electronic design

THE AUTHORITY ON
EMERGING TECHNOLOGIES
FOR DESIGN SOLUTIONS

May 2014 electronicdesign.com

$10.00 A Penton® Publication

Periodicals Postage Paid • USPS 100 Approved Poly

WE'VE BEEN PROVIDING MEASUREMENT INSIGHTS FOR 75 YEARS.
AND THAT'S JUST THE BEGINNING.

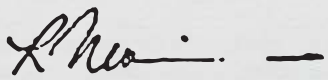
The company shaped by William Hewlett and Dave Packard in 1939 and championed through Agilent's Electronic Measurement Group is becoming a new stand-alone company.

Of course as our customer, you've always been a priority. Today you become an imperative. Because we never forget that our success depends on your success, and your ability to unlock insights.

To do this, our mission is clear. We must deliver for you. We must provide insights for you. That's why we're focusing all of our experience, all of our energy on what's next in test and measurement.

Our new name is Keysight Technologies. And our focus is unlocking test and measurement insights for you.

Sincerely,



Ron Nersesian, CEO

www.keysight.com

electronic design

THE AUTHORITY ON
EMERGING TECHNOLOGIES
FOR DESIGN SOLUTIONS

May 2014 electronicdesign.com

one BRIGHT issue

$10.00 A Penton® Publication
Periodicals Postage Paid • USPS 100 Approved Poly

ONE STOP

Prototype to Production®

Source: #1 Rated Website, 2013 Design Engineer and Supplier Interface Study, Hearst Business Media Electronics Group

1.800.344.4539

DIGIKEY.COM

Digi-Key® CORPORATION

1,000,000+ PRODUCTS IN STOCK | 650+ INDUSTRY-LEADING SUPPLIERS | 3.6 MILLION PARTS ONLINE

ecia ecsn member CEDA

"Superinductors"

That's what engineers are calling our new ultra-low DCR power inductors

Super*con*ductors pass current with virtually no resistance.

Our new XAL/XFL inductors do much the same. Their DCR is incredibly low: often half that of similar size parts.

And their current handling is equally impressive. Coilcraft's proprietary core material has a soft saturation characteristic that prevents drastic inductance drops during current spikes.

Competitors' 4.7uH inductors have much higher DCR per mm³ than Coilcraft's XAL5030.

Unlike competitive parts, these inductors don't suffer from thermal aging. And we give you far more footprint options to maximize PCB density.

To see what else makes our new XAL/XFL inductors so super, visit **coilcraft.com/xal.**

Coilcraft®

WWW.COILCRAFT.COM

coilcraftdirect.com
No min order. Next day delivery.

More CR2032 Holder Choices

MPD batteryholders.com

ENGINEERS START HERE.

Research. Design. Prototype.

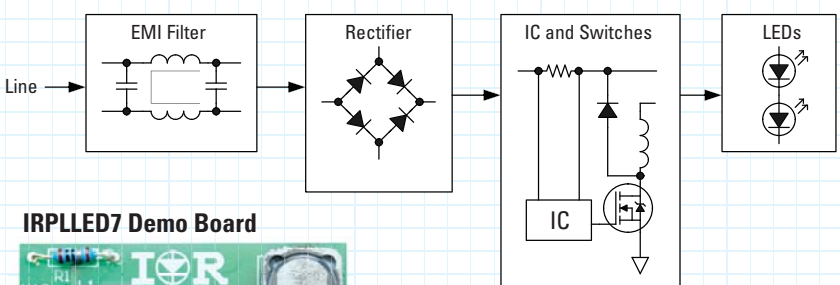
From data sheets to development kits & tools to components, Newark element14 offers what you need for every stage of your design. **newark.com** | **800.463.9275**

molex®

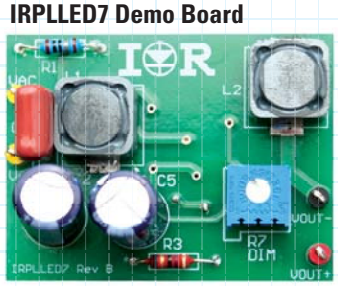
Featured product:
Mega-Fit Power Connector

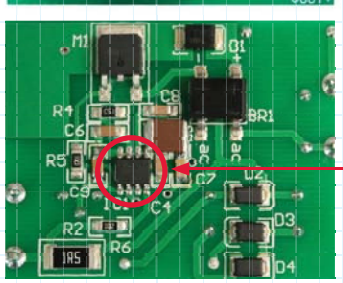
Newark™ element14™

High-Voltage Buck Control ICs for Constant LED Current Regulation



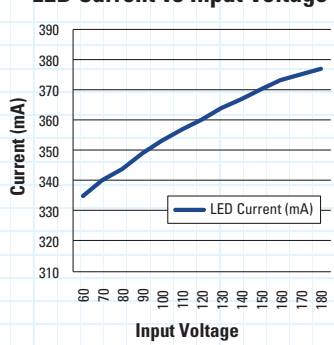
IRPLLED7 Demo Board





LEDrivIR™
IRS2980

IRPLLED7 Demo Board
LED Current vs Input Voltage



IRS2980 Features

- Internal high voltage regulator
- Hysteretic current control
- High side current sensing
- PWM dimming with analog or PWM control input
- Free running frequency with maximum limiting (150kHz)

IRS2980 Benefits

- Low component count
- Off-line operation
- Very simple design
- Inherent stability
- Inherent short circuit protection

Demo Board Specifications

- Input Voltage 70V to 250V (AC)
- Output Voltage 0V to 50V (DC)
- Regulated Output Current: 350mA
- Power Factor > 0.9
- Low component count
- Dimmable 0 to 100%
- Non-isolated Buck regulator

Part Number	Package	Voltage	Gate Drive Current	Startup Current	Frequency
IRS2980S	SO-8	450V	+180 / -260 mA	<250 µA	<150 kHz
IRS25401S	SO-8	200V	+500 / -700 mA	<500 µA	<500 kHz
IRS25411S	SO-8	600V	+500 / -700 mA	<500 µA	<500 kHz

for more information call 1.800.981.8699 or visit us at www.irf.com

International
IOR Rectifier
THE POWER MANAGEMENT LEADER

InThisIssue

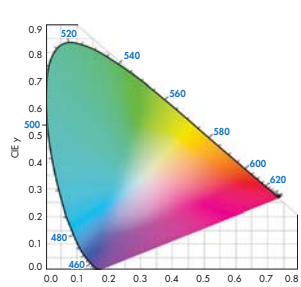
FEATURES

18

26

NEWS & ANALYSIS

COLUMNS



42

EDITORIAL MISSION:
To provide the most current, accurate, and in-depth technical coverage of the key emerging technologies that engineers need to design tomorrow's products today.

ELECTRONIC DESIGN (ISSN 0013-4872) is published monthly by Penton Media Inc., 9800 Metcalf Ave., Overland Park, KS 66212-2216. Paid rates for a one-year subscription are as follows: $120 U.S., $180 Canada, $240 International. Periodicals postage paid at Shawnee Mission, KS, and additional mailing offices. Editorial and advertising addresses: ELECTRONIC DESIGN, 1166 Avenue of the Americas, New York, NY 10036. Telephone (212) 204-4200. Printed in U.S.A. Title registered in U.S. Patent Office.

Agilent's Electronic Measurement Group is becoming **Keysight Technologies**.

Does the work of many. Takes the space of few.

Make every inch of precious rack space count thanks to the Agilent N8900 Autoranging Series. Choose from 5 and 10 kW models that can be easily paralleled to create 'one' power supply with up to 100 kW of power. Now that's a powerful promise.

Agilent N8900 Series Autoranging DC Power Supplies
Autoranging output does the job of many power supplies
Up to 10 kW in 3U maximizes rack space
Parallel multiple units for up to 100 kW of power
18 models: up to 1000 V, up to 340 A

Newark element14

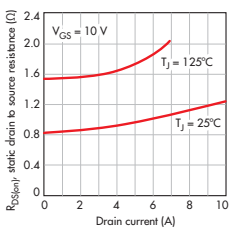
800-463-9275
www.newark.com/agilent

To find the right high-power supply for your needs, get your Power Products Selection Guide at
www.newark.com/Agilent_Power_Supply

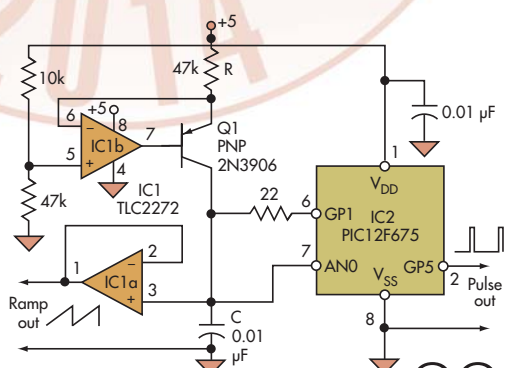
Agilent Technologies

May 2014
VOLUME 62, ISSUE 5

DISTRIBUTION RESOURCE



DESIGN SOLUTION



IDEAS FOR DESIGN

PRODUCT TRENDS

on electronicdesign.com

ACCREDIT YOUR WIND TURBINE'S NOISE PERFORMANCE IN SIX EASY STEPS

Applying for accreditation doesn't have to be frustrating.

blogs

PAUL WHYTOCK
ELECTRONIC DESIGN EUROPE
- Have Consumers Swallowed Too Many Tablets?

DON TUITE
ANALOG/POWER
- PMBus, GaN, And More Dominate APEC 2014

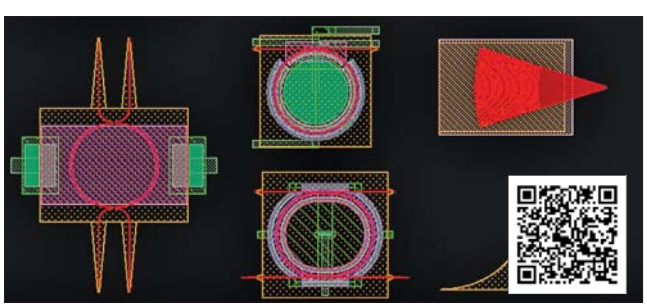
LOUIS FRENZEL
COMMUNICATIONS
- Long Live Vacuum Tube Amps

BILL WONG
EMBEDDED/SYSTEMS/SOFTWARE
- Science Fair Rules

join us online

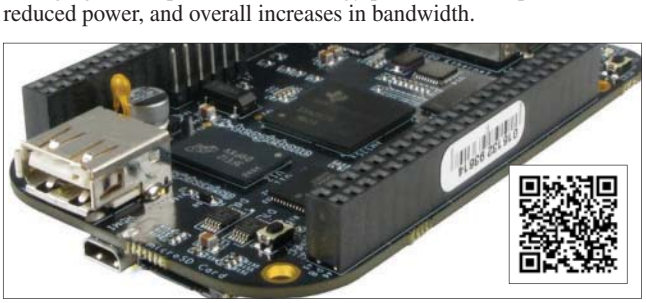
ENGINEERING SCHOOLS DIVE INTO DEEP R&D

University researchers are developing some of the most cutting-edge innovations in the medical, commercial, robotics, and alternative energy markets.



SILICON PHOTONICS BRING NEW CAPABILITIES TO IC DESIGN

Emerging silicon photonics technology promises better performance, reduced power, and overall increases in bandwidth.

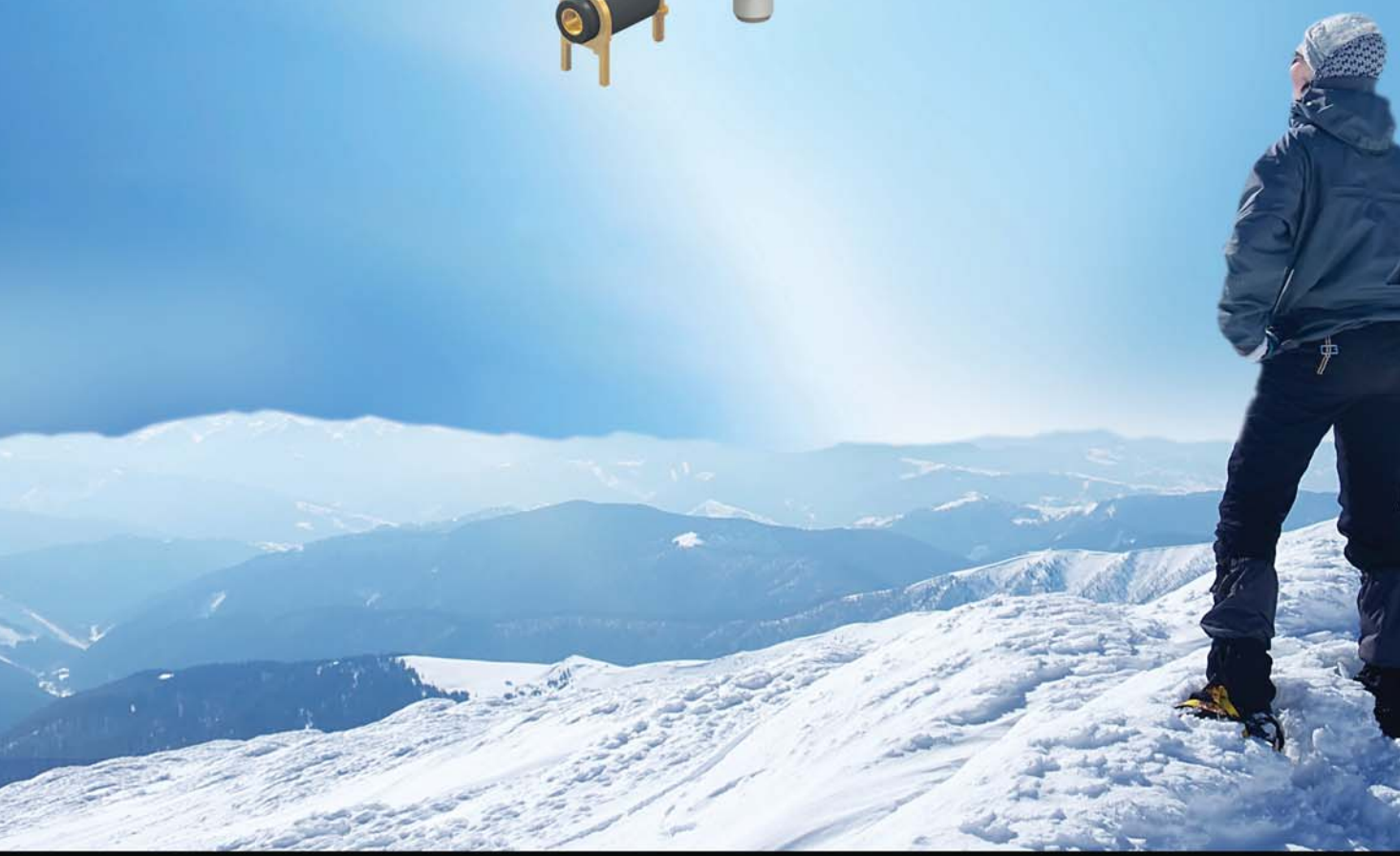


THE BEST OF EE LIVE

We report on the most significant product announcements and demonstrations at this year's EE Live conference in San Jose.

THINK™

PINS, PLUGS, JACKS & SOCKETS



• Audio Jacks • Banana Jacks/Plugs • Binding Posts • Phono Jacks & Plugs • Test Jacks/Plugs • Micro Jacks
• Micro Pins • Shorting Jacks and Pins • Transistor Sockets • Transistor Mounting Kits • TO-3 Covers and Insulators
• USB Jacks and Plugs • Firewire, IEEE 1394 Jacks and Plugs • Request Catalog M60.2

IT'S WHAT'S ON THE INSIDE THAT COUNTS

KEYSTONE®
ELECTRONICS CORP.

www.keyelco.com • (718) 956-8900 • (800) 221-5510

electronic design
A Penton® Publication
MAY 2014

Agilent's Electronic Measurement Group is becoming **Keysight Technologies**.

No other oscilloscope can touch it. But you can.

The oscilloscope experience redefined.

Agilent 4000 X-Series Oscilloscopes	Agilent 3000 X-Series Oscilloscopes
200 MHz to 1.5 GHz	100 MHz to 1 GHz
Starting at $5,611*	Starting at $3,222*
12.1" capacitive touch display	8.5" display
InfiniiScan Zone touch triggering	—
1M waveforms/sec update rate	1M waveforms/sec update rate
Fully upgradable: bandwidth, MSO, dual-channel WaveGen, DVM, serial analysis including USB	Fully upgradable: bandwidth, MSO, WaveGen, DVM, and serial analysis

* Prices are in USD and are subject to change

Scan the QR code or use the Layar app to see a video

TESTEQUITY

800-732-3457
www.testequity.com/agilent

Experience the difference.
Get time-saving app notes.
www.testequity.com/Agilent_Scope

Agilent Technologies

Infinite Designs, One Platform

with the only complete system design environment

NI LabVIEW is the only comprehensive development environment with the unprecedented hardware integration and wide-ranging compatibility you need to meet any measurement and control application challenge. And LabVIEW is at the heart of the graphical system design approach, which uses an open platform of productive software and reconfigurable hardware to accelerate the development of your system.

LabVIEW system design software offers unrivaled hardware integration and helps you program the way you think–graphically.

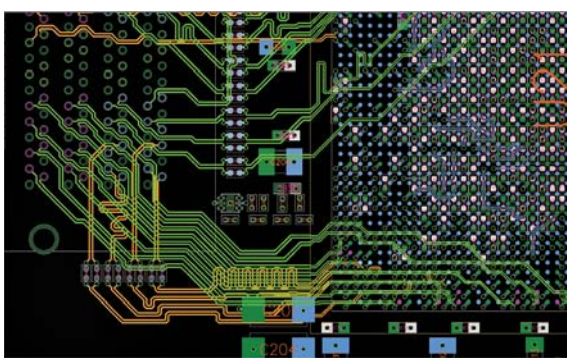
>> Accelerate your system design productivity at ni.com/labview-platform

800 453 6202

NATIONAL INSTRUMENTS

BILL WONG | Embedded/Systems/Software Editor
bill.wong@penton.com

Today's Design Tools Improve



1. Mentor Graphics' Xpedition xPCB Layout program simplifies interactive routing of differential signals.

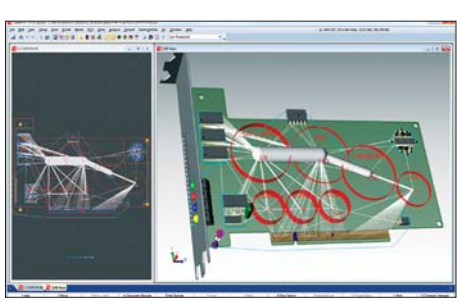
Anyone who has worked on a system design lately knows that creating a printed-circuit board (PCB) is no longer simple. Differential signals and multiple layers are the norm. RF is needed for Bluetooth, Wi-Fi, ZigBee, Z-Wave, and more. Signal integrity is as important as making sure the right pins are connected together.

Likewise, boards are more complicated. More layers are often needed to address the density of systems-on-chip (SoCs) that have hundreds of balls packed into an ever-tighter space. This complexity lends itself to automatic routing, but many designers still prefer manual routing because it can address issues that are sometimes hard to quantify to a program.

Companies like Altium, Cadence, Zuken, and Mentor Graphics have PCB layout programs designed to address these issues. Mentor Graphics' latest Xpedition xPCB Layout simplifies interactive routing of differential signals *(Fig. 1)*. Its high-level, hierarchical placement tool can operate in 2D and 3D modes *(Fig. 2)*.

Xpedition's 3D mode and mechanical enhancements allow designers to address the 3D aspects of a design, not just the circuit layout issues. The system can perform automatic placement and management. Yet its auto-assisted routing and customizable multi-pass autorouting impressed me the most when the company demonstrated its latest software. Auto-assisted routing is an interactive process. Just start from a pin, drag the cursor to about where the path should be, and watch the results.

Running differential pairs was just as easy. The "multiplow" process lets a designer adjust a collection of paths like a data bus in one step. It keeps the paths in sync with each other, providing the nice, parallel layout that is usually the result of a fully manual but time-consuming process. The system can even be programmed to allow arcs or angles when required for tight routing like around ball-grid array (BGA) balls. The push and shove manual/auto-assist also works in 3D mode with objects like chips.



2. Xpedition's 3D view supports hierarchical placement.

I have not laid out a board in a couple years. But if it is this easy, I might try again soon. ed

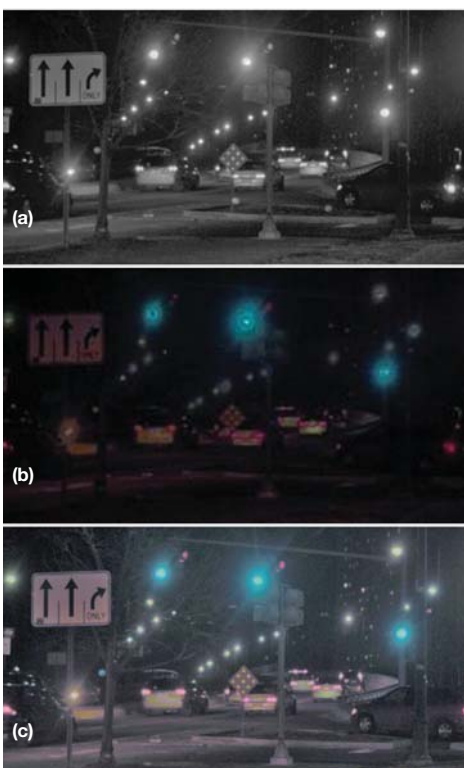
Point Of View

CLIFF DE LOCHT | Melexis
cde@melexis.com

NIR Technology Improves Driver Assistance Systems

Although the figures have steadily dropped over recent years, there are still 75 fatalities on Europe's roads every day, according to the European Commission. In the U.S., 11.4 automotive deaths per 100,000 citizens are recorded annually. The use of optoelectronics to provide video support in modern automated driver assistance systems (ADAS) can greatly reduce the likelihood of accidents.

Through such implementations, drivers will benefit from improved visibility levels. For example, sudden bends in the road or potential obstacles can be determined much earlier, so drivers can take appropriate action much sooner. Yet ensuring an accurate visual assessment of the traffic situation in dark, rainy, or misty conditions is a major challenge not only for the human eye but also for imaging devices, as the viewing area often is limited to the range of the headlamps.



While driving at night, HDR systems combine the luminance picture (a) and RGB color image (b) to form a composite image (c).

Video cameras are used as a front end for these systems. They can capture details such as the location, shape, size, brightness, and color of objects in the line of sight, regardless of the lighting conditions. Captured images can be displayed on the vehicle's instrument panel or analyzed via software to generate warnings—even intervening in the vehicle's operation if necessary.

There are issues, though. The dynamic range of a scene (i.e., the brightness ratio between the brightest and darkest point in the scene) will, in many cases, far exceed the capabilities of conventional image sensors based on standard CMOS technology that exhibit linear sensitivity. The lights from oncoming vehicles will also seriously impair the ability of the eye (or a camera) to detect hazards that lie ahead.

If detailed imaging data can't be acquired due to the camera's lack of dynamic range, safety may be compromised. Increasing the dynamic range of a camera or image sensor will improve its ability to determine where potential dangers lie. The application of a non-linear approach presents a way to achieve this by reducing the background noise, at the same time ensuring that pixel saturation only begins at much higher signal strengths.

HDR DEVICES

The emergence of high dynamic range (HDR) imaging devices is allowing the extended sensitivity that car manufacturers have been seeking. ADAS operational performance then can be enhanced to cope with adverse weather and nighttime driving.

The pixels of some image sensors now can deliver dual functionality. They can cover the full sensitivity range, including the visual and near infrared (NIR) range, and are much more sensitive than the conventional color pixels currently used in automotive imaging systems. They also can be used to estimate the fraction of NIR in the RGB pixel signals, so an unwanted NIR signal can be taken out of the color signal. The true color image then can be created by combining the visible and NIR signals.

Figure a shows that the clear pixels are supplying a sufficiently bright grayscale image. The relatively dark color image shown in Figure b mainly reflects the colors of the lights on the almost black background. Since the spectral energy in the visible region is small compared to the entire range of sensitivity of the image sensor, the brightness component of the filtered color is significantly weaker than the luminance of the pixels. The combined final image in Figure c provides a natural representation of all traffic-related color information.

Reduced visibility in poor conditions increases the risk of accidents significantly, as the state of the road can be misjudged or obstacles not detected. Active driver assistance mechanisms based on HDR image sensors with smoother pixel response curves, and using highly advanced proprietary algorithms, offer the means to enhance visibility levels in such circumstances. This can increase safety in the driving environment. Furthermore, the generation of multi-kneepoint HDR images in a single exposure can effectively eliminate the presence of motion artifacts.

ON THE MARKET

Melexis has developed a series of image sensors to improve ADAS effectiveness. They feature high sensitivity across all the wavelengths in the NIR spectrum, as well as provisions for full-color reproduction. The six-kneepoint multiple-slope CMOS pixel functionality utilized means the discharge rate of photon energy increases in proportion to the incident light intensity.

While dark pixels are only partially discharged during the integration time, very bright pixels will witness complete discharge so they are ready to begin image recording again within the remaining shortened integration time. This process can be repeated several times with ever-lower recharge voltages and shorter rest periods.

The result is what can be considered as a linear approximation of a logarithmic curve. A proprietary adaptive control algorithm is used to adjust the shutter speed and expand the dynamic range, ensuring that the incremental signal-to-noise ratio (iSNR) always remains above a minimum threshold.

New developments won't just improve the quality of images that a car's ADAS can access, though. They also will effectively enable tuning of ADAS sensitivity. The system will identify the decisive moment, based on data regarding the driver's level of alertness, when to warn the driver (or alternately, when to execute an automatic braking or avoidance maneuver). Imaging improvements will include raised HDR sensitivity characteristics, elimination of motion artifacts, increased resolution, higher speed, and extended functional safety, supplemented by other emerging sensing technologies. ED

CLIFF DE LOCHT is product marketing manager for the Optoelectronics Division of Melexis. He has a master's degree in microelectronics and telecommunications from the University of Brussels.

News & Analysis

BILL WONG | Embedded/Systems/Software Editor

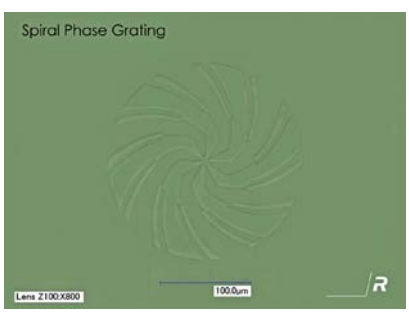
Tiny Lensless Image Sensor Suits The IoT

Rambus is developing a tiny lensless imaging system that covers a typical photodiode array with a specially designed diffraction grating. The diffraction approach eliminates the lens and support structure used with a refraction-based camera, but the data requires significantly more preprocessing to obtain an image *(Fig. 1)*. Luckily, this can be done using a conventional DSP or GPU.

The diffraction-based imaging system trades off mechanical complexity and cost for computational complexity. At this point there is a resolution limitation. The current sensor provides a 128- by 128-pixel image with a 100° view. The resolution is not likely to grow significantly, and telephoto operation is not applicable because no lens is involved.

Part of this limitation is also based on the diffraction approach as well as the diffraction grating. In particular, the diffraction grating needs to work with full-spectrum visible light. Still, many insects and other animals function with this level of resolution. Similarly, many proximity-sensing applications can operate without high-resolution images.

Essentially the system uses the diffraction grating to spread incoming light across the sensor array. This means that light from a source will hit multiple pixels. The software then extracts the image by reducing the complex mapping imposed by the diffraction grating. The spiral architecture then comes into play because the algorithms know about its structure so it can decompose the captured data into the original image.



1. The Rambus lensless imaging system uses a specially designed spiral diffraction grating above a photodiode array.

Compare this to a refraction approach where the lens focuses light from a source onto adjacent pixel sensors. In this case it is a simple matter of dumping the sensor data to obtain the image. The advantage is the simple sensor implementation and minimal data-packing overhead compared to some complex calculations for the new diffraction approach. The lens-based system scales well but requires more expensive glass optics to deliver high-quality images.

The diffraction approach won't replace the technology in digital cameras anytime soon, but it does have advantages that make it an ideal sensing technology, especially for systems designed for the Internet of Things (IoT). For example, motion sensing and basic object position sensing require quite a bit of computation to analyze an image. This would take more time with a diffraction system if the image was recreated first, but tasks like this are easier to accomplish using the raw data from the sensor array. Changes from a region being viewed will show up as changes in

LED LAMPS ENLIST GaN FOR BETTER PERFORMANCE

RESEARCHERS AT THE Fraunhofer Institute for Applied Solid State Physics IAF in Freiburg, Germany, are turning to voltage transformers that feature gallium-nitride (GaN) transistors for the kind of robust construction that LED lamps demand, enabling more light for less energy. GaN components can operate at higher currents, voltages, and temperatures than standard silicon transistors. They also can switch at high frequencies, which has a significant impact on the size of the coils and condensers built into the drivers for energy storage.

one or more pixels on the sensor array, so it is possible to have a "tripwire" of a few pixels instead of analyzing the whole image to detect the change. This significantly reduces processing requirements and, hence, power consumption.

The system also makes tracking of angular movement between images easier; since the incoming light is spread across the imager, the system can track a fractional pixel movement. Rambus says the sensor has 1 arc minute of accuracy. This could be useful for a fiducial LED tracking system that might be found on a virtual reality helmet. For many applications, just knowing about the change is sufficient. Likewise, the change in angle to detect movement can be achieved more easily using the raw data rather than the processing normally required for two sequential images.

A simple implementation is another advantage of diffraction. Initial tests were performed with a commercial array and a custom diffraction grating but it should be possible to fabricate the system on-chip using an additional step *(Fig. 2)*. Melding the system construction into the chip creation process has a number of advantages, from elimination of alignment issues that a lens requires to lowering system costs. ■

2. Rambus placed its special diffraction grating (a) over a commercial photodiode array (b). The test grating had a number of different patterns, allowing the company to test different system configurations.

ROGER ALLAN | Contributing Editor
rsallan@optonline.net

Solid-State LED Lighting

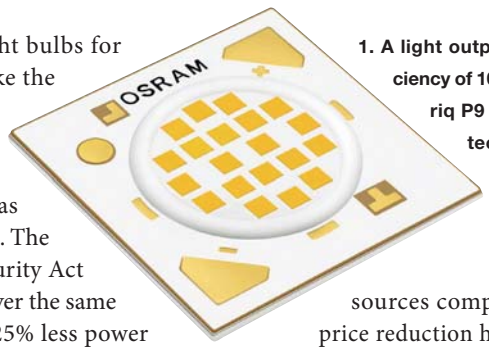
Responds To System Needs

Solid-state LED illumination has been around for decades. But only over the past decade has it had an impact on indoor and outdoor illumination, where it has steadily gained a foothold with continuing albeit slow decreases in LED chip costs. The technology has the potential to significantly reduce energy use and costs.

LED-based lighting product prices have decreased more rapidly than had been expected according to market research firm Yole Développement. It estimates that the 2013 packaged LED product market of $13.9 billion will reach $16 billion by 2018, driven mainly by general lighting applications.

There's progress in better chip performance and lower cost. But system-level attention needs more focus to reduce the costs of supporting drivers, thermal management, optics, and package housings.

Consumers today can buy LED light bulbs for as little as $9.95 from major outlets like the Home Depot, Lowe's, and Walmart. However, there is some confusion about the various types of light bulbs available on the shelves besides LEDs, as well as the rating nomenclature on them. The federal Energy Independence and Security Act of 2007 requires LED light bulbs to deliver the same amount of light output using at least 25% less power than the other types of bulbs they would replace.



1. A light output of 2000 lumens and luminous efficiency of 100 lumens characterize the Osram Soleriq P9 LED chip. Using chip-on-board (CoB) technology, it has a surface diameter of just 9 mm in a 15- by 15-mm package and is aimed at spotlight applications in retail outlets and museums.

EFFICIENCY ACHIEVEMENTS

LED efficiency levels have risen to more than 160 lumens/W in the last decade. Cree has demonstrated in the laboratory a record 303-lumen/W white light at a correlated color temperature (CCT) of 510 K and 350 mA. (The theoretical maximum output for LEDs is about 683 lumens/W.) Of course, a higher light output level comes at the expense of greater heat dissipation, leading to more thermal management.

Osram Opto Semiconductors is using chip-on-board (CoB) technology to offer LEDs with a luminous flux of 2000 lumens and an efficiency of 100 lumens/W from a light-emitting surface diameter of just 9 mm in a 15- by 15-mm package *(Fig. 1)*. The compact Soleriq P9 is aimed at spotlight applications in retail outlets and museums.

The company also has demonstrated what it claims is the world's most efficient LED lamp, which achieves an efficiency of 215 lumens/W. That's as much light output as what compact fluorescent lamps (CFLs) or LED tubes deliver, yet Osram's lamp dissipates one-half the power. This record-setting efficiency is based on the use of high-efficiency red LED chips and green-whitish Osram-developed phosphor.

Yet progress in getting more LEDs into the public domain and in homes, buildings, and outdoor settings has been slower than what the technology has promised. Manufacturers have learned that for them to move forward more rapidly, they must deal with even more complex issues than just the chip's cost. Manufacturing costs involving wafer materials, processing, and packaging are a big challenge and form a significant part of a light bulb's cost.

Cree has introduced the first 800-lumen module intended to replace 150-W ceramic metal-halide lamps in high-ceiling public areas such as convention centers, airports, auditoriums, and shopping malls *(Fig. 2)*. It uses 63% of the power used by metal-halide lamps and lasts three times as long. "It allows us to effectively address high-ceiling, high-lumen applications without sacrificing color reliability and quality," says Wesley Johnson, Cree's product manager for Hi-Lite Manufacturing.

Still, LED light bulb prices have steadily narrowed the cost difference between LED illumination and incandescent and even CFLs. There's no question that the energy and cost savings over a longer-term basis are key attributes of LED lighting sources compared to other sources. This gain in price reduction has been the result of more advanced materials, better optics, smarter drive circuitry and controllers, and innovative thermal management methods. Helping all of this is the government's mandate to phase out much less efficient incandescent bulbs and eventually CFL bulbs.

The Department of Energy's (DoE's) Energy Efficiency and Renewable Energy initiative has been a major driver. 100-W and 75-W tungsten light bulbs were phased out of the market a couple of years ago, and 60-W and 40-W bulbs will follow. Retailers, however, are allowed to sell off existing inventory.

Because luminaire, lamp, and trough lighting applications must satisfy many variable requirements in the area they're illuminating, the LEDs within them must be designed to be flexible enough to meet those requirements. LED chip makers may find it more practical to begin a design from not just at the chip level, but also continue through to the application level. Optics adaptability to the application is just one example in need of tackling.

For instance, Philips Lumileds Lighting's Luxeon Z family of un-domed micro-sized LEDs provides unmatched optical flexibility for precise light-beam control *(Fig. 3)*. Just 13 by 17 mm in size, the one-step McCadam Ellipse warm-white LEDs enable unsurpassed color consistency, luminance, flux density, and design flexibility for future lighting solutions.

Flexibility for lighting fixture and other end users is a must. They need to have easy light-level adjustments, programmable control, dimming capability, a package form factor that fits the intended application, the right color rendering index (CRI), color-correlated temperature (CCT), and a package that fits the intended application. However, more light output is needed in a practical costs/lumen manner with enough white light output to fit the application.

