

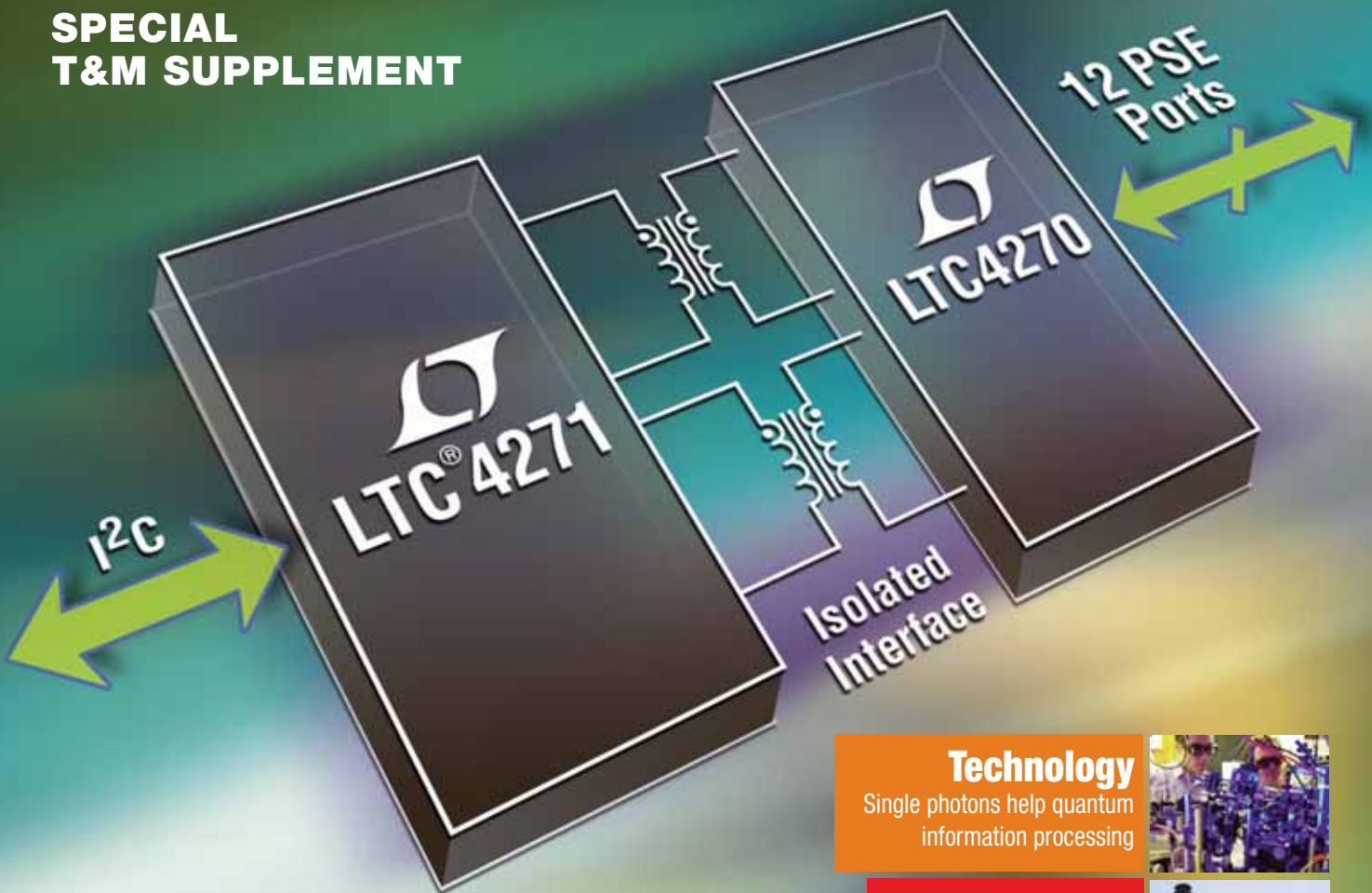
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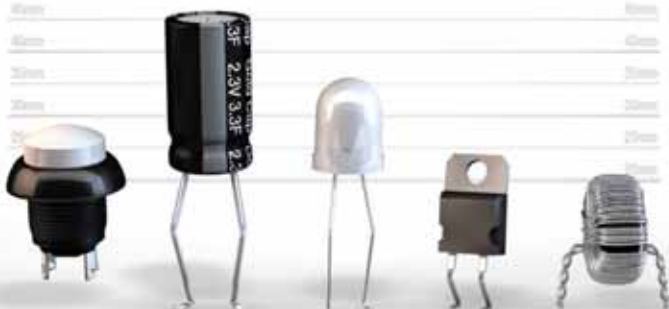
Mobile broadband



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NETWORK AVAILABILITY

In a fast-moving mobile network industry more firms are turning to rented test equipment options to reduce financial exposure and increase flexibility. With smartphones, netbooks, tablets and other devices running mobile-optimised operating systems – all placing bandwidth under growing pressure – access, speed, quality of service (QoS) and quality of experience (QoE) continue to be critical in the mobile broadband industry.

A year ago the number of mobile broadband subscribers surpassed that of fixed broadband subscribers. This gap will undoubtedly continue to widen over the next three years, with market analysis firm Close Infonetics Research predicting that, by 2014, the number of LTE subscribers will reach 164 million worldwide.

New figures from Cisco also suggest that, in 2015, wired devices will account for 46% of IP traffic, while Wi-Fi and mobile devices will account for 54% of it. In addition, Cisco predicts that video will account for an incredible 90% of all internet traffic within three years.

Flexible Options

To meet the demanding and often changing needs of this fast-moving market, testing needs must also continue to grow and evolve. Yet, when project requirements have a high likelihood of change, investing in specialised test equipment outright can be extremely risky.

Similarly, while it is crucial to be prepared, it's not always possible to accurately predict exactly when the equipment will be needed or, indeed, how much of it will be required.

The requirement for test equipment will inevitably vary throughout the duration of a project, with design engineers requiring access to many different measurements during the early stages and the requirements extending or changing later as a production test regime is established.

Similarly, field testing may also have different requirements and be project based in nature. Directly linked to new technologies being introduced or key investments delayed,

Network providers and installation and commissioning contractors often adopt a more cautious approach when investing large sums into specialised equipment

testing requirements could also change, expand or contract during the course of a project, making a significant difference to its overall success.

For these reasons, many key stakeholders, such as network providers and installation and commissioning contractors, often adopt a more cautious approach when investing large sums into specialised equipment.

Rental solutions provide an obvious choice, not least in terms of flexibility. With commitments starting at one week, many installation and commissioning companies and network manufacturers are opting for rental options to give users the ability to change the equipment at different stages, as well as deal with the peaks and troughs that are common in this market.

In addition to reducing the need to invest in expensive instruments for every changing requirement, rental options also provide organisations with increased financial flexibility, so that large amounts of capital are not tied up in expensive instrumentation, and equipment needed can be increased or decreased accordingly.

Financial Sense

Throughout these fast-moving times for mobile broadband, but also uncertain times for business and the economy, using financing options intelligently can, without doubt, not only help users to get the latest technology but also help free them from budget constraints.

As demand for broadband services rises rapidly with the proliferation of smartphones and tablets, the race to meet the network requirements to serve the growing millions of data-hungry mobile broadband users will undoubtedly continue to bring significant opportunity for those organisations most able to operate and react with flexibility.

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MID-SIZE BUSINESSES LOSE TALENT WAR

Mid-tier technology companies are losing out in the race for talented technical staff as workers flock to exciting start-ups or large firms offering big salaries.

At a roundtable debate discussing the impact of the Government's investment in tech hubs, and held by hosting specialist UKFast, Tash Whitmey, CEO of digital marketing agency EHS 4D, said: "The young, talented, innovative people are leaving because they are interested in exciting start-ups, so being in London – or one of these tech hubs – and having all of these new opportunities on their doorstep really opens up the possibilities for people."

Elizabeth Varley, co-founder of the community for technology entrepreneurs TechHub, said that start-ups are not alone in drawing technical talent away from mid-

tier companies: "Within these areas we have got the big companies that can pay the big salaries; they suck all of the talent from the entrepreneurial pool. The competition is fierce for the best people within the 'tech hub' areas like Silicon Roundabout."

It is well-known that there is a shortage of talent in the field of high technology, and established mid-tier companies can find it difficult to compete with the excitement of start-ups or the massive salaries of the big tech players.

Among the suggestions to attract high tech staff are: raising average salaries, companies ensuring their workplace is a great place to be through positive company culture, job security and stability, team work and good opportunities for career growth.

RAINBOW TECHNOLOGY SAYS IT WILL REVOLUTIONISE PCB MANUFACTURE

Rainbow Technology Systems claims its innovation will revolutionise printed circuit board (PCB) production. Its so-called 'Rainbow Process' represents a breakthrough for the electronics industry as it incorporates coating, imaging and developing of PCBs in one compact, automated unit which makes board production faster, easier and more profitable.

The completely self-contained unit takes up only 12m² of floor space and does not require a clean room environment. The process requires minimal operator intervention and is capable of delivering a double-sided panel every 15-20 seconds, ready for etching.

Key to the success of the Rainbow Process is the proprietary etch wet resist which does not require pre-drying (using a curing oven) before

imaging. The resist is 100% solids- and solvent-free. Using only UV LEDs and standard photo-tools tracks and gaps of 20 microns and below are easily achieved. The unit has very low running costs with power consumption averaging 3kW.

"Until now the only way to produce fine line PCBs (typically 50 microns and under) was to use expensive Laser Direct Imaging

equipment," said Jonathan Kennett, chief executive and founder of Rainbow Technology Systems. "We are offering the industry

an alternative which is less expensive, greener and more efficient. Other target markets for this technology include touchscreens, flat panel displays, chemical milling and chemical machining."



Rainbow render

Single Photons Created for Quantum Information Processing and Study of Dynamics

Physicists have developed a new way to rapidly and efficiently create single

photons for potential use in optical quantum information processing.

with well-known properties is important to several research areas, including quantum information systems.

and unable to provide the number of entangled photons needed for complex systems.

Georgia Tech physicists adjust optics as part of research into the production of single photons for use in optical quantum information processing (Georgia Tech Photo: John Toon)



Using lasers to excite just one atom from a cloud of ultra-cold rubidium gas, the 'atom blocking' technique takes advantage of the unique properties of atoms that have one or more electrons excited to a condition of near-ionization known as the Rydberg state. Atoms in this highly excited state – with a principal quantum number greater than 70 – have exaggerated electromagnetic properties and interact strongly with one another. That allows one Rydberg atom to block the formation of additional excited atoms within an area of 10 to 20 microns. That single Rydberg atom can then be converted to a photon, ensuring that only one photon is produced from a rubidium cloud containing hundreds of densely-packed atoms.

Reliably producing a single photon

"We are able to convert Rydberg excitations to single photons with very substantial efficiency, which allows us to prepare the state we want every time," explained Alex Kuzmich, a professor in the School of Physics at the Georgia Institute of Technology. "This new system offers a fertile area for investigating entangled states of atoms, spin waves and photons. We hope this will be a first step toward doing a lot more with this system."

Physicists have been studying quantum information systems that rely on mapping information from atoms onto entangled pairs of photons, but the Raman scattering technique they have been using to create the photons was inefficient

"This new photon source is about a thousand times faster than existing systems," said Yaroslav Dudin, a graduate research assistant. "The numbers are very good for our first experimental implementation."

For the Georgia Tech group, the next goal may be development of a quantum gate between light fields. The quantum gating of photons has been proposed and pursued by many research groups, so far unsuccessfully.

"If this can be realized, such quantum gates would allow us to deterministically create complex entangled states of atoms and light, which would add valuable capabilities to the fields of quantum networks and computing," added Kuzmich.

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LTPOE++ EXTENDS POE TO 90W WITH RELIABLE AND EASY-TO-USE STANDARD

by Heath Stewart, Senior Design Engineer, Linear Technology Corporation

Power over Ethernet, or PoE, is an increasingly popular way to deliver both power and data over existing Ethernet cable, thus freeing applications from the constraint of AC-power proximity. As the number PoE solutions have grown so has the applications' appetite for power.

A new proprietary standard, LTPOE++, satisfies this hunger by extending the PoE and PoE+ specifications to 90W of PD delivered power. LTPOE++ also dramatically reduces engineering complexity in power sourcing equipment (PSEs) and powered devices (PDs) when compared to other power-expansion solutions. Plug-and-play simplicity and safe, robust power delivery are hallmarks of LTPOE++. The capabilities of this standard expand the field of Ethernet-powered applications by several orders of magnitude, enabling entirely new classes of PDs, such as power-hungry picocells, base stations or heaters for pan-tilt-zoom cameras.

HISTORY OF POE

PoE is a standard protocol for sending DC power over copper Ethernet data wiring. The IEEE group that administers the 802.3 Ethernet data standards added PoE capability in 2003. The original PoE spec, known as 802.3af, allowed for 48V DC power at up to 13W. Although the initial specification was widely popular, the 13W cap limited the number of possible applications. In 2009, the IEEE released a new standard, known as 802.3at or PoE+, increasing the voltage and current requirements to supply 25.5W of power.

The IEEE standard also defines PoE terminology, as shown in Figure 1. A device that provides power to the network is known as a PSE, or power sourcing equipment, while a device that draws power from the network is known as a PD, or powered device. PSEs come in two types: endpoints (typically network switches or routers), which send both data and power, and midspans, which inject power but pass data through. Midspans are typically used to add PoE

PSE PART	# PORTS	DELIVERED PD POWER (MAX)
LTC4274A-1	1	35W
LTC4274A-2	1	45W
LTC4274A-3	1	70W
LTC4274A-4	1	90W
LTC4266A-1	4	35W
LTC4266A-2	4	45W
LTC4266A-3	4	70W
LTC4266A-4	4	90W
LTC4270A	12	35W–90W (pin selected)

Table 2: LTPOE++ PSEs

capability to existing non-PoE networks. Typical PD applications are IP phones, wireless access points, security cameras, cellular femtocells, picocells and base stations.

The IEEE PoE+ specification specifies backward compatibility with 802.3af PSEs and PDs. The PoE+ specification defines Type 1 PSEs and PDs to include PSEs and PDs delivering up to 13W. Type 2 PSEs and PDs deliver up to 25.5W.

LTPOE++ EVOLUTION

The IEEE PoE+ 25.5W specification had not yet been finalized when it became clear that there was a significant and increasing need for more than 25.5W of delivered power. In response to this need, the LTPOE++ specification reliably allocates up to 90W of delivered power to an LTPOE++ PD.

The LTPOE++ specification provides reliable detection and classification extensions to existing IEEE PoE protocols. LTPOE++ is backward compatible and interoperable with existing Type 1 and Type 2 PDs. Unlike other proprietary power-extending solutions, Linear's LTPOE++ provides mutual identification between the PSE and PD. LTPOE++ PSEs can differentiate between an LTPOE++ PD and all other types of IEEE compliant PDs, allowing LTPOE++ PSEs to remain compliant and interoperable with existing equipment.

LTPOE++ PSEs and PDs seamlessly interoperate with IEEE 802.3af Type 1 and Type 2 devices. Type 1 PSEs generally encompass 802.3af functionality at and below 13W. Type 2 PSEs extend traditional PoE to 25.5W. The interoperability matrix is shown in Table 1.

LTPOE++ ADVANTAGES

Standard PoE PSEs use two of the four available Ethernet cable pairs for power. Some power-extending topologies use two PSEs and two PDs over one cable to deliver 2 x 25.5W power. This "dual Type 2" topology is shown in Figure 2. The main problem with this strategy is that it doubles the number of components, thus doubling PSE and PD costs.

In contrast, LTPOE++ solutions, as shown in Figure 3, require only a single PSE, PD and DC/DC converter, resulting in significant board space, cost and development time advantages.

DEVICE	PSE		PD					
	STANDARD	802.3AT	LTPOE++					
	TYPE	TYPE 1	TYPE 2	38.7W	52.7W	70W	90W	
802.3AT	TYPE 1	13W	13W	13W	13W	13W	13W	
	TYPE 2	13W	25.5W	25.5W	25.5W	25.5W	25.5W	
	38.7W	13W	25.5W	38.7W	38.7W	38.7W	38.7W	
	52.7W	13W	25.5W	—	52.7W	52.7W	52.7W	
	70W	13W	25.5W	—	—	70W	70W	
90W	13W	25.5W	—	—	—	90W		

Table 1: PSE and PD power delivery matrix shows extended power levels of LTPOE++

LLDP INTEROPERABILITY AND OPTIONS

During selection and architecture of a PoE system, many PD designers are surprised to discover the hidden costs of Link Layer Discovery Protocol (LLDP) implementations. LLDP is the IEEE-mandated PD software-level power negotiation. LLDP requires extensions to standard Ethernet stacks and can represent a significant software development effort. Unfortunately the open-source community effort to provide LLDP support is still in its infancy.

While Type 2 PSEs may optionally implement LLDP, fully IEEE-compliant Type 2 PDs must implement both physical classification and LLDP power negotiation capabilities. First, this places the burden of LLDP software development on all Type 2 PDs. In addition, designs are complicated by the dual power requirements inferred by the LLDP requirement. Specifically, the PD-side processor must be fully functional at the 13W power level and then have the ability to negotiate, via LLDP, for the delivery of additional power. Clearly this requirement can increase development and system costs and complexity.

LTPoE++ offers LLDP implementation options. LTPoE++ PSEs and PDs autonomously negotiate power level requirements and capabilities at the hardware level while remaining fully compatible with LLDP-based solutions. In short, LTPoE++ gives system designers the choice to implement or not implement LLDP. Proprietary end-to-end systems may choose to forgo LLDP support. This creates time-to-market advantages while further reducing BOM costs, board size and complexity.

POWER CLAIMS DEMYSTIFIED

PoE power paths can be divided into three main components: the power produced by the PSE, the power delivered to the PD and the power delivered to the application. Claims of PSE and PD power delivery capabilities must be carefully examined before useful comparisons can be made. One vendor may describe the power as delivered by the PSE, another the power delivered to the PD, while the PD designer typically cares about power consumed by the application.

Systems architects should carefully consider the power rating description. For example, the LTPoE++ 52.7W standard delivers more power to the PD than many vendors "60W" solutions.

PSE AVAILABILITY

Linear Technology is committed to LTPoE++ technology and provides an entire family of PSE and PD solutions. A full family of PSEs, spanning 1- to 12-port solutions is now available, shown in Table 2.

CONCLUSION

LTPoE++ offers a robust, end-to-end high power PoE solution with up-front cost savings. Combined with Linear Technology's excellent

application support, proven delivery record and reputation for reliability, LTPoE++ is the most comprehensive high power solution on the market. LTPoE++ systems simplify power delivery and allow system designers to concentrate their design efforts on their high value applications.

