Volume 116 • Issue 1892
August 2010 • £4.60

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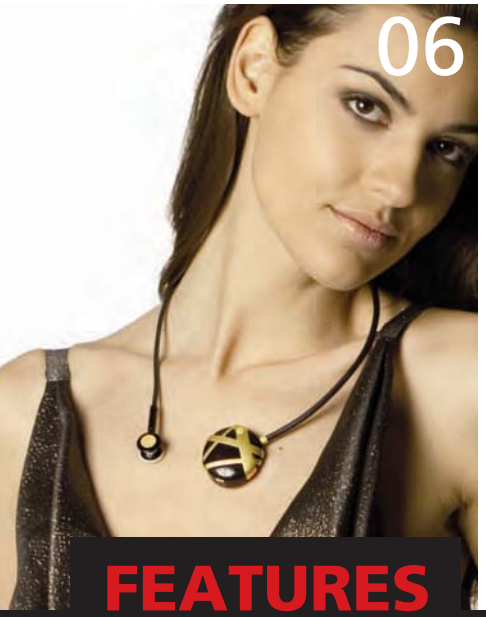

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FEATURES

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

Quasar Electronics Limited
PO Box 6935, Bishops Stortford
CM23 4WP, United Kingdom
Tel: 01279 467799
Fax: 01279 267799
E-mail: sales@quasarelectronics.com
Web: www.quasarelectronics.com

Postage & Packing Options (Up to 0.5Kg gross weight): **UK Standard 3-7 Day Delivery** - £4.95; **UK Mainland Next Day Delivery** - £11.95; **Europe (EU)** - £11.95; **Rest of World** - £12.95 (up to 0.5Kg)
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POWERLINE COMMUNICATIONS:

The Home Network's Invisible Secret

BY MICHAEL WILSON

What this piece states is that the proliferation of home network communications and networking technologies in the home are an unstoppable trend.

We've hit rush hour on the Information Highway, as telecommunications operators building next-generation broadband infrastructures converge with utilities and other service providers offering IP-based smart grid applications to maximise energy efficiency. Traffic's spiking inside the home, too, where networks are now evolving to manage this information surge. Simply sharing a web connection or printer between computers is no longer enough. Savvy consumers now need their home network to coordinate three distinct tasks:

- Connect consumer entertainment devices and allow access to music libraries, photography archives and high-definition (HD) movies, anywhere, anytime.
- Automate home security and monitoring.
- Manage home energy consumption.

In the entertainment sphere, cable, satellite and IPTV service providers have traditionally enabled consumers to view or listen to digital content sourced from outside the home at one or more locations inside the home. This can be thought of as an access extension, and the technology of choice varies by geography. In the US, typically larger homes may already contain some cable, so coax-based access extension technologies are popular. These technologies, such as Multimedia over Coax Alliance's MOCA deployed by Verizon, and the HomePNA Alliance's HomePNA deployed by AT&T, connect the access point to one or more set-top boxes. Elsewhere in the world, powerline communication technologies such as the Homeplug Powerline Alliance's Homeplug AV, now an IEEE standard in form of IEEE 1901, have proven successful for communicating HD IPTV services from the home gateway to the set-top box.

As Homeplug AV/IEEE P1901 products proliferate, they can be used to create self-installable entertainment home networks which seamlessly incorporate operator-provided access extension. Other technologies have also been used on a smaller scale, including CAT-5 Ethernet or passive optical cable and – to a lesser extent – WiFi. In the energy-management sphere, two technologies have risen to the top in smart grid trials and deployments: IEEE 802.15.4 wireless-based solutions (the most prevalent being Zigbee) and powerline communications. US utilities, understanding that 100% coverage is crucial to smart grid success, encouraged the Zigbee and Homeplug Powerline alliances to create the Smart Energy 2.0 profile, which combines the flexibility of wireless (Zigbee) with the coverage of powerline (Homeplug) communications.

The third sphere – home automation, also known as the "domotic" sphere – has used a variety of wired and wireless technologies to control lighting, doors and windows for security, surveillance systems and other devices. These technologies include Zigbee, Z-wave, Bluetooth and a variety of low-frequency narrowband powerline communications technologies such as X10 and Lonworks. Going forward, a unified home network is needed that facilitates intra-sphere communication and interoperability between all devices, whether tethered to a power cable such as a home gateway, or "nomadic" such as an iPod, or unpowered in a fixed location such as a window sensor. The network's underlying technologies must deliver the ubiquity of WiFi combined with the performance of CAT5 Ethernet, without requiring that new wires be installed. To do this, they must use all available media: air, power lines, and coax and phoneline (if they are there). They also must be capable of intelligently switching between channels according to channel conditions and the traffic's quality of service (QoS) requirements, and they must be capable of bonding all channels together for ultimate performance. Further developments are needed to embrace nomadic and low-bandwidth automation devices. To this end, the Homeplug Powerline Alliance has announced a suite of three interoperable standards that greatly expand powerline channel capabilities and will enable, for instance, an entertainment device inside a home gateway to communicate with an energy-management device in a heater control.

> "FURTHER DEVELOPMENTS ARE NEEDED TO EMBRACE NOMADIC AND LOW-BANDWIDTH AUTOMATION DEVICES"

Homeplug GP (Green PHY), the low-power/bandwidth/cost solution for energy management, automation and plug-in electric vehicle applications, is complete and products will be available later this year. Building on the tried and trusted Homeplug AV compliance and interoperability program, certified IEEE P1901 products are already out. Homeplug AV2 is the solution for multiple streams of HDTV and the specification will be completed this year.

Michael Wilson is Vice President of Corporate Business Development at Gigle Networks and Vice President at the Homeplug Powerline Alliance

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

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

John Patrick Publishers

ADI's Devices Go Into Antarctic 'Ice' Telescope to Find Neutrinos

Buried two kilometers under solid ice on one of the coldest continents on Earth, Analog Devices's data converters and amplifiers are helping scientists at the South Pole build the world's largest telescope to search for the smallest subatomic particles known.

The innovative "underground" telescope project is called IceCube and uses a cubic kilometer of pure, ultra-translucent ice at the South Pole as a telescopic "window" or particle detector to search the universe for neutrinos. These are subatomic particles that lack an electric charge produced by the decay of radioactive elements and elementary particles. Neutrinos travel at near the speed of light and, due to their size, can typically pass through solid matter without colliding with any atoms. However, when neutrinos collide with an atom, light energy is emitted that can help detect the presence and direction of these sub-atomic particles.

IceCube will search for neutrinos from the most violent astrophysical sources, including events like exploding stars, gamma ray bursts and cataclysmic phenomena involving black holes and neutron stars. The IceCube telescope is a powerful tool to search for dark matter and could reveal new physical processes associated with the enigmatic origin of the highest energy particles in nature.

The 'IceCube' telescope modules will reside up to 2.5km under water in the Antarctic

IceCube uses Antarctica's ice sheet as the largest instrumented volume of ice/water in the world. Neutrinos passing through the ice sheet collide with atoms creating a blue light at impact that can be detected by IceCube's Digital Optical Modules (DOMs).

Analog Devices's data converters and amplifiers are installed in more than 5,000 of these DOMs. The DOMs are 13 inches in diameter glass pressure spheres and are deployed under the ice on a cable at depths of up to 2.5km. Over the next 25 years while embedded in ice, the DOMs will detect and transmit experimental data about particle collisions.

"We needed low-power, reliable products capable of providing the longevity needed for this project, especially on the main board in the DOMs. Design teams at Lawrence Berkeley National Laboratory (LBNL) and the University of Wisconsin-Madison used ADI data converters and amplifiers that fit our needs and requirements," said Jerry Przyblski, LBNL design engineer. "We used ADI products, such as analogue-to-digital converters, DACs and amplifiers, in the DOMs and the communications system. So far, IceCube's scientists have gathered data equal to thousands of DOM years of operation."

The construction of the IceCube underground telescope will be completed in 2011. The National Science Foundation awarded the University of Wisconsin lead responsibility in building IceCube. The project is a collaboration among researchers from around the world, including Belgium, Germany, The Netherlands, Switzerland, Japan, the United Kingdom, New Zealand and Sweden.

Novero's communications-enabled jewellery will be made of precious metals and stones

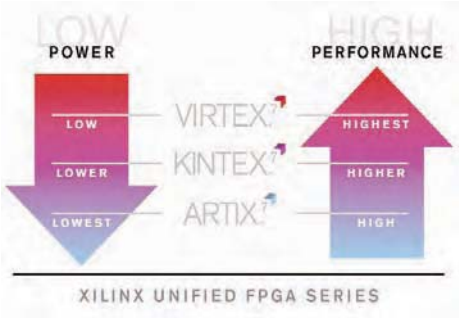
COMMS DEVICES GET THE MAKE-OVER BY NOVERO

A German company called novero has used fashion trends to create a fashionable and artistic set of communications devices. Entitled the Victoria collection, the 'jewellery' series consist of Bluetooth-enabled devices.

The initial line will be crafted from precious metals and stones, but for those who require something more 'special' there's the "première édition" with some items reaching a price tag of over £100,000, where each piece can be custom made with fine jewels. The pieces will be available at select retail stores later in the year.

"This is the dawn of a new era," said Razvan Olosu, novero's CEO and founder. "The Victoria line showcases beauty's victory over cold technology. We have created pieces of delight that open the mind to the possibilities of the future – where devices deliver far more than pure functionality. No longer will those who appreciate the finer things have their sense of style disrupted by unattractive accessories. But make no mistake, this is just the beginning."

Among the materials used to 'jazz up' the Bluetooth devices will be gold, silver, pearls and lapis lazuli.



Same architecture allows different Xilinx 7 FPGA families to scale up or down

Xilinx 7 Series FPGAs Reach 2 Million Logic Cells But At 50% Lower Power Consumption

Programmable logic devices vendor Xilinx has introduced the industry's first FPGA series with total power consumption reduced by 50% on previous devices and increased capacity of up to 2 million logic cells. The devices are implemented on 28nm process technology, courtesy of Taiwanese foundry TSMC.

By default a smaller node size delivers more transistors per square cm, which in turn causes problems such as gate leakage or static power and increased power consumption and heat dissipation. To avoid these, the partners combined a high dielectric constant to reduce gate leakage and a form of clock gating (in the hardware as well as customer selectable through the tools) to reduce dynamic power.

Xilinx now says that its new generation devices will help designers take full advantage of 2 million logic cells at clock speeds of up to 600MHz, up to 4.7TMACS in DSP performance symmetric mode (2.37TMACs in non-symmetric mode) and up to 2.4Tbps high-speed connectivity, all while staying within their power budgets.

There are three new families part of the Xilinx 7 series: Virtex-7, Kintex-7 and Artix-7. They are tweaked differently for power saving, cost saving and gate and memory capacity among others, which will appeal to different design projects, but ultimately they all share the same architecture (logic fabric, Block RAM, clocking technology, DSP slices, SelectIO technology) and, hence, are fully scalable up or down.

Technology Innovation Fund Gives UK Businesses Access to Measurement Expertise

The National Physical Laboratory (NPL), the UK's measurement Institute, is calling for businesses to apply for support through its new Technology Innovation Fund (TIF), providing access to NPL's unsurpassed leadership in measurement, innovation and scientific research.

The new fund will help the UK's growing high-tech industries speed up route to market by improving their products, cutting costs and meeting standards.

Highly accurate measurement is critical to the success of many new products and innovations. It ensures that standards are met, that new product parts fit together and optimises efficiency in the manufacturing process.

TIF offers UK businesses three different levels of support to service a range of measurement issues. It is designed to help companies benefit from measurement to quickly take ideas to market with minimised business risk. It achieves this by providing a successful mix of world-class research and development expertise with proven commercial insight.

The new fund is inspired by the successful Measurement for Innovators (MFI) programme. This was developed in response to a government innovation report and introduced many businesses to the expertise available at NPL for the first time. It provided participants with business benefits worth almost £10m through over 400 secondments, consultancies and joint industry projects over a five-year period.

Solderability testing of electronic components

RS COMPONENTS UNVEILS A NEW GATEWAY TO ONLINE DESIGN SUPPORT

In a follow-up to its multi-tiered design and development environment introduced in May this year (see *Electronics World*'s June issue), RS Components has now announced the launch of DesignSpark, the centrepiece of its initiative to provide an authoritative online design environment for engineers.

DesignSpark is an online gateway that aims to give engineers trusted and reliable information and resources, bringing together design information, user generated reviews and new free-of-charge tools to speed up their design processes.

"DesignSpark is more than just a website…," said Glenn Jarrett, Head of Electronics Marketing at RS Components, "…it provides the electronic engineering community with an environment where they can not only find design tips and reviews that help inform the start of new designs, but also connect with partners, exchange ideas and contribute to a variety of valuable information sources available from across the Internet which are relevant for the whole design cycle."

Part of this launch is a free, fully-featured PCB design tool called DesignSpark PCB. It is available to all registered members of DesignSpark.

Users can now access this site at www.designspark.com.

THE CYCLES ARE DEAD... LONG LIVE THE CYCLES

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

BARING A CATASTROPHE, 2010 is a done deal, with virtually everyone now agreeing chip growth will be in the 30% range. The big question now is: "What happens next?"

Despite perceived wisdom, the chip cycles are not over, tamed or moderated, nor will they ever be; all the while demand lead-times are measured in weeks and supply-side changes much longer, amplified by the fact only a small handful of players invest counter-cyclically. As such, the industry is obliged to suffer the full ravages of Hog and Cobweb cycle dynamics.

Hog cycles will continue because of capacity lead-times lag changes in market demand by a minimum one quarter (the fab and assembly cycle time); one year if additional production equipment and capacity is required.

Cobweb cycles exist because firms have to decide how much capacity to build several quarters before the product goes to market. As a result, they are planning to make parts without really knowing what the actual demand will be.

Forget all of the intellectual arguments about expanded geographical customer base, broader application range and the smoothing effects these would produce, the Hog and Cobweb dynamics mean supply and demand are impossible to balance. The cycles are dead … long live the cycles!

After five quarters of growth, the industry now finds itself in the full flood of a classic upturn. Capacity is strained, lead times are up, inventories are low, with current order books clearly reflecting real demand, inventory replenishment/build and double ordering.

Replenishment started in Q2-2009, due to the severe inventory over-depletion in Q4-2008/Q1-2009, and was over by Q4-2009 to be replaced by inventory building in 1H-2010, driven by lead-time extension. Typically every week of extra lead-time adds at least half a week to WIP.

Double – even triple – ordering (due to supply shortages) only really started in 1H-2010 and is definitely getting worse. We can expect many more announcements, as recently with Alcatel-Lucent and Nvidia, blaming component shortages for missing quarterly numbers.

It is not as if any of this is new or different. The really smart OEMs would have started building inventory and double ordering in Q4-2009, given a capacity crunch was clear and inevitable, but as so often with this industry, few firms even acknowledged there might be a supply risk potential, aided and abetted by the traditional Q1-2010 seasonal demand slow-down.

So, for this cycle at least, history will again repeat itself. We can expect it to replicate its historical roller coaster dynamics. Put another way, when you are in the growth side of the cycle, the inevitable next step is down, the only questions being: how long will it take to reach the peak of the cycle, how low it will drop and how fast will it fall?

"FORGET ALL OF THE INTELLECTUAL ARGUMENTS ABOUT EXPANDED GEOGRAPHICAL CUSTOMER BASE, BROADER APPLICATION RANGE AND THE SMOOTHING EFFECTS THESE WOULD PRODUCE, THE HOG AND COBWEB DYNAMICS MEAN SUPPLY AND DEMAND ARE IMPOSSIBLE TO BALANCE"

One of the real problems that the industry faces is its very poor visibility into what real demand actually is (we desperately need a trade association to gather and publish this data) not helped by the fact that the WSTS no longer publishes bookings and the book-to-bill ratio, hence industry now has no structural way of knowing just how much orders and sales are getting out of synch.

That said, double ordering is just that – double ordering. It has not yet fed through to shipments, i.e. sales because there is not enough capacity to meet real demand let alone the inflated demand caused by inventory build and double orders. Given the current capacity situation, this is unlikely to change until Q4-2010 at the earliest.

The industry went into this recession in Q3-2008 with supply and demand more or less balanced and overall capacity utilisation at 90%. Since then, capacity has been cut back by an unprecedented 15%. Given the derisory low levels of Cap Ex spend in 2009 there will be minimal net new capacity coming on stream in 2010.

Granted current Cap Ex is now running twice its 2009 level, but this will

not impact capacity until Q4-2010 at the earliest, more likely 1H-2011. It is also too little in absolute terms. Whilst past track record shows the chip industry always does a good job at 'squeezing' capacity, the extent of the current (lack of capacity/underinvestment) problem is so great that it will not be resolved until Cap Ex spend is at least doubled again.

Even the most optimistic calculations show only a 15% capacity increase in 2010, all of which will be late second-half year loaded and, therefore, unable to seriously impact IC unit sales until Q1-2011 at the earliest. Also with Q1-2010's capacity down 15% on its Q3-2008 peak, a 15% increase does not even take Q1-2011's capacity back to where it was two and a half years previously. At the same time, 2010's real IC unit demand will be up 10-12% on Q3-2008's peak, meaning industry will be running tight on capacity throughout most of 2011.

But, no up-cycle lasts forever. Bust will follow boom, with the bust cycle triggered, as always, by overcapacity caused either by over-investment or a sudden fall in demand, which in turn is triggered by an economic crisis or inventory correction. It is the combination of lower unit growth and collapsing ASPs that combine to make market collapses so steep.

Economic collapses will always be unforecastable, so there is little one can do about this other than react fast and batten down the hatches. Likewise with inventory correction but there will be an early warning sign namely when delinquency and lead-times stabilise. Once this happens, customer cancellations and rescheduling will inevitably kick in but this always happens so fast its usefulness is poor.

Excess capacity is much more foreseeable as there will be up to three quarters early warning of this (four quarters actually less the one quarter delay in publishing the stats). Just keep a very watchful eye on Cap Ex spending (the three quarter out indicator), ASML's advanced litho shipment trends (the two quarter indicator), TSMC's sales and orders (the one quarter indicator).

Based on current Cap Ex trends, the over capacity trigger for the next industry down cycle will not be fired until Q3-2011 at the earliest. This, therefore, leaves one big unanswered question. If prices fall so precipitously when supply exceeds demand, why is it prices take so long to increase when demand exceeds supply?

Most of the time the chip industry runs on over-capacity putting pressure on pricing. This is clearly no longer the case, there is no spare capacity, yet (memory aside) ASPs have barely changed. This is economic and industry madness. It's time for industry to 'double' prices now. If (when) customers complain, remind them of the past five years or more of ASP decline, doing more for less, and the need for the chip industry to rebuild its cash and profits if it is to recover and survive.

Then sit down for a serious price negotiation selling capacity, not chasing purchase orders based on a minimum five year rolling contract with cast iron, non-cancellable commitments. That way industry will finally have long-term order commitments, capacity planning can be improved and investment risks shared. The alternatively adversarial 'chip business as normal' model simply exasperates the cycle dynamics to the detriment of everyone. The chip cycles are dead … long live the cycles! ■

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

The Common Grid Gain Stage CGS

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

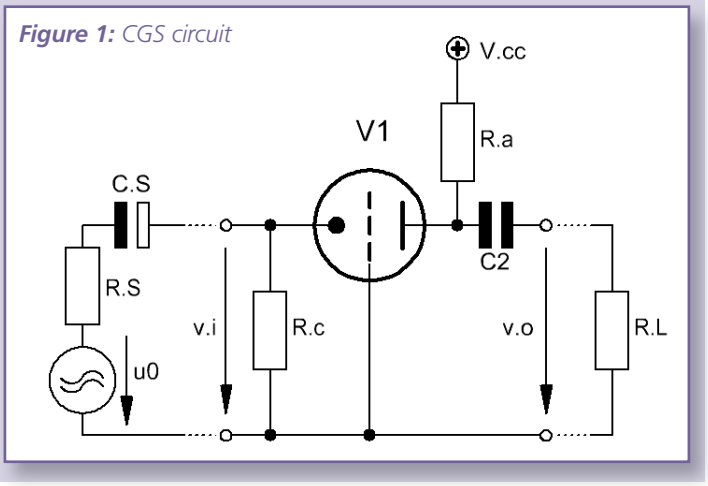


Figure 1: *CGS circuit*

AS STANDALONE gain stage, the CGS is rather rarely used in the audio world. In most cases, as a second stage in conjunction with a CCS, it forms a cascode gain stage (CAS) that can play a very high gain role for very low level audio signals. The discussion on this type of double-triode gain stage will be the task of the next issue's part.

There are only a few triodes on the market being capable to work as CGS. The basic CGS circuit is given in **Figures 1, 2** and **3**, and it shows the respective small signal equivalent circuit. In contrast to the valve gain stages that also allow bypassing the cathode resistor by a capacitance, here we have the gain stage's input at the cathode and the output at the anode. Consequently, the source resistance R_S plays a specific role too.

Generally, the CGS is a gain stage with a very low input resistance R_i and an output resistance R_o like the one of a CCS. In contrast to the CCS the CGS gain is independent of the cathode resistance R_c and there is no 180° phase shift between the input and output signals. However, its output resistance R_o depends on the source resistance R_S, which is not the case for the CCS.

One of the major advantages of a CGS comes from the fact that the Miller capacitance doesn't play a role; the input capacitance C_{gc} between the grounded grid and the cathode is very low. In conjunction with the very low input resistance R_i at the cathode C_{gc} doesn't play any role in audio applications. That's also an ideal situation to be widely used in high frequency applications.