"Lighting quality should be considered in a contextual manner. Sometimes, for example, a certain output lumen level is not suitable for a particular application," says Derry Berrigan, co-founder and chairwoman of Light Think University, a non-profit organization that seeks to educate college students about lighting and realistic expectations in terms of other disciplines like architecture *(see "Changing Technologies Require New Lighting Perspectives" at electronicdesign.com)*.

Medium-output and high-output LEDs are beginning to appear in a variety of applications, many of which showcase solid-state lighting (SSL) technology's capabilities. Notable

The true test in NAND flash innovation: is it ready to fly?

How many times have you looked at using the latest technology — only to find that the 'next big thing' hasn't yet been cleared for take off? With people, products — entire industries — relying on your designs to achieve smaller, lighter, faster, more robust products, timing is everything. The market is moving at supersonic speed. You have to sort through the hype, dodge the spin makers and find reliable technology that delivers a competitive solution. Who can you count on to get it right the first time? ■ Moving at the speed of technology requires an experienced navigator, and you can rely on Toshiba. After all, we invented NAND flash technology. Clear skies ahead. **toshiba.com/taec/technologymoves**

TOSHIBA NAND
MEMORY SOLUTIONS

UFS NAND

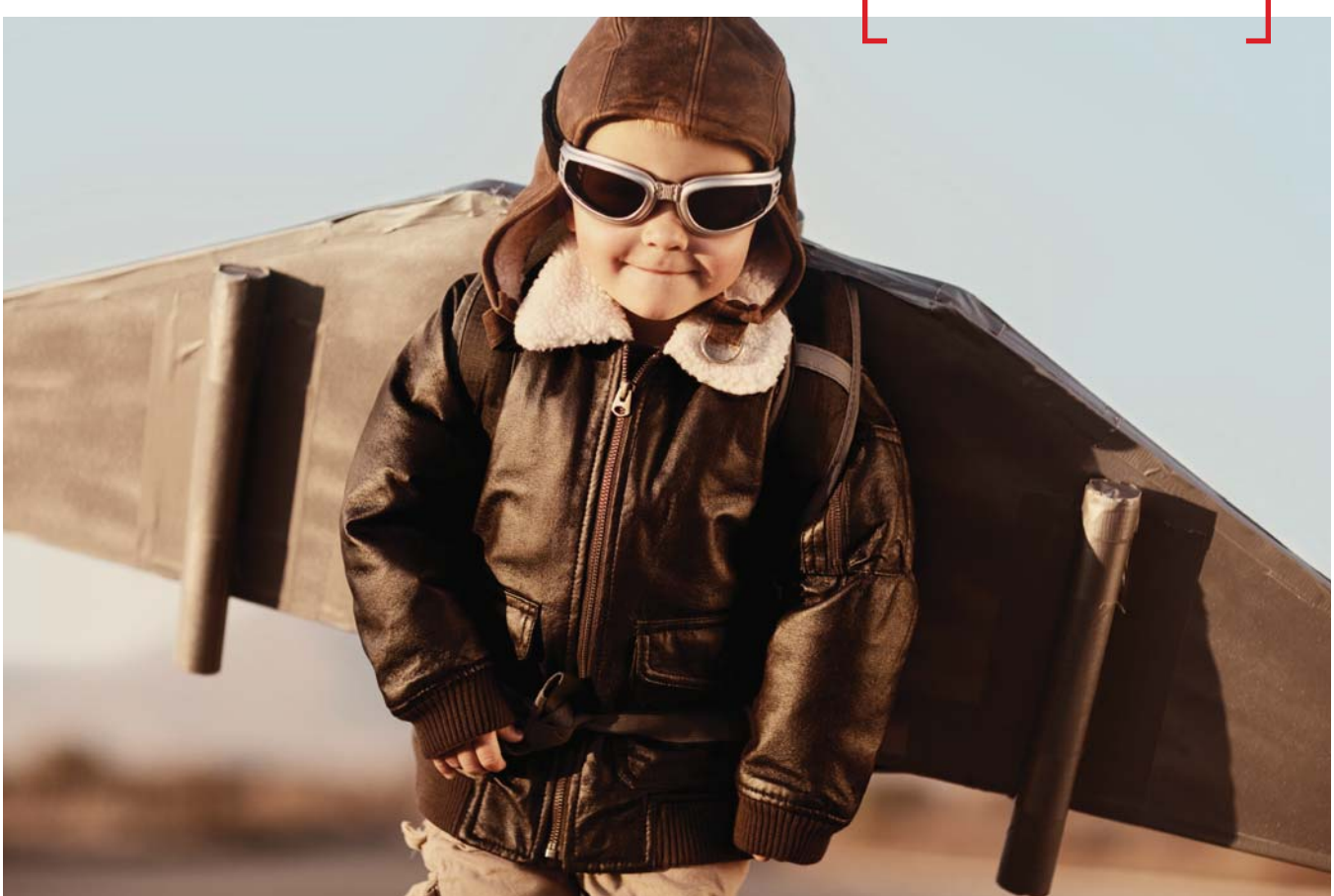
Managed NAND

Enterprise NAND

NAND with ECC

SLC NAND

INVENTOR OF FLASH MEMORY



[When Toshiba moves, technology moves.]

toshiba.com/taec/technologymoves

TOSHIBA
Leading Innovation »»

SmartNAND is a registered trademark of Toshiba Corporation. Universal Flash Storage (UFS) is a trademark and product category for a class of embedded memory products built to the JEDEC UFS standard specification. e-MMC is a trademark and a product category for a class of embedded memory products built to the JEDEC e-MMC Standard specification.

2. This Cree 800-lumen module is intended to replace 150-W ceramic metal-halide lamps in convention centers, airports, auditoriums, and shopping malls. It uses 63% of the power used by metal-halide lamps and lasts three times as long.

applications for outdoor and indoor LED illumination worldwide are plentiful. LED flood lamps now wash programmable palettes of red, green, and blue (RGB) shifting colors across the exterior of buildings, tunnels, stadiums, and bridges worldwide at costs less than alternative lighting sources and with greater lifetimes.

The western span of San Francisco's Oakland Bay Bridge, which celebrated its 75th anniversary in 2011 with 25,000 RGB lights, is just one of many examples. This type of lighting is reported to be more efficient than other lighting sources, lasts tens of thousands of hours, cuts the costs of replacing hard-to-reach burnt-out other types of bulbs, and requires only about $30 worth of electricity to power at night.

SSL is gaining more traction than CFL products, reports James Brodérick, the DoE's Lighting Program manager, and is being adopted much faster than CFLs, although not as fast as consumer electronics technology. He credits action taken by the DoE's Commercially Available LED Product Evaluation and Reporting (CALiPER), Gateway and Lighting Facts programs, various energy efficiency programs, and standards organizations that helped the LED industry avoid the problems that plagued CFL market development.

Late last year, the DoE allocated nearly $10 million to support LED R&D and manufacturing efforts for SSL as part of cutting energy waste and doubling energy productivity by 2030. The funding also includes funding for organic LED (OLED) technology efforts. The DoE expects the present roughly 150-lumen/W output levels to increase 250 lumens/W by then.

The DoE Caliper program has issued recent reports on MR16 and PAR38 lamps to help LED lighting makers and suppliers adjust to market conditions.[1] The two lamp forms are popular housings used in the illumination market.

WHICH GaN TECHNOLOGY?

The use of gallium nitride (GaN) on silicon wafers is a mainstream way to grow LED chips. Another is GaN on sapphire. There is no clear sign which technology will be the front runner for the next few years, although many experts agree that both will prosper. There are also competitors like GaN on GaN, silicon carbide (SiC), and even indium gallium aluminum phosphide (InGaAlP).

Many major LED chip manufacturers including Plessey Semiconductor, Osram Semiconductor, Cree, Philips, and Sharp Corp. are using the GaN-on-silicon process. To ease the transition to GaN-on-silicon LEDs, Azzurro Semiconductor created a GaN-to-silicon wafer template. The company claims it achieved 3-nm wavelength uniformity in a production setting and 1 nm in the lab. Azzurro's intellectual property eases the transition for GaN-on-silicon LED manufacturers and deals with bowed wafers and variable wafer thicknesses.

For those IC companies making GaN on sapphire, which is expensive and difficult to process, SemiLEDS developed and patented a technique that eliminates the need for sapphire. The method significantly reduces the carbon footprint of the LED. It deposits GaN on a copper alloy *(Fig. 4)*. The lack of sapphire also removes a thermal management bottleneck while providing an environmentally friendly LED.

Soraa has developed what it says is the world's most efficient LED with its third-generation Gen3, which outperforms its nearest competitor by 20% at normal operating conditions, according to the company. Made using CoB technology, it provides unmatched efficiency and brightness, full visible-spectrum color, and whiteness rendering. It will be integrated into large form-factor lamps.

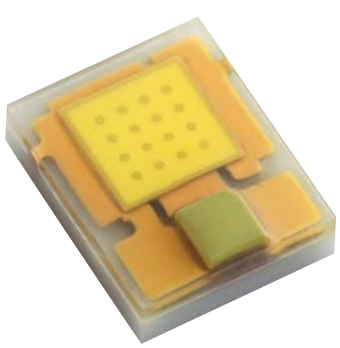
One indication of a market adjustment to reduce the cost of LED manufacturing is the move by Bridgelux Inc. to sell its GaN-on-silicon technology to Toshiba. This enables Toshiba to produce lower-performance LEDs using larger wafer-size GaN-on-silicon technology and leaves Bridgelux to concentrate on its core GaN-on-sapphire technology to make higher-performance LEDs on smaller wafers.

THE PACKAGING CHALLENGE

As experience has shown, the packaging challenge is pushing LED semiconductor chip manufacturers (and there are hundreds of them) to work more closely with lighting product providers. The DoE recognized this challenge in its Manufacturing Roadmap for solid-state lighting and R&D workshop report prepared last September.[2]

Packaging takes the biggest chunk out of the manufacturing process for an LED where costs associated with die-level packaging activities tend to dominate *(Fig. 5)*. LED manufacturers need to pay closer attention to it to realize greater cost savings, states the report. The DoE expects these packaging costs to come down to about 17% of 2013's value by 2020.

As mentioned earlier, CoB technology is becoming more common in LED packaging. Bridgelux produces the V series (connector-less) and the Vero series (connectors) of LED

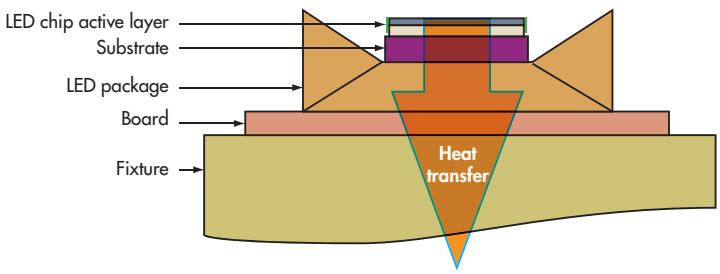


3. Philips Lumileds' Luxeon Z family of undomed micro-sized LEDs provides unmatched optical flexibility for precise light-beam control. Just 13 by 17 mm, they provide a warm-white output with unsurpassed color consistency, luminance, flux density, and design flexibility for future lighting solutions.

chips using CoB technology. Bridgelux's latest product is the Outdoor Lighting Module (OLM). "This represents a higher level of integration for outdoor lighting," says Todd Farmer, senior marketing manager for exterior and industrial lighting. "It takes the CoB approach and integrates it with optical control, with outdoor environmental protection (IP66). It solves the capital expenditure problem by the way optics are designed."

Luminous Devices Inc. also uses CoB technology in its Xnova LEDs, which deliver 145 lumens/W at 5000 K and 132 lumens/W at 3000 K at room temperature. The company credits its AccuWhite technology for delivering the industry's best CRI of 98.

Samsung is offering advanced flip-chip LEDs, the FC and FCOM, for packages and modules that offer a high degree of design flexibility and reliability for use in bulbs, packages, and downlights. The LED chips are flipped over and adhere to a phosphor film for each LED. There's no need to place a plastic mold over each chip, as other companies normally do. This allows for packages down to a chip-scale size, enabling more compact lighting fixture designs.



4. SemiLEDS developed and patented an eco-friendly technique for making LED chips without the use of any costly and difficult-to-process sapphire. It deposits GaN on a copper alloy, which significantly reduces the carbon footprint of the LED. It deposits GaN on a copper alloy LED.

DRIVERS ADD COSTS

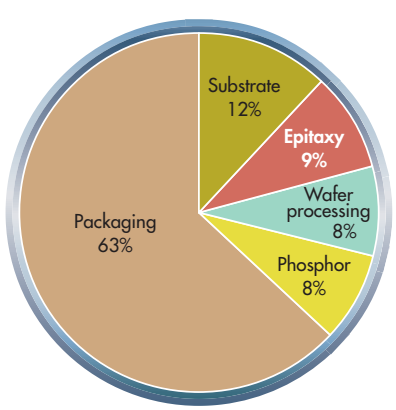
LED lamps require driver circuits that can add significant costs for SSL. The challenge is to deliver a lamp with high-quality light at affordable costs, while meeting a high enough CRI and dimming capability similar to incandescent bulbs. Moreover, the LED lamp and its driver must be compatible with the dimming capability already installed in the home or building. And, it must provide flicker-free dimming with no shimmer.

Fairchild Semiconductor's FAN5346 boost LED driver supports pulse-width modulated (PWM) dimming. This asynchronous constant-current driver drives LEDs in series to ensure equal brightness for all LEDs. It's available in two versions: a 20-V output for driving five LEDs (FAN5346S20X), and a 30-V output to drive eight LEDs (FAN FAN5346S30X).

Marvell Semiconductor says its 88EM8187 LED constant-current controller delivers unparalleled deep dimming performance and the industry's highest level of integration in eight-pin and 14-pin small-outline IC (SOIC) packages. It features over 90% driver efficiency and the industry's best regulation of less than 2% over a wide ac line voltage range.

The STEVAL385LEDPSR evaluation board and reference design for intelligent LED-based streetlight designs from STMicroelectronics includes the STM8-microcontroller-based STLUX385A digital power controller IC, which can implement SSL driver functionality. It also provides a variety of interfaces including network connectivity.

"Digitally controlled lighting is the key to saving energy in outdoor installations," says Matteo Lo Presti, group vice president and general manager for STMicroelectronics' Industrial and Power Conversion Division. "As grids get progressively smarter, cities will be able to control the streetlamps to produce even greater savings because all the key communications protocols are already incorporated in the STLUX385A." ed



5. Packaging for an LED chip takes the biggest chunk of costs (63%) out of the manufacturing process where die-level packaging activities tend to dominate. Packaging costs will come down to about 17% of 2013's total by 2020. *(courtesy of the U.S. Depatment of Energy)*

REFERENCES

1. "DOE Publishes CALiPER Snapshot Report on LED MR16 Lamps" and "CALiPER Application Reports," www1.eere.energy.gov
2. "Solid State Lighting Research and Development Manufacturing Roadmap," http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_manuf-roadmap_sept2013.pdf

BILL WONG | Embedded/Systems/Software Editor
bill.wong@penton.com

Ultra HD Displays Are The Next BIG Thing

Ultra High Definition (Ultra HD) was plastered all over this year's International CES in Las Vegas in January. With 3840- by 2160-pixel resolution, Ultra HD televisions and monitors are now the norm at most consumer electronics stores. Also known as 4K Ultra HD or 2160p, Ultra HD has about 8 million pixels compared to the 1080p high-definition televisions that have dominated the landscape until this year.

A 1080p display offers 1920- by 1080-pixel resolutions. Like the lower-resolution 720p format, 1080p and Ultra HD both provide a 16:9 aspect ratio. 1080p also has a quarter the number of pixels compared to Ultra HD. The jump from 720p to 1080p is only a factor of 2. As with 1080p, the high resolution will initially dominate the high end of the product spectrum, but eventually push its way down the food chain. Cost is the main issue, though the improved resolution is more important with larger screens.

The higher-resolution advantage will be clear to anyone who has viewed an Ultra HD display, although viewers need to know the source of the content. As many cable customers know, a 1080p or 1080i signal does not mean a high-quality image when the source is providing a downsampled video stream. Still, a high-quality Ultra HD video stream supplies an impressive image.

1. Sharp's Aquos 4K series delivers 3840- by 2160-pixel Ultra HD resolution.

The 4K video standard employed at most movie theaters has 4096-by-2160 resolution. That's slightly wider than the consumer Ultra HD specification, but it has the same number of lines. Carving 128 pixels off each edge is not such a bad thing. It is definitely less noticeable than letterboxing, though some movies are shot using other aspect ratios such as 21:9. In this case, even an Ultra HD display will use letterboxing unless some cretin tries to stretch the movie to 16:9.

SHARP DEVELOPMENTS

Sharp's Aquos 4K series is a good representation of the latest crop of Ultra HD televisions, including a 70-in. version at the top end of the line *(Fig. 1)*. The series employs Sharp's Super Bright technology to improve the display's overall brightness. Its 120-Hz refresh rate comes courtesy of Sharp's AquoMotion 240 technology, which provides a better rendering for fast moving video and is useful for active 3D. Each television comes with two pairs of wireless Bluetooth 3D glasses.

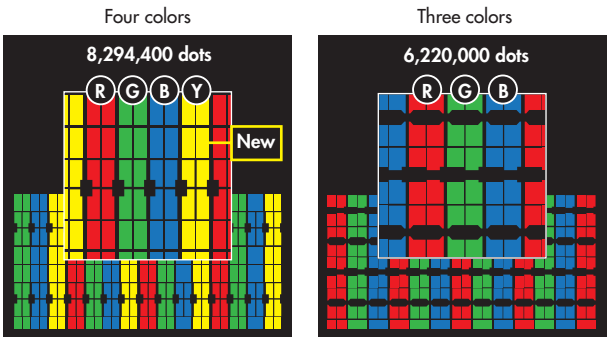
The Aquos 4K televisions use the Sharp Revelation 4K Upscaler to play lower-resolution content. The system is THX 4K certified, which is handy for hooking into a more sophisticated audio setup. Also, turning off the Sharp Aquos does not have to mean a blank screen. The wallpaper mode displays an Ultra HD image of your choice. Companies are working to deliver everything from old masterpieces to nature scenes to keep these displays in use.

Sharp's Aquos Q+ line uses 1080p displays, but these televisions also can display 4K Ultra HD content. The Aquos Q+ essentially downscales the image, though the system performs some interesting tricks on the display side. For instance, Sharp employs yellow sub-pixels in addition to the usual red, green, and blue (RGB) pixels *(Fig. 2)*. The 4K series uses RGB. The added pixel extends the color range that the display can deliver. It also helps increase the brightness, especially for yellow-based colors.

The Q+ series includes 60-, 70-, and 80-in. versions. The four HDMI inputs are 4K ready, which is how the Q+ gets that 4K content. The HDMI standard has been extended to handle higher resolutions, which was needed for the 4K displays.

One of the challenges in getting Ultra HD and 4K downscaling to work is the electronics behind the system. The electronics have to work in a fanless environment to minimize the display thickness. These systems-on-chip (SoCs) need to be turned around quickly because of market pressures.

Synopsys has worked with many of these vendors, including RealTek. The RealTek RTD2995 smart TV controller handles 4K2K downscaling for 1080p displays. It is a multicore ARM-based system with multiple 3D GPUs. Also, it supports Android, which has been dominating the smart television interface. It even supports gesture control, gaming, and apps. It has a gigabit Ethernet interface as well as USB 3.0 support.



2. Sharp's Q+ series utilizes four color pixels, adding yellow to the conventional red, green, and blue (RGB).

It can drive 8/16-lane 120-Hz Vby1 panels directly. And, it is designed to meet the demanding thermal limitations of the last crop of LCDs.

CURVED ULTRA HD

Flat screens are easier to make and simple to mount on a wall, but curved displays can provide a more immersive experience. At one extreme is the IMAX theater, which is almost spherical. The new curved displays are more like some conventional theater screens.

In theory, the curved display provides a wider, perceived viewing area *(Fig. 3)*. For projection theaters, this approach can provide brighter edges since the reflected light will be aimed toward the center. Keeping the audience near the centerline of the display reduces any distortion the display architecture may impart, providing a superior image from those positions. The problem occurs for viewers on the edge or to the side of the display. This is uncommon for theaters but not for many places where Ultra HD displays will be used, and a curved display may not be ideal.

LG Electronics' curved, 105-in. 4K Ultra HD TV has a 21:9 aspect ratio *(Fig. 4)*. It also is an organic LED (OLED) display. Its aspect ratio matches the 21:9 CinemaScope screen used for many movies, so its resolution is 5120 by 2160. The wider display also could be used for 16:9 Ultra HD video with space on the sides for additional information.

Several vendors have been making curved displays available. Large versions make sense for theater-style installations. Curved displays have also been found at the other end of the size spectrum in high-end smartphones. Here, the curved nature is easily accommodated since the user can adjust the viewing angle, and there is typically only one viewer. Midrange curved displays also can make sense where a single viewer is most common, such as computer monitors. The challenge will be for midrange televisions because of multiple viewers and viewer placement.

Flexible displays that can be changed from curved to flat may gain ground. This adjustable approach makes sense for

Agilent's Electronic Measurement Group is becoming **Keysight Technologies**.

Don't risk your company's reputation on a bad calibration.

If your test instruments are not measured during calibration to the specs you depend on, the devices you test are at risk. That can be costly. A detailed calibration report is the only way to verify for sure your instruments are performing to spec. Learn what to look for.

Check the cal. Scan or visit qrs.ly/ka3sxc8 for videos.

Are your measurements what you expect?
Find out at www.agilent.com/find/checkthecal

u.s. 1-800-829-4444 canada: 1-877-894-4414

Agilent Technologies

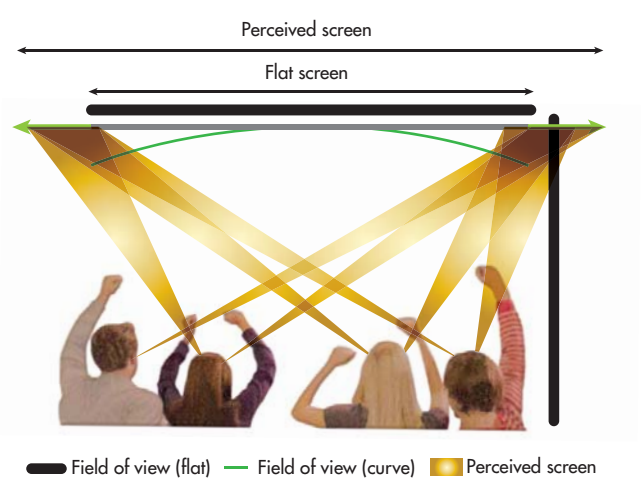
4. With its 21:9 aspect ratio, LG's 105-in. curved OLED screen provides a cinema-style viewing experience.

environments where a display may be used in the flat mode when viewers may be located anywhere and in the curved mode when viewers are centered around the display. For now, large curved displays are likely to be a specialized niche.

OLED AND QUANTUM DOTS

LCDs still dominate the display market. However, OLEDs continue to grow in popularity and size. OLEDs may command a premium price, but they deliver better images with higher contrast and brighter pixels than LCDs.

3. The perceived view size is larger with a curved display, but distortions occur when the viewer is too far from the centerline of the screen.



OLEDs also offer improved brightness since each pixel can emit light, unlike LCDs, which are lit from behind. This also makes OLEDs more power efficient, which is more of an issue for large displays and smaller, portable displays. They have a wide field of view, on the order of 170 degrees. And, they can be manufactured in almost any form factor, including very large displays.

The challenges have been in OLED lifetime compared to LCDs. Manufacturing costs have been the major reason why OLED displays cost so much, but they are falling. LCD technology is not standing still, though. Rendering an image in its original form is the challenge of LCDs in terms of resolution and color. Ultra HD improves the resolution, but color is an independent issue.

LCDs continue to improve. For example, quantum dots now enhance their color spectrum and brightness. Companies like Nanosys and QD Vision provide quantum dot technology for displays *(see "Investigating The Curious Case Of The Blue LED" at electronicdesign.com)*. QD Vision's Color IQ technology replaces white LEDs with blue ones and adds a layer of quantum dot crystals between the LEDs and the display.

The blue light causes the quantum dots to generate a "better" or fuller spectrum white light than the white LEDs *(see "QD Vision's Carlson And Coe-Sullivan Discuss Why Color Matters," p. 46)*. The problem is that the color spectrum avail-

Low Drift, High Accuracy

frequency counter with rubidium timebase

SR625 ... $6,950 *(U.S. list)*

The SR625 combines the atomic accuracy of a rubidium timebase with the best available single-shot time resolution (25 ps) of any counter — at an unbelievable low price. It measures time interval, frequency, period, phase, pulse width, event counting, and much more.

- ***Rubidium atomic timebase***
- ***2 GHz prescaler input***
- ***25 ps single-shot time resolution***
- ***11-digit frequency resolution (1 s)***
- ***Statistical analysis & Allan variance***
- ***GPIB and RS-232 interfaces***

The SR625 Frequency Counter consists of a frequency counter (SR620), a high-accuracy rubidium timebase (PRS10), and a 2 GHz input prescaler. The rubidium timebase ensures excellent frequency accuracy with a long-term drift of less than 5×10^{-11}/month.

The SR625 is ideal for critical measurements like clock jitter, pulse-to-pulse timing, oscillator characterization, and frequency stability. Please contact us for details.

SRS Stanford Research Systems

(408)744-9040

www.thinkSRS.com

able via an LCD will differ based on the light source and the LCD panel. Not all LCDs are created equal from a color-rendering standpoint. Improving the backlight source in either brightness or spectrum results in a potentially better image.

ULTRA HD MONITORS

Consumer Ultra HD will tend to be found in larger displays where the higher resolution will be more noticeable. There probably will be Ultra HD televisions in the smaller form factors, but a plethora of 720p and 1080p displays likely will fill out the lower end of the spectrum because of cost concerns. Ultra HD offers resolution that can command a higher price.

The story is a little different with monitors. Going back to the CRT days, monitor resolution greatly exceeded television resolution. The advent of 1080p displays changed that. The typical desktop or laptop display is now 1080p. It provides sufficient resolution for most apps and games and matches the capabilities of DVD and Blu-ray movies.

While common, 1080p monitors are not the only resolution available. Monitors with other features like higher resolution are quite common, so 4K Ultra HD monitors are not surprising. For example, Lenovo's ThinkVision Pro2840m is a conventional desktop monitor with a 3840- by 2160-pixel resolution that can handle Ultra HD video.

5. Lenovo's ThinkVision 28 is an all-in-one device that runs Android 4.4.

Also, Lenovo's premium ThinkVision 28 is an all-in-one device that runs Android 4.4 on an NVidia Tegra SoC and supports Miracast Sync *(Fig. 5)*. It has an adjustable stand and touchscreen. The DisplayPort connection allows it to be used as a display. Ethernet lets Android connect to the cloud. The dual noise-cancelling microphones, 2-Mpixel front-facing camera, and dedicated controls make video conferencing easy.

STREAMING ULTRA HD

Getting native Ultra HD content is not impossible, but it is more limited than HD content. The fact that movies

6. The Nuvola NP-1 streams Ultra HD videos and provides a gaming platform that runs an NVidia Tegra 4.

are shot in 4K, or better, means most new movies will be available in this format. HDMI and Blu-ray support Ultra HD from a standards point of view with new Blu-ray players supporting Ultra HD and connecting to Ultra HD televisions via HDMI.

Comcast has announced support for Ultra HD, but streaming video is likely to be the wave for Ultra HD assuming you can get an Internet connection with bandwidth that isn't throttled. Uncompressed 1080p streams use a little over 1 Gbit/s. Compressed, they use significantly less bandwidth and have allowed companies like Netflix to deliver streaming video over wired and wireless connections to HDTVs.

Netflix, Amazon, M-GO, and YouTube have all talked about Ultra HD support, and many companies have partnerships with television vendors that are building support into smart TVs. Netflix has indicated its Ultra HD streams will require 15 Mbits/s. Netflix is using Eyeio's THX certified compression technology.

There are independents as well *(see "4K Ultra HD Streaming Media Player from Nanotech Entertainment" at engineeringtv.com)*. NanoTech Entertainment's Nuvola NP-1 runs Android on an NVidia Tegra 4 and can play HEVC and VP9 compressed video *(Fig. 6)*. HEVC and VP9 are video streaming standards. HEVC is the follow-up to H.264/MPEG-4, while Google developed VP9.

The NP-1 can access games that run on the Tegra 4 via Google Play and NVidia's TegraZone. The system also has USB 3.0 support for local content. It can support 1080p and 720p content and displays as well. The box has gigabit Ethernet and 802.11n 2×2 multiple-input multiple-output (MIMO) Wi-Fi support. It comes bundled with access to 10 free movies on the NanoFlix UltraHD Network. And, it uses a Bluetooth remote control and supports wireless game controllers.

Ultra HD displays will be successful because of the content that can be viewed on them. That is something that is immediately available for monitors, especially digital signage that typically requires larger displays. They are a hit with high-end videophiles, and the emerging Ultra HD content is likely to catch up faster than Blu-ray did initially. Streaming Ultra HD is the wave of the future on the provider side. 8K is waiting in the wings, but it is likely that Ultra HD will be the technology for the decade, at least this year. ed

Sometimes more is actually less.

CMEMS® oscillators from Silicon Labs
Superior reliability, lower cost, highly customizable.

10 YEAR

10 YEAR OPERATING LIFE

BEST-IN-CLASS STABILITY OVER TEMPERATURE

2 WEEK LEAD TIMES THE INDUSTRY'S BEST

LOW-COST, HIGH-VOLUME CMOS FOUNDRIES

CMEMS®

Timing simplified™

Silicon Labs single-chip CMEMS® oscillators deliver unmatched reliability over 10 years across temperature, vibration and shock. Available in volume for as low as 20 cents.

www.silabs.com/timing

SILICON LABS

BILL WONG | Embedded/Systems/Software Editor
bill.wong@penton.com

Dev Kits Light Up
The Internet Of Things

Incorporating IoT connectivity involves more than adding a protocol stack.

Today's development kits provide complete development environments in addition to hardware. The latest trend is toward versions that simplify building applications that also fit into the Internet of Things (IoT). IoT development now targets just about everything that could include a micro, such as wearable technology like smartwatches that can track location and heart rate. Tools, then, must be more sophisticated because they need to address the hardware in the box and the Internet outside the box.

SHEDDING LIGHT ON IoT

Lighting is a natural application for connectivity and the IoT. The Z-Wave Alliance and ZigBee Alliance both have standards that address wireless communication for home and business environment control including lighting control. Companies that support these standards, then, also provide development kits that make the creation of products using these standards easier. They can also help developers support the interoperability aspects of these standards.

The Texas Instruments (TI) TI Z-Stack Lighting Kit is based on TI's CC2530 ZigBee system-on-chip (SoC) microcontroller *(Fig. 1)*. It provides ZigBee Light Link (ZLL) support. The kit includes a pair of ZigBee Z-Light2 reference boards in addition to a ZLL Remote Control *(Fig. 2)*. The components come pre-programmed with a Z-Stack Lighting application that uses the Z-Stack Lighting installer and TI's ZigBee-compliant protocol stack, Z-Stack.

The kit is designed to show developers how to take advantage of the ZigBee Light Link Public Profile. The modules have LEDs that can be controlled remotely, but the same approach can be used for a wide range of lighting technologies. The remote control can adjust color, intensity, and saturation in addition to turning the LEDs on and off.

MULTIPROTOCOL INDUSTRIAL KITS

Echelon's FT 6000 EVK targets industrial IoT devices that utilize Echelon's multiprotocol IzoT platform *(Fig. 3)*. The kit consists of an Ethernet-based IzoT router that supports the pair of evaluation boards that are connected via a free topology (FT) wiring system. It additionally includes five FT 6050 chips that can be employed to build custom modules that can be connected to the router. The modules give designers a way to get up and running quickly while the chips can be used to build prototypes.

The modules can be used to control a range of devices including lighting. In fact, Echelon's technology is employed in applications like smart street lighting and smart building

1. Texas Instruments' ZigBee Light Link (ZLL) Development Kit includes a pair of CC2530-based LED modules and a ZLL Remote Control.

2. The ZLL Remote Control can manage an array of ZigBee-based lights.

3. Echelon's FT 6000 EVK targets industrial IoT devices using the company's multiprotocol IzoT platform.

control. They have debugging hooks that allow developers to experiment with the system but have fine diagnostic control.

The router supports Echelon's IzoT Server stack, which bridges between the FT and Ethernet network. The kit includes IzoT NodeBuilder software for creating, debugging, and testing applications for IzoT-compatible devices. Developers can use the graphical IzoT Commissioning Tool to create, manage, and maintain devices and networks. The tool is based on Microsoft Visio.

The environment links to the IzoT Network Services Servers, which run on Microsoft Windows. It supports IzoT networks as well as OpenLNS and LNS. It can handle different networks including IzoT, LONWORKS, and IP-852.

There are a number of companies that deliver support similar to Echelon, providing Web-based support, modules, and even chips. For example, Digi International's iDigi IoT framework targets machine-to-machine (M2M) applications like Echelon *(see "The Embedded Cloud Floats Everywhere" at electronicdesign.com)*.

IoT MOTOR CONTROL

Texas Instruments took a collaborative approach with its $19.99 TIVA C Series Connected LaunchPad. The LaunchPad board and software start out with the conventional development kit tool chain that includes the Code Composer Studio (CCS) IDE V.5. An additional USB-based microcontroller provides debugging support.

The board has a 120-MHz TIVA C Series TM4C1294NCPDTI microcontroller based on an ARM Cortex-M4F *(Fig. 4)*. The built-in Ethernet support provides a mechanism for turning the system into an IoT device, but the board also has a pair of BoosterPack header sets. They are on both sides of the board so a system could employ up to four BoosterPack modules. The modules also can be stacked.

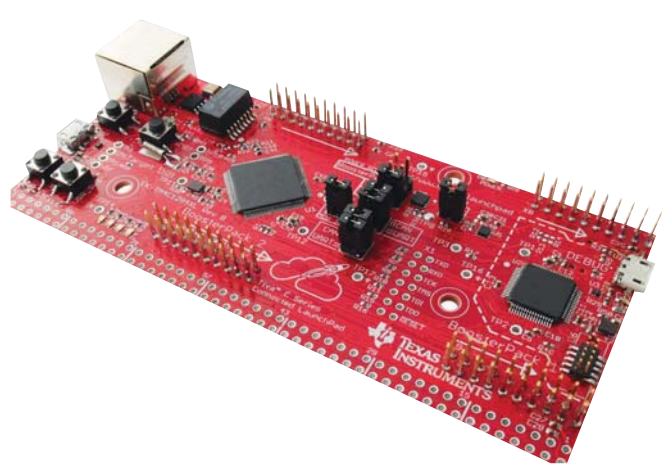
BoosterPacks are available for a wide variety of peripherals and displays. Some of these peripherals' modules include sensors, while others provide wireless support like the SimpleLink CC2541 and SimpleLink CC3000 BoosterPacks, which provide Wi-Fi support. The wireless support offers another avenue for IoT communication.

The board has the usual plethora of peripheral ports including I^2C, UARTs, SPI, USB, and even a pair of CAN ports. There is a pair of 12-bit analog-to-digital converters (ADCs) with a 2-Msample/s sample rate plus three analog comparators. For motor control, there is an advanced motion control pulse-width modulation (PWM) subsystem plus a pair of quadrature encoder interfaces.