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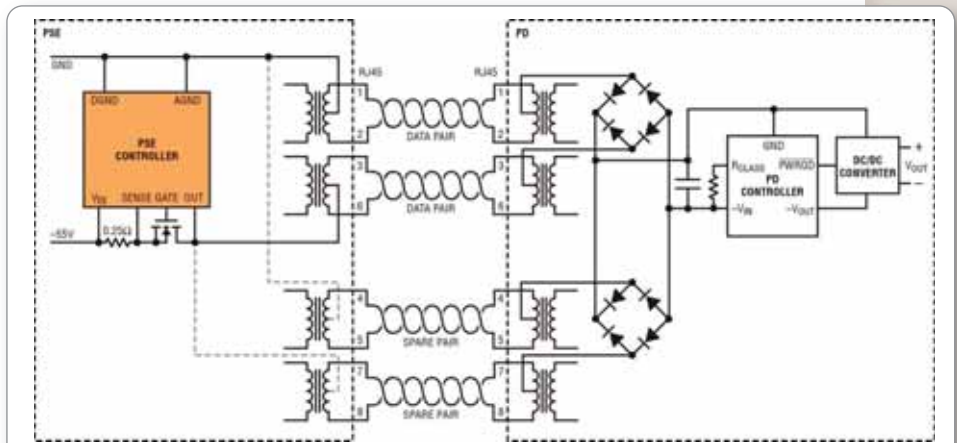


Figure 1: Typical PoE system

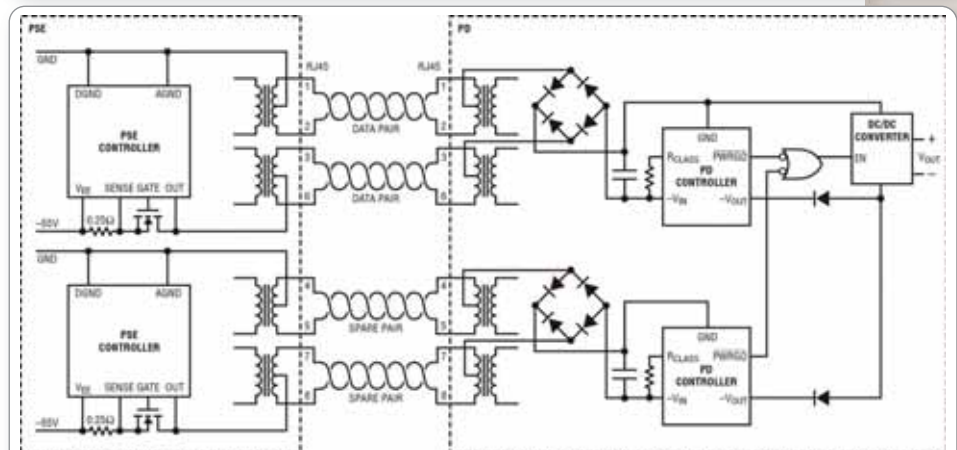


Figure 2: The expensive way to extend PoE+ power. Dual Type 2 PD provides more power than standard PoE+ PD, but it also doubles the cost and component count

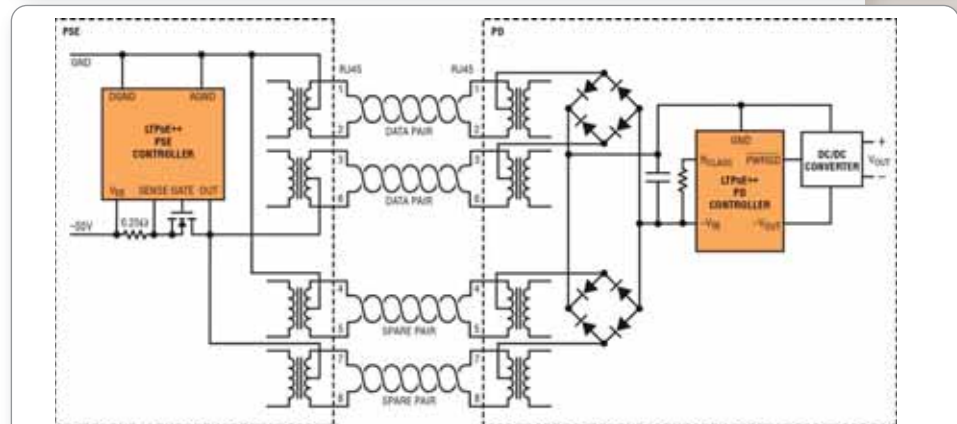


Figure 3: The LTPoE++ architecture is the only PoE power-extending solution that provides 90W at the PD while keeping complexity and costs in check



The RSSI – It tells lies

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In the simplest possible universe, a low power wireless module would only have one input and one output: raw baseband audio, or formatted serial data – it doesn't really matter which. We do not live in that universe, and our radios are somewhat more "interesting". We have control signals, status lines, analogue and digital I/O... and an interesting pin usually labelled "receive signal strength indicator" or, just occasionally, "S-meter".

The RSSI pin is an output from a receiver (or the receive portion of a transceiver) that provides an analogue

measurement of the signal strength, it is not calibrated to any degree of accuracy, nor is its transfer function necessarily linear (with respect to input volts, or dBm). It is not necessarily a low impedance voltage output, it may have various amounts of noise on it (at various signal strengths) and it does not always swing from ground to +5V (or whatever the rail is). Zero volts on the pin does not always correspond to "no signal" at the RF input, and the response time can vary from less than a millisecond to well over a tenth of a second. The dynamic range of the output rarely matches the receiver; anything

Testing a batch of modules for RSSI voltage versus signal input level, and rejecting those a few percent outside the median is NOT reasonable.

4. **"Carrier level" is not the same as "noise derived mute"**. An RSSI output will indicate "strong signal" in the presence of wide band interferers (like spark noise) and will open, rather than close, a "voice" receiver's squelch (mute) gate.

That said, the RSSI is a useful output if used within its limits. To the manufacturer it is a very useful aid in setting up a receiver's circuitry, as it allows the test operative to peak for actual maximum signal, rather than signal to noise ratio. Combined with a (suitably timed) frequency sweep, it facilitates the measurement (and set-up) of a unit's pass-band shape and it can form the basis of quick "go/fail" testing of receiver sensitivity.

To the user, an RSSI reading can provide a good comparison between the strengths of multiple carriers (in intelligent diversity systems) and can give an approximation as to the "integrity" of a signal. In listen before talk systems it is used to detect "channel in use", and as part of adaptive power control systems it is used to control the output power of a distant transmitter.

The most important thing to keep in mind when using an RSSI output is the "I" – it's an indicator. Don't assume it is anything more! ●

signal, usually a voltage, but occasionally a constant current, which is proportional to the input signal strength.

Unfortunately, bearing in mind the various uses that it gets put to, that is all that you can guarantee the output providing.

Before doing anything with a radio's RSSI, it is vitally necessary to carefully read the supplier's data sheet to find out what they have interpreted the pin function to actually mean. There are pitfalls: It does not give an absolute

over 60dB should be looked on as good.

Users frequently expect more of the RSSI than it actually gives, as well:

1. **It is not a "valid signal detector"**. It only indicates that RF power is present at the receiver's input, not what that RF signal might be.
2. **It is not a range indicator**. A weak signal may come from a more distant source, but it could also result from a reflection/refraction fade, or an intervening obstruction.
3. **It is not a calibrated voltmeter**.

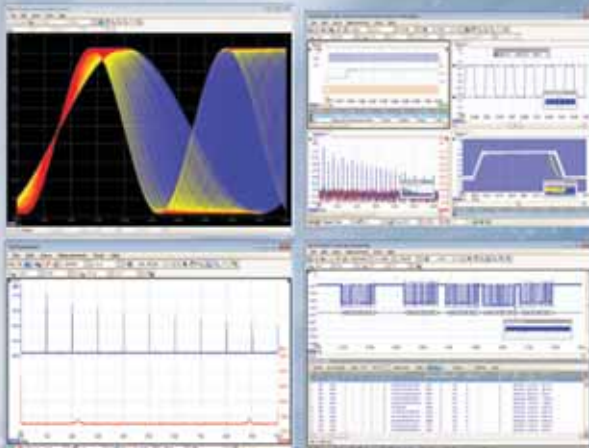
Zero volts on the pin does not always correspond to "no signal" at the RF input, and the response time can vary from less than a millisecond to well over a tenth of a second



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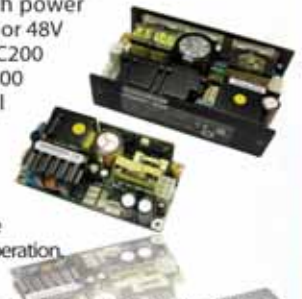
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Offering a compact size with high power density, single outputs of 12V, 24V or 48V are available from stock in 200W ABC200 open frame 2" x 4" and 400W ABC400 U-channel 3" x 5" units. A universal input range of 90 to 264V with active power factor correction and up to 91% efficiency. Ideal for: industrial equipment; telecom & datacom applications where space is at a premium. -10°C to +70°C operation.



Configurable Power Supplies up to 1450W

Configured and despatched within 48 hours, the Xgen series power supply units offer wide ranging solutions: high current/low voltage; low current/high voltage with up to 12 regulated, isolated outputs; from an input of 85 to 264Vac or 120 to 380Vdc, in a single low profile (fits in 1U chassis). All configurations carry full safety agency approvals: UL60950; EN60950; CE. -20°C to +71°C operation.



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Latest Medical Approvals Implications for Power Supplies

ROB HUTTON, NEW PRODUCT INTRODUCTIONS MANAGER AT TDK-LAMBDA EMEA, OUTLINES THE LATEST NEEDS FOR POWER, ESPECIALLY IN THE FIELD OF MEDICAL EQUIPMENT

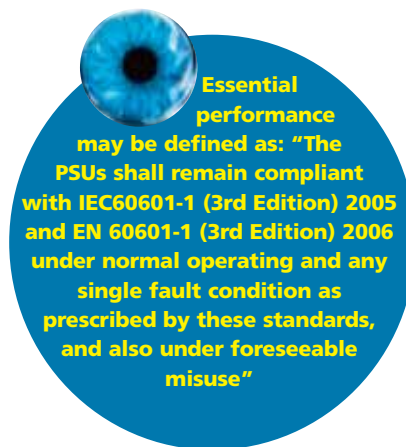
The medical industry has understood the 60601-1 second Edition for a long time. With the introduction of Edition 3, one of the biggest challenges for component power supply manufacturers is designing to/or meeting both 2nd and 3rd Editions during the transition period from 2nd Edition to 3rd Edition.

Key examples include aligning the tougher spacing requirements of the 2nd Edition and the more onerous Y-capacitor requirements of the 3rd Edition. There is also a fine balance between meeting required EMC levels and the sometimes low leakage current targets of medical equipment. As the allowable leakage currents for the power supply decrease, meeting Class B EMC limits can become more of a challenge.

Risk analysis has been introduced and a Risk Management File for final equipment in accordance with ISO 14971. However, the IECCE Certification Management Committee has confirmed the recommendation whereby a CB (Certified Body) test certificate to IEC 60601-1: 2005, 3rd Edition may be granted to power supplies without conducting a risk management process required by the standard, provided the risk management process exclusion is clearly stated on the CB test certificate and CB test report.

Although having a risk management system is not mandatory for a component power supply designer/manufacturer, the ability to provide supporting information for risk management (should customers request it) requires additional planning and resources.

'Essential Performance' has also been introduced; in relation to a power supply, essential performance may be defined as: "The PSUs shall remain compliant with IEC60601-1 (3rd Edition) 2005 and EN 60601-1 (3rd Edition) 2006 under normal operating and any single fault condition as prescribed by these standards, and also under foreseeable misuse".



Make vs Buy

The reality is that there will always be a cost consideration with a 'make or buy' decision – almost always the power supply will be more expensive to design in-house, unless it is produced in very high volumes, which is not usually the case with medical equipment.

Meeting the 60601-1 standard, while keeping abreast of the frequent changes to the standard and being able to forecast likely changes between new editions is a challenge; a power supply manufacturer that is approved by the Underwriters Laboratories Inc (UL) to 60601-1 3rd Edition will help ensure that its medical power supplies are tested and approved to the highest safety standards. Also, by

having a greater knowledge and experience in the safety requirements of 60601-1, the power supply manufacturer is more capable of providing standard and custom products to meet customer requirements.

Generally, for OEM clinical and system design engineers, power supply design is not a core competence – when designing a medical-grade power supply from scratch the risks associated with the unknown may compel the OEM to over design, which can extend the project design cycle and increase OEM's time to market. An experienced power supply manufacturer will be familiar with the latest topologies and use leading edge technology in power supply design, and have documented field test data from existing medical applications and power supply designs.

An in-house design may achieve the complete specification wish-list for the OEM, so using an existing component PSU may mean a different approach is called for or a compromise. However, modified standard or full custom designs are available from most leading power supply manufacturers.

Key Considerations

The depth of understanding of 60601-1 standards can vary across OEMs; one of the main challenges for medical OEMs is understanding the safety requirements of 60601-1 as applied to power supplies.

The end equipment isolation diagram provided by the manufacturer is the main factor in specifying the right power supply. The key elements of an isolation diagram are the MoPP (Means of Patient Protection) or MoOP (Means of Operator Protection) isolation and spacing requirements:

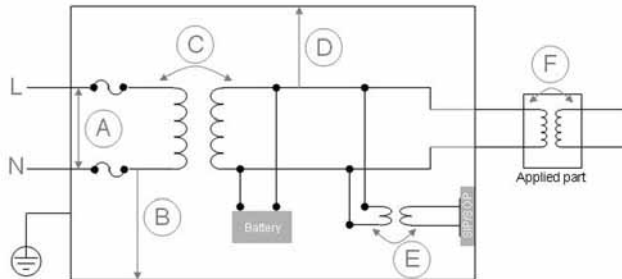


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Figure 1: Example isolation diagram



For each location A to F the following information is determined:
Insulation type, max working voltage, required creepage (mm), required clearance (mm),
measured creepage (mm), measured clearance, dielectric strength.

- Between mains circuits and secondary circuits;
- Between mains circuits and earth;
- Between secondary circuits and earth;
- Between secondary circuits and applied part.

Secondly, it is important to determine the allowable leakage currents for the power supply, as especially low leakage current requirements can present challenges for EMC compliance. Additionally, the safety Class must be determined, Class I if the end equipment requires a permanent Earth connection or Class II, no earth – double insulated, a particular requirement of the home medical market. Consideration should also be given to the power supply environment including transportation, storage and use of the medical end-equipment; rarefied atmospheres, fluids and high altitude can alter the construction of the power supply required.

If the OEM requires accreditation or compliance of the end product to ISO13485 (medical quality standard), then selecting a power supply manufacturer that already complies with the standard can be a benefit. In addition, since the 3rd Edition is not fully accepted by all countries (at time of writing), the medical OEM may need a power supply that is approved to both 2nd and 3rd Editions.

A power supply designer/manufacturer can identify relevant and reliable

products by providing experience, knowledge and sound technical support through all aspects of the project and product life, providing

*Generally, for
OEM clinical and system
design engineers, power
supply design is not a core
competence*

products with greater efficiency, improved thermal management and increased E-cap (electrolytic capacitor) life. Additionally, a reputable supplier will provide advice and information concerning the power supply and integration into the end equipment during the approval phase.

Finally, meeting environmental constraints and, in particular, equipment intended for use at high altitudes can create a considerable challenge. A power supply that is intended for use at 5000m must be designed with increased spacing as per the multiplication factors for air clearance in IEC60601-1, 3rd Ed, clause 8.9.1.5, table 8. Operation at low air-pressure can be confirmed through testing to IEC60068-2-13, whilst this can simulate operation at altitude it does not confirm the construction requirements of IEC60601-1 noted above. ●

NEW COMPONENTS CALL FOR HARDWARE COMPARISON OF RECEIVER ARCHITECTURES

TODD NELSON, SIGNAL CHAIN MODULE DEVELOPMENT MANAGER AT LINEAR TECHNOLOGY, PROBES THE PERCEPTIONS AND REALITIES OF THE HARDWARE DIFFERENCES BETWEEN THE SUPERHETERODYNE AND DIRECT CONVERSION (HOMODYNE OR ZERO-IF) RADIO ARCHITECTURES



T

he battle between the superheterodyne radio architecture and the direct conversion (homodyne or zero-IF) radio architecture goes back to the 1930s.

Each has its advantages for particular types of equipment. Superheterodyne is popular in cellular base stations and direct conversion has proliferated in software-defined radio applications such as municipal radios.

The simplicity of direct conversion hardware promises lower cost, lower power consumption and less board space than superheterodyne which is attractive to cellular service providers. Yet the hardware simplicity is offset by the software complexity to deal with inherent problems of DC offset. This article will probe the perceptions and realities of the hardware differences, exploring the easy path and simply ignoring the software issues.

The tsunami of data transmitted over cellular networks was brought on by

tremendous advances in smart phones, tablets and other devices that access the Internet in these frequency bands. This has increased the technical requirements while pressuring suppliers to reduce costs. Modern base stations take many forms: from traditional racks to smaller units operating on just a few Watts of power. The circuitry required to support multiple channels in tiny base station form-factors assume a variety of approaches to integration. With recent developments, just how significant is the difference between superheterodyne hardware and direct conversion hardware?

Review of the Basic Architectures

Edwin Armstrong invented the superheterodyne receiver architecture in 1918, by most accounts. In this common type of receiver, the radio frequency (RF) signal is mixed with a local oscillator (LO) signal to generate an intermediate frequency (IF) which is then demodulated. The LO frequency is offset from the RF

carrier frequency, creating images of the signal. The IF signal is passed, while all other images are rejected by filtering. In modern receivers, the IF signal is converted to digital using an analog-to-digital converter (ADC) and then demodulated in the digital domain (see Figure 1).

The direct-conversion receiver was developed a few years later as an alternative to the superheterodyne receiver. However, unlike the superheterodyne, the LO frequency is not offset from, but equal to the received signal's frequency. The single mixer is replaced by two mixers, one fed with the RF and LO signals and the other fed with the RF signal and a quadrature LO signal. The result is a demodulated output which is digitized by two ADC converters at baseband (see Figure 2). In other words, the intermediate frequency is zero. The filtering requirement is simplified because only a lowpass filter is required – unlike the superheterodyne with its bandpass filter.

Evolution of Hardware

Regardless of the architecture, there have been steady improvements over the decades. The performance of all the integrated circuit (IC) components continues to improve, while at the same time consuming less power and requiring less printed circuit board (PCB) area. The ADC resolution and sample rates have improved to allow wider bandwidth signals and higher input frequencies.

An early attraction of the direct conversion receiver was the single frequency conversion to baseband. In past decades, the superheterodyne receiver used multiple frequency downconversion stages. Gradually, as mixer and filter technology improved, stages were consolidated to the point where a typical superheterodyne receiver has only one frequency conversion stage in analog and one digital downconversion stage implemented in a digital signal processor.

Another attraction of the direct conversion architecture is the lowpass filtering. The superheterodyne architecture requires a bandpass filter at the IF. In many cases, the bandpass filter is of a high order or of a surface acoustic wave (SAW) type. SAW filters require a hermetic package and are often quite large and expensive. While there have been tremendous improvements in SAW filter technology and packaging, the lowpass filter is still considered to be more attractive.

Latest Hardware Comparison

To attempt a reasonable comparison of cost, power and board space, it is necessary to collect the components to implement four receiver channels for a small base station suitable for 20MHz signal bandwidth. Each superheterodyne receiver uses a single mixer, a variable gain amplifier, a SAW filter, a second IF amplifier stage and a high-speed ADC. Each direct conversion receiver uses an I/Q demodulator, two baseband amplifiers and two high-speed ADCs. An example board layout is used to compare the estimated board space required for these components and the nominal power consumption is simply calculated from data sheet parameters. The expectation is that the direct conversation architecture will prove to be significantly better in both respects.

On a percentage basis, the board area used for the superheterodyne receiver is 39% more than the direct conversion, which is a significant percentage but in real PCB area the difference is not so great

Superheterodyne Example

For four channels of superheterodyne, there are commonly available dual mixers in QFN packages of 5mm x 5mm – so two duals are required. With integrated balun transformers and internal matching components for the RF and LO inputs, the number of passive components is minimal and mostly 0201 and 0402 sizes – these will be ignored in this comparison since they are also required for direct conversion.

Similarly, there are dual digital VGAs available in suitable frequency ranges. Such dual VGAs are also available in 5mm x 5mm QFN packages; again, two are required to implement four channels. A bit of filtering may be required following the mixer stages, so a few 0402 inductors and 0201 capacitors are in order. To achieve the required selectivity, a SAW bandpass filter is required for superheterodyne receivers. A separate SAW filter is required for each of the four channels.

At RF frequencies, SAW filters can be quite small. In the common IF range from 70MHz to 192MHz, SAW filters can be

found in 5mm x 7mm packages. The SAW filter will require a few matching components even if the output of the preceding VGA and input of the following amplifier are 50 ohms. Normally, another gain stage is required to make up for the insertion loss of the filter. However, a new quad ADC with integrated amplifiers is offered in a System in Package (SiP), the LTM9012-AB μ Module ADC from Linear Technology. At 15mm x 11.25mm, it is smaller than the equivalent quad ADC with four differential amplifiers and the associated bypass capacitors and anti-alias filter components. With 20dB of gain, the LTM9012 achieves 68.5dB signal to noise ratio (SNR) and 79dB spurious-free dynamic range (SFDR). The amplifiers and the filtering within the LTM9012-AB limit the input frequency to about 90MHz. Therefore, a 70MHz IF is suitable, but not the higher IFs often implemented with superheterodyne receivers in base station applications. Nonetheless, this offers the most compact implementation.

