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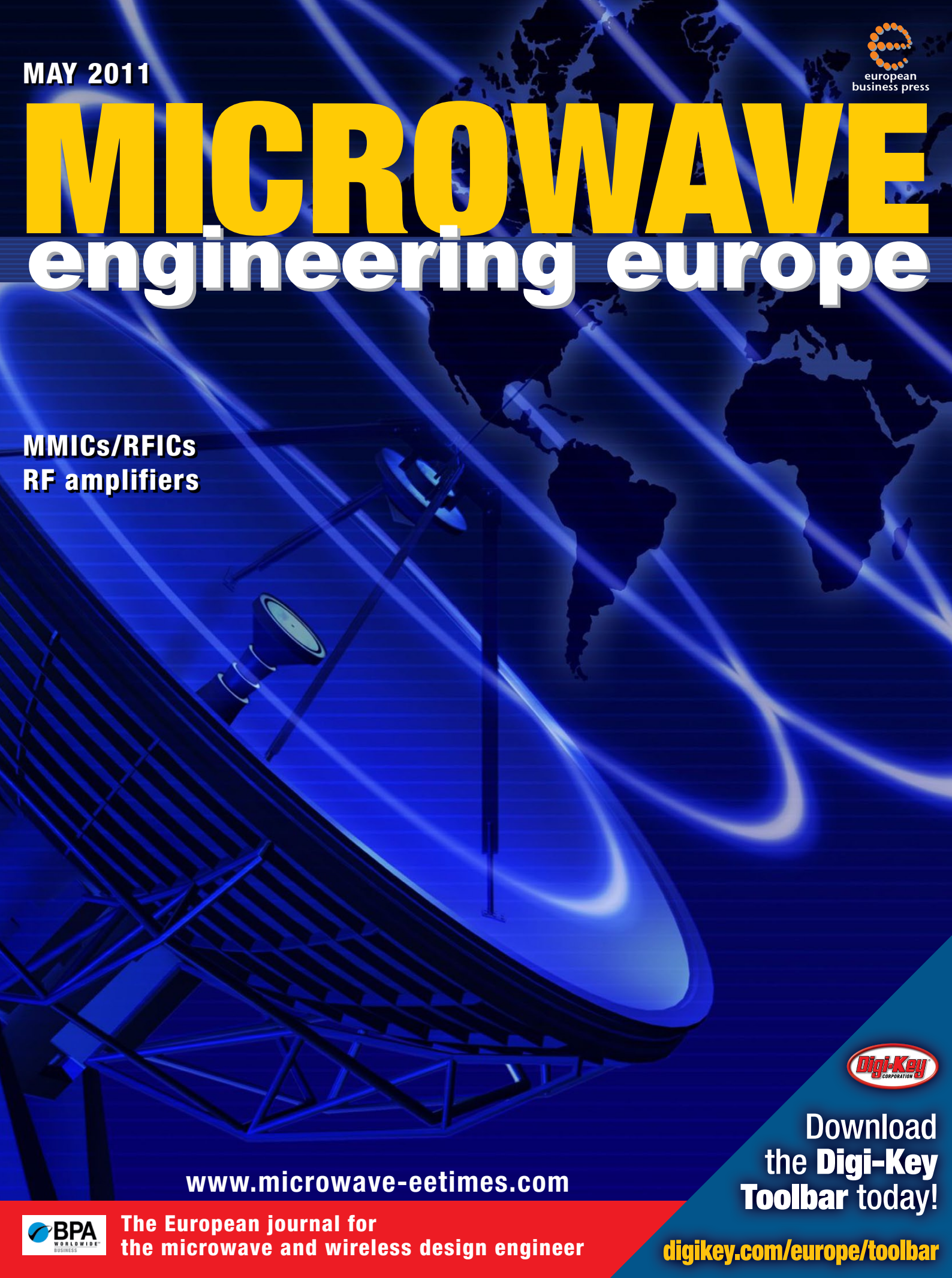
MMICs/RFICs
RF amplifiers



www.microwave-eetimes.com

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GET CONNECTED

IN BRIEF

BEEcube targets data centers, RF

BEEcube (Fremont, CA) is planning moves both into the data center and software-defined radio on the road map for its FPGA development platform to be shown at the Embedded Systems Conference.

The company plans to rack and stack its boards that house multiple Xilinx Virtex FPGAs. The work will create systems-level accelerators that could be used in tandem with traditional servers to run specialty apps, said Joseph Rothman, senior vice president of marketing at BEEcube.

In a separate effort, it is also planning to plug high-precision, high data rate analog-digital converters that support multiple Nyquest rates into the mezzanine slots of the boards. The resulting digital RF development systems will be used for testing cognitive and software-defined radio, radar and MIMO designs.

www.beecube.com

M/A-COM buys Optomai

M/A-COM Technology Solutions Inc., has acquired Optomai Inc., a fabless semiconductor company that develops integrated circuits and modules for next-generation 40- and 100-Gbps fiber optic networks.

Based in Silicon Valley, CA, Optomai's product portfolio in GaAs and InP circuit design complements M/A-COM Tech's existing CATV/broadcast and point-to-point/infrastructure businesses. Optomai is a provider of high-speed optoelectronic ICs such as laser modulator drivers and transimpedance amplifiers (TIA).

M/A-COM is a supplier of high performance semiconductors, active and passive components, and subassemblies for use in radio frequency (RF), microwave, and millimeter-wave applications.

Financial terms of the transaction were not disclosed.

www.macomtech.com

ABI Research projects 16 million mobile LTE subscribers by year's end

LTE is starting to gain critical momentum as we move through 2Q-2011. Currently 12 countries have commercial LTE services, and according to ABI Research VP of Forecasting Jake Saunders, "ABI Research projects that by the end of the year there will be some 16 million subscribers using LTE mobile devices."

A wide range of business models underpin LTE services. In Germany, T-Mobile's LTE service, called "Call & Surf Via Funk," is priced at $53/month in districts where xDSL fixed-broadband services are limited. The end-user is entitled to a fixed telephony line and an LTE connection, using a Huawei-manufactured wireless router offering download speeds of up to 3 Mbps.

NTT DoCoMo's LTE service, branded "Xi" (and pronounced "Crossy") allows customers to enjoy high broadband speeds in the Tokyo, Nagoya and Osaka areas. Population coverage stands at 7% through the coverage of 1,000 base stations. NTT DoCoMo aims to attain 70% coverage relying on 35,000 base stations by 2014. Monthly tariffs will run between $12 and $79.

Even at this early stage LTE is not only being deployed in mature markets but also in emerging markets. TeliaSonera has begun rolling out coverage in Uzbekistan.

A key success factor for LTE will be LTE smartphones. "The shift to 4G differs from the shift to 3G because of smartphones' capabilities," says research director Phil Solis. "In the US, people are actively looking for 4G as a handset feature, spurred by heavy marketing of 4G smartphones. Sprint's success with WiMAX smartphones is an indicator of the scale Verizon Wireless and AT&T can achieve with LTE smartphones this year."

In March 2011, the Global mobile Suppliers Association reported there were 100 LTE-ready devices. Only 13% were smartphones and media tablets, but these devices will see higher volumes. In 2014, more than 205 million LTE mobile devices will ship, 72% of which will be handsets.

www.abiresearch.com

EnOcean systems are now fully interoperable with TCP/IP

The EnOcean Alliance, a consortium of companies working to standardize and internationalize energy harvesting wireless technology for green intelligent buildings, announced that its wireless, battery-less energy harvesting sensors and associated control systems are now fully interoperable with TCP/IP.

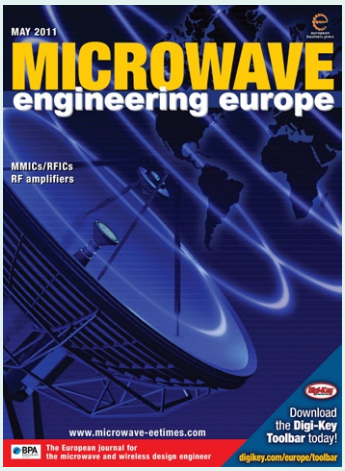
With escalating customer demand to manage and monitor building automation controls over IP networks, the EnOcean Alliance has responded, enabling building owners to fully leverage the flexibility of IP technologies that offer interoperability and convergence advantages to more effectively manage their facilities' energy consumption.

By establishing TCP/IP interoperability with its wireless, battery-less enabled end-devices and their associated IP-based control systems, the EnOcean Alliance offers a complete building management solution for maximum energy and operational efficiency. Building owners and facility managers can now monitor, manage, and control these systems centrally and from any web-enabled device, from anywhere in the world.

Small-to-medium sized buildings are seldom equipped with building automation systems because of the relatively high upfront costs and longer payback periods. Up front, fixed costs, such as software and dedicated servers, are proportionally more burdensome for smaller installations. In contrast, IP and web-based solutions offer an alternative to these hurdles either through more cost-effective building management systems or more mobile and accessible interfaces.

Variable costs incurred by labor have also limited the penetration rate of building automation systems (BAS), making IP-based sensor and control technologies more attractive. EnOcean Alliance-based wireless technologies can greatly reduce labor costs related to wiring, including opening and closing walls to connect and network devices together.

www.enocean-alliance.org/en



This month's cover depicts a radar application. A key issue in radar and electronic warfare applications is delivering high power outputs over broad bandwidths at high frequencies up to 100 GHz. Further, size and weight constraints often come into play as well.

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IN BRIEF

Silicon Image to buy SiBeam for $25 million

Silicon Image Inc., a supplier of high-definition connectivity ICs, has announced it has agreed to acquire privately-held SiBeam Inc., for $25.5 million in cash and Silicon Image stock.

SiBeam (Sunnyvale, CA) was founded in 2004 by a team of engineers from the Berkeley Wireless Research Center and communications industry veterans. The company developed 60-GHz chipsets using CMOS technology for use with high bandwidth services such as uncompressed HD video distribution.

SiBeam raised about $114 million over multiple rounds from such venture capital companies as New Enterprise Associates, US Venture Partners and Foundation Capital and is founding member of the WirelessHD Consortium and an active member of the Wireless Gigabit Alliance (WiGig).

