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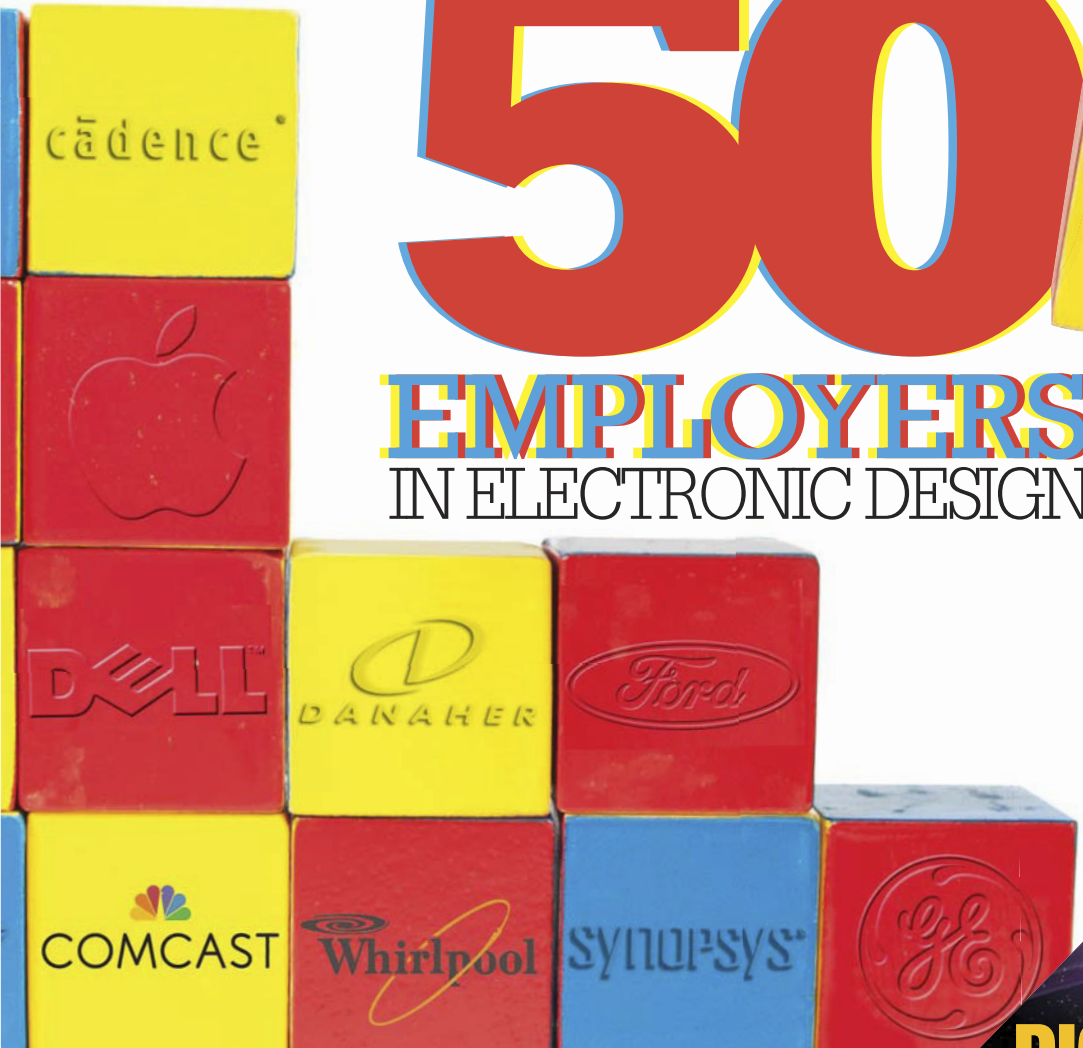
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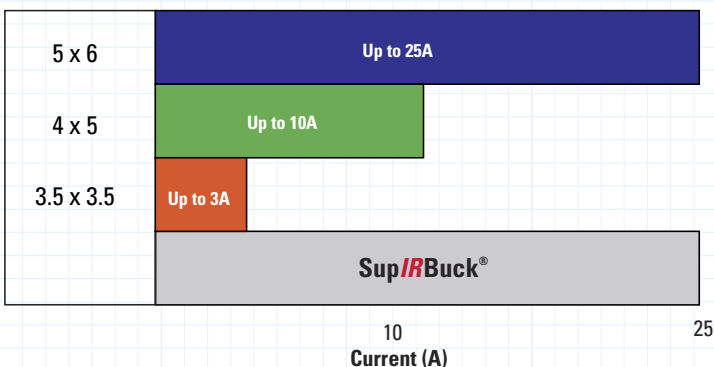
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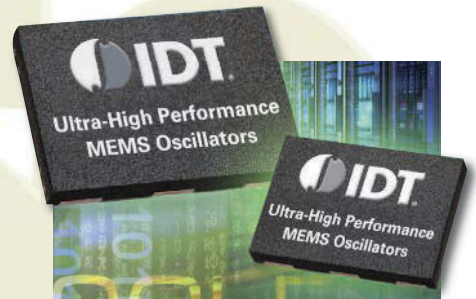
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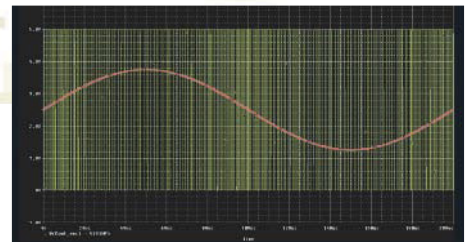
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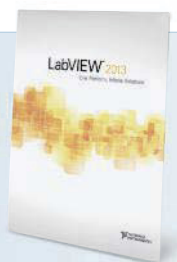
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JOE DESPOSITO
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As Editorials Go, This One Ranks Last

ast as in final, that is. Yes, this is my final editorial and for a very good reason. After six years as Editor-in-Chief of *Electronic Design* and more than 30 years covering the industry, I have decided to retire. I have had a wonderfully enjoyable career, like most people whose interests fit perfectly with their daily work.


It's hard to believe that when I began my career as technical editor at *Popular Electronics* back in 1981, the main editorial tools were a pencil and electric typewriter. No one in my office had computers on their desks at the time. In fact, I was hired specifically because of my knowledge of the Apple II+ computer. The magazine was looking for an editor who could cover a new beat about personal computers.

Today's editors, of course, have a daunting array of tools at their disposal, from powerful notebook computers to smart phones, high-quality digital cameras, and video equipment. The list keeps growing as far as gadgets go, but the tools don't stop there. The Internet, software, apps, and social media all combine to give editors unbelievable ways to connect with readers on a daily basis.

In these past six years, *Electronic Design* has evolved from a print publication with a Web presence to a brand with a full-blown Web site that has become a trove of highly technical "evergreen" content as well as a conduit for readers to interact with our staff editors and industry experts who possess a wealth of knowledge and experience.

Truly amazing to me is the way *Electronic Design's* talented staff continues to come up with new ideas to make our Web site more enticing and valuable to our readers. Just recently, we launched our Ask the Experts series, which is simply a way to better interact with our growing cadre of Contributing Technical Experts. We've also begun

posting image galleries in earnest, so you get to see what we see at trade shows and other events.

As I leave to tend to the grandkids and other assignments my wife thinks up, I want you to know that this magazine will now be in the very capable hands of Nancy Friedrich, our Group Director of Editorial Content, who I'm sure will continue to bring new ideas and insight to our loyal readers. 

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The Evolution Of Sensor Analog Front Ends

We live in an analog world full of information useful to our civilization. We measure just about everything imaginable via sensors and convert the data into digital signals utilizing analog-to-digital converters (ADCs). In most cases, the output from sensors requires amplification and conditioning to provide the best possible signal to the ADC.

This combination of conditioning circuitry is called an analog front end (AFE). Sometimes this combination even includes the ADC. Sensor AFEs can be found in everything from personal health monitors to the enormous Large Hadron Collider sensor arrays.

THE HISTORY OF THE AFE

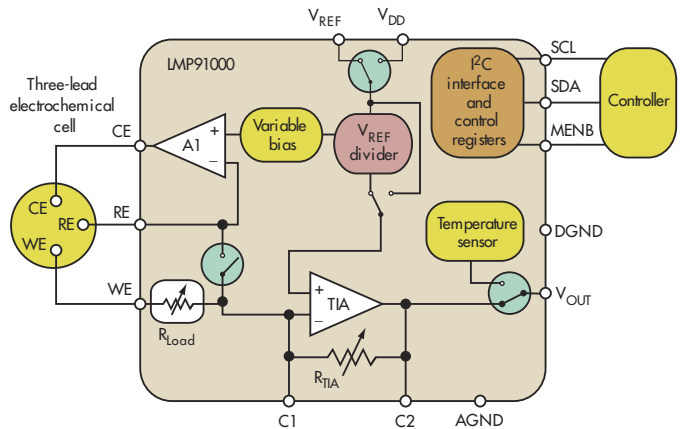
Electronic sensing can be traced to the discovery of the photovoltaic effect by physicist A.E. Becquerel in 1839, along with the exploration of the pyro-electric and piezoelectric effects throughout the 18th and 19th century. As electronics matured in the 20th century, these effects were crafted into sensors coupled to analog systems to measure and monitor a multitude of phenomena. Early systems were completely analog and found in medical monitoring, process control, and other industrial applications such as steel manufacturing and chemical plants.

With the advent of the IC microprocessor and later the invention of the DSP by Texas Instruments in 1978, the requirement to convert physical effects to digital signals became a focus for engineers. Integrated ADC technology was designed to convert a voltage (the analog signal) to digital bits.

Many precision ADCs use successive approximation registers (SARs) to slice the analog voltage latched on a sample and hold (S/H) into smaller and smaller pieces, yielding bits as the process proceeds. The delta-sigma method employs a modulation technique and a single comparator to produce a stream of digital bits, often in applications requiring a very large dynamic range, such as seismic detection of oil deep underground. Even high-resolution ADCs still require a voltage to convert.

CONDITIONING SENSOR SIGNALS

Engineers involved in sensing understood the limited output signals from many sensors and designed analog conditioning circuitry using operational amplifiers (op amps) and differen-



Electrochemical sensors rely on analog front ends to convert the analog signals they receive into digital

tial amplifiers to convert these tiny changes in the sensors to large enough signals to supply an ADC. This takes full advantage of the dynamic range of the ADC and helps maintain the signal-to-noise ratio (SNR). This circuitry also was used to compensate for offsets and other error sources, such as the cold junction temperature found in thermocouple applications.

Beyond the amplification and conditioning of the signal, filtering is required to remove unwanted signals from the system. Often, external electric fields impart noise into a sensor system such as the ubiquitous 50- and 60-Hz power-line noise, which can be heard in audio systems as a low-frequency hum. This electric noise can add significant error to a low-frequency signal from a sensor and must be either filtered or prevented (via shielding) from entering the system.

A major issue with ADCs is aliasing caused by frequency components present in the signal that are greater than the Nyquist Criterion (half the sampling frequency or $F_s/2$). If this occurs in a sampled system such as an ADC, the signals above half the sample frequency will be folded back or “aliased” into the first Nyquist zone (frequencies between dc and $F_s/2$). The higher-frequency components appear in the digitized output as lower frequencies, which could be confused with a real change in a sensor input. To prevent this phenomenon, an analog anti-aliasing filter is placed before the ADC input to remove frequencies above the $F_s/2$ point.

For most ADC architectures such as SAR, this filter can be challenging and may require several orders to provide the correct cutoff. Using oversampling, digital filtering and decimation can reduce the analog anti-aliasing requirements, but may increase power consumption.

For many sensor applications requiring a large dynamic range, delta-sigma ADCs are often used. These converters utilize a delta-sigma modulator to convert the analog signal into a digital count within a given interval, and they often run at many times the input frequency. This over-sampling allows quantizing noise to be pushed out of the band of interest. Filtering and decimating digitally then increases both the SNR and the usable dynamic range (often referred to as the effective number of bits, or ENOB). This configuration can greatly reduce the requirements of the anti-aliasing filter.

SENSOR AFE REQUIREMENTS

Many sensors require some form of excitation—that is, a signal that allows the sensor to provide a usable output. This signal may be a constant voltage or current, or even an ac signal such as a sine wave. Sensors that require excitation include resolvers, capacitive-based sensors (the capacitance changes as a result of the input to the sensor) such as proximity detectors, wideband zirconia sensors used in oxygen detection, and other electrochemical cells.

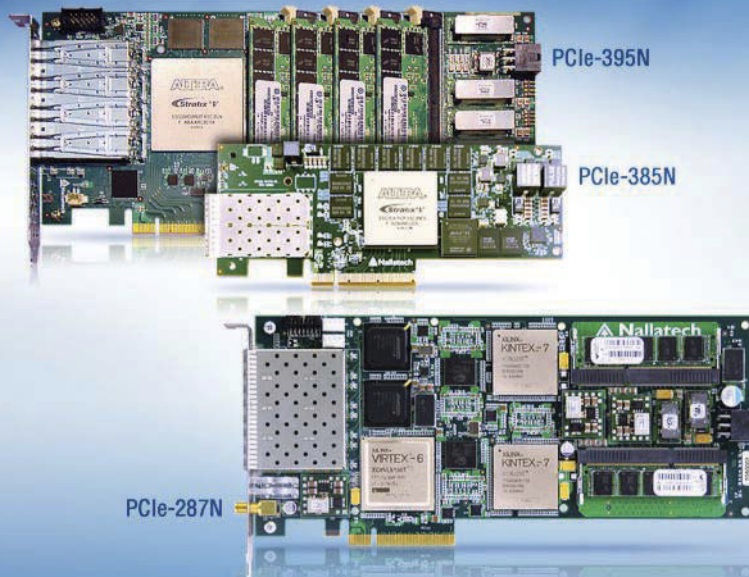
Along with the requirement to correctly digitize the output from the processed sensor signals, these types of cells require additional circuitry to allow the sensor to operate properly. Without the excitation signal, a sensor may provide incorrect readings or not work at all.

For example, electrochemical potentiostat cells work by the impedance change of an electrolyte as it comes in contact with a certain chemical or gas. Typically, these sensors have three connections: the counter electrode (CE), the reference electrode (RE), and the working electrode (WE).

In operation, current is driven into the CE connection and the circuitry moni-

tors the voltage at the RE point. A closed-loop control circuit keeps this voltage constant, which in turn changes the return current present at WE. The resulting return current at the WE connection can be converted to a voltage via a transimpedance amplifier (TIA). The voltage between CE and RE, as well as the overall change in impedance (amount of current change at WE), varies from sensor to sensor.

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To simplify the system design and provide sensor flexibility, semiconductor vendors have begun to integrate all of this front-end analog circuitry into a single device. For example, the LMP91000 is a fully integrated AFE for both two-wire and three-wire electrochemical sensors (see the figure). It is programmable via an I²C port to allow both the cell bias voltage (the voltage that appears between CE and RE) and the gain

of the TIA that supplies the output voltage to the ADC to be altered. Its built-in temperature sensor helps adjust for drift in the electrochemical cell.

Many more of these sensor AFEs are tailored for such applications as automotive oxygen sensing, infrared absorption gas detectors, PH probe front ends, multi-wire resistive thermal devices (RTDs), and capacitive proximity sensors. All of these sensors have quite different requirements, and the availability of highly integrated analog subsystem front ends makes developing instrumentation far easier today than just a few years ago.

CONCLUSIONS

Converting physical phenomena to electronic signals requires a multitude of sensor technology. Many of these sensors require significant analog circuitry to operate properly. With highly integrated AFEs, much of the hard work has been done. With microelectromechanical systems (MEMS), entire sensor systems can be placed on a single device, such as pressure sensors where the sensing element is part of the die.

The near future will yield MEMS gas sensors—tiny chemical laboratories on a chip that will take this integration even further. To keep our society safe, this technology along with other highly integrated sensors will find their way into our everyday lives beyond the common carbon-monoxide detectors found in many homes. Eventually, every smart phone will be equipped with gas sensors to alert users (and possibly first responders) of the environment around them. All of this will be possible due to advances in sensor technology and the AFEs that make them work. 

RICHARD ZARR is a technologist at Texas Instruments. He holds a BSEE from the University of South Florida as well as several patents.

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News & Analysis

Smart-Phone Market To Double By 2017

Thanks to today's wide range of available models, the number of smart phones shipped soon will double, according to the Mobile & Wireless Communications Report from IHS Inc. The information and analytics provider expects total shipments to reach 1.5 billion units in 2017, up from 712 million in 2012.

Year to year, shipments will rise from 712 million in 2012 to 897 in 2013, with a compound annual growth rate (CAGR) of 15.8% taking that total to 1.1 billion in 2014, 1.2 billion in 2015, and 1.4 billion in 2016, IHS says (*see the figure*).

"The volume of new flagship smart-phone releases from top original equipment manufacturers (OEMs) this year has been astounding," said Wayne Lam, senior analyst for consumer and communications at IHS. "These include the new BlackBerry Z10, the aluminum uni-body HTC One, and an update

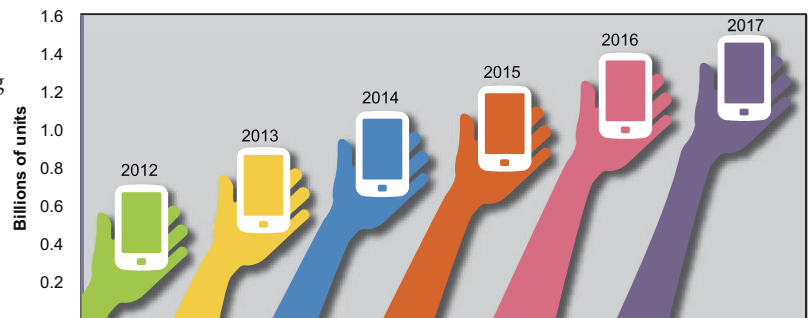
to the Samsung Galaxy S4 featuring a Full HD 5-inch active matrix organic light emitting diode (AMOLED) display."

Despite this overall growth, Apple's 3.74 million iPhones in the first quarter fell below expectations. With Apple's next model not expected until the second half of the year, iPhone

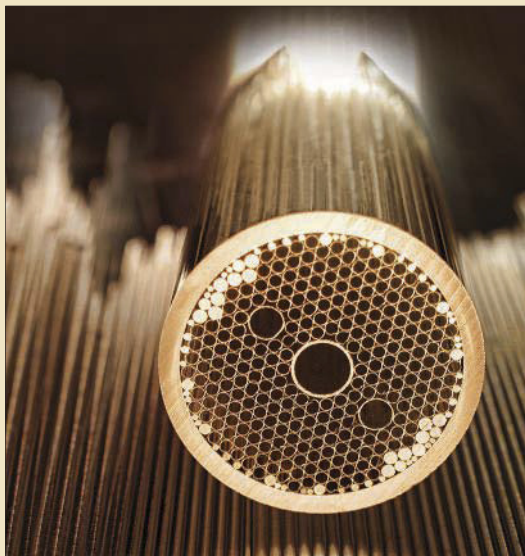
full-year sales volume may be essentially flat at around 150 million units, compared to 134 million in 2012.

"The possible slowing growth of the iPhone and the rapid pace of competitive smart-phone releases speak to the ferocious nature of the handset business, especially now as the market continues to pivot from a market dominated by lower-end handsets known as feature phones to one that is increasingly smart-phone-centric," Lam said.

Smart-phone penetration continued to increase in the fourth quarter of 2012 and the first quarter of 2013 as smart phones outshipped feature phones in the overall branded cell-phone market. After total mobile handsets topped 400 million for the



Worldwide shipments of smart phones will double from 2012's total of 712 million to 1.5 billion in 2017. (courtesy of IHS Inc.)



OPTICAL FIBER Enables High- Power Military Sensors

The Defense Advanced Research Projects Agency (DARPA) has developed a novel fiber design that uses a hollow core to improve performance by forcing light to travel through channels of air instead of the glass around it. It is the first fiber to demonstrate single-spatial-mode, low-loss, and polarization control, which is key for military applications like optic gyroscopes for inertial navigation.

first time in the fourth quarter of 2012, they contracted by nearly 50 million in the first quarter of 2013 with the close of the holiday shopping season.

Samsung's strong growth continued in the first quarter with a sequential increase of 9 million units. Also, Cool-

pad and Gionee outshipped HTC and Motorola in the first quarter. Chinese smart-phone OEMs achieved their growth through a catalog of largely available smart phones, while Samsung rolled out low-cost variants of its high-end flagship products.



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IHS believes these competitive forces and changing consumer demand will pressure Apple and other OEMs to innovate and diversify their offerings. Consumers are looking for more immersive experiences and visual content. Many smart phones are moving to 5-in. or larger full HD displays to accommodate these market needs.

As the display expands, so does the overall footprint because of larger batteries, which support more powerful processors, memory, and sensors. These features, though, drive up costs for OEMs. Still, IHS anticipates opportunities for component supplies to win design slots to multiply as smart-phone design variations increase. ■

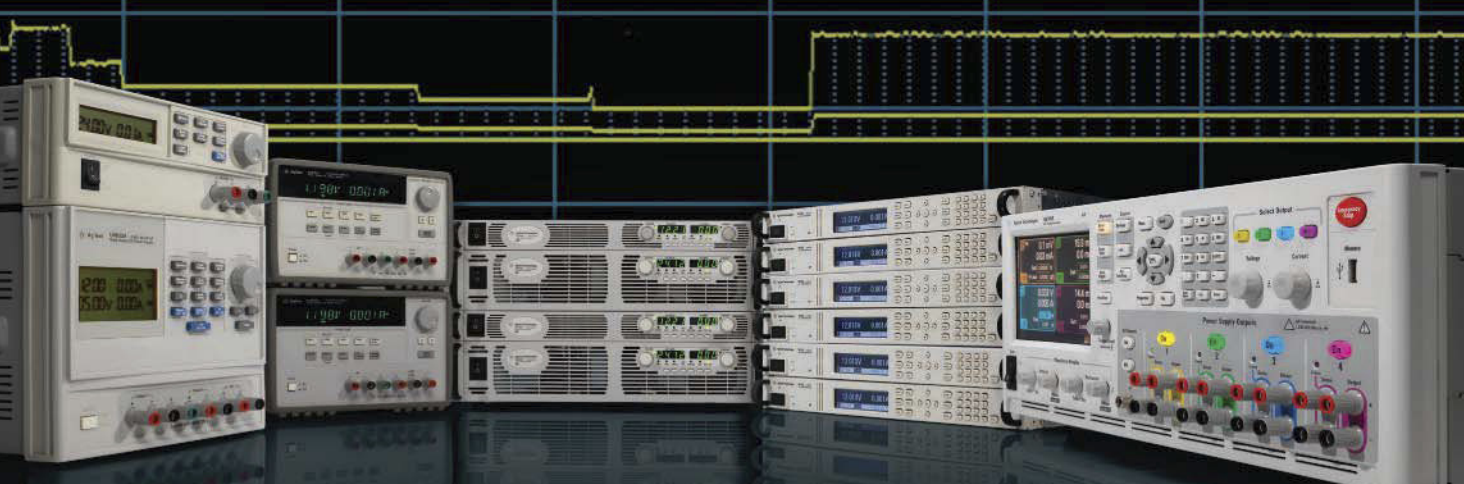
ELECTRONIC DESIGN STAFF



ROBO SALLY COMES TO THE RESCUE

DESIGNED BY THE Johns Hopkins Applied Physics Laboratory (APL), Robo Sally uses haptic feedback to mimic human abilities and relay sensation back to its operator, improving its ability to manipulate objects in bomb disposal, chemical leak, and security applications. It also uses recently developed autonomous and semiautonomous manipulation and mobility techniques to reduce its cognitive load. (courtesy of APL)

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IEEE-USA Petitions FCC For Ruling On Spectrum Above 95 GHz

THE IEEE-USA HAS positioned the Federal Communications Commission (FCC) to declare the spectrum that's above 95 GHz as "a new technology or service." Such a ruling would foster more rapid capital investment in research and development that would lead to new commercial wireless equipment and services.

Broadband wireless and the ever-expanding demand of cellular LTE and other services have been eating up all existing spectrum below 3 GHz, creating a serious spectrum shortage. Spectrum auctions, mergers and acquisitions, and spectrum trading help, but the demand for more space continues.

One solution is to keep moving higher in frequency. This means pushing development of the millimeter-wave bands above 30 GHz. Some radar, satellites, and backhaul services already use segments of this spectrum. The newest IEEE 802.11ad wireless local-area network (WLAN) standard uses the 60-GHz band. And, some research continues on the higher frequencies.

A formal statement from the FCC would clear up any hesitancy on the part of venture capitalists and other investors to invest without regulatory uncertainty in the new technologies that would make this spectrum more practical and useful.

A similar FCC declaration 28 years ago led to the development of the 802.11 standards and the Wi-Fi technology that we all use. A comparable statement by the FCC would quickly lead to faster development of components and products that would make the 95-GHz spectrum a new frontier of commercial business.

With such a declaration, companies could move ahead and develop the technology with minimal risk, a major factor in pursuing any new technology investment. Other countries are already working in this frequency range, so the U.S. needs to take action fast and get in on the potential that this spectrum opens up. To see the IEEE-USA petition, www.ieeeusa.org/policy/documents/FCCPetitionJuly2013.pdf. ■

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HV256	295V (max)	32	2V/μs	72V/V	12MΩ	715μA (max)	715μA (max)	3000pF (max)	Amp Only	Yes	MQFP-100
HV257						500μA (max)	500μA (max)	3000pF (max)	Amp with S/H		
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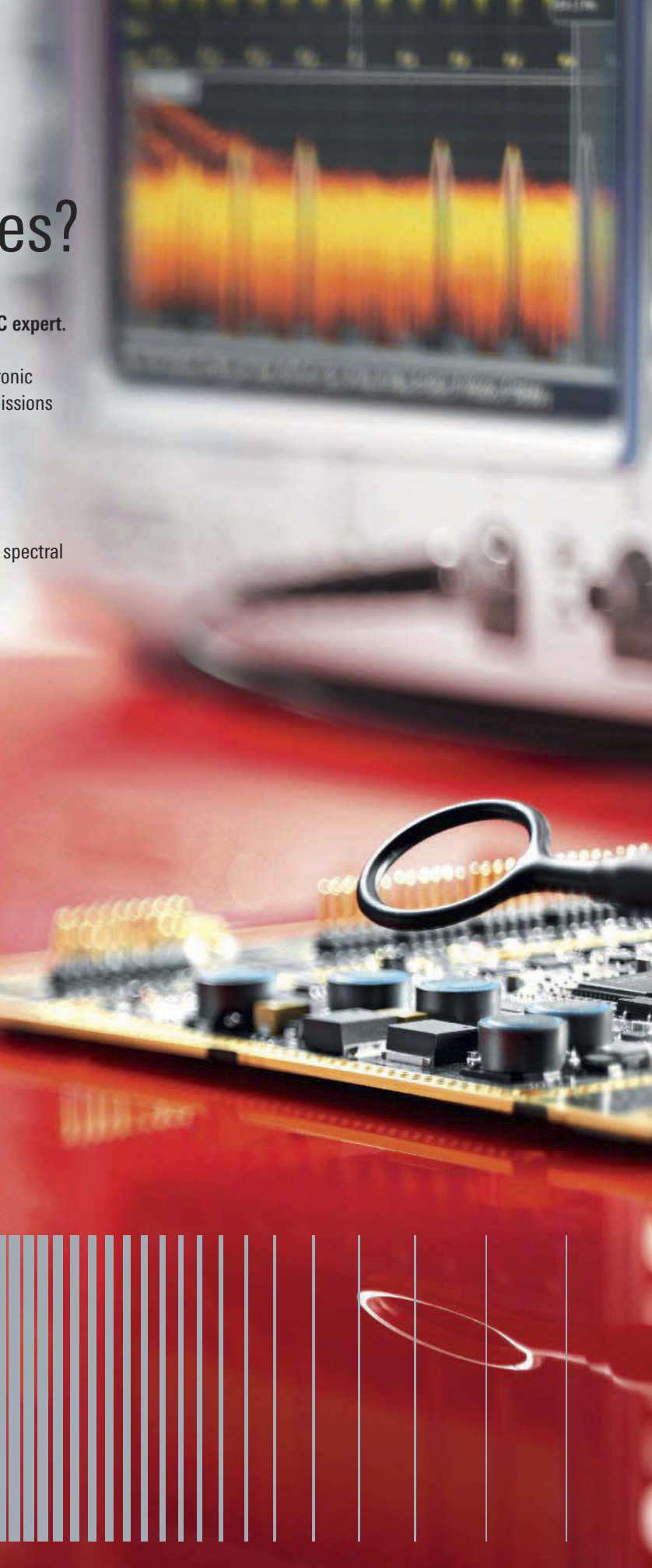
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EngineeringFeature

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It has been five years since the fall of Lehman Brothers and the start of the Great Recession, but economic growth is still stuck. Despite some progress in 2010 and 2011, not much changed in 2012. There still isn't enough demand to fuel increased economic growth. Yet some companies are forging ahead, continuing a strategy of cautious investments in staff, capital, and R&D along with a focus on controlling expenses and managing the balance sheet.

