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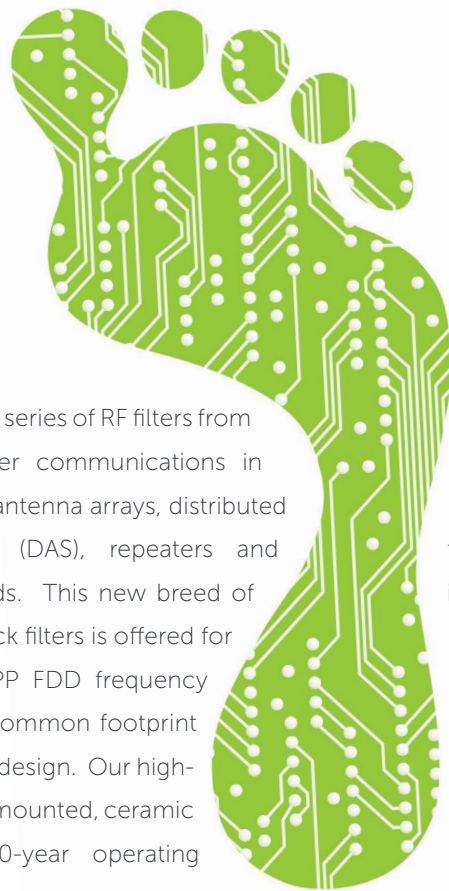
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Shown: the USD004 Duplexer

	UMD DUPLEXER For Metro Cell	USD DUPLEXER For Small Cell	UPD DUPLEXER For Pico Cell
Input Power Rating	20W Avg 200W Pk	6W Avg 60W Pk	1.5W Avg 15W Pk
Insertion Loss (5MHz AVG)	2.2dB	2.6dB	3.0dB
Rx Band Isolation*	80dB	72dB	63dB
Tx Band Isolation	74dB	66dB	57dB
Universal Footprint Size (mm)	62 x 44	63 x 18	44 x 18
Operating Temp Range	-40 to +85°C	-40 to +85°C	-40 to +85°C

* Note: "Difficult" bands may have 2dB lower worst case Rx band isolation.



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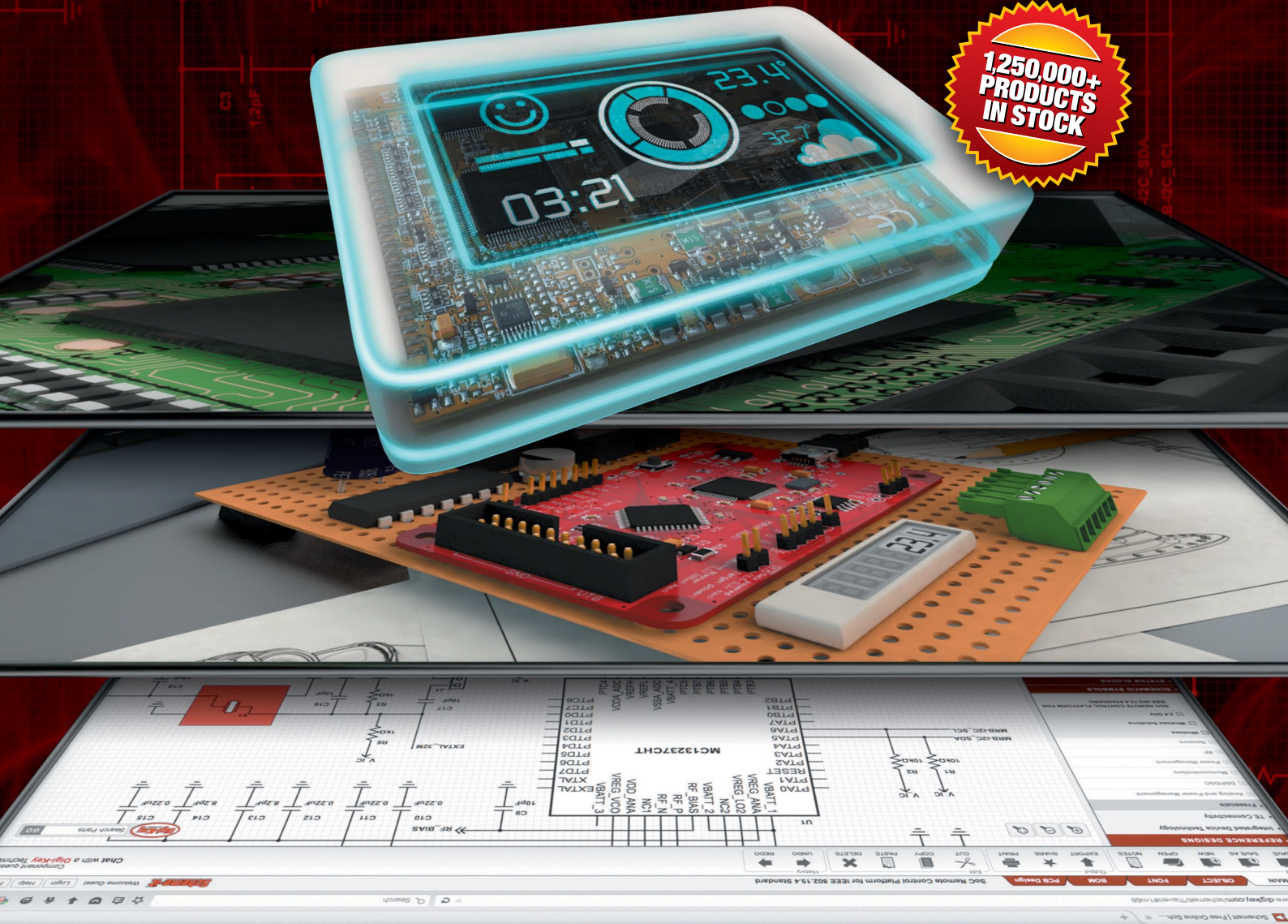


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5G will be as disruptive as the Industrial Revolution



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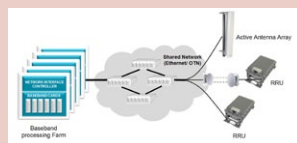
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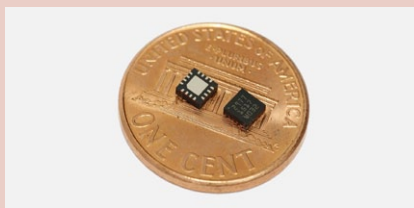
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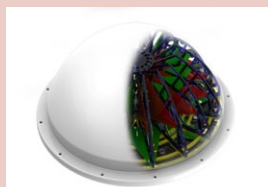
Velocity implies speed... and direction



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Low power WAN, WiFi and Bluetooth development module

3D DF antenna



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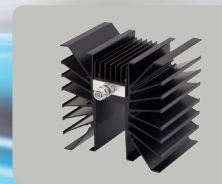
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5G will be as disruptive as the Industrial Revolution

5G is not here, but the LTE and the emerging IoT landscape are early indicators of what is to come should 5G realise its full potential. It is obvious that the mobile revolution has already changed the world dramatically, evidenced by the fact that most people cannot live without a mobile phone.

However, this is just the beginning. 5G looks like it will be a combination of many protocols, modulation schemes and air interfaces all run through a Software Defined Network (SDN) implementing separate Data and Control Planes. Such a network could be configured on the fly with minimum set up times while using scalable inexpensive hardware akin to data centres.

The promise here is that finally everything will be able to be connected across the world. There will be opportunities and massive disruption. The way cities and healthcare are run are already prime candidates for change. 5G will unify disparate technologies such as AI, robotics, logistics (drones), medicine, IoT, automation, data.... Companies will in effect be digitised.

Pierre Nanterme, CEO of Accenture, in an article for the World Economic Forum contends that digital is the main reason that just over half of the companies on the Fortune 500 have disappeared since the year 2000.

Connecting everything is a challenge but satellites and LTE have been used to bring broadband to rural areas. In this context drones are seen as the future of bringing wireless to everyone. The Guardian recently reported that Google is testing solar-powered drones at Spaceport America in New Mexico to explore ways to deliver wireless high-speed internet potentially 40 times faster than 4G, in a secret project codenamed Skybender.

In terms of technology, 5G has many challenges to overcome, but as we have seen with 5G and LTE, these can be potentially overcome fairly quickly. Even though 5G is at least 4 to 5 years out research into areas such as Massive MIMO and millimetre wave have progressed rapidly.

NYU WIRELESS has just announced it will build an advanced programmable platform to rapidly design, prototype,

and validate technologies vital for the millimeter wave radio spectrum, which is potentially key to launching the next ultra-high-data-rate generation of wireless communication, or 5G. This software defined radio (SDR) platform will integrate an electrically steerable phased array with no physically moving parts and near-instantaneous steering.

Equipment from NYU WIRELESS affiliate sponsor SiBEAM, a Lattice Semiconductor company, will provide the RF front end for this testbed another affiliate sponsor, National Instruments will provide a high

benefit enormously from smart systems that connect all the dots and give technicians precise control over resources and data.

Leading ICT policymakers at last years Global Forum hosted in Oulu, Finland, see the 5G revolution as the greatest positive upheaval in the field since the creation of the GSM standard in the early 1990s.

"Possible business areas and models to benefit from 5G networks can range from health care and security to retail and manufacturing, and everything in between. Fast 5G networks can

become a powerful enabler for businesses, but only if the regulators allow the frequencies to be used without prohibitively steep license fees", said Matti Pennanen, Mayor of Oulu.

At the eve of the Global Forum, Professor Matti Latva-aho of University of Oulu commented, "Regulators are soon set to face an unavoidable moment of truth. Will they have enough courage to make radical choices in allocating and licensing radio frequencies to push

positive development? The US has already taken the first decisive steps in this direction — will Europe be left behind?"

One question in all this is where the IoT fit in with respect to 5G. Low-Power Wide Area Networks (LPWAN) such as those developed by Sigfox and LoRa have taken on a momentum of their own. Even though technology such as LTE for machine-to-machine communications (LTE-M) or Narrow-Band LTE (NB-LTE) are set deploy in the near future Sigfox and LoRa are already there. However, the idea of minimising the number of networks required is attractive from cost point of view. Another key here is incorporating all this into an SDN, which will make it easier to add protocols and modulation schemes into the mix. Last year a Nokia Networks' blog asked the question: Is Sigfox/LoRa the new WiMAX?

By Jean-Pierre Joosting, Editor



bandwidth and massive baseband processing system to create millimeter wave prototypes capable of high data rates and very low latency.

Technology such as Massive MIMO will probably end up being absorbed into evolving 4G standards but I expect the transition to 5G will happen when millimeter wave becomes a part of the standardisation process.

However, 5G also depends heavily on regulators. While 5G is still seen as a positive force in changing the world, like all technology revolutions many will struggle to adapt to such changes that typically manifest themselves in deflationary periods and changes in the types of jobs available. For example, will 5G by connecting everything make Globalisation a necessary component of any economy? Will this imply that wages across the globe will need to be more uniform?

On the positive side, renewable energy healthcare and cities could

Spirent acquires Epitiro for Wi-Fi experience monitoring

Spirent Communications has acquired Epitiro, a pioneer and leader in the Wi-Fi experience monitoring market. The acquisition builds on the success of a strategic partnership which has led to experience monitoring system deployments at multiple customers. Service providers and large enterprises increasingly rely on Wi-Fi to provide users with high-quality voice, video and data services and access to business-critical applications. Unfortunately, the complexity of Wi-Fi and its dynamic interaction with LTE and other mobile technologies often leaves providers and enterprises blind to the actual end user experience.

