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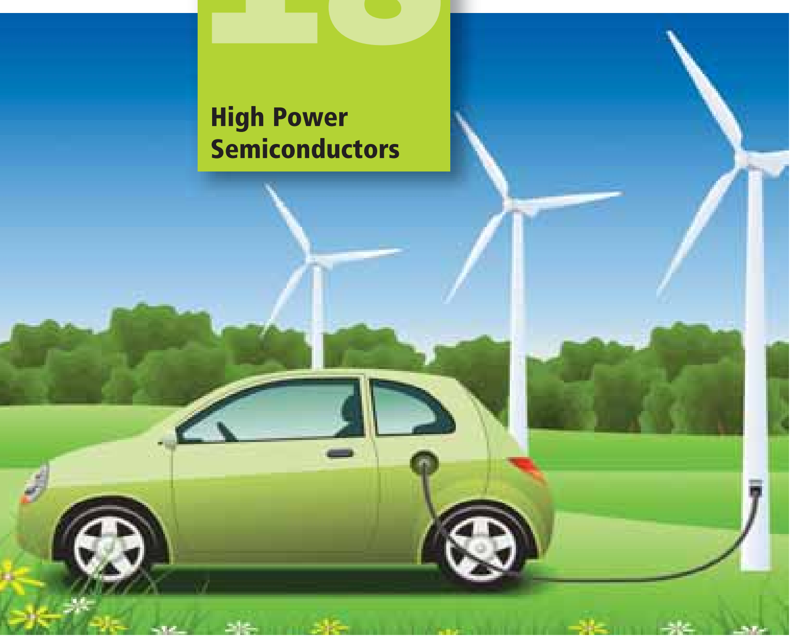
REGULARS



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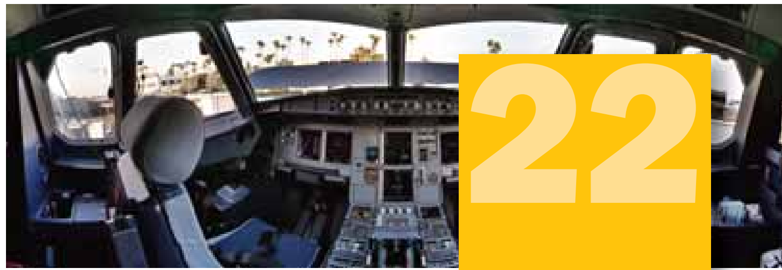

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FEATURES

THE SLOW ROAD FROM 'CLASSIC' BLUETOOTH TO 'BLUETOOTH SMART' IN CONSUMER MEDICAL DEVICES

Market analysts at IMS Research envisage that the transition from 'Classic' Bluetooth to 'Bluetooth Smart' in consumer medical devices will be slow, with 31% of all consumer medical devices containing Bluetooth sold in 2016 still using Classic Bluetooth (Version 2.1) as opposed to the latest low-energy variant, Bluetooth Smart (Version 4.0).

According to the recently published report "*Wireless Opportunities in Health and Wellness Monitoring – 2012 Edition*" this is due to the high certification costs and strict regulations, which will lengthen the design cycle for companies planning to launch Bluetooth Smart variants of their consumer health devices.

"High certification costs for consumer medical devices, coupled with long design cycles and strict regulation is going to mean companies currently using Classic Bluetooth will continue to do

The ecosystem of Bluetooth Smart devices in the market is still very low, with only a handful of devices able to communicate natively with any new Bluetooth Smart device

so, while slowly bringing Bluetooth Smart variants to the market over the next five years," said Phillip Maddocks, IMS Research Analyst. "As long as customers feel the battery life and reliability of devices using Classic Bluetooth devices are satisfactory, there is no great urgency to switch to Bluetooth low energy."

As long as customers feel the battery life and reliability of devices using Classic Bluetooth devices are satisfactory, there is no great urgency to switch to Bluetooth low energy

Another key factor is the uptake of Bluetooth low energy in connectable devices such as cellular handsets. As the penetration of Bluetooth Smart Ready in these devices is still low, manufacturers of consumer medical devices are less inclined to support a smaller ecosystem when they have a much larger one based on Classic Bluetooth. This forecast is likely to change, however, as 100% of cellular handsets that would typically contain Bluetooth will be Bluetooth Smart Ready by 2016.

"The ecosystem of Bluetooth Smart devices in the market is still very low, with only a handful of devices able to communicate natively with any new Bluetooth Smart device. This is set to change over the next five years with more devices – in particular cellular handsets – adopting Bluetooth Smart Ready technology instead of the traditional Classic Bluetooth technology," said Maddocks.

IMS Research's latest report "*Wireless Opportunities in Health and Wellness Monitoring – 2012 Edition*" assesses the uptake of ten connectivity technologies, including wired, Classic Bluetooth, Bluetooth low energy, Wi-Fi, ZigBee, DECT ULE, ANT, NFC, 5kHz, as well as proprietary technologies and others) in five consumer health monitoring devices. There's a differentiation made between consumer medical devices and telehealth medical devices (blood pressure monitors, blood glucose monitors, pulse oximeters, implantable devices, and so on). Also, additional information is provided for five types of health hubs (dedicated/standalone hubs, cellular handsets, PC/laptop/tablets, residential gateways and others), and five sports and fitness monitoring devices (heart rate monitors, pedometers, footpods, speed and distance sensors, and cycling computers). There's also information on the geographical split for the uptake of these devices across the three major regions: the Americas, EMEA and Asia-Pacific.

IMS Research is a supplier of market research and consultancy to over 2500 clients worldwide. It was established in the UK in 1989 but was recently acquired by IHS, a source of information, insight and analytics for businesses and governments. IHS has been in business since 1959 and now employs over 6,000 people in more than 30 countries. www.ihs.com

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RFEL STRETCHES THE DYNAMIC RANGE OF ADCS FOR T&M EQUIPMENT

RFEL, the UK-based high performance electronic signal processing solutions specialist, has found a way to overcome the common performance bottleneck of the dynamic range of high-speed ADCs. The firm has successfully extended the dynamic range of an 8-bit 800MSPS ADC from 52dB up to 74dB (see figure) in order to meet specific customer requirements for an industrial test product design.

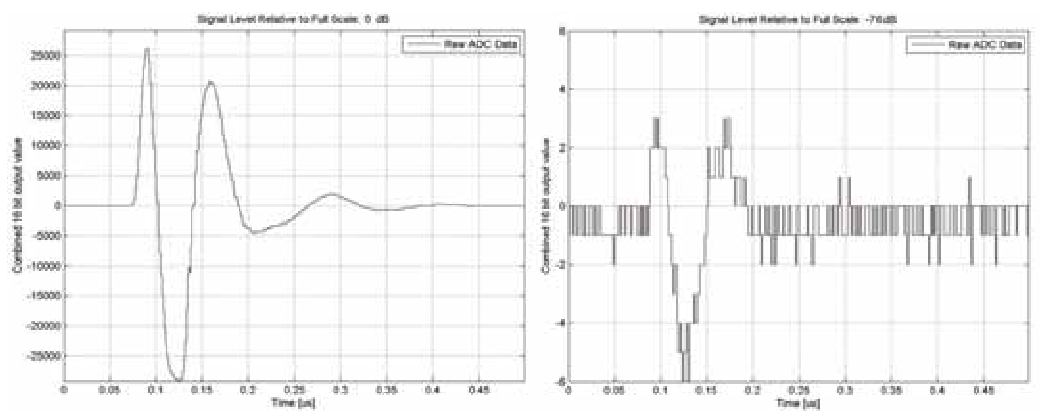
The dynamic range of the ADC was extended by employing a stacked ADC architecture. This approach provides large gains in dynamic range by use of parallel data capture paths with staggered attenuation settings. Matching the frequency, phase and amplitude characteristics on these parallel paths is critical to a successful implementation, so special attention was paid to the architecture of the analogue design to mitigate potential mismatch of device characteristics.

After the received signal has been converted to the digital domain, the input data rate for each channel is 29Gb/s. Initial signal processing reduces the rate whilst maintaining full timing precision. Further time and frequency domain measurements are applied before passing results on to the processor. Software handles final adjustments to the data and manages the user interface. A network connection allows control, data transfer and updates to be carried out via remote access.

"Our many man-years of leading-edge signal processing design knowledge enabled us to really push the envelope of the ADCs' dynamic range so that the customer could get a new product on the market that has 'best in class' performance," said Dr Alex Kuhrt, RFEL's CEO.

"Breaking through the dynamic range limit of the ADCs was just one of the design challenges for this project. RFEL was responsible for the entire design flow from initial concepts and algorithms through to PCB layout, design of firmware, software, mechanical housing and final environmental and EMC testing," he added.

Although RFEL won't disclose at this time who the T&M customer is, it did say that the ADCs were supplied by e2V. The multi-channel analogue and digital design uses six, quad speed, EV8AQ160 ADCs, two 1.6GHz PLLs, four high speed FPGAs and a processor. The complexity of integrating multiple large BGA devices and associated high speed I/O into a small area required a 14-layer PCB design. The added signal sensitivity requirement necessitated linear power supply regulators, low noise analogue components and careful layout of power planes. Analogue simulation was used to prove the stability and frequency response of the input chain whilst the RTL design was checked against a bit true Matlab model.



RFEL has successfully extended the dynamic range of an 8-bit 800MSPS ADC from 52dB up to 74dB

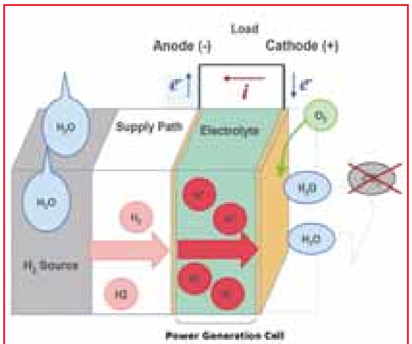
Solid Fuel Type Hydrogen Fuel Cells Deliver High Efficiency and Increased Safety

Rohm Semiconductor, Kyoto University and Kyoto-based Aquafairy Corp have jointly developed compact, lightweight, high-power hydrogen fuel cells for portable devices. These fuel cells overcome the drawbacks of dry cells, lithium-ion cells and direct methanol fuel cells, significantly reducing their weight and increasing the output power, while providing a higher level of safety. Such features make it possible to provide power in places where AC power is not available or cannot be used, but also are expected to drive expansion into new markets and applications.

There is already extensive use of fuel cells using methanol and hydrogen; however, with methanol fuel cells it is difficult to increase their power output, and hydrogen fuel cells require the use of cylinders, making them harder to handle, and cannot be miniaturized.

Rohm and Aquafairy have succeed in solidifying calcium hydride in a sheet configuration using proprietary technologies. They've managed to generate approximately 4.5 litres of hydrogen from a sheet less than 3cc in volume (measuring 38 x 38 x 2mm), providing a power output of 5Whr. The hydrogen fuel cells are compact and can operate at ambient temperatures, making them suitable for use in smartphone chargers, tablet PCs, as power sources outdoors and in remote areas, and in emergency backup power supplies. In addition, they emit no carbon dioxide or hazardous gases and can be disposed of as general waste.

The two companies, alongside Kyoto University, will continue to work on assessing reliability and making further improvements, with production targeted for April 2013.



The construction of a hydrogen fuel cell

STMicroelectronics Perfects Advanced Process Technology for New Generation of Sensor Electronics

STMicroelectronics (ST) has unveiled a new generation of ICs using an advanced manufacturing process that helps save energy, improve accuracy and simplify the design of sensors for applications from automotive electronics to smart buildings and industrial controls.

The new ICs are miniature op-amps used to condition very small sensor signals. Benefiting from the advanced 16V CMOS manufacturing process, developed in-house, ST's new op-amps deliver better accuracy than existing devices, with greater long-term stability. Moreover, the process enables tiny die sizes permitting ultra-small surface-mount packages. Extremely low power consumption makes the op-amps ideal for battery or solar-powered equipment.

The new op-amps also have enhanced electrostatic discharge protection, up to 4kV, and can operate from -40°C to 125°C, making them suitable for use in harsh industrial or automotive environments. The TSX561, TSX562 and TSX564, containing one, two and four op-amps respectively, operate over a wide supply-voltage range from 3V to 16V, and can be used with different supply voltages from 3V, 5V and 12V to ±5V.

Other features of the series include an input-offset voltage of 600μV max, input bias current of 1pA, typical quiescent current of 240 μA at 5V, typical gain-bandwidth product of 900kHz and different package options.

The devices are in mass production now, priced from $0.50 depending on the configuration/package, in quantities of 1,000 units.

The new series of op-amps is based on ST's advanced 16V CMOS manufacturing process

ON Semiconductor Joins Imec's GaN-on-Si Research Program

IC manufacturer ON Semiconductor has joined the Gallium Nitride (GaN) on silicon (Si) research programme at Imec, a leading nanoelectronics research center in Belgium. This is already a multi-partner industrial development effort, which aims to create a new generation of power and RF devices.

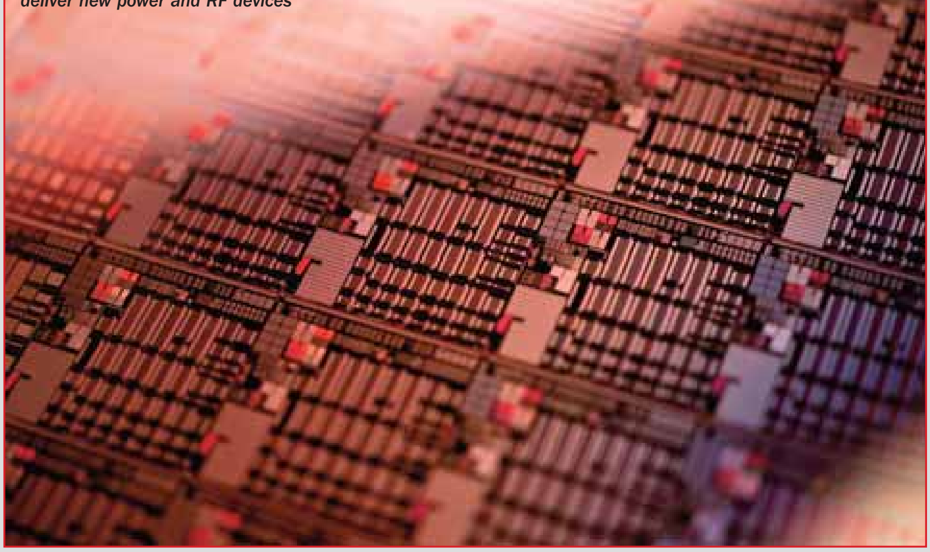
GaN is characterized by superior electron mobility, higher breakdown voltage and good thermal conductivity properties, making it ideal for power and radio frequency (RF) devices which need high-switching efficiencies. Today, GaN-based power devices are too expensive for large volume manufacturing, as they are fabricated on small diameter wafers using non-standard production processes.

"As a top 20 global semiconductor supplier with a portfolio focused on energy-efficient devices, ON Semiconductor has been researching GaN silicon technologies for several years and is presently building a GaN processing line in its Oudenaarde facility in Belgium," said Hans Stork, senior vice president and Chief Technology Officer (CTO) at ON Semiconductor. "Partnering with Imec will help strengthen our current market position."

Imec's broad-scale research program is focused on developing GaN-on-Si technology on 200mm wafers, as well as reducing the cost and improving the performance of GaN devices.

"Extraordinary developments continue to emerge from our GaN-on-Si Affiliation Program, creating further inroads to drive down production costs. The newest addition, of ON Semiconductor as a strategic program partner, further advances our collective expertise. Leveraging joint efforts will help us overcome the next hurdle toward economical volume manufacturing, ultimately bringing GaN power devices to the market," said Rudi Cartuyvels, vice president of smart systems and energy technology at Imec.

Gallium Nitride on silicon research promises to deliver new power and RF devices



UNMATCHED MEASUREMENT PRECISION WITH HIGH DEFINITION OSCILLOSCOPES

Combining Teledyne LeCroy's HD4096 high definition 12-bit technology, with long memory, a compact form factor, 12.1" multi touch screen display and powerful measurement and analysis tools, the HDO6000 is the ideal oscilloscope for circuit validation, system debug and waveform analysis. The powerful feature set provides analytical tools and unique application packages to streamline the testing process. Tools such as WaveScan Search and Find and History Mode, combined with advanced triggering, identify and isolate problems while Spectrum Analyzer Mode provides analysis tools in the frequency domain.

HD4096 TECHNOLOGY

Oscilloscopes with HD4096 technology have higher resolution and measurement precision than 8-bit alternatives. The high sample rate 12-bit ADCs provide high resolution sampling at up to 2.5 GS/s. The high performance input amplifiers deliver phenomenal signal fidelity and provide a pristine signal to the ADC to be digitized. The low-noise signal architecture ensures that nothing interferes with the captured signal and the oscilloscope displays a waveform that accurately represents the signals from the device under test.

16X MORE RESOLUTION COMBINED WITH LONG MEMORY

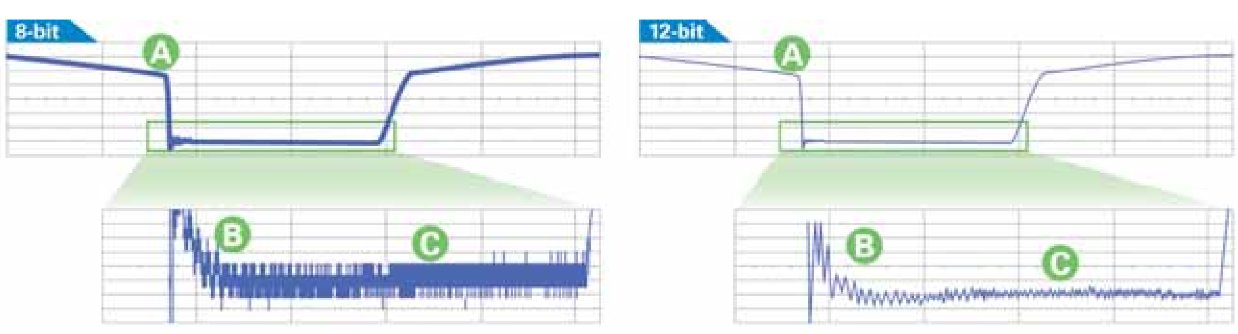
12-bits of vertical resolution provides sixteen times more resolution than 8-bits. The 4096 discrete levels reduce the quantization error. Signals captured with lower resolution oscilloscopes have a higher level of quantization error resulting in less accurate waveforms on the display. Signals captured on an

oscilloscope with 12-bit HD4096 technology are accurately displayed with minimal quantization error.

With up to 250 Mpts of memory the HDO High Definition Oscilloscopes can capture large amounts of data with more precision than other oscilloscopes. The 2.5 GS/s, 250 Mpts architecture provides the ability to capture a fast transient or a long acquisition.

Ⓐ Clean, Crisp Waveforms - When compared to waveforms captured and displayed by 8-bit oscilloscopes, waveforms captured with HD4096 technology are dramatically crisper and cleaner. Oscilloscopes with HD4096 acquire waveforms at high resolution, high sample rate and low noise to display the most accurate waveforms.

Ⓑ More Signal Details - Signal details often lost in the noise are



clearly visible and easy to distinguish when captured on oscilloscopes with HD4096. Details which were previously diffi cult to even see can now be easily seen and measured. Using the oscilloscope zoom capabilities gives an even closer look at the details for unparalleled insight to the signals on screen.

- Unmatched Measurement Precision - Precise measurements are critical for effective debug and analysis. HD4096 enables oscilloscopes to deliver unmatched measurement precision to improve testing capabilities and provide better results.

ADVANCED TOOLS FOR WAVEFORM ANALYSIS

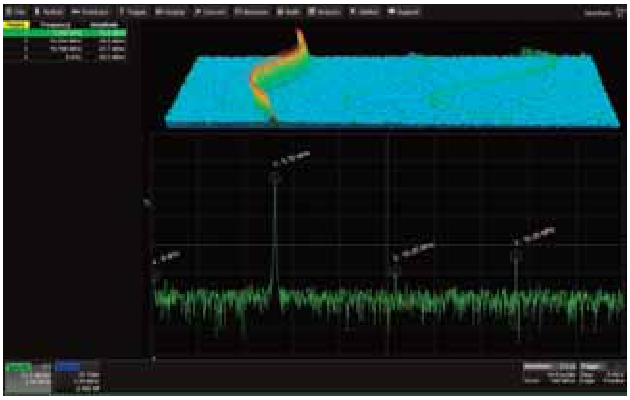
The full range of Teledyne LeCroy analysis options are available for HDO oscilloscope so there is no compromise between higher resolution and analysis capabilities.

WAVESCAN ADVANCED SEARCH AND FIND TOOL

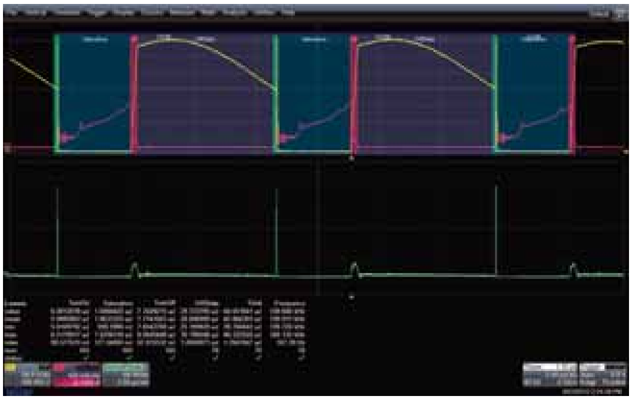
Standard WaveScan tool provides powerful isolation capabilities that hardware triggers can't provide. WaveScan provides the ability to locate unusual events in a single capture (i.e., capture and search), or "scan" for an event in many acquisitions over a long period of time with more than 20 search modes.

LABNOTEBOOK

The standard LabNotebook feature of HDO6000 provides a report generation tool to save and document all your work. Saving all displayed waveforms, relevant settings, and screen images is all done through LabNotebook, eliminating the need to navigate multiple menus to save all these fi les independently.



Spectrum Analyzer Mode
View the frequency content of signals with spectrum analyzer style controls, easily adjust the frequency span, resolution bandwidth and center frequency. A unique peak search detects spectral components and presents frequency and level details in an interactive table. Use the spectrogram display to see changes in the spectrum over time. This option is standard on all HDO6000 models.



Power Analyzer Measures and Analyzes Power Conversion Devices and Circuits
The Power package enables measurement and powerful analysis of the operating characteristics of power conversion devices and circuits. With the software, the HDO oscilloscopes analyze all aspects of switched-mode power devices with tools for automatic power loss measurements, control loop modulation analysis, and line power harmonics testing, all within a streamlined user interface that simplifies probe and measurement setup.