The proposed transaction is expected to close in the second quarter of 2011, Silicon Image said

www.siliconimage.com

Anite LTE conformance test receives GCF approval

Anite has announced that its LTE protocol conformance testing solution — Anite Conformance Toolset — is the first to be approved by the Global Certification Forum (GCF) for the certification of devices intended for deployment on LTE Bands 01, Japan, and 07, Europe. With Test Platform Approval Criteria (TPAC) having been met for these two new bands, the Conformance Toolset further extends its capabilities as the only solution available that meets the industry's stringent test coverage requirements for LTE protocol testing across LTE bands 01, 07, 13 and 20 and TD-LTE bands 38 and 40. As more devices become ready for certification, Anite's Conformance Toolset is immediately available to meet certification requirements ahead of target

www.anite.com

Selective encryption said to cut wireless power

Selective encryption can protect the most important content in wireless streaming video without running down batteries on mobile devices, according to a university researcher.

Today, users must choose between using unsecured wireless transmissions that draw down batteries just to prevent eavesdropping on video streams. The new selective encryption technique could cut battery usage, claims Wei Wang, engineering professor at South Dakota State University in Brookings who headed a five university research team.

"We want to achieve good quality and strong security with limited battery and limited computing power," said Wang.

By dissecting the content of streaming video files, the researchers identified those elements that require detailed rendering and separated them from those requiring less resolution without affecting the overall video. The encryption routines then dedicate more resources to the encryption of important elements, while using faster encryption routines for the elements that can get by with less fidelity. The result is less energy used to encode and decode streaming video.

Wang's team has demonstrated that single image files can be dissected to discern those areas that need detailed rendering and those that don't require strong encryption. For instance, a scanned bank check requires high-fidelity for rendering its numbers and amounts, but weak encryption is sufficient for solid color.

The researcher hope to convince industry to adopt their technique of use in adjusting encryption accuracy on the fly to reduce power consumption in mobile devices.

www.sdstate.edu

Integrated chips fuel smartphone growth

Silicon integration will be the key differentiator in smartphones which could grow to 600 million units in 2014, driven by expansion in low-cost handsets, according to a presentation at the inaugural Linley Tech Mobile Conference.

"The next 300 million smartphones will come from feature phone replacements," said Linley Gwennap, principal of The Linley Group, organizer of the event. "The pressure for smartphone designers will be in reducing systems cost to meet this growing demand for lower cost smartphones and silicon integration is a key," Gwennap said.

Much of the integration will come from combining application and baseband processors. By 2014 nearly 70 percent of all smartphones will use such integrated chips, up from 40 percent in 2010, Gwennap predicted.

Such chips will be key as designers try to hit prices as low as $100 for smartphones sold in emerging markets. Meanwhile, "the percentage of the market you can address with stand-alone application and baseband processors is slowly diminishing" to about 80 to 100 million units a year, Gwennap said.

"We totally believe most of the growth will come from integrated processors," said Raj Talluri, a senior Qualcomm manager at the event. "We did some analysis of the smartphone tiers and found greater than 50 percent of the market is for handsets costing less than $150—and that segment is growing.

"When you get into that class the BoM doesn't support standalone apps and modem processors," Talluri added.

LG, Motorola and Samsung are among the largest feature phone vendors and thus best positioned for the next round of smartphone growth. Qualcomm and Marvell led the move to integrated application and baseband processors and along with Broadcom and ST Ericsson own the pieces required for next-generation integrated chips, Gwennap said.

Qualcomm is shifting from a four- to a three-chip smartphone set in 2012 with separate devices for digital, RF and analog, he added. However many integrated chips may actually use multiple die in a package.

In application processors, dual core is sweeping the market this year. Nvidia led the way with its Tegra 2 processor already shipping in LG smartphones and Motorola tablets. A half a dozen other dual-core mobile processors from all the leading chip makers will ship in systems this year, Gwennap predicted.

www.linleygroup.com

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Future smartphones will need even more integration

Silicon integration will be the key differentiator in smartphones which could grow to 600 million units in 2014, driven by expansion in low-cost handsets, according to a presentation at the inaugural Linley Tech Mobile Conference by Linley Gwennap, principal of The Linley Group.

Much of the integration will come from combining application and baseband processors. By 2014 nearly 70 percent of all smartphones will use such integrated chips, up from 40 percent in 2010, Gwennap predicted.

Mobile phones got to their level of sophistication today through extensive integration, even at the Front End. GaAs has been successful in mobile phones partly because designers were able to integrate functionality using a GaAs process. For example, one company that has been very successful with this approach is TriQuint.

Needless to say, even more integration is needed. There are two main drivers here, the first being cost, the second power consumption.

Power has always been an issue in any mobile platform due to battery and heat dissipation constraints in a small form factor. Consequently, as smartphones look to "do everything", power management is a key requirement.

The other reason is cost. The mobile phone market is geared to selling very high volumes and the top end phones with all the features are, typically, over a period of a few years, driven down in cost through innovative integration at the silicon and GaAs level. This trend is most likely to repeat itself with the smartphone and emerging tablet market. It might take longer due to the high complexity of these devices, but the trend has already been set with the latest generation of Android smartphones and tablets, a direct response to Apple's iPhone and iPad.

Lastly, please note that with MTT-S 2011 approaching rapidly, Microwave Engineering Europe will be there to cover the news emanating from the world's leading Microwave exhibition and symposium. So feel free to contact me with any news or articles that you would like to bring to the attention of our readers.

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IN BRIEF

LTE chip startup raises $26 million

Mobile communications fabless chip company Altair Semiconductor has raised $26 million in a venture capital round led by Jerusalem Venture Partners (JVP). Altair (Hod Hasharon, Israel) said it will use the money to develop next-generation LTE chips.

The VC round, which included established investors BRM Capital, Bessemer Venture Partners, Giza Venture Capital and Pacific Technology Partners, brings the amount invested in Altair since its formation in 2005, to $74 million.

www.altair-semi.com

Microsemi buys AML

Microsemi has signed a definitive agreement to acquire AML Communications for $2.50 per share in an all-cash transaction. The total transaction value would be approximately $28 million.

AML Communications had previously entered into a definitive merger agreement with Anaren on Feb. 14, 2011 whereby Anaren would acquire AML for $2.15 per share in an all-cash transaction. On April 5, 2011, AML Communications' board determined that Microsemi's proposal to acquire AML represented a superior offer to its shareholders.

www.microsemi.com

MIPS: Android remains processor neutral

Processor intellectual property licensor MIPS Technologies is fully involved in Android antifragmentation efforts and is one of many companies invited to participate by Google, according to Art Swift, vice president of business development and marketing at MIPS. Swift says Google's moves continue to be architecture neutral and that there is an Android Native Development Kit (NDK) for each major processor architecture.

www.mips.com/blog

MEMS for consumer electronics set to boom in 2011

After only four years of existence, a segment of the microelectromechanical system (MEMS) market known as new MEMS—specifically for consumer electronics (CE) and mobile handsets—will grow by a remarkable 157.4 percent in 2011, powering the expansion of the overall MEMS industry, according to new IHS iSuppli research.

Revenue this year for new CE and mobile MEMS devices will reach $457.3 million, up by more than a factor of 2.5 from $177.6 million in 2010. A category including devices such as 3-axis gyroscopes and pico projectors, the new MEMS segment did not even exist in 2006. However, growth has been nothing short of explosive after the category was devised in 2007 to differentiate the segment from that of older, established MEMS. By 2014, new MEMS will generate revenue of $1.4 billion.

Compared to the triple-digit growth rate of new CE and mobile MEMS, the established MEMS segment is poised to expand only 10.4 percent this year. With older products like accelerometers and single- or dual-axis gyroscopes in its stable, established MEMS will continue to produce bigger revenue overall, but growth as a whole in the next three years will be confined to the range of 9 to 12 percent.

Meanwhile, expansion rates for new CE and mobile MEMS will amount to a hefty 31 to 62 percent from 2012 to 2014.

www.ihs.com

Arasan Chip Systems is first to unveil MIPI RFFE core

Arasan Chip Systems, claims to be the first to introduce a MIPI RFFE product. The standard is currently a 1.0 document. The Arasan MIPI RFFE provides everything required for integrating RFFE solutions — IP core, Verification IP, software drivers and hardware development platform.

The IP core includes RMM-compliant synthesizable, OVM verified RTL. The IP core provides enhanced programmable features for minimizing application complexity and pre/post message processing. It can be easily integrated into any design project and customized for a native interface or bridging function. A Verification IP for RFFE is also available to accelerate verification and testing of your system. Software drivers are readily available in Linux and can be ported to a variety of different OS platforms. The Radio Frequency Front End (RFFE) was developed by the MIPI standards committee as a means of controlling multiple transceiver systems.

www.arasan.com

Fuel-cell-on-a-chip demonstrated

Fuel cells on-a-chip could replace small batteries, according to Harvard University researchers who showed a wafer containing 145 solid-oxide fuel cells.

The research team, led by professor and principal investigator Shriram Ramanathan, had previously proven the concept of fabricating thin-film membranes for solid-oxide fuel cells, but only at sizes too small to replace small batteries. Now the team, in collaboration with SiEnergy Systems LLC (an Allied Minds company in Boston), has demonstrated that the technology can successfully be scaled up.

The team fabricated the tiny fuel-cells with 100-nanometer thick membranes on chips that scaled up their area from 100 microns to 5 millimeters wide, achieving a power density of 155 milliwatts per square centimeter (at 510 degrees Celsius).

Next the team plans to fabricate nanostructured anodes for hydrogen-alternative fuels and microstructured electrodes, which together should enable the tiny fuel cells to replace small batteries.

www.harvard.edu

Future EW environment calls for high RF power

By Joseph Hajduk, CEO, dB Control, www.dbcontrol.com

Since the dawn of electronic warfare, RF engineers have relied on the vacuum tube – specifically the traveling wave tube amplifier (TWTA) – to produce high microwave frequencies of up to 100 GHz and very high power levels over a broad bandwidth. While solid-state amplifiers are smaller and lighter than TWT amplifiers, even the most impressive gallium nitride (GaN), silicon LDMOS, or GaAs RF power transistors produce at most just over 1 kW of RF power, and then only at comparatively low frequencies.

While some solid-state devices can achieve a wide frequency range of 2 to 18 GHz, their output power remains at a maximum of about 20 W. The ideal solution is to exploit the integral advantages of solid-state and TWT technologies to deliver the best of both worlds — which is exactly what a microwave power module (MPM) accomplishes.

MPMs – a compact alternative to the TWTA

About 20 years ago, a joint project of the U.S. Armed Forces produced small, high-power amplifier modules in a common form factor that operated from low-voltage DC power supplies. The design used a solid-state driver amplifier based on MMICs or discrete RF power transistors to drive a mini-TWT. This was combined with a power supply and control circuits in a very compact enclosure. Today, MPMs from dB Control and other manufacturers are available with RF outputs up to about 300 W continuous wave (1 kW pulsed), and at frequencies as high as 50 GHz.