These factors all affect employment. Overall job gains in the economic recovery mostly have been found in lower-paying positions, often attached to part-time hours. According to *The Wall Street Journal*, U.S. GDP growth for the first quarter of 2013 was revised downward to 1.8%. Most consumers aren't earning enough to cover the costs of health care, education, and retirement, let alone discretionary income for consumer goods and services.

Leading companies provide hope in an economy defined by stagnant wages and fewer opportunities.

TOP 50 EMPLOYERS In Electronic Design

Lower-paying jobs with no benefits have replaced well-paying jobs with benefits, doing no good for the health of the economy. These lower-wage jobs and underemployment aren't stimulating much demand, so companies have little incentive to go out and hire more workers. Many companies also aren't offering raises to their current personnel, since they know those employees won't be leaving for other jobs, adding to the lack of spending that's ultimately hurting the economy.

So, which companies are doing well enough to rise above the stagnant economic tide? We based our list of the Top 50 Employers in Electronic Design (Table 1) on a formula using public financial data with bonus points awarded using the results of our annual *Electronic Design* Reader Profile Survey (see "The Method Behind Our Mathematics" at electronicdesign.com).

BY THE NUMBERS

According to the Bureau of Labor Statistics, more Americans are working part-time involuntarily. These part-timers now number more than 8.2 million, which is an increase of 322,000 workers from May and almost double the number this time five years ago. Also, a July National Employment Law Project (NELP) study concluded that real median hourly wages declined by 2.8% averaged across all occupations from 2009 to 2012.

This 2.8% decline is astounding, since productivity has increased by 4.5% over the same period. Workers are producing more goods and services per hour but earning less than they were when the recovery began! According to *CNN Money*, U.S. median income fell to \$50,054 in 2011, the most recent full year in which data is available. That's down 8.1% since 2007, before the recession started. Overall, median income has fallen 8.9% from its peak in 1999.

Meanwhile, the middle class is shrinking, according to *The Washington Post*. During the recovery, job gains have been concentrated in lower-wage occupations, which grew nearly three times as quickly as middle-wage and higher-wage occupations, according to another NELP study. State and federal governments, for example, have cut 835,000 jobs over the past four years—many of them middle-income positions, according to *The Huffington Post*.

The official unemployment rate is 7.6%, but the real number is about twice that. A statistic known as the U-6 figure includes the unemployed, plus those "marginally attached" to the labor force (they want a job but have largely given up looking), plus those working part-time but who want a full-time job. The U-6 number for June 2013 was a resounding 14.3%, up half a percentage point from May. Fewer working-age Americans are working than at any time in the past 30 years. The employment-to-population ratio is 58.7% according to the Department of Labor, a drop from 63% five years ago, before the recession hit.

However, corporate profits as a percentage of GDP are now at an all-time high, which means that workers' wages as a percentage of the economy have hit an all-time low. Corporations are now paying employees less than they ever have as a share of GDP. Companies aren't seeing viable opportunities to use cash for investment, hir-

TABLE 1: TOP 50 EMPLOYERS IN ELECTRONIC DESIGN		
No.	Company	Fiscal 2012 Rank
1	QUALCOMM INC.	1
2	SEAGATE TECHNOLOGY PLC	2
3	LSI CORP.	2
4	CADENCE DESIGN SYSTEMS INC.	2
5	APPLE INC.	5
6	WESTERN DIGITAL CORP.	6
7	EMC CORP.	7
8	NATIONAL INSTRUMENTS CORP.	8
9	HONEYWELL INTERNATIONAL INC.	8
10	FORD MOTOR CO.	10
11	MOTOROLA SOLUTIONS INC.	11
12	TERADYNE INC.	12
13	NCR CORP.	12
14	CATERPILLAR INC.	12
15	MENTOR GRAPHICS CORP.	15
16	THE BOEING COMPANY	17
17	GENERAL ELECTRIC CO.	16
18	SYNOPSIS INC.	17
19	MICROSOFT CORP.	19
20	ROCKWELL AUTOMATION INC.	19
21	HARMAN INTERNATIONAL INDUSTRIES INC.	21
22	3M CO.	21
23	MEDTRONIC INC.	23
24	INTERNATIONAL BUSINESS MACHINES CORP.	23
25	RAYTHEON CO.	23
26	COMCAST CORP.	23
27	UNITED TECHNOLOGIES CORP.	27
28	WHIRLPOOL CORP.	28
29	CISCO SYSTEMS INC.	29
30	DANAHER CORP.	29
31	VERIZON COMMUNICATIONS INC.	29
32	XEROX CORP.	29
33	MOOG INC.	29
34	BROADCOM CORP.	29
35	AGILENT TECHNOLOGIES INC.	29
36	LOCKHEED MARTIN CORP.	36
37	TEXTRON INC.	36
38	LEAR CORP.	36
39	DELL INC.	36
40	MAXIM INTEGRATED PRODUCTS INC.	40
41	INGERSOLL-RAND PLC	41
42	ITT CORP.	41
43	ANALOG DEVICES INC.	41
44	EATON CORP.	41
45	KLA-TENCOR CORP.	41
46	CIRRUS LOGIC INC.	41
47	LAM RESEARCH CORP.	41
48	INTEL CORP.	48
49	XILINX INC.	49
50	PARKER-HANNIFIN CORP.	49
51	ANALOGIC CORP.	49



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ing, pay raises, or even rewarding shareholders, so it is accumulating on the balance sheet.

Union wages are a rare commodity as well. In 2012, the median salary of unionized workers was about \$49,000, com-

pared to \$39,000 for their non-union counterparts, according to PBS Frontline. Fewer workers are earning union salaries, though. Thirty years ago, one in five U.S. workers was a union member. Today, it's about one in 10.

FORD TO EXPAND ELECTRIFICATION ENGINEERING TEAM BY 50%

FORD HAS ANNOUNCED plans to expand its Electrification Engineering team by 50% this year, growing to 500 salaried employees. The company, which rose 50 slots in our Top 50 Employers in Electronic Design to reach tenth place on this year's list, also is investing \$50 million more in electrified product development and testing centers in Dearborn, Mich. It will double its electrification and battery-testing capabilities by the end of the year as well to a total of 160 individual battery-test cells, helping to speed hybrid and electric vehicle development by as much as 25%, Ford says.

"This investment in new engineers and expanded facilities helps us prepare for growth," said Raj Nair, group vice president of Ford Global Product Development. "All of us at Ford remain absolutely committed to offering customers a choice of leading fuel-efficient vehicles, from EcoBoost gasoline engines and hybrids to plug-in hybrids and electrified vehicles."

Ford's share of the U.S. electrified vehicle market grew to 16% in the first half of 2013. It reported electrified vehicle sales of 46,197 units through June, which is more than 400% higher than the same period a year ago, driven by sales of the C-MAX Hybrid and C-MAX Energi plug-in models (see the figure). Ford also says that 64% of C-MAX Hybrid buyers in June came from non-Ford brands.

The company additionally has plans for its larger vehicles with continued development of a rear-wheel-drive hybrid system for its pickups and SUVs. The research began as a joint project with Toyota. The new system, which will be available by the end of the decade, will be based on an all-new architecture that will deliver the capability that SUV and truck custom-



The C-MAX Hybrid (shown) and the C-MAX Energi plug-in drove Ford's 2013 growth in the electrified vehicle market. According to Ford, the Hybrid gets 47 mpg city and 47 mpg highway.

ers demand while providing greater fuel economy, Ford says.

"We know what it takes to build world-class hybrids, and we now will build and leverage that expertise in-house," Nair said. "By continuing to develop a rear-wheel-drive hybrid system on our own, we can extend our advanced hybrid technologies to new vehicle segments and deliver even better fuel economy across our lineup."

The new staff will include more than 200 electrification engineers. Work will include the design and engineering of transmissions, batteries, and control systems, in addition to the new rear-wheel-drive system. Over the past year, Ford has invested more than \$355 million to design, engineer, and manufacture key components of its electrified vehicle lineup.

"Engineers and technical professionals are in as much demand as our cars, trucks, and SUVs," said Felicia Fields, Ford group vice president for human resources.

"Global demand and increasing capacity in North America and Asia requires that we aggressively seek out technical professionals in order to continue our growth."

Overall, Ford plans on hiring more than 3000 salaried employees in 2013 in the United States, including 2400 technical professionals in product development, manufacturing, quality, purchasing, and information technology. According to Fields, more than 1500 of these positions remain open. Last year, Ford hired 1850 salaried workers in the United States.

In the immediate future, Ford says it wants to continue improving the on-road fuel economy performance of its 2013 hybrid vehicles in the United States and Canada. Starting in August, the company will make calibration updates designed to improve on-road fuel economy for owners of the 2013 Ford C-MAX Hybrid, the 2013 Ford Fusion Hybrid, and the 2013 Lincoln MKZ Hybrid.

These calibration updates will include control system enhancements for a variety of highway driving conditions, short trips, and climate control system use. For example, the maximum pure electric speed will be increased from 62 mph to 85 mph for more electric-only highway driving. Active grill shutters will be optimized to reduce aerodynamic drag under more driving and temperature conditions.

Electric fan speed will be reduced as a function of coolant temperature to minimize its energy consumption. Engine warm-up time will be shortened by as much as 50% to enable electric-only driving and engine shutdown at stops sooner after cold starts. And, the climate control system will be optimized to minimize use of the air conditioning compressor and reduce the energy used in cold weather.

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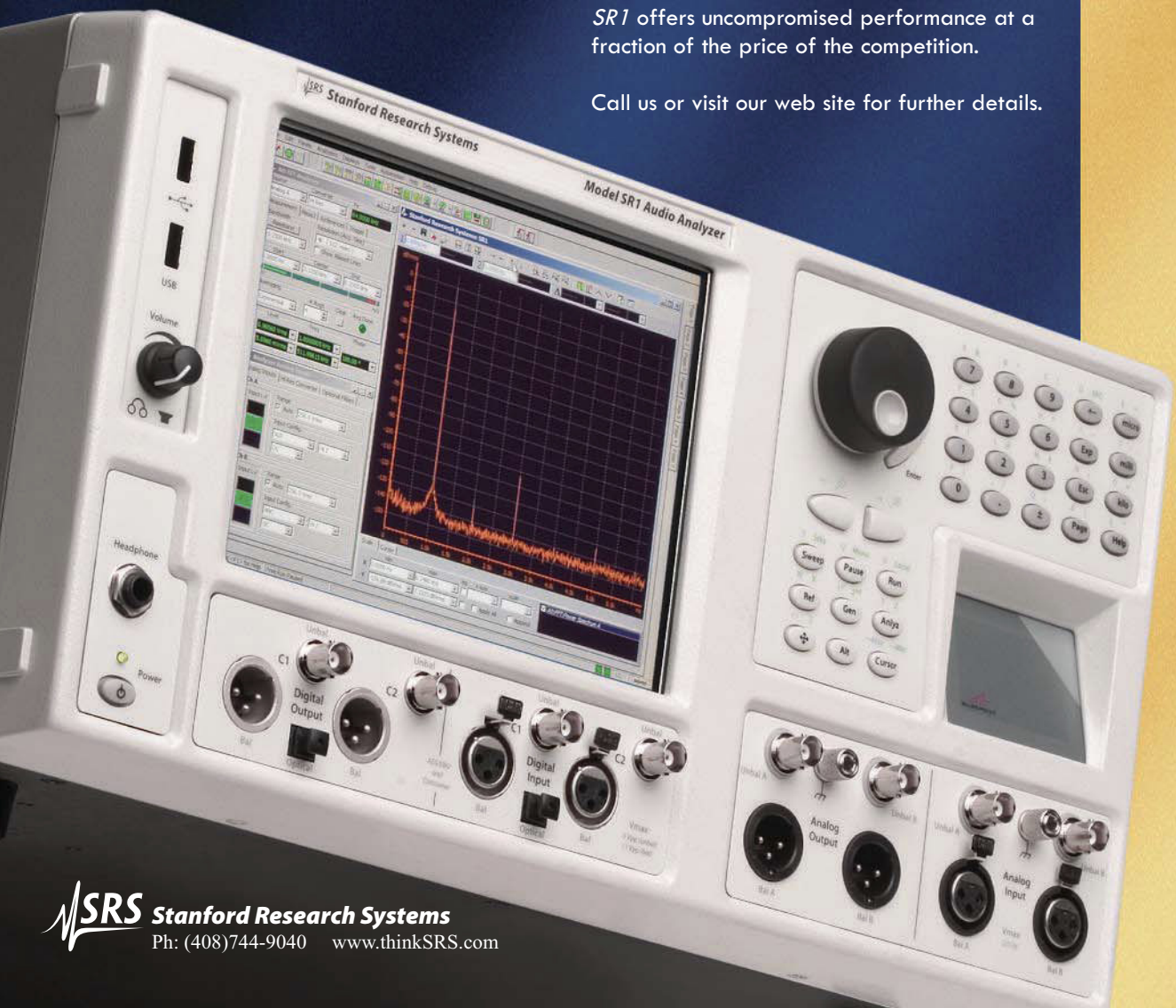
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TABLE 2: INDUSTRY GAINS IN KEY AREAS

Category	Fiscal 2012 versus 2011	Fiscal 2011 versus 2010
Employee growth	2.6%	3.0%
Sales growth	3.5%	9.7%
Pretax income growth	-17.2%	8.0%
Pretax margin improvement	-2.6 points	-0.2 points
Debt to equity ratio improvement	5.6 points	-3.5 points
Research & development expense	6.1%	8.9%
Electronic Design Reader Profile Survey respondents	480	365

WHAT'S NEXT?

The IMF's July 2013 update of its World Economic Outlook cut the forecast for 2013 global growth to slightly above 3%, matching the 2012 forecast. Caterpillar Inc., twelfth on our list, is a bellwether for broader economic growth. Its ties to infrastructure, its global footprint, and its exposure to China give it a strong view as to how global growth will unfold.

CAT's recent economic outlook expects U.S. growth of around 2% for all of 2013, which won't have much impact on unemployment or inflation. As a result, the Federal Reserve is likely to keep rates near zero for a fifth straight year.

China's economy will grow around 7.5% this year, with industrial production set to rise by around 9%. That's slower than the pace seen early in the recovery, but it should still lead to more construction and commodity use. Factory output slowed in China, however. HSBC's Chinese Manufacturing Purchasing Managers' Index dropped to 47.7, an 11-month low. It was down from a final result of 48.2 for June, with any reading below 50 indicating a contraction in activity

According to CAT, recovery from the financial crisis in 2009 has been very slow by historic standards. Governments and central banks have consistently overestimated inflation problems and underestimated the need for economic growth. The result has been continued high unemployment.

The Eurozone just completed its seventh quarter of recession, resulting in both the lowest construction and highest unemployment in the last 20 years. The Eurozone economy is weak, and CAT believes economic policies are insufficient to support improvements. The risk of a disruptive economic crisis, one that would impact growth in other countries, remains.

A closer look at the 98 companies we examined to determine our Top 50 reveals some important trends (Table 2). In almost all of the criteria we used, we saw a decline in performance versus last year's results. Given the many other challenges in the economy, these companies would do well merely to replicate fiscal 2013's results.

There are no more major downsizing opportunities. Costs are cut to the bone. Debt continues to be reduced. Sales are growing, but at the expense of margins. And, companies are doing what they can to continue their R&D investments. Until the consumer is in a better position with discretionary income to increase demand once again, global GDP will continue to merely sputter along. Some companies have shown extraordinary success despite these challenges, though, leaping up dozens of places on our list between 2012 and this year (Table 3).

TERADYNE SOARS 76 SLOTS

Teradyne leaped 76 slots from last year to land in a tie at twelfth place this year. It designs, develops, manufactures, and sells automatic test systems and solutions used to test semiconductors, wireless products, hard-disk drives, and circuit boards in consumer electronics, wireless, automotive, industrial, computing, communications, and aerospace and defense.

Its customer base includes integrated device manufacturers (IDMs), outsourced semiconductor assembly and test providers (OSATs), wafer foundries, fabless companies that design but contract with others for the manufacture of ICs, developers of wireless devices and consumer electronics, manufacturers of circuit boards, automotive suppliers, wireless product manufacturers, storage device manufacturers, and aerospace and military contractors.

Teradyne's first-quarter 2013 financial results were better than expected, with revenue and earnings coming in above guidance and consensus estimates. The company delivered 47% sequential order growth, driven by a 42% increase in semiconductor test and 322% increase in wireless test. Bookings in the first quarter of 2013 were \$400, of which \$259 million were in semiconductor test, \$109 million in wireless test, and \$32 million in systems test. Teradyne also raised its outlook for the second quarter of 2013.

"Design wins in LTE cellular test and 3.5-in. hard-disk drive test along with broader demand for semiconductor



With 68,000 employees, Whirlpool saw \$18 billion in sales in 2012, led by brands like its Jenn-Air line of elegant and energy-efficient line of kitchen appliances.

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SEAGATE TECHNOLOGY, WHICH rose 53 places in our list this year, is now shipping its Enterprise Turbo SSHD. According to the company, it is the world's fastest hard drive and the industry's first enterprise solid-state hard drive.

The Enterprise Turbo SSHD combines hard-drive capacity with solid-state flash to enable high-speed performance for mission-critical data, Seagate says. It also increases random performance by a factor of three compared to existing 15k-rpm drives and offers 600 Gbytes of capacity and 32 Gbytes of NAND in a 2.5-in. form factor, Seagate reports.

Seagate has been working with major OEMs to test the Enterprise Turbo SSHD over the past year. For example, IBM has introduced it as an option for its System x servers, which target small and medium businesses or distributed large enterprises. These hybrid drives combine a cache of NAND flash and conventional media to accelerate hard-disk drive (HDD) performance for higher I/O performance while leveraging the capacity and cost of spinning media for primary storage, IBM says.

test systems drove nearly a 50% uptick in company orders in the first quarter," said CEO Mike Bradley. "As expected, the test equipment market is on a steady recovery path driven by wireless and applications processor, power management, and microcontroller demand. With the substantial growth in orders, we've raised our second quarter revenue plan to meet the expanding capacity needs of our customers."

In October 2011, Teradyne acquired privately held LitePoint, a test equipment maker for wireless products, for around \$580 million in cash, to expand its product portfolio of test equipment in the wireless test sector. LitePoint designs, develops, and supports advanced wireless test solutions for developing and manufacturing wireless devices, including smart phones, tablets, notebooks, laptops, personal computer peripherals, and other Wi-Fi and cellular enabled devices.

LitePoint became Teradyne's wireless test segment. There are strong growth prospects for wireless test equipment due to the increasing penetration of mobile devices. LitePoint's product offerings and exposure to the higher-growth wireless arenas will allow this segment to substantially outgrow the overall test equipment market in the coming years.

First-quarter 2013 LitePoint bookings performance suggests that Teradyne could exceed its target of cellular test share gains. Wireless test new orders in the first quarter of 2013 were 27% of Teradyne's total new orders, while they represented only 9% of the new orders in the fourth quarter of 2012.

Teradyne's decision to acquire LitePoint appears to have been a smart strategic move that already has produced strong results, and it can expand Teradyne's total available market by more than \$1 billion. The world is moving toward mobile, wireless, and simple-to-use product platforms.

According to IDC, worldwide shipments of smart connected devices grew 29.1% year over year in 2012, and the entire market pushed past 1 billion units shipped, with a total market value of \$576.9 billion. Tablet sales grew 78.4% year over year in 2012 and are expected to pass desktop sales in 2013 and portable PCs in 2014.

According to semi.org, the North American semiconductor equipment industry posted a book-to-bill ratio of 1.08 in April. The North American book-to-bill ratio was below one in the second half of 2012, but since January 2013, it has been above one. Last quarter, Teradyne's book-to-bill ratio of 1.43 was significantly higher than the semiconductor equipment industry's average book-to-bill ratio.

Semiconductor and semiconductor equipment manufacturers have historically been highly cyclical, with periods of strong growth and high margins, which have caused companies to raise capital investment, and in effect causing excess supply followed by periods of weakness. The economic data and companies' comments all say essentially the same thing, which is that the semiconductor equipment industry has already passed through the bottom of the current cycle.

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The presentations by Apple CEO Tim Cook on May 28 and by Google executives at that company's developer conference on May 14 suggest that new Web applications will extend the computing environment to everyday devices like smart television, wearable computing, cars, light bulbs, and more. This development will increase the demand for semiconductor test equipment.

Teradyne also continued its strong performance in the second quarter of 2013, reporting a 53% sequential growth in sales. Additionally, the company delivered its sixteenth consecutive quarter of profitable operations with strong growth in its semiconductor and wireless test businesses, despite the rollercoaster of demand that characterizes most of its markets.

Bradley added that the seasonal pattern in the semiconductor test cycle gets some of the credit for the uplift so far this year, but the company also had good market share momentum in semiconductor test, both system-on-chip (SoC) and memory, as well as a strong first half showing from LitePoint. Semiconductor test orders grew 40% in the quarter driven by the mobile, power management, microcontroller, and memory test sectors. Wireless and systems test orders declined in the quarter as customers adjusted their capacity to market demand.

"Our momentum in SoC test is very good as we've registered back-to-back increases of nearly 40% in bookings through the first two quarters of the year," Bradley explained. "Wireless and power management continue as bright spots, coupled with a very strong surge in microcontroller and digital probe applications."

TABLE 3: MOST IMPROVED COMPANIES, 2011-2012

Category	Rise in the ranks
TERADYNE INC.	76
SEAGATE TECHNOLOGY PLC	53
INGERSOLL-RAND PLC	50
FORD MOTOR CO.	50
WHIRLPOOL CORP.	47

Teradyne introduced the new model of its J750 test system with higher frequency and pin count this year. It helped post the best J750 order rate in three years and the second highest quarterly total in more than eight years, with 4400 sold to date. The company has taken the system pin count up to over 2000, doubled the operating frequency, and added more features to shorten the time it takes customers to bring new

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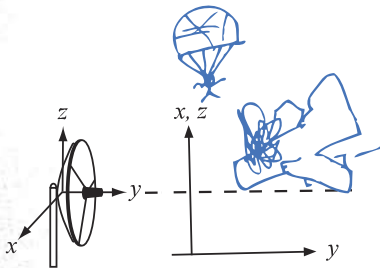
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TABLE 4: TOP 10 EOEM EMPLOYERS

Category	Fiscal 2012 OEM rank	Fiscal 2012 overall rank	Category
QUALCOMM INC.	1	1	Communications
CADENCE DESIGN SYSTEMS INC.	2	2	Test equipment
LSI CORP.	2	2	Components & subassemblies
NATIONAL INSTRUMENTS CORP.	4	8	Test equipment
MENTOR GRAPHICS CORP.	5	15	Test equipment
SYNOPSIS INC.	6	17	Test equipment
AGILENT TECHNOLOGIES INC.	7	29	Industrial controls
BROADCOM CORP.	7	29	Components & subassemblies
MAXIM INTEGRATED PRODUCTS INC.	9	40	Components & subassemblies
ANALOG DEVICES INC.	10	41	Components & subassemblies

chips to volume production. These new instruments and software features can be plugged into existing J750s so customers get the maximum leverage from their installed base.

Memory test has been another bright spot, with the six-month order total exceeding the 2012 yearly total. As performance requirements in NAND and DRAM increase, Teradyne is well positioned with the Magnum and the Ultra-FLEX M systems, and they should outgrow the market by a good bit this year.

As for LitePoint, orders for the first half were just under \$200 million, which is down from the \$230 million it saw last year. But keep in mind that sales more than doubled from 2011 to 2012 driven by record connectivity buying. There is a temporary lull in connectivity demand after the record year in 2012, as the market digests the large capacity adds. However, Teradyne now has an expanded addressable market going forward.

The wireless test market presents huge opportunities due to increasing product complexity, driving test times up, new standards obsoleting the installed base, and unit growth driving tester demand somewhat offset by the increasing productivity of new testers and more efficient test operations at its customers.

In 2012, dual-band Wi-Fi drove the market higher. This year, digestion of

last year's spending and improved efficiencies have reduced the market size. For next year and beyond, 802.11ac, multiple-input multiple-output (MIMO), LTE, and future standards will be more widely deployed and wireless unit growth will continue. LitePoint, with its production-optimized test solutions, should be a long-term winner in the growing wireless test market.

With new product rollouts, a strong R&D pipeline, and solid market share, Teradyne should continue to deliver positive results in the third quarter of 2013 and beyond.

WHIRLPOOL RISES 47 SLOTS

Whirlpool Corp. surged 47 places since last year's edition to climb to 28 on this year's list of the Top 50 Employers in Electronic Design. As a manufacturer and marketer of home appliances, it operates in North America, Latin America, the Europe, Middle East, and Africa (EMEA), and Asia. Its principal products include laundry appliances, refrigerators and freezers, cooking appliances, dishwashers, mixers, and other portable household appliances (see the figure). It also produces hermetic compressors for refrigeration systems.

The company produces its home appliances in North America and Latin America, with 65 manufacturing and

technology research centers around the world. Its brands include Whirlpool, Maytag, Kitchen Aid, Amana, Jenn-Air, Bauknecht, Brastemp, and Consul. With one of the strongest global brand portfolios in the consumer appliance industry, it has been improving since 2008 following the financial crisis and entered 2013 with strong momentum in sales and profits and a share price that has more than doubled in just two years.

The major appliance industry is one of the most competitive. It is volatile with demand driven by new home construction and consumer sentiment. It's sensitive to rising interest rates since refrigerator and range replacements can be deferred readily in economic slowdowns. Today, many tailwinds exist for Whirlpool. Housing starts are rising, but remain below the rate of family formation, suggesting they will continue to rise.

Consumer confidence is slowly increasing. So is employment. Interest rates are low, and while most observers think they eventually will rise, they also see no imminent risk of any drastic rise when the Federal Reserve has been clear that the low-interest-rate environment will persist for a while. Commodity prices for inputs like copper, aluminum, steel, plastic, and electronic components are relatively low and benefit the company's margins.

Earlier this year, the U.S. International Trade Commission ruled in favor of Whirlpool against Korean and Mexican

appliance exporters, Samsung, LG, Daewoo, and Electrolux were imposed duties anywhere from 11% to 151%, easing the competitive pricing pressure on Whirlpool. According to IBISWorld, revenues of appliance manufacturers have fallen by an average annual rate of around 5.2% since the housing decline began, while Whirlpool's sales have dropped from \$19.4 billion to \$18.1 billion in that time period, or an average annual decrease of just 1.3%.

However, Whirlpool did place first among all major appliance companies for customer satisfaction in the 2012 American Customer Satisfaction Index. The company has led or tied for first place each year since 1996. In the second quarter of 2013, Whirlpool also saw strong unit and revenue growth in every region, strong margin expansion, rising full-year earnings guidance, and strong underlying cash generation.

Net sales grew by 5%, gross margin was up 1.1 points, operating profit was up 69%, and operating margin was up 2.6 points. The operating margin improvement was mostly driven by cost and capacity reductions and somewhat driven by improved price/mix and higher productivity/lower materials costs.

The North American industry demand forecast for 2013 has been significantly adjusted up from 2% to 3% to 6% to 8%, as Whirlpool continues to see very positive trends in U.S. housing as well as a pickup in all segments of the market from

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a demand perspective. This is very encouraging as the company derives more than half of its sales from North America and about 15% of its sales through the “new install” channel from new housing installers.

In EMEA, the expectation is flat to -2%, downgraded from flat, as a weak demand environment continues across the Eurozone, although there is some optimism. While southern

Europe continues to lag, there are some positive trends in Germany, the Nordic countries, and the United Kingdom.

