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Leveraging EM Analysis: K-Band Satcom GaN HPA Design Success

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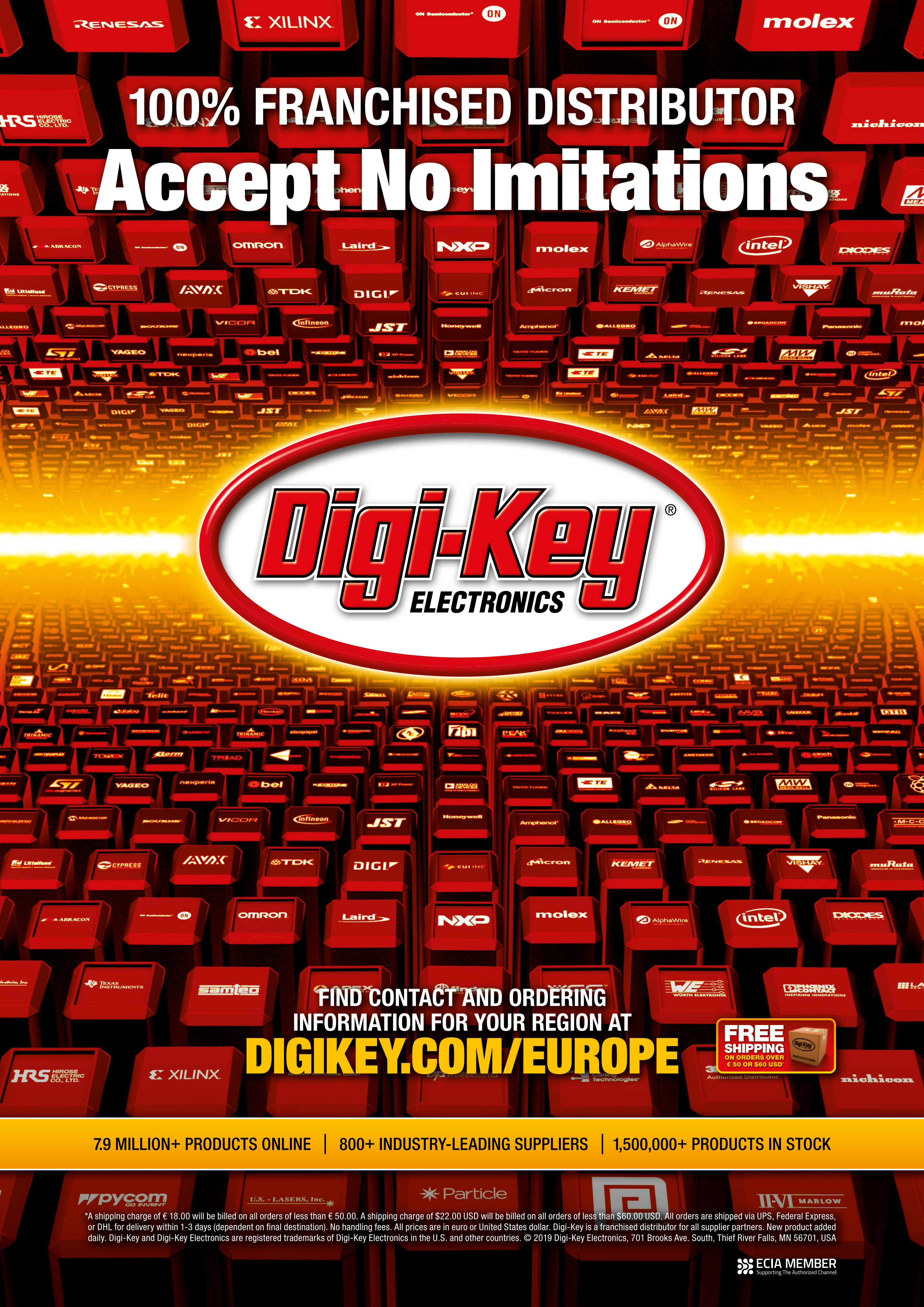
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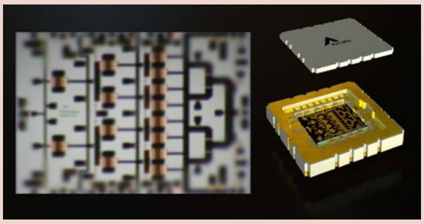

