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IoT projects relying more on out-of-the-box systems

IoT spans many diverse applications and requirements. Consequently end-to-end IoT systems are complex and difficult to implement. Issues such as centralised and local data, usage of data, and data mining expose projects to technical and legal issues. To help companies implement systems there are a variety of providers that offer IoT platforms, including Microsoft, Amazon, IBM, Intel, GE, Google, PTC and SAP.

Marker research firm IoT Analytics has published a white paper that serves as a guide to streamline IoT development – helping companies steer through the challenging development process to accelerate their IoT endeavours. The paper cites lessons learned from sixteen specific and recent projects across the five major phases of IoT project development. IoT Analytics stresses that three areas demand special attention when developing IoT projects – security, interoperability and manageability. To further simplify the complexity of end-to-end IoT systems, the paper breaks down IoT systems into five distinct layers and 15 components.

“Our research shows just how challenging IoT Solution Development still is in 2016,” reveals IoT Analytics’ CEO, Knud Lasse Lueth. “We estimate approximately 3,000 new enterprise IoT projects will be launched in 2016. I recommend that these project teams read our guide to avoid making mistakes others have made and instead follow a structured solution development framework.”

Though there are many wireless protocols such as Bluetooth, Zigbee, LoRa and Sigfox, Wi-Fi is also a contender in the IoT space due to its prevalence. Currently Wi-Fi is only suitable where there is a power source such as in homes and offices, but there is a lot of research going into cutting the power hungry Wi-Fi down to size. Whether Wi-Fi can eventually compete against low-power radio architectures remains to be seen.

In the majority of cases, the IoT will drive distributed sensor systems with potentially billions of devices deployed. Most of these will rely on batteries for their entire lifecycle.

Recently, Lithium polymer pioneer BrightVolt (Redmond, WA) raised over $5m to move its flexible battery technology to IoT applications

“There is enormous upside market potential for BrightVolt battery technology in the expanding IoT space, including sensors, labels, medical devices and wearables,” said Todd Peters, BrightVolt CEO.

www.BrightVolt.com
www.iot-analytics.com

By Jean-Pierre Joosting, Editor, MWEE

LTE and 5G infrastructure to hit $32 billion by 2020

In its latest report on LTE, LTE-Advanced and 5G, RnRMarketResearch forecasts that by 2020, LTE and 5G infrastructure investments are expected to account for a market worth $32 Billion, which includes spending on distributed macrocells, small cells, C-RAN architecture equipment and mobile core solutions.

The report concludes that with over 500 fully commercial network launches, LTE has become a mainstream technology, and a number of mobile operators have already deployed LTE-Advanced technology. The research estimates that LTE service revenues will account for over $600 Billion in 2016. The figure is further expected to grow at a CAGR of more than 5% over the next four years.

While LTE and LTE-Advanced deployments are still underway, mobile operators and vendors have already embarked on R&D initiatives to develop so-called “5G” networks, with a vision of commercialization by 2020. Large scale LTE-Advanced rollouts are expected over the 2016 to 2020 period

www.rnrmarketresearch.com

Smart Homes face vulnerability to hackers

ABI Research forecasts 360 million smart home device shipments by 2020 as vendors and startups scramble to become a part of home automation, smart home movement. However, many companies are leaving open major security flaws in their rush to market, producing products riddled with bugs and unpatched vulnerabilities. Ignoring cybersecurity at the design level provides a wide open door for malicious threat actors to exploit smart home products.

“We see an alarming increase in ransomware in smart TVs and IP cameras, code injection attacks, evidence of zero-day threats, and password eavesdropping for smart locks and connected devices,” says Dimitrios Pavlakis, Industry Analyst at ABI Research. “The current state of security in the smart home ecosystem is woefully inadequate. Smart home device vendors need to start implementing cybersecurity mechanisms at the design stage of their products.”

Numerous attack vectors have been identified in popular smart home communication protocols, such as ZigBee, Z-Wave, and Wi-Fi. Many companies are creating and selling easy-to-tamper smart locking systems, easy-to-hack sensor systems, and products that host a plethora of software vulnerabilities.

Despite the bleak outlook, some smart home vendors are starting to take cybersecurity seriously. A small number of vendors, including Amazon, Apple, Google, Samsung, and Philips, now include security within the project design phase, which primarily means securing the network, making use of encryption key management, and placing limitations on communication protocols.

www.abiresearch.com

Wirepas and Telit partner on large scale IOT

Wirepas and Telit have partnered to bring new, Wirepas enabled, ultra-low power connectivity modules to the market – by combining Wirepas software with the Telit Bluemod+S42 platform at 2.4 GHz.

Wirepas Connectivity is a de-centralized radio communications protocol for large scale Industrial IoT applications such as smart metering, lighting, asset tracking, logistics and environmental sensoring. It enables limitless scale, ultra-low power operations, high reliability, and it is easy to deploy. The key to the performance is in the de-centralized network architecture. The devices decide the best actions by themselves locally. No central network management is needed. The local decision-making ensures that the devices always operate the similar way, independent of the network size or the devices’ locations within the network.

BlueMod +S42 is CE, FCC, IC and KCC certified and qualified according to the Bluetooth v4.2 specification.

www.telit.com, www.wirepas.com

Fitness trackers prone to security flaws

Fitness trackers are increasingly popular. In the first quarter of 2016 alone, almost 20 million units have been sold worldwide. By GPS, these devices measure the distances walked by their users, they measure heart rates and notice if the wearer sleeps. But these data are not used solely to the purpose of determining the user’s personal health status; instead, they increasingly are used by third parties for other purposes, notes Ahmad-Reza Sadeghi, professor for system security at the University of Darmstadt’s Cyber Security (CYSEC) department.

In the United States, for instance, data from fitness trackers are already admitted as evidence in lawsuits. They are regarded as a kind of “black box” of the human body, wrote newspaper NY Daily News recently. What’s more, several health insurers offer discounts if the customer allows them to process their data. This openness in handling the data is frequently attracting fraudsters who manipulate the data to gain unfair benefits or even manipulate lawsuits, Sadeghi says.

In order to investigate the security level of these trackers, Professor Sadeghi and his team performed a study along with the University of Parma (Italy). They scrutinized 17 fitness tracker models from market leading vendors such as Xiaomi, Garmin or Jawbone as well as from less well known brands. The tests focused on manipulating the data sent from the tracker to a cloud server by means of a man-in-the-middle attack. The result was less than satisfying even though all cloud-based tracking systems encrypted their data transfers through the HTTPS protocol. Nevertheless the researchers in all cases succeeded in intercepting and manipulating the data. Most of the trackers in the test had no protection mechanisms in place; just four vendors used minor measures to protect data integrity.

www.tu-darmstadt.de

Tackling Interference Issues in the Field with Real-Time Spectrum Analysis

Rolland Zhang, Keysight Technologies

With the widespread increase of wireless technologies now used in commercial, aerospace and defense applications, interference problems are becoming more common and more severe. To mitigate these issues, many aerospace and defense (A/D) systems—and some 5G designs—are moving to the millimeter-wave band. Related enhancements include the use of narrow radar pulses and highly encrypted communication signals.

While these approaches can overcome externally generated interference, they make field troubleshooting more difficult. Thus, new tools and technologies are needed to effectively maintain deployed systems. One example is real-time spectrum analysis (RTSA), which is especially effective for interference hunting and signal monitoring. When high-speed, gap-free RTSA measurements are added to a handheld spectrum analyzer or combination analyzer, field personnel can use one instrument to detect, locate and fix interference problems.

DEALING WITH TODAY'S TRANSIENT SIGNALS

Current-generation systems pose many challenges for field personnel. For example, radar and electronic warfare (EW) systems are becoming more dynamic and faster moving. The abundance of multi-format, high-rate communication systems is increasing the likelihood of interoperability problems.

Many recent signal techniques use pulsed modulation and are "bursty" in nature, relying on a combination of short duration and low power. When such signals interfere with nearby systems, troubleshooting can become especially difficult when performed with traditional spectrum analyzers. These have difficulty capturing and detecting signals with unpredictable duration, power and behavior.

As signals become increasingly complex and agile, gap-free measurement techniques such as RTSA are moving from niche status to mainstream acceptance. Instruments such as Keysight's FieldFox handheld analyzers are taking this a step farther by making these capabilities available in a single handheld, portable unit, alleviating the need to carry multiple large, and power-tethered multiple instruments into the field (Figure 1).

Figure 1: Designed for field applications, rugged FieldFox handheld analyzers with RTSA weigh just 3.2 kg and provide battery life of about 4 hours.

DISPLAYING MEANINGFUL INFORMATION

As signal environments become more complex, it is increasingly important to represent large amounts of data on a single screen. For example, FieldFox with RTSA can produce > 120,000 spectra per second but the average human eye can detect only 30 per second. Therefore, to take advantage of real-time results, each display update needs to represent about 4,000 x 30 in a useful way.

The most informative displays are created by compiling statistics and displaying how often a particular value occurs (e.g., a specific amplitude at a specific frequency). One example is the density display, which is a spectrum measurement enhanced to show frequency of occurrence. These displays are coded using color or trace intensity, and a persistence function can focus attention on recent events as older data fades away (Figure 2).

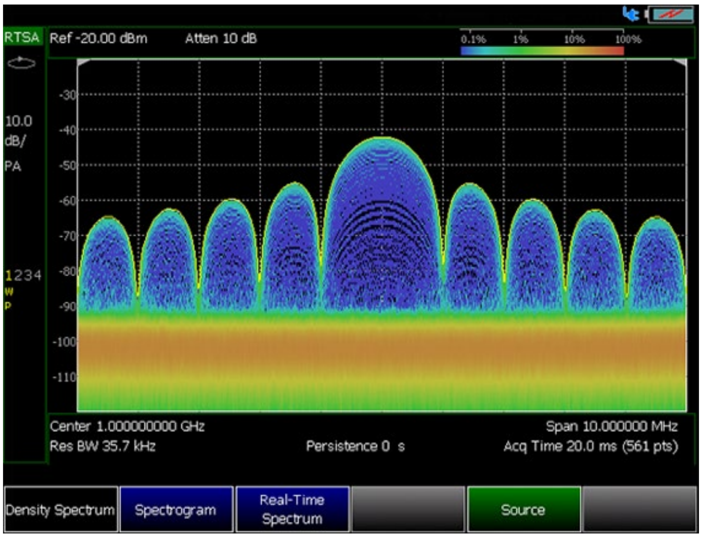

Figure 2: A density display with user-selected persistence time makes it easier to understand the behavior of multiple signals occupying the same frequency channel.

This approach allows field personnel to see and focus on infrequent events or transients, then separate them from other behavior. By changing the persistence and color-weighting settings, specific behaviors can be highlighted.

RTSA also can reveal signals within signals. In a highly dynamic environment, it can be difficult to see weak signals with low duty cycles when the frequency content overlaps with signals that are wider, stronger or more frequent. Adjusting the persistence time can enhance the small differences that reveal elusive signals (Figure 3).

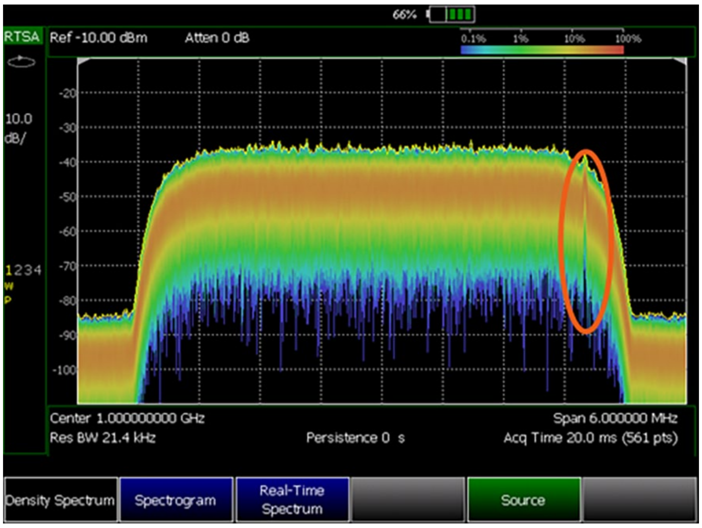

Figure 3: *This measurement reveals a suspicious narrowband RF signal trying to hide beneath a W-CDMA carrier signal.*

ENHANCING REAL-WORLD MEASUREMENTS

The characterization of radar signals in the field provides a good example. With a pulsed radar system, the analyzer must provide a variety of RBW and span settings that enable measurements of characteristics such as pulse repetition frequency (PRF), pulse width, duty cycle, and peak power. For over-the-air testing, precise triggering functions are needed to capture specific pulses

The spectrogram display makes it possible to view an entire pulse train over a period of time, and an individual frequency spectrum (i.e., a single horizontal line in the spectrogram) can be selected for viewing in a separate trace (Figure 4). This type of measurement is not possible with a swept spectrum analyzer.