For Latin America, Whirlpool is forecasting lower but still positive industry growth for the year. Instead of 3% to 5%, the company is now seeing 1% to 3%. There is plenty of opportunity in Brazil as penetration levels are still low. Finally, Asia is forecast to be flat, down from a previous forecast of 3% to 5%. Given these changes, however, the overall global industry demand assumption has increased for the year.

Whirlpool is a top brand across all of its markets in unit sales and average sales price per unit. There is little cannibalization between its brands, and its higher-end and lower-end brands serve distinct markets. Its future growth is likely to target higher-end and higher-margin products, moving into markets previously the realm of appliance manufacturers such as Sub-Zero.

The company must continue to aggressively control raw material costs and pass through increases to customers to keep improving margins. The primary raw material inputs are steel, oil, plastics, resins, and other base metals, making up around two-thirds of operating expenses.


Since there is continual pressure from competitors such as LG, Samsung, Haier, Kenmore, Electrolux, Siemens, Daewoo, and GE, Whirlpool needs the best cost structure to win. It has segmented its brands into higher, mid-range, and lower-end, with cost structures to match, although the average price point is leaning to the higher end.

Whirlpool’s main opportunities continue in South America, where no compelling domestic brands exist, and in Asia, where there is stiff competition. With favorable trends in U.S. housing and growth opportunities in emerging markets and with continuing sales and profit growth, margin expansion, and strong cash generation, it will carry strong momentum into 2014. 


For profiles of Seagate Technology, Ingersoll-Rand, and Ford Motor Co., see the online version of this article at electronicedesign.com.

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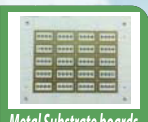
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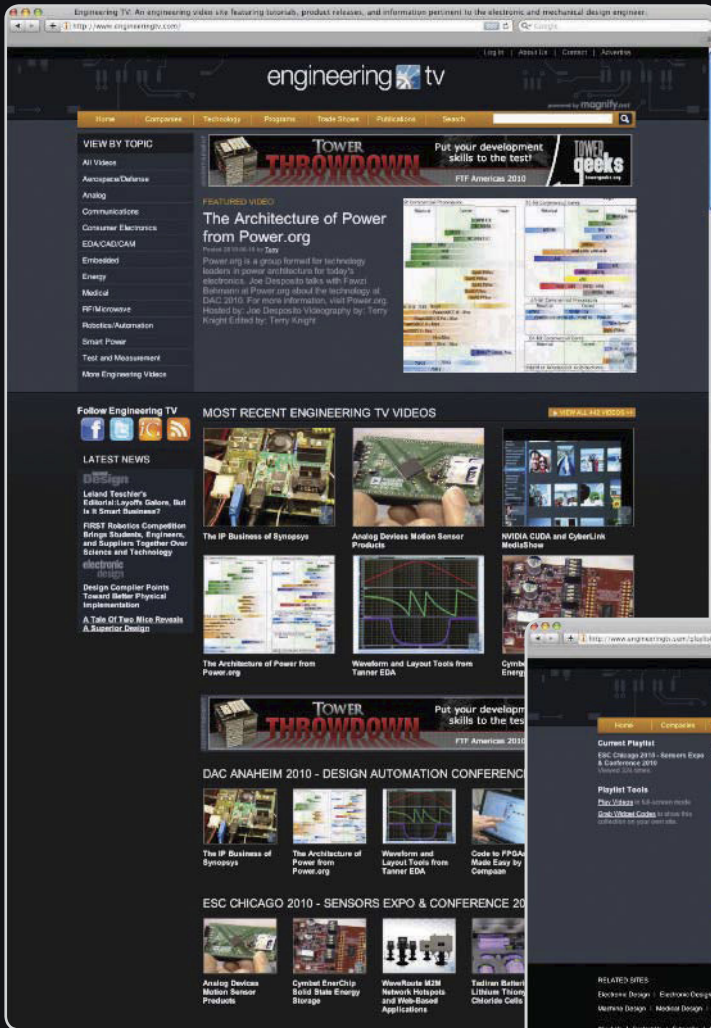
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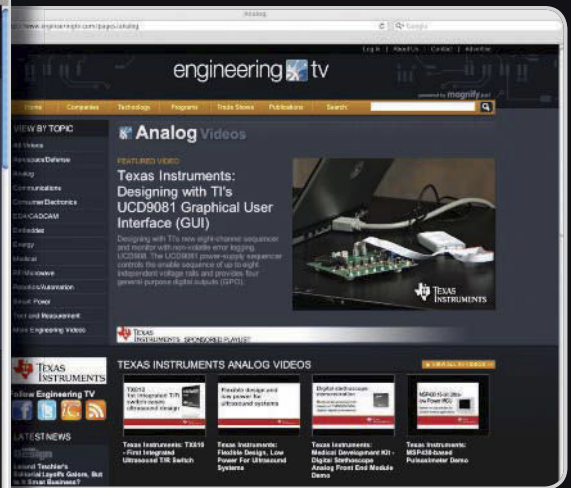





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MEMS

Microelectromechanical-systems (MEMS) designers are getting ready for the future as MEMS ICs proliferate across many disciplines and new applications loom. The industry is feverishly improving its processing, packaging, assembly, testing, and hardware and software designs to meet more demanding applications in the industrial, consumer electronics, automotive, medical and biomedical, building automation, and geophysical fields.

NOW IN DEVELOPMENT

To prepare for the next generation of MEMS devices, STMicroelectronics is working with research partners on a pilot line for 200-mm wafers under a project funded in part by European taxpayers. The 30-month, \$36 million LabMEMS project seeks to augment MEMS wafer fabrication with magnetic and piezoelectric materials as well as 3D packaging. It will eventually move to 300-mm wafers.

Magnetic and piezoelectric materials form the basis of advanced energy harvesting techniques that are gaining prominence in industrial and medical applications. The project will develop packaging technologies using flip-chip, through-silicon via (TSV), and through-mold via technologies, enabling the development of 3D integrated devices. The research aims to perfect a lead-zirconate-titanate (PZT) deposition process compatible with mass production and integrate it into established MEMS processes.

Researchers expect the development of innovative sensors, actuators, micro-pumps, and energy harvesters in system-on-chip (SoC) products that can meet the demands of future data-



1. Integrated Device Technology's piezoelectric MEMS resonator technology does not use crystals and enables the production of high-performance very low jitter MEMS oscillators. The CrystalFree pMEMS oscillators are aimed at communications, cloud computing, consumer, and industrial applications.

storage, ink-jet, healthcare, automotive, industrial-control, smart-building, and consumer electronics applications like smart phones and navigation devices. Piezoelectric and magnetic power sources are key elements in low-power energy harvesting technologies.

Last year, Integrated Device Technology (IDT) introduced a piezoelectric MEMS resonator that does not use crystals and enables the production of high-performance MEMS oscillators. The company's low-voltage positive emitter-coupled logic (LVPECL) 625-MHz CrystalFree pMEMS oscillators feature phase jitter well below 1 ps that suits high-performance communications, cloud computing, consumer, and industrial applications (Fig. 1).

S Technology Gears Up For Big Innovations

Processing, assembly, packaging, and testing disciplines are being honed to meet the demands of new materials and performance requirements across a very wide spectrum of applications.

STMicroelectronics and Invensense have made an inertial MEMS sensor available on multi-project wafers for development. Also, X-FAB is beginning production for a first lead customer of a product based on its open platform for three-axis accelerometers and gyroscopes that gives those MEMS chip makers more control in-house using their own ASICs or packaging technology.

An advanced initiative for MEMS ink-jet-based printing technologies is underway by Silex Microsystems, which has joined the European Nanoelectronics Initiative Advisory Council (ENIAC) project known as Processes for MEMS by Inkjet Enhanced Technologies (PROMINENT). It leverages the proven benefits of inkjet technologies to enable higher

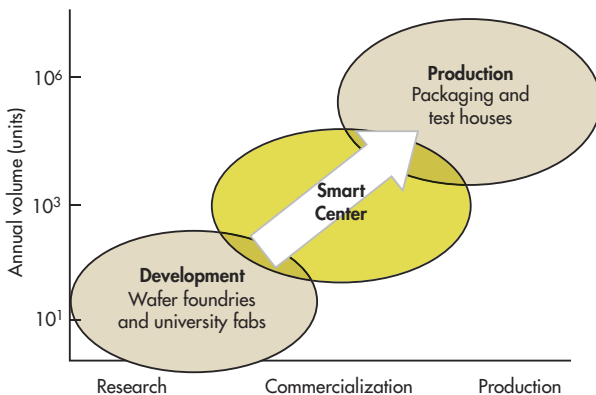
manufacturing efficiencies, increased production innovation, faster time-to-market, and lower costs throughout the entire manufacturing process. Silex's contributions include low-cost technologies for low-cost through-wafer vias, hermetic high-vacuum seals for wafer-to-wafer bonding including material deposition, advances in piezo-MEMS fabrication, and other functional materials processing.

Wafer-level packaging and 3D integration are two rapidly emerging trends in MEMS technology where the focus is on developing CMOS-compatible processes for monolithic integration using low-temperature wafer bonding and integrating external passive inductor, capacitor, and resistor elements. Another trend is die stacking in low-cost leadless packages to minimize chip size and meet smaller footprint requirements.

Using silicon interposers to interconnect vertically two or more die stacked in a 2.5D and 3D configuration is a key wafer-level packaging (WLP) challenge under intense investigation. Ultimately, the silicon chip may serve as the package itself, using metal pads for post-fabrication testing and application.

Sencio BV's nCapsulate freeform packaging approach offers complete freedom of shape for MEMS devices and cuts down on system assembly costs. The packaging method uses transfer molding with a thermosetting compound that delivers better isotropy and thermo-mechanical stability than the thermoplastics of standard injection molding technologies.

"Packaging, testing, and the manufacturing method are all highly dictated by the application for MEMS devices," explains Matt Apanius, director of the Richard Desich Smart Commercialization Center for Microsystems at Lorain County Community College (LCCC) in Elyria, Ohio, a MEMS foundry for packaging, assembly, and test on an accelerated time-to-market basis (Fig. 2).



2. Bringing MEMS technology packaging, assembly, and testing under one roof within a fabrication facility like the Smart Commercialization Center for Microsystems accelerates time-to-market and reduces development costs. (courtesy of the Richard Desich Smart Commercialization Center for Microsystems at Lorain Community College)

The LCCC Center develops manufacturable packaging integration solutions for customers developing next-generation micro-system products by leveraging leading-edge facilities and highly knowledgeable engineering teams. The State of Ohio Department of Development program, which aims to bring manufacturing facilities back to the state, many of which have gone overseas, generously funds it with the college.

“This is vital in applications like bio-MEMS where extremely small size MEMS pressure sensor ICs are required as in guided-wire cardiovascular catheterizations where catheters as small as 350 μm in diameter are used,” Apanius adds. The sensors are needed to determine the amount of stenosis, an abnormal narrowing in a blood vessel or other tubular organ or structure.

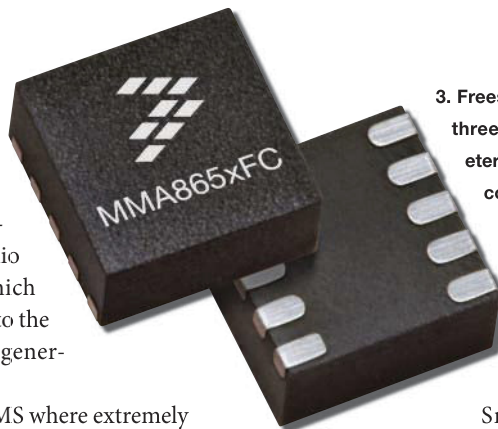
Microfluidic MEMS devices are being increasingly used in medical, pharmaceutical, life-sciences, and in-vitro diagnostic applications. This a growing market according to Yole Développement, which expects it to increase swiftly from \$1.4 billion this year to \$5.7 billion by 2018, an impressive 27% growth rate.

SF Fluidics in the U.S. is collaborating with Singapore’s A*STAR Institute of Microelectronics to develop a portable diagnostic tool to rapidly triage traumatic brain injury (TBI) victims. The microfluidic tool is a fully automated biosensor that requires only a drop of blood to detect up to three biomarkers released by the brain after an injury. TBI is one of the most common causes of death and disability in the world, resulting from blasts, falls, knocks, traffic accidents, and assaults.

INERTIAL SENSORS IMPROVING

Performance levels for MEMS accelerometers and gyroscopes are consistently getting better. Some MEMS sensors include the accelerometer and gyroscope in the same package. They’re seeing greater use in the automotive sector spurred on by the car safety systems now mandated by the government. These sensors provide inertial inputs to a car’s electronic stability control (ESC) system and can save a lot on packaging costs and space.

The MPU-6500 six-axis chip from Invensense combines a three-axis accelerometer and a three-axis gyroscope as well as an onboard digital motion processor in a 3- by 3- by 0.9-mm quad flat no-lead (QFN) package. It operates from 1.8 V and consumes only 6.1 mW in the full operating mode. The accelerometer features a typical offset of only ± 60 mg and 250 $\mu\text{g}/\sqrt{\text{Hz}}$ of noise, and it draws only 18 μA of current in the low-power mode. The gyroscope fea-



3. Freescale Semiconductor’s MMA865xxFC three-axis FC Xtrinsic MEMS accelerometer exemplifies a new generation of low-cost, small form-factor, power-thrifty, better noise-proof, and higher-resolution devices needed for future smart phones.

tures a $\pm 5^\circ/\text{s}$ zero-rate-output and 0.01 $^\circ/\text{s}/\sqrt{\text{Hz}}$ of noise.

Smart phones are one target for MEMS sensors like the Invensense MPU-6500.

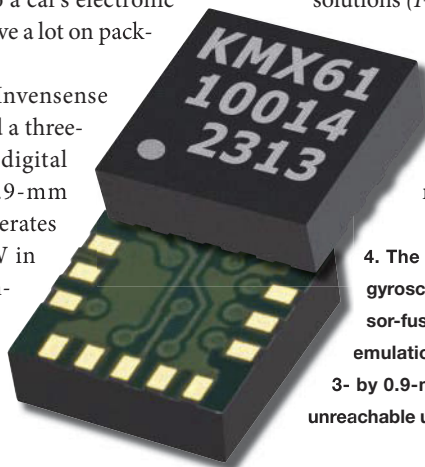
The chip also can be found in many other consumer electronics applications like tablets, gaming consoles, and navigation devices. Juniper Research expects smart phones to generate nearly \$8 billion in revenue by 2018.

Freescale Semiconductor is aiming at the exploding smart-phone market with its MMA865xxFC three-axis accelerometer, which exemplifies a new generation of small-form-factor, power-thrifty, better noise-proof and higher-resolution devices yet is lower in cost. In a 2- by 2-mm ultra-small package, the FC Xtrinsic accelerometer consumes just 7 μA of current, has 150- $\mu\text{g}/\sqrt{\text{Hz}}$ low noise, and boasts a sensitivity of 1 mg/LSB. It costs just 77 cents (U.S.) in large-volume lots (Fig. 3).

Smart-phone designers can now avail themselves of tunable RF MEMS digital variable capacitor ICs from Cavendish Kinetics for the front end of their designs to improve the quality and connectivity of wireless coverage between their phones and towers. They’re available in chip-scale packages (CSPs).

Many mobile devices can benefit from Kionix’s KMX61G six-axis MEMS accelerometer/gyroscope/magnetometer with leading proprietary sensor-fusion software that delivers highly accurate gyroscope emulation and draws a mere 550 μA of current in a 3- by 3- by 0.9-mm package. This dramatic reduction of power consumption versus conventional gyroscopes enables applications previously unreachable using traditional nine-axis solutions (Fig. 4).

“We see many applications in mobile devices that can benefit from gyroscope functionality but do not require the extreme performance of a traditional gyroscope. This magnetic gyroscope can meet these needs well while offering power,



4. The Kionix KMX61G six-axis MEMS accelerometer/gyroscope/magnetometer uses leading proprietary sensor-fusion software to deliver highly accurate gyroscope emulation and draws a mere 550 μA of current in a 3- by 3- by 0.9-mm package. It enables applications previously unreachable using traditional nine-axis solutions.

cost, and size benefits that are very attractive,” says Jeremie Bouchard, director and senior principal analyst at IHS Suppli.

To reduce the cost and increase the number of applications for magnetic sensing, MEMSIC introduced the MMC246xMT two-axis magnetic sensor. Provided in a miniature 2.0- by 2.0- by 1.0-mm land-grid array (LGA) package, it can operate from a single 1.8-V supply and offers the industry’s best performance at the lowest power consumption for a two-axis magnetic sensor, making it ideal for portable applications (Fig. 5). It’s designed for electronic compassing, in-vehicle GPS assist, GPS wristwatches, and industrial field measurements including traffic control and parking management.

The MMC246xMT is made using MEMSIC’s proprietary anisotropic magnetic resistive (AMR) technology to achieve its high performance. Operating over the range of ± 6 Gauss full scale, its full integration provides all of the necessary circuit functions to facilitate its design into systems while saving space,

reducing cost, and increasing reliability over currently available solutions that require external circuit elements.

The sensor also exhibits superior performance in critical electrical design parameters including dynamic range, accuracy over temperature, and power consumption. Its low noise of 0.8-mG total RMS and resolution of 0.25 mG per least significant bit (LSB) result in a more accurate heading determination with less averaging in addition to a bias error of less than ± 2 mG over the -40°C to 85°C temperature range.

The low operating current of 20 μA (in 14-bit mode) and 50 μA (in 16-bit mode) along with its less than 20 nA of current in the power-down mode also make it the most energy efficient two-axis magnetic sensor commercially available today, claims MEMSIC, extending battery life to accommodate the stringent power budgets demanded in portable applications.

Smart phones and tablets may use better displays derived from digital light processing (DLP) technology developed

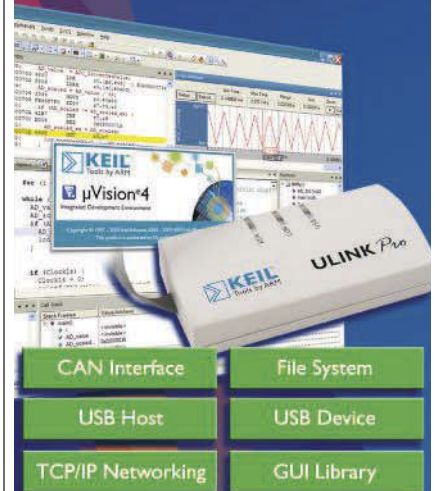


5. To reduce the cost and increase the number of applications for magnetic sensing, MEMSIC’s MMC246xMT two-axis magnetic sensor comes a miniature 2.0- by 2.0- by 1.0-mm LGA package. It operates from a single 1.8-V supply and offers the industry’s best performance at the lowest power consumption for a two-axis magnetic sensor, making it ideal for portable applications.

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by Texas Instruments (TI) that uses micro-mirrors. At last year's Society for Information Display (SID) Display Week in Canada, Qualcomm showed off its Mirasol MEMS-based display technology with a 5.1-in. diameter display. Mirasol uses ambient light and MEMS to create small air gaps. As their size changes, the light color passing through the air gaps is manipulated.

The company says Mirasol displays may show up in small-screen consumer devices with displays of 1.5 in. in diameter like cell phones and watches this year. Qualcomm appears to have overcome some of the obstacles of the Mirasol technology to achieving larger-size and higher-resolution displays.

Mirasol boasts very low power dissipation, up to six times less than conventional LCDs and organic LED (OLED) displays, and very high-resolution color. The demo at the SID event showed great resolution of 2564 by 1440 pixels with a pixel density of 577 pixels/in. The Samsung Galaxy 4S smart phone has a comparative resolution of just 440 pixels/in. and a resolution of 1920 by 1080 pixels. Could this be the next display for the potential Apple iWatch?

TI also is actively looking into applications for its MEMS DLP technology beyond projection products. "Engineers have been trying to rip apart projectors to use the DLP for their new ideas, so we formed a product line around these interests," says Gina Park, TI's product line manager. For example, a doctor in Europe has used DLP to create a photolithography tool to protect the skin of psoriasis patients from damaging ultraviolet (UV)

rays by focusing the UV treatment light only onto the infected areas.

TI sees many promising applications, such as 3D printing for making precision molds for hearing aids and jewelry as well as dental scanning to map a tooth or make a crown mold. There's also 3D machine vision for fast and precise industrial inspection and measurement. According to TI, commercialization into these areas involves optimizing the window for UV transmission and enhancing the DLP control software.

INDUSTRIAL AND BUILDING AUTOMATION

The industrial sector is ready to make wider use of MEMS devices, which offer reliability, scalability, sensitivity, and cost-effective solutions. MEMS-based sensors and actuators have experienced a slow yet steady growth in industrial automation to measure and control pressure, flow, level, temperature, vibration, acceleration, tilt, and other functions.

As the industrial arena moves toward intelligent, distributed, and wireless monitoring and control, MEMS technology will likely play an increasingly vital role. Recognizing this, Analog Devices has introduced the ADIS 16229 iSensor wireless vibration MEMS sensor node. It combines dual-axis digital MEMS acceleration sensing with advanced frequency- and time-domain signal processing.

"The primary driver of predictive maintenance is the reduction of factory system downtime, which currently relies on periodic offline performance trend analysis," says Bob Scannell, Analog Devices' iSensor business development manager, MEMS/Sensors Group. "With MEMS-based vibration sensors that continuously monitor machine tools, turbines, pumps, conveyors, compressors, engines, and other equipment, factory operators receive real-time statistical performance data and process control feedback that allow them to prevent costly system shutdowns."

Omron recently introduced a non-contact D6T MEMS thermal sensor that

MORE MEMS

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6. Omron's non-contact D6T MEMS sensor offers high noise immunity. It is more reliable than conventional pyroelectric, IR, and passive IR sensors used in industrial, building, and home automation applications.

can reliably detect the presence of people without needing them, aimed at creating advanced new energy appliances for the home, building automation, and factory automation applications (Fig. 6). It offers $\pm 1.5^\circ\text{C}$ accuracy and 140-mK noise immunity (measured as equivalent temperature difference).


According to Omron, the D6T is more reliable than conventional pyroelectric, infrared (IR), and passive IR (PIR) sensors used in industrial, building, and home automation applications. It uses a MEMS micro-mirror structure for efficient IR radiation detection with a high-performance silicon lens to focus the IR rays onto thermopiles. Proprietary ASICs make the necessary computations and convert sensor signals into digital ones for output to an I²C bus.

Relative sensing and temperature are two important measurement and control parameters in today's industrial environments. The MVH300D series of digital relative humidity and sensing chips from MEMS Vision offers a combination of high-performance features. The company capitalizes on its expertise

in MEMS and ASICs and on its revolutionary MoSiC platform to offer a range of environmental sensing products and advanced MEMS-based solutions.

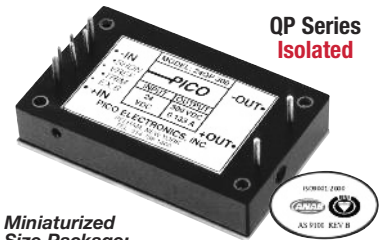
The series boasts $\pm 1.5\%$ relative humidity accuracy (the MVH3001D), superior ruggedness, reliability, and durability, thanks to silicon-carbide (SiC) technology. It also offers a rapid response time of 6 s typical, small package size of just 2.4 by 3 by 0.8 mm, and extremely low power consumption of 2 μW for each relative humidity and temperature measurement/s (at 1.8 V and 8-bit resolution). Temperature measurement accuracy is guaranteed to be within $\pm 0.2^\circ\text{C}$ to $\pm 0.3^\circ\text{C}$.

SUMMARY

There's plenty of room for MEMS technology to grow, but many sensor types need time to mature and become more widespread. Roger Grace of Roger Grace Associates points out that more improvements are needed in "design for manufacturing and research and development, two efforts that are ongoing." There's also a need for better marketing efforts and greater venture capital funding. 

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Understanding Delta-Sigma Modulators

Specific equations can help designers quantify the various improvements that delta-sigma modulators can provide.

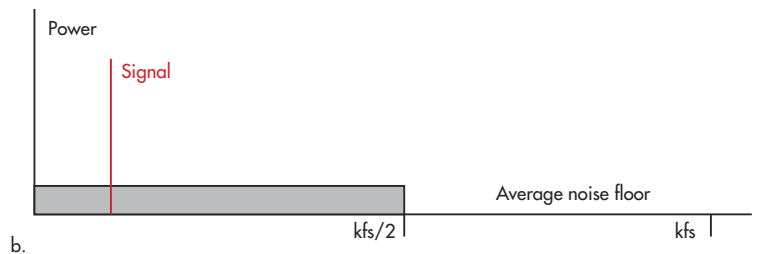
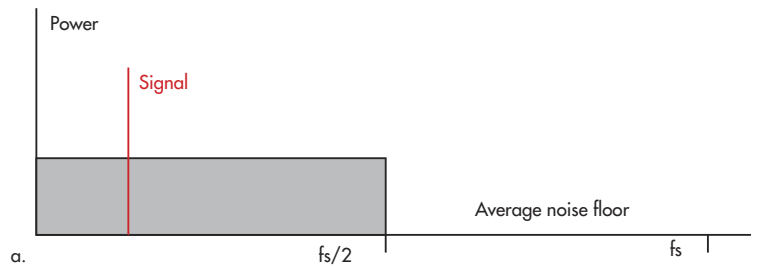
Delta-sigma analog-to-digital converters (ADCs) are fascinating—almost mythical in their ability to support low- to medium-speed and high-resolution applications. They take advantage of the speed of analog circuits, along with the robustness of digital circuits. They also reduce the amount of analog circuitry used in the converter. More importantly, the analog parts of the circuit don't need to be very accurate. Of course, the digital blocks then must work at higher sampling clocks and, thus, consume more power.

DELTA-SIGMA MODULATORS

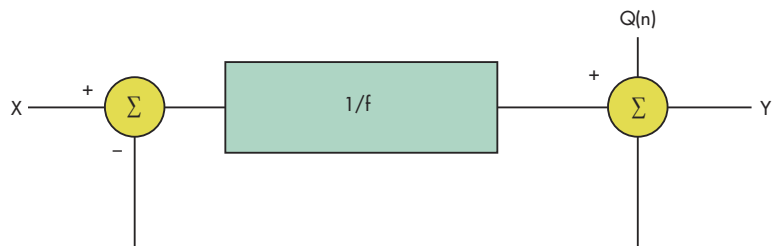
A delta-sigma ADC generally comprises a delta-sigma modulator, followed by a decimation filter. Delta-sigma modulation is one of the most effective forms of conversion in the data converter world. Its applications include communication systems, professional audio, and precision measurements.

The goal of delta-sigma modulation is to achieve higher transmission efficiency by transmitting only the changes (delta) in value between consecutive samples, rather than the actual samples themselves. ADCs and digital-to-analog converters (DACs) both can use delta-sigma modulation.

Oversampling reduces the effect of noise within the signal bandwidth of interest, benefiting the delta-sigma ADC's analog operation. Next, noise shaping pushes the noise out of signal bandwidth. Digital operation then filters out the noise that's out of the band of interest. Finally, this digital filter decimates or down-samples the data. Before considering the modulator



1. A hypothetical delta-sigma spectrum of signal components in a delta-sigma converter includes what its average noise floor looks like when it is sampled at an arbitrary sampling frequency: f_s (where $f_s > 2f_o$, i.e., greater than Nyquist) (a). With the sampling frequency increased by a factor, k , the noise energy is distributed over a wider range of frequencies (b).



2. To achieve noise shaping, the output signal, Y , is fed back and summed with the input signal, X . The result is then fed to an amplifier block with gain of $1/f$, the output of which summed with the signal $Q(n)$.

itself, though, it's necessary to become familiar with a few concepts that play a significant role in converters: quantization noise, oversampling, and noise shaping.

QUANTIZATION NOISE

In an ADC, the quantized signal can be described as the input signal plus quantization noise:

$$V_{\text{Quantized}} = V_{\text{In}} + \varepsilon \quad (1)$$

$V_{\text{Quantized}}$ and V_{In} are, respectively, the quantized signal and the input signal; ε is the error associated with this process, or the difference between the input and output of the quantizer.