Serial Trigger and Decode Options
Debugging serial data busses can be confusing and time consuming. The serial data trigger and decode options for HDO6000 provide time saving tools for serial bus debug and validation. Protocol triggering quickly identifies and captures key messages on the bus while the color-coded overlay decodes it for simple debugging. Long memory in
the HDO enables the capture of many serial data packets, sorting through these packets is easy with the interactive decode table and convenient protocol specific search function.

ROHS Recast: Falling Under the CE Umbrella

BY **THOMAS WESTCOTT**, LEGISLATION PROJECT MANAGER EUROPE, FARNELL

CE marking, the easily recognisable symbol of product conformity across the European Union, is adding another spoke to its 'umbrella' directive. As of 2nd January 2013 the CE mark will also demonstrate RoHS (Restriction of Hazardous Substances) compliance as full CE obligations are incorporated into the RoHS recast. Good news for consumers but what effects will this have on OEMs trading in the EU?

To answer this, we must first look at the reasons behind the inclusion of the CE mark under RoHS. In broad terms, the purpose was to expand the scope of products to which the CE obligations would apply. As of the 2nd January 2013 all equipment falling within scope of the recast of the RoHS directive (2011/65/EU) will carry CE marking obligations, unless specifically excluded.

CE marking has been implemented by the European Commission to allow products to be freely distributed across the common European market, without the need for separate conformity declarations in each member state. Affixing the CE mark is a declaration by the producer that the product has been designed, tested and manufactured to meet the essential requirements of all applicable new approach directives. Not only does it declare that a product is safe, but it is also suitable for use in the function for which it was designed and that it will not have adverse effects on its surroundings. This comprehensive approach to proving compliance is the reason for its inclusion in the RoHS recast.

At present, the RoHS directive restricts the use of six substances (lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls and polybrominated diphenyl ethers) present over maximum concentration values by weight in homogeneous materials, covering a scope of eight categories. Following the recast, the scope of RoHS will increase to ten categories from 2014, with a final category 11 being added in 2019 (the 'open scope' category). In order to prove compliance, producers are required to provide satisfactory evidence in the form of technical documentation or information, known as the Certificate of Compliance (CoC). However no specific guidance exists on what form this evidence should take resulting in a multitude of applications in differing formats with differing information. CE marking, on the other hand, removes this ambiguity with clearly defined methods of compliance.

CE obligations require a three step approach to proving conformity – a technical file, a Declaration of Compliance (DoC) and, finally, by affixing the CE mark itself. Proof of compliance must be provided in the technical file, along with the specifics given in Module A of Annex 2 - 768/2008/EC.

Technical file evidence must contain information on the following: a general description of the product, conceptual design and manufacturing drawings (with necessary descriptions/explanations), a list of harmonised standards the product is complying with (if any have been applied) and final test reports.

Secondly, the DoC (explained in Annex VI of the RoHS Directive 2011/65/EU), must detail the name and address of the manufacturer; the manufacturer's acceptance of responsibility; details of the object being declared; confirmation that the object meets RoHS requirements; details of other harmonised standards being declared against; any additional technical information; and, finally, the manufacturer's signature.

CE Obligations

As mentioned earlier, CE obligations have much greater clarity in their requirements and this is demonstrated in the form of the DoC template provided within the directive itself. This is in direct contrast to the certificate of compliance which can exist in multiple formats. The CoC will be replaced by the DoC on finished goods and equipment, but will still be required for components. Finally, once all measures are in place, the manufacturer must affix the CE mark in accordance with the requirements of the directive. It must be at least 5mm high, visible, legible and indelible on the product, and if there is not sufficient space then on the accompanying documents or the packaging.

So what effect will these additional CE marking RoHS obligations have on OEMs in Europe? Put simply, and unfortunately repeating previous concerns, it is the burden of additional data collection. Compiling the amount of information required for the technical file will demand additional resources from manufacturers, although the CE committee responsible for writing the harmonised EU standard for RoHS compliance has suggested that the work

> **The DoC (explained in Annex VI of the RoHS Directive 2011/65/EU), must detail:**
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> - details of other harmonised standards being declared against;
> - any additional technical information; and, finally,
> - the manufacturer's signature

> *The scope of RoHS will increase to ten categories from 2014, with a final category 11 being added in 2019*

required is essentially what manufacturers should already be doing. Compiling information for the DoC should be a straightforward requirement but, again, the size of the task could be huge as all DoCs will need to be amended for all EEE sold in the EU. Finally, affixing the CE mark should not be an issue as the majority of products are already marked to show compliance with one of the other directives already covered by the CE umbrella.

The issue for OEMs is not necessarily the complexity of proving compliance but the volume of products it will apply to. It is also important to note that the responsibility to prove conformity covers the full supply chain. Specific obligations for manufacturers, importers and distributors are listed in articles 7, 9, 10 and 11 of the RoHS Recast.

The inclusion of CE mark obligations into the scope of RoHS has practical intentions.

The CE mark will demonstrate compliance with hazardous substance restrictions in addition to the other directives under its umbrella. It will also clarify RoHS compliance processes through the provision of detailed product investigations. But the very fact that the requirements are so comprehensive – and will lead to an increase in an already stretched data collection resource, is likely to prove a major problem for industry. There will undoubtedly be significant repercussions on businesses across Europe but in particular those SMEs who are subject to CE requirements but struggle with the resources to manage the process.

Visit: www.element14.com/legislation for details.

It's In the Pipe

MYK DORMER IS SENIOR RF DESIGN ENGINEER AT RADIOMETRIX LTD
WWW.RADIOMETRIX.COM

My concerns are usually centred firmly around RF design problems. The entertaining peculiarities of radio frequency circuitry are more than enough to occupy an engineer's brain for an entire career. Unfortunately – or fortunately – I am yet unsure if such variety in life is a blessing or a curse, I am also occasionally called upon to deliver considerably more than my regular "wireless module" fare, when a customer orders and is prepared to pay for an entire working system.

Going beyond the "component level module" brings up a whole load of additional issues, but one that in my experience frequently looms large is "the box you put it in".

A product which is intended to sit on a bench, or desk, for the whole of its working life presents problems of its own: appearance and ergonomic issues, customisation to fit the design's interfaces and controls, price, RF shielding – there is no surprise that dozens of companies are dedicated to little else; but when the product has to survive outdoors, in the British rain and gales, the difficulties multiply.

Weatherproofing is a vast subject, starting with the whole "IP rating" system and then moving into even less understandable areas. Ultimately, however, what I have recently found is that cases with sufficient resistance to rain, sun and wind tend to be:
1. Expensive and 2. Rarely the shape I need.

The second issue is usually the biggest problem. High IP rating housings are typically intended for mains power cabling or industrial control gear. These things tend to call for square or squat rectangular shapes. If you add the antenna to your radio system (and you really don't want to get into the subject of weatherproof RF connectors and the problems of aerial pilferage), then your desired form-factor usually ends up very long and thin. This leaves apparently two options: an expensive custom-moulded case or a very oversized housing.

However, there is a third option perfectly suited to housing radio equipment. Its form-factor is ideal, it is inexpensive, easily customised, waterproof, resistant to UV light and weathering, has a low dielectric loss factor and is very robust. You'll most likely find some under your kitchen sink. Domestic plastic waste pipe! It makes an excellent housing for radio circuitry and the associated antenna. Select the polypropylene push-fit/compression fitting variety over the cheaper solvent weld variety (the base material is far stronger than the cheaper PVC, and the mess and fume hazard of the solvent cement is avoided), cut to length and add suitable end fittings and, as if by magic, you have an instant waterproof casing.

The materials come in two common diameters: nominally 32mm and 40mm; and there is a wide range of bends, tees and couplers compatible with them (as all amateur plumbers probably already know). The fittings most useful to electronics engineers are the pipe-to-pipe coupling (in comp-ression or push-fit types) and the end plug, which turns a coupling into a blank end. Stock is held by most plumbers' merchants and DIY stores, and larger volumes are easily sourced from distributors (but do not expect volume discounts unless your require-ment is in the tens of thousands: the building trade uses a lot of these products).

There are a few caveats for the use of this material (nothing is ever 100% perfect!): Obtain samples and carefully measure them. Real internal diameter and wall thickness varies between the five or six commonly encountered manufacturers, and not all fittings fit all pipes properly.

Quality varies between manufac-turers. Once you have a good solution with one type of fitting and pipe, stick to it; do not "shop around".

Understand that designing circuit boards to fit into long tubular housings is, if not difficult, rather different from the rectangular boards we are all familiar with. Be constantly aware of the three dimensional issues, and be prepared to work with properly done scale drawings to fit everything in.

Keep the customer aware of the aerial location: it is very easy to mount a waste pipe enclosure to a wall or mast with brackets, but a metal clamp around the middle of your aerial will seriously degrade its efficiency.

Running cables (power, data, signal, etc) into the enclosure will require a gland, and those cannot be fixed to a curved wall. Either modify an end plug (machining it smooth and drilling a hole) or fit a drilled plate in the end of a compression coupler.

Polypropylene is fiendishly difficult to glue. If you start getting adventurous with the custom mechanicals then it will be necessary to source one of the very few structural acrylic adhesives suitable for "low surface energy plastics".

This approach is not the absolute panacea for all outdoor housings. It requires some assembly skill – cutting the pipe at an accurate enough right angle requires the assembly of a jig – and the resulting assembly still looks like drainpipe; but it does give an alternative solution for otherwise difficult to house sub-assemblies – and the satisfaction of using a "lateral thinking" solution. ●

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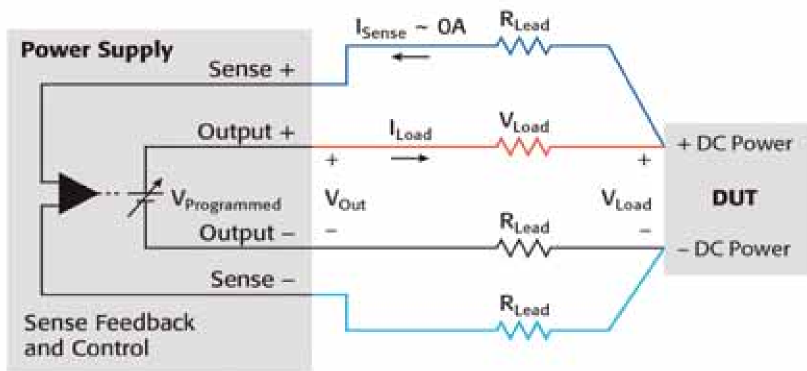
GETTING THE MOST PERFORMANCE FROM A POWER SUPPLY

ROBERT GREEN, SENIOR MARKET DEVELOPMENT MANAGER AT KEITHLEY INSTRUMENTS, A TEKTRONIX COMPANY, DISCUSSES THE IMPORTANT CONSIDERATIONS WHEN SELECTING A POWER SUPPLY AND THE TECHNIQUES FOR TAKING ADVANTAGE OF ITS CAPABILITIES

Power supplies are not one of the more glamorous instruments on a developer's bench or in a test system. After all, they are a one-function DC device designed to output a controlled voltage. Typically, designers spend very little of their time investigating power supply specifications and performance.

However, there are capabilities and specifications that should be investigated to ensure the power supply meets the application's requirements. Understanding the power envelope of the power supply is important, so it can deliver the power at the voltage and current parameters needed for the task. When using the power supply as an accurate voltage source for testing a circuit over its operating voltage range or as a calibrating source, it's important to ensure that the specified accuracy of the supply at the input to the device-under-test (DUT) can be obtained. For development, characterization and testing of circuits that generate or measure low-level signals, selection of the design topology of the power supply and investigation into its noise performance are a necessity so the power supply does not interfere with circuit performance. Applications such as these will require a more detailed investigation into a power supply's characteristics.



Without Sense Leads:

$V_{Load} = V_{Out} - 2{*}V_{Lead} = V_{Out} - 2{*}I_{Load}{*}R_{Lead}$

$V_{Out} = V_{Programmed}$

$V_{Load} < V_{Programmed}$

With Sense Leads:

$V_{Load} = V_{Out} - 2{*}V_{Lead} = V_{Out} - 2{*}I_{Load}{*}R_{Lead}$

$V_{Out} = V_{Programmed} + 2{*}V_{Lead}$

$V_{Load} = V_{Programmed}$

Figure 1: Remote sensing overcomes voltage drops in the source leads to deliver the programmed voltage to the DUT

Getting the Necessary Voltage and Current Capacity

The most significant decision is ensuring that sufficient power is available to energize the DUT. While this is obvious, it is important to be aware that different types of power supplies have different power envelopes.

One type of power supply has a rectangular power envelope in which any current can be supplied to the load at any voltage level. This is certainly the most versatile power envelope and it is the easiest to understand on a power supply data sheet. An alternative version of this type of supply has multiple rectangular power envelopes representing multiple voltage ranges. Reviewing the literature is a must however, since the maximum current the supply can output will not be available at the maximum voltage.

The importance of this type of power envelope is that it permits higher values of one parameter at the expense of another. For example, a supply with this type of envelope can output a higher level of current, but at a lower maximum voltage.

Some supplies have a hyperbolic power envelope, a more continuous transition than a multiple range power supply. With this power envelope, one parameter is inversely proportional to the other. High power output supplies tend to have the multi-range or hyperbolic envelope. It's important to know exactly what the application requires, so the selected supply delivers the required power at the levels of voltage and current at which it will be tested.

Maximizing Output Accuracy

If tight control of voltage at the load is essential for experimentation, device characterization or production testing, then a careful review of the power supply's output accuracy and readback specifications are also important. However, that accuracy can be compromised if the supply is controlling the voltage at its output terminals. What will be needed is feedback control right at the DUT. That means the supply should include sense connections (remote sensing) that can be connected to the DUT where the power leads are connected. The sensing circuits measure the voltage at the DUT so the supply can compensate for any voltage drop in the test leads (see Figure 1). If a multiple channel power supply is being considered, then it's worth having remote sensing on all channels.

No matter how accurate the power supply output is, it cannot be guaranteed that the programmed output voltage is the same as the voltage at the DUT's load. This is because a power supply with two source terminals regulates its voltage only at its output terminals. However, the voltage that needs regulating is at the DUT's load, not at the power supply's output terminals.

The power supply and the load are separated by lead wires that have a resistance, R_{lead}, determined by the length of the lead, the conductivity of the conductor material and the geometry of the conductor. Without remote sensing, the voltage at the load is:

$$V_{Load} = V_{Programmed} - 2 * V_{Lead}$$
$$= V_{Programmed} - 2 * I_{Load} * R_{Lead}$$

If the load requires high current, then I_{load} is high and V_{lead} can easily be a few tenths of a volt, especially if the power supply leads are long, as can be the case in an automated test rack. A voltage at the load could easily be 80mV to 160mV lower than the desired voltage (with 2A to 4A flowing through a five foot length of 0.004Ω/foot, 16-gauge wire).

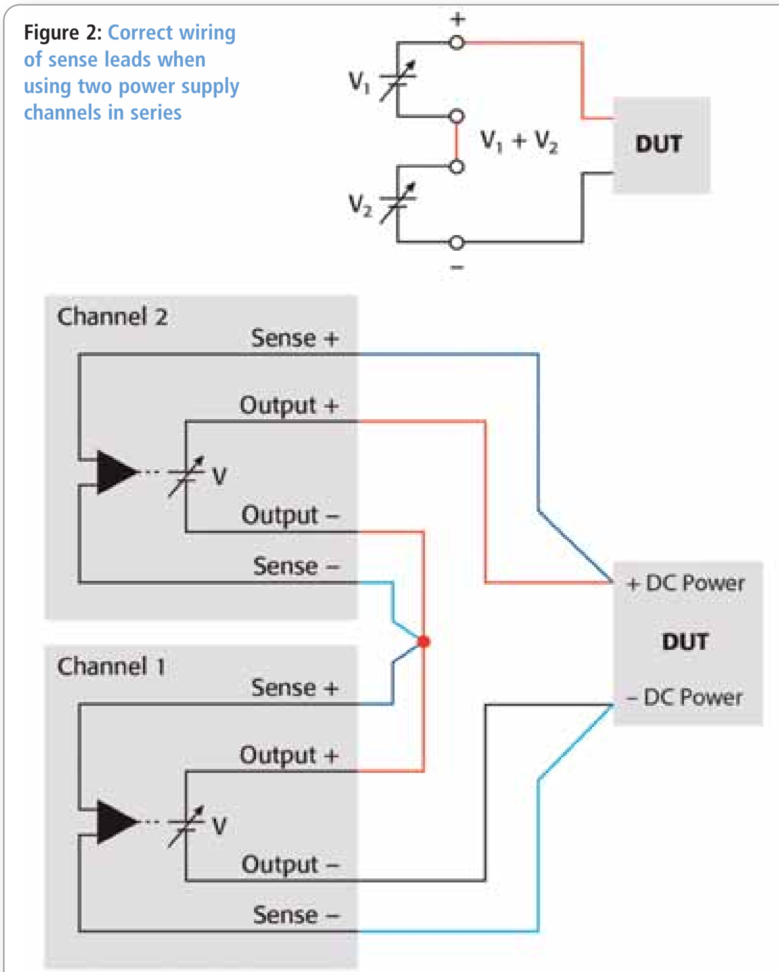


Figure 2: Correct wiring of sense leads when using two power supply channels in series

The remote sensing technique solves the problem of voltage drop in the leads by extending the power supply feedback loop to the input of the load. Two sense lines from the power supply are connected to the power inputs. These sense leads are voltage measuring lines that connect to a high impedance voltage-measuring circuit in the power supply. Since the voltage measuring circuit is a high input impedance circuit, the voltage drop in the sense leads is negligible, and the sense lead voltage measurement circuit becomes the feedback control loop for the power supply. The voltage at the load is fed back to the power supply by the sense leads. The power supply raises its output, V_{out} to overcome the voltage drop in the source leads so that $V_{lead} = V_{programmed}$. Thus, only with remote sensing can the accuracy of the power supply be applied to the load.

> It's important to know exactly what the application requires, so the selected supply delivers the required power at the levels of voltage and current at which it will be tested

If a multiple channel power supply is considered, make sure the supply has isolated channels. Isolated channels offer the most flexibility for expanding the voltage and the current capacity of the power supply. With isolated channels, two identical channels can be either combined in series to double the voltage output or combined in parallel to double the output current. To ensure the programmed voltage is delivered to the load, it's best to select a multiple channel power supply with remote sensing connections for each channel. There is additional wiring complexity, but it is outweighed by the accuracy of the voltage at the load.

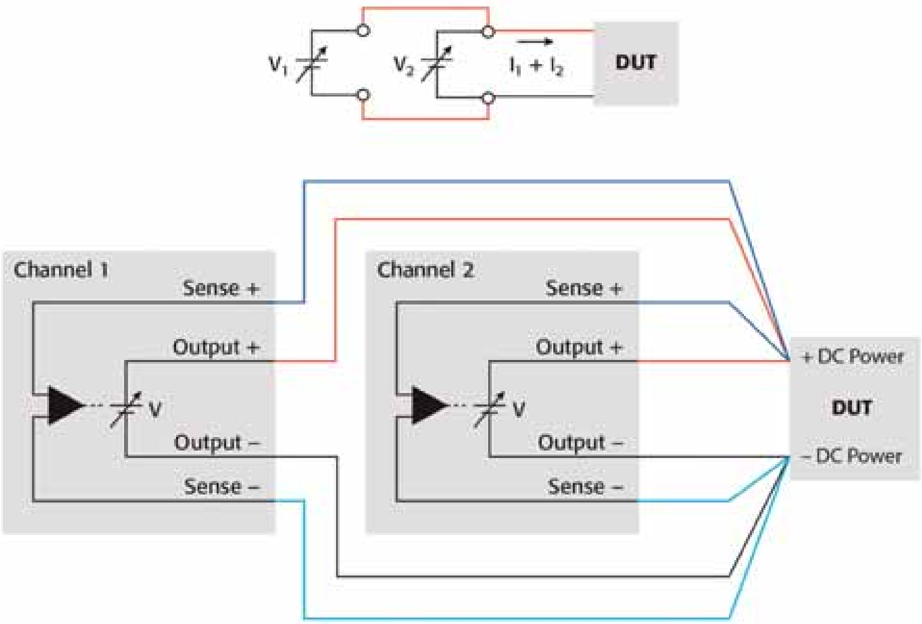


Figure 3: Correct wiring of sense leads when using two power supply channels in series

Using Multiple Channels

When using multiple channels to output a higher voltage or current than a single channel alone could output, it is important to ensure that the remote sense connections are properly configured. Each channel's sense lead must monitor the voltage of its channel only. For a series connection of channels to increase voltage, the sense lines between the DUT and the common point of the two channels should be connected (see Figure 2). This will ensure that each channel's sense lines monitor only the output of their channel, and the total voltage at the load is the sum of the programmed voltage without any loss due to voltage drops in the output leads. To avoid any small differential voltage between the sense leads, the common sense leads should be connected to the same point at the common output connection. This could create a small error in the voltage at the load. The wiring for a parallel connection of two channels is more straightforward (see Figure 3) since both channels are operating at the same voltage.

A multiple channel power supply can be used to power a bipolar circuit. The connection scheme is similar to the series combination of two channels, with the addition of a connection from the common point of the two channels to the common of the bipolar DUT.

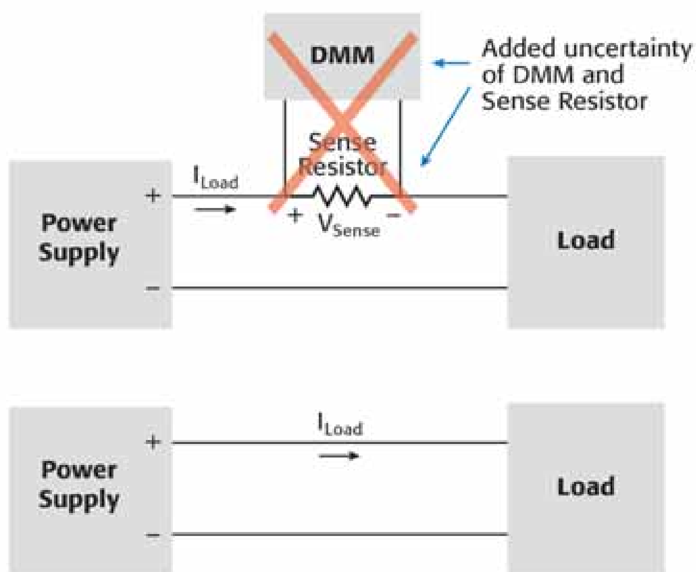


Figure 4: Use a power supply with good current measurement accuracy and reduce test bench or production test system complexity

Accurately Measuring Load Currents

To measure the current the load is drawing, a sense resistor could be placed in the line and a DMM used to measure the voltage across it. The measured voltage divided by the sense resistor's resistance determines the load current. Alternatively, the DMM could be inserted in series with the power supply and load to directly measure the load current.