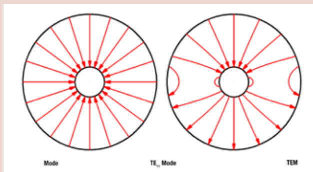

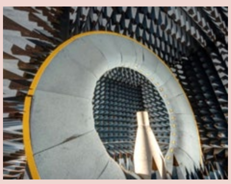

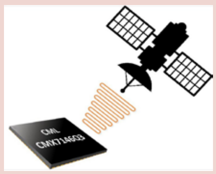

2019 is the year 5G begins its long march

The term 5G has been exhausted to death, but 2019 is the beginning of a massive multiyear rollout. However, there could be significant bumps on the road ahead, both political and in terms of technology. For example, the role of mmWave still depends on trials and is still further out into the future. In spite of this, fixed wireless is where mmWave is getting the most attention.

Politics will play a big role in 5G as the USA and China in particular fight for dominance. In particular the USA has started looking to disengage from globalisation and has singled out 5G as a security issue with respect to China, and in particular Huawei. This has led to Huawei being banned form selling 5G networking equipment in the USA and some other countries, as well as being potentially denied access to US technology from American companies such Qualcomm, Intel and Google (Android). As with all things political the situation is fluid and uncertain.

China has already started steps to ensure it does not find itself vulnerable to the whims of trade politics in the future, and for Huawei in particular this means fostering home grown technology to replace what it cannot import anymore. Whether other regions, like Europe, take heed of the message that global trade has changed in nature and look to be more self-reliant in the future remains to be seen.

An example of this is the recent announcement by Huawei of HarmonyOS, a microkernel-based distributed OS for all platforms including mobile phones, wearables, laptops, and televisions. Based on a modularised concept, HarmonyOS can be nested and adapted flexibly to any device to create a seamless cross-device experience. HarmonyOS can run Android apps and is a potential replacement for Android, though Huawei insist they will continue to use Android on their smartphones for the foreseeable future. Currently HarmonyOS is being targeted at Internet of things (IoT) devices.

Politics aside, one of the key drivers of 5G infrastructure is the IoT. Fortune Business Insights in its latest report details how the IoT is rapidly evolving and is driving the global 5G infrastructure market to high double digit growth.

The report suggests that the global 5G infrastructure market will rise at a high CAGR of 76.29% during the forecast period, covering 2018 through to 2026. There is a massive demand for high speed internet among end-use industries and 5G infrastructure plays a crucial role in deploying such high speed internet services.

The analysts in the report predict that the global market is anticipated to reach US$ 50,640.4 Mn by 2026, as against US$720.6 Mn in 2018.

"5G technology is expected to positively influence connected agriculture, smart cities, machine-to-machine communication, and home automation," says a lead analyst at Fortune Business Insights. "Moreover, some of the prominent challenges faced by organizations with regards to improving reliability, performance, and connectivity can be resolved through 5G infrastructure," he added.

According to the report, North America is expected to maintain its dominance in the global 5G infrastructure market. Early adoption of advanced technologies such as automation, IoT are significant factors driving growth. Growth in this region is also attributable to the rising demand for on-demand video services and rising trend of smart cities.

In Asia, 5G growth is complemented with strong LTE demand. Highlighting this is a recently published report from Dell'Oro Group that finds that healthy LTE growth and surging 5G investments in the Asia Pacific region added fuel to the Radio Access Networks (RAN) market upswing that began in the second half of 2018.

A key takeaway from the report is that the Asia Pacific region, including China, comprised more than 80 percent of worldwide RAN growth between 1H 2018 and 1H 2019.

One factor in 5G is the push of IoT markets offering both low-power, low bandwidth and high-bandwidth use cases. Narrowband IoT (NB-IoT) deployments allow users to transmit a small amount of data from multiple devices at low-power levels. The high-bandwidth and low latency of 5G will also enable IoT use cases in applications such automotive and healthcare.