The converter's full range divided by the number of its quantization levels defines its least significant bit (LSB). An N -bit converter has 2^N levels of quantization. Therefore, the width of any of these quantization levels is $FS/(2^N - 1)$. For an ADC with a quantization width of Δ , the quantization noise has equal probability of falling anywhere between $-\Delta/2$ and $+\Delta/2$ and a probability density function that is uniform over the range of quantization error. The quantization noise power can be calculated by integrating the error over this range as in:

$$\varepsilon_{\text{rms}}^2 = \frac{1}{\Delta} \int_{-\Delta/2}^{+\Delta/2} \varepsilon^2 d\varepsilon = \frac{1}{\Delta} \frac{\varepsilon^3}{3} \Big|_{-\Delta/2}^{+\Delta/2} = \frac{\Delta^2}{12} \quad (2)$$

which describes the noise power in terms of LSB width. However, it can be rewritten to express it in terms of number of bits and full scale:

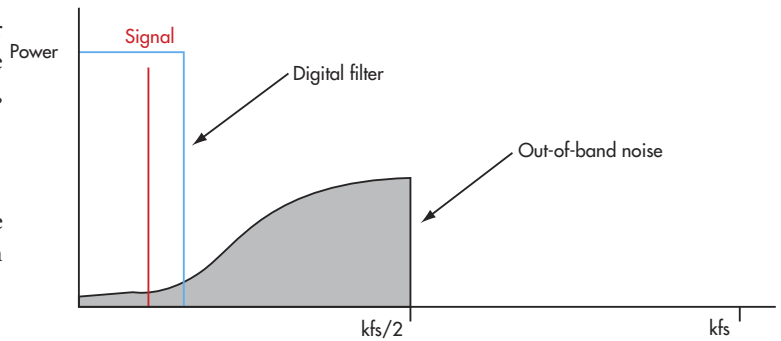
$$\varepsilon_{\text{rms}}^2 = \frac{\Delta^2}{12} \approx \frac{FS^2}{3 \cdot 2^{2N}} \quad (3)$$

OVERSAMPLING

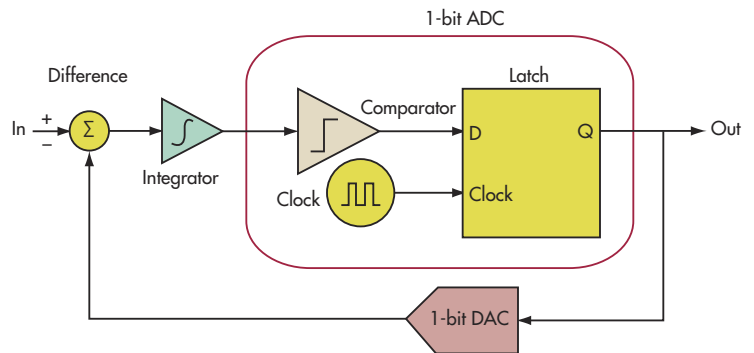
In general, the signals can be sampled with a frequency that is much greater than the Nyquist frequency. The ratio of sampling frequency (f_s) to Nyquist frequency ($2f_0$) is called an oversampling ratio (OSR), where f_0 is the frequency of the input signal. So, OSR can be written as:

$$OSR = \frac{f_{\text{OS}}}{2f_0} \quad (4)$$

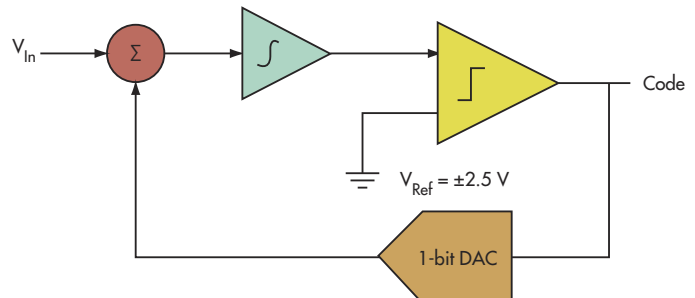
Under oversampled conditions, the noise power that falls within the signal bandwidth (0



3. Following noise shaping, a digital filter removes most of the noise. Filtering can be performed in the digital or analog domain. In this case, the modulator is emitting a bit stream, so a digital filter is appropriate. Because the oversampling factor was k , noise is pushed out to higher frequencies. By filtering at $fs/2$, most of the noise will be out of band.



4. In a typical first-order modulator, the input signal is sent to a difference block where the feedback signal is being subtracted from it. The resulting signal is sent to an integrator and the comparator acts on the integrator's output. The comparator compares a reference voltage with the integrator's output and generates a "high" or "low," accordingly. In turn, the sub-DAC uses the output of the sub-ADC and generates one of the two available reference voltages. This reference voltage is passed to the difference block to be subtracted from the input again. This feedback forces the DAC's output average to be equal to the input signal. The DAC's output is an analog representation of its input, which is the modulator's output.



5. In a conceptual diagram for a first-order modulator, the input voltage to the modulator is 1 V, and the DAC V_{Ref} s are ± 2.5 V. The table shows how the voltages are calculated and passed around within the modulator to create the resulting bit stream.

to f_O) is given by:

$$n^2 = \int_0^{f_O} \epsilon^2(f) df = \epsilon_{rms}^2 \left(\frac{2f_O}{f_{OS}} \right) = \frac{\epsilon_{rms}^2}{OSR} \quad (5)$$

As the equation illustrates, oversampling reduces the in-band rms noise by the square root of the oversampling ratio (Fig. 1). The reduction is quantified in:

$$n = \epsilon_{rms} \left(\frac{2f_O}{f_{OS}} \right)^{\frac{1}{2}} = \frac{\epsilon_{rms}}{\sqrt{OSR}} \quad (6)$$

OVERSAMPLING’S EFFECT ON NOISE

While oversampling the input to the converter reduces noise, this reduction is even greater for delta-sigma modulators. In fact, higher-order modulators can further decrease noise.¹ The general formula for calculating the noise of a modulator with an order of L and OSR of M is given by:

$$n = \epsilon_{rms} \left(\frac{\pi^L}{\sqrt{2L+1}} \right) \left(\frac{1}{M} \right)^{L+\frac{1}{2}} \quad (7)$$

Note that Equation 6 could be obtained from Equation 7 for the case in which no delta-sigma modulation is used. In that case, the order of modulation would be considered zero.

NOISE SHAPING

By oversampling, the noise spectrum is distributed over a wider frequency range. The next step in a sigma-delta is shaping the noise and pushing most of the noise spectrum to higher frequencies so the in-band noise is reduced significantly. This concept is called noise shaping (Fig. 2). This simple feedback system can be represented by:

$$Y = (X - Y) * \frac{1}{f} + Q(n) \quad (8)$$

$$Y = \frac{X}{1+f} + \frac{Q(n)*f}{1+f} \quad (9)$$

Note that in Equation 9, as frequency approaches zero, Y approaches input component X. As the frequency increases, the first term (with the input signal component) approaches zero, and the output approaches Q(n). In other words, at high frequencies, the output consists mostly of quantization noise. Overall, it seems as if a low-pass filter is acting on the signal in the forward path and a high-pass filter is acting on noise in the feedback path. Noise shaping has been achieved! After that, all that needs to be done is to filter out the noise at high frequencies (Fig. 3).

HOW THE MODULATOR WORKS

A first-order delta-sigma modulator comprises an integrator, a comparator that acts as a sub-ADC, and a sub-DAC (Fig. 4). The sub-DAC can be as simple as a multiplexer that switches between two reference voltages. Latch operation is usually embedded in the comparator.

OVERSAMPLING’S EFFECT ON SNR

Oversampling improves signal-to-noise ratio (SNR). When noise power is reduced, an increase in SNR is expected. From a quantitative point of view, starting with the quantization noise for non-oversampled converters obtained by Equation 2, the theoretical SNR value for quantized noise is expressed by the ratio of input signal to noise signal:

$$SNR = 20 \log \left(\frac{V_{In}(rms)}{V_{Noise}(rms)} \right) = 20 \log \left(\frac{V_{Ref} (2\sqrt{2})}{\Delta / \sqrt{12}} \right) \quad (10)$$

$$SNR = 20 \log \left(\sqrt{\frac{3}{2}} * 2^N \right) = 6.02N + 1.76 \text{ dB} \quad (11)$$

where N is the number of bits in the converter. Equation 6 expresses the noise power for an oversampled converter. Using Equations 6 and 10, the SNR for a converter with an oversampling ratio of OSR could be calculated as:

$$SNR = 10 \log \left(\sqrt{\frac{3}{2}} * 2^{2N} \right) + 10 \log(OSR)$$

$$SNR = 6.02N + 1.76 \text{ dB} + 10 \log(OSR)$$

lets (12)

$$OSR = 2^M$$

$$M = 1, 2, 3 \dots$$

$$SNR = 6.02N + 1.76 \text{ dB} + 10 \log 2^M$$

$$SNR = 6.02N + 1.76 \text{ dB} + m \cdot 3 \text{ dB}$$

SNR improves by 3 dB, or 0.5 bit, each time the sampling frequency is doubled. For example, a 16-bit converter has a theoretical value for SNR of about 98 dB. But with an oversampling ratio of 8, the SNR is increased to 107 dB for an increase of 3 dB/octave, or 9 dB in total.

EFFECT OF HIGHER-ORDER MODULATORS ON SNR

Using higher-order modules, delta-sigma will further improve SNR. A second-order modulator improves SNR by 15 dB for each doubling of oversampling ratio. The improvement that is achieved for each doubling of oversampling ratio generally can be calculated from:

$$3(2L + 1) \text{dB} \quad (13)$$

VOLTAGE CALCULATIONS

$V_{in} = 1$	Summing node	Integrator V_o	Comparator	DAC
	1	1	H	2.5
	$1 - (2.5) = -1.5$	$1 + (-1.5) = -0.5$	L	-2.5
	$1 - (-2.5) = 3.5$	$(-0.5) + 3.5 = 3$	H	2.5
	$1 - (2.5) = -1.5$	$3 + (-1.5) = 1.5$	H	2.5
	$1 - (2.5) = -1.5$	$1.5 + (-1.5) = 0$	H	2.5
	$1 - (2.5) = -1.5$	$0 + (-1.5) = -1.5$	L	-2.5
	$1 - (-2.5) = 3.5$	$(-1.5) + 3.5 = 2$	H	2.5
	$1 - (2.5) = -1.5$	$2 + (-1.5) = 0.5$	H	2.5

hard to visualize and check the correctness of the digitized input signal at its output (Fig. 5 and table). For example, code 10111011 is obtained by reading the comparator's output for each comparison. The full scale in this example is $(2.5 - (-2.5)) = 5$ V.

On a 5-V scale, since the lower reference is sitting at -2.5 V, a 1-V signal will be 3.5 V above the lower reference. This is 0.7 of the full scale ($3.5/5 = 0.7$). The resulting code (HLHHHLHH or 10111011) has six highs and two lows, so six out of eight of the bit-stream codes

for each doubling of OSR. Equation 13 also shows that for a first-order modulator (where $L = 1$), there is a 9-dB improvement for every oversampling ratio of two. For a second-order modulator ($L = 2$) with the same OSR, this improvement increases to 15 dB—that is, there is a 6-dB improvement for each additional order of modulator.

HIGHER-ORDER MODULATORS

Since the modulator's output is a digital bit stream, it is

are high. Thus, the average value is $6/8 = 0.75$. This average value is close to the actual value of the input (0.7).

If one continues the operation and obtains more bits for the table, the average value gets closer and closer to 0.7. For this type of modulator, it is understood that for values that are closer to $+V_{Ref}$ the modulator generates more highs. For input values that are closer to $-V_{Ref}$ the modulator generates more lows. A typical sine-wave input generates a code that has more highs or lows at its two peaks. As the input gets closer to

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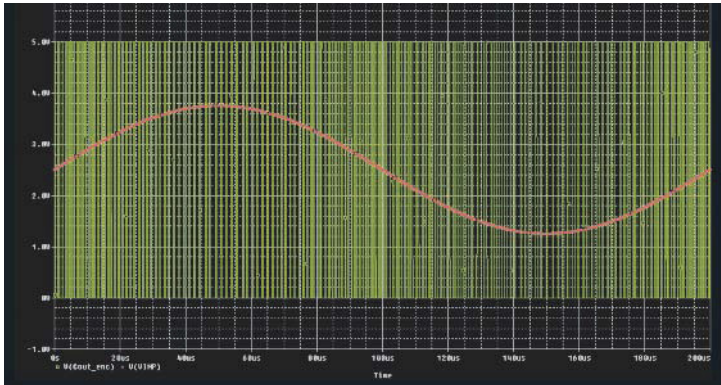
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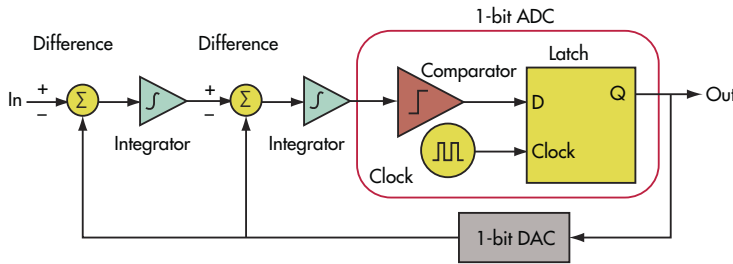
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6. The A sine wave and the resulting bit-stream out of the first-order modulator show the various density of ones and zeros.



the mid-range, on average, the resulting number of ones and zeros becomes comparable (Fig. 6). Typically, the modulator takes an order that is greater than one (Fig. 7).

The bit stream output by the model of a sixth-order modulator is followed by a decimation filter to form a 24-bit delta-sigma ADC, resulting in this output. Again, as the input amplitude is increased, the modulator generates more ones and, moving toward the lowest voltage of the input, more zeros (Fig. 8).

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2. "A Sigma-Delta Modulator as an A/D Converter," R.J. Van de Plassche, IEEE Transactions on Circuits and Systems, Vol. CAS-25, July 1978, pp. 510-514.
3. "Principles of Oversampling A/D Conversion," Max W. Hauser, Journal Audio Engineering Society, Vol. 39, No. 1/2, January/February 1991, pp. 3-26.

7. The order of modulator dictates the order of filter that follows. Generally, the order of the filter is equal to the order of modulator, plus one.

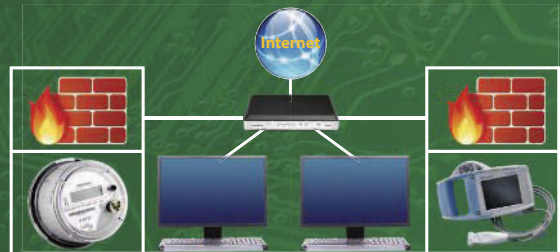


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Stateful packet inspection	Yes	Yes	Yes
Port, protocol and address limits	15 ports, 10 protocols, 10 IP addresses & 10 MAC addresses	100 ports, 100 protocols, 100 IP addresses & 100 MAC addresses	100 ports, 100 protocols, 100 IP addresses & 100 MAC addresses
Threshold-based filtering	No	No	Yes

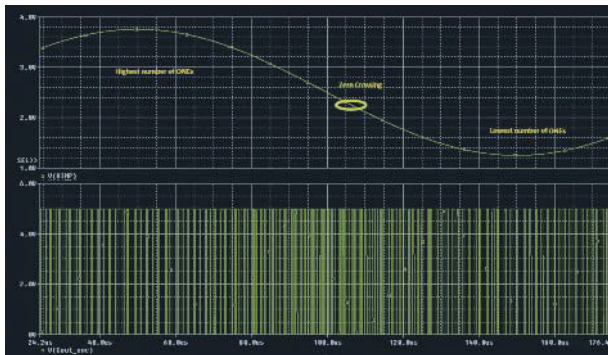
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EZ80F91GAZ0CEG	Standard	256 KB	16KB	-40°C to 105°C	144-pin LQFP
ZGATE000100ZCOG	ZGATE Embedded Security Development Kit				



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8. The bit stream output by the model of a sixth-order modulator is followed by a decimation filter to form a 24-bit delta-sigma ADC, resulting in this output. Again, as the input amplitude is increased, the modulator generates more ones, and, moving toward the lowest voltage of the input, more zeros.

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 8. "Low power Decimation Filter Architectures for Σ - Δ ADCs," Özge Gürsoy, Orkun Saglamdemir, Mustafa Aktan, Selçuk Talay, Günhan Dündar
 9. For more information on data converters, visit www.ti.com/dataconverters-ca.



ARASH LOOEE is a Member of TI's Group Technical Staff. As Senior IC Design Engineer, he is responsible for designing transistor- to system-level projects. He received his PhD in EE and MSEE from Southern Methodist University and his BS in physics from the University of North Texas. He also was a lecturer at the University of Texas at Dallas from 2005 to 2011, where he taught various analog-related topics. He has three patents, with one pending.

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Semblant's Steve McClure Explains Conformal Coatings

Semblant's PlasmaShield plasma conformal coating technology can prevent solids and liquids from coming in contact with electronics. It can protect the electronics from damaging vapors, moisture, pollutant gasses, and salts as well. PlasmaShield also plays a role in the fight against tin whiskers, which can arise while using the tin-based solder that has replaced the more toxic lead-based solder, thanks to the European Union's Restrictions on Hazardous Substances (RoHS). Tin whiskers can cause shorts and other problems, presenting a major issue for military and avionics projects as they move to RoHS parts. Steve McClure, Semblant's vice president of worldwide sales and marketing, recently explained PlasmaShield and conformal coating technology.

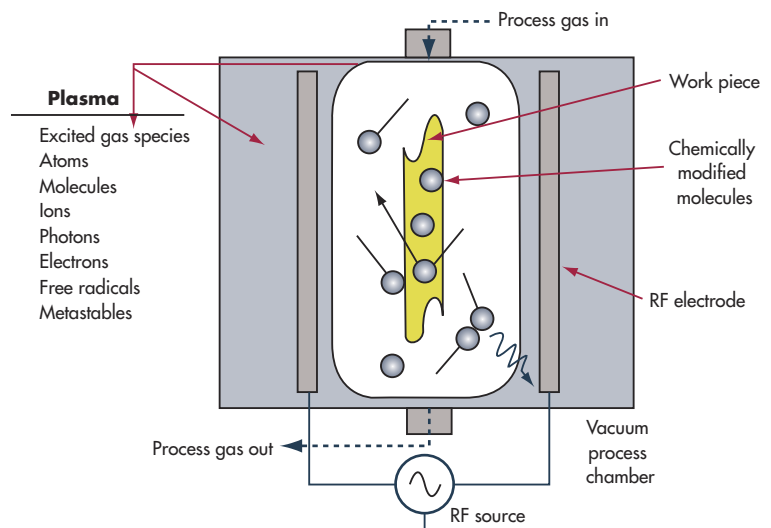
WONG: What new advances are available for conformal coatings?

MCCLURE: A new class of conformal coat has been developed using a low-power plasma chamber and depositing an ultra-thin polymer coating. The types of materials that can be deposited using this method range from acrylics to silicones and fluoropolymers. Plasma deposition is a simple, one-step process that can be used to apply a thin, uniform film as a true conformal coating that requires no curing or the use of any solvents. In some cases, this can also remove the requirement for masking contacts and connectors, eliminating a labor- and time-intensive step from the conformal coating process.

Plasma-deposited conformal coating from Semblant now allows products to be coated that could not be coated before. Our advanced materials and material deposition process provides the

protection against harmful liquids and gasses with an economic manufacturing process.

Electronics to be coated are placed into a plasma-deposition RF vacuum chamber that operates at room temperature.



WONG: Should electronics manufacturers still consider conformal coating as part of the final electronics design process?

MCCLURE: Yes, but now with plasma deposition, the design rule and “keep-out” requirements of traditional conformal coats can be reduced or eliminated. This provides increased design flexibility and can provide more compact and simplified product design. Without conformal coatings, many electronics would not survive initial field deployment and would succumb to the harsh environments they must survive. Alternatives to conformal coats would be expensive, complex mechanical housings or hermetic seals. Often these would be cost prohibitive or limit the size of the market a product can

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PORTABLE RADARS Bring Surveillance Where Needed

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RADAR MADE SMALLER isn't a slogan for SpotterRF (www.spotterrf.com), although it certainly could be. This innovative company has developed a number of compact radar systems that can literally be hauled around in a backpack—then set up in minutes to establish a surveillance barrier around any desired perimeter. This small but technologically agile firm is bringing radar technology to a wider group of users (spanning commercial, military, and industrial markets) than ever before.

Control and access are enabled through a standard laptop computer, tablet, or smartphone, and with the low-power

radar system running on a rechargeable battery. Whether a SpotterRF radar system becomes a standard part of a residence's surveillance/security system has yet to be seen but, for small forces needing agility and looking for an electronic edge, these portable radar systems are quickly becoming more necessity than accessory.

SpotterRF has been issued patent No. 7755533 for its technology—specifically, for the use of a switched-beam radar device to measure the three-dimensional (3D) position of an object without need of more expensive phased-array antennas (see *Microwaves & RF*, June 2013, p. 43;

(continued on p. 26)

TEAMWORK YIELDS ASIC Flight Control Computer

A COLLABORATIVE EFFORT between aircraft manufacturer Airbus (www.airbus.com) and device manufacturer ON Semiconductor (www.onsemi.com) has led to the development of a complex Application Specific Integrated Circuit (ASIC) for the A350 XWB Flight Control Computer. The custom silicon device, code-named JEKYLL, was designed using ON Semiconductor's internal 110-nm semiconductor process technology and manufactured at the firm's Gresham, OR facility. The project represents a successful collaboration that extends from the feasibility stage to the delivery of first-time-right prototype ASICs and on-time transfer of the prototype design to full production.

Suitable for flight-critical aerospace applications, the ASIC was designed in compliance with D0-254 aerospace needs and to meet Airbus' demanding reliability requirements. The device provides optimized performance for the Flight Control Primary Computer on the A350 XWB. According to Vince Hopkin, Vice President of ON Semiconductor Mil/Aero, Digital, Foundry, IPD, and Image Sensor products division, "This successful complex ASIC development is the result of a strong and detailed collaboration between Airbus and ON Semiconductor, and

(continued on p. 8)



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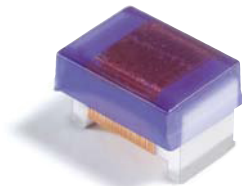
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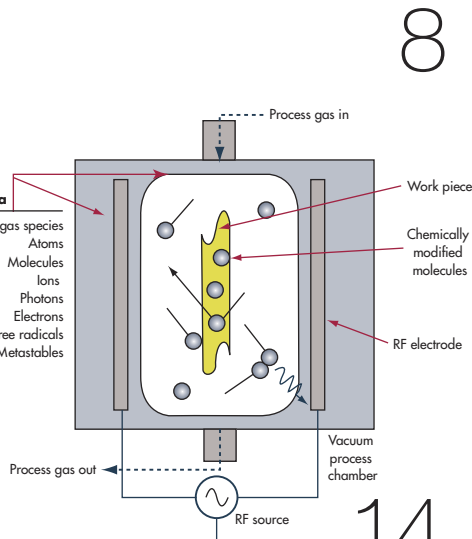
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Surveillance By Remote Control

DRONES ARE playing an increasingly prominent role in modern warfare. All one needs for proof is to observe the growing sophistication of miniature unmanned aerial vehicles (UAVs), and how more and more organizations—including police departments—are considering their use for general law-keeping and surveillance functions.

The United States' Defense Advanced Research Projects Agency (DARPA; www.darpa.mil), has marked the significance of robotics for warfare by inviting research and development firms to partake in the DARPA Robotics Challenge (DRC; www.theroboticschallenge.org). The primary technical goal of the DRC is the development of ground robots capable of completing complex tasks in areas or environ-

ments that might be too dangerous for human beings. DARPA is encouraging widespread participation in the DRC, soliciting universities; small, medium, and large businesses; and even individuals who might be willing to contribute.

Some of the advances sought by DARPA relate to the robots and some to the operators. Improvements in robotic technology will be judged by such parameters as mobility, dexterity, strength, and platform endurance. But the success of this competition will also depend on the effective control of the robot by inexperienced operators and under less-than-ideal conditions.

Sophisticated robots provide an alternative to the use of humans in battlefield and other hostile environments. DARPA

has been a long-time proponent of the potential for intelligent robots—machines that are not only capable of following the commands of a human controller, but also of making decisions when necessary. Given the computing power of available microprocessor chips, operating programs capable of performing rudimentary decision making can readily be installed within the control centers of new intelligent robot designs.

Because of the amount of data that can be captured by remote surveillance, by means of UGVs or UAVs, shifting decision making from a human operator to a machine is not inconceivable in the near future. DARPA's interest in improving drones and video surveillance is nominally to avoid the misidentification errors that lead to fatalities on the wrong side. If decision-making on the part of those drones can be applied to help avoid costly mistakes, then these investments in robotics technology will be well worth it. **de**

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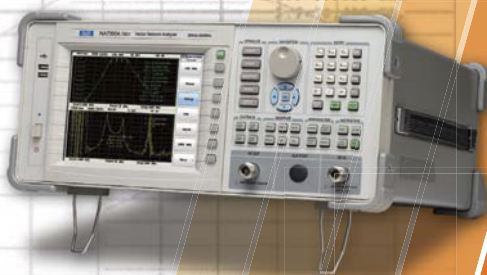
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(continued from p. 1)

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PHOENIX PARTNERS WITH ECM ON CONNECTORS

The Phoenix Company of Chicago has appointed East Coast Microwave (ECM) Distributors, Inc. (www.ECMstockroom.com) as its authorized global franchised distributor for its lines of RF/microwave connectors and contacts. ECM brings 25 years of experience as a stocking distributor, in addition to extensive knowledge of high-frequency connectors and contacts.

According to Michael Machura, Chief Executive Officer of Phoenix, "Partnering with ECM allows us to serve our customers more efficiently by providing high quality, technology-driven components directly from ECM's StockRoom."

ECM's President and CEO, James Doyle, adds: "Our long-term strategy has always been to provide superior customer service to our customers and to continuously improve our customers' experience by working side by side with best-in-class manufacturers in the RF and microwave industry. The relationship between ECM and Phoenix truly allows us to combine our companies' strengths, which will greatly benefit our existing customers and new ones in the future." ■



Sensor System Guides Helicopter Pilots

HELICOPTER PILOTS received some guidance, in the form of the HeliSure products from Rockwell Collins (www.rockwellcollins.com). The product line includes the Helicopter Synthetic Vision System (H-SVS) and Helicopter Terrain Awareness and Warning System (H-TAWS). Introduced at the Paris Air Show earlier this year, these sensor-fueled systems provide helicopter pilots with situational awareness in congested and hazard-filled airspaces, supplying sensor data in real time through an intuitive user interface with three-dimensional (3D) visualization for quick and easy processing.

As noted by Phil Jasper, Executive Vice President and Chief Operating Officer, Government Systems, for Rockwell Collins,

"With the introduction of HeliSure, Rockwell Collins is the only company offering a completely unique portfolio of products combining visualization, displays, sensors and databases that together increase situational awareness."

The H-TAWS system provides pilots with advanced warning about dangers along their flight path, including graphically depicting terrain and known obstacles. The H-SVS solution features a high-resolution synthetic vision display and a known obstacle database. In addition to defense-related applications, these systems are suitable for helicopter applications in emergency medical services (EMS), law enforcement, search and rescue, or any number of other demanding mission profiles. ■

Astronics Extends Supply Agreement With Rockwell Collins

LUMINESCENT Systems Canada, Inc. (LSI Canada), a wholly owned subsidiary of Astronics Corp. (www.astronics.com), has signed a long-term enterprise sourcing agreement with Rockwell Collins (www.rockwellcollins.com).

LSI will continue to provide the illuminated cockpit control panels, keyboards, display bezels, and related assemblies that form an integral part of Rockwell Collins' advanced avionics products. These components are used

in a wide range of fixed-wing and rotor craft vehicles across the various military, commercial, and business aircraft served by Rockwell Collins. The agreement covers the full breadth of products currently supplied by LSI Canada, along

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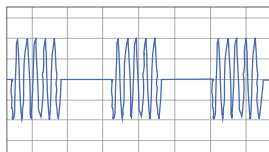
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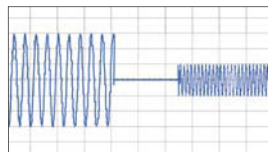
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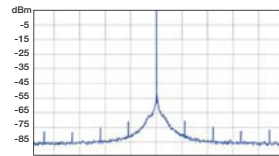
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with any new products that will become part of Rockwell Collins' next generation of avionics products.