This LaunchPad can be used as a conventional development platform, but TI went a step further by partnering with Exosite, a cloud-based services company. Exosite already provides cloud-based platforms and portals for remote monitoring of devices.

The LaunchPad comes with an application installed that works with Exosite's services out of the box. A developer can set up a management interface on Exosite's website to work with LaunchPad for free. It can track the board's operation once it is connected to the Internet via the Ethernet port. The Web-based server can check the board's sensors and control its LEDs. This is designed to show how easy it is to link to and utilize the service.

4. Texas Instruments' Tiva C Series Connected Launchpad comes with a 120-MHz TIVA C Series TM4C1294NCPDTI microcontroller based on an ARM Cortex-M4F.



MORE THAN 450 MILLION PHOTOS ARE UPLOADED FROM SMARTPHONES EVERY DAY.

Get the storage built for mobile lifestyles.

People are taking more photos with their smartphones than ever before. Photo app usage is skyrocketing. And the need for storage has never been greater. That's why for 25 years, SanDisk has been expanding the possibilities of storage and enabling companies to create visionary products. **sandisk.com/storage**

Source: Cooper Smith, Business Insider, November 2013.

SanDisk®

5. Sierra Wireless' Legato platform and development tools are designed to bring Sierra Wireless modules like the AirPrime into the IoT fold. For example, modules can be linked to the Sierra Wireless M2M Cloud.

The development tools to recreate and extend the sample application are provided as well. Features and additional items can be monitored. Of course, Exosite will be glad to help provide additional services and support for more devices for a fee. This is likely to cost less than rolling your own Web framework, but TI's development platform will easily accommodate other Web-based service vendors as well as custom connections.

MODULARIZING WIRELESS IoT

Sierra Wireless' Legato is not a kit per se; rather, it is the entire development environment and IoT support framework that targets Sierra Wireless wireless modules *(Fig. 5)*. Like the TI LaunchPad, developers can take the wireless modules and incorporate them into their application to provide basic wireless connectivity. They can also be linked to Sierra Wireless' AirVantage M2M Cloud, which includes

the AirVantage Enterprise Platform and the AirVantage Management Service.

Legato obviously targets Sierra Wireless' services, but tuning the infrastructure to match a different IoT service platform is simpler because Legato is built on an open-source platform. The modules run Linux that was co-developed with Wind River. The system supports an application sandbox that is designed to isolate applications without the overhead of using hardware virtualization and a dedicated operating system for those applications. It uses Linux cgroup support to limit resources, memory, and execution time in addition to providing file access restrictions.

The Eclipse-based tools also incorporate the Yocto tool set *(see "Interview: Mike Woster Discusses The Yocto Project" at electronicdesign.com)*. Yocto provides a standard way to build a Linux deployment for embedded applications. The platforms also support C and C++ in addition to a wide range of other programming languages such as Python. And, Legato includes middleware components that can be reused in addition to the usual runtime libraries and board support packages (BSPs) for Sierra Wireless' hardware.

VIRTUALIZING INDUSTRIAL IoT

Typically when people talk about the IoT, they discuss devices, gateways, and Web-based servers, encompassing a wide range of implementations. But sometimes, those Web-based services may be hosted locally. Maybe a customer has particular security or control requirements, or an IoT solutions vendor then could provide all of the hardware and

6. Intel's Industrial Solutions System Consolidation Series is a pre-integrated, pre-validated solution for virtualizing and consolidating embedded industrial systems.

software for an application. To do this more easily, companies can provide a virtual platform solution that targets a standard hardware platform.

Intel's Industrial Solutions System Consolidation Series is a pre-integrated, pre-validated solution for virtualizing and consolidating embedded industrial systems *(Fig. 6)*. It is designed to provide a virtual machine hosting environment in a rugged industrial package. It can be used for a variety of purposes such as application or device consolidation. One of these applications can be an IoT host service.

The first version is based on Adlink's Matrix MXE-5301 fanless embedded computer, which runs an Intel Core i7 processor. It has optional, internal wireless support including Wi-Fi, cellular, and GPS interfaces.

Intel's software stack is built on a Wind River Hypervisor that is preconfigured to support three partitions running two instances of Wind River VxWorks for real-time applications and one instance of Wind River Linux 5.0 for non-real-time applications. The system can support additional partitions and operating systems.

The Industrial Solutions System Consolidation Series includes a software tool suite known as the Intel System Studio that provides build support as well as analysis and tuning tools. Intel System Studio is also part of the Intel Developer Program for Internet of Things.

Furthermore, Intel is looking to deliver the software on a flash drive like a typical Linux distribution so it can be installed on similar, standardized platforms. Intel wants its hardware partners to be able to provide platforms that can run the framework out of the box that can in turn run the developer's virtual machines.

IoT is more than a buzzword these days, although it means different things to different people *(see "The Internet Of Thingamajigs" at electronicdesign.com)*. Not all chip, module, or board vendors are targeting IoT specifically, but more are. It has long been impractical for developers to build every part of their application, so instead they turn to operating systems and middleware to provide a base to build the application-specific code.

IoT is one more part, though it spans multiple systems and features like remote updates, security, and management that are requirements in the IoT space. Developers need to provide these parts, but they will not want to build them from scratch. ed

Analog Isolation using linearity optocouplers, HCNR201/200

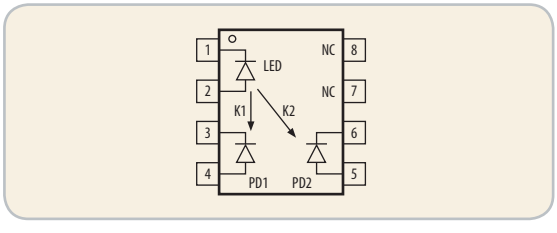
Introduction

Analog isolation is still widely used in motor drives, power monitoring, etc whereby applications typically use inexpensive analog voltage control for speed, intensity or other adjustments.

The HCNR201/200 analog optocoupler is commonly added to isolate the analog signal in the front end module of an application circuitry. The optocoupler will be placed between the analog input and the A/D converter to provide isolation of the analog input from the mixed signal ADC and other digital circuitries. The HCNR201/200 is an excellent solution for many of the analog isolation problems.

Key Features and Specifications

TThe HCNR201/200 analog optocoupler consist of a single LED with two photodiodes, PD1 and PD2 as shown in the diagram below. The two photodiodes are closely matched, with PD1 on the input side and the PD2 on the output side of the application circuitry. The output current of the photodiode is linearly related to the light output of the LED. Having an input photodiode, PD1 allows a direct monitoring of the LED condition, hence stabilizing the light output of the LED. With close matching of the two photodiodes and with suitable application circuitry, HCNR201/200 can achieve high linearity and stable gain characteristics. The advantage of using HCNR201/200 lies in its flexibility of operating in a wide variety of different modes, such as in unipolar/bipolar, ac/dc and inverting/non-inverting configurations. Both HCNR201 and HCNR200 are housed in 400mil DIP8 widebody package.



The key features and characteristics of HCNR201/200 High Linearity Analog Optocoupler are as follow:

- Low Cost Analog Isolation, High Linearity, Flexible design with ease of accessing the two photodiodes
- Tighter K3 (IPD2/IPD1) Transfer Gain - Current flowing in output photodiode PD2 vs current flowing in the input photodiode PD1, this indicate how closely match are the two photodiodes
- Low Nonlinearity – Maximum deviation (in %) of the full scale output of a "best fit" straight line drawn from the plot Ipd2 vs Ipd1 from 5nA to 50µA. Straight line drawn is based on 11 point equally spaced from 5nA to 50µA. IPD2 error to best fit line is the deviation above and below the best fit line.
- Low Transfer Gain Temperature Coefficient - Gradient of K3 vs temperature plot. This indicate the transfer gain to temperature variations
- Wide Bandwidth : DC to > 1MHz
- IEC60747-5-5 certification for reinforced insulation with continuous working voltages at 1414 Vpeak and transient voltages of 8kVpeak for HCNR201/200

Table 1. Key technical specifications of HCNR201/200

Parameter	HCNR201	HCNR200
Transfer Gain, K3	0.95 to 1.05 (±5%)	0.85 to 1.15 (±15%)
Non Linearity, NL_{BF}	0.05% max	0.25% max
Temperature Coefficient, ΔK1/ΔTA	-0.3%/°C typ	-0.3%/°C typ
Temperature Coefficient, ΔK3/ΔTA	-65ppm/°C typ	-65ppm/°C typ
Bandwidth (LED)	9MHz typ	9MHz typ
Common Mode Noise Rejection, IMRR	95dB typ	95dB typ
Operating Temperature	-40°C to 85°C	-40°C to 85°C
Continuous Working Voltage, V_{IORM}	1414 V peak	1414 V peak
Isolation Voltage, V_{ISO}	5000 V	5000 V

High Speed, Low Cost Implementation Using HCNR201/200

Avago had various circuitries that are designed to be used together with the HCNR201/200 to provide isolation and using them in a number of industrial applications, such as motor drives, switched mode power supplies, transducer, current loop, etc.

HCNR201/200 are used in different circuit configurations. Figure 1 illustrates a high speed, low cost implementation using HCNR201/200, achieving a high bandwidth of 1.5MHz with stable gain characteristics. For applications looking for high bandwidth, high speed and low cost solutions, this will be a suitable implementation as the circuitry consists of only discrete transistors (No op-amps). But it will have to tradeoff accuracy to achieve the high bandwidth and speed. This configuration is typically used in the feedback path of the switched mode power supplies. The transfer function is governed by:

$$V_{OUT}/V_{IN} = R2/R1$$

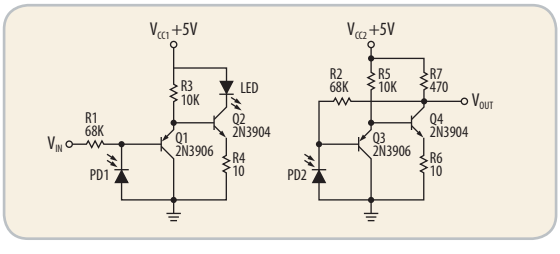


Figure 1: Low Cost, High Speed analog isolation using HCNR201/200

Voltage Monitoring in Servo Motor, Inverter and Power Supplies

HCNR201/200 are used for voltage monitoring in the feedback loop in the servo motor, inverter and power supplies applications.

The advantage of using HCNR201/200 is the compensation for LED characteristics drift due to temperature, aging or other non-linearities effect. They are used in servo motor drives whereby the input photodiode is placed in the feedback path to control the LED current using external components, such as op-amps. This is shown in the figure 2 for a positive input voltage, VIN. Bipolar input circuit will use either two HCNR201 or two HCNR200. The capacitor C1 is compensating capacitor for stability. The two op-amps LM158 are two separate packages and not two channels in a single dual channel package, otherwise galvanic insulation will not be present.

Input photodiode current, $I_{PD1} = V_{IN}/R1$. To achieve linearity, with R1 at 80kΩ, the input voltage, V_{IN} will need to be maximum of 4V and keeping the maximum photodiode current at 50µA (as specified in the datasheet).

The linear transfer function for this application circuit is governed by :

$$V_{OUT}/V_{IN} = K3 * R2/R1$$

The relationship between V_{IN} and V_{OUT} is linearly related as the above equation is independent of the light output of the LED. Gain of the amplifier circuit can be adjusted by ratio of R2 to R1.

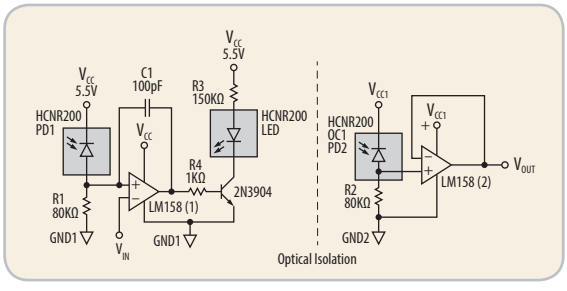


Figure 2: Positive Polarity Input Voltage using HCNR201/200

Current Loop

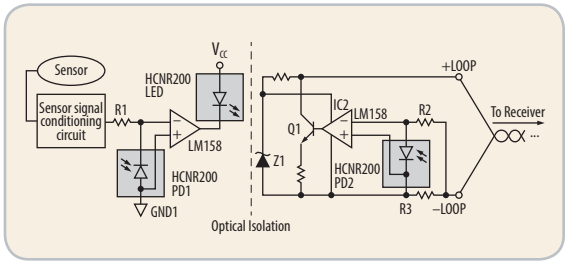
Current loop had become the standard method for sensor signal transmission. Current loop is suitable in industrial environments whereby long cable lengths are required or high electromagnetic interference are present. The distance from the sensor stage to the controller (PLCs, PC) can be a long distances. High voltage insulation or galvanic isolation is needed to protect the equipment. There are a couple of types of current loops: analog (a linear current represents the analog signal), logic (high and low logic levels represent MARK and SPACE states respectively), and a combined analog and digital current loop that uses the HART® (Highway Addressable Remote Transducer) communication protocol. Compared to voltage signals, current loops have the benefits of insensitive to noise and errors from line impedance, long distance transmission without loss, and lower EMI sensitivity.

Transmitter Circuit

From Figure 3, zener Z1 establishes the voltage required by the loop side op-amp, IC2. The loop side of the circuit is powered by the loop current, thus eliminating the need for an isolated power supply.

$$ILOOP/V_{IN} = K3 * (R2 + R3) / (R2 * R1)$$

For a 4-20mA current loop transmitter, with chosen R2 = 25Ω, R3 = 10kΩ, R1 = 80kΩ, the resistor values are selected such that when input voltage is 0.8V, loop current will be 4mA. And when input voltage is 4V, the loop current will be 20mA. (Assume transfer function, $K3 = I_{PD2}/I_{PD1} = 1$).



Note: Isolated 4-20mA current loop Receiver not shown here

Figure 3: Isolated 4-20mA Current Loop Transmitter using HCNR201/200

Evaluation Boards

Evaluation board allows designers to implement the HCNR201/200 analog optocouplers in their applications in the fastest possible way. HCNR201/200 analog optocoupler is versatile and suitable for many other industrial applications, such as voltage/current sensing, current loops, etc. Evaluation boards are available upon request from Avago. The Evaluation Board User manual is available for download at www.avagotech.com/docs/AV02-1134EN.

Spice Models

Spice models accurately predict circuit performances in accordance to HCNR201/200 AC and DC datasheet specifications as close as possible. The HCNR200 spice model is available and can be downloaded from the internet. The spice circuit simulations of various Avago circuit configurations is available for download at www.avagotech.com/docs/AV02-3334EN.

IMS2014 - Tampa Bay, Florida

POWERING THE WAVES

For more information please visit:
HTTP://IMS2014.MTT.ORG

IEEE MTT-S

IMS2014 POWERING THE WAVES

CONFERENCE DATES: ***1 - 6 JUNE 2014!***

How Data, Devices and Personalization are Fueling Demand for Innovation

Vida Ilderem - *Vice President, Intel Labs;*
Director, Integrated Computing Research, INTEL CORPORATION

Vida Ilderem is Vice President of Intel Labs and Director of the Integrated Computing Research [ICR] for Intel Corporation. ICR explores the next revolution in computing with focus on new emerging platforms. The research vectors include breakthrough technology innovations for seamless connection, highly integrated small form factors, and enablement of Internet of Things. Prior to joining Intel in 2009, Vida served as vice president of Systems and Technology Research at Motorola's Applied Research and Technology Center. Vida holds a PhD in Electrical Engineering from Massachusetts Institute of Technology, and has 27 issued patents.

See **New Products** from over **500 Exhibitors**
Learn in the world-class technical **conference & workshops**
Network at the many **social events!**

DON TUITE | Analog/Power Editor
don.tuite@penton.com

Blend Blue LEDs And Phosphors To Make HB LEDs

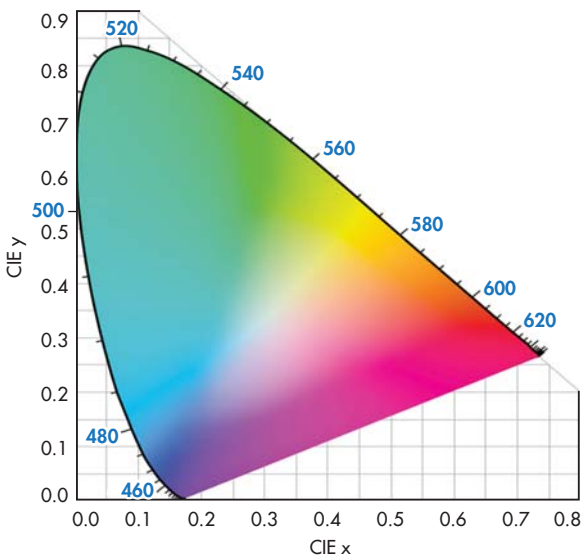
Juggling LED diode emissions and phosphors is part science, part art.

LEDs work because whenever a forward current is flowing through a semiconductor junction diode, energy is released as a photon each time an electron and a hole recombine. The color of the light is related to the energy of the photon, which is in turn determined by the energy band gap of the semiconductor material. Aluminum gallium arsenide (AlGaAs) yields red, indium gallium nitride (InGaN) yields green, and zinc selenide (ZnSe) yields blue.

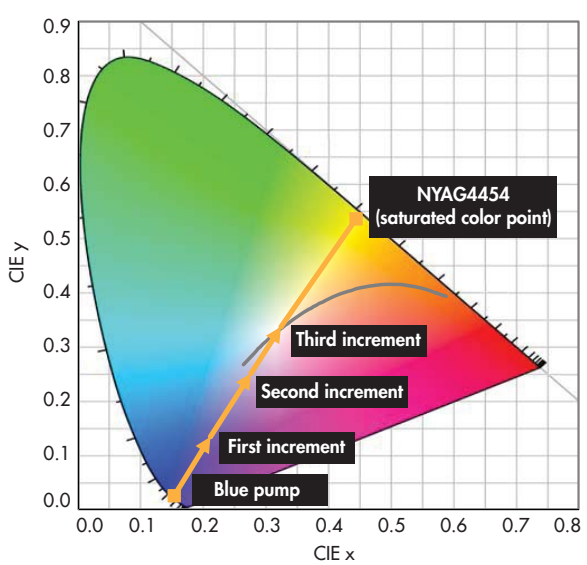
The industry never worked out a satisfactory way to simply combine multiple colored LEDs to produce "white" light. In 1989, though, Isamu Akasaki developed a laboratory process for gallium-nitride (GaN) p-n junction blue/ultraviolet (UV) LEDs. In 1993, Shuji Nakamura developed a commercially viable process for making blue GaN LEDs with very high luminous efficacy—essentially a measure of efficiency in terms of light output in lumens relative to watts input.[1]

Achieving a blue LED junction with high luminous efficacy became a holy grail for LED researchers because it opened the door to the manufacture of high-brightness (HB) "white" LEDs. HB white diodes combine a blue InGaN diode with one or more yellow phosphors such as cerium-doped yttrium aluminum garnet (Ce3+:YAG) coated on the inside of the device lens. Thus, the eye "sees" photons from the phosphor and perceives them along with photons from the diode junction.

This leads to the use of multiple phosphor layers with different photon energies to spread the emitted spectrum, which results in a more natural lighting effect. Of course, this introduces the question of what's "natural," leading to a discussion of color rendering index (CRI) and color temperature.



1. The CIE chromaticity diagram presents a way of looking at all of the colors and intensities a person can ideally see (the so-called gamut of human vision).



2. More phosphor in the optical path shifts the color point toward the saturated phosphor's coordinates (a warmer light). Less shifts it toward the blue of the LED, i.e., a "cooler" light.

CRI AND COLOR TEMPERATURE

Color temperature relates to the radiation of an ideal black body. It is related to the surface temperature of such a body, expressed in kelvin. It's common to say that ordinary daylight has a color temperature of approximately 6000 kelvin, although that's not the actual surface temperature of the sun.

CRI is a measure of how closely the colors of an object being illuminated artificially resemble those colors when they are viewed under actual sunlight. However, the colors created by sunlight vary with the time of day. Despite that variability, CRI is the standard used to describe artificial light sources. That

may be because, in terms of actual temperature and the light distribution at various frequencies, incandescent lamp filaments behave a lot like ideal black bodies.

CRI is important to color photographers because it makes it possible to design imaging sensors and chemical photographic films, as well as to compare and repeat photographic effects. It's important in sales and in interior decoration because it affects how people respond to the colors of goods, packaging, and the environments they live in. If people are shooting pictures or video on a cellphone, or displaying products in a store, or setting a mood in a restaurant, they all want their light sources to exhibit a high CRI.

For the LED maker, a high CRI implies lower luminous efficacy than single-color LEDs. But for natural-looking colors, good CRI is essential, so it presents a tradeoff with luminous efficacy. Happily, Shuji Nakamura gave the makers of HB white LEDs considerably more luminous efficacy than conventional halogen incandescent lamps. The rest of the story is in the phosphors that react to the blue and ultraviolet photons that semiconductor diodes based on his inventions emit.

HOW MUCH PHOSPHOR?

To obtain the specific CRI from a blue/UV diode, it is not enough to simply smear some phosphor on the lens. It is, rather, a matter of just how much phosphor there is in the optical path from the diode junction to the viewer's eye. To understand this more concretely, it helps to use the International Commission on Illumination (CIE) color space chromaticity diagram *(Fig. 1)*.[2]

The diagram is an empirical description of the effects of color mixing on a generalized model of human vision.[3] Each point along the curved edge of the gamut represents a color of a specific wavelength. Moving in from the edge toward the center of the diagram, color saturation decreases until, at the center of the diagram, a dimensionless spot represents "white" light, where all hues are represented.

MAKING "WHITE" LIGHT

Offsetting the blue of the LED is a matter of managing additive complementary colors, so it requires a phosphor, the saturated color of which lies on a line on the chromaticity diagram between the blue of the LED and the color of the phosphor and passes as closely as possible through the white point of the diagram.

In an application note titled "Considerations for Blending LED Phosphors," Intematix uses NYAG4454, a YAG-based (yttrium aluminum garnet) phosphor that complements blue LED chips with outputs ranging from 455 nm to 470 nm.[3]

The ultraviolet radiation from the LED junction adds to the output of the phosphor, but it does not significantly affect what the apparent color is because the UV is all but invisible to most people.

Aiming for a "warm" or "cold" white light is where the amount of phosphor comes in. More phosphor in the optical path shifts the color point toward the saturated phosphor's coordinates (a warmer light). Less shifts it toward the blue of the LED, i.e., "cooler" *(Fig. 2)*. The LED itself exhibits a 454-nm dominant blue wavelength on the chromaticity diagram at approximate coordinates x = 0.154 and y = 0.025.

There are five points on the diagram, a starting value, and three incremental additions of NYAG4454. Each addition shifts the color point towards a saturation value at (x = 0.444, y = 0.536). The first data point is definitely cool, the second is somewhat warm r, and the third is a good approximation of "white" light. The gray curve is the chromaticity diagram's black body locus, with points representing color temperatures from 5000 to 6200 K.

Further complexity arises when phosphors are blended, although Intematix says that color temperatures of 4000 K and higher are attainable with a single phosphor. On the other hand, color temperatures lower than 4000 K cannot generally be achieved with a single phosphor.

BLENDING PHOSPHORS

To obtain a lower color temperature with multiple phosphors, LED makers might blend a phosphor with an emission spectrum "above" the blue LED with another phosphor "below" it. Thus, a combination of a yellow-green phosphor and a red phosphor can produce the required saturated end point. (This is covered in greater detail in Reference 3.)

What makes this subtle is the interaction between the phosphors—that is, some colored photons are absorbed by other phosphors and re-radiated.

The wavelength of the "blue" LED itself is a complicating factor as well. It affects the required ratio of red and yellow phosphors. Also, as the blue wavelength is shortened, the amount of red phosphor required will decrease, which shifts the required ratio of one phosphor to the other. Another impact of variations in the blue wavelength is change in the color rendering index. Then, it might be necessary to switch phosphors to maintain a satisfactory CRI.

REFERENCES

1. For more on luminous efficacy, see "Understanding LED Application Theory And Practice" at http://electronicdesign.com/components/understanding-led-application-theory-and-practice#efficacy
2. "CIE 1931 color space," http://en.wikipedia.org/wiki/CIE_1931
3. "Considerations for Blending LED Phosphors," Intematix Corp., www.intematix.com/uploads/Phosphor%20blending%20app%20note%2020130110-FINAL.pdf

Agilent's Electronic Measurement Group is becoming **Keysight Technologies**.

Welcome to the New Standard.

The next generation of oscilloscope technology.

6000 X-Series: The new standard in price performance
- Industry's best price performance
- Unmatched signal visualization
- Unprecedented instrument integration

S-Series: The new standard in superior measurements
- Industry's best signal integrity
- Most advanced platform
- Broadest range of capabilities

	Agilent InfiniiVision 6000 X-Series	Agilent Infiniium S-Series
Starts from	$14,900 ($29,500 6 GHz*)	$17,500 ($68,000 8 GHz*)
Bandwidth	1 GHz – 6 GHz	500 MHz – 8 GHz
Max sample rate	20 GSa/s	20 GSa/s
Industry-leading noise floor**	115 µVrms (1 mV/div)	90 µVrms (1 mV/div)
Plus	• 450,000 wfms/s update rate • Hardware InfiniiScan Zone trigger • 12.1" capacitive multi-touch • 6 instruments in 1 • Voice control	• 10 bit ADC • 100 Mpts std. memory • 15" capacitive multi-touch • Advanced Infiniium GUI

* Prices are in USD and subject to change ** at 1 GHz

Scan the QR code to see video demos.

Experience the difference for yourself. Get a live demo today!
www.agilent.com/find/getmydemo

u.s. 1-800-829-4444 canada: 1-877-894-4414

Agilent Technologies

one BRIGHT issue

Q&A

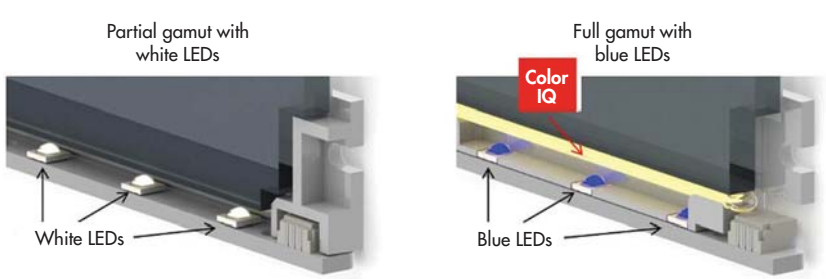
BILL WONG | Embedded/Systems/Software Editor
bill.wong@penton.com

QD Vision's Carlson And Coe-Sullivan Discuss Why Color Matters

Picture quality is key to any display. Pressure to improve color performance and accuracy, particularly in large formats, is driving innovation. To protect profit and remain competitive in the crowded consumer space, manufacturers and panel designers must close the color performance gap at the lowest possible cost of technology and integration. With these goals in mind, QD Vision and its chief officers Jason Carlson and Seth Coe-Sullivan deliver commercially viable quantum dot optical components that provide full-gamut color and cost savings for advanced display solutions.

WONG: Tell me about QD Vision.
QD VISION: QD Vision Inc. was founded in 2005 to advance the work of its cofounders and scientific advisors, including MIT professors Vladimir Bulovic and Moungi Bawendi, considered by many to be the father of quantum dot technology. Leveraging this rich set of intellectual assets, we developed QD Vision and our proprietary Color IQ technology *(see the figure)*. Today, the company operates the world's largest quantum dot production facility and has the distinction, with the 2013 introduction of 10 production model Sony Bravia TVs, of being the first to market with a commercially viable quantum dot technology solution in displays. Today, we hold over 50 patents in quantum dot materials, methods, and applications, with more than 200 patents pending.

WONG: Tell me about quantum dots and Color IQ.
QD VISION: Quantum dots are a semiconductor nanocrystal technology that precisely and efficiently emits light to provide full-gamut color performance and accuracy in LCDs. Color IQ optics, our brand of optical components, enables LCD TVs to produce very saturated and narrow bands of color at any wavelength. While most LCD TVs and displays today offer color quality with a partial color gamut often ranging from 60% to 70% of the NTSC standard, products using Color IQ optical components can achieve 100% of the standard and beyond without compromising accuracy. The result provides the most radiant reds, brilliant blues, and gorgeous greens you will ever see.



QD Vision's Color IQ technology replaces white LEDs with blue LEDs and adds a layer of quantum dots between the LEDs and the LCD.

WONG: How will quantum dots and Color IQ influence LCDs?
QD VISION: We believe that by improving LCD technology, Color IQ optics will help to extend LCD TVs' lifetime in the market. Full-gamut color refers to the ability of an LCD device to display the widest range of colors available with 100% overlap of a color space as defined by the content creation community. Quantum dot-based solutions are not limited to the current gamut specifications and, in fact, can support color gamut well beyond what is available today. Because quantum dot materials are inherently efficient light emitters, they don't require the cost/performance tradeoffs typical of other materials and lighting technologies. These are just some of the reasons we believe that the adoption of quantum dot technology, Color IQ optics, and full-gamut color is inevitable for LCDs.

WONG: How does color affect image quality and viewer perception?
QD VISION: Research links the perception of quality with highly saturated

colors, enabled by expanded color gamut, to both viewer attention (dwell time) and preference.

There is both a psychology and biology associated with color's role in the perception of picture quality. Humans are trichromatic, meaning we are tuned to distinguish a wide variety of wavelengths and hues of blue, green, and red. In the last 10 years, rigorous research has demonstrated that colorfulness is the main perceptual attribute underlying image quality.

For viewers, color accuracy is closely related to the perceived "naturalness" of an image, based on memory color and skin tone. Researchers have found that while the perception of quality rises with color saturation, it is only true up to the point at which skin tone starts to appear "unnatural."

WONG: Does increased color gamut indicate a tradeoff with color accuracy?

QD VISION: Not at all. In fact, full-gamut color is necessary to achieve both dimensions of viewer preference: colorfulness and color accuracy.

Video content creators define accuracy by agreeing on various color space dimensions within the total area of perceivable color. Thus, accuracy is the correct display of colors exactly as intended within a standard color gamut. TV industry consultants and technicians calibrate and measure the degree to which a consumer device accurately displays colors within the area of a particular color-gamut standard. Examples include NTSC, Rec. 709, Adobe RGB, and DCI. These standards are important in that they give TV designers a metric of compliance to content creator choices.

The relationship between full color gamut and accuracy is an important distinction for quantum dot-based solutions. With Color IQ optics, the accuracy is not compromised as gamut is expanded.

WONG: Recent single-digit TV set market growth reports have put enormous pressure on LCD panel makers to reduce costs. So why would they invest in color-gamut expansion now?

QD VISION: To protect profit, it is imperative that panel designers close the color performance gap completely. The most compelling argument for immediate implementation of full-gamut color is the now established commercial viability of quantum dot optical products. Quantum dots enable OLED-quality (organic LED) color at product costs well within the range of LCD TV retail pricing targets. Quantum dot optical products ship in volume today, delivering well-received full-gamut color in both television and tablet LCDs.

WONG: How is the full-gamut LCD market shaping up?

QD VISION: As with the transition from standard definition to HD, there are short-term gaps to address in content distribution standards, content availability, and the software layer to better support the new optical components' capabilities. But these challenges are readily addressable by several large-ecosystem communities that are incented to tackle them.

Content creation and processing equipment makers, as well as display suppliers, are anxious to offer consumers the next level of performance, bringing a cinema-quality viewing experience to mainstream, affordable home theaters. All of the ingredients are available to make full-gamut color display a reality. And like prior display technology transitions, including the transition to LEDs themselves, better consumer value will drive surprisingly rapid penetration. This is why QD Vision believes that full-gamut LCD TVs with quantum dot optics will achieve significant market penetration in 2014. ed

VICTORIA FRAZA KICKHAM | DISTRIBUTION EDITOR victoria.kickham@penton.com

Top 50 Companies See Business Improvement In The Americas

Top distributors report a business uptick in the first quarter and are maintaining a positive outlook, especially in North America.

FOR THE FOURTH straight year, Avnet Inc. takes the top spot on *Global Purchasing*'s annual Top 50 Electronics Distributors list, with sales of $26.7 billion worldwide in 2013. Nearly $11 billion of that comes from sales to customers in the Americas, where the global giant sells electronic components and technology solutions to a wide range of end users. Avnet and its chief rival Arrow Electronics—which ranks second on our list for the fourth consecutive year at $21.4 billion in sales—are the biggest companies on our list by far, dwarfing their nearest competitor by $13 billion and $8 billion, respectively.

Global Purchasing presents its Top 50 Electronics Distributors report each May, providing a look at the largest players in the electronics distribution market. Today's global marketplace is reflected in the list, as most of these companies support customers around the world and more than 10% are based outside of the United States. Newcomer WPG Holdings,

Continued on Page 50

Connected Devices Drive Electronics Market

The global need to stay connected continues, with 6 billion new Internet-enabled devices produced in 2014.

THE WORLD MARKET FOR Internet-connected devices will rise 6% over 2013 to represent the largest increase in four years, according to industry researcher IHS Technology. Global demand for cell phones, tablets, and computers will push production of connected equipment to 6.18 billion units this year compared to 5.82 billion in 2013. Production rates will slow in the next few years, although total units produced will still increase, IHS adds. The market hasn't seen such growth since 2010, when global production of connected equipment rose 10%.

"The improved growth this year of the connected devices industry marks the return of higher production as manufacturers deliver all sorts of connectivity equipment to users," explains Jagdish Rebello, senior director for information technology at IHS. "Given the voracious appetite of consumers for social media and their yen for always-on connectivity, it's little surprise that makers will continue to turn out such devices to keep buyers engaged."

Continued on Page 58

Top 50 Companies

Continued from Page 49

coming in at number 3, is based in Taiwan, for instance, and Rebound Technology Group Holdings Ltd., which debuts at number 16, is based in the U.K.

But no matter where they are located, the top 50 companies are poised to take advantage of slowly improving market conditions around the world in hopes of climbing out of the flat slump of the last few years. In doing so, some of these leaders are looking to traditional markets such as automotive and transportation—which are reviving, especially in the United States—and new and growing markets such as the Internet of Things and lighting. It all adds up to an optimistic outlook for Lindsley Ruth, executive vice president of number 4-ranked Future Electronics, based in Montreal.

"I would say 2014 is shaping up to be another record year for Future Electronics. Our investments in demand creation are paying huge dividends. Notwithstanding any global economic surprises, with the market set to grow 3% to 4% [Future should] exceed two times market growth," says Ruth. "I think we're looking pretty good. My outlook is fairly positive, geographically."

A CLOSER LOOK AT THE TOP 50

Avnet and Arrow are unique in the Top 50, as their total worldwide sales include the sale of computer/peripheral products, which are separated into both companies' technology solutions/enterprise computing businesses. But together, the companies' component and technology sales illustrate their size and scope, and their presence helps set the pace of the electronics distribution channel.