To illustrate this, a report from Information Services Group (ISG) finds that enterprises in the Nordic countries see the rollout of 5G mobile services, with their faster networking speeds, as a catalyst for the broader adoption of IoT systems. The report sees connected vehicles and smart buildings as the next big growth areas for the IoT in the Nordic region. Growth in the connected vehicles segment will be driven by usage-based insurance, vehicle diagnostics and vehicle-based computing platforms, the report says. Interest also is growing in intelligence transportation systems.

In the smart buildings space, the focus is on automation and security, with interest in using the technology in both commercial and residential buildings.

To conclude, the rollout of 5G is accelerating rapidly today and is expected to become dominant over the course of the next 5 to 10 years. The technology will enable a revolution in communications beyond the smartphone with an emphasis on IoT and AI use cases.

The mmWave part of the 5G paradigm is still further in the future, though developments in fixed wireless are poised to go mainstream. There are still hurdles in technology to overcome with the focus on higher frequencies below 6 GHz and mmWave. To this end, advances in GaN process technology continues to push the envelope in terms of frequency, power and cost.

The big curve ball facing 5G will be political, with the potential balkanisation of standards and networks. Hopefully, the worst case scenarios do not play out, but regions and countries need to be more cognisant of the changes facing global trade.

www.isg-one.com
www.delloro.com
www.fortunebusinessinsights.com

By Jean-Pierre Joosting
Editor MWEE

Swiss startup to market 3D printed satellite antenna tech

Swiss startup, SWISSto12 is a spin-off from research lab EPFL developing metal-coated 3D-printed satellite antenna components. To bring its technology to market, SWISSto12 has raised CHF18.1m ($18m) to scale up the production and marketing of its 3D printed satellite antenna technology.

The firm will use the cash to ramp up marketing of its 3D-printed metal waveguides and expand its offices in the US and Israel. Investors include Swisscanto Invest, Swisscom Ventures and CNB.

SWISSto12 uses a patented process to manufacture metal-plated 3D-printed components using a complex maze of tiny conduits, each custom-built for a specific application. This allows the satellite antenna technology to be ten times lighter than all-metal versions.

"We may be a new player on the scene, but we've already attracted the attention of major names in the satellite and aerospace industries," says CEO Emile de Rijk, whose PhD thesis led to the spin-off. "Our partners include Airbus Defense and Space, Thales Alenia Space, Cobham Advanced Electronic Solutions and the European Space Agency." SWISSto12's technology could also change the way miniature satellites and constellations, two fast-growing market segments, and the antennas fitted to airplane fuselages are designed and manufactured.

"This investment will allow us to take our business to the next level," added de Rijk. As SWISSto12 expands its new premises in the US and Israel, it intends to begin production of complete antennas – waveguide and transmitter combined. It is also exploring some initial opportunities in terrestrial communication systems such as 5G.

www.swissto12.com

Next-generation PON access devices

Tibit Communications, a CA based start-up developing next-generation access devices for Passive Optical Networking (PON), has announced the completion of its Series B funding led by Intel Capital and including two new investors – Swisscom Ventures and AJU IB Investment.

The MicroPlug™ OLT (Optical Line Terminal), which has been developed by Tibit, is a revolutionary departure from legacy fiber access systems, that are traditionally part of large, proprietary chassis with multiple internal switching layers. Tibit fits all PON Layer 1 and 2 functionality inside the space of a transceiver optics case that plugs neatly into standards-based, commercially-available switches.

This allows carriers a very flexible and cost-effective deployment for fiber access. The elimination of unnecessary management layers within the OLT equipment itself further enables PON management to be virtualized and moved into the carrier's cloud architecture.

www.tibitcom.com

Low-power, low-cost mmWave network for billions IoT devices

Researchers at the University of Waterloo have developed a cheaper and more efficient method for Internet-of-Things (IoT) devices to receive high-speed wireless connectivity.

With 75 billion IoT devices expected to be in place by 2025, a growing strain will be placed on requirements of wireless networks. According to the researchers, contemporary WiFi and cellular networks won't be enough to support the influx of IoT devices.