As function of the output load R_L and with r_g = infinite the general gain equation for the CGS becomes:

$$G(R_L)=\frac{v_o}{v_i}=(1+\mu)\frac{R_a}{r_a+R_a+r_aR_aR_L^{-1}} \quad (1)$$

and the R_L dependent input resistance $R_i(R_L)$ at the V1 cathode can be derived as:

$$R_i(R_L)=R_c\frac{r_a+\left(R_a^{-1}+R_L^{-1}\right)^{-1}}{r_a+\left(R_a^{-1}+R_L^{-1}\right)^{-1}+(1+\mu)R_c} \quad (2)$$

$R_i(R_L)$ is also the resistance parallel to C_c in Figure 2 in last issue's Part 2. Now, with a corner frequency f_c (should be << 20Hz) we can calculate C_c of Part 2 too:

$$C_c(R_L)=\left[2\pi f_c R_i(R_L)\right]^{-1} \quad (3)$$

The CGS input capacitance $C_S(R_L,R_S)$ depends on R_L and R_S. It thus becomes:

$$C_S(R_S,R_L)=\left[2\pi f_c\left(R_S+R_i(R_L)\right)\right]^{-1} \quad (4)$$

We can derive the output resistance $R_o(R_S)$ at the anode of V1 as function of the source resistance R_S and the anode resistance R_a; we obtain:

$$R_o(R_S,R_a)=R_a\frac{r_a+(1+\mu)\left(R_c^{-1}+R_S^{-1}\right)^{-1}}{r_a+R_a+(1+\mu)\left(R_c^{-1}+R_S^{-1}\right)^{-1}} \quad (5)$$

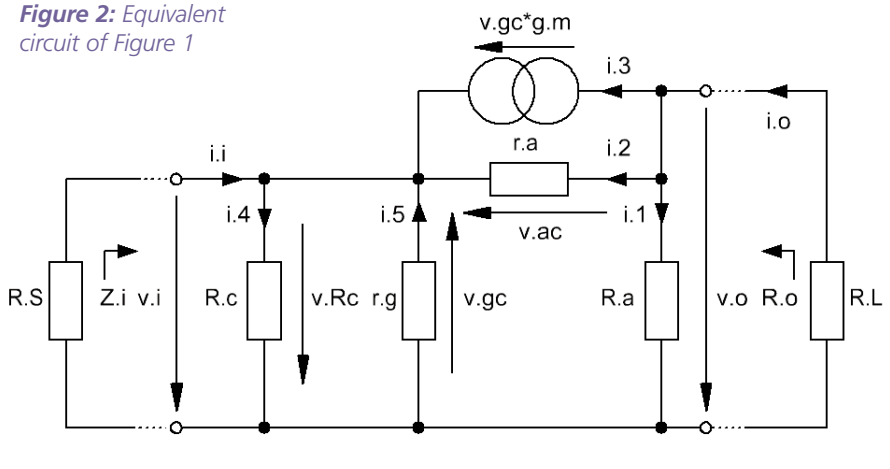


Figure 2: *Equivalent circuit of Figure 1*

In the CGS case (and also in the CAS case) the input and output capacitances C_i and C_o have their own indication in data sheets. However, even an additional stray capacitance C_{stray} = 10pF at the input and the output won't hurt the flat frequency and phase response in B_{20k}. Hence, in audio applications we can ignore C_i and C_o.

With a constant Va = 250V for the circuit of Figure 1, we can plot graphs (see **Figures 3-9**) for the example triode EC92/6AB4 (note: with a constant V_a a constant R_a means automatically a changing V_{cc} for a changing I_a; "$_k$" indicates the number of the ten I_a values from 1mA to 14mA). ■

Figure 3: *CGS gain G with vs. anode current I_a (R_L = 1MΩ, R_a = 100kΩ)*

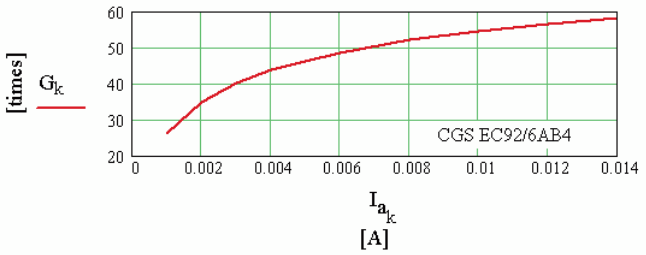


Figure 4: *CGS gain G vs. output load R_L (I_a = 10mA, R_a = 100kΩ)*

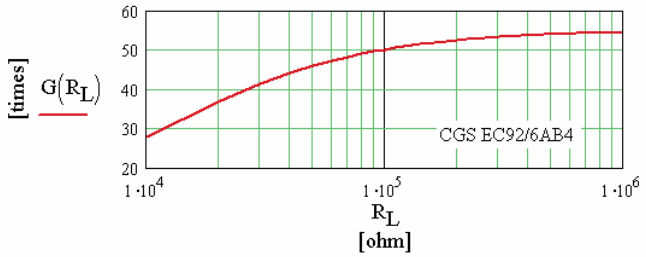


Figure 5: *CGS output resistances R_o vs. anode current I_a (R_a = 100kΩ, R_S = 5kΩ)*

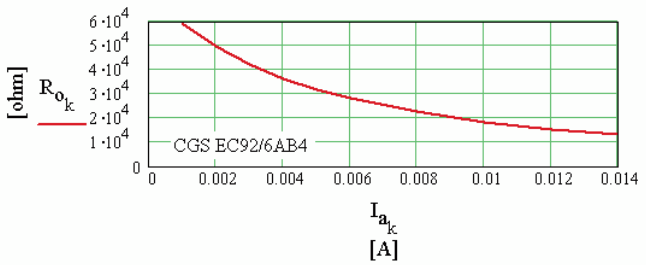


Figure 6: *CGS output resistances R_o vs. source resistance R_S (I_a = 10mA, R_a = 100kΩ, Rc = 200Ω)*

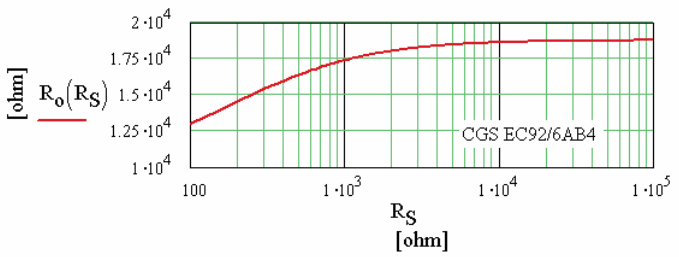


Figure 7: *CGS input resistances R_i vs. anode current I_a (R_a = 100kΩ, R_L = 1MΩ)*

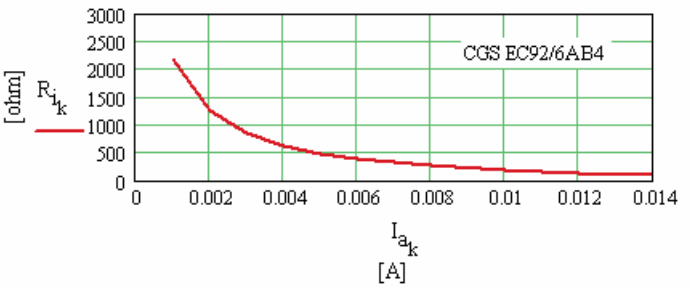


Figure 8: *CGS input resistances R_i vs. load resistance R_L (I_a = 10mA, R_a = 100kΩ, R_c = 200Ω)*

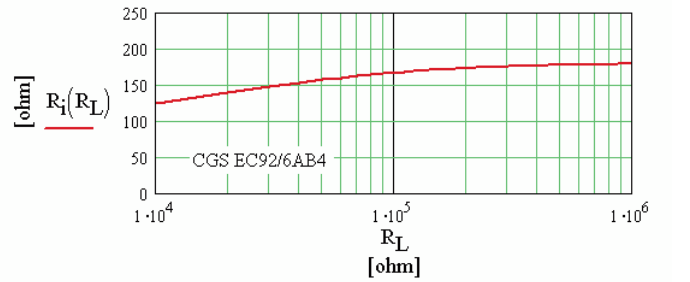
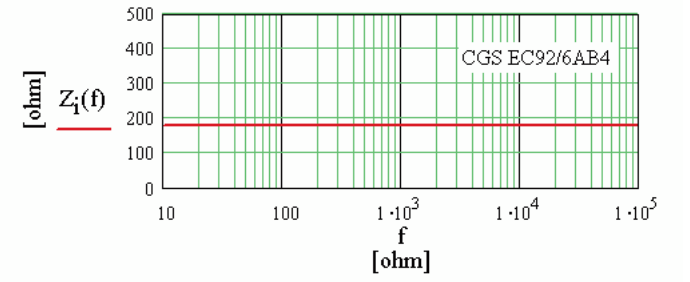


Figure 9: *CGS input impedance $Z_i(f)$ vs. frequency f (I_a = 10mA, R_c = 200Ω, R_L = 1MΩ, R_a = 100kΩ)*



Coming in the next issue is Part 4:
'The Cascode Stage CAS'.

If you missed any of the previous two parts, you can order them online by going to Electronics World's website at

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MINIATURISATION – 'SMALLER IS BETTER'

Jeff Bierman, Senior VP at Volex Group, says that component manufacturers can transform product performance and deliver the innovation required to achieve real market differentiation by embedding their expertise and experience in the core design

FEW MANUFACTURERS are maximising the value component suppliers can deliver early in the design phase to both optimise technology and inform logistics decision-making.

Why are laptop manufacturers, for example, willing to spend several hundred man years on design, yet only consider the issue of connecting the screen to the laptop well into the design process? By contrast, those manufacturers that have embraced signal interconnect expertise early in the design process have not only been able to deliver significant performance improvements through the use of highly innovative technologies that are designed in tandem with the core product values, but also reduce environmental impact and improve product safety. Critically, they have achieved a better design with fewer iterations, less cost and faster time to market.

Integrated, end-to-end supply chains are a fundamental component of modern manufacturing processes. But where should this supply chain start: from day one of product manufacture or during the design phase?

Considering the design implications of signal interconnects and cable assemblies early in the process is proving to be increasingly essential across a range of products from MRI scanners to laptops and mobile basestation equipment. This is a complex marketplace and one that offers significant challenges for product design teams. New ISO standards are continually being developed, whilst environmental regulations, which vary from country to country, have a growing influence on the design process.

As such, growing numbers of manufacturers are now looking to leverage the expertise and experience of component providers not just in delivering slick logistics but also underpinning product design expertise.

Apple, for example, has interconnect experts in its design team in California to ensure the key issue of cable assembly technologies are considered from day one of product design. With this approach the company knows that every aspect of the power cable product is created to match Apple's stringent and innovative design criteria; ensuring components are the right size, shape, style and quality.

But just how cost-effective would this approach be for other manufacturers with a less design-conscious approach to product specification? In fact, this strategy is not just about delivering the most innovative design and a better performing end product – although that is certainly a core outcome; it is also about minimising design iterations to drive down costs. Producing the exceptional data-rates and signal quality required to show high definition (HD) movies on a laptop, for example, requires acute attention to the interconnect cable to the screen. Failure to incorporate an interconnect capable of this specification will not only compromise product performance, but incur heavy costs for late redesign and even replacement of malfunctioned units that could have been otherwise avoided.

By failing to effectively pre-empt these issues as part of the core design process, manufacturers are also failing to maximise the available technology. For example, the right signal cable and/or interconnect will minimise resistance and, hence, use less power. Leveraging this technology within the core design will enable a laptop manufacturer to advertise a greater battery life to customers, while organisations running large data centres can minimise the cost of cooling systems and meet CSR objectives, and financial institutions can reduce latency to further improve time-sensitive deal-making.

Obviously this technology is available at any time. Any manufacturer can decide to incorporate halogen-free cables, for example, to support consumer-led initiatives for greener technology, or ensure technology that may be used by children does not include any carcinogenic materials. But at what cost in both additional design requirements and slower time to market?

Opportunities should be taken as soon as they present themselves early in the design phase. Product designers should be enabled to consult component experts as part of the day to day design process that a manufacturer can maximise these differentiation opportunities, minimise product iterations and get new, innovative solutions to market earlier and at a lower overall cost to design.

Too often companies are developing amazing, innovative new products with an assumption that interconnect cable assemblies are

"PIECEMEAL DESIGN STRATEGY RESULTS IN A SIGNIFICANT BUSINESS COST, BOTH IN ADDITIONAL DESIGN WORK AND THE LOST OPPORTUNITIES ASSOCIATED WITH A DELAY IN GETTING A PRODUCT TO MARKET"

just standard components that can be simply plugged in. As a result, issues from signal integrity to safety concerns and environmental demands leave the manufacturer either facing an expensive custom design from a component supplier or a significant redesign of the core product.

This piecemeal design strategy results in a significant business cost, both in additional design work and the lost opportunities associated with a delay in getting the product to market.

The key thing is that whilst organisations are looking to improve safety, meet environmental regulations and deliver design innovation, cost will always be the fundamental consideration. It is by extending the supply chain to include component suppliers at the very beginning of the design process that manufacturers can exploit technologies to maximise product differentiation, achieve even more agile manufacturing processes and deliver products to market faster and at a lower cost than ever before. ■

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KEEPING A CLEAN INTELLECTUAL PROPERTY

Katherine Chin Quee, Legal Consultant at Protecode, endeavours to demystify open source software by explaining how it works and provides a primer on some of the most frequently used open source licences and their obligations

IN 2008, the open source community saw the year end with a headline catching lawsuit, the Free Software Foundation files suit against Cisco for General Public Licence (GPL) violations.

Not to be outdone, 2009 also ended with a bang. Best Buy, Samsung, JVC and eleven other consumer electronics companies were named in a copyright infringement lawsuit filed on December 14, 2009, by the Software Freedom Law Center (SFLC) on behalf of the Software Freedom Conservancy. The scope of this lawsuit is unprecedented as it includes fourteen defendants.

The suit alleges that the defendants have distributed products containing the Software Freedom Conservancy's product BusyBox in violation of the terms of its GPL Version 2 licence (the General Public Licence Version 2 superseded Version 1 in 1991, and is still widely used despite the creation of Version 3 in 2007).

Specifically, the Software Freedom Conservancy alleges that the defendants have not made BusyBox's source code available to downstream users. BusyBox is a tool that combines many UNIX utilities into a single executable and is commonly incorporated into household electronic devices. The Software Freedom Conservancy was seeking damages, injunctive relief and legal fees.

BusyBox has been at the centre of several other, high profile, GPL violations; the SFLC has in the past settled on behalf of BusyBox with Extreme Networks, Monsoon Multimedia, Xterasys Corporation, High-Gain Antennas and Verizon.

The Software Freedom Conservancy was not the only one to file a lawsuit for GPL violations as 2009 drew to a close. On December 2, 2009, Artifex Software filed a lawsuit against Palm based on Palm's alleged unauthorized copying and distribution of Artifex's muPDF, a PDF interpreter that can be integrated with PDAs. The muPDF is licenced under the GPL or under Artifex's standard commercial licence for companies that are unwilling or unable to comply with the terms of the GPL. Artifex alleges that Palm has neither obtained a commercial licence nor complied with the terms of the GPL.

These enforcement actions drive home the importance of taking inventory of what open source software is included in each product, what licensing obligations apply to each component and compliance with these obligations.

Open source licence compliance is particularly important, given the growing ubiquity of embedded computer systems – the impugned products in the lawsuit against Best Buy et al include Insignia Blu-ray Disc players and Samsung LCD HDTVs.

> "ENFORCEMENT ACTIONS DRIVE HOME THE IMPORTANCE OF TAKING INVENTORY OF WHAT OPEN SOURCE SOFTWARE IS INCLUDED IN EACH PRODUCT, WHAT LICENSING OBLIGATIONS APPLY TO EACH COMPONENT AND COMPLIANCE WITH THESE OBLIGATIONS"

WHAT IS OPEN SOURCE SOFTWARE?

Open Source Software (OSS) refers to software in which, among other things, the source code is made available to the public. This is important because the open source community and various ecosystems can modify, improve and incorporate the code into other works. Whereas with proprietary software, usually only the machine-readable compiled code is made available.

It is important to clarify the concept of "free". OSS is often referred to as free. While most OSS is indeed free of charge, it should be noted that "free" does not necessarily mean free of charge but rather refers to the freedom to use, modify and redistribute the source code, so long as certain conditions are met. Conversely, a product that is free of charge is not necessarily open source.

Many assume that the open source movement runs contrary to the concept of Intellectual Property (IP) rights. This, however, is a myth. The open source movement is actually made possible by IP rights. In most jurisdictions, such as the United States and Canada, software is automatically protected by copyright as soon as an original work has been created.

Copyright law grants copyright owners the exclusive right to reproduce, prepare other works based on the protected work, distribute and publicly display the work. In general, open source licences use these exclusive rights to ensure that the code remains open and accessible so that successive developers can innovate around it. Anyone violating the conditions of the licence may be held liable for copyright infringement.

There are many benefits to using OSS. Users can edit the code, fix programming bugs and even tailor the program to fit their specific needs. OSS is also significantly less expensive than proprietary software. In Jacobsen v. Katzer, the United States Federal Court of Appeal recognized the substantial benefits of distributing copyrighted works under public licences. The Court noted that program creators may generate market share for their programs by providing certain components free of charge. Similarly, a programmer or company may increase its national or international reputation by incubating open source projects.

The Court also noted that improvement to a product can occur rapidly and free of charge from an expert not even known to the copyright holder.

WHAT ARE OPEN SOURCE LICENCES?

The Open Source Initiative (OSI) is a public benefit corporation that refers to itself as the stewards of the open source definition (OSD). The OSI is a community-recognized body for reviewing and approving licences as OSD-

"MERELY MAKING THE SOURCE CODE AVAILABLE DOES NOT NECESSARILY MEAN THE LICENSOR HAS PERMITTED YOU TO MODIFY OR REDISTRIBUTE THE SOFTWARE"

conformant. A licence must comply with the OSI's ten distribution terms in order to be approved as open source. The three major requirements include royalty free redistribution, available source code, and the licence must allow for modifications and derived works. Derived works are essentially works based upon the licenced work. The OSI's website lists all of the approved open source licences. You should also be aware that source code that is made available but is not approved by the OSI is still often referred to as open source. Merely making the source code available does not necessarily mean the licensor has permitted you to modify or redistribute the software. The OSI has criticized companies that have advertised their software as open source when the licence was not approved by the OSI board. Such software might be more accurately described as source available software.

Open source licences ensure that others are generally free to use, modify and redistribute the OSS. More generally, licence agreements are a type of contract. There are, however, subtle differences in the interpretation of licences and contracts that can have harsh implications for a party that is caught offside the licence.

A licence gives a person permission to use another's IP in a way that would otherwise constitute infringement. A licence will set out the conditions of use and if the user violates these conditions the licence allows IP owners to exercise their property rights. This is an important distinction because it is easier to obtain an injunction when one's property rights have been violated, e.g., copyright infringement, than it is for a breach of contract. An injunction orders a party to refrain from the infringing activity and can halt business operations, whereas the ordinary remedy for a breach of contract is damages. In 2008, the United States Federal Court of Appeal in Jacobsen v. Katzer confirmed that if a licence is limited in scope and the licencee acts outside the scope, the licensor can bring an action for copyright infringement.

WHY CARE ABOUT OPEN SOURCE LICENCES?

In all likelihood your company has encountered OSS. OSS is becoming ubiquitous as companies that initially cast a wary eye on it have now realized its numerous benefits, including its ability to drive down development costs. It is now difficult to find commercial software that does not incorporate OSS in at least some areas.

While open source offers many benefits, it also heightens the probability of code contamination or unclean IP. Code contamination occurs when content is brought into a development project without regard for the licensing or copyright obligations.

The value of a company and its product often depend on the cleanliness of their IP and not solely on the protection of it. Disregarding licence obligations can have surprising and costly consequences for many stakeholders. In any merger and acquisition or funding deal, uncertainty over clean IP can:

- Generate risk and threaten successful closure.
- Increase product time to market.
- Affect software IP valuation and overall business valuation.
- Result in a litigation that can drag on for years draining company resources.
- Produce negative press and public scrutiny.

One of the most well-known examples of an open source surprise attack comes from Cisco and Linksys. Linksys routers used chipsets supplied by Broadcom, and Broadcom outsourced development of these chips to an overseas developer. In 2003, Cisco acquired Linksys for $500m.

After the acquisition, the Free Software Foundation (FSF), an organization that actively seeks companies that violate open source licences, determined that the chips contained copyrighted code under the GPL and that Cisco was distributing the product in violation of the licence. Cisco agreed to remediate the situation by releasing the source code. As a result, the software Cisco believed to be proprietary when it conducted its business and IP valuation of Linksys was now freely available to the public.

In 2008, the FSF sued Cisco for copyright infringement claiming that Cisco never completed the compliance process. In 2009, Cisco paid an undisclosed amount to the FSF and settled.

THE MAIN OBLIGATIONS OF OSS LICENCES

Despite the many benefits of OSS, companies often shy away from it because they do not fully understand the obligations of various licences. There is fear that using OSS will require a company to give away all of its software for free – this is not accurate.

This section will explain the primary obligations of some of the most frequently used open source licences. As you will see, open source licences can be diverse and can range from quite permissive to quite restrictive. Some of the most frequently used open source licences that will be reviewed are:

- GNU General Public Licence (GPL) 2.0;
- GNU General Public Licence (GPL) 3.0;
- GNU Lesser General Public Licence (LGPL) 2.1;
- New BSD Licence;
- Apache Licence 2.0;
- Mozilla Public Licence (MPL) 1.1.