A reliable, efficient source for high power that is both compact and lightweight, MPMs are now extensively used in ECM, radar, and satellite communications systems. For example, dB Control's MPMs are used to power Synthetic Aperture Radar (SAR) systems like the Lynx SAR/GMTI onboard General Atomics Aeronautical Systems' MQ-9 Reaper Unmanned Aerial Vehicles. These long-range UAVs can remain in the air for up to 35 hours at altitudes of more than 65,000 feet while being controlled from a secure base.

In addition to military applications, UAVs are being employed worldwide for disaster management, wildfire detection, law enforcement and pollution monitoring. In fact, the U.S. Air Force's Global Hawk UAV was used to acquire images of damaged nuclear reactors in the aftermath of Japan's recent earthquake and tsunami.

Selecting a radar transmitter

Both the application and the platform must be considered when selecting a high-power radar transmitter. For example, the radar applications with multiple functions require time-shared roles for each function – which in turn requires a special type of transmitter. In addition, if the radar system is used to deliver countermeasures against jamming, the transmitter must provide wide bandwidth to enable frequency agility.

The installation platform is also important because it can impose size, weight, and thermal limitations on the transmitter. Some platforms test the transmitter's reliability by exposing it to harsh environmental conditions (i.e., extreme temperature, high altitude, dust, humidity, and vibration). Others, such as satellite communications systems, require a transmitter with an extremely long operating life. Fortunately, TWTAs have a life expectancy of 100,000 hours, enabling them to reliably deliver its rated performance continuously for more than 11 years — well beyond what is required for most defense applications.

TWTAs advancing to meet new requirements

As frequencies ascend, future radar transmitters may be required to provide up to 3 GHz of reliable bandwidth and handle a multitude of secure modulation formats. Also, for military groups to be able to communicate with allies in times of war and during emergencies, radar systems must be equipped to use additional modes of operation and new frequency bands and/or spectrums.

Fortunately, TWTAs continue to be top of mind for research and development engineers worldwide. DARPA, the U.S. Department of Defense's Advanced Research Projects Agency responsible for the development of new military technology, has a High Frequency Integrated Vacuum Electronics (HiFIVE) Program that is developing a 50- to 100-W TWTA at 220 GHz that can operate for 100+ hours in a high-bandwidth tactical communications link. The goal is to achieve throughput comparable to optical fiber – with no degradation.

Internationally, TWTA research is being conducted to develop products that will meet the needs of systems operating in the upper echelons of the millimeter-wave region. At the 2011 International Vacuum Electronics Conference in Bangalore, India for example, novel technologies for new components and materials, including high-density graphite, were explored.

While TWT technology may not be familiar to every microwave or RF engineer, it is ubiquitous throughout terrestrial, airborne, and space-based defense systems worldwide, and in commercial and scientific applications as well. Solid-state amplifiers may be chipping away at the lower echelons, but they're chasing a target that is moving upwards in both frequency and RF output power – a situation that is likely to remain for decades to come.

TriQuint brings GaAs to the masses

By Mark LaPedus, EE Times

In 1985, a group of engineers left Tektronix Inc., and founded TriQuint Semiconductor Inc., to pursue gallium arsenide (GaAs) technology for high performance wireless applications.

For years, GaAs was touted as the ''next big technology" that would eventually replace silicon. GaAs never realized those promises and TriQuint plodded along, selling into niche wireless applications.

But more recently, TriQuint has been on a roll on several fronts. The company's power amplifiers, modules and related RF devices have been incorporated into various and hot mobile devices from Apple, HTC, Motorola, RIM, Samsung, among others. In many of those designs, TriQuint sells an RF module that integrates a duplexer, power amplifier and a filter.

And this week, TriQuint cut the ribbon for a new design center in San Jose, which will propel its ongoing efforts in its growing networking business. The center involves employees within WJ Communications Inc., a company that was acquired by TriQuint in 2008.

The design and test engineering center, which has 90 employees, develops network infrastructure products, such base stations chips, CATV ICs, small signal devices and others. It is also developing products for the company's eventual entry or expansion into the RFID and smart grid segments.

The company is also expanding its fab capacity, which is supply constrained, according to analysts. And it appears that TriQuint will resume its aggressive acquisition efforts.

With little or no fanfare, TriQuint has moved beyond being a mere GaAs house. "In essence, we were once a GaAs foundry," said Brian Balut, vice president of networks at the company's design center here this week. ''Now, we're a RF solutions house."

The company's fortunes jumped three to four years ago, when it obtained an RF design win for Apple Inc.'s iPhone, said analyst Todd Koffman, who follows TriQuint for Raymond James & Associates Inc. Design wins for Apple's iPhone and iPad, and more recently, mobile phone maker HTC, "have really catapulted them," Koffman said. It also catapulted them as the "second largest RF company, behind Skyworks."

TriQuint's sales have more than doubled, from $401.79 million in 2006 to $878.7 in 2010. This year, the company's sales are projected to hit $1.03 billion, according to Zacks.

TriQuint faces several challenges, namely to continue to win sockets in the mobile space. Competition remains fierce in the RF chip market against the likes of Anadigics, RF Micro Devices and Skyworks. And it competes against various players in the network transport arena.

"The biggest issue is that (TriQuint has) run out of manufacturing capacity," Koffman said, adding that TriQuint is expected to expand its fab capacity by roughly 30 percent by year's end.

Not long ago, it was hard to envision the success at the device maker. Following its formation in 1985, GaAs pioneers Gazelle Microcircuits, Gigabit Logic, and TriQuint merge under the TriQuint Semiconductor name in 1991.

Over the years, TriQuint continued to expand its portfolio via acquisition. In 1998, it acquired Texas Instruments' GaAs MMIC business and Raytheon TI's Defense Systems and Electronics Group. In 2001, TriQuint bought Sawtek Inc., a surface acoustic wave (SAW) provider.

In 2002, TriQuint signed an agreement with Philips Semiconductors, guaranteeing controlled access to TriQuint's indium-gallium-phosphide (InGaP) and heterojunction bipolar transistor (HBT) 150-mm wafer processing facilities. A year later, it acquired Infineon's GaAs business.

The company seemed to turn the corner in 2002, when it hired Ralph Quinsey, a executive from On Semiconductor, as its president and CEO. The company continued on the acquisition spree in 2005, when it bought TFR Technologies, adding bulk acoustic wave (BAW) expertise to the corporation's technology arsenal.

TriQuint stumbled in 2005, when it sold the assets of its unprofitable optoelectronics operation to CyOptics, an optical components manufacturer. Meanwhile, TriQuint acquired Peak Devices in 2007, bought WJ in 2008, and snapped up TriAccess in 2009.

Today, TriQuint offers products in three segments: mobile, networks and defense. It also provides a GaAs and GaN foundry service. In February of 2011, TriQuint said revenue for the fourth quarter was $253.4 million, up 7 percent from previous quarter and up 31 percent from the like period a year ago. Net income for the fourth quarter of 2010 was $42.5 million, down 62 percent from the previous quarter but up 143 percent from the like period a year ago.

Revenue for 2010 was $878.7 million, up 34 percent from 2009. Net income for 2010 was $190.8 million, up 1,078 percent over 2009.

The company believes first quarter revenue for 2011 will be between $215 million and $225 million. At the midpoint, this implies revenue growth of 22 percent over the first quarter of 2010. For the full year, the company believes continued robust growth in demand should lead to revenue growth of about 20 percent.

Revenues from mobile device products accounted for approximately 66 percent of it total revenues in 2010, compared to 67 percent of revenues in 2009 and 63 percent of revenues in 2008.

For years, the company has been mostly known for its "power amplifiers and front-end modules," Koffman said. In the mobile space, it sells transmit modules, RF filters, power amplifiers and power amplifier modules and duplexers.

GaAs never replaced silicon, but it found a home in power amps despite competitive threats from silicon germanium and silicon. "GaAs material and device design can provide key performance advantages over silicon, such as higher frequency operation, improved signal reception and transmission, better signal processing in congested bands and greater power efficiency for longer battery life, all important attributes of the mobile phone experience," according to the company's annual report.

TriQuint has RF silicon in many of the hot mobile devices today-with the exception of Apple's iPhone sold by Verizon, he said. Besides that phone, TriQuint is "sitting pretty" in the mobile space, he said.

Needless to say, the cell-phone power amp business is competitive. The volumes are huge, but the margins are smaller and average selling prices (ASPs) tend to fall.

This article originally appeared in EE Times.

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CHANGING THE STANDARDS

Meeting the challenge of over-the-air MIMO testing

By Nigel Wright and Mike McKernan, Spirent Communications, www.spirent.com

Multiple-Input-Multiple-Output (MIMO) antenna techniques are a key factor in achieving the high data rates promised by next-generation wireless technologies such as LTE and LTE-Advanced. These new techniques impose significant challenges on the design and development of wireless devices, greatly complicating the associated RF testing.

With multiple antennas used to differentiate multiple incoming faded signals, it is necessary to test actual reception over the air (OTA). Field OTA testing can record results at a specific time and place, but cannot produce the required statistically meaningful data sets. A better approach is to identify real-world RF characteristics and re-create them in the laboratory using RF channel emulators and a chamber to provide a realistic, controllable, and repeatable test at reasonable cost. More has to be learnt about the OTA behaviour of MIMO systems before it will be possible to create virtual OTA models, so current laboratory testing is performed physically in two forms: the one using a large anechoic chamber and the other using a smaller and less costly reverberation chamber.

This article will discuss some basics of MIMO as well as the need for (and challenges of) MIMO-OTA testing and how successful it can be in emulating real-world propagation conditions.

Requirements for MIMO testing

MIMO operation is based on the idea that receiving antennas can distinguish between separate data streams transmitted in the same frequency band as long as there is some spatial (directional) difference in the routes taken from transmitting antennas to receiving antennas.

This is a tall order in a pocket-sized smartphone, but it is nonetheless a fundamental part of LTE. An MxN MIMO system – ie with M transmitting and N receiving antennas can at best increase maximum data rates by min{M,N} times that available from a Single-Input Single-output (SISO) system. For example, a 4x2 MIMO would double the data rates while a 4x4 MIMO system would quadruple them given ideal conditions. Real-world conditions, however, reduce that advantage.

