GaAs processes above offer better NF and linearity. Acceptable NF and adequate linearity are essential requirements for point-to-point links and the processes identified are most suited to providing this. GaAs processes also have the advantages of a semi-insulating substrate and low inductance through substrate vias, making higher levels of RF integration easier to achieve.

As the total gate width increases (more gate fingers and/or wider unit gate width), the parasitic effects increase (e.g. gate inductance and phase delay between gate fingers). This reduces the available high frequency gain of the transistors. Essentially on any given process the maximum useful device size is limited. Beyond this size the device does not provide an adequate level of gain for practical implementation of circuit functions (6dB is considered as the practical minimum). This is discussed in more detail later on.

The most difficult requirement to satisfy when designing E-band amplifiers is output power capability/linearity. The maximum practical transistor sizes on the commercially available 0.15µm or 0.13µm gate length PHEMT processes results in relatively modest output power capability.

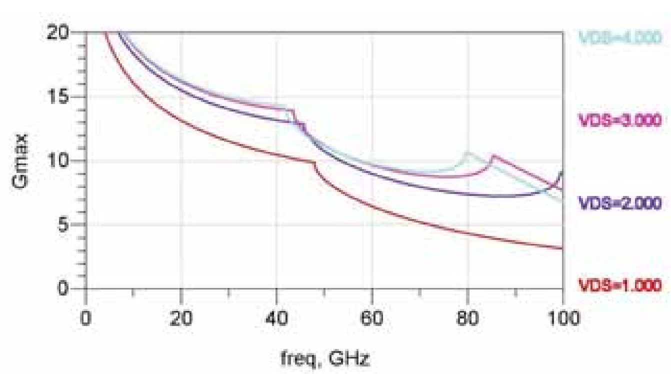


Figure 1: *Simulated Gmax and NFmin for different Vds values (2 x 50µm transistor)*

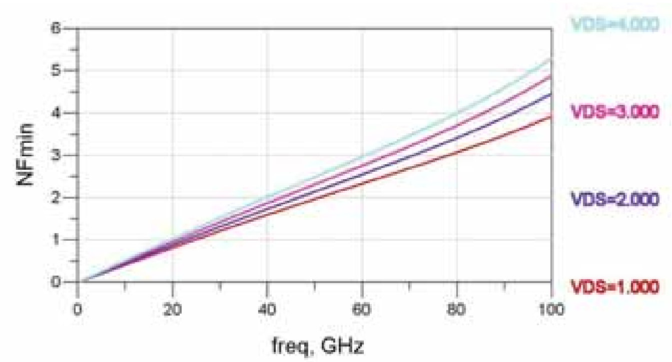


Figure 2: *Simulated Gmax and NFmin for different Ids bias (2 x 50µm transistor at 3V Vds)*

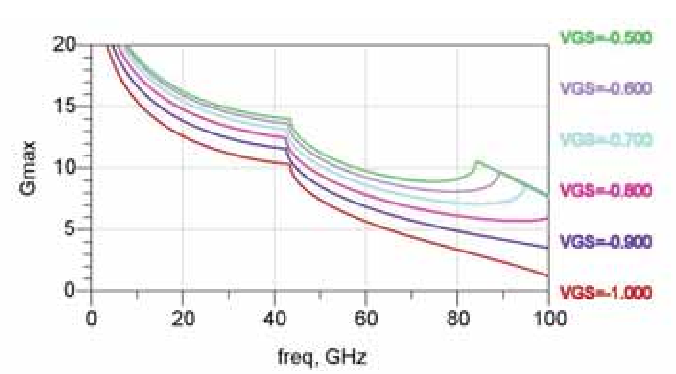


Figure 3: *Simulated Gmax and NFmin for different unit gate widths (biased at 3V Vds, 40% Idss)*

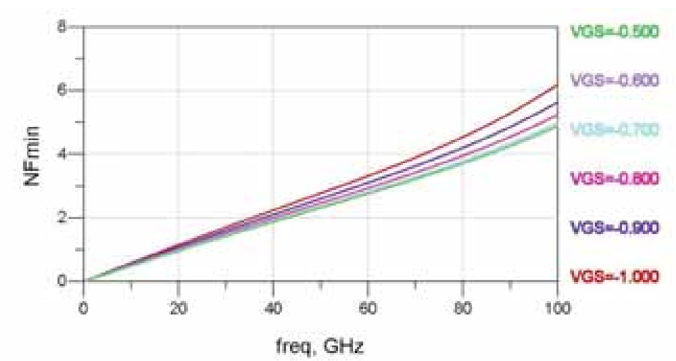


Figure 4: *Simulated Gmax and NFmin for different number gate fingers (biased at 3V Vds, 40% Idss)*

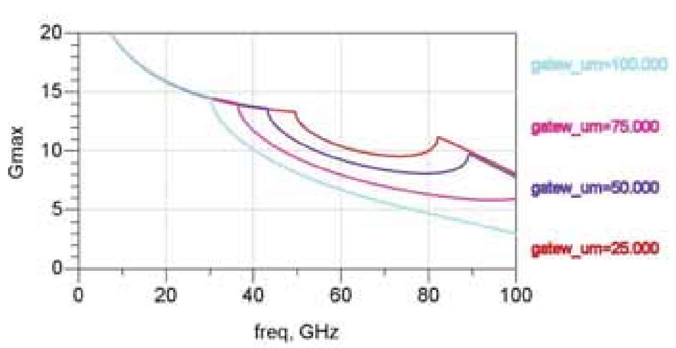


Figure 5: *Simulated Gmax and NFmin for 2 x 39μm transistor biased at 2.7V Vds, 30% Idss*

Whilst increasing the output power by combining multiple devices is obviously a possibility more gain is required to overcome the additional losses of the combiner networks. Increasing device count to achieve higher output power is thus a process of diminishing returns.

MHEMT processes offer more gain and slightly lower minimum Noise Figure (NF) than PHEMT processes of the same gate length. However, their power density (output power per mm of gate width) is lower than for PHEMT processes and they are less suitable for the realisation of amplifiers requiring higher linearity or output power. Of today's commercially available GaAs processes the most appropriate choice for output power and linearity is the 0.1μm gate length PHEMT.

Another process feature that needs to be considered is substrate height (thickness). Most commercially available GaAs processes have a substrate thickness of 100μm. However some processes are available with a thinner substrate thickness of 50μm, which provides performance advantage at E-band.