The table on the next page follows groups together six of the most frequently used open source licences based on their salient obligations. Please note that this is not an exhaustive explanation and it should not be construed as legal advice; you should consult with an attorney.

LESSONS LEARNED

GPL violations and other open source licence violations occur on a regular basis, even if unbeknownst to the offender. The lawsuits in 2009 demonstrate that licencees cannot simply ignore their open source licensing obligations. As seen in this article, licensors are willing to enforce the terms of the licences in a court of law.

The lawsuit against Best Buy et al highlights the importance of understanding what OSS is, taking inventory of what OSS is included in each product, what licensing obligations apply and compliance with these obligations. This process can be facilitated by IP audits, now made easier with automated source code scanning tools that analyze and identify the presence of open source code, IP ownership and what type of licence applies.

It's become common in many industries for products to contain hundreds and thousands of software components, so companies will increasingly seek assurances of clean IP. The Cisco-FSF saga described above serves as a cautionary tale to acquirers, targets and other stakeholders in the software food-chain that IP audits should be conducted not only during the due diligence phase preceding a closing, but also throughout the product life-cycle from conception. ■ (see over for **Table 1**)

Table 1: *What's needed to keep a clean IP license*

LICENSE \ OBLIGATIONS	I PLAN ON USING THE LICENSED SOFTWARE INTERNALLY ONLY	CAN I DISTRIBUTE THE LICENSED SOFTWARE UNMODIFIED?	DO I HAVE TO RELEASE THE SOURCE CODE OF MY MODIFICATIONS?	CAN I DISTRIBUTE LICENSED SOFTWARE (MODIFIED OR UNMODIFIED) THAT HAS BEEN COMBINED OR LINKED WITH CODE COVERED BY ANOTHER LICENSING MODEL?	CAN I USE THE LICENSED SOFTWARE AS PART OF A TECHNOLOGICAL MEASURE?
GPL v.2	There are no restrictions on use if the GPL licensed software is used internally and is not distributed outside the organization. You may even combine GPL licensed software with proprietary licensed software.	Yes If the unmodified licensed software will be conveyed outside the organization, there is an obligation to make the source code available to downstream users and publish the original copyright notices and warranty disclaimers. You may not impose any further restrictions on the recipient's rights.	Yes If the modified code will be conveyed externally, there is an obligation to make the source code for all original and modified portions of the licensed code available to all downstream users. You must prominently notify users what files have been modified and the date of change. Include all original copyright notices and warranty disclaimers. You may distribute the GPL licensed software for a fee, but purchasers have the freedom to release it to the public without a fee.	Maybe Any software that contains GPL code or is derived from GPL code must be licensed as a whole under the GPL terms. What this means is that in order to distribute software that has combined or linked GPL code with non-GPL code, the licenses must be compatible. For example, GPL v.2 is not compatible with GPL v.3. (See http://www.fsf.org/licensing/licenses) The GPL does not explicitly state that linked files create a work derived from the GPL code. However, it is generally understood that static linking, which modifies the code of one program, creates a derivative work and therefore must be licensed under the GPL. It is less clear whether or not dynamic linking creates a derivative work. Dynamic linking does not necessarily modify any code. As this issue has not been litigated, it might be prudent to assume that under the GPL, statically or dynamically linked files both create derivative works.	Yes No specific restriction
GPL v.3	No restrictions on internal use as long as your license otherwise remains in force.	Yes If the unmodified licensed software will be conveyed outside the organization, there is an obligation to make the source code available to downstream users and conspicuously publish on each copy the original copyright notices, warranty disclaimers, and give all recipients a copy of the license. You may not impose any further restrictions on the recipient's rights. However, you may remove additional permissions and place additional permissions on material added by you.	Yes If the modified code will be conveyed externally, there is an obligation to make the source code for all original and modified portions of the licensed code available to all downstream users. You must prominently notify users what files have been modified and the date of change. Include all original copyright notices and warranty disclaimers. Prominently notify users that the work is released under this license and of any additional permissions.	Maybe Please see the above explanation for GPL v.2 and refer to http://www.fsf.org/licensing/licenses for a more in depth look at license compatibility.	Maybe The US Digital Millennium Copyright Act and similar non-US laws prohibit the intentional circumvention of technological measures designed to prevent unauthorized use/access to copyrighted works. (Note: Canada does not currently have any anti circumvention laws) The GPL v.3 does not stipulate what you can and cannot program. However, it does state that the licensed software shall not be deemed part of an effective technological measure. When you distribute the licensed work, you waive any legal power to forbid circumvention of the technological measures.

continued >

LGPL v.2.1	No restrictions on internal use.	Yes If the unmodified licensed software will be conveyed outside the organization, there is an obligation to make the source code available to downstream users and publish the original copyright notices and warranty disclaimers. You may not impose any further restrictions on the recipient's rights.	Yes If the modified code will be conveyed externally, there is an obligation to make the source code for all original and modified portions of the licensed code available to all downstream users. You must prominently notify users what files have been modified and the date of change. Include all original copyright notices and warranty disclaimers	Maybe The LGPL has an exemption that allows for the linking of LGPL code to non-LGPL code, without violating the license and without requiring source code disclosure of non-LGPL files. The license describes a library as a collection of software functions intended to be conveniently linked with application programs to form executables. A program that is designed to work with the LGPL licensed library by being compiled or linked with it, and does not contain a portion of the licensed library, is a work that uses the library, and is not a derivative work and therefore outside the scope of the LGPL. Any modifications to the licensed library itself or any work that contains portions of the licensed library is considered a derivative work and therefore covered by the LGPL.	Yes No specific restriction. However, with LGPL v.3 licensed software you waive any legal power to forbid circumvention of the technological measures when you distribute the licensed work.
New BSD License	No restrictions on internal use.	Yes No obligation to disclose source code. Redistribution of source and binary code must retain the copyright notices, and you must not use the name of the licensor to endorse or promote products derived from the software.	No No obligation to disclose the source code of your modifications	Yes No restrictions	Yes No specific restriction.
Apache License 2.0	No restrictions on internal use.	Yes No obligation to disclose source code. You may redistribute the original or modified code as open source or proprietary. You may copy and distribute the software so long as you provide a copy of the license and retain the copyright, patent, trademark and attribution notices from the originating file.	No No obligation to disclose the source code of your modifications. Prominently notify users of any modified files. You may add your own copyright statement and license terms to your modifications so long as you do not remove any of the original license requirements.	Yes No restrictions.	Yes No specific restriction.
Mozilla Public License (MPL) 1.1	No restrictions on internal use.	Yes Include a copy of the license with every copy of the source code you distribute. Duplicate the notice contained in Exhibit A in each file of the source code.	Yes You must make the source code of your modifications available. Maintain a file documenting modifications, date of the change, and a prominent statement that the modification is derived from the original code, and include the name of the initial developer in the source code.	Yes Unlike strong copyleft licenses, code under the MPL may be combined with code not licensed under the MPL. When such a larger work has been created, MPL source code and any modifications thereof must remain under the terms of the MPL, however non-MPL code remains non-MPL.	Yes No specific restriction.

It's just +5V, isn't it?

Myk Dormer

THERE ARE A LOT OF specifications to consider when selecting a low-power wireless module. Size constraints, power dissipation, radio performance, transmitter power… the list goes on and on. Unfortunately, when I read customer enquiries or discuss possible applications, the one simple parameter that gets overlooked or ignored most often is perhaps the most important: the supply rail which powers the device.

To be fair, absolute power consumption is rarely overlooked (although all too often it just gets specified as 'very low' with no further thought about the radio's actual task) but what gets forgotten is the actual supply voltage, where it comes from and any restrictions or peculiarities associated with it. There is no solid rule regarding the nature of a radio module's supply:

- Some designs require external regulated rails (usually 3V or 5V).
- Some have limited ranges of input voltage, for example 2.2-4V or 3.1-9V.
- Others have 'full' regulation and can accept a wide range of voltages, i.e. 3.1-15V.
- A few have wide operating voltages, but are restricted by thermal dissipation limits, such as "4-15V but 4-9V recommended for 100% duty cycle".

Most modules will draw a fairly constant current, irrespective of the voltage (inefficient at the upper end of the range), but a few will employ much more efficient switching supplies, which draw a constant power. However, an unseen problem here is that, as input voltage falls, the current rises, making them very vulnerable to problems with supplies having a high effective series resistance (such as batteries, especially as they age). Current variations in normal module operation can also be a problem. As transmitter sections switch on and off the current can rise from next to nothing to (for a 500mW module) over 400mA in tens of milliseconds. Again, a high ESR power source will fail, as it will be unable to maintain voltage as the transmitter keys up. In the worst case this will cause a potentially damaging low frequency oscillation: transmitter keys up; power supply voltage droops; transmitter resets; supply rises again; transmitter tries to key up again. Repeat ad infinitum. This is sometimes referred to as 'motorboating'.

And then there is the vexed issue of 'automotive' power supplies. A car or van's main supply is usually '12V', although in practice this is really 11-14V, with 13.8V as a good median guess. Unfortunately, it also suffers periodic glitches, interruptions and brown-outs (as the engine is started, or high current utilities such as headlights are switched) and, most damaging of all, it can suffer alternator load dump transients of 45-60V or more for several milliseconds (see footnote).

A simple module designed to operate from, for instance, 7-15V is unlikely to survive connection to such a supply, unless it has been specifically designed with over-voltage tolerant circuitry and good brown-out watchdog/reset behaviour in mind. If the supplier isn't specifying "automotive supply" then it's best to err on the safe side.

"MOST MODULES WILL DRAW A FAIRLY CONSTANT CURRENT, IRRESPECTIVE OF THE VOLTAGE, BUT A FEW WILL EMPLOY MUCH MORE EFFICIENT SWITCHING SUPPLIES, WHICH DRAW A CONSTANT POWER"

Frequently, the easiest solution is to build-in a separate voltage regulator to provide a cleaned-up, safe supply rail for the radio; many semiconductor suppliers have parts specifically rated for automotive applications and there are some effective 'supply conditioning' modules available.

So, how can supply problems be avoided?

- Match your module spec to your available power supply (obvious, but I've seen some obvious mistakes made).
- If your module requires a regulated supply, then give it a separate one of its own. Ideally from a low noise linear

FOOTNOTE 1:

Automotive supplies, while nominally 12V (closer to 13.8V actually) suffer short voltage spikes up to 45-60V under 'alternator load dump' conditions. An alternator load dump is what happens when the connection to the battery is broken and the alternator alone is supplying the 12V bus. The alternator output voltage then peaks, reaching 45-60V for a few milliseconds as the energy in the magnetic circuit of the device is dumped, before the regulator circuits bring things under control.

regulator ('regulated supply needed' infers 'sensitive radio circuits connected directly to supply pin'). These radios will be intolerant of digital or switch-mode noise on the rails.

- Allow adequate current capacity and sufficient voltage headroom, over all possible operating conditions. Do not take risks with this parameter.
- If using a battery supply, design for the worst case (cold, almost discharged batteries). And test the design with such a power supply.
- Provide some extra supply decoupling – low resistance series inductors, large and small decoupling capacitors. It's easier to delete it later if not needed than shoehorn it in when it is.

And finally, as I've said often before, test everything. Supply issues are easier to diagnose than some of the more awkward RF related faults. A lot can be done with a basic oscilloscope. If the voltages aren't what they ought to be, or there are odd looking waveforms where there should be clean DC, then a power supply fault is likely.

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The Solution to FM DISTORTION due to Multipath Transmission Part 1

Archie Pettigrew from Ampsys Electronics Ltd revisits the issues behind receiving the perfect FM broadcast radio signals

LORD KELVIN once said: "You only understand something when you can measure it; only when you can measure it, can you improve it".

It is now sixty-five years since Murlan Corrington published his seminal paper on the problem of distortion caused by radio echoes in broadcast FM. Sadly, no real satisfactory progress has been made in the intervening years to remedy this situation. Diversity reception, DAB or satellite radios have not provided an acceptable quality and cost-effective solution to this problem. This is especially so since the FM car radio is the primary means of mobile public communications and this takes place most commonly in urban areas.

In this environment, distortion due to echoes or multipath transmission is exceedingly common. Despite all the advances in this period in receiver and transmitter design, this malfunction is as prevalent today as it ever was.

Anomalies, Enigmas and Fallacies

Multipath distortion (MPD) is a problem that occurs in many locations, with the highest likelihood of happening in highly populated urban areas. One common location where an MPD zone is experienced within a moving vehicle is at traffic lights. The surrounding buildings block the line-of-sight transmission, causing the radio waves to refract around buildings or reflect off adjacent buildings. The resulting radio reception sounds almost unintelligible, provoking the listener to switch the radio off. Yet as soon as the vehicle moves, even a small distance, the fault clears and good reception and audio quality returns.

A common enigma is that MPD can occur when the carrier strength is quite strong and well above the threshold point of weak signal reception. It is thought that it is the spike noise of threshold reception that causes the crackles and spits.

Improvements in low noise amplifiers over the decades should have reduced this nuisance. Indeed, the threshold level of modern tuners is ten times lower than the valve amplifiers of 1945. The problem still persists despite this twenty-decibel improvement in the threshold point.

Perhaps it is time to look at the problem afresh and see if some important principle has been overlooked in the science of FM transmission and reception.

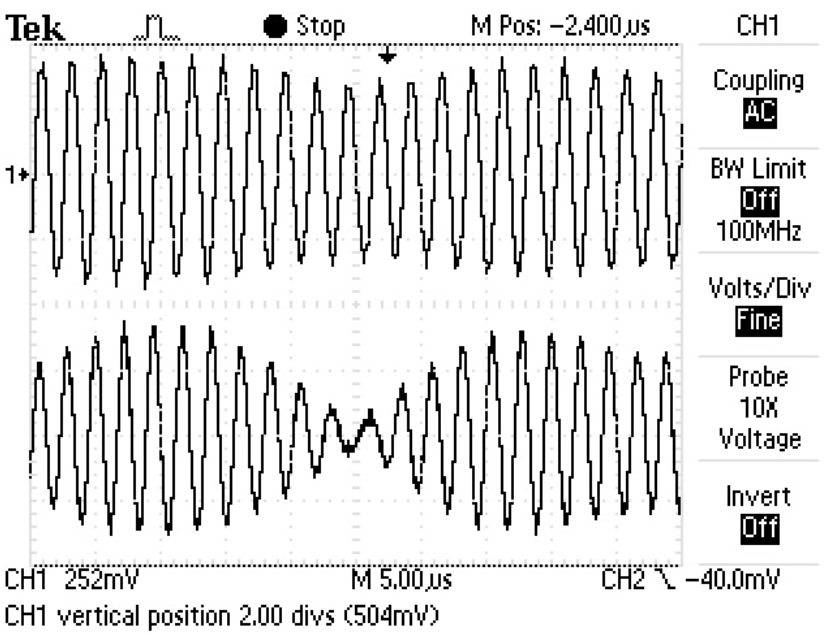

Figure 1a: *The top trace is the flat envelope FM carrier and the lower trace is the envelope when in a zone of severe distortion. It shows the square root carrier envelope passing through zero at a fixed repetition frequency of 38kHz*

Corrington Paper on FM Distortion

Corrington measured multipath distortion by sending an FM signal down a long coaxial cable and adding the output of the cable to the original signal. Unfortunately, he used a length of coax measured in kilometres starting from about 2km to about 10km. This resulted in a series of sharp spikes at a specific difference frequency. This difference frequency increased with the increasing delay distance. In a small leap of imagination,

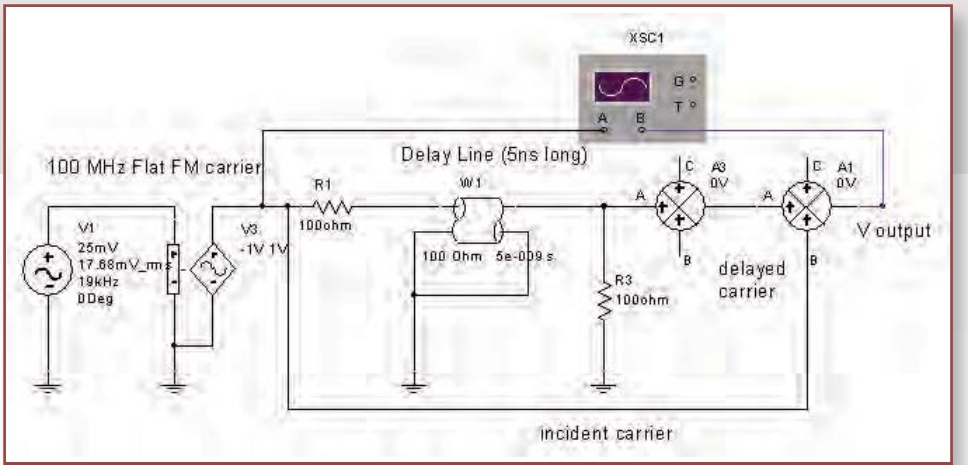

Figure 1b: *The top trace is the flat envelope FM carrier and the lower trace is the envelope when in a zone of severe distortion. It shows the square root carrier envelope passing through zero at a fixed repetition frequency of 38kHz*

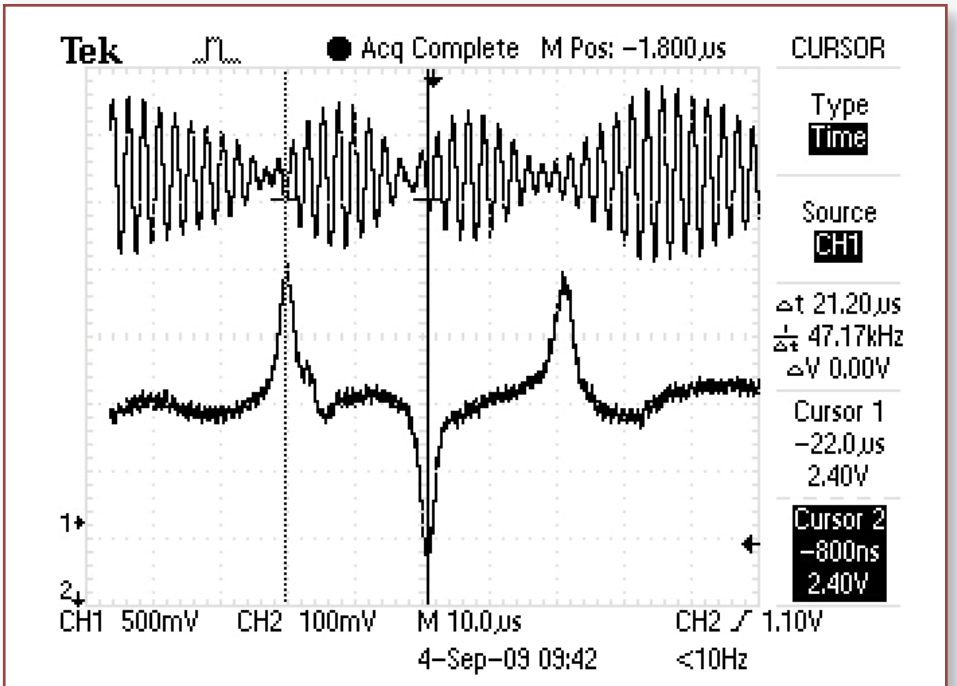

Figure 2: *The upper trace shows the FM carrier converted to double sideband suppressed carrier amplitude modulated FM when in an MPD zone. The lower trace shows the demodulated audio signal with distortion spikes*

these spikes were ascribed to be the cause of the distortion. The enigma here was the sound made by the high difference frequency was not the same as the snap crackles and pops on road tests.

No attempt was made to examine short delay distances, say equivalent to one half wavelength or 1.5m at 100MHz carrier frequency. The fallacy that cannot be ascribed to Corrington is the use of the Rayleigh distribution to describe the characteristics of an ensemble of FM carriers arriving at the antenna with different amplitudes and phases. This line of reasoning probably came from the intensely mathematical work of S. O. Rice of the Bell Laboratories in the 1950s.

The use of the Rayleigh distribution must be called into question because FM demodulation is a highly non-linear process in the transfer from modulated carriers to demodulated signal. There is the so-called capture effect that causes the weaker of two carriers to be suppressed and the stronger to be demodulated. In multi-carrier reception conditions, it is only the dominant and the sub-dominant carrier that are of any concern. All the other carriers can be discarded as of little or no importance.

Measuring FM Distortion Outside the Laboratory

During the evaluation of a new demodulator, in a car park surrounded by some three and four story buildings, some new observations were made. Severe distortion could be heard when the car was positioned in certain locations. At all other times, the audio quality was normal. Observing the IF carrier on a portable oscilloscope, amplitude modulation was seen, while triggered by a new waveform called the corrective time function (CTF). This waveform gives a spike tip exactly where the FM carrier envelope is at zero so the envelope shape was seen easily.

With the car placed in the centre of the distortion zone, the envelope was that of a square root function. This occurs only when two sidebands are present (at minimum) and there is no unmodulated carrier, like double sideband-suppressed carrier AM. In the short intervals when there was no audio modulation on the carrier, there was a distinct frequency of 38kHz and nothing else (see **Figure 1a**).