The LTM9012 represents a different

Figure 1: Superheterodyne receiver architecture

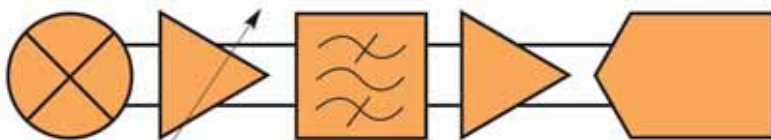
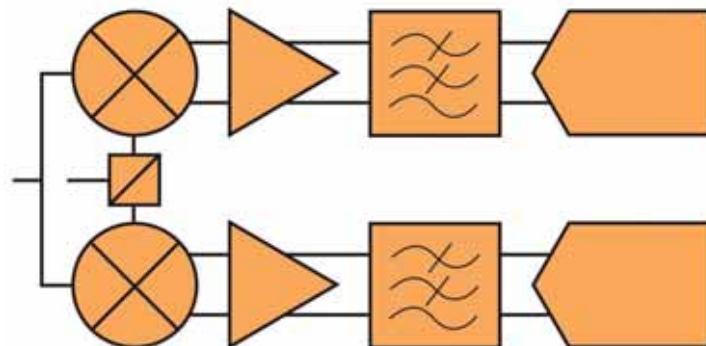


Figure 2: Direct conversion receiver architecture



approach to integration. The μ Module or SiP packaging allows a separate die to be assembled along with various passive components on a laminate substrate and molded such that it looks like a regular ball grid array (BGA) integrated circuit (IC). In this case the ADC is optimized for low power and good AC performance using a small geometry CMOS process.

The amplifiers use a silicon-germanium (SiGe) process in order to maximize their performance. These are traditional differential amplifiers, so the gain is set with resistors at 10V/V or 20dB. A true op-amp input simplifies the matching by isolating the high frequency sampling glitches from the signal path and allows for single-ended signals to mate up with the differential ADC inputs internally.

Most monolithic ADCs with buffered front-ends provide no gain at all; they are still differential and only offer the isolation of the glitches. Equally beneficial is the anti-alias filtering that limits the wideband amplifier noise. In terms of overall board space, since all of the reference and supply bypass capacitors are inside the package, the overall system can be packed very tightly without compromising performance. Such compromises often occur when reference and supply bypass capacitors are near digital signals which

can then corrupt the data conversion process. Finally, the substrate allows the pin assignments to flow logically: analog inputs on one side, digital outputs on the other side of the package.

In this example, the number of active components is five, with four SAW filters and 80 other small passive components (see Figure 3). The overall area is about $43\text{mm} \times 21\text{mm} = 903\text{mm}^2$, although not all of that area is utilized, so the effective area is more like 700mm^2 . Of course, this is on one side of the board and company-specific design rules may allow for an even more compact layout.

For power calculations this example uses the LT5569 as the dual mixer, the AD8376 as the dual VGA and the LTM9012-AB as the combination of the second amplifier stages and quad ADC. The mixer is an active type, which operates over a wide 300MHz to 4GHz frequency range, so a single part can be configured to operate on any of the cellular bands from 700MHz to 2.7GHz. With best-in-class power consumption, it also has robust inputs that can withstand strong in-band blocking interference signals without significantly degrading its noise figure. The overall power consumption of the four channel system is 4.9 Watts, not including possible power dissipated in resistive dividers.

Direct Conversion Example

For four direct conversion channels our only options are individual I/Q demodulators, so four of those in $5\text{mm} \times 5\text{mm}$ QFN packages are required. Some, like the LT5575, have integrated RF and LO baluns to minimize the number of external components. A bit of filtering is beneficial and, of course, some small bypass capacitors. For the lowpass filter, multiple L-C and R-C sections are done. For the gain stage, the LTM9012-AB is again appropriate. As a quad, it only supports two direct conversion channels, so a second one is needed.

In this example, the number of active components is 6 with 84 small passive components, see Figure 4. The overall area is about $27\text{mm} \times 24\text{mm} = 648\text{mm}^2$.

For power calculations this example uses the LT5575 I/Q demodulator and two of the LTM9012-AB. The overall power consumption of the four channels is 5.1W, not including possible power dissipated in resistive dividers. However, the ADC is sampling at 125Msps, which is common but likely more than is necessary for 10MHz. At 65Msps, the same function could be done with much less power consumption in the ADC. Recalculating the power consumption brings the new total to 4.6W.

Figure 3: Example layout of superheterodyne receiver

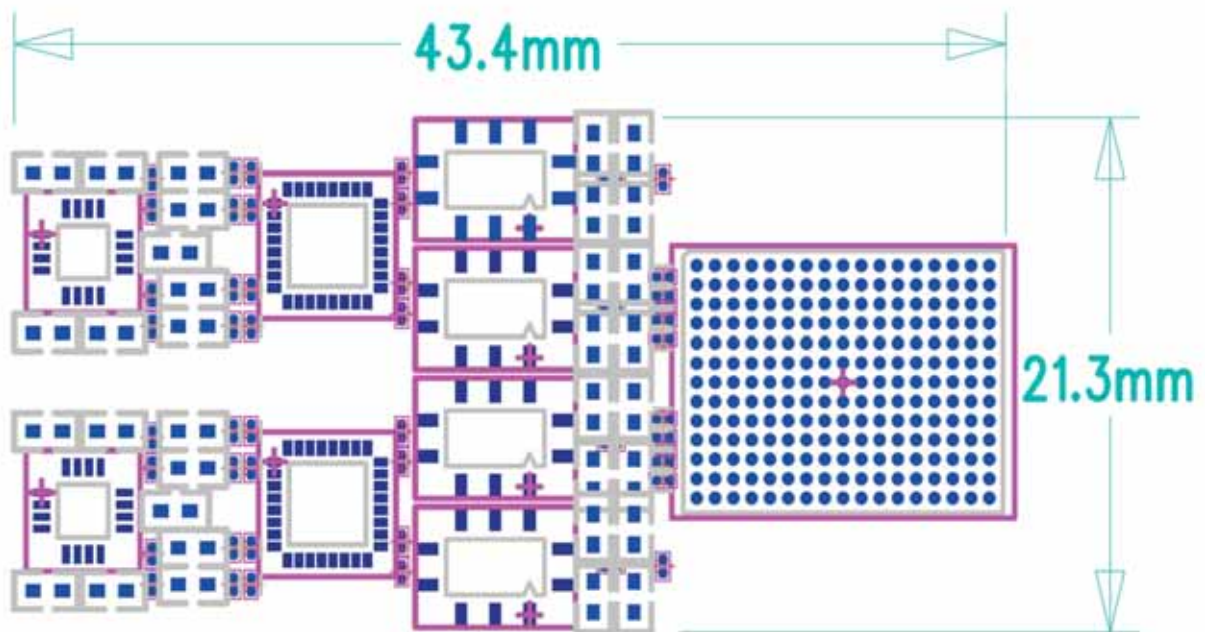
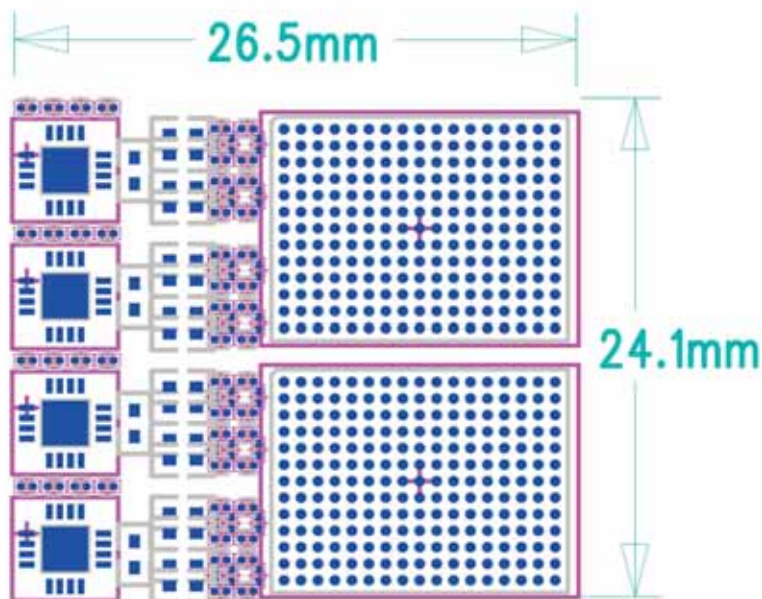


Figure 4: Example layout of direct conversion receiver



Perhaps one day a technological breakthrough will occur and highly selective bandpass filters will be feasible on-chip; until then, the direct conversion receiver architecture has a distinct advantage for potential integration of the entire receiver chain where performance allows it

Perception and Reality

Not too many years ago, a superheterodyne receiver used multiple mixers and multiple SAW filters per channel. And SAW filters in the day could be 25mm x 9mm. The passive core mixers required additional gain stages to account for the insertion losses. Such recent history clouds the perception of the gap in hardware complexity between superheterodyne and direct conversion receivers.

On a percentage basis, the board area used for the superheterodyne receiver is 39% more than the direct conversion, which is a significant percentage, but in real PCB area the difference is not so great; 39% of 903mm² is 352mm², or about the size of a thumb print. The power consumption difference is not significant on a percentage basis at all.

The perception of a significant size and power penalty for the superheterodyne receiver is relative to the overall size of the base station transceiver itself, of course. For a traditional rack-mount form factor, a thumb-sized amount of PCB area may not matter. For a tiny base station that could fit in the palm of a hand, a thumb-sized amount of PCB area is very significant.

The reality is that integration continues, sometimes slowly and sometimes in great leaps. The reduction in board space or power consumption may apply to one type architecture more than to another.

Recent examples that apply to the superheterodyne are products such as the LT5569 dual active mixer. The author is not aware of any dual I/Q demodulators available for cellular base station applications, although they do exist for other applications at lower frequency ranges. The recent example of integration that applies to both architectures is the LTM9012 quad ADC with integrated amplifiers. The device's LVDS serial interface not only allows the ADC to be smaller, but may allow the field programmable gate array (FPGA) or digital signal processor (DSP) also to be smaller than that of four ADCs with parallel interfaces. However, the direct conversion architecture still requires twice the number of ADCs.

The example discussed above makes the assumption that the performance requirements of the cellular base station are such that high performance components are required throughout the chain. The products used in the example utilize optimized semiconductor processes such as silicon germanium (SiGe) or complementary metal oxide semiconductor (CMOS) processes that are otherwise not conducive to integration with each other – or at least not without performance degradation.

Certain size base stations may have performance requirements that allow the use of highly integrated, single-chip

transceivers, such as femtocells. Improvements in the integrated blocks of such chips will allow them to be applied to larger base stations. And here the two architectures reach a barrier: the signal filter. The direct conversion receiver uses a lowpass filter that can be implemented in silicon.

To date, the bandpass filter used in superheterodyne has proven extremely difficult to implement in silicon. This is a reality of the moment, not necessarily a permanent barrier. Perhaps one day a technological breakthrough will occur and highly selective bandpass filters will be feasible on-chip. Until then, the direct conversion receiver architecture has a distinct advantage for potential integration of the entire receiver chain where the performance allows.

In Summary

The direct conversion receiver architecture for cellular base stations is simpler than the superheterodyne receiver architecture, at least in terms of hardware. Recent products allow multichannel implementation of superheterodyne receivers to be much smaller than before. While still larger on a percentage basis, the difference may not be significant. Therefore, the superheterodyne is expected to remain the preferred receiver architecture for cellular base stations. ●

USING LOW POWER RADIO IN EMBEDDED APPLICATIONS

PROFESSOR DR DOGAN IBRAHIM OF THE NEAR EAST UNIVERSITY IN CYPRUS DESCRIBES THE FEATURES OF LOW POWER RADIO (LPR) AND SHOWS HOW A MICROCONTROLLER-BASED WIRELESS TEMPERATURE MONITORING SYSTEM CAN EASILY BE DESIGNED USING A COMMERCIALY AVAILABLE LPR TX/RX PAIR

The terms 'low power radio' (LPR), 'low power device' (LPD) and 'short range device' (SRD) are used interchangeably to describe limited power transmitting and receiving

equipment that is operated without the need for an end-user license. Although the range is not defined when terms 'low power' and 'short range' are used, many installations using such equipment may operate over several kilometres, though more typically over several hundreds of metres.

Although LPR can in general be used in any application requiring short range radio communication, typical application areas are:

- Handheld/portable terminals
- Remote data acquisition and logging
- Remote control of equipment
- EPOS and barcode readers
- Alarm systems
- RFID
- Medical implants
- Building automation
- Automotive data acquisition and management

Short Distance Radio Communication Systems

Short range devices in Europe are standardized and regulated by the

THE LOW POWER RADIO ASSOCIATION (LPRA)

IN THE UK ([HTTP://LPRA.ORG](http://lpra.org)) REPRESENTS THE INTERESTS OF THE SHORT RANGE DEVICE INDUSTRY,

its manufacturers, users and employees. Membership to the association is open to all organizations, consultants and users interested in joining and having an active role in the decision making mechanisms while new standards are prepared, or watching the developments in the short range device industry.

European Standards. ETSI (European Telecommunications Standards Institute) produces the standards but their regulation is carried out by CEPT (Conference of Postal and Telecommunication Administrations) through three principal working groups, acting through ECC (European Communications Council). The laws for the use of the radio spectrum are produced by the EC (European Commission), acting through several committees.

Some of the generic standards covering the widely used 25MHz to 1GHz frequency range, which is the interest in this article, are:

- EN 300 220, which covers the technical characteristics and test methods for radio equipment with power levels up to 500mW.
- EN 301 489, which covers the

electromagnetic compatibility (EMC) standards for radio equipment and services.

There are also many other ETSI standards that cover other frequencies of interest.

There are several protocols and technologies used for short distance wireless radio communication. Some commonly used systems are Wi-Fi, Bluetooth and ZigBee.

- **Bluetooth:** It is used to exchange data over short distances using the 2.4GHz ISM band. Although it was originally conceived as a wireless replacement of the RS232, Bluetooth is a packet based protocol with master-slave structure, where a master can communicate securely and reliably with up to 7 slaves.

Bluetooth is intended to be used for mobile communication where, for example, a picture or an audio file can be transferred from one mobile phone to another. The maximum permitted power is 20dBm (100mW) with a practical range of around 50m. Version 2.0 Bluetooth can achieve throughput of 2.1Mbps. Today, most mobile phones and laptop computers support Bluetooth connectivity.

	WI-FI	BLUETOOTH	ZIGBEE	UHF
Band	2.4GHz	2.4GHz	2.4GHz + 868MHz (UK)	433MHz
Power	100mW	100mW	30mW	Various
Range	100m	50m	75m	500m
Data rate	54Mbps	2.1Mbps	250Kbps	Various
Security	Various	128-bit encryption	128-bit encryption	various

Table 1: Short distance radio features

FREQUENCY RANGE	ADVANTAGES	DISADVANTAGES
2.400 – 2.500 GHz	Small antennas, widely used in Wi-Fi, Bluetooth and ZigBee	Poor penetration into buildings, short range, band congested, difficult to develop hardware, high power consumption
902 – 928 MHz	Small antennas, range up to 1km	Not used in UK
458 MHz	Range up to several kilometres, high power (500mW), un-crowded band	Only few channels are allowed, larger antenna (16cm)
433.05 – 434.79 MHz	Widely used, choice of many manufacturers, range up to 500m	Low power (10mW), band is overcrowded, larger antenna (16cm)
VHF	Up to 10km range, low power consumption	No specific frequency allocation, long antenna, low data rate
HF	High power, simple hardware	No specific frequency allocations, long antenna, low data rate, overcrowded band

Table 2: Comparison of ISM band frequencies

● **Wi-Fi:** It is intended for residential equipment and its applications. Its main use is in connecting laptop and desktop computers wirelessly to the LAN. Currently most mobile phones are equipped with Wi-Fi capabilities and can also be connected to the LAN. Wi-Fi and Bluetooth technologies were designed for two completely different purposes. Bluetooth products make it easy to connect various electronic devices to each other, while

the Wi-Fi products were designed as a replacement or an extension of an existing LAN. The latest Wi-Fi technology enables data transfers up to 54Mbps with sophisticated data encryption algorithms. The range of Wi-Fi is up to about 100m.

● **ZigBee:** It is intended for use in short range embedded applications requiring low data rates and low power consumption. The protocol defines a mesh network based

architecture that can be used for industrial control, data collection, embedded sensing, building automation etc. Perhaps the biggest advantage of ZigBee is its very low power consumption (30mW), with most devices having battery life in excess of a several years. ZigBee operates on the 2.4GHz and 868MHz (UK) ISM bands with a bandwidth of 250kbps and a range of up to 75m. The protocol provides data transfers



Figure 1: The commonly used ISM band frequencies

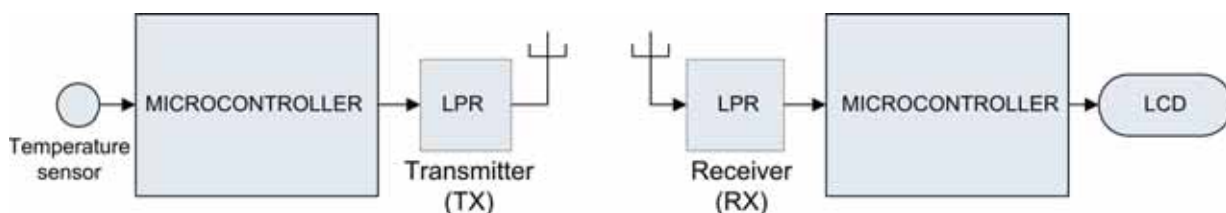


Figure 2: Block diagram of the example system

LCD. Its block diagram is shown in Figure 2.

The transmitting side consists of a microcontroller, a temperature sensor and a LPR transmitter device. Similarly, the receiving side consists of a microcontroller, an LPR receiver device and an LCD. The temperature is measured every 10 seconds by the transmitting side and is sent to the receiving side which displays the temperature on its LCD.

The circuit diagrams of the example transmitter and receiver systems are shown in Figure 3 and Figure 4 respectively. The temperature is measured using a LM35 type analog semiconductor temperature sensor. This is a 3-pin sensor providing an output voltage proportional to the temperature measured, i.e. $V_o = 10\text{mV}/^\circ\text{C}$. Thus, for example at 20°C the output is 200mV and so on.

The output of the sensor is converted into digital using one of the 10-bit A/D channels of the PIC16F877 microcontroller from Radiometrix. Although a PIC16F877 microcontroller is used in this project, it is possible to use any other microcontroller from the PIC family or from any other microcontroller family, provided that the device has built-in UART for serial communication (the serial communication can also be implemented in software without UART).

The measured temperature data is sent to a TXL2 type LPR transmitter device that broadcasts the data in the 433MHz ISM band. On the receiving side, a matching RXL2 type LPR device receives the temperature data and it sends it to a microcontroller where the data is displayed on an LCD.

The TXL2/RXL2 Pair

The TXL2 and RXL2 (see Figure 5) are matching LPR transmitter and receiver devices respectively, manufactured by Radiometrix. The devices are UHF multi-channel transparent data link, 9600 baud simplex radio modems, housed in SIL footprint. The beauty of these devices is their simplicity of use. Only an external antenna is required to operate the transmitter and the receiver. Serial raw ASCII data without encryption sent to the transmitter appears at the receiver

output after the device latency time. The devices conform to the European standard EN 300 220-3 and EN 301 489-3.

TXL2/RXL2 can be set to 1 of 8 unique addresses for point-to-point operations. In addition, operation on 5 different channels in the frequency band 433.925MHz to 434.565MHz is possible. The devices are supplied configured with address 0 and channel 0 (433.925MHz), although this configuration can easily be changed by programming the devices, for example using a serial terminal. A 32-byte data buffer is provided on both the transmitter and the receiver devices to buffer the user data.

The TXL2 is the 8-pin transmitting device offering +10dBm (10mW) power to a 50Ω antenna, consuming only 28mA at 5V during transmit. The device measures 42mm x 18mm and 7mm in thickness. Operation of the device requires only the TXD input to be driven with the serial user data, usually from a UART at 9600 baud (a 4800 baud version is also available).