Epitiro's web-based platform provides continuous visibility of the end-user experience by proactively performing tests that emulate realistic user activities. Key metrics include availability of Wi-Fi connectivity, file transfer and web browsing speed, availability and performance of social media applications...

www.spirent.com

xG Technology to acquire Integrated Microwave Technologies

xG Technology, Inc., a leader in providing critical wireless communications for use in challenging operating environments has announced that it has entered into a binding letter of agreement to acquire the assets of Mt. Olive, NJ-based Integrated Microwave Technologies, LLC ("IMT") from Skyview Capital, LLC ("Skyview").

The \$3MM purchase price reflects a combination of cash and long-term debt. The purchase is expected to close by no later than February 15, 2016. IMT, which recorded annual revenues of \$7.2MM in 2015, is a leader in high-performance video transmission technology, and has 20 years of experience in the design and manufacture of state-of-the-art wireless digital and analog video products. Its primary market focus is in the following sectors: broadcast (with clients including, but not limited to, the major broadcast television networks, and NFL, MLB and NHL professional sports teams); and MAG (military, aerospace and government).

www.xgtechnology.com

CMOS wireless transceiver chip achieves 56 Gbps over 72 to 100 GHz

The Tokyo Institute of Technology and Fujitsu Laboratories have developed a CMOS wireless transceiver chip that can process signals at high speeds with little loss across a broad range of frequencies, from 72 to 100 GHz.

They also developed technology to modularize the transceiver and have succeeded in achieving wireless transmission speeds of 56 Gbps, claiming to be the fastest to date.

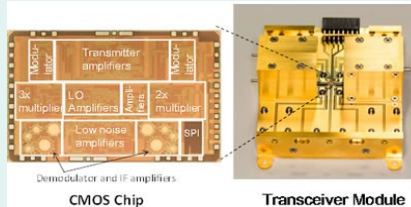
In recent years, to cope with the large increase in data traffic resulting from the widespread use of smartphones and other devices, networks that link base stations use optical fiber. One issue with this approach, however, is that it is difficult to expand service in areas where it is difficult to install a network of optical fiber cables, such as in urban areas or areas surrounded by rivers or mountains. To deal with this issue, Tokyo

Institute of Technology and Fujitsu Laboratories developed high-speed wireless transceiver technologies that use the millimeter-waveband (30-300 GHz), where there are few competing wireless applications, and which are capable of large-capacity communications.

This technology makes it possible to have high-capacity wireless communications equipment that can be installed outdoors in applications where fiber-optic networks would be difficult to lay.

The newly developed CMOS wireless transceiver chip and the wireless module that includes it (see Figure) are comprised of two key technologies: a low-loss, high-bandwidth transceiver circuit and modular technology in the form of a CMOS circuit. A special interface between the circuit board and waveguide has also been developed.

www.titech.ac.jp/english



Miniature wireless implants monitor brain injury before dissolving

Led by John A. Rogers, a professor of materials science and engineering at the University of Illinois at Urbana-Champaign, and Wilson Ray, a professor of neurological surgery at the Washington University School of Medicine in St. Louis, researchers have developed a new class of small, thin electronic sensors can monitor temperature and pressure within the skull then melt away when they are no longer needed, eliminating the need for additional surgery to remove the monitors and reducing the risk of infection and hemorrhage.

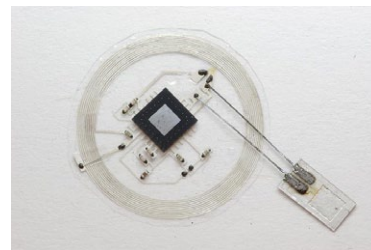
Similar sensors can be adapted for postoperative monitoring in other body systems as well. The sensors, smaller than a grain of rice, are built on extremely thin sheets of silicon — which are naturally biodegradable — that are configured to function normally for a few weeks, then dissolve away, completely and harmlessly, in the body's own fluids.

After a traumatic brain injury or brain surgery, it is crucial to monitor the patient for swelling and pressure on the brain. Current monitoring technology is bulky and invasive, Rogers said, and the wires restrict the patient's movement and hamper physical therapy as they recover. Because they require continuous, hard-

wired access into the head, such implants also carry the risk of allergic reactions, infection and hemorrhage, and even could exacerbate the inflammation they are meant to monitor.

The researchers have demonstrated these devices in animal models, with a measurement precision that's just as good as that of conventional devices. The researchers are moving toward human trials for this technology, as well as extending its functionality for other biomedical applications.

www.illinois.edu

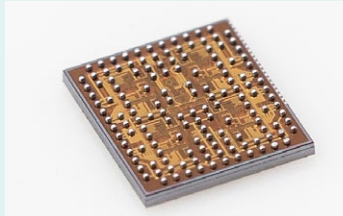


Low-cost, low-power chip for multi-gigabit 60 GHz communication

At the IEEE International Solid-State Circuits Conference (ISSCC2016), nanoelectronics research center imec and Vrije Universiteit Brussel (VUB) presented a four-antenna path beamforming transceiver for 60 GHz multi Gb/s communication in 28nm CMOS technology.

The transceiver is a breakthrough in developing a small, low-cost, and low power chip for multi-gigabit communication targeting WiGig® as well as 60 GHz wireless backhaul applications.

Due to the tremendous growth of mobile data traffic, display and audio applications, new spectral resources in the mm-wave frequency bands are needed to support user demand for high data rates. The 60 GHz transceiver architecture features direct conversion and analog baseband beamforming with four antennas. The architecture is inherently simple and is not affected by image



frequency interference. Moreover, a 24 GHz phase-locked loop that subharmonically locks a 60 GHz quadrature oscillator is inherently immune to the pulling disturbance of the 60 GHz power amplifier.

The prototype transceiver chip (7,9 mm²), implemented in 28nm CMOS, integrates a four-antenna array. The chip was validated with a IEEE 802.11ad standard wireless link of 1m. The transmitter consumes 670 mW and the receiver 431 mW at 0.9 V power supply. The transmitter-to-receiver EVM was better than -20 dB in all the four WiGig® frequency channels (58.32, 60.48, 62.64 and 64.8 GHz), with a transmitter equivalent isotropic radiated power (EIRP) of 24 dBm. This allows for QPSK as well as 16QAM modulations according to the IEEE 802.11ad standard, achieving very high data rates up to 4.62 Gbps.

www.imec.be

The Internet of the future is open source and programmable

Research described in a paper by the High Performance Networks (HPN) group in the University of Bristol's Department of Electrical and Electronic Engineering has found a scientific approach that enables future internet infrastructure to become completely open and programmable while carrying internet traffic at the speed of light.

The current internet infrastructure is not able to support independent development and innovation at physical and network layer functionalities, protocols, and services, while at the same time supporting the increasing bandwidth demands of changing and diverse applications.

The research addresses this problem with a new high performance network infrastructure that is open and programmable and uses light to carry internet traffic. It introduces new concepts of open source optical internet enabled by optical white box and software defined network technologies.

www.bristol.ac.uk

Lighter coaxial cables based on carbon nanotube nano-coating

The Rice University lab of Professor Matteo Pasquali has developed a nanotube-based coating that could replace the tin-coated copper braid that transmits the signal and shields the cable from electromagnetic interference. The metal braid is the heaviest component in modern coaxial data cables. Replacing the outer conductor with the new nanotube-based, flexible, high-performance coating would benefit airplanes and spacecraft, in which the weight and strength of data-carrying cables are significant factors in performance, potentially making common coaxial cables 50 percent lighter

Rice research scientist Francesca Mirri, lead author of the paper, made three versions of the new cable by varying the carbon-nanotube thickness of the coating. She found that the thickest, about 90 microns — approximately the width of the average human hair — met military-grade



standards for shielding and was also the most robust. It handled 10,000 bending cycles with no detrimental effect on the cable performance.

"Current coaxial cables have to use a thick metal braid to meet the mechanical requirements and appropriate conductance," Mirri said. "Our cable meets military standards, but we're able to supply the strength and flexibility without the bulk."

Coaxial cables consist of four elements: a conductive copper core, an electrically insulating polymer sheath, an outer conductor and a polymer jacket. The Rice lab replaced only the outer conductor by coating sheathed cores with a solution of carbon nanotubes in chlorosulfonic acid.

Compared with earlier attempts to use carbon nanotubes in cables, this method yields a more uniform conductor and has higher throughput, Pasquali said.

Public testbed to speed development of 5G

The NYU WIRELESS research center will build an advanced programmable platform to rapidly design, prototype, and validate technologies vital for the millimeter wave (mmWave) radio spectrum, which is key to launching 5G.

Funded by a National Science Foundation (NSF) program that supports exploratory work on potentially transformative research, the platform will be one of the first of its kind available to researchers from academia, government, and industry who are driving the early stages of mmWave technology.

Current mmWave prototyping systems use directional horn antennas mounted on mechanically rotatable gimbals. These mechanical systems are too large and slow for mobile applications. The new software-defined radio (SDR) platform will integrate an electrically steerable phased array with no physically moving parts and near-instantaneous steering. NYU WIRELESS affiliate sponsor SiBEAM, a Lattice Semiconductor company, and National Instruments (NI) will provide equipment

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Cloud RAN and Mobile Edge Computing – a dichotomy in the making

By Harpinder Singh Matharu, Xilinx Inc.

Over the past few years, wireless infrastructure deployment has increasingly moved to distributed base station architecture. This architecture centralizes the baseband processing pool, sometimes called super Macro, which is capable of feeding a larger number of radios and therefore is more effective for coverage and load balancing. The concept of Cloud RAN takes centralized base station pool all the way into the Cloud co-located with the content or data repositories in the data center. There are merits in Cloud RAN as it allows use of lower cost compute, leveraging off-the-shelf server chassis for cost effective RAN deployment, load balancing and significant ease in network provisioning. In parallel, Mobile Edge Computing, under the auspices of the ETSI Mobile Edge Computing Industry Standard Group (MEC ISG), is emerging with a concept of placing compute at the edge, co-located with the baseband pool, to maintain a local content cache to provide improved services to users. Caching content locally based on user preferences for lower latency and handling ephemeral data such as location based analytics needs edge computing. These two architecture concepts are proposing to deploy compute at different nodes within the network. On the surface, these two competing architectures appear to be creating opposite pulls, resulting in a dichotomy within the network. A deeper look suggests that a balanced approach to deploying networks could leverage merits of both, thereby transitioning these two competing technologies to complement each other for enabling new services.

More than a decade ago, the concept of distributed base stations emerged with a desire to overcome power loss in sending signals using coaxial cable from traditional base stations located at the foot of towers to antennas mounted on the top of tower. Radio heads were located remotely in close proximity to the antenna on tower top to eliminate power losses. Remote radio heads were connected to baseband BTS chassis using fiber.

Protocols such as the Common public radio protocol (CPRI) were devised to transport data and synchronize remote radios. In some situations when fiber was not available, microwave or millimeter wave radios were used to transport CPRI payload. This architectural shift raised hopes for operators to mix and match radio and baseband chassis from different system vendors to lower costs, improve supply chain, and ease inventory management. Interoperability concerns prevented this from happening, nevertheless it opened the way for tier-1 system vendors to leverage radios from smaller vendors for managing the rapid increase in a variety of radios for different geographies.

Distributed base station architecture has taken roots. This architecture is centralizing the baseband processing pool, sometimes called super Macro, which is capable of feeding a larger number of radios and therefore more effective coverage and load balancing. Success of data center and Cloud computing resulted in the emergence of Cloud RAN concept that extends distributed base station architecture by virtualizing base band pools running on server farms. There are merits in Cloud RAN as it allows use of lower cost compute, leveraging off-the-shelf server chassis for cost effective RAN deployment, load balancing and significant ease in network provisioning. Cloud RAN, when implemented broadly, holds

the promise of allowing third party providers to own the network, enabling multiple virtual network providers to concentrate on content and services.