The advantage stems from the reduced via inductance inherent in the thinner substrate. The via inductance acts as series inductive feedback around the transistor and with larger transistor sizes this can degrade stability. This effect becomes more pronounced with increasing transistor size. This means that, whilst the transistor might have higher "Maximum Available Gain" (MAG), the losses that must be introduced to ensure unconditional stability can reduce the practical gain that can be achieved to below the 6dB practical limit. This is discussed in more detail in the "Design Challenges" section in this article. A thinner substrate is, therefore, preferred for optimum realisation of E-band amplifiers.

With a 0.1μm gate length PHEMT having adequate breakdown voltage and a 50μm substrate height, it is estimated that an E-band amplifier with an IP3 of +34dBm would be practical. For optimum performance it is believed that separate design would be appropriate for the 71-76GHz and 81-86GHz bands.

The demonstrator amplifier described in this article was realised on the 0.15μm gate length power PHEMT process of WIN Semiconductor (PP15-20). This was selected purely on convenience, as space was available on a process run being undertaken primarily for different purposes. The process can be used for realising E-band amplifiers but is not necessarily the optimum choice.

Design Challenges and Approaches

Once the process has been selected, detailed investigations into the design can commence. The example amplifier discussed in this article was designed on the 0.15μm gate length Power PHEMT (PP15-20) process of WIN Semiconductors. This process is not suitable for particularly high output power or linearity at E-band. However, it is able to provide a useful level of gain and a process run was available on which to fabricate a demonstrator circuit.

The available gain of the PP15-20 transistors at E-band is marginal for the effective realisation of amplifiers. Care must be taken with selection of device size and bias point if the available

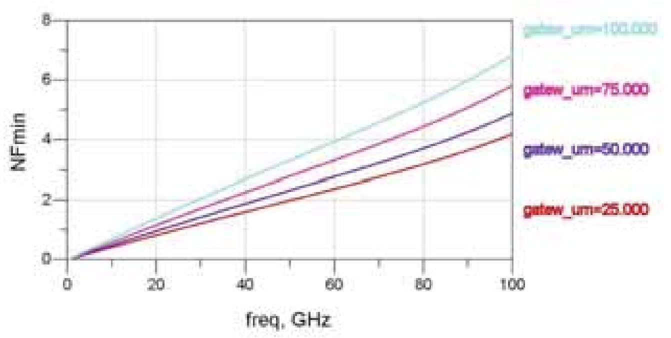


Figure 6: *Schematic of single stage E-band amplifier (ideal matching components)*

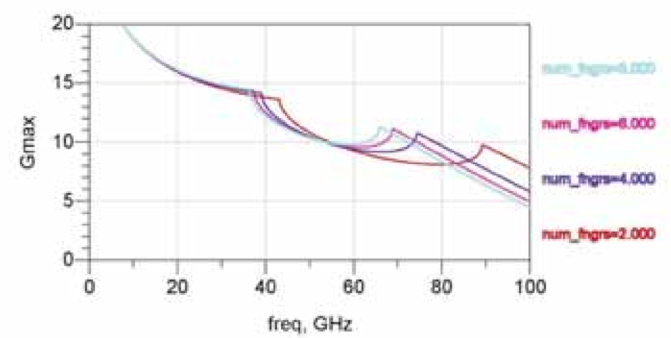


Figure 7: *Simulated s-parameters of single stage E-band amplifier (ideal matching components)*

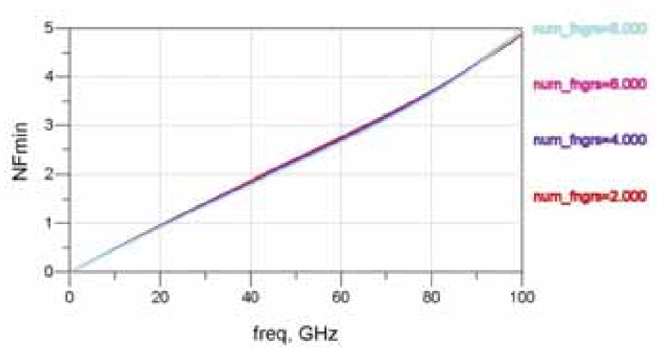


Figure 8: *Input impedance of MIM capacitor and ground via compared to radial stub*

gain is to be kept above the 6dB level that is considered the lower limit for practical circuit implementation. In order to choose the most appropriate bias point the effect of Vds bias on gain was evaluated.

Figure 1 shows the effect of drain-source bias voltage (Vds) on maximum available gain (Gmax) and minimum NF for a fixed device size (2 x 50μm). It is clear that using a lower Vds results in lower NF. The effect of Vds on gain is modest above around 2.5V. Below this the available gain reduces with Vds.

The shape of the Gmax curves is also of interest. The kink in the response at around 48GHz marks the point at which the transistor transitions from being conditionally stable (K<1) to being unconditionally stable (K>1). At lower frequencies, where the device is only conditionally stable, Gmax cannot be determined and the gain response plotted is actually the MSG (Maximum Stable Gain). The MSG is a figure of merit that cannot be realised. If operated in this region some gain must be sacrificed to stabilise the transistor. By contrast, other than an allowance for the losses of matching components, something close to the Gmax can be achieved when the transistor is unconditionally stable.

The transition from a region of conditional stability at lower frequencies to a region of unconditional stability at higher frequencies is a well understood phenomenon. It happens because the gain of the transistor reduces with increasing frequency and eventually becomes low enough to ensure that the device is unconditionally stable. However, the gain curves of Figure 1 have another kink at or just above 80GHz (depending on Vds) where the transistor reverts back to being conditionally stable (or potentially unstable).

This occurs because the reverse isolation is reducing with increasing frequency (feedback is increasing). It only tends to happen in short gate length devices that have gain to very high frequencies. If processes are available on thinner substrate heights, the grounding inductance for the transistor is reduced and the stability at high frequencies is improved. If a 3V or lower Vds is selected, the transistor is unconditionally stable across the entire of the E-band frequency range, which is an attractive feature.

Care must be taken if it is decided to select a transistor that is only conditionally stable in the band of interest. Additional MSG beyond the 6dB Gmax limit quoted earlier must be available to allow for the required gain sacrifice in stabilising the transistor.

The choice of Vds bias is obviously a compromise between linearity, NF, stability and available gain. This compromise must be reassessed once the choice of device size has been made as it is device size dependent. For the demonstrator amplifier presented here, a 3V supply was selected with the transistor itself operating from a 2.7V Vds. Drain line resistors were included for out-of-band stabilisation (discussed in more detail later) and these were used to drop the 3V supply to the 2.7V level.