The TXD pin is inverted and can be connected directly to a microcontroller UART output. Interfacing with a RS232 device will require a transistor level converter or a RS232 line driver (e.g. MAX232). All the transmit time synchronization, valid data identification, error checking, automatic noise squelching and data stream buffering are handled by the device.

The RXL2 is the 7-pin receiving

device having a sensitivity -107dBm and adjacent channel rejection of 60dB @320kHz. The device measures 47mm x 17mm and 7mm in thickness.

Received data is available at the RXD output, which is normally connected to a UART to capture the data. RXD pin is inverted and, thus, can be directly connected to an UART input. As with the TXL2, interfacing with a RS232

```

BEGIN
  Configure I/O ports
  Configure UART
  DO FOREVER
    Read analog channel 0
    Convert to °C
    Convert to floating point string
    Send to transmitter buffer
    Wait 10 seconds
  ENDDO
END

```

Figure 7: Operation of the transmitter program

```

BEGIN
  Configure I/O ports
  Configure UART
  Initialize LCD
  DO FOREVER
    Read data from UART
    IF end of data THEN
      Display data on LCD
    ENDIF
  ENDDO
END

```

Figure 8: Operation of the receiver program

```

void main()
{
  unsigned int T;
  float mV, Temperature;
  unsigned char Txt[15];
  unsigned char *res;
  TRISA = 1; // AN0 is input
  ADC_Init(); // Initialize A/D
  UART1_Init(9600); // initialize UART

  for(;;) // Endless loop
  {
    T = ADC_Read(0); // Read analog data
    mV = T * 5000.0 / 1024.0; // Convert to mV
    Temperature = mV / 10.0; // Convert to temperature
    FloatToStr(Temperature, Txt); // Convert to string
    res=streat(Txt,"X"); // Add terminator character
    UART1_Write_Text(res); // Send to UART (TX)
    Delay_Ms(10000); // Wait 10 seconds
  }
}

```

Figure 9: Transmitter program

```

// LCD configuration
sbit LCD_RS at RB4_bit;
sbit LCD_EN at RB5_bit;
sbit LCD_D7 at RB3_bit;
sbit LCD_D6 at RB2_bit;
sbit LCD_D5 at RB1_bit;
sbit LCD_D4 at RB0_bit;

// LCD pin directions
sbit LCD_RS_Direction at TRISB4_bit;
sbit LCD_EN_Direction at TRISB5_bit;
sbit LCD_D7_Direction at TRISB3_bit;
sbit LCD_D6_Direction at TRISB2_bit;
sbit LCD_D5_Direction at TRISB1_bit;
sbit LCD_D4_Direction at TRISB0_bit;

void main()
{
  unsigned char rec,k = 0;
  unsigned char buffer[15];
  Lcd_Init(); // Initialize LCD
  UART1_Init(9600); // Initialize UART

  for(;;) // Endless loop
  {
    while(UART1_Data_Ready() == 1)
    {
      rec = UART1_Read(); // Read character
      if(rec != 'X') // If terminator
      {
        buffer[k] = rec;
        k++;
      }
      else
      {
        buffer[k] = 0x0;
        k = 0;
        Lcd_Cmd(_LCD_CLEAR); // Clear LCD
        Lcd_Out(1,1,"T="); // Display "T="
        Lcd_Out_Cp(buffer); // Display temperature
        Lcd_Chr_Cp('C'); // Display "C"
      }
    }
  }
}

```

Figure 10: Receiver program

device will require a transistor level converter, or a line receiver chip. In addition, a BUSY output is available that can be used to generate interrupts when data is received in interrupt driven applications.

Three types of antennas are recommended by Radiometrix. At 433MHz, a whip antenna can be used for high performance and it can be constructed from a 16.4cm wire, rod, or PCB track. Alternatively, a helical antenna can be used where space is restricted (20mm x 4mm diameter), or a loop antenna can be used for the benefit of added immunity to proximity effects.

The hardware of the test system was



Figure 11: Typical output displayed on the LCD

constructed using two easyPIC6 microcontroller development boards (see Figure 6): one for the TX and one for the RX. The board contains a large number of LEDs, push-button switches, LCD, GLCD, programmer, in-circuit debugger (mikroICD), keypad, USB, RS232 and PS/2 interface and many more. The TXL2/RXL2 pair was placed on a small breadboard during the tests.

The Software

The software of the test system was based on the mikroC (www.mikroe.com) language. This is a highly popular C language for the PIC family of microcontrollers. The mikroC language offers a large number of built-in library

functions to support peripheral devices such as RS232, RS485, SPI, I2C, PS/2, UART, SD card and many more.

Programmes written using mikroC are compiled and can be transferred to the target microcontroller by simply clicking a button. In addition, the code can be debugged in real-time using the in-circuit debugging tools provided by the integrated user environment.

Figure 7 shows operation of the transmitter program. The program simply reads the temperature from analog channel 0, converts it into °C and then sends the data to the TXL2 in serial format using the mikroC built-in UART functions. Floating-point arithmetic is used in the code for higher temperature accuracy. This process is repeated forever with 10 second delay between each output.

Operation of the receiver program is shown in Figure 8. The program consists of an endless loop. Inside this loop the received data is extracted from the RXL2 using the mikroC built-in UART functions and then displayed on the LCD.

The actual microcontroller program codes are given in Figure 9 and Figure 10 for the transmitter and receiver respectively. Notice that a terminator character ("X") is added to the data in the transmitter to signal the end of data. The receiver program extracts data from the RXL2 while there is data in the UART (Data_Ready = 1). The received characters are inserted into a buffer as they are read from the UART. When the terminating character "X" is read, the LCD is cleared and the current temperature is displayed on the LCD. In addition, the buffer pointer "k" is initialized to 0, ready for the next sample of data.

Figure 11 shows a typical output displayed on the LCD. ●



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DESIGNING AND BUILDING RF MEASUREMENT SYSTEMS

DESIGNING AND BUILDING AN RF MEASUREMENT SYSTEM REQUIRES CAREFUL CONSIDERATION. HOWARD VENNING OF ASPEN ELECTRONICS PROVIDES SOME GUIDANCE

W

ith the roll out of new digital wireless systems, the accurate measurement of medium power RF signals becomes more critical. This article reviews the choices

engineers have and investigates what steps are required to build an accurate measurement system.

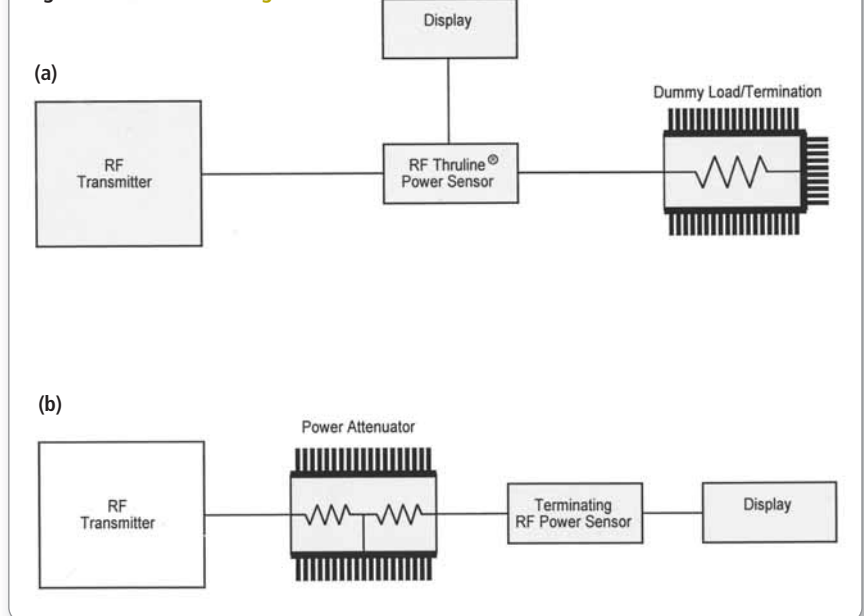
As such, we shall be considering medium power applications where the RF frequency range extends from 2MHz to 4GHz. Medium power covers the range from 50mW to 100W, which is typical of the output power of the majority of transmitters in use today. In short, we are looking at measurement systems applicable to 90% today's RF systems.

Measurement System Components

The key components are the power sensor, attenuator, directional coupler and various cables and accessories. There are a couple of basic decisions that will need to be made early on, depending on the end application and degree of accuracy required. System accuracy can depend not only on the measurement method, but also the type of components selected (see more in 'Understanding Accuracy').

There are two basic methods of measuring the output from an RF transmitter: 'Terminating' (Figures 1a and 1b) and 'through-line' (Figures 2a and 2b).

Figure 1a & 1b: Terminating method



Both methods require direct connection to the output of the transmitter and this article will concentrate on systems using coaxial cables and connections.

The terminating method is generally used in a lab/production environment where the power output from the transmitter is absorbed by a power attenuator or dummy load/termination.

The through-line method is particularly useful for field-based measurements or permanent installations where power measurement takes place while the transmitted signal is being applied to the antenna.

When using a terminating sensor to measure the output of a transmitter, the first consideration is how to attenuate the output power of the transmitter to match the working range of the terminating sensor. There are three common methods to achieve this.

1. Use an attenuator to provide the required attenuation for direct input into the terminating measurement sensor.
2. Use a directional coupler to provide the

attenuation required by the terminating sensor and to allow configuration of the measurement system such that the output signal from the transmitter can be broadcast or monitored by another instrument.

3. Alternatively, the through-line method delivers the best of both worlds, as the directional coupler and measurement sensor are packaged in a single sensor. An advantage of this type of technology is that the through-line power sensor does not need any additional components (other than a dummy load, if configuring a terminating measurement system).

Power Sensors

The typical operating range of terminating sensors lies between -50dBm and +20dBm. For the best performance in terms of accuracy, this operating range is effectively reduced to around -20 to +10dBm. For discussion purposes, consider the case where the optimum input level is 0dBm.

For medium power applications with transmitter output from 100mW to 100W, the transmitted power level will need to be attenuated down to 1mW (or 0dBm). This works out to be 20dB (for 100mW output) and 50dB (for the 100W output).

Terminating power sensors more commonly offer the user a wide dynamic range and a wide operating frequency range. Some sensors, designed to cope with higher power ranges, may have power attenuators incorporated.

Most through-line sensors consist of a precision, high directivity coupler, plus detection system all-in-one package. They might have less dynamic range and a narrower operating frequency range but they will still cover 95% of medium power applications. The real advantage of a through-line power sensor is that no further system components are required.

Attenuators

Selecting a good attenuator is a relatively simple job. The key parameters to consider are: power rating, attenuation value, attenuation accuracy, attenuation flatness vs frequency, and VSWR.

When considering the power rating, a good rule of thumb is to choose an attenuator with twice the power rating of the transmitter. Essentially, as the attenuator dissipates heat it gets hot and the internal components expand. This can impact the parameters listed above. In addition, the terminating sensor is typically connected directly to the attenuator and as such may also be subject to the effects of the attenuator as its temperature rises.

When looking for attenuators try to find a manufacturer who quotes a low temperature coefficient. This will be specified as dB/dB/°C. A good figure to aim at is approximately 0.0005dB/dB/°C, which means a 30dB attenuator that rises in temperature, from say room temperature at 20°C to 45°C, will give a total change in attenuation of 0.375dB. In addition it is important to calibrate the attenuator “hot”. A good calibration house should be able to do this and the user will ultimately have a better understanding of the true effects of attenuation variation on overall power measurement accuracy.

Virtually all attenuator manufacturers quote accuracy and VSWR for their products. However, figures are typically “worst case” and an attenuator with an attenuation accuracy of ± 1 dB for example will contribute more than 25% to overall system accuracy. So, once again, it is vital to calibrate this component if it is used in a measurement system.

The attenuation value should be selected to suit the system under test. Ideally the attenuation value will ensure the power applied to the sensors is approximately 0dBm, the sensors most accurate region.

As an example, measuring a transmitter with a nominal 50W output will require a 47dB attenuator in order to achieve an output power of 0dBm.

A further word of advice when it comes to calibrating the attenuators is to specify clearly the frequency range over which measurements will be made and make a note of the attenuation variation and VSWR vs frequency.

Note that while VSWR variations can adversely impact measurement accuracy, there is also a positive effect, as it can mask what might otherwise be a poor source VSWR.

When looking for attenuators try to find a manufacturer who quotes a low temperature coefficient – this will be specified as dB/dB/°C. A good figure to aim at is approximately 0.0005dB/dB/°C

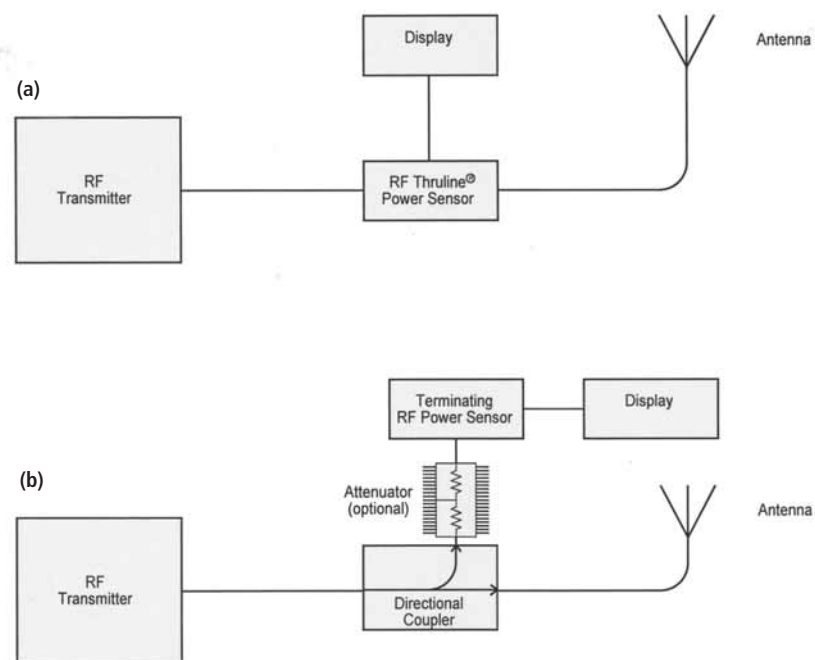
Directional Couplers

When choosing a directional coupler it is necessary to review the same parameters as for selecting an attenuator, as well as, importantly, directivity. In the case of directional couplers, the attenuation figure is typically referred to as “coupling factor”.

Directional couplers are designed to operate by allowing the majority of the signal applied to the input to pass straight through to the output, while taking a small sample of the signal which is directed to the coupled port.

All directional couplers exhibit a certain amount of insertion loss, which will attenuate the transmitted signal. This insertion loss increases with lower coupling figures. Therefore, a good coupling factor to aim for is 30dB. To

Figure 2a & 2b: Throughline method



ACCURACY COMPARISONS

OBTAINING A TOTAL ACCURACY FIGURE FOR SENSORS CAN BE A COMPLICATED TASK. THE MOST CONCISE DEFINITION FOR TOTAL SENSOR ACCURACY IS AS FOLLOWS:

$$\text{Accuracy} - \text{Total Error (RSS)} = \sqrt{(\text{Mm}^2 + \text{CF}^2 + \text{L}^2 + \text{N}^2 + \text{T}^2)}$$

where: Mm = Mismatch, CF = Cal Factor, N = Noise, L = Linearity, T = Temperature. Total error is typically calculated as: Root Sum of the Squares (RSS) of Mismatch + Cal Factor + Linearity + Temperature.

Table 2 shows the accuracy figures (where available/published) for a selection of products currently on the market. Not all manufacturers, it seems, are as ready or willing as others to publish the accuracy figures of their products clearly and unambiguously. This makes it impossible to fully understand some overall accuracy figures and, equally, to compare them.

measure the output of a 100W transmitter, with a target input to the sensor of 0dBm, an additional 20dB of attenuation is required. This can be achieved by using a low power attenuator fitted to the output of the coupled port, giving a total attenuation of 50dB.

Once the required components have been selected they can be calibrated to determine overall attenuation vs frequency and VSWR. In the case of a directional coupler plus attenuator combination, it is best if these can be calibrated as a pair or complete assembly.

The one parameter unique to directional couplers is 'directivity'. This can have a major effect on overall measurement system accuracy and so needs special attention. The impact of directivity on overall accuracy is especially important where measurements are being made in the field, that is, on systems that terminate in an antenna, as opposed to lab/production systems where the terminating element is typically a precision 50ohm load with a good VSWR. For instrumentation grade products directivity figures of between 35dB to 40dB are the norm. For 'system' products typical directivity specifications will be between 20dB to 25dB.

With such a wide variation in these parameters, if accuracy is critical then it is

Table 1: Power sensor uncertainty

Total Error (RSS) = $\sqrt{(\text{Cal}^2 + \text{Lin}^2 + \text{Noise}^2 + \text{VSWR}^2 + \text{Temp}^2)}$								
Manufacturer		Cal Factor	Linearity	Noise	Temp.	VSWR	Total	Total %
Terminating Sensors								
A	Max	0.212	-	0.01	-	0.075	0.225	5.32
	Min	0.17	-	0.01	-	0.075	0.186	4.38
B	Max	0.083	0.229	0.01	0.15	0.088	0.299	7.14
	Min	0.047	0.022	0.01	0.058	0.067	0.103	2.40
C	Max	0.293	0.293	0.01	0.043	0.067	0.422	10.21
	Min	0.073	0.064	0.01	0.01	0.067	0.119	2.77
D	Max	0.45	0.46	0.01	-	0.088	0.650	16.13
	Min	0.17	0.26	0.01	-	0.067	0.318	7.60
Inline Power Sensors								
E	Max	0.162	-	-	0.06	-	0.173	4.06
	Min	0.162	-	-	0.06	-	0.173	4.06
F	Max	-	-	-	-	-	-	5.00
	Min	-	-	-	-	-	-	5.00

Notes
 1) All figures stated above are in dB
 2) All VSWR error figures assume a source VSWR of 1.25:1
 3) A maximum temperature range of 0 to 50Deg C was used.
 4) Manufacturer A quoted "power accuracy" - this is essentially a combination of linearity, instrumentation accuracy and traceability to absolute accuracy at 50MHz, 0dBm
 5) Manufacturer F simply quoted "total accuracy".

vital to select instrumentation grade products and get them calibrated.

In building an accurate measurement system, the inclusion of an attenuator and/or directional coupler will affect the overall measurement accuracy and, therefore, care needs to be taken to ensure the appropriate components are selected. There is little point in choosing an accurate sensor and then compromising its performance with a poorly performing coupler or attenuator.

Other System Components

When it comes to assembling a practical measurement system additional cables and coaxial adaptors may be needed. Wherever possible try to avoid

unnecessary connections as each cable and/or adaptor will add to overall VSWR, which in turn will add to the overall system error.

Ensure cables are as low loss as possible and are correctly fitted with the best quality connectors. Spending £2,000+ on power measuring equipment and then trying to save £50 by using a low cost cable is false economy.

The Bottom Line

Power sensors range in price from approximately £800 to £2,500. It is interesting to note that through-line sensors are only marginally more expensive than terminating sensors, but do not require additional components, which

Table 2: VSWR vs accuracy examples

Source VSWR	Load VSWR	Source Gamma	Load Gamma	Uncertainty +	Uncertainty -	Accuracy
1.10	1.10	0.0476	0.0476	0.0197	-0.0197	0.454%
1.25	1.05	0.1111	0.0244	0.0235	-0.0236	0.543%
1.15	1.15	0.0698	0.0698	0.0422	-0.0424	0.976%
1.20	1.15	0.0909	0.0698	0.0549	-0.0553	1.273%
1.25	1.20	0.1111	0.0909	0.0873	-0.0882	2.030%
1.25	1.25	0.1111	0.1111	0.1066	-0.1079	2.484%
1.30	1.40	0.1304	0.1667	0.1868	-0.1909	4.395%

can make them a significantly cheaper solution.

Application-specific directional couplers can cost from £50 up to £500 or more. Precision grade directional couplers can cost almost as much as the sensor and in some cases even more – between £800 and £2,500.

For attenuators with power ratings up to 100W, expect to pay around £150, and up to £250 for high power attenuators. Low power attenuators, needed to increase the coupling attenuation of directional couplers or to increase the total attenuation of high power attenuators, can be purchased from numerous sources from as little as £20.