Where did this difference frequency come from and why was it always the same? Why was there an abrupt change from severe distortion to perfect reception over a short

$$V_{incident}(t) = 1.0\cos(\omega_{carr}t + \beta\sin\omega_m t)$$
$$V_{reflected}(t) = m\cos(\omega_{carr}(t-\tau) + \beta\sin\omega_m(t-\tau))$$

where m = ratio of the reflected to the incident waveform

and τ represents the time delay

For simplicity let m = 1.0 or loss free reflection

and setting τ *to* $\frac{\pi}{\omega_{carr}}$

$$V_{inc}(t)+V_{ref}(t) = \cos(\omega_{carr}t + \beta\sin\omega_{mod}t)+\cos(\omega_{carr}(t-\tau)+\beta\sin\omega_{mod}(t-\tau))$$

After angle reduction and assuming that ω_{carr} is much greater than ω_{mod} :

$$V_{inc}(t)+V_{ref}(t) = \beta\pi\frac{\omega_{mod}}{\omega_{carr}}\cos\omega_{mod}t\sin(\omega_{carr}t+\beta\sin\omega_m t)$$

distance of say five to ten centimetres? Something was happening that had never been predicted in the laboratory.

Unlocking the Door

Armed with no more than these two observations, a simulation was prepared where a carrier at 10MHz was applied to a delay line of length equivalent to 50 microseconds. With 100kHz peak deviation and 19kHz modulating frequency, the original signal and the delayed signal were simply added together. The result was a carrier with a square root envelope at a repetition frequency of 38kHz.

By halving the modulating frequency, the amplitude of the output halved. The situation seemed simple enough to apply some elementary trigonometry. Using the standard FM carrier equation and the same function delayed by τ seconds, both functions were added at equal amplitude and rationalisation performed.

This results in the fundamental equation describing FM multipath distortion for a half wavelength carrier delay with a loss-free reflection. The carrier at, say, 100MHz has been removed, leaving all the sideband pairs of the original FM modulation combined with amplitude modulation of the differentiation of the modulating signal. The combination is then scaled down by the ratio of π/ω_{carr}.

This then explains why the envelope repeated at twice the input modulation frequency and why the shape was that of a square root function. In simple terms, the flat envelope of the FM transmitter is transformed into a double sideband, suppressed carrier, amplitude modulated FM signal. In the car park, the 38kHz was simply double the 19kHz pilot tone for decoding the stereo signal.

A further observation was made that as the delay increased from π to (2n-1)π, the output increased by this amount at least until the small angle approximation starts to break down. This fundamental yet elementary analysis has been overlooked for some sixty-four years, certainly since the Corrington paper. Many if not all the enigmas, anomalies and fallacies start to be explained.

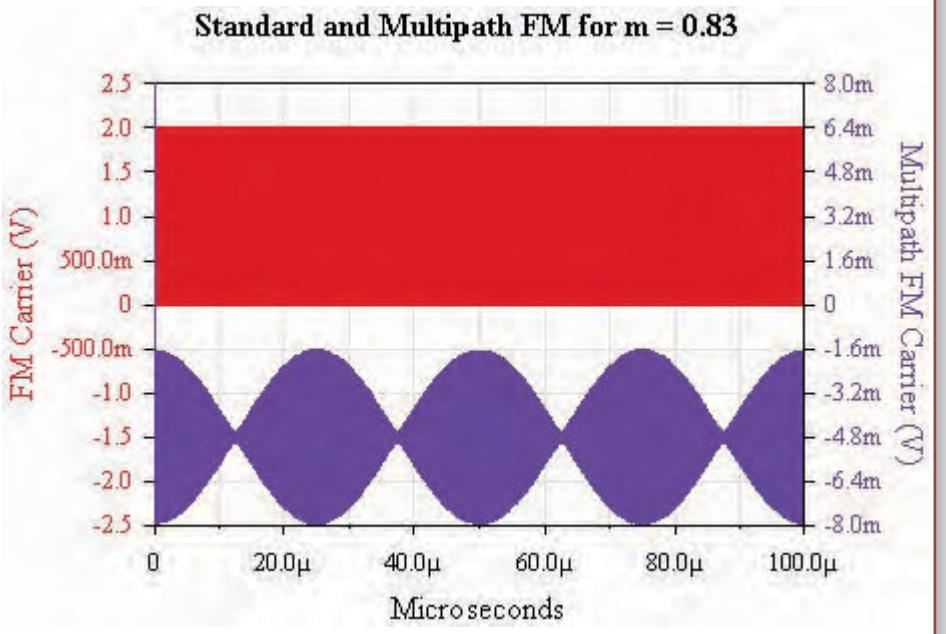

Figure 3: *This image shows the simulation of the effect of multipath distortion on the FM carrier. The trace shown in grey represents the ideal FM carrier. The blue trace represents the same FM carrier affected by multipath*

The Door is Opened

Using the typical broadcast frequency of 100MHz and a peak modulation of 100kHz for arithmetic simplicity, the FM delay (FMD) equation predicts an attenuation of 100kHz/100MHz multiplied by π giving 3.142mV output for an input of 1.00V. This output rises as the delay is increased by another wavelength. This process continues until the output almost doubles at about 500 wavelengths or 1500m. It then reduces in the same manner and returns to the original value measured at one half wavelength, namely 3.142mV. This occurs at 1000 wavelengths or 3000m.

In the FMD equation, the phase of the carrier is changed by 180 degrees as the modulating signal passes through zero. This abrupt discontinuity causes a large

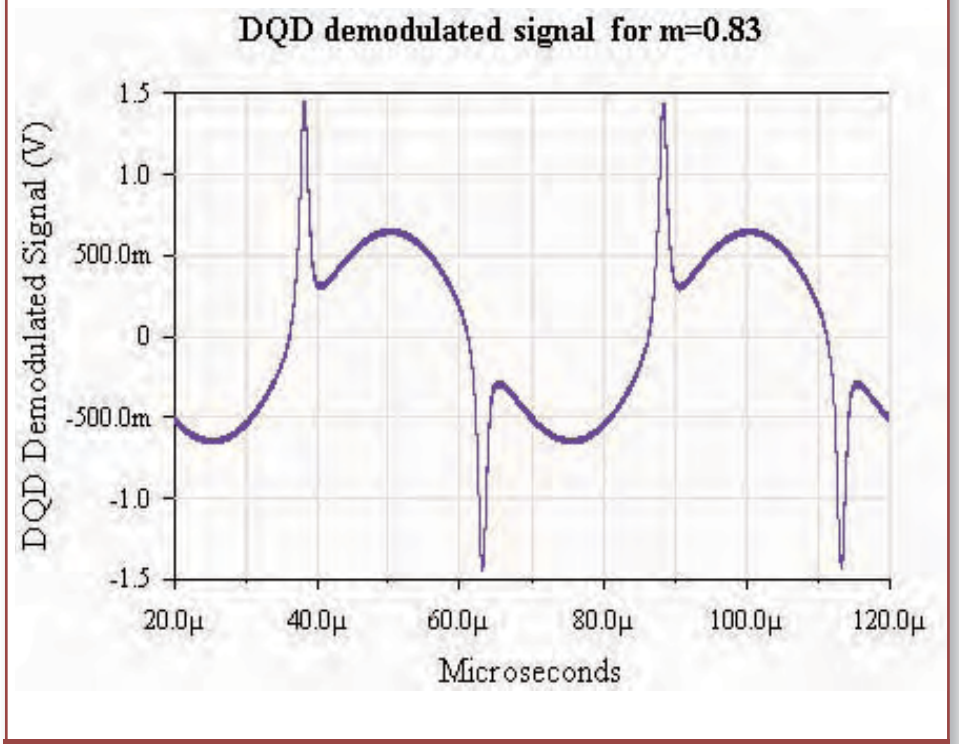

Figure 4: *An example of a demodulated 20kHz signal showing large distortion spikes at every zero crossing due to the 180-degree phase-change as the modulation changes sign*

spike at the output of the demodulator that makes the audio barely intelligible. At last, here is the explanation for severe distortion occurring even when the carrier was well above threshold. There is a double fault, the composite carrier is attenuated, but there is also a destructive spike that destroys the signal, independent of the original carrier strength.

If the delay distance was offset from the 180-degree point, the spike pairs move towards each other either in the positive or negative half cycle. Eventually they meet at the peak, coalesce and vanish. It is at this point that the distortion disappears. The amplitude of the output doubles in size to become 6.284mV. The change in the delay distance from the original 1.500m can be seen to be 1.5mm or $\lambda_{carr}/2$ multiplied by $\omega_{mod}/\omega_{carr}$.

This is the length of the distortion zone for the first half wavelength, or 3mm from start to finish. The zone increases by the factor of (2n-1) up to 500 wavelengths and then reduces again to 3mm at 1000 wavelengths. The length of the zone at 500 wavelengths is approximately 1.0m. These zones are now defined as multipath distortion (MPD) zones.

An approximation can be made as to the probability of being caught in an MPD zone. It will be the summation of the discrete lengths of every MPD zone up to 1000 wavelengths. The total length – 3000m – will divide this.

The value of m, the ratio of the reflected wave to the incident, must now be factored in. Observations have been made that if the value of m is less than 0.6, there is negligible nuisance. But between 0.6 and 1.0 there is serious distortion. This would mean factoring in a probability of (1-m) or 0.4. However, distortion can occur equally badly if the reflection is greater than the incident wave. So the factor must be doubled to give the final combined probability of 0.8 times the first probability.

There are clearly a number of simplifications including the angles of attack of the two rays, but greater analysis is beyond the scope of this article. There is a further point concerning compound reflections or more than one echo. For an MPD zone to exist the two waves must be approximately the same size and 180 degrees out of phase. If a third wave occurs, then it must be in phase with the existing reflection and the combined amplitudes must equal the incident wave amplitude. These joint probabilities become vanishingly small and may be neglected for all practical purposes.

Reception can be good at small depths of modulation. When the signal increases, the distortion is suddenly intolerable. This can be explained that at small signal levels, the MPD zones are also small and may lie just outside critical delay distance. When the signal increases, the MPD zone is breached and failure occurs.

Another phenomenon can be explained whereby a moving object like a passing car appears to cause distortion. This is due to the m ratio changing to bring the reflected wave nearer to the value of the incident wave since the delay distances are much more static.

While listening to music, especially classical, the distortion was clearly evident and when the track was played, yet almost disappeared entirely when the programme returned to the studio announcer. This defied explanation.

Examining this condition, a sub-carrier at 38kHz was added to the normal audio signal to simulate the left minus right stereo signal. It became clear that distortion was proportional to the number of zero crossings and, therefore, spikes in the output. By some non-linear mixing process, these spikes produce the crackles in the audio spectrum, which cannot be filtered. When the track was being played, the stereo signal became fully active and MPD was heard. When the announcer returned, the sub-carrier modulation stopped and the distortion disappeared.

Referring back to the words of Lord Kelvin, we are now in a position to measure the MPD zones, explain the anomalies, enigmas and fallacies. Now FM distortion is more comprehensively understood, are we in able improve the situation? ■

This article continues in the next issue of Electronics World magazine.

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The SPECTRUM Anomaly

Barry McKeown from Datod Ltd explains some of the challenges that need to be met to have an interference-free FM broadcasting

IN THE DECEMBER 2006 edition of *Electronics World* magazine, appeared an article by Dr Pettigrew entitled "*A New Approach to Demodulation*". Wherein, Dr Pettigrew outlines details of his current understanding of the phenomenon of multipath propagation and interference. This work follows on from a previous article in *Electronics World* in 1996 relating the separation of two interfering FM signals occupying the same transmission frequency bandwidth; subsequently criticized by E Forster, also in 1996.

One would think that after nearly 100 years of development in the science of demodulation that the nature of radio wave propagation would be understood. Sadly it is not, as OFCOM can also testify in "*Tomorrow's Wireless World: 7/5/08*": though we are only manipulating the parameters of frequency with respect to amplitude, phase, polarisation and time in various combinations.

I believe that Dr Pettigrew has performed the telecommunications industry a service by his determined pursuit of this technology. There is, however, a barrier that Dr Pettigrew has overlooked, namely politics and the finance associated with spectrum auctions and the question as to whether governments want a solution to be in the public domain or the interference problem solved.

With the current migration from 3G to 4G and the larger bandwidth requirements for wireless data traffic, especially healthcare applications, utilising devices such as tablets and improved smartphone technologies, something will have to give or the networks shall go into gridlock.

The Interference Barrier

The logic behind spectrum auctions is the premise that when a secondary transmitted signal occupies the same transmitted frequency spectrum already occupied by a primary wanted signal, this results in what is perceived as interference by the telecommunications receiver (see **Figure 1**). Accordingly, governments and international standards agencies have sought to regulate "the spectrum" as a shared resource worldwide to mitigate this interference effect.

The issue at stake is the "erroneous assumption that the spectrum is finite".

The electromagnetic spectrum is an incomplete mathematical model of physical reality. Another Scotsman, James Clerk Maxwell, the originator of this model, stated this aspect quite clearly. In the field of wireless/radio there is a vast literature devoted to this historical problem of interference, ranging from the work of Corrington to Rice, where each researcher has provided differing mathematical models of physical reality, but with each advanced mathematical model developed, none have overcome this interference issue.

What most people have not appreciated is that if you deployed

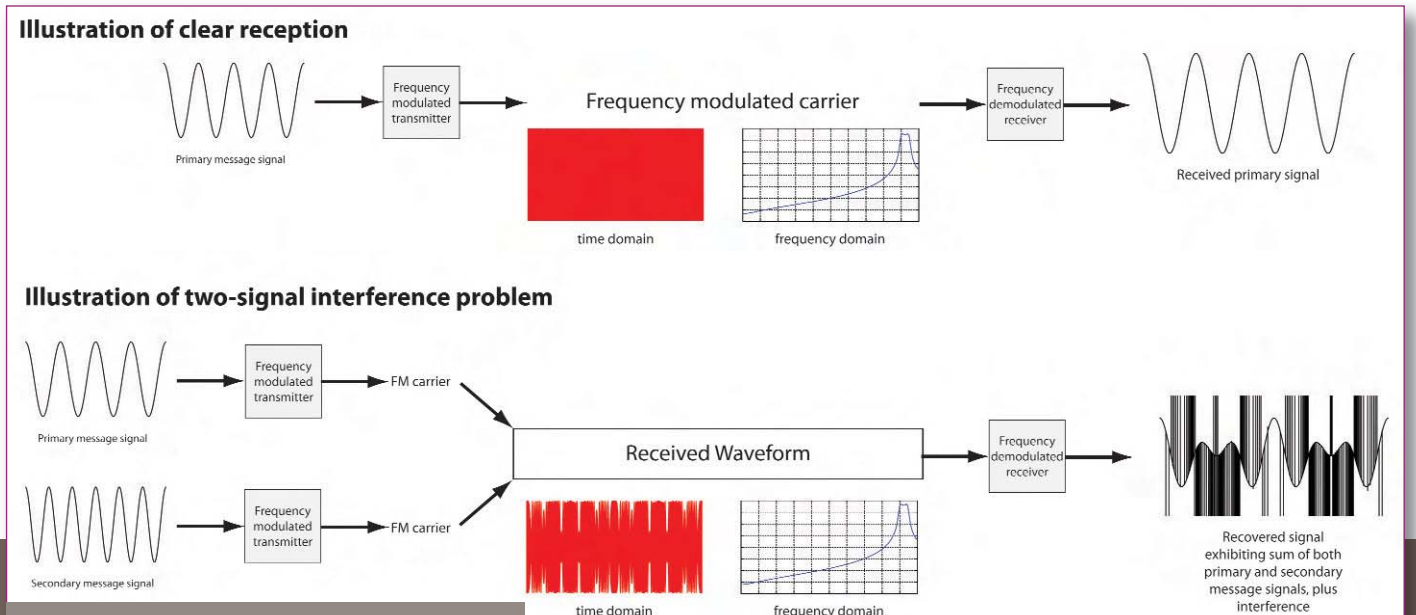


Figure 1: *Illistration of two-signal interference case*

The following schematically illustrates the datod demodulation scheme when applied to two independently-modulated FM or PM transmissions. Here, two baseband signals x_1 and x_2 independently modulate carrier waves of the same or similar carrier frequency. At the point of reception, these carrier waves combine to give a received waveform V(t).

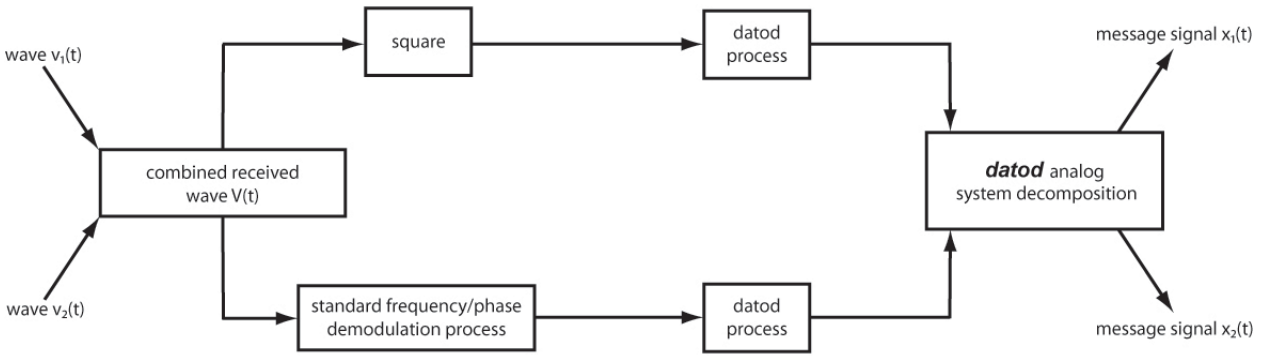


Figure 1: *Datod FM/PM Demodulator Interference susceptibility scheme*

interference-free technology tomorrow, you have not solved the interference problem. All technology subsequently could be interference-free but what is known as the incumbent spectrum users would still have their deployed systems susceptible to interference. This is known as the co-existence problem.

There are a number of issues to be addressed. First, you need to begin with a basic measurement instrumentation capability to ascertain the level of susceptibility of the incumbent demodulator technology to interference exactly. Datod has developed the basic signal processing algorithms for such an instrument (see **Figure 2** and **3**). Second, you require a managed migration from the existing analogue technology to digital technology, with inherent interference, then another migration to a digital without interference era. This transition can only be achieved and managed through governments and the International Telecommunication Union (ITU) – over a twenty year timeframe, at least. We are currently going through this analogue to digital switchover period.

Demos

In article of 2006, Dr Pettigrew tackles the multi-path problem, a less onerous variant on the interference problem, where you are dealing with reflections due solely to the original transmitted signal, but in the article Dr Pettigrew is still advocating an experimental approach and applying simplistic mathematical modelling arguments. He also is still using offsets in his designs.

With respect to this article the following specific points should be noted. The context in which the Rayleigh model applies to multi-path and, in particular, the concept of "Rayleigh Fading", does not appear to have been fully understood.

The multi-path signals do not appear like Rayleigh noise at the antenna, rather, fading occurs when multiple reflections of the carrier combine in such a way that their resultant wave approaches that of the carrier, but is of the opposite sign to the carrier.

On the definition of suppressed carrier amplitude modulation on frequency modulation SCAM-FM, it appears to me that Dr Pettigrew has attempted to fit a heuristic model of what he believes is occurring mathematically onto his experimental measurement data. Multi-path distortion occurs when one or more reflected signals combine in such a way that their resultant is of opposite sign to the primary received signal.

An FM carrier is not in general converted to an amplitude-modulated signal.

The first three equations cited in the article represent respectively:
(a) A carrier which is modulated by a sinusoid ('pure tone') signal;
(b) A reflected, and consequently delayed and modified in amplitude, wave;
(c) The sum of (a) and (b) and is:

$$v_{total}(t) = \cos(\omega_c t + \beta \sin \omega_{mod} t) + m \cos(\omega_c (t-\tau) + \beta \sin \omega_{mod}(t-\tau))$$

The article states that "after some basic trigonometry" that the equation (c) reduces to:

$$v_{total}(t) = \beta\pi \frac{\omega_{mod}}{\omega_c} \cos \omega_{mod} t \; x \cos(\omega_c t + \beta \sin \omega_m t)$$

for the delay in the region of π radians.
It does not. The correct summation is:

$$v_{total}(t) = A(t)\cos(\omega_c(t) + \theta(t))$$
$$A(t) = \sqrt{1 + m^2 + 2m\cos\phi_d(t)}$$

where $\theta(t) = \beta \sin \omega_m t + \tan^{-1}\left(\frac{m \sin \phi_d(t)}{1 + m \cos \phi_d t}\right)$

and

$$\phi_d(t) = -\omega_c \tau - 2\beta \sin(\omega_m \tau/2)\cos \omega_m (t - \tau/2)$$

In the case, where the incident and reflected signals are of equal magnitude (m=1), the amplitude term becomes:

$$A = \sqrt{2\,(1 + \cos\phi_d(t))}$$

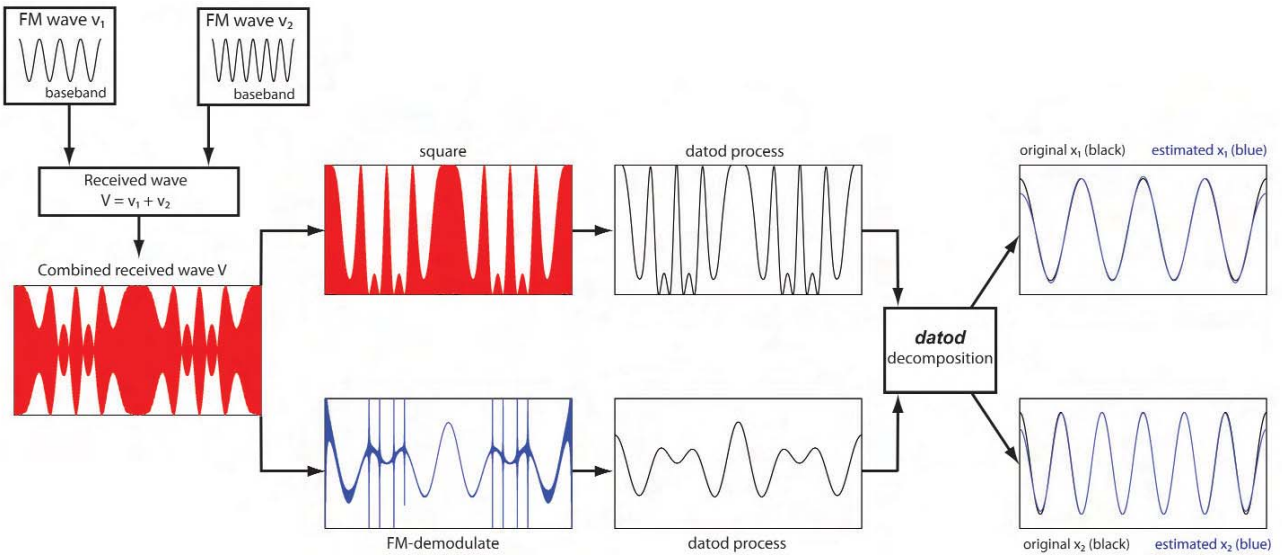
where the term φ_d is given by:

$$\phi_d(t) = -\omega_c \tau + \beta\left[\sin \omega_m (t-\tau) - \sin \omega_m t\right]$$

and, hence, only in the restricted case where ($\omega_m \tau$) is an odd multiple of π, the amplitude term can be written as:

$$A(t) = 2 \sin(\beta/2 \sin \omega_m t)$$

Figure 3: *Datod Demodulator TesT Scheme with two sinusoid tone information signals*



Observe that the presence of the quantity $\omega_c\tau$ in φ_d means that the amplitude term cannot generally be written in the form given in the article. Also observe that it is the value of $(\omega_m\tau)$ and not the value of τ itself, which determines the multipath distortion.