Broken down, Avnet's sales are split nearly 60-40 between component and technology business: 63% of the distributor's sales are from electronic components and 37% are from the technology solutions side of the business. The split is the same for Arrow, with 63% of sales coming from its components business and 37% from its Enterprise Computing Solutions or ECS business. Both compa-

global purchasing — 2014 TOP 50 ELECTRONICS DISTRIBUTORS — distribution resource

Company	Headquarters	URL	2013 global sales
1. AVNET INC. [1]	Phoenix, Ariz.	www.em.avnet.com	$26.7 billion
2. ARROW ELECTRONICS [2]	Englewood, Colo.	www.arrow.com	$21.4 billion
3. WPG HOLDINGS LIMITED	Taipei, Taiwan	www.wpgholdings.com	$13.6 billion
4. FUTURE ELECTRONICS [3]	Pointe Claire, Quebec, Canada	www.futureelectronics.com	$7.7 billion
5. ELECTROCOMPONENTS PLC/ ALLIED ELECTRONICS INC. [4]	Oxford, U.K.; Fort Worth, Texas	www.alliedelec.com	$2.05 billion
6. TTI INC.	Fort Worth, Texas	www.ttiinc.com	$1.68 billion
7. DIGI-KEY CORPORATION	Thief River Falls, Minn.	www.digikey.com	$1.56 billion
8. NEWARK ELEMENT14 [5]	London, U.K.; Chicago, Ill.	www.newark.com	$1.5 billion
9. MOUSER ELECTRONICS	Mansfield, Texas	www.mouser.com	$701 million
10. DAC/HEILIND	Wilmington, Mass.	www.heilind.com	$665.3 million
11. N.F. SMITH & ASSOCIATES LP	Houston, Texas	www.smithweb.com	$586 million
12. AMERICA II ELECTRONICS	St. Petersburg, Fla.	www.americaii.com	$215 million
13. SAGER ELECTRONICS	Middleborough, Mass.	www.sager.com	$214 million
14. PEI-GENESIS	Philadelphia, Pa.	www.peigenesis.com	$200 million
15. MASTER ELECTRONICS	Santa Monica, Calif.	www.masterelectronics.com	$172 million
16. REBOUND TECHNOLOGY GROUP HOLDINGS LIMITED	Berkshire, United Kingdom	www.reboundeu.com	$140 million
17. BISCO INDUSTRIES INC.	Anaheim, Calif.	www.biscoind.com	$121 million
18. POWELL ELECTRONICS	Swedesboro, N.J.	www.powell.com	$120 million
19. CLASSIC COMPONENTS CORP.	Torrance, Calif.	www.class-ic.com	$113 million
20. FLAME ENTERPRISES	Chatsworth, Calif.	www.flamecorp.com	$98 million
21. ELECTRO ENTERPRISES INC.	Oklahoma City, Okla.	www.electroenterprises.com	$77.9 million
22. STEVEN ENGINEERING INC.	San Francisco, Calif.	www.steveneng.com	$67 million
23. HUGHES PETERS	Dayton, Ohio	www.hughespeters.com	$66.1 million
24. BEYOND COMPONENTS/NEDCO ELECTRONICS	Westford, Mass.	www.beyondcomponents.com	$62.6 million
25. RFMW LTD.	San Jose, Calif.	www.rfmw.com	$58.5 million

Out of Time?
THINK ALLIED℠

Order Up to:

10 PM ET
Same-Day Shipping

8 PM ET
Next-Day Delivery

When the Clock Is Ticking, Count on Allied

thinkallied.com

ALLIED ELECTRONICS®

1.800.433.5700

nies saw mid-single-digit sales increases last year—6% and 5% respectively—which is in line with the average sales increase of 7% among the top nine companies returning to the top 10 this year.

Outliers include three companies that reported double-digit sales increases—Digi-Key, number 7, at 11% growth; Mouser, number 8, at 14% growth; and DAC/Heilind Electronics, number 9, at 14% growth. All three have been pushing to expand globally in recent years. Mouser has seen considerable growth across Europe and Asia. Digi-Key launched a major expansion into Europe, the Middle East, and Africa in 2013 and followed up with a recent push to build its physical presence in Asia with a new location in Shanghai. DAC/Heilind grew considerably with its 2012 acquisition of Brazil-based distributor Kotek Eletro Electronica, which increased its business in South America.

Such growth in a slowly improving global climate is impressive, especially in an industry just getting accustomed to less than double-digit sales increases year after year. Indeed, some companies on our list reported sales declines or remained flat in 2013, underscoring the still uncertain outlook in many market sectors. Looking at the top 20 companies, Sager Electronics, number 13, and PEI Genesis, number 14, are among those reporting sales declines compared to what was reported in last year's Top 50. Sager's sales were down only slightly, about 1%, and PEI Genesis reported a 6.5% sales drop. Powell Electronics, number 15, was among those reporting flat sales. Flame Enterprises, number 20, also reported virtually flat sales.

global purchasing — 2014 TOP 50 ELECTRONICS DISTRIBUTORS — distribution resource

Company	Headquarters	URL	2013 global sales
26. SYMMETRY ELECTRONICS CORPORATION	Hawthorne, Calif.	www.symmetryelectronics.com	$52.8 million
27. MARSH ELECTRONICS	Milwaukee, Wis.	www.marshelectronics.com	$43.9 million
28. ELECTRO SONIC INC.	Markham, Ontario, Canada	www.e-sonic.com	$43.2 million
29. ASTREX ELECTRONICS INC.	Plainview, N.Y.	www.astrex.net	$37.6 million
30. IBS ELECTRONICS INC.	Santa Ana, Calif.	www.ibselectronics.com	$36.5 million
31. HAMMOND ELECTRONICS INC.	Orlando, Fla.	www.hammondelec.com	$30.3 million
32. ADAMS MAGNETIC PRODUCTS CO.	Elmhurst, Ill.	www.adamsmagnetic.com	$30 million
33. CRESTWOOD TECHNOLOGY GROUP	Yonkers, N.Y.	www.ctg123.com	$29.9 million
34. SMD INC.	Irvine, Calif.	www.smdinc.com	$28.4 million
35. AIR ELECTRO INC.	Chatsworth, Calif.	www.airelectro.com	$25 million
36. HOUSE OF BATTERIES	Fountain Valley, Calif.	www.houseofbatteries.com	$22.8 million
37. MARCH ELECTRONICS	Bohemia, N.Y.	www.marchelectronics.com	$22 million
38. PUI (PROJECTIONS UNLIMITED INC.)	Irvine, Calif.	www.gopui.com	$21.2 million
39. DIVERSE ELECTRONICS	St. Laurent, Quebec, Canada	www.diverseelectronics.com	$19.4 million
40. HARRY KRANTZ COMPANY	Edgewood, N.Y.	www.harrykrantz.com	$17.5 million
41. CTRENDS	Foothill Ranch, Calif.	www.ctrends.com	$16.8 million
42. 4 STAR ELECTRONICS INC.	San Clemente, Calif.	www.4starelectronics.com	$16.3 million
43. GOPHER ELECTRONICS	St. Paul, Minn.	www.gopherelectronics.com	$16.2 million
44. CUMBERLAND ELECTRONICS STRATEGIC SUPPLY SOLUTIONS	Harrisburg, Pa.	www.ce3sdirect.com	$15.5 million
45. AREA51-ESG INC.	Irvine, Calif.	www.area51esg.com	$14.1 million
46. COMPONENTS CENTER	Fountain Valley, Calif.	www.componentscenter.com	$13.2 million
47. VEC SUPPLY	Charlottesville, Va.	www.vecsupply.com	$12.7 million
48. MARINE AIR SUPPLY	Frederick, Md.	www.marineairsupply.com	$12 million
49. EAST COAST MICROWAVE DISTRIBUTORS	Woburn, Mass.	www.ecmstockroom.com	$10 million
50. ADVANTAGE ELECTRIC SUPPLY	Hayward, Calif.	www.advantageelectricsupply.com	$9.5 million

1 Sales figure includes sales of computer/peripheral products

2 Sales figure includes sales of computer/peripheral products

3 Sales figure is a Global Purchasing estimate

4 Sales figure is a company-provided estimate for fiscal year 2014, ended March 31, 2014

5 Sales figure reflects worldwide sales for Premier Farnell, Newark element14 for fiscal year 2013, ended July 2013

We are a step ahead

of the competition

FUTURE
ELECTRONICS

www.FutureElectronics.com 1-800-FUTURE-1

THE METHODOLOGY BEHIND OUR SURVEY

GLOBAL PURCHASING IS proud to publish its fourth annual Top 50 Electronics Distributors list, compiled from nomination forms submitted during February and March. Each company in our list is ranked according to its total global sales volume, and all figures are reported in U.S. dollars. We used self-reported data from each company and verified the information against annual reports and earnings statements, where possible, as well as in follow-up interviews with some of the companies at the top of the list.

Figures for Avnet Inc., ranked first, and Arrow Electronics, ranked second, include the sale of computer products, which comprise large segments of each company's business. Sales listed for privately held Future Electronics, ranked fourth, are based on Global Purchasing estimates.

Figures for Allied Electronics, fifth, reflect its worldwide sales as part of Britain-based Electrocomponents plc, which also operates RS Components in Europe. The figure here is a company-provided, fiscal-year 2014 estimate for global sales. Allied's sales were roughly $446 million in North America in fiscal year 2014, ended March 31, according to company-provided estimates. Likewise, sales for eighth place Newark element14 reflect worldwide sales as part of its parent company, Britain-based Premier Farnell.

There are some newcomers to this year's list as well. Taiwan-based WPG Holdings debuts at number 3, with $13.6 billion in sales. This causes a shift in our list this year—especially in the top 10, which has remained largely unchanged since we started our report in 2011. Future Electronics moves down to number 4, followed by Electrocomponents plc/Allied, which edged out TTI Inc. this year and moved to number 5. TTI ranked sixth, followed by Digi-Key Corp., which maintained its place at number 7. Newark element14 dropped to number 8, followed by Mouser at ninth place and DAC/Heilind in tenth. Large independent distributor N.F. Smith & Associates, which has long held the number 10 spot, dropped to 11.

Other newcomers to the 2014 Top 50 include United Kingdom-based Rebound Technology Group Holdings Ltd., which came in at number 16, with $140 million in sales; Torrance, Calif.-based Classic Components, number 19, with $113 million in sales; San Jose, Calif.-based RFMW Ltd., number 25, with $58.5 million in sales; Marsh Electronics, number 27, based in Milwaukee, with $43.9 million in sales; Adams Magnetic Products Co., Elmhurst, Ill., at number 32, with $30 million in sales; Canada-based Diverse Electronics and New York-based Harry Krantz Co., at numbers 39 and 40, with $19.4 million and $17.5 million in sales, respectively; and St. Paul, Minn.-based Gopher Electronics, at number 43, with $16.2 million in sales.

Our goal is to provide a comprehensive list of the largest electronic components distributors in the market today. We will begin compiling information for next year's report early in 2015 and we welcome your input. Send your questions or comments to sourceESBeditor@penton.com. n

Declines in government and military spending continue to hurt some firms, as do slowing conditions in some markets in Asia. The biggest of the big remain diverse enough to weather the storm, however, and are committed to their expansion strategies. Stephen Wong, president of Avnet Electronics Marketing Asia, recently commented on the company's ahead-of-the-curve investment in inland China as one example *(see "Avnet Seeks Global Growth," p. 56)*. Avnet Electronics Marketing Asia has more than 30 locations in China, many of which are in emerging cities inland.

"The potential business in the western part of China is [great]," Wong explains. "Having established there well ahead is to our advantage."

Future's Ruth agrees that China remains a hot target as one of the world's largest economies, but he also points to Japan as a "great opportunity" and notes that Malaysia, Vietnam, Thailand, and India remain strong markets in the region as well. By far, however, the best-performing sectors for Future in Q1 are those that are a bit closer to home. Ruth says Future experienced a "nice uptick" in Q1 in North America and Europe in particular, noting that the company saw one of its strongest quarters in Europe in recent history.

"In the Americas, we are absolutely seeing increased demand and a very positive outlook," says Lindsley Ruth, executive vice president, Future Electronics.

"In the Americas, we are absolutely seeing increased demand and a very positive outlook," he adds, citing Mexico as potentially one of the fastest-growing markets over the next three to five years.

A CAUTIOUS OUTLOOK

Number 5 on this year's Top 50, TTI Inc. saw a strong first quarter as well.

Continued on Page 60

YOU'RE WORKING ON THE NEXT BIG...

You need application knowledge, design support and product information.

At Sager Electronics, our field application engineers have the technical expertise to guide you from the front end of design through production. And with solutions from leading manufacturers like Artesyn Embedded Technologies, GE Critical Power, Mean Well, Murata Power Solutions, Phoenix Contact, and SL Power, we are positioned to power your growth.

WE CAN HELP.

Contact your local Sager sales representative or service center at 1.800.724.3780 or visit us at www.sager.com.

ARTESYN EMBEDDED TECHNOLOGIES

GE Critical Power

MEAN WELL

muRata Power Solutions

PHOENIX CONTACT INSPIRING INNOVATIONS

SL POWER ELECTRONICS

AUTHORIZED ecia SOURCE

SAGER ELECTRONICS

Sager Electronics is a wholly-owned subsidiary of TTI Inc., a Berkshire Hathaway Inc. company.

19 Leona Drive, Middleborough, MA 02346-1404

Avnet Seeks Global Growth

Stephen Wong, president of Avnet Electronics Marketing Asia, weighs in on the top-ranked distributor's operations in China.

THE ROAD TO ECONOMIC recovery continues in 2014, as most electronics distributors report improving business conditions in their key end markets. Globalization is an ongoing theme, as many of them work to expand their reach, especially in Asia. Stephen Wong, president of Avnet Electronics Marketing Asia, points to the distributor's ahead-of-the-curve thinking as a main reason for its success in adapting to China's changing business climate. He talked about some of those issues in an interview with *Global Purchasing* earlier this year.

GLOBAL PURCHASING: Are you seeing customer migration to inland China? And if so, what effect is it having on your business in the region?

STEPHEN WONG: Yes. This is a very obvious trend. Business migration to inner China is definite and is already happening in a big way.

As manufacturers—big or small—migrated into China, they first established in places most convenient: the coastal cities. After that, over the past 20 years, the cost of doing business in those places has risen tremendously; land price, labor, and other costs have become very expensive. [Those costs are] still lower than in the West, but more compared to inland China—specifically western and northern China.

We invested in this geographic [shift] way ahead of the curve. In fact, today we have more than 50 offices in Asia and we increase that every year. In China alone, we have over 30 locations … We invested not only in Shanghai and Beijing, but we invested in what we call "emerging cities." We started doing this six or seven years ago, and that starts to pay off as more customers move inland.

So, this movement to inland China is playing into our hands.

"The world economy, being led by the United States, is recovering gradually and consistently. China is also under new leadership and is showing traction right now. All these are good things and point to a stable economy," said Stephen Wong, president of Avnet Electronics Marketing Asia, in an early 2014 interview.

GLOBAL PURCHASING: What are local customers in Asia seeking from their distributor partners?

WONG: In general, the customer is looking for a supplier that is consistent in service and has a reasonable price. Those [customers] that are engaging in manufacturing services are looking for supply chain distributors like us. And for those OEM customers that involve R&D, besides supply chain services, they are looking for design support, which Avnet provides also. Customers also want distributors who see their business as a long-term [commitment]. They want a distributor that cares about them, that is there all the time. That is very important.

GLOBAL PURCHASING: Do you see a growing interest in purchasing from franchised or authorized distribution in this part of the world—as opposed to brokers and other, similar sources?

WONG: Customers in China are starting to become more and more sensitive [to this, and many are] demanding to purchase products from franchised distributors. The reason is, in the past China's major advantage was being low cost. Now, they are trying to build an economy based more and more on domestic consumption and R&D. As these things become more important, [manufacturers] want [to ensure the quality of their] product and they insist on getting that product from franchised distributors for that reason.

GLOBAL PURCHASING: Compared to other regions, how do you expect business in Asia/Pacific to shape up this year?

WONG: For this year, 2014, if you look at it from a macro point of view, the world economy, being led by the United States, is recovering gradually and consistently. China is also under new leadership and is showing traction right now. All these are good things and point to a stable economy. I see brightness. I see great things. At the same time, I am also highly sensitive to changes.

GLOBAL PURCHASING: How does this affect the way that you approach the market?

WONG: We need to work hard in terms of servicing the customers, working with suppliers, and investing our resources, money, and time in the right place. I feel much better [about the economy] than [I did] six months ago. This year will be a good year. ■

ADDITIONAL STORIES

For more about the distributor market, go to *globalpurchasing.com*.

VISHAY®

Global Excellence

Congratulations to Vishay, 2013's Global Operations Excellence winner! This exclusive TTI Supplier Excellence Award recognizes the supplier earning the most program points around the globe in North America, Europe and Asia.

Best Quality Award

KOA SPEER ELECTRONICS, INC.

Diamond Award

Platinum

Electronic Components KEMET CHARGED.

KOA SPEER ELECTRONICS, INC.

BOURNS®

Littelfuse® Expertise Applied | Answers Delivered

PHOENIX CONTACT

VISHAY®

Silver

FCI

muRata INNOVATOR IN ELECTRONICS

TDK

Bronze

nichicon

molex® one company › a world of innovation

AUTHORIZED ecia SOURCE

The Specialist in Electronic Component Distribution

A Berkshire Hathaway Company | 1.800.CALL.TTI • ttiinc.com

tti®

Connected Devices

Continued from Page 49

Connected devices allow users to interact with the Internet via embedded connectivity made possible through built-in semiconductors. Video game consoles, media tablets, mobile handsets, LCD televisions, set-top boxes, and mobile PCs are among the fastest-growing products in 2014. Digital still cameras, camcorders, desktop PCs, DVD players, and portable media players are expected to decline in production.

Game consoles are expected to see the largest growth numbers, up 45% following a seven-year drought of new models. Sony's PlayStation 4 and Microsoft's Xbox One lead the pack, according to IHS. Media tablets and cell phones will see substantial growth this year as well, with production up 25% and 7% respectively. The outsize presence of market leaders Apple and Samsung in particular will keep average selling prices of media tablets and cell phones elevated as a whole, resulting in larger factory revenue projections, IHS says.

The mobile PC segment also is expected to perform well, including tablet PCs, though overall PC production is expected to rise by just 2%. Industry watchers expect a new class of entry-level PC tablets to make a difference, driven by a new generation of processors from chipmakers Intel and AMD. Additionally, IHS expects LCD TV production to rise 5%, driven by emerging markets, and set-top box production to rise 7%, spurred by cable digitalization.

A STRONG IoT/M2M MARKET

The Internet remains an industry game changer, as a report on the Internet of Things (IoT) and machine-to-machine (M2M) communications market also attests. MarketsandMarkets pegs the segment's growth at a compound annual rate of 24% over the next five years, reaching nearly $500 billion by 2019. The organization's March report also outlines key segments, drivers, restraints, opportunities, and challenges in this new and growing market.

IoT is all about connectedness—connecting people, processes, and things to the Web—and presents opportunities for manufacturers, distributors, and makers of electronic components. The researchers expect IoT and M2M communication to bring physical business benefits such as high-resolution management of resources and products, better collaboration between enterprises, and improved life-cycle management, pointing to industry verticals such as public safety and security, retail, residential markets, IT, and telecommunications.

The report analyzes global adoption trends and growth potential, along with the competitive outlook, market ecosystem, and value chain of the IoT and M2M market. It also examines market size and revenue forecasts for North America, Europe, Latin America, Asia Pacific, the Middle East, and Africa. ■

Sensor Technologies Improve

New products from Honeywell, All Sensors, and STMicroelectronics boast long-term stability and ultra-compact forms.

COMPANIES DEVELOPING SOME OF the newest sensor products tout their ability to improve overall long-term stability and the benefits of their ultra-compact forms. The DLVF series digital output sensor from All Sensors, Honeywell Sensing & Control's TSC TruStability pressure sensors, and STMicroelectronics' LPS25H digital barometer microelectromechanical-systems (MEMS) pressure sensor are a few examples.

All Sensors' DLVR series mini digital output sensors are based on the company's CoBeam2 technology, which reduces package stress susceptibility, resulting in improved overall long-term stability. The technology also improves position sensitivity compared to single-die devices, the company says. Applications include heating, ventilation, and air conditioning; medical breathing; industrial controls; environmental controls; and portable, handheld equipment.

The supply voltage options are designed to ease the integration of the sensors into a wide range of process control and measurement systems, enabling direct connection to serial communications channels. The sensors also can enter very low-power modes between readings to minimize load on the power supply in battery-powered systems.

Honeywell Sensing & Control's TruStability TSC pressure sensors eliminate the need for system calibration over temperature and offer reduced part-to-part variation.

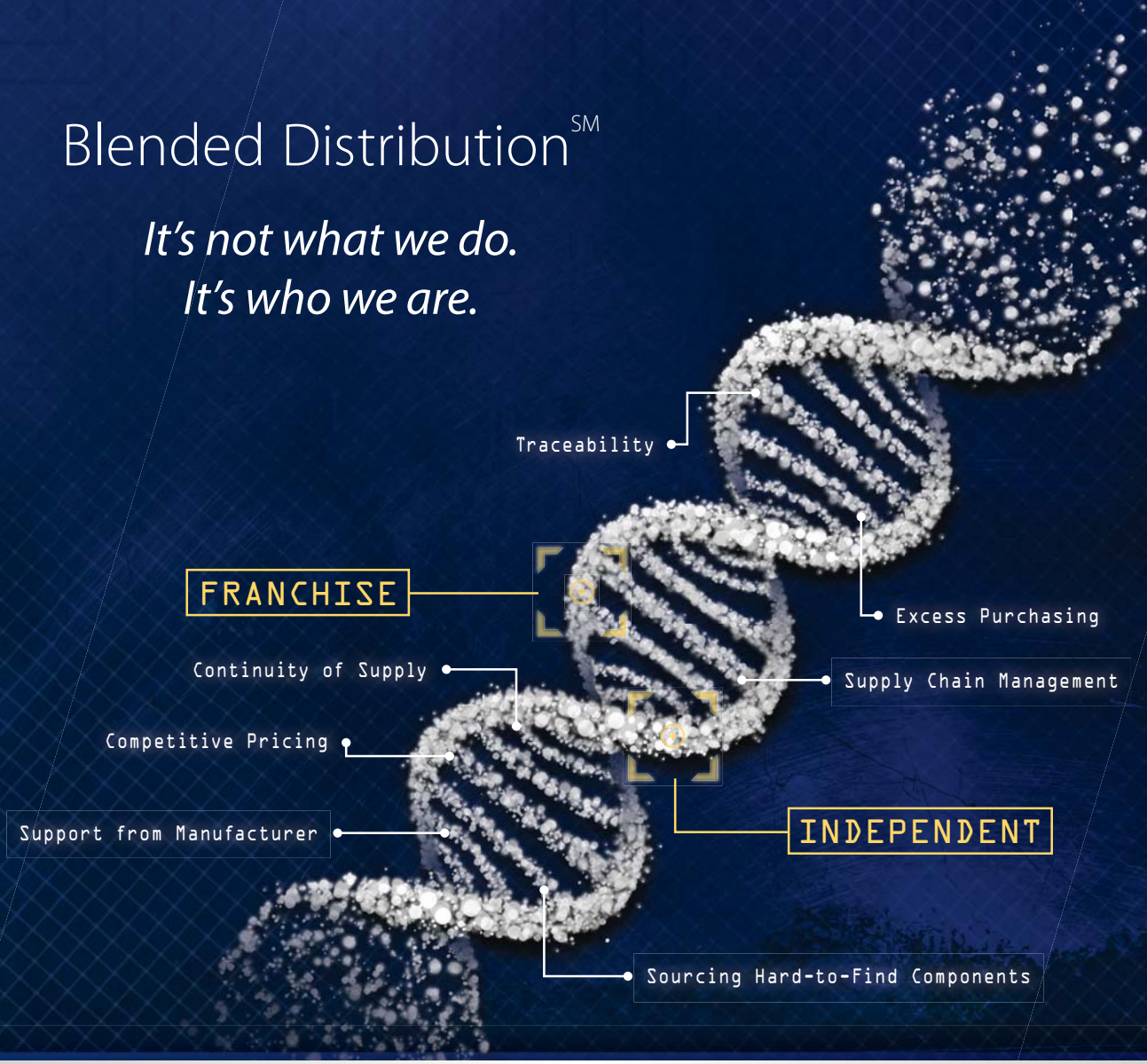
According to the company, these calibrated and compensated sensors provide accurate, stable output over a wide temperature range. They are intended for use with non-corrosive, non-ionic working fluids. A protective parylene coating is optionally available for moisture and harsh media protection.

Honeywell Sensing & Control's TruStability TSC and NSC pressure sensors eliminate the need for system calibra-

Continued on Page 60

Blended Distribution℠

It's not what we do.
It's who we are.



This is America II's Blended Distribution℠

America II has direct relationships with hundreds of manufacturers and maintains an inventory of 4 billion components in stock. In addition, our global purchasing team sources hard-to-find components, while a team of inventory solutions experts offers asset recovery through excess purchasing programs. We have ***blended*** the traits of the independent channel with those of franchise distribution. It is truly the best of both worlds, so customers have the ability to find everything they need — no matter what their requirements are — right here at America II.

Celebrating 25 Years
1989 – 2014

800.955.5302
www.americaii.com/dr

AMERICA II ELECTRONICS® Inc.
Quality, inventory, people. Making a difference.

Top 50 Companies

Continued from Page 54

Michael Knight, senior vice president for the Americas, points to particular strength in North America during that time. He notes that bookings and billings are up and says TTI seems to be bucking the trend toward slower growth. Inventory reductions in the channel at the end of last year—Q4 and even into the first quarter of this year—and a lengthening of lead times among some component manufacturers have been a boon to TTI, which has the inventory on hand to support a resulting demand for components.

"That all favors us with our inventory position," he says, noting that TTI maintains between the high 90s and 140 days' sales in inventory. "The uptick we're having [is because of] our strong inventory position at the right time."

Knight says he maintains a cautiously optimistic outlook for the remainder of the year and notes some challenges that are likely to have a long-term effect on the industry. First is a lack of business investment throughout the channel.

"No one is investing in this space to support it when the market turns around," he says, pointing to research and development spending among public manufacturers and capacity and technology spending as key areas of underinvestment. And then there is headcount reduction.

"The uptick we're having [is because of] our strong inventory position at the right time," says Michael Knight, senior vice president, Americas, for TTI Inc.

"When you have three to four years of flat, you focus on productivity improvement—which means taking people out of the business, by and large," Knight explains, noting that all of these conditions will "bite us in the future" when lead times shoot up.

Companies that have the ability to take a longer-term view, maintaining investments in people and technology, have an advantage, he says. Declining margins are another concern, as customers continue their now built-in need for ongoing cost reduction.

"I don't know how that lasts forever," Knight says, adding that such pressure affects everyone's ability to invest in their business.

Knight also notes 3D printing, new sources of supply such as Amazon and Google, and cloud computing as potential game changers, noting that it is "foolish to say traditional distribution will remain unchanged." Despite the challenges, Knight says he still believes the electronic components business has its best days ahead. The fundamental need for electronics and electronic components is "just getting bigger."

Ruth calls the growing Internet of Things (IoT) market, the drive to connect more devices and processes to the Internet, a prime opportunity. Other opportunities include wearable technology, healthcare, and lighting. There is even growing opportunity in older markets such as automotive and industrial, where many distributors are seeing a pickup in business due to the adaptation and proliferation of electronics in cars, trucks, and factories.

"Our strategy is simple. We're going to mine for gold in new markets—IoT, wearables, and so forth—while continuing to maintain a focus on traditional markets," Ruth explains. ■

Sensor Technologies

Continued from Page 58

tion over temperature and offer reduced part-to-part variation. They measure differential or gage pressures and are intended for use with non-corrosive, non-ionic gases. Numerous package styles and mounting options are available. Both series are piezoresistive silicon pressure sensors that offer a ratiometric analog output for reading pressure over the specified full-scale pressure span and temperature range.

The TSC series is temperature compensated and unamplified *(see the figure)*. Compensation makes it easier to integrate into a system by eliminating the need to calibrate the system over temperature. It also offers reduced part-to-part variation. The NSC series is uncompensated and unamplified, allowing customers the flexibility of performing their own calibration while still benefitting from the stability, accuracy, and repeatability that TruStability Pressure Sensors provide.

STMicroelectronics' LPS25H ultracompact absolute piezoresistive pressure sensor includes a monolithic sensing element and an IC interface that can take the information from the sensing element and provide a digital signal to the external world. The sensing element consists of a suspended membrane realized inside a single mono-silicon substrate. It can detect the absolute pressure and is manufactured with a dedicated process developed by the company.

The membrane is small compared to traditional silicon micromachined membranes. An intrinsic mechanical stopper prevents breakage. The IC interface is manufactured using a standard CMOS process that allows a high level of integration to design a dedicated circuit that is trimmed to better match the sensing element characteristics. ■

INSTANT SOLUTIONS.

OBSOLETE, HARD-TO-FIND AND ALLOCATED PARTS AT YOUR FINGERTIPS – FROM CTG

Frustrated with excess inventory, need for cost reduction, long lead times or out-of-production parts? CTG has the answers.

As a Value-Added Reseller, CTG provides the bridge between your requirement and the manufacturer, taking responsibility for all quality control and logistics, while reducing the cost of acquisition.

CTG also maintains one of the largest, most diverse inventories of electronic and electromechanical components, hardware and more - tested for authenticity and ready to ship. Our expert Quality Control and Counterfeit Avoidance Program is unrivaled in the industry.

With a comprehensive inventory of immediately available, quality-assured parts, CTG is the supplier that buyers depend on for fast solutions in obsolescence and allocation. We make it as easy as one-two-three. **www.CTG123.com**

THE 2012 TOP 50 DISTRIBUTORS

THE 2013 TOP 50 DISTRIBUTORS

One Odell Plaza, Suite 139, Yonkers NY 10701
(914) 779-3500 • info@ctgnow.com

CTG®
Crestwood Technology Group

LEADING SUPPLIER OF QUALITY-ASSURED PARTS

DesignSolution

ALEX TYSHKO | PetroMar Technologies
atyshko@petromartech.com

Analyze MOSFET Parameter Shifts Near Maximum Temperatures

Designs would benefit from modeling MOSFET performance at close to the maximum vendor-specified operating temperature, where the drain-to-source voltage drop and associated conduction losses increase significantly.

Dealing with the inevitable heat dissipation of a discrete power transistor such as a MOSFET is an ongoing engineering problem. In many cases, a heatsink is the solution: the better the heatsink, the smaller the difference between the ambient temperature and the transistor die's temperature. The optimal heatsink choice is a compromise between the size, cost, and required reliability.

But what happens to the MOSFET's performance if the ambient temperature is close to the maximum temperature T_{jmax} in the manufacturer's spec? Where is the breaking point? What do you do if the equipment using this MOSFET has to operate near the hot engine or in the hot oil well, where the ambient temperature can be above 150°C, 175°C, or even higher? How does the MOSFET behave, and how do the conduction losses change? Is there a sign of life behind the specified T_{jmax}?

BY THE NUMBERS

When the temperature rises, the drain-to-source voltage drop V_{DS} increases significantly *(Fig. 1)*. At the same time, it depends on the drain current.[1]

Manufacturers now provide excellent datasheets with the important reference data including $R_{DS(on)}$, measured at a specific test current, I_{Test}, for maximum pulse and maximum continuous currents, at 25°C and 150°C. This data usually is backed with a set of graphics showing the output drain characteristics, such as drain current I_d versus drain voltage V_d and a static drain-source on resistance for 25°C and 150°C.

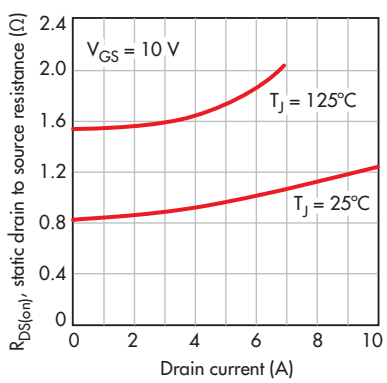
Figure 2 is an example of the combination of these two drain characteristics for the IPB60R099 MOSFET, based on the datasheet graphs.[2] The blue curve represents the drain characteristic for 25°C. The red one is for 150°C. Both curves are for the 10-V gate voltage. The manufacturer's datasheet also provides two $R_{DS(on)}$ values, measured at I_{Test} = 18 A for 25°C and 150°C shown as small circles #1 (0.09 Ω) and #2 (0.23 Ω). Ratio K of voltage #2 to voltage #1 is an important thermal characteristic:

$$K = R_{DS(on)150°C}/R_{DS(on)25°C} \quad (1)$$

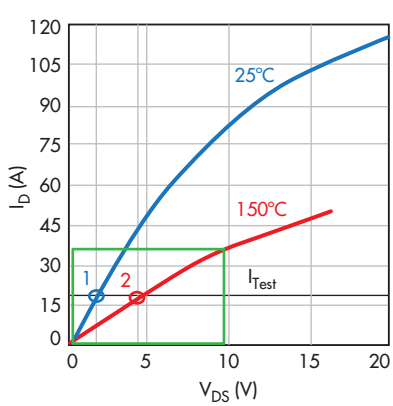
Different transistors have different voltages and current ratings and respectively different values of I_{Test}, of course.

In most cases, the MOSFET is used as a switch and its drain current is a parameter determined by other components and conditions, while its drain voltage is a function to be defined or calculated to find both momentary and average power dissipation. An analytical equation providing the momentary resistance value $R_{DS(on)}$ versus temperature and drain current would be very useful for evaluating the numbers using computer simulation.

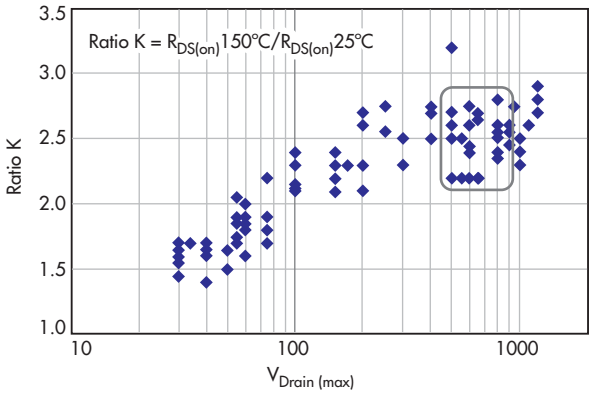
The Design Note[3] provides an equation for the dependence of $R_{DS(on)}$ on



1. The drain-to-source voltage drop (V_{DS}) for the IRF3301 increases significantly with temperature.



2. The green zone depicts recommended limits of the "safe" operation the IPB60R099 for die temperature below 185°C.



3. K values vary for MOSFET maximum drain-voltage ratings, based on data for several groups of MOSFETs with maximum drain voltages from 30 V to 1200 V.

the temperature, but its current dependence was left out of the picture:

$$R_{DS(on)}T = R_{DS(on)(25°C)}(T/300)2.3 \quad (2)$$

where T is absolute temperature (K).

Reference 4 proposes methods to determine another equation for $R_{DS(on)}$ versus temperature, without current effects:

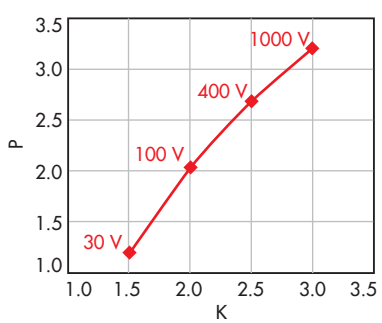
$$R_{DS(on)} = R_{DS(on)(25°C)}(a * T_j^2 + b * T_j + c) \quad (3)$$

Two expressions describing the dependence of $R_{DS(on)}$ on the temperature are available. One is a simple linear equation, and the other is a more precise second-order equation. However, neither of these includes an important current dependency.