Good quality, high power, low-loss cables can cost from £50 to as much as £400, for a 1m cable terminated with low VSWR high frequency N-type connectors,

AS MANUFACTURERS QUOTE ACCURACY FIGURES IN BOTH PERCENTAGE (%) TERMS AND DB TERMS IT IS IMPORTANT TO UNDERSTAND THE RELATIONSHIP BETWEEN THE TWO AND TO BE ABLE TO CONVERT QUICKLY DB ERROR INTO % ERROR AND VICE VERSA.

A % error, expressed in dB is calculated as: $10 \log P1/P2$.

So a 5% error expressed in dB will be $10 \log 1.05/1.00 = 0.21\text{dB}$.

Conversely a % error figure, expressed in dB is calculated as:

$(10^{(\text{error in dB}/10)}) - 1 \times 100 = \% \text{ error}$.

Insertion loss variations within your system will be specified in dB and, as such, it's good to instinctively know that, for example, a variation of 0.2dB is approximately equal to an accuracy of $\pm 5\%$.

and supplied with a calibration certificate and test results. Good quality 'measurement' grade adaptors can cost almost as much as cables.

Building an accurate RF power measurement system is relatively simple if you consider the above. Depending on the application, budget £2000 to £6,000 for a complete system, to include calibration of

the power sensor and additional components.

Remember, calibration is vital and the calibration data correctly applied to the overall measurement system accuracy. Using standard published specification figures could possibly degrade the overall measurement system accuracy by, in some cases, as much as $\pm 50\%$ or more. ●

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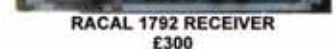
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CMOS-ON-SAPPHIRE TECHNOLOGY ENABLES INTEGRATION OF HIGH-PERFORMANCE RF AND POWER MANAGEMENT

JAMES SWONGER, PETER BACON AND GARY WU FROM PEREGRINE SEMICONDUCTOR DISCUSS THE ULTRACMOS PROCESS – AN RF CMOS IC PROCESSING UTILISING A SAPPHIRE SUBSTRATE – AS A VIABLE APPROACH FOR POWER-HUNGRY RF SYSTEMS USED IN SPACE SYSTEMS

RF CMOS IC processing utilizing a sapphire substrate (silicon-on-sapphire, or SOS) has a long history in space-borne systems. Improvements to this technology have brought SOS firmly into the mainstream in commercial and military RF applications, and the benefits of performance, integration, density, signal speed and cost are now added to the familiar radiation resistance of the technology. Known as UltraCMOS technology (a registered trademark of Peregrine Semiconductor Corp), it is being applied to the space markets for improved power management.

Power Management

Power management and power conversion are fundamentally important for system designs, regardless of the market. For instance, these functions are essential to support the proliferation of portable electronic devices, ensuring that

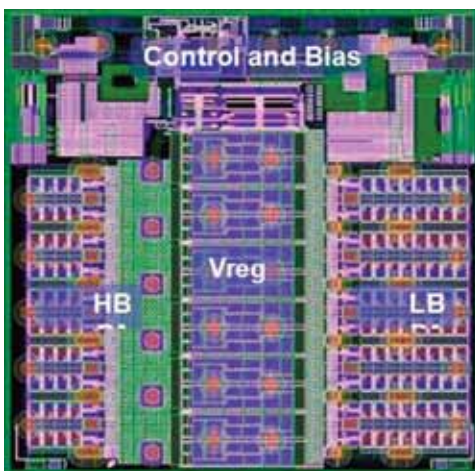


Figure 2: Dual-band RF power amplifier in CMOS on sapphire, with on-chip low dropout regulator

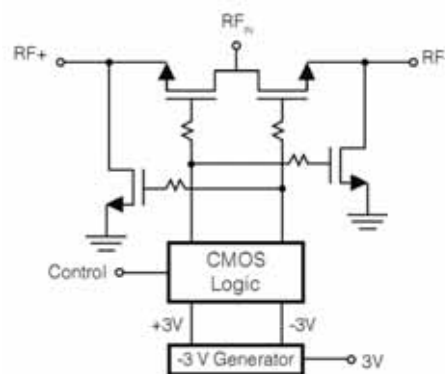
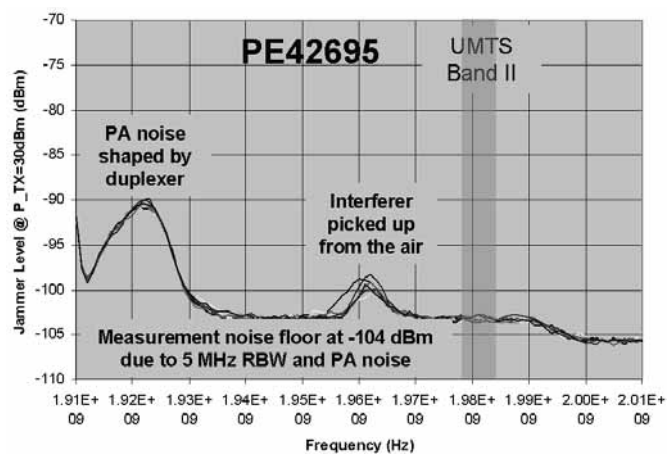


Figure 1: UltraCMOS RF switch with on-chip charge pump negative voltage generator (top) noise performance and (bottom) block diagram

finite battery resources are optimized. Certainly space systems are challenged in power resources, and man-portable military electronics need to maximize duration while minimizing battery weight and bulk. To support these needs, power management techniques are now being integrated into non-power-conversion products.

There are many applications where

silicon-on-sapphire (SOS) technology has addressed power management issues: from micro-power charge pumps embedded in RF switch products, to integrated regulation within RF power amplifiers, power management/bias control chips in transmit/receive (T/R) modules, and commercial-space integrated DC-DC converter standard products. A key attribute of the sapphire

substrate is that its isolation enables high integration and high performance.

In RF applications, noise is one of the greatest concerns. The insulating sapphire substrate in UltraCMOS SOS technology offers the highest known isolation available, making it particularly well suited for applications where noise is a concern. Peregrine's UltraCMOS technology differs from other SOI methods. Specifically, the UltraCMOS process has no conductive underlayer, eliminating this source of noise coupling.

A key attribute of the sapphire substrate is that its isolation enables high integration and high performance

Power Management in RF Products

Engineers often find it difficult to address on-chip power conversion in RFICs. For instance, there may be a need for more supply voltages than one battery can provide. When the required supply voltages are greater than (or outside of) the battery rail voltages, some form of power conversion is needed. SOS technology can be used to improve power management in numerous types of RF devices, such as switches, power amplifiers (PAs), T/R modules and DC-to-DC converters for applications such as cellular telephone, military and satellite systems.

RF switches built on CMOS on Sapphire enable high performance due in large part to the use of stacked low-threshold FETs on a fully insulating substrate. These switches require a negative control voltage. If the negative voltage were to come from an off-chip supply, it could lead to a power consumption penalty in single-supply systems, and it could also act as a path for potential noise injection. Generating the negative voltage on-chip avoids these issues. The challenge for the switch designer, then, is to bring the negative voltage supply on chip without degrading noise performance (see Figure 1). The structure of UltraCMOS technology makes it resistant to substrate coupling, so concerns about noise issues are reduced. As proof of performance, these types of switches are currently shipping in high volume.

The RF PA in cellular phones, military radios and portable data appliances is often the single largest power drain in the system. High-performance RF circuits are often designed with FETs that perform well at high frequencies but are poor at turning off and have relatively low voltage tolerance. Power management functions need to control the power level within the system, ensuring that devices are not damaged by voltage extremes (such as high VSWR and overcharge scenarios), and maximizing the power efficiency of the circuit.

Dual-band constant-envelope PAs built using UltraCMOS technology typically include embedded low drop-out (LDO) regulators to optimize power-management functions (see Figure 2). The on-chip LDOs allow a 3V CMOS technology to operate across a 2:1 battery voltage range which allows the RF PA to be maintained at its ideal operating point for performance and reliability.

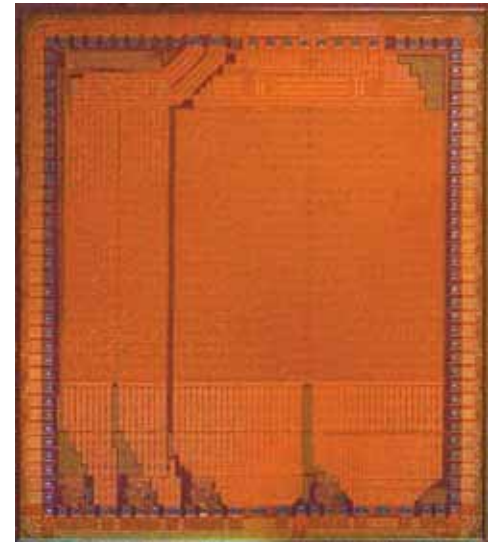


Figure 3: An UltraCMOS T/R module element control chip with four drain switches and active bias control channels, 48 level shifting attenuator/phase shifter control I/Os and serial interface

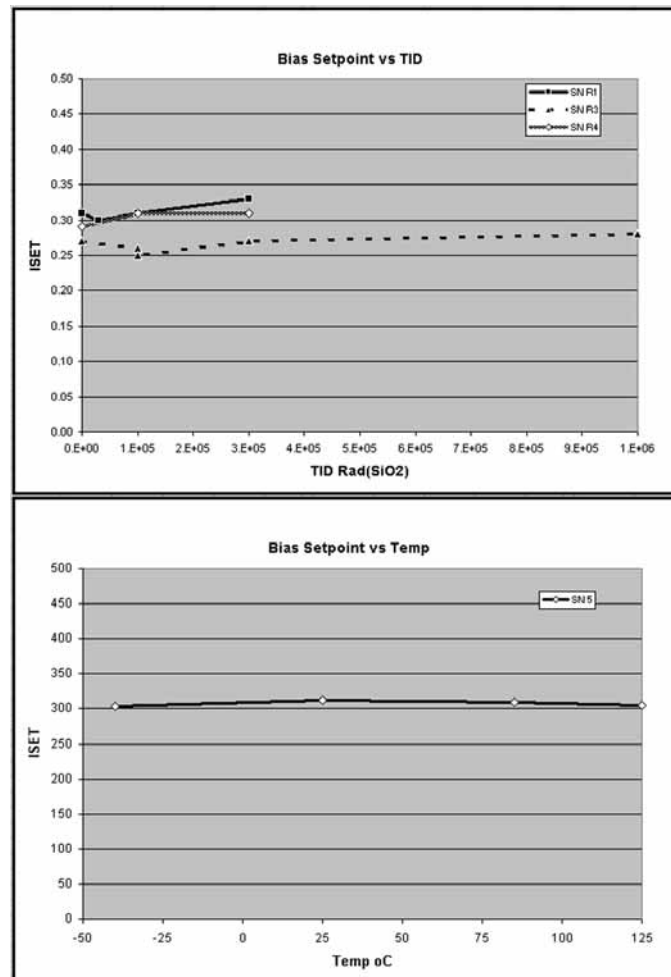


Figure 4: (Top) TX active bias setpoint vs total ionizing dose (TID) and (bottom) temperature

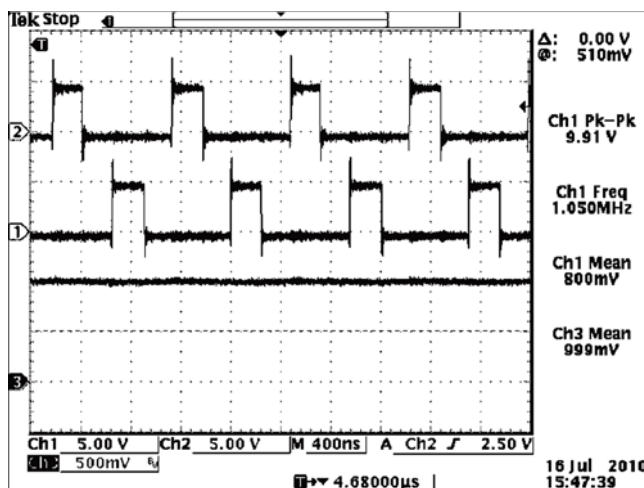
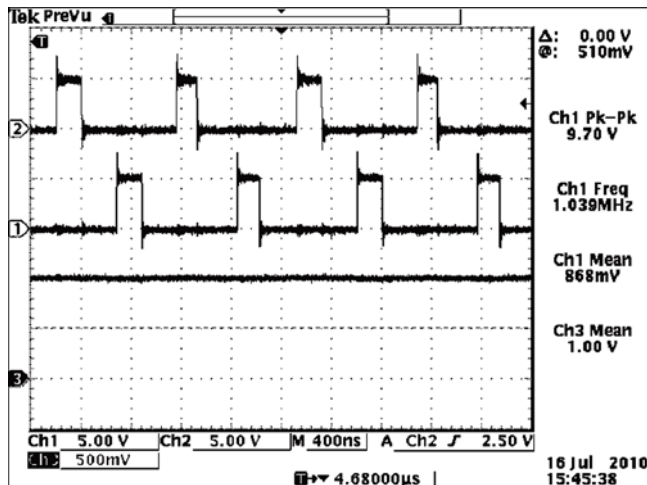
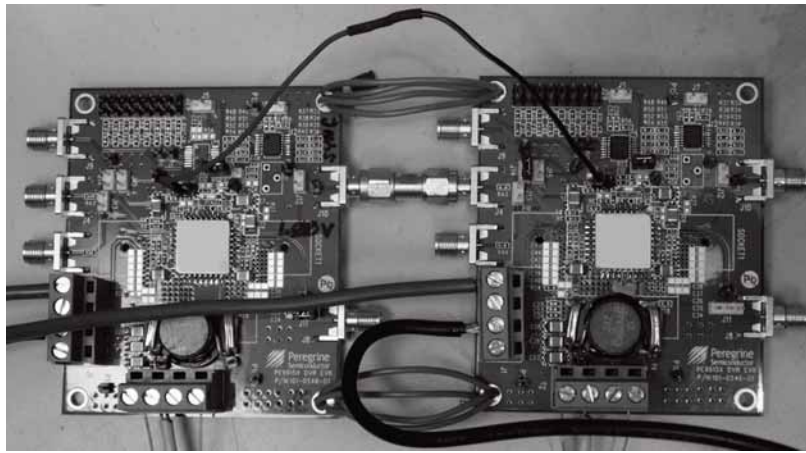


Figure 5: A 20A 2-phase DC-DC buck regulator (converter) using two wires. No-load and 14A waveforms; 1mV load regulation 0-14A; negligible voltage ripple

T/R Module Power Management and Bias Control

T/R modules for space-borne radar present an unusually large power-management problem. These systems feature up to tens of thousands of radiating elements that can draw hundreds of milliamps each when active, so it is necessary to carefully control power draw. The radar performance, particularly uniformity of element power which affects beam quality, also requires tight control of each element's bias-point across line, temperature and aging. Unfortunately, the III-V MMICs used at common radar frequencies cannot effectively throttle

UltraCMOS

technology can be used to integrate custom operational transconductance amplifiers and reference ladders to accurately control bias-point

power by themselves. This complex set of needs can be addressed using custom UltraCMOS element control devices for radar systems (see Figure 3).

Raw power control in T/R modules requires drain switches that handle high current and have low on-resistance. For example, in systems using 3.5V PHEMT/MHEMT technology, a single or stacked UltraCMOS PMOSFET can handle 1A current at under 100mΩ. Two and four-channel versions have been fabricated. The drain switches incorporate fault protection (cross-lockout and gate control under-voltage). This is relatively easy to achieve in an integrated approach, but it is less practical with discrete devices. In the case of the UltraCMOS switch, a serial control channel with numerous level shifter outputs translates the positive CMOS control signals from the host system to the -3V gate control voltages required by the MMIC. The insulating sapphire substrate enables the design of a chip with four separate power domains (CMOS Vdd, TX, RX and the -3V VC gate control voltage).

UltraCMOS technology can be used to integrate custom operational transconductance amplifiers (OTAs) and reference ladders to accurately control

bias-point. Closed-loop power control maintains bias set point accuracy across 100krad, and it is insensitive to supply and temperature (see Figure 4). Settling time (inclusive of drain switch turn on) is under 500ns worst case, enabling agile radar power cycling.

Point-of-Load DC-DC Buck Regulators for Advanced Low-Voltage Logic

The use of high-performance IC technology in space systems is limited by the availability of qualified, low-voltage power-supply solutions. In fact, the majority of available pulse-width-modulation (PWM) and linear regulator ICs are unusable at modern low supply voltages for a number of reasons. These include reference voltage and the fact that high step-down ratios are unachievable, such as those required to take a 40V bus down to a 1V logic supply. However, many space systems use a 5V rail for high current capacity, so a distributed power approach using this resource with point-of-load (POL) converters makes sense.

POL DC-DC buck regulators with integrated power FETs have been designed and manufactured in UltraCMOS technology and are being used to power advanced logic devices such as SiRF FPGAs (a hardened version of Xilinx V5). Advanced FPGAs typically draw more than 10A from a 1V supply (as well as I/O and AUX supplies at 2.5V), and they feature continuous current ratings of 2A, 6A and 10A that handle most applications. For higher currents, load sharing and polyphase operation can be supported on

the UltraCMOS DC-DC buck regulators using simple pin-strapping (see Figure 5).

The high speed of UltraCMOS technology allows these converters to run up to 5MHz SYNC (provided that suitable passives can be obtained), and minimizes switching losses. Figure 6 shows that peak measured efficiency is more than 92% at 1MHz for a 10A integrated POL DC-DC buck regulator.

The UltraCMOS-based integrated DC-DC buck regulator requires only small passive components that were deliberately left off-chip to allow easy access to setpoint voltage, loop dynamics, etc. (Note in Figure 7 that the power inductor is actually larger than the DC-DC buck regulator device.)

Another challenge for many power-management products used in space applications is a high single-event transient amplitude and duration. These may be tolerable in a higher voltage, low/constant current application where filtering can be used to ride out the overshoot or undershoot. Modern logic ICs, however, are much more demanding in terms of DC and step currents, meaning that passive filtering alone cannot suffice. Today's logic ICs are also much less tolerant of overstress (as little as 200mV overshoot is outside absolute maximum ratings), and 30% undershoot could erase the configuration memory or at least make its contents unreliable (see Figure 8).