Cloud RAN architecture is seeing some early acceptance in the Asia pacific region where operators have significant fiber assets to deploy remote radio heads. Carriers are investigating hosting layer 1-3 base station stacks and evolved packet cores on off-the-shelf servers as virtual machines. General purpose compute cannot implement the layer 1 baseband functions, packet processing, and security efficiently for high throughput and low latency. These functions would require servers to use specialized accelerator cards. The ability to host base stations as a set of software functions offers significant benefits. Carriers no longer need to build out network gear per peak capacity requirements. Instead, base stations can be instantiated in the Cloud on a need basis to provide the desired coverage and capacity. Cloud RAN allows base stations to be co-located in data centers where most of the content resides. This leads to higher efficiencies and effective dissemination of content.

There are few hurdles on the way to Cloud RAN that are slowing down adoption. Latency and low jitter long distance connectivity to remote radio heads is a big challenge. Off-the-shelf servers do not have compute resources

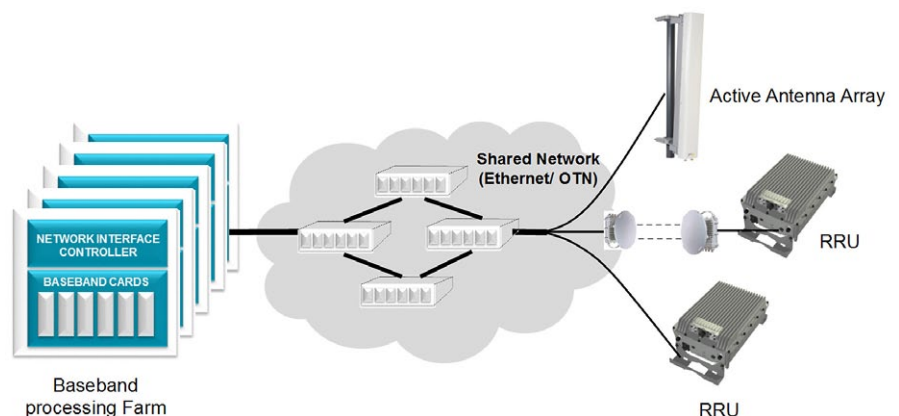


Figure 1: Cloud RAN network architecture.

to efficiently run baseband processing. Telco grade servers with accelerator cards for layer 1 baseband are needed to host pools of baseband processing running in virtualized environments. System vendors that are lagging in certain geographies are championing this cause to disrupt markets and gain market share, forcing incumbents to follow suite to secure their market share. Carriers are welcoming this trend with a desire to harmonize their Cloud computing assets with network infrastructure to ease deployment and maintenance.

Distributed base stations have their own unique benefits in terms of caching content as per local users' preferences for improving service delivery and processing data close to the source for latency sensitive applications. Proximity to users at the edge results in ultra-low latency access that opens opportunities to deploy customized services. MEC envisages convergence of IT and communication segments at the network edge to enable new services and business segments. Location services, Internet-of-Things (IoT), video analytics, augmented reality, local content distribution, and data caching are some of the use cases identified by MEC. MEC architecture proposes adding servers to macro and super macro base station sites for local compute and storage to enable new applications. Application development stack, tools, and framework are in the making to allow ecosystems to launch new applications and integrate services for multiple business verticals. Key hurdles in the path of MEC are cost in terms of space rental for adding server and storage to base stations, maintenance, and charging policies. Currently, policy charging and rules function is part of the core network controlled by carrier. A derivative PCRF function would need to be hosted locally at the base station to allow carriers and other content providers to fairly charge end users for services.

5G proposals for the information society of 2020 are adding further twists to the dilemma imposed by the architecture pull between Cloud RAN and MEC. In order to meet projected data demands in 2020 with increasingly scarce and limited spectrum, 5G proposals are aiming to continue to improve spectral efficiencies using techniques such as Massive MIMO for both <6 GHz and >6 GHz spectrums. Massive MIMO systems use large number of antennas to create beams per user.

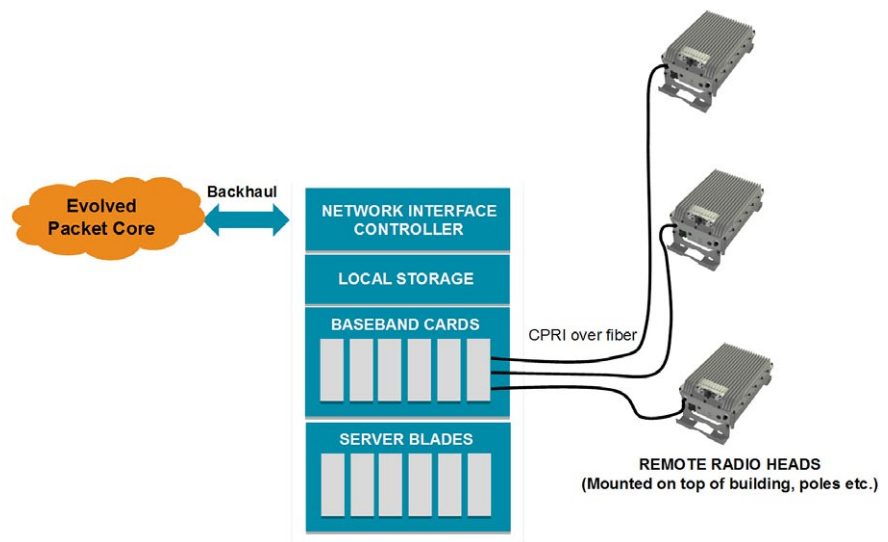


Figure 2: Conceptual Diagram of Mobile Edge Computing.

This allows significant improvement in energy efficiency and throughput. An additional benefit of massive MIMO is use of inexpensive lower power components for antenna signal chains. Massive MIMO techniques are well suited for millimeter and centimeter frequencies, an inexpensive and underutilized spectrum resource that is available in large contiguous chunks. Narrow pencil beams at these frequencies result in large antenna gains that compensate for high propagation. Along with these benefits come some hurdles. There is a significant increase in complexity in supporting a large number of active radio signal chains and layer 1 baseband with pre-coding for digital beamforming. Bandwidth requirements increase sharply between baseband processing signal chains and radios. In order to economically realize these systems, it is necessary to integrate layer 1 baseband signal processing with the radio. Such

a functional split in the future may lead to network nodes that may go back to traditional base station architecture where all L1-L3 and radio functions are co-located.

Mobile edge computing and massive MIMO techniques may imply consolidation of distributed base stations thereby hindering the move to Cloud RAN. In reality, limited spectrum necessitates leveraging merits of multiple different network architectures co-existing together to meet an ever increasing growth in demand for bandwidth. Cell densification enables reuse of a scarce spectrum resource. In coming years, this trend will result in distributed base station sites to become more like mini data centers. On the other hand, splitting Cloud RAN into numerous mini data center may be a way to overcome tight deterministic latency and synchronization requirements with remote radio head connectivity. The two

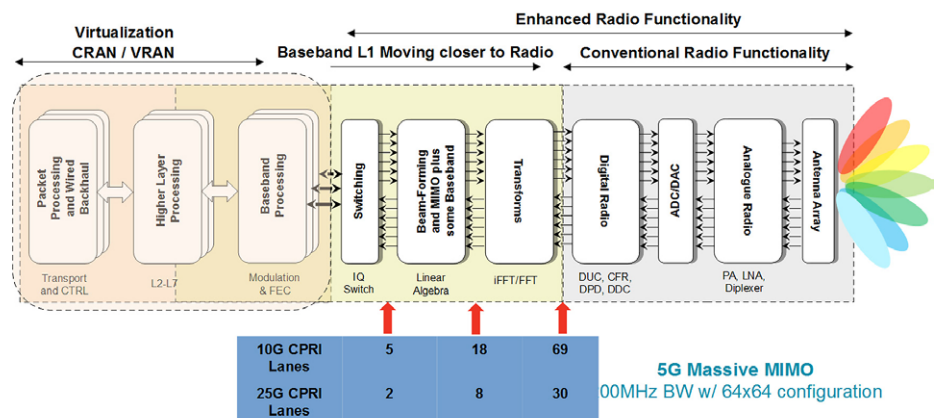


Figure 3: Millimeter Wave Massive MIMO (200 MHz 64x64 antenna array) System.

architectures may appear to converge in the middle. Cloud RAN and MEC architectures can coexist to complement each other. Cloud RAN can rely on latency and the proximity merits of edge computing nodes and edge computing can benefit from centralized network deployment, management, and service provisioning. Only time will tell how these two architectures would see adoption in the next 3-5 years as indus-

try gears up for 5G deployment. End user applications, operator preferences based on cost of network deployment and maintenance, and system solutions from equipment vendors may likely be key factors in dictating a delicate balance between the two.

In summary, heterogeneity in wireless network is expected to continue to increase. There is unlikely to be a clear winner. A good balance of Cloud

enabled RAN and mobile edge compute equipment is needed to effectively serve wireless broadband services. Instead of letting the hype pendulum swing to one extreme, the broadband wireless ecosystem needs to make balanced investments to continue to build complimentary technologies to effectively serve the information society of 2020.

Mobile Edge Computing core software points to 5G

Quortus has announced significant upgrades to its EdgeCentrix (ECX) technology, aligning its cellular core network systems with Mobile Edge Computing (MEC) principles.

The ETSI-endorsed MEC initiative enables innovative wireless services by moving intelligence to the network edge — a trend that Quortus has pioneered for several years.

The developments also move the Quortus Evolved Packet Core (EPC) to the split user/control plane and network slicing architectures that will be a key feature of 5G networks.

MEC architectures combine wireless technology with an IT-type service environment to deliver efficient communications services with ultra-low latency and high bandwidth. MEC software applications can tap into local content and information about network conditions so that traffic can be handled in an optimal way. Examples include local traffic offload and caching, and video optimization.

The company's ECX technology takes this principle a step further, by implementing core network functions themselves in software at the network edge. The combination of these two approaches will allow service providers to truly deliver on the promise of MEC. Services are provided where they are consumed — at the network edge.

"To date, the thinking around MEC has focused on the user plane — looking at the traffic in the network and making decisions on 'over the top' optimizations such as video encoding or caching," said Andy Odgers, Quortus CEO. "By also implementing network functions at the edge we open up even more powerful possibilities. We can use the capabilities of the network itself to create new services and optimize the user experience. At the



same time we retain the robustness, security and control that's expected by both mobile network operators, and their customers."

New versions of Quortus' ECX Enterprise and ECX Core, mark the first time a core network has been MEC-aligned, allowing for 5G evolution and enabling compatibility with a host of IoT and other applications. These innovations will be particularly powerful within the enterprise environment, where they will enable genuine integration between local IT resources and operator-provided cellular networks.

The latest Quortus technology will allow MNOs and systems integrators to build a variety of new service offerings. Potential applications include offering SMEs presence-based solutions, or 4G-based digital media services that work "out of the box" without the need for a local IT department. For larger organizations, MEC strategies will allow local data and voice offload with PBX and LAN integration. This is particularly useful in campus type or remote locations, where sending data back to the core network might introduce unacceptable latency or security risks. MEC has also aroused interest for IoT applications as diverse as building control and medical monitoring, which require devices such as sensors and actuators to be connected to local computing

resources, again without the need to touch the core network.