The Ids Bias Consideration

The next consideration is Ids bias. A 50% Idss bias (approximately -0.5V Vgs on the PP15-20 process) is the traditional class A bias point. **Figure 2** shows the Gmax and NFmin for a 2 x 50μm transistor, biased at 3V Vds, as the Vgs is changed between -0.5V and -1V (approximately 50% and 20% Idss). Reduced current bias results in reduced Gmax and improved high frequency stability. A bias of 30% Idss (approximately -0.7V Vgs) was selected. It should be noted that there is some variation in typical Vgs with device size for a percentage Idss bias.

Having selected the device bias the next step is to select the device size. At E-band the challenge is to maximise the device size that can be used whilst retaining adequate available gain. **Figure 3**

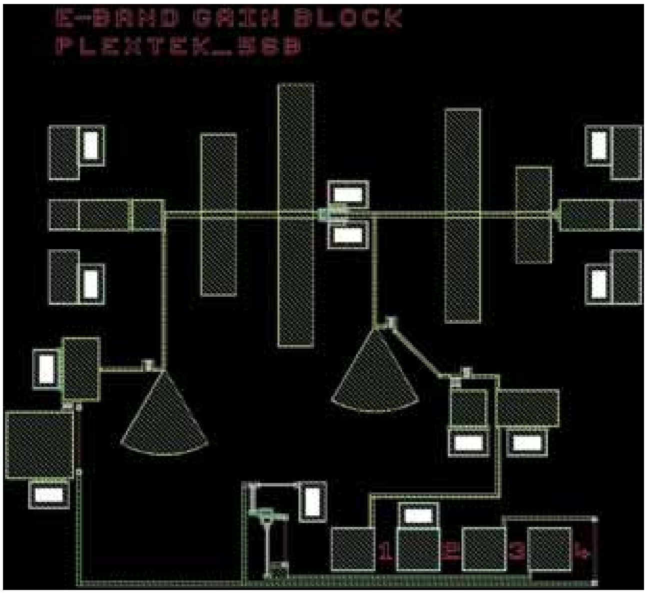


Figure 9: *Layout of the E-band demonstrator amplifier*

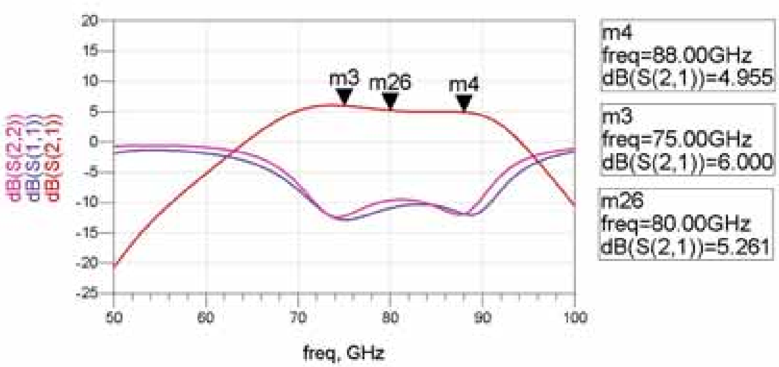


Figure 10: *Simulated s-parameters of the single stage E-band amplifier (circuit simulation only, no EM)*

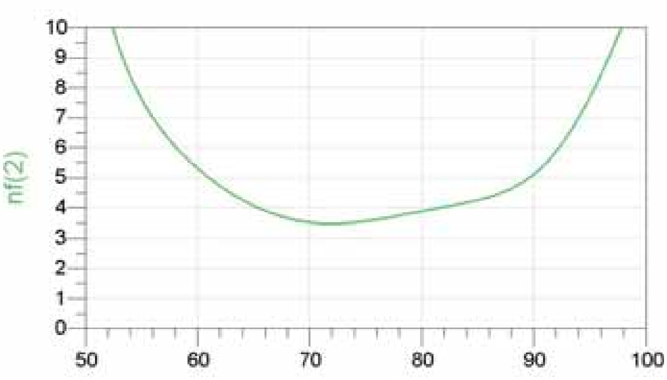


Figure 11: *Simulated NF of the single stage E-band amplifier (circuit simulation only, no EM)*

shows the Gmax and NFmin for various unit gate widths (two finger devices). **Figure 4** shows the available gain and NFmin for various numbers of gate fingers (unit gate width fixed at 50μm).

In all cases, the transistors are biased at 3V Vds and 40% Idss. It is clear that increasing unit gate width decreases available gain and increases NFmin. Gain decreases because of distributed/parasitic effects and NFmin increases because of increased gate resistance. The most significant effect of increasing the number of fingers is to reduce the frequency at which the transistor reverts to a region of potential instability. Whilst it may appear that more device fingers offers the potential for additional gain, this is unlikely to be the case once unconditional in-band stability is assured. For the demonstrator amplifier a 2 x 39μm device size was selected.

The Gmax and NFmin of the selected 2 x 39μm transistor biased at 2.7V Vds and 30% Idss is plotted in **Figure 5**. It can be seen that unconditional stability is exhibited across the entire of E-band. Potential instability is apparent above and below the operating band and the amplifier design must incorporate circuitry to ensure stability in this region. It can also be seen that the Gmax across E-band is only around 7dB. The amplifier design process is, thus, essentially an exercise in conjugately matching the transistor at input and output (and injecting the DC bias) whilst incurring as little loss as possible. Techniques such as matching for improved NF and linearity would cost gain and are luxuries that can only be considered at lower frequencies. This is essentially the case for all current commercially available processes capable of E-band operation.

In addition to implementing simultaneous conjugate impedance matching at input and output, DC bias must also be injected. The bias networks can also be configured to provide losses above and below the operating band that ensure unconditional stability for the resulting amplifier at all frequencies.

The first step in the design process was to implement the design using ideal components. **Figure 6** shows the circuit schematic of the initial ideal component based design. Both input and output matching networks are essentially low pass structures. Series capacitors were also included for DC blocking but were optimised in value during the design process. At this stage the drain and gate bias chokes (L3 and L6) were ideal RF blocks.

The simulated s-parameters of the amplifier with ideal matching components are shown in **Figure 7**. The next step was to determine how the ideal components could be implemented practically and to simulate the resulting performance.