Power-Hungry RF Applications

The UltraCMOS process is able to address issues in power hungry RF

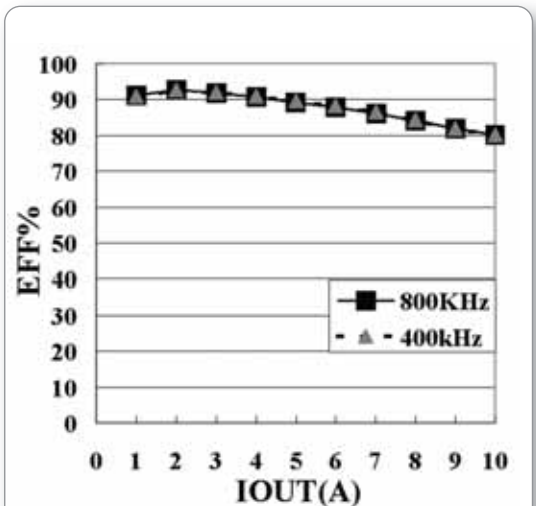


Figure 6: Measured 10A integrated POL DC-DC buck regulator "wallplug" efficiency vs load current [1]

applications, and is a viable approach for systems used in space. With more than a billion RFICs shipped into a variety of markets, UltraCMOS technology has achieved volume manufacturing, high functional density, and high-performance, high-speed operation in of a variety of RF integrated circuits. Over the years, it has been used to integrate RF, digital, analog and power functions for commercial high volume applications, as well as specialized high-reliability military and space products. ●

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- [1] Customer-furnished data from EVK sample
- [2] Spacecraft Electronics for NASA, O'Bryan et al, IEEE NSREC 2006 W-4

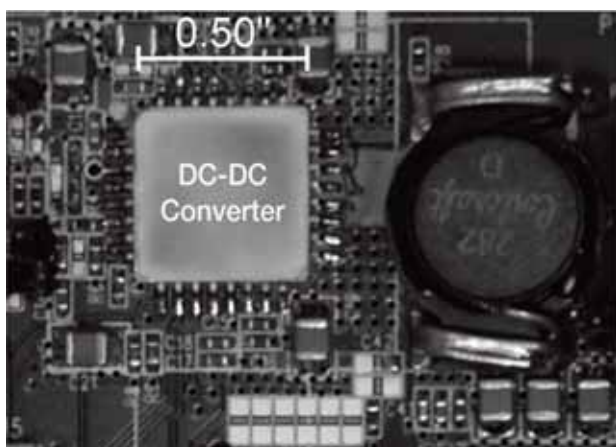


Figure 7: DC-DC buck regulator evaluation-kit photo with scale

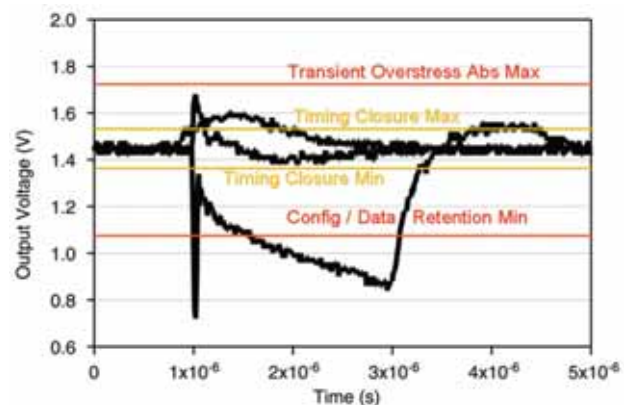


Figure 8: Linear LDO single event transients and LV logic IC performance/reliability limit voltage values compiled by NASA [2]

MOBILE OPERATORS SWITCH ON SMART WI-FI

STEVEN GLAPA, DIRECTOR OF FIELD MARKETING AT RUCKUS WIRELESS, DISCUSSES HOW WI-FI CAN BE INTEGRATED INTO A CELLULAR NETWORK ENVIRONMENT TO PROVIDE ADDITIONAL BANDWIDTH FOR MOBILE BROADBAND

S

ubscribers want seamless mobile data access and Mobile Network Operators (MNOs) want to provide it quickly and cost-effectively. Ironically,

Wi-Fi is the new technology for operators needing to address both sets of needs. Using dual-band 802.11n technology with adaptive antenna switching and smart mesh networking, MNOs can now deploy a complete, end-to-end, managed wireless infrastructure, providing reliable public access as well as low cost backhaul.

Smarter Wi-Fi technology now enables operators to scale capacity, efficiency and footprint of their existing macro networks and deliver unprecedented reliability within the unlicensed spectrum, addressing their stringent Tier 1 and Tier 2 requirements. It's a system level solution that provides better radio performance through industrial strength Wi-Fi.

In addition to wireless broadband access, MNOs can maximise numerous other commercial opportunities rapidly; using the agility to provide community and managed enterprise Wi-Fi services allowing them to increase their wireless footprint to expand branded broadband services and keep their subscribers.



Outdoor access points



Outdoor access points

The Challenges

No single product or technology alone will accommodate the current and future increase in data traffic. Many solutions, such as more licensed spectrum, femtocells, small cells and Wi-Fi, working in concert can and should be considered. The challenge for operators is not the decision of which solution to select but how best to integrate multiple technologies within their networks; how to find the right balance to maximise their cumulative benefits; and how to leverage existing

assets to facilitate the evolution of their networks.

As smartphone traffic continues to rise exponentially (accompanied by growth in usage of laptops and tablets), mobile operators and broadband service providers everywhere are challenged by network congestion and dealing with higher user densities. The results are commercially unviable – poor user experiences create churn. Subscribers have the choice to go elsewhere and, in the knowledge that their needs can be

instantly gratified simply by shopping around, they will.

Congestion appears at four main choke points:

- the access radio network,
- the signaling and control portions of the network,
- the network packet core, and
- the backhaul network.

The challenges have been traditionally addressed by increasing capacity of the affected resource, off-loading the network resource to relieve congestion, or other measures such as usage caps and rate limiting in the core of the network.

About a year ago operators started to think about Wi-Fi for mobile data offload. The problem with such solutions is that they tend to be short-term and tactical; they stem the bleeding for a while, but they don't fix the wound. While Wi-Fi hotspots help offload data traffic, these hotspots become disparate islands of connectivity that insulate operators from their subscribers, hampering their ability to provide value-added services to them wherever they might roam.

Doubling capacity in the face of exponential growth, for example, fails to serve as a strategic response to market dynamics. This is why carriers are now assessing the long-term role for Wi-Fi as a complement to LTE in future-proofing their radio access networks.

Wi-Fi and LTE – Together They're Stronger

Wi-Fi was initially designed for relatively low mobility but high capacity density environments. Conversely, LTE and other licensed cellular technologies offer macro coverage and relatively high mobility but at a much higher investment. A complementary solution is achieved when the two technologies are deployed in tandem. With no spectrum licenses, no long lead times or complex configuration, Smart Wi-Fi technology delivers reliable, indoor/outdoor, always-on, broadband services at a fraction of the cost and complexity of conventional macro alternatives.

The broad range of applications readily facilitated through Smart Wi-Fi technology includes:

- **Wireless broadband access** – Enabling large-scale, reliable

broadband access, using Smart Wi-Fi in locations where fixed line or macro wireless technologies are not available or cost effective.

- **Small cell solutions** – Offloading data traffic in high density areas.
- **Backhaul** – Long-range, affordable and high-speed Wi-Fi backhaul for LTE, GSM and wireless broadband access.
- **3G/4G offload** – Easing data congestion on cellular infrastructures by increasing capacity and coverage.
- **Enterprise WLAN managed services** – Providing reliable turnkey wireless services to small and

Doubling capacity in the face of exponential growth, for example, fails to serve as a strategic response to market dynamics

medium business requiring mobile connectivity for their customers, employees and guests.

Wi-Fi offers a new approach for delivering increased capacity of the magnitude sufficient to deal with exploding mobile Internet bandwidth demand. Where wireline phone and cable TV infrastructures don't exist (most of the world, in fact), broadband is not easy to introduce.

The cost of deploying new wireline infrastructure, or large-scale macro-cellular wireless models like WiMAX, is prohibitive; a barrier to further broadband subscriber growth. Using Smart Wi-Fi for wireless broadband access offers a solution that reduces the capital costs for broadband operators by a factor of five or more, opening opportunities for profitable new customer segments. When combined with 'build-as-you-grow' business models, this new approach delivers attractively short breakeven timelines, even in low-ARPU markets.

Carriers Re-Evaluating the Use of Wi-Fi

Operators have historically avoided sharing access with Wi-Fi hotspots, because they are remote islands of

disparate connectivity, which are outside of their control. The carriers' aversion to hotspots is based on the fact that Wi-Fi uses unlicensed spectrum, which can be used by anyone and suffers from 802.11 and non-802.11 interference, carriers have not viewed it as a useful access technology over which to deliver a reliable service. But recent technology advances in Wi-Fi have changed their opinion.

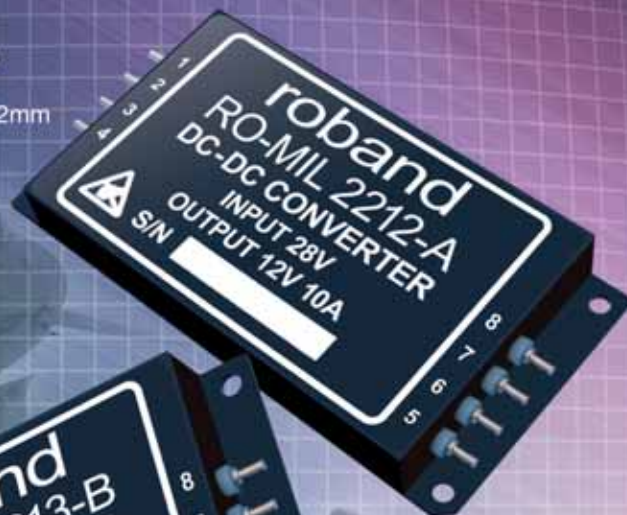
Smarter Wi-Fi that provides greater range and reliability through the use of advanced adaptive antenna technology offers an ideal end-to-end solution for last-mile access using the IEEE 802.11n standard coupled with enhancements to advances in Wi-Fi signal controls, meshing and predictive channel management.

The approach includes meshed Wi-Fi access points integrated with 3G/4G small-cell radios within a small form-factor device that can be installed closer to subscribers. Also included in this new approach is high-speed wireless backhaul within the 5GHz band along with a comprehensive network-wide element and service management at the edge of the mobile operator network. By intelligently learning about the Wi-Fi environment with the ability to adapt in real time to changes in the RF environment, the impact of interference is reduced while capacity density is increased. This allows better performance at longer ranges, reduced packet loss and the ability to support more concurrent users by optimizing the use of precious spectrum resources. While a single sector in a macro cell may provide a greater range over Wi-Fi, it suffers from the inability to consistently provide service indoors where 70% of users access wireless services.

With smarter Wi-Fi systems that increase the range and reliability of connections, operators can now deliver radio energy where they need to; for example in urban environments, which are typically challenging coverage applications from a radio perspective. Large-scale success has now been repeatedly demonstrated for this approach in the crucial test of real-world deployments. India now boasts the largest outdoor production Wi-Fi network in the world with over 50,000

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Variant	Input	Output
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and outdoor coverage to increase capacity and offload traffic – as much as 80% during peak times.

The mounting locations of small cell nodes (utility poles or other street-level assets, for example) will rarely be as convenient for fibre or microwave solutions as the operator might hope. Whilst LTE self-backhaul or meshing is a possible solution, it rapidly consumes scarce (and expensive) LTE access-capable spectrum with backhaul traffic. The same problem prevailed with early mesh Wi-Fi networks that attempted to provide access and meshing all within the same spectrum band. A channel-rich alternative using a 5GHz 802.11n point-to-point (PTP) or point-to-multipoint (PTM) solution can easily deliver more than 100Mbps of backhaul capacity an LTE cell needs.

While small cells benefit 3G service deployments today, their importance will only grow as the industry moves towards higher capacity 4G/LTE, especially in urban environments. In this small cell world, conventional point-to-point microwave, bonded copper and fibre-based backhaul solutions can quickly become impractical or uneconomical. Traditional solutions must now be rethought in the context of moving to smaller cells.

While microwave point-to-point equipment costs have come down in recent years, it generally requires a line-of-sight (LOS) link with the connecting backhaul hub, a condition many small-cell locations will be unable to meet. Sub-6GHz NLOS solutions using a point-to-multipoint architecture

are better suited for dense underlays, but when using licensed spectrum, narrow bandwidth channels put strict limits on backhaul capacity, and most sub-6GHz spectrum bands are expensive and frequently not available for licensing.

Fibre is the preferred backhaul option for mobile operators but can clearly never be pulled to every small cell location due to obvious factors such as cost and disruption.

Whilst the operator may be able to lease fibre, if available, from a fixed line carrier the solution not only drives up operational costs, but the fibre POPs will not necessarily exist in specific locations where the MNO needs to place the small cell.

When using licensed spectrum, narrow bandwidth channels put strict limits on backhaul capacity, and most sub-6GHz spectrum bands are expensive and frequently not available for licensing

New Backhaul Options

Unlicensed smart Wi-Fi has become a viable and affordable option to solve this problem and looks to play a crucial role in backhauling licensed small-cell traffic.

A small cell network, deployed as an infill underlay radio network to add access capacity, would comprise lower-

powered 3G and/or Wi-Fi nodes. In the future it might also include LTE radio nodes.

Regardless of the technology, the data still has to get back to the network. Small cells only increase network capacity when they're close to subscribers trying to access the network. This makes site acquisition a major determinant and a potential constraint in the effectiveness of small cell deployment.

The combination of integrated adaptive directional antennas with smart meshing technology and predictive channel management – all used within the channel-rich 5GHz 802.11n spectrum – makes the use of Wi-Fi for both line-of-sight and non line-of-sight backhaul applications advantageous. Figure 1 shows a typical potential network topology.

Adaptive antenna arrays deliver more reliable connectivity at longer ranges by focusing and steering RF energy only where it helps deliver the best throughput across a specified link. As the environment changes, these smart antennas mitigate Wi-Fi and non-Wi-Fi interference, constantly selecting better signal paths that yield the highest data rates and lowest latency at any given time. When used within the 5GHz band, these antenna arrays become ideal for constructing highly resilient, long range, adaptive backhaul connections between Wi-Fi nodes.

Predictive channel management is then used to optimise RF channel selection by maximising network capacity specifically in high density, noisy public Wi-Fi environments. It does this by measuring channel throughput and building a statistical model that allows access points to learn over time what channel will yield the highest capacity. By relying on real-time, observed capacity on all 2.4 and 5GHz frequencies, backhaul links can be automatically moved to a better channel with less interference, thereby realising higher data rates.

Using smart mesh techniques with adaptive antenna arrays as an alternative to fixed PTP links eliminates much of the complexity associated with aiming and alignment during the installation process. This also results in a much more affordable solution, with greater resiliency in crowded urban

environments, given its intrinsic capabilities to dynamically adjust to changing conditions by choosing alternate paths to the network.

In live field trials with multiple network operators today, this small cell Wi-Fi backhaul approach has proven to deliver reliable, carrier grade transport of 3G mobile data and circuit-switched voice traffic along with the prioritised transport of timing signals (e.g. IEEE 1588v2/PTP or NTP) necessary for small cell network synchronisation.

Wi-Fi backhaul technology is currently being built into small cell nodes housing cellular and Wi-Fi access – within a fairly small footprint. This allows operators to deploy a single box to provide Wi-Fi access, cellular access and backhaul together.

Smarter Wi-Fi For 3G/4G Offload

Traffic growth outstripping the capacity of 3G network deployments in urban “hot zones” is a common problem for mobile network operators. A smarter approach to Wi-Fi employs advanced interference rejection

techniques and adaptive signal controls to provide the range and predictable performance critical to commercial success for these operators. In addition, a seamless subscriber roaming experience, clean integration into the 3GPP core and a complete range of Wi-Fi form-factors (from indoor access points to outdoor mesh access nodes, point-to-point/multipoint backhaul to comprehensive network management) are all essential elements of a next generation Wi-Fi solution for mobile operators.

Purpose-built Wi-Fi systems offer the following benefits:

- Increased reliability of the unlicensed spectrum through advanced radio implementation;
- Extended signal coverage using high gain, software controlled, directional antenna systems;
- Seamless integration of Wi-Fi with essential core services;
- Higher speed and lower cost long-range 802.11n backhaul links;
- Stable connectivity and consistent performance through interference

rejection technology;

- Self-organising mesh deployment.

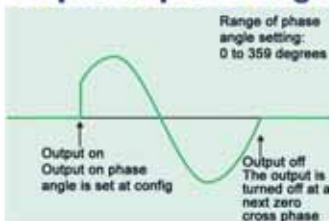
The Extra Mile

In combination with adaptive antenna technology that delivers superior interference rejection, smart Wi-Fi systems now enable MNOs to get the radio energy where it's needed such as urban environments that are typically challenging coverage applications from a radio perspective. So, it's a system level solution and a fundamental advance in the state of mobile networking that addresses end-to-end challenges; from provisioning and authenticating the client, through the radio performance and back to the core network integration – seamlessly and cleanly with the 3G network.

In the most challenging environments, carriers can serve larger numbers of mobile subscribers with higher bandwidth and reduce churn in the process. Carriers can also go further in terms of offering services that they might not have been able to consider before. ●

AC POWER SUPPLIES

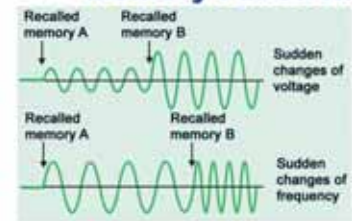
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WHAT THE READERS SAY

ANSWERING THE CATT

QUESTION

The Catt question: At

<http://www.electromagnetism.demon.co.uk/cattq.htm> one finds an instructive question, together with an animation that the reader may wish to view before continuing. It was posed decades ago by Ivor Catt (<http://www.ivorcatt.org/>).

Catt presents a reasoning (and other gedanken experiments) from which he concludes that classical electromagnetic theory is wrong and, as such, due for a thorough revision. Here we consider a less drastic approach, saving Maxwell's neck.

The question is the following: Consider an ideal transmission line formed by two parallel wires (Figure 1). A battery is connected at one end (assumed to the left in Figure 1), causing a voltage step and associated current step to travel along the line.

By Maxwell's equations, the step travels at light speed (assuming the medium is air).

When the step has travelled to a point at a certain distance from the battery, the entire line to that point is at the DC voltage determined by the battery, and hence charges $\pm q$ must be present along this entire distance. Since the electrons carrying the charges have non-zero mass and hence cannot travel at light speed (Einstein), how can the charges get there?

Approach: We assume that standard electromagnetic theory (Maxwell) correctly describes what happens when the step travels along the line and what charges $\pm q$ appear. Then, to eliminate the anomaly suggested by Catt, we have to show only how the charges can get there at the appropriate time instants without travelling at relativistic speeds.

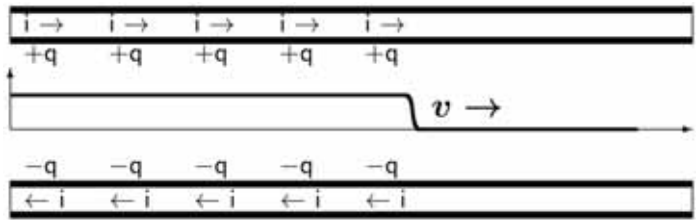


Figure 1: Illustrating the problem statement

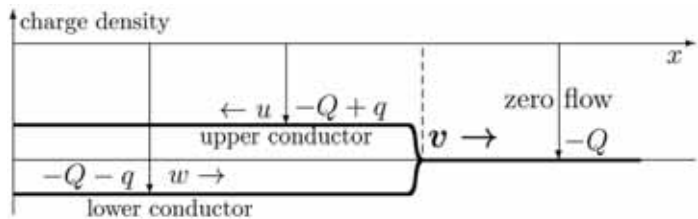


Figure 2: Densities and velocities of charges

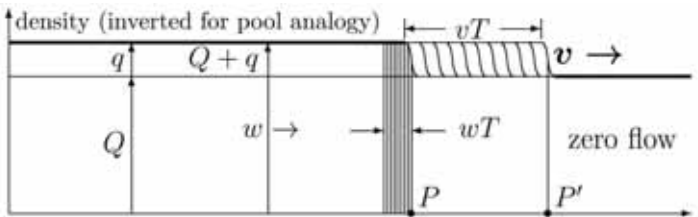


Figure 3: Relating the speed of the charges to the speed of the wavefront

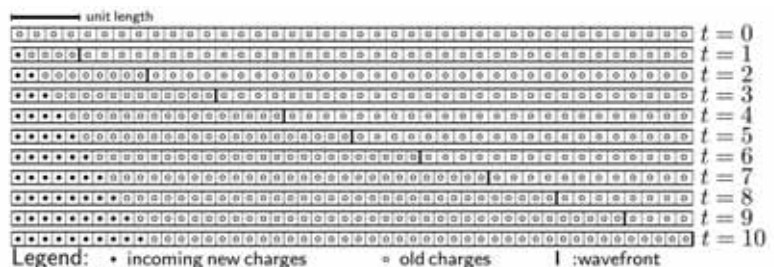


Figure 4: How the wavefront travels much faster than the charges

To access a broad audience, the approach is intuitive, avoiding the usual mathematics of the telegrapher's equation and making extensive use of pictures instead. The quantitative calculations near the end, indispensable to obtain an intuitive feel for the orders of magnitude involved, require only basic arithmetic.

The answer – how the charges get there: Wires are metallic. The charges $\pm q$ are established by a shortage/excess of free electrons w.r.t. the neutral state. For a more intuitive picture, we let all symbols denote positive quantities and indicate negative polarities explicitly by a preceding minus sign. Let $-Q$ be the charge per

unit length (charge density) constituted by free electrons. We show later that this supply is huge compared to q . So most charges are already there; they just have to move to carry current. The question is: how fast?

Figure 2 shows the flow of electrons on both wires as the voltage step moves to the right. Although the free electrons are milling around locally at tremendous speeds, it is the collective (average) movement along the wire that constitutes current. This takes place at (much lower) drift velocity.