While extending the sourcing agreement, Rockwell Collins also recognized Astronics and LSI Canada as its 2013 Human Machine Interface Supplier of the Year during Rockwell Collins' Annual Supplier Conference this past March. The award is an acknowledgement of significant contributions made during the year by suppliers to Rockwell Collins and is based on quality, delivery, total cost of ownership, lead time, and

customer service. This is the fourth consecutive year that LSI Canada has received this award. For LSI Canada, James S. Kramer, Executive Vice President and General Manager, comments, "Rockwell Collins collaborated with us on Lean initiatives to ensure that our products incorporate best-in-class technology and manufacturing concepts. The recognition that Rockwell Collins has provided via the extension of the sourcing agreement and the Supplier of the Year Award provide a strong framework for continued collaboration." ■

Testing Aims To Achieve Enhanced UAS Safety

UNMANNED AIRCRAFT systems (UAS) are becoming a growing part of the national airspace, but it will not take place without strong efforts to maintain safety with piloted vehicles. As part of those efforts, the National Aeronautics and Space Administration (NASA) and Rockwell Collins completed the first in a series of risk-reduction tests meant to create a safer operating environment for UAS in the United States' air space. The data-link waveform tests simulated communications between an aircraft and a ground-based pilot station, with the intent of verifying that the communications made efficient use of the available radio spectrum.

Dave Schreck, Director of UAS and Control Technologies for Rockwell Collins, explains: "There are a number

of areas where the ability to safely operate unmanned systems in US airspace will provide significant benefits, including public safety enhancements, agricultural solutions, and other applications that are unforeseen today." He cautions: "However, we all agree that there are many considerations that must be thoroughly researched to allow the safe, efficient, and routine operation of unmanned systems in the national airspace."

The testing is part of a project co-funded by Rockwell Collins, which is seeking the development of an open, non-proprietary data-link waveform that may eventually be released as a public resource, and to help in developing a practical set of rules and requirements for unmanned flights. ■

Light-Wheeled Vehicles Assist Choppers

LIGHT-WHEELED COMBAT vehicles are designed for in-field flexibility and maneuverability, as might be needed when dismounting from a helicopter. This type of vehicle solution has been developed successfully by strategic partners EPS UK (www.enhancedpro.com) and DEE Ltd. (www.dee-ltd.co.uk). The companies recently unveiled a number of "battlefield enhancements" during the Defense Vehicle Dynamics (DVD) show, held June 19-20 in Millbrook, Bedfordshire, England.

For example, the latest upgraded variant of the Whippet Wheeled Vehicle Light platform (*see photo*), designed for



The Whippet Wheeled Vehicle Light platform made its debut at the recent Defense Vehicle Dynamics (DVD) show.

dismounted close combat support, was shown at DVD for the first time. The vehicle is available in two versions, with a single seat in a center position or with two seats side by side. Both versions feature many new features, including a full touchscreen electronic dashboard and an integrated data-logger with advanced health and usage monitoring systems (HUMS) functionality.

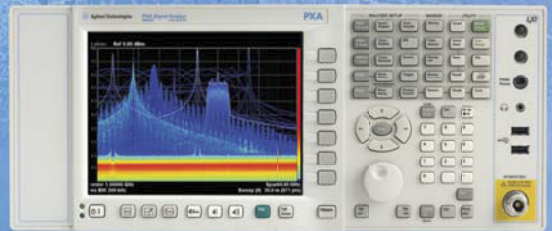
The vehicles' electronic dashboard is complimented by intuitive software that can display Global-Positioning-System (GPS) data and command and control information in real time. It can optionally handle feeds from surveillance or thermal imaging sources.

The Whippet is designed for insertion in a battle theatre by means of helicopter. It can be deployed within the V22 Osprey and above. The dimensions of the light-wheeled craft are compact to accommodate loading on a small aircraft, with an overall width of only 60 in.

The base 4 x 4 platform is designed to carry a hefty payload of as much as 900 kg in the single-seat version and as much as 1250 kg in the two-seat version. Both companies believe that the Whippet is a viable battlefield replacement for quad bikes, since it can also tow a trailer.

Power for the trailer will be provided separately by a 750-cc diesel engine which can double up to provide an on-board generating capability when required. The trailer has been designed for a payload based on a standard 1-ton pallet. ■

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Curtiss-Wright Controls Helps BAE With Bradley

CURTISS-WRIGHT CONTROLS (www.cwcontrols.com) has received a contract from BAE Systems (www.baesystems.com) to provide lifecycle management services for the Bradley Fighting Vehicle and its Turret Drive Control Unit (TDCU). Under the terms of

the contract, Curtiss-Wright Controls' Defense Solutions business group will supply an obsolescence-free upgraded version of the Tech Data Pack (TDP) used in the TDCU.

The initial contract is valued at \$300,000. It covers the development phase of the program for the new TDP and is

scheduled to last through early 2014. The production phase of the program is scheduled to continue through 2015, but may be accelerated. The contract, part of an obsolescence mitigation upgrade program for the Bradley's TDCU, may expand to as much as \$20 million once full production begins.

Of working with BAE Systems, Tom Quinly, President of Curtiss-Wright Controls, explains: "Curtiss-Wright has a long, successful history as a manufacturing partner for BAE Systems. We are proud to have been selected to provide our industry-leading lifecycle

support services to extend and maintain longevity of the Bradley Fighting Vehicle." As part of the Bradley Fighting Vehicle, the TDCU controls the drive and stability of the vehicle's turret system, enabling it to strike targets accurately while on the move. Under the agreement, Curtiss-Wright will identify and replace end-of-life or obsolete electronic devices in the legacy TDP; the firm will upgrade the unit's three-module card set with long-lifecycle components and a lifecycle management plan that will significantly extend the life of the Bradley. ■

Rockwell Collins Wins Two CRAG Contracts

ROCKWELL COLLINS (www.rockwellcollins.com) has been awarded two contracts by the US Air Force for service and support on the KC-135 Pacer Compass, Radar, and GPS (CRAG) program. These contracts combine to cover the repair of nearly 4000 line-replaceable units (LRUs) across the fleet of 417 KC-135 aircraft, and represent one of the largest repair contracts in terms of volume in the 80-year history of Rockwell Collins. The contract has a one-year base with three one-year options covering the Rockwell Collins Multimode Weather Radar, moving toward a longer-term sustainment solution.

Additionally, Rockwell Collins was awarded a three-year, \$4.8-million contract by the US Air Force Air National Guard for service and support of the KC-135 Pacer CRAG program.

The Pacer CRAG program represents the Air Force's commitment to modernizing the KC-135 fleet to extend its functional life to 2040, which is when the airframe is scheduled to be decommissioned. The Pacer CRAG avionics upgrade to the KC-135 fleet is a commercial, off-the-shelf modification program that eliminates the need for a navigator on most missions.

Rockwell Collins was selected in 1995 as the prime contractor on the Pacer CRAG program to upgrade the KC-135 with compass, radar, and GPS technology. Subsequently, in 1999, the company was selected as the prime contractor for the KC-135 Global Air Traffic Management (GATM) program, which enabled the aircraft to meet airspace mandates while addressing critical obsolescence issues. The Rockwell Collins KC-135 GATM system is fielded and operational, with 417 aircraft delivered on time and on budget. ■

DARPA Eyes ATK For Study On Advanced Surveillance Technology

ATK (www.atk.com) was awarded a study contract by the United States Defense Advanced Research Projects Agency (DARPA) to better understand innovative surveillance technology for battlefield imagery. ATK will apply its expertise in small, cost-effective space system solutions as part of the Space Enabled Effects for Military Engagements (SeeMe) program to develop practical surveillance methods for the warfighter. The SeeMe program is aimed at developing technologies capable of providing reliable surveillance data in the field, using small, low-cost satellites that are launched quickly to support the speed of military operations.

As part of the contract, ATK intends to transition advanced, imagery-processing algorithms used on unmanned aerial vehicles (UAVs) to small satellites in space, taking advantage of the latter's strategic advantages. By partnering on the contract with Logos Technologies, Inc. (www.logos-technologies.com) and the University of Southern California/Information Sciences Institute (www.isi.edu), ATK hopes to shave satellite size, weight, power, and cost. ATK Space Systems Division Vice President and General Manager Tom Wilson explains: "This award allows ATK to demonstrate our ability to deliver on every aspect of design, development, and integration for low-cost, low-risk flight systems."

In addition, the development of ATK's new A100 small satellite product line, aimed at serving the microsat market, could provide a unique capability to transition SeeMe technology to industry, research, and military operational markets. ■

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Lead-Free Designs Deliver High Reliability In Safety Critical Applications

The initial worries about lead-free designs required by RoHS have faded, with new solder materials and techniques now delivering improved reliability to safety-critical applications.

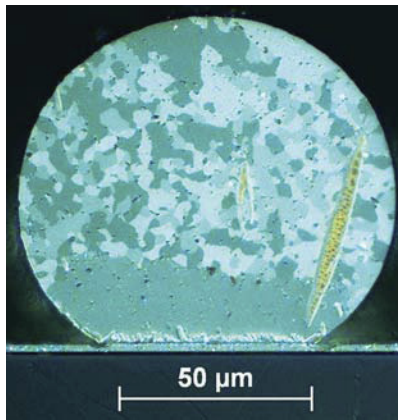
THE EUROPEAN Restriction of Hazardous Substances (RoHS) initiative rumbled through the consumer electronics world and much of the industrial electronic arenas rather quickly when it was first introduced. But safety-critical applications for military and avionic customers lagged behind, with certification and reliability requirements cited. The latter is changing now as designers of military and avionics have come to a better understanding of RoHS technology.

Another factor in completing the move to RoHS is the general and widespread availability of lead-free compo-

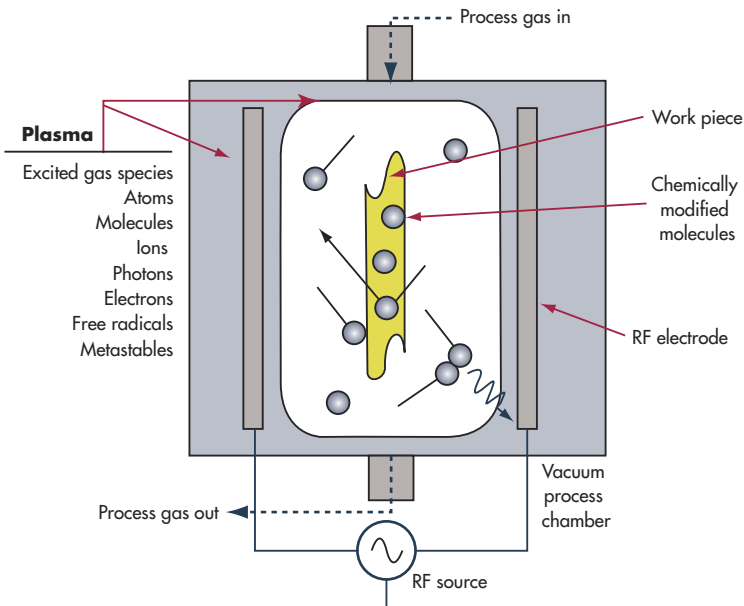
nents, effectively eliminating the availability of components fabricated with lead-based solder. It is now difficult to find lead-based electronic parts, especially for newer, high-density BGA packages. Applications that require lead-based support often need go through the time and expense to convert lead-free parts to lead-based parts. In the end, moving to exclusively lead-free components makes the most sense.

The introduction and adoption of RoHS has resulted in extensive evaluation of lead-free technology. One very interesting point is that small lead-free solder joints under 100 µm are actually more reliable than their lead-containing counterparts (Fig. 1), owing to a different solder structure for these smaller joints. This is critical, since designs are moving to smaller connections even as the number of connections is increasing.

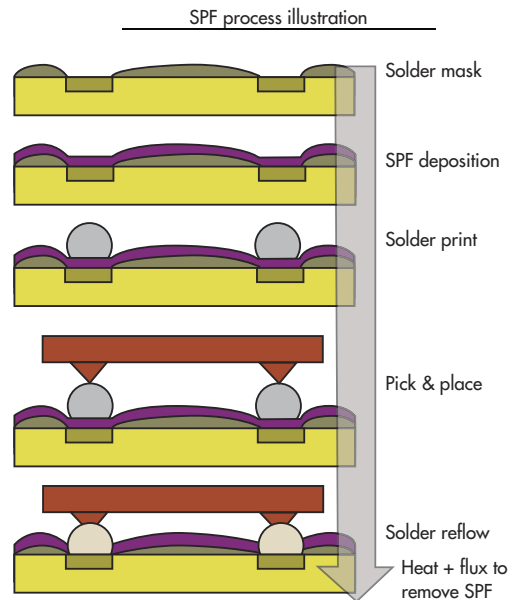
The Pb-Free Electronics Risk Management (PERM) Consortium (www.aia-aerospace.org), formally known as the LEAP (Lead free Electronics in Aerospace Project), was organized to address lead-free issues in aerospace, defense, and high-performance (ADHP) communities. Tin whiskers have been a con-



1. Lead-free solder joints under 100 µm are actually better than lead-based counterparts due to changes in the structure of the joint.



2. Semblant uses a plasma to deposit the SPF onto the surface of a PCB.



3. The SPF is placed on the PCB before the devices are soldered to the PCB.



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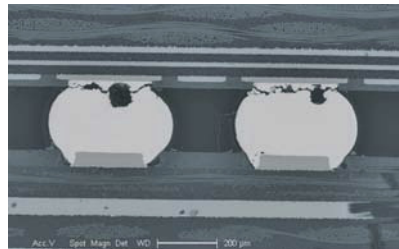


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cern with lead-free electronic designs—especially for critical military and avionic applications—but conformal coats are one way to mitigate their growth. Military and avionic projects often required coatings for other purposes, including protection from environmental hazards.

Most designers follow the GEIA-STD-005-2 standard from Tech America (www.geia.org) for mitigating the effects of tin whiskers in aerospace and high performance electronics. The use of acrylic-based conformal coatings such as Parylean-C addresses a range of issues,



4. Solder joint cracks are typically caused by movement due to vibration or thermal fluctuation.

including the prevention of short circuits. These types of coatings are used in some industrial applications as well, but less often in consumer applications.

Conformal coatings can address environmental issues for consumer and industrial applications. For example, customers in Asia were noticing corrosion problems when silver solder was used. This was due to the higher humidity and sulfur found in those areas. Likewise, nickel-gold solutions tend to be a challenge at high RF frequencies that were less common in the past. More solutions now utilize high-speed serial interfaces such as PCI Express, 10 Gb/s Ethernet, MIPI, InfiniBand, and Serial RapidIO. Tin-based solder with a conformal coating typically addresses these performance and environmental issues.

The Semblant Plasma Finish (SPF™) coating developed by Semblant (www.semblant.com) puts about 50 nm coating using a low-energy, low-environmental-impact system (Fig. 2). The plasma approach coats everything within the chamber. It operates at room temperature and uses very little energy. The thin SPF layer is put on a printed-circuit board (PCB) at the start of the circuit-board creation process (Fig. 3). Any solder applied to the circuit board actually melts through the SPF layer. A conformal coating is about 1 μm thick; it would be added after devices are placed and soldered onto the PCB. The plasma system is used in the same fashion, but takes slightly longer.

A number of concerns surface when using lead-free solutions. These include

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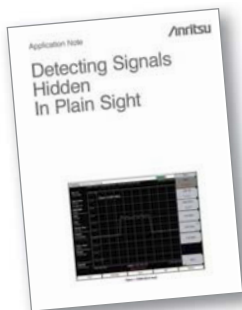


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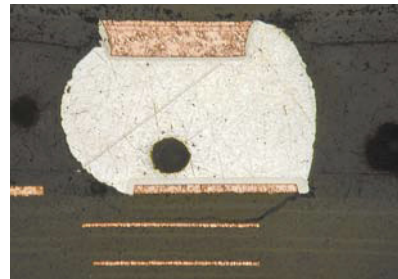
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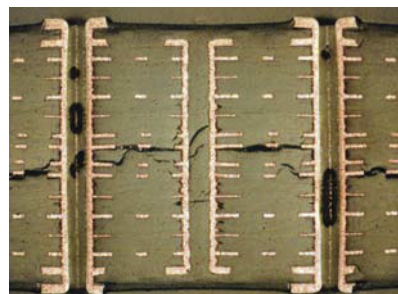
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issues with solder joint cracks, pad cratering, and PCB delamination. Such issues exist with lead-based support but were not as common. Proper design techniques can minimize these issues for lead-free designs. Solder joint cracks (Fig. 4) can be difficult to detect because the

joints may work to a degree if the PCB is flexed. The cracks are typically caused by movement due to vibration or thermal fluctuation. Cracks can grow over time. Voids can also occur within the joint that exacerbate this problem. Pad cratering (Fig. 5) is one of the major failure modes



5. Pad cratering occurs when a pad is lifted off the PCB. It can be caused by vibration or thermal cycling.



6. PCB delamination occurs when the layers of the PCB separate.

with BGA packaged components. In this case, the solder joint does not break, but the pad is lifted off the PCB.

Lead-free solder requires higher temperatures than when processing leaded solder. This can lead to PCB delamination where layers separate (Fig. 6), occurring when there is moisture or contaminants on or within the board. The higher temperatures used with lead-free solder increase the water vapor pressure. This tends to be more commonplace with multilayer board. All of these issues can be addressed with proper selection of materials, as well as by following proper design rules and procedures. For example, moving BGAs away from the edge of the board will reduce flexing issues.

RoHS designs have been successful in the commercial and consumer space. Substantial research has been done on lead-free designs, and more is being done in the ADHP space, as well. By following proper design rules, choosing suitable materials and using proper process procedures can actually result in improved solutions. **de**

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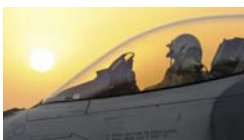
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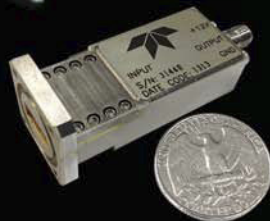
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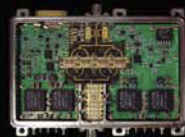
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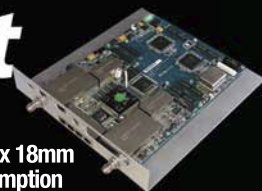
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Surveillance Systems Continue To Shrink

Whether they are compact radar systems for detecting men and machines, or surveillance systems for gathering intelligence, these systems grow smaller and more effective with time.

TWO OF the key electronic functions of warfare—radar and surveillance—are undergoing transformations that are literally making the hardware for these systems disappear. Radar systems, which were once associated with building-sized vehicles on the battlefield or huge antennas riding along large aircraft carriers at sea, can now be made portable enough to fit in a backpack (as detailed in this issue's cover story on SpotterRF's portable radar solutions). Surveillance systems are also becoming more portable and remote, often being transported to an area of interest by means of an unmanned aerial vehicle (UAV) or an unmanned ground vehicle (UGV). Once deployed, they gather essential intelligence data without putting a soldier in danger.

Radar systems, of course, represent a form of surveillance. And as they are made smaller, lighter, and more portable, they add new flexibility and dimensions to a troop's surveillance strategies. Tracking enemy vehicles and troop movements no longer requires airborne support or the positioning of large radar/surveillance systems in the field. Many of these next-generation portable radar systems are small and light enough to be contained in a standard backpack, and can be set up quickly and easily almost anywhere in the field.

For example, each of SpotterRF's M600C radar units measures just 8.75 x 10.125 x 2.25 in., weighs only 4 lbs, and

consumes only 10 W power during normal operation. The company bundles a complete system together with two radar units, rechargeable batteries, antenna stands, and other accessories within a single backpack.

But SpotterRF is not alone in filling these growing battlefield demands



1. The Blighter B202 Mk 2 is a compact UAV capable of performing unseen surveillance functions for a variety of different markets.

for greater surveillance portability and flexibility. Another impressive portable radar system is the Blighter B202 Mk 2 (Fig. 1) from Blighter Surveillance Systems (www.blighter.com), a Plextek company. This system combines the firm's patented solid-state passive electronic scanning array (PESA) technology with a frequency-modulated-continuous-wave (FMCW) source and Doppler signal processing, providing effective surveillance capability from a small system.

Blighter B202 Mk 2 systems are designed to function under less-than-ideal weather conditions and in hostile terrain. They operate without moving

mechanical parts and are even touted as being so reliable that they require no normal maintenance for five years. They can operate over land or water, and can detect an intruder within a scanned area in excess of 3000 km². The movement-detection radar system can detect a human intruder to a distance of about 3.3 km and a vehicle to a distance of about 8 km. The Blighter radar system weighs about 15 kg and achieves high target detection with low-power operation, maintaining low power consumption to minimize probability of intercept by threat surveillance systems and to maximize run time. The Blighter B202 Mk 2 radar can run on batteries or solar power.

This innovative portable radar/surveillance system include high-quality Doppler audio functionality to aid in recognition of difficult targets, such as soldiers crawling along the ground. In addition, for challenging applications such as border patrols, multiple Blighter radars can be linked to form ad hoc networks for continuous surveillance of long sections of border or other areas of interest.

For somewhat increased weight and size, somewhat more range is available from a portable radar system featuring the AN/PPS5-C Manportable Surveillance and Target Acquisition Radar (MSTAR) from DRS Technologies (www.drs.com). With a system weight of about 30 kg, it may be better suited for two-person transport. But what it brings to the battlefield is a much wider surveillance area than the smaller portable radar systems, with a maximum range of about 42 km. This is a system that has proven its worth over time in the Balkans, Iraq, and Afghanistan in terms of high performance and reliability.

In addition to a growing use of portable radar systems by the military for surveillance, another trend is the growing use of UAVs and UGVs for remote surveillance operations. For example, sur-

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veillance drones were used in Northern Ireland during the recent G-8 Summit to scan the countryside for terrorist threats. In support of drones, a recent study conducted by the Institute for Homeland Security Solutions (IHSS; sites.duke.edu/ihss) and RTI International (www.rti.org)

indicates that 57% of the American public polled (2000 respondents) support the use of unmanned aircraft systems for a wide range of applications. These including search-and-rescue, surveillance, and Homeland Security missions.

Many military applications are being



2. The Aeryon Scout is a palm-sized UAV that has been developed for police use.

served by two different types of UAVs: fixed-wing units and vertical-take-off-and-landing (VTOL) models. The fixed-wing UAVs require more room to take off and land, but can fly for much longer distances than the VTOL units. But the VTOL units allow stationary positioning and monitoring.

Michael Toscano, President and CEO of the Association for Unmanned Vehicle Systems International (AUVSI; www.auvsi.org), has this to say about the survey results: "Unmanned aircraft have the potential to be beneficial in a wide range of applications, from helping to search for lost children and missing hikers to helping Homeland Security keep our borders safe. This public support shows the importance of safely integrating [unmanned aircraft systems (UAS)] into the national airspace in a timely manner." RTI conducted the poll to better understand the implications of UAV and UGV technologies, perhaps even for law-enforcement applications.

To facilitate improved communications among unmanned vehicles, the US military has expressed its interest via numerous petitions for common data link (CDL) radios suitable for use on UAVs. The use of CDL hardware would be a further step toward a more universal user and communications interface.

To help companies involved with UAVs and UGVs, Information Gatekeepers (www.igigroup.com) recently made available its "2013 Components for Unmanned Vehicles—Marketing

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CTT's UAV experience includes participation in data and video communication links on programs including Shadow, Hunter, Predator/Reaper, Pioneer, Global Hawk and others.

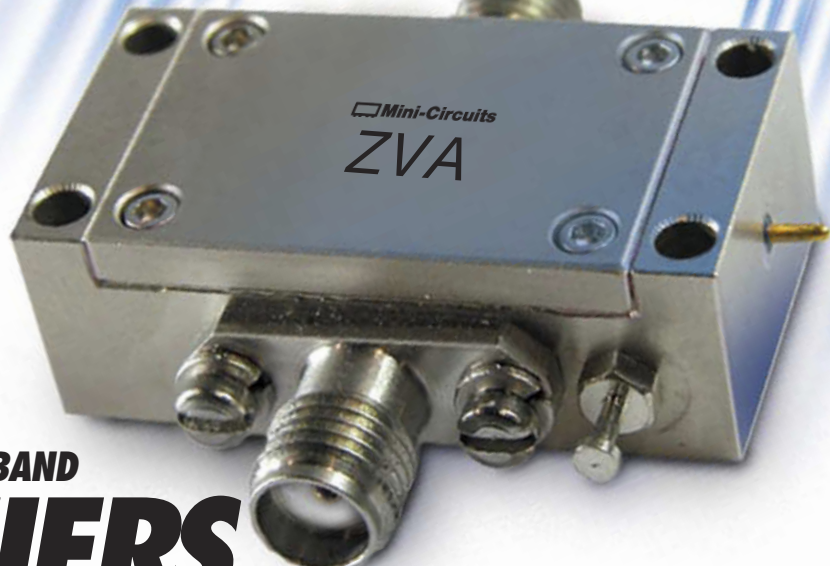
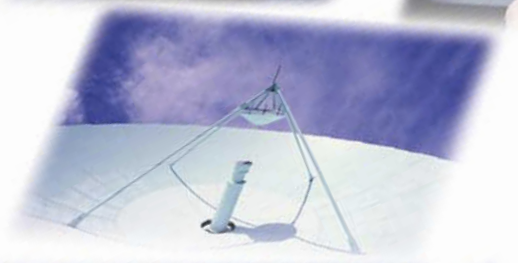
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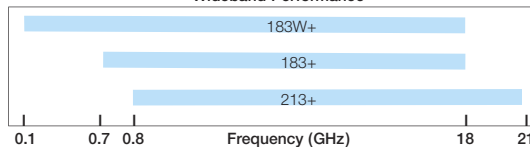
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Guide and Directory” to assist companies manufacturing and working with UAVs. The directory includes over 1000 companies in 100 different product categories in support of growing UAV markets.

The use of UAVs may eventually extend beyond military applications and

to police work. For example, the Scout from Aeryon (www.aeryon.com) is a micro-UAV developed for police work that can fit within the palm of one’s hand and easily into backpacks (Fig. 2). The Scout can fly into wind speeds of 31 miles/hour and can handle wind gusts

to 50 miles/hour. It can carry a number of different payloads, including infrared (IR) and video cameras. It also has a 1.9-mile (3-km) range and 25-minute flight time with payload.

Along with improving UAV technology, DARPA has invested in improving its video surveillance capabilities. DARPA’s Autonomous Real-time Ground Ubiquitous Surveillance-Imaging System (ARGUS-IS) program has the goal of high-resolution video surveillance from a considerable distance, such as from a larger UAV at an altitude of 20,000 ft. It is still unclear as to which drone or group of drones will be fitted with the ARGUS video system. Nonetheless, it is likely the highest-resolution video camera in the world, capable of resolving details as small as six inches from an altitude of 20,000 ft. From 20,000 ft., it can observe an area of 10 square miles at one time.

ARGUS captures video images at 12 frames/s using 1.8 Gpixels provided by 368 smaller sensors. According to DARPA, these 368 sensors are merely 5 Mpixel sensors—those typically found in smartphones. ARGUS’s sensors are focused on the ground via four image-stabilized telescopic lenses. Capturing that much video imagery is one part of the challenge, while processing all that video information in digital form is perhaps the larger part of the challenge; 1.8 Gpixels at 12 frames/s is around 600 Gb/s data.

DARPA is involved in more than a few other programs meant to push surveillance technology further. Its Military Imaging & Surveillance Technology (MIST) program, for example, is intent on developing a new optical intelligence, surveillance, and reconnaissance (ISR) technology capable of providing precise three-dimensional (3D) images of targets at longer ranges than possible with existing technologies. In addition to developing new technologies, plans are in place for versions of the hardware systems that can be integrated onto UAVs and made portable enough for soldier backpacks. **ce**



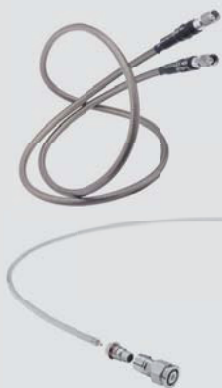
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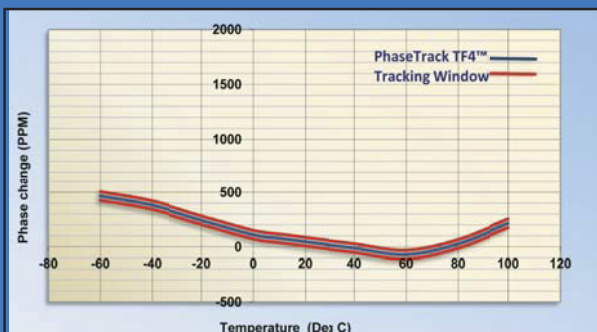


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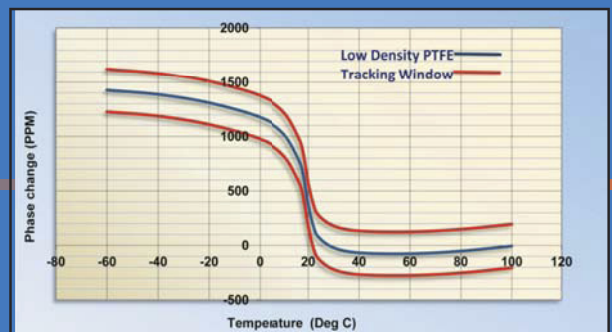
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2. A key part of the Radar Backpack Kit is the SpotterRF M600C radar unit which includes an Ethernet port for ease of connection to a portable computer.