The series inductors of the ideal implementation of **Figure 9** are easily realised as short lengths of high impedance transmission lines. The inductor values are small and the required transmission line equivalents are very practical. The series capacitors are also easily realised as standard MIM (Metal Insulator Metal) structures.

Figure 12: *Simulated P-1dB of the single stage E-band amplifier (circuit simulation only, no EM)*

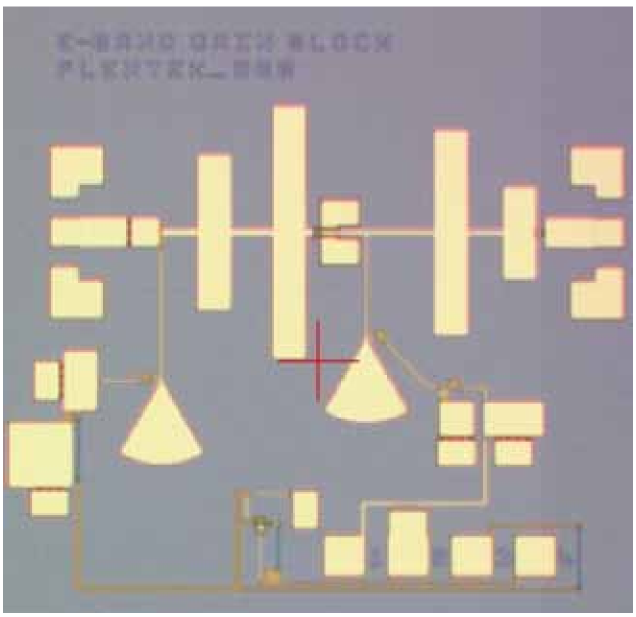


Figure 13: *Photograph of the E-band amplifier*

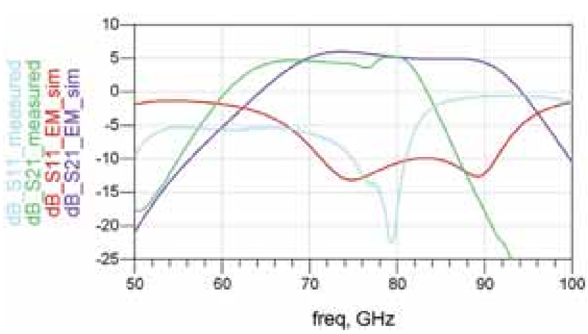


Figure 14: *Measured versus original circuit simulated S21 and S11 for the single stage E-band amplifier*

Whilst the shunt capacitors could also be realised as MIM capacitors, the inductance of the through substrate vias is significant at E-band (20pH is 10Ω reactive at 80GHz) and has a considerable impact on the value of the shunt matching capacitors. When ideal capacitors and perfect grounding are used in the simulation (Figure 7) the largest value shunt capacitor is just 0.292pF.

Allowing for the inductance of the vias reduces this and incorporating practical models for the MIM capacitors reduces it further to just 0.0654pF, which is just 9μm square. The concern was that variation in via inductance and capacitor size (value) with process spread could significantly modify the effective capacitance value. The approach used to address this problem was to realise the shunt capacitors (C2, C3, C6 and C7) as distributed transmission line structures (open circuit shunt stubs behave as capacitors at frequencies where their electrical length is less than λ/4).

The bias chokes used at gate and drain (L3 and L7 in Figure 6) were realised as high impedance shunt stubs of nominal length λ/4. The E-band short-circuit (realised using grounding capacitors C4 and C9) would thus be transformed to an open-circuit at the RF path. Bias can therefore be injected at the end of the λ/4 line without affecting the E-band performance of the amplifier. It is also convenient to use the bias networks at gate and drain to stabilise the transistor below band.

Any transistor with available gain at E-band has substantial gain at lower RF frequencies and below. Resistors and lower frequency de-coupling can be introduced at the end of the bias stub to stabilise the transistor at lower frequencies. The stabilisation components are included in the schematic of Figure 6 (R1 and C5 at the gate side; R2 and C10 at the drain side).

The difficulty with implementing the bias network at E-band is that the MIM capacitor and via at the end of the bias stub does not provide a particularly good short circuit. The inductance of the via and the electrical length of the MIM capacitors means that even a modest capacitor size, such as 0.5pF, looks inductive at E-band.

The Demonstrator Amplifier

An alternative approach that can be considered is to use a radial stub to realise a short circuit across the 71 to 86GHz frequency range. **Figure 8** is a plot of the input impedance of a radial stub (green trace) and three values of MIM capacitor and ground (0.5pF, 1pF and 2pF). It can be seen that the radial stub provides a good short circuit at 80GHz whereas the MIM capacitors and vias all look inductive.

Whilst it is possible to reduce the length of the λ/4 bias stub so that the capacitors are open circuit at the amplifier, the fact that they do not provide a good short-circuit at E-band means that the bias components (including the lower frequency stabilising components) can affect the in-band performance and reduce the gain slightly. Whilst this would not be a problem at lower mm-wave frequencies, at E-band the available gain is marginal and every effort must be made to avoid reducing it. It was, therefore, decided to implement the demonstrator amplifier with radial stubs for the

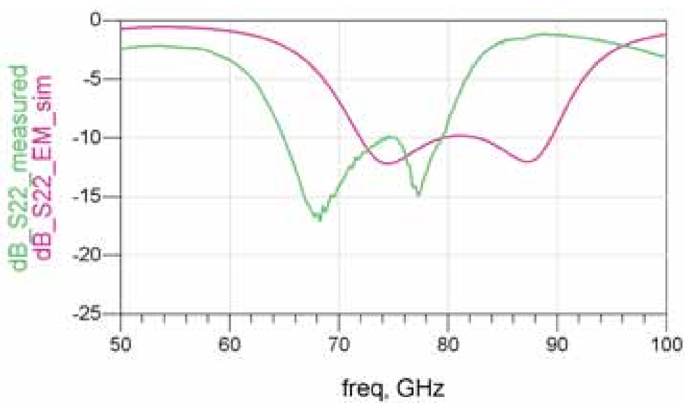


Figure 15: *Measured versus original circuit simulated S22 for the single stage E-band amplifier*

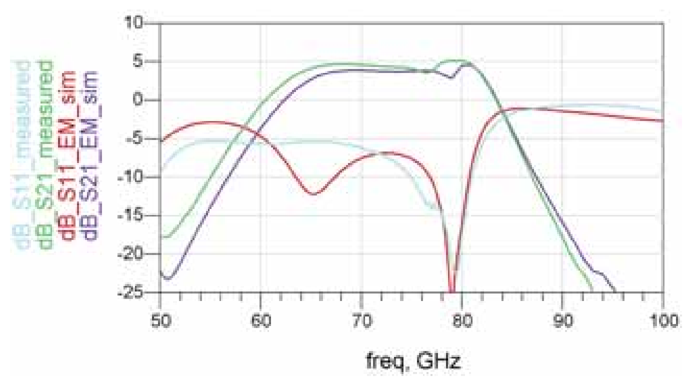


Figure 16: *Measured versus original circuit simulated S21 and S11 for the single stage E-band amplifier*

bias grounds. The resulting layout of the demonstrator amplifier is shown in Figure 9.