This prompts two logical questions. First, do these equations cover all MOSFETs, or do MOSFETs with dissimilar maximum-voltage ratings behave differently? Second, how can at least one of these equations be modified or improved to add a current as a second parameter?

The first question was answered using a sophisticated Monte Carlo method. It took considerable time to gather the information from the datasheets for several groups of MOSFETs with maximum drain voltages from 30 V to 1200 V and then to calculate K for each group. Figure 3 shows a scatter plot of K versus maximum drain-voltage rating.

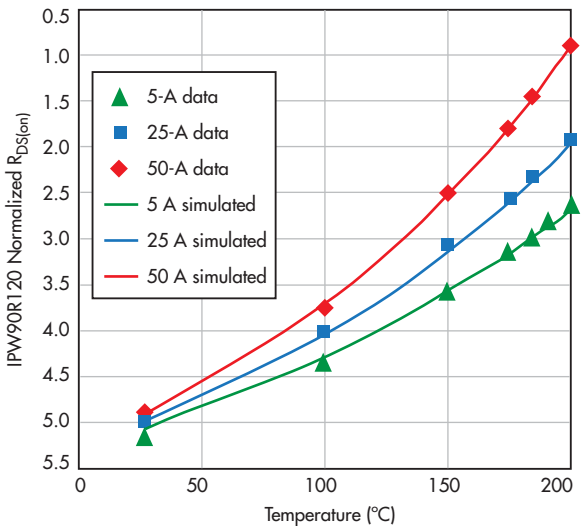
The trend in the data clearly indicates that K depends on the MOSFET's maximum voltage rating V_d and K changes from ≈1.5 for low-voltage transistors to ≈2.9 for high-voltage ones.



4. Based on Equation 2, power value P (shown for P = 2.3) can be charted against K (1) and the related V_d max rating (blue line) from 30 to 1000 V.

SIMULATION RESULTS FOR FIVE MOSFETS

MOSFET	V_D max, V	I_{Test}, A	$R_{DS(on)}$ Ω	a	b	c	R	σ rel
IPB60R099	600	18	0.09	0.07	2.6	0.32	0.999	0.017
STP11N80	800	5.5	0.35	0.04	2.6	0.32	0.991	0.059
SPP17N80	800	11	0.29	0.05	2.4	0.34	0.998	0.027
IXFH24N90	900	12	0.42	0.03	2.7	0.15	0.999	0.023
IPW90R120	900	26	0.12	0.08	2.7	0.35	0.999	0.025



5. Normalized $R_{DS(on)}$ results for the IPW90R120 from 25°C to 200°C were used to determine key performance parameters and confirm simulation results.

The power value P in Equation 2 can be 2.3 only for certain MOSFETs *(Fig. 4)*. Due to the author's involvement in the practical designs for power buses in the range of 400 V to 600 V, the group of interest was narrowed down to the 600-V to 900-V range of the maximum drain-voltage ratings (green zone, Figure 3). The next steps were to use these common-sense assumptions:

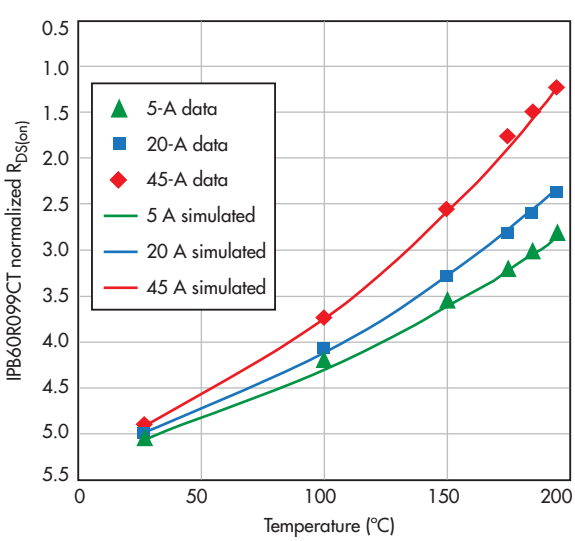
- Make it simple. For room temperature, use a linear dependence of $R_{DS(on)}$ on drain current. For higher temperature, use a corrected exponential.
- Use a model describing a normalized resistance R_n like Equations 2 and 3 to be able to apply this single model to the multiple MOSFETs, with the minimum coefficient correction.
- Use data that's currently available from the manufacturer's datasheets.
- If possible, get at least a few practical data points to verify the accuracy of the proposed equations, especially at high temperatures that exceed the manufacturer's recommended operating-temperature range.

The starting point is:

$$R_{DS(on)}(T,I) = R_{DS(on)(25°C,\ ITest)}R_n \quad (4)$$

where $R_{DS(on)}(T,I)$ is drain-source resistance at junction temperature T and drain current value I; R_n is a normalized (non-unit) drain resistance function of temperature T and current I; and $R_{DS(on)(25°C,\ ITest)}$ is a typical value of drain-source on-state resistance from the datasheet.

To use the normalized resistance function R_n, the normalized drain-current function M is used:



6. Normalized $R_{DS(on)}$ results for the IPB60R099 from 25°C to 200°C were used to determine key performance parameters and confirm simulation results.

DESIGN NOTES

Driver for 14-Bit, 4.5Msps ADC Operates Over a Wide Gain Range

Design Note 526

Guy Hoover

Introduction

The LTC®2314-14 is a 14-bit, 4.5Msps, serial output ADC with an integrated high performance reference. The single-ended input of the LTC2314-14 is easy to drive and in many instances does not require a buffer. A driver, such as the LT6236 op amp, may be required for a signal that is small or has high output impedance. The LT6236 is a 215MHz gain bandwidth product, rail-to-rail output op amp/SAR ADC driver that features 1.1nV/√Hz input-referred noise voltage density and draws only 3.5mA of supply current with a typical offset of only 100µV. The LT6236 is a good choice for these applications because of its high bandwidth, low noise, low supply current and low offset.

The driver presented here is characterized over a range of gains, sampling frequencies and input frequencies to establish its application suitability.

Driver Operation

Figure 1 shows a non-inverting amplifier driving the LTC2314-14. The driver has a gain between one and ten depending on the value of R3, as shown in Table 1. Capacitor C1 and resistor R1 limit the input bandwidth to 68MHz. C1 also acts as a charge reservoir for the ADC sample-and-hold capacitor and helps to isolate the LT6236 from the transient that occurs at A_{IN} when the ADC goes into sample mode. R1 is also used to help isolate the op amp from the ADC sampling transient.

Table 1. Gain and Input Range Settings for Various Values of R3

R3 (Ω)	GAIN	A_{IN} RANGE (V)
∞	1	0 to 4.096
2k	2	0 to 2.048
499	5	0 to 0.8192
221	10	0 to 0.4096

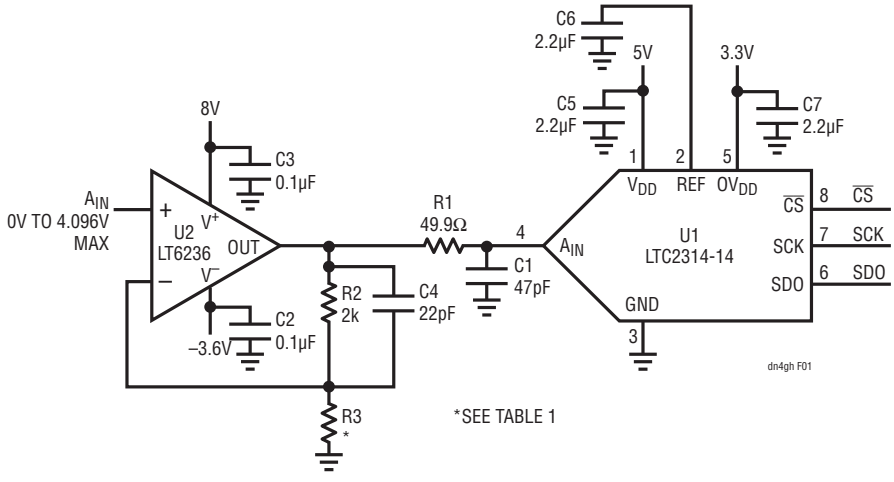


Figure 1. Single-Ended ADC Driver with Up to 0V to 4.096V Input Range

Driver Performance

The FFT in Figure 2 shows that with a gain of one this circuit has an SNR of 77dB and a THD of –84dB, with a sampling rate of 4.5Msps and a 600kHz input frequency. These numbers are close to the typical data sheet performance specifications for the LTC2314-14 alone, indicating that there is minimal performance degradation of the ADC when using this driver. Figure 3 shows SINAD performance vs sampling rate for gains of one through ten. The SINAD remains about the same for all gains at approximately 75dB to 76dB, with sampling rates from 1Msps to 4.5Msps, which is the maximum rated sampling frequency for this part.

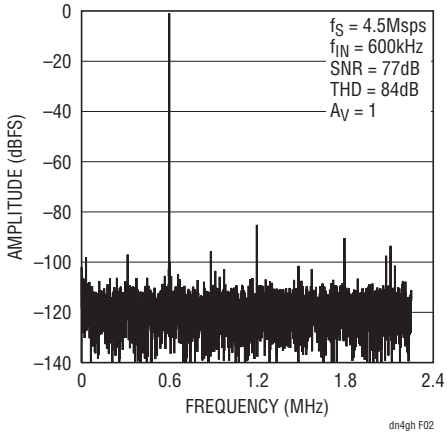


Figure 2. 16k-Point FFT for the Circuit of Figure 1

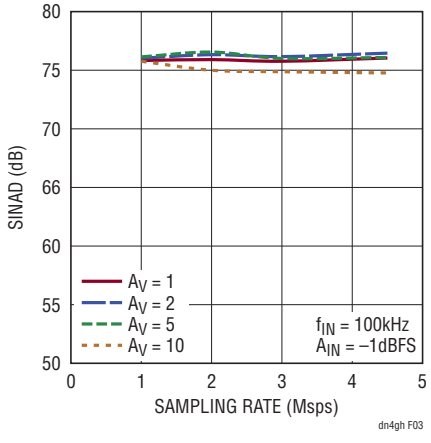


Figure 3. SINAD vs Sampling Rate

Figure 4 shows SINAD performance vs input frequency for gains of one through ten. The SINAD starts at 75dB to 76dB for an input frequency of 100kHz but falls as the input frequency and gain rises. For most applications a drop in SINAD of 3dB should be acceptable. At a gain of one, SINAD is reduced to 73dB beyond 2.2MHz. At a gain of two, SINAD is reduced to 73dB at approximately 1.2MHz. At a gain of five, SINAD is reduced to 73dB at approximately 600kHz. At a gain of ten, SINAD is reduced to 73dB at approximately 250kHz.

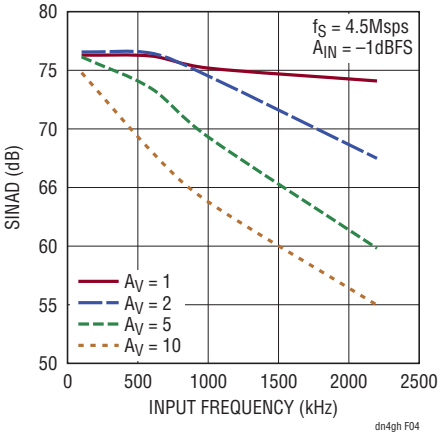


Figure 4. SINAD vs Input Frequency

Conclusion

The LTC2314-14, 4.5Msps, 14-bit serial sampling ADC can be driven by the LT6236 rail-to-rail output, 215MHz low noise op amp/SAR ADC driver with gains ranging from one through ten, sample rates from 1Msps to 4.5Msps and input frequencies ranging from 100kHz to 2.2MHz. This driver circuit is appropriate for small or high output impedance signals. The results shown in Figures 3 and 4 can be used to assess the suitability of this driver for an application with a particular input signal bandwidth and gain.

Data Sheet Download

www.linear.com/LTC2314-14

For applications help,
call (408) 432-1900

Linear Technology Corporation
1630 McCarthy Blvd., Milpitas, CA 95035-7417
(408) 432-1900 • FAX: (408) 434-0507 • www.linear.com

dn526f LT/AP 0514 111K • PRINTED IN THE USA

$$b + c = \frac{\log K}{\log\left(\frac{423}{300}\right)} = 6.7 * \log K \quad (8)$$

$$R_{DS(on)(T,I)} = R_{DS(on,test)} * \left[1 + a\left(\frac{I}{I_{Test}} - 1\right)\right] * \left(\frac{T}{300}\right)^{b+cI/I_{Test}} \quad (10)$$

$$M = I/I_{Test} \quad (5)$$

At room temperature (≈300 K), the normalized resistance R_n is a function of a normalized current M:

$$R_n = 1 + a(M - 1) \quad (6)$$

where a is a resistance coefficient derived from the Point 1 voltage and current (Figure 2, at 25°C).

The next step is to add a current-correction component c × M to the exponential part of Equation 2:

$$2.3 \rightarrow b + c * M \quad (7)$$

At 150°C (423 K) and a drain current equal to the test current (Point 2, Figure 2, M = 1), you get Equation 8. Finally, the expression is completed with all the necessary ingredients:

$$R_n = [1 + a(M - 1)] * (T/300)^{b+cM} \quad (9)$$

The full version includes all parameter definitions, as seen in Equation 10.

To check how close the proposed equation is to the real-life conditions, a few MOSFETs with maximum drain voltage ratings of 600 V to 900 V were tested using the standard low-power dissipation approach with 10-µs pulses at a 1-second period *(see the table)*. The test setup was designed to run MOSFETs up to 200°C and up to 50-A pulses maximum.

The drain voltage was measured for each of 10 transistors in the test setup. The averaged values of both drain voltages and drain currents were used to calculate $R_{DS(on)}$ for each point. Coefficient a was calculated per Equation 6, while the b and c values were found using a standard fitting procedure to maximize the correlation factor R.

The first MOSFET tested was the 900-V IPW90R120, specified at 0.12-Ω $R_{DS(on)}$ at 25°C, with 26-A test current and 10-V gate voltage according to the datasheet.[5] Figure 5 shows R_n (normalized measured data) as scattered points and the simulated results as smooth lines of the similar color, with green for 5 A, blue for 25 A (calibration current 26 A, M = 1), and red for 50 A. Figure 6 presents similar normalized measured data and simulated R_n curves for a second tested MOSFET IPB60R099 (600 V, 0.09 Ω at 25°C, and 18-A test current).

SUMMARY

After examining the dependence of $R_{DS(on)}$ change and related thermal coefficient K versus the maximum drain-voltage rating, the statistical analysis shows that MOSFETs with low V_d max are less dependable from a temperature perspective. The proposed solution is an enhanced empirical equation for simulation of the MOSFET drain-source resistance $R_{DS(on)}$ versus both the junction temperature and the drain current for the extended temperature range up to 200°C, as seen in Equation 10.

The proposed equation for simulation has been tested as well, with results and the relevant simulation coefficients provided for several MOSFETs with V_d maximum ratings covering the 600-V to 900-V range. ed

REFERENCES

1. Ralf Locher, "Introduction to Power MOSFETs and Their Applications," Application Note AN-558, National Semiconductor, 1988.
2. IPB60R099 datasheet, Infineon.
3. Design Note AN9010, K.S. Oh, Fairchild Semiconductor, 2000.
4. "Using Simulation to Estimate MOSFET Junction Temperature in a Circuit Application," David Divins, International Rectifier, 2007.
5. IPW90R120 datasheet, Infineon.

ALEX TYSHKO is a principal electrical engineer at PetroMar Technologies Inc. He has an MSEE from Kiev Polytechnic Institute, Ukraine, and holds several patents.

Ramp Generator Uses Microcontroller Emulation Of Unijunction Transistor

DEV GUALTIERI | TIKALON LLC gualtieri@ieee.org

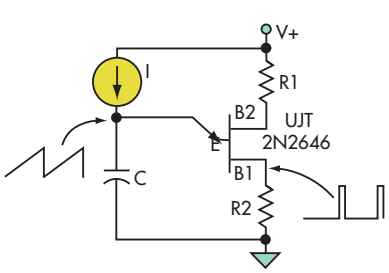
UNIJUNCTION TRANSISTORS (UJTs) were common circuit elements several decades ago. A simple ramp generator could be built from a single UJT and a few other components *(Fig. 1)*.

The operating principle is simple. The base-emitter junction is initially in a high-impedance state, and the current source linearly charges the capacitor until a breakdown voltage is reached. At that point, the capacitor discharges through the UJT base until a lower threshold voltage is reached. Then, the base-emitter connection returns to a high-impedance state, and the capacitor can recharge.

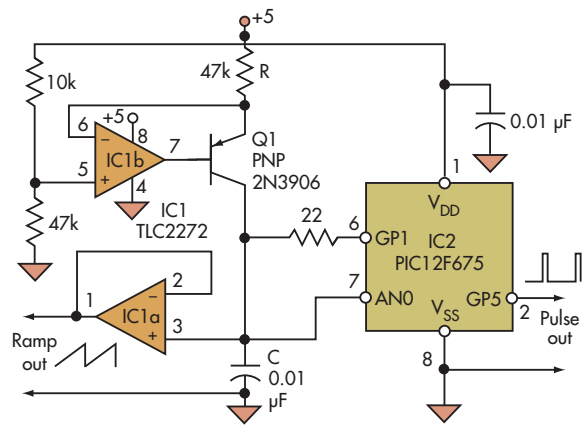
This approach still has a few advantages over digital circuitry, as there are tradeoffs when using a digital-to-analog converter (DAC) to create a ramp. Inexpensive microcontrollers include high-resolution analog-to-digital converters (ADCs), but high-resolution DACs are expensive peripheral components. While such DACs have limited resolution, an analog ramp like one produced by a UJT has infinite resolution.

It's possible to emulate the action of a UJT using just three I/O pins of a microcontroller and a few other components. Most microcontrollers allow their I/O pins to be dynamically reconfigured to function as either a high-impedance input or as an output. This feature is the basis for a simple UJT-emulated ramp generator.

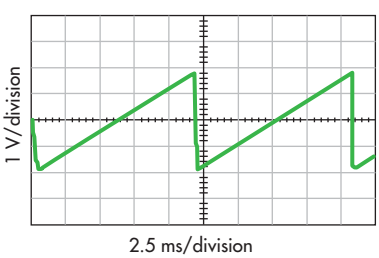
In the microcontroller emulation, the current source is implemented by the rail-to-rail operational amplifier IC1b of a dual device and Q1, while IC1a buffers the voltage on capacitor C and provides the ramp output *(Fig. 2)*. This capacitor is connected to both analog/digital converter pin AN0 of the microcontroller (IC2) and to its I/O pin GP1, which is initially configured as an input. A 22-Ω current-limiting resistor allows high-value capacitors to be used without damage to the microcontroller.



1. In a simple UJT-based ramp generator, the current source linearly charges the capacitor to create a voltage ramp. A synchronizing output pulse is also available.



2. The microcontroller-based emulation of a UJT ramp generator switches the function of an I/O pin from a high-impedance input state to an output state to implement the ramp-generation function.



3. The ramp output repetition rate is about 85 Hz using the values shown. It can be changed via resistor R, which sets the charging current, and capacitor C.

The pseudocode listing for the microcontroller continually monitors the capacitor voltage *(see the code at electronicdesign.com)*. When it reaches a threshold, it switches the I/O pin from its high-impedance input state to an output state at ground potential. When the capacitor voltage goes below another threshold, the I/O pin is switched back to a high-impedance state, and the cycle repeats *(Fig. 3)*. The circuit also provides a pulse synchronized with the ramp cycles that can be used for timing and triggering.

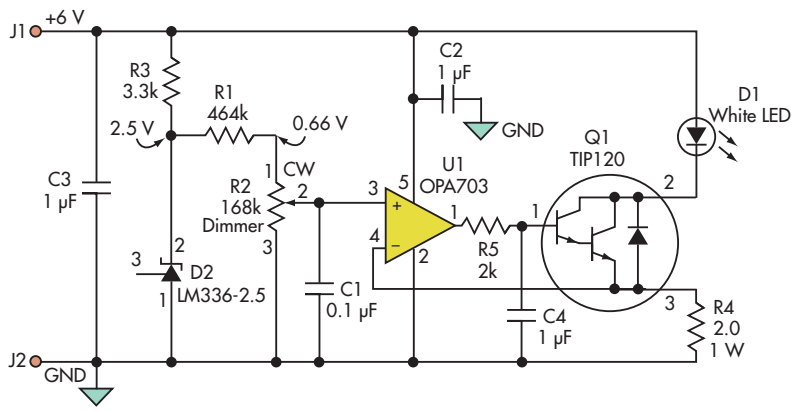
DEV GUALTIERI received his PhD in solid-state science from Syracuse University in 1974. He now does computer, electronic, and embedded-systems projects at his consulting company, Tikalon LLC (www.tikalon.com) in Ledgewood, N.J.

Current Source For LED Microscope Illuminator Provides Full-Spectrum Light

JAMES S. CAMPBELL | MED DESIGN jimcampbell@ieee.org

WHEN THE BUILT-IN incandescent light source of my venerable Olympus microscope failed after many years of use, I decided to design a reliable modern replacement. A 1-W white LED (SEOUL X42182, 350 mA max, Vf = 3.25 V) was the obvious choice to provide high brightness and full-spectrum light without the heat of incandescent or xenon arc lamps. The microscope lamp brightness needs to be adjustable, however, to accommodate the different objective lenses, which offer magnifications from 40× to 1000×.

This simple circuit allows full-range dimming by driving the LED with a stable current source while generating little heat *(see the figure)*. Shunt voltage regulator Q2 sets a stable 2.5-V reference that is divided by R1 and R2 to give a maximum voltage of 0.66 V at the top of R2. Different values of R1 and R2 may be used as long as the sum of their values is greater than 20 kΩ, so as to keep Q2 in regulation.



This circuit provides adjustable dimming of the white LED over a wide range, a requirement for the microscope application with its settable magnifications. It takes what appears to be a linear current source and uses it in a PWM mode.

As the nominal end-to-end resistance of potentiometers may have wide tolerances, measure the value of R2 that you are using and then calculate R1 to provide the 0.66-V maximum voltage at the non-inverting input of U1.

The inverting input of U1 monitors the voltage generated by the current through R4 and sets that voltage to match the voltage at the potentiometer wiper. The current through R4 must pass through the LED and Q1. Although this circuit appears to be a linear current source, the combined gain of U1 and Q1 is so high that the op amp operates in pulse-width modulation (PWM) mode, running at about 100 kHz. R5 and C4 create a 12.5-kHz low-pass filter, reducing any ripple of the current through the LED to less than 1%. The circuit thus creates a stable and fully adjustable light source without discernible flicker.

The LED requires a 1-W heatsink, which may also be used for the mechanical mounting to hold the LED rigidly in place in the optical axis of the microscope, as the LED must not jiggle if the microscope is touched or adjusted. Q1 also needs a small heatsink as it generates about 0.75 W of heat at full brightness, while R4 produces only 0.25 W of heat and barely gets warm.

Any 6-V isolated dc supply capable of providing 400 mA or more can be used for powering the circuit. Commercial wall-plug switching supplies are available and work well here. For certain medical or laboratory use, though, voltage isolation and leakage-current specifications of the supply might have to meet special standards such as IEC 60601.

JAMES STEWART CAMPBELL, EE, MD, is the owner of MEDesign in Pfafftown, N.C.

DON TUITE | Analog/Power Editor
don.tuite@penton.com

LED Controller Provides "Half-Watt Standby"

The "Half-Watt Standby" requirement for plug-in ac-dc power supplies has been a requirement—first in California's CEC400 energy efficiency standard and then as part of Energy Star—for almost a decade. When a "wall wart" is plugged in, but the device it is powering is not turned on, the ac-dc supply must not consume more than 500 mW.

That's still a challenge in LED lighting that uses a dimmer to control brightness by means of a ZigBee, Bluetooth, or Wi-Fi link. "Half-Watt Standby" implies that, even when the LED bulb is dark, the supply for the LED driver and radio receiver cannot consume more than 500 mW.

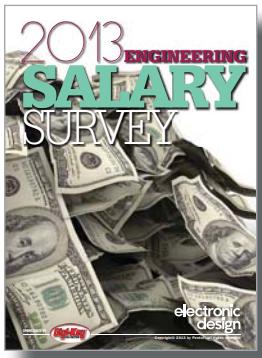
To meet government standby efficiency standards in wireless LED dimming, Marvell built the ac-dc supply for the wireless part of the system into the dimmer and used a simple I²C interface. The 88EM8189 and 88MZ100 are compatible with ZigBee and can accommodate other wireless and wired standards.

Marvell meets these standards with the compact 88EM8189 single-stage, constant current, intelligent LED controller (with an integrated I²C-compatible interface) and the 88MZ100 ZigBee microcontroller, which interfaces with the 88EM8189. The ac-dc supply for wireless functionality is built into the dimmer.

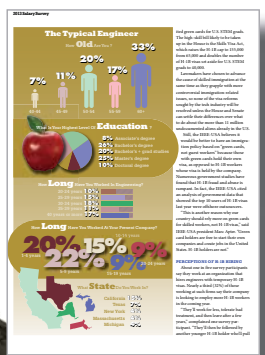
The 88EM8189 includes an energy-efficient on-chip supply for the ZigBee IC, which implements the wireless aspect of dimming. In fact, many wireless or wired controllers could be used with the 88EM8189, as long as they have an I²C interface. The 88EM8189 can be used in buck-boost (non-isolated) or flyback design topologies *(see the figure)*.

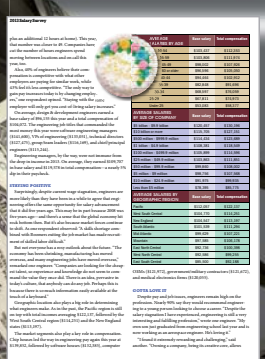
Don't Miss
electronic design's

2013 ENGINEERING SALARY SURVEY



Compare your salary and work environment to other Electronic Engineers that responded to our survey and provided feedback on their jobs and industry!





What's inside:

- 34 unique data tables, charts and infographics
- 18 pages of expert analysis and commentary covering the past, present and future of Electronic Engineer's across the United States
- In-depth coverage on: Unemployment rates, H-1B Visas, Wage stagnation, How Engineers are staying positive, Job satisfaction, How Engineers keep their skills current, Offshoring and outsourcing and more

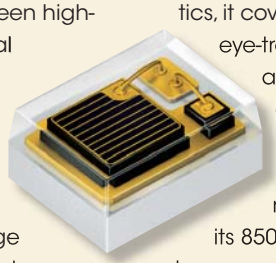
Go to www.electronicdesign.com to see more!

SPONSORED BY

Digi-Key CORPORATION

Mid-Power Infrared LED Focuses On Industrial, Machine-Vision Apps

OSLAM OPTO Semiconductors' latest infrared light-emitting diode (IRED) closes the gap between high- and low-power IREDs. Designed for industrial applications, the Oslon Compact SFH 4710 has a typical output of 270 mW from an operating current of 500 mA. As such, it offers an output range midway between the company's Power TopLED and Oslon Black IREDs. It integrates a chip with an edge length of 750 µm. The Oslon Compact's package measures 1.6 by 1.2 by 0.8, which isn't much larger than the chip itself. Emission angle is ±65°. The IRED doesn't require internal optics or reflectors. Without external optics, it covers the near-field range of a few meters, suiting eye-tracking and gesture detection. However, its light also can be injected into narrow-angle external optics. With external optics, the LED can be used for illumination in surveillance applications and machine-vision tasks (e.g., pattern recognition, 3D measurement). In these apps, its 850-nm wavelength is barely perceptible to the human eye but is easily detectable by camera systems.



OSRAM OPTO SEMICONDUCTORS
www.osram-os.com/pr-SFH4710

RGB-Illuminated Pushbutton Switch Offers Multiple Design Options

CIT RELAY & Switch's AD pushbutton switches come in standard 4.5-mm long-travel (AD01) or 3.5-mm shorter-travel (AD02) versions. Gold-plated contacts boost reliability and extend lifetime to 5 million operations (typical). Actuation force is 250 ±50 gF. LED colors include red, green, yellow, blue, and white. In addition, six bicolor LEDs and custom red, green, and blue (RGB) LEDs provide a wide array of color combinations. Numerous combinations of diffuser, semi-transparent, and transparent cap options increase design flexibility. Potential applications range from broadcast and audio/video equipment to home keys.

CIT RELAY & SWITCH
www.citrelay.com

HDMI, DVI Extenders Enhance Reliability In Digital Video Signage

ADDER TECHNOLOGY'S ADDERLink DV100 HDMI and DV120 DVI extenders deliver reliable HD-quality digital content to digital signage with remote control and monitoring of up to 150 feet from the source. The DV100 and DV120 use an uncompressed communication system; the pixels of every frame are sent without loss. They support resolutions up to 1920 by 1200 at 60 Hz (WUXGA). The DV100 also supports the High-bandwidth Digital Content Protection (HDCP) of the HDMI standard. Video, audio, and power all pass along a single CATx cable, providing a maximum 50-meter extension. In addition, Adder's ADDERLink DV104 digital video extender and splitter includes the company's Proof of Display (P.O.D.) technology, which provides four outputs.

ADDER TECHNOLOGY
www.adder.com

Ad Index

IR's Robust 600V IR25750 SOT-23 Current Sensing IC Boosts Overall System Efficiency While Delivering Dramatic Space Savings

IR introduces the robust IR25750 general purpose current sensing IC available in an ultra-compact SOT23-5L package that boosts overall system efficiency while delivering dramatic space savings for high current applications.

Measuring high currents (10-100A) through a power MOSFET or IGBT typically requires a large resistor which generates excess power losses (10~30W). By extracting the voltage across the internal Rds(on) of a power MOSFET or the VCE(on) of an IGBT during the switch's on-time, the IR25750 eliminates large external current sensing resistors, heatsinks, and excess power losses.

The IR25750's gate drive input provides the VCC supply voltage to the IC and synchronizes the Rds(on) or VCE(on) sensing circuit to the on and off times of the MOSFET or IGBT. Leveraging IR's proprietary high-voltage technology, the device also features 600V blocking capability necessary for blocking high VDS or VCE voltages during the switch off-time. Other key features include low gate input capacitance, internal filter delay at turn-on (200 nsec typ.) and internal 20.8 V zener clamps on GATE and CS pins.

Featuring integrated ESD and excellent latch immunity on all inputs and outputs to enable rugged monolithic protection, the IR25750 is qualified to industrial grade and moisture sensitivity level 1 (MSL1).

More information is available on the International Rectifier website at
http://www.irf.com/press-room/press-releases/nr140320
For more information, contact Sian Cummins, **scummin1@irf.com, 310-252-7148.**

BILL WONG | Embedded/Systems/Software Editor
bill.wong@penton.com

Java 8 Arrives
With More Functionality

Java 8 is now out of the gate. It's big step forward for embedded applications, and a few of its many new features stand out. First is the simplification and unification of the different versions of Java. There is now just Java SE and Java ME, and they are the same versions. Also, Java ME is a proper subset of Java SE.

Java ME now incorporates connected limited device configuration (CLDC), the Generic Connection Framework (GCF), and the Java ME Embedded Profile (MEEP). Even Java SE can fit onto smaller platforms like a microcontroller with 16 Mbytes of RAM and 10 Mbytes of flash.

Next is the inclusion of lambda expressions in the Java language. I used lambda expressions in Lisp, and Java is not in the same league. Lambda expressions in Java are a definite plus, though. A lambda expression is essentially a nameless function. Many applications require a callback function, which allows a programmer to define inline, typically as an argument in a method call.

Lambdas use the -> operator with the argument list on the left and a function body on the right, as shown:

```
(String s) -> { System.out.println(s); }
```

This is a function with a single string argument that prints out the value. Lambdas make a functional programming style easier. They also are handier for embedded applications that use functional arguments. The underlying system has been enhanced to improve support for these new features.

Lambdas play well with another enhancement in Java 8, streams. Java 8's stream application programming interface (API) specifies a set of interface methods that allow code such as this:

```
List<Block> blocks = /* … */
int total = blocks.stream()
                  .filter(b -> b.GetValue() > 100)
                  .sum();
```

In this example, the blocks list provides a stream object that has its elements filtered and then added together. Methods like filter return a stream, while sum returns a value. The type of the lambda argument for filter is inferred. Inferred types are another enhancement that is useful in almost any context. The argument parentheses for the lambda parameter are also not required since there is a single argument. The lambda body assumes the block element value is obtained using the GetValue method. All the elements whose value is over 100 will be added together.

Type annotations are a new addition that can be used anywhere a type is needed in Java code. For example, one might want to make sure a variable was never set to a null value. The variable must always reference an object. This is what a string definition would look like:

```
@NonNull String myString;
```

This is just a simple example. The type annotations also can apply to more complex type definitions. Java does not have a type-checking framework, but Java 8 supports pluggable checkers that can do that job. Static analysis tools can do more, though improved type checking can help keep bugs out of code.

ADDITIONAL FEATURES

Java JVMs can run other programming languages like Groovy and Scala *(see "If Your Programming Language Doesn't Work, Give Scala A Try" at electronicdesign.com)*. Java 8's Nashorn Javascript engine adds Javascript to the mix. Javascript has been used a lot on the Web, and it is a completely different language from Java. There are probably more Javascript programmers than Java programmers, but now both can take advantage of Java 8.

Java is yet another language that takes aim at the Internet of Things (IoT). Its advantage is its wide range of communication and prepackaged middleware. The SE/ME spread also means sensors can use the lightweight Java ME, and higher-end applications can run Java SE systems. Other useful features include an upgraded date and time API, which was needed to address international date and time issues that were not handled well in earlier versions of Java.

The JavaFX 8 graphics toolkit now includes an embedded graphics stack. The toolkit also now handles HTML5 *(see "Understanding HTML5" at electronicdesign.com)*, adds many new user interface controls, and improves 3D support.

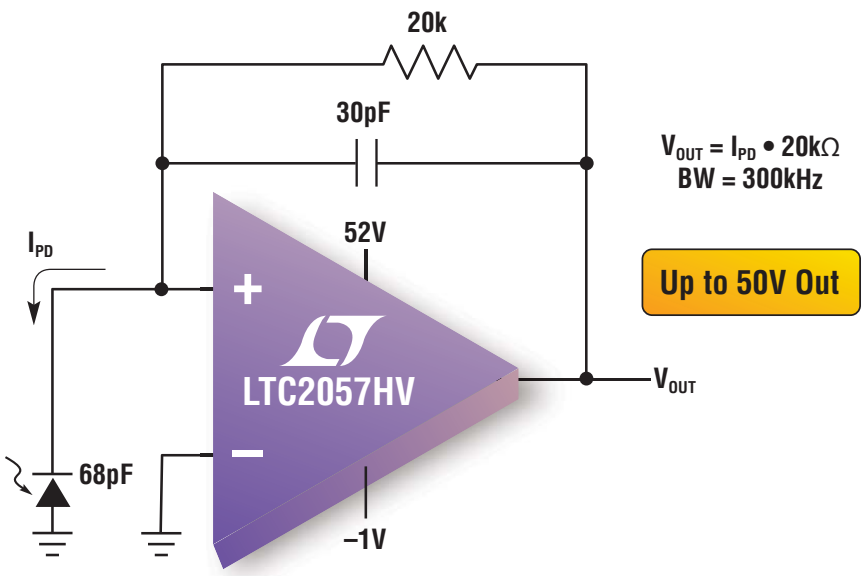
Easy. Powerful.
The R&S®RTE: Simply more scope.