SISO device testing typically uses 'conducted' signals – connected by cable and bypassing the antenna. SISO antenna performance characterisation is less complex than in MIMO, so it is tested separately in an anechoic chamber to measure Total Radiated Power (TRP) and Total Receiver Sensitivity (TRS). For SISO devices, TRP and TRS are adequate measures, but MIMO performance is a function of so many factors – including propagation environment, antenna design/orientation and baseband algorithms – that it needs a radically different approach to testing. The figure of merit most commonly used to differentiate between a "good" and "poor" MIMO device is data throughput under realistic operating conditions.

Such "realistic operating conditions" involve two factors: realistic faded signals, combined with realistic reception at the antennas. While channel emulators such as Spirent's SR5500 or its new VR5 HD can create the appropriate signals, conducted-signal testing would not address MIMO's dependence on the physical antenna design. This is why, with our increased reliance on MIMO techniques, radiated OTA testing has become critical and will become ever more critical as the number of antennas increase in future devices.

MIMO OTA testing needs to replicate the real world propagation environment. In the context of a relatively wide-bandwidth technology like LTE, it is important to emulate the spatial aspects of the wireless channel. MIMO OTA testing uses the 3GPP's Spatial Channel Model (SCM) and Spatial Channel Model Extension (SCME) channel models for this purpose.

The models are defined with six RF paths, each representing the signal received after reflecting from a cluster of "scatterers" located near the device. Both the Angle of Arrival (AoA) at which the signals arrive at the receiver, and the angle spread (AS) must be modelled, in addition to the Angle of Departure (AoD) from the transmitter that also influences the channel throughput.

Instead of being received from uniformly distributed directions, each multipath signal component is spatially concentrated, resulting in a particular angle spread and a unique angle of arrival. The directional distribution of power per component is quantified as the "Power Azimuth Spectrum" (PAS).

When the user is on the move, the signal path's unique AS and AoA will be affected by Doppler shift, producing a unique Doppler spectrum. While the composite-environment Doppler spread may resemble the U-shaped spread seen in narrow-band channels, the per-path Doppler spread will retain their wideband characteristics.

All of these variables need to be accounted for in order to create a valid MIMO OTA test.

Anechoic versus reverberation chambers

MIMO-OTA testing requires a signal source, one or more channel emulators and a number of transmitting antennas installed within a shielded chamber that can be either:

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1) An anechoic chamber – typically a large chamber with RF absorbent walls to eliminate reflection. Although this can be a costly solution, it allows great control because the RF signals provided by the wireless channel emulators come directly from the antennas in the chamber, which can be precisely and repeatably situated.
2) A reverberation chamber – typically a smaller chamber that allows reflections from the chamber walls. Mechanically controlled reflective "stirrers" or "paddles" can be used to model dynamic conditions.

The two types of chamber offer different benefits. Although some useful, cost-effective MIMO-OTA testing can be performed in a reverberation chamber, more detailed testing requires an anechoic chamber that allows the generated field to be precisely controlled for better spatial fine-tuning in a controlled and repeatable manner.

Anechoic chamber testing

Taking the 3GPP's Spatial Channel Models (SCM) as an example: modelling the SCM over the air requires properly matched statistical properties, notably the spatial correlation properties, defined in terms of 20 spectral components. One obvious approach would be to reproduce these components using 20 separate antennas, but this is not practical considering that the SCM actually contains many reflecting clusters, each consisting of 20 specular components. What's more, the model must accurately represent the AS and AoA at the device.

After extensive research, Spirent has determined that it is possible to fully match these spatial correlation properties with as few as three antennas per reflecting cluster. Precise control of transmission parameters can accurately reproduce all the correlation properties, AS and AoA of the SCM-modelled signals. Additionally, Spirent's research has shown that each transmit antenna in the chamber can be used to contribute signal content for the multiple reflecting clusters that make up the SCM model.

Although this does dramatically reduce the number of antennas required, it complicates matters in other ways that need to be addressed. For example, the time-domain characteristics of the signal need to match the SCM, and the signal received by the mobile must have the same level-crossing rate or "fading rate" as the SCM model. The limited number of antennas make this something of a challenge, but channel emulators can be used to create accurately controlled faded signals into each transmit antenna in such a way as to match both the correlation properties and the time-domain statistics of the SCM. The combination of generated signals must also be shown to have a Doppler spectrum resembling the target model.

Finally, in order to generate an accurate radiated SCM for devices with good polarisation diversity, both the vertical and horizontal components must be modelled and matched to the SCM reference model. Accounting for multiple vertically polarized antennas is relatively straightforward, but combining horizontally polarized signals is much more challenging.

All this would add up to a considerable exercise in mathematical calculation, and increased error risk, were it not taken care of by Spirent's MIMO-OTA Environment Builder software. Used in combination with the Spirent VR5 HD Spatial Channel Emulator or SR5500 Wireless Channel Emulators, setting up the environment requires just three steps:

1) Setting up the channel model parameters. This can be as simple as selecting a standard channel model from a drop-down box, then entering mobility and other parameters – otherwise customized models can also be created.
2) Describing the in-chamber transmitting hardware. Probe-specific parameters are selected, and even greater accuracy is achieved by a one-time chamber calibration process that tells the software how to account for radiated path loss, etc.
3) In-test editing. During test execution, on-screen controls allow dynamic adjusting of parameters in order to quickly see the effects of realistic environmental variations, such as editing angles of departure and arrival, as well as the total signal power received. On-screen graphics offer immediate feedback to minimize user error.

The MIMO-OTA Environment Builder provides comprehensive graphical summaries of the effects of the modelled channel as shown in the two tab views in Figure 1.

The left side of Figure 1 shows per-probe values of power distribution related to both the vertical and horizontal polarizations. It also contains (on bottom left) a polar summary of the power angle profile for the given model overlaid on a representation of the actual antenna probes as configured in the chamber. The graphic to the right of this polar plot in Figure 1 is a map of the generated channel correlation as compared to the ideal narrow-band model. The two plots on the upper right-hand side depict the ideal and generated Doppler spectra, while the two on the bottom show the power azimuth spectra at both the base station and the device under test.

Spatial Channel Emulation with Spirent VR5

Emulating a MIMO channel requires MxN separate emulated radio channels, where M is the number of antenna elements at the transmitter and N is the number of elements at the receiver. If bi-directional or handover

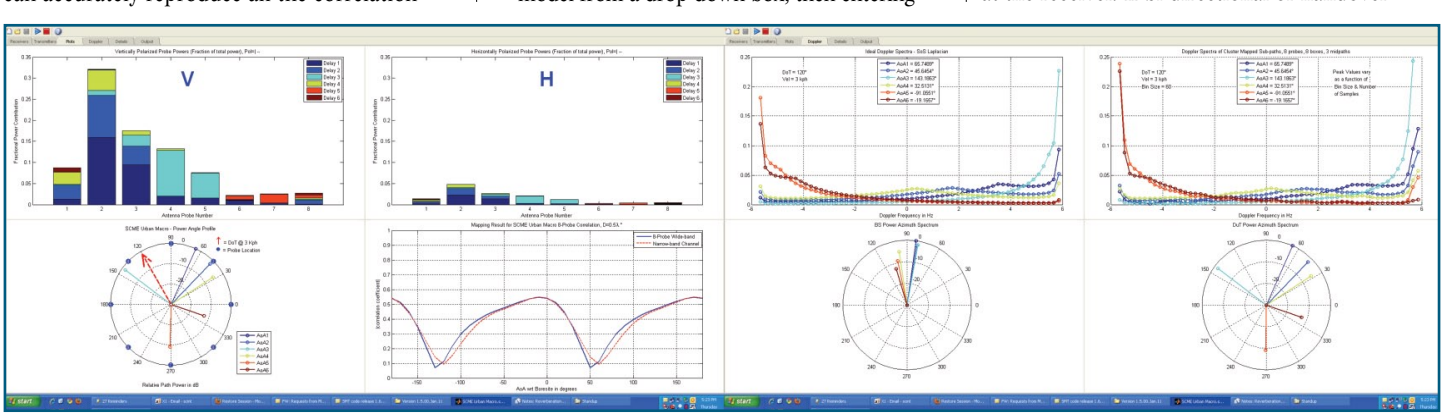


Figure 1: The MIMO-OTA Environment Builder provides comprehensive graphical summaries of the effects of the modelled channel.

testing is required, the number of required links immediately doubles. Deployments using 4x2 MIMO are currently under development and will be followed by 4x4, 8x2 and 8x4 schemes. The number of channels required for testing already numbers in the dozens, but can be provided in a single 6U high hardware unit by the latest Spirent VR5 HD Spatial Channel Emulator.

Passive components such as splitters, combiners and duplexers are integrated within the unit, while both the system's output power and dynamic range are designed to eliminate the need for outboard amplifiers.

The VR5 renews some of the hardware features that made its sibling, Spirent's SR5500 Wireless Channel Emulator, an industry favourite: internal power meters at each input and output help ensure accuracy and repeatability, and feed real-time updates on the front-panel display. Controlled additive interference (AWGN) generated by the unit is also measured in real time and those measurements are displayed to the user.

New test equipment targeted to the wireless market should always be "future-proofed" by implementing an order-of-magnitude increase in the quality of RF specifications. With its considerable performance headroom – radical RF handling capabilities, including cutting-edge output power range, noise floor, and overall channel quality – the VR5 will easily handle test requirements for several years to come.

Particular attention has been paid to the user interface. As the technology gets ever more intricate, testers find themselves having to do more with fewer resources, usually in step with very aggressive product schedules.

The VR5 design team built an interface specifically designed to simplify control over a complex MIMO environment. The front-panel touchscreen offers sophisticated control with just a few swipes of the finger, all while minimizing the opportunities for user error.

During setup and configuration, the front panel presents a step-by-step process offering combinations of test cases, environment scenarios and operator parameters. Graphical configuration information is presented at each step to help the operator quickly recognize and correct setup errors. While most test cases can be configured strictly through this high-level control, the user still has the option to set lower-level parameters for customized testing. Most test cases, even complex high-antenna-count scenarios, can be set up in less than a minute.

During test execution the graphical feedback is sustained. The Channel Player shows real-time updates of the power and delay associated with individual fading paths. The VR5 adds the Temporal Player view, which provides real-time updates of selectable measured parameters such as C/N, input power, or output power. The Temporal Player is best used with the Dynamic Environment Emulation (DEE) feature, allowing the user to map out per-path fading parameters in a spreadsheet, varying over time. The emulator reads the spreadsheet file and physically creates the defined RF channel.

DEE can also be used to minimize the cost and time spent drive-testing mobile devices. Drive-route data can be captured and stored using a commercial cellular scanner. Optional Spirent software converts the captured data into a DEE file for playback in the lab. Aside from the convenience and cost savings of re-using data captured from a single drive route, this "virtual drive test" method adds a level of repeatability that is not possible by repeated physical drive-testing.