However, in the case of low-β (for example, values of $\beta < 0.1$, such as that which would yield a maximum deviation of 100kHz on a 100MHz carrier), the above amplitude might appear as the term $\beta\sin(\omega_m t)$ – as it is the case $\sin x \approx x$ when x is small.

This approximation clearly falls down when β is not small, as illustrated in **Figure 4**. The combined waveform v(t) is shown in red, the correct amplitude term A(t) as given in (*) is in black, and the term $\cos\omega_m t$, which is used by Dr Pettigrew, is plotted in blue. In this figure we consider two cycles of a sinusoidal signal (that is $w_m = 2$), and a waveform which is the sum of the carrier wave and a reflected wave of equal amplitude. The delay considered here is such that the product $\omega_m\tau$ is an odd multiple of π.

This small angle criterion is also the root cause of many misunderstandings relating to phase noise and jitter measurements and when it is appropriate to apply it.

The Digital Solution to Co-channel FM Signal Recovery

Whereas Dr Pettigrew has gone down the analogue path, Jon Hamkins, a leading expert in spherical coding, at JPL went down the digital path. In April 2000 he published a digital analytic technique solution, providing both simulated and measured field data, which could separate more than the two signals of the Platinum III; such as to accommodate 5 or 12 FM crossing over signals.

Indeed M signals may be tracked using a trellis with 2^(M-1) states. However, this technology is covered by the mighty US International Traffic in Arms Regulations (ITAR) Laws.

Further endeavours in the field of Interference Cancellation Technology (ICT) by another JPL engineer, John Thomas, the founder of TensorComm, was published in the September 2006 issue of RF Design and indicated how to maximise spectral efficiency in CDMA and WCDMA systems. Other effort is still currently underway worldwide in this field.

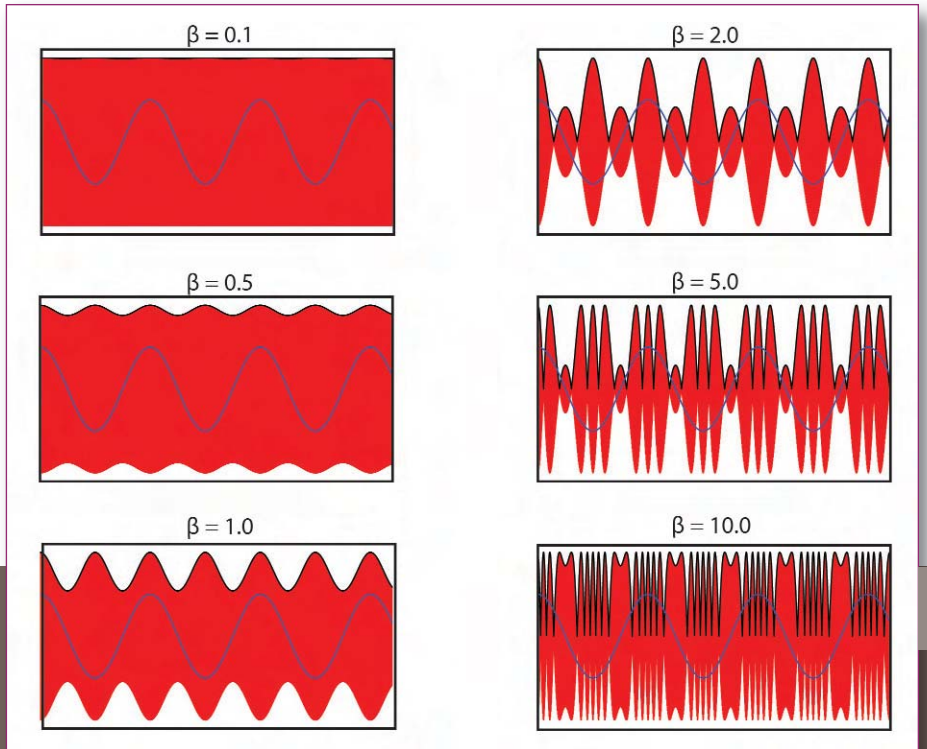


Figure 4: *The values of beta = 0.1, 0.5, 1, 2, 5, 10*

US NTIA and FCC Regulatory Model and the Test Bed

In the US, regulatory separation exists between the National Telecommunications and Information Administration (NTIA), charged with maximizing

spectrum efficiency and arbitrating on technical issues, and the Federal Communication Commission (FCC) who conduct and manage spectrum Auctions. In the UK OFCOM has both remits.

In January 2008, the FCC began Public Auction 73 of the "700MHz Band" spectrum licenses. With this event the worldwide rollout of the 4G Wireless Telecommunication Network(s), agreed by the ITU the previous October, began in earnest. This spectrum auction ended in April 2008, rising over $19bn. We are still awaiting the UK 4G spectrum auction by OFCOM.

Concurrently with this FCC spectrum Auction the NTIA began a process of providing a spectrum sharing innovation test-bed of dynamic spectrum access (DSA) technologies. The NTIA defines this as a technical capability which "allows a radio device to (i) evaluate its radio frequency environment using spectrum sensing, geo-location, or a combination of spectrum sensing and geo-location techniques, (ii) determine which frequencies are available for use on a non-interference basis and (iii) reconfigure itself to operate on the identified frequencies." The critical issue is item (ii).

Furthermore, "The test-bed pilot program will evaluate the ability of DSA devices employing spectrum sensing and/or geo-location techniques to share spectrum with land mobile radio (LMR) systems operating in the 410-420MHz federal band and in the 470-512MHz non-federal band. To address potential interference to incumbent LMR spectrum users, the test-bed pilot program will include both laboratory and field measurements performed in three phases to characterize the interaction with DSA enabled devices."

The NTIA selected the following parties to participate in this test-bed pilot program: Adapt4 LLC, Adaptrum Inc, BAE Systems, Motorola Inc, Shared spectrum Company and Virginia Polytechnic Institute and State University. Its first report was posted in May. The program is scheduled to continue Phase I testing beyond October 2011. This project timescale would optimistically enable DSA technology to be deployed post 2015.

The cardinal issue is how this DSA technology is positioned to upgrade the 4G LTE network with its OFDMA and SC-FDMA modulation formats and resolving the "spike" problem.

The Missing Ingredient

It shall come as no surprise by now that I disagree with this historical approach. It appears to me that Dr Pettigrew and all the other communication engineers have missed the point about "spikes"; they are actually informing you about the composition not only of the signals present but also the geometry and propagation characteristics of the channel.

Historically, scientists and engineers have sought to eliminate these artefacts as interference effects, whereas I believe that, instead, you must incorporate an analysis process which recovers and extracts the information present, including geo-location, in the "spikes" before removing them.

I believe that the whole historical approach fundamentally ignores this issue i.e. the textbooks cite the fact that "spikes" arise in FM demodulation schemes but then proceed to discuss how to circumvent them or eliminate them, as schemes for interference cancellation attempt to suppress an unwanted signal. Similar arguments relate to the equalisation process in current digital systems. Such an analysis stage could only be applied digitally. It also would be required to manipulate fractional frequency information which current FFT algorithms cannot process, especially in an OFDM(A) environment for 4G.

A Way Forward

Rationalisation, regulated by the EU, in the telecommunications industry is currently underway in the UK with spectrum allocation playing a major consideration in merger negotiations between two parties from the major five UK network carriers.

Unfortunately OFCOM, appears to me to, have a conflict of interest with respect to raising another fortune on the new 4G spectrum auctions for the Treasury and developing Reusable Spectrum Technology (RST) solutions. The new government shall eventually address this anomaly in the 2003 Communications Act, along with other issues in the "Digital Britain/Economy" program, as it reviews the remit of OFCOM.

The first 4G spectrum auction began in the US. The 4G spectrum auction in Germany and India were completed in May and June respectively. The OFCOM UK 4G spectrum auction is still currently awaited and according to reports in the Financial Times, anticipated figures of £4.4bn are expected to accrue.

I would submit that it is now an urgent necessity for the "NTIA functional remit" to be striped from OFCOM, in order to free up some spectrum for use as a UK test-bed program. Such that UK DSA candidate technologies be permitted to evolve; be tested and further developed in public without resort to secrecy or obsessive commercial confidentially considerations in the national interest, instead of leaving everything to the US.

In the final analysis, I suspect history will look kindly and gratefully on Dr Pettigrew for his persistence with technology which still has its place and technical merit. I suspect that the same will not be said for governments and spectrum auctions.

The ball is now in the new government's court. ■

George Lamb, VP of operations and support at Nextivity, goes in the detail of how to tackle the problem of poor signal quality inside enclosed environments

Solving the Indoor Wireless COVERAGE Crisis Design

THE VAST MAJORITY of mobile phone use takes place indoors but it's long been accepted that, in many homes and offices, signal strength is less than perfect and call quality suffers accordingly. The situation has been highlighted further with the advent of mobile broadband services – despite the promise of multi-megabit connections, very few mobile users experience the advertised maximum speeds. Sub-megabit connections are common and a significant proportion of users are simply unable to access a 3G network in their home or office.

The in-building coverage issues are well known in the industry and we should expect to see more of it with booming sales of 3G smartphones, dongles and netbooks/smartbooks. The owners of those devices are all trying to access data-hungry services and for many the experience disappoints. Operators that sort the issues out quickly will be handed a huge competitive advantage but the solutions already proposed, including femtocells to create an in-building 'mobile cell' and an increase in base station density and capacity, have considerable capital and operational implications and they will take some time to implement effectively.

The performance of any mobile device is directly related to signal quality and that signal quality is influenced by distance from the base station, receiver sensitivity of the access device and most critically, physical obstruction – it's a cruel irony that, although most mobile voice and data connections originate indoors, mobile networks just don't like walls, floors, ceilings and windows. Today more than ever, the requirement for high quality indoor wireless signals presents a huge challenge for cellular network operators. With more than 70% of all 3G wireless voice and data services being used indoors, the ability to penetrate walls ceiling and floors with the higher frequency signals used in 3G networks is key.

Current Technologies

Until recently, although industrial grade signal repeaters have been, and continue to be used in commercial applications, there haven't been viable and affordable solutions that solve the problem for individuals, homes and businesses. User installable bi-directional repeaters, for instance, have been outlawed in many countries due to the harmful impact that they can have on wireless networks. The issues associated with this sort of device were highlighted recently in the United States by a proposal to the FCC from repeater manufacturer Wilson Electronics to Raise Cell Phone Signal Booster Certification Standards. The proposal more than 500 written responses and to quote the Cellular Telephone Industry Association (CTIA); "…issues associated with 'Self-Help' unauthorized use of signal repeaters have continued to grow. These devices widely disrupt mobile communications and can overwhelm nearby cells which both blocks ordinary calls and disrupts public safety systems." AT&T's response to the FCC supported that view; "…a single CMRS booster aboard the yacht "Miss Penny" caused severe harmful interference that adversely affected three AT&T cell sites with a peak interfering signal level of -69dBm measured. Specifically, the CMRS booster on the ship caused interference to three sites, resulting in approximately 3,055 blocked calls over a four-day period."

Clearly, the 'raw' and indiscriminate signal boosting characteristics of traditional repeater technology isn't the answer but this demand for network friendly improvements in indoor coverage has been the genesis of a range of proposed solutions.

One solution; Unlicensed Mobile Access (UMA), which is also known as Generic Mobile Access (GAN), works by placing a Wi-Fi transceiver into the mobile handset. This additional radio can then be used for VoIP or data transmission via existing 802.11 wireless networks, assuming one is available. When 802.11 is not available the handsets operate over the cellular network. UMA/GAN requires that the user purchases a special handset and that the user has access to an 802.11 network. Implementation of this system requires significant upgrades to the carrier network and back office systems, but it does offer the advantage of being able to work in areas where there is no cellular coverage.

Another solution being introduced places a miniature base station, known as a femtocell, in the home or office which, like GAN solutions, uses the consumer's fixed broadband connection to backhaul the call or data session to the mobile operator's core network. Femtocells are a relatively new concept which combines the functionality of a 3G Node B and some of the functionality of a 3G Radio Network Controller (RNC) into a single unit. The use of a femtocell assumes the existence of broadband connectivity as the link between the femtocell and multiple new network elements. The principle network elements are the Access Controller and the Provisioning Management Server.

Both GAN and femtocells require significant operator investment in network infrastructure, software integration and ongoing operating expenditure (OPEX). Both solutions are also limited by the quality of service provided in the consumer's fixed broadband connection, thus eliminating the promise of super high speed wireless data offered through advances such as LTE. In addition, both GAN and femtocells can have a significant impact on the signalling required to support the movement of mobile users from the outdoors to indoors (hand-in) and from indoors to outdoors (hand-out). GAN does have the advantage of not causing the macro network interference that is of concern when deploying femtocells.

Figure 1: *Both units' stopwatch*

Being in Control

GAN and femtocell technologies inevitably mean the operator loses control of at least part of the voice or data transmission and relies on a third party network and it is that situation that inspired the Nextivity's development of the Cel-Fi system. Cel-Fi, short for Cellular Fidelity, is designed to be self installed by the consumer and, unlike GAN or femtocells, does not require a fixed broadband connection to operate.

The Cel-Fi solution consists of a Window Unit (WU) and a Coverage Unit (CU), each about the size of an ADSL router. The WU is placed in an area of the home or office where at least some 3G signal exists (a single 'bar' is more than sufficient). The CU is placed somewhere near the centre of the home or office. Signal from the macro network is picked up by the WU and delivered to the CU where it is re-broadcast, thus 'lighting up' the building from the inside out.

A four sector antenna system built into the WU allows directionality and selectivity without requiring the end user to "point" the unit in any particular direction. The significant advantage of a directional antenna is that it allows high gain from a targeted sector without bringing in the pilot pollution from all the other three sectors. Thus the WU brings in a cleaner signal at 5 to 7dB higher gain as compared to the omni-directional, unity gain, antenna of a typical cell phone. This improved reception not only provides more 'bars' throughout the building, but also delivers a significantly improved signal to noise ratio, which can be directly translated into improved data rates for wireless broadband service. Best placement of the WU is made possible through the use of a familiar five bar display on the front of the unit. The more bars shown, the better the result.

The cellular signal is transferred between the WU and the CU, over the 5GHz unlicensed spectrum, using a proprietary protocol developed by Nextivity. This protocol delivers significantly lower latency than traditional 802.11 protocols. In fact, the total end to send system delay of the Cel-Fi systems allows it to fit easily within the 20ms window of the rake receiver on both the handset or the NodeB (3G base station), thus making signals received through Cel-Fi appear to the handset and the network as just another multipath. As such there is no requirement for 'hand-in' and 'hand-out' and the significant increase in network signalling that goes along with it.

Downlink gain on the CU is set automatically using the path loss between the WU and CU; the higher the path loss (up to 100dB) the higher the gain on the CU. This has the effect of automatically sizing the coverage footprint. In a smaller space the two units are placed closer together, thus creating a smaller sphere of coverage from the omni-directional transmit antenna of the CU; in larger spaces the opposite is true. Automatic feedback cancellation between the WU and CU means that there is no requirement for a safety margin, back off on the CU gain.

Patented co-existence algorithms allow the Cel-Fi system to operate in

Figure 2: *Bridging the gap between base station and handset*

the same space as other 5GHz devices, such as Wi-Fi routers and baby monitors. The system is also fully compliant with regulations for automatic channel selection and real time radar detection required for operation in the UNII 2 band of the unlicensed spectrum.

The combination of AGC and feedback cancellation on the on the downlink enables a very simple customer interface to guide in the placement of the CU. If the WU and CU are placed less one meter apart a red icon shows that the units are too close to each other. If the WU and CU are placed more than 100dB (approximately 20 meters and 2-3 walls) apart, then a different red icon shows that the units are too far apart. A green icon, coupled with a numeric gain indicator (the higher the number, the better placement) indicates operational CU placement.

Uplink gain is also automatically set. This is a key feature, as an unregulated gain on the uplink could easily overdrive the front end of the NodeB, thus raising the noise level and making reception of cell edge users impossible. In Cel-Fi, uplink gain level is based on a real time path loss calculation between the WU and the NodeB. The transmit power level of the NodeB is transmitted as part of the system information broadcast of the overhead message. The WU reads this information and then performs a simple path loss calculation of TX power level at the NodeB versus RX power level at the WU. This real time path loss calculation is used to create a gain ceiling that is automatically adjusted based on changes in the RF environment. In order to further limit the impact to the network, the uplink path from the WU is gated so that when there is no active device in the coverage area of the CU, the uplink transmitters of the WU are shut down.

Carrier Specific

It should also be noted that the Cel-Fi system is carrier specific, thus allowing subsidy protection to the operator who chooses to give it away to gain a small business client or reduce churn in its higher ARPU residential customers. The Cel-Fi system automatically selects a carrier frequency from a range of frequencies provisioned at the time of manufacture. To prevent use in other markets where the same carrier frequency is re-used, the carrier network ID (PLMN-ID) is also pre-provisioned and validated during use.

By eliminating the impact of the path loss associated with building construction, and limiting the impact of noise on the uplink, the Cel-Fi system has the specific advantage of increasing the number of users who can be served simultaneously with a given amount of power on a single channel. The less power required to serve each indoor user, the

Figure 3: *Internal network indicator panel*

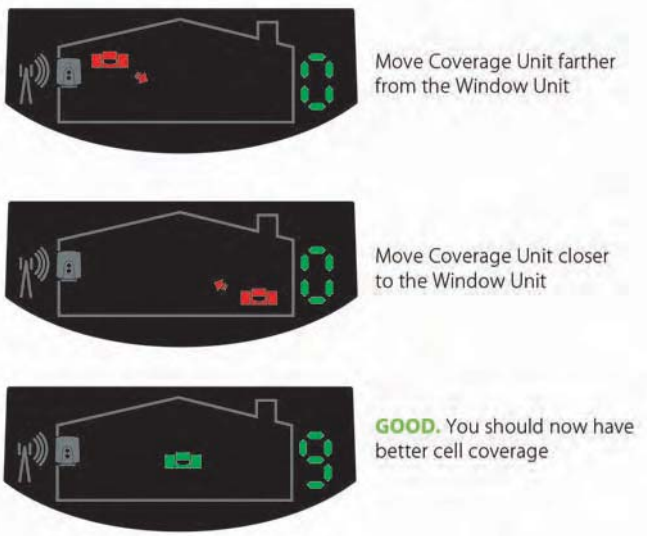


Figure 4: *Nextivity custom chip-set*

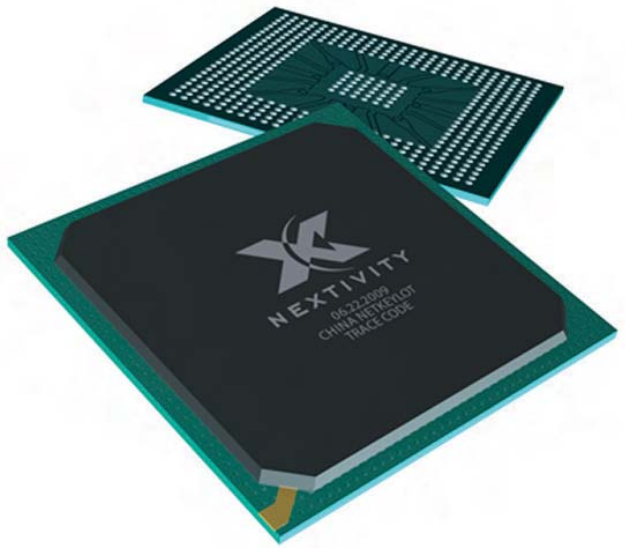


Figure 5: *Signal bar indicator*

Figure 6: *Window Unit and Coverage Unit*

more power to share among other users. As such the higher the density of Cel-Fi installations in a network, the higher the Radio Access Network (RAN) capacity, as such making Cel-Fi a scalable solution. Consumers get the benefit of decreased uplink power requirements which can be directly translated into longer battery life.