Quickly master everyday T&M challenges.
More confidence in your measurements, more tools and fast results, more fun to use – that's the R&S®RTE oscilloscope from Rohde&Schwarz. From embedded design development to power electronics analysis to general debugging, the R&S®RTE offers quick solutions for everyday T&M tasks.

See for yourself: www.scope-of-the-art.com/ad/rte

ROHDE&SCHWARZ

60V Zero Drift



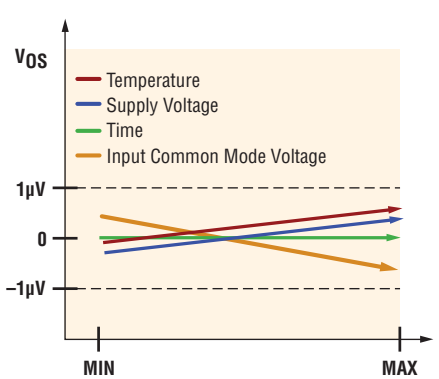
Zero Drift • 200nV$_{P-P}$ Noise • 30pA I$_{BIAS}$

The LTC®2057HV delivers rock-solid, zero-drift performance for systems requiring the highest levels of precision over time, temperature, input common mode voltage and power supply range. Operating on a 4.75V to 60V supply, the LTC2057HV features many improvements over prior zero drift amplifiers, including a high 100kHz chopping frequency with low spurs, low wideband noise and 30mA short-circuit output current.

HV Signal Conditioning

Part Number	Description
LTC2057	60V Zero-Drift Op Amp
LTC6102	105V High-Side Current Sense Amp
LTC6090	140V Precision Op Amp
LTC6016	76V Over-The-Top® Op Amp
LT®5400	±80V Quad Precision Matched Resistors
LT1990	±250V Difference Amplifier

Zero Drift



Info & Free Samples

www.linear.com/product/LTC2057

1-800-4-LINEAR

video.linear.com/4470

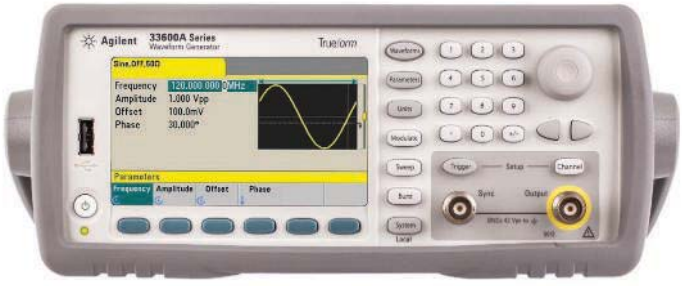
LINEAR TECHNOLOGY

defenseelectronicsmag.com

defense electronics

A Special Section to PENTON'S DESIGN ENGINEERING & SOURCING GROUP

APRIL/MAY 2014



1. The 33600A series Trueform waveform generators provide a straightforward operating interface with a 4.3-in. LCD screen to show waveforms.

Digital Sources Generate WAVEFORMS TO 120 MHz

JACK BROWNE | Technical Contributor

WAVEFORM GENERATION is critical for evaluating electronic circuits and systems, especially as those electronic products operate with ever more complex modulation formats. Fortunately, the 33600A series of waveform generators from Agilent Technologies (www.agilent.com) can provide clean, precise waveforms to 120 MHz at sampling rates to 1 GSample/s, thanks to the company's exclusive Trueform signal-generation technology. These stable, distortion-free signals represent a huge leap forward from the synthesis capabilities of direct-digital-synthesizer (DDS) signal-generation technology, with tremendous benefits for users in both the frequency and time domains.

The 33600A series of waveform generators *(Fig. 1)* includes single- and dual-channel models with top frequencies of 80 or 120 MHz. The two-channel models can sum and combine as many as four signals to create complex output waveforms. Each model is essentially a function generator, arbitrary waveform generator, and pulse generator within a single, compact package, showing generated signals and waveform details on a 4.3-in. WQVGA liquid-crystal-display (LCD) screen. Based on a 1-GSample/s, 14-b-resolution digital source, these waveform

(continued on p. s24)

BMS MARKET Projected to EXPLODE

ACCORDING TO a recent report from MarketsandMarkets (www.marketsandmarkets.com), the battlefield management systems (BMS) market is expected to be worth $12.6 billion (USD) by 2019. The firm makes these projections in "Battlefield Management Systems Market (Land, Airborne and Naval Platforms, Commander Systems, Dismounted Soldier Systems, Tracked and Armored Vehicles, Communication Network Systems and BMS Software)—Forecast & Analysis 2014-2019." The report estimates a BMS market at $10.36 billion in 2014 and a compound annual growth rate (CAGR) of 4.0%.

The report details major defense spenders for different regions and platforms within the market, including for air, land, and naval platforms. It also explains spending by different applications—e.g., soldier systems, tracked and armored vehicles, communications networks and equipment, and software. In addition, it projects major competitors for the global BMS market along with their key products and services. The report explains some key emerging economies for this market, including countries such as India, Brazil, and Japan. It notes that land-based systems will have the highest CAGR and will account for the majority of the market share growth. ■

(continued on p. s8)

Micro Lambda's Bench Test Boxes...
Simple and Easy to Use!

MLBS-Synthesizer Test Box – 600 MHz to 20 GHz
Standard models cover the 0.6 to 2.5 GHz, 2 to 8 GHz, 8 to 20 GHz and 2 to 20 GHz frequency bands. All versions of the MLSP synthesizer product family can be easily inserted into the test box. Tuning consists of a control knob, key pad, USB and Ethernet connections. Units provide +10 dBm to +13 dBm output power levels and are specified over the lab environment of +15°C to +55°C and are CE certified.

Units are provided with a power cord, USB cable, Ethernet cable, CD incorporating a users manual, quick start guide and PC interface software.

MLBF-Filter Test Box – 500 MHz to 50 GHz
Standard models utilize any Bandpass or Bandreject filter manufactured by Micro Lambda today. Bandpass filter models cover 500 MHz to 50 GHz and are available in 4, 6 and 7 stage configurations. Bandreject (notch) filter models cover 500 MHz to 20 GHz and are available in 10, 12, 14 and 16 stage configurations. Units are specified to operate over the lab environment of +15°C to +55°C and are CE certified.

Units are provided with a power cord, USB cable, Ethernet cable, CD incorporating a users manual, quick start guide and PC interface software.

See our complete line of wideband, low noise components


MLSP-series Synthesizers
600 MHz to 20 GHZ


MLSW-series Synthesizers
600 MHz to 16 GHz


MLTO-series TO-8 Oscillators
2 to 16 GHz


MLSMO-series Surface Mount Oscillators
2 to 16 GHz

www.microlambdawireless.com

MICRO LAMBDA WIRELESS, INC.

"Look to the leader in YIG-Technology"

46515 Landing Parkway, Fremont CA 94538 • (510) 770-9221 • sales@microlambdawireless.com

▶ Network Analyzers

Anritsu | Since 1895

Signal Generators

Spectrum Analyzers

Power Meters

Confidence in your measurements. Confidence in your component design.

VectorStar™ MS4640B
Vector Network Analyzer

Confidence on the Cutting Edge

Test equipment shouldn't limit your active and passive component performance.

The Anritsu Vector**Star** MS4640B Series offers the **best VNA performance** across the widest frequency band. Microwave capability from **70 kHz to 20/40/50/70 GHz**, broadband measurements from **70 kHz to greater than 110 GHz**, high accuracy time domain, wide dynamic range frequency domain measurements, noise figure capability to **125 GHz**, Pulse**View**™ for pulsed measurements, and Differential**View**™ for true mode stimulus measurements make the Vector**Star** the ideal tool for microwave component designers and manufacturers.

Get the true view. Download our complimentary application note, ***Noise Figure Measurements***

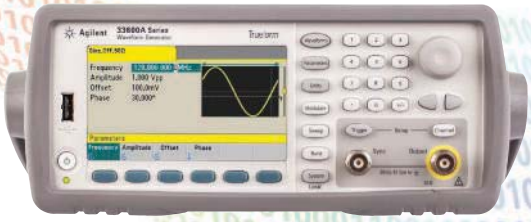
Visit us online at: **www.anritsu.com/en-us/VectorStarMWRF**

Designed and Manufactured in U.S.A.

USA/Canada 1-800-ANRITSU Europe 44 1582-433433 Japan 81 (46) 296-1208
Asia-Pacific (852) 2301-4980 Singapore-South Asia (65) 6282-2400
South America 55 (11) 3283-2511

Anritsu

In This Issue



1

FEATURES

8

12

NEWS SHORTS

CONTRACTS

PRODUCT FEATURE

16

defense electronics

A Penton® Publication

Leading the Way in High-Performance GaN

With extensive and continuing R&D programs, TriQuint continues to find new ways to:

- ***Drive advancements in GaN process technology***
- ***Achieve higher system efficiency and power over a wider bandwidth***

Richardson RFPD provides extensive technical expertise and design-in assistance for TriQuint's industry-leading GaN portfolio for defense and commercial applications.

On TriQuint's new GaN Tech Hub, brought to you by Richardson RFPD, get the latest:

- ***Product releases***
- ***Videos***
- ***Webinars***
- ***Technical papers***
- ***and much more!***

Visit www.richardsonrfpd.com/TriQuint-GaN

TriQuint
Reach Further • Reach Faster™

Image Courtesy of Lockheed Martin

Your Global Source for
RF, Wireless & Energy Technologies

RichardsonRFPD
An Arrow Company

www.richardsonrfpd.com | 800.737.6937 | 630.208.2700

Taking The Man Out of the Military

MILITARY CONFLICTS originate on a human level, more often than not in a disagreement over a boundary, possession, or ideology. Likewise, the oversight of vital military operations, such as monitoring and surveillance, has traditionally fallen under the purview of man. Yet increasingly, military functions are being performed by a machine—specifically, some form of a robotic system, like an unmanned aerial vehicle (UAV) or unmanned ground vehicle (UGV). One cannot help but wonder how far military history will be able to proceed as this trend continues.

Since the mid-1990s and the development of early UAVs (such as the Global Hawk), the creation of unmanned vehicles both large and small has been on a steady rise, with the electronic systems within these vehicles growing in sophistication along with the mechanical capabilities. A report in this issue on unmanned vehicles (see p. S16) notes that more than 400 companies currently serve military markets for UAVs. It is a wide range of firms that includes Boeing (www.boeing.com), Lockheed Martin (www.lockheedmartin.com), Northrop Grumman (www.northropgrumman.com), and Raytheon Co. (www.raytheon.com), as well as much smaller companies. The markets for these vehicles, of course, include healthy sub-markets for associated equipment, such as communications systems, surveillance systems, and radars.

Design goals for these unmanned vehicles are helping to quickly boost their usefulness for military applications—e.g., increased flying times and altitudes for flying vehicles, and capabilities to handle larger loads with greater agility for ground vehicles. Ideally, these unmanned vehicles can carry an increased amount of weight in the form of electronic systems while also becoming smaller in size. Goals common to unmanned vehicles whether on land, at sea, or in the air include increased efficiency and reliability—for longer operating times on less fuel. Designers and manufacturers throughout the industry are also stressing the use of commercial-off-the-shelf (COTS) hardware wherever possible, so as to achieve the desired reliability levels while also controlling costs.

Military applications are not the only areas benefitting from the increased availability of unmanned vehicles: A growing number of unmanned vehicles is being produced for non-military practices, including for law enforcement; firefighting and emergency management; gas leak detection; and environmental and wildlife monitoring. Such applications as public safety do not require unmanned vehicles with the massive airframes of military applications, but can often be handled by much smaller solutions, such as the palm-sized UAVs offered by Aeryon Labs (www.aeryon.com).

Over time, unmanned vehicles are being developed with a trend to minimize human interaction—that is, for a system such as a UAV to carry enough processing and intelligence to perform a certain amount of "decision making" based on what it has detected, without the need of the human operator. Cynics might compare this growing use of unmanned vehicles in military settings to a video game, with the former human combatants sitting safely behind computer screens. But at the very least, until humans learn to stop fighting, this use of machines is helping to save lives.

(continued from p. s1)

Raytheon Demonstrates Griffin Block III

RAYTHEON CO. (www.raytheon.com) demonstrated the latest version of its formidable Griffin missile, the Griffin Block III, with several direct hits against static and moving targets. The Griffin missile's new seeker adds enhanced electronics and signal processing for improved performance under challenging environmental conditions. The Griffin missile is 43 in. long, weighs 33 lbs., and carries a 13-lb. warhead. The missile is currently in production, and is expected to serve as the core weapon for current and future Griffin users.

Mike Jarrett, vice president of air warfare systems with Raytheon Missile Systems, notes that "the Griffin is already well known for its ability to destroy targets with pinpoint accuracy using an advanced GPS and semi-active laser guidance. The Griffin Block III introduces an improved semi-active laser seeker and a new Multi-Effects Warhead System that maximizes the weapon's lethality against a variety of targets." Jarrett adds that "Block III's enhancements will improve the warfighter's ability to engage a broad set of static and fast-moving targets with assured confidence and greater performance." ■

Rockwell Collins Crafts Radar Systems For Coast Guard

THE UNITED States Coast Guard has selected Rockwell Collins (www.rockwellcollins.com) to provide the MH-65E Radar Sensor System (RSS) for 102 MH-65E aircraft. The solution will feature Rockwell Collins' RTA-4114 MultiScan Weather Radar with enhanced ground/shoreline mapping and a new maritime surface search mode. Per the contract, Rockwell Collins will provide an enhanced RTA-4114 radar for shoreline and over-water use.

The RTA-4114 MultiScan Weather Radar system automatically scans ahead of an aircraft; it combines radar returns through advanced digital signal processing (DSP) and analysis algorithms to display not just precipitation rates, but actual weather threats. The weather radar system features automated tilt, clutter removal, and gain management, and performs automatic compensation for predictable atmospheric and climatic conditions. ■

Rockwell Collins Signs MOU With Russian Aviation Firm

ROCKWELL COLLINS recently signed a memorandum of understanding (MoU) with Transas Aviation, a division of the Transas Group based in St. Petersburg, Russia. The MOU is for the American firm to address forward-fit and retrofit avionics opportunities for Russian aircraft platforms. Transas Aviation is known for its aviation solutions for Russian and international fixed-wing aircraft and helicopters. According to the terms of the MoU, Rockwell Collins will expand its footprint in Russia and the Commonwealth of Independent States (CIS); Transas Aviation will gain access to Rockwell Collins' global business development capabilities, engineering, and certification expertise.

Claude Alber, vice president and managing director, Europe, the Middle East, and Africa (EMEA) for Rockwell Collins, explains that "the Russian and CIS aviation market segment is quickly emerging and, to successfully meet demand, strong relationships like we have with Transas Aviation are becoming more critical....Together, we will deliver robust solutions for Russian aircraft by leveraging the market-leading expertise of both companies." ■

NOW!

ULTRA-REL®

CERAMIC MIXERS

300 MHz to 12 GHz

from only **$5.95** ea. qty. 10

- **Hermetically Sealed,** *100% Tested*
- Rugged LTCC Construction
- Easy Visual Solder Inspection, *gold-plated terminals*
- Low Profile, *only 0.06"/1.5 mm thick*

- Highly Repeatable Performance
- Flat Conversion Loss & High Isolation across the whole band
- Outstanding Thermal Stability, *-55 to +125°C*

Mini-Circuits new MAC mixer family combines rugged ceramic construction with monolithic quad semiconductor technology to produce the most reliable mixers available in the marketplace today—the only mixers anywhere backed by a ***3-year guarantee!*** Top to bottom, inside and out, they're designed and built for long-term reliability under hostile conditions such as high moisture, vibration, acceleration, and thermal shock from -55 to +125°C.

Excellent electrical performance across the entire frequency range makes them ideal not only for aerospace and military ground applications, but anywhere long-term reliability adds bottom-line value: instrumentation, heavy industry, high-speed production, and unmanned facilities, to name just a few. So why wait? Go to minicircuits.com for performance data, technical specifications, and ***remarkably low prices***, and see what MAC mixers can do for your applications today!

Mini-Circuits®

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

Lockheed Martin Guides Navy Testing

LOCKHEED MARTIN (www.lockheedmartin.com) has been awarded a $103-million contract by the US Navy to produce automated test systems designed to increase aircraft mission readiness. The award authorizes two low-rate initial production options for the first 36 electronic Consolidated Automated Support System (eCASS) stations and associated support equipment. The US Navy and US Marines employ eCASS test systems to troubleshoot and repair aircraft assemblies both at sea or ashore.

"eCASS will be the workhorse for avionics repair across the Naval Aviation Enterprise," says Chris Giggey, deputy program manager for automatic test systems of the US Navy's Naval Air Systems Command's Aviation Support Equipment Program Office (PMA-260). "This system provides us with capabilities critical to support of naval aircraft and gives us the ability to launch combat-ready aircraft from carriers anytime and anywhere in support of the nation."

The new eCASS test systems are meant to replace CASS test systems currently in use and originally fielded in the early 1990s. Randy Core, director of enterprise test solutions at Lockheed Martin Mission Systems and Training, explains the benefits of the eCASS equipment: "eCASS runs 20% faster, is even more reliable, and is highly compatible with legacy CASS stations. This speed and reliability will ultimately help the Navy increase aircraft availability." The first eCASS test station is scheduled for delivery in November 2014. ■

Oman Seeks Missile Defense From Raytheon

THE SULTANTE of Oman has contracted Raytheon Co. (www.raytheon.com) for the National Advanced Surface-to-Air Missile System (NASAMS), intended for the protection of the region. The award, which is valued at $1.28 billion, includes ground support equipment, a full training package, and technical assistance. The system already provides protection in six nations, including the United States (District of Columbia).

The contract was announced in Oman at a signing ceremony attended by Mohammed bin Nasser al Rasbi, secretary general at the Ministry of Defence; Air Vice Marshal Matar bin Ali al Obaidani, commander of the Royal Air Force of Oman; and Tom Kennedy, chief operating officer (COO), Raytheon Co.

Raytheon will supply the system to the Sultanate of Oman working with long-term partner Kongsberg Defence Systems (www.kongsberg.com). Work will be performed by Raytheon at the Integrated Air Defense Center (Andover, MA) and by Kongsberg in Kongsberg, Norway. ■

Air Force Acquires Bomb Kits

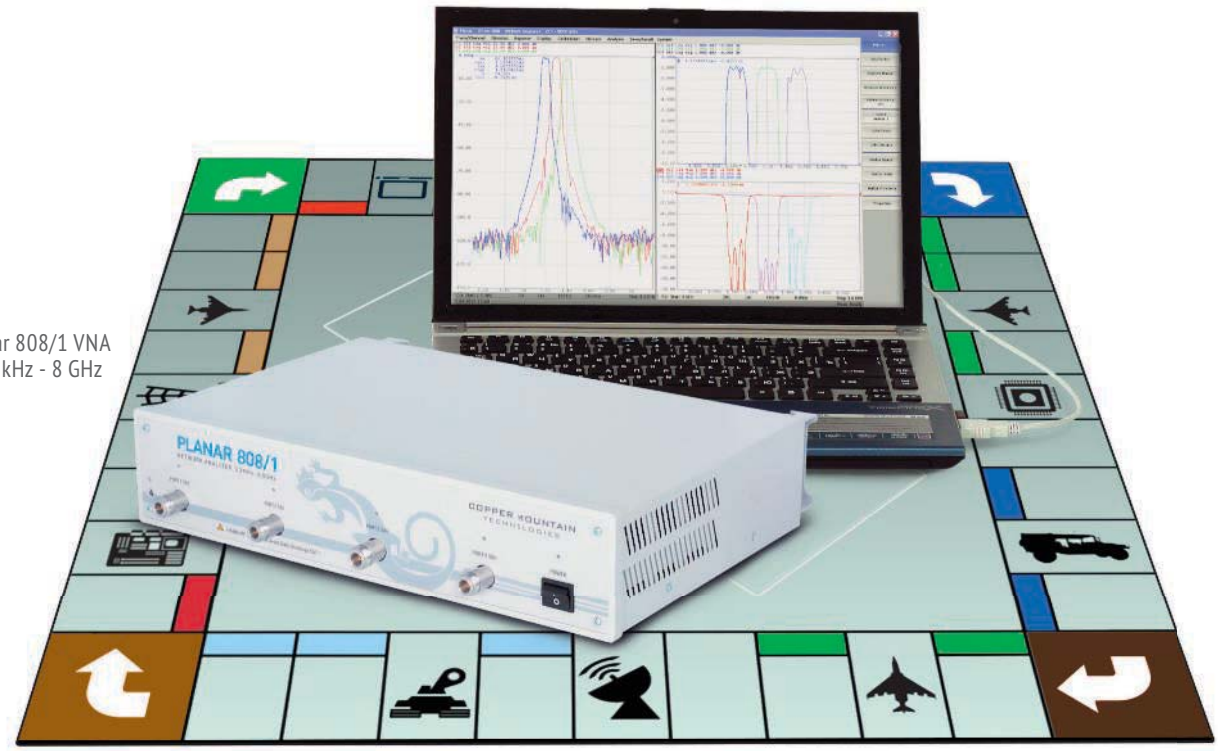
LOCKHEED MARTIN has also received a $31-million contract from the United States Air Force for production of Paveway II Plus Laser Guided Bomb (LGB) kits. The LGB features an enhanced laser guidance package and will include computer control for GBU-10 and GBU-12 bombs. The LGB kit consists of a MAU-209C/B computer control group with electronic guidance system and airfoil group to provide lift and stability to weapons in various configurations. Lockheed Martin has already delivered more than 130,000 training rounds, in excess of 70,000 Paveway II LGB kits, and 7000 dual mode systems to the US Navy, Marine Corps, and Air Force, in addition to international customers. ■

Arotech Nets Battery System Orders

THE BATTERY and Power Systems division of Arotech Corp. (www.arotech.com) recently reported $2.4 million in new orders from military customers—primarily for batteries and related systems for military applications. Notes the firm's chairman and chief executive officer (CEO), Robert S. Ehrlich: "Military customers repeatedly order our battery systems as the build quality and underlying technology in our products are unparalleled in the market. Our leadership is the result of many years of R&D investment which continues today, and we are now developing the technologies that we foresee the military will need in the upcoming years. In particular, these include the batteries for powering unmanned systems and robots." ■

Game changer

A VNA that goes beyond the call of duty in performance and portability.



Planar 808/1 VNA
100 kHz - 8 GHz

Lightweight, affordable, and highly accurate vector network analyzers from CMT perform exceptionally well on a lab bench and in the field, with no need for data purging. The VNA software operates on an external PC, which makes data transfer, automation, and system integration easy, so you can **put an advanced VNA where one hasn't gone before.**

COPPER MOUNTAIN
TECHNOLOGIES

R54 Reflectometer
85 MHz - 5.4 GHz

TR1300/1
300 kHz - 1.3 GHz

5048
20 kHz - 4.8 GHz

Planar 304/1
100 kHz - 3.2 GHz

Planar 814/1
100 kHz - 8 GHz
Direct receiver access

US +1.317.222.5400 | Singapore +65.63.23.6546 | coppermountaintech.com

JACK BROWNE | Technical Contributor

Military Communications Embraces Many Technologies

Military communications technology must be developed for efficient use of available bandwidth, as well as for effective interoperability of equipment among the armed forces.

MILITARY COMMUNICATIONS technologies are vast and complex: Systems designers seek to boost security and reliability with available bandwidths, whether on land, at sea, or in the air (or space). Each generation of communications equipment seeks to leverage improvements in component life, such as extended operating time for portable radios running on new rechargeable batteries or increased processing power from the latest high-power microprocessors.

No one technology dominates military communications systems. Rather, a large number of technologies are employed to provide security and reliability for them, and military systems designers are constantly seeking to integrate whatever new technologies may improve military radios and communications systems.

Communications systems for military applications start on the ground and work their way through the atmosphere, with communications systems as traditional as high-frequency (HF) two-way radios to more elaborate satellite-communications (satcom) systems. One of the top challenges currently facing military technology managers concerning communication is integration—trying to achieve interoperability among so many different systems and technologies.

Another concern has to do with spectrum management. In time, this may morph into spectrum sharing as frequencies for different systems and functions are reallocated. As expected, the US Federal Communications Commission (FCC) is heavily involved in reworking the allocation of available bandwidths for different military, industrial, and commercial applications. But the US Department of Defense (DoD) is similarly concerned and involved. The agency recently released its "Electromagnetic Spectrum Strategy" report (available for download in PDF form at www.defense.gov/news/dodspectrumstrategy.pdf), which details the DoD's observations and guidance on the shared used of spectrum.

The Whetstone vehicular radio has been called a "network in a box" and is compatible not only with satcom systems, but also with ground-based VHF and UHF military radios. [Photo courtesy of Lockheed Martin (www.lockheedmartin.com)]

As the DoD notes, the growing consumer demand for EM spectrum (e.g., smartphones) is pressuring federal agencies such as the FCC to make the most efficient use of available spectrum as possible. A possible solution lies in repurposing spectrum currently used by government and military and allocating it to consumer or shared use. As an example, about 18% of the spectrum from 300 MHz to 3 GHz is currently allocated for federal or military use. Such actions as spectrum auctions help to repurpose some of this bandwidth and generate revenues for government use.

Although significant investments are still made in the development of effective terrestrial radios (for more on portable radios, see p. s26), a growing number of systems are incorporating satellites as part of their communications links. The Whetstone network and radios developed by Lockheed Martin (www.lockheedmartin.com), for example—which the firm refers to as a "network in a box"—represent totally flexible and adaptable military communications systems. These are modular and scalable systems for vehicular mounting for critical voice, data, and video communications. The radios *(see figure)* have a small form factor and can be configured to fit within almost any vehicle in less than an hour.

Whetstone radios provide the flexibility that is increasingly found in military communications equipment. In addition to satcom connectivity, they boast backwards compatibility with ground-based VHF and UHF radios, as well as with single-channel ground and airborne radio system (SINCGARS) radios. For use with SINCGARS radios, the Whetstone systems operate in the VHF FM band with 25-kHz channels from 30 to 88 MHz. They offer both single-frequency and frequency-hopping modes, with 111 frequency hops per second for security. The Whetstone equipment is representative of modern military communications equipment in its flexibility, as well as its small size, weight, and power (SWaP)-friendly design.

In working with the Marine Corps for its communications and command needs, General Dynamics (www.generaldynamics.com) recently completed a successful critical design review of the Aviation Command and Control Subsystem (AC2S), a part of the Marines' new Common Aviation Command and

USB & Ethernet Programmable

ATTENUATORS

0–30, 60, or 90 dB 1 MHz to 6 GHz *from* $395

Mini-Circuits programmable attenuators give you more options and more freedom with both USB and Ethernet control. Available in versions with maximum attenuation of 30, 60, and 90 dB with 0.25 dB attenuation steps, all models provide precise level control with accurate, repeatable performance for a wide range of test applications. Our unique designs maintain linear attenuation change per dB over the entire range of attenuation settings. Supplied with user-friendly GUI control software and everything you need for immediate use out-of-the-box, Mini-Circuits programmable attenuators offer a range of solutions to meet your needs and fit your budget. Visit minicircuits.com for detailed performance specs, great prices, and off-the-shelf availability!

RoHS compliant

	Models	Attenuation Range	Attenuation Accuracy	Step Size	USB Control	Ethernet Control	RS232 Control	Price $ ea.
	RUDAT-6000-30	0 – 30 dB	±0.75 dB	0.25 dB	✓	-	✓	$395
NEW	RCDAT-6000-30	0 – 30 dB	±0.75 dB	0.25 dB	✓	✓	-	$495
	RUDAT-6000-60	0 – 60 dB	±1.00 dB	0.25 dB	✓	-	✓	$625
	RUDAT-6000-90	0 – 90 dB	±1.70 dB	0.25 dB	✓	-	✓	$695
NEW	RCDAT-6000-60	0 – 60 dB	±0.30 dB	0.25 dB	✓	✓	-	$725
NEW	RCDAT-6000-90	0 – 90 dB	±0.40 dB	0.25 dB	✓	✓	-	$795

Mini-Circuits®

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

Control System (CAC2S). The firm will build four AC2S engineering development models (EDM) for integration into a CAC2S system for developmental testing and operational assessment.

The CAC2S system helps share mission-critical voice, video, sensor, and other command and control data during any mission. This data subsystem can fuse sensor inputs from a variety of sources, including radar systems, weapon systems, and even unmanned aerial vehicles (UAVs), to provide a high-resolution display for analysis.

In addition, General Dynamics recently delivered a trio of ground stations for its Mobile User Objective System (MUOS) for the US Navy (Lockheed Martin is the prime contractor). Each ground station has three freestanding 18.4-m Ka-band antennas that rest on 53-ft.-high pedestals. These ground stations, which are located in Hawaii, Virginia, and Australia, act like cell-phone switches; they receive radio calls relayed through MUOS satellites from service members around the globe, connecting them to ground-based DoD communication networks in only seconds.

Advances in the world of military satcom technologies have included the growth of a major communications system from Boeing Co. (www.boeing.com), and increased use of Advanced Extremely High Frequency (AEHF) satellite terminals from Raytheon Co. (www.raytheon.com) by the US Air Force for secure protected communications at the highest levels. Last year, for example, Boeing shipped its sixth Wideband Global SATCOM (WGS) satellite, which is forming the US military's largest satellite-based communications systems.

The Air Force awarded Raytheon a contract to develop the Global Aircrew Strategic Network Terminal (Global ASNT) to send and receives alert messages to bomber, tanker, and reconnaissance air crews during nuclear and nonnuclear missions. It relies on the AEHF satellites for communications. The Global ASNT systems will be designed to withstand anything that comes their way, including a nuclear attack.

In at least one case, satcom technology is even being reinvented for practical aircraft use. Northrop Grumman (www.northropgrumman.com) has converted one of its satcom systems, based on gallium-nitride (GaN) power amplifiers, for use on board the firm's Firebird aircraft. The demonstration system, which was housed within a pylon-mounted structure attached to the Firebird fuselage, sent full-motion video to the ground during the demonstration. de

OMNIYIG INC.

CELEBRATING 41 YEARS IN BUSINESS

Omniyig's advanced products are designed into some of the world's most sophisticated systems, including commercial, EW, and ECM programs such as the ALQ-99, ALQ-117, ALR-172, ALR-56C, ALR-62, ALR-64, ALR-67, ALR-69, APR-39, WLR-8, Rapport III and we are on board the F-15, F-16, F-18, EA6B, EF111, B-1, B2 Stealth, L-130, F-35 and more.

FUNDAMENTAL YIG-TUNED OSCILLATOR

Frequency Range	2.0 to 18.5 GHz
Min. RF Power Output	10 dBm
RF Power Output Variation	± 3
Max. 2nd Harmonic (typ)	> 10 dBc
FM Noise @ 100 KHz Away	> 120 dBc

0-10 Volt Analog or 12 Bit Digital Driver Available!

YIG OSCILLATORS HARMONIC > -45dBc

Model	Freq Rg.	Harmonic	RF Power
YOM3977DD	2-8 GHz	> 45dBc	> 13dBm
YOM3979DD	8-18GHz	> 45dBc	> 13dBm

Operating Temperature -54C to +85C
0-10 Volt Analog or 12 Bit Digital Driver Available!

DUAL BAND REJECT YIG FILTERS

Model	Freq Rg.	40dbBW	Ins Loss
MR3278DD	2-8 GHz	> 45dBc	< 2.0dB
MR3280DD	8-18GHz	> 45dBc	< 2.0dB

Operating Temperature -54C to +85C
0-10 Volt Analog or 12 Bit Digital Driver Available!

- YIG FILTERS
- YIG OSCILLATORS
- YIG MULTIPLIERS
- LIMITERS
- DETECTORS
- COMB GENERATORS
- FRONT END TUNERS
- SUB SYSTEMS

Since 1973, **Omniyig** has continued technology improvement with expansions in Yig technology and new microwave products in thousands of designs developed and built for Customers Worldwide. MIL-E-5400 Class II, MIL-STD-883, in frequencies 0.5 GHz to 40.0 GHz, both Octave & Multi-Octave.

Ask Around - **Omniyig** Delivers.

OMNIYIG INC.
Since 1973

3350 Scott Blvd., Bldg. #66 • Santa Clara, CA 95054
[t] 408.988.0843 • [f] 408.727.1373
Omniyig@ix.netcom.com • http://www.Omniyig.com

Since 1973 | *Celebrating 41 Years!*

OMNIYIG INC.

JACK BROWNE | Technical Contributor

Unmanned Vehicles
Are Gaining Ground

Using a variety of propulsion systems and a wide range of electronic subsystems, these unmanned vehicles are playing increasingly important roles in modern military strategies.

UNMANNED VEHICLES have become increasingly important systems within the armed forces, now serving a growing number of functions that range from artillery to surveillance and radar. The number of these types of systems continues to grow, with more than 80 different unmanned aerial vehicles (UAVs) currently in use or in development by the United States military and more than 400 companies now manufacturing unmanned vehicles worldwide.

Although these unmanned systems may have started on the ground, they are now supporting applications at sea, in the air, and even in space. Even though they are associated with military efforts, unmanned vehicles can also prevent emergencies and save lives—both in commercial and military applications.

On the ground, the Havoc combat vehicle from Lockheed Martin (www.lockheedmartin.com) is an 8×8 design designed to move soldiers and payloads quickly *(Fig. 1)*. The basic unmanned ground vehicle (UGV) has many different configurations that have already been delivered across six countries. It has been used for peace-keeping as well as combat applications, and its modular design allows for a wide range of weapons, sensors, and communications equipment to be installed in the vehicle. The UGV provides 12.3 m^3 of interior space for equipment or to carry as many as 12 people.

Havoc is constructed with a high-torque power pack and independent hydro-pneumatic suspension for full mobility even when carrying a full load. The vehicle is also amphibious for applications at sea. The UGV includes a modular protection system that guards against ballistic threats, including those posed by high blast-force levels.

The Remotec ANDROS F6 UGV from Northrop Grumman (www.northropgrumman.com) is characterized by its large integrated arm and gripping mechanism. It includes a full-color surveillance camera for surveillance and monitoring, plus a 24-in. camera extender to assist with remote viewing. The gripper mechanism allows for continuous rotation, while the integrated arm features seven degrees of freedom for full dexterity. The vehicle incorporates patented articulating tracks to help it climb stairs and move through ditches, rough terrain, and other obstacles. The UGV/robot is available with a number of different data links, including fiber-optic cable deployed from a remote vehicle wireless radio controller.

The firm is also busy putting UAVs into the air, with numerous different models from which to

3. The Triton is a high-speed UAV capable of operating at altitudes to 50,000 ft. [Photo courtesy of Northrop Grumman (www.northropgrumman.com)]

1. Havoc is a UGV with an 8×8 drive system that can conquer a wide range of rough surfaces. [Photo courtesy of Lockheed Martin (www.lockheedmartin.com)]

2. The MQ-HC Fire Scout is an unmanned helicopter capable of capturing real-time video information. [Photo courtesy of Northrop Grumman (www.northropgrumman.com)]

SUPER ULTRA WIDEBAND

AMPLIFIERS

up to +27 dBm output... 0.1 to 21 GHz

from $845 *ea.*

Ultra wide coverage and super flat gain make our ZVA family ideal for ECM, instrumentation, and test systems. With an output power up to 0.5 Watts, they're simply some of the most usable amplifiers you'll find, for a wide range of applications and architectures!