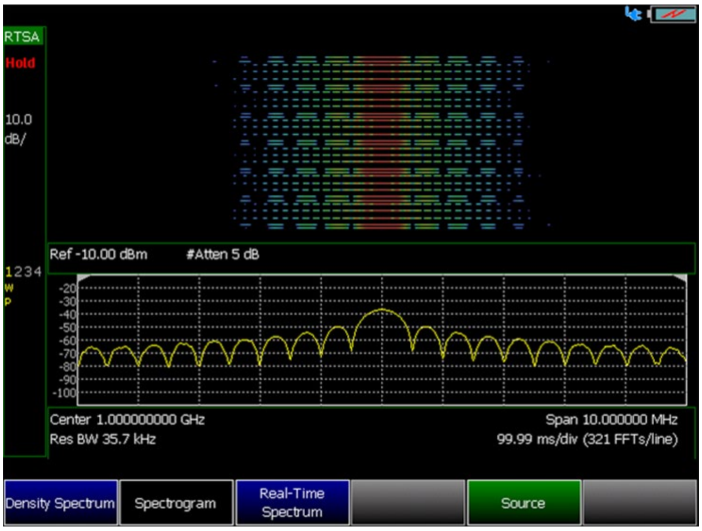

Figure 4: *The spectrogram (top) uses a color-coded overhead view of frequency spectra (x-axis) versus time (y-axis) that reveals pulses at a variety of widths, and each individual spectrum display (bottom) lets the user view the details at a specific instant in time.*

If any pulse fails verification testing, the source of the problem is often found inside the system: a transmit/receive module, a filter, an antenna or a cable. With built-in VNA and cable/antenna tester capabilities, the same FieldFox analyzer can be used to perform measurements such as phase response and insertion loss to troubleshoot suspect devices inside the radar system itself.

LOCATING INTERFERING SIGNALS

With a handheld directional antenna connected to the handheld analyzer, interfering signals can not only be discriminated in time and frequency, but also geospatially. Since the source and interfering signals are ultimately in different positions, pointing the directional antenna in different directions can enable the interfering signal to stand out more. The direction of the antenna where the interfering signal power is the strongest is the direction of the location of the interfering signal.

CONCLUSION

With today's multiplicity of wireless technologies, advanced measurement tools are needed to effectively maintain deployed A/D and commercial systems. In a millimeter-wave FieldFox handheld spectrum or combination analyzer, RTSA is especially effective for interference hunting and signal monitoring. Field personnel can use this single instrument to detect, locate and fix interference problems in wide range of scenarios. Learn more: www.keysight.com/find/FieldFox

Slow smart cities growth cuts IoT chip forecast

Lower sales projections for connected cities has prompted IC Insights to cut \$1.9 billion from the sales of semiconductors for IoT applications over the next four years.

Total IoT semiconductor sales are still expected to rise 19% in 2016 to \$18.4 billion. However, the firm has trimmed the compound annual growth rate (CAGR) it foresees for IoT semiconductors over the period 2013-to-2019 from 21.1% to 19.9%. Semiconductor sales for IoT system functions are now expected to reach \$29.6 billion in 2019 versus the previous projection of \$31.1 billion in the final year of the forecast.

The most significant changes in the latest outlook are that semiconductor revenues for connected cities applications are projected to grow by a CAGR of 12.9% between 2014 and 2019 (down from 15.5% in the original forecast) while the connected vehicles segment is expected to rise by a CAGR of 36.7% (up from 31.2% in the previous projection).

www.icinsights.com

Virtual reality via satellite demonstrated

SES S.A., and Fraunhofer Heinrich Hertz Institute HHI in Berlin, have demonstrated a groundbreaking R&D project at IBC this year showcasing the transmission of a 10K x 2K panoramic video signal via satellite to multiple devices.

The panoramic signal was received at the SES stand and transmitted to an Ultra HD display, as well as a set of virtual reality (VR) head-mounted devices. The viewer is able to choose a viewing angle, zoom in and out, turn the picture on the TV display using a simple remote control – or choose to wear a VR headset, where the video signal is delivered simultaneously.

Filmed with an OmniCam-360 camera developed by Fraunhofer HHI and transmitted via SES's ASTRA 19.2 degrees East orbital position, this demonstration will provide a first glimpse of what a future VR 360° video would look like. For the first time, it allows the viewer a truly immersive experience of being part of a virtual event, whether its sports, concerts or other live shows.

"We use a combination of technologies here exactly to showcase what is possible when using hybrid approaches," said Dr. Ralf Schäfer, Fraunhofer HHI's Head of Division Video. "There is no stadium in the world providing enough seats for all enthusiastic fans. So imagine a live event somewhere in the world – filmed with professional cameras like our OmniCam-360 and then delivered to a huge global audience via satellite."

Thomas Wrede, Vice President Reception Systems at SES, added, "Satellites are the perfect distribution path for these new kinds of video experiences, as they can manage huge volumes of data being offloaded from terrestrial networks. Furthermore, technology standards like SAT>IP not only allow the viewers at home to pick and choose a device – the TV screen, tablet or virtual reality equipment – but also they can now choose their favourite viewing position."

www.hhi.fraunhofer.de

Smartphone volume to rise from 2016 to 2024

According to Persistence Market Research the global smartphone market is projected to register a healthy CAGR of 7.9% in terms of value and 5.8% in terms of volume during the forecast period 2016 to 2024.

On the basis of operating system, the iOS segment is anticipated to account for US\$ 584.9 billion by 2024, registering a substantially high CAGR of 9.1% over the forecast period with a relatively high value share of 59.8%. The Android segment is expected to follow closely with a value share of 47.6% and a CAGR of 6.7%. In terms of volume, the Android operating system is estimated to account for the largest market share of 69.3% in the global smartphone market by the end of 2016 and is expected to increase to 70.0% by 2024. The Android segment is estimated to account for 50.7% value share in 2016 while the iOS segment is estimated to account for a revenue share of 46.2% in 2016.

www.persistencemarketresearch.com

EMC shielding with coatings a few micrometres thick

Researchers at Drexel University (Pennsylvania) and the Korea Institute of Science and Technology have discovered a cost-effective and efficient way to shield electronic components and enclosures using a spray-compatible coating only a few micrometres thick.

Instead of relying on thick metals or layers of conductive coatings with limited shielding effectiveness, the researchers relied on layers of two-dimensional titanium carbide, a 2D material only a few atoms thick that conducts like metals and graphite. The novel nanomaterial, part of the MXene family of 2D transition metal carbides only recently discovered a few years ago, is extremely good at absorbing electromagnetic waves.

The researchers tested samples of MXene films at different thicknesses, from a couple of micrometres up to 45 µm. They found that a coating of MXene only 8 micrometres thick could block 99.9999 percent of all radiations in a frequency range from cell phones to radars.

When electromagnetic waves come in contact with MXene, some are reflected from its surface but the majority passes through the surface and then get dissipated within the material's atomically thin layers, through multiple internal reflections.

The MXene was proven to have a shielding effectiveness beating that of today's copper and aluminium foils. What's more, the new material retains its shielding effectiveness even when combined with a polymer to make a composite coating.

www.drexel.edu

Radar evolution from solid-state to automotive

By Jean-Pierre Joosting

The traditional defence and commercial radar markets are growing modestly and are expected to continue growing over the next decade as older commercial aviation systems are upgraded and military spending by countries continues to grow.

Market research firm Markets and Markets expects the radar systems market to grow from USD 20.29 billion in 2016 to USD 26.37 billion by 2021, at a CAGR of 5.39% from 2016 to 2021. According to the firm, factors, such as increased usage of radar systems in unmanned vehicles and homeland security, are expected to drive the growth of the radar systems market.

The report notes that the commercial segment is expected to lead the radar systems market, which can be mainly attributed to the increasing demand for radars across various industries, such as automotive and oil and gas.

SOLID-STATE AN ENABLING TECHNOLOGY

One of the key drivers in the radar market is the rising use of GaN solid state power amplifiers, which are achieving higher power levels and wider bandwidths than before. Solid-state devices offer many advantages over older radar technology, such as lighter weight, smaller size, instant turn on, wide band capabilities leading to higher resolution, high efficiency, and low power operation. Solid-state radar also enables designers to implement phase-array systems that have no moving parts and that enable radar signal to be digitised, with a host of signal processing benefits from target recognition to adaptive and cognitive systems.

Higher power, and higher frequency power transistors enable more and more applications to be addressed with solid-state radar.

To illustrate the abilities of GaN-on-SiC, which is a higher power process then GaN-on-Si, Wolfspeed, a Cree Company, recently completed a lineup of GaN-on-SiC high efficiency, high gain, and wide bandwidth C-band radar parts with the introduction of the CGHV59070 GaN HEMT for C-band radar systems.

"First demonstrated at this year's International Microwave Symposium, the market release of the 70-W CGHV59070 pre-driver completes Wolfspeed's C-band radar lineup of pre-drivers, drivers, and output stages, enabling 1 kW, all-GaN SSPAs for C-band radar applications," said Jim Milligan, RF and microwave director, Wolfspeed. "This latest introduction also further extends our comprehensive radar product portfolio, which helps designers achieve smaller, lighter, and higher power RF amplifiers that are critical for the development of the next-generation military, aerospace, and commercial radar applications."

On the cost side, Ampleon use LDMOS to target lower power radar applications, though the company also have GaN for radar as well. Ampleon offer two 400-W S-band power amplifier pallets designed for a variety of civil and military radar applications. These small form factor modules, measuring just 55- x 35-mm, reduce the overall size of the PA sub assembly in addition to reducing the BOM cost of the design.

Optimised for SWaP-CR (size, weight and power – cost and reliability) constraints, these 9th generation 32-V LDMOS technology pallets meet the industry requirements of cost and reliable performance. ITAR-free, the BLS9G3135P-400 and BLS9G2934P-400 are 50 Ohm matched modules that help engineers create high power systems. The BLS9G2934P-400 has an output power >400 W, a gain of >10 dB, an efficiency >40%, and can operate in the range 2.9 to 3.4 GHz. Production quantities are expected to be available in Q4, 2016.

GaN RF power transistors based on a 0.5 µm HEMT process technology from Ampleon comprise 10 W, 30 W, 50 W and 100 W devices that are suitable for multiple applications such as drivers up to C band, through to 100 W and 200 W push-pull packages for use in final stages up to S band. Housed in a compact and thermally stable ceramic package, the whole CLF1G family of devices are ideal for use in a broad range of applications that need to meet specific requirements of SWaP (size, weight and power).

ADAPTIVE AND COGNITIVE RADAR

As military systems get more complex with the trend to adaptive and cognitive radar, signal processing in the digital domain is becoming even more challenging. Such radar systems might be jammed and adaptive radar that can work around jamming signals adds to the overall effectiveness of the system. Consequently, radar is moving from fixed analog systems to programmable digital systems that are agile and can adapt their behaviour to their environment. In turn, as battlefield capabilities evolve and radar becomes smarter, EW systems need to be able to rapidly characterise emerging radar threats, implement electronic countermeasures, and assess the effectiveness of the response.

In the USA, DARPA are running the Adaptive Radar Countermeasures (ARC) program, which aims to enable airborne EW systems to automatically generate effective countermeasures against new, unknown and adaptive radars in real-time in the field.

According to DARPA, ARC technology will enable radar systems to:

- Isolate unknown radar signals in the presence of other hostile, friendly and neutral signals.
- Deduce the threat posed by that radar.
- Synthesize and transmit countermeasure signals to achieve a desired effect on the threat radar.
- Assess the effectiveness of countermeasures based on over-the-air observable threat behaviors.

One company actively involved in this program, BAE Systems, contends that final implementation of the ARC program is projected to occur by 2018, with demonstrations through live flight tests on an existing EW system. As part of ARC Phase 2, BAE Systems will deliver a prototype system that will feature software algorithms capable of detecting and countering emerging radar threats, providing a major capability enhancement without the need for costly hardware upgrades.

On the automotive side, complex environments involving many slow moving objects need to be detected, especially at close proximities and at a resolution that enables the target to be identified by software algorithms. The challenge here is to be able to identify targets that need to be avoided faster than a human driver is capable of achieving – implying the need for compute intensive signal processing for advanced driving aids and eventually an AI system on wheels for future autonomous vehicles.

AUTOMOTIVE RADAR TO DRIVE A NEW MARKET

Radar promises to be a major contender for autonomous cars due to its ability to measure the velocity, range and angle of objects. Radar requires less processing power than a camera and uses much less data than Lidar. It can also work in every weather and lighting condition as well as use reflection to see behind obstacles. Cameras and Lidar also have advantages — Lidar can generate precise 3D maps of its surroundings, while cameras are ideal for scene interpretation. It is expected that all three will play an important role in autonomous driving. Radar is already in the market for applications such as forward collision warning systems and adaptive cruise control.

According to market research firm, Wise Guy Reports, the global automotive radar market accounted for $1.2 billion in 2015 and is expected to reach $3.9 billion by 2022 growing at a CAGR of 18.7% from 2015 to 2022. The market is being driven by increasing advancements in design and functionality of products, growing use of parking and collision sensors and higher demand for self driving features.