The demonstrator amplifier includes G-S-G pads for RFOW probing. An on-chip active bias network is included to generate the required Vgs from a fixed -3V supply. The use of active biasing provides improved unit to unit repeatability and reduced performance variation with temperature. Four DC pads are included, the +3V amplifier bias, the -3V supply to the active bias network, a pad to sample the gate voltage generated by the active bias network and a ground to allow convenient off-chip de-coupling during RFOW test.

The ideal components in the initial design were gradually replaced by practical component models. The final circuit simulated s-parameters are plotted in **Figure 10**. This simulation includes transmission line and MIM capacitor models and models for all tee and cross-junction discontinuities. A gain of around 5dB is achieved with terminal matches of around 10dB. The drain current was 11mA. Optimising over a narrower bandwidth would allow improved matches and slightly higher gain.

Although it is essential to EM simulate designs operating at such high frequencies, the timescale for the tapeout of the available mask set did not allow this and so all pre-fabrication simulation was based on circuit simulations only and no EM simulation was undertaken prior to tapeout.

The simulated NF of the demonstrator amplifier is shown in

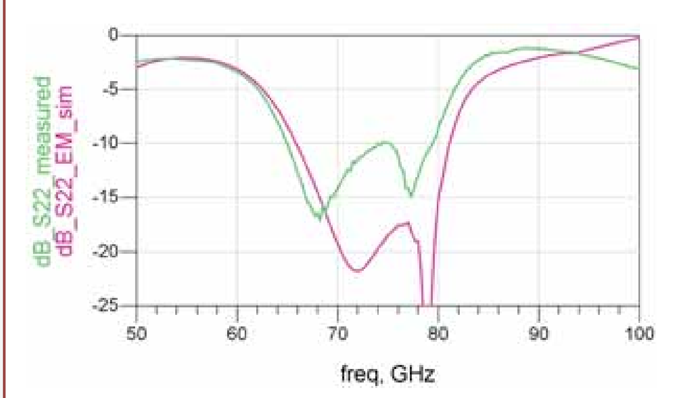


Figure 17: *Measured versus original circuit simulated S22 for the single stage E-band amplifier*

Figure 11 and is around 3.6dB at 71GHz rising to 4.3dB at 86GHz. The simulated 1dB gain compressed output power is plotted against frequency in **Figure 12**.

At around 10dBm the power compression (and so linearity) of the amplifier is modest. It is believed that a design offering a little more power could be possible on this process but this is likely to be at the expense of gain. The maximum practical P-1dB from a single-chip E-band amplifier designed on this process is expected to be around 18dBm. This would utilise multiple power combined transistors. However, this approach provides diminishing returns as the combiner/matching networks further reduce the already modest gain.

Realisation and Measured Performance

The amplifier was fabricated on the PP15-20, 0.15μm gate length PHEMT process of WIN Semiconductor. It was realised as a sub-circuit within an array targeting a different application. As such it was only suitable for RFOW evaluation and is not available as a stand-alone die. A photograph of one of the E-band amplifiers is shown in **Figure 13**.

The s-parameters of the demonstrator amplifier have been measured and are plotted against the original circuit simulated performance in **Figure 14** and **Figure 15**.

As would be expected, there is a modest reduction in gain and a drop in frequency of the overall response, particularly at the high end of the band. These effects can be adequately simulated and accounted for with detailed EM simulations.

Despite these differences, the agreement between circuit simulated and measured performance is reasonable and indicates that the foundry models are adequate for design at E-band.

Post Realisation EM Simulated Performance

Following fabrication and measurement a detailed EM simulation of the design was undertaken. The EM simulated s-parameters of the demonstrator amplifier are plotted against the measured performance in **Figure 16** and **Figure 17**. It can be seen, as would be expected, that the agreement with measured performance is considerably closer than for the circuit simulated performance. In particular the prediction of high frequency gain roll-off is very close. This indicates that there is a viable route to designing and simulating E-band circuits. ■

ZERO CROSSING DETECTOR

THE CIRCUIT HERE is that of a zero crossing detector. The circuit diagram is depicted in **Figure 1**. The circuit is powered from the mains.

The circuit was made and simulated in the TINA software. The intention was to make a zero crossing detector for Triac control.

The output was available in two formats, one was on the emitter of final transistor and the other output was for use with the internal comparator provided in modern microcontrollers. The circuit is straight forward.

R1, C1, R3, C2 and D1, D2, D3, D4 and R5, Z1, C3 produce the DC voltage. T1, T2 form the comparator type circuit. The full wave at base T1 and the reference DC at base of T2 produce the differential pulsating DC at the collector of T2. This is then converted to output pulses across R11.