Importantly, Cel-Fi dynamically manages bandwidth provisioning within the home or office environment and actually increases the capacity of the operator's RAN (radio access network) making it 'network safe'. The customer-friendly setup process makes this a solution that can be mass deployed immediately, with no requirement for additional network infrastructure or software.

The Cel-Fi technology is now being adopted by a range of operators in multiple markets and is being further developed. The custom designed chipset allows the design and deployment of a services platform that could deliver more than the voice coverage and data speed improvements already offered. ■

Bassam M. Al-Mahadeen from the Tafila Technical University in Jordan, **Widad Ismail** from the Universiti Sains Malaysia and **Mokhled Altarawneh** from the Mutah University in Jordan present an early warning system describing desert roads that also provides feedback to the local authorities and travellers to avoid any road-related problems

A Wireless Image Sensors Network for Monitoring Dust on Roads in ARID CONDITIONS

DESERT ROADS have casual dust events in which the dust may completely cover several kilometers of the road for several hours and this usually causes breathing problems and may deadly accidents for travellers.

Here, we present an early warning system describing such roads, which will also provide feedback to the local authorities to take the proper action and give travellers the current status of the road to avoid such problems.

The system is based on a real-time analysis to classify the activity of the dust of the acquired images. The analysis is performed by processing the images within the wireless nodes and extracting information about the dust events. The system output will be used to generate a real-time alert to the authorities and travellers in the event of an emergency caused by dust.

Figure 1: A sample image of dust storm on desert roads

Traditional versus Modern Systems

Normal video surveillance systems need continuous human monitoring for the acquired images in real time and to alert the authorities if any unusual events happen in the scene that is being monitored. In desert environments, it is hard to deploy traditional video surveillance systems due to resource constraints. As such, wireless sensor networks would be more appropriate due to their attractive features such as rapid deployment, self-organization and fault tolerance.

Recently wireless image sensor networks have become of a great importance due to their wide application range such as video surveillance, remote sensing, tracking, face recognition and so on. A wireless sensors network consists of low cost and low energy sensors which are deployed in a region of interest to observe a phenomenon, and send the observations to a fusion centre or a base station to make a global assessment. In a wireless sensor network, communication bandwidth and energy are a limited resource. Hence it is very essential to limit the communication between the sensors and the fusion centre as much as possible, since not all the data transmitted from all sensor nodes will be useful always.

Desert roads have casual dust storm events in which the dust may completely cover several kilometers of the road for several hours and this usually causes breathing problems and accidents for travellers.

Dust storm as in **Figure 1** is a meteorological phenomenon common in arid and semi-arid regions and arises when a gust-front passes. It is unpredictable phenomena where high winds lift dust or sand into the air, creating suffocating clouds of particles and reducing visibility to nearly nothing in a matter of seconds.

System Model and Design

Our system is based on a real-time analysis to classify the activity of the dust of the acquired images to three levels: High, Medium or Normal. The analysis is performed by processing the images and extracting information of dust events within the wireless node.

To manage the huge flow of information, to avoid sending useless transmission from sensor nodes and local base-stations, and at the same time manage the power very efficiently for a long battery life, the sensor nodes are made to transmit only useful results of the analyzed images to the local base-stations.

A wireless image sensors network consists of image sensors or cameras as nodes. The image sensors capture images at fixed

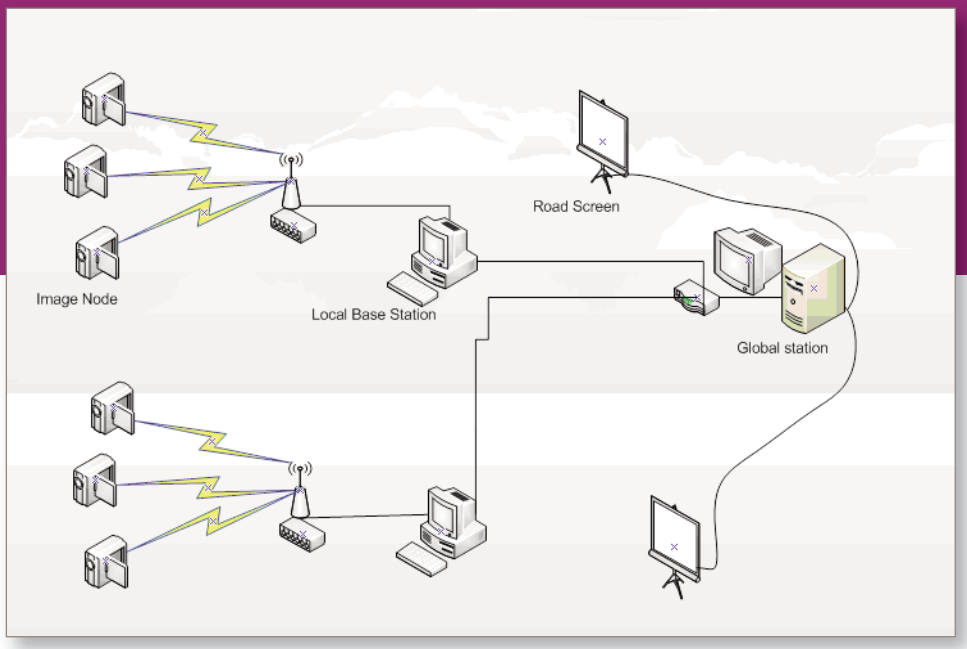


Figure 2: *System architecture for a wireless image sensors network*

intervals of time. Instead of sending raw image data from the wireless image nodes to local base station, the nodes are required to carry out simple image-features extraction using local computations. These local computations help the sensor nodes to carry out local decisions. The local decisions at each sensor are of the form of "2", "1" or "0" for a high, medium and no existence of dust respectively. Hence, by sending such decisions wirelessly to the local base station, the energy consumption and the data transmission between the sensor nodes and the base station are reduced to a great extent.

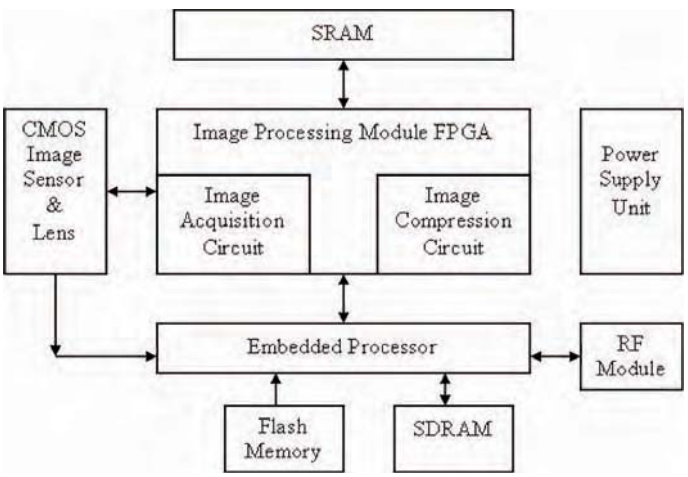
The local decisions are relayed to a fusion centre which makes a final decision by aggregation of decisions from all its sensors and making a global decision. Usually RF video transmitter-receivers are used to provide the local base stations with information about the ongoing status of the dust activity and sending alert messages in the event of emergencies based on the analyzed results of captured images.

The proposed system has many attractive features such as reducing the need for human intervention to monitor and analyze the dust activity, managing the energy and communication bandwidth efficiently, and providing the authorities with a real-time status of dust event. The local base stations wouldn't be a significant bottleneck because the image processing algorithm will run on the wireless nodes, the wired back-end system is responsible of making the final decision based on the final results of the processed images received from its local wireless nodes.

There are few processing steps that need to be performed by a local sensor prior to making a local decision. These steps involve the implementation of image feature extraction algorithms at the sensor level. The RGB image color histogram and threshold are used to extract the image features, and then three thresholds levels are defined at the sensor level, high, low and normal to define the existence of dust event locally at the node level.

Figure 2 shows the proposed system configuration. The installed surveillance camera can be monitored in real time, the dust intrusion can be checked and the warning signal can be sent to right direction to take the proper action.

Figure 3: *System architecture for an image sensor node*



Wireless Node Architecture

A prototype of wireless node architecture is shown in **Figure 3**. The system architecture consists of sensor nodes that perform communication, computation and sensing. They are typically deployed in sensor patches. Depending on the application, they might form a linear transect, a grid region, or a volume of nodes for three-dimensional monitoring.

Each sensor patch has a gateway that sends data from the patch through a transit network

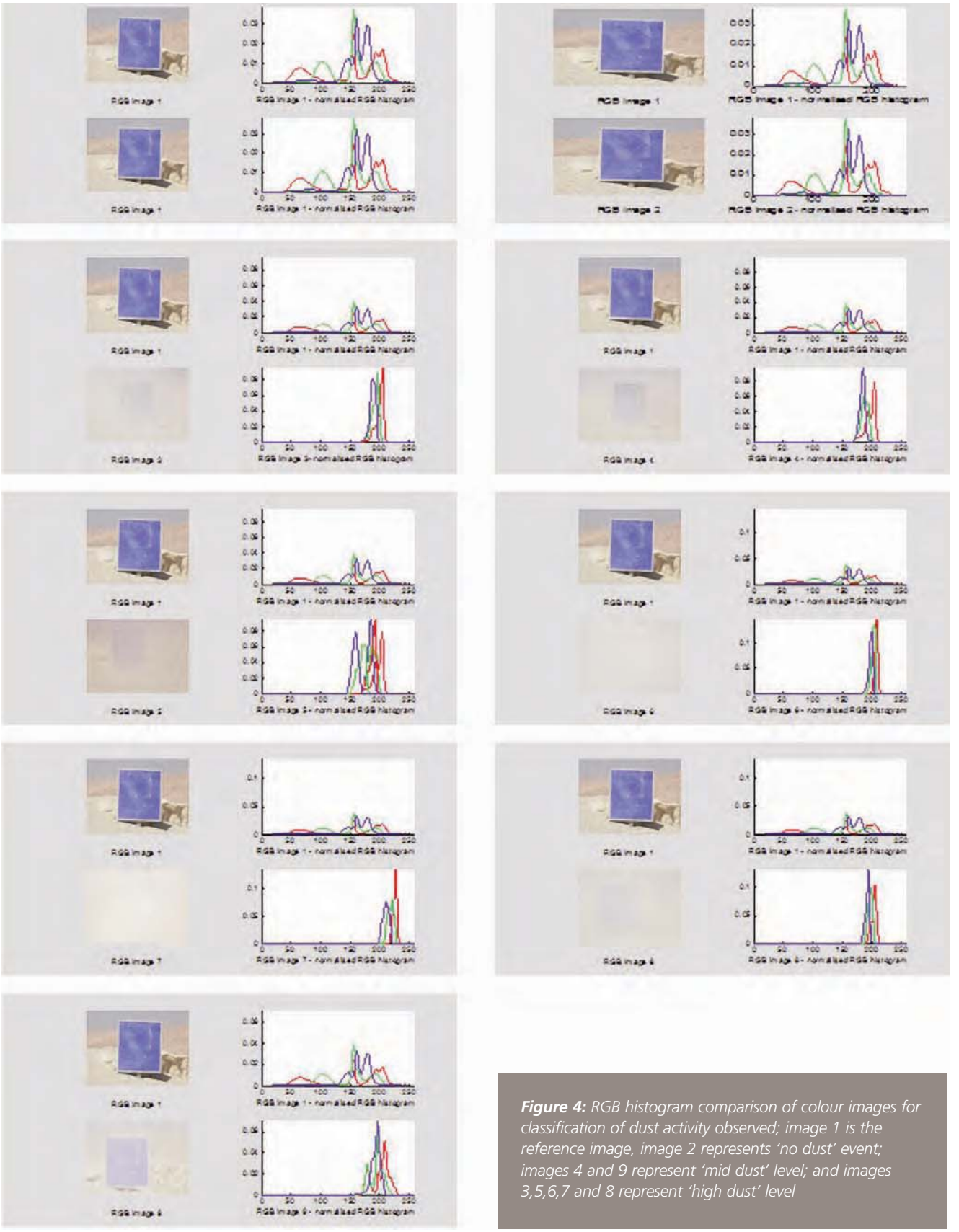


Figure 4: *RGB histogram comparison of colour images for classification of dust activity observed; image 1 is the reference image, image 2 represents 'no dust' event; images 4 and 9 represent 'mid dust' level; and images 3,5,6,7 and 8 represent 'high dust' level*

to a remote base station via the base station gateway. The base station provides Internet connectivity services. It should handle disconnected operation from the Internet. Remote management facilities are a crucial feature of a base station.

For distributed image sensing applications in wireless sensor networks, the processing and memory limitations in current mote designs are

Fig.1	Bhattachar. Distance	chiSquared Distance	Euclidean Distance
Fig.1	0	0	0
Fig. 2	0.4322	0.5931	0.0644
Fig. 3	0.6818	1.1513	0.1233
Fig. 4	0.6488	1.0315	0.1108
Fig. 5	0.6751	1.1316	0.1157
Fig. 6	0.8333	1.6246	0.1791
Fig. 7	0.9492	1.9383	0.1614
Fig. 8	0.7712	1.4317	0.1527
Fig. 9	0.6718	1.1576	0.1024

Table 1: *Values of Bhattachar., chiSquared and Euclidean Distance of the images in Figure 1*

the critical factors. Generally, as seen in Figure 3, the sensor node is based on a microcontroller and accessing an on-chip RAM. An expansion interface is provided to support multiple mid- and low-resolution image sensors concurrently, as well as traditional sensors.

Wireless communication is also provided by RF which operates in the 2.4GHz band and is compliant with the IEEE 802.15.4 standard. An integrated USB and serial debug interface allows simple programming and debugging of applications. The node can either be powered by a stationary power supply if available or battery-operated for mobile applications or easy deployment. Flash memory card provides sufficient and scaleable non-volatile memory for temporary frame buffering or even image storing.

Wireless Communications

In the proposed system, as shown in Figure 3, image sensor data flow from the wireless nodes to a gateway using RF over the IEEE 802.15.4 protocol, then from the gateway over a wired Internet back-end to centralized server, and finally from the server to the travellers.

The maximum data rate of 802.15.4 is 250kbps, which is too low for wireless image nodes to transmit images back to the server at a high enough quality and frame rate for real-time applications. The basic idea of the design is to localize the computation within the wireless nodes and send only post-processed data in real time back to the centralized server and travellers. The Zigbee sensor network environment could be used, which is a low rate and low power network technology for short range communication.

Strategy Adopted and Experimental Results

To classify dust events, each wireless node is placed in a fixed position with respect to a road sign, without any obstruction, to define the target area being analyzed. The dust event will be classified as a high (2), medium (1) and low event (0).

Each wireless image sensor captures images in fixed interval of time to minimize the power consumption, to reduce the communication between nodes and local base stations. Each node should process and analyze the acquired images locally and sends only its final decision to the local base station using RF in form of 2, 1, or 0.

A software tool for RGB image comparison is implemented and used in each node to extract certain features from the captured images, without the need for human intervention. So, a reference image is used in each node, then each captured image should be compared with the reference image and as a result a Bhattacharyya Distance, Chi-squared Distance and Euclidean Distance are calculated. The threshold ranges for worst, fair and normal cases are empirically defined, according to the visual images.

The critical dust events can be classified or the absence of any meaningful activity can be notified. A road sign is placed in front of each wireless image node with a distance that represents the minimum possible vision that should be between two consecutive vehicles.

As an example, **Figure 4** shows the RGB histogram comparison of images 1 to 9, where image 1 represent the reference image that shows the absence of dust activity and images 2 to 9 represent different levels of dust activity. **Table 1** shows the calculated values of the Bhattacharyya Distance, Chi-squared Distance and Euclidean Distance for the images in Figure 4.

The classification algorithm uses three levels of threshold values empirically defined and based of these values dust event is classified to high, low or normal. Once the event has been classified, a suitable alert is sent to the locale base station, then the base station collects the alert messages from its wireless nodes to form its local decision based on the incoming values, and sends the local decision to a road sign screen to notify the drivers as well as the authorities to take the proper action in case of dust event and its level.

Table 1 shows the values of Bhattacharyya Distance, Chi-squared Distance and Euclidean Distance for the images in Figure 4. The threshold for event classification can be based on any of these values, if the chiSquaredDistance is selected, from the table the threshold can be defined as follows: if the chiSquaredDistance < 0.6 the dust level is accepted (send value 0 to the local base station); if chiSquaredDistance > 0.6 and < 1.16 indicates a mid dust level (sends value 1 to the local base station), so an awareness message is sent to travellers; and if the chiSquaredDistance > 1.16 then the dust level is high (sends value 2 to the base station), so the road might be closed or an alternative way might be suggested for travellers.

If the classification of dust event should be based on the computed values of Bhattacharyya Distance, the threshold values for the classification of dust event can be defined empirically from the table as follows: < 0.44 for the normal case, 0.44 to 0.675 for the mid dust level and > 0.675 for high dust level.

As can be noted from the previous discussion, the communication bandwidth will be at its minimum level, also the power consumption needed for the communication will be very low and these are the main important factors for the wireless image sensors network system.

Early Warning System

This system is structured to work as an early warning system describing the desert roads status and to provide a feedback for the authorities to take the proper action and to give travellers up-to-date information about current status of the road to avoid breathing and vehicle accident problems.

The proper action might be closing the road during the dust event or taking an alternative way if possible. The basic idea of the system is the in-node processing of the captured images to reduce the power consumption and communication bandwidth. By sending only the final results to local base station inform of 2, 1, or 0 local base stations are guaranteed to be free of bottlenecks. ■

PLC with PIC16F648A Microcontroller

Part 22

Professor Dr Murat Uzam from Nigde University in Turkey presents a series of articles on a project that focuses on a microcontroller-based PLC. This article is the last in the series and it explains seven solutions for the seven control scenarios for a remotely-controlled model gate system described in the last issue

Figure 1: *Ladder diagram for the user programUZAM_plc_8i8o_ex38.asm*

```
.
      #include <definitions.inc>    ;basic PLC definitions, macros, etc.
      #include <cntct_mcr_def.inc>  ;Contact & Relay based macros
.
;--------------- user program starts here ------------------------

      ld          I0.0        ;rung 1
      out         Q0.0

;--------------- user program ends here --------------------------
.
```

Figure 2: *The user program UZAM_plc_8i8o_ex38.asm*

IN THIS SECTION, we will explain the solutions to the seven control scenarios described in the previous article for the remotely controlled model gate system, namely UZAM_plc_8i8o_exN.asm, N = 38, 39…44.

In order to test the example, you can download the files from http://host.nigde.edu.tr/muzam/ and then open the UZAM_plc_8i8o_exN.asm, N = 38, 39…44 program by MPLAB IDE and compile it. After that by using the PIC programmer software, take the compiled file "UZAM_PLC_8i8o_ exN.hex" and with your PIC programmer hardware send it to the program memory of PIC16F648A microcontroller within the UZAM_PLC. After loading the "UZAM_PLC_8i8o_exN.hex", switch the 4PDT in "RUN" and the power switch in "ON" position. Finally, the program is ready to run.

The ladder diagram for the first scenario is shown in **Figure 1** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex38.asm", is shown in **Figure 2**. In this example, when B0 (I0.0) is being pressed, the gate will open (Q0.0 will be ON). However, in this case if B0 is released then the gate will stop. This means that the program does not remember whether or not the B0 was pressed.

The ladder diagram for the second scenario is shown in **Figure 3** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex39.asm", is shown in **Figure 4**. In this example, once B0 (I0.0) is pressed, with the help of NO contact Q0.0 that is connected in parallel to the NO contact I0.0, the gate will open (Q0.0 will be ON). Here, the NO contact Q0.0 is a "sealing contact", which helps the program to remember whether B0 was pressed. The problem here is that when the gate is completely opened, the motor will not stop.

The ladder diagram for the third scenario is shown in **Figure 5** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex40.asm", is shown in **Figure 6**. In this example, once B0 (I0.0) is pressed, with the help of NO contact Q0.0 connected in parallel to the NO contact I0.0, the gate will open (Q0.0 will be ON). Here, when the gate is opened completely, the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

The ladder diagram for the fourth scenario is shown in **Figure 7** and its UZAM_PLC representation, the program "UZAM_plc_8i8o_ex41.asm", is shown in **Figure 8**. In this example, once B0 (I0.0) is pressed, with the help of NO contact Q0.0 connected in parallel to the NO contact I0.0, the gate will open (Q0.0 will be ON). Here, when the gate is opened completely, the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

Similarly, once B1 (I0.1) is pressed, with the help of NO contact of Q0.1 connected in parallel to the NO contact I0.1, the gate will close (Q0.1 will be ON). Here, when the gate is closed completely, the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1. The problem with this example is that if both B0 and B1 are pressed at the same time, then both outputs will be ON. This is not a desired situation. The solution to this problem is given in the next example.