Using either method means adding another instrument to the circuit, which could add another voltage drop due either to the sense resistor when the DMM is measuring voltage or the internal shunt resistor when the DMM is in current mode.

By selecting a power supply with good readback accuracy and high resolution, the power supply can measure the load current directly without the complexity of the sense resistor and the DMM (see Figure 4). Some power supplies have current measurement accuracies as good as 0.05%. This is equivalent to the current measurement accuracy of 5½-digit DMMs and even some 6½-digit DMMs. The extra complexity and cost of adding another instrument in the test circuit can thus be eliminated.

Minimizing Internal and External Noise Sources

When powering a circuit that measures very low signals such as a transducer that must pick up millivolts or microamp current signals, then noise sources may cause problems. The power supply itself is one noise source, and this noise can be broken into two components: normal mode noise and common mode noise.

Normal mode noise is noise generated across the power supply's output terminals due to the power supply's internal circuitry. Common mode noise is earth-referenced noise originating from the power line and stray capacitance across the main transformer. For sensitive circuits, linear power supplies provide much lower normal mode output noise than supplies designed using switching technology. The trade-off is that linear power supplies have low power-conversion efficiency and can be heavy and large. Switching supplies are endowed with improved power conversion efficiency and can house more output power in a smaller enclosure. A linear supply can have five-to-ten times lower noise (< $5mV_{pp}$ vs > $50mV_{pp}$) than a switching supply. Whenever noise is an important concern, a linear supply should be used.

Linear power supplies also generally have lower common mode noise than switching supplies. Common mode noise is generated whenever changing voltages, such as AC voltages and transients (dv/dt) on the primary windings of an isolation transformer couple current across the barrier. Whenever this current flows through impedance a noise voltage is generated, which under some circumstances can degrade the DUT performance or cause measurement inaccuracies.

The magnitude of the noise term is primarily related to the stray capacitance of the power supply transformer. Voltage transients from rectifier diodes turning on and off and either the 60Hz line movement or the abrupt voltage transient common with switching power supply's primary circuits are also sources of common-mode noise.

Figure 5 shows a simple block diagram of a power supply. Good quality transformer construction with sufficient shielding between primary and secondary can minimize the stray capacitance. If the transformer primary and secondary windings are not shielded sufficiently from each other, then the coupling capacitance can be large and milliamps of current can flow into the load. This common mode current can create performance problems and load current measurement errors. When developing or testing low power and sensitive components, modules or end products, a power supply with low common mode performance should be used. A good, low common-mode current specification is under 10µA.

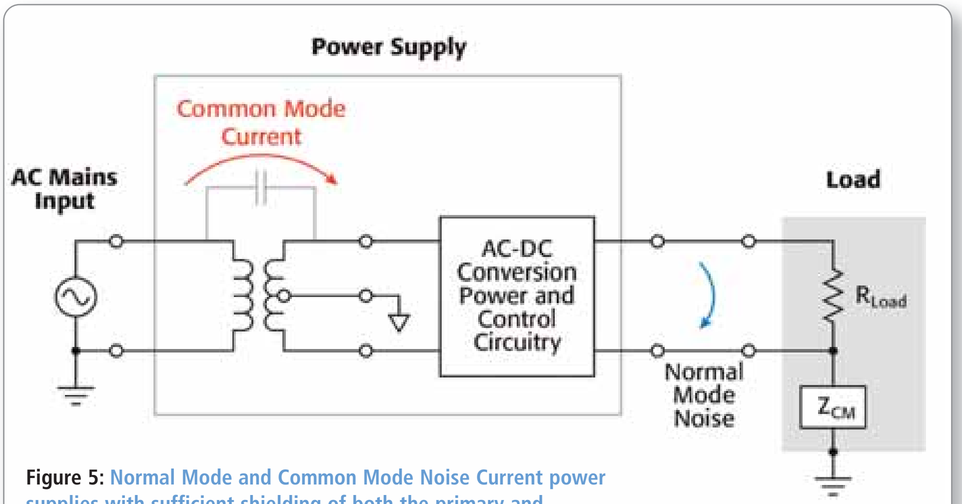


Figure 5: Normal Mode and Common Mode Noise Current power supplies with sufficient shielding of both the primary and secondary windings keep common mode current low

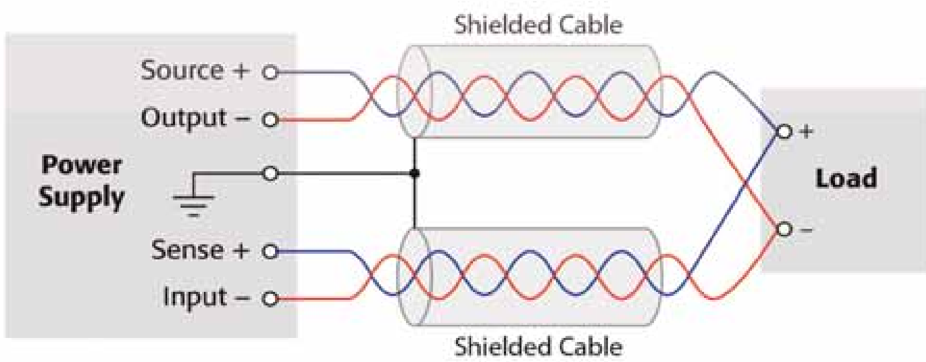


Figure 6: Keep external noise out of both, the sense leads and the source leads, by using shielded cable, and also keep the sense leads separate from the source leads

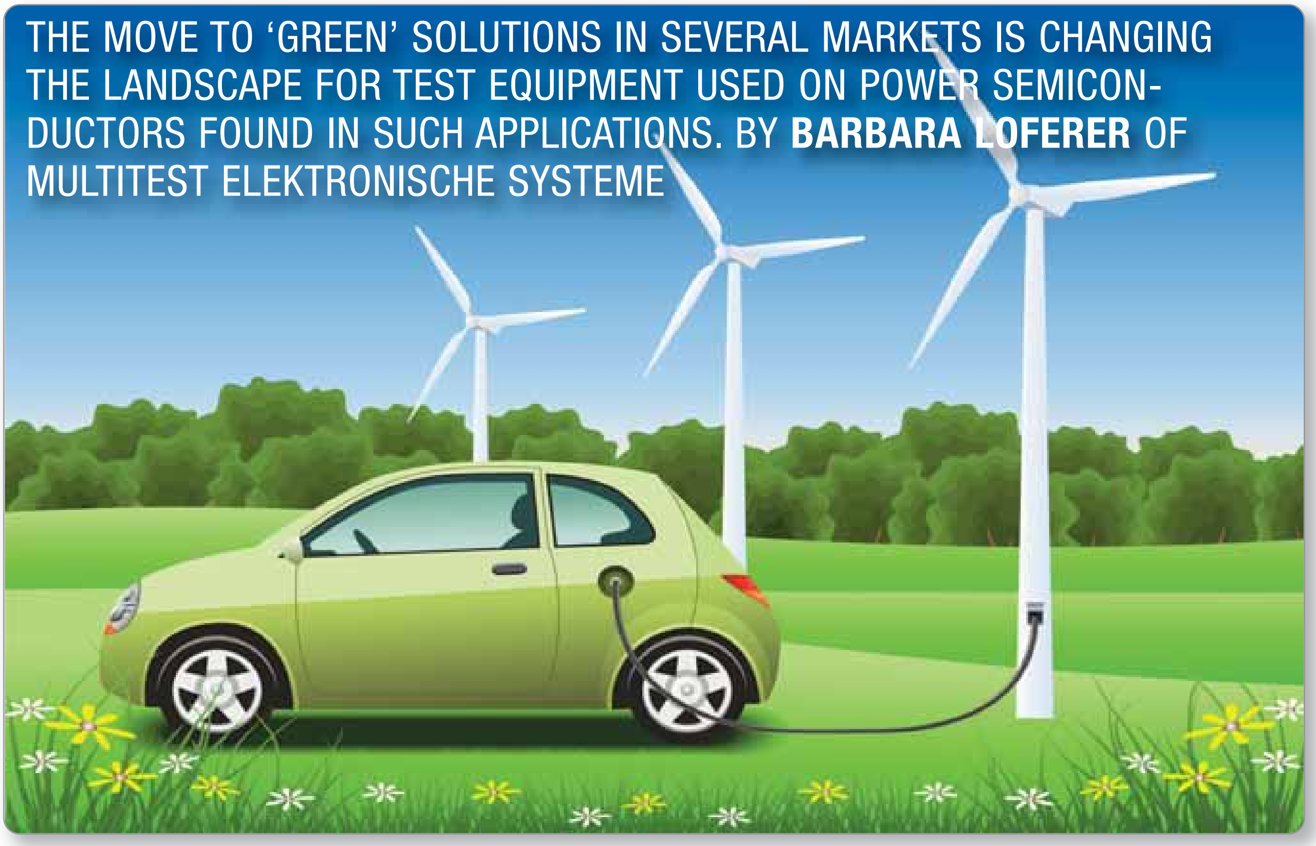
In addition to minimizing noise sources within the power supply, it is important to keep environmental noise out of a low level signal detection circuit. For that reason, shielded cables should be used to source power and feed back the remote voltage to the power supply via the sense lines.

The sense lines should always be shielded and separate from all other wiring since they are transmitting a signal to a high-impedance-input measurement circuit. Even small amounts of current can create a large error voltage in a high impedance circuit. For DUTs that measure small signals, the source lines should be shielded as well to eliminate all potential sources of interfering signals (see Figure 6). Finally, ensure the circuit is grounded at only one point to eliminate ground currents which can create error voltages in conducting pathways.

Knowing the Power Supply

While simple from the standpoint that power supplies are single-function instruments, is wise to investigate thoroughly a power supply's performance and features to verify that it will meet both current and future requirements. The supply's power envelope should be reviewed to ensure it has all the needed capacity.

For maximum accuracy, remote sensing should be used, making sure the measurement accuracy is sufficient. The power supply's design topology (linear vs switching) and its noise performance should be known. Then, use good measurement techniques to take advantage of the supply's performance. A good review upfront will ensure that the power supply is of the same caliber as the rest of the instrumentation used. ●



THE MOVE TO 'GREEN' SOLUTIONS IN SEVERAL MARKETS IS CHANGING THE LANDSCAPE FOR TEST EQUIPMENT USED ON POWER SEMICONDUCTORS FOUND IN SUCH APPLICATIONS. BY **BARBARA LOFERER** OF MULTITEST ELEKTRONISCHE SYSTEME

"GREEN" EFFORTS INCREASE DEMAND FOR HIGH POWER SEMICONDUCTORS

The demand for power semiconductors is mainly driven by environmental trends such as energy saving and investment in clean energy. The efforts for sustainability and efficient use of electricity can be predominantly found in the industrial and automotive segments but also in the consumer electronics industry. Some typical applications are solar and wind power generation plants, electric power steering and the idling-stop systems in hybrid electric vehicles.

In the consumer electronics market, so-called white goods striving for energy savings will be a major application. Air conditioners, refrigerators and washing machines are examples here. Besides a higher general environmental awareness and a general understanding of the limitation of resources, governmental subsidy policies in many countries further support this.

Many of the established semiconductor manufacturers offer power ICs and discrete components for these applications, in packages that are often very mature. They ensure well established processes, but at the same time are not optimized for today's state-of-the-art production methods. Typically, packages such as TO, SO and QFN are seen nowadays, and IGBT power modules are applied for extreme current requirements. However, dedicated and more exotic packages are emerging for power applications too.

Final Test of Power Semiconductors

Final test is a functional test of the device before it is shipped to the customer. Many who are not involved in the back-end processes of semiconductor manufacturing are not aware of this very last step in production, and those who are aware of it don't like it as it adds cost, but no value – except ensured quality.

Reliable operation of power semiconductors is crucial for critical applications such as cars. For other uses, it is simply more cost-efficient to get a tested package rather than taking the risk that a malfunction will be discovered only after the semiconductor is already in the final product.

A typical test cell for final test consists of:

- Tester (ATE)
- Handler
- Load Board
- Contactor(s).

The tester (ATE) performs measurements, evaluates the test results and is capable of diagnosing faults. The handler loads the devices from their transport media (e.g. a JEDEC tray or a tube), soaks them thermally to the required test temperature, then inserts them into the contactor and finally sorts them according to the test results.

Load board and contactor(s) are

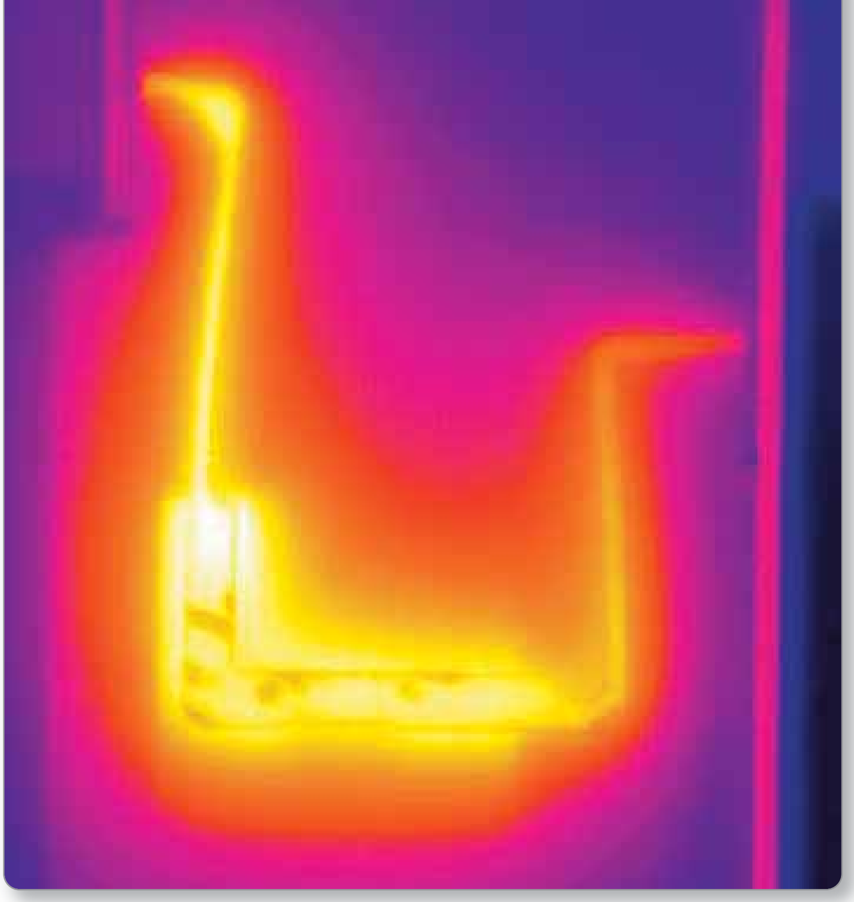
electrical interfaces between the device under test (DUT) and the tester. Whereas the load board is designed according to the tester requirements, the contactor is the socket where the DUT is inserted for test and therefore is more precisely determined by the package itself.

General Requirements For Final Test

General requirements for final test also apply to the test of power semiconductors. Some general conditions that need to be fulfilled by the test cell and its components to make it as cost-efficient and productive as possible:

- **Accuracy.** Accurate measurements are essential in order to provide valuable information about the tested devices – in production as well as development. For the handlers it is positioning accuracy to ensure highest yield and thermal accuracy for test at high (up to 200°C) or low (down to -55°C) temperatures, e.g. for automotive applications. The maximum temperature drift for high power automotive applications is in the range of ±3°C at the test site.
- **Speed.** For the tester, this is the actual time needed to perform the electrical test (test time). For the handler, it is the time needed for internal material transportation, time for soaking and time for exchanging the DUT at the contact site to the tester. State-of-the art testers feature short test-times. The handler needs to be fast enough so it doesn't limit the full range of the advanced tester capabilities. Maximum achievable overall speed directly transfers to test cell throughput. With low throughput, the test cell can create a potential bottleneck and slow the entire production process.
- **Reliability.** Reliability of the test cell equipment avoids unscheduled downtime but also ensures the reliability of the test results that may be otherwise negatively influenced by bad contacting performance, mis-sorting of the packages after test etc.
- **Modularity.** In order to add or improve some testing functionalities, the test equipment must be able to evolve. This can be achieved primarily through the modularity of the entire test cell, as well as of the tester and handler on their own.

Figure 1: Image from an IR camera



> The focus on 'Power Integrity' simulation is currently less understood than traditional signal integrity, but the time is approaching when it will become essential in order to achieve a successful result

Special Test Requirements

High power is a challenge when testing high-power semiconductors. This mainly concerns the tester (ATE), but also the test interfaces (load board and contactor). Safety issues due to high-voltage/high-current also need to be considered.

Arcing is another issue. Measures for avoiding equipment damage on the resulting from arcing must be established. Finally, thermal stability during test also requires special attention.

Also, testers need to ensure low parasitic effects. This point is very important in power semiconductors testing. Modularity and removable devices-under-test inevitably lead to more connection wires and therefore to increased parasitic inductances, when compared with operation in industrial power converters. This parasitic effect must be reduced as much as possible in order not to reduce the testing capability of the ATE (achievable di/dt and safe testing area). This requirement becomes more and more important as the current-over-voltage ratings of the device-under-test increase.

Handlers for High Power Semiconductors

Dedicated handler set-ups are able to ensure the required temperature accuracy at the DUT by advanced


Figure 2: LEMSYS tester TRd 2030

thermal control features. The measurement and adjustments need to take place at the DUT while it is inserted; doing this at the soak station alone will not suffice.

In order to avoid arcing, the clamping of the DUT has to be of dedicated materials and design. High-voltage and/or high-current are dangerous situations and the handlers must have safety features that stop testing as soon as they are no longer docked to the tester. This mechanical event needs to be recognized by the handler and communicated to the tester.

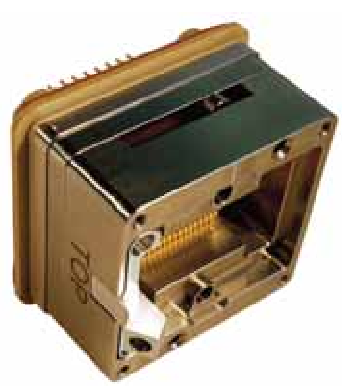


Figure 3: Multitest ecoAmp

Large packages are often deployed for power semiconductors. This requires sufficient soak capacity of the handlers; otherwise soaking will slow down the handler and, finally, decrease the test-cell throughput.

Most of the high power semiconductors are tested single site (one DUT inserted at one point in time). However, once the parallelism increases, the handler needs to support the load board design with sufficient widely-spread contact sites.

Load Boards for High Power Semiconductors

A combination of higher currents, lower voltages and faster switching speeds are creating increased problems with Power Distribution Network (PDN) design and thermal control on the device interface board (DIB). Those designers who take a 'rule of thumb' approach to PDN design are now getting caught out by inadequate or inappropriate decoupling strategies and networks whereby the entire loop inductance budget is used up on the board.

Power supply planes, capacitor choice and capacitor placement, as well as the return path of the power supply must all be carefully considered in order to prevent IR drop problems. Power supply sensing must be considered on an application-specific basis rather than a 'one size fits all' approach.

Just as increasing signal speeds led to an increase in high-speed simulation, the new demands on PDN design are now bringing into focus 'Power Integrity' simulation, and while this is currently less understood than traditional signal integrity, the time is approaching when it will become essential in order to achieve a successful result.

The DIB designer needs to ensure that heat generated within the board due to high current, particularly under large BGAs, does not approach the glass transition temperature (Tg) of the board material. However, in the specific area of ATE where thermal stability is crucial, it is also important not to create such an effective heat sink that the board influences the stability of 'hot' testing.

Contactors For High Power Semiconductors

There are two major issues that contactors for high-power semiconductors need to address: resistance stability and temperature stability. Thermal management and highly accurate symmetry to share the current load is important for high current applications, as some applications run up to several hundred amps and current is shared by more than one contact pin. In addition, heat caused by high currents must be reliably dissipated by the right materials using innovative designs. Only contactors optimized for these challenging applications will have a reasonable life span.

Resistance stability is influenced by

Figure 4: Multitest MT2168

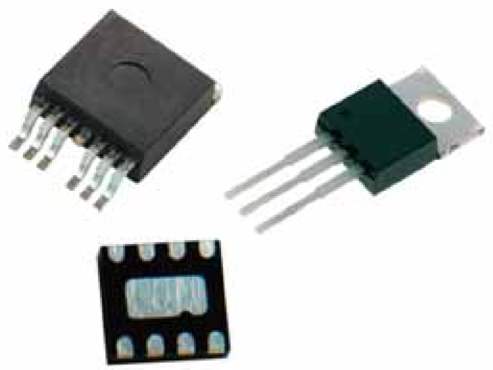


Figure 5: Typical high power ICs

the contact spring itself and the condition of the device pin. Since TO/DIP packages are often used for these high power applications, old molding tools are used, which generate an extreme amount of debris/mold flashes on the IC leads, which in turn causes high contact failure rates.

Temperature stability is not easy to achieve. Due to the inductance requi-rement to enable fast signals, the length of the contactor pin is limited. A short length limits the thermal insulation in the contact area. In addition the contact springs will be quite sizeable to carry the current, which will end up with a very good thermal coupling between board and IC. Many massive copper layers in the board will also act like a "big heat sink". Integrated solutions of load board and contactors with insulation on the tester side of the load board are one way to ensure the required temperature accuracy.

Meeting the Challenges

Final test of high power semicon-ductor is an electrical challenge, but also requires partnership solutions with the equipment suppliers. Generally, the testing of power semiconductors follows the rules of standard semiconductor test, but it can add even more compre-hensive requirements to the test cell components.

Now, special solutions are emerging and will continue to do so. Some examples are the Lemsys tester (TRds 2015-2020) and the Multitest ecoAmp Kelvin contactor. To address the special test requirements of power semicon-ductors, optimizing each single test-cell component individually will not result in a satisfying performance. Optimum test set-ups can be developed by inter-disciplinary collaboration of the suppliers of the tester, handler, load board and contactor.

Understanding the features of the other test cell components, which are particular to the support of high power test, is a start. Defining ideal interfaces supporting these features can be the next step. At the end of the day, equipment vendors need to understand the overall setup and finally deploy suitable methods across all components to optimize the functions and features. The handler-tester communication to avoid safety issues and the thermal insulation on the load board are some examples of this approach, which have been addressed here. ●

RADAR AND RADIO RANGE SIMULATION USING FIBRE OPTIC DELAY LINES

JERRY LOMURNO AND **JOE MAZZOCHETTE** OF EASTERN OPTX DESCRIBE HOW TO USE FIBRE OPTIC MICROWAVE DELAY LINES (FODL) – A RELATIVELY NEW TECHNOLOGY – TO ENABLE THE MEASUREMENT OF KEY RADAR PARAMETERS

Outdoor range testing of radio and radar systems is costly, complex and time-consuming. Fibre Optic Delay Line (FODL) systems are used in test and development laboratories to eliminate this type of test, with the main advantage of simulation repeatability.