The negative battery terminal pumps electrons into the lower conductor, lowering the charge density from $-Q$ to $-Q - q$. Imagining electrons as water



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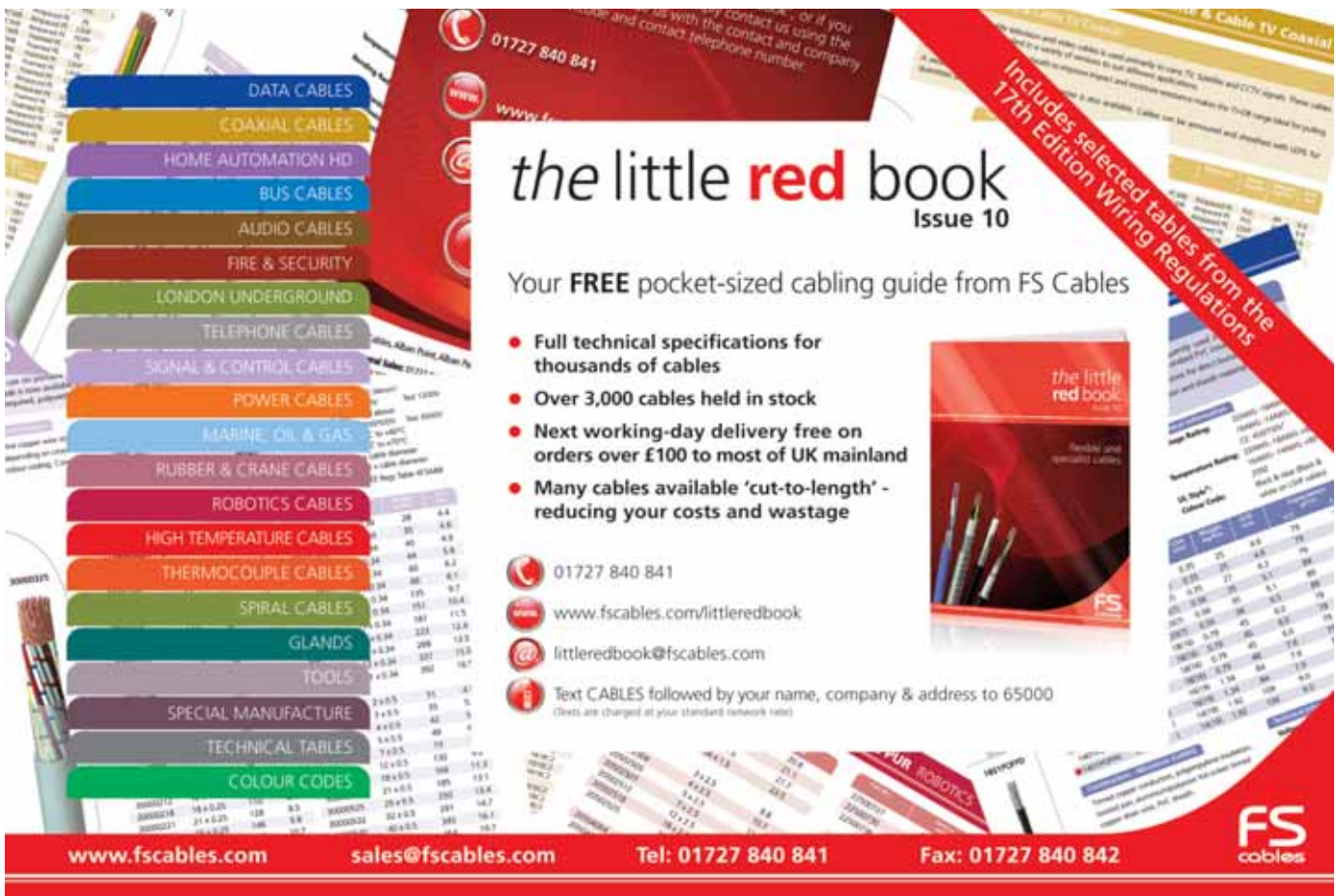


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coming from the left into a quiescent pool, it is easy to see that the rising level causes a wave that can move faster than the water particles themselves, tsunami-like. Another analogy is an elastic rod that is pushed from one side in the length direction. However slowly one pushes, the effect propagates at the speed of sound (for the material of the rod).

The (drift) velocity w of the electrons in the lower conductor can be related to the velocity v of the wavefront via Figure 3, inverting Figure 2 to exploit the intuitive pool analogy.

Consider a time duration T during which the wave moves from P to P' , so $PP' = vT$. During that time the charge density along PP' must increase from Q to $Q+q$, so the charge itself must increase from $Q \cdot PP'$ to $(Q+q) \cdot PP'$. This increase is $q \cdot PP'$, which equals qvT , and must be supplied by charges coming in from the left. These come at velocity w and with density $Q+q$, so the charge supplied during time T is $(Q+q)wT$. Hence $(Q+q)wT = qvT$, or $w = vq/(Q+q)$.

This result is illustrated in Figure 4 for $q = Q/4$. To obtain a simple picture we use arbitrary units, calling them u length, u time and u charge. Assume that at $t = 0$ the charge density Q is $4u$ charge/ u length and $v = 1u$ length/ u time. Behind (i.e. to the left of) the wavefront (thick vertical dashes), $Q = 5u$ charge/ u length. Since $w/v = q/(Q+q) = 1/5$, charges must travel only $(1/5)u$ length/ u time. At a density of $5u$ charge/ u length, this amounts to $1u$ charge/ u time.

We shall see that, in reality, Q is very much larger than q , making $w = vq/Q$ a very good approximation.

MORE OF CATT, PLEASE

My name is Cameron, and I am 19 years old. I find Catt Theory extremely easy to grasp. It inherently makes a lot of sense to me, and seems to do the same for others around my age that I share it.

I am not fully schooled in

What happens in the upper conductor? There the positive terminal drains electrons from the wire, lowering the density of electrons. Quantitatively, $(Q-q)uT = qvT$ and hence $u = vq/(Q-q)$.

If Q is much larger than q , then $u = vq/Q = w$ is a good approximation.

Concrete numbers: Without concrete numbers it is difficult to appreciate the extreme differences of magnitudes that enter into the picture here.

How large is Q ? For instance, in copper the free electron density is $8.5 \cdot 10^{28}/m^3$ and the charge of an electron is $1.6 \cdot 10^{-19}C$ (Coulomb). The 3D charge density is therefore $1.36 \cdot 10^{10}C/m^3$.

A wire of 1mm diameter has a cross-section of $0.79 \cdot 10^{-6}m^2$, so the free charge per meter length is $1.07 \cdot 10^4C/m$, which is huge. For simplicity replace the battery by a voltage source such that $I = 0.107A$ (more about this later). Then, approximately, $u = w = I/Q = 1 \cdot 10^{-5}m/s$. No hurry indeed!

Refining the numbers: Is $I = 0.107A$ realistic? What voltage would be needed?

First, some conventions. Assume the (ideal) line has capacitance C and inductance L per unit length. The propagation velocity v along the line is given by $v = 1/\sqrt{LC}$ and the characteristic impedance Z by $Z = \sqrt{L/C}$.

To make further number estimates simple, we assume that the line has the same relevant numerical values as free space, namely $C = \epsilon_0 = 8.854 \cdot 10^{-12}F/m$ and $L = \mu_0 = 4\pi \cdot 10^{-7}H/m$. This is realistic; it suffices that the ratio of the

conventional theory, and I think this is what makes Theory C so much easier to comprehend. I have found virtually no stumbling blocks, and have yet to run into one of those situations where my studies come to a standstill while I resolve two

distance d between the wires and the radius r satisfies $d/r = e^\pi \approx 23$, which is nothing special (11.5mm wire separation for 1mm wire thickness).

Then $v = 3 \cdot 10^8m/s$ and $Z = 377\Omega$. Hence the voltage source would have to deliver about 40V.

Sanity checking: Consider the following sanity check for charges along the line.

A line segment of length x starting from the battery has capacitance Cx . If the step voltage is V , the total charge when the step reaches the end is VCx , the charge budget. On the other hand, the battery current I after connection is given by $I = V/Z$. The travel time t is given by $t = x/v$. The charge delivered by the battery into the line during that time is It . Now $It = (x/v)(V/Z) = x\sqrt{LC} \cdot V/\sqrt{LC} = VCx$. So the charge budget is met, which constitutes a sanity check.

Final note: We have assumed that the wave (or ripple) has not reached the end of the line. The obtained results pertain to an infinite line, or a line that is loaded by a resistor with value Z at the other end. Otherwise, reflected waves appear on the line. However, this was not the issue here.

Raymond Boute

I am 19 years old [and] I find Catt Theory extremely easy to grasp; it inherently makes a lot of sense to me, and seems to do the same for others around my age

different ways of thinking with each other.

Publishing his papers could be a huge opportunity for others like me, and I would be very grateful of you doing so.

Cameron Mercer

IF YOU WOULD LIKE TO COMMENT

on this subject on any other that you have read on in Electronics World magazine, please write to the Editor at Svetlana.josifovska@stjohnpatrick.com

The publisher reserves the right to edit and shorten letters due to space constraints

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Analog To DIGITAL CONVERTER (ADC)

IN THIS SERIES, MAURIZIO DI PAOLO EMILIO, TELECOMMUNICATION ENGINEER, SOFTWARE DEVELOPER AND DESIGNER OF ELECTRONIC SYSTEMS, PRESENTS A TUTORIAL ON DATA ACQUISITION SYSTEM DESIGN

Connecting digital circuitry to sensor devices is simple if the sensor devices are inherently digital themselves. Switches, relays and encoders are easily interfaced with gate circuits due to the on/off nature of their signals. However, when analog devices are involved, interfacing becomes much more complex. What is needed is a way to electronically translate analog signals into digital (binary) quantities, and vice versa.

An analog-to-digital converter, or ADC, performs the former task while a digital-to-analog converter, or DAC, performs the latter. Typically, an ADC (Figure 1) is an electronic device that converts an input analog voltage or current to a digital number proportional to the magnitude of the voltage or current. However, some non-electronic or only partially electronic devices, such as rotary encoders, can also be considered ADCs.

The number of output bits from an analog-to-digital converter does not fully specify its behaviour. Real A/D converters can differ from ideal behavior in many ways. While static imperfections, such as gain and offset, are easy to quantify, the success of many signal processing applications depends on the dynamic behaviour of the A/D converter.

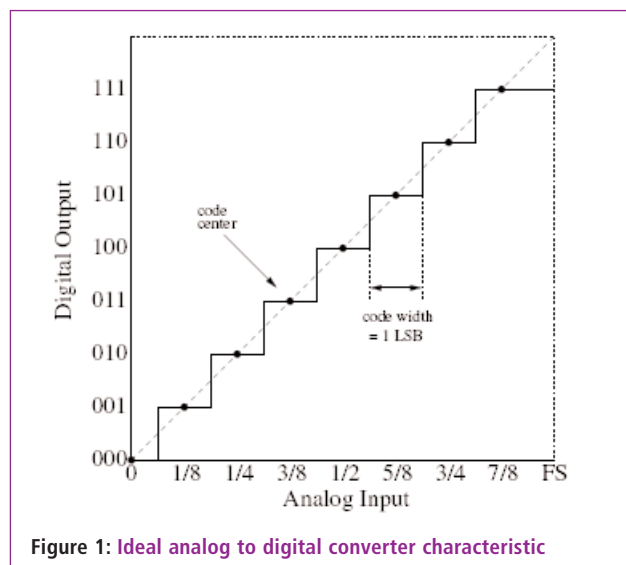


Figure 1: Ideal analog to digital converter characteristic

Ultimately, the application determines the requirements and A/D converter resolution may not be either necessary or sufficient to specify the required performance. In many cases, the quality of the A/D converter must be tested for the specific application.

The wide variety of analog-to-digital converter applications leads to a large number of figures of merit for specifying performance. These figures of merit include accuracy, resolution, dynamic range, offset, gain, differential nonlinearity, integral nonlinearity, signal-to-noise ratio, signal-to-noise-and-distortion ratio, effective number of bits, spurious-free dynamic range, intermodulation distortion, total

While static imperfections, such as gain and offset, are easy to quantify, the success of many signal processing applications depends on the dynamic behaviour of the A/D converter

harmonic distortion, effective resolution bandwidth, full-power bandwidth, full-linear bandwidth, aperture delay, aperture jitter, transient response and overvoltage recovery.

Most converters sample with 6 to 24 bits of resolution and produce less than 1 megasample per second. Thermal noise generated by passive components, such as resistors, masks the measurement when higher resolution is desired. For audio applications and at room temperatures, such noise is usually a little less than $1\mu\text{V}$ of white noise. If the most significant bit (MSB) corresponds to a standard 2V of output signal, this translates to a noise-limited performance that is less than 20 ~ 21 bits.

One method of addressing the digital ramp ADC's shortcomings is the so-called successive-approximation ADC (Figure 2). This method uses a very special counter circuit that is known as a successive approximation register. Instead of counting up in binary sequence, this register counts by trying all values of bits that start with the most significant bit and end with a least significant bit (LSB).

Throughout this counting process, the register monitors the comparator's output to see if the binary count is less than or more than the analog signal input, and adjusts the bit values accordingly.

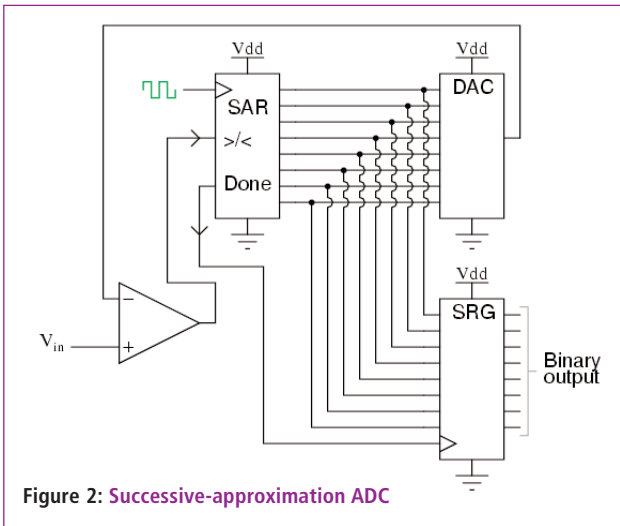


Figure 2: Successive-approximation ADC

The digital approximation analog-to-digital converter circuit typically consists of four main sub-circuits:

1. A sample-and-hold circuit to acquire the input voltage (V_{in}).
2. An analog voltage comparator that compares V_{in} to the output of the internal DAC and outputs the result of the comparison to the successive approximation register (SAR).
3. A successive approximation register sub-circuit designed to supply an approximate digital code for V_{in} to the internal DAC.
4. An internal reference DAC that supplies the comparator with an analog voltage equivalent of the digital code output of the SAR for comparison with V_{in} .

The successive approximation register is initialized so that the most

significant bit is equal to a digital 1. This code is fed into the DAC, which then supplies the analog equivalent of this digital code ($V_{ref}/2$) into the comparator circuit for comparison with the sampled input voltage. If this analog voltage exceeds V_{in} the comparator causes the SAR to reset this bit; otherwise, the bit is left as 1. Then the next bit is set to 1 and the same test is done, continuing this binary search until every bit in the SAR has been tested. The resulting code is the digital approximation of the sampled input voltage and is finally output by the DAC at the end of the conversion (EOC).

Mathematically, let $V_{in} = xV_{ref}$ so x in $[-1, 1]$ is the normalized input voltage. The objective is to approximately digitize x to an accuracy of $1/2^n$. The algorithm proceeds as follows:

1. Initial approximation $x_0 = 0$.
 2. i_{th} approximation $x_i = x_{i-1} - s(x_{i-1} - x)/2^i$
- where $s(x)$ is the signum function ($\text{sgn}(x)$) (+1 for $x \geq 0$, -1 for $x < 0$). It follows using mathematical induction that $|x_n - x| \leq 1/2^n$.

Successive approximation register analog-to-digital converters (SAR ADCs) have been widely used for medium-speed, medium-resolution applications due to their excellent power efficiency and digital compatibility. Recently, SAR ADCs are also penetrating applications that have been earlier dominated by delta-sigma ADCs and pipeline ADCs.

Many microcontrollers contain on-chip ADCs. Typical devices include the Microchip PIC167C7xx family and the Atmel AT90S4434. Most microcontroller ADCs are of the successive approximation type because this gives the best tradeoff between speed and the cost of real estate on the microcontroller die. For example, the PIC16C7xx microcontrollers contain an 8-bit successive approximation ADC with analog input multiplexers. ●

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New Dual MOSFET Simplifies Synchronous Buck Converter Design

Advanced Power Electronics Corp (USA), a manufacturer of MOS power semiconductors for DC-DC power conversion applications, has announced the new AP6922GMT-HF-3, a space-saving dual MOSFET for synchronous buck converter applications, with both the high-side (control) FET and low-side (synchronous) FET in one single 5 x 6mm PMPAK package.

AP6922GMT-HF-3 is a rugged device combining fast switching, low on-resistance and high cost-effectiveness. The control MOSFET (CH-1) has a drain-source voltage rating of 30V, a maximum on-resistance of 8.5m Ω , and a continuous drain current rating at 25degC of 15A, chosen to optimise switching performance.

The synchronous MOSFET (CH-2) also has a drain-source voltage rating of 30V and a continuous drain current rating at 25degC of 25.7A, with a maximum

on-resistance of 3.8m Ω to minimise conduction losses. The reduced parasitic inductances (as a result of the short internal conduction paths) also contribute to improved performance.

The devices are in an industry-standard 5 x 6mm package and are RoHS-compliant and halogen-free.

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The new A4979 from Allegro MicroSystems Europe is a programmable stepper motor driver IC with microstepping capability and improved programmability and diagnostics.

The new device is a flexible microstepping motor driver with a built-in translator for easy operation. It offers a single-chip solution for operating bipolar stepper motors in full, half, quarter and sixteenth-step modes at voltages up to 50V and currents up to 1.5A.



The A4979 uses all digital timing, with no need for external timing components, and utilizes a serial port (SPI) for programming operating parameters and reading back diagnostic information. The device can be controlled by simple step and direction inputs or through the SPI-compatible serial interface.

The current regulator can be programmed to operate in fixed off-time or fixed frequency pulse-width modulation modes, with several decay modes available to reduce audible motor noise and increase step accuracy.

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ROBUST CURRENT SENSORS FOR USE IN HARSH CONDITIONS

Harting has introduced a new range of Hall-effect current sensors with robust design and construction that makes them ideally suited to use in harsh conditions in areas such as rail technology and renewable energy.

The new sensors are designed to provide rapid and accurate current measurement for use in regulating power semiconductor systems such as frequency converters, uninterruptible power supplies and welding plant. Developed for these markets in close consultation with customers, they are designed to sense currents between 200 and 2000A, and offer high levels of measurement accuracy and immunity to interference from external magnetic fields.

The Harting current sensor product family is based on the proven and tested Hall effect. The galvanically-isolated devices measure current via the magnetic field of the conductor using two principles of measurement: compensation current sensing, for the most demanding measurement tasks, and open-loop current sensing where there is less demand for accuracy.

www.harting.com



Giant Starter Kits for Memory-Hungry And Energy-Efficient Applications

Energy Micro introduced two feature-rich starter kits (STKs) for designers building complex battery-powered products such as portable health and fitness devices and smart accessories.

Based on the already available EFM32 Leopard Gecko and Giant Gecko microcontrollers, the new STKs incorporate onboard debug and current probe functionality, and all of the features required to demonstrate the Gecko MCUs' 400nA sleep modes and 1MB built-in Flash memory.

The two EFM32 starter kits support the most memory-rich devices within the 240-strong ARM Cortex-M EFM32 Gecko family. Including full SEGGER J-Link support, the kits are the first products to feature the enhanced version of Energy Micro's real-time current probe, the energyAware profiler. This Advanced Energy Monitoring system (AEM) ensures that current data can be viewed with improved accuracy and 100 times faster than earlier versions, eliminating the need to connect external instruments to find current drains.

energymicro.com



Mouser is Offering New Arduino TinkerKit Development Kits

Mouser Electronics announced it is stocking new product from Arduino. The Arduino TinkerKit Development Kits include the Base Kit, Starter Kit, Pro Kit, Scuola Kit and Scuola Lab.