The waveforms are shown in **Figures 2-7**. ■

Jayant Kathe
ERTL,
Mumbai,

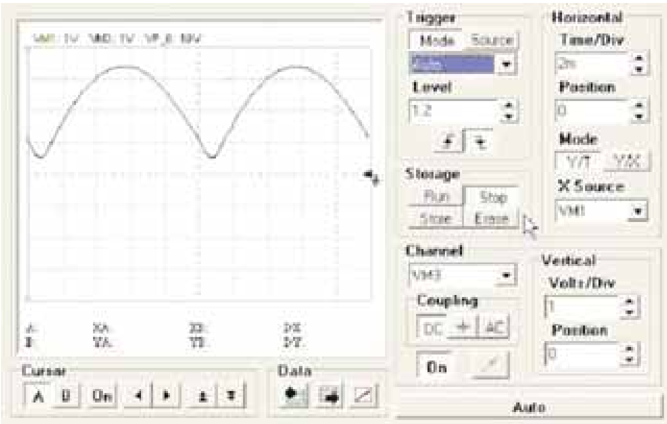


Figure 1: *Full wave across bridge*

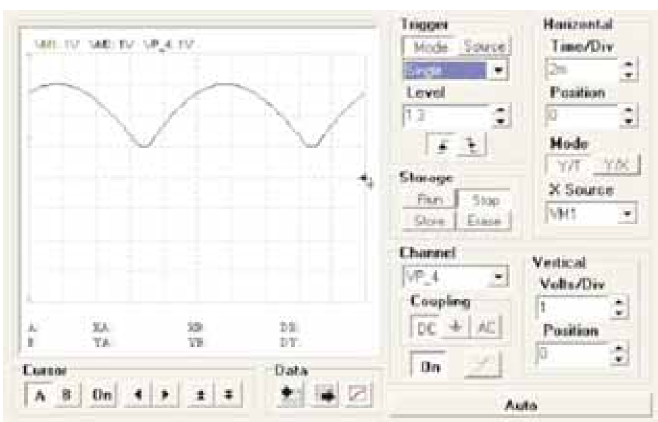


Figure 2: *Base of transistor T1*

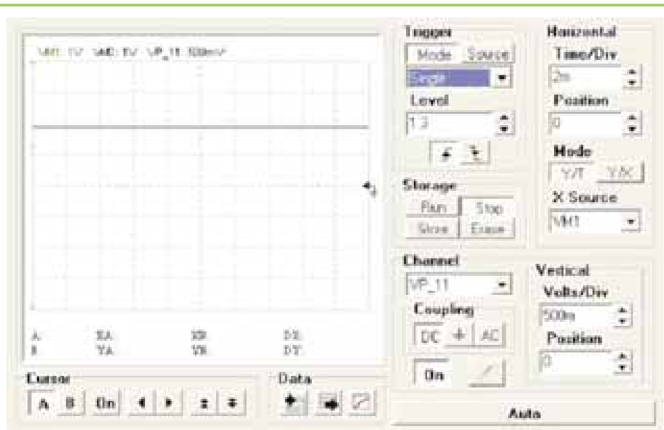


Figure 3: *DC voltage at base of transistor T2*

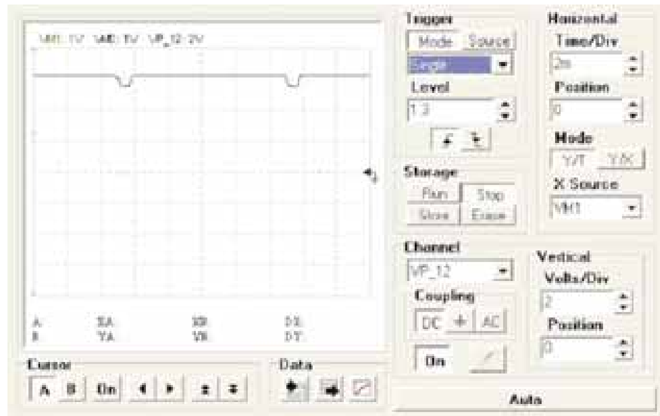


Figure 4: *DC voltage at base of transistor T3*

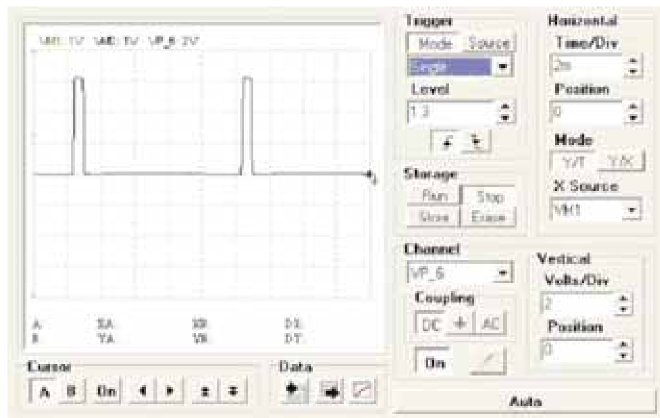


Figure 5: *DC voltage at emitter of transistor T3*

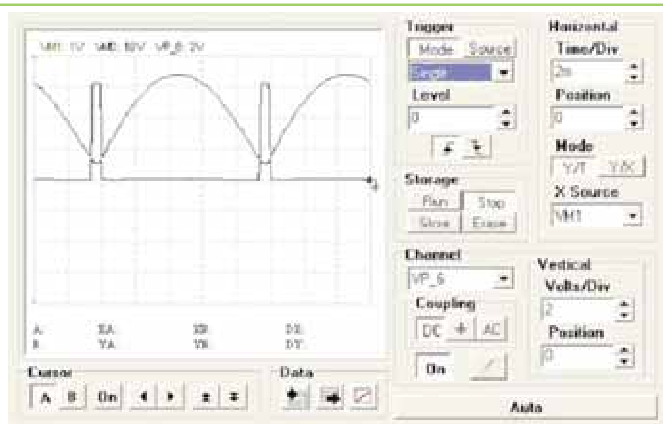


Figure 6: *Combine waveform*

COM EXPRESS COMPATIBLE ULTRA COMPUTER-ON-MODULE WITH THE INTEL ATOM PROCESSOR E6XX SERIES

The launch of the Kontron Computer-On-Module nanoETXexpress-TT brings four major innovations to the market, available in one single product. In addition to being Kontron's first ultra small form-factor COM Express compatible module (55mm x 84mm) with the new Intel Atom processor E6XX, it is also equipped with the newly defined PICMG COM Express Type 10 pin-out that was added to the COM.0 R2.0 specification.

With industrial grade components, functional in the range (E2) -40 to +85degC and different options for data storage, it is ideal for use in harsh environments and, thus, complements the existing portfolio perfectly.

Finally, the nanoETXexpress COM family gains four new members broadening the scalability from 600MHz to 1.6GHz and throughout the industrial-grade temperature range.

The nanoETXexpress form-factor is very attractive for developers of small devices who want to rely on the high level of standardization and the high scalability of the COM Express specification.

www.kontron.com

INTERCHANGEABLE (RT CURVE MATCHED) NTC THERMISTORS

ATC Semitec now stock a full range of SP series interchangeable NTC thermistors that offers very high precision (±0.2°C 0~70C or better) at significantly lower pricing to that of existing interchangeable NTCs.