<http://mwrf.com/systems/radar-continues-scanning-outward>). The company offers the world's first complete portable radar system with its Radar Backpack Kit (Fig. 1), which contains everything needed to establish a surveillance radar system for covering a 150-acre area. It all fits within a small, three-day backpack weighing only about 20 lbs.

A Radar Backpack Kit contains two

of the company's model M600C radars, a lightweight tripod, a model HUB6A network hub, a model 2590 battery, system cables, and an Android tablet. Each of the M600C radar units (Fig. 2) is completely sealed from the weather and environment. It weighs only 4 lbs., measures just 8.75 x 10.125 x 2.25 in., and can detect and track walkers or multiple targets to a distance of 1000 m from

the antenna unit. A model M600C radar system is energy efficient, consuming only 10 W power for a relatively long running life on the rechargeable battery.

For the hardy hiker carrying four M600C radar units into the field, a 360-deg. coverage area can be established in a manner of minutes, with a total coverage range of approximately 1000 x 800 m or about 150 acres for every M600C radar. Each M600C unit features an Ethernet interface for ease of interoperability with a laptop or tablet computer, showing a cursor on a target on a display screen.

The maximum surveillance range is about 1 km for a walker and about 1.5 km when tracking a vehicle. The range resolution is 3 m, with an angular accuracy of ± 3 deg. The radar system provides an update rate of once per second (1 Hz) and can support 20 simultaneous tracks. It operates at X-band (10.0 to 10.5 GHz), using frequencies licensed by the

MORE INTEGRATORS REACH FOR PORTABLE RADARS

MILITARY CUSTOMERS such as Camp Williams and the United States Army have made clear their interest and satisfaction with the capabilities of the SpotterRF M600C mobile radar units, not only in performance but in ease of training required to operate the systems. The radar system provides powerful perimeter protection to small forces. But it is also cost-effective enough that some commercial customers are considering how these SpotterRF radar systems might meet their own perimeter protection requirements.

The list of strategic integrator partners for SpotterRF is growing quickly as resellers seek to meet the

demands for SpotterRF's patented radar/surveillance technology. These companies extend to all part of the globe and include:

Damar Security Systems (www.damarsecuritysystems.com), one of Canada's leading integrators on electronic security solutions to residential, commercial, retail, industry and financial clients; Delex Fairfax ISS (www.dfiss.com), an international physical security integration company based in the Washington, DC area; GM Radars (www.gmradar.com), a company headquartered in Athens, Greece and involved in non-destructive testing, defense, and safety

equipment and in providing security solutions globally; HurleyIR (www.hurleyir.com), a leading leading manufacturer of infrared, visual, and night vision cameras which combines SpotterRF's technology with different types of visual and IR camera for early-detection solutions; Infralogic (www.infralogic.dk), a firm based in Sweden that combines video analytics, thermal sensors, UAV with SpotterRF radar technology to meet the highest requirements of protection for both property and people; IT&T (www.itt.com), a defense contractor based in Virginia; and Zone Advanced Protection Systems (www.zoneaps.com.au), an Australian

developer of high-security software products and a distributor of mission critical electronic security and surveillance solutions from some of the world's leading manufacturers.

According to Logan Harris, Chief Executive Officer (CEO) of SpotterRF, "Today's small force technology must be lightweight and cost-effective, while providing real-time battlefield information that is accurate and actionable," in explaining the popularity of his company's systems. He adds that "SpotterRF fits the bill, proven as providing better

(continued on next page)

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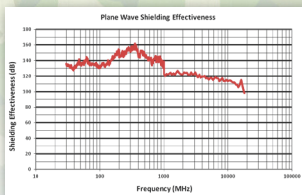
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COVER STORY



3. A very low-power surveillance radar system can be assembled using the C40 compact surveillance radar (CSR) unit, which measures just 6.9 x 9.0 x 1.7 in.

United States Federal Communications Commission (FCC; www.fcc.gov).

The SpotterRF M600C radar units are designed for operating temperatures from -30 to $+65^{\circ}\text{C}$. With their Ethernet interfaces and Internet connectivity, they can be easily integrated into existing security systems in support of current equipment. The radar units provide output information as Global Positioning System (GPS) coordinates of real-time tracks shown in a Web browser (e.g., Google Earth) or via other situational-awareness software.

The company actually offers several choices of radar systems and sizes, with its even-smaller C40 compact surveillance radar (CSR) measuring only 6.9 x 9.0 x 1.7 in. and weighing a mere 1.5 lbs. for ease of installation around a domestic or busi-

(continued from p. 26)

protection for our soldiers on the ground."

With their compact sizes and relatively low costs, these SpotterRF systems enable virtually every war-fighter to enjoy the benefits of radar coverage. At one time, radar systems were associated with only large troops, tanks, or large sea-faring vessels. But the SpotterRF radar systems are available in extremely compact packages, portable and battery powered (consuming as little as 8 W power), with the lightest of four different-sized systems weighing only 1.5 lbs. These compact radar systems are programmed to communicate with a variety of different situational-awareness software programs, including Google Earth, RaptorX, and Falconview. As noted by the growing number of integrators, SpotterRF radar systems are readily integrated with other technologies. And one of the beauties of these systems is that they are easy to operate, with training requiring less than 30 minutes in the field.


“ This small but technically agile firm is bringing radar technology to a wider group of users (spanning commercial, military, and industrial markets) than ever before.”

ness perimeter. The company claims a setup time of only about 10 minutes, using Web User Interface (UI) software for installation. This smaller radar system has a coverage area of 350 x 300 m or about 20 acres, with a maximum detection range of 350 m for a walker and 500 m for a vehicle. It works in all types of weather conditions and consumes less than 8 W power using supplies from +12 to +30 VDC by means of a power over Internet (PoE) injector. The system can process 20 simultaneous tracks and is priced at less than \$12,000 for all required hardware and software.

The SpotterRF portable radar systems have been used at the US Army's Camp Williams (UT) for mobile force protection training, with only 30 to 60 minutes required for training. This testing provided an evaluation of the SpotterRF's radar system's effectiveness in conjunction with existing US Army surveillance systems. The SpotterRF CSR solutions can provide effective perimeter protection for small forces that require agility.

One of the instructors at Camp Williams, Sgt. First Class Paul Diamond, notes that "Troop position may change overnight or in an hour. Since we can make SpotterRF radar operational from pack to track in just a few minutes, we minimize the time our troops are at greatest risk. This ultimately saves lives."

The different SpotterRF CSR systems are designed for integration with existing equipment, such as infrared (IR) cameras and other intrusion-detection-system (IDS) equipment. The CSR systems can be linked by means of Ethernet network and can communicate with

Google Earth, RaptorX, Falconview, and other situational awareness software. 

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MILITARY ELECTRONICS design involves squeezing as much functionality into as little space as possible, and Mercury Systems Ltd. (www.mrcy.com) has built a strong reputation by means of some innovative squeezing. The firm offers standard integrated microwave assemblies (IMAs), as well as IMAs designed and built to a customer's requirements—and sometimes even their hopes and dreams. With RF/microwave capabilities that extend from 10 MHz to 40 GHz in narrowband or broadband single-layer and multilayer configurations, the company exercises a comprehensive suite of computer-aided-engineering (CAE) tools.

The IMAs are built from a variety of materials, depending upon the needs of the application. These include soft boards, low-temperature-cofired-ceramic (LTCC), and alumina circuit substrates; all are manufactured and tested in Class-10,000 clean rooms. The company has designed and produced a wide range of IMAs qualified for military and high-end-commercial use.

An example of Mercury's RF/microwave integration capability is a Ku-band transceiver for satellite communications (satcom). This high-power transceiver (HPT) enables frequency upconversion from L-band to Ku-band frequencies. It consists of five major sub-assemblies: block-upconverter/block-downconverter (BUC/BDC), 25-W power amplifier, 115-VAC power supply,

10-MHz frequency reference, and digital interface and control circuitry. Frequency upconversion and downconversion functions are phase-locked to a 10-MHz frequency reference.

Upconverted Ku-band signals are boosted by the power amplifier and sent to an antenna for transmission. The 400-W power supply accepts aircraft-supplied



Model HDS-6502AC is an OpenVPX high-density-server (HDS) module that includes a pair of quad-core i7 microprocessors, on-die GPUs, and a generous amount of high-speed memory for processing information in radar, SIGINT, and other data-intense applications.

voltages from 100 to 120 VAC at frequencies from 360 to 800 Hz. The digital interface is based on a microprocessor running the LINUX operating system (OS); it supports extensive built-in-test (BIT) functions for the system and application, which was initially a commercial airborne application and successfully passed DO-160E qualification testing.

Mercury also provides densely packaged processor technologies. All are designed to address highly data-intensive signal and image processing applications within environmentally constrained military and commercial platforms.

As an example, Mercury's Ensemble® 6000 Series OpenVPX™ High Density Server (HDS) data/graphics modules for Gen 2 Serial RapidIO® and 10Gigabit Ethernet subsystems, such as the model HDS-6502AC (*see figure*) module, pack an enormous amount of functionality into the tight OpenVPX format. The modules are available in air-cooled, conduction-cooled (VITA-48.2), and air-flow-by (VITA-48.7) configurations. Air-cooled modules are rated for operating temperatures from -25 to +85°C and altitudes from 0 to 50,000 ft. altitude; conduction-cooled units are designed for operating temperatures from -40 to +71°C and altitudes from 0 to 100,000 ft.; and air-flow-by versions specific to a design are available.

The HDS-6502AC module is built upon a pair of 2.4-GHz quad-core i7-4700EQ processors from Intel Corp. (www.intel.com) with native advanced vector extensions 2.0 (AVX2), on-die GT2 graphics processing units (GPUs), and third-generation PCIe interfaces backed by 16 GB of 1600-MHz DDR3 memory. The OpenVPX module provides reliable communications by merit of its proven field-programmable gate array (FPGA)—a Stratix 5SGXA7 from Altera (www.altera.com)—that can orchestrate Gen 2 Serial RapidIO at 3.125, 5.00, and 6.25 Gbaud/s.

Aided by Mercury's Protocol Offload Engine Technology (POET™) firmware, this module is well suited for working with sensors and applications reading and writing data from sensors, including in radar and signal-intelligence (SIGINT) systems. The POET firmware can execute upgrades on the module's fabric protocol without any modifications to the hardware for flexibility as needed. **ce**

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This high-reliability SPDT switch provides a broad bandwidth to 8.5 GHz with excellent electrical performance, as well as the capability to resist the effects of various forms of radiation.

SPACE IS a harsh environment, and radiation in space can disrupt the operation of any number of high-frequency components. But certain components—such as the model PE95421 high-reliability (hi-rel) single-pole, double-throw (SPDT) RF switch from fabless semiconductor company Peregrine Semiconductor Corp. (www.psemi.com)—are designed and fabricated in such a way as to be enhanced-low-dose-rate-sensitivity-free (ELDRS-free), resistant to single-event radiation, and capable of handling a total ionizing dose (TID) of radiation of 100 krad without disruption in service. The model PE95421 is an absorptive/non-reflective switch with low loss and high isolation from 1 to 8500 MHz, based on the firm's UltraCMOS® silicon semiconductor process and HaRP™ technology.

The model PE95421 hi-rel SPDT switch (see figure) is fabricated on a highly insulating sapphire substrate, making it immune to radiation-induced single-event-latchup (SEL) effects. The switch minimizes performance drift even under radiation-dose conditions to 100 krads. It achieves excellent numbers for two key performance parameters—insertion loss and isolation. The tested insertion loss is only 0.85 dB at 1 GHz, while the measured isolation is typically 55 dB (also at 1 GHz). The insertion loss ranges from 0.77 dB at 100

MHz through about 1.38 dB at 8.5 GHz. Isolation extends from 86.5 dB at 100 MHz to 27.8 dB at 8.5 GHz. The switch offers electrostatic discharge (ESD) tolerance to 1000 V per the human body model (HBM).

The hi-rel SPDT switch supports circuits with high linearity, handling 2 W (+33 dBm) typical input power at 2




Model PE95421 is a broadband, hi-rel SPDT switch capable of operating to 8.5 GHz with low loss and high isolation, and resistant to the effects of radiation.

GHz at 1-dB compression. The typical third-order-intercept point (IIP3) is +60 dBm at 2 GHz. The rugged switch, which is supplied in a seven-lead QFP housing, measures 66.6 x 5.5 mm. It can be used with drain voltages from +3.0 to +3.6 VDC and typically draws 100 µA drain current.

As if this hi-rel switch wasn't enough, Peregrine recently introduced a pair of lower-frequency switches for use in public safety and military radios at the IEEE International Microwave Sym-

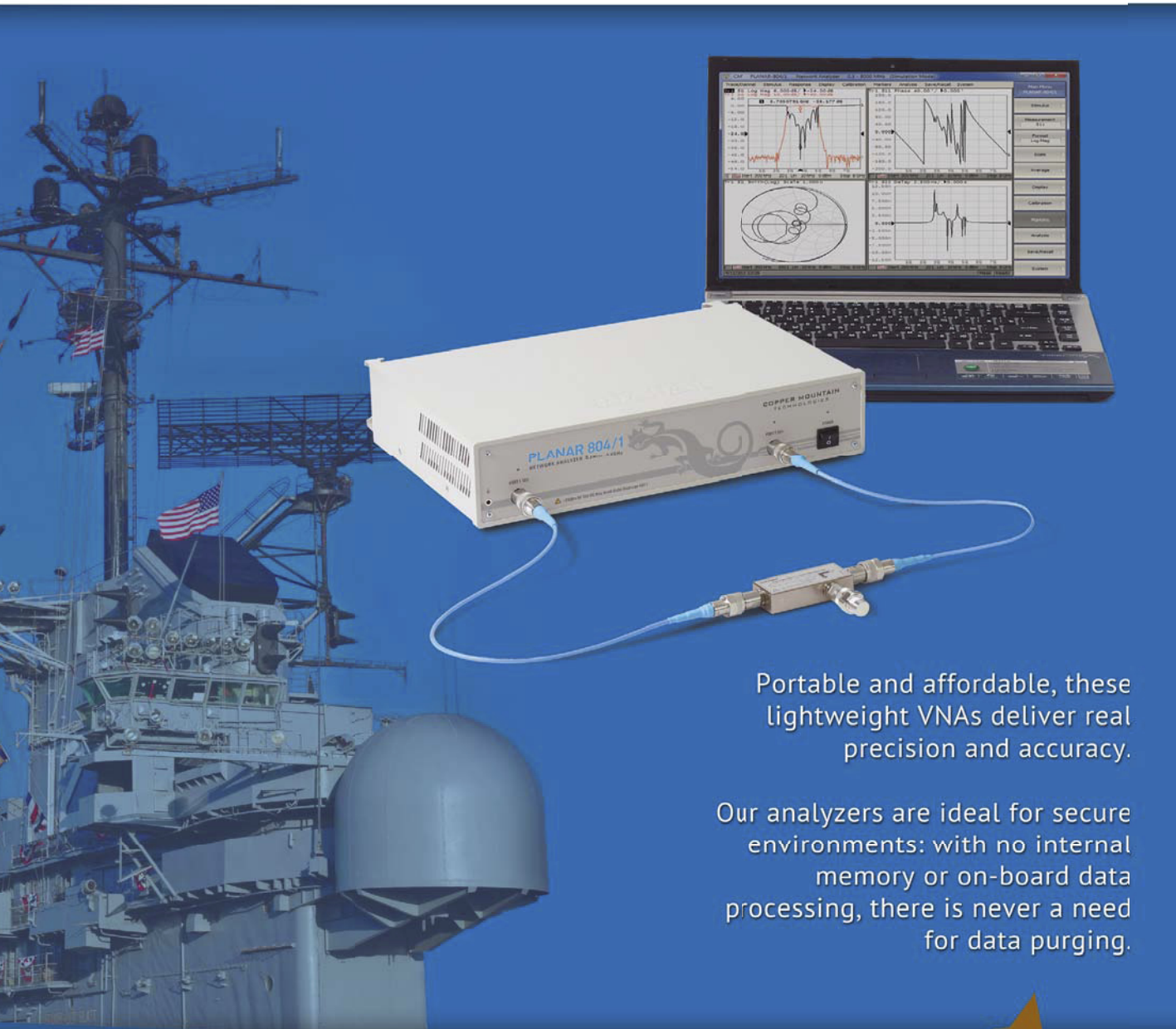
posium (IMS) in Seattle, WA. Models PE42850 and PE42851 are single-pole, five-throw (SP5T) switches that also combine the company's UltraCMOS and HaRP technologies to achieve impressive RF/microwave switch performance. Each switch is RoHS compliant and supplied in a 5 x 5 mm, 32-lead QFN package; either one can be configured as a single-pole, three-throw (SP3T) component for flexibility. Both deliver high ESD performance of 1.5 kV HBM. And both switches provide low power consumption for extended battery life in portable applications. In addition, both are rated for high throw counts, making them ideal for use in military Land Mobile Radios (LMRs).

Model PE42850 is usable from 30 to 1000 MHz, with only 0.35 dB insertion loss at 1 GHz and 36 dB isolation at 520 MHz. It offers a 1-dB compression point of typically +45.5 dBm, and can switch signals with power levels to 17 W with high linearity. It operates from supply voltages of +2.3 to +5.5 VDC and typically draws only 130 µA current.

Similarly, model PE42851 is usable from 100 to 1000 MHz, with only 0.4 dB insertion loss at 1 GHz and 36 dB isolation at 520 MHz. It also reaches a 1-dB compression point of +45.5 dBm, drawing about 130 µA current from a drain voltage of +2.3 to +5.5 VDC. Both SP5T switches boast excellent second- and third-harmonic performance, at -90 dBc into a 1.15:1 VSWR for the PE42850 and -80 dBc into a 1.15:1 VSWR for the model PE42851 switch. Both switches are supplied in 32-lead QFN housings measuring just 5 x 5 mm for minimal consumption of space in portable and battery-powered circuits. 

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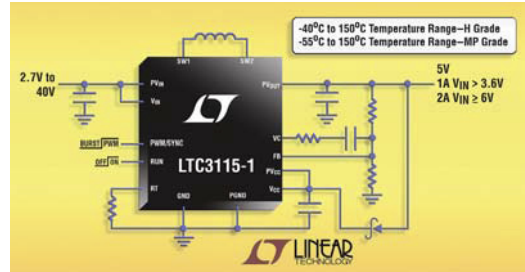
DESIGNED FOR applications from 1 to 18 GHz, model P2T-1G18G-10-R-5V-SFF-HIP10W-HERM is a hermetic, reflective, single-pole, double-throw (SPDT) PIN diode switch capable of handling input power levels as high as 5 W CW. The port-to-port isolation is typically 25 dB across the frequency range while the insertion loss is typically 2.5 dB. The component achieves switching speeds of typically better than 40 ns and no worse than 100 ns. The typical input/output VSWR is 2.0:1. It requires a single +5-VDC voltage supply and consumes 35 mA current. The switch incorporates a TTL-compatible driver for ease of system integration. The SPDT switch, which measures just 1.2 x 1.0 x 0.5 in., is supplied with removable female SMA connectors. It is designed for an operating temperature range of -54 to +100°C and meets the applicable requirements of MIL-STD-202F for shock, vibration, altitude, and temperature cycling.

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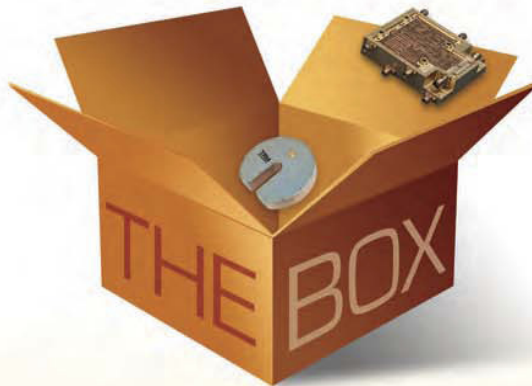
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serve. Another alternative would be the use of potting compounds. Not only are potting compounds costly, but they limit the practicality of rework. Should something go wrong at final test, the entire unit could be scrapped.

WONG: What factors should be considered when selecting a conformal coating?

MCCLURE: The first consideration should be the environment in which the product must perform—which pollutants, harmful gasses, or liquids could the electronics be exposed to? Once the environmental requirements are understood, the type of components requiring protection should be considered—are there connectors, mechanical devices, LEDs, test points? If so, traditional conformal coats often require masking of these components. With Semblant's plasma-deposited conformal coat, masking can often be eliminated.

WONG: Can you tell us more about the plasma polymerization process for conformal coating?

MCCLURE: Semblant's plasma deposition takes place in an RF vacuum chamber (see the figure). The process operates at room temperature and is a dry process. There is no cure time or time required for cooling or drying. Once the chamber is loaded with electronics to be coated, precursor materials in gas form flow into the chamber. The materials are energized by RF electrodes, and the plasma material deposits in a thin, pinhole-free layer. The thickness and properties of this PlasmaShield can be controlled during the deposition process.

WONG: What are some existing and future applications for conformal coatings?

MCCLURE: Conformal coatings are used across a variety of applications today. For example, industrial controls are often exposed to SO₂ (sulfur dioxide) in the air or to flowing water for cleaning. Both of these can damage sensitive electronics. Similar issues exist in aerospace and medical equipment. Medical equipment is often cleaned with isopropyl alcohol (IPA). In-flight electronics can often be exposed to liquid condensation. In both instances, exposure can damage these electronics.

WONG: What industries will benefit from the technology?

MCCLURE: The flexibility that plasma-deposited conformal coating offers is compelling. Industries using conformal coat today such as industrial, automotive, aerospace, and medical can simplify their manufacturing process, eliminate design restrictions, reduce manufacturing costs, and improve their overall product designs. Industries such as consumer electronics that do not normally use conformal coats due to the manufacturing cost and complexity can now begin to offer products that will be resilient to exposure to liquids such as water, soda, or coffee. ☑

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Global Business Climate Brings Manufacturers, Suppliers Closer

Supply chain collaboration takes center stage as manufacturers seek growth in an increasingly global business environment.

PARTNERSHIP, TRANSPARENCY, AND VISIBILITY are key words in today's global business world as manufacturing companies seek to forge even closer relationships with their suppliers. Collaboration has long been the mantra of distributors as they seek to become indispensable parts of their customers' operations. However, a new report on the state of manufacturing points to a heightened spirit of partnership across the supply chain today as manufacturing organizations dig deeper into their supplier relationships for innovation, ideas, and long-term planning. The change may signal a new wave of cooperation that will bring businesses closer together even as they reach further around the world to accomplish their goals.

"Companies are adopting a number of strategies to stay ahead of the curve, including a deeper emphasis on collaboration with partners and

Continued on Page 52

Tough Environments Drive Connector Trends

Sealed connectors for harsh environments top customer demand.

CONNECTORS MAY NOT BE the most technological products on the components market, but distributors say customers are demanding advanced solutions that can do and withstand more in just about every industry today.

"Customers want more weather resistant, environmentally sealed connectors," says Dave Rome, president of New York-based interconnect and electromechanical specialist Peerless Electronics. "Whether it's avionics or transportation or medical, you still have to keep all the debris out. They also want the connectors to be lighter, smaller, and more rugged."



Dave Rome,
Peerless Electronics

That's good news for companies like Peerless, which specializes in value-added solutions that include everything from making switch,

TE Connectivity's Cee-Lok Fast-T connector system responds to today's demand for high-speed, rugged, small solutions to connector applications.



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Global Business

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suppliers in the search for new ideas,” according to the 2013 *Global Manufacturing Outlook* report from consulting firm KPMG International, released in May. The report points to a new wave of benefits that “will be the most dramatic yet, with a new spirit of partnership, transparency and visibility across the value chain creating enormous economic value from a technology-enabled, demand-driven supply chain,” explains Jeff Dobbs, KPMG’s global sector chair for diversified industrials.

The trend is not lost on the electronics supply chain, which offers a focused look at the growing spirit of collaboration identified in the KPMG report, particularly as distributors and customers forge stronger design/supply collaboration strategies.

A pointed example of this is a recent announcement from small manufacturing firm Sensuss on the release of its new sports-impact measurement products. Sensuss credits its seven-year relationship with distribution partner Avnet Electronics Marketing as a key part not only in bringing the products to market but also in helping to ensure the long-term success of a startup company.

“We were looking to buy parts and Avnet filled that void for us. The relationship has ballooned from there,” says Jeff Lawson, CEO of Sensuss, which launched its S2 and S3 sports impact measurement products this summer. Both use a combination of Analog Devices sensors, NXP microcontrollers, and a EuroTech Helios aggregator that uses Intel-based technology.

“We were surprised at how quickly we became more than just a customer, and that was so important to us. We were not looking for a ‘just quote me the price on 10,000 of these and I’ll go to the next person next time’ type of relationship. We were looking to find a close working relationship with a supplier and we evolved to that really quickly,” he says.

“ A new report notes a heightened spirit of partnership across the supply chain as manufacturing organizations dig deeper into their supplier relationships for innovation, ideas, and long-term planning.”

Sensuss’ S3 is a helmet-based or glove-based device that monitors impacts, capturing the information, using machine-to-machine (M2M) technology to transmit and store the data, and cloud-based applications providing real-time assessments that can protect the athlete from further potential harm. The S2 is a translucent helmet-based device that lights up when an athlete experiences a pre-defined level of impact, immediately sending an alert that a critical event may have occurred.

Both products were rolled out this summer, and Sensuss’ goal is to penetrate the youth sports market with technology that can help prevent traumatic brain injuries (TBIs). Nearly 4 million mild traumatic brain injuries (MTBIs) or concussions are reported each year due to impacts in sports and recreational activities, according to the Centers for Disease Control.

Lawson says he and his colleagues at Sensuss understood early in the process that they needed strong supply chain partners to help them achieve their goal to design at home and manufacture anywhere in the world for what they predict is a large and growing market.

“One of the keys to choosing a supplier was that we needed someone who had the right roadmap for all of the key products [that we needed],” explains Lawson, pointing to Avnet’s ability to

bring together technical experts and key component manufacturers early in the design process. “Very early on, we made a conscious decision to do a single point of contact for all of the [bills of materials]. We said, ‘we want you to stock for our forecast, deliver the products we ask for to us here [in the United States], but also deliver them anywhere that we stipulate in the world.’”

FORGING STRONGER CONNECTIONS

According to the KPMG report, today companies view their channel partners as more of a network critical to achieving a “demand-driven” supply chain, one that provides a real-time view to total demand, supply, and capacity information.

“For companies of all sizes, genuinely closer working relationships between suppliers and other partners will be critical to maximizing their responsiveness to changes in the market,” the report points out. “More effective and efficient collaboration enables firms to optimize inventory, logistics and other operational costs.”

Such activities are a crucial part of the Sensuss/Avnet relationship. Both Lawson and Avnet EM account manager Stan Marszalek point to the companies’ close collaboration from design through to production, which includes not only technical support on the design side but also special supply chain logistics programs that balance end-market forecasts with supplier lead times and other key issues to ensure a seamless flow of products and support services.

“[Sensuss] needed a solid roadmap. When we sat down with Jeff, we talked about the business requirements from prototype, to production, to next generation, to costs, logistics, and so forth,” explains Marszalek. “We have a centralized, focused team for both technical and logistics support, so we’re there to provide the entire support package, from early design support now moving into production and [going forward]”



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Lawson characterizes it as a higher-level partnership than what may have occurred in years past.