For special cases where statistically anomalous fast fading is required, a second fading engine is built into the unit. The fine-time engine, called Fading Lab, lets advanced users create RF environments based on sample-by-sample RF data parameters. For example, RF researchers can generate sample data by using commercial mathematical software (e.g. MATLAB®), ray-tracing software or custom software. Channel-sounder data is another potential source of this fine-time information. The Fading Lab engine processes this data and creates the corresponding physical RF environment.

Conclusion

Mobile users are demanding ever-increasing levels of performance that can only be met by costly investment in 4G technology. A key component of LTE and LTE-Advanced platforms is MIMO multiple antennas, and realistic testing of MIMO devices presents an enormous challenge.

Whether testing is carried out in an anechoic or a reverberation chamber, the VR5 HD Spatial Channel Emulator, with software packages for building the environment and emulating dynamic conditions, allow even inexperienced operators to run sophisticated tests without error. Continual graphical feedback during execution is further insurance against misleading results.

Although the final test will always be in the mobile user's hands, Spirent's test expertise provides the best insurance that the test will be passed with flying colours.

Maximizing battery life in Wireless Home Automation systems

By Brendan Daly, Analog Devices, www.analog.com

Building and home automation systems are gaining a lot of momentum. There are several factors that are combining to enable this "smart building" technology. Almost 40 percent of the world's energy is consumed in the heating, cooling and lighting of buildings. Making them more efficient can result in substantial environmental and financial savings. For this reason, governments and local authorities are implementing legislation to mandate more energy efficient buildings. Coupled to this legislative push are emerging technologies such as LED lighting, energy harvesting and an ever increasingly connected world, which all lend themselves to building automation.

Figure 1 gives an overview of a smart building. A key ingredient in smart buildings is having more sensors to monitor and measure temperature, motion, occupancy, light. Knowledge of these conditions can allow the smart building to communicate and control the lights, HVAC (Heating, Ventilating and Air Conditioning), blinds and other building elements to optimize performance.

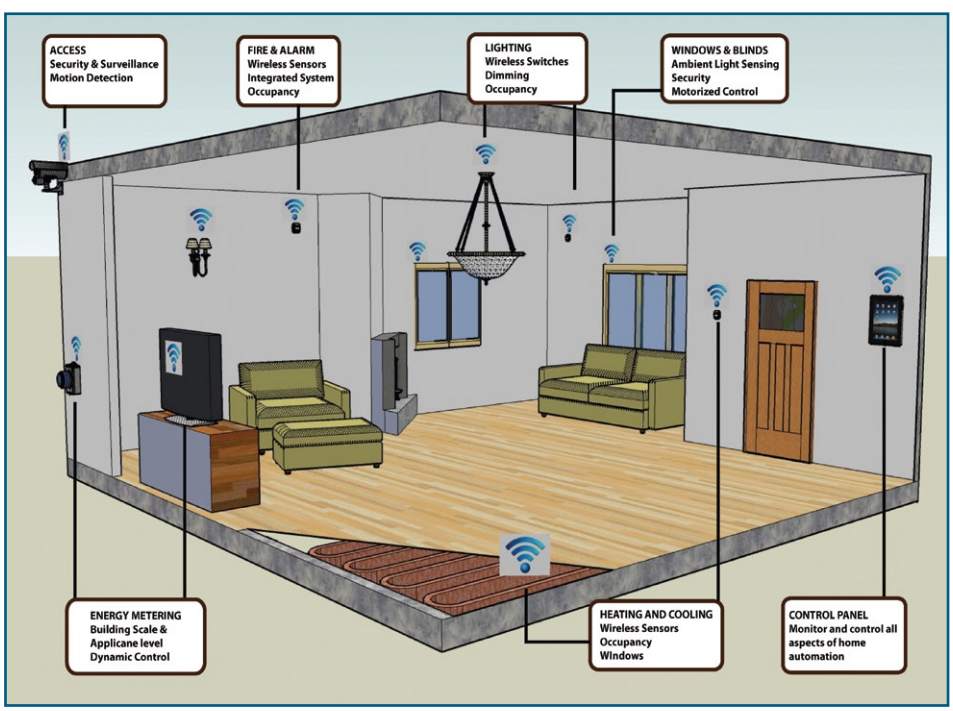
There is an obvious attraction in having these sensors wireless, as it is cheaper, more flexible and easier to implement than running wires everywhere. With the addition of multiple wireless sensors, comes the need for multiple batteries or energy harvesting devices in the building. This article investigates methods to minimize the amount of power consumed by a wireless sensor, thus allowing for longer battery life. It considers parameters that may not immediately spring to mind, but may have a large impact on battery life and system performance. Topics such as power conversion, RF performance, communications protocol and others will be explored.

Current consumption (I_{DD})

Traditionally, operating current consumption (I_{DD}) is the first spec that system designers look at when approaching a new design. However, unless the components are operating constantly, then this number may not have a major influence on the power budget, or average current consumption of the system.

In applications where the system spends long periods in sleep mode, it may be more important to focus on the usage pattern, power budget and average power consumption. This means looking at the different sleep modes' power consumption, and the amount of time the system is likely to spend in each state. Even the transition times to enter and exit different operating modes can be a significant contributor to the average power consumption. So while I_{DD}, the operating current in normal operation, is an important consideration, it

Figure 1: A smart building with wireless sensors and control.



Mode	Current	Time	Duty Cycle	Charge/Year
Standby	2 uA	14m 58.4sec	99.84%	17 mA-hr
On	5 mA	1 sec	0.1%	43 mA-hr
Transmit	800 mA	100 ms	0.01%	700 mA-hr
Receive	13 mA	500 ms	0.05%	57 mA-hr

Table 1: Power Budget for 15 minute cycle, high output power example.

Mode	Current	Time	Duty Cycle	Charge/Year
Standby	2 uA	14.82 sec	98.8%	17 mA-hr
On	5 mA	150 ms	1%	440 mA-hr
Transmit	25 mA	5 ms	0.03%	65 mA-hr
Receive	13 mA	25 ms	0.15%	170 mA-hr

Table 2: Power Budget for 15 second cycle, medium output power example.

will not be the sole criteria to choose the best devices for the job.

The power budget is perhaps the biggest factor that a system designer needs to consider. This involves calculating how long the system needs to be in full operating mode, computation mode, communication mode, standby mode and so on. This usually begins with some fundamental specifications, such as how often computation and communication needs to happen, and the amount of energy that the battery will contain.

In general though, these systems will often spend most of their time in standby mode, only waking up due to an external event triggering, or in a periodic fashion, to make a measurement and transmit the data to the host system. For this reason, the sleep mode current spec, or quiescent current spec (I_Q) becomes a very important factor. See tables 1 and 2 for examples of power budgets that could be used in battery powered sensor applications. These break down the different modes of operation and show their power consumption contribution to the overall system.

In the past IC companies would have focused heavily on I_{DD}, and not taken so much care over I_Q. But with the proliferation of battery powered devices, there is now a real push in the semiconductor industry to reduce this number as much as possible. This is a combination of smart IC design coupled with newer and smaller IC geometry fabrication. So what is a good target I_Q spec to look for? This obviously varies wildly depending on the complexity of the IC, but I_Q numbers in the order of hundreds of nanoamps (nA) are quite common today, with some companies even talking picoamps (pA).

This drive for lower power consumption is really evident in the area of microcontroller development. Newer microcontroller cores such as Cortex M3 and M4 offer a sweet spot for battery powered applications versus their older ARM7 counterparts. The low I_{DD} and low I_Q specs are realized while still offering a high level of computation power. Several start-up and established microcontroller vendors are investing heavily in this area, with a particular focus on low power consumption.

Power conversion

Power conversion and regulation is another tricky topic. The aim of the game in maximizing efficiency is to limit the amount of power conversion stages as much as possible. Whereas the obvious thing to do is place a series of linear regulators (LDOs) to generate the voltage rails needed from the battery, this may not be the optimal approach. With any linear regulator (think LDO here), the larger the difference between input and output voltage, the more energy is wasted. LDO Efficiency (n) is roughly given by the formula $n = (V_o/V_{in})*100$ percent. So LDOs operate most efficiently when V_{in} is kept close to V_{out}.

The LDO cannot store energy and any energy not delivered to the load is dissipated as heat. Power dissipated (PD) $= (V_{IN}-V_{OUT})*(I_{IN})$. The LDO's drop-out specification, which is a measure of how little voltage drop it can tolerate from input to output, can be a major factor in the efficiency of the power conversion and regulation stage. Even for a single part, the choice of package may result in a different dropout specification. This is due to the loss in the bond wire of the particular package. Chip scale packages offer great performance in this aspect.

Using a switching regulator rather than an LDO may not be something that many

designers will consider in the design of their power stage. The instinct may be to think that they are noisy, bulky and complicated. But switching regulators offer much higher efficiency power conversion compared to an LDO, especially as the difference between the input and output voltage gets bigger. Concerns about switching regulators being noisy are not necessarily true. Here's a link to some more detail on this subject: www.analog.com/static/imported-files/tech_articles/Powering_High_Speed_ADCs.pdf.

It may be worth considering the use of a power switch (such as Analog Devices' ADP190) between the battery and the load. These devices effectively cut off all power from the battery to the load, only providing power to the load when needed. This is a good scheme when the load cannot be put into a low power/sleep mode, or if the sleep modes of the load devices consume too much quiescent current.

Of course, this may not be an option if the load needs to retain some logic or memory information, as they are completely shutdown in this configuration. Also, these power switches do consume a certain amount of current themselves to operate, but this is of the order of 100 nA, which can be 10 to 100 times lower than the quiescent current of the load devices. And they also do have a power loss associated with them, as they are directly in the power path between the input and output. These devices are becoming increasingly popular in cell phone and other battery powered applications. Figure 2 shows a typical load switch.

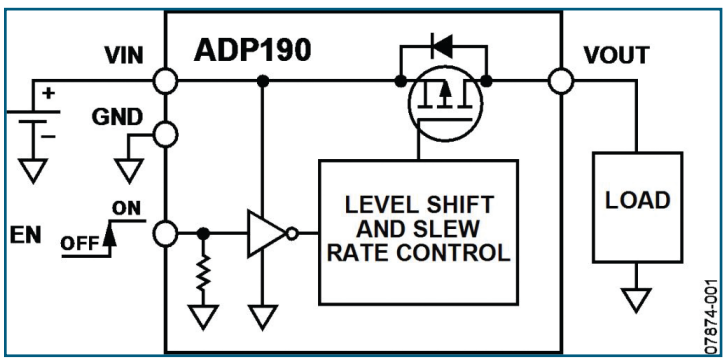


Figure 2. Load Switch implementation.