With the roll-out of 5G, millimeter wave (mmWave) networks will offer multi-gigahertz of unlicensed bandwidth – more than 200 times that allocated to today's WiFi and cellular networks. However, the hardware required to use mmWave is expensive and power-hungry, which are significant deterrents to it being deployed in many IoT applications.

"To address the existing challenges in exploiting mmWave for IoT applications we created a novel mmWave network called mmX," said Omid Abari, an assistant professor in Waterloo's David R. Cheriton School of Computer Science. "mmX significantly reduces cost and power consumption of a mmWave network enabling its use in all IoT applications."

In comparison to WiFi and Bluetooth, which are slow for many IoT applications, mmX provides much higher bitrate.

"mmX will not only improve our WiFi and wireless experience, as we will receive much faster internet connectivity for all IoT devices, but it can also be used in applications, such as, virtual reality, autonomous cars, data centers and wireless cellular networks," said Ali Abedi, a post-doctoral fellow at the Cheriton School of Computer Science. "Any sensor you have in your home, which traditionally used WiFi and lower frequency can now communicate using high-speed millimeter wave networks.

www.uwaterloo.ca

Small cell antennas ready for 5G

Telekom is working with HUBER+SUHNER to prepare its network for the introduction of 5G small cell antennas. The Swiss company has developed five small cell antennas for Telekom that support 4G and 5G frequencies. The SENCITY Urban antennas cover the frequency range from 1.7 to 4.2 GHz. Small cells enable the targeted expansion of data throughput in locations where a large number of customers are on the move or surfing.

The new small cell antennas are initially operating in Telekom's 4G network. Once the 5G spectrum is available, the small cells can be upgraded to 5G in just a few simple steps. SENCITY Urban antennas will be used for the first time in Kiel, Lüneburg, Osnabrück, Munich and Mülheim.

In the future, small cells will play an increased role in Telekom's network. Within the area they cover, they provide a significant increase in data capacity. Currently, up to an additional 150 Mbps.

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www.hubersuhner.com

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UWB demonstration showcases automotive applications

With a concept vehicle, Volkswagen and NXP have presented future applications of UWB communications technology in automobiles. The focus is on secure access, but UWB also has a whole range of other worthy applications.

Keyless entry systems for vehicles are notorious for their poor theft protection – with relatively inexpensive equipment they can easily be tricked. Volkswagen has now unveiled a concept vehicle in which UWB use ensures that keyless entry systems will be safer in future.

To secure the radio link, the developers use UWB's ability to measure the "time-of-flight" (ToF) in order to determine a very precise location and distance between the radio key and the vehicle. Techniques which obtained access authorisation by extending this radio link are no longer possible in this way. In addition to precisely determining the distance, Volkswagen also uses artificial intelligence to secure access. The result is a personalized, teachable access algorithm that not only uses an intelligent UWB car key, but also recognizes the user's movement patterns and gestures.

UWB, according to Volkswagen and NXP in a press release, offers a significant improvement over existing wireless technologies such as WiFi, Bluetooth and GPS due to its very accurate localization capabilities. The ability to capture contextual information such as the position and movement of the UWB anchor, or to process the distance to other devices with an unprecedented accuracy of just a few centimeters in real time, opens up a wide range of new applications.

www.nxp.com

Bluetooth® platforms for low-power wireless

Advanced connectivity engines from Skyworks Solutions are being leveraged by Nordic Semiconductor for ultra-low power Bluetooth® wireless communications. Specifically, Nordic is utilizing Skyworks' family of fully-integrated front-end products in conjunction with their multi-protocol system-on-chip (SoC) for Bluetooth® Low Energy (LE) and emerging Bluetooth® 5 applications. Together, the combined platform provides superior efficiency — making it ideal for battery-powered Internet of Things (IoT) devices — while delivering a 4x range advantage for connected home and outdoor usage cases.

Bluetooth® LE is a critical protocol for IoT, given its upgraded communication capabilities and minimal power consumption requirements. Bluetooth® 5 further enhances benefits and supports additional breakthrough features such as extended ranges, higher data throughputs and improved co-existence, all key elements in an increasingly dense network.

www.skyworksinc.com

Using Wi-Fi to measure speed and distance of indoor movement

Researchers from North Carolina State University have developed a technique that uses a novel combination of Wi-Fi signals and accelerometer technology to track devices in near-real time. Suitable for measuring speed and distance in indoor environments, the Wi-Fi technique could be used to improve navigation technologies for robots, drones, or pedestrians trying to find their way around an airport.