“Supply chain is really the wrong word, from our perspective,” Lawson says. “What we were looking for was not supply chain. The old word is that sergeants talk supply but generals talk logistics. We needed the logistics to replenish our stock, align ourselves with technology, to figure out the vendors we needed to be with, to target our product to market and to provide service. That’s what Avnet provided.”

IDEAS, NOT JUST SUPPLY

Looking ahead, both Lawson and Marszalek say the partnership will grow, especially in light of its forward-thinking nature. They say they have taken next-generation activity into account from the start of the project, for instance, planning for a continuous and rapidly evolving product cycle.

“I think it’s easy to think about this in a singular format: we had this idea, we designed this product, and now we’re taking it to manufacture,” says Lawson. “But we’re doing so much more than that. We’re focusing on next-generation activity now. We’re also in the stages of redesigning on two separate fronts. Our design team is different from our manufacturing team and Avnet is interfacing with both. So, it’s a never-ending cycle. In this product portfolio we have a tremendous need to stay ahead of the rapid-turn cycle. So we need to align ourselves with the right suppliers and line everything up to meet our roadmap.”

Lawson echoes another key point from the KPMG 2013 *Global Manufacturing Outlook*: that, increasingly, companies are placing the supply chain at the center of their strategies to innovate.

“Many companies are starting to see their suppliers as a source not just of production and logistics but also of ideas,” the report says. “Half of our survey respondents say that partnerships, rather than in-house efforts, will characterize the future of innovation.” ■

Distributors Expand Embedded Services Offerings

New embedded technology solutions and a key acquisition for Avnet in Europe topped component distribution news this summer.

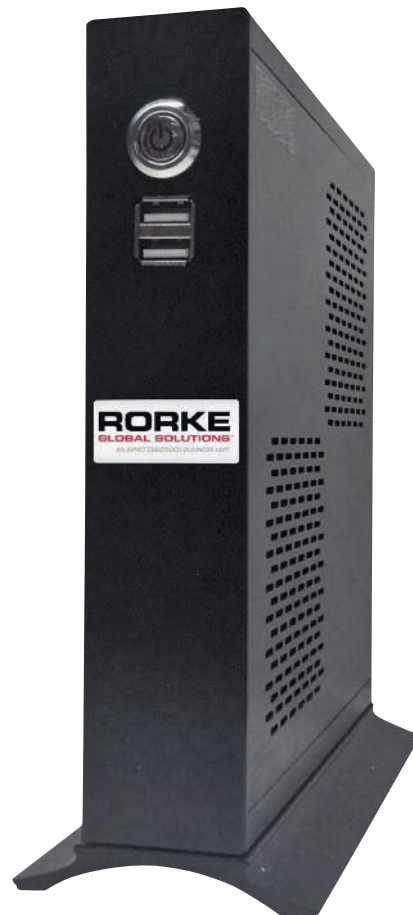
ELECTRONICS DISTRIBUTOR AVNET INC.

announced in July the expansion of its presence throughout Europe with the acquisition of MSC Investoren GmbH, a European distributor of electronic components, embedded computing technology, and display solutions. Avnet said it will acquire “MSC Group” in a two-step approach, first acquiring a majority interest in the company with the intent to acquire the remainder “within a short time frame.”

MSC Group is a value-added distributor that leverages a combination of distribution, production, and system integration capability to address emerging customer demand for more complex electronic products. The company generated more than \$450 million (U.S.) in revenue in 2012, with embedded computer technology (including display solutions) accounting for almost 50% of sales.

“The addition of the MSC Group is a strong fit with our strategy to invest in margin-enhancing acquisitions that complement our existing design and supply chain services, while also expanding growth opportunities in the region,” Harley Feldberg, president of Avnet Electronics Marketing Global, said in a statement announcing the deal.

“With extensive engineering resources and a strong focus on design-in services, the MSC Group has built a solid reputation as a single source for complete solutions serving customers in the European industrial electronics market. By leveraging the combined skills of both organizations, we will be well positioned to better serve the needs of our customer base in the region,” he added.



Rorke Global Solutions has expanded its Paladin product line to include a new digital signage media player developed around the Intel Core architecture and the Intel Retail Client Manager content management software platform.

MSC Group will be integrated into the European business region of Avnet’s Electronics Marketing operating group. The company’s product portfolio com-

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Avnet, Future Launch New Divisions

Future Electronics and Avnet Inc. each announced in July new company divisions focused on providing integrated technology solutions to a range of customers.

THE AVNET EMBEDDED DIVISION launched Rorke Global Solutions, a business unit offering combined hardware, software, and related solutions to OEMs, independent software vendors, and others looking for unique solutions and services that cover product development all the way up to end-of-life and asset recovery. Rorke's solutions will combine internal products and services with off-the-shelf technologies from a wide range of manufacturers, the distributor said.

Chuck Kostalnick, senior vice president of Avnet Embedded, will lead the business unit, which will also include a dedicated sales and consulting group led by Avnet veteran Scott MacDonald, who will serve as vice president of sales and market solutions.

"Today, many OEMs and ISVs (independent solution vendors) go through multiple iterations of solution development and invest a lot of personnel and time coordinating multiple product and service vendors when they introduce a new technology into their product line, supply chain, or business," explained MacDonald.

"My group's goal is to simplify this into one coordinated process so that our customers achieve the highest return on investment when they deploy digital signage, security and surveillance, M2M (machine-to-machine), IT infrastructure, or open-compute technologies," MacDonald said.

In a similar move, Future announced a new division of the company focused on the M2M marketplace. Future Connectivity Solutions (FCS) offers marketing, sales, technical sales, and solutions support to customers looking for communications and connectivity products and services, especially wireless technology.

"Future Electronics has a long history of providing focused and dedicated sup-

“ Many OEMs and ISVs go through multiple iterations of solution development and invest a lot of personnel and time coordinating multiple product and service vendors when they introduce a new technology into their product line, supply chain, or business.”

port to emerging vertical segments such as solid-state lighting and energy solutions. We believe that our customers' increasing desire to enhance wireless options for their own products validates the need for a unique and focused service model," Dan Casey, Future's executive vice president of global engineering,

said in a statement announcing the division July 17.

Along with a dedicated product marketing team, FCS has a team of dedicated sales managers and wireless advanced engineers.

"The availability of dedicated resources and highly specialized experts who completely understand the wireless ecosystem is something customers have requested and we are now delivering," Casey said.

FCS plays the role of technology integrator, adding value to customers' businesses by showing how emerging technologies can create enhanced efficiency, productivity, and new revenue streams, the company said. Healthcare, industrial, agriculture, transportation, intelligent buildings, and M2M infrastructure are key areas Future has pegged for growth in the connectivity market.

Avnet Inc. ranked first and Future Electronics ranked third in Global Purchasing's 2013 list of the Top 50 Electronics Distributors. For more, go to www.globalpurchasing.com. ■

CARTS International Announces Call For Technical Papers

CARTS INTERNATIONAL, THE ANNUAL technical conference for the passive electronics industry, announced a call for technical papers for its March 2014 meeting. Submissions are due by November 15, 2013.

The conference, which is sponsored by the Electronic Components Industry Association, will bring together experts in electronic component technologies from around the world. It is slated for March 31- April 3 in Santa Clara, Calif.

Conference organizers are requesting technical papers that focus on the use of electronic components in embedded systems, with an emphasis on automotive, aerospace, and energy exploration. The conference promotes information exchange among manufacturers, users, and academia involved with capacitors, resistors, filters, magnetics, integrated devices, embedded, and other passive components.

Entrants should submit a 200- to 300-word abstract describing the nature, scope, content, and key points of the proposed technical paper. They must also include the author's name, affiliation, and complete contact information. Submissions can be made online by visiting www.eciaonline.org/CARTSInternational/2014/. ■

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Distributors Expand

Continued from Page 54

plements Avnet's core business in the region and improves its offering of microcontrollers, memory, programmable logic, opto, and LED products, said Patrick Zammit, president of Avnet Electronics Marketing EMEA.

"The embedded computing and display solutions businesses enhance our competencies in systems-level solutions, thereby increasing our value add with customers in these higher growth product segments," Zammit explained. "We are excited about MSC Group and its talented employees as this represents another step in our business evolution as we progress up the technology value chain and provide additional services that our customers need."

In a separate announcement, Avnet said its new Rorke Global Solutions business unit has expanded its Paladin product line to include a new digital signage media player developed around the Intel Core architecture and the recently announced Intel Retail Client Manager content management software platform.

The Paladin digital signage media player is the first in a series of digital media products due out in the coming months, the distributor said, and is ideal for retail outlets, information points, or waiting areas such as medical facilities or transporta-

tion depots. It comes with a fully integrated content management system optimized for the Intel Core processor family. Rorke Global offers customization, installation, and integration services and was expected to add hosting and call center support for the Paladin product line by mid-August.

SOLUTIONS FROM MICRIUM, CYPRESS

In other embedded technology news, Micrium has announced a partnership with Clarinox Technologies for a best-in-class Bluetooth solution that couples the ClarinoxBlue application programming interface (API) with Micrium's popular uC/OS-III Kernel solution, reducing development time, according to the companies.

ClarinoxBlue handles complex applications utilizing both multiple Bluetooth profiles and multiple local Bluetooth devices, allowing an application to interact with several local Bluetooth devices simultaneously, the company says. ClarinoxBlue provides a built-in protocol analyzer as a debugging tool to enhance visibility and simplify debugging, benefitting applications such as the formation of complex networks.

"For the very stringent applications where you would use Micrium, we are satisfied to recommend our customers use Clarinox for their Bluetooth needs," says Christian Legare, executive vice president and chief technology officer for Micrium. "Micrium is always looking at partners that have many values in common with our own business values, and Clarinox is a perfect example."

Earlier in the year, Cypress Semiconductor announced the first of two product families from its PSoC 4 programmable system-on-chip (PSoC) architecture, available through its authorized distributors. The PSoC 4100 family is the lowest-cost ARM-based PSoC, bringing PSoC flexibility and integration to cost-sensitive, high-volume applications. The PSoC 4200 family features faster processor and analog-to-digital converter (ADC) sampling speeds and PLD-based (programmable logic device) enhanced universal digital blocks (UDBs).

In addition, Cypress released its \$25 PSoC 4 Pioneer Development Kit, which extends PSoC programmability to the established Arduino marketplace at an affordable price. The PSoC 4 PSoC architecture combines the company's best-in-class PSoC analog and digital fabric and industry-leading CapSense capacitive touch technology with ARM's power-efficient Cortex-M0 core.

"Our first two PSoC 4 device families were specifically designed for high-volume, low-end, 8-bit, 16-bit and 32-bit embedded applications," John Weil, senior director of PSoC marketing for Cypress' Programmable Systems Division, said in announcing the release this spring. "There are an almost limitless number of applications that can benefit from the high flexibility, low power, and low cost of these families. Our team has executed flawlessly to deliver these products in record time, and our customers are eager to start designing." ■

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Tough Environments

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cable, and connector assemblies to circuit breaker and relay panels. Making products watertight and heat-resistant is par for the course at this specialty distributor, especially as more customers outsource such production requirements and seek partners that will take on small-volume orders.

"Sub-contractors overseas don't want to do 100 or 200 pieces," explains Rome. "But we fit into that niche. No order is too small for us."

Rome also points to growing demand for higher speed and broader bandwidth in interconnect solutions.

"We never heard that with connectors before and now that's all I'm hearing," he says.

Mike Smith, vice president of Ohio-based distributor Hughes-Peters, agrees and notes strong demand for environmentally sealed connectors and for those that can withstand high current. Hughes-Peters is a regional interconnect, passive, and electromechanical (IP&E) specialist focused on value-added services like cable assemblies, wire marking, panel assembly, and a range of inventory management solutions.

"Anything harsh environment, sealed/IP67, and high current" is what customers are looking for, Smith says, adding

that low cost is the key demand on the printed-circuit board (PCB) side.

Manufacturers are keeping up with that demand, with some of the largest companies focused on high-speed, lightweight products, adds Rome. He points to TE Connectivity's Cee-Lok Fast-T connector system, a rugged, small form-factor, 10-Gigabit Ethernet, field terminable I/O connector for aerospace, defense, and marine markets (*see the figure*).

Smith says that smaller manufacturers are now focused on niche applications, pointing to CW Industries' custom high-density connectors for the military, which are available in small order quantities.

CAUTIOUS OUTLOOK

Smith says business has been consistently flat, and he expects that to continue through the end of 2013. As of early summer, Peerless Electronics' sales were up over last year, with slowing sales on the military side offset by strength in commercial aviation, medical, and industrial markets, Rome says.

"I'm cautiously optimistic," Rome says. "I think we're so well diversified in that we have field people designing in product, our new e-commerce site is going [strong], and we also have our value added services business, so we have several different things going on here." ■



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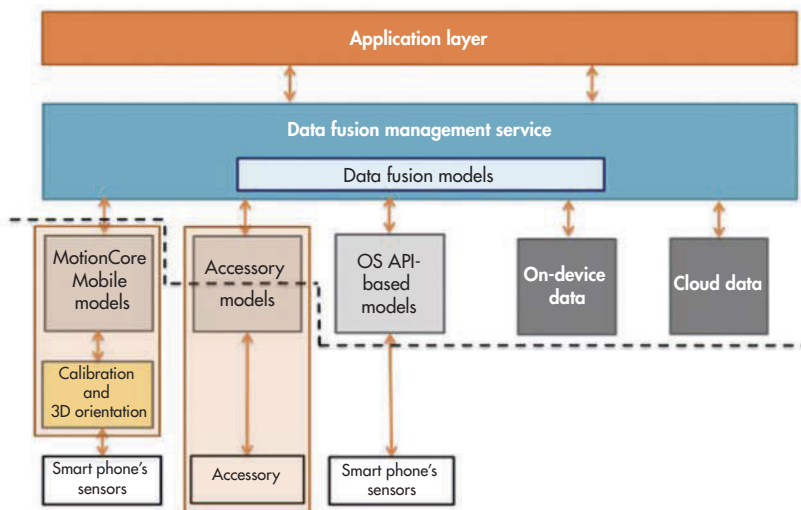
Imagine a world where your phone has really become your personal assistant, able to detect your needs and anticipate your next move. Your friend Eva sends you a text message reminding you that you're having dinner with her after work. It's 7 p.m. and you're in a rush to leave the office to make it to your 7:30 p.m. restaurant reservation.

By having access to your messages and schedule, and detecting that you're headed for the train station, your phone determines that you're on your way to meet Eva. What you didn't know was that there are massive delays in the subway. But because your phone also has access to your favorite public transit app, it alerts you that your train is running late so taking a cab is your best bet. Phew! A mini-crisis is averted. Now you can focus on the things that really matter.

This scenario requires your phone to have access to a lot of different information and types of data. This growing demand for applications that understand our context drives a need to analyze a wider variety of data sources. This, in turn, requires a shift from platforms that offer "sensor fusion" to those that feature "data fusion." And as we'll see, data fusion solutions will power the next generation of smarter devices and services.

SENSOR FUSION FALLS SHORT

Sensor fusion intelligently combines and processes data streams from multiple sensors so the output result is greater than the sum of individual sensor results. It eliminates deficiencies of individual devices and provides a synthesized smart output from a combination of accelerometers, gyro-



1. Data fusion models ensure communications between motion-based models, manage synchronization issues and data validity lifetime, implement some system rights, and manage competitive access to certain models.

scopes, and magnetometers. The signals are consumed and processed simultaneously to detect device orientation and enable compelling mobile applications such as games, tilt-compensated e-compasses, augmented reality, and more (see "Augmented Reality Will Be Here Sooner Than You Think" at electronicdesign.com).

Sensor fusion can provide a very accurate 3D orientation based on inertial sensor data. Many other features then can be built on top of this data. The technology raises awareness of the power of using sensors in combination and is a market driver for devices using combinations of microelectromechanical systems (MEMS) in mobile devices.

Today, sensor fusion solutions are pretty widespread, offered by semiconductor manufacturers and sensor fusion software experts. However, many solutions on the market are not robust enough and are tied to specific hardware, since they're provided by hardware manufacturers, in effect limit-

ing customers to their solutions. Continued market growth will increasingly depend on features that require additional sensors and different types of data on the device and in the cloud.

The demand for smarter applications and services on increasingly connected devices drives requirements for OEMs. Consumers are asking for a higher level of awareness and intelligence—devices that know, for example, where they are, what they're doing and with whom, and provide personalized services based on these data points. Moreover, they want applications that can leverage this context and other data to anticipate users' needs and deliver the right information, at the right time, in the right way.

By the same token, phone OEMs and app designers need to provide access to available services anytime, anywhere by providing developers the best context-based platform to enable easy-to-use and high-performing devices and applications. To facilitate this, OEMs and the application developer

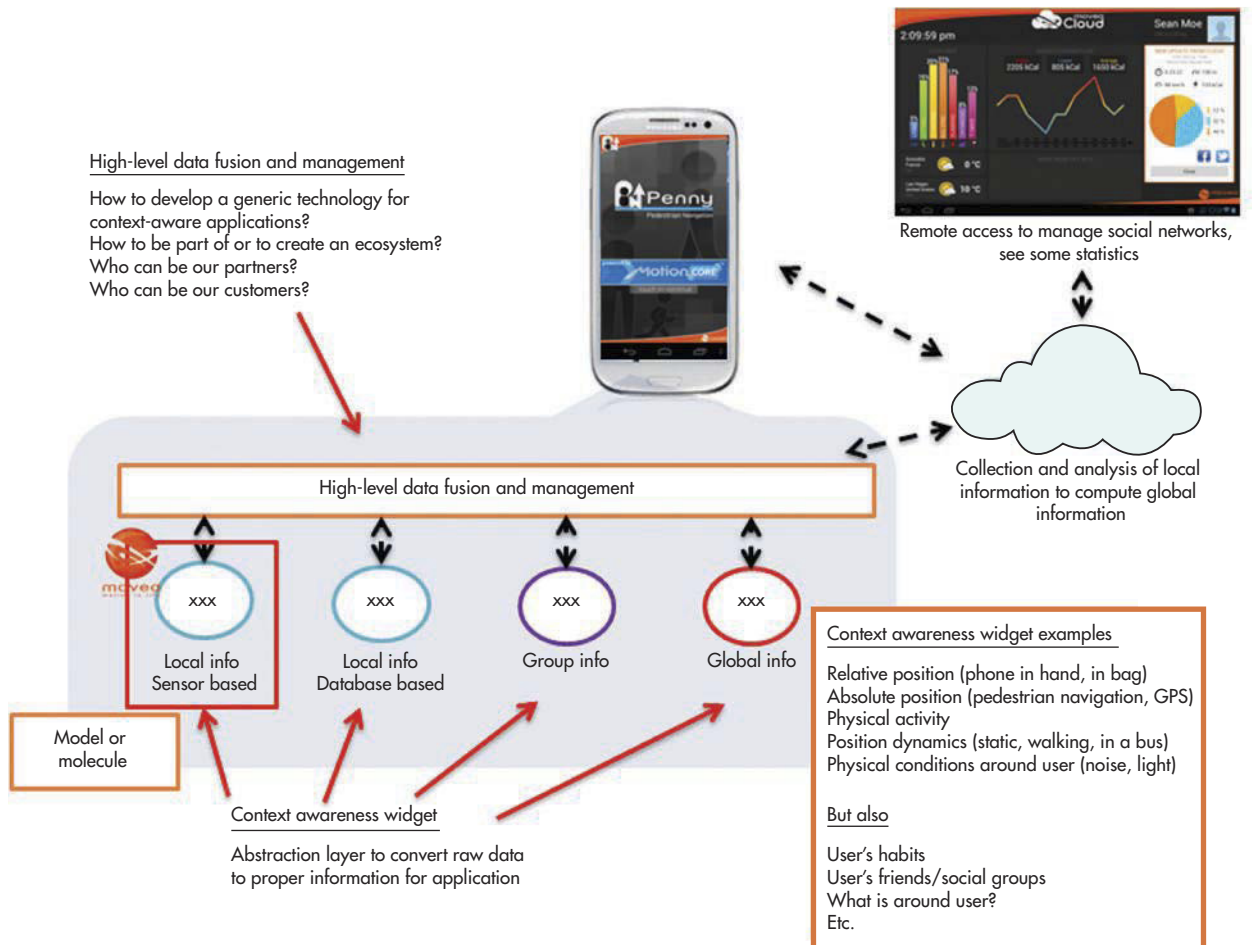
community need developer kits, cloud-hosted libraries of data models, and a platform that enables natural user interfaces without sacrificing power, computing, and appropriate sensor availability.

THE MOVE TO DATA FUSION

Delivering on the promise of smarter and context-aware applications demands a shift from sensor fusion to data fusion—gathering data to determine the device's state, the user's activity, and environment, and merging with additional user data present on the phone or in the cloud. Data fusion is a critical enabling technology for pervasive context awareness on mobile devices. A wide variety of conditions could be detected:

- Device state: on the table; connected to a docking station; in hand; by an ear; in a backpack; in a pocket; in a purse; in a holster; in a shoulder bag

2. Data fusion merges a user's motion data and maps it for accurate indoor navigation. Raw accelerometer, gyroscope, and magnetometer data are calibrated and serve an input into the heading and step count modules.



- User activity: standing, sitting, walking, or running; biking, riding, or skating; lying face up or down
- User environment: in a car, bus, train, or plane; in an elevator; going in/out the door

Many companies want to provide context awareness solutions for their customers, including Intel, Qualcomm, Google, and Freescale Semiconductor. But the industry needs to come together to overcome several obstacles to enable pervasive applications and services for smarter devices.

Among the challenges in developing a user-centric offering is an open framework supportive of data fusion, in which different players with very different skills can contribute to create smarter devices and apps. This open framework needs to multiplex many sources of data in vastly different formats across heterogeneous networks.

The results can be tuned to new data types and new use cases, which is yet another challenge. Then one needs to accommodate different data rates, data synchronization, and data loss. Effective learning strategies need to be developed when no a priori knowledge exists about mappings from data to response. Finally, data and metadata representation standards need to be developed.

FRAMEWORK AND ARCHITECTURE

The next generation of intelligent and aware mobile applications will rely on enabling data fusion models and services to gather and process data from a variety of sources in a power-efficient and cost-efficient way.

Data fusion can use embedded motion processing models that would be deployed to mobile phones and accessory devices. It also can provide operating systems (OSs) to these models through a data fusion management service that accesses external data and provides more accurate models, which then can be exposed to applications running above the OS. Embedded motion models examples include:

- Small untriggered gestures, such as face up/down, free fall, directional shake, single/double tap, and seesaw
- Activity recognition and energy expenditure
- Complex gestures, both for triggered and untriggered recognition
- Pedestrian navigation for such functions as a 3D magnetic compass, floor change detection, step cadency detector, and distance estimator

The data fusion models ensure a robust communication process between motion-based and other kinds of models such as user personal information, agenda, social media, or cloud. The models also can manage data synchronization issues and data validity and data lifecycle. They additionally

can implement some system rights and manage competitive access to models when needed (*Fig. 1*).

In addition to these embedded models, data fusion models also can run at the OS layer where they include map matching for indoor navigation optimization and activity monitoring and location combined with additional external information, such as e-mail, weather, train schedules, and traffic, enabling developers to create new compelling apps and services.

CONTEXT-AWARE APPLICATIONS

In effect, combining embedded and hosted data fusion models enables smarter applications, based on user location, activity, environment, and external data. Smart application examples include:

- Locating the position of people when driving to the airport to pick them up
- Turning off a cell phone when entering a theater
- Analyzing activity and schedules to indicate the best route to an appointment
- Locating where you are, what you are doing (walking, sitting, running), and sending notifications when your train is late so you don't have to rush

Let's take a look at one data fusion application in detail: how to find your car in a parking lot, or how to find your favorite store in a mall (*Fig. 2*). Data fusion merges a user's motion data and maps it for accurate indoor navigation. Raw accelerometer, gyroscope, and magnetometer data are calibrated and serve an input into the heading and step count models. The heading model computes the smart phone's change in direction with respect to due north. The smart phone's observed direction is the heading of the trajectory.

When the user is walking, the step count model calculates the user's step cadency. Combined with the user's step length and height, the model computes the distance walked by the user in a given time period.

The trajectory model then uses an initial position, the current heading, and the distance walked to create a trajectory, based on a sequence of positions over time, expressed in the coordinates of a given map. The system also uses a pressure sensor to detect floor changes, which can be used to trigger the map-matching module to load different maps according to the current floor.

Some algorithms can detect whether you're walking, sitting, standing, in an elevator, running, or lying down. This posture and activity detection enables a smart phone to adapt application behavior in accordance to the context, depending on the position and location. As an example, knowing that you are sitting down at work, the system will power down the location services.

Today's solutions enable consumers to use their smart phone and other accessory devices to monitor, track, and share their activity to encourage healthy behavior and choices. Such offerings are available from companies such as Nike with the FuelBand, Jawbone with its Up, and Fitbit with its Flex.


By adding data fusion models to these products, we can expect more groundbreaking advances in the near future. Data fusion offers the ability to measure and track a wider array of sports and personal activities for advanced analyses of running, tennis, cycling, and more, making the mobile device and its accessories the single entry to a brand new way of better knowing yourself.

LOOKING AHEAD

Integrated services based on a user's context and consumer's desire for smarter applications that can anticipate our needs and provide us with the right information at the right time and in the right way are the market drivers for mobile OEMs and apps developers to expand beyond basic sensor fusion. Data fusion, which merges and processes data from a wide variety of sources, is the key to enabling more intelligent apps.

However, there is still a need for smooth integration and a long learning curve since standards need to be developed.

The industry shift to data fusion allows the creation of a new level of intelligent mobile applications such as pedestrian navigation (allowing you to find your way anywhere outdoors and indoors), advanced activity monitoring (for a unified solution to measure yourself and make healthier decisions), and simplifying your everyday life, adapting the device behavior to the context.

The promise of a truly connected and contextually aware world is within our grasp. But to make it a reality, ecosystem players, mobile OEMs, semiconductor manufacturers, applications developers, and data giants need to unite and collaborate now to deliver this wide array of new intelligent services consumers are demanding. 



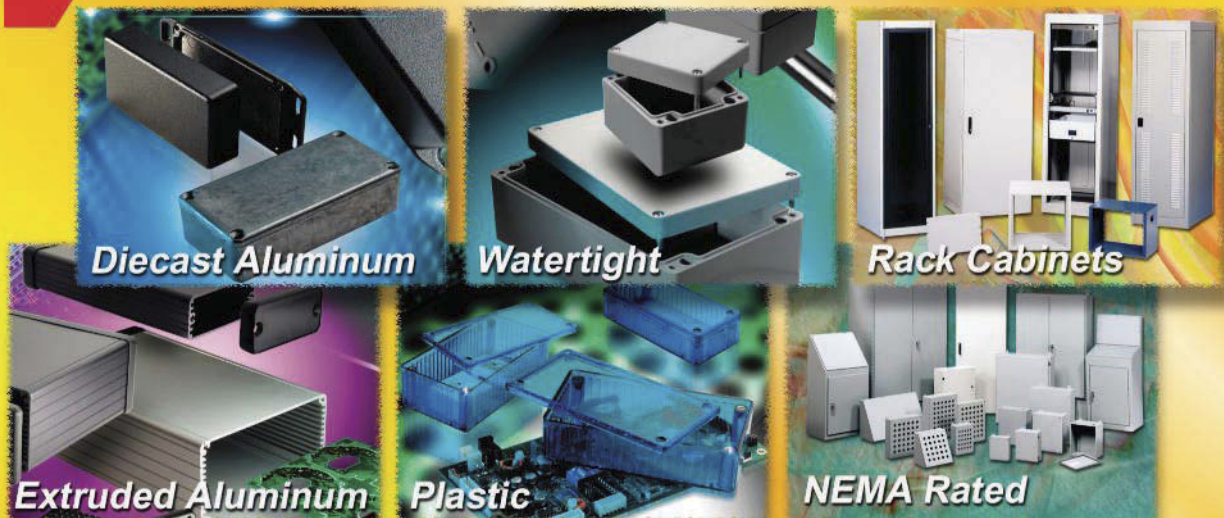
DAVE ROTHENBERG is Movea's director of marketing and partner alliances. He has more than 14 years of experience productizing and commercializing new technologies for companies in Silicon Valley and Europe. He takes an interdisciplinary approach to business, having held senior management roles across multiple fields. He holds dual degrees in aerospace engineering and physics from the University of Colorado, Boulder.