FODL eliminates environmental anomalies such as weather and interfering transmissions. Planning and preparation costs of setting up range tests alone are all too often lost due to very minor unforeseen operational and system errors. Thousands of dollars and hundreds of hours can be saved using FODL in place of, or together with, reduced range testing.

Among the other advantages of FODL systems are:

- Dramatic savings in test cost and time, keeping projects on time and under budget;
- Accuracy, repeatability and reliability;
- In-lab testing up to 150 miles, including "range formula" level set;
- Designers can perform device under test (DUT) optimization in a lab;
- Brings testing into 21st century by combining optics with microwave technology.

Delay Line Core Technology

Fibre optic delay line technology enables the conversion of microwave signals to optical signals (E/O), time delaying the signal, then reconverting the light back to original microwave signal (O/E). This method results in superior fidelity over traditional time delay methods. Products using this technology include radar target simulation, radar altimeter testing, channel simulation (air interface) and multipath creation. This approach allows users to test in the lab, resulting in dramatically lower costs and higher efficiencies than available with outdoor test ranges.

Systems are available with fixed or programmable delays ranging from a few nanoseconds (2 feet) to hundreds of microseconds (150 miles), input RF frequencies of up to 40GHz and internal attenuation control that accurately simulates free space propagation loss. All features can be touch-screen controlled using an intuitive graphical user interface (Figure 1).

Airbus cockpit

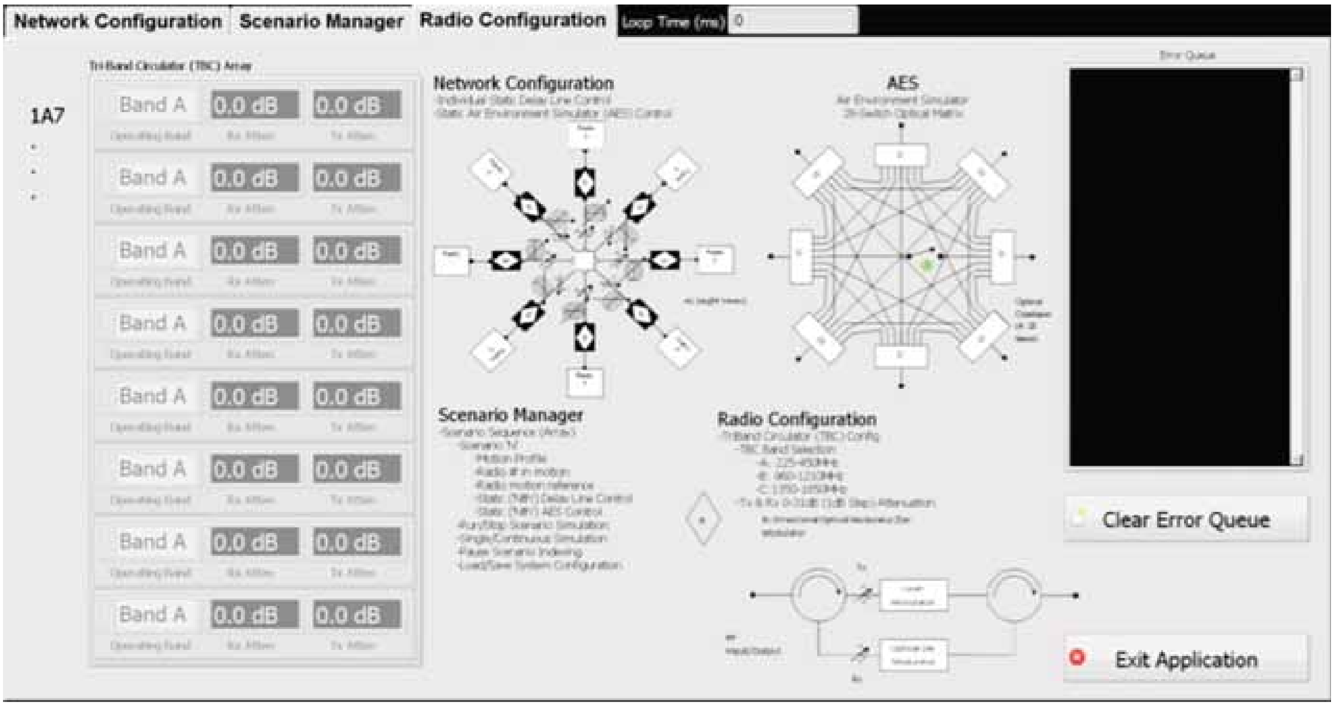


Figure 1: All features of the Eastern OptX Series 7000 can be controlled on a touch-screen using the intuitive graphical user interface shown here

Testing 95% of a radar system has always been an easy and interesting task. An abundance of test equipment has been available since the mid 1940s to do the job, including spectrum analyzers, power meters, signal generators, oscilloscopes, etc. Pulse width, frequency, rise/fall time, pulse profile, even FM deviation of chirp signals can easily be measured with a relatively simple suite of test equipment.

However, "live" testing for range accuracy is expensive, time consuming and, in many cases, not as accurate as needed, not to mention the community's concern about radiating high-power microwaves over the local population. To test a radar range, usually an airplane is sent out that squawks its position continuously while the tester monitors the radar's range indicator for accuracy. Radar return signal quality is diminished by weather conditions, multipath interferences, as well as by other transmitting signals nearby.

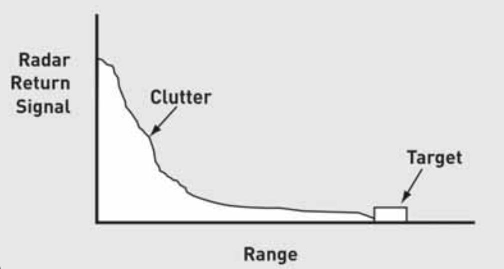
Shorter range radars can use fixed targets such as putting a radar reflector on bore site towers, existing structures such as tall buildings, or even mountains. Again, the neighbourhood and environment represent certain impediments. In fact, many modern types of radars transmit signals with complex phase modulation so any wobble of a bore site tower makes the reflections useless.

Receiver Sensitivity

Since a radar system processes everything that bounces back into the receiver, signals from buildings, trees, ground reflections and even water (ground and sea clutter) show up as noise (Figure 2). In order to accurately measure the minimum discernible signal (MDS), the test engineer needs the target return to be out beyond the clutter. Until recently, a delaying pulse generator and signal generator set to a radar's transmit frequency could adequately replicate this scenario (Figure 2). Again, now that these radars use complex modulation and/or frequency hopping on the TX pulse, the pulse/signal generator becomes useless.

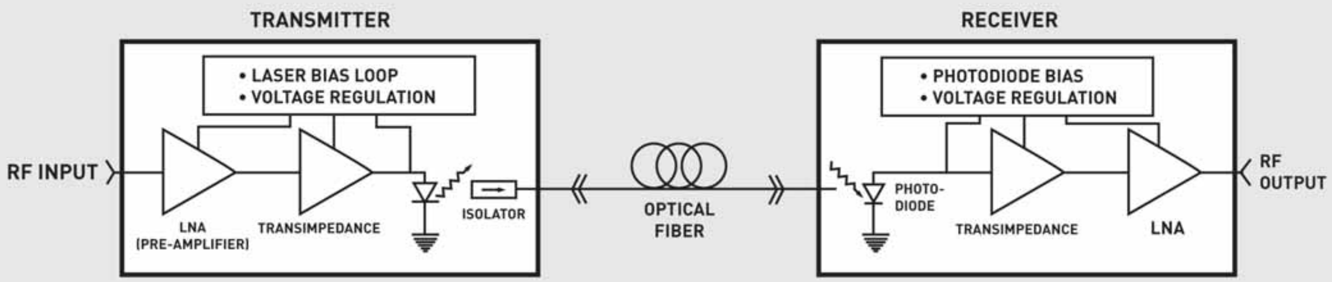
> "Live" testing for range accuracy is expensive, time consuming and not as accurate as needed, not to mention the community's concern about radiating high-power microwaves over the local population

Figure 2: A typical radar return display showing why a target must be out beyond clutter returns in order to measure MDS (minimum discernible signal) level



Today's high technology digital radios require all the tests and simulations mentioned above. In addition, they also require extensive field testing for interoperability, rejection of interference and, in most cases, position location algorithm verification. FODL-based products accommodate up to eight radios operating in full duplex mode. An innovative operator GUI makes use of mapping graphics, allowing the

Figure 3: Block diagram of Eastern OptX unidirectional FODL. For bidirectional systems F/O circulators are incorporated along with two light sources set at different wavelengths



operator to position each radio via drag and drop. The system is scalable when more than eight radios need to be tested.

Benefits of utilizing FODL for radio testing include:

- Reduced test preparation time and cost;
- Reducing expensive, time-consuming field testing;
- Increased accuracy and repeatability;
- Broad instantaneous bandwidth;
- Protocol agnostic;
- No radiation;
- Secure – no sensitive protocols are transmitted to the outside world;
- No cumbersome regulatory approvals required;
- No safety hazard to community.

Fibre Optic Delay For Superior Performance

Delay line technology developed by Eastern OptX uses optical signals offering superior performance over competing techniques (Figure 3). The radar's transmit signal is used to modulate a light source, which is then connected to a proprietary-wound optical fibre coil. The coil length is selected to produce a specific time delay. The output of the fibre terminates into an optical receiver that then demodulates the signal, faithfully reproducing the original electrical waveform.

Fibre-based delay lines offer greatly reduced insertion loss and dramatically improved signal quality. They have a constant delay versus frequency, are immune to vibration and are largely resistant to electromagnetic interference. Furthermore, fibre delays do not radiate energy that may interfere with the operation of other electrical devices or allow unauthorized detection.

Since fibre is athermal, the fibre optic approach does not require complex thermal control. Finally, the fibre optic system is smaller, lighter and lower loss than the coaxial transmission line approach. For example, a 1km fibre optic delay (5μs) will produce less than 0.04dB of loss, weigh less than 0.45 pounds and require a spool that is less than 3.5 inches in diameter and less than 2.5 inches tall.

Using optical switches, multiple delay lines may be configured in parallel or serial groupings. These configurations provide either low loss fixed delays or a binary summation of multiple delays which allow the user to change the total delay in small step sizes. Figures 4 and 5 show block diagrams of the two approaches. A hybrid of both configurations is also possible.

Fibre-based delay lines can deliver superior performance, higher reliability, reduced manufacturing costs, reduced size, reduced power consumption, EMI/EMC/vibration immunity and longer life cycles. Fibre-based delay lines are a much-needed test and simulation tool for radar systems of the future and for refurbishment of existing aging systems.

Fibre optic delay lines are also available with programmable attenuation set to "range formula", Doppler shift, full duplex for testing transponders, radar repeater systems with built-in GPS position reporting, ability to insert interfering signals and multipath options with variable range and amplitude. ●

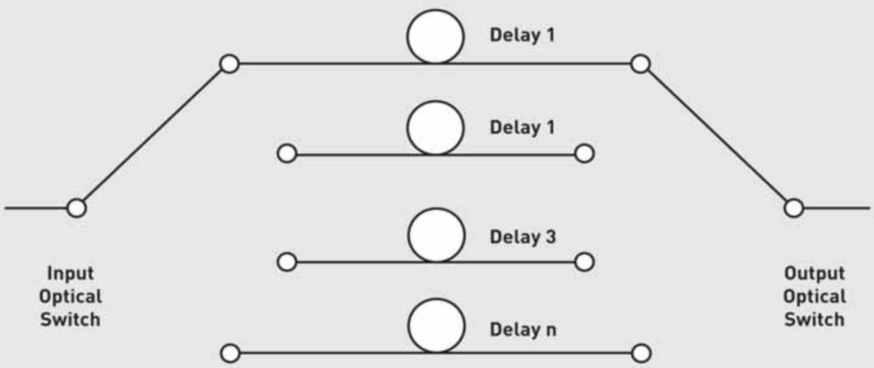


Figure 4: Parallel configuration of multiple delay lines using optical switches

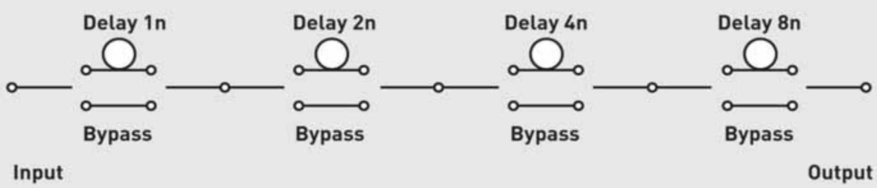


Figure 5: Serial configuration of multiple delay lines using optical switches

BOUNDARY-SCAN TESTING IN THE REAL WORLD

MOST OF THE MATERIAL PUBLISHED ABOUT BOUNDARY-SCAN TESTING HAS BEEN THEORETICAL. HERE, **JAMES STANBRIDGE**, SALES MANAGER UK OF JTAG TECHNOLOGIES, INTRODUCES THE BASICS OF THIS WIDELY USED PCB TEST METHOD AND OUTLINES A REAL-LIFE USER CASE STUDY

The boundary-scan test architecture was developed in the late 1980s by an ad hoc group (the Joint Test Action Group or JTAG committee) whose initial aim was to solve the problems associated with building and testing PCBs that would (back then) soon start using Surface Mount Technology (SMT) components.

The mechanism that the JTAG committee was to introduce comprises a chain of test cells linked together to form a so-called boundary-scan register in each compliant part. These test cells can subsequently control the compliant part's output pins in order to drive test patterns onto PCB interconnects and also sample these values on corresponding input pins.

Data flow through the part is controlled by a compact state machine known as the TAP controller (where TAP is the Test Access Port) and the entire structure is accessed via four (sometimes five) pins known as TDI (Test Data In), TDO (Test Data Out), TCK (Test Clock) and TMS (Test Mode Select) with an optional reset line TRST (Test Reset). See Figure 1.

The acronym 'JTAG' stuck as the name for the group's solution, which was formally established as IEEE 1149.1 in 1990. Subsequently, as the JTAG-initiated standard gained acceptance throughout the 1990s, a number of boundary-scan tool vendors introduced solutions, mostly aimed at PCB manufacturing test.

The tools they developed took basic design information from CAD tools to create quickly so-called structural tests for detecting short- and open-circuits, and also to perform simple logic tests on memories, bus logic and so on.

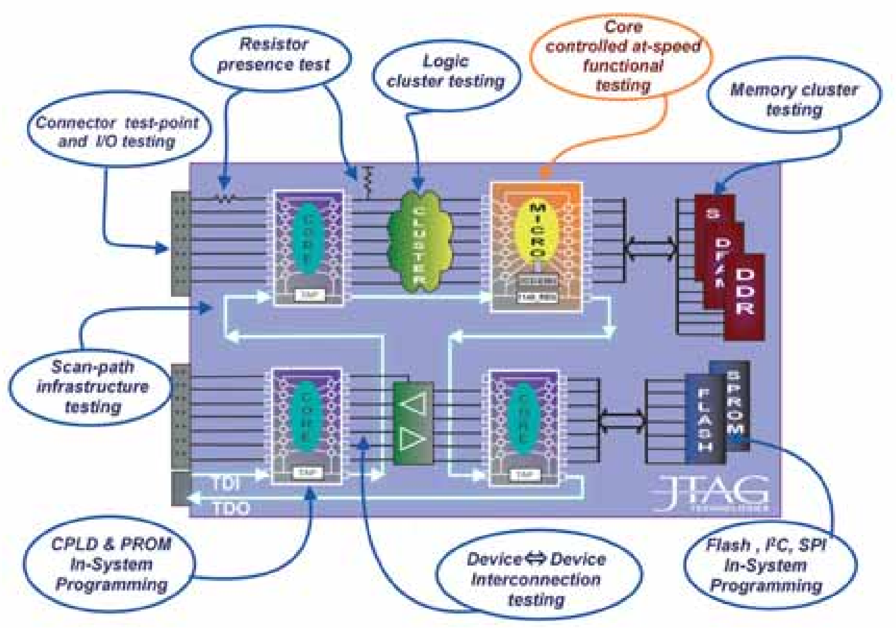


Figure 1: A reminder on how boundary scan is implemented at board level with boundary-scan components daisy-chained together. The Test Data Out (TDO) of one device connects to the Test Data In (TDI) of the next, and so on. Not shown here, three other boundary-scan signals – Test Clock (TCK), Test Mode Select (TMS) and Test Reset (TRST, if present) – are effectively in parallel with compliant devices. The balloons illustrate the variety of tests and programming applications that can be developed using boundary scan.

Access Granted

One well-known UK electrical test company which now uses JTAG as an integral part of its manufacturing process is Megger, based in Dover. A first-time user of boundary-scan technology, Megger turned to JTAG Technologies to help with a new range of Portable Appliance Test (PAT) units.

The name Megger is synonymous with portable electrical test equipment and the company is always striving to bring high-performance products to market. Recently, the company designed a new family of PAT testers with an impressive range of features including: an internal database for results storage, rapid start-up and instant re-start after temporary disconnection when moving between test locations.

Each member of the product family contains four analogue/mixed-signal cards and a processor card (which Megger wanted to be common to all family members).

Megger selected the credit-card-sized SODIMM form-factor for the processor card, which contains an Atmel processor, NOR and NAND Flash, SDRAM and an Ethernet IC. The card's 200-pin edge connector interfaces with the analogue/mixed-signal cards and a TFT display.

As part of its manufacturing processes Megger would normally test the card using an ATE bed-of-nails, but with components – including three BGAs – mounted on both

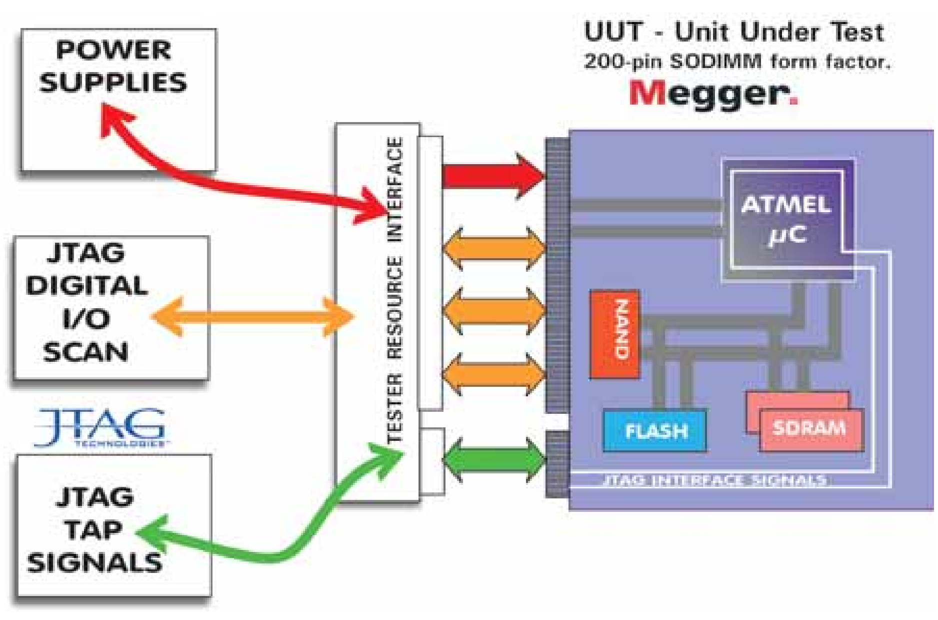


Figure 2: Basic layout of the board and tester interface. During the boundary-scan test phase the board is tested for valid interconnection to the external DIOS hardware; crucially testing the SODIMM interface and looking for shorts between pins on the Atmel processor. On the board itself further tests take place on the interfaces to the memory parts (SDRAM, NOR Flash and NAND Flash), additional logic 'clusters tests' also check out the functionality of logic blocks.

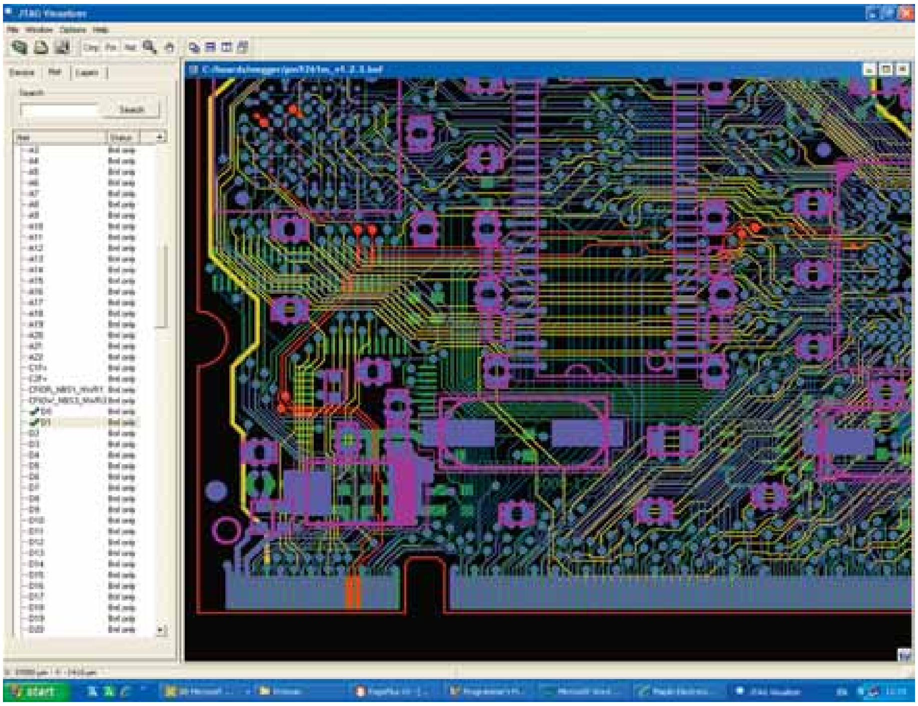


Figure 3: Megger used JTAG Technologies's Runtime and Visualizer tools to pinpoint any manufacturing problems, where the latter works by superimposing the boundary-scan application on to the PCB layout/schematic. The above screen is highlighting two suspected data-lines that might be short-circuited.

sides of the board that was not an option. They simply had no room for test points.

However, one device – the Atmel processor – is boundary-scan capable. Could that be utilised? Megger consulted JTAG Technologies, who established that even with just one boundary-scan device available test coverage of around 75% would still be possible.