Communication protocol

The software stack that manages the communications protocol can have an impact on battery life. Whereas ZigBee is becoming a popular standard in a lot of application areas, it has quite a large code size to implement the stack. This larger code size results in the processor, transceiver or both having to churn through more code overhead. This obviously results in a reduction of battery life.

Alternatives, such as PopNet and SNAP, have smaller code sizes. A lot of end users state this as the major barrier against implementing ZigBee. Wi-Fi is another attractive option due to the existing infrastructure already available in any building with an existing wireless network. However, the protocol stack of Wi-Fi is a lot larger than ZigBee's. This results in much more computational and communication overhead, which results in more power consumption (estimates are that Wi-Fi's power consumption is more than twice as much as ZigBee's)[1].

System partitioning of the communication protocol also needs to be considered. In a typical system, a microcontroller (or similar) manages the software stack, and a radio performs the physical communication. If the designer only adds up the operating current consumption of these elements, then it might not give the whole picture. Some transmitters (such as Analog Devices' ADF7023) implement some of the software stack management protocol without having to wake up the microcontroller. This means that the microcontroller can stay in sleep mode for longer, lowering the overall average power consumption of the system. Also, some radio ICs available today have embedded wake-up timers that mean that they can wake themselves up without relying on a microcontroller to activate them. The microcontroller can then remain in sleep mode until the radio determines that some communication or computation needs to be performed.

When choosing the radio transmitter, there are many parameters to consider. If the user is not bound by a certain protocol, such as ZigBee (which operates in the 2.4 GHz ISM band), then the choice of RF frequency band will have a major impact. Lower frequencies transmit further than higher frequencies, given the same transmission output power. Or, looking at it another way, lower frequencies can transmit at a lower output power than higher frequencies over the same distance. It depends on the environment and other factors, but a rule of thumb is that operating in the 433 MHz ISM band will have twice the range of operation of working in the 900 MHz ISM band.

The sensitivity of the RF receiver will impact the required output power of the transmitter. Therefore, it is important to use as low a receiver sensitivity as possible. It follows that the transmitter can then transmit at as low a power level as possible.

On the surface, this seems like a simple calculation. The Receive Strength Signal Indicator (RSSI) function on the receiver could be used to measure the signal strength it is receiving from the transmitter. Then a dedicated algorithm could be developed to communicate back to the transmitter about how much it can reduce its output to minimize its output power, and optimize its battery life while still maintaining error free communication.

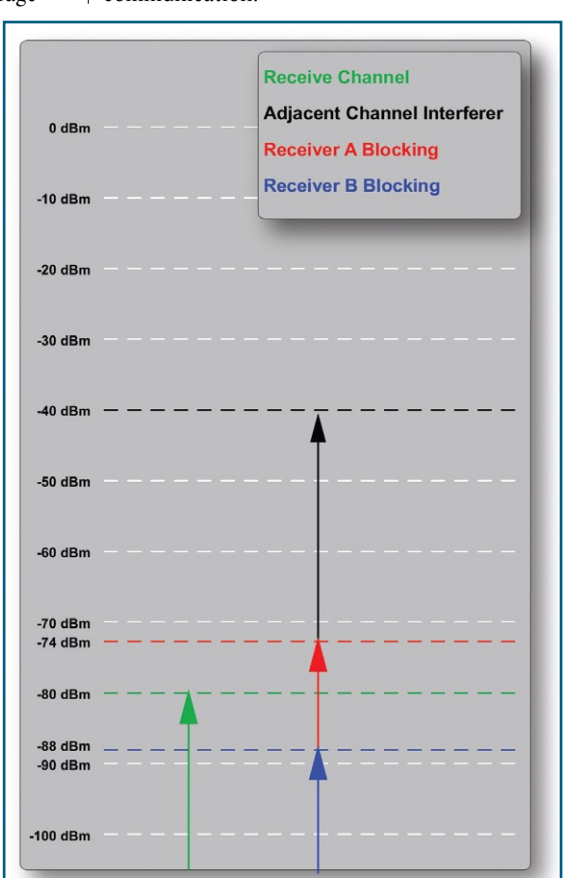


Figure 3: Adjacent Channel Blocking.

Unfortunately, that is not the full picture. Adjacent channel interference impacts the usable sensitivity of a receiver; remember that ISM bands are notoriously noisy environments. To calculate the usable sensitivity, the adjacent channel blocking performance needs to be considered.

Let's look at an example, to highlight this. See Figure 3 for reference. In the example, we are trying to receive a signal of -80 dBm signal strength. Now consider using two different receivers. Receiver A has a sensitivity of -101 dBm, and an adjacent channel blocking of 34 dBm. Receiver B has a sensitivity of -95 dBm, and an adjacent channel blocking of 48dBm. On the face of it, Receiver A is the obvious choice, as it can receive signals as low as -101 dBm, which is lower than its competitor at -95 dBm.

But now assume that there is an interferer signal of -40 dB in the adjacent channel to the channel you are trying to receive. These are typical numbers in an ISM band wireless transmission. The usable sensitivity of the receiver is calculated as (Adjacent Channel Interferer Amplitude – Receiver Blocking Capability)

Receiver A has an adjacent channel blocking spec of 34 dBm. The result is that it can only attenuate the interferer signal by 34 dBm from -40 dBm to -74 dBm.

Receiver B has an adjacent channel blocking spec of 48 dBm. The result is that it can attenuate the interferer signal by 48 dBm from -40 dBm to -88 dBm.

So, as can be seen, Receiver A has a sensitivity spec of -101 dBm, which is great in an ideal situation where there is no interference in adjacent channels. But in a real life example, it will not be able to receive anything lower than -74 dBm, as the adjacent channel interference will be too great. Receiver B on the other hand will be able to operate with -88 dBm sensitivity, so it is in fact a better choice for this system. This can now be factored into the software algorithm to tell the transmitter that it can optimize its transmit output power to achieve this performance.

Transceiver frequency hopping can be another way to optimize the power consumption. In a noisy environment with many interference signals, a transmitter might need to boost its output power to overcome its noisy neighbours to ensure data is transmitted without corruption. However, if the transmitter is free to roam the frequency band, it can scan for the quietest location, and transmit at that frequency at a lower power level. Frequency hopping capability is an integrated feature in many ISM band transceiver ICs.

Conclusion

Chasing every last nanoamp of current consumption is not a straightforward task for a wireless home automation system. Just like everything else in the world of engineering, it comes down to a series of trade-offs that need to be made. This article highlights some good practices to follow for the system designer to follow, and gives them an insight into other areas they may not have considered before. Of course, cost considerations must also be considered in any practical design.

Reference

1.) Energy Efficiency Comparisons of Wireless Communication Technology options for Smart Grid Enabled Devices – Drake et al, General Electric. (http://energypriorities.com/library/ge_zigbee_vs_wifi_101209.pdf)

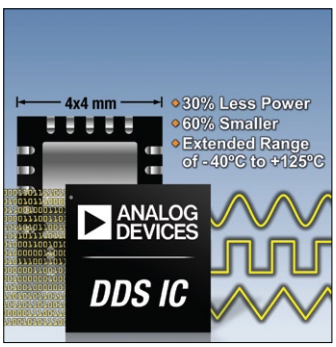
Direct digital synthesis ICs

offer power and size savings

Analog Devices has introduced direct digital synthesis (DDS) ICs that offer 30 percent lower power consumption and a 60 percent reduction in footprint than competing devices while operating over the extended temperature range of 40 to 125 °C. The AD9838 DDS and AD9837 DDS ICs consume as little as 11 mW when operating from clock rates up to 16 MHz.

The devices are well suited for industrial and communications applications, including sensory excitation, impedance spectroscopy and battery-enabled diagnostic and communication equipment.

The AD9838 DDS and AD9837 DDS ICs settle in nanoseconds with granularity well below 100 MHz. Along



with an on-chip, 10-bit, low-power DAC (digital-to-analog converter), the new products offer 28-bit fine-tuning granularity and high SFDR (spurious-free dynamic range) performance that enable them to more quickly and accurately generate a stable signal in the band of interest.

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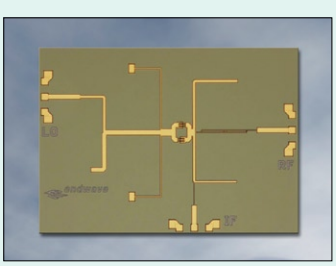
Sub-harmonically pumped mixer MMIC

performs through 97 GHz

Endwave Corporation has announced the release of a new sub-harmonically pumped mixer (2 x LO) MMIC. Designed and manufactured in cooperation with WIN Semiconductor Corporation's 0.1 µm PHEMT process development, model EWM9002ZZ offers a broadband frequency performance of 67 to 97 GHz with LO to RF isolation of over 30 dB and a conversion loss of 12 dB.

The device, which can be used both as an upconverter or downconverter, also delivers RF return loss at better than 10 dB, LO drive level of +15 dBm, and is highly repeatable.

Subharmonic mixers are often used in communications system in order to eliminate the unwanted effects of LO self-mixing, which occurs in



many fundamental frequency mixers. EWM9002ZZ has the advantage of high RF to LO isolation and LO noise cancellation across a very broad frequency band.

The device utilizes anti-parallel connected PHEMT diode pairs to mix the second harmonic of a fixed-frequency LO with the input signal, and is well suited for E-band point to point microwave radio applications, W-band defense electronics and commercial communications systems.

www.endwave.com

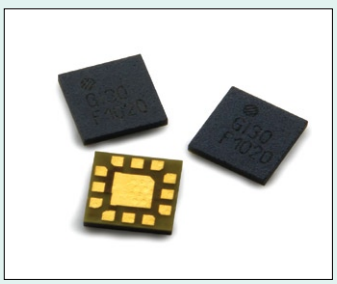
Integrated front-end module

enables WiFi and Bluetooth coexistence

Avago Technologies has announced a front-end module with robust filtering for 802.11 b/g/n WiFi and Bluetooth radios in handsets and mobile routers for tablets and other portable PC devices.

The AFEM-S102 module integrates a Film Bulk Acoustic Resonator (FBAR) coexistence filter, SP3T antenna switch and TX path coupler in a small 2.2 by 2.2 by 0.55 mm package that is ideal for space-constrained applications. The 2.5-GHz module delivers superior out-of-band rejection enabling concurrent operation of WiFi and Bluetooth data-communication with cellular communication standards.