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Simple Addition Permits Voltage Control Of DC-DC Converter's Output

EUGENE PALATNIK | ITEC ENGINEERING epalatn@itecengineering.com

IN A STANDARD DC-DC converter, a resistor divider typically defines a fixed output voltage. However, applications like programmable output voltage power supplies and motor control circuits require dynamic control of the dc-dc converter's output voltage. The circuit described here allows control of the converter's output voltage, V_{Out} , with a control voltage, V_C .

In a conventional dc-dc buck converter, V_{Out} is:

$$V_{Out} = V_{fb} \left(\frac{R1 + R2}{R2} \right) \quad (1)$$

so V_{Out} is fixed by the values of $R1$ and $R2$ (Fig. 1).

The added circuitry in Figure 2 enables users to control the same dc-dc converter's output voltage using V_C . In this case, $R2$ is not connected to the ground but, rather, to V_r . Equation 1 then becomes:

$$V_{Out} - V_r = (V_{fb} - V_r) \left(\frac{R1 + R2}{R2} \right) \quad (2)$$

Since $R1 = 20 \text{ k}\Omega$ and $R2 = 10 \text{ k}\Omega$, Equation 2 can be simplified to:

$$V_{Out} - V_r = 3(V_{fb} - V_r) \quad (3)$$

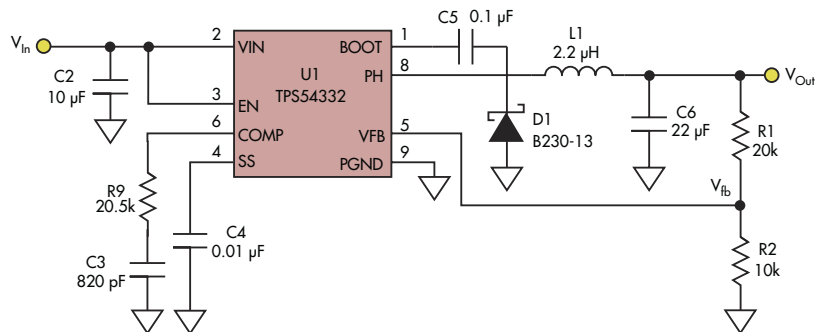
or:

$$V_{Out} = 3 V_{fb} - 2 V_r \quad (4)$$

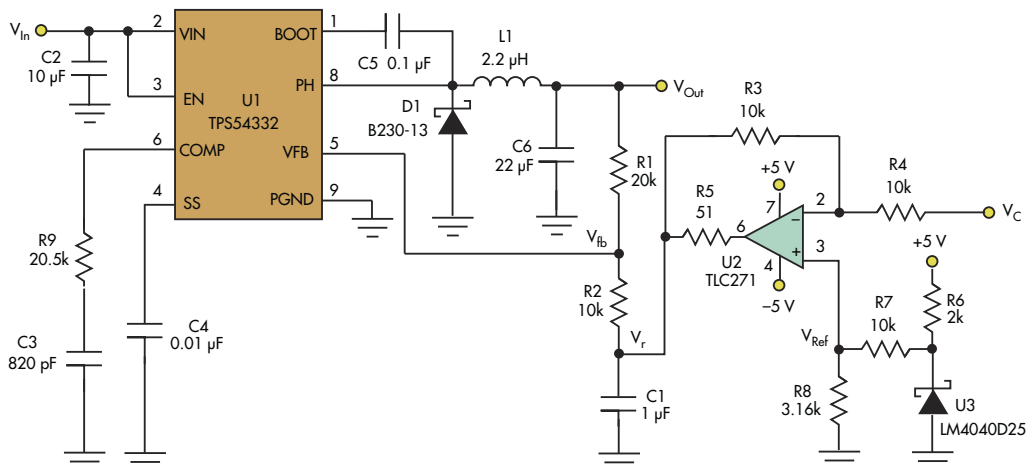
$R3$ and $R4$ have the same value, $10 \text{ k}\Omega$, so amplifier $U2$'s output voltage is:

$$V_r = 2 V_{Ref} - V_C \quad (5)$$

where V_{Ref} is the reference voltage generated by $U3$ after resistor divider $R7/R8$.



1. The output voltage in a conventional dc-dc buck converter is fixed and depends on the resistor divider, $R1/R2$.



2. The added circuitry in this version of the dc-dc converter permits control of V_{Out} by varying a control voltage, V_C .

LTC3883 senses inductor temperature and compensates for the temperature coefficient of the winding resistance. This method ensures the accuracy of the readback current and overcurrent limit.

The **LTC3883**'s control loop uses peak current mode control to achieve fast transient response and cycle-by-cycle current limit. Figure 2 shows the typical waveforms for a 10A load step transient, resulting in only a 60mV maximum deviation from nominal.

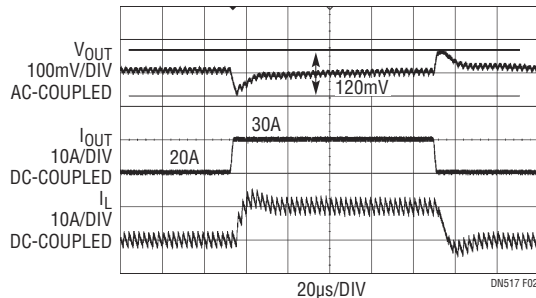


Figure 2. Transient Performance for a 10A Load Step

Input Current Sensing

The LTC3883 features input current sensing via a resistor in series with the input side of the buck converter—a 5mΩ sense resistor, as shown in Figure 1. The sense voltage is translated into a power stage input current by the LTC3883's 16-bit internal ADC. In addition, an internal IC sense resistor senses the chip's supply current at VIN, so it can provide both the chip and the power stage's input current measurements.

Inductor DCR Auto-Calibration

The problem with conventional inductor DCR current sensing is that the tolerance of the DCR can be as large as ±10%, greatly limiting the current read back accuracy. To solve this problem, the LTC3883 uses a

proprietary inductor DCR auto-calibration function. Figure 3 shows the simplified diagram of this circuit.

The LTC3883 accurately measures the input current, IIN, the duty cycle (D) and the current sense voltage (VCS) and calibrates the real DCR value based on the relation:

$$DCR_{CALIBRATED} = V_{CS} \cdot \frac{D}{I_{IN}}$$

With this auto-calibration method, the output current read back accuracy is within 3% regardless of inductor DCR tolerance.

LTpowerPlay™ GUI

All power system management functions can be controlled by LTpowerPlay, a PC-based graphical user interface compatible with all of Linear's power system management products. With LTpowerPlay, designers can easily program and control the entire power system without writing a line of code. With this tool, it is easy to configure any chip on the bus, verify system status, read the telemetry, check fault status and control supply sequencing. LTpowerPlay can be downloaded at www.LTpowerPlay.com.

Conclusion

The LTC3883 combines a best in class analog DC/DC controller with complete power system management functions and precision data converters for unprecedented performance and control. Multiple LTC3883s can be used with other Linear Technology PMBus products to optimize multirail power systems. The powerful LTpowerPlay software simplifies the development of complex power systems. If dual outputs are needed, use the LTC3880 which shares common power system management features.

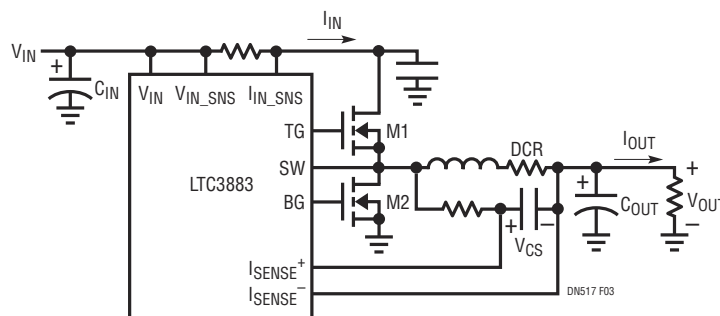


Figure 3. DCR Auto-Calibration

Data Sheet Download

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Combining Equation 4 and Equation 5:

$$V_{\text{Out}} = 3 V_{\text{fb}} - 4 V_{\text{Ref}} + 2 V \quad (6)$$

To simplify Equation 6, choose components that make:

$$3 V_{\text{fb}} = 4 V_{\text{Ref}} \quad (7)$$

Then Equation 6 becomes:

$$V_{\text{Out}} = 2 V_C \quad (8)$$


The internal voltage reference of U1 is 0.8 V. By choosing R7 = 10 kΩ and R8 = 3.16 kΩ, $V_{\text{Ref}} = 0.6$ V, satisfying Equation 7.

Finally, C1 lowers U2's output impedance at high frequencies, maintaining the stability of U1's feedback loop.

The added circuitry allows users to control the buck converter's output voltage, V_{Out} , in the range of 0 to 5 V with a control voltage, V_C , in the range of 0 to 2.5 V. Similar circuitry can



EUGENE PALATNIK is an electrical engineer and president of ITEC Engineering LLC. He is active in the design of electronics for medical, scientific, and industrial applications.

be designed for use with a boost converter, or any other dc-dc converter, as long as its feedback voltage pin is accessible. 

Simple NiCd Battery Charger Includes Charge Indication

ABEL RAYNUS | ARMATRON INTERNATIONAL INC. abelr@armatronintl.com

RECHARGEABLE NICKEL-CADMIUM (NICD) BATTERIES are widely used in consumer electronics because of their high energy density, long life, and low self-discharge rate. Standard NiCd cells can be charged at different rates: a fast charge with high current, or overnight with low current.

Regardless of the charge speed, a steady current should be provided to

the battery during charging. Also, more energy must be supplied to the battery than its actual capacity to compensate for energy loss during charging.

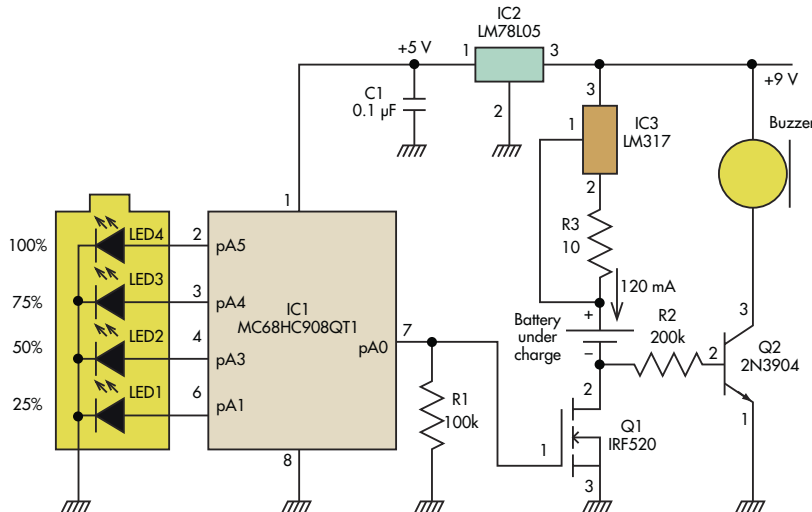
However, two problems must be addressed when designing a charger for them: how to set the proper charging-current value, and how to stop the charging process when the battery is

full, to avoid overcharging. This simple and inexpensive charger overcomes both problems. The cheapest and safest way to charge a NiCd battery is to charge at 10% of its rated capacity per hour for 16 hours. The battery pack used contained two AA-size 1200-mAh NiCd cells, so the battery should be charged with 120-mA current.

In the charging circuit of Figure 1, a constant charge current is generated by a current regulator comprising IC3 (an LM317 LDO) and resistor R3, where R3 is 1.25 V/120 mA, about 10 Ω. Switching MOSFET Q1 (IRF520) was chosen because of its very low open-state (conductive) impedance of 0.3 Ω.

The best charging practice is to use a timer to prevent overcharging to continue past 16 hours. This approach does not require an end-of-charge sensor, and it ensures a full charge. The timing function is performed by microcontroller IC1, which also reports the state of charge via the LEDs.

Any microcontroller could be used in this project. Here, the inexpensive eight-pin Motorola (Freescale) MC68HC908QT1 microcontroller was used.



1. The constant charging current is produced by an LDO and resistor and gated by Q1, which in turn is managed by an output of the microcontroller. A quartet of LEDs, also microcontroller-driven, indicates charge status to the user.

Each charging step is indicated by lighting a corresponding LED. The number of steps is determined by the number of available outputs of the microcontroller, without adding any extra components. Since the microcontroller has five outputs, one of them is used for charge triggering, and so the four can be used for charge indication. To minimize the number of components, LEDs with built-in resistors are used (WP710A10YD5V, www.kingbrightusa.com).

To make the process more visual, these LEDs should be located in line with the outline of the battery drawn around them, so lighting the LEDs one by one will clearly indicate the progress of charging. It is reasonable to choose the time intervals to be equal, with the LEDs indicating 25%, 50%, 75%, and 100% of battery-charge time.


The program starts blinking the corresponding LED at the beginning of each time interval and up to the end of each interval. After that, it lights the LEDs steady on. When charging is over, all four LEDs are on, so the user knows the charge status at any time. (As an optional feature, a buzzer could be added to provide an audio signal when charging is over.)

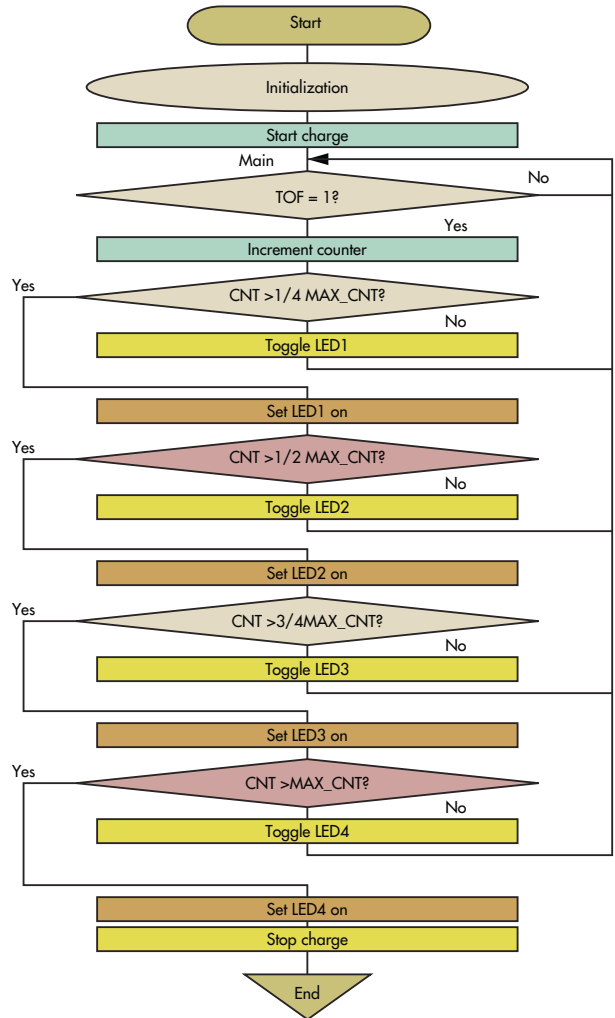
The microcontroller program of Figure 2 is straightforward. The assembler code listing can be found with the online version of this article at <http://electronicdesign.com/power/simple-icd-battery-charger-includes-charge-indication>.

The LED blinking period is set at one second. The built-in oscillator of the microcontroller generates a frequency of 12.8 MHz and provides a one-cycle duration of 312.5 ns. By setting the timer prescaler to 64 and timer modulo register to 50,000 (C350H), the timer overflow (TOF) period is equal to one second ($0.3125 \mu\text{s} \times 64 \times 50,000$). The program toggles the LED at each TOF period.

The overnight “long” charge lasts 16 hours, with counter constant MAX_CNT calculated as $16 \times 60 \times 60 = 57,600$ (E100H). Any maximum charge time can be set in the same way. Obviously, it’s not convenient to wait for 16 hours to test the program, and a period such as 20 minutes, for example, would be more practical.

For that shorter period, constant MAX_CNT should be set to $20 \times 60 = 1200$ (04B0H). The duration of each of four time intervals will then be automatically set by firmware once the maximum charge time is entered.

This approach is very flexible and can be applied to charge any NiCd battery by choosing resistor R3 accordingly. In addition, nearly any type of microcontroller can be used, because the program is simple and uses only standard instructions. 



2. The flowchart shows the straightforward level-check/step-through iteration sequence of the code for driving the charge-indication LEDs.

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ABEL RAYNUS is an engineer with Armatron International Inc., Malden, Mass.

Controller Lets Designers Replace Rectifier Bridge Diodes With MOSFETs

WITH LINEAR Technology's LT4320 ideal-diode bridge controller, power supply designers can replace each of the four diodes in a conventional full-wave bridge rectifier with a low-loss N-channel MOSFET. (For any given rating, N-channel devices are physically smaller and cheaper than P-channel devices.) The output voltage range is 9 to 72 V with an 80-V absolute maximum. Power output depends on the MOSFET ratings. It may range from one to hundreds of watts

In operation, the LT4320 reads the incoming ac voltage waveform and smoothly turns on the appropriate pair of MOSFETs for each half cycle (see the figure). The gate drive for the MOSFETs comes from an internal charge pump. The capacitors for the charge pump are already inside the IC.

Replacing conventional bridge rectifier diodes with MOSFETs eliminates the silicon diode's inescapable 0.6-V forward voltage drop (V_f) and associated thermal effects. For a MOSFET, $V_{DS(on)}$ losses can be much lower. Linear says the typical advantage is a reduction in losses by a factor of 10.

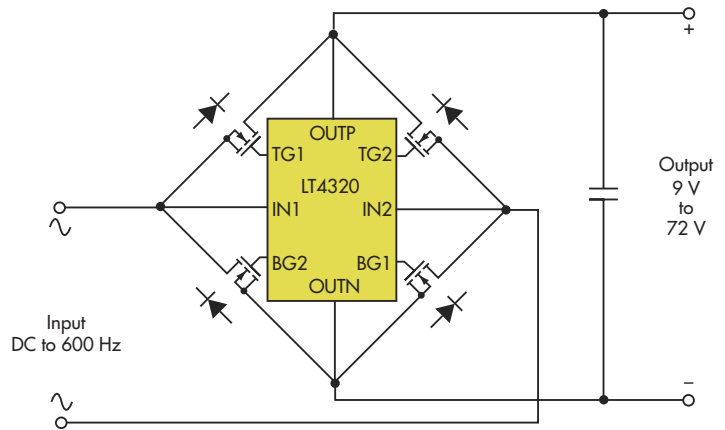
The company points out some less obvious advantages of the design. For example, in Power over Ethernet (PoE) applications, the 9-V low end of the operating range allows the use of 12-V wall adapters as the power source, while the 80-V capability allows the use of the 48-V supplied by powered Ethernet ports. Further, the dc to 600-Hz input line-voltage spec covers 50- and 60-Hz worldwide standards and 400-Hz aircraft ac buses. Higher frequencies are possible depending on MOSFET size.

Operating temperatures range from -40°C to 85°C . Packaging options comprise an eight-pin, 3- by 3-mm dual flat no-lead (DFN) package and a 12-lead mini small-outline package (MSOP) with enhanced high-voltage pin spacing. Pricing starts at \$2.95.

LINEAR TECHNOLOGY

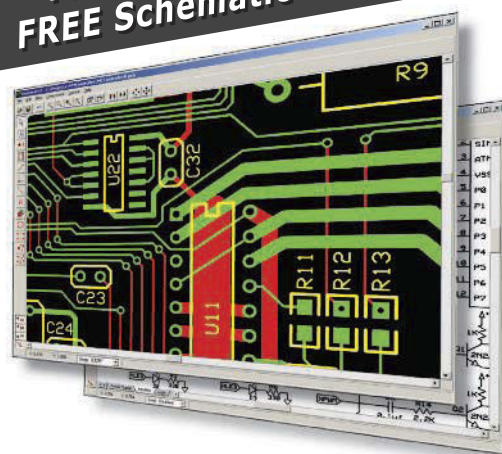
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DON TUITE



Replacing the silicon rectifier diodes in a full-wave bridge with N-type MOSFETs eliminates the V_f drop in each conducting pair. The effects of the gain in efficiency are not trivial. To accomplish this, Linear Technology has introduced the first controller IC that handles the task of syncing the MOSFETs to the power line. To provide gate drive for the MOSFETs, it integrates a charge pump, including capacitors.

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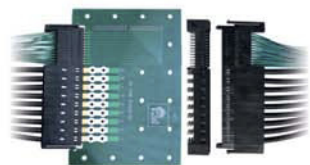
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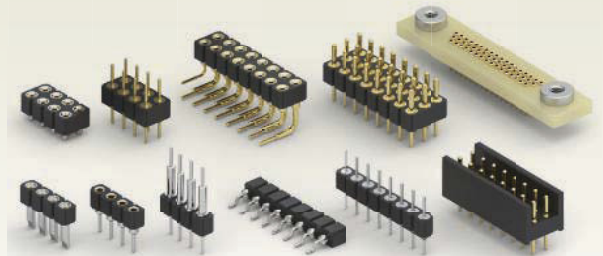
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ARM Fills In Midrange With Cortex-A12

ARM EXPECTS its 32-bit Cortex-A12 architecture to show up in chips in 2014. It delivers a 40% performance boost over the Cortex-A9 while using the same amount of power. Also, it

provides high-end features like big.LITTLE support, 40-bit addressing for access to 1 Tbyte of virtual memory, security features for hardware virtualization, and ARM's TrustZone support.

The Cortex-A12 fits between the Cortex-A7/A9 and Cortex-A15, which is the basis for a number of multicore systems-on-chip (SoCs) including Nvidia's Tegra 4. It fits well below ARM's 64-bit Cortex-A50 offerings, though the Cortex-A12 will support up to four cores while targeting the latest 28-nm technology.

The architecture incorporates a dual-issue, out-of-order, 11-stage, dynamic length pipeline that's tightly integrated with the NEON SIMD engine and floating-point units. The L1 and L2 caches are optimized for mobile workloads. Its CPU and GPU cores are connected via a 128-bit AMBA ACE. The Accelerator Coherency Port provides I/O coherency for DMA units.

The chips will include an ARM peripheral port designed for low-latency peripherals that do not have to utilize the AMBA ACE, eliminating related memory traffic congestion.

The architecture supports the midrange Mali-T622 GPU. This second-generation GPU supports OpenCL 1.1, Renderscript Compute, and OpenCL ES 3.0. The Cortex-A12 also can be paired with the Mali-V500 video engine, which includes up to eight cores. It can handle 1080p 60-Hz HD video encode and decode and is scalable to 4K120. It also supports AFBC (ARM frame buffer compression), which can reduce bandwidth by 50%. It supports a TrustZone secure video path for content protection as well.

The Cortex-A12 comes with Processor Optimization Pack (POP) IP support that was used with the Cortex-A50 family and the Cortex-A7, Cortex-A15, Cortex-A5, and Cortex-A9. For big.LITTLE support, the Cortex-A12 will be paired with a Cortex-A7 core. It provides a lower-cost, lower-power solution to a Cortex-A15/A7 pairing.

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More information is available on the **International Rectifier** website at <http://www.irf.com/whats-new/nr130710.html>
For more information, contact Stan Cummins, scummin1@irf.com, 310-252-7148

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Time-Of-Flight 3D Coming To A Device Near You

Microsoft's Kinect introduced Xbox 360 gamers to 3D sensors and body gesture recognition. It utilized technology from PrimeSense that projects an infrared (IR) pattern and uses a conventional IR sensor array to detect that pattern. A custom system-on-chip (SoC) does the heavy-duty number crunching so the host gets a depth map instead of information overload. The Xbox One comes with the second generation of the Kinect. However, it switches to a new technology for 3D imaging, time-of-flight (ToF).

TIME-OF-FLIGHT SENSOR

ToF measures the time a light pulse takes to travel from an emitter, reflect off an object, and return to the sensor. The distance to the object is half the time of travel. Simple. All you need is a sensor that works fast enough and performs the calculations quickly. Hard.

ToF sensors have been around for a very long time. They can be very accurate even at distances of miles. The Apollo 11, 14, and 15 missions placed retroreflectors on the moon so 1D ToF lasers could help accurately measure the distance to the Earth.

Cost is a major factor in adopting ToF 3D technology. Light detection and ranging (LIDAR) using a rotating mirror and a single laser source often is used in 2D ToF scenarios. The mirror causes the 1D ToF range finder to scan along a line. 3D LIDAR is possible but more challenging mechanically.

LIDAR units have been big, bulky, and expensive. Compact sensors like Hokuyo's URG-04LX have reduced the cost, but they are still too expensive for consumer applications. LIDAR can use visible light laser sources, but normally IR is used so its operation is invisible. A laser light show can be rather annoying and possibly distracting when a driverless car rolls by.

ToF cameras bring range finding to 3D. Instead of a single sensor, they use an array similar to those used for digital cameras. The challenge is handling the timing and then crunching lots of numbers. It's a great application for an FPGA.

SoftKinetic has done a lot of work with IR-based 3D ToF cameras. The intensity of the illumination source affects the range. If it's too bright, the light will overpower the sensor. On the other hand, more light is important for items more than a meter away. This is the difference between detecting fingers in front of a laptop and a body gyrating in front of a large HDTV.



1. SoftKinetic's DS311 can handle hand and finger recognition at a range of 0.15 to 1 m. It can also manage body recognition from 1.5 to 4.5 m using a brighter IR emitter setting.

NEAR FINGERS AND LIMBS AFAR

SoftKinetic's DS311 could be considered old technology since it was announced at the end of 2011 (Fig. 1). But getting the DepthSense CMOS in front of everyone's hands takes a while. It handles near-field hand and finger recognition from 15 cm up to 1 meter or a person or two at a distance of 1.5 to 4.5 meters, all at 60 frames/s with a resolution of 160 by 120 pixels. The DS325 provides 320 by 240 pixels but for near-field only.

For many embedded applications, range information is sufficient. For many applications like gaming, pairing the range sensor with a visible light camera makes sense. This is what DepthSense and Microsoft's Kinect does. Alignment helps so the color image can be combined with matching distance information.

Texas Instruments licensed the sensor technology from SoftKinetic. Creative Labs is turning it into a product, but crafting custom 3D sensor cameras isn't as hard as it might appear. Of course, checking out SoftKinetic's modules, reference design, driver, and gesture recognition software helps as well (Fig. 2).

So with all this hand waving, I close with Arthur C. Clarke's third law from "Hazards of Prophecy: The Failure of Imagination": Any sufficiently advanced technology is indistinguishable from magic. ☞



2. SoftKinetic modules can be used in embedded applications.

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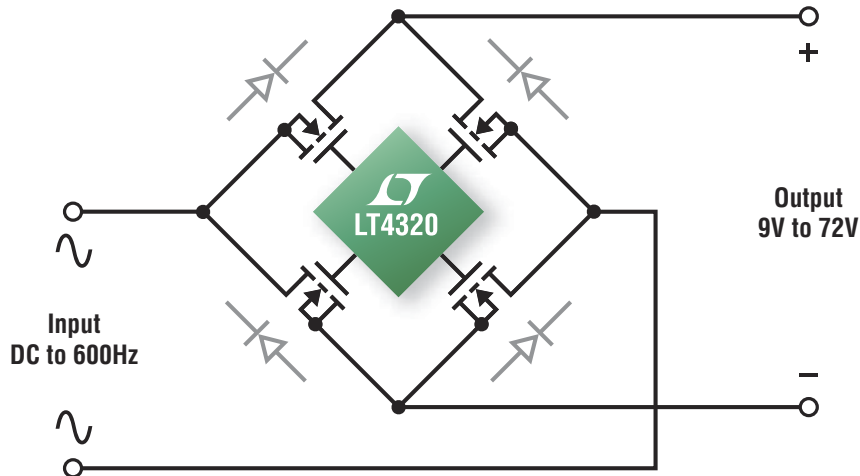


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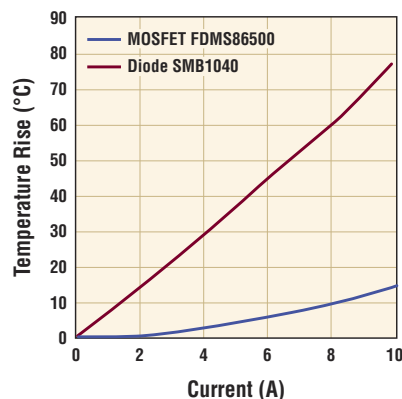
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