Though the majority of automotive radar applications are expected to centre around 77 and 79 GHz, other frequencies are being looked at. It should be noted that the 24 GHz band in the EU is temporary for automotive radar use as it faces issues with interference. It is used by radio astronomy stations and the band will be closed before usage becomes too dense.

Already working with automotive radar market leader Infineon Technologies AG at 79 GHz in 28nm CMOS, the IMEC research institute (Heverlee, Belgium) is looking at yet a smaller wavelength to add machine learning to the back end of its sensors.

According to Wim van Thillo, program director for perceptive systems at IMEC, his group is already working on a 140 GHz chip. At this frequency the wavelength is 2.2 mm. IMEC is aiming for more than 4 GHz of bandwidth from a chip measuring 1 square millimeter.

Advantages will include higher distance and angular resolution at lower power in a much smaller system size with the radar able to include the antenna-on-chip. In addition to angle and distance, the radar is able to provide speed information via a mini-doppler effect. The use of multiple antennas integrated on to the chip will result in enhanced Doppler resolution and a better depth resolution.

The signal processing that will be needed to extract speed information is likely to be taken further with the use of algorithms for pattern recognition and automatic learning. As a result Van Thillo envisages a time when the radar will be able to recognize and distinguish the signature of pedestrians, bicycles and cars from their mini-Doppler signatures.

www.ampleon.com
www.wolfspeed.com
www.baesystems.com
www.darpa.mil
www.marketsandmarkets.com
www.wiseguyreports.com
www.imec.be

Startup Celeno closes investment round to drive disruptive Wi-Fi technology

Celeno Communications has closed a new investment round of $38 million to drive its rapid growth and expansion, which was led by Red Dot Capital Partners, a capital fund focused on growth stage investments funded by Temasek, an investment company based in Singapore, through its enterprise development unit.

Additional new investors are Poalim Capital Markets, the investment arm of Bank HaPoalim, the largest financial banking group in Israel, and OurCrowd. Existing investors including Liberty Global, Cisco, Pitango, 83North (formerly Greylock IL), Vintage and Miven also participated in the round.

According to Gilad Rozen, Celeno founder and CEO, Celeno address many current problems with Wi-Fi technology such as speed, coverage and interference at the physical layer, as well as multi-access point (AP) co-ordination and QoS at the upper layers. Celeno Wi-Fi address these issues using both silicon and software virtualization to create smart adaptive Wi-Fi networks for the home market.

Gilad describes the company's approach, "Celeno is able to take the technology found in enterprise systems, put them into a chip, and sell into mass end markets such as the home market. Working primarily through the service provider channel, Celeno silicon, known as Quicksilver, and software is designed into home gateways, home routers and set-top boxes, to help service provides alleviate QoE (Quality of Experience), Opex and customer churn issues."

Quicksilver 4x4 802.11ac Wave 2 standards-based silicon includes value added features such the Argus in-chip dedicated RF circuitry and DSP-based engine for spectrum scanning and analysis, ControlAIR™ multi-AP management software, and Smart Antenna Steering technology.

The antenna steering technology delivers the optimum Access Point coverage by dynamically selecting 4 out of an up to 16 antenna array – enhancing immunity to device orientation, polarization and mobility, as well as maximising system performance across multiple rooms and floors.

ControlAIR™ multi-AP management software boosts capacity, coverage and speed of Wi-Fi when adding smart access points, repeaters or extenders in the home. It addresses the key issues of QoS and multi-access acess point co-ordination – providing an intelligent network in the house that delivers load balancing and hand-over between access points.

Gilad points out that, "Celeno smart Wi-Fi eliminates the so called 'sticky client' problem that is common in today's home Wi-Fi networks and enables data to be allocated to devices according to their needs, which may include data streams to TV set-top box, OTT, file download to a game console or even a hotspot for street users, without one stream dominating the Wi-Fi network."

Celeno continues to gain market traction with tens of millions of its Wi-Fi chipsets being deployed by top tier service providers in home gateways, routers and set top boxes designed by leading global OEMs.

Zvika Naggan, Managing Partner at Red Dot has joined Celeno's Board of Directors. Mr Naggan notes that, "Celeno has made the crucial transition from an innovative, disruptive start-up to a global player alongside some of the Wi-Fi semiconductor industry's largest players and the solution of choice for many of the most important global service providers."

"With this significant new investment round, combined with the calibre of investors backing us, we are able to continue executing our strategy, building a world class global company that will bring value to investors and shape the industry as a market leader," says Gilad Rozen. "With this new round we have taken Celeno to the next level and are able to further accelerate our growth and expansion in the market as well as focus on enhancing R&D efforts and further developing our disruptive solutions."

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Designing a more efficient broadband 100 W Doherty power amplifier for cellular base-stations

By X Moronval, Ampleon France SAS, Toulouse,
and J Gajadharsing, Ampleon Netherlands BV, Nijmegen

The proliferating frequency bands and modulation schemes used in modern cellular networks are making it increasingly important that the RF power amplifiers used in base-stations offer the right combination of output power, multiband support and efficiency – at both peak and average power outputs.

Industry is responding by developing variants of the Doherty power amplifier (DPA) architecture, which already combines high efficiency with limited design complexity and cost.

The Doherty architecture, first proposed in 1936 [1], is traditionally seen as a narrowband solution. Recent publications have proposed DPAs with greater bandwidth, but many of them are either complex for example requiring input drive conditioning [2]; of limited power output (less than 100 W) [2] [3]; or only suitable for sub-GHz applications [5].

BUILDING A BETTER DOHERTY AMPLIFIER

We have already developed [4] a variant of the DPA, called an integrated DPA (iDPA) architecture, which operates from 1.805 to 2.17 GHz, and reaches 47% efficiency at 6 dB back-off (that is, 6 dB less than peak operating power). Unfortunately, this design's symmetric topology means that its efficiency drops off rapidly when used at greater levels of back-off. This is a drawback, since the complex modulation schemes used in 4G networks create signals with high peak-to-average power ratios (PAPR), which means base-station power amplifiers often need to operate with 8 to 16 dB of back-off.

To counter this issue we have developed a four-way iDPA topology that offers multi-band capability and good efficiency when operated with a lot of back-off.

The conventional output-matching scheme for the discrete power transistors of a Doherty amplifier works by resonating the drain-to-source parasitic capacitor CDS with a shunt induc-

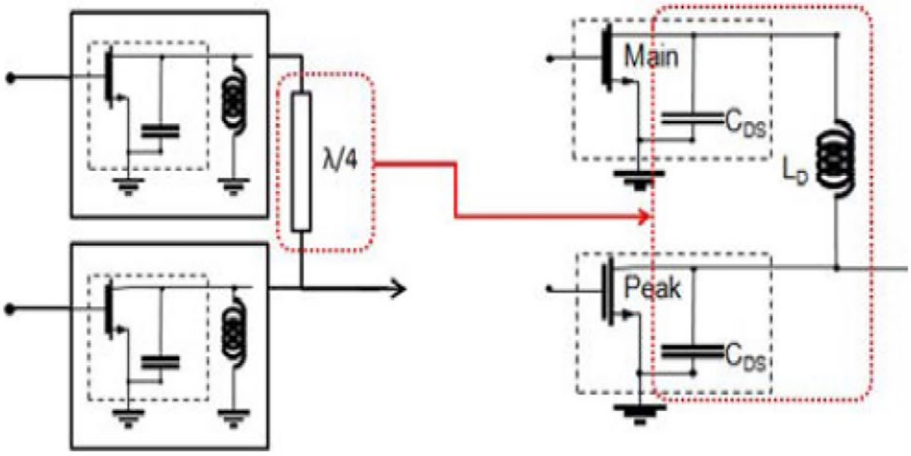
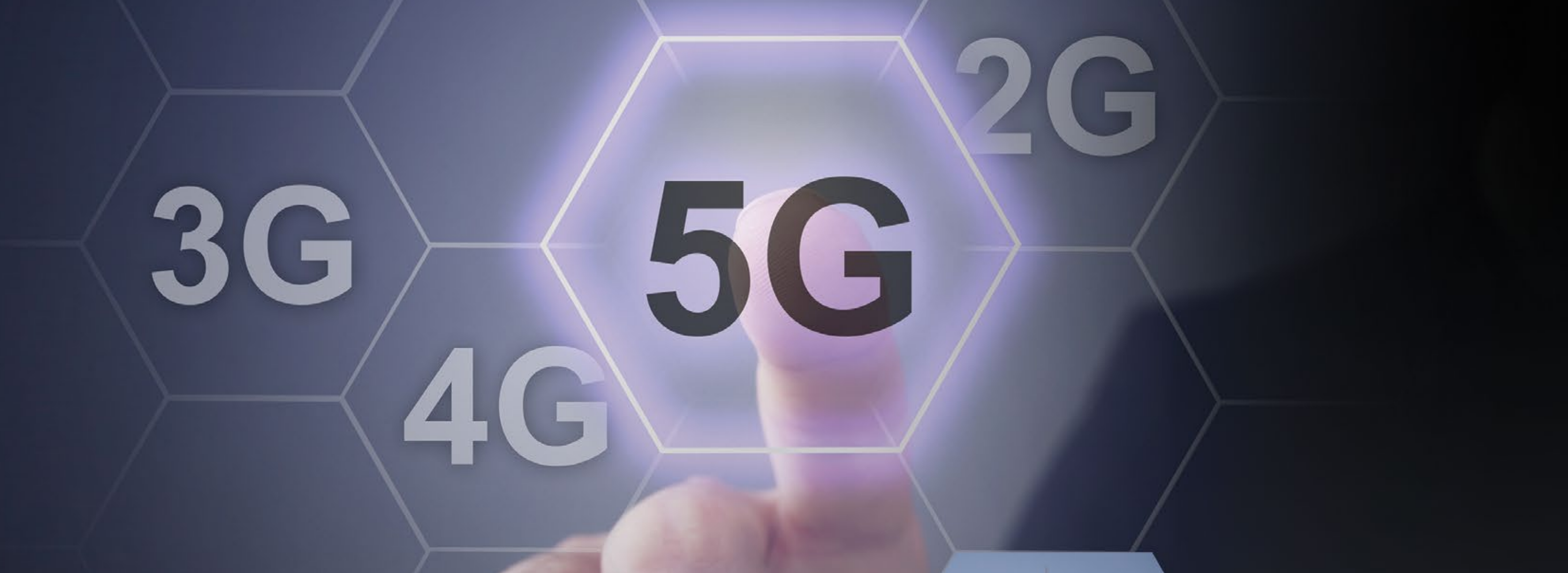
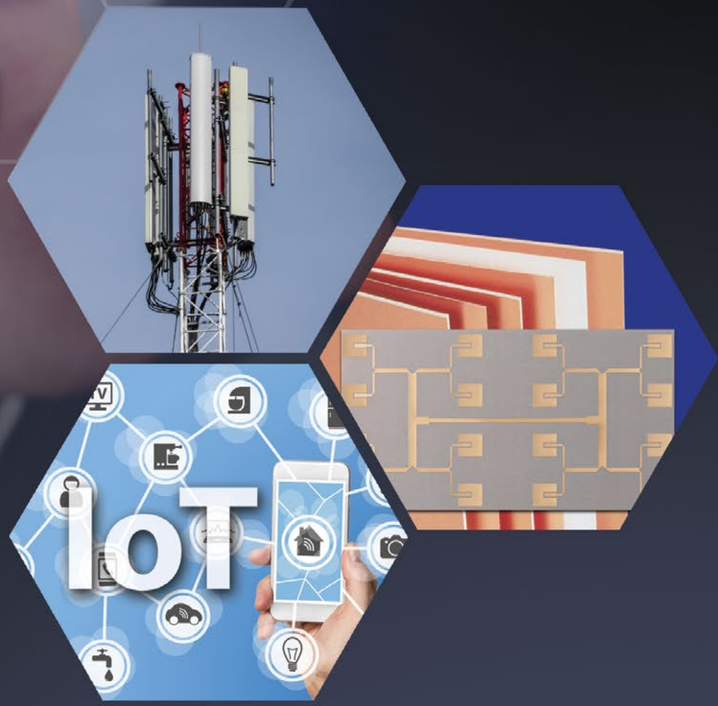


Figure 1: A conventional DPA output combining strategy at left, and the integrated DPA approach at right (source: Ampleon).

Figure 2: Comparing the efficiency of various DPA architectures (Source: Ampleon).



Forward Thinking



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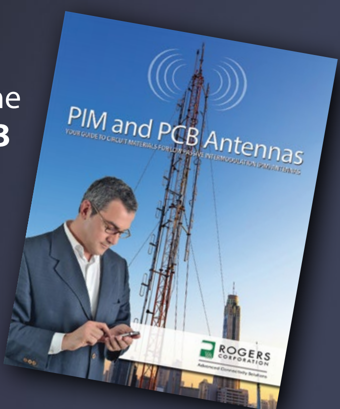

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tance. This approach works, but limits the amplifier's fractional bandwidth (a measure of its wideband capabilities) to a maximum of 10%.