This allows a wider range of users to achieve more accurate temperature control and, thus, more energy-efficient and comfortable working environments.

The chief features of the SP range are as follows:

R25 Values : From 1kΩ to 100kΩ
Accuracy : ±0.2K from 0°C~70°C
Temperature Range : -40°C/+150°C
Fast Response : 2.6mm Bead Size

Evaluation samples and ex-stock pricing are available.

www.atcsemitec.co.uk

CODED ENTRY FOR PRINTED CIRCUIT BOARDS

Rittal has introduced a standardised coding system which provides 4096 different coding options on a 6U plug-in printed circuit board.

Simple plastic coding keys are fitted into cavities in the back of handles on the plug-in board front panel and in the front of a range of guide rails installed in the subrack. Available in red or grey the keys are offset and if installed the same way on both the guide rail and the plug-in board, they will interfere, thus preventing insertion.

The IEC60297-3-103 compliant system can also be implemented for rear I/O transition boards. Although printed circuit boards of only 3U height are equipped with one handle at the bottom of the front panel, they can still employ 64 combinations of coding.

Compatible guide rails include red, yellow, grey and green for 160mm and 220mm plug-in boards, as well as the plastic front section for a 3-part guide, the aluminium centre section of which allows infinite PCB depth variation. They also include the rear transition 80mm guide rails and those designed for power supply usage in CompactPCI with a 1/2 HP offset.

www.rittal.co.uk

SLIMLINE CONNECTOR FOR INTERFACING UP TO 168 POINTS IN TEST SYSTEMS

Now available exclusively in the UK from the Peak Group is the i2 Micro iCon connector from Virginia Panel Corporation. Offering up to 168 signal contacts in a slimline configuration, the new connector offers a mass interconnect solution for automatic test systems including equipment based on PXI cards.

Incorporating capabilities for discrete wiring, horizontal and right-angle PCB mounting, the i2 connector features a 30° cable exit for vertical stackability, along with a 0.8-inch wide footprint for horizontal stackability. The engaging mechanism integrates spring locking tabs that fasten over the latching post for secure engagement. Keying pins and a square locking mechanism ensure even and precise engagement.

The 30º angled cable exit reduces the height required by the connector, allowing more space in front of the rack for instrumentation and minimising the vertical space between connectors in a multi-connector panel layout.

www.thepeakgroup.com

SCOPECORDER NOW PRE-ANALYSES WAVEFORM DATA DURING ACQUISITION

A new advanced utility option in Yokogawa's Xviewer waveform display and analysis software boosts the hard disk recording capability of the recently introduced DL850 ScopeCorder by allowing an engineer to pre-analyse waveform data while the acquisition is still in progress.

The new DL850 advanced utility option for Xviewer uses a file transfer tool to transfer recorded data files from the DL850 to a PC without stopping actual hard disk recording.

During hard disk recording the DL850 divides measurement files into smaller files which are automatically transferred to a PC through an Ethernet or USB connection during real-time recording. These files can already be analysed using the dedicated Xviewer software while the actual measurement continues.

The file utility tool adds file merging, divide and conversion functions that enable smooth file handling of DL850 waveform files using Xviewer.

www.tmi.yokogawa.com/ea

NEW AND INNOVATIVE SENSOR TECHNOLOGY OFFERS UNMATCHED SENSITIVITY FOR DIFFERENTIAL LOW PRESSURE MEASUREMENT

Sensortechnics's new LBA series offers differential low pressure measurement with ranges of 250 and 500Pa Full Scale. The LBA sensors perform fully analogue on-chip CMOS signal conditioning to allow for linear and temperature compensated outputs with high differential pressure resolution of typically 0.1% and fast response times of typically 1ms.

The LBA sensors feature superior sensitivity and offset stability. The devices are based on thermal flow measurement of gas through a micro-flow channel integrated within the sensor chip. This very narrow channel decreases the flow through the LBA sensor by several magnitudes compared to other flow-based pressure sensors. The extremely low gas flow ensures high immunity to dust contamination and condensation.

The highly sensitive sensors are ideal to detect very small pressure differences in many medical respiratory devices as well as industrial HVAC applications.

www.sensortechnics.com/lba

MOUSER FIRST TO ANNOUNCE STOCK ON INFINEON ISOFACE 8-CHANNEL ISOLATED HIGH-SIDE DRIVER FAMILY

Mouser Electronics announced it is the first distributor to announce stock on the Infineon ISOFACE 8-Channel Isolated High-Side Driver.

The Infineon ISOFACE Coreless Transformer 8-Channel Isolated High-Side Driver family of devices are fully protected multi-channel high-side power switches providing galvanic isolation for digital output interfaces. The ISOFACE ISO1H8xxG isolated 8-channel high-side driver is intended for driving any kind of resistive, inductive, or capacitive load, addressing the exact requirements in industrial automation systems, such as Programmable Logic Controllers, Distributed Control Systems and Industrial PCs. With complete system integration of the digital interface, coreless transformer and power stage, these Infineon ICs can be directly connected between the microcontroller and independent power loads. Also, fully protected high-side switches with diagnostic output for over temperature make the ISOFACE an extremely rugged device.

With its broad product line and unsurpassed customer service, Mouser offers customers the latest, most technologically advanced components for their newest design projects.

www.mouser.com

TESTING IN DEVELOPMENT

Gennum Corporation provides semiconductors and sub-assemblies for high speed data communications, broadcast and video applications. As well as providing Integrated Circuit and Sub-Assembly hardware, it also provides services to help its customers develop their board level modules.

Among its products are the 10GB/s optical receivers and transmitters, which are instrumental in extending the scope of high speed data, from trunk applications to metro area and enterprise networks, and now in fibre to the home.

At these phenomenally high data rates, precision testing is critical to the development of stable and reliable products. According to Richard Bastable: "Our policy is to buy test equipment for our basic requirements and rent in to meet peak demand."

Microlease met these peak demands. The company specialises in precision test equipment for short-term rental and longer term lease, with an inventory of more than 3,000 instruments so it can meet most requests immediately.

Whether for rental, purchase or maintenance, Gennum's Bastable is content to work with Microlease. "The service is good and they respond well," he said. "You get the sense they want to help."

www.microlease.com

WET ELECTROLYTIC TANTALUM MODULES SAVE BOARD SPACE

AVX Corporation has developed a wet electrolytic tantalum module that provides high capacitance values of up to 6,600uf at 25 volts, and up to 450uf at 125 rated volts, while saving board space. Developed using several of AVX's patented high capacitance cathode system that enables high CV designs beyond the values specified in the Mil-PRF-39006 drawing, the TWM Series wet electrolytic tantalum module is manufactured and tested to the 93026 specification, and withstands the harsh shock and vibration requirements of M39006.