EPC CHANGES IN DETAIL

The updated ECX Enterprise and ECX Core systems announced split the control and user plane operations within the Serving Gateway (SGW) and Packet Data Network Gateway (PGW) network entities, key parts of the Quortus Evolved Packet Core (EPC). This allows user plane operations to be implemented locally within a MEC appliance, while control plane operations remain under the control of the mobile network operator (MNO), and can be located at the edge, in the cloud, or centrally.

The resulting architecture allows operators to offer tighter and local integration with Enterprise services while offloading burdensome local traffic from the core, and retaining control of subscriber data, authentication and bearer policies. Simultaneously, it addresses some of the shortcomings of pure user-plane MEC strategies: for example, the resulting system can page a 4G UE, set up a dedicated bearer for VoLTE calls, and gracefully satisfy legal intercept (LI) requirements.

The result is an operator-friendly, 5G-aligned system that supports the most advanced capabilities of cellular networks.

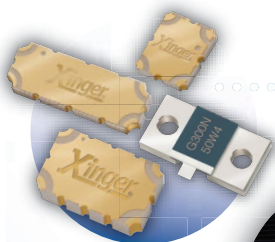
Quortus's ECX Enterprise is a software-based product that can run embedded on a small cell, on standard hardware (such as a router or local virtual machine), or on a hosted services platform owned by an MNO or other third party. Capable of operating standalone or with reach-back to an MNO network, it is the first system that fully supports voice over LTE (VoLTE) for enterprises.

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Design and evaluation of a 5-W X-band PA using a low-cost plastic-packaged GaN transistor

By Stuart Glynn, Tony Richards and Liam Devlin

This article describes the design of a single stage 5-W X-band GaN Power Amplifier using a low-cost SMT packaged transistor. The amplifier is optimized for the 9.3 - 9.5 GHz band: it has 11 dB small signal gain, and provides more than +37 dBm output power at 3 dB gain compression with a corresponding drain efficiency of greater than 55%. The design is based on a commercially available discrete 0.25 μ m GaN transistor, housed in an over-moulded SMT plastic package mounted on Rogers 4003 PCB. Fast drain switching circuitry is also included on the same PCB to facilitate pulsed operation with a turn-on time of just 20ns.

Gallium nitride (GaN) discrete transistors suitable for operation at microwave frequencies are now commercially available from a number of vendors. The higher breakdown voltage and maximum junction temperature of GaN transistors make them well suited to the realisation of high power amplifiers.

Most commercially available GaN transistors intended for X-band operation are offered as bare die or in ceramic packages. The use of low cost over-moulded SMT plastic packages for such discrete devices has the advantage of greatly simplifying handling and assembly as well as providing a significant reduction in product cost. There are obviously challenges in developing SMT packaged microwave power transistors: an assembly approach that avoids excessive RF performance degradation must be found; thermal performance must be adequate; the assembly must be very repeatable to provide consistent part to part performance; and accurate device models are required to account for the performance of the packaged part. Here it is demonstrated that excellent performance can be realized at X-band from such an SMT packaged part, in this case the TGF2977-SM from Qorvo, shown in Figure 1.

The TGF2977-SM is a 0.25 μ m GaN device of 1.26mm gate width, housed

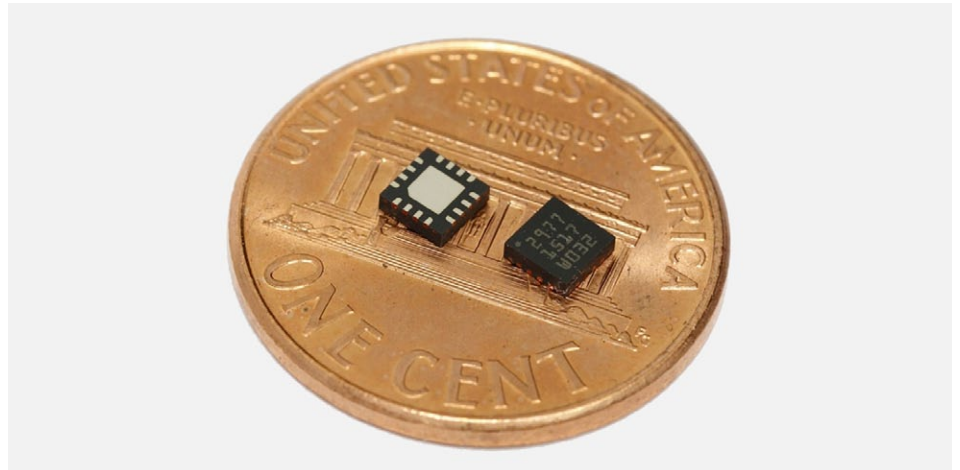


Figure 1: The Qorvo TGF2977-SM is a plastic-packaged 0.25 μ m GaN device measuring 3mm x 3mm.

in an over-moulded plastic package measuring just 3mm x 3mm. The package incorporates a solid copper base to ensure good thermal and electrical contact to the PCB ground.

DESIGN OF PA

The performance of the transistor, mounted on the chosen PCB material, was measured; drain bias was 32V with a quiescent bias current of just 25mA. The chosen PCB material was Rogers 4003, 0.008", with 1oz (25g) final metal-

ization, and copper-filled through-PCB vias were used for transistor grounding to provide improved thermal performance.

The measured maximum available gain of the transistor showed breakpoints occurring at 4.8 GHz and 12.5 GHz, indicating that the band of interest lies well within a region of unconditional stability and that a maximum gain of around 14 dB is available. The final amplifier gain will obviously be less than this, due both to real losses as-

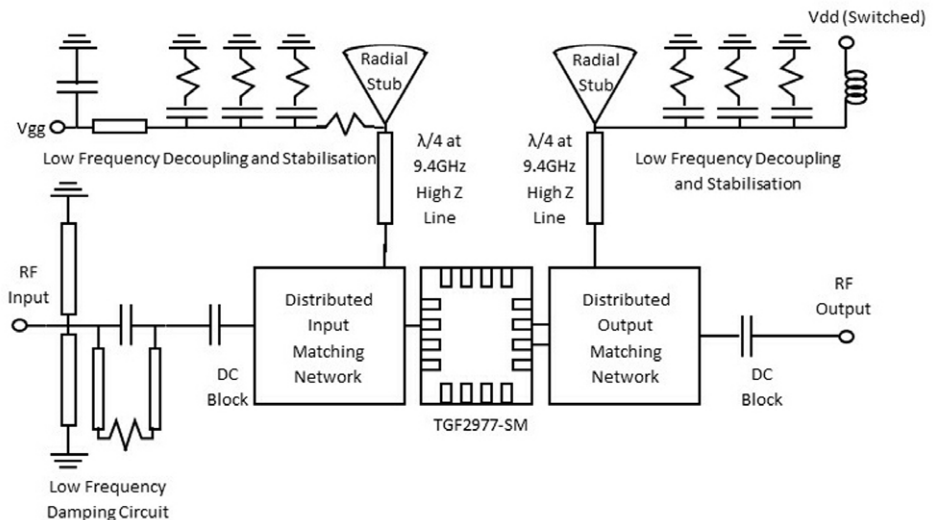


Figure 2: Amplifier schematic.

sociated with adding the matching and bias networks and to the fact that the amplifier output will be power-matched rather than matched in a conjugate fashion.

Although the device is unconditionally stable across the whole of X-band, at frequencies above 12.5 GHz and below 4.8 GHz it is potentially unstable, so steps must be taken to ensure stability in these regions. There is also a significant amount of low frequency gain and it is good design practice to suppress this to avoid potential low frequency stability issues in the final amplifier.

Large-signal load-pull data for the mounted device demonstrated that at 9.4 GHz the device is capable of delivering around 37.5 dBm output power at 3 dB compression. The target load impedance to present at the output reference plane was found to be $12.98\Omega - j9.39\Omega$, and the target source impedance to present at the input reference plane was found to be $11.64\Omega - j55.75\Omega$. The reference planes are set at the edges of the SMT pads required for attachment of the transistor to the PCB.

The amplifier schematic is shown in Figure 2 – all passive components are 0603. The bias networks for both the drain and gate make use of radial stubs which provide a short circuit at mid-band. This was the preferred means of implementing an RF short circuit as it offers better performance, tolerance and bandwidth compared to a shunt SMT capacitor. It also provides a convenient point at which other bias decoupling components can be added without affecting in-band performance. These components are used to provide lower frequency supply decoupling and stabilization, and significantly reduce the low frequency gain.

The short circuit provided by the radial stub is subsequently transformed to an open circuit by a narrow high-impedance quarter-wavelength line, such that the drain and gate bias networks have almost no effect in-band. This offers some flexibility in positioning the bias networks: convenient points in the distributed matching networks were chosen that were beneficial for both the layout and out of band performance.

A damping circuit was employed at the input to the amplifier, which was a further measure for ensuring low frequency stability and gain reduction. The circuit consists of two parallel short-circuited stubs in front of a parallel arrangement of a capacitor and a lossy inductor, formed by a resistor and two

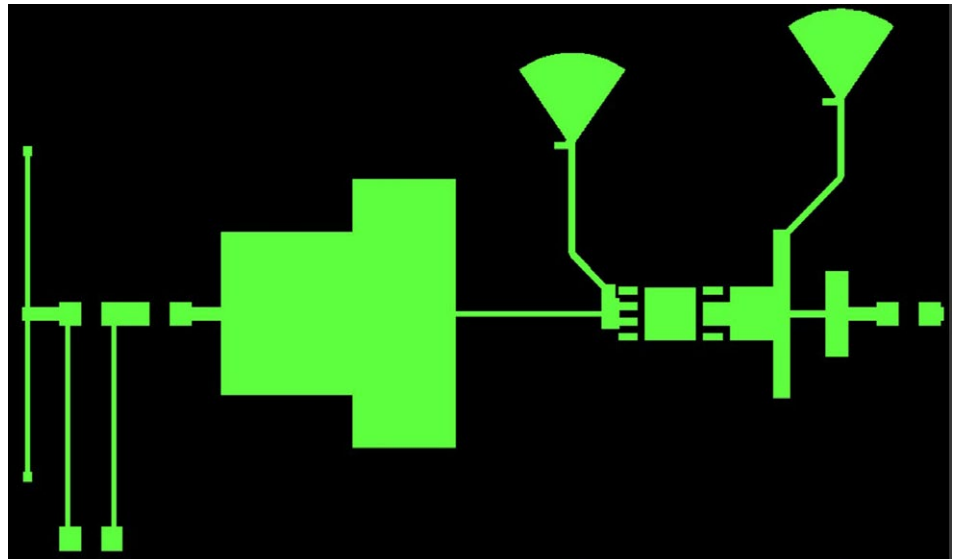


Figure 3: RF metal work layout.

narrow lines. The position and topology of the circuit was carefully chosen to provide maximum low-frequency rejection with minimum impact on in-band performance. An important feature of the topology is that it avoids presenting any undesirable impedance to the device which could lead to oscillation.

The DC blocking capacitor employed at both the input and output was a high quality 0603 multi-layer component. 2-port s-parameter simulations were carried out using a representative model which included the effects of the mounting pads on the chosen substrate. The value selected was the one which gave the lowest in-band insertion loss.

Input and output matching networks were implemented as distributed 2-section low pass structures. Moving backwards from the input reference plane, the input matching network is essentially: shunt C, series L, shunt C, series L. In a similar way, moving forwards from the output reference plane, the output matching network is essentially series L, shunt C, series L, shunt C. It is worth noting that an unbonded pin was conveniently used as an open-circuit stub to form part of the first input shunt C.

This in Figure 3, which shows the layout of the final RF metal work.