The AFEM-S102 module exhibits low insertion loss that combines with high noise rejection to meet stringent coexistence requirements and enable fewer interference issues between WiFi, Bluetooth



and other radios. Effectively leveraging the company's 0.25 µm GaAs enhancement-mode pHEMT process and its leading-edge proprietary FBAR filtering technologies, the module delivers 2.6 dB maximum insertion loss for the TX path and 35 dB rejection in the 2110 to 2170 MHz range.

The company's FBAR technology delivers steeper roll-off and lower insertion loss than ceramic or SAW filters and other competing technologies, and does so in a more compact form factor

www.avagotechwireless.com

Tunable FPGA mezzanine card RF platform

targets next generation network applications

Lyrtech has launched an FPGA mezzanine card (FMC), the Radio420X, which targets applications such as femto and pico base stations, micro access points, software-defined radio, TV white space and next-generation Wi-Fi, WiMAX, and LTE. Discussions are already underway with a number of customers worldwide who plan to use this innovative solution.

The Radio420X is a powerful multimode SDR RF transceiver module that can be used with any FMC carrier on the market. It is designed around the state-of-the-art, multistandard, multiband Lime Microsystems LMS6002D integrated RF transceiver. The LMS6002D replaces several individual transceiver ICs and allows quick and simple reconfiguration, resulting in considerable reductions in size, time to market, bill of materials and inventory for OEMs.

The Radio420X is completely integrated to Lyrtech's own Virtex-6 Perseus advanced mezzanine card (AMC), which provides thorough integration to powerful software design tools.

The FMC's clock management facility offers low-phase-noise clock distribution, a PLL core, dividers, dual VCOs, and a jitter cleaner feature.

www.lyrtech.com

RoHS compliant VCO operates at 3710 to 3744 MHz

Z-Communications announces an RoHS compliant VCO (Voltage-Controlled Oscillator), designated model SMV3727A-LF, for the S-band. The VCO operates at 3710 to 3744 MHz with a tuning voltage range of 0.5 to 3 Vdc. This VCO features a typical phase noise of -83 dBc/Hz at 10 kHz offset and a typical tuning sensitivity of 142 MHz/V. The SMV3727A-LF is designed to deliver a typical output power of 3 dBm at 2.7 Vdc supply while drawing 10 mA (typical) over the temperature range of -40° to 85° C. The VCO features typical second harmonic suppression of -15 dBc and comes in Z-Comm's standard SUB-L package measuring 0.76- x 0.76- x 0.20-cm (0.3- x 0.3- x 0.08-inch). It is available in tape and reel packaging for production requirements. The VCO is also ideal for automated surface mount assembly and reflow.

www.zcomm.com

Direct digital synthesis ICs
offer power and size savings

Amplifier Technology has developed a compact broadband amplifier, model number 8790, which operates at the higher frequencies used by WiMAX, 3G and 4G phones. The 8790 can be integrated into a variety of systems, for different applications. It is suitable for jamming or for laboratory testing, or could be used to drive other RF devices.

Amplifier Technology has designed this amplifier to be compact, light and easily portable whilst achieving exceptional RF performance. The GaN technology used in the design results in a massive frequency range from 20 MHz and 6.0 GHz, with a guaranteed minimum saturated output power of 10 W and a minimum efficiency of 15 percent at 10 W.

Measuring just 65- x 120- x 25-mm and weighing less than 250 g, the broadband amplifier is one of the smallest available on the market with this specification. It compliments the other counter IED amplifiers, the 8778 (30 W, 0.5- to 2.5-GHz) and the 8780 (25 W, 2- to 6-GHz) currently produced by the company.

www.amplifiertechnology.com

ZigBee Pro module

features 20 to 50 percent smaller footprint

RF Monolithics has introduced the ZPM3570 2.4 GHz ZigBee Pro module, which features small size of under 0.63 square inches, 1-MB data logging flash memory, chip antenna, and ZigBee Smart Energy and Home Automation Profiles support—making the module ideal for enabling smart homes that can control appliances, lighting, environment, energy management and security. Further, the surface mount design of the ZPM3570 eliminates the need for costly connectors.

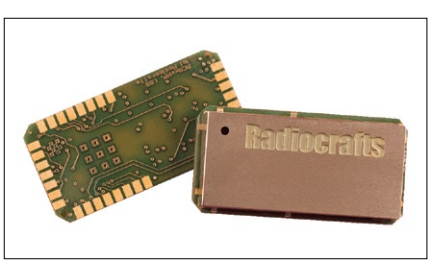
Quickly implementing products that provide vendor-interoperable Smart Energy and Home Automation is achieved through an intuitive API that simplifies connectivity of the module to an application processor. OEMs wishing to implement their own application in addition to the ZigBee stack can take advantage of the on-board 32-bit M3 Coretex ARM processor.

The ZPM3570 incorporates Ember's EM357 ZigBee RFIC and is coupled with a power amplifier, plus low noise amplifier that increases the RF transmit power and receive sensitivity. The module provides a 250 kb/s RF data rate with +20 dBm (100 mW) RF power coupled with a receive sensitivity of -103 dBm to provide exceptional range and performance all in an FCC, IC and ETSI certified module.

www.rfm.com

Long range AMR metering module

uses the 169 MHz band, claims world first



Radiocrafts AS is expanding their Wireless M-Bus product line with a module using the 169 MHz band for long range Automatic Meter Reading (AMR), designated RC1700HP-MBUS. The module is compliant with the latest prEN 13757-4:2011 requirements, operating in the new harmonized frequency band for meter reading in Europe.

Based on a proposal from Radiocrafts, a new narrowband communication mode has been defined in the Wireless M-Bus standard. The combination of VHF frequency, true narrowband operation and high output power, gives superior communication range and coverage even in urban environments. The typical range is 1.5 km in urban areas and 20 to 40 km in open terrain with quarter-wave antennas.

Being the world's first compact RF module in the market compliant with the latest standard, it offers true narrowband performance in a 12.5 kHz channel, and up to 500 mW output power, achieving a link budget of 150 dB. The module supports two-way communication at 2.4 and 4.8 kbps in 6 narrowband channels, and 38.4 kbps in a 50 kHz channel.

www.radiocrafts.com

Two-way power divider

covers 800 to 2500 MHz

Narda, an L-3 Communications company, has introduced the Model 4372-2, a two-way power divider that operates from 800 to 2500 MHz and is an excellent choice for a broad array of applications including commercial wireless and defense systems.

The Model 4372-2 has amplitude balance of 0.2 dB or less, phase balance of 3 degrees or better, insertion loss of 0.4 dB or less, isolation of at least 22 dB, and VSWR of no more than 1.35:1. The power divider can handle an RF input power of 30 W, has SMA female connectors, and measures 7.87- x 4.06- x 1.27-cm (3.1- x 1.6- x 0.5-inches).

www.nardamicrowave.com/east

High power SP4T switch

broadband applications

RFMD's latest RF1604 single-pole four-throw (SP4T) switch is designed for switching applications requiring very low insertion loss and high power handling capability with minimal DC power consumption. Its excellent linearity performance makes it ideal for use in multimode GSM/EDGE/WCDMA and LTE applications.

Very high isolation between the RF ports provide greater RF separation between the transmit and receive paths, critical in full-duplex systems. The device also includes integrated decoding logic allowing operation from two low voltage control lines. It is packaged in a very compact 2.5- x 2.5-mm, 12-pin, leadless QFN package.

Key features include: low frequency to over 2.7 GHz operation covering all standard cellular frequency bands, low insertion loss of 0.4 dB at 1 GHz, high isolation of 40 dB at 1 GHz, and high linearity with IIP2 greater than 120 dBm.

www.rfmd.com

High frequency VCO

targets 4G wireless and high-speed data

Precision Devices has unveiled the VC40, a high frequency VCXO that covers 60 MHz to 800 MHz. To ensure maximum accuracy, the VC40 can be adjusted by as much as ±100 ppm via the voltage adjustment pin, over a tuning range of 0 V to 3.3 V. Stability is from ±50 ppm over -40 to +85 °C. The VC40 uses High Frequency Fundamental (HFF) technology to generate frequencies up to 230 MHz with low phase noise. For higher frequencies, a (PLL is avoided, and analogue technology is used instead to provide class-leading phase noise and jitter.

www.pdixtal.com

LDMOS RF power transistors

target next-gen amplifier systems

Freescale has introduced two LDMOS RF power transistors that allow wireless base station amplifiers to cover all channels in an entire allocated frequency band. These RF power LDMOS transistors deliver a compelling combination of high linearity, high efficiency, wide instantaneous bandwidth and high power that extend the instantaneous signal bandwidth to a leading 160 MHz.

In addition, the wide instantaneous bandwidth of the LDMOS devices increases network flexibility for network operators by allowing network equipment sharing between operators and by simplifying upgrades. Operators can add/exchange spectrum holdings within a frequency band without upgrading equipment, and because wideband/multi-band PAs are generally agnostic to modulation formats, operators can upgrade to 4G LTE and other wireless standards with a simple software change and no additional hardware.

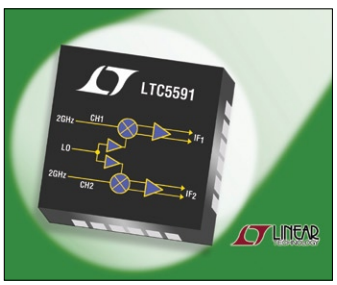
The MRF8P20165WH/S and MRF8P20140WH/S meet linearity requirements for PCS and TD-SCDMA standards while delivering efficiency of at least 43.7 percent when amplifying multiple wireless carriers separated by up to 65 MHz (PCS) and 10 MHz (TD-SCDMA).

www.freescale.com

High linearity dual downconverting mixers

reduce power consumption for 4G MIMO receivers

Linear Technology has unveiled the LTC559x family of four high dynamic range dual downconverting mixers covering the 600 MHz to 4.5 GHz wireless infrastructure frequency range. The LTC559x dual mixers offer outstanding IIP3 (Input Third-Order Intercept) of more than 26 dBm, low noise figures of less than 10 dB and high conversion gain of 8.5 dB, enabling excellent dynamic range performance for both MIMO (Multiple-Input, Multiple-Output) and diversity wideband receivers.