The solution devised was a dedicated test card (housed in a test box) that mates with the 200-pin edge connector of the processor card. The test card has two JTAG headers: one to access the Atmel device, the other to control boundary-scan devices that connect to the edge connector, and thus access many nets on the processor card. See Figure 2.

By connecting the processor card to the test board and controlling it via boundary-scan, Megger's engineers can exercise all of the signal lines on the 200-pin connector. If there is a track or connector pin damaged, or shorts between SMD pins/pads, the interconnect test will find it. Then, having confirmed the integrity of the interconnects, Megger is able to check the correct fit and read the IDs of the memory devices.

The company uses JTAG Technologies's Runtime and Visualizer tools to pinpoint any manufacturing problems, where the latter works by superimposing the boundary-scan application on to the PCB layout/schematic. See Figure 3.

The tools enabled Megger to refine its manufacturing processes when going into production by helping the engineers make judgement calls on re-work. For example, if the fault was with the seating of an SMD resistor pack or BGA-packaged device, then stencils were adjusted and the reflow oven tuned.

Megger is currently very close to achieving 100% yield.

Latest Developments

Though not employed in the project above, boards like Megger's processor card can also benefit from other JTAG-accessed test features. For example, in 2011 JTAG Technologies released its CoreCommander range of chip access modules.

Unlike traditional JTAG/boundary-scan tools, CoreCommander functions control pins not by the conventional serial boundary-scan register (BSR) but by taking control of a processor's core; usually via the device's on-chip debug (emulation) mode.

Presently the CoreCommander range supports ARM7, ARM9 (as featured in the Atmel part used by Megger) ARM11, Cortex , PowerPC and others. The benefits of device access via the core include faster test operation (often at system clock speed) plus access to mixed signal peripherals such as built-in ADCs that would allow analogue measurements to be registered and checked via JTAG.

The Future

As more and more designers and production engineers see the benefits of improved time-to-market thanks to a less frustrating debug phase and rapid new product introduction, the use of JTAG for both prototype debug and production test is predicted to increase rapidly while the cost of tools is likely to continue to fall.

You can also expect that the JTAG-accessed on-chip debug features will be joined by BIST (Built-In Self Test) logic 'cores' (for example embedded into FPGAs) that will provide further 'at speed' testing opportunities for peripherals such as DDR memories.

Further additions to the JTAG standard, including IEEE Std. P1687, should also define mechanisms to access embedded 'test instruments' to offer even more value via the tried and trusted JTAG port.

A FREE TASTE OF JTAG

HIGH-END JTAG/BOUNDARY-SCAN TEST DEVELOPER TOOLS CAN RUN TO SEVERAL THOUSANDS OF POUNDS, DEPENDING ON THE FEATURES REQUIRED. HOWEVER, YOU CAN TRY OUT BASIC BOUNDARY-SCAN FUNCTIONS AT NO COST BY DOWNLOADING THE LATEST RELEASE OF JTAGLIVE BUZZ.

The Buzz utility is an interactive continuity tester and pin sampler that connects to your unit under test via any of a number of supported JTAG controllers (e.g. Altera USBBlaster, JTAGLive controller Xilinx downloader).

Since the system requires no CAD data – only basic scan chain details – you can be up and running in minutes. Its main use is to 'buzz out' pin-to-pin connections, as you might with a DMM; however a multiple-pin drive and sense feature extends the capabilities to allow simple logic tests to be set up. Visit www.jtaglive.com to obtain a copy. The site also includes product descriptions, answers to frequently asked questions and highlighted experiences from JTAGLive users.

EXTRA CHANNELS EXPAND THE SCOPE OF MSO APPLICATIONS

BY **CLIVE DAVIS**, YOKOGAWA EUROPE

While much of the news coverage of new developments in oscilloscopes has focused on the high-end multi-gigahertz products, the fact is that over 50% of all oscilloscope measurements are carried out at frequencies of 500MHz or lower. Applications in this sector cover a broad spectrum of industries and technologies, including many that fall outside the area that is traditionally regarded as the "electronics" industry.

Apart from sectors such as embedded microcontrollers and automotive electronics, general industrial applications now involve an increasing element of "mechatronics", where physical parameters from mechanical elements such as motors and actuators interact with multiple control signals which can include analogue, digital and high-power content. Similarly, measurements on motor drives and inverters often have to deal with 3-phase electrical supplies, where each input or output involves at least three separate signals.

Against this background, an increasing number of oscilloscope users are finding that the traditional four channels that have been the norm for decades are no longer sufficient. Indeed, there are instruments available which provide eight or more channels, but these are normally oscillographic recorders which do not offer sufficiently high bandwidth and sampling rate. Some users have created 8-channel set-ups by combining two 4-channel oscilloscopes, but this approach requires the instruments to be synchronised: something that is only normally possible in tightly controlled laboratory conditions.

The following comments from actual users illustrate the challenges provided by existing 4-channel users in different industries:

"We develop motor control systems, and we typically need to look at three current channels and three high-voltage channels, as well as two channels for other parameters such as link voltages."

"We need to observe the waveform details of more than four channels of engine control unit signals, along with sensor signals of spinning speed, pulse of fuel injector, crank angle, etc."

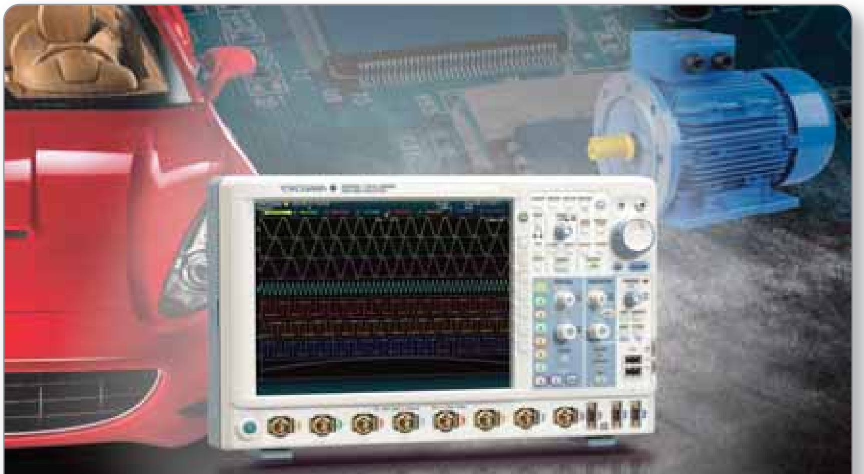


Figure 1: The DLM4000 is suitable for various applications, from automotive to industrial

Eight Channels Provide The Answer

To address these challenges, a new generation of 8-channel oscilloscopes (Figure 1) has been developed that offer comprehensive measurement capabilities for embedded, automotive, power and mechatronics applications.

The new range comprises two models, with bandwidths of 350 and 500MHz and a sampling rate of 1.25GS/s (gigasamples per second), expandable to 2.5GS/s with interleaving. The channels can be allocated as eight analogue channels or seven analogue channels plus one 8-bit digital input. A future option will add 16 more channels of logic to allow seven channels of analogue plus a 24-bit digital input.

> An increasing number of oscilloscope users are finding that the traditional four channels that have been the norm for decades are no longer sufficient

Not only do these oscilloscopes provide enough channels for analogue applications such as 3-phase voltage and current measurements, they also enable users to view the actual waveform shape of digital signals. This helps the digital debug process, as glitches are often caused by such things as noise and crosstalk which are invisible when viewing just ones and zeros.

The new instruments feature exceptionally long memory (up to 62.5M points per channel and 125M points in interleave mode), allowing both long recordings and multiple waveforms to be acquired. A history memory function, which does not reduce the oscilloscope's high waveform acquisition rate, allows up to 20,000 previously captured waveforms to be saved in the acquisition memory, with any one or all of them displayed on screen for cursor measurements. Waveforms can be displayed one at a time, in order, or automatically played back, paused, fastforwarded or rewound. The history memory in combination with the advanced waveform-search feature enables users to capture and see the details of anomalies on individual waveforms when their characteristics are still unknown.

Advanced measurement and analysis features include histogram and trending functions, digital filtering, zoom windows, user-defined mathematics and serial bus analysis.

The instruments incorporate a large (12.1-inch) high-resolution XGA display, and yet are housed in a compact body which is less than 18cm deep and weighs just 6.6kg. The display is enhanced by a fine grid, high luminance and viewing angle, and on-screen markers with simultaneous display of cursors and automatic parameters.

Other features include backlit buttons, additional knobs and jog shuttle, on-screen information in English, German, French, Italian and Spanish, two zoom windows with 80:20 or 50:50 zoom/main area split, and a choice of first-cycle or screen average mode for frequency measurement.

The instruments are offered with a variety of easy-to-configure triggers combining analogue and logic inputs such as edge, enhanced and B-triggers. These include dedicated trigger functions for FlexRay, CAN, LIN, UART, I2C and SPI serial bus patterns, as well as the ability to perform simultaneous analyses on two different buses operating at different speeds. This capability is enhanced by the extensive search facilities, allowing the user to look for specific data in the very long memory.

Application: Embedded Systems

As embedded control systems become more sophisticated and complicated, more I/O signals are used in the system and, because of noise introduced into the systems from inverters or other power supplies, faster sampling and higher bandwidth are required in the measurement instruments used for observing the various signals.

In automotive engine control units, for example, it is necessary to capture actual system waveforms for developing and debugging the software of an engine control unit (ECU). Unfortunately, neither a 4-channel mixed-signal oscilloscope nor an oscillographic recorder can satisfy these requirements in terms of bandwidth, acquisition speed or channel count.

Now, however, by using the 8-channel oscilloscope with the 16-bit logic input, it is possible to carry out comprehensive and efficient measurements. Many waveforms can be captured without changing the probe connection and, by capturing logic and bus inputs as analogue signals, signal quality effects such as surge and noise can be evaluated and compensated for to contribute to an overall improvement in system reliability. A further benefit in the automotive sector is that up to two CAN/LIN, FlexRay, I2C, SPI or UART (RS232) channels of data can be decoded and displayed in real-time.

Up to 62.5Mpoint per channel of memory enables long-term measurement even at the highest sampling rate. Slow phenomena from mechanical equipment and fast electric signals from the cont-roller can be measured at the same time.

For longer time measurements and measurements combining various physical signals along with CAN bus data, it is possible to use a ScopeCorder such as the Yokogawa DL850 in combination with the 8-channel oscilloscope. ●

Figure 2: DLM4000

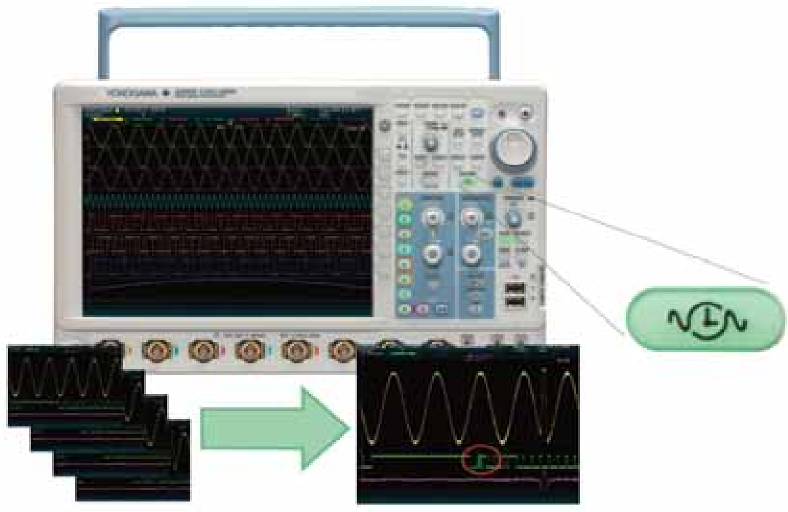
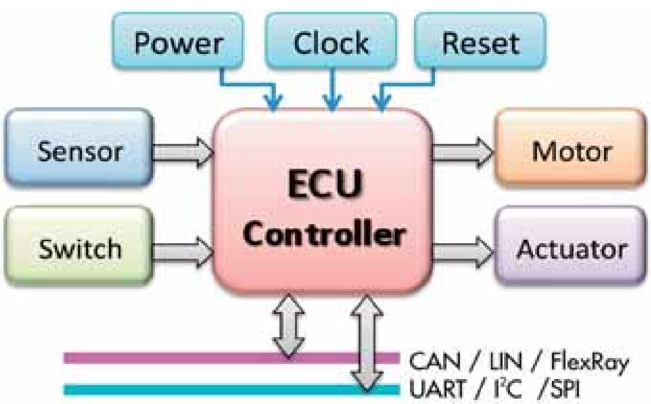


Figure 3: Embedded applications and ECU testing



TESTING AND CHARACTERIZING ANALOG AUDIO SYSTEMS

HIGH-PRECISION OSCILLOSCOPES ARE IDEAL FOR AUDIO WORK. WITH THE RIGHT SOFTWARE, THEY CAN DISPLAY SIGNALS IN THE TIME OR FREQUENCY DOMAIN, AND CALCULATE PARAMETERS SUCH AS RMS VALUES AND DISTORTION, SAYS **PETE DARBY** OF PICO TECHNOLOGY

The analog-to-digital converters (ADC) in most digital oscilloscopes have 8-bit resolution, which provides 256 quantization levels. This is equivalent to an ideal dynamic range of 48dB. A high-precision oscilloscope with a 16-bit ADC has 65,536 quantization levels, increasing the ideal dynamic range to 96dB. This is the theoretical figure, but in practice the acquisition system has some noise that reduces the usable dynamic range.

The dynamic range of the generator and oscilloscope was measured with the generator output directly connected to channel A's input. In this, case the oscilloscope had a built-in signal generator, which was connected as shown in Figure 1.

Figure 2 shows a spectrum view of a sine wave input. To measure the dynamic range we aligned two rulers with the signal peak and the noise floor. The delta between the two rulers was 98dB.

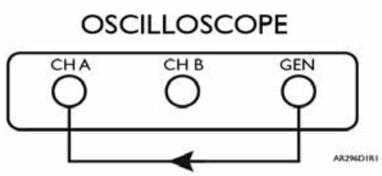


Figure 1: Measuring dynamic range by feeding signal from built-in generator into oscilloscope

Dynamic range 94 dB
http://youtu.be/FxluPd1nZ8I

Automatic Total Harmonic Distortion Measurement is 94 dB. The THD measurement is the sum of all harmonic components.

Monitoring waveform distortion is a test that measures distortion in a stereo amplifier (see Figure 3). It shows how distortion measurements can reveal harmonics even when the time-domain waveform looks clean.

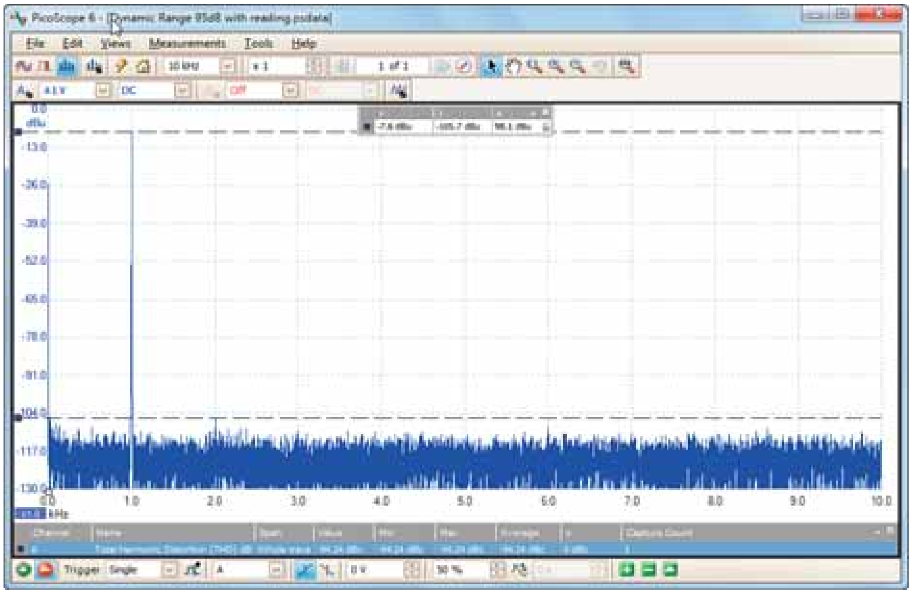


Figure 2: Using rulers to measure the dynamic range of the test system

Figures 4 and 5 show a time-domain view and a spectrum view for each of the two channels.

In the time-domain view we cannot see distortion. The distortion measurement shows that Channel B has -61dB Total Harmonic Distortion (THD).

With increased power output level, we can start to see some distortion harmonics in the channel A spectrum display. The channel B spectrum has THD of -28dB at this level. We can start to see the distortion in the time-domain display (lower left panel).

Monitor channel A and B app: http://youtu.be/2UeBOuj3lOo

Audio Measurements

Severe distortion can be spotted by feeding the left and right channels into the scope's two inputs. With the two waveforms displayed one above the other, any difference between them becomes obvious (see Figure 6).

Output level can be defined as a chosen output voltage level, output power level or distortion level. In this example a power output level of 30W across a 15-ohm load was chosen. This is equivalent to a voltage of 21.2VRMS.

Probes are connected to channel A and B outputs terminated with 15-ohm loads. The four-view display shows time domain and frequency-domain plots of each channel. The low level of harmonics indicates that both channels are operating in the amplifier's linear region. Distortion is down at -73dB and -79dB.

Probes are connected to the amplifier's input and output. PicoScope displays an overlay of channels A and B. The peak-to-peak measurements are used to calculate the gain. The volume control is adjusted to give a gain of 20 (see Figure 8).

The measurements table shows channel A

and B peak-to-peak voltages. Gain is calculated from the automatic measurements: 2.88/0.1 = 28.8 (see Figure 9).

Channel B output voltage is clean. Distortion level is -64dB. Channel A is starting to clip on the negative half cycle due to an amplifier bias fault (see Figure 10). The THD on Channel A is only -20dB.

Channel B output voltage can increase to 26.8V before clipping starts. This can be easily measured in the channel B spectrum display.

Level monitoring and gain app: http://youtu.be/dKQvP5oU3_M

The generator can be set to any specified frequency, for example 1kHz, 10kHz and 20kHz. The frequency response at these frequencies can then be checked very quickly. In this example the effect of the treble control of an amplifier has been measured.

Three output waveforms were acquired at 10kHz (see Figure 12) for different treble control settings: flat, cut and maximum lift. The three waveforms were stored to reference memories.

To do the sweep measurements follow the list below:

- Set generator to sweep mode
- Sweep frequency from 100Hz to 20kHz
- Set acquisition to spectrum mode
- Set spectrum mode frequency range to 20kHz
- Set spectrum bins to 256
- Set window function to Flat
- Set display mode to Peak Hold
- Set scale to Log
- Acquire signal.

There is no noticeable lift or cut across the audio spectrum (see Figure 14).

The ruler measurement shows that the treble cut is 9.89dB (see Figure 15).

The ruler measurement shows that the treble lift is 10.25dB (see Figure 15).

frequency response sweep treble max lift: http://youtu.be/3iMtcDZ8lf4

The loudness control on an amplifier boosts the bass and high audio frequency response. This can be measured with a sweep input from 40Hz up to 20kHz (see Figure 16). The spectrum mode with max hold display can plot the amplifier's characteristic.

We can see that low frequencies are

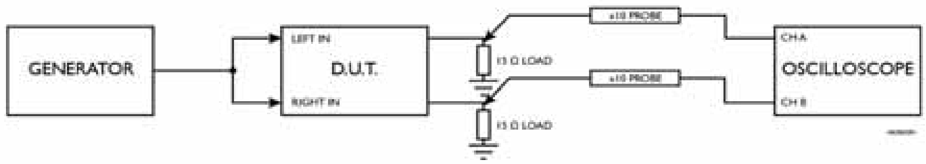


Figure 3: Setup for distortion measurement

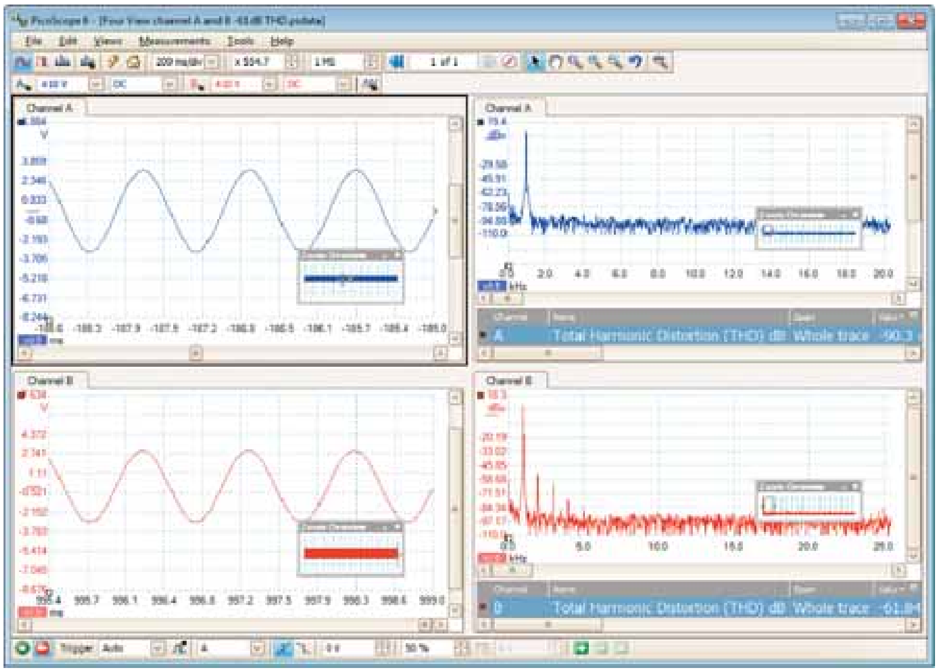


Figure 4: Channels A and B in time and frequency domains

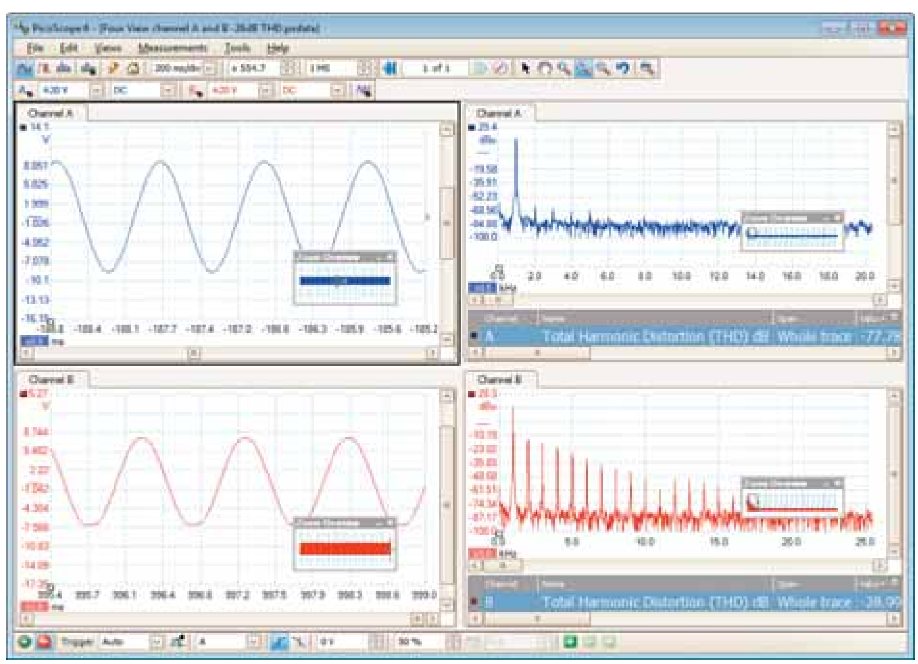


Figure 5: Channels A and B

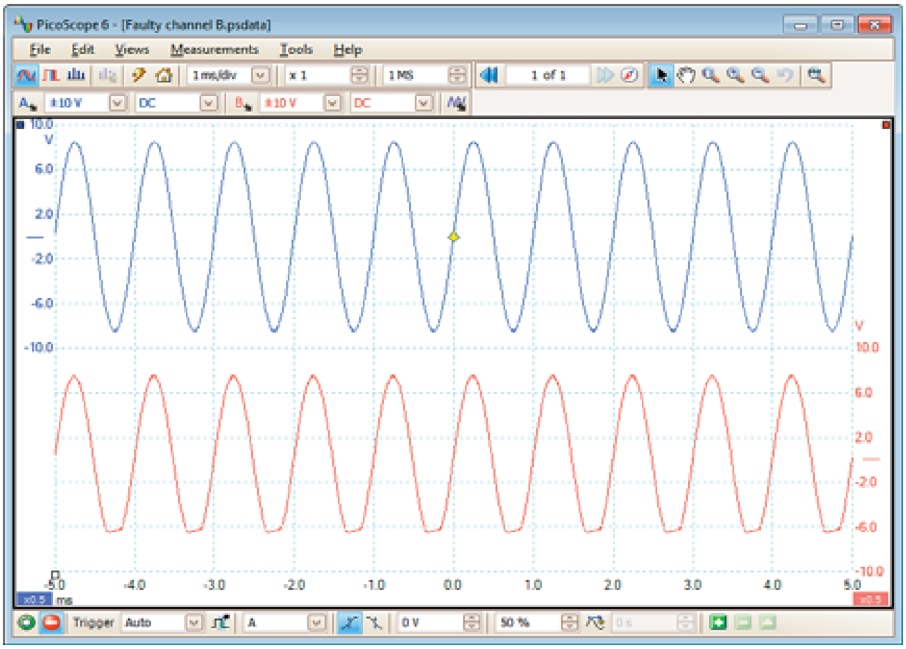


Figure 6: Visible distortion on channel B

Figure 7: Monitoring power output on channels A and B

$$SNR = 20\log_{10}\left(\frac{RMS\ value\ of\ datum}{\sqrt{sum\ of\ squares\ of\ all\ values\ excluding\ datum\ and\ harmonics}}\right) \quad (1)$$