The ladder diagram for the fifth scenario is shown in **Figure 9** and its UZAM_PLC representation, the user program "UZAM_plc_8i8o_ex42.asm", is shown in **Figure 10**. In this example, if the gate is not closing (Q0.1=0) once B0 (I0.0) is pressed, then the gate will open (Q0.0 will be ON) with the help of NO contact of Q0.0 connected in parallel to the NO contact I0.0. In this case, when the gate is opened completely (I0.2=1 and therefore NC contact of I0.2 will open), the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

Similarly, if the gate is not opening (Q0.0=0) once B1 (I0.1) is pressed, then the gate will close

Figure 3: *Ladder diagram for the user program UZAM_plc_8i8o_ex39.asm*

```
      #include <definitions.inc>    ;basic PLC definitions, macros, etc.
      #include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ------------------------

      ld          I0.0        ;rung 1
      or          Q0.0
      out         Q0.0

;--------------- user program ends here --------------------------
```

Figure 4: *The user program UZAM_plc_8i8o_ex39.asm*

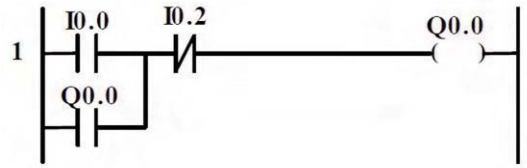


Figure 5: *Ladder diagram for the user program UZAM_plc_8i8o_ex40.asm*

```
      #include <definitions.inc>    ;basic PLC definitions, macros, etc.
      #include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ------------------------

      ld          I0.0        ;rung 1
      or          Q0.0
      and_not     I0.2
      out         Q0.0

;--------------- user program ends here --------------------------
```

Figure 6: *The user program UZAM_plc_8i8o_ex40.asm*

```
      #include <definitions.inc>    ;basic PLC definitions, macros, etc.
      #include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ------------------------

      ld          I0.0        ;rung 1
      or          Q0.0
      and_not     I0.2
      out         Q0.0

;--------------- user program ends here --------------------------
```

Figure 7: *Ladder diagram for the user program UZAM_plc_8i8o_ex41.asm*

```
      #include <definitions.inc>    ;basic PLC definitions, macros, etc.
      #include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ------------------------

      ld          I0.0        ;rung 1
      or          Q0.0
      and_not     I0.2
      out         Q0.0

      ld          I0.1        ;rung 2
      or          Q0.1
      and_not     I0.3
      out         Q0.1

;--------------- user program ends here --------------------------
```

Figure 8: *The user program UZAM_plc_8i8o_ex41.asm*

(Q0.1 will be ON) with the help of NO contact Q0.1 connected in parallel to the NO contact of I0.1. Here, when the gate is closed completely (I0.3=1 and therefore NC contact of I0.3 will open), the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1. Therefore, once the gate is being opened we can not force it to close, and vice versa.

The ladder diagram for the sixth scenario is shown in **Figure 11** with its UZAM_PLC representation, the user program "UZAM_plc_8i8o_ex43.asm" in **Figure 12**. In this example, if the gate is not closing (Q0.1=0) once B0 (I0.0) or RF transmitter button (I0.5) is pressed, then the gate will open (Q0.0 will be ON) with the help of NO contact of Q0.0 connected in parallel to the NO contact of I0.0. In this case, when the gate is opened completely (I0.2=1 and therefore NC contact of I0.2 will open), the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0. When the gate is completely open (I0.2=1), an on delay timer (TON_8) is used to obtain (10×524.288ms) 5.24 seconds time delay.

After waiting 5.24 seconds, the status bit TON_8Q0 of the on delay timer becomes true. If the gate is not opening (Q0.0=0) and if the NO contact of TON_8Q0 is closed (i.e. 5.24 seconds time delay has elapsed), then the gate will close (Q0.1 will be ON) with the help of NO contact of Q0.1 connected in parallel to the NO contact of TON_8Q0. Here, when the gate is closed completely (I0.3=1 and therefore NC contact of I0.3 will open), the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1.

The ladder diagram for the seventh and last scenario is shown in **Figure 13a**. The first rung cannot be implemented as it is in UZAM_PLC. Therefore, the ladder diagram shown in Figure 13a is modified. The UZAM_PLC implementation of this ladder diagram is shown in **Figure 13b**, and is provided as the user program "UZAM_plc_8i8o_ex44.asm" as shown in **Figure 14**.

In this example, if the gate is not closing (Q0.1=0) once B0 (I0.0) or RF transmitter button (I0.5) is pressed, then the gate will open (Q0.0 will be ON) with the help of NO contact Q0.0 connected in parallel to the NO contact I0.0. In this case, when the gate is opened completely (I0.2=1 and therefore NC contact of I0.2 will open), the motor will stop with the help of NC contact of I0.2 inserted before the output Q0.0.

If the gate is closing (Q0.1=1) and the presence of an obstacle is detected in the gates' path (I0.4=0), then the gate will open (Q0.0 will be ON). When the gate is completely open (I0.2=1), an on delay timer (TON_8) is used to

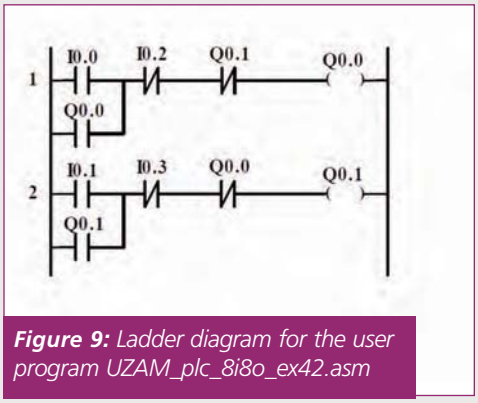


Figure 9: *Ladder diagram for the user program UZAM_plc_8i8o_ex42.asm*

```
#include <definitions.inc>    ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>  ;Contact & Relay based macros

;--------------- user program starts here ------------------------

      ld          I0.0        ;rung 1
      or          Q0.0
      and_not     I0.2
      and_not     Q0.1
      out         Q0.0

      ld          I0.1        ;rung 2
      or          Q0.1
      and_not     I0.3
      and_not     Q0.0
      out         Q0.1

;--------------- user program ends here --------------------------
```

Figure 10: *The user program UZAM_plc_8i8o_ex42.asm*

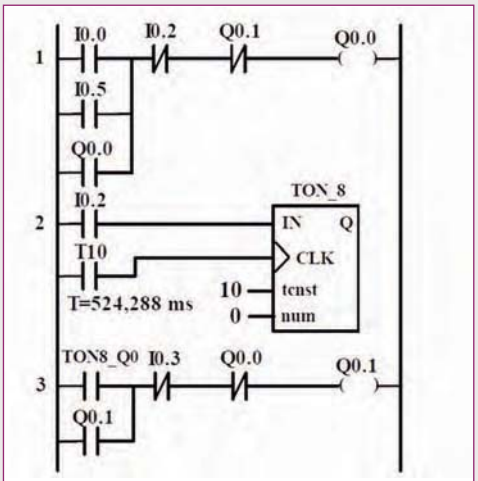


Figure 11: *Ladder diagram for the user program UZAM_plc_8i8o_ex43.asm*

```
#include <definitions.inc>    ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>  ;Contact & Relay based macros
#include <tmr_mcr_def.inc>    ;Timer macros

;--------------- user program starts here ------------------------

      ld          I0.0        ;rung 1
      or          I0.5
      or          Q0.0
      and_not     I0.2
      and_not     Q0.1
      out         Q0.0

      ld          I0.2        ;rung 2
      TON_8       0,T10,.10

      ld          TON8_Q0     ;rung 3
      or          Q0.1
      and_not     I0.3
      and_not     Q0.0
      out         Q0.1

;--------------- user program ends here --------------------------
```

Figure 12: *The user program UZAM_plc_8i8o_ex43.asm*

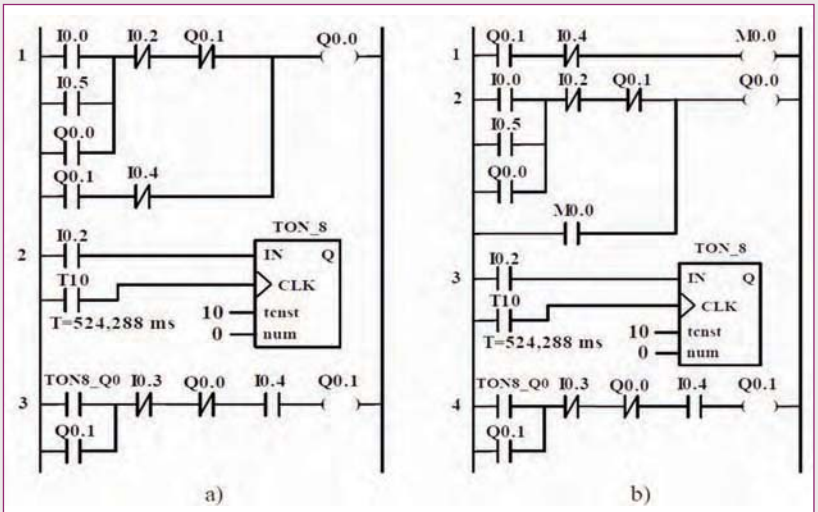


Figure 13a (left) *and* **(b) right:** *Ladder diagrams for the user program UZAM_plc_8i8o_ex44.asm*

```
#include <definitions.inc>    ;basic PLC definitions, macros, etc.
#include <cntct_mcr_def.inc>  ;Contact & Relay based macros
#include <tmr_mcr_def.inc>    ;Timer macros

------------ user program starts here ------------------------

ld          Q0.1        ;rung 1
and_not     I0.4
out         M0.0

ld          I0.0        ;rung 2
or          I0.5
or          Q0.0
and_not     I0.2
and_not     Q0.1
or          M0.0
out         Q0.0

ld          I0.2        ;rung 3
TON_8       0,T10,.10

ld          TON8_Q0     ;rung 4
or          Q0.1
and_not     I0.3
and_not     Q0.0
and         I0.4
out         Q0.1

------------ user program ends here --------------------------
```

Figure 14: *The user program UZAM_plc_8i8o_ex44.asm*

obtain (10×524.288ms) 5.24 seconds time delay. After waiting 5.24 seconds, the status bit TON_8Q0 of the on delay timer becomes true.

If the gate is not opening (Q0.0=0) and if the NO contact of TON_8Q0 is closed (i.e. 5.24 seconds time delay has elapsed), then the gate will close (Q0.1 will be ON) with the help of NO contact Q0.1 connected in parallel to the NO contact of TON_8Q0. Here, when the gate is closed completely (I0.3=1 and therefore NC contact of I0.3 will open), the motor will stop with the help of NC contact of I0.3 inserted before the output Q0.1. If the gate is closing (Q0.1=1) and the presence of an obstacle is detected in the gate's path (I0.4=0), then the output Q0.1 will be switched OFF by means of the NO contact of I0.4 inserted before the output Q0.1. ■

This is the last article in the series of the "PLC with PIC16F648A Microcontroller" project. If you missed any of the previous articles, you can order them on line at ***www.electronicsworld.co.uk***

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ASSESSING THE POWER OF AN ATHLETE USING A MCU-BASED VERTICAL JUMP TEST DEVICE

THE ABILITY OF a person to perform any kind of physical work depends on skill, muscle power and the speed of movement. Physical work is performed through muscle contraction and such a contraction is performed when biochemical energy is converted into mechanical energy.

In general, biochemical energy is classified in two groups: aerobic energy and anaerobic energy. Aerobic energy involves activities of low to medium intensity and energy is supplied to the muscles in the presence of oxygen. Aerobic physical activities can be continued over minutes or even hours.

Aerobic fitness is a characteristic of a person and does not normally indicate the muscle power of a person. The term anaerobic means "in the absence of oxygen" and anaerobic energy is supplied to the muscles in the absence of oxygen, and these activities are very intense and can only be continued for a few minutes or less.

Anaerobic power, or anaerobic fitness, represents a local characteristic of a muscle that exists independent of blood and oxygen supply to that muscle. Anaerobic power is referred to as "high intensity exercise". Collectively, the anaerobic power produced during a muscular contraction depends on both the force and the velocity factors.

In general, there are several methods to determine an athlete's power. Among the commonly used techniques are the Wingate tests, vertical jump tests, long jump tests, weight-lifting, etc. The Wingate test is used commonly and is considered one of the tests for measuring muscle performance. This test is based on cycling at maximum possible speed for 30 seconds, against a constant braking force. Power is then measured from the knowledge of the force and velocity where force equals the braking force and velocity is the distance travelled over time at the flywheel perimeter.

Vertical Jump Tests (VJT)

Vertical jump test is also known as the Sargeant Jump. This test is a well-known method used to demonstrate the lower body strength and power and is still a valuable tool for athletes and coaches today.

In a classical VJT, the athlete stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. The athlete then stands away from the wall and jumps vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempt to touch the wall as the highest point of the jump. The difference in distance between the reach height and the jump height is the height jumped.

Another form of Vertical Jump Test is the extended VJT where the athlete jumps for a longer period of time and the power is then calculated from the measurements of the flight time and the number of times the athlete has jumped in this period. One of the commonly used tests is known as the 60 second test where the athlete jumps for 60 seconds and the total flight time and the number of jumps are measured during this period. The following formula is then used to calculate the power of the athlete:

$$P = \frac{gx60xT_f}{4n(60 - T_f)} \qquad (1)$$

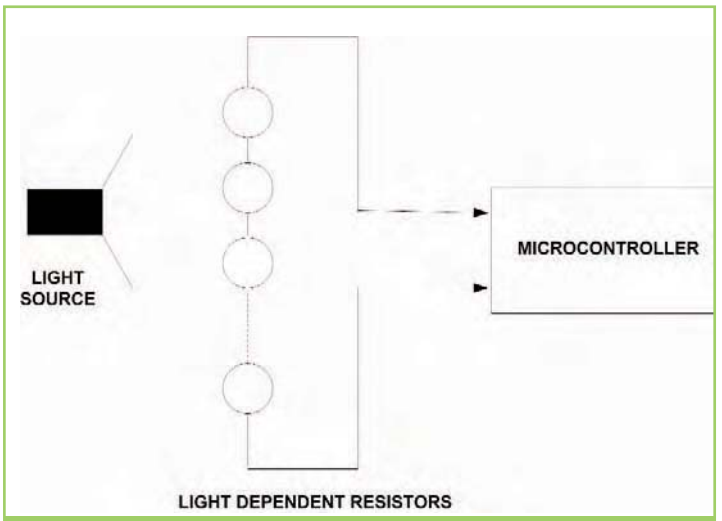

Figure 1: *Block diagram of the VJT device*

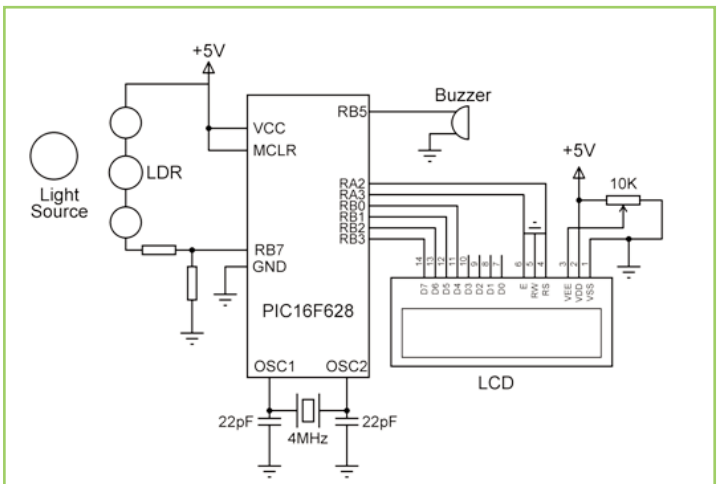

Figure 2: *Circuit diagram of the VJT device*

where:

P	is the power (W/BM)
g	acceleration due to gravity (9.8m/s^2)
BM	is the body mass (kg)
T_f	is the flight time (s)
n	is the number of jumps

or:

$$P = \frac{147xT_f}{n(60 - T_f)} = 14.7 \qquad (2)$$

For example, if in a 60 second period the total flight time is 40 seconds and the athlete has jumped 20 times, the athlete's power is 14.7W/BM. Assuming that the body mass of the athlete is 80kg, the power will be 1176W.

```
Main Program:

BEGIN
        Configure I/O ports
        Configure Timer interrupt (25ms)
        Wait until athlete in position
        Display JUMP…
        Wait for interrupt
        DO WHILE stop_flag = 0
                Display remaining time on LCD
        ENDDO
        Turn ON Buzzer for 2 seconds
        Calculate power of the athlete
        Display flight time and power on LCD
END

Interrupt Service Routine:

BEGIN
        Increment flight time by 25ms
        Re-enable timer interrupts
        IF one second elapsed
                Increment seconds count
                IF 60 seconds elapsed
                        Set stop_flag = 1
                        Disable Timer interrupts
                ENDIF
        ENDIF
END
```

Figure 3: *Operation of the software*

The block diagram of the device designed for vertical jump test measurements is shown in **Figure 1**. A number of series connected Light Dependent Resistors (LDR) are used in the design as light sensors. During a test, a light beam is directed towards the sensors. The athlete then jumps between the light beam and the sensors. As the athlete jumps the light beam is broken and this is sensed by the microcontroller. The microcontroller calculates the total flight time (air time) of the athlete and also measures the number of times the athlete has jumped in a 60 second period. Then, **Equation 2** is used to calculate the power of the athlete and the result is displayed on the LCD.

Figure 2 shows the circuit diagram of the VJT device. The design is based on a PIC16F628 type microcontroller. The program was developed using the Hi-Tech PIC C language and the operation of the program is described as a PDL in **Figure 3**.

When the athlete is at rest the light beam is broken and logic 0 is sent to the microcontroller. When the athlete jumps (i.e. when in flight) the light beam is not broken and logic 1 is sent to the microcontroller. The operation of the program is based on a 25ms interrupt routine. Every 25ms the status of the athlete is sensed and, if the athlete is in air, the total flight time is incremented by 25ms. Also, the number of times the athlete jumps is increased by one when the athlete breaks the light beam.

When the athlete is in position, ready for jumping the message "JUMP…" is displayed on the LCD. As soon as the athlete starts jumping, a 60 seconds timer is started and the state of the light beam is sensed at 25ms intervals. The display counts down from 60 to 0 to indicate the progress of the test. At the end of the 60 second period the buzzer sounds to indicate the end of the test. At this point the total number of jumps, the flight time and the athlete's power are all displayed on the LCD. The device designed has the advantage that it is simple and its cost is very low. ■

Dogan Ibrahim and **Shahin Ahmedov**
Near East University
Cyprus

BELDEN FIBEREXPRESS FIELD-INSTALLABLE CONNECTORS OFFER SIMPLICITY AND SPEED

Belden has introduced a range of FiberExpress Brilliance Field-Installable Connectors designed to enable fast and easy fiber termination. In fact, terminations can typically be made in five seconds, with no termination tools required – a performance unmatched by any other product in the marketplace today.

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- Step 2 - Using the index finger, slide the connector's switch-like activator toward the fiber to be terminated to bring about the splice/crimp.
- Step 3 - Slide the boot on the connector body – and that's it!

This fiber installation procedure is accomplished without using any specific or proprietary installation tools. The built-in activator tab performs the fiber splicing and crimping action in one simple motion, thus reducing the number of steps.

www.beldensolutions.com

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Power supply specialist Powersolve announces the TOP Series of open-frame power supplies designed to provide up to 200W from a space-saving footprint as small as 101.6 x 50.8mm (4 x 2in).

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www.powersolve.co.uk

MINI-ITX MOTHERBOARD SUPPORTS INTEL I7/I5/I3 64-BIT PROCESSORS

BVM's LV-67C mini-ITX motherboard is based on the Intel Q57 and supports versions of the Intel i7 high end, the i5 mainstream and the i3 entry-level 64-bit processors in the LGA 1156 socket. The 32nm versions of the i5 and i3 have HD graphics capability with VGA and DVI output interface, the 45nm i7 and i5 versions do not. Up to 8GB of 1333 DDR3 memory is supported. Intel Turbo Boost technology and Hyper-Threading technology maximizes performance to the workload; the unit is the ideal platform for high-performance systems in industrial control, automation, retail, gaming, print imaging and digital signage applications.

The LV-67C is well provided with I/O, it has 3 x RS232C, 1 x RS232/422/485, 2 x Giga LAN and 8 x USB2.0 ports. The Q57 chipset with a Realtek ALC888 Codec supports High Definition Audio, providing high performance 7.1+2 Channel High Definition Audio..

www.bvmltd.co.uk

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KONTRON COMPACTPCI PROCESSOR BOARD BRINGS INTEL CORE I7 PERFORMANCE TO 6U SYSTEMS

Kontron introduced the 6U CompactPCI processor board CP6002 based on the latest Intel Core i7 mobile processor technology. It is designed to bring leading-edge performance with low power consumption and low heat dissipation to a broad range of applications in the communications, military, aerospace, medical, industrial and monitoring systems markets.

With the 2.53GHz Intel Core i7-610E and the LV 2.0GHz Intel Core i7-620LE, the long term available Kontron CP6002 not only speeds up multiprocessing tasks via hyper-threading technology (HTT), but also processes single-threaded tasks much faster thanks to the new Intel Turbo Boost technology. This allows for a clock speed of up to 3.33GHz without exceeding the defined thermal design power (TDP) and without the need to oversize the entire system for peak loads.

On the memory side, up to 8GB of soldered DDR3 1066MHz ECC memory ensures data accuracy for demanding and safety-critical applications like radar, sonar, or imaging systems.

www.kontron.com

UHF NARROWBAND TRANSCEIVER MODULE

Radiometrix has introduced a new UHF narrowband transceiver specifically suited to power-constrained applications where existing single frequency wideband UHF modules cannot deliver the range required.

Supporting data rates of up to 10kbps, the NTR2 module provides a low power, highly reliable wireless data link, even in the most uncompromising of industrial settings. With an RF power output of 10dBm and a receiver sensitivity of -118dBm, its usable range can extend beyond 500m.