A photograph of the final assembled amplifier is shown in Figure 4. The 0.008" thick Rogers 4003 PCB is mounted onto an aluminium alloy T-carrier, which in turn is mounted onto a heat-sink. A fast drain switching circuit is provided on the same PCB. This area is coated in green solder resist which is omitted from the RF section.

An end plate mounts onto the rear face of the T-carrier through which bias and control is applied. The blue wire is for the gate bias, the red wire for the drain bias, the yellow wire enables the drain switching and the black wire is

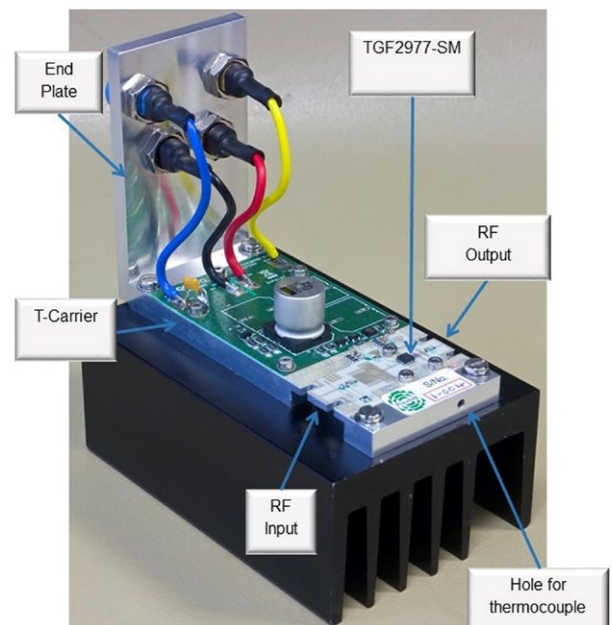


Figure 4: Final amplifier assembly.

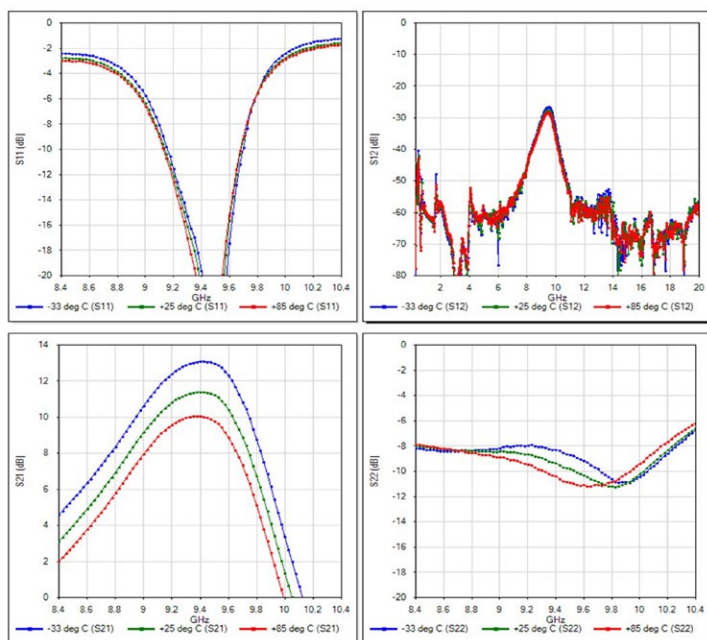


Figure 5: Amplifier s-parameter measurements.

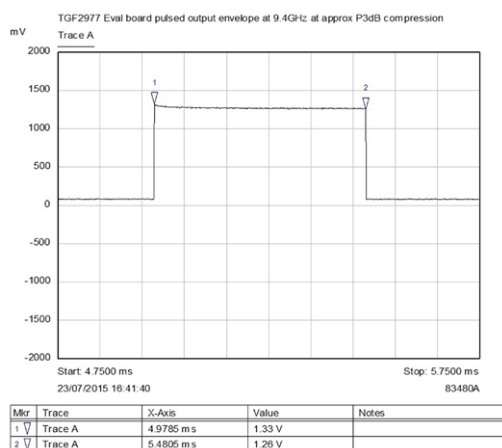


Figure 6: Pulsed power output envelope at 9.4 GHz and 3 dB compression.

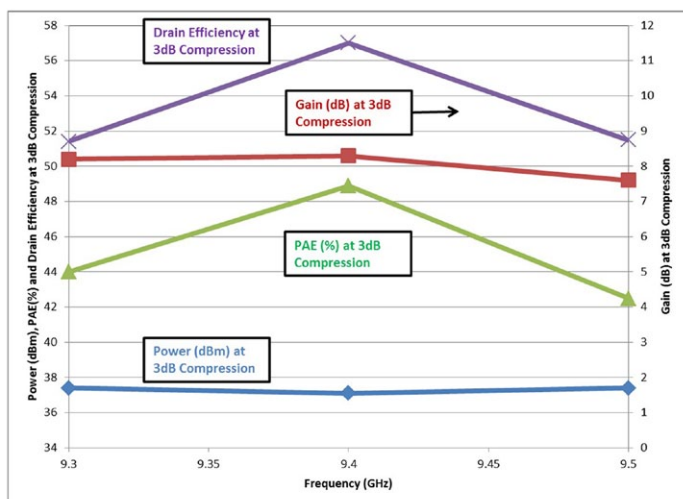


Figure 7: Summary of key performance metrics at 3 dB compression and 25°C.

0V. The RF input and output have been designed to mate with edge-mount South West Microwave connectors. Note the hole in the front face of the T-carrier – this is to allow a thermocouple to be placed underneath the packaged device. Thermal analysis determined that the thermal resistance between the thermocouple and the package (through the PCB) was 8°C/W, which allows the package temperature to be conveniently calculated for a given power dissipation.

MEASURED PERFORMANCE

Small signal s-parameter measurements were carried out on the fully assembled amplifier at package base temperatures of -33°C, 25°C and 85°C. These measurements were carried out under CW conditions, and the results are shown in Figure 5. The s-parameter data demonstrates that the final amplifier has a small signal gain of around 11 dB across the band, which varies by around ± 1.5 dB over temperature. The input return loss is hardly affected by temperature and is better than 15 dB across the band. The output return loss is nominally around 9.2 dB and varies by around ± 1 dB over temperature.

Large signal measurements were also carried out over temperature. These measurements were performed under pulsed conditions and utilized the on-board drain switching circuit, which provided a turn-on time of just 20ns. The duty cycle was 10% and the pulse width was 500μs. The RF envelope during the 500μs pulse is shown in Figure 6 for the amplifier running at 3 dB compression at mid-band. Clean, fast edges were evident, and there is very little power drop across the pulse period.

During the large signal measurements, the input power was swept from around 10 dB back-off, up to and slightly beyond, 3 dB gain compression. Over the power sweep, the dissipated power in the package increases so the package temperature increases. The gain under linear conditions reduced with temperature from 12.5 dB at low temperature (-33°C) down to 10.1 dB at high temperature (+85°C), with a 25°C nominal room temperature value of around 11.1 dB. The results were taken at mid-band. 3 dB gain compression occurred at an input power of 28 dBm at low temperature, 29 dBm at nominal temperature and 29.5 dBm at high temperature. A Pout versus Pin plot indicated that the mid-band output power at 3 dB compression is nominally 37.1 dBm, varying by just ± 0.2 dB over temperature.

Drain efficiency was also measured, showing that at 3 dB compression, the nominal drain efficiency is 57%, while at low temperature it is around 55% and at high temperature around 54%. Power added efficiency (PAE) at 3 dB compression was 48.5% at nominal temperature, around 48.5% at low temperature also and around 44% at high temperature.

The key performance metrics at 3 dB compression, at nominal temperature across the band of interest, are summarized in the plot in Figure 7.

SUMMARY

This article has demonstrated that excellent performance at X-band can be realized from a GaN transistor housed in an over-moulded SMT plastic package such as the TGF2977-SM from Qorvo. A single-stage power amplifier based on this device was designed for optimum performance in the range 9.3 - 9.5 GHz. At mid-band under nominal conditions, the amplifier has over 11 dB small signal gain, and provides over +37 dBm output power at 3 dB compression with a corresponding drain efficiency of 57%.

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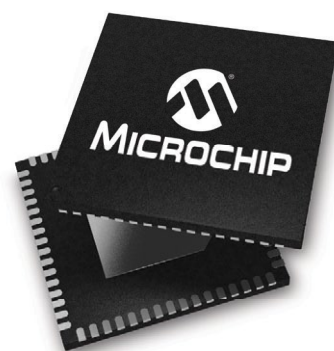
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Ready for launch – the importance of validating VoLTE

By Marko Falck, Senior Product Manager, Cobham Wireless

The deployment of Voice over LTE (VoLTE) has been hailed by many as a revolutionary voice technology for the mobile market. VoLTE, if implemented correctly, will dramatically improve subscriber satisfaction while bringing in a consistent and welcome revenue stream for mobile operators. At present, however, the failure of the industry to reach interoperability agreements is hampering the test processes at the core of successful deployments. Only by overcoming this inaction can operators ensure robust networks and the effective integration of widespread VoLTE services.

The demand for VoLTE is being driven by the rapid and widespread uptake of LTE services by mobile subscribers. As 4G networks proliferate and become capable of offering widespread communications, VoLTE has become the clear choice for next-generation voice services. While VoLTE has the potential to offer a new level of audio quality for consumers, it is rightly seen as one of the most difficult technical challenges mobile network operators will face during the next two years.

When you consider that subscribers demand consistency from their voice services more than any other mobile network service, the stakes for operators to deliver seamless and effective VoLTE communications could not be higher. VoLTE services must at least match legacy voice services in terms of quality and reliability to avoid subscriber churn. In fact, the technology should considerably exceed legacy 2G and 3G communications if operators are ever to portray VoLTE as a premium service – and realise the increased revenues that would result from this.

To guarantee their subscribers experience a superior service level, operators must test and validate VoLTE using complete application emulation, encompassing the full range of complexities within an intelligent modern network. This must include accurate prioritisation of traffic, given the range of high-bandwidth services being provided over the same data network, and the priority given by

users to voice communication. In addition to ensuring traffic is correctly prioritised, operators must adopt the correct authentication protocols alongside developing robust handover technology to switch back to legacy technology. This must be done using complete scenario testing and call volume and regularity tests.

The methods currently in place to measure the quality of calls made over voice networks are inadequate when it comes to validating VoLTE performance at a macro-network level. Current techniques involve monitoring real-world calls at wide intervals, but this does not allow for the identification of instantaneous network issues to enable them to be ad-

not thousands, of calls taking place in tandem in real-world conditions.

TEETHING PROBLEMS

A number of early adopters have already rolled out VoLTE to a number of their customers, who have discovered considerable issues when it comes to ensuring service and general network performance. Issues arising after the service launch can be extremely disruptive, lead to subscriber churn and potentially undermine the rollout (and therefore the investment) of the technology in the first place. It is imperative that operators validate these new voice networks before launch where possible, and that they do

so in the correct conditions for the subscribers that will be making use of the service.

One of the key problems for the effective rollout of VoLTE is that while LTE protocols have been well standardised, the IMS (IP Multimedia Subsystem) that defines VoLTE is still relatively new and, as such, is undefined by industry bodies and equipment manufacturers. This brings about considerable interoperability and standardisation issues and, while some providers have already

launched their own interpretations and configurations, these differ to those used and tested in labs. Failing to agree upon and enforce a consistent protocol will lead to consumer dissatisfaction, as they will not tolerate a lack of interoperability between what they will see as identical voice services. Beyond single vendors losing out on VoLTE, failure to agree on general industry-wide protocols could see the VoLTE launch timeline delayed as failed deployments deplete the appetite for further investment.

VoLTE deployment provides a wide range of issues which need to be addressed quickly and thoroughly to ensure the success of next-generation voice and the promised boost in usage and revenue. Interoperability will allow for consistent technology and consistent testing – without this the new technology is doomed to failure.



dressed effectively, nor does it give network managers a robust understanding of end-to-end call quality. To accurately identify why problems occur, providers need to investigate what else was happening on the network at the time of the problem which may have interrupted the packet flow and led to an unsatisfactory calling experience. The range of technical metrics requiring examination and the scale required is extensive, but crucial, to the successful deployment of VoLTE.

It's no surprise that two calls tested in isolation on the network would likely lead to excellent results, however it's scaling-up that causes problems, especially when taken into account with the other high-bandwidth traffic which may strain the network at the same time. The testing process must therefore account for this, and should encompass a testbed that can scale to emulate hundreds, if

Velocity implies speed... and direction

Laboratory testing is coming out of the woodwork and into the lime-light, driven by growing realisation that today's customer is king – and extremely flighty by kingly standards. It is nice to be valued, but it also increases pressure on processes that never were that simple but are rapidly growing more complex and suffering ever-greater time constraints. Can anything be done to integrate and automate test lab management and execution asks David Hill VP EMEA Spirent

In the dynamic, trendy environment of information technology and digital communications so much excitement initially focused on the brilliant inventive minds of the visionaries thinking up all this new stuff. Far less attention was drawn to the developers who had the relatively tedious task of getting it to work – let alone the testers who had to confirm that it really did work. Actually that was nice: you were left to get on with the job.

But success has its drawbacks, and these included raising customer expectations to dizzying heights. Also the communications revolution itself was making sure that, if anything failed to work one hundred per cent, everyone would know about it within minutes. According to Liz Herbert, Forrester Research VP and Principle Analyst: "We believe that this Age of the Customer is such a powerful shift that it is creating change – even in organisations that might not think of themselves as directly linked to the customer"

Testing could never again be an afterthought: it had to be integrated into the development process itself as part of a dynamic, on-going DevOps collaboration. This is the point where one would ideally take time to step back and re-think the whole business: time to re-structure and re-equip the test department, its procedures and management processes. But not only is the test department growing in size and complexity, there is also even greater time pressure as part of a larger dynamic and interactive DevOps team.

So many large organisations now have elaborately equipped test facilities and highly skilled teams scattered across the globe, together with a pressing need to make better use of these resources. We have indeed inherited a very wasteful culture: one where a single person taking a couple of hours a day to commute to and from work has to spend many thou-

sands of pounds on a car that will be gathering dust for the remaining twenty two hours.

One solution is catching on: it is equivalent to the virtualization process that has taken datacentres by storm. Today's high-speed connectivity is making it increasingly practical to consolidate all those separate test skills and equipment into one global test resource, and then subdivide the whole resource as needed into virtual test facilities. So, instead of having assets duplicated across every physical laboratory and lying idle for a lot of the time, these resources can be used far more efficiently by spinning them up when and only when some virtual test procedure across the globe needs them.

In the past this ability might have been seen as a great opportunity to downsize the test engineering facility and sell off redundant equipment but, in today's pressured 'Age of the Customer' business environment, it is seen rather as an opportunity to get better return on investment by squeezing a lot more testing out of existing facilities.

Virtualization of the test department has much to offer, but it is also yet another burden on management: one that demands new ways of thinking, planning and working. This is again the point where it would be nice to step back, take time to re-think the whole operation and come up with a fresh, integrated and efficient way to operate. But again, there is simply not enough time to step back once you have become a key player in a dynamic, on-going DevOps team. Instead, lab management & capital expenditure are getting out of control.

Our research and customer feedback identifies five main issues associated with poorly managed Labs:

1. Insufficient lab-utilisation metrics;
2. No unified interfaces for creating and re-creating network topologies;
3. Limited automation ability;
4. Inadequate control of user behaviours;
5. Delayed projects.

So, is there a solution?

TEST EQUIPMENT MOVING WITH THE TIMES

Pressure on test laboratories is not a brand new phenomenon. Ten years ago



there was already a market for more intelligent test equipment that would help to simplify test measurement and reporting and so make it easier to standardize tests across different teams and laboratories.

As test tools grew more sophisticated they could not only standardize tests but also add automation. In the last five years test automation has greatly reduced the manual labour of repeated testing and the risk of human error during boring repetitive tasks. Automation also allows tests to run unattended 24/7 for far more efficient use of resources and time. Major service providers, CSPs and virtual network operators rely on these developments to increase efficiency, ensure consistency and reliability – but the downside is that the more powerful and feature rich the equipment used, the more pressure there will be to ensure Return on Investment.

The test lab manager in such a large organisation might now be responsible for a half dozen satellite labs around the world employing several hundred test engineers using over ten thousand test assets. As the operation grows it becomes harder to ensure security, keep track of who is using what assets and which are currently available for use, and maintain consistent workflows between projects and sites. As a result test bed set-up takes longer and is more error prone, critical projects are delayed and secure projects may be compromised.

So the need now is not just for new improved test tools, but also for lab

Laboratory Testing

management solutions to orchestrate the whole operation. This includes resource management to avoid human or equipment bottlenecks as well as allocating resources efficiently by managing the queue for shared equipment. Consistency is ensured by the standardisation and sharing of test protocols assets and the use of approved equipment. Today's lab management solutions will be cloud-enabled to ensure consistency across multiple sites and to increase resilience against disaster or loss of compute power at any site.

There is no shortage of helpful lab management software available – even free software solutions. For someone already in control of the situation and with a clear management strategy, these tools will help to implement, accelerate and standardise lab management. But if the real problem is driven by increasing scale and change, who has time to re-think and design that clear management strategy? What might work well in a physical environment requires very different management in today's fluid virtual setting.

Velocity, my own company's solution to this problem, begins with one major advantage – integration. As test equipment providers we offer a management solution that is fully integrated with test case execution and so, from the very beginning, you get better visibility into

equipment use. As a cloud solution it offers access to a central repository of equipment, test cases and topologies to simplify the creation and sharing of assets for regression testing.

But that does not mean we are promoting a plug and play solution to the lab management crisis. There is still that fundamental need to step back and re-think what lab management means in an increasingly virtual environment, and that need is built into our thinking. The solution begins with collaboration from a support team comprising certified networking and test automation professionals with years of training and experience of testing and troubleshooting in a comprehensive range of industries and applications. That team offers itself as a trusted partner to help with the design as well as the implementation of a management solution. The team offers leadership throughout: including design, planning, implementation, adoption, training and project management – as well as solution architects – to deliver a complete test solution.

Of course no two organisations are identical or can be satisfied with off the peg solutions, and that is why the team explores your specific challenges as partners: addressing the role of all stakeholders as well as the tools needed for a comprehensive solution. For a man-

ager under so much stress to deliver, this encouragement to step back and re-think can be disconcerting. As one customer put it: "For the first week or so Spirent was doing 95% of the work, and some of the staff were wondering what we had taken on. A few weeks later we were doing 70% and in a month or two it all looked so straightforward that from then on we only needed a basic support contract for upgrades and reassurance".

As for time sacrificed to enable this process: that loss is more than made up for in the acceleration resulting from best practices: faster test development, test bed configuration, test execution and results analysis. This is the lasting legacy of an integrated lab management solution geared to meeting pre-defined goals in an optimal, efficient manner.

There is no doubt that test teams themselves are now facing testing times, the question is how best to respond. Do you continue to struggle under increasing pressure and become ever more involved in fire-fighting resulting errors and project delays? Or do you allow time to step back and re-align your test strategies for the future? It is much easier to make the second, bold decision when you know that there are people out there already possessing the necessary skills and experience to help.

CES is the largest selection of insecure devices

By Alan Grau, President, Icon Labs

The annual Consumer Electronics Show in Las Vegas has just wrapped up. With 160,000 attendees, 3,800 exhibitors and almost 2.5 million square feet of exhibit space, this is the largest electronics show in the world. The array of new products and technologies has been featured on virtually every media outlet from Good Morning America to Conan.

There is something for every interest on display, from self-driving cars and drones, to video games, virtual reality, and smart appliances. I saw products for exercise, infant care, elder care, food preparation and smart trash cans and toilets. It is really exciting to see the extremes of modern day technology. However, two important themes caught my attention.

First, everything is being connected. And by everything I really mean everything, whether it really needs it or not. Each of the products I mentioned pro-

vides connectivity, most of them using some type of wireless interface.

Second, everything is insecure. In this case, when I say everything, I again mean everything. It is a hacker's delight.

Some companies have started to build security into their products, and in the more security and safety critical areas, progress is being made. Despite this, very few vendors have made security a priority. What I find truly worrisome is that the majority of the new products have not adequately addressed even the most basic security requirements. From drones to vehicles to smart home appliances, very few products have implemented strong security. Many of these developers are in such a rush to get their products to market - and to connect them to the cloud or smartphones - that they simply ignore the need for security.

As a techie I enjoy CES. It's fun for me to check out all the new gadgets and

devices. I get excited about self-driving cars and intelligent baby monitors that can reduce the number of deaths due to Sudden Infant Death Syndrome (SIDS).

But as a security professional, I have very mixed feelings. Many of the silicon vendors have begun to recognize this challenge and are now starting to add hardware security modules to their platforms. These are the security building blocks that can be used to create new devices with much higher layers of security. But the overwhelming number of devices that have not yet adopted these solutions is, well, the reason I consider CES to be the largest collection of insecure devices in the world.

Alan Grau is the President and cofounder of Icon Labs, a leading provider of security solutions for embedded devices.

www.iconlabs.com

Low power WAN, WiFi and Bluetooth development module

Pycom, a start-up IoT module manufacturer, is launching its second project on Kickstarter – the LoPy, a WiFi, Bluetooth and LoRa (Low Power WAN) enabled



module supporting 10 x faster programming with MicroPython scripting. This latest Kickstarter project follows Pycom's successfully oversubscribed 2015 WiPy Kickstarter project.

LoPy's use of MicroPython's open source scripting language reduces micro-controller coding time, greatly decreasing the time to market for connected products. The number of applications for developers using the LoPy is endless and includes a long range messaging device for outdoor expeditions where the LoPy becomes the bridge between a smart-phone and the LoRa network providing network coverage where there's no GSM. Other uses include a pet/person/vehicle tracker with the LoPy and a GPS receiver and an agriculture sensor to monitor temperature, soil moisture and sun light on farm land and crops.

The LoPy is being developed following feedback from Pycom's WiPy Kickstarter backers where 60% expressed a preference for a new WiFi and Bluetooth module and 20% for a new WiFi and LoRa module. The LoPy has all three and doubles up as a LoRa Nano Gateway able to connect up to 100 other LoPys in a 5km radius.

www.pycom.io/Kickstarter2

Mobile edge computing system for harsh environments

ADLINK Technology, Inc., and Saguna have announced a joint Mobile Edge Computing (MEC) system designed for deployments in harsh outdoor environments.

As MEC gains momentum, and new trials and live deployments are underway,



the need for robust, no-fault equipment increases. Bringing the Internet closer to users and the things of the IoT requires MEC platforms to be deployed at the edge of the Radio Access Network (RAN), which is often in harsh outdoor environments.

The integrated system from Saguna and ADLINK addresses this market need for rugged, outdoor deployments.



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It is comprised of Saguna Open-RAN, an advanced and fully virtualized MEC platform, operating on ADLINK's rugged SETO-1000 extreme outdoor server platform designed for extreme conditions. The system is compact, cost-effective and easy-to-install. By co-locating the MEC infrastructure with existing network real estate, mobile operators can reduce costs while delivering new services and improving network performance.

www.adlinktech.com
www.saguna.net

6-GHz RF power amplifier module delivers 1-W COFDM

Triad RF Systems has introduced the Model TA1167, a compact GaAs RF power amplifier module that delivers over 5 W peak power from 6400 to 7200 MHz (other bands available) and is designed for wireless communications applications that require a boost in linear RF power.

The TA1167 incorporates circuits that produce over 1 W of linear COFDM power



when amplifying a +19 dBm signal. It has gain of 11 dB, return loss of -10 dB (2:1 VSWR), rise and fall times of less than 1 μ s, and accepts a maximum RF input of +27 dBm.

The amplifier is protected from high, low, and reverse DC bias, thermal overload, and high impedance mismatch, and will operate over a temperature range of -10 to +85 degrees Celsius and altitude up to 30,000 ft. The TA1167 uses SMA female connectors for the RF input/output and a 9-pin micro D-sub for the single +12 VDC supply that can range from +9 to +14 V.

www.triadrf.com

3D DF antenna

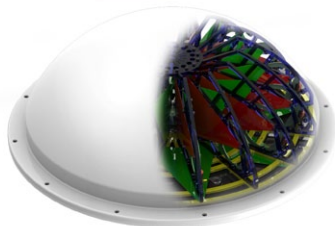
covers 9 kHz to 40 GHz

Available in different versions the IsoLOG 3D 360° DF antenna from Aaronia covers a frequency range of 9 kHz to 40 GHz.

The array consists of a total number from 16 to 40 directional antennas with horizontal and vertical polarization.

Additionally 8 to 16 special LF antennas can be added in order to cover a frequency range starting at 9 kHz. Overall, the antenna can be equipped with up to 64 independent antennas.

The IsoLOG 3D achieves a high sector-resolution of 22.5° without mechanical



rotation. The extremely fast tracking speed of up to 1 μ s is achieved by use of high-end digital switches, whereby a signal transmission is also possible with up to 100-W per antenna.

The antenna can be operated with any standard spectrum analyzer and is controllable in any software environment, thanks to the included SDK (Ethernet connection).

Thanks to the robust design, the antenna withstands high mechanical stresses (vibration, shock). A further highlight is the extreme useful temperature range of -40° to 60° Celsius.

www.aaronia.com

75 Ohm fixed attenuators cover in 1 to 20 dB

Model series 373-049-XXX are 75 Ohm fixed attenuators available in 1 to 20 dB attenuation values feature an operating frequency range of DC-1 GHz.

The attenuation accuracy is ± 0.3 dB maximum DC to 500 MHz and ± 0.6 dB maximum 500 MHz to 1 GHz. Maximum VSWR is 1.40:1, input power is 1-W average, RF connectors are TNC male and TNC female and the operating temperature range is -55°C to +100°C.

www.broadwavetech.com



Full suite of high-performance passive DAS products

Radio Frequency Systems (RFS) has enhanced its portfolio of passive RF components with an entire suite of new products – 90 in all – to provide a full range of products for all wireless in-building commercial and mission-critical communications requirements.

These latest products complement the company's comprehensive line of low loss RF feeder cables and jumpers for DAS and include passive DAS components such as couplers, power splitters, tappers and hybrid combiners.

The comprehensive, passive DAS product portfolio from RFS enables RF wideband, multi-band, multi-technology, and multi-operator support. It provides the ability for future systemic



shifts between operators or frequency bands to support any changes in macro network providers and/or technologies, including re-banding/re-farming of spectrum. All RFS components deliver high-quality and highly reliable in-building wireless systems for both commercial and mission-critical applications. RF cables combine flexibility and strength with low attenuation and high power ratings; non-cable components maintain overall system and PIM performance; and RF-over-fiber repeaters can be used to re-amplify signals across long distances.

All frequency bands are now covered including mission-critical (380-520MHz), commercial wireless (698-2700MHz), broadband and ultra-broadband (380-2700 MHz) in 2G, 3G, 4G LTE and TETRA. Mission-critical and commercial communications can be configured to function over one broadband network.

In addition to a broad offering of frequency bands, hybrid combiners and hybrid couplers from RFS can combine multiple signals within the same wireless band in a common cable. Directional couplers (5 dB, 6 dB, 7 dB, 8 dB, 10 dB, 15 dB, 20 dB and 30 dB) uniformly dis-

tribute RF signals for unequal splitting to compensate for cable loss at higher floors.

www.rfsworld.com

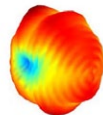
Flexible antennas

target positioning applications

Antenova Ltd has added two new positioning antennas, Bentoni and Asper, to its range of flexible FPC antennas.

Bentoni is a positioning antenna for all of the global public satellite constellations: GPS, GLONASS, Beidou and GALILEO. It is designed to be used in trackers, portable devices, network components, drones and wearable electronics. Asper is a dual antenna with two separate antenna systems in a single form factor. It combines a 1559 – 1609 MHz antenna with a 2.4 – 2.5 GHz antenna in the same part for positioning applications with wireless connectivity as well. This antenna is suitable for sports cameras, trackers, dash cams, portable devices, network devices and wearable electronics.

Both antennas offer high performance and maintain good isolation in situ within a device. Bentoni and Asper are the latest flexible FPC antennas in Antenova's flexiiANT product range. They are supplied with an I-PEX MHF connector and a 1.13 mm RF cable in a choice of three lengths. They can be folded to save space in operation within a device.



www.antenova-m2m.com

High power PIN diodes

for T/R switch and attenuator applications

Skyworks has introduced two high power, surface mount, series connected PIN diodes suitable for high-power, high-



volume, large signal switch and attenuator applications ranging from 10 MHz to beyond 6 GHz.

Typical resistance for the SMP1331-085LF and SMP1331-087LF is 0.50 Ω at 100 mA and the maximum capacitance is 0.35 pF at 30 V. The low capacitance, low parasitic inductance devices are ideal for use in land mobile radios and infrastructure systems. They come in a low profile, ultra-miniature quad-flat no-lead (QFN) 2 x 2 x 1 mm package.

www.skyworksinc.com

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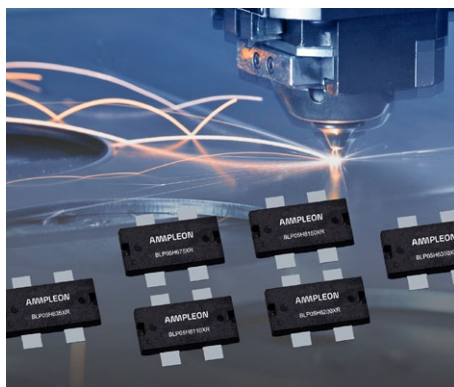
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Rugged LDMOS RF power transistors

in cost effective overmoulded packages

Ampleon has released a comprehensive portfolio of overmoulded plastic (OMP) RF power transistors using the well known, extremely rugged LDMOS technology.

Aimed at manufacturers of broadcast and ISM transmitters or generators, target markets for the BLP05H6xxxXR series transistors are FM/VHF radio and TV broadcasting, and industrial, scientific and medical RF power generators. Ranging in power from 35-W up to 700-W CW (continuous wave), all of these 'best in class', extremely rugged RF power transistors utilise the same SOT1223 package outline and can be used in any RF power application in the HF to 600 MHz frequency range.



Able to withstand extreme load mismatch conditions, the transistors feature high efficiency, so energy usage and operating costs are reduced. As less cooling is needed, system requirements are simpler, which is beneficial for overall bill of material costs (BOM). Specific examples of end equipment applications include CO2 plasma lasers, MRI medical scanners, particle accelerators, plasma lighting, FM radio, and VHF digital TV.

In just one of many examples of the BLP05H6xxxXR series transistors' performance capabilities, Ampleon has produced a demonstration circuit of the BLP05H635XR as an MRI (magnetic resonance imaging) driver amplifier for a high power final output stage using multiple BLF188XR transistors. In this example pulsed power is provided, but the part is also eminently suitable for full CW applications up to 35-W at a gain of 29 dB with an efficiency of greater than 75%.

www.ampleon.com

Test software

supports manufacturing of IoT and M2M devices

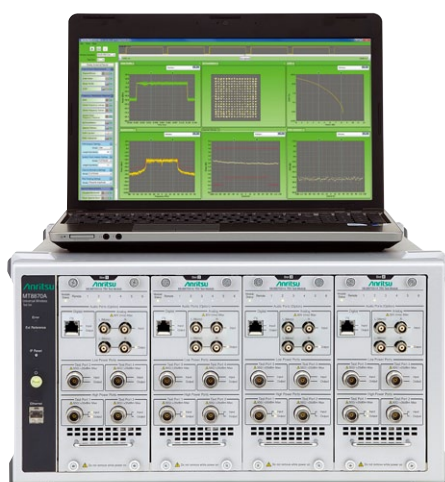
Anritsu Corporation has announced the availability of three measurements software packages expanding the functions of the Universal Wireless Test Set MT8870A to support manufacturing tests of IoT/M2M applications.

With these releases, Anritsu has added support for 802.11p, Bluetooth DLE, and Z-Wave to its measurement software product line for the MT8870A, covering a frequency range from 10 MHz to 6 GHz.

The MX887032A/MV887032A software package supports 802.11p RF tests for the 700-MHz and 5.9-GHz bands to be used for automotive roadside and vehicle-to-vehicle wireless communications. When used in combination with the MT8870A PC application software, it supports RF tests of 802.11p compliant chipsets, modules, dashboard equipment, and can also be used to configure a fully automated test environment with control of device chipsets.

The MT8870A already supports existing wireless communications systems used by in-vehicle equipment, such as the current WLAN 802.11a/b/g/n/ac standard as well as Bluetooth and GNSS, offering a low-cost test solution for all wireless communications technologies in one set.

The MX887040A-001/MV887040A-001 software package supports wireless tests



for the latest Bluetooth Core Specification version 4.2, which expands the Bluetooth low energy data length from 37 octets to 255 octets to improve system throughput by reducing the data transmission overhead and speeding-up communications between a host device, such as a smartphone, and a nearby sensing device, such as a wearable.

The latest MX887061A/MV887061A software package supports ITU-T G.9959 Z-Wave RF tests. Z-Wave is a low-power wireless technology using the 900-MHz band and targeting the home-automation market, such as home security and remote control of home appliances. It incorporates both Wi-Fi, enabling connection between a smart-home router functioning as the home-automation hub, smartphones and PCs, as well as mobile communications like LTE to connect with public networks and the Internet.

www.anritsu.com

Surface mount SP2T switch

handles 100-W of continuous power from 100 MHz to 1 GHz

Microsemi Corporation has announced high power monolithic microwave surface mount (MMSM) series-shunt SP2T PIN diode reflective switch, the MPS2R10-606.

The device is optimized for high frequency (HF), very high frequency (VHF) and ultrahigh frequency (UHF) high power transmit/receive (T/R) switching in applications such as magnetic resonance imaging (MRI) receive arrays and first responder, military, aviation and marine radio communications.

The MPS2R10-606 switch provides frequency coverage from 100 MHz to 1 GHz with 0.2 dB insertion loss, 15 dB return loss and 55 dB of isolation at mid-band. A simple analog control voltage allows the device to achieve 500 ns switching speeds while handling up to 100 W of continuous wave (CW) power. Available in a compact, non-magnetic 2.03 mm x 1.27 mm format, the MPS2R10-606 switch meets RoHS requirements per EU directive 2002/95/EC, and is fully compatible with pick and place and surface-mount technology (SMT) solder reflow manufacturing techniques.

In addition, technology used in the MPS2R10-606 supports public safety, aviation, marine, and military handheld and rack mount radio hardware (JTRS), which are critical in combating multiple international and domestic threats. As the company's PIN diode MMSM switches are nonmagnetic, they offer the high density and performance required for the implementation of MRI receive arrays.

www.microsemi.com

Phase-locked oscillators

target high-reliability applications

Link Microtek is making available a line of high-performance phase-locked coaxial resonator oscillators that are particularly suitable for use in high-reliability applications such as military satellite-communications systems, where stability and accuracy are of paramount importance.

Manufactured by L3 Narda-MITEQ, the ruggedly constructed BCO series oscillators feature high-Q ceramic resonators and can be specified with output frequencies ranging from 100 MHz to 4 GHz for fundamental configurations and 4 to 16 GHz for multiplied configurations.

The devices can be phase locked to either an external 1 to 200 MHz reference source or to the internal TCXO crystal reference. Phase noise typically ranges from -70 dBc/Hz at 10 Hz offset from carrier to -150 dBc/Hz for a 10 MHz offset.



Available with operating voltages from 5.2 to 15 VDC, the BCO series oscillators have an input impedance of 50 ohms and a nominal load VSWR of 1.5:1.

These compact devices weigh less than 100g and have maximum dimensions of only 57.2- x 57.2- x 15.3-mm, excluding the female SMA connectors used for the RF inputs and outputs. All units are supplied fully burnt in and temperature tested.

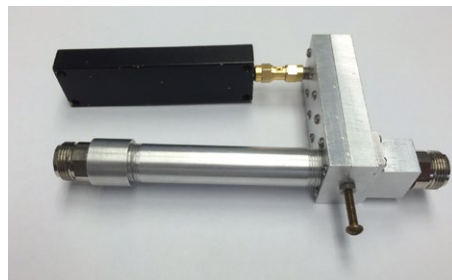
www.linkmicrotek.com

High power absorptive lowpass filters

RLC Electronics has introduced high power absorptive lowpass filters to its already broad filter portfolio. In addition to the high power reflective filters that RLC has been manufacturing for years, we have recently developed an effective method for the filter to absorb the stopband power and avoid reflecting the power back to the source.

These filters are designed for operation up to 10 GHz with a power handling of 250- to 500-W average in the passband. These filters have low loss and low VSWR in the passband, and maintain a VSWR of less than 3.0:1 throughout the stopband.

As an example, a 7 GHz filter has less than 0.5 dB insertion loss, exhibits greater than 50 dB rejection from 9.4 to 18 GHz, and can handle 300-W cW passband power and 40 W reject band power.



www.rlcelectronics.com

Bluetooth and Wi-Fi SiPs save space

CEL has released two system-in-package (SiP) devices, significantly broadening the scope and capabilities of its existing portfolio of multi-standard wireless modules.

Both devices, dubbed 'nano modules', complement the company's current Bluetooth® and Wi-Fi® family of 'mini modules.' Each nano module/SiP employs an identical chipset and RF circuit topology as used on its larger mini module sibling.

Customers now have the option of rapidly transitioning their designs to these more compact, highly integrated devices for instances when their product volumes increase or a smaller form factor is required. All software ports directly between the nano and mini modules since the same core microprocessor and transceiver are utilized for both variants.

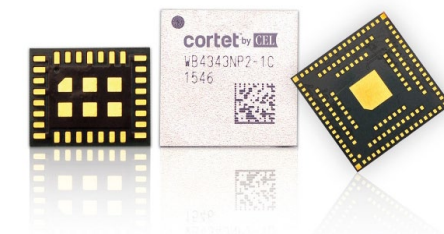
The B1012 Bluetooth Smart Nano Module comes fully integrated with a CSR1012 chip scale package IC coupled with two crystals, a low pass filter, and a 64KB EEPROM. As with its B1010 Mini Module sibling, the B1012 supports Bluetooth Low Energy (Bluetooth Smart or v4.1), as well as the innovative mesh networking capabilities provided by the CSRmesh™ protocol. Plans are also underway to support the Bluetooth mesh networking standard when it is released later this year. The device offers a best-in-class RF range of 50m to 100m, with +8.5 dBm of output power. The B1012 Nano Module comes in a 36-pin, 7.2-mm x 8.8-mm surface mountable package.

Overall size reduction over its mini module sibling is on the order of 79% (antennas not included in the relative comparison).

The WB4343 Wi-Fi + Bluetooth Nano Module integrates a Broadcom BCM4343x, a 32-bit ARM Cortex-M4 microprocessor with FPU, two crystals, a low pass filter and RF matching circuitry for a complete, one-chip Wi-Fi + Bluetooth solution. The device matches the capabilities of the newly released WB4343 Mini Module, supporting Wi-Fi 802.11 b/g/n, Bluetooth Classic and Bluetooth Smart. The WB4343 Nano Module also leverages the world-class WICED SDK toolset from Broadcom, further accelerating design time for customers looking to migrate from the WB4343 Mini Module.

The WB4343 Nano Module offers a best-in-class wireless range, utilizing the BCM4343x with Wi-Fi and Bluetooth output power levels of +17 dBm and +8 dBm, respectively. The device comes in a 151-pin, 10-mm x 10-mm surface mountable package. Overall size reduction over its mini module sibling is on the order of 67% (again, antennas not included in the relative comparison).

Each SiP is 100% RF tested and comes pre-certified for FCC, IC, CE compliance (when coupled with CEL's reference antenna designs), as well as



compliance with the applicable wireless standards (Wi-Fi and/or Bluetooth).

<http://cortet.cel.com/SiPs>

DAS platform

delivers superior coverage and capacity in a small footprint

Advanced RF Technologies, Inc., (ADRF) has launched the ADX V, an evolution of its DAS platform, which uses modular architecture and is ideal for supporting both single carrier and neutral host applications.

The ADX V claims to be the most flexible platform on the market that provides a genuinely future-proofed option allowing consumers to only pay for what they need now. The ADX V provides all the benefits of ADRF's legacy DAS, including modular-

ity, hot-swappable design, user friendly web-based monitoring system, and power consumption efficiency, and it also comes in a significantly reduced form factor. With up to 60% in space saving, the ADX V is not only smaller in dimension but also lighter in weight, which results in a small, more aesthetic enclosure which is simpler to install even in a small telecom closet with limited space.

Featuring unique, patented technologies, the ADX V is ideal for providing



wireless coverage for multiple dwelling units (MDU), commercial buildings, large venues and campuses, and metropolitan areas since it can eliminate the need for multiple wireline infrastructure by using a single strand of fiber to support multiple wireless operators.

The flexible platform allows any combination of 700 MHz, 700/800 MHz Public Safety, Cellular, SMR800, PCS, AWS, WCS, and 2.5 GHz. It is IP66 rated for NEBS compliancy and provides output power of 2-W, 5-W, 20-W, and 40-W in all bands.

The ADX V saves up to 60% rack space compared to the previous ADX DAS Series, with improved power efficiency. It supports up to a maximum of 64 Remote Units per Head End, requires only a single strand of single mode fiber per Remote Unit, and supports MIMO on all bands, within the same chassis.

<http://adrfttech.com>

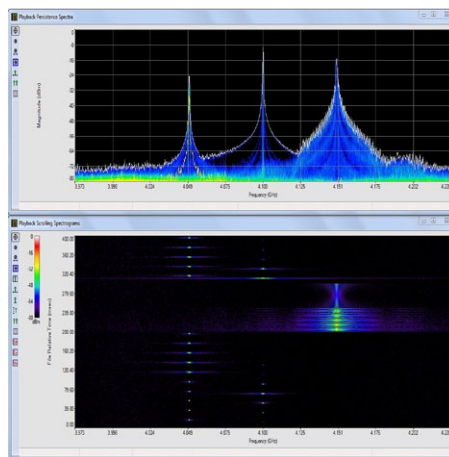
Spectro-X signal analysis software

boasts enhanced capabilities

X-COM Systems, LLC, a subsidiary of Bird Technologies, has introduced the latest version of its Windows-based Spectro-X signal analysis software that adds new features to tools for developing and testing radar, ELINT, SIGINT, ECM, ESM, commercial and military communications systems.

The latest version of the software makes it easier to quickly find signals

of interest and pinpoint them in time, enhanced broader pulse signal analysis and waveform search capability, and filtering of export files to include only specific signals.



Spectro-X software greatly simplifies the task of detecting and analyzing signals in data files produced by over-the-air signal capture using X-COM's IQC5000B Series or IQC91000A signal record and playback systems, or by custom spectrum files created in MATLAB. It can simultaneously analyze up to four files of any size over any range of frequencies with file alignment of ± 1 sample, allowing the user to "zoom in" to signals of interest contained within files containing hundreds of thousands of emitters.

The new features in Spectro-X include the ability to display real-time event markers that can be useful for precisely pinpointing the timing of spectral events, and markers with both relative and absolute sample counts that aid tracking of timing information when using the gated triggering capability of the IQC5000B or IQC91000A.

www.xcomsystems.com

Integrated wideband RF synthesiser IC

covers 1.925 GHz to 16 GHz

STMicroelectronics claims to offer the highest-frequency and widest-range integrated wideband RF synthesiser with its StuW81300, that covers the 1.925 GHz up to 16 GHz frequency range on a single IC.

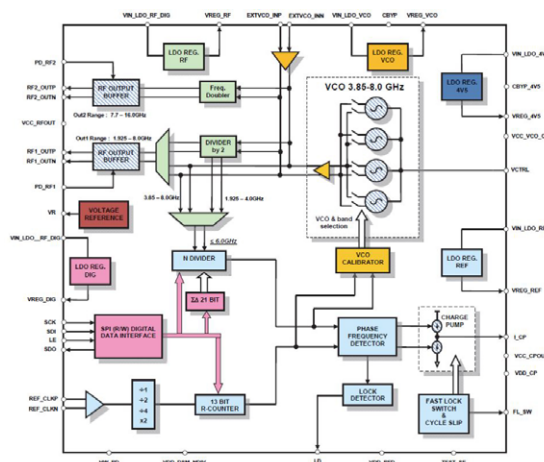
Implemented in ST's integrated BiCMOS SiGe technology, the

StuW81300 enables versatile RF architectures at greater economy (BOM reduction) than traditional microwave solutions based on III-V technologies with low integration capabilities.

The StuW81300 is based on a fractional-N phase-locked-loop (PLL) core with low-noise wideband voltage-controlled oscillators (VCOs) and voltage regulators. It has a broad range of programmable hardware options to accommodate the needs of most current and future RF/Microwave applications, including radio links, satellite communications, base stations, and test and measurement equipment.

The IC covers the frequency range from 1.925 GHz to 16 GHz (split over two RF outputs) and delivers +6 dBm at 6 GHz and +4 dBm at 12 GHz power at the internally broadband matched RF outputs.

Other key features include fundamental VCO rejection at doubler output higher than 20 dB; normalised in-band phase-noise floor of -227 dBc/Hz; VCO phase noise (6.0 GHz) of -131 dBc/Hz at 1 MHz offset; and noise floor (6.0 GHz) of -158 dBc/Hz.



Phase noise (12.0 GHz) is -125 dBc/Hz at 1 MHz offset, while noise floor (12.0GHz) is -154 dBc/Hz. Typical RMS jitter is 0.13 ps.

www.st.com



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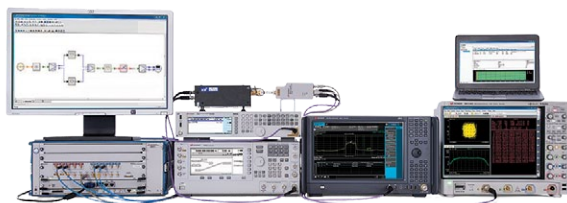
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