$$THD = 20\log_{10}\left(\frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + V_5^2 + V_6^2 + V_7^2}}{V_1}\right) \quad (2)$$

$$THD + N = 20\log_{10}\left(\frac{\sqrt{sum\ of\ squares\ of\ RMS\ values\ excluding\ datum}}{RMS\ value\ of\ datum}\right) \quad (3)$$

boosted, and that the output response increases steadily from 1kHz to 20kHz.

For an HF filter example, see Figure 17. The HF filter cuts off the frequency response sharply at 20kHz.

frequency response HF filter: http://youtu.be/xk-b3nKZYfI

Crosstalk Measurement

To measure crosstalk from signal on left channel to the undriven right channel, see Figure 18, and follow the list below:

- Apply 1Vpk-pk signal to amplifier left channel
- Connect oscilloscope Ch A to amplifier left output
- Connect oscilloscope Ch B to amplifier right output
- Increase amplifier gain to set output level of 20VRMS
- Measure output level of Channels A and B.

For crosstalk at 1kHz, see Figure 19 and Table 1, whereas for crosstalk at 10kHz see Figure 20 and Table 2. The test for crosstalk at 10kHz shows that the crosstalk at 10kHz is nine times larger than at 1kHz.

Signal To Noise Ratio Measurement

SNR is the ratio, in decibels, of the mean signal power to the mean noise power (see Equation 1). Hann or Blackman windows are recommended because of their low noise.

To make signal to noise ratio (SNR) measurements, set the generator output level to 900mV at 10kHz (see Figure 21).

- Connect generator output to input of amplifier under test
- Connect x10 probe to input channel A
- Connect tip of probe to the 15-ohm load at the output of the amplifier
- Select spectrum mode
- Select Hann or Blackman window type, recommended because of their low noise.
- Select Signal to Noise Ratio measurement.
- Measure SNR.

The automated measurement shows signal to noise ratio as 114dB. The cursor also measures mean noise as -114dB.

Distortion Measurement

Total Harmonic Distortion (THD) is the ratio of the sum of harmonic powers to the power at the fundamental frequency (see Equation 2).

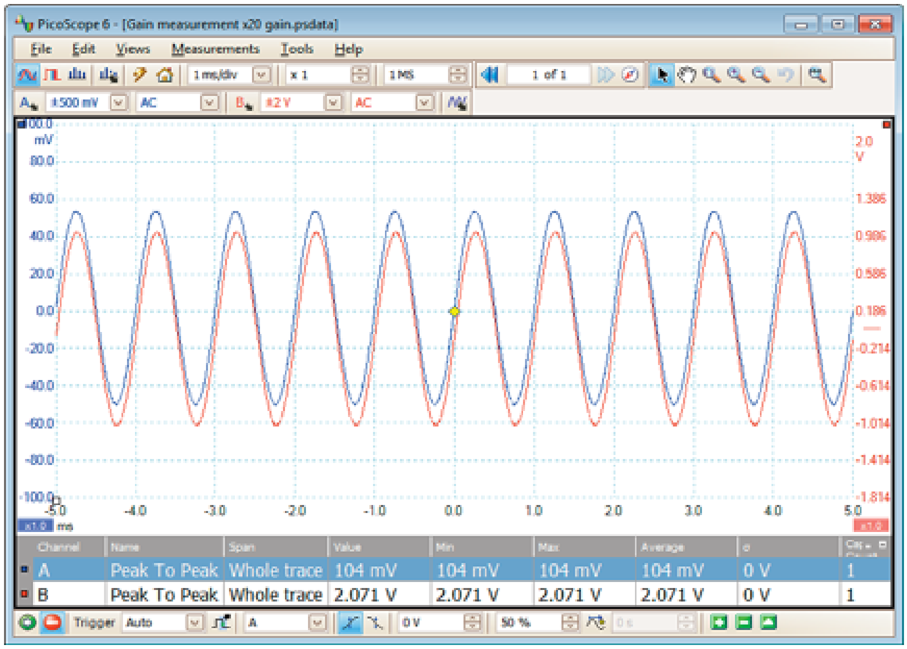


Figure 8: Adjustment for gain of 20

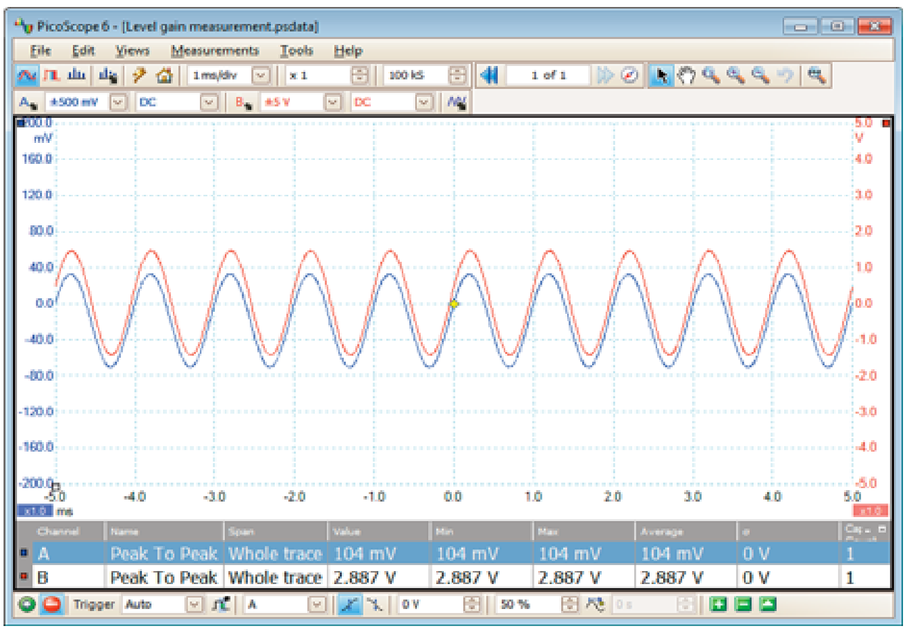


Figure 9: Measuring arbitrary gain

Total Harmonic Distortion plus Noise (THD+N) is the ratio of the harmonic power plus noise to the fundamental power (see Equation 3). THD+N values are always greater than the THD values for the same signal.

This test (see Figure 22) checks THD for various output power levels, depending on the device under test. The maximum output power is then the highest power output that meets the THD specification.

At 1W output power the THD is -90dB (see Figure 22) and at 15W output, the total harmonic distortion has increased to -50dB (see Figure 23).

At 45W the output power waveform starts to clip (see Figure 24), which increases the distortion. This can be seen in the spectrum display as the third harmonic has become large.

Signal+Noise+Distortion to Signal+Noise Ratio (SINAD) is the ratio, in decibels, of the signal-plus-noise-plus-distortion to noise-plus-distortion.

The SINAD measurement (see Equation 4) is another method for measuring waveform quality. This measurement compares distortion plus noise to the actual signal level.

Two phase-shift measurements are possible:

- Phase shift from input to output of each channel of the amplifier
- Phase shift between the left and right channels

For phase shift from input to output see the setup in Figure 25. For phase shift probe compensation do as follows:

- Set generator amplitude to 1V at 1kHz
- Measure phase shift between amplifier left channel input and output.

It is important to compensate x10 probes by connecting both probes to the generator output, then while monitoring both channels adjusting the probe compensation so that the phase difference is close to zero.

phase shift with probe compensation: http://youtu.be/nN7doRSpNCk

To do a phase shift channel A input and output at 1kHz (see Figures 27 and 28, and Table 3 for the results):

- Change generator frequency to 10kHz
- Repeat phase shift measurement.

Similarly, to measure phase shift between left and right channels, the setup is the same as for the Channel A/Channel B distortion measurement (see Figures 29-31):

- Connect generator signal to amplifier input left and right channels
- Set generator frequency to 1kHz
- Connect oscilloscope input A to amplifier left channel 15-ohm output load
- Connect oscilloscope input B to amplifier right channel 15-ohm output load
- Set generator frequency to 1kHz
- Measure phase shift between A and B
- Set generator frequency to 10kHz
- Measure phase shift between A and B.

$$SINAD = 20\log_{10}\left(\frac{\text{RMS value of datum}}{\sqrt{\text{sum of squares of all RMS components except datum}}}\right) \qquad (4)$$

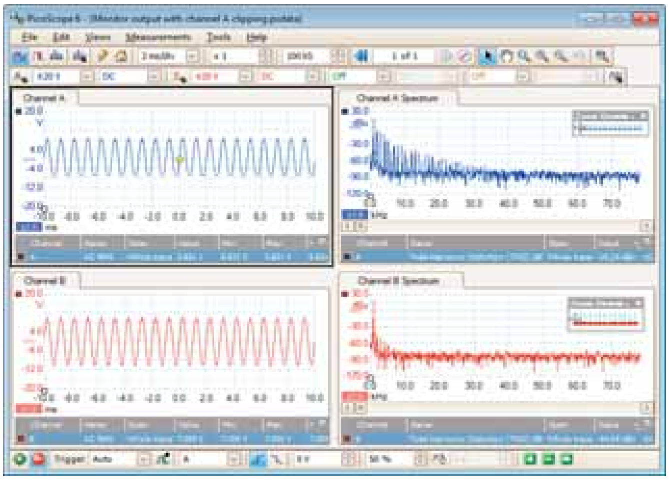


Figure 10: Monitoring output level with channel A clipping

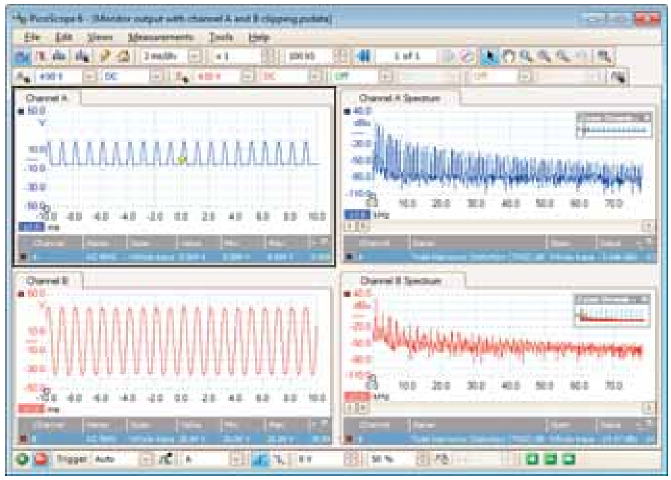


Figure 11: Monitoring output level with channels A and B clipping

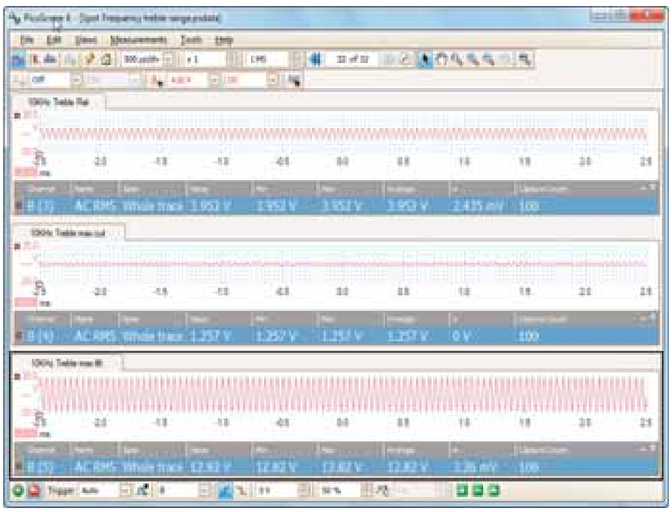


Figure 12: Generator frequency set to 10kHz

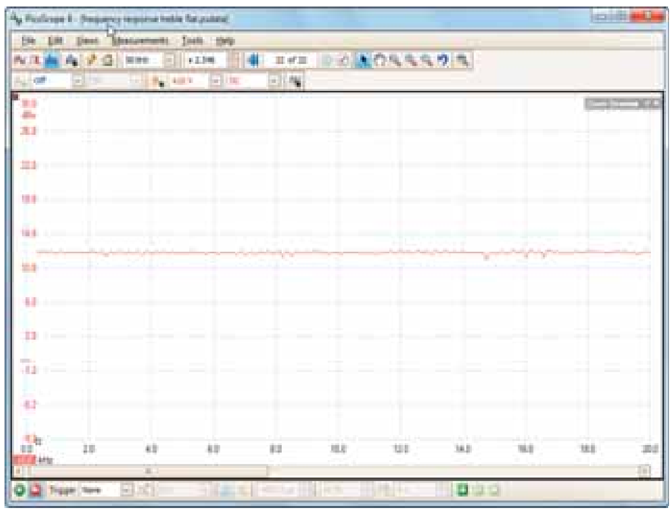


Figure 13: Generator sweep 100Hz to 20kHz with treble control set to flat

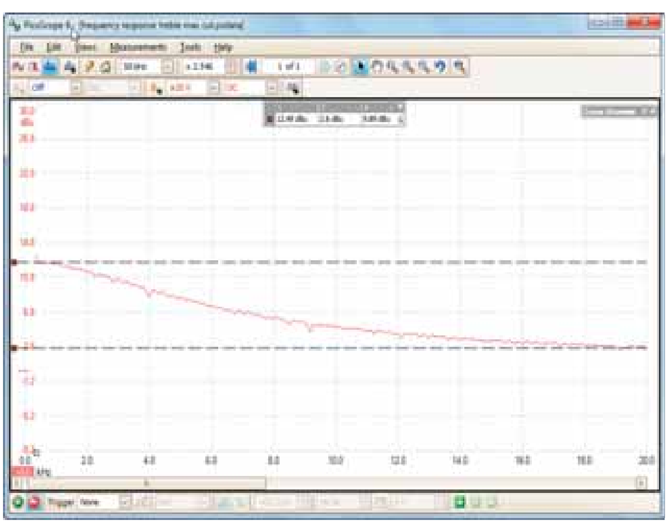


Figure 14: Generator sweep 100Hz to 20kHz with treble control set to max cut

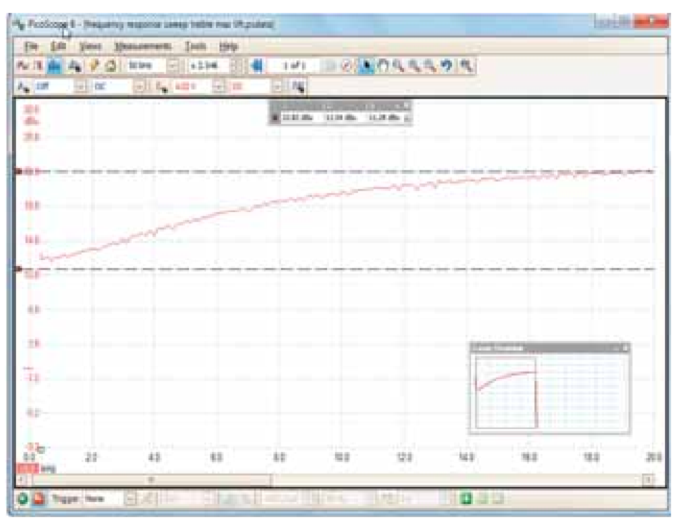


Figure 15: Generator sweep 100Hz to 20kHz with treble control set to max lift

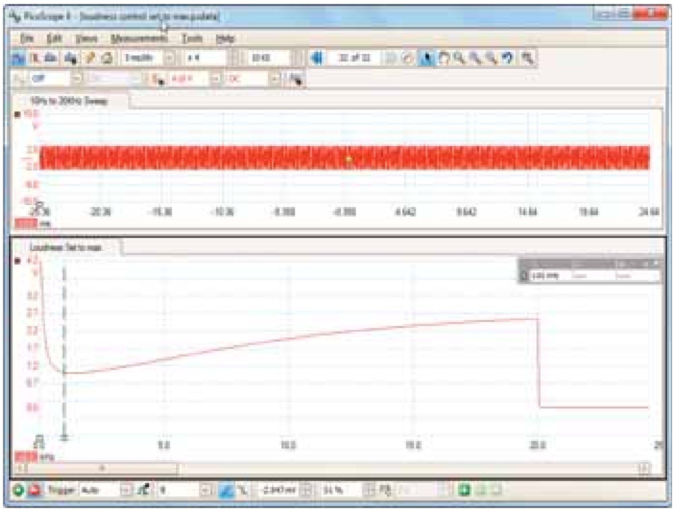


Figure 16: Loudness frequency response

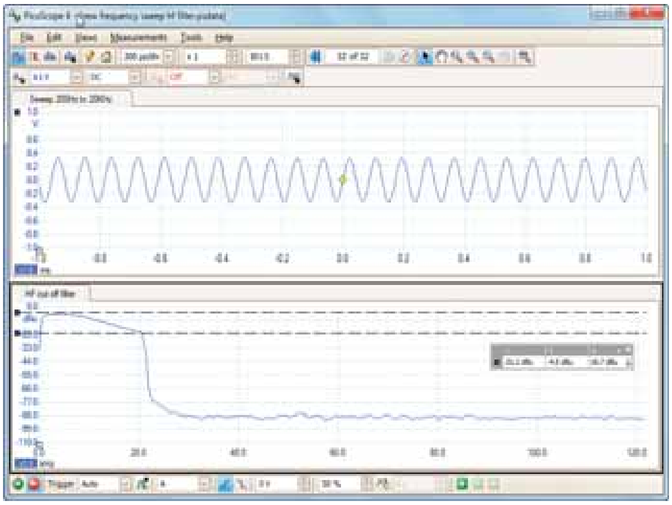


Figure 17: HF cut-off filter frequency response

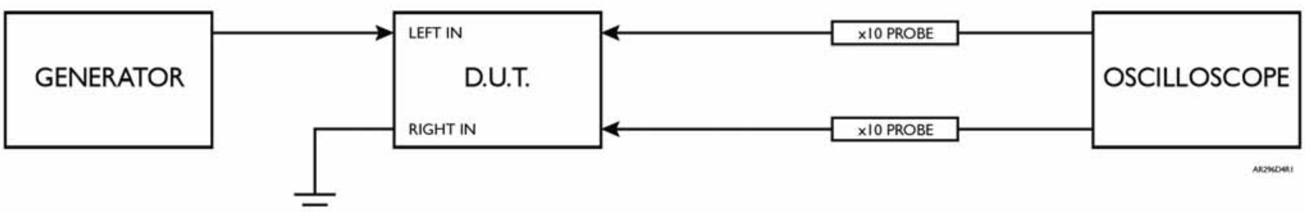


Figure 18: Setup for crosstalk: left channel driven, right channel undriven

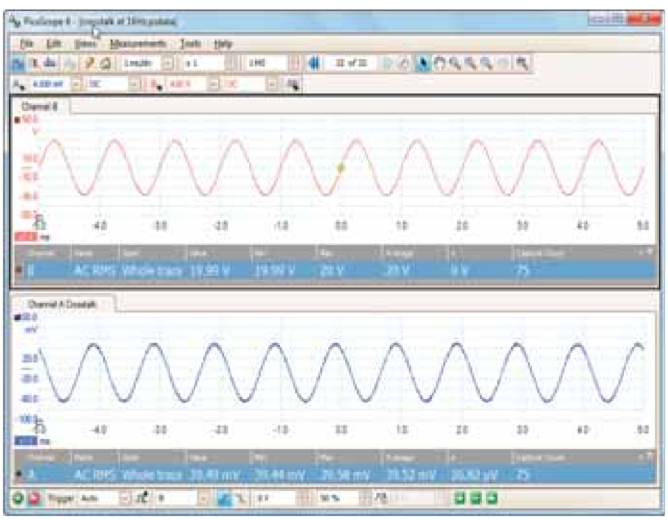


Figure 19: Upper view: left output channel driven at 1kHz; Lower view: right output, channel not driven