TinkerKit simplifies electronic prototyping throughout a wide variety of sensors and actuators soldered on orange-colored boards that can be hooked up to the Arduino through the Sensor Shield and three-pin cables. A small signal amplifier helps to stabilize the signals running on the cables, ensuring clean analysis from the sensors even on long distances (1m-5m).

TinkerKit was originally conceived for school teaching and museum exhibitions and, thus, it allows for the set-up of interactive environments on the run without using a soldering iron or breadboard. The Arduino TinkerKit Development Kits are each a different pack of various TinkerKit modules, selected to help the user start designing interactive environments/prototype interfaces without using a breadboard or soldering iron.

www.mouser.com/arduinoTinkerKit

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Keithley Instruments, a global supplier of advanced electrical test instruments and systems, is offering 20% off list price on a range of broad-purpose Test & Measurement instruments to its European customers.

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- Integrated Switch/Multimeter Instruments;
- A range of programmable DC Power Supplies.

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Lane Electronics has made available the Binder 423 Series of circular connectors designed for severe industrial and commercial applications. Lane Electronics is a franchised distributor for Binder in the United Kingdom.

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designers looking to specify a circular connector for tough environments in any situation.

Incorporating rugged metal shells, the Binder 423 Series features straight or right angle cable connectors with internal strain relief. To improve applications flexibility, the right angle connectors are adjustable in four radial positions. Users can specify Binder 423 Series connectors with 2 to 24 gold or silver-plated contacts.

Lane is an ideal source for all key connector types including circular, filtered, RF, coaxial, sub – miniature, backshells and adaptors, D connectors, aerospace, test & measurement, IDC, PCB connectors, edge connectors and connectors for rack and panel applications.

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Unipower Modules are at the Heart Of “Silent” Power Shelf From Communications Audit

Communications Audit UK Ltd (CommsAudit), the UK-based manufacturer of high performance RF equipment and systems, has used Unipower’s modules for its solutions.



The power modules selected by CommsAudit are Unipower’s Ranger Series of hot-swappable power supplies which are available in several power output versions capable of providing up to 100A for the 12V model. Ranger modules provide output voltages from 12 to 54.4V. With a height of just 3.5in or 2U and a power density of up to 11W/in³, three Ranger modules can be accommodated in a 19in rack mount system with active load sharing and integral ORing diodes.

With a power factor reading of 0.99, Ranger units meet all applicable EMI and ESD standards, including Bellcore GR-1089-Core and EN61000-4-2. Each module weighs just 4.6kg (10.15lbs).

Although Unipower’s Ranger modules are fairly “silent”, CommsAudit’s power shelf filters out any remaining conducted and emitted noise, resulting in a silent power source that provides the basis of its monitoring and receiving systems.

www.unipowerco.com

AMD EMBEDDED G-SERIES PLATFORM NOW SUPPORTS WINDOWS EMBEDDED COMPACT 7 RTOS

AMD announced that its AMD Embedded G-Series platform now supports Windows Embedded Compact 7, the next generation of the Windows Embedded CE real-time operating system.

Windows Embedded Compact 7, paired with AMD Embedded G-Series Accelerated Processing Units (APU) is optimized to deliver feature-rich applications on small, specialized devices for industries such as medical, retail and industrial automation. This enables board, module and system OEMs, among others, to develop a wide range of applications requiring high performance and integrated graphics processing with minimal size, power and cooling constraints.

AMD Embedded G-Series APUs set a new standard for high performance processing and multimedia content delivery for embedded designs. With the combination of AMD Radeon graphics and the low-power Bobcat x86 core, AMD Embedded G-Series APUs can provide superior performance-per-watt ratios.

Features include Silverlight for Windows Embedded, an updated version of Internet Explorer with support for Adobe Flash 10.1, and multi-touch support optimized for intuitive, natural input capabilities and gesture-based interactions.

www.amd.com/embedded



Binder UK Launches Marketing Initiative on Low-Cost IP67 Connectors

The Binder Series 620 and 720 are lightweight and compact with 11.5mm diameter (620) and 16.0mm (720). They are protected to IP67 and have excellent electrical characteristics up to 7A and 250V. The range has a unique snap-in fitting method that provides high levels of connect integrity and an extremely convenient and safe connect and disconnect action.

The range has been expanded recently with the introduction of moulded and dip solder versions for mounting directly on to a PCB and this makes it highly suited to many applications including drives and control systems, data-logging, medical equipment, industrial measuring equipment, sensors, laboratory instrumentation, communications, LED lighting and security systems.

Now Binder UK has set up a promotional campaign (to run for the remainder of 2012), whereby samples can be obtained free of charge for product evaluation. Binder UK will be mailing samples to engineers within its own database and its main distribution partners Aerco, Foremost Electronics, Northern Connectors and Quadrant Connections.

www.binder-connector.co.uk



INTELLIGENT BATTERY CHARGER DETECTS AND CHARGES LI-ION AND LI-POLYMER CELLS

An intelligent battery charger that can automatically detect and charge up to four Li-Ion or Li-Polymer cells is announced by Powersolve. The microprocessor-controlled PSCH15LI Smart Charger is “clever” enough to identify the cells in series and provide the necessary output to fully charge the cells and then turn itself off.

The PSCH15LI features a universal AC input and incorporates an IEC320 C8 2-pin AC input connector. Powersolve can supply the charger with various DC output connectors.

Output voltage is auto switching from 4.2V to 16.8V ±1.5% for 1, 2, 3 or 4 cells and charging current is from 500mA to 1A. Safety ground leakage current is < 0.5mA.

Overvoltage and short circuit protection is standard as is protection against reverse polarity. An LED status indicator confirms standby, charging and fully charged states.

Housed in a compact desk top plastic enclosure measuring 96 x 44 x 30mm, the PSCH15LI has an operating temperature range of 0 to 40°C.

www.powersolve.co.uk



REDUCED PACKAGE SIZE TEMPERATURE PHOTOCOUPLERS MEET REINFORCED INSULATION

Toshiba Electronics Europe (TEE) has launched two new high-speed logic IC photocouplers that comply with the reinforced insulation class of international safety standards, are half the size of equivalent DIP8 devices, and offer guaranteed operation at temperatures from -40°C to 125°C.



The TLP2766 and TLP2768 are supplied in miniature SDIP6 packages measuring just 9.7mm x 4.58mm x 3.65mm yet have a minimum isolation voltage of 5000Vrms. Both will operate with supply voltages of between 2.7V and 5.5V. This makes them compatible with a wide range of existing industrial applications as well as ensuring they meet the needs of new and emerging low-voltage designs.

Toshiba's new couplers are designed for high-speed data transmission and offer typical data rates of 20Mbps. As a result they are ideal for use in high-speed communication interfaces in factory automation systems, measurement and control equipment and digital home appliances. Inverter logic totem pole outputs enable both sink and source drive implementations.

www.toshiba-components.com

HIGH BRIGHTNESS LEDs FOR AUTOMOTIVE EXTERIOR LIGHTING

ROHM Semiconductor has announced its new ultra-high-bright PLCC4 LED SML-Y1 Series for optimum light emission, reliability and power efficiency. Featuring 4 pins, the series is the latest addition to the PLCC line-up. While providing the same guaranteed operating temperature range (-40°C to 100°C), its derating characteristics have been significantly enhanced compared to PLCC 2 packages. A gold-plated frame is utilized for superior sulfuration resistance.

Suited for automotive applications such as stop lamps as well as for general consumer electronics,

the series supports automotive standards for exterior lighting (611-625) and is available in a variety of colours. Customers can select from three different models for multiple efficiency and design options – the large current type SML-Y17U2T with a maximum driving current of 150mA, the high efficiency type SML-Y16U2T (IF max 70mA) and the standard type SML-Y15U2T (IF max 70mA).

Samples are available now; volume production is scheduled to begin in June 2012.

www.rohm.com/eu



COME-CCT6 MARKS ENERGY EFFICIENT ENTRY-LEVEL INTO MULTICORE TECHNOLOGY

Kontron launched its new COM Express compact Computer-on-Module, COMe-cCT6. It is the company's energy efficient entry-level multicore module based on next-generation Intel Atom processors with 32nm technology.

The module is available in three multicore performance levels up to 2x 1.86GHz and offers an increased performance per watt ratio. Compared to platforms based on the second generation of Intel Atom processors, it offers twice the graphics capability, up to 28% higher processor performance and half of the processor thermal design power (TDP). The COM Express pin-out type 6 definition enables the module to provide these increased capabilities via a scalable interface range that offers suitable options for both cost and power-sensitive applications alike.

The module's space-saving COM Express compact form factor (95mm x 95mm) is ideal for designs requiring the full range of interfaces provided by the COM Express pin-out type 6 in a small solution.

www.kontron.com



NEW FLAME RETARDANT EMC SHIELDING GASKET FROM KEMTRON

Kemtron, the British manufacturer of RFI/EMI shielding gaskets, materials and components has launched a flame retardant, low smoke, low toxicity EMC shielding gasket.

It's tested and approved to the international standard UL94V-0 by Underwriters Laboratories for flame retardancy, file number E344902. Also tested for smoke density to BS 6853:1999: Annex D.8.3 and oxygen index to BS EN ISO 4589-2:1999, confirming the material meets the requirements for minor internal use on vehicles category 1a, such as gaskets for electronic enclosures, is making it highly suitable for applications in underground transportation, trains and other safety critical applications.

The material is nickel-coated graphite loaded into silicone elastomers, product code SNG-FR. This allows the gasket to provide a highly electrically-conductive path between

mating flanges of an electronics equipment enclosure giving a high level of RFI/EMI shielding. The material can be supplied as an extruded strip in various profiles, "O" rings or flat die cut gaskets.

www.kemtron.co.uk



Free Cabling Guide – Issue 10 of 'The Little Red Book'

Issue 10 of the FS Cables cabling guide 'The Little Red Book' is the ideal companion for any electronics buyer responsible for the sourcing or specification of electrical cable.

Featuring 176 pages in a handy A5 size, 'The Little Red Book' lists technical data and images for thousands of cables, as well as technical tables for reference. Cables listed include data, coax and bus, signal & control, telephone and audio cables, high temperature

including silicones and PTFE, rubber & crane, spiral cables and a section on fire & security cables. A range of tools make an appearance for the first time, including cable cutters, strippers and crimpers, tools for coaxial and structured wiring.

Each page of the guide features a clear key indicating the variety of sheathing options available over the standard PVC, such as Low Smoke Halogen Free, duct grade or armoured SWA.

www.fscables.com/littleredbook



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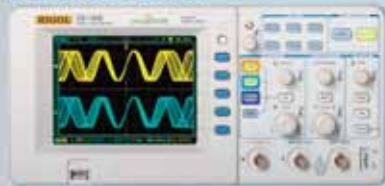
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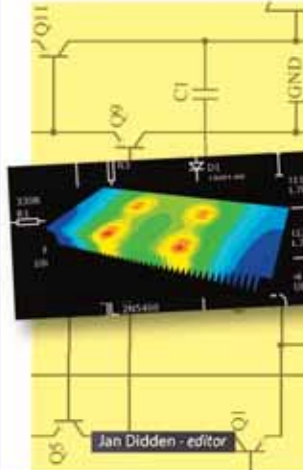


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NANOKTN PUBLISHES POSITION PAPER ON THERMOELECTRICS

The Nanotechnology Knowledge Transfer Network (KTN), one of the UK's primary knowledge-based networks for micro and nanotechnologies, has published a 'position paper' called "*Why the UK should invest in Thermoelectrics and the Role of Nanotechnology – a Position Paper*". The paper follows the KTN's one-day workshop held last year to explore emerging technologies and opportunities in the development of next generation thermoelectric and thermionic devices.

Thermal energy harvesting (and solid state cooling) represents a global £1bn industry for improved products in a range of markets and application scenarios. However, barriers exist to widespread adoption, and it is concluded that nanotechnology offers the potential for new approaches and a paradigm shift in performance through nanomaterials development, nanostructuring, nano and microelectronic devices and thin film technologies.

The event which sparked the report was held in April 2011, hosted in partnership with Johnson Matthey and Royal Holloway University of London, saw presentations from key players in industry and academia, and highlighted the huge commercial potential in harvesting energy from waste heat, but also the significant barriers to increasing conversion efficiency and finding alternative, sustainable, thermoelectric materials.

The market pull for harvesting waste recovery is growing, led primarily by the automotive sector. The position paper concludes that significant new market opportunities would open up if a new generation of higher efficiency and more sustainable materials could be developed, e.g. in harvesting: automotive and HGV exhaust heat, solar thermal energy, high temperature industrial processes, powering sensors and remote off-grid domestic electricity generation. Since the heat already exists and is free, the cost payback time should be the key measure to evaluate these systems.

"To date, harvesting energy hasn't had that much attention but now this is changing as people realise a huge amount of heat is being lost. Harvesting energy from wasted heat is both a technical and economic opportunity with the current global market of thermoelectric devices estimated to be around \$300m. If the technical challenges can be overcome then the potential applications are extremely wide and the potential market would be many billions of pounds and we will fulfill the ambition to create more highly skilled jobs in science and engineering," said Dr Martin Kemp, Theme Manager, NanoKTN.

Currently, the major market pull for this technology is from the automotive industry, but other sectors such as space and the built environment may emerge as strong drivers. Energy scavenging will also be important in miniaturized electronic devices such as MEMS and self-powered sensor networks, and could feature as part of a combined heat and power (CHP) system, with thermoelectric generators providing significant energy for domestic and commercial buildings.

PROFESSOR DR DOGAN IBRAHIM, Near East University in Nicosia, Cyprus: Heat is wasted in most consumer, commercial and industrial processes. Harvesting energy from the wasted heat represents a potential market of many billions of dollars. In this economic downturn and with the cost of energy rising constantly, it makes sense to invest in utilising this "free", wasted, heat energy. Perhaps the UK should lead the research in this field as well as build plants to develop products based on harvesting the wasted thermal energy. This will help to create more skilled jobs and at the same time increase the much needed confidence in the economy.

HAFIDH MECHERGUI, Associate Professor in Electrical Engineering and Instrumentation, University of Tunisia: The nanotechnology is one of the principal technologies of this century; it is rich in promises for the consumers. At present, the setting in market of many nanomaterials is so new that one does not know yet the requirements relating to safety when they are used and managed.

The UK tries to develop this sector to gain the confidence of the consumers concerning the safety and effectiveness of nanotechnology. This initiative will ensure the success of the primary products of nanomaterials on the market. Nanoelectronics structures are not consuming energy as such, and this is why it can exploit thermoelectricity, which can ensure the direct conversion of heat into electricity. Indeed, one can produce electricity from waste heat. Thus one can develop thermoelectric materials for complex nanotechnology structures.

Of course the UK should invest in thermoelectrics, as the use of this energy will solve enormous problems, especially when it comes to using sensors in mediums where power is not available. I believe that if well developed this sector will be promising for the economy of any country.

However, until now nanotechnology remains a new research and application area and its risks, just as its benefit, are still the object of examination and evaluation. I think that the UK is best placed to develop these new sectors and become a world leader in nanotechnology, which is in direct correlation with thermoelectricity.

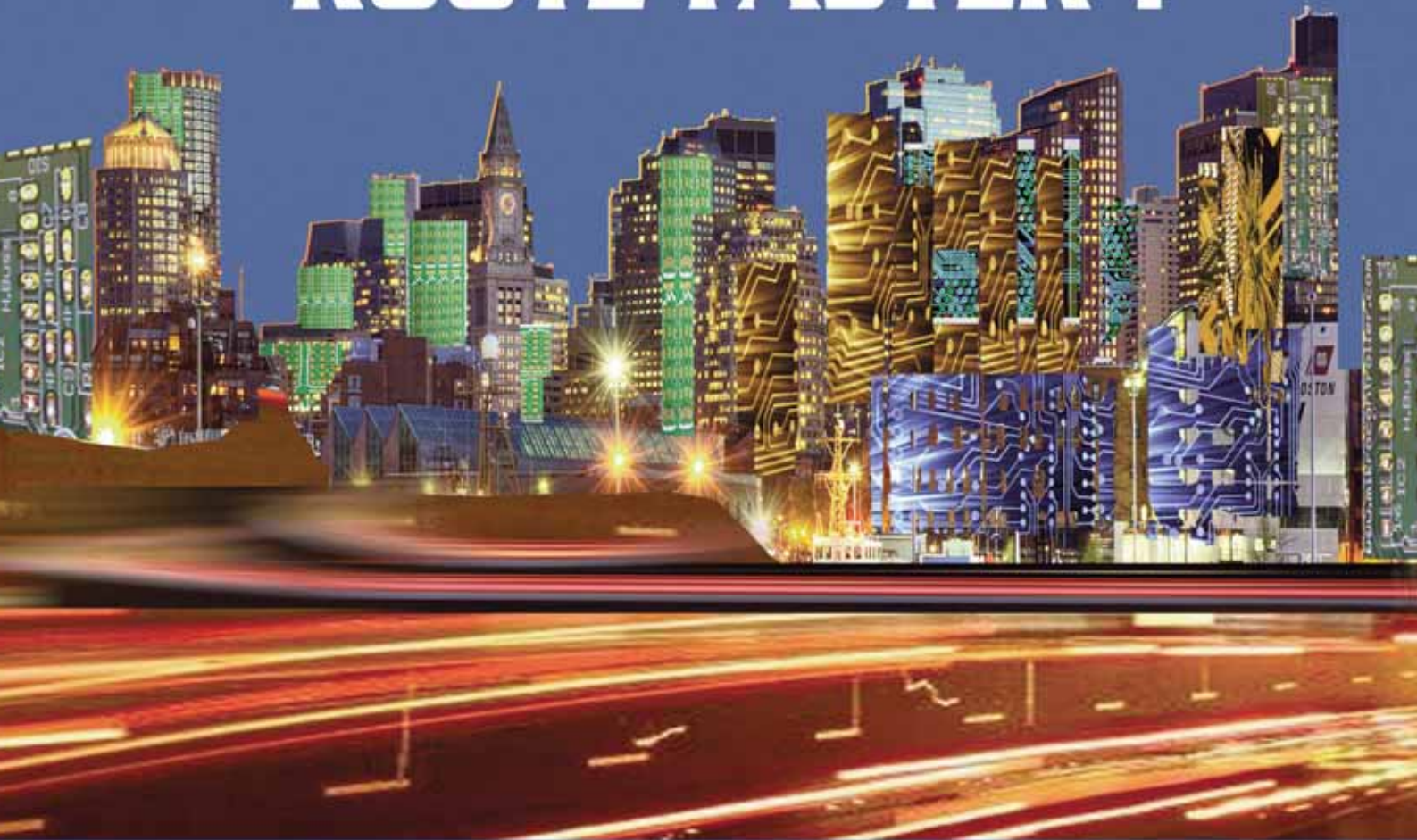
BARRY MCKEOWN, RF and Microwave Engineer in the Defence Industry, and Director of Datod Ltd, UK: Engineering developments are imminently required for harvesting "waste" heat from the human body for Wireless Body Area Networks, especially as this requirement is related to overcoming one of the limiting barriers for such widespread adoption – namely wearable batteries and prolonged use. Current generation power sources for devices such as smartphones definitely need improved upon for both longevity and ease of use. Whereas you can plug in a smartphone for recharging plugging in a wearable WBAN for recharging defeats the purpose of the mobility requirement. Whether this candidate technology fits the bill remains to be seen as only time shall tell.

MAURIZIO DI PAOLO EMILIO, Telecommunications Engineer, INFN – Laboratori Nazionali del Gran Sasso, Italy: Most benefits of nanotechnology depend on the fact that it is possible to tailor the essential structures of materials at the nano scale to achieve specific properties, thus greatly extending the well-used toolkits of materials science. Using nanotechnology, materials can be made stronger, lighter, more durable, more reactive, more porous, or better electrical conductors, among others.

Nanotechnology is already in use in many computing, communications and other electronics applications to provide faster, smaller and more portable systems that can manage and store larger and larger amounts of information.

If you are interested in becoming a member of our panel and comment on new developments and technologies within the electronics sector please register your interest with the editor by writing to Svetlana.josifovska@stjohnpatrick.com

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