All of our ZVA models are unconditionally stable, ruggedly constructed, and able to withstand open or short circuits at full output. For more details, from data sheets to environmental ratings, pricing, and real-time availability, just go to minicircuits.com!

All models IN STOCK!

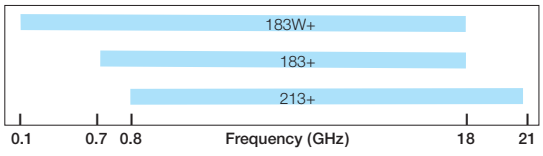
RoHS compliant

Electrical Specifications (-55 to +85°C base plate temperature)

Model	Frequency (GHz)	Gain (dB)	P1dB (dBm)	IP3 (dBm)	NF (dB)	Price $ * (Qty. 1-9)
NEW ZVA-183WX+	0.1-18	28±3	27	35	4.0	1345.00
ZVA-183X+	0.7-18	26±1	24	33	3.0	845.00
ZVA-213X+	0.8-21	25±2	24	33	3.0	945.00

* Heat sink must be provided to limit base plate temperature. To order with heat sink, remove "X" from model number and add $50 to price.

Wideband Performance



Mini-Circuits®

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

choose—including its MQ-8C Fire Scout unmanned helicopter for the US Navy *(Fig. 2)*. In fact, the firm and Navy jointly completed testing the second Fire Scout for the first time during recent trials at the Naval Base Ventura County, in Point Mugu, CA. These tests are to validate the flight capabilities of the UAV prior to ship-based flights set for this summer.

The Fire Scout UAV employs on-board sensors to capture full-motion video, identify targets, and then distribute information to users in real time. The system's first flight took place on Oct. 31 of last year. These subsequent flight tests (more than 40 in total) help reveal more information about the UAV's autonomous control systems and capabilities as a multifunctional UAV.

Northrop Grumman is also busy working with the US Navy on a slightly faster UAV, the Triton *(Fig. 3)*. This vehicle is undergoing a process referred to as envelope expansion, by which it is being tested for capabilities to operate across a range of altitudes, speeds, and weights. These tests are being performed at Northrop Grumman's facility in Palmdale, CA. The tests have included endurance flights as long as 9.4 hours at altitudes to 50,000 ft. The Triton UAV is also put through maneuvers referred to as doublets, intended to evaluate the aircraft's capabilities to recover from small perturbations in its flight path due to turbulence.

Each Triton is equipped with a host of intelligence, surveillance, and reconnaissance sensor payloads and can perform surveillance, radar analysis, and communications over long distances. The US Navy plans to field 68 of the Triton aircraft, pairing them with manned P-8 Poseidon maritime patrol aircraft during surveillance missions.

Another UAV system from Northrop Grumman, the Broad Area Maritime Surveillance Demonstration (BAMS-D) aircraft, is performing maritime surveillance on a regular basis. Based on the Global Hawk, which was designed for over-land surveillance, the BAMS-D UAVs *(Fig. 4)* were modified to work in a maritime environment. They are capable of flying missions exceeding 24 hours in total time at high altitudes. The BAMS-D aircraft are also helping the Navy to better understand the operation of the Triton UAVs under development.

Mantis is a twin-engine UAV developed by BAE Systems (www.baesystems.com) as an advanced technology demonstrator for the United Kingdom Ministry of Defence (MoD). The first flight took place on October 21, 2009. Developed with the aid of a number of UK suppliers,

4. BAMS-D UAVs were modeled on the Global Hawk UAV but designed for maritime use. [Photo courtesy of Northrop Grumman (www.northropgrumman.com)]

in addition to various divisions of BAE Systems, the development program is noteworthy in that it required only 19 months from concept to first flight.

Another UAV program, the A160T Hummingbird program by Boeing (www.boeing.com), was designed for vertical takeoff and landing and for use with the most hostile ground/landing conditions. This rotary winged UAV, which was designed for intelligence, surveillance, and reconnaissance missions, achieved a then-record 18.7 hours of flight in May 2008. The UAV features an optimum-speed-rotor (OSR) system that allows the blade rate per minute to be tailored to flight conditions to significantly improve engine efficiency, in contrast to conventional helicopter rotor systems with fixed rotor revolutions per minute (RPM).

The A160T's RMP can actually be varied to account for differences in weight, altitude, and cruising speed to achieve peak efficiency. The A160T Hummingbird UAV features a rotor diameter of 6 ft. and length of 35 ft. It handles a maximum payload of 2500 lbs. and reaches a maximum cruise ceiling of 20,000 ft. at a maximum cruising speed of 165 knots.

Not all military unmanned vehicles are carrying weapons or performing surveillance. One of the longest-running UAVs, Northrop Grumman's Global Hawk, has been used in a wide range of applications, with more than 100,000 flight hours and with extensive flights over the battlefields in Iraq, Afghanistan, and Libya. But it has also helped bring humanitarian assistance and relief efforts following Typhoon Haiyan in the Philippines late last year.

The long endurance, persistence, and range of the Global Hawk UAV have enabled the high-altitude system to carry radar, electro-optical sensors, and infrared (IR) sensors simultaneously. The unmanned system was used to collect hundreds of wide-area images of the typhoon-ravaged area in the Philippines before returning to Andersen Air Force Base and to help the US Air Force organize its relief efforts for the area. Global

Hawk actually collected more than 1000 images of the storm-ravaged area to help plan for recovery efforts.

For those seeking more information on the available components for unmanned vehicles, an online guide produced by Information Gatekeepers Inc. will prove useful. For more information, visit www.mwrf.com/systems/drones-applications-components-and-market-view.

DESIGNING POWER SYSTEMS FOR UAVs

KERIMA BATTE | CEO/President
Abbott Technologies, Inc., 8203 Vineland Ave., Sun Valley, CA 91352; (818) 504-0644, www.abbott-tech.com

Engineers working on power distribution systems for unmanned vehicles can "future proof" their systems by paying attention to five critical factors.

ACTUATORS AND CONTROLS of the pneumatic and hydraulic variety are fast becoming outdated for unmanned aerial vehicles (UAVs)—now being replaced by electrical motors and electronic computers and sensors. Designers working on power distribution systems for unmanned vehicles must realize this trend and consider five key factors when specifying components for a UAV power system: efficiency and weight; quality; built-in test and control functions; flexibility; and cost. Prioritizing each of these factors is now a critical part of power distribution design.

The efficiency of power converters and bus switches will affect the use of the available fuel load and thermal management in a UAV platform. This is true whether the unmanned vehicle uses MIL-STD-704 400-Hz AC power, a high-voltage DC bus, or a low-voltage DC bus. Ultimately, waste heat energy derived from fuel must be dissipated, which can be quite a problem for a high-altitude UAV where avionics are often located in pressurized compartments and composite construction makes heat transfer extremely challenging.

Reducing system heat load will reduce the weight of the cooling system and extend the range and payload capacity of the UAV, thereby increasing overall efficiency. Therefore, liquid cooling using fuel or polyalphaolefins is sometimes employed in these vehicles.

Furthermore, designing power converters or transformer rectifier units that meet specific system requirements for minimum size and weight will result in more efficient use of fuel and available payload capacity. Advanced thermal design techniques; a lightweight case; potting and connector materials; and the use of more recent semiconductor technologies, such as silicon-carbide

PIT CREWS BACK UP RACE CAR DRIVERS. ADVANCED ASSEMBLY BACKS UP ENGINEERS.

Engineers rely on us for low-volume, ITAR compliant PCB assembly because our culture is all about getting things done. Working with us is like having an assembly expert sitting beside you (except our state-of-the-art equipment won't fit). We will work with you throughout the assembly process and when changes do occur – which they usually do – we adjust quickly to make it happen.

And we can do it all in as little as 1 day… at a price too good to be true.

Contact us for a free, same-day quote.
1-800-689-1587 or visit www.aa-pcbassembly.com

ITAR Inc. 5000 ISO 9001:2008 CERTIFIED COMPANY RoHS compliant UL REGISTERED FIRM

U.S. Based and Assembled

1-800-689-1587 or visit www.aa-pcbassembly.com

(SiC) semiconductors; are typically used to achieve the appropriate balance between weight and efficiency.

As size and weight of power conversion or control equipment decreases, maintaining reliability becomes a growing concern. It becomes essential that an AS9100C-certified manufacturer is chosen for the project to ensure the manufacturing processes are being carefully controlled and monitored to maintain overall reliability. Also, the system designer must work closely with the component manufacturer, ensuring that all aspects of the design are carefully analyzed and components are selected to work reliably in the anticipated application of the system.

Adding test, control, and monitoring functions to an existing system using commercial-off-the-shelf (COTS) power converters can be costly and will occupy greater volume and add to the weight of a system. Therefore, a system designer must determine the needs for specific control and monitoring functions within the power system components as early in the design process as possible.

As UAV missions become more complex, the demand for accurate, real-time system information continues to increase. For example, it will be necessary to test, control, and monitor power converters to include output voltage and current, temperature, and input voltage. The increasing demand for test, control, and monitoring functions will continue to grow in the future, and it will be necessary to prioritize them early in your power system design process.

To save time and money, system engineers may choose to work with a supplier able and prepared to modify its standard product offering in a timely manner to meet specific system requirements without excessive nonrecurring-engineering (NRE) charges. Flexibility is critical to a UAV design over the long term. Designing a flexible power distribution system will not only help to minimize fuel waste, but also enable the system to grow with evolving mission requirements.

The final factor is cost, which is important for both commercial and military applications. Reliable but flexible components should be chosen to avoid incurring large expenses in the future, when it becomes necessary to modify a UAV's power distribution system.

Furthermore, a power distribution system should be designed that maximizes efficiency, so that operating costs can be controlled while reducing fuel waste. A flexible and balanced system designed today with high-quality, military-grade components will save money and reduce problems over the long term. de

Yeah, we do that.

Trying to send and receive a small signal among big interferers on your repeater platform?

We should talk.

513.870.4087

mpg POLE ZERO
A DOVER COMPANY

www.polezero.com

> “These stable, distortion-free signals represent a huge leap forward for the synthesis capabilities of DDS signal generation technology, with major benefits for users in both the frequency and time domains.”

(continued from p. s1)

generators can be outfitted with as much as 64 MSamples of waveform memory for generation of complex signals and sequences of different signals.

As pulse generators, the 33600A series waveform generators are impressive, with their capabilities to set leading and trailing pulse edges independently and to produce signals with pulse widths as narrow as 5 ns. Pulse edges can be set with resolution as fine as 2.9 ns. But these are also stable and quiet sources, with only 1-ps jitter and nonharmonic spurious levels at or below –75 dBc. Total harmonic distortion (THD) is a mere 0.03%.

The combination of Trueform technology and built-in arbitrary waveform editing enables complex waveforms to be produced accurately, as well as for pulses to be set precisely. For example, the low jitter makes it possible to set trigger points more accurately than with other arbitrary signal sources, including DDS-based sources. (Low jitter in the time domain translates to low phase noise in the frequency domain.) These waveform generators can make output voltage changes as miniscule as 1 µV, which is critical when characterizing low-voltage circuits and devices. The waveform generators also include variable-bandwidth noise generators, which is essential for those waveforms where noise is a critical part of recreating an accurate waveform.

The 33600A series waveform generators incorporate waveform sequencing for creating multiple configured waveforms and building long, complex waveforms using minimal instrument memory. They are capable of pseudorandom binary sequence (PRBS) pattern generation for testing digital serial buses by streaming standard PRBS patterns (PN3 to PN32) without a separate pulse generator.

The rear panels are almost as packed as the front of these instruments *(Fig. 2)*, since they include a connection for an auto-sensing power supply and Universal-Serial-Bus (USB) and local-area-network (LAN) ports. They also are LXI and SCPI compatible and can be equipped with a GPIB port as an option. These waveform generators are backed by capable software tools, including the firm’s BenchVue and Waveform Builder Pro software packages for a personal computer (PC). Bench Vue 1.0 software, for example, allows access and control of a test bench from a mobile device, while Waveform Builder Pro software enables creation of custom waveforms. The BenchVue software, which can be downloaded free of charge (www.agilent.com/find/benchvue), makes it possible to capture waveforms on oscilloscopes and recreate them with these waveform generators.

While the single-channel 33600A series waveform generators offer a great deal of test capabilities, the dual-channel models offer the flexibility to produce differential signal pairs for testing or even complex in-phase/quadrature (I/Q) modulated signals for testing components and systems. Currently available models include the single-channel, 80-MHz model 33611A; the dual-channel, 80-MHz model 33612A; the single-channel, 120-MHz model 33621A; and the dual-channel, 120-MHz model 33622A. P&A: $3995 (single-channel, 80-MHz model 33611A) and up; stock. de

2. The rear panels of the 33600A series Trueform waveform generators provide many of the control and data interfaces that will be needed for acquiring and creating a library of waveforms.

AGILENT TECHNOLOGIES Inc., 5301 Stevens Creek Blvd., Santa Clara, CA 95051; (877) 424-4536, (408) 345-8886, FAX: (408) 345-8475, e-mail: us@agilent.com, *www.agilent.com*

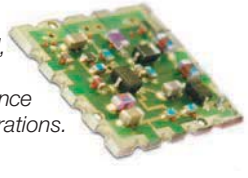
WORLD'S WIDEST SELECTION

VCOs

12 to 6840 MHz from $11.95 ea. (qty. 5)

Want a miniature surface mount, shielded plug-in, or rugged coaxial voltage controlled oscillator with the right stuff for your project? Go to minicircuits.com! You'll find over 800 standard catalog models, ***always in stock***. They're optimized to meet specific requirements, from narrow, broad, or octave bandwidths to linear tuning, low phase noise, dual output, 5V PLL/synthesizer implementation, or size, as small as 0.25 x 0.25 x 0.1". Selection is a snap, even with so many models to choose from! Just enter your requirements, and our patented search engine, Yoni2, searches *actual test data* to find the models that meet your needs. And if you need a custom design, challenge us with a phone call or email! We constantly design new models to meet new needs—so you'll get a quick response, fast turnaround times, and all at a surprisingly low price. Give your competition *real competition*...specify a Mini-Circuits VCO!

All SMT components are glued, as well as soldered, in place for long-term, reliable performance even after multiple reflow operations.



RoHS compliant

Mini-Circuits®

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

359 rev W

JACK BROWNE | Technical Contributor

Radios Shrink In Size, Not In Power

Radios for tactical and non-tactical military applications are getting smaller with a growing number of functions in support of portable voice, data, and video communications.

MILITARY RADIOS were once associated with large backpacks full of heavy electronic equipment, all of which yielded limited operating functionality and reliability. But as wireless communications has advanced in the form of lightweight cellular telephones for civilians, it has also evolved into compact, highly reliable and secure portable radios for the battlefield—whether said battlefield happens to be on land, at sea, or in the air.

Tactical radios have incorporated anti-jamming functions, frequency hopping, software-defined-radio (SDR) technologies, and various battery/power technologies to enhance usability and reliability. What follows is a sampling of some of the newer portable and man-pack radios for tactical use and other critical applications, such as search-and-rescue (SAR) operations, along with some of the technologies supporting these radios.

A firm long synonymous with tactical portable radios (as well as the cellular telephone), Motorola, has helped push the evolution of battlefield radios as much as any company. At present, Motorola Solutions USA (www.motorolasolutions.com) is encouraging its radio designers to make use of commercial-off-the-shelf (COTS) components in their radio products to achieve performance and reliability levels needed for the battlefield at reduced costs.

As an example, the SRX 2200 combat radio is built for the battlefield with COTS components but is also backwards- and forwards-compatible with all of the firm's mission-critical radio systems. It also meets the latest Project 25 (P25) standards (www.p25.com) for interoperability. P25 is a suite of standards for digital radio communications in North America that allows different government agencies to communicate. It is somewhat similar, although not interoperable, with the European Terrestrial Trunked Radio (TETRA) protocol used in Europe.

Using COTS components and technology, the SRX 2200 *(Fig. 1)* is designed for use in the harshest environments. It includes a receiver with 80-dB dynamic range, is compliant with US Department of Defense (DoD) standards for APCO waveforms and encryption, and meets Federal Information Processing Standard (FIPS) 140-2 Level 3 security for use in the most sensitive environments. The radio offers a full suite of communications-ready features and applications, such as secure encrypted voice and text messaging and over the air programming (OTAP), a tactical over-the-air-rekey (OTAR) function, and individual location information (ILI). It meets MIL-810 specifications and exceeds the IP67 submersion specification (allowing it to be submerged under 2 m of water for 2 hours).

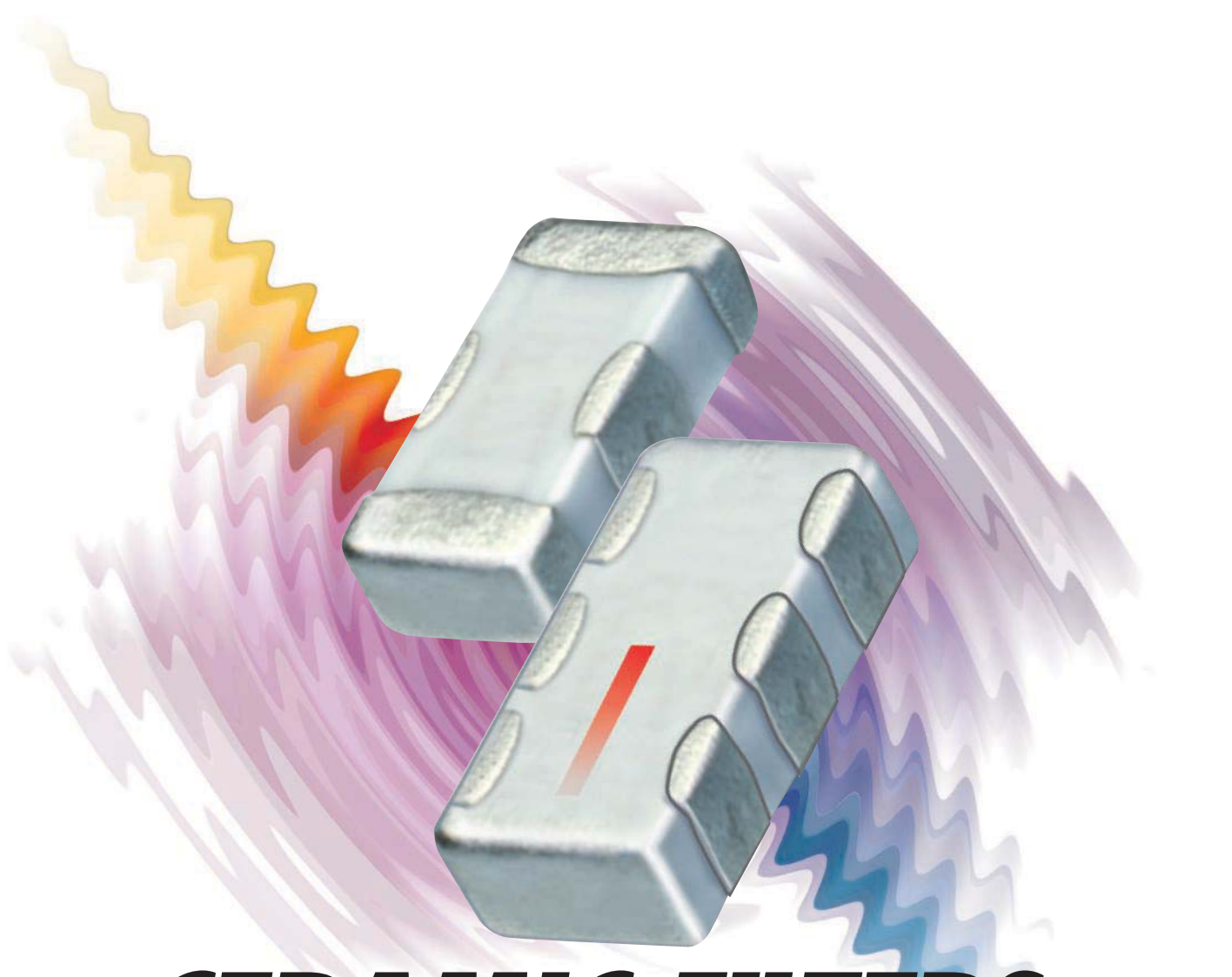
1. The model SRX 2200 combat radio is built for the battlefield with COTS components. [Photo courtesy of Motorola Solutions (www.motorolasolutions.com)]

Another name strongly connected with tactical radios is Harris Corp. (www.harris.com). The firm recently received orders from the US Air Force for Falcon III AN/PRC-117G multiband man-pack and AN/PRC-152A multiband handheld tactical radio systems *(Fig. 2)*. These wideband radios will help provide wideband networking capabilities to a wide range of US Air Force users.

Both radios are equipped with the Harris Adaptive Networking Wideband Waveform, which is designed for interoperability among a wide range of radio systems and software applications. The radios are also certified to operate with the Joint Tactical Radio System (JTRS) waveform and can also work with SINCGARS, HAVEQUICK, and P25 waveforms for secure tactical use.

The AN/PRC-152A is truly a multiband radio, with traditional amplitude-modulation (AM) and frequency-modulation (FM) coverage from 30 to 512 MHz (12.5 to 25.0 kHz for narrow band) and 1.2 MHz for wideband operation with networking waveforms from 225 to 450 MHz. It uses 5-W transmit power for line-of-sight (LOS) use and 10-W transmit power when working in satellite-communications (satcom) mode. The radio can also test signals from 762 to 870 MHz with 10-Hz tuning resolution across all of the frequency ranges.

George Helm, president



CERAMIC FILTERS

LOW PASS BANDPASS HIGH PASS

45 MHz to 15 GHz *from* **99¢** *ea. qty.3000*

Over ~~167~~ 185 models…only 0.12 x 0.06" These tiny hermetically sealed filters utilize our advanced Low Temperature Co-fired Ceramic **(LTCC)** technology to offer superior thermal stability, high reliability, and very low cost, making them a must for your system requirements. Visit our website to choose and view comprehensive performance curves, data sheets, pcb layouts, and everything you need to make your choice. You can even order direct from our web store and have units in your hands as early as tomorrow!

Wild Card KWC-LHP LTCC Filter Kits *only* $98

Choose any 8 LFCN or HFCN models
Receive 5 of ea. model, for a total of 40 filters
Order your KWC-LHP FILTER KIT TODAY!

RoHS compliant U.S. Patents 7,760,485 and 6,943,646

Now available in small-quantity reels at *no extra charge:*
Standard counts of 20, 50, 100, 200, 500, 1000 or 2000. Save time, money, and inventory space!

Mini-Circuits®

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

of Harris' US Department of Defense business unit, elaborates: "Harris' Falcon III radios provide secure voice communications and enable operators to send and receive images, video, e-mails, text messages, and even participate in teleconferences." He adds: "The Air Force is deploying our JTRS-certified radios to provide two-channel communication capabilities. JTRS-certified wideband networking allows users to connect seamlessly to the Global Information Grid, a secure, classified version of the Internet." The company has shipped more than 40,000 AN/PRC-117G and AN/PRC-152A radios to all branches of the US military and to more than 15 allied nations.

Boeing (www.boeing.com) has worked closely with the US Air Force to support its combat survivor evader location (CSEL) program, with a new multifunction handheld radio designated the AN/PRQ-7. It transmits on at least 121.5, 243.0, and 406.025 MHz (the COSPAS-SARSAT satellite tracking SAR system). The radio system also receives Global-Positioning-System (GPS) signals. The radio is designed to securely communicate position and text messages via a data link through the CSEL UHF SATCOM network.

The AN/PRQ-7 portable radio is software programmable and upgradable and can receive over-the-horizon (OTH) waypoints and text messages. It includes NSA-certified encryption and decryption of LOS and OTH messages. The radio, which works with a wideband flat blade antenna, is rated to withstand 10-m liquid submersion and operating temperatures from –20 to +55°C. It is tested to MIL-STD-810 requirements and weighs only 32 oz. with its rechargeable battery. It includes four UHF/VHF guard channels for voice transmissions.

The US Army recently designated the two-channel AN/PRC-155 manpack tactical radios for inclusion in its Capability Set (CS) 14, a package of radios, satcom systems, software, and

2. The AN/PRC-152A is truly a multiband radio, with total frequency range extending from sections of 30 to 870 MHz. [Photo courtesy of Harris Corp. (www.harris.com)]

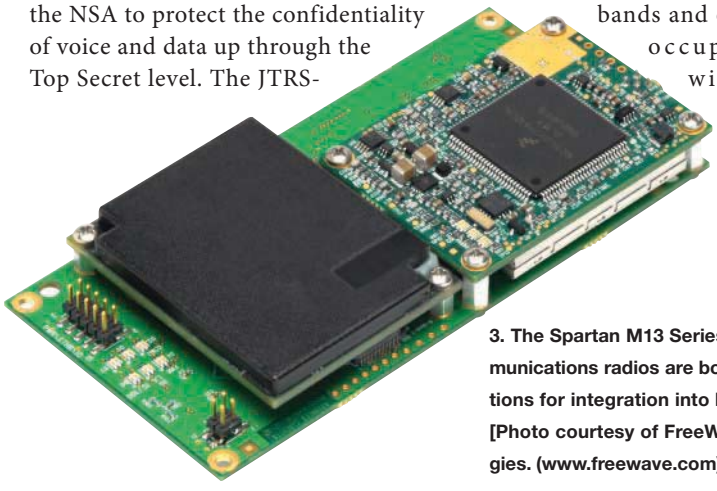
portable electronic devices for network communications.

The two-channel AN/PRC-155 radios from General Dynamics C4 Systems (www.gdc4s.com) and Rockwell Collins (www.rockwellcollins.com) will provide wireless connections to the Soldier's Network, which includes a Warfighter Information Network-Tactical (WIN-T) link and other capabilities. The radio is part of the US Army's modernization plan and will provide secure network communications in ground-based and airborne vehicles.

The Army is also in the process of making a transition from its former SINCGARS radio technology to JTRS radios, such as the widely fielded PRC-148 multiband inter/intra team radio (MBITR) tactical radio from Thales Communications (www.thalescomminc.com). Operating from 30 to 512 MHz, this compact radio system hosts all modern tactical core waveforms and is certified by the NSA to protect the confidentiality of voice and data up through the Top Secret level. The JTRS-approved radio features programmable INFOSEC interoperability with a wide range of legacy radio systems. It is upgradable by means of software and is also available in a vehicle-mounted version.

Some radios for tactical and government are designed for use outside of the normal frequency bands and are targeted for integration within larger systems, such as the Spartan M13 Series of data-communications board-level radios from FreeWave Technologies (www.freewave.com). They are as small as 106.7 × 50.8 ×14.1 mm for a serial board-level radio and designed for use at operating temperatures from –40 to +75°C. These compact radios *(Fig. 3)* work from 1.350 to 1.390 GHz with user-selectable data rates of 115 or 153 kb/s. They offer transmit power levels from 20 mW to 1 W and can achieve LOS communications at distances to 60 miles.

The board-level radios offer seven user-selectable frequency-hopping bands and operate with occupied bandwidth of 230



3. The Spartan M13 Series of data-communications radios are board-level solutions for integration into larger systems [Photo courtesy of FreeWave Technologies. (www.freewave.com)]

kHz. With their small size, they are ideally suited for applications in unmanned aerial vehicles (UAVs) and unmanned ground vehicles (UGVs) where saving size and power are concerns. They include 32-b cyclic-redundancy-check (CRC) error detection for reliable data transmissions and FIPS 140-2 Level 2 encryption.

At lower frequencies, the Centaur Light Weight VHF Portable (LWVP) Radio from Excelis Inc. (www.excelisinc.com) is a lightweight tactical radio that operates within the 30- to 88-MHz band and is backwards compatible with existing analog radios. It measures a mere 44 × 94 × 194 mm and weighs just 0.9 kg, but can handle voice and data communications at rates to 16 kb/s. It achieves transmit power levels to 5 W, is resistant to jamming and interference, and includes an embedded GPS receiver and IP router. It is designed for operating temperatures from −40 to +71°C.

Some secure radio solutions are meant for applications outside of the battlefield, such as the VHF (112 to 156 MHz) and UHF (225 to 400 MHz) R&S Series 4200 SDRs from the Radiocommunications Systems Division of Rohde & Schwarz (www.rohde-schwarz.com), which target military and civilian air-traffic-control (ATC) systems. Both radio lines provide as much as 50-W output power.

The radios operate with 8.33- or 25.0-kHz channel spacing at VHF and 8.33-, 12.50-, and 25.00-kHz channel spacing at UHF. They include receivers with the capability of detecting simultaneous transmissions to alert an air traffic controller. These radios allow as many as seven Voice-over-Internet-Protocol (VoIP) sessions to be established within the receiver or transmitter, and the radio can be connected to as many as two VoIP voice recorders simultaneously.

These radio systems provide the security required for battlefield operations, but not always associated with applications such as air control. With growing concerns about civilian air-traffic control integrity, they provide numerous "fail-safe" features that prevent signal jamming and interception.

While these are radios that are extremely helpful to military users, they are also reminders that military radios find uses in many applications above and beyond the battlefield and that current trends for improving reliability, economy, and interoperability for different types of military radios will serve many difference branches of the military in many different applications. de

For more information please visit:
HTTP://IMS2014.MTT.ORG

IEEE MTT-S

IMS2014 POWERING THE WAVES

CONFERENCE DATES: ***1- 6 JUNE 2014!***

KEYNOTE

How Data, Devices and Personalization are Fueling Demand for Innovation

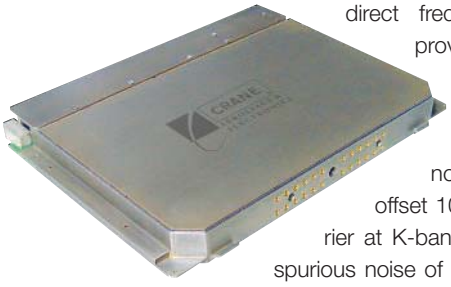
Vida Ilderem - *Vice President, Intel Labs;*
Director, Integrated Computing Research, INTEL CORPORATION

Vida Ilderem is Vice President of Intel Labs and Director of the Integrated Computing Research [ICR] for Intel Corporation. ICR explores the next revolution in computing with focus on new emerging platforms. The research vectors include breakthrough technology innovations for seamless connection, highly integrated small form factors, and enablement of Internet of Things. Prior to joining Intel in 2009, Vida served as vice president of Systems and Technology Research at Motorola's Applied Research and Technology Center. Vida holds a PhD in Electrical Engineering from Massachusetts Institute of Technology, and has 27 issued patents.

See **New Products** from over **500 Exhibitors**
Learn in the world-class technical **conference & workshops**
Network at the many **social events!**

VPX Line Includes Synthesizers And Frequency Converters

A VPX PRODUCT line includes three products: a direct frequency synthesizer, a seven-channel indirect frequency synthesizer, and a quad intermediate-frequency (IF) frequency up/downconverter. All are supplied in a modular VPX configuration for flexibility. The modular VPX direct frequency synthesizer provides output signals at X- and K-band frequencies, with residual phase noise of –144 dBc/Hz offset 10 kHz from the carrier at K-band carriers and with spurious noise of less than –72 dBc. The synthesizer is supplied in a Vita 48.2, Type-1 package and is designed for an operating temperature range of –0 to +85°C. Output signals are available at SMPB blind-mate connectors. The seven-channel VPX frequency synthesizer serves output signals at S- and C-band frequencies with better than 75-dB isolation between channels and less than –65 dBc spurious noise. Also housed in a Vita 48.2, Type-1 package, the VPX frequency upconverter/downconverter operates at S- and C-band higher frequencies and L-band lower frequencies. It boasts four selectable RF pass bands and better than 60-dB isolation between channels.

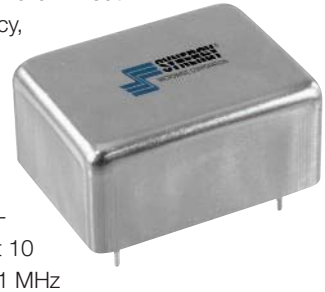


CRANE AEROSPACE & ELECTRONICS, MICROWAVE SOLUTIONS

Signal Technology, 340 North Roosevelt Ave., Chandler, AZ 85226; (480) 961-6293, e-mail: mw@crane-eg.com, www.craneae.com/mw

Crystal Oscillator Remains Stable At 128 MHz

MODEL HPXO128 is a high-performance crystal oscillator with outstanding stability at 128 MHz. It provides at least +10 dBm and typically +15 dBm output power at that frequency, along with low phase noise. The single-sideband (SSB) phase noise is typically –138 dBc/Hz offset 100 Hz from the carrier, with phase noise of typically –160 dBc/Hz offset 1 kHz, –172 dBc/Hz offset 10 kHz, and –180 dBc/Hz offset 1 MHz from the carrier. Jitter is 10 fs maximum and typically only 6 fs. Harmonic levels are no worse than –25 dBc and typically –35 dBc. The stable oscillator draws 300 mA maximum current from a +12-VDC source during warmup (300 s minimum warmup time) and 120 mA current during steady-state operation. It is designed for an operating temperature range of –20 to +60°C.



SYNERGY MICROWAVE CORP.

201 McLean Blvd., Paterson, NJ 07504; (973) 881-8800, FAX: (973) 881-8361, e-mail: sales@synergymwave.com, www.synergymwave.com

GaAs MMIC Amplifier Handles 10 To 17 GHz

MODEL CMD167 is a gallium-arsenside (GaAs) monolithic-microwave-integrated-circuit (MMIC) amplifier with usable frequency range of 10 to 17 GHz. It achieves better than 15-dB gain at 14 GHz, with +11-dBm output 1-dB compression point and 1.8-dB noise figure. The MMIC device, which is supplied as a bare die, is matched to 50 Ω for ease of installation in communications and electronic-warfare (EW) circuits and systems. It operates from a single positive supply voltage of +3 VDC with 55 mA typical current consumption. The model CMD167P3 is a packaged version of the amplifier, supplied in a 3×3-mm plastic surface-mount-technology (SMT) package.

CUSTOM MMIC

1 Park Dr., Unit 12, Westford, MA 01886; (978) 467-4290, www.CustomMMIC.com

Emerson Network Power Connectivity Solutions delivers innovation in interconnect technology for maximum signal integrity. Your system's performance can be enhanced and assured by Emerson Connectivity Solutions through:

- Harsh environment optical connectors
- Twinax and microwave cable assemblies
- High performance RF & microwave connectors and components

Emerson Connectivity Solutions brings together technology and engineering to create innovative customer solutions.

Get Connected...

EmersonConnectivity.com

Toll free: 800-247-8256
Phone: 507-833-8822

Connectivity Solutions

EMERSON™
Network Power

EMERSON. CONSIDER IT SOLVED.™

Analyzer Aids Satcom Monitoring

THE MS2830A spectrum analyzer/signal analyzer is now compatible with the Monics satellite carrier monitoring system from SAT Corp. (www.sat.com), a subsidiary of Kratos Defense & Security Solutions (www.kratosdefense.com). The test instrument has been equipped with a new driver that allows the analyzer to be integrated into the Monics enterprise networked carrier monitoring system used by government agencies, satellite operators, satellite-communications (satcom) service providers, and telecommunications companies. The signal analyzer is available as a variety of models with different frequency ranges, including from 9 kHz to 3.6, 6.0, 13.5, 26.5, and 43.0 GHz. Analysis bandwidths can be as wide (optionally) as 125 MHz. The analyzer can be used for a variety of measurements, including bandwidth, center frequency, carrier-to-noise (C/N) ratio, and equivalent isotropic radiated power (EIRP) level. The instrument can also be used to detect interference based on known carrier plans and saved reference traces.