In a symmetric iDPA topology, the drain-to-source parasitic capacitance CDS is absorbed in a broadband manner, using an equivalent transmission line suitable for Doherty operation (see Figure 1). This allows up to 28% of fractional bandwidth.

This topology works well with silicon LDMOS devices, as their intrinsic operating voltage, power density and parasitic capacitances enable the 90° phase shift and optimum load impedance necessary for the Doherty inverter to work properly.

However, the efficiency of this symmetric approach falls steeply and linearly versus power at 6 dB output back-off.

NEW TOPOLOGIES

Various other topologies have been proposed to address this issue, such as asymmetric 2-way or symmetric N-way (N > 2) , and their efficiencies are shown in Figure 2.

An asymmetric two-way architecture is often chosen for base-station power amplifiers, because it only uses two devices and yet achieves excellent back-off efficiency. A 2:1 asymmetric architecture can achieve its optimum efficiency at 9.54 dB back-off, more than 3.5 dB better than with a symmetrical architecture. However, this topology also degrades the amplifier's bandwidth.

A four-way, 1:1:1:1 topology has the advantage of using equal-sized devices, and reaches optimum efficiency at 12 dB back-off. It also works well within an iDPA approach.

To create a broadband, four-way DPA using the iDPA architecture, we use two iDPA amplifiers, each housed in a dual-path package. The output matching networks (OM in Figure 3) are designed with an electrical length equivalent to a 180° phase shift, and a wideband impedance inverter is used, showing an improved fractional bandwidth from 28 to 50% [5].

Through simulation, we found that there are two operating modes for this topology, one we call 'linear' and the other 'maximum efficiency'. Although the second sounds attractive, it has a non-linear output that is difficult to overcome using digital pre-distortion, especially for the highly linear modulation schemes used in multi-carrier GSM. Linear operation happens when

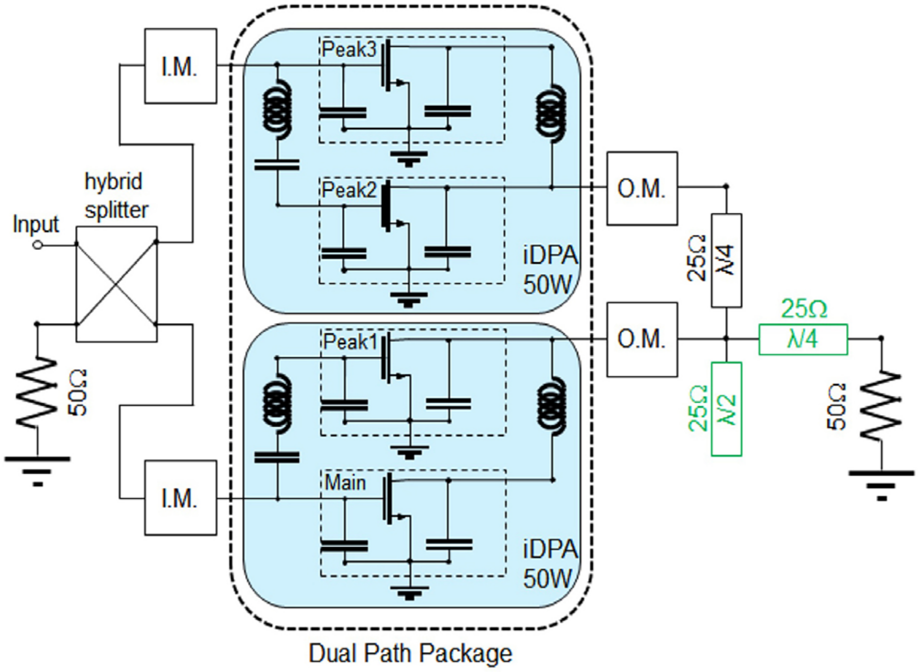

Figure 3: Proposed architecture for the 4-way iDPA (Source: Ampleon).

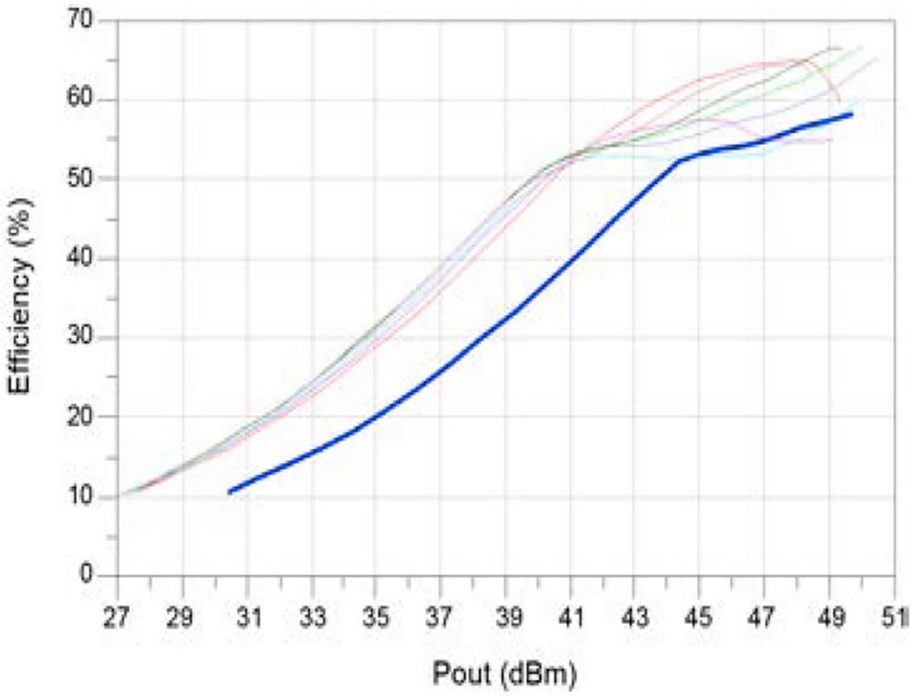

Figure 4: Simulated efficiencies of the four-way iDPA operating at 1.805 – 2.17 GHz (narrow colours) compared with a symmetric iDPA topology (bold blue) operating at 1.99 GHz (Source: Ampleon).

both Peak2 and Peak3 transistors are biased at the same gate voltage, giving two efficiency peaks when operating in back-off mode.

A second set of simulations, using electro-thermal non-linear models, gives the efficiency response versus output power curves for LTE bands from 1.805 to 2.17 GHz, as shown by the narrow lines in Figure 4. The figure also shows that a 100 W power amplifier using the four-way iDPA topology can achieve substantial improvements in efficiency operating at various levels of back-off, when compared to a standard symmetric iDPA operating at its central frequency (represented in bold blue).

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IMPLEMENTING THE NEW TOPOLOGY

The new iDPA topology is implemented by mounting two iDPA dies in a dual-path air-cavity plastic package, on a low-cost industry-standard PCB. The external dimensions are 50- x 80-mm, and the effective area excluding connectors and screws is less than 10 cm^2 (Figure 5).

This highly integrated four-way Doherty amplifier offers 13.4 dB gain, as well as an average efficiency of 46 to 48% at 8 dB output back-off from the 100 W peak power output, across a frequency range of 1.805 to 2.17 GHz – which is close to a 20% fractional bandwidth.

These results are close to the performance of single-band DPAs, and is paving the way for the next generation of flexible and efficient cellular base-stations.

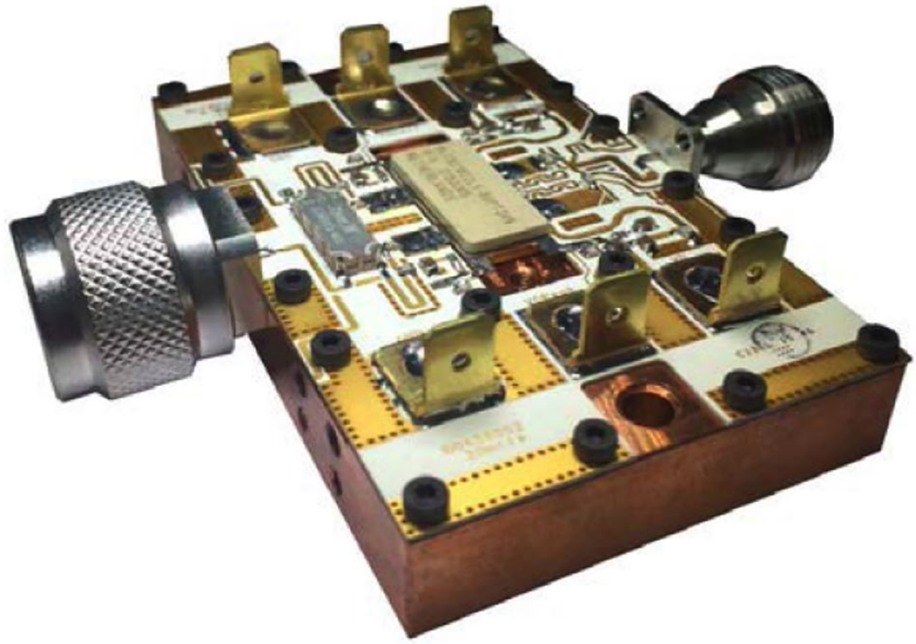

Figure 5: Fabricated fixture of the 100 W four-way iDPA (source: Ampleon).

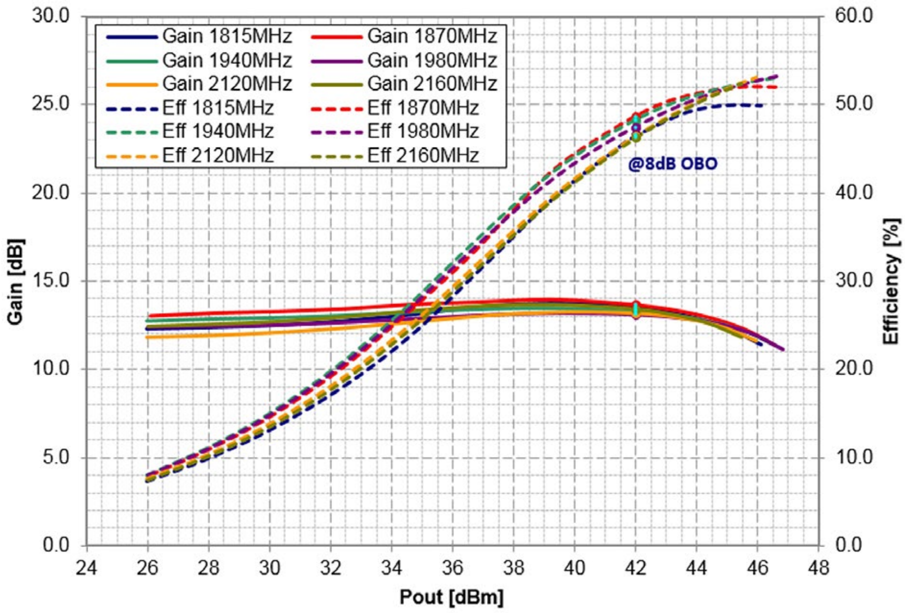

Figure 6: Measured performance with a 20 MHz-wide LTE signal (Source: Ampleon).

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Five things to consider when choosing a crystal oscillator

By Steve Fry, Greenray Industries, Inc.

Most electronic systems require some sort of oscillator as a critical functional block in their design. Some typical uses would include: a clock for a digital system that synchronizes the operation, a stable RF signal for a receiver or transmitter, an accurate frequency reference for precision measurements or a real time clock for accurate timekeeping. The specifications for the system and how the oscillator needs to function will determine most of the parameters of the device.

The key component in any oscillator is the resonator which will control the frequency and determine what stability specifications may be achieved. While it is possible to implement a simple oscillator with an LC or RC resonator that may suffice for some applications, the addition of a quartz crystal will greatly improve the frequency stability of the device by several orders of magnitude, often with a minimal cost impact.

1. OUTPUT FREQUENCY

The most fundamental attribute of any oscillator is the frequency that it will produce. By definition, an oscillator is a device that accepts an input voltage (usually a DC voltage) and produces a repetitive AC output at some frequency. The frequency that is needed is dictated by the type of system and how it will be used.

Some applications call for low frequency crystals in the kHz range. A common example would be a watch crystal at 32.768 kHz. But most current applications need higher frequency crystals ranging from less than 10 MHz to greater than 100 MHz.

2. FREQUENCY STABILITY AND TEMPERATURE RANGE

The required frequency stability is determined from the system requirements. The stability of an oscillator is simply given as the change in frequency due to some phenomenon divided by the center frequency.

That is: Stability = Change in Frequency ÷ Center Frequency

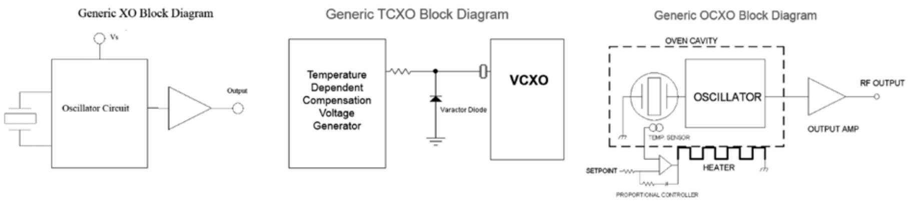


Figure 1: Generic oscillator block diagrams.