The TWM Series wet electrolytic tantalum module is ideal for output filtering, battery holdup and energy storage and delivery in harsh environment applications.

The TWM features an operating temperature range of -55°C to +125°C. The modules are available in a wide range of capacitance and voltage. They include 93026 case sizes T3 (D case, up to 100uf in 125VDC) through T4 (E case up to 150uf in 125VDC). AVX also offers customized capacitance and voltage packages.

www.avx.com

HARWIN'S ARCHER M50/M52 RANGE DELIVERS FINE PITCH RELIABILITY

Harwin has developed the Archer brand of 1.27mm pitch headers and sockets which are offered at competitive pricing with free samples and on immediate delivery.

Harwin's successful M50 and M52 fine pitch board to board connector series are now available in a wide variety of mating heights, with sockets from 2.2 to 8.5mm, and with different mounting options. Available in SIL and DIL styles with row spacings of 1.27 or 2.54mm, Archer M50 and M52 connectors feature a current rating of 1A per contact, voltage rating of 150V AC and an insulation resistance of 1000MΩ minimum. Insertion force is as low as 0.6N and operating temperature range is -40 to +105degC.

Harwin's broad range of Archer M50 and M52 fine pitch connectors are available as evaluation samples from www.harwin.com/archer. They are suitable for a huge number of applications including industrial controls, test equipment, PoS terminals, security systems, automotive control units, communications and datacoms products, diagnostic equipment and Mil/Aero systems.

www.harwin.co.uk

LATEST BINDER M16 CONNECTORS AVAILABLE NOW FROM FOREMOST

Foremost Electronics announces the introduction of an extended range of M16 connectors from the premier manufacture Binder.

The availability of screw clamp terminated versions of the already extensive and highly successful Binder M16 range allows simple mounting or service replacement in the field, without the need for a soldering iron.

These new connectors will complement and are fully interchangeable with the existing solder versions and are available across the complete M16 range encompassing both the IP40 series 581 and IP67 series 423 connectors. Each connector is supplied with an Allen key for terminating connecting cables.

Available for cable sizes from 4 to 8mm, the Binder M16 range is manufactured in nickel plated brass, have screw clamp termination contacts for wires up to 0.75mm², AWG 20, are supplied in 3, 4 and 5-pole format and have a current rating of 6 to 7A. Gold plated contacts ensure in excess of 500 mating cycles.

www.4most.co.uk

SMALL COMPANIES HOT, SMALLER GADGETS NOT

Cambridge Consultants has announced the results of its recent online survey aimed at discovering attitudes towards past, present and future technological development, which was conducted as part of the company's 50th anniversary celebrations. Receiving over 1,000 responses, the research revealed that two out of three people believe that small, fast-growing companies will be responsible for the most influential technologies in the future. This put them way ahead of large, multinational companies. The Cambridge Consultants survey also revealed that being small isn't necessarily important in terms of gadgets – reducing the size of devices was a priority for less than 2% of respondents. Making gadgets faster was also a surprisingly low priority for consumers, with less than 5% indicating that it was of high importance. Instead, gadget users would prefer to see technology products capable of solving new problems (with over a third of votes) and become easier to use (27%).

Our panel of commentators says the following on this development:

PROFESSOR DR DOGAN IBRAHIM, THE NEAR EAST UNIVERSITY IN NICOSIA, CYPRUS:

The recent online survey on the future of technology and product design, conducted by Cambridge Consultants, has revealed yet again that being small isn't necessarily important in terms of gadgets. The functionality and the ease of use have shown to be more important factors when considering a gadget. These results are not surprising as the 1980s' saying "small is beautiful" does not seem to be valid for many gadgets any more. Consumers are looking for gadgets that offer more functionalities and are also easy to use.

BARRY MCKEOWN, RF AND MICROWAVE ENGINEER IN THE DEFENCE INDUSTRY, AND DIRECTOR OF DATOD LTD, UK:

Congratulations to Cambridge Consultants Ltd (CCL), having evolved through the ADL venture in 1972, to the management buy-out in 2002; backed by Altran, Europe's largest consultancy company. Many companies have successfully spun out of CCL, more are required, given the fertile breeding ground occupied near to Cambridge University, one of the world's leading universities. Arguably the most technically proficient spin-out being Data Conversion Systems Ltd, in 1987; who from initial military ventures now specialise in world leading digital audio products.

Whereas I firmly believe that although the customer is always right, they don't always know what they want until they see it.

I also, don't agree with the comment about solving "new" problems. We still have old ones to solve first. However, I follow the philosophy that if you don't understand the problems you cannot be part of the solution. The issue is in knowing what the problems really are in the first place but I don't want to get into marketing arguments.

MAURIZIO DI PAOLO EMILIO, TELECOMMUNICATIONS ENGINEER, INFN – LABORATORI NAZIONALI DEL GRAN SASSO, ITALY:

Many millions of people the world over crave faster and more reliable Internet access. Our demand and needs become increasingly more insatiable. You are now – or will be soon – looking for a faster, better and more reliable Internet Broadband service. Imagine the prospects and potential of a second wave of connectivity, where interconnected "intelligence" is embedded in the objects and materials of our daily lives appliances, automobiles, homes and even clothing.

Internet telecommunications technology has been hot and will continue to dominate the interest of both consumers and business professionals alike. It will be a thriving, low-cost network of billions of devices by 2020, says a major survey of leading technology thinkers.

HAFIDH MECHERGUI, ASSOCIATE PROFESSOR IN ELECTRICAL ENGINEERING AT THE UNIVERSITY OF TUNISIA:

I think that the online survey idea is a good one. From the published report, one can draw some conclusions to adjust the level of technological innovations and how to be competitive. In my opinion, the small companies are those that can be most inventive.

I think that, today, one must put more effort into new innovations as these last few years science and technology have not been functioning according to a 'linear' process, i.e. towards the market, but more of a network of academic and industrial partnerships.

It is very significant to work advantageously and to put more effort into developing technologies that are alluring to the consumer and easing the use of gadgets.

If you'd like to comment on this subject or want to become a member of our panel, please write to the Editor at Svetlana.josifovska@stjohnpatrick.com