ANRITSU CO.

490 Jarvis Dr., Morgan Hill, CA 95037-2809; (408) 778-2000, FAX: (408) 776-1744, www.anritsu.com

Amplifiers Drive Signals To 50 GHz

SOLID-STATE AMPLIFIER models GT-1000B (with option 06), GT-1050B, and GT-1051B provide broadband frequency coverages of 100 MHz to 20 GHz, 100 MHz to 50 GHz, and 2 to 50 GHz, respectively. The amplifiers are based on monolithic-microwave-integrated-circuit (MMIC) technology. The GT-1000B offers 5 W output power from 100 MHz to 18 GHz, while the GT-1050B and GT-1051B provide 0.5-W output power through 40 GHz and 0.25-W output power through 50 GHz. The amplifiers provide typical ±3.5-dB gain flatness.

GIGA-TRONICS, INC.

4650 Norris Canyon Rd., San Ramon, CA 94583; (925) 328-4650, FAX: (925) 328-4700, e-mail: info@gigatronics.com, www.gigatronics.com

Phase Shifter Tunes 6 To 18 GHz

FOR SYSTEMS operating from 6 to 18 GHz and requiring tight control of phase, model PS-360-DC-3 with option 618-15D is a phase shifter with 360-deg. adjustment range over that frequency range. The 8-b digitally controlled phase shifter offers phase accuracy of ±5.2 deg. with typical phase-shift adjustment speed of 22 ns. The typical insertion loss is 10 dB with maximum VSWR of 2.0:1 over the full frequency range. The sideband suppression is 22 dB while the carrier suppression is typically 26 dB. The component exhibits phase-modulation/amplitude-modulation (PM/AM) characteristics as low as ±0.8 dB with harmonics of –25 dBc or better. The phase shifter, which is powered by supplies of +5 VDC and –12 to –15 VDC, is supplied with removable female SMA connectors in a housing measuring 1.6 × 1.75 × 0.5 in.

PLANAR MONOLITHICS INDUSTRIES, INC.

4921 Robert J. Matthews Pkwy., Ste. 1, El Dorado Hills, CA 95762; (916) 542-1401, FAX: (301) 662-1731, e-mail: sales@pmi-rf.com, www.pmi-rf.com

ADVERTISERS INDEX

photo courtesy of the
U.S. Military & NASA

ULTRA-REL®

10 MHz to 6 GHz

CERAMIC MMIC AMPLIFIERS

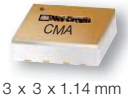
Low NF 0.5 dB High IP3 up to 38 dBm Low DC current 65 mA $4.95 ea. (qty 20)

When failure is not an option. Our new CMA MMIC amplifiers deliver outstanding performance in a rugged, nitrogen-filled, hermetic LTCC design, just 0.045" high. These models are so tough, they've qualified for use under MIL environmental conditions:

Robust performance across wide bandwidths makes them ideal for instrumentation, or anywhere long-term reliability adds bottom-line value. Go to minicircuits.com for all the details today, and get them in your hands as soon as tomorrow!

MIL Qualifications *(see website for complete list and details)*

Gross and Fine Leak	*HTOL (1700 hours+ @ +105°C)*
Mechanical Shock	*Thermal Shock*
Vibration	*Steam Aging*
Acceleration	*Solder Heat Resistance*
PIND	*Autoclave (and more)*



3 x 3 x 1.14 mm

Electrical Specifications *(-55 to +105°C)*

	Model	Freq. (GHz)	Gain (dB)	P_{OUT} (dBm)	IP3 (dBm)	NF (dB)	DC (V)	Price $ ea. (qty 20)
	CMA-62+	0.01-6	15	19	33	5	5	4.95
	CMA-63+	0.01-6	20	18	32	4	5	4.95
	CMA-545+	0.05-6	15	20	37	1	3	4.95
NEW	CMA-5043+	0.05-4	18	20	33	0.8	5	4.95
NEW	CMA-54SG1+	0.4-2.2	32	23	36	0.9	5	5.45
NEW	CMA-162LN+	0.7-1.6	23	19	30	0.5	4	4.95
NEW	CMA-252LN+	1.5-2.5	17	18	30	1	4	4.95

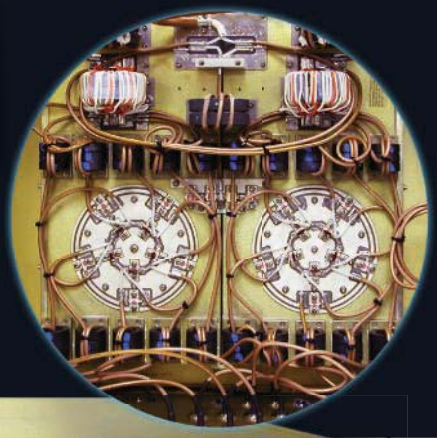
RoHS compliant

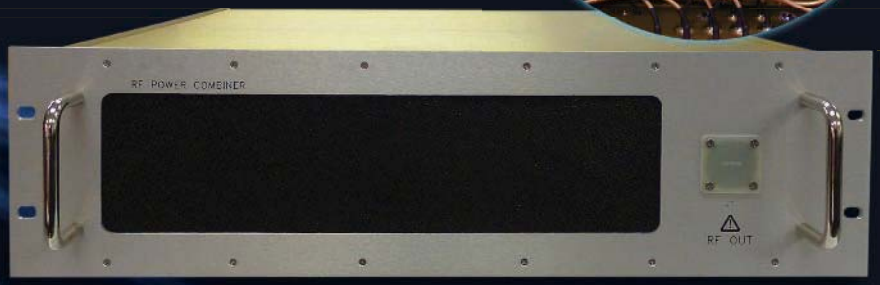
Mini-Circuits®

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

Announcing TRM Microwave's*

STELLAR HIGH POWER DIVISION





4 Way Integrated Rack Mount Power Combiner/Sensor, 1.6 - 30 MHz, 5000 W

We've taken your requests for an expanded product line seriously. Now, in addition to our five-star line of low power, directional couplers, power dividers and hybrids, TRM will fulfill your high power needs. From ready-to-build catalog parts and custom components to integrated assemblies, TRM can help you solve the most challenging requirements for your defense, aerospace and commercial applications.

- 200 plus years of combined engineering talent
- Fully integrated system assemblies
- 10 KHz to 8 GHz
- Power levels to 10 KW
- Directional Couplers to 100 KW
- Harmonic Filters to 16 KW peak
- Optimized custom solutions for specific applications
- ISO 9001: 2008 Certified

* Formerly Putnam RF Components.

Call 603.627.6000 or Email infohp@trmmicrowave.com for more information.

TRM MICROWAVE
COMPLETING YOUR IDEAS®

603.627.6000
280 South River Road
Bedford, NH 03110
infohp@trmmicrowave.com
trmmicrowave.com

Agilent & Our Distributor Network

Right Instrument. Right Expertise.
Delivered Right Now.

Agilent Basic Instruments

May–July 2014

Newark
element14
TESTEQUITY
microlease
The experts in Test Equipment management

Agilent Technologies
Authorized Distributor

Check it out.

NEW higher frequency waveform generator from Agilent.

Our Featured Distribution Partners make it easy to buy.

PAGE 3

BUY FROM DISTRIBUTORS

Upgrade to your Ultimate Scope

Get Up to 16 scope applications for the price of 1!

See promos on page 8 or scan QR Code for complete promo listing.

Anticipate ___Accelerate ___Achieve

Agilent Technologies

Eliminate the uncertainty and generate the signals you expect to see

When your tests demand a precise and predictably shaped signal, can you be sure your signal generator is outputting the signal you expect?

The drawbacks of DDS

Direct digital synthesis (DDS) is a simple and inexpensive method that produces approximations that are acceptably close to the ideal for many applications, which is why lower-cost waveform generators typically use this technology.

However, these signals are indeed approximations, which can create problems with harmonic distortion, jitter, aliasing, and even skipped points in the waveform.

Because DDS generators have a fixed sample clock, if they output one unique point for each sample clock, they would be able to output only one frequency. When a lower frequency is needed, the generator needs to use many clock cycles to output a single point and will repeat points. When a higher frequency is needed and the generator can't output all of the points in waveform memory, it will skip over some points. The higher the frequency, the more points are skipped—and the less the output resembles the signal you expect to see.

Moreover, DDS generators use internal algorithms to determine which points are skipped. These algorithms put a priority the phase of a signal, which results in signals that don't necessarily skip the same samples in every cycle.

True signals with True*form* technology

True*form* waveform generators use proprietary technology that allows waveforms to be expressed with the same shape, regardless of frequency. Designers working with complex waveforms can use True*form* generators to generate signals with complex modulation and abnormalities. Digital waveforms with transients and pulses can be reproduced with the same characteristics every time.

Figure 1 shows an example of the dramatic differences between DDS and True*form* waveforms. Note the three small peaks in the True*form* signal and compare the DDS output; these signal characteristics are distorted or missing entirely.

Dramatic reduction in jitter

Another key benefit of the True*form* architecture is extremely low jitter. Cycle-to-cycle jitter for the new Agilent 33600A Series, for example, is specified at less than 1 ps for all waveforms, including arbitrary, sine, and square waves. That's about 200 times less jitter than DDS-based generators (**Figure 2**).

Missing the point

Figure 3 illustrates the problem of missing points in DDS outputs. At 1 kHz, both generators were able to create an accurate waveform with all seven aberrations, but when the frequency was dialed up to 2 MHz, three of the seven signal features disappeared from the DDS output. At even higher frequencies, the aberrations can be become intermittent or distorted—or all of them can disappear completely.

To learn how to overcome your function generator challenges with True*form* technology, view videos and download free measurement briefs, visit **www.agilent.com/find/trueformTC**

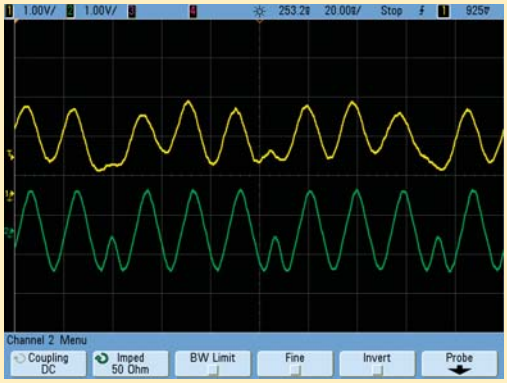


Figure 1:
Signals at the same frequency created by a DDS generator (upper trace) and a Trueform generator (lower trace)

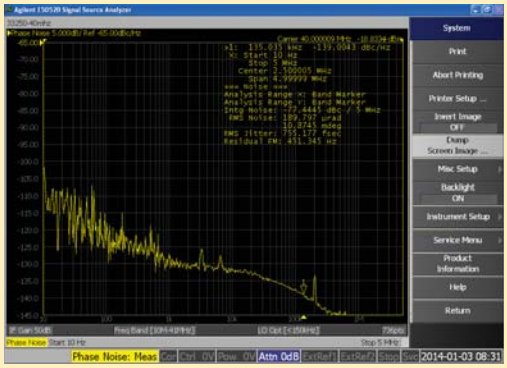


Figure 2:
This 40 MHz sine wave from the 33600A shows less than 800 femtoseconds of jitter.

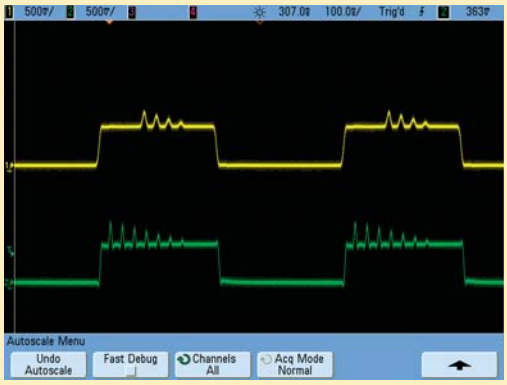
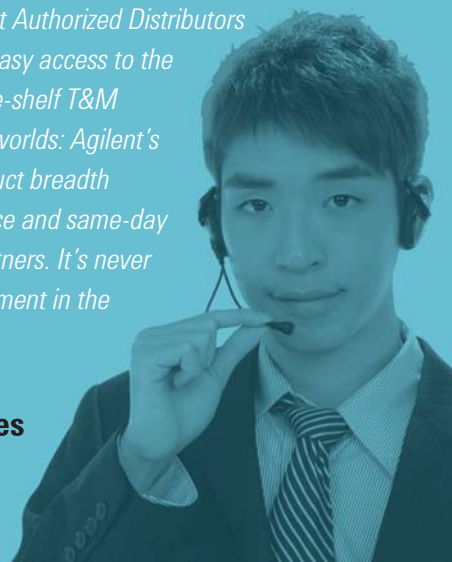


Figure 3:
A DDS generator (upper trace) was unable to output all seven aberrations in this 2 MHz arbitrary waveform.



High performance, multifunction counters cover the RF and microwave spectrum from 50 MHz to 46 GHz

53200 Series RF and universal frequency counters

- Frequency, frequency ratio, time interval, rise/fall time, phase, and much more
- Histograms, trending, data logging, and built-in math and statistical functions
- 53230A offers: 20 ps single-shot, burst microwave, and continuous gap-free measurements with time stamped edges
- Optional 6 or 15 GHz RF channel
- USB, GPIB and LAN (LXI) connectivity

Model	Key specifications	Price from (US)
53210A	350 MHz RF frequency counter, 10 digits/s	$2,165
53220A	350 MHz universal frequency counter/timer, 12 digits/s, 100 ps	$2,507
53230A	350 MHz universal frequency counter/timer, 12 digits/s, 20 ps	$3,918

Speed, accuracy, and measurement versatility

E4980AL precision LCR meter

- 20 Hz to 300 kHz / 500 kHz / 1 MHz
- Exceptionally low noise at both low and high impedance to improve test quality; 0.05% basic impedance accuracy
- High speed at an affordable price: 12 ms (SHORT), 118 ms (MED), 343 ms (LONG) @ 1 MHz
- 16 impedance parameters
- 100 µV to 2 Vrms, 1 µA to 20 mA variable test signal
- 201-point programmable list sweep

Price from (US): $4,266

General purpose function generators with arbitrary waveform capabilities and high signal fidelity

33200 Series waveform generators

- Sine, square, ramp, triangle, noise, pulse generation with variable edge, DC waveform, AM, FM, and more
- Linear and logarithmic sweeps and burst operation modes
- USB, GPIB and LAN (LXI) interfaces included
- BenchVue software compatibile

Model	Key specifications	Price from (US)
33210A	10 MHz, 1-Ch, 14-bit, 50 MSa/s, 8 K point, 5 MHz pulse (optional arb)	$1,321
33220A	20 MHz, 1-Ch, 14-bit, 50 MSa/s, 64 K point, 5 MHz pulse	$2,487
33250A	80 MHz, 1-Ch, 12-bit, 200 MSa/s, 64 K point, 50 MHz pulse	$4,953

MEASUREMENT HINT

Need to visualize multiple instrument measurements simultaneously? Capture data, screen shots, or system states? Return your entire bench to an earlier state to replicate tests? Remotely monitor and control your bench with a mobile device? You can do it all with Agilent BenchVue. Data capture simplified: Click. Capture. Done.

WAVEFORM GENERATORS
FREQUENCY COUNTERS

Validate your most challenging designs with realistic test signals using exclusive Trueform technology

33500B Series waveform generators

- True*form* waveform technology generates signals with the low jitter (<40 ps) and harmonic distortion (<0.04% THD)
- Arbitrary waveforms: 1 M points (16 M optional), sequencing, and embedded editor
- Sine, square, ramp, triangle, noise, DC, AM, FM, PWM, Sum, PRBS, and more
- 16 bits of resolution, 1 mVpp to 10 Vpp
- USB, GPIB and LAN (LXI) connectivity
- BenchVue software compatibile

Model	Key specifications	Price from (US)
33509B (Arb optional), 33511B	20 MHz, 1-Ch, 20 MHz pulse	$1,707
33510B (Arb optional), 33512B	20 MHz, 2-Ch, 20 MHz pulse	$2,607
33519B (Arb optional), 33521B	30 MHz, 1-Ch, 30 MHz pulse	$1,914
33520B (Arb optional), 33522B	30 MHz, 2-Ch, 30 MHz pulse	$2,922
33502A	Isolated amplifier, dual channel, 50 V peak-to-peak	$2,812

Higher frequency with Trueform technology delivers unparalleled signal integrity.

33600A Series waveform generators

NEW

- Exclusive True*form* technology generates high-fidelity, gap-free signals with very low jitter and low harmonic distortion
- Arbitrary waveforms: 4 M points (64 M optional), sequencing, and embedded editor
- Sine, square, ramp, triangle, noise, DC, AM, FM, PWM, Sum, PRBS, and more
- 14 bits of resolution, 1 mVpp to 10 mVpp
- USB, LAN (LXI), and optional GPIB connectivity
- BenchVue software compatibile

Model	Key specifications	Price from (US)
33611A	80 MHz, 1-Ch 660 MSa/s arb, 60 MHz pulse	$3,995
33612A	80 MHz, 2-Ch 660 MSa/s arb, 60 MHz pulse	$5,695
33621A	120 MHz, 1-Ch 1 GSa/s arb, 100 MHz pulse	$4,695
33622A	120 MHz, 2-Ch 1 GSa/s arb, 100 MHz pulse	$6,695

Quickly and accurately evaluate your DUTs with precision/low-noise sourcing and easy-to-use GUI

B2900A Series source measure units (SMUs)

- Superior graphical I-V Curve
- High sourcing and measurement resolution (6½ digit)
- Wide output range (210 V / 3 A DC / 10.5 A pulse)

Price from (US): $6,133

B2960A Series low-noise power sources

- Ultra-low noise performance with the external low noise filter (10 µVrms)
- High sourcing resolution (6½ digit, 100 nV/10 fA)
- Innovative sourcing capability such as ARB and DC emulation

Price from (US): $6,133

You need it when? Agilent distribution partners offer expedient delivery.

High performance DC power

Anticipate new demands with high speed, versatility, and accuracy

N6700 low-profile modular power system

- Ideal DC power supply solution for automated test systems: small, fast, and flexible
- Small 1 U high mainframe (400, 600, 1200 W) with slots for up to 4 programmable DC power modules
- Mix and match the performance you need with your choice of over 30 programmable DC power modules: basic, high performance, and precision (mA and µA); available in 50, 100, 300, and 500 W
- USB, GPIB and LAN (LXI) connectivity
- BenchVue software compatible

Price from (US): $2,627

N6705B DC power analyzer

- Get deep insight into DUT power consumption—without assembling a complex test system
- Integrate up to four DC programmable power modules with DMM, scope, arb, and data logger features; up to 600 W total power
- New source/measure units and application-specific modules for battery-drain analysis, functional test and more
- USB, GPIB and LAN (LXI) connectivity
- BenchVue software compatible

Price from (US): $7,471

6600 Series high-performance DC supplies

- Fast, low-noise outputs improve measurement accuracy and test throughout
- 40 to 6600 W, single output, up to 120 V, and up to 875 A
- Programmability and built-in V & I measurements simplify test setups
- GPIB connectivity

Price from (US): $2,488

N3300 DC electronic load mainframe

- Stable and accurate: these loads are easy to integrate into your test system
- Automated command list execution reduces workload on system controller
- 1800 W mainframe accepts up to six 150 to 600 W modules for simultaneous testing
- Maximum inputs up to 240 V and 120 A
- GPIB connectivity

Price from (US): $1,833

For applications that require precise, accurate measurements and efficient analysis of AC power

6810B Series AC power sources/ power analyzers

- One-box solutions provide generation, measurement, and AC power analysis by combining the capabilities of a multimeter, oscilloscope, harmonic analyzer, arbitrary waveform generator, and power analyzer
- Available in 375, 750, and 1750 VA models, with 300 Vrms, 3.25 to 13 Arms, and 40 to 80 A peak

Price from (US): $7,610

High value

Solid performance and robust features help you achieve more on lower budgets

N8900 Series autoranging high-power system supplies

- 5 kW and 10 kW basic, single-output, autoranging programmable DC power for ATE applications
- Just the right amount of performance at just the right price
- 18 models that offer up to 1000 V or 340 A
- Easily parallel units to create "one" power supply with 100 kW of power
- USB, GPIB, LAN (LXI) connectivity and analog programming

Price from (US): $7,722

N5700 and N8700 Series system DC power supplies

- Basic, high-power, single-output power supplies
- 45 affordable models in compact 1 U (750 and 1500 W) and 2 U (3.3 and 5 kW) packages
- Up to 600 V or up to 400 A
- Programmability and built-in V & I measurements simplify test set ups
- USB, GPIB and LAN (LXI) connectivity

Price from (US): $2,611

E3600 Series DC power supplies

- Output noise as low as 1mVp-p/0.2mVrms
- Tight 0.01% load and line regulation
- Fast load transient response time (<50 µs)
- 30 to 200 W outputs
- BenchVue software compatible

Price from (US): $657

6030 Series basic autoranging DC supplies

- Autoranging to do the job of multiple power supplies
- 240 or 1200 W output, up to 500 V and up to 120 A
- Programmability and built-in V & I measurements simplify test setups
- GPIB connectivity

Price from (US): $5,338

Agilent offers more than

300 power products to meet your specific needs.

The free *Agilent Power Product Catalog* helps you choose your instrument by the number of outputs, output power characteristics, packaging, special features and application specific solutions.

www.agilent.com/find/highpower

Modular flexibility and universal channels for a wide range of measurements with no external signal conditioning

34970A/72A data acquisition switch units

- Low-cost, 3-slot unit with 6½ digit DMM and built-in signal conditioning
- Choose from 8 plug-in modules, up to 120 1-wire (60 2-wire) channels or 96 cross points
- BenchLink Data Logger software included, optional 34830A BenchLink Data Logger Pro
- GPIB & RS-232 connectivity (34970A) USB & LAN (LXI) connectivity (34972A)—built-in web interface for easy control

Price from (US): $1,745/$2,015

34970A/72A plug-in modules

Model	Key specifications
34901A/02A/08A multiplexers	Up to 300 V, 16, 20, or 40 channels
34903A GP switch	300 V, 20 actuator channels
34904A matrix	4x8 matrix
34905A/06A RF switches	2 GHz dual, 50 and 75 Ω
34907A multi-function	DIO, DAC, totalizer

34980A multi-function switch/ measurement unit

- High performance, 8-slot mainframe with 6½ digit DMM and built-in signal conditioning
- Choose from 21 plug-in modules, up to 1024 1-wire (560 2-wire) channels or 4096 cross pts.
- Optional 34832A BenchLink Data Logger Pro
- GPIB, USB,LAN (LXI) connectivity—built-in web interface for easy control

Price from (US): $2,803

34980A plug-in modules

Model	Key specifications
34921A–34925A multiplexer switch modules	Up to 300 V, 40, 70, or 80 channels
34937A–34939A GP switch modules	Up to 64 channels, 5 A, 300 V
34931A–34934A matrix switch modules	Up to 512 crosspoints per module
34941A–34947A RF & µWave switch modules	Up to 26.5 GHz bandwidth
34950A–34952A system control modules	DIO, DAC, totalizer, frequency period, counter

MEASUREMENT HINT

Configure a low-cost, high-performance RF solution for wireless transceiver measurements by pairing a **N9320B/N9322C** spectrum analyzer with the **N9310A** RF signal generator using a **33500B/33600A** Series waveform generator as its modulation input. You can measure any wireless connectivity device with ASK, FSK, or GFSK modulation across a range of industrial, automotive, and consumer electronics.

Achieve more on a tight budget: Solid performance with robust measurement features

N9330B handheld cable and antenna tester

- Frequency range: 25 MHz to 4 GHz
- 3.0 ms/data point sweep time
- VSWR/return loss/cable loss; distance-to-fault
- 4-hour battery life

Price from (US): $5,248

N9340B handheld spectrum analyzer (HSA)

- Frequency range: 9 kHz to 3 GHz
- One-button features: channel power, ACPR, OBW, field strength, spectrum emission mask
- 3 GHz tracking generator: insertion loss, amplifier gain, filter passband
- AM/FM IBOC and xDSL measurement

Price from (US): $8,599

N9320B basic spectrum analyzer (BSA)

- Frequency range: 9 kHz to 3 GHz
- DANL: -148 dBm with pre-amp on
- RBW: 10 Hz to 1 MHz
- LAN, GPIB, and USB connectivity
- 3 GHz tracking generator
- PowerSuite: channel power, occupied bandwidth, and more
- AM/FM and ASK/FSK demodulation analysis
- Free remote control PC software
- BenchVue software compatible

Price from (US): $8,452

N9322C basic spectrum analyzer (BSA)

- Frequency range: 9 kHz to 7 GHz
- DANL: -152 dBm typical, with preamp on
- RBW: 10 Hz to 3 MHz
- 7 GHz tracking generator, built-in VSWR bridge
- AM/FM, ASK/FSK demodulation
- Free remote control PC software
- BenchVue software compatible

5-in-1 RF analyzer

- Spectrum analyzer
- Stimulus and response tester
- Spur and interference analyzer
- ASK/FSK modulation analyzer
- Peak and average power meter

Price from (US): $11,699

EDN 2013 HOT 100

Professional performance and compact size for general purpose testing needs

N9310A RF signal generator

- 9 kHz to 3 GHz CW output, 20 Hz to 80 kHz low frequency (LF) output
- -127 to +13 dBm output level range (max +20 dBm settable)
- - 95 dBc/Hz SSB phase noise
- Extensive analog modulation: AM, FM, phase, and pulse modulation
- Optional IQ modulator, 40 MHz bandwidth
- Up to ± 0.1 ppm aging rate

Price from (US): $7,808

Agilent distribution partners: fast, local response with a direct line to Agilent's test and measurement experts

Benchtop DMMs

Exceptional performance and ease of use

BenchVue software compatible

Model	Description	Features							Max reading rate at 4½ digits (rdgs/s)	Built-in PC Interfaces	Price from (US)
		Digits of resolution	DCV, DCI True RMS ACV/ACI	2– and 4–wire Ω	freq/ period	diode/ cont	cap.	temp.			
U3401A	Dual display. Elegantly simple and affordable DMMs with basic capabilities	4½	•	•	•	•			3	None	**$497**
U3402A		5½							22		**$662**
U3606A	DMM with built-in 30 W power supply. Halves bench/rack space needed for two instruments	5½	•	•					37	USB, GPIB	**$1,258**
34450A	Faster measurement speed, ultra-bright OLED with dual display, and basic statistical tools	5½	•	•	•	•	•	•	190	USB, Serial interface (RS-232), optional GPIB	**$813**
34460A	Display DMM results in ways you never have before and measure with unquestioned True*volt* confidence	6½	•	•	•	•		•	300	USB, optional GPIB and LAN	**$945**
34461A									1,000	USB, LAN optional GPIB	**$1,095**
34401A	Industry standard for accuracy, speed, measurement ease and versatility	6½	•	•	•	•			1,000	GPIB	**$1,159**
34410A	Dual display. Highest throughput of benchtop DMMs, best choice for system use	6½	•	•	•	•	•	•	10,000	USB, GPIB, LAN	**$1,404**
34411A									50,000		**$2,235**
34420A	Nano volt/μΩ meter. Very accurate, low-level measurements	7½	DCV only	•				•	250	GPIB	**$4,349**
3458A	The fastest, most flexible and most accurate multimeter, ideal multimeter for demanding applications	8½	•	•	•				100,000	GPIB	**$9,568**

Handheld DMMs

Rich features and robust design for real-world conditions

- High-contrast OLED display with 160° viewing angle (U1273AX, U1273A and U1253B)

The U1177A
Infrared (IR)-to-*Bluetooth*® Adapter:
Enables *Bluetooth* connection to ALL Agilent U1200 Series handheld meters. Use with the complimentary Mobile Meter and Mobile Logger, on your Android device to monitor and log data remotely and wirelessly (up to 3 handheld meters).

Agilent U1177A: an electronics industry multiple award winner for 2013.

	U1230 Series	U1240 Series	U1250 Series	U1270 Series	U1210 Clamp Meter Series
Counts	6,000	10,000	50,000	30,000	4,000
AC bandwidth	1 kHz	2 kHz	30 to 100 kHz	100 kHz	2 kHz
Voltage AC/DC	600 mV to 600 V	1 to 1,000 V	50 mV to 1,000 V	30 mV to 1,000 V*	4 to 1,000 V
Current AC/DC	60 μA to 10 A	1 μA to 10 A	500 μA to 10 A	300 μA to 10 A	40 to 1,000 A
Battery life	500 hours	300 hours	72 hours*	300 hours	60 hours
Additional features	Built-in flashlight, continuity alert with flashing backlight, Z_{Low} non-contact voltage detector with V_{sense}*	Switch counter, harmonic ratio, dual and differential temperature measurements*	20 MHz frequency counter, programmable square wave generator*	Low pass filter, AC and/or DC voltage check, low impendance mode offset compensation* Operational down to -40 °C*	Large 2" jaw size, back light with dual display, ACI, ACV/ DCV, diode test, R, C, frequency 400 Ω to 40 MΩ resistance 4 to 4,000 μF capacitance*
Connectivity	IR-USB and Infrared (IR)-to-*Bluetooth*				
Price from (US)	**$101**	**$206**	**$390**	**$347**	**$255**

* *Specification available on select models only.*

Maximum versatility to troubleshoot today's challenges and anticipate tomorrow's needs

U1600 Series handheld scopes

- 5.7-inch VGA TFT LCD display with indoor, outdoor, and night-vision viewing modes
- 3-in-1 instrument: oscilloscope, DMM, and data logger
- Fully isolated channels (U1610A, U1620A)
- Up to 2 GSa/s sample rate and up to 2 Mpts deep memory to zoom in on critical details
- Benchtop-like dual window zoom for more detailed waveform analysis

Price from (US): $1,388

Big scope performance with a small scope price

1000 Series oscilloscopes

- 50 to 200 MHz, 2 and 4 channel DSO models with up to 20 kpts memory
- 5.7-inch color display offers powerful signal capture and display
- Up to 2 GSa/s sample rate
- 23 automatic measurements, sequential acquisition, mask testing and digital filters provide advanced measurement capabilities
- Accelerate your productivity with an 11-language user interface, USB connectivity, and a standard educator's kit

Price from (US): $520

See the big picture without losing sight of the details

N2820A & N2821A High sensitivity current probes

- Measure currents as low as 50 µA
- Measure currents as high as 5 A
- Measure AC and DC
- Also use as a voltage probe with as low as 3µV sensitivity
- Bandwidth; 3 MHz Zoom-Out Channel, 500 kHz Zoom-In Channel
- Compatible with InfiniiVision 3000X and InfiniiVision 4000X

Price from (US): $2,100/$3,200

For the complete list of available probes: www.agilent.com/find/probes

M E A S U R E M E N T HINT

The **N2820A** 2-channel high sensitivity current probe comes with two parallel differential amplifiers inside the probe with different gain settings. The low gain side allows you to see the entire waveform, the "zoom out" view of the waveform, and the high gain amplifier provides a "zoom in" view to observe extremely small current fluctuations, such as a mobile phone's idle state.

Breakthrough scope technology lets you see more, do more and get more for your money

InfiniiVision Oscilloscopes

- Up to 1,000,000 waveforms/sec update rate
- MegaZoom IV responsive, uncompromised smart memory
- Integrated—5 instruments available in one
- Fully upgradable—bandwidth, MSO, memory, serial analysis, built-in WaveGen function generator, or digital voltmeter
- BenchVue software compatible

2000 X-Series

- 70 to 200 MHz bandwidth, up to 1 Mpts memory, DSO and MSO models
- 8.5-inch WVGA display offers 2x the viewing area and 5x the resolution of competitive scopes
- Standard 5 year warranty

Price from (US): $1,258

3000 X-Series

- 100 MHz to 1 GHz bandwidth, up to 4 Mpts memory, DSO and MSO models
- 8.5-inch WVGA display is 50% larger and 3x the resolution of competitive scopes
- Segmented memory optional
- Standard 3 year warranty

Price from (US): $3,222

4000 X-Series

Experience speed, usability and integration

- 200 MHz to 1.5 GHz bandwidth, 4 Mpts smart memory, DSO and MSO models
- 12.1-inch capacitive touch display is 40% larger than competitive scopes
- InfiniiScan Zone touch triggering—if you can see it, you can trigger on it
- Segmented memory standard
- Standard 3 year warranty

Price from (US): $5,611

Gain greater insight with powerful applications

See the complete list at www.agilent.com/find/scope-apps

Description	2000 X-Series	3000 X-Series	4000 X-Series
20 MHz WaveGen	DSOX2WAVEGEN	DSOX3WAVEGEN	DSOX4WAVEGEN2
3-digit voltmeter	DSOXDVM	DSOXDVM	DSOXDVM
DSO to MSO upgrade	DSOX2MSO	DSOX3MSO*	DSOXPERFMSO
CAN/LIN trigger/decode	DSOX2AUTO	DSOX3AUTO	DSOX4AUTO
I^2C/SPI trigger/decode	DSOX2EMBD	DSOX3EMBD	DSOX4EMBD
RS232/UART trigger/decode	DSOX2COMP	DSOX3COMP	DSOX4COMP
USB full/low trigger/decode			DSOX4USBFL
USB high trigger/decode			DSOX4USBH
USB signal quality test			DSOX4USBSQ

2-ch AWG

** 1 GHz models require DSOXPERFMSO*

*Get a **FREE** 30-Day Trial License.* **www.agilent.com/find/30daytrial**

Agilent distribution partners: your local connection to Agilent's global technical resources

Agilent Technologies

P.O. Box 3828, Englewood, CO 80112-5910

Unsubscribe:
To unsubscribe from Agilent direct mail, please send your name and address to: privacy_advocate@agilent.com and we will remove your name from our list.

Printed in U.S.A., May 1, 2014

5991-3975ENUS

Higher frequency signals, meet True*form* signal integrity.

Introducing the new
80 & 120 MHz 33600A Series
True*form* waveform generators

SEE PAGE 2

PROMOTIONS

Special promotions available only through Agilent distributors

Check out these great offers*

RF

Buy a N9310A RF Signal Generator and get a free IQ Modulator.
Ends 6/30/14.

RF Promo FREE 5 Year Warranty.
Ends 9/30/14.

SCOPES

Upgrade to your Ultimate Scope with the InfiniiVision X-Series Application Bundle.
Ends 9/30/14.

WAVEFORM GENERATORS

Buy a New 33600A Series Trueform Waveform get FREE Waveform Builder Pro License
Ends 8/31/14.

**Certain restrictions apply.*

See our complete list of current promotions.
www.agilent.com/find/promotions

Our Featured Distribution Partners

TESTEQUITY
http://agilent.testequity.com
800-588-3457

Newark element14
www.newark.com/agilent
800.463.9275

microlease
The experts in Test Equipment management
www.microlease.com/agilent
800.432.3424

Agilent Technologies
Authorized Distributor

Anticipate ___Accelerate ___Achieve

Find an Agilent distributor today at
www.agilent.com/find/distributor