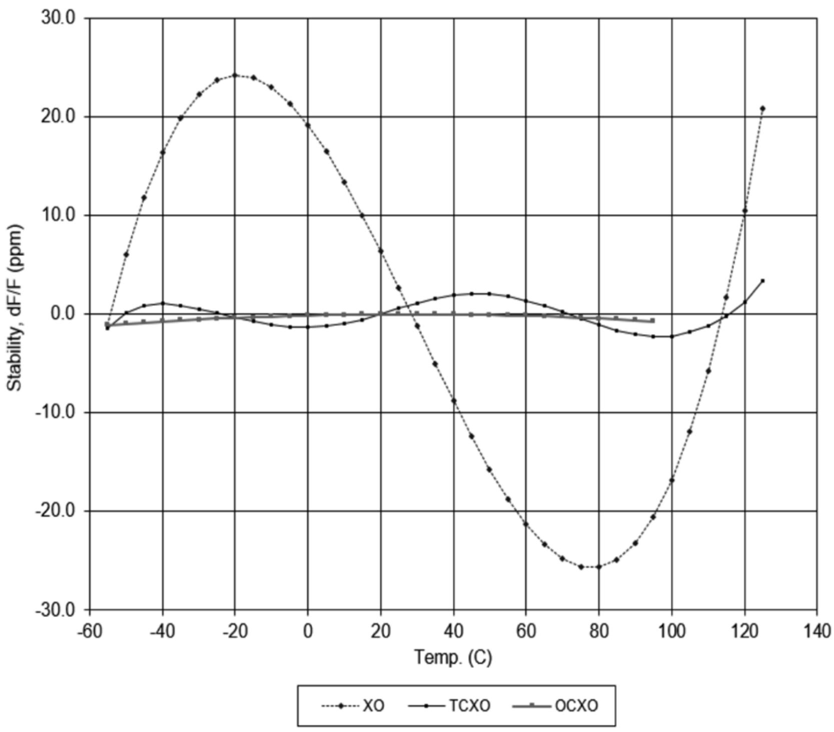


Figure 2: Frequency versus temperature stability of crystal oscillator types.

For example, if the oscillator output frequency is 10 MHz and it changed 10 Hz over temperature, it's temperature stability would be: 10/10,000,000 = $1x10^{-6}$ = 1ppm. Typical stabilities for a crystal oscillator could range from 100ppm to 0.001ppm.

The frequency stability is usually determined by the requirements of the application and will subsequently determine the type of crystal oscillator that will be needed. The temperature range over which the oscillator must operate is a major factor in determining the stability that can be achieved.

CRYSTAL OSCILLATOR TYPES

Simple Crystal Oscillator (XO):

This is the most basic type where the stability is totally determined by the inherent characteristics of the crystal resonator itself. The higher frequency crystals in the MHz range are fabricated from a quartz bar in such a way as to provide a relatively stable frequency even though the ambient temperature may vary as much as -55°C to +125°C (-67°F to +257°F). A stability of ±25ppm is achievable with a properly cut quartz crystal even over this wide of a temperature range. This is a substantial improvement over other passive resonators such as an LC tank circuit which may change 1% or more (10,000ppm). But even 25ppm is not good enough for some applications so additional measures must be employed.

Temperature Compensated Crystal Oscillator (TCXO):

If the inherent frequency versus. temperature stability of the quartz crystal is not adequate for an application, a temperature compensated unit may be employed. A TCXO uses a temperature sensing device along with circuitry which generates a voltage curve which is the exact inverse of the crystal over the temperature range and ideally cancels out the drift of the crystal. Typical stability specifications for a TCXO range from less than ±0.5ppm to ±5ppm depending on the type of TCXO and the temperature range.

Oven Controlled Crystal Oscillator (OCXO):

For some applications the frequency versus temperature stability of a TCXO will still be inadequate. In these cases, an OCXO may be called for. As the name implies, an oscillator with an oven heats the crystal to an elevated temperature which is controlled so that the temperature of the crystal remains stable even though the ambient temperature may vary widely. Since the temperature of the crystal and the sensitive portions of the oscillator see very little variation, the frequency versus. ambient temperature stability is substantially improved. The stability of an OCXO may be as tight as 0.001ppm over the ambient temperature range. This improved stability, however, comes with the cost of increased power consumption in order to supply the heat to the oven. A typical OCXO may require from 1- to 5-W of power to maintain the internal temperature. A warmup period after turn on is also needed to wait until the temperature and frequency have stabilized, typically from 1 minute to greater than 10 minutes depending on the type of unit.

Voltage Controlled Crystal Oscillator (VCXO):

In some applications it is desirable to be able to tune or adjust the frequency of the oscillator in order to phase lock it to a reference in a phase locked loop or possibly to modulate the waveform. A VCXO provides this capability via an Electronic Frequency Control (EFC) voltage input. The tuning range specification for a VCXO may vary from ±10ppm to ±100ppm or even higher for some specialized devices.

TCVCXO and VCOCXO:

A TCXO or OCXO will often include an EFC input voltage. This allows adjustment in order to calibrate the output frequency precisely to a nominal value.

3. INPUT VOLTAGE AND POWER

Crystal oscillators of any type can usually be designed to operate with a DC input supply voltage that is already available in the system. In a digital system it is normally desirable to use a voltage which matches the voltage used by the logic devices in the system that the oscillator will be driving so that the logic levels will be directly compatible. +3.3 V or +5 V are common inputs for these digital units. Other devices with higher power outputs may use higher voltages such as +12 V or +15 V. Another consideration is the amount of current that is needed to power the device. An XO or TCXO may only need a couple of milli-amps so in a low voltage system they could operate on less than 0.01 W. On the other hand, some OCXO's could draw 5 W or 6 W at turn on.

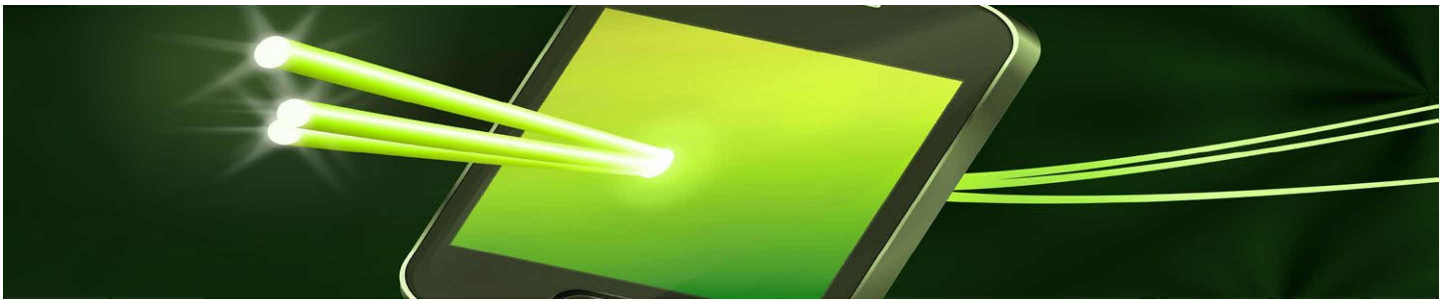
4. OUTPUT WAVEFORM

The output waveform would then be selected to match the load that the oscillator will be driving in the system. One of the most common outputs would be CMOS to drive logic level inputs. A CMOS output would be a square wave swinging between ground and the Vdd rail for the system. For higher frequencies greater than about 100 MHz a differential square wave is often used. These oscillators have two outputs 180° out of phase with fast rise and fall times and very little jitter. The most popular types are LVPECL and LVDS. If the oscillator is used to drive RF components such as a mixer or other devices with a 50 Ω input, a sinewave output at some power level is usually specified. The output power produced would typically fall between 0 dBm and +13 dBm (1 mW to 20 mW) although higher power may be possible if needed.

5. PACKAGE SIZE AND OUTLINE

The package required for a crystal oscillator will vary widely depending on the type of oscillator and the specifications. Simple clock oscillators and some TCXO's can be housed in packages as small as 1.2- x 2.5-mm while some OCXO's may be as large as 50- x 50-mm or even larger for some particular designs. Although some through-hole packages such as dual-in-line 4 or 14 pin types are still used for larger parts such as the OCXO's or specialized TCXO's, the majority of current designs use surface mount packages. These surface mount configurations may be either a hermetically sealed ceramic package or an FR-4 based assembly with castellations for the I/O's.

As has been shown, there are many different options to be considered when specifying a crystal oscillator. However, by examining the system in which the unit will be used, the most convenient selections will become obvious such as the input voltages that are available to power the unit and the type of device that the output of the oscillator will be driving. Other constraints of the application such as physical size and the operating environment must also be taken into account. In addition to these basic parameters there is a multitude of other specifications that may be invoked for specific applications. But when all things are considered, it is likely that a crystal oscillator can be found to satisfy the requirements of your system.



Wireless technology cuts power in high-speed mm-wave communications

By Julien Happich

MUsing a proprietary coding technology between antenna subarrays, Fujitsu Laboratories has built a prototype wireless unit capable of high-speed transmissions in excess of 10 Gbps. What's more, these high data rates were achieved at power consumption levels on par with today's Wi-Fi, claim the researchers.

Typically, research efforts using the millimeter waveband focus on massive multiple input, multiple output (massive MIMO) technology, which controls multiple antenna elements to send radio wave beams to each device. Each antenna element requires D/A circuits to convert digital signals to analog before they are emitted by the antenna. But performing digital beamforming requires the control of multiple high-speed D/A circuits, hence increasing power consumption.

Through what it calls hybrid beamforming, Fujitsu Laboratories aims to reduce the number of circuits in use. By carrying out some of the signal processing in the analog antenna element, multiple antenna elements can be connected to a single D/A circuit, reducing overall power consumption.

Fujitsu Laboratories' first attempts revealed reduced transmission rates, due to signal cross-interferences. In a system with 128 antenna elements, and 8 multiplexed beams, the number of D/A circuits with hybrid beamforming could be reduced to one sixteenth that of digital beamforming, but because the multiplexed beams interfered with each other, the transmission rate fell to one eighth that of a purely digital solution. The researchers managed to cancel out these interferences by crafting an interleaved structure and developing a novel inter-subarray coding format.

The interleaved-type device allows for more spacing between antenna elements within a subarray (a collection of antenna elements connected to one D/A circuit). When an antenna's range is spread out, its beam becomes narrower, and as the antenna elements are spread out, a type of undesired emission called a grating lobe can occur. If the elements for different subarrays are placed alternately (see figure 1), then the signals from both subarrays, A and B, are sent as radio waves in both directions the arrays are transmitting.

Signal A, however, is sent in the same phase of radio waves in both directions, while, due to the positional relationship between the antenna elements, the radio wave phase will change for B, depending on the direction.

By coding the signal appropriately between subarrays as shown in figure 2, the interferences can be cancelled out and the beam can be multiplexed.

With this system, an A+B signal is input into one subarray, while an A-B signal is input into the subarray in the other direction, resulting in one direction having an (A+B) + (A-B) = 2A signal, leaving only the radio waves for signal A, while the other direction has (A+B) - (A-B) = 2B, leaving only the radio waves for signal B.

The newly developed interleaved hybrid beamforming unit leverages this inter-subarray coding scheme in the 60 GHz band to support 10 Gbps links through a narrow multiplexed beam.

The researchers are now working on further increasing the speed of their wireless millimeter-band equipment while reducing power consumption per bit rate. They hope to make this technology ready for practical implementation by 2020.

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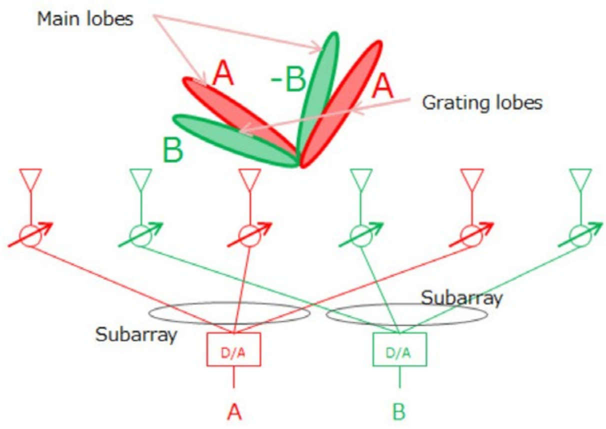


Figure 1: Interleaved hybrid beam multiplexing.