The LTC559x family of dual mixers provides best-in-class capability to maintain a low noise figure in the presence of strong blocking interferers, enhancing receiver sensitivity and robustness. Unlike other dual mixers in their class, the downconverting mixer family can operate on a single 3.3 V supply without compromising performance, reducing power consumption by more than 24 percent compared to the closest competing solution.

www.linear.com

Millimeter-wave signal analyzer

extended performance up to 325 GHz and beyond

Agilent Technologies has announced that its PXA signal analyzer is now the industry's highest performance millimeter-wave signal analyzer, covering frequencies up to 50 GHz. With external mixing, it can cover 325 GHz and beyond. The result is easier, more accurate millimeter-wave measurements.

The lower noise offered in all measurement configurations, allows the PXA to achieve the same sensitivity as other analyzers at a resolution bandwidth that is 10 times greater, resulting in sweep times of 100 times faster or more.

Using the low noise path, the PXA is able to realize a displayed average noise level (DANL) of -138 dBm at 50 GHz. In addition, utilizing NFE, the PXA is able to further improve DANL by approximately 6 dBm. These performance characteristics, coupled with the PXA's extended frequency range, what is claimed to be the industry's widest analysis bandwidth of 140 MHz, high-performance full-band preamplifier to 50 GHz, industry-best close-in phase noise of -110 dBc/Hz at 10 kHz offset, and third-order intercept of +13 dBm (nominal) at 50 GHz, make it ideal for aerospace and defense engineers looking to extend operating frequency to millimeter wave.

www.agilent.com

2G module with integrated A-GPS

claims to be world's smallest

The GE864-GPS from Telit Wireless Solutions, is a quad band module and claims to be the smallest, most efficient GSM/GPRS M2M module on the market with embedded GPS receiver. In a compact BGA form factor, the module is especially suited for highly integrated positioning solutions in automotive, tracking or security applications requiring 2G network connectivity in a small footprint.

The GE864-GPS shares the identical form factor and is pin-to-pin compatible with Telit's successful GE864 family, making it the smallest GSM/GPRS module in the market with full 48-channels A-GPS functionality. It combines the high performance of the company's proven GSM/GPRS core technology with the latest SiRFstarIV™ high sensitivity single-chip A-GPS receiver.

The assisted GPS receiver features an optimized power management function, which allows to maintain hot start capability at minimal energy consumption, offering a position resolution accuracy of less than 2.5-m. Moreover, the GE864-GPS supports Satellite Based Augmentation Systems, such as WAAS, EGNOS, MSAS and GAGAN. The GPS receiver is equipped with a flash-based memory, so the firmware can be upgraded, and supports Over-the-Air firmware updates.

www.telit.com

Startup upgrades 4x4 Wi-Fi chips

delivers 600 Mbits/second at the physical layer

Quantenna Communications has doubled throughput and shrunk to two chips its high-end 802.11n chip set amid increasing competition. The QHS710 supports 4x4 MIMO signaling at 5 GHz to deliver a 600 Mbits/second at the physical layer.

The startup has gained design wins at a time when existing players are both playing catch up and planning leapfrog moves. In June, Atheros Communications rolled out a single-chip supporting 3x3 MIMO claiming 450 Mbits/s throughput. Meanwhile 802.11ac and WiGig Alliance members are planning Gbit/s level products.

The QHS700 family is aimed at wired products such as set-tops and routers. It maintains the same power consumption levels as the company's previous products which are being used by NetGear and others.

www.quantenna.com

Rugged external wireless antenna

suitable for portable devices

Laird Technologies has released the WTS2333C-FRSMM WiMAX external wireless dipole antenna. Specifically designed for portable devices, this rugged antenna operates in the 2.3 to 2.7 GHz and 3.3 to 3.9 GHz frequency bands with a max gain of 2.3 to 2.7 dBi. It offers an omnidirectional radiation pattern, and emits power consistently and evenly in all horizontal directions in one plane.

The RoHS-compliant antenna features a half-wave coaxial dipole design which reduces ground dependence, thereby enabling it to work as a stand alone antenna. With industry standard connectors and cables that are included, the antenna is ideal for 802.11 b/g/n WLAN, Bluetooth®, WiMAX MMDS and WiMAX 3.5 GHz applications.

www.lairdtech.com

K-band linear power amplifier

operates over 18 to 26.5 GHz

The Ducommun Technologies power amplifier model AHP-22092825-01 with single supply operates in the 18 to 26.5 GHz frequency range.

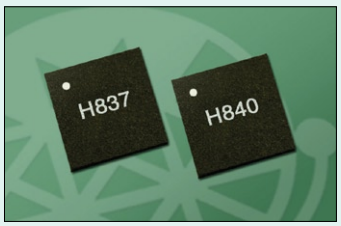
The power amplifier provides a minimum 25 dB gain with a minimum output power at 1 dB gain compression of +28 dBm and 2:1 maximum VSWR.

The amplifier has in integrated voltage regulator and operates at +12 Vdc and

draws 1.0 A current, typical. It utilizes K (f) connectors and measures has a dimension of 2-x 1.3- x 0.6-inches (l x w x h).

www.ducommun.com

Ultra-low noise tri-band frequency PLLs with integrated VCO

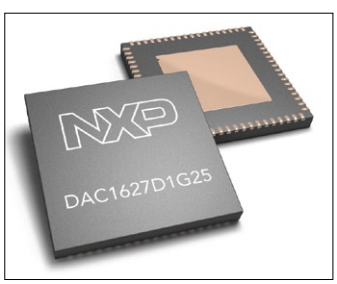


Hittite Microwave Corporation has launched two full-featured fractional-N PLLs with integrated voltage controlled oscillators (VCOs). The HMC837LP6CE and HMC840LP6CE include a wideband, low noise VCO with auto-calibration subsystem, low noise PFD and dividers, and a precision charge-pump.

Both devices feature exact frequency mode operation, deliver exceptional phase noise and leading spurious performance while consuming only 630 mW. The company claims that no other pre-packaged PLL solution is capable of reliably delivering this level of phase noise performance: -227 dBc/Hz figure-of-merit (FOM) in fractional-N mode and -230 dBc/Hz FOM in integer-N mode. The integrated double side band phase noise for these products is lower than -50 dBc. RMS jitter is less than 180 fs.

www.hittite.com

High performance RF DAC enables linearity performance breakthroughs



NXP Semiconductors has unveiled a 16-bit dual-channel LVDS DDR interface digital-to-analog converter which supports output update rates of up to 1.25 Gsps. The company claims that the high-speed DAC offers best-in-class single tone SFDR performance and two-tone intermodulation distortion across a broad output bandwidth of 200 MHz.

Developed primarily for wireless infrastructure applications, the DAC1627D1G25 is fully compliant to the Multi-Carrier GSM spectral mask and the LTE and LTE-Advanced transmit specification, with comfortable margins. As a result, the DAC1627D is ideal for multi-standard radio base stations, allowing design engineers to employ a single DAC transmit architecture, which minimizes the system bill-of-material costs.

Maury Wood, general manager, High Speed Converters product line, NXP Semiconductors, declared: "The opportunity for this DAC is focused on base stations and wireless infrastructure associated with the dramatic growth in mobile data traffic. We are currently seeing around 0.6 exabytes per month of global mobile data traffic which is estimated to go up to 6.3 exabytes per month by 2015. What is driving that growth is mostly video with internet access, M2M connections as well as gaming and VOIP. There is a lot of growth in mobile data traffic which is driving a need for base stations".

"The DAC1627D1G25 is a high-speed 16-bit, dual-channel radio frequency DAC which uses a LVDS DDR digital parallel interface. We will have over the next few months a CGVxpress version of this device that uses the serial interface which allows us to put it into a smaller package".

"Perhaps the most important point, however, is that we are fully compliant to the very challenging Multi-Carrier GSM spectral mask which requires a combination of high linearity, low noise and high dynamic range. We also comply with LTE/LTE-A Tx specifications by a comfortable margin".

www.nxp.com

CALENDAR

LTE World Summit 2011
17th - 19th May 2011
Amsterdam RAI
The Netherlands
http://ws.lteconference.com

LIDAR & RADAR 2011
26th - 29th May 2011
Hohai University
Nanjing, China
www.lidar2011.org

2011 Microwave Industry Exhibition in China
1st - 4th June 2011
Qingdao International Convention Center
Qingdao, Shandong, China
www.cnmw.cn

DAC 2011
5th - 10th June 2011
San Diego Convention Center
San Diego, CA, USA
www.dac.com

Paris Air Show 2011
20th - 26th June 2011
Paris le Bourget, Parc d'Expositions
France
www.paris-air-show.com

Wireless Sensor Networks and RTLS Summit Europe 2011
21st - 22nd June 2011
Holiday Inn Munich City Centre, Germany
www.idtechex.com/wireless-rtls-europe-11

International Microwave Symposium 2011 (IMS 2011)
5th - 10th June 2011
Baltimore Convention Center
Baltimore, Maryland, USA
www.ims2011.org

2011 IEEE Radio Frequency Integrated Circuits Symposium
5th - 7th June 2011
Baltimore Convention Center
Baltimore, Maryland, USA
www.rfic2011.org

EMC 2011
14th - 19th August 2011
Long Beach Convention Center
Los Angeles, CA, USA
http://emc2011.org

Wireless Technologies 2011
27th - 28th September 2011
Schwabenlandhalle
Stuttgart-Fellbach, Germany
www.mesago.de/en/wireless/0

European Microwave Week 2011
9th - 14th October 2011
Manchester Central
Manchester, UK
www.eumweek.com

4G World 2011
24th - 27th October 2011
McCormick Place
Chicago, USA
www.4gworld.com

Wireless Congress 2011: Systems & Applications
9th - 10th November 2011
Konferenzzentrum München
Munich, Germany
www.wireless-congress.com

Cartes & IDentification 2011
15th - 17th November 2011
Villepinte Exhibition Center
Paris, France
www.cartes.com

Productronica 2011
15th - 18th November 2011
New Munich Trade Fair, Munich
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http://productronica.com

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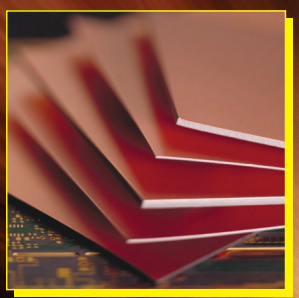

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	Low thermal coefficient of dielectric constant	Stable electrical performance versus temperature
	Low coefficient of thermal expansion	High reliability in complex multilayer designs
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	Low z-axis coefficient of thermal expansion	Plated through hole capable
	Light weight	Advantage for airborne applications
RT/duroid® 6035HTC	Highest thermal conductivity (1.44 W/mk) for 3.5Dk printed circuit board laminates	Excellent power handling capability
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