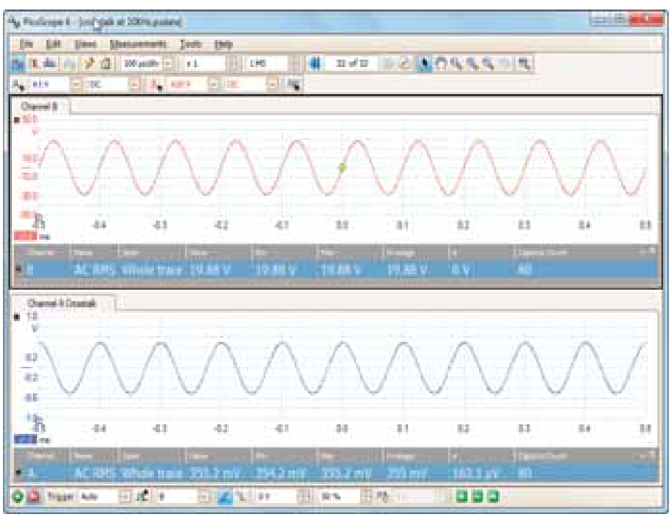


Figure 20: Upper view: left output channel driven at 10kHz; Lower view: right output, channel not driven

Measurements at 1 kHz	Upper view: 19.99V Lower view: 39.49mV
Results	Ch B: 20V RMS Ch A: 39.5mV RMS Crosstalk Ratio: 1:506

Table 1: Measurements at 1kHz

Measurements at 10 kHz	Upper view: 19.88V Lower view: 355mV
Results	Ch B: 19.88V RMS Ch A: 355mV RMS Crosstalk Ratio: 1:56

Table 2: Measurements at 10kHz

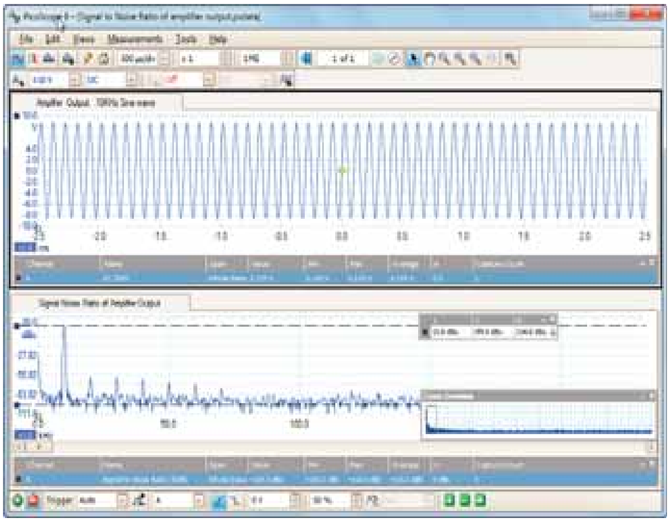


Figure 21: Signal to noise ratio of amplifier output

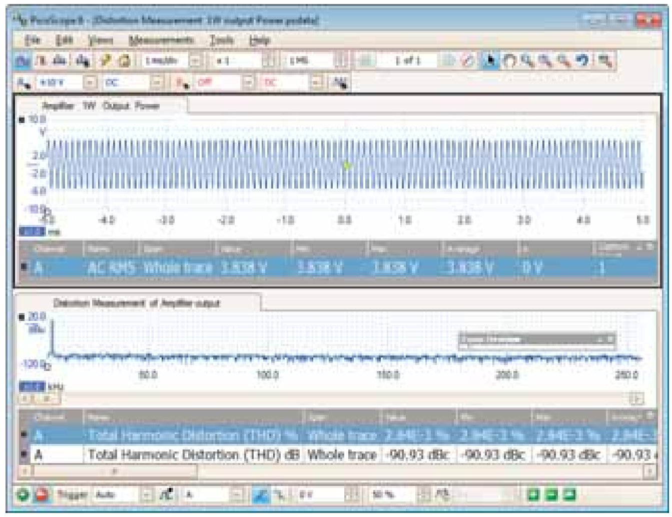


Figure 22: Distortion measurement at 1W output power

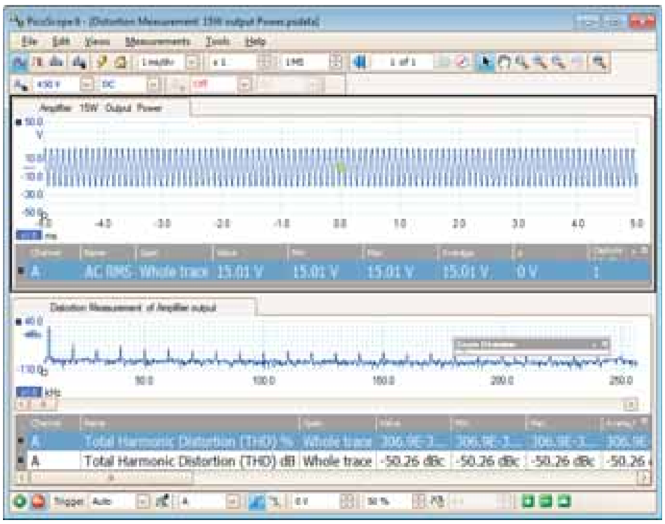


Figure 23: Distortion measurement at 15W output power

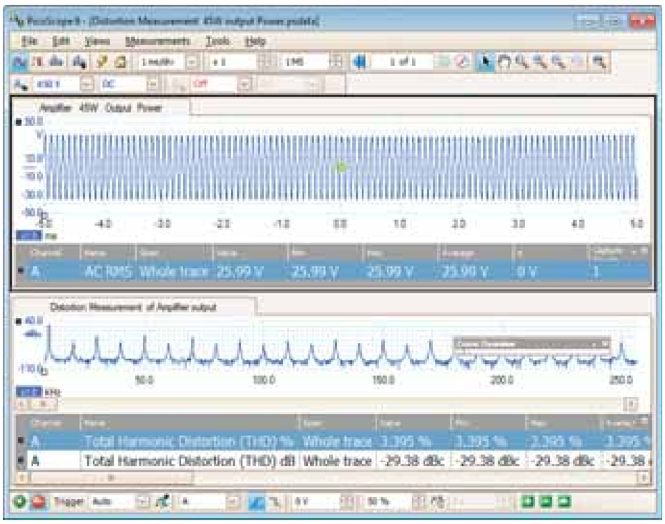


Figure 24: Distortion measurement at 45W power output

Measured phase shift at 10kHz	7.3°
Cursor measurement	
Cycle time: Output leads input by: Phase shift:	100 µs 2.1 µs 360° x (2.1 / 100) = 7.5°

Table 3: Results

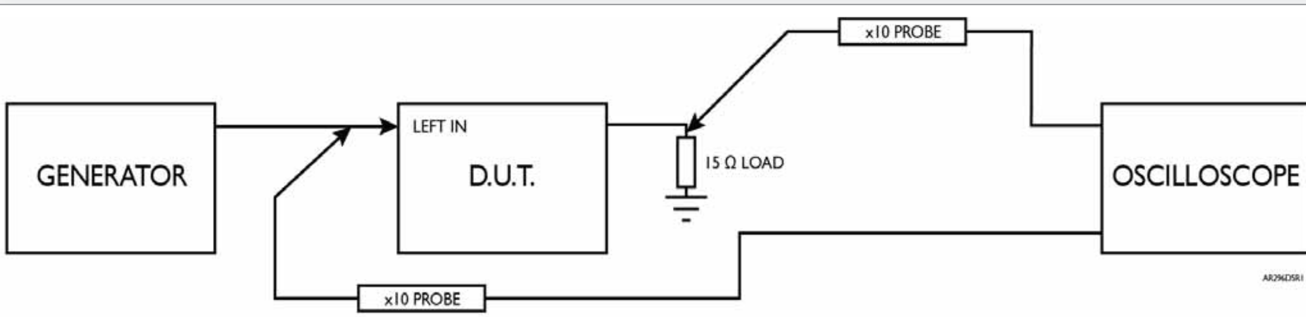


Figure 25: Setup for input-to-output phase shift measurement

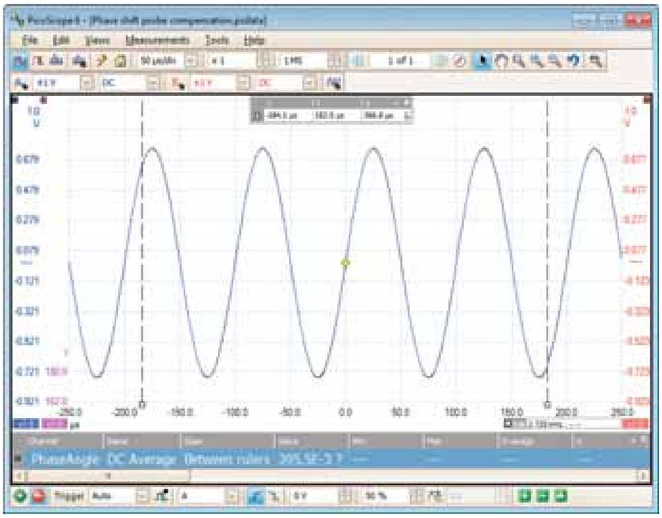


Figure 26: Phase shift probe compensation

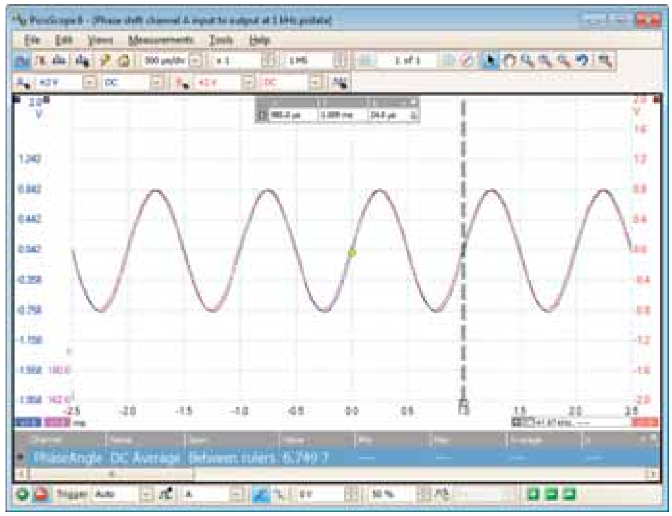


Figure 27: Phase shift channel A input to output at 1kHz

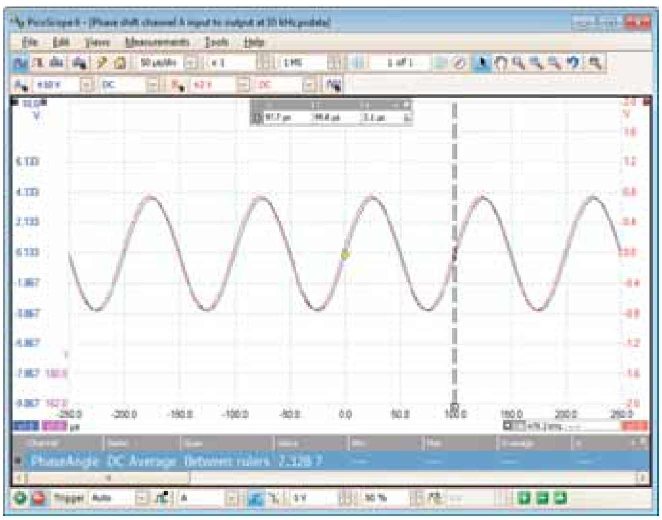


Figure 28: Phase shift channel A input to output at 10kHz

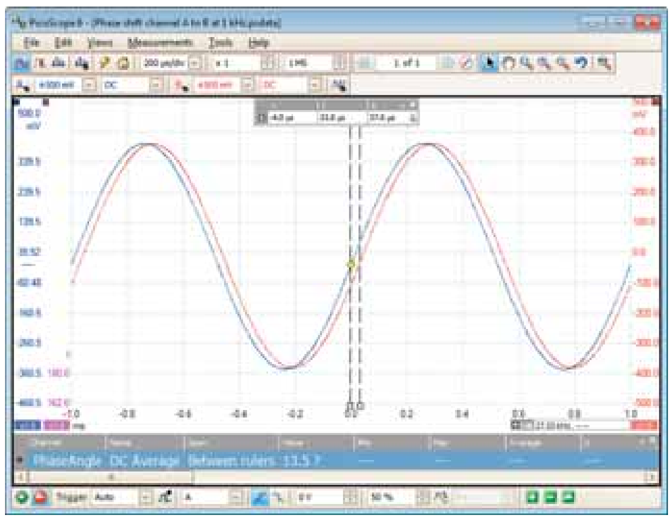


Figure 29: Phase shift channel A to B at 1kHz

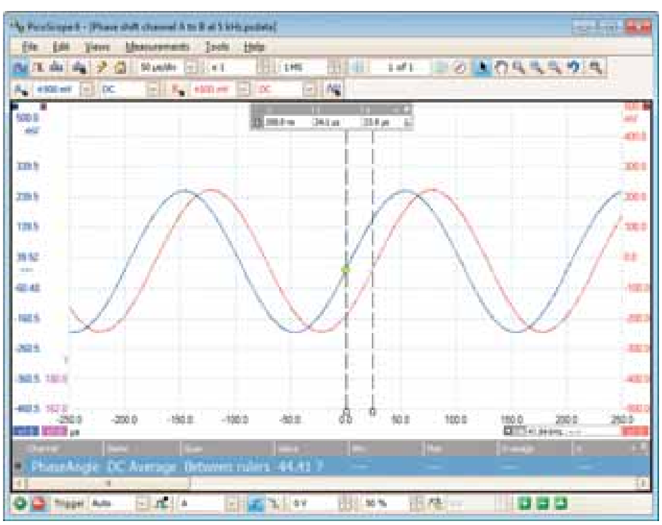


Figure 30: Phase shift channel A to B at 5kHz

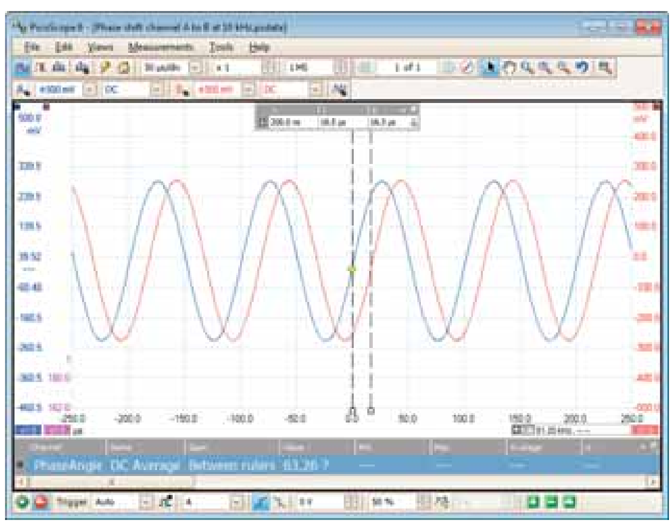


Figure 31: Phase shift channel A to B at 10kHz

THIS IS A NEW MONTHLY COLUMN COVERING ISSUES RELATED TO TEST AND MEASUREMENT (T&M)

Testing Memory Buses – A Touchy Subject

BY **REG WALLER**, EUROPEAN DIRECTOR, ASSET INTERTECH INC

Last month (October issue) I talked about how difficult it has become to test and validate high-speed memory buses. Take a deep breath, because it's only going to get worse as the speeds of memory buses like DDR continue their upward explosion. In fact, the fourth generation of DDR was recently released and it has a top speed of 4.266 gigatransfers per second (GT/s), doubling DDR3's rate of 2.133 GT/s.

As DDR and other memory buses get faster and faster, they're harder to test because most board designers eliminate the test pads that are used by oscilloscopes and, in manufacturing, in-circuit test (ICT) systems. With no test pads there's no place to place a probe on the board to test the memory bus. The pads are eliminated because when bus speed reaches a certain level the pads start to distort the signals on the buses. No one wants distorted signals. We use scopes to find distortions, not generate them.

So, probe-based test equipment is not as effective as it once was, but there is still hope.

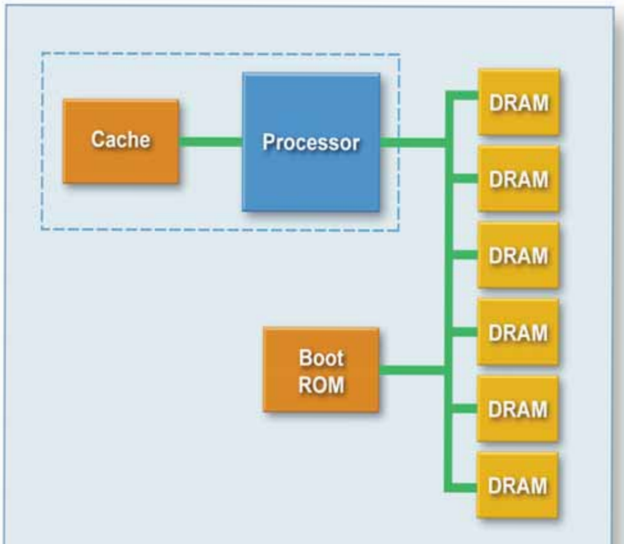


Figure 1: Memory test

Many engineers are turning to non-intrusive test methods based on embedded instrumentation and don't need to probe anything. These methods test from the inside out, not like scopes and ICT which test from the outside in.

One non-intrusive method is processor-controlled test (PCT). Some people think of PCT as a functional test method, but it's not a classic functional test as such, which requires that the board or system be functional. That's not the case with PCT. In fact, you can use PCT to test memory before the board's operating software environment is completely integrated.

> *Many engineers are turning to non-intrusive test methods which are based on embedded instrumentation and don't need to probe anything*

PCT gets its name from the fact that it either puts code into the processor's cache memory or uses the processor to drive the board's address/data bus directly to create memory tests. Figure 1 shows a common design where the processor is directly connected to on-board memory. PCT works through the processor to test the connected buses. If there's a memory management unit (MMU) between the processor and the memory devices, PCT can write to registers on the MMU to configure communications to the DDR memory.

PCT does memory test in one of two ways. First, its algorithms can be run from the PCT tool platform attached to the board-under-test or they can run on the board-under-test in its memory.

Since they operate out of a microprocessor, designers of PCT memory test routines must understand the ins-and-outs of the microprocessor, even though the memory test routines themselves are not dependent on the hardware design.

The real beauty of some non-intrusive memory test techniques like PCT is that they can be used during the early stages of board bring-up, long before the software engineers have finished developing the board's operating firmware. With PCT you can be a lot further along validating the hardware by the time the firmware is typically available.

Memory Board

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

Modern super-fast microprocessors can process a huge amount of data in a short time. They need data to be input at the same speed, otherwise, they'll have to sit idle and wait for the input/data, as the speed of input is much lower than the speed of processing data, resulting in reduced performance and wasted power.

A Typical Instruction-Execution Cycle

Memory consists of a large array of words or bytes, each with its own address. A central processing unit (CPU) fetches instructions from memory according to the value of the program counter; these instructions may cause additional loading from and storing to specific memory addresses. A typical instruction-execution cycle can be:

- Fetching an instruction from memory. The next instruction is fetched from the memory address that is stored in the Program Counter (PC) and in the Instruction register (IR).
- Decoding an instruction. The decoder interprets the instruction.
- Fetching operands from memory. In case of a memory instruction (direct or indirect) the execution phase will be in the next clock pulse.
- Executing an instruction on the operands. The Control Unit (CU) of the CPU passes the decoded information as a sequence of control signals to the relevant function units to perform actions required by the instruction, such as reading values from registers, passing them to the Arithmetic Logic Unit (ALU) to perform mathematical or logic functions on them, and writing the result back to a register. If the ALU is involved, it sends a condition signal back to the CU.
- Storing results back in memory. The result generated by the operation is stored in the main memory, or sent to an output device. Based on the condition of any feedback from the ALU, the PC may be updated with a different address from which the next instruction will be fetched. The cycle is then repeated.

An instruction cycle (sometimes called fetch-and-execute cycle, fetch-decode-execute cycle, or FDX) is the basic operation cycle of a computer. This is the underlying process of a computer: it retrieves a program instruction from its memory, determines what actions the instruction requires and carries out those actions. This cycle is repeated continuously by the CPU, from boot-up to computer shut-down.

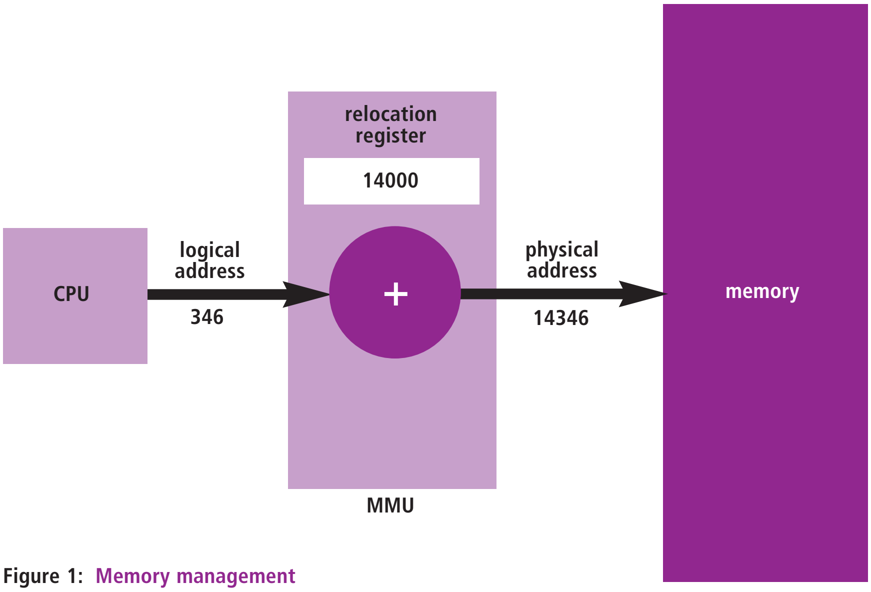


Figure 1: Memory management

Address Binding

Address binding of instructions and data to memory addresses can happen at three different stages:

- Compile time: if memory location is known at the compile time, an absolute code can be generated; but code must be re-compiled if or when the starting location changes.
- Load time: the compiler must generate re-locatable code if the memory location is not known at compile time.
- Execution time: binding delayed until run time, if the process can be moved during its execution from one memory segment to another.