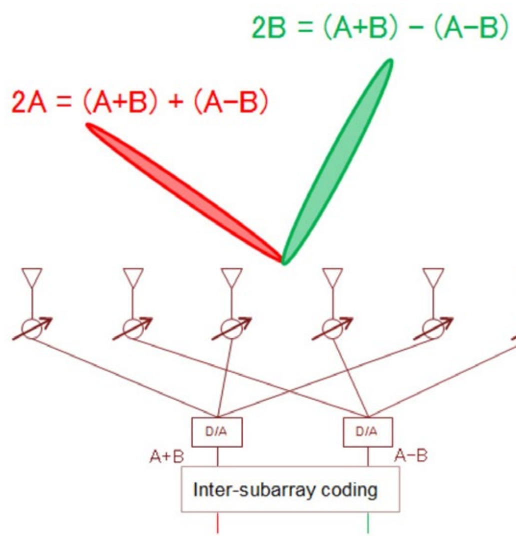


Figure 2: Beam multiplexing with inter-subarray coding.

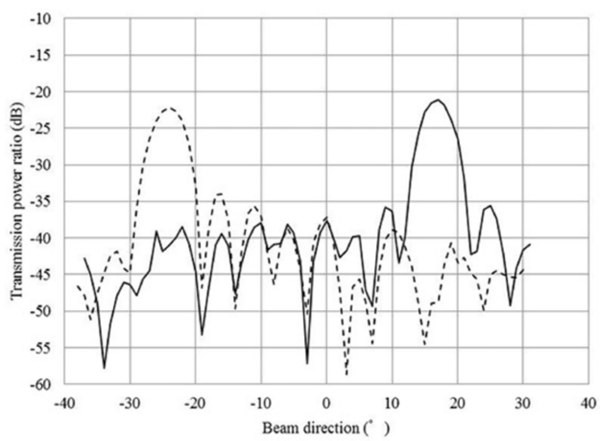


Figure 3: Measurement results of inter-subarray coding.

Will Quantum computing threaten cybersecurity?

A report by the Global Risk Institute (GRI) contends that emerging quantum computing technologies threaten to undermine even the most sophisticated cybersecurity systems installed by businesses and governments.

The report estimates that there is a one-in-seven risk that these technologies will undermine some of the most critical public-key cryptography tools within the next 10 years, and a 50% risk that many of these tools will be obsolete by 2031. Public-key cryptography is the foundation for digital commerce at many large organizations, including financial institutions, online retailers, and government agencies.

According to Dr. Michele Mosca who wrote and researched the report, "Quantum physics has surely been one of the most unexpected threats to cybersecurity. As we learn to handle attacks from currently familiar sources, cyber criminals are finding new ways to attack our cyber systems."

Dr. Michele Mosca is a special advisor on cybersecurity to the GRI, co-founder of the Institute for Quantum Computing at the University of Waterloo and a founding member of the Perimeter Institute for Theoretical Physics.

The threats stem from the power of quantum computing to execute tasks far beyond the reach of conventional computers. Existing computers use long strings of "bits" that encode either a 0 or a 1. By contrast, quantum computing enables the bit to embody the 0 and 1 states at the same time. By manipulating a large collection of quantum bits, known as qubits, a quantum computer can process countless configurations of 0s and 1s simultaneously.

"As the ideas continue to move toward working technologies and then to solutions for real problems, there is a global race for industry leadership in quantum technologies," the GRI report notes. However, it adds, "one unintended consequence is that these technologies will break some of the cryptographic tools currently underpinning cybersecurity."

One example is digital signatures, a fundamental requirement for online security. These signatures allow a verifier, such as a user's browser, to confirm that a piece of code comes from a trusted source and has not been tampered with. Another basic security function is establishing the security key that encryption algorithms use to protect confidentiality.

The report cautions that "when the cryptographic foundations on which a cyber system is built are fundamentally broken, the system will crumble with no quick fixes. A fail-safe replacement generally takes years to develop."

"It is very important that we are not caught off-guard and forced to fire-fight a threat that takes years of preparation to properly defend ourselves against," the report adds.

http://globalriskinstitute.org

Evaluate circuit material effects on PCB antenna PIM

By John Coonrod, Rogers Corp.

Antennas are key components in modern communications systems, and printed-circuit-board (PCB) antennas are attractive for their capabilities of providing strong performance in small footprints. As PCB antennas are used over wider frequency ranges and in communications devices ranging from base stations to handsets, circuit designers are faced with understanding how different PCB material characteristics relate to antenna performance. In particular, as the number of wireless applications, wireless signals, and antennas grows, passive intermodulation (PIM) becomes an important performance parameter for PCB antennas, requiring an understanding of how different circuit material attributes can affect printed antenna PIM performance. PIM is a form of interference and is a circuit or system issue, and it is cautious to be aware that circuit materials can contribute to PIM issues. An educated choice of circuit material can pave the way for fabricating wireless PCB antennas with low levels of PIM that also meet their other antenna performance goals.

Many of the circuit material parameters important for active or passive circuits used at RF/microwave frequencies, such as dielectric constant (Dk), dissipation factor (Df), thermal conductivity, coefficient of thermal expansion (CTE), and thermal coefficient of dielectric constant (TCDk), can also provide insights into how well a circuit material will perform when used for a PCB antenna. Understanding what each parameter means in terms of antenna performance, along with how a circuit material can affect the PIM performance of a PCB antenna, can help guide the selection of antenna-grade circuit materials that will deliver predictable, dependable antenna performance.

Any choice of antenna-grade circuit material will start with Dk, with the value for a given circuit material an indication of the size of the circuit dimensions required for a particular wavelength and frequency. In general, materials with higher Dk values will support smaller antenna structures for a given frequency, although materials with lower Dk values typically support stronger and more consistent radiation patterns.

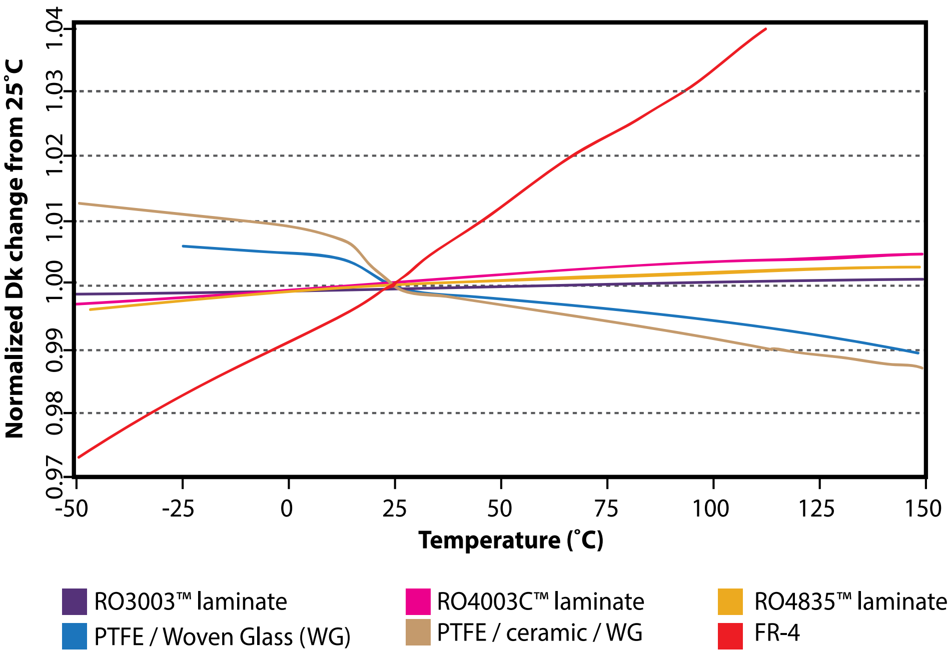


Figure 1: Changes in Dk with temperature relative to room temperature (+25°C) are plotted for a variety of PCB materials including three commercial circuit materials from Rogers Corp.

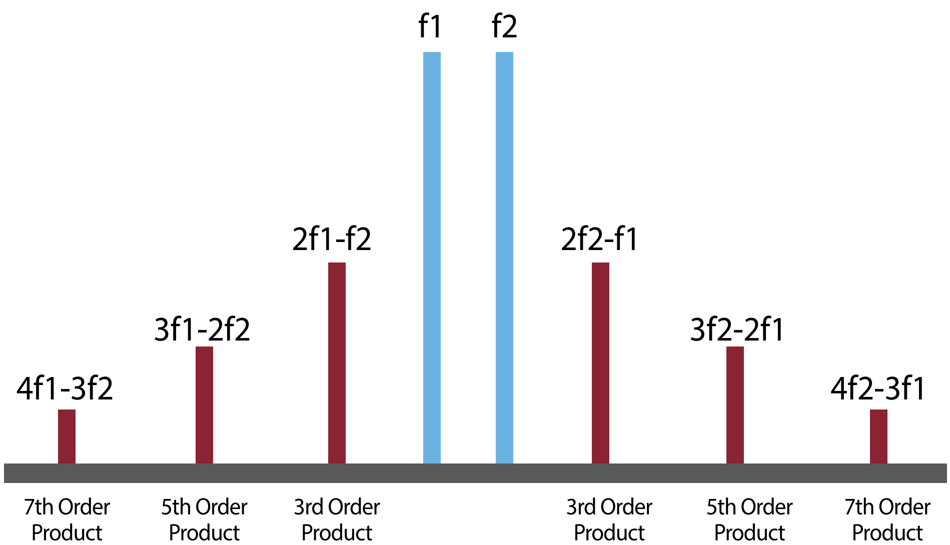


Figure 2: Intermodulation distortion is caused by the mixing of two or more fundamental-frequency tones and their harmonics.

The Dk consistency across a PCB material is one factor in achieving consistent and repeatable radiation patterns with a given printed antenna design, as is TCDk one barometer of how consistent PCB antenna performance will be with changes in temperature.

A circuit material's TCDk parameter is typically referenced to room temperature (+25°C) and by how much the Dk changes at other temperatures. In terms of antenna performance, since a PCB antenna is designed to resonate within a particular frequency range, and the dimensions of

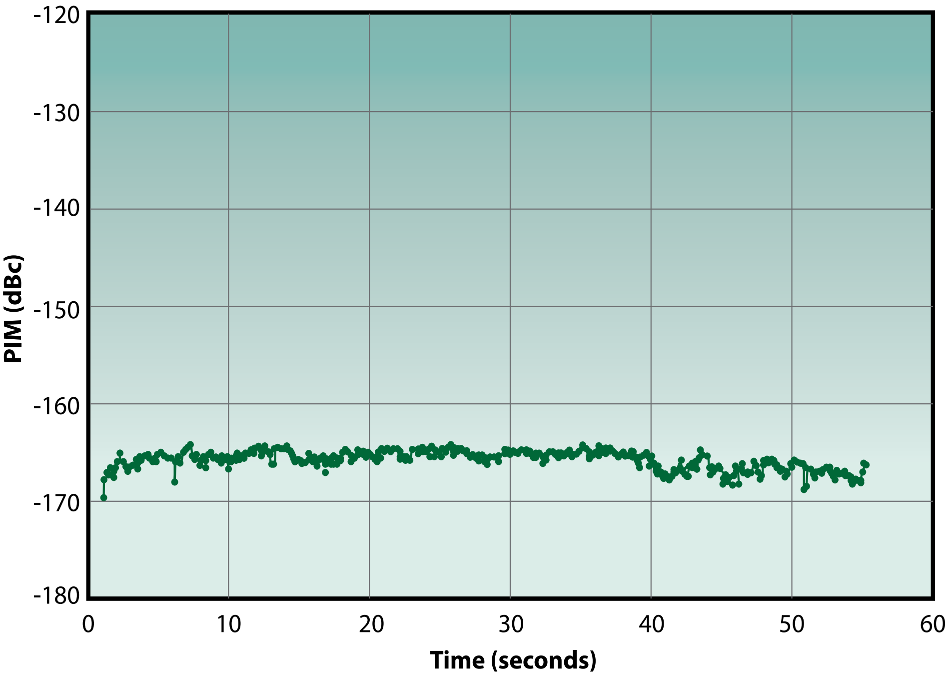


Figure 3: This plot shows PIM as a function of time for a microstrip transmission-line test circuit.

Product	Material	Dk	Df	TCDk (ppm/˚C)	PIM (dBc)
AD255C™ laminate	PTFE, ceramic, woven glass	2.55	0.0014	-75	< -160
AD300C™ laminate	PTFE, ceramic, woven glass	2.97	0.0020	-25	< -160
RO4725JXR™ laminate	Hydrocarbon, ceramic, woven glass	2.55	0.0023	34	< -160
RO4730JXR™ laminate	Hydrocarbon, ceramic, woven glass	3.00	0.0023	32	< -160
RO4730G3™ laminate	Hydrocarbon, ceramic, woven glass	3.00	0.0025	26	< -160

Table 1: High frequency circuit materials used in PIM-sensitive PCB antenna applications.

Copper Surface roughness as RMS (microns)	Average PIM (dBc)
0.5	-163
2	-145
4	-140
5	-137

Table 2: Summarizing the correlation between PCB copper surface roughness and PIM performance.

its resonant structure are based on Dk, even moderate changes in Dk with temperature can result in variations in antenna frequency and radiation pattern.