Available in 434.075MHz, 434.650MHz and 458.700MHz versions, as well as customized options offered right across the 433MHz (EU) and 458MHz (UK) licence-exempt bands, these transceiver products combine effective screening with internal filtering to minimise spurious radiation and susceptibility. They conform to both ETSI EN 300 220-3 and EN 301 489-3 standards. In addition, they have an operating temperature range of -10°C to + 60°C.

www.radiometrix.com/content/ntr2

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Kemtron manufactures a range of conductive Elastomers as gaskets and gasket strip for EMI shielding of electronic devices. The base Elastomer is silicone for normal environments and Fluorosilicone for fuel and oil resistance, both offer a wide temperature range of -40°C to +160°C and up to +200°C for some grades. The conductive fillers available are silver plated aluminium, silver plated copper, pure nickel and nickel coated graphite. Other fillers such as silver plated nickel are available to special order.

The manufacture of a conductive Elastomer is a balance of conductive particle loading and distribution throughout the silicone base, the distribution must be sufficient to ensure that the particles are in contact with each other to ensure a good conductive path through the Elastomer but the loading must not be so great to cause the silicone to lose its elastomeric properties.

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www.sensortechnics.com/lba

IDT EXPANDS PORTFOLIO OF SERIAL RAPIDIO GEN2 SWITCHES

Integrated Device Technology (IDT) announced a new family of Serial RapidIO Generation 2 (Gen2) switches, which builds on its industry-leading portfolio of Serial RapidIO 1.3 switches. These new switches are designed to support the Serial RapidIO 2.1 standard and leverage best-in-class technology from the IDT CPS and TSI product lines. The new Serial RapidIO Gen2 switches are ideal for use in the wireless infrastructure, defense, medical and industrial imaging, and professional video markets.

The new IDT Gen2 switches double the data rate up to 20 gigabits per second (Gbps), while reducing power by 40% and improving latency to 100ns in cut-through mode. The initial products include the CPS-1848 48-lane switch, with 240Gbps of non-blocking bandwidth for use in large processor clusters or backplanes, and the CPS-1616 16-lane switch, with 80Gbps of non-blocking bandwidth optimized for line cards and smaller processor clusters.

www.idt.com/go/SerialRapidIOGen2switches

DE-SKEW CORRECTION FOR ACCURACY OF OSCILLOSCOPE-BASED POWER MEASUREMENTS

High-frequency power measurements can now be carried out with greatly enhanced accuracy using a de-skew correction signal source, along with voltage and current probes, in conjunction with the /G4 power measurement option on the Yokogawa ranges of digital and mixed-signal oscilloscopes.

Even though power measurement using an oscilloscope is fundamentally less accurate than using a digital power meter, it offers much higher bandwidth. It is particularly suitable for measuring high-frequency switching losses in switched-mode power supplies. It also provides a power measurement capability using a general-purpose product which has other uses, an option that may be more acceptable to users who are not ready to invest in a true power meter or have limited budgets for test equipment.

The de-skew correction signal source is an accessory, specifically designed to maximize the measurement accuracy of oscilloscopes when they are used for power measurements involving fast switching devices and high-frequency waveforms.

www.tmi.yokogawa.com/ea

INDUSTRY'S FIRST 0.9V DRIVE ECOMOS MOSFETS

ROHM Semiconductor has introduced the first MOSFETs capable of drive operation from 0.9V.

The ECOMOS devices exhibit a dramatic improvement in RDS(ON) values, particularly when low gate voltages are required, which results in a power consumption that is up to 90% lower than in comparable devices, such as bipolar transistors when operated at ultra-low voltages. In the fabrication process, every effort was made to minimize environmental impact, including the use of halogen-free resins.

The improved electrical performance combined with ROHM's unique packaging design provides both – high-efficiency, excellent power dissipation and a small device footprint in smaller, lower profile packages. This adds up to greater energy saving, a longer battery life, a simplified circuit design, as well as the reduction of external parts. Target applications are portable devices such as mobile phones, digital cameras, portable audio players, electronic dictionaries, IC recorders, smart phones, LED control, pre-drive blocks, solar batteries, muting circuits, low-side circuits and many more.

www.rohmeurope.com

PICMG 1.3-COMPLIANT BACKPLANE FOR PCI EXPRESS GEN 2 SYSTEM DESIGNS

The new Kontron 4U Backplane xPB-13E9P3 for PICMG 1.3-based system designs offers comprehensive PCI and PCI Express Gen 2 support for full-height 4U systems. With double the PCIe lanes of any previous solution, 32 in total, the PICMG 1.3-compliant backplane tackles bandwidth-intensive applications with its cost-effective and densely-packed design for use with standard PCIe and PCI extension cards.

In order to support any standard PCIe extension card, an integrated non-blocking switch doubles the 16 PCI Express lanes from the system host board (SHB) to the four PCIe x4 Gen 2 slots and the PEG slot on the backplane. The switch is configurable via software, allowing each of the x4 slots to be individually populated with x1, x2 or x4 I/O cards. The PCIe bandwidth can also be routed directly to dedicated ports without disturbing the CPU board. The three PCI slots of the Kontron xPB-13E9P3 allow OEMs to easily leverage existing PCI extension cards.

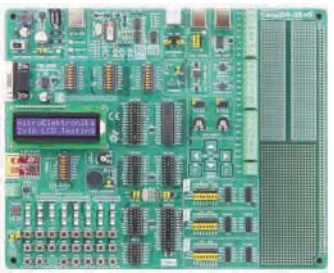
www.kontron.com

EASY24-33 V6 – NEW PIC24 AND DSPIC33 DEVELOPMENT SYSTEM

mikroElektronika has introduced a new product called Easy24-33 v6 Development System. The board is aimed at developing and designing devices using 14-, 18-, 20- and 28-pin Microchip PIC24 and dsPIC33 microcontrollers. The new system includes features such as USB 2.0 programmer with mikroICD and many peripheral modules including Touch Sense, Serial RAM, Serial EEPROM, Piezzo Buzzer and more.

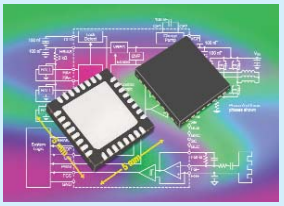
Each feature of the board is supported by practical examples written in mikroC, mikroPascal and mikroBasic PRO for dsPIC30/33 and PIC24 compilers. The tool also comes with a comprehensive, full colour, printed documentation.

www.mikroe.com



OFFICE AUTOMATION THREE-PHASE BRUSHLESS DC MOTOR PRE-DRIVER IC

The new A4936 from Allegro MicroSystems Europe is a three-phase brushless DC motor pre-driver IC targeted at applications within the office automation sector including laser printer and copier drum drives.



The new device incorporates outputs for the direct high-current gate drive of an all N-channel power MOSFET three-phase bridge with a maximum supply voltage of 38V. Also included in the A4936 device are three Hall-element inputs, a sequencer for commutation control, fixed off-time pulse width modulation (PWM) current control, and locked-rotor detection.

Output current is scaled by the capability of the external MOSFETs and locked-rotor detection delay is set by an external capacitor on the CLD terminal. The PWM, DIR, BRAKE and STOP inputs can be used to control motor speed, position and torque. The motor speed can be determined using the motor's FG (frequency generator) coil signal, which is amplified and shaped with the internal differential amplifier and comparator to produce a digital FG signal output.

www.allegromicro.com

VICOR ADDS 28 V WIDE-INPUT MINI FAMILY OF DC-DC CONVERTERS

Vicor Corporation announces the addition of a new 28V Wide Input Mini Family of DC-DC converters. With a wide input range of 9 to 36V, the modules are appropriate for MIL-COTS and industrial applications operating from 12V or 24V inputs, which are typical for battery systems in vehicles. Fully encapsulated, Vicor Mini modules utilize a proprietary spin-fill process to assure complete, void-free encapsulation making them suitable for the harshest environments.

The new 28Vdc Mini Series models offer eight different output voltages, ranging from 3.3V to 48V with a maximum power of 150W, and four operating temperature grades, including -55°C. Baseplate options include slotted, threaded and through-hole.

The 9-36V input range enables designers to specify one converter to operate in both 12V and 24V vehicle systems, making this product particularly cost-effective for the end user.

Lead times can be as short as three weeks for prototype quantities.

www.vicorpower.com

R&S FSVR FAMILY OF SPECTRUM ANALYZERS UP TO 30GHZ

The new R&S FSVR real-time spectrum analyzer from Rohde & Schwarz is the first instrument to combine the functions of an all-purpose signal and spectrum analyzer with a real-time spectrum analyzer. In real-time mode, the R&S FSVR detects everything, from sporadic events to ultrashort signals. Measurement without blind times is a major advantage for developers of RF components for commercial transmission systems such as LTE, WiMAX, WLAN, Bluetooth and RFID, and for general RF applications such as radar and frequency hopping transmission. Designed on the basis of the R&S FSV, the R&S FSVR provides the full functionality of a signal and spectrum analyzer – with a measurement speed up to five times faster than any other analyzer on the market.

In the real-time mode, the R&S FSVR seamlessly captures RF signals with a bandwidth of up to 40MHz, computes up to 250,000 spectra per second and displays the result graphically. Many display modes and measurement functions are available to visually and metrologically analyze the results.

www.rohde-schwarz.com

POWER INTEGRATIONS'S NEW LINKSWITCH-PH AND LINKSWITCH-PL

Power Integrations announced two new families of TRIAC-dimmable, single-stage, power-factor-corrected LED driver ICs, targeting solid-state lighting (SSL) applications. LinkSwitch-PH (optimized for isolated systems) and LinkSwitch-PL (optimized for non-isolated systems) deliver flicker-free monotonic TRIAC dimming and a user experience similar to that provided by incandescent illumination.

The LinkSwitch-PH and LinkSwitch-PL product families feature integrated single-stage power factor correction (PFC), enabling SSL luminaires to achieve PF > 0.9. LinkSwitch-PH devices incorporate primary-side-control technology, which eliminates the optocoupler and supporting components used in traditional isolated flyback designs. Non-isolated LinkSwitch-PL designs further reduce component count, resulting in improved reliability and a reduced bill of materials (BOM). Both IC families are monolithic – incorporating the controller and MOSFET onto a single silicon die.

The new LinkSwitch products are optimized for high efficiency in simple flyback designs and operate at input voltages up to 305VAC, enabling the development of both single-voltage and universal-input products suitable for residential and commercial lighting applications worldwide.

www.powerint.com

AVX SUPPLIER OF THE YEAR AT CONTINENTAL AUTOMOTIVE

AVX has been named Supplier of the Year by Continental Automotive in the Plastic-Mechatronics category at a recent awards ceremony held in Hanover, Germany.

The Supplier of the Year Awards are based on previous performance and forward potential and consider technology, supply, quality and cost elements. Presenting the award in the Plastic-Mechatronics category,

Pete Venuto, Vice President of Sales at AVX said: "We are truly delighted to receive this prestigious award from Continental. AVX is well known as a leading supplier of passive electronic technology solutions and this award clearly demonstrates our equally compelling capability in interconnect and mechatronic product technologies."

www.avx.com

AOI HELPS WILSON PROCESS SYSTEMS IMPROVE QUALITY

Contract manufacturer Wilson Process Systems (WPS) is increasingly relying on automated optical inspection methods to reduce defects and improve yield with the ever-more complex PCB assembly work the company is undertaking.

Since visual inspection methods alone are often not enough, the firm has invested in the Vantage S22 Post Reflow AOI System from Orbotech to guarantee the quality of assemblies. With an inspection speed of up to 20cm²/sec, the Vantage S22 system is designed to detect the presence and absence of components and verify placement accuracy and polarity. The unit can also detect insufficient or excess solder, tomb-stoning, bill-boarding, co-planarity, lifted leads and shorts.

www.wps.co.uk

EUROPEAN BUSINESSES TARGET UK **SOLAR OPPORTUNITY**

Solar experts warn the UK to act now and take advantage of the new solar business opportunities before their European competitors take control. Countries such as Germany, Spain and Italy have already embraced solar photovoltaic (PV) systems, but the UK is behind.

"It will take time to develop the UK market. Currently there is a lack of knowledge, so education of potential customers and businesses is needed," said Clive Collison, owner of South Facing, PV systems installer.

To encourage households and businesses to install renewable energy systems including solar PV, the UK government had just introduced new Feed-In Tariffs (FITs). However, on average it has taken Germany, Spain and Italy some three years after the start of their FITs to reach a substantial market scale.

"Having experienced the benefits that FITs have to offer, European countries are now looking to capitalise on the emerging UK market," says Edwin Koot, CEO, Solarplaza, solar PV industry virtual trade space.

Our panel of commentators says the following on this development:

BURKHARD VOGEL, MANAGING DIRECTOR, GERMANY:

It is one of the major advantages of Europe that there are so many strong countries that can compete against each other on any economy field – as long as they want to and as long as they are able and willing to identify the importance of that "allowance". This is the best way to create first-in-class results! Solar technology is one of those fields.

Thanks to the FITs, it's interesting to see how tiny energy plants (on roofs of all kinds of buildings) are popping-up like mushrooms all over central EU during the last decade. The disadvantages have to be discussed as well: the control of the EU-wide energy nets will become a kind of nightmare. Nevertheless, this is another, manageable, new challenge. A well organised FIT system is essential to push forward the end-user's willingness to act accordingly.

The UK should not hesitate to take the best they can get from the broad experience results made on the continent.

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

Politicians know that what people say and what they actually do are distinct. Accordingly regulation, involving financial incentives such as FITs, is required to overcome consumer resistance to change for adopting green technology, such as this solar-powered photovoltaic technology. After all, most people just want electrical power, at the least cost, irrespective of how it is produced. FIT programs have been successfully adopted in over 60 countries in the past thirty years. Unfortunately the PV technology (as with wind power technology) has to be imported due to the lack of indigenous UK material science industry as previously commented upon.

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

The solar energy business has started to gain momentum in many European countries, such as Germany, Spain and Italy where they have already been investing heavily in the solar business. But, now we are beginning to see much smaller countries such as Cyprus starting to invest in solar energy by building new photovoltaic module manufacturing plants and associated products in Cyprus.

It is good news that the UK government is encouraging households and businesses to install solar PV systems. We hope that with this initiative the UK solar business market will gain momentum and start to grow and share a large proportion of the existing solar market. What seems to be required is that the UK Government should promote the solar industry by educating the general public and businesses on the advantages and benefits of the solar market. This could be in the form of TV programmes, adverts, leaflets, radio interviews and so on. In addition, universities, research organizations and solar equipment manufacturers should be encouraged to organize new PV-based conferences, and to participate in related European conferences and seminars by presenting papers and/or exhibiting their products.

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

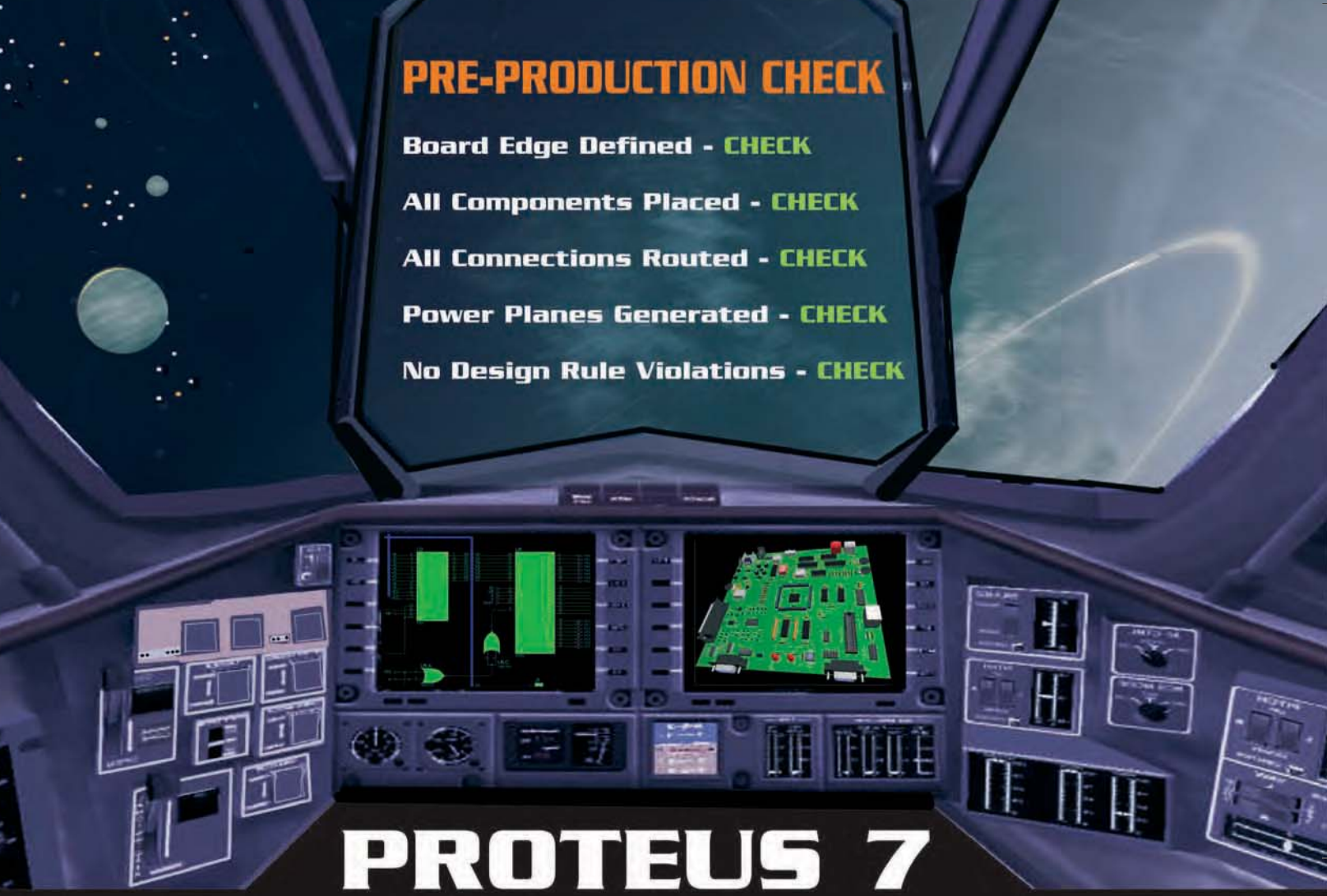
The global solar photovoltaic (PV) market continues to grow at an unprecedented rate, outpacing the annual growth rate of almost every other energy technology. Spire continues to accelerate the photovoltaic industry's growth by assisting new participants into the PV manufacturing business quickly, efficiently and ready to compete.

PV is an increasingly important energy technology; its energy source, sunlight, is free and abundant, PV systems can offer virtually guaranteed access to electric power.

However, this technology faces several large obstacles, most notably the costs relating to power generation and transmission as well as difficulties in obtaining funding for the development of advanced technology. Research is underway for development of so-called second generation – or thin-film – PV technologies to bring down the costs associated with PV energy.

Moreover, photovoltaic solar cells are becoming more popular in various fields, and the variety of applications keeps widening. Businesses dealing with these products will benefit from them in the coming years, whether from distribution or internal use.

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



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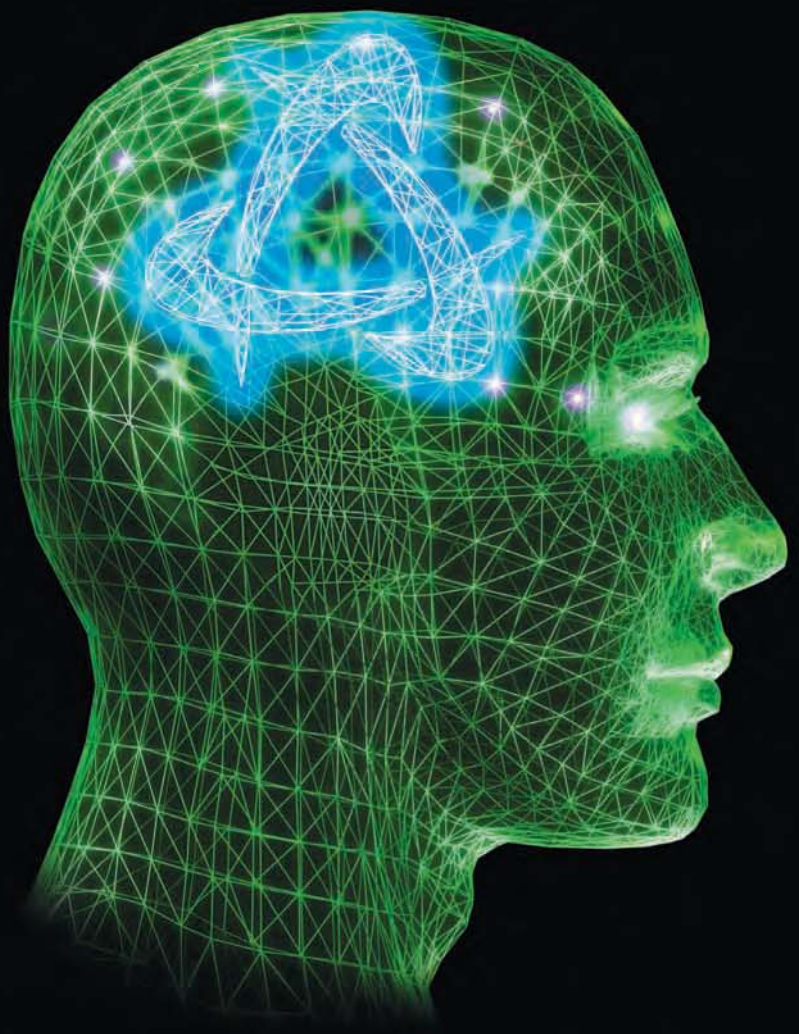

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