Memory management (Figure 1 and 2) is the act of managing computer memory. The essential requirement of memory management is to provide ways to dynamically allocate portions of memory to programs at their request, freeing it for reuse when no longer needed. This is critical to the computer system. Several methods have been devised that increase the effectiveness of memory management. Virtual memory systems separate the memory addresses used by a process from actual physical addresses, allowing separation of processes and increasing the effectively available amount of RAM using paging or swapping to secondary storage. The quality of the virtual memory manager can have an extensive effect on overall system performance.

Virtual Memory

Virtual memory is a method of decoupling the memory organization from the physical hardware. The applications operate via virtual addresses. Each time an attempt to access stored data is made, the virtual memory data orders translate the virtual address to a physical address. This enables granular control over memory systems and methods of access.

- **Protection:** Protection is another important aspect of virtual memory. In virtual memory systems the operating system limits how a process can access that memory. This feature can be used to prevent a process to read or write to memory that is not allocated to it, preventing malicious or malfunctioning code in one program from interfering with the operation of another.

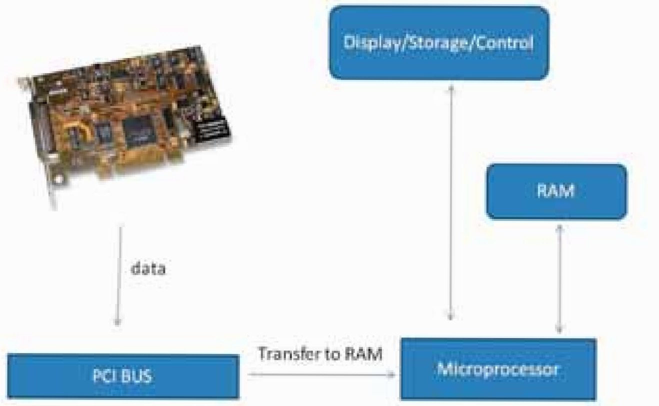


Figure 2: Outline of DAQ memory

- **Sharing:** Even though the memory allocated to specific processes is normally isolated, some processes sometimes need to share information. Shared memory is one of the fastest techniques for inter-process communication.
- **Physical Organization:** Memory is usually classed by access rate, as primary storage and secondary storage. Memory management systems handle moving information between these two levels of memory. ●

NEW RANGE OF DEEP MEMORY MIXED-SIGNAL OSCILLOSCOPES

The new range of mixed-signal oscilloscopes (MSOs) from Pico Technology combines the deep memory and high performance of the PicoScope 3000 Series with a powerful 16-channel logic analyzer. With a built-in function generator and arbitrary waveform generator also included, these oscilloscopes offer a complete test-bench in one compact, USB-powered device.

The new MSOs have 2 analog channels with bandwidths from 60MHz to 200MHz, a maximum single-channel sampling rate of 500MS/s and 100MHz digital inputs. Buffer memory sizes range from 8MS to 128MS. Serial data in I2C, UART/RS232, SPI, CAN bus, LIN and FlexRay formats can be decoded and displayed in binary, decimal or hexadecimal formats.

The 16 logic inputs are organized in two banks, each of which has its own adjustable logic threshold to allow testing of mixed-logic designs.

www.picotech.com

REFERENCE BOARD FOR POWERFUL VIDEO WALL SYSTEM DESIGN

congatec AG introduces a new reference board for video wall system design. Video wall systems increasingly rely on high-quality videos and (3D) graphics and therefore require a maximum number of graphics interfaces. The congatec reference board offers up to nine independent DisplayPort connectors in combination with an MXM graphics module and a COM Express CPU module. Both are equipped with AMD technology and provide concentrated graphics and computing power.

The video wall baseboard reference platform is based on the new COM Express specification 2.1 for pin-out Type 6, making it ideal for new designs. Displays can also be connected via additional VGA or LVDS ports. There's also a wide range of important ports for embedded applications such as 2x Gbit Ethernet, 4x SATA, 2x USB 3.0, 4x USB 2.0, high definition audio and a 19V power supply for standard notebooks.

www.congatec.com

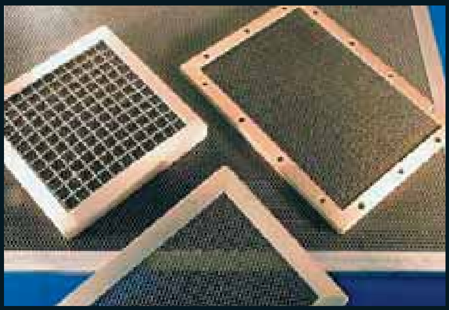
ROHS-COMPLIANT EMC VENTILATION PANELS

Kemtron has introduced a RoHS-compliant aluminium passivation process for its aluminium honeycomb EMC ventilation panels. The process has eliminated the hexavalent chromium which is present in some aluminium passivation processes; the new conversion coating meets the requirements of Mil-C-5541E for corrosion and electrical conductivity.

Kemtron uses fully programmable CNC machines for the notching and cutting of the frame extrusions, and drilling of exact and repeatable holes combined with the latest TIG welding equipment allows Kemtron to offer a fast delivery, competitive range of aluminium vent panels produced to customer designs. This advanced technology also eliminates the need for additional tooling and set-up charges needed with older production techniques.

The standard honeycomb vent panel is constructed from two layers of aluminium honeycomb set at 90°to each other and set in an extruded aluminium frame.

www.kemtron.co.uk



KIKUSUI PCR-SERIES DRIVES ADVANCED POWER TESTING

With increasingly demanding test and conformance regimes, high-reliability instruments like Kikusui's AC power supplies are a must. Together with their advanced measuring and logging options they provide great flexibility – 40Hz through 500Hz 0-270VAC – with DC offset capabilities.

PCRs have built-in testing support features, such as variable frequency and 380V DC capability waveform-amplifier option. Kikusui's advanced feature-set extends to simulation/testing of mains power, EMC, margin test, aviation (400Hz) and automotive testing applications, all with settable protection limits and high accuracy, e.g. set frequency to 0.1Hz resolution.

This is also one of the families that UK distributor Telonic offers for a whole new range of applications where reliability, precision setting and measuring of variable AC power/frequency is required. Accurate measuring functions enable EUTs and loads to be monitored as they respond across a wide range of tests.

www.telonic.co.uk

Protocol Analysis Also In The MSO Entry Level Class

Apart from functions like parameters with statistics an important customer demand could be fulfilled: HAMEG Instruments offers the option HOO12 which allows triggering and decoding of CAN and LIN protocols for less than 500€. Combined with the options HOO10/11for I2C, SPI and UART/RS-232, HAMEG now offers to most of the customers in the automotive, medical, aircraft and automation industries a complete solution for the development of embedded systems.

The HMO series oscilloscopes can decode two CAN buses simultaneously, hence they are especially useful for system designers. For individual measuring tasks the 2/4 analog channels and 8/16 digital channels can be annotated which is very useful. Users who are mainly interested in the protocol level may even use the least expensive oscilloscope of the HMO series, the 70MHz HMO722 and the CAN option to analyze this bus for less than 1,700€.

www.hameg.com

ULTRA-LOW JITTER, HIGH BANDWIDTH SOLUTIONS FOR 100G TRANSCEIVER TESTING

Tektronix announced a new Phase Reference Module, the 82A04B, for the DSA8300 oscilloscope that when combined with new electrical sampling modules provide instrument jitter of < 100 femtoseconds (typ). This represents one of the lowest instrument jitters around, sampling or real-time, making the DSA8300 the instrument of choice for design, debug and characterization of critical 100G transmitters and links on up to 6 channels as defined in the IEEE802.3ba & 32G Fibre Channel test specifications.

The DSA8300 can support simultaneous acquisition of up to three differential (or six single-ended) signals with ultra-low jitter for multi-lane system testing common in today's 100G electrical designs.

Designed for use with the DSA8300 mainframe, the new 82A04B Phase Reference Module supports input clock frequencies from 2-32GHz with an option available to support up to 60GHz.

www.tektronix.com

V PANEL EXPRESS IS A SINGLE-SYSTEM PANEL PC FAMILY

The Kontron Panel PC family V Panel Express is now available with the Intel Core i7 dual-core processor. Compared to its predecessors, this version offers nearly double the performance and is ideally suited for industrial high-performance applications. While increasing the performance, the system remains fanless – positioned for deployment in harsh industrial environments. Operating as a combined real-time control and visualization system for industrial imaging helps eliminate the need of purchasing two separate systems, saving customers costs and space. Kontron has already presented matching reference designs with RTS Hypervisor, VxWorks, Linux and Windows.

Apart from its overall high-performance features, the Kontron Panel PC V Panel Express impresses with its consistent industrial-purpose design. Thanks to its 100% passive cooling concept, the Panel PC needs neither a fan nor a fan filter to be replaced and is therefore completely maintenance-free.

www.kontron.com

New Schottky Rectifier Diodes For Switching Power Supply Applications

AVX Corporation is introducing new Schottky rectifier diodes designed for switching power supply applications. A unique leadless packaging technology eliminates the lead frame and wire bond to give the chip top-bottom symmetry for fewer mounting problems, and better heat transfer and current handling capability (compared to SOD devices). With the addition of the diodes, in addition to the recent extension of its inductor line-up, AVX is now able to cover all the major passives needs of switching power supply designers.

Featuring a high rated current of 0.1A up to 8A and available in various different case sizes from 0402 up to 3220, AVX's new Schottky rectifier diodes are mechanically robust and offer a very low profile, low VF. Fully RoHS compliant and halogen-free, the devices are ideal for use in switch mode power supplies, high frequency rectification and battery powered devices.

www.avx.com

NEW LOW-COST REGULATOR IC FOR ON-BOARD DC/DC CONVERSION

Advanced Power Electronics Corp (USA) announced the APU3037-3 controller IC designed to be a low-cost synchronous buck regulator for on-board DC/DC converter applications.

The APU3037-3 features an internal 200kHz oscillator (400kHz for the A version), under-voltage lockout for both Vcc and Vc supplies, and external programmable soft-start function, as well as output under-voltage detection that latches the device off when an output short is detected. It operates with single 5V or 15V supply in fixed frequency voltage mode and has a 500mA peak output drive capability.

The package is halogen-free and compliant with both current RoHS and REACH environmental requirements for hazardous materials.

Applications include DDR memory source/sink Vtt, graphics cards and hard disk drives, or any other products that require a low cost on board 1.8, 2.5, 3.3 or 5V DC/DC converter.

www.a-powerusa.com

NEW 1.25MM CONNECTORS FOR DEMANDING APPLICATIONS

Harwin has introduced a new high-reliability connector family based on a 1.25mm pitch. Named Gecko, the new connectors have benefited from Harwin's exceptional track record of manufacturing high-reliability connectors for safety-critical applications.

Harwin's low profile G125 series connectors are designed to offer high performance in a miniature package. The 1.25mm pin spacing results in a 35% space saving over other high-performance connectors such as Micro-D. The connectors are rated to handle 2A per contact. Tested and proven to allow high performance in extreme conditions, the G125 family can operate within a wide temperature range (-65 to +150degC) and under extreme vibration (Z axis 100g 6m/s). This high performance is made possible by Harwin's four-finger patented Copper Alloy contact.

The Gecko family offers up to 50 contacts per connector and available in dual row cable-to-board and board-to-board configurations.

www.harwin.com

Video Testers For Analog Audio/Video Interfaces Tests

Rohde & Schwarz has introduced an analog analyzer module for the R&S VTC video test centre, the R&S VTE video tester and the R&S VTS compact video tester. This module enables manufacturers of consumer electronics equipment to comprehensively test the latest digital interfaces such as HDMI and MHL as well as classic analog audio/video interfaces using only one measuring instrument. The R&S VTx family of video testers from Rohde & Schwarz now offers the widest range of interfaces and functionalities on the market.

The new R&S VT-B2370 analog AV RX analyzer module comes with one composite input and two analog audio test interfaces. As an option, three inputs for analyzing SD and HD component signals and VGA (RGBHV) can be activated. Analog video signals can be analysed in the time domain.

www.the-av-experts.com

SARA – A NEW RANGE OF VERSATILE, LOW-POWER GSM/GPRS MODULES

Alpha Micro has added to its product portfolio SARA, a new line of versatile, low-power GSM/GPRS modules from u-blox. Ideal for cost-sensitive M2M and automotive applications, SARA modules are suitable for automatic meter reading (AMR), remote monitoring automation and control (RMAC), surveillance and security, road pricing, asset tracking, fleet management, anti-theft systems and point of sales (PoS) terminals.

Packaged in a compact 16 x 26mm LGA module, SARA modules provide a perfect solution to a wide range of M2M applications requiring dual or quad-band GSM/GPRS, voice and/or data, optional Internet suite (embedded TCP/IP, UDP/IP, HTTP and FTP), and in-band modem support for eCall and ERA GLONASS emergency call applications. Extremely low power consumption makes SARA perfect for portable applications.

The SARA Land Grid Array (LGA) form-factor enables compact designs and easy integration.

www.alphamicro.net

MICROCHIP'S NEW GESTIC TECHNOLOGY ENABLES MOBILE-FRIENDLY 3D GESTURE INTERFACES

Microchip announces its patented GestIC technology, which enables the next dimension in intuitive, gesture-based, non-contact user interfaces for a broad range of end products. The MGC3130 is the world's first electrical-field (E-field) based, configurable 3D gesture controller, offering low-power, precise, fast and robust hand position tracking with free-space gesture recognition.

With power consumption as low as 150 microwatts in its active sensing state, the MGC3130 enables always-on 3D gesture recognition, even for battery-powered products where power budgets are extremely tight. The MGC3130's low-power design and variety of configurable power modes provide the lowest power consumption of any 3D sensing technology, up to 90% lower than camera-based gesture systems.

GestIC technology achieves the exceptionally high gesture-recognition rates required by today's consumer products through its on-chip library, called the Colibri Suite, of intuitive and natural human gestures.

www.microchip.com/get/S238

Brady BBP33 Label Printer Offers Unbeatable Speed and Ease of Use

Brady Europe is offering the new BBP33 label printer, an easy-to-use printing system featuring "drop-in" supplies that allow users to perform a complete supply changeover in less than 20 seconds, with no adjustments or calibration needed.

Designed to make label making faster and easier, BBP33 was built for users who need frequent material changeovers. The new label printer also helps to save costs and improve productivity by eliminating wasted blank labels by quality printing on the first label.

The BBP33 printer is also compatible with Brady's software programs, including Markware, LabelMark and CodeSoft labelling software. These label software programs allow fast label and barcode creation and symbol and data importation.

www.bradyeurope.com

TYPE PK RADIAL FERRITE INDUCTORS AVAILABLE FROM TFC

Supplied by Total Frequency Control the type PK radial inductors provide compact high value inductance. The use of high performance ferrite material results in high Q components from 1µH to 150mH.

A unique lead to winding construction method provides excellent mechanical strength and the product is epoxy coated for maximum protection against humidity and may additionally be sleeved to customers order.

Operating temperature range of -20 to +100°C, based on maximum ambient temperature rating at +80°C and max temperature rise of 20°C during operation. Possible applications are endless including TV and audio equipment, telecommunication devices, personal computers, switching power supplies and noise filters, commercial and military.

"Whilst chip inductors have replaced many volume applications for this product type there remains substantial demand for custom values and the use of specific ferrite materials," said Edward Mills, Technical Director at TFC.

www.tfc.co.uk

RS COMPONENTS ENHANCES ITS 3D CAD MODEL SELECTION TOOLS

RS Components (RS) has launched a new, dedicated 3D-CAD microsite, giving customers faster, easier access to its extensive library of more than 30,000 3D CAD models from over 40 manufacturers, downloadable free-of-charge from the RS website.

The extra functionality provided via the new RS 3D CAD microsite enables users to search for the 3D CAD models by product category and by manufacturer, and incorporates a model viewer function, making it significantly easier and quicker for engineers to locate, view and download the appropriate model required for their design from a vast selection of components, including connectors, relays, switches and semiconductors. The new look page also integrates the existing 3D CAD tutorial video, 3D CAD FAQs and 3D CAD file format features.

Access to the model library is also available via the ModelSource component library on DesignSpark, the RS online community for engineers.

www.rs-components.com

New Relay Launched, Building On A Proven Design

The economical JQ relay, which has proven itself in the field, has been improved, resulting in a new relay named LQ. Manufacturing is completely automatic, which ensures consistent quality. Both series can be used in place of the other. For existing applications and qualifications, the JQ relay will continue to be produced.

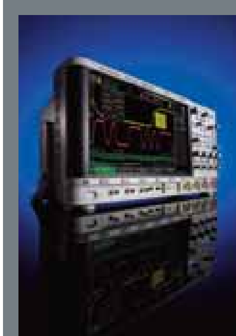
Thanks to their specifications, both the LQ and JQ relay series lend themselves especially for household applications, e.g. in washing machines, dishwashers, microwave ovens, stoves, refrigerators, air conditioners, boilers, jalousies, rolling shutters, coffee machines and more. On top of that, they can also be used in industrial and building automation or even in office devices.

Among its most important specifications are the 10A nominal switching capacity, 250VAC load voltage, one normally open (NO) or one changeover contact, AgNi contact material, compact design (WxLxH): 10mm x 20mm x 16mm, withstand voltage between contact and coil of 4,000 Vrms and so on.

www.panasonic-electric-works.co.uk

REDEFINING THE SCOPE EXPERIENCE WITH THE INFINIIVISION 4000 X-SERIES

Agilent Technologies introduced its groundbreaking InfiniiVision 4000 X-Series digital-storage and mixed-signal oscilloscopes. This new series establishes unprecedented levels of flexibility and ease of use among units that use an embedded operating system.



As the only fully upgradeable family of five-in-one oscilloscopes in the category, the InfiniiVision 4000 X-Series also provides excellent investment protection.

The new lineup offers bandwidths from 200MHz to 1.5GHz and several benchmark features. First is an industry-leading update rate of one million waveforms per second with standard segmented memory, which uses patented MegaZoom IV smart memory technology. Next are a 12-inch capacitive touch screen – the industry's largest – and the exclusive, all-new InfiniiScan Zone touch-triggering capability.

The hallmarks of the 4000 X-Series are speed, ease of use and integration. With the high-speed waveform update rate, operation is always fast, even with digital channels, protocol decoding, math functions or measurements activated.

www.agilent.com

EU PROJECT MODE-GAP UNVEILS PROGRESS TOWARDS NEXT-GENERATION INTERNET

MODE-GAP, the European collaborative R&D project which is part of the EU 7th Framework Programme, aims to provide Europe with a lead in the development of the next generation Internet infrastructure.

The MODE-GAP consortium consists of key European organisations drawn from industry and academia. Between them they presented ten major papers describing advances in critical components, measurement techniques, transmission and system aspects at this year's ECOC event in Amsterdam.

MODE-GAP also hosted an SDM workshop in conjunction with the Japanese EXAT project on the eve of ECOC, titled Optical Components and Characterisation Requirements for SDM Networks. Spatial Division Multiplexing (SDM) using Mode Division Multiplexing (MDM) is the approach MODE-GAP is focusing on in order to significantly increase the data capacity of a single fibre. This is achieved by using multiple modes within the same core of Few-Mode Fibres (FMF) as independent channels, each capable of similar capacity to an individual single mode fibre.

"Progress in optical communication systems over the past few decades has been profound," says MODE-GAP Project Manager Dr Ian Giles. "As a consequence of successive breakthroughs, both in terms of photonic and, more recently, digital signal processing technologies, the latest laboratory transmission experiments are rapidly closing in on fundamental information theory limit. At the same time, traffic on the world's optical communications networks is increasing by 40% year on year, leading to the distinct possibility of a capacity crunch."

"What we need is radical innovation and that is what MODE-GAP is trying to deliver. We have already made significant progress and the presentations and workshop at ECOC have demonstrated some of that work," added Dr Giles.

PROFESSOR DR DOGAN IBRAHIM, Near East University in Nicosia, Cyprus: The project goal of MODE-GAP is to develop the advanced technology and concepts needed to create next generation super-fast Internet infrastructure and at the same time reduce energy consumption. Few-mode optical fibres seem to be the way to satisfy the ever-increasing demand for bandwidth in long-distance optical fibre communication systems. The papers presented by MODE-GAP at ECOC are based on state-of-the-art few-mode fibre communications systems. Undoubtedly these papers will establish the basis for the next generation Internet infrastructure.

MAURIZIO DI PAOLO EMILIO, Telecommunications Engineer, INFN – Laboratori Nazionali del Gran Sasso, Italy: MODE-GAP is a key project seeking to provide Europe with a lead in the development of next generation Internet infrastructure to address the potential capacity crunch, as traffic on the world's optical networks continues to increase dramatically. Optical networks can extend cabling lines farther than copper cables, making it easier to distribute high-definition video feeds around. Optical networking has the potential to revolutionize technology in a variety of sectors, however this is highly dependent on major infrastructure upgrades as new high-performance optical networks need to be installed to support advanced capabilities.

HAFIDH MECHERGUI, Associate Professor in Electrical Engineering and Instrumentation, University of Tunisia: The action program of the union project MODE-GAP constitutes a radiant future for Europe. Indeed, the project ensures a bond between industry and academia.

The topics framed by the MODE-GAP are principal sectors for the future of the Internet, as the infrastructure of the MODE-GAP is associated with the services of universal communication and it offers integrated support.

Implementation of the Internet in a new guise makes it possible to deploy a vast range of applications such as research and development of sectors with diversified activities. This new tendency requires a high-speed technology, thus it is essential to conceive architectures and protocols with very high speeds.

What is more important is that MODE-GAP is based on the relationships between many European industrial partners and member states.

MODE-GAP encourages the development of the telecommunications sector because it has global reach. The development of the technology of optical fibers constitutes one of the key elements of the telecommunication revolution based on optical technology; a technology that will ensure long distance communication at very high speeds.

The Europeans set the best example of co-operation and development of high technology projects, and MODE-GAP is one joint effort that will bring many advantages to the further development of the telecommunication sector and is an innovating sector for the worldwide economy.

> Optical networking has the potential to revolutionize technology in a variety of sectors, however this is highly dependent on major infrastructure upgrades as new high-performance optical networks need to be installed to support advanced capabilities

BARRY MCKEOWN, RF and Microwave Engineer in the Defence Industry, and Director of Datod Ltd, UK: The essence of this program is to determine an appropriate long-haul capability to what is, as yet, an undetermined capacity crunch. The fundamental building blocks are the mathematical techniques developed for understanding the behaviour of solitons, through the non-linear mathematics required to augment the linear mathematics of the Fourier bounded framework of optics based on the superposition principle.

The physical chemistry aspects relate to controlling the wave model effects associated with refraction, diffraction and dispersion. But ultimately this technology will lead to an appreciation of what is needed to overcome the interference problem that plagues the standard electromagnetic model.

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

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