Different circuit materials behave differently with changes in temperature. To demonstrate, Figure 1 plots Dk as a function of temperature for a number of circuit materials commonly used for high-frequency circuits, including PCB antennas. The circuit materials include polytetrafluoroethylene (PTFE) circuit materials with woven glass (WG) and ceramic fillers, low-cost FR-4, and three high-frequency circuit materials from Rogers Corp. (www.rogerscorp.com): RO3003™, RO4003C™, and RO4835™ circuit materials.

The Dk values of these materials are low, typically from about 2.1 through the thickness (z axis) of the material for PTFE-based circuit materials to about 4.8 for FR-4 circuit materials. As the plots of Dk with temperature show, the Dk values can change a great deal with temperature, resulting in circuit and antenna performance that will also change with temperature. For the RO3003, RO4003, and RO4835 materials, with Dk values ranging from 3.00 to 3.48 and held to a tolerance of ±0.05 or better across the circuit board, the changes with temperature are minimal, indicating that the impedances of circuit transmission lines and antenna traces will be consistent with temperature for consistent antenna performance with temperature.

Although circuit materials are readily available with higher values of Dk, circuit materials for PCB antennas generally exhibit a Dk of 3.5 or less through the material thickness when measured at 10 GHz. The use of a circuit material with lower Dk value allows for the use of wider conductors for a design frequency and for efficient radiation. One design goal for any PCB antenna is to minimize loss exhibited by the antenna circuitry as well as any loss when transferring high-frequency energy from the feedlines to a PCB antenna's radiating elements. The use of circuit materials with Dk of about 3.5 or less promotes the design of efficient conductors. By selecting materials with low Df and smooth copper conductor surfaces for a PCB antenna, insertion losses can be minimized.

Intermodulation distortion, including PIM in passive PCB antennas, is of increasing concern with the growing numbers of wireless emitters. As Figure 2 shows, intermodulation results from the mixing of two or more closely located transmitted fundamental-frequency signals, f1 and f2, and their harmonics, 2f1, 2f2, 3f1, 3f2, and so on. The total of the coefficients of two mixing signals, such as 2f1 – f2 (2 and 1), determines the order of the resulting intermodulation product. As wireless services and their numbers of users increase, opportunities for intermodulation increase, with greater numbers of transmitted high-frequency signals. Intermodulation can occur in active circuits, such as frequency mixers or amplifiers, or as PIM in passive circuits, such as filters, couplers, and antennas.

CIRCUIT MATERIALS AND PIM

From Figure 2, it can be seen that PIM levels decrease with increasing order number, and that the third-order PIM products are usually of the greatest concern. Figure 2 does not show them, but even-order intermodulation products are also produced, and these can be a concern in some broadband applications. When the frequencies of any intermodulation products are within the frequency range of a nearby receiver, and the levels of the intermodulation products exceed the sensitivity of the receiver, they essentially function as noise to the receiver and can cause dropped calls, loss of data, and generally degraded wireless service.

While no circuit material is immune to the PIM of a passive circuit, such as a patch antenna, some circuit materials do better with PIM than others. PTFE-based high-frequency circuit materials have traditionally been known for low PIM levels, although such materials can require specialized processing steps and can be expensive choices for fabricating PCB antennas. Some non-PTFE-based thermoset circuit materials have fared well in PIM-sensitive designs, including as PCB antennas. Early concerns with the use of thermoset materials in such applications was that they lacked the low-loss (low Df) performance of PTFE-based circuit materials. But as the values in Table 1 show, a number of non-PTFE hydrocarbon circuit materials have been developed for PCB antennas with low Df loss and with PIM performance on par with PTFE-based circuit materials. The materials listed in Table 1 feature reasonably good TCDk values for stable performance with temperature, where |50| ppm/°C or less is considered good.

PIM can be caused by any number of variables in a system, including types of cables, loose connectors, and dirt on conductive surfaces. Materials with ferromagnetic properties are generally known to be potential sources of PIM. Ferromagnetic content of even 100 ppm or less in a dielectric material can elevate the PIM levels of a circuit material. For printed circuits, a number of factors can contribute to PIM performance, including the type of dielectric material, the quality of the etched circuitry, the quality of plated through holes (PTHs), the cleanliness of the PCB, soldermask, assembly issues, even the roughness of the copper conductor .

In fact, it is the surface roughness of the copper at the copper-substrate interface which has been found to be critical to PCB PIM performance. For the same material and transmission line, for example, smoother copper at this interface will result in lower levels of PIM. Table 2 lists the results of an internal study performed at Rogers Corp. which details the correlation between the root-mean-square (RMS) surface roughness of the copper at the copper-dielectric interface and the average PIM level. For the four items listed, the same substrate material, same dielectric thickness, same copper thickness, and same circuit design were used, with the only variation being the type of copper which had different amounts of surface roughness.

The treatment at the copper-substrate interface is not always considered in circuit material PIM studies, but it is generally not purely copper at that interface but a metal alloy used as a treatment to enhance the bond between the copper and the substrate material. The treatment also acts as a thermal barrier to the formation of copper oxide and to ensure good thermal robustness in the interface structure for the temperatures that will be used in processing the circuit material. While most copper treatments do not degrade PIM performance, some can and it must be considered as a possible factor that can contribute to circuit material PIM. For example, a nickel alloy copper treatment was found to have deleterious effects on PIM performance, since nickel is a ferromagnetic material.

Thickness	Average PIM (dBc)				
	20W	10W	5W	2W	1W
0.060" (1.52mm)	-145	---	---	---	---
0.030" (0.76mm)	-133	-137	-144	-147	-151
0.020" (0.51mm)	-135	-138	-145	-145	-152

Table 3: Average PIM levels for PCB material with high copper surface roughness at various power levels.

TESTING FOR PIM

As Table 2 indicates, small differences in versions of PCB materials can result in differences in PIM performance for printed antennas and other high-frequency circuits. With the low levels of PIM that are being evaluated, however, testing materials for PIM can be extremely challenging. No standard test method exists for evaluating circuit materials for PIM performance, although a test method has been developed at Rogers Corp. using a commercial PIM tester from Kaelus (www.kaelus.com) based on the behavior of a 300-mm-long 50-Ω microstrip transmission line circuit when fabricated on a circuit material of interest. With over a decade of collecting PIM data on circuit materials, Rogers has found that the test results using this microstrip test method can at best be held to a tolerance within ±6 dBc. With considerable experience in testing, it has been found that PIM varies with time and can vary even during the process of making the measurements on the microstrip transmission lines. Even to achieve that ±6 dBc measurement tolerance, it is important to ensure that the test equipment and test environment is stable before conducting the PIM measurements. Figure 3 shows an example of results as a function of time for a microstrip transmission-line circuit being tested for PIM.

As the plot shows, the level of PIM is relatively stable for a relatively long test period. The test data were collected over a period of 55 seconds, with 10 data points for every second of test time. In this case, testing was of a known good PIM circuit material with a thickness of 60.7 mils (1.54 mm). It has been found that if a thinner substrate of the same material is tested, the PIM performance will degrade slightly. This is likely due to the fact that a thinner 50-Ω microstrip transmission-line circuit will contain a narrow conductor with a resulting higher power density.

Power levels have been found to be critical to PIM testing: At low power levels, it is relatively easy to achieve good PIM levels for almost any circuit material under test. The results collected for Figure 3 were based on test-signal levels of +43 dBm at approximately 1900 MHz, which is considered a high power level for PIM testing. To illustrate this relationship of material thickness and test power level, the data of Table 3 were collected for three different thicknesses of the same circuit material. Since this is not considered an antenna-grade material and exhibits somewhat high levels of PIM, the dependency of average PIM level on test signal level and material thickness is apparent, with higher test levels resulting in poorer PIM performance.

It can also be seen from Table 3 that the PIM performance degrades as the substrate material grows thinner, with the best PIM performance (-145 dBc) measured with the highest test power (20 W) for the thickest (152-mm-thick) substrate material. Of course, remembering the PIM test tolerance of ±6 dBc, the values shown in Table 3 should be considered as trends rather than as precise values, although even as trends, the connections can be made between measured PIM, material thickness, and test power.

The growth of wireless services and devices appears relentless, especially with projections of billions of wireless devices connected to the Internet by means of Internet of Things (IoT) technology and an explosion of wireless networks and wireless devices to be produced as part of the coming Fifth Generation (5G) of cellular communications. As the number of wireless devices growths, the need to control and minimize PIM also grows and, for PCB antennas, the choice of circuit material can play a large role in keeping PIM in check.

Chip scale atomic clock
delivers low power holdover

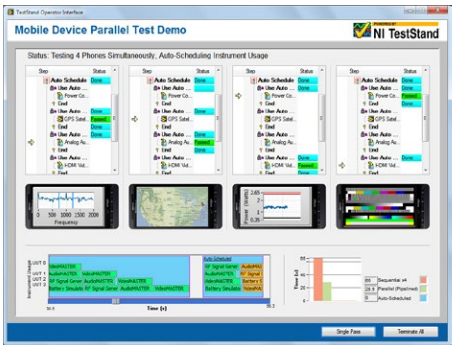
Microsemi Corporation has launched its new thermally improved Chip Scale Atomic Clock (CSAC) products with full operating and storage temperature. The devices offer the lowest power holdover atomic clock technology without compromising size, weight and power (SWaP) while operating at a wide temperature range.

With an operating temperature range of -10 to 70 degrees Celsius, these CSAC components are highly reliable, with improved product design, process enhancements and robust product verification/validation. The revolutionary technology enables new applications and missions not possible in the past with traditional OCXO and Rubidium clocks, claiming to offer the lowest SWaP clock technology in the industry at 17 cubic centimeters (cc) in size, 35g of weight and only 120 mW of power.

The CSAC product offers ±5.0E-11 accuracy at shipment and a typical ≤9.0E-10/month aging rate, which makes it suitable for many low power atomic clock holdover applications.

www.microsemi.com

Test management software
boosts productivity



TestStand 2016 from NI is the latest version of its industry-leading test management software, which focuses on helping the more than 10,000 current users to further increase their productivity while also helping to ensure the initial success of new developers.

TestStand 2016 continues to deliver features that drive faster development, deployment and maintenance of automated test systems through: a redesigned Property Loader for importing/exporting test sequence variables, limits, properties and more; additional right-click options and a native enumeration data type to help increase productivity when developing and modifying test sequences in the TestStand Sequence Editor; and simultaneous execution and development of multiple independent applications through TestStand Environments.

When compared to the development and maintenance costs inherent in building an in-house test executive, commercial off-the-shelf test management software can help users drastically shorten overall time to market. Developers can take advantage of out-of-the-box functionality for common tasks like sequencing, parallel test execution, report generation, database logging, operator interfaces and system deployment, and customize each functionality per their requirements.

www.ni.com/teststand/demos

GaN HEMT
completes C-band radar lineup

Wolfspeed, A Cree Company, has announced their complete lineup of high efficiency, high gain, and wide bandwidth C-band radar parts with the introduction of the latest CGHV59070 GaN HEMT for C-band radar systems.

Designed to operate at 4.5 to 5.9 GHz from a 50 V rail, the new 70-W GaN HEMT is an ideal driver for the highest power C-band radar device on the market – the 350-W CGHV59350 GaN HEMT for 5.2 to 5.9 GHz operation, which was released in

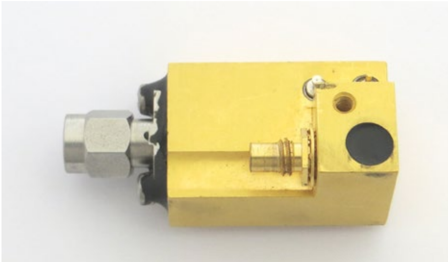
May of last year. Delivering 90 W typical POUT at 50 V, in addition to 55% drain efficiency at high 14 dB power gain, the internally matched CGHV59070 offers a general purpose broadband solution for a variety of RF and microwave applications, and is especially ideal for use in linear and compressed amplifier circuits in marine radar, weather monitoring, air and maritime vessel traffic control, and port security applications.

www.wolfspeed.com

RF and microwave detectors and limiters

RLC offers a broad range of RF and microwave detectors and limiters, including detectors with built-in limiters to protect the diode from potential damaging signals.

The company manufactures tunnel, zero bias, biased schottky, pulse present, threshold, and waveguide type detectors up to 50 GHz. These devices are available in connectorized, surface mount and



drop-in packages. Key features include flat frequency response and high sensitivity, fast rise and fall times, quick recovery time, and low noise.

www.rlcelectronics.com

Chipset covers all major PMR systems

CML Microcircuits has further enhanced The Function Image™ suite of the CMX7241/CMX7341 PMR common platform processors from CML Microcircuits now support all major PMR systems, including DMR, dPMR, NXDN, ARIB STD-T102, ARIB STD-T98 and legacy Analogue PMR, all with automatic digital/analogue detection.

These common platform processors enable a radio manufacturers to build a single platform radio that supports many different PMR standards.