"We call our approach Wi-Fi-assisted Inertial Odometry (WIO)," says Raghav Venkatnarayan, co-corresponding author of a paper on the work and a Ph.D. student at NC State. "WIO uses Wi-Fi as a velocity sensor to accurately track how far something has moved. Think of it as sonar, but using radio waves, rather than sound waves."

Many devices, such as smartphones, incorporate technology called inertial measurement units (IMUs) to calculate how far a device has moved. However, IMUs suffer from large drift errors, meaning that even minor inaccuracies can quickly become exaggerated.

In outdoor environments, many devices use GPS to correct their IMUs. But this doesn't work in indoor areas, where GPS signals are unreliable or nonexistent.

"We created WIO to work in conjunction with a device's IMU, correcting any errors and improving the accuracy of speed and distance calculations," says Muhammad Shahzad, co-corresponding author of the paper and an assistant professor of computer science at NC State.

The researchers wanted to test the WIO software but ran into a problem. They could not access the Wi-Fi network interface cards in off-the-shelf devices such as smartphones or drones. To address the problem, the researchers created a prototype device that could be used in conjunction with other devices.

www.ncsu.edu

Consortium to develop/ promote UWB technology

Four sponsor members – Swedish lockmaker Assa Abloy, NXP Semiconductors, Samsung Electronics and Bosch – have formed the FiRA consortium to help develop the ultrawideband (UWB) ecosystem. FiRa stands for "fine ranging" and this highlights the use of UWB to deliver high accuracy at low power when measuring the distance or determining the relative position of a target. FiRa plans to develop the ecosystem for interoperable services by setting standards and certifications. Besides the four founder members the follow three companies have joined the consortium; Sony Imaging Products & Solutions Inc., LitePoint and the Telecommunications Technology Association (TTA).

The starting point for UWB technology is the IEEE standard 802.15.4/4z, which defines the essential characteristics for low-data-rate wireless connectivity and enhanced ranging. It is the aim of the FiRa Consortium to build on what the IEEE has already established.

www.firaconsortium.org

Leveraging EM Analysis: K-Band Satcom GaN HPA Design Success

By Thomas Young, Arralis Ltd., and David Vye, AWR Group, NI

OVERVIEW

K/Ka-band satellite communications (satcom) can provide constant, uninterrupted access to information, driving companies like Facebook, Amazon, Inmarsat, and SpaceX to invest heavily in this spectrum for global broadband services. SpaceX, for example, currently has plans to deliver Ka-band payloads across a constellation of 4,425 satellites.

These systems are enabled through high-power amplifiers (HPAs), which form the final link in the RF power chain of next generation, satellite-based, RF front-end components. The Leonis chipset from Arralis Ltd (Limerick, Ireland), initially developed as part of the European Space Agency (ESA) ARTES program, addresses the growing demand for lower cost K/Ka-band satellite equipment.

The chipset includes mixers (IQ and sub-harmonic), up and downconverter core chips, switches, phase shifters, low-noise amplifiers (LNAs), and PAs. Within this chipset, the company's LE-Ka1330308 is a high-power monolithic microwave integrated circuit (MMIC) amplifier fabricated on space qualified 0.25 µm gallium nitride on silicon carbide (GaN on SiC).

Arralis successfully demonstrated transceiver architectures for both uplink and downlink communications. Figure 1 illustrates the low-band transmitter architecture and performance with the integrated HPA.

GAN MMIC TECHNOLOGY

Through the use of GaN technology, Arralis offers higher efficiencies, power density, and thermal conductivity compared with equivalent gallium arsenide (GaAs) parts. In addition, GaN can operate at higher temperatures without loss of reliability, making it especially well-suited for satellite communications. Device thermography measurements of the die show a thermal resistance of 2.62 °C/W, resulting in a lifetime estimate of 5e7 hours.

The LE-Ka1330308 operates from 17.5-20 GHz and typically delivers 10 W saturated output power, with power-added efficiency of 25% and large-signal gain of 20 dB in a compact die size of 3.7 x 3.0 mm (Figure 2). The three-stage MMIC amplifier is fabricated on the United Monolithic Semiconductors (UMS) GH25-10 process. This 0.25 µm, GaN on SiC technology is space-qualified and International Traffic in Arms Regulations (ITAR)-free. It is matched to 50 Ω with integrated DC blocking capacitors on RF ports and incorporates an output power detector to assist with system integration.

During the design phase, extensive circuit design and simulation was performed using the NI AWR Design Environment platform, specifically Microwave Office circuit design software, AXIEM EM simulator for 3D planar structures (MMIC manifold feed network, on-chip passives, and PCB evaluation board), and Analyst™ EM simulator for 3D EM analysis of the package. The simulation software works with the active and passive MMIC component models developed by the foundry and organized into process design kits (PDKs) developed through collaboration between the NI and UMS modeling teams (refer to sidebar and Figure 6).

The MMIC die was represented in simulation using foundry-verified, schematic-based models and EM analysis, allowing the designers to reliably predict and optimize key performance metrics.

Figure 3 shows the correlation between measured and modeled S-pa-

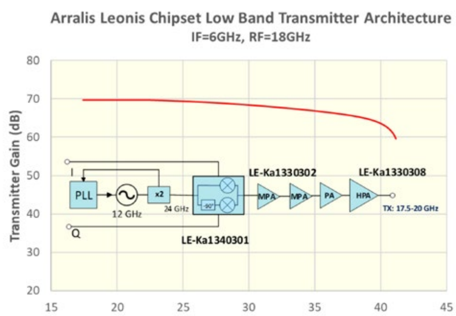


Figure 1: Arralis Leonis chipset for low-cost K/Ka-band satcom applications.

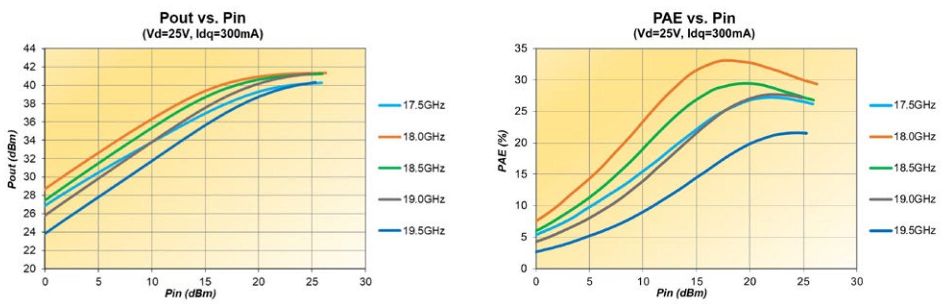


Figure 2: Output power (dBm) and PAE (%) as a function of input power over the 17.5 to 19.5 GHz range.

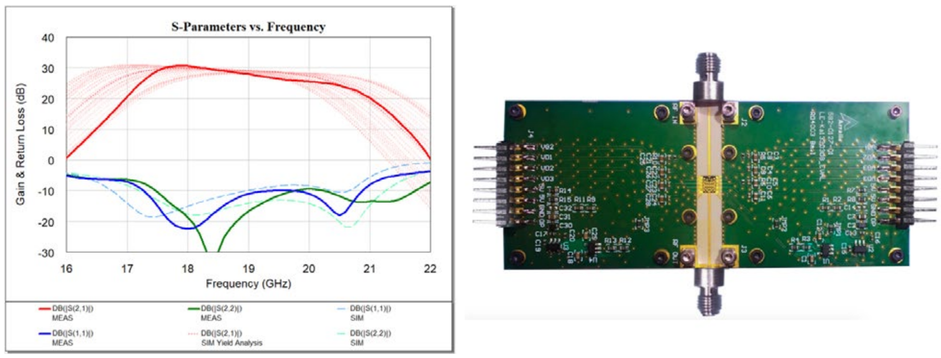


Figure 3: Simulated data including yield analysis vs. modeled small-signal frequency response for the LE-Ka1330308 reference board (right).

rameters. The graph also shows the simulated gain variation due to process tolerances. Measured gain performance falls on the high side of the variation, however it is within the predicted limits of the simulation.

Significant EM analysis and design optimization was carried out at the component and subcircuit level to ensure that parasitics and inadvertent EM coupling between structures is incorporated into the simulation. Towards the end of the design phase, larger and more integrated EM analysis was used as final verification and to ensure that all interactions were captured in simulation. These EM simulations were conducted using the AXIEM EM simulator.

The characterization and modeling methods implemented by the foundry have been validated through a well-established process/model qualification procedure, developed over years, that has been proven to yield reliable device models for the foundry's family of semiconductor processes. The extracted nonlinear models account for trapping phenomena and transistor self-heating. In addition to electrical characterization, the UMS modeling team performs a comprehensive study of the thermal device behavior and other non-stationary effects to improve the quality of its nonlinear device modeling.

PACKAGED DEVICE

The success of the bare die MMIC has fuelled the subsequent development of a packaged part that will facilitate a more convenient solution for system integration. For best performance, a high thermal conductivity epoxy needs to be used and unwanted voiding eliminated. A packaged solution removes this delicate step for the customer while also providing an easy to handle part with integrated decoupling and wire bonding.

The Kyocera SGMR-B1193, a commercially available 7 x 7 mm ceramic quad-flat no-leads (QFN) package, was selected for investigation, as shown in Figure 4.

This package will provide a hermetically sealed solution with enough space to accommodate the die and decoupling capacitors, while also minimizing the RF I/O bond-wire length. A coefficients of thermal expansion (CTE)-matched MoCu heat sink will provide a reliable thermal path through the base. The ceramic QFN package is a compact size of 7 x 7 mm.

This RF transition has been simulated using the Analyst EM simulator (Figure 5) to minimize return loss due to impedance mismatches between the MMIC, the package, and the evaluation board. The simulation results show a well-matched transition with insertion loss of 0.25 dB. This will translate to an overall gain reduction of 0.5 dB and power reduction of 0.25 dB for the packaged part compared to bare die option.

CONCLUSION

Arralis engineers have successfully designed a K/Ka-band chipset, inclusive of a 10 W saturated output power HPA, for satellite communications applications. The three-stage MMIC amplifier, fabricated with space-qualified, 0.25 μm GaN on SiC, was developed using state-of-the-art semiconductor technology, foundry-qualified device models, and NI AWR software circuit/EM simulation technology. Transceiver architectures for both uplink and downlink communications were demonstrated with this chipset and the integrated HPA. Additional development efforts are focused on integrating the bare die into a suitable package with initial samples of the packaged HPA, expected in early 2020.

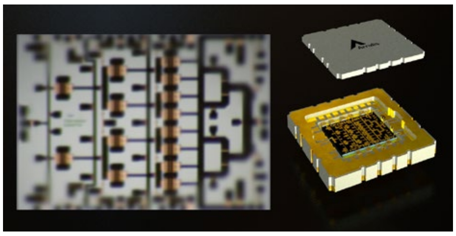


Figure 4: Proposed packaging (Kyocera SGMR-B1193) for K-band HPA. Image courtesy of Kyocera Corporation.

PROCESS DESIGN KITS (PDKs)

Active device models and passive on-chip components, along with their parametric layout cells (PCells), are organized into PDKs to support MMIC development. These PDKs provide simulation-ready device models to use in the construction of ICs for analysis and generation of layout masks for fabrication.

The NI AWR software UMS GH25 PDK, available directly from the foundry, includes a layout process file (LPF), which defines the material stackup and metallization layers for EM simulation and physical realization of the MMIC. Select parameters of the active and passive device models, such as gate width/number of fingers or capacitor/inductor values, can be adjusted by the designer. In addition to PCells, models come with a symbol representation for schematic editing. Figure 6 shows the UMS GH25 PDK within the NI AWR software element browser, along with the corresponding schematic and layout views of various active and passive devices contained within the PDK. More information is available at: **https://www.ums-gaas.com/foundry/design-kits.**