With an embedded audio codec (ADC/DAC) the devices provide a complete baseband implementation with a flexible interface to support both software and hardware implementations of the AMBE+2 Vocoder. A high level of advanced functionality is included that minimises both host interactions and host real-time control constraints. The CMX7241/CMX7341 PMR common platform processors can deliver FDMA digital PMR/LMR, 2-slot TDMA digital PMR/LMR and legacy analogue PMR/LMR. Based on the company's FirmASIC® component technology, a Function Image™ is uploaded into the device to determine the overall functions and operating characteristics.

The PMR chipset comprises a low power RF direct conversion receiver (DCRx) IC (CMX994A/E) and a PMR common platform processor (CMX7341) with DMR/dPMR/NXDN/ARIB STD-T102/ARIB STD-T98 air interface coding and analogue PMR embedded within Function Images.

www.cmlmicro.com

ANT protocol stacks v2.0.0

The latest production revisions of the ANT protocol stacks are now available for licensing and download.

The latest 2.0 versions of the S212 ANT SoftDevice and the S332 ANT/BLE SoftDevice are compatible with the production release of the Nordic NRF5 SDK v12.0.0 and can be used with the Nordic nRF52 Development Kit (PCA10040) and the Dynastream D52 Starter Kit.

The revision 2.0 stacks include numerous functional enhancements for the SoftDevice and protocol stacks. New ANT protocol features include High Duty Search, Time Sync, Scalable Channels and support for PA/LNA control. For BLE, support for longer MTU, data packet length extension, Privacy 1.2 and LL Ping have been added.

www.thisisant.com

Dielectric resonator oscillators

boast leading frequency stability

Link Microtek offers an extensive range of mechanically tunable dielectric resonator oscillators (DROs) that offer excellent frequency stability when subjected to variations in temperature or VSWR.

Manufactured by L-3 Narda-MITEQ, the DRO-ST series are ruggedly constructed using thin-film hybrid microcircuit technology and are designed for operation under

severe environmental stress in applications such as military satellite-communications systems.

These free-running oscillators achieve superior stability through their impressively low temperature coefficient of frequency drift – 5ppm/°C maximum – and a frequency pulling factor of less than 5 MHz peak-to-peak for a 1.5:1 VSWR varying through all phases.

Available with a choice of 13 operating frequency bands spanning 2.4 to 40 GHz, the devices deliver a minimum microwave output power of +13 dBm up to 16 GHz and +11 dBm between 16 and 40 GHz. The DROs exhibit low microphonics (noise caused by mechanical vibrations) and excellent phase noise performance, typically ranging from 105 dBc/Hz at 2.4 GHz to 70 dBc/Hz at 40 GHz for a 10 kHz frequency offset.

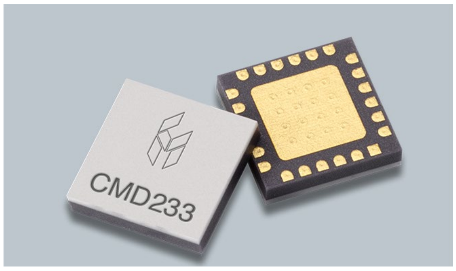
All RF connectors are female SMA types and, depending on the frequency band, package sizes range from 36.83- x 26.67- x 12.19-mm to 69.85- x 53.34- x 23.62-mm excluding connectors and tuning elements.

www.linkmicrotek.com

Distributed amplifier

covers 2-18 GHz in 4- x 4-mm QFN package

Custom MMIC has added a new amplifier to its Broadrange Distributed Amplifier™



portfolio, the CMD233C4. The 2-18 GHz distributed amplifier is a packaged version of the CMD233 die product.

The CMD233C4 is a wideband GaAs MMIC distributed amplifier with a low noise figure of 4.5 dB and output 1 dB compression point of +20.5 dBm. This amplifier delivers over 9 dB of gain and operates from a single 3- to 6-V supply.

The CMD233C4 is a replacement for the CMM4000, now in packaged form. The product is a 50 ohm matched design which eliminates the need for external DC blocks and RF port matching. Applications include military, space and communication systems.

www.custommmic.com

25-W bi-directional amplifier

covers 4.4 to 5.0 GHz

The TTRM1008 bi-directional amplifier from Triad RF Systems is rated at 25 W and covers the 4.4 to 5.0 GHz frequecy range. It is compatible with nearly all military and commercial radio systems operating in the 4400 to 5000 MHz band.

The bi-directional amplifier offers 25 W of peak power for signals such as QPSK/BPSK, but is also linear enough to provide 4- to 5-W of power with more highly modulated signals such as 64QAM.

www.triadrf.com

Versatile LXI digitizers

provide fully synchronous multi-channel acquisition

Spectrum has expanded its popular LXI-based digitizerNETBOX series by releasing eight new DN6.49x instruments offering from 24 to 48 fully synchronized channels, ehich are suitable for applications where a large number of signals need to be acquired and analyzed with speed and precision, such as with sensors, detectors, rectifiers, antennas and other electronic devices.

Each channel of a DN6.49x series digitizer is equipped with a high precision 16 bit analog-to-digital converter (ADC) and a versatile front-end amplifier that features six input ranges from ±200 mV up to ±10 V, switchable input impedance (50 Ω and 1 MΩ) and programmable offset. Users can choose between models that offer maximum sampling rates of 10 or 60 MSamples/s with on-board acquisition memory of either 64 MSamples (128 MB) or 128 MSamples (256 MB) per channel.

For maximum measurement versatility, the input channels can be single ended or differential, delivering from 12 to 24 true differential inputs. All the ADCs are clocked synchronously to ensure signal timing and inter-channel phase relationships are always preserved. The flexible front-end and clocking systems are complemented by advanced trigger circuitry to capture the widest range of input signals. For example, each individual trigger input can be combined with others to create conditional pattern triggers with standard AND/OR logic.

The DN6.49x series also delivers exceptional accuracy and precision. The 16 bit ADCs typically offer much better resolution than other measuring systems, such as scopes or analyzers, and optimized digitizer performance allows the finest signal details to be detected.

Acquisition modes include single shot (Transient Recording), streaming (FIFO), segmented (Multiple Recording), gated (Gated Sampling) or a combination of segmented and slow chart recorder operation (ABA mode). Timing between events is possible, thanks to a built-in trigger time stamping function.

www.spectrum-instrumentation.com

High performance analyzer

covers LTE-U in tiny form factor

The ultraportable Site Master™ S331P from Anritsu Company is the lightest, smallest, fastest and most cost-efficient Site Master field cable and antenna analyzer ever developed.

Addressing the market need for broad frequency coverage and high performance in an extremely compact and economical design, the S331P provides wireless operators and contractors, DAS installers, and public safety network installers and maintenance professionals with the first pocket-sized headless cable and antenna analyzer that can measure the new LTE-U frequencies.

Two models covering 150 kHz to 4 GHz and 150 kHz to 6 GHz are available. This unique wide bandwidth capability enables the S331P to support low frequency radio communications environments, including public safety networks, as well as higher frequency applications, such as LTE-U in the 5 GHz unlicensed spectrum. With a sweep speed of 500 μs/data point, the S331P is the fastest Site Master on the market, for more efficient testing.

Leveraging the same user interface as the industry leading Site Master S331L, the ultraportable S331P offers field technicians and engineers easy operation, even in the most challenging field environments.

Optimized for field use, the S331P comes standard with an N(m) connector for easy direct connection to N(f) devices, eliminating the need for phase stable cables.

www.anritsu.com

LTE Cat M1 module

targets IoT applications

Swiss company, u-blox plans to launch modules supporting Category M1 (Cat M1) LTE networks, which will allow a larger number of devices to connect to the Internet of Things (IoT).

The first SARA-R4 module developed by u-blox will be available in Q4 2016 targeting mobile network operators in the US market. With the recently launched SARA-N2, which claims to be the first cellular NB-IoT module, the latest LTE Cat M1 complements the company's extensive product offering for the IoT.

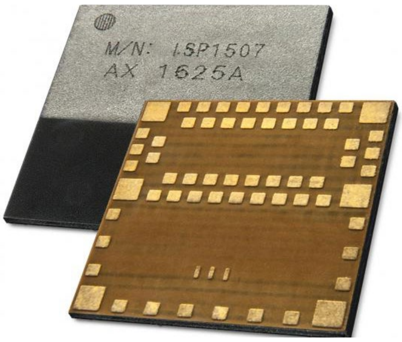
Along with NB-IoT, LTE Cat M1 is part of the new 3GPP Release 13 standard supporting low power wide area (LPWA) technologies in the licensed spectrum and is designed for IoT applications with low to medium data throughput rates, as well as devices that require long battery lifetimes. Additionally, M1's vehicular handover capability delivers the technology necessary to support vehicle, asset and people tracking. It also supports lower latency applications and a data rate of 375 kbps in half duplex mode and 1 mbps in full duplex mode.

www.u-blox.com

Bluetooth LE module

tiny, long battery lifetime

Building on the success of its ISP1300 series modules, Insight SIP is releasing the ISP1507 to offer customers the next generation in Bluetooth Low Energy Technology in a 8- x 8- x 1-mm System-in-Package.



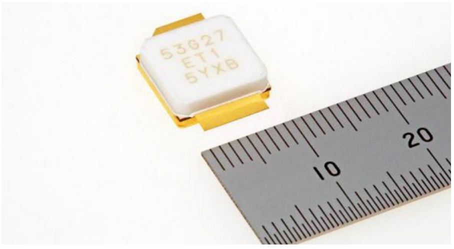
The module integrates the nRF52832 chip from Nordic Semiconductor (running Bluetooth 4.2), offering a 32-bit ARM Cortex M4 CPU, 512kB of flash memory, analogue and digital peripherals SPI, I 2C and GPIO. Combined with its integrated 32 MHz and 32 kHz crystal, RF antenna and matching circuit, this module forms a fully featured standalone Bluetooth Low Energy node.

It draws 5.5 mA typical for transmission and reception, 1.5 µA in standby mode and 0.7 µA in deep sleep mode, ensuring best in class performance with a long battery lifetime. Transmission output power reaches +4 dBm and reception sensitivity is -96 dBm.

www.insightsip.com

GaN-HEMT

suitable for 2.6 GHz-band 4G base stations



Mitsubishi Electric has developed a 220-W-output power Gallium Nitride High Electron Mobility Transistor (GaN-HEMT) offering a high drain efficiency of 74% for 2.6 GHz-band base transceiver stations of 4G mobile communication systems.

Sampling will start in November. Several part numbers are available to cater for the power needs of macro-cells and small cells. The high efficiency will result in simpler cooling system, which reduces BTS size and power consumption, notes the company.

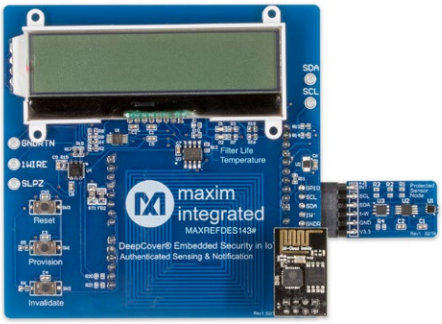
www.MitsubishiElectric.com

IoT reference design

speeds development of authenticated data chains

Addressing the many issues related to system security in Industrial Internet of Things (IIoT) installations, the MAXREFDES143# embedded security reference design from Maxim Integrated Products provides protection against counterfeit sensor data, guaranteeing its authenticity and integrity along the entire data chain, from transducer to the cloud.

The reference design's sophisticated architecture and components, Arduino-compatible hardware interface, and ARM mbed libraries support simplifies development of secure, uncorrupted, and authenticated sensor-to-web data. It is ideal for analog sensor node and data authentication in factory automation and industrial processing applications.



The reference design's two-stage hierarchical architecture consists of a shield that communicates to a web server, and a protected sensor node for data acquisition and authentication. The shield includes a Wi-Fi module; a DS2465 secure coprocessor for offloading SHA-256 cryptographic computation; 1-Wire® and I2C interfaces; user-interface LCD, LEDs, and pushbuttons; as well as alarm and logging functions. The sensor node contains a DS28E15 secure authenticator, DS7505 temperature sensor, and MAX44009 light sensor.

The reference design delivers fast time-to-market, significantly reducing development time using the provided hardware and source code to implement an authenticated node solution and web server interface.

www.maximintegrated.com

Ku-band power amplifier

with optional internal L-band BUC

Tango Wave has introduced an ultra-compact, 400-W peak, Ku-band TWT-design outdoor power amplifier, with optional internal L-Band BUC, at the IBC 2016 conference and exhibition.

The Model PA17-Ku400P is a traveling wave tube (TWT) power amplifier that will deliver 180-W of linear power over the 12.75 to 14.5 GHz band and offers small size and weight with less power consumption than existing amplifier products. The optional L-Band block up-converter (BUC) is an internal design that does not add to the size of the amplifier.

According to Travis Stewart, Vice President Engineering, "Satellite News Gathering (SNG) operators are looking for uplink amplifiers with lower power consumption, smaller size, less weight and more linear power. Efficiency is the driving factor in the size, weight and power (SWaP) performance of our new SATCOM uplink amplifier."

www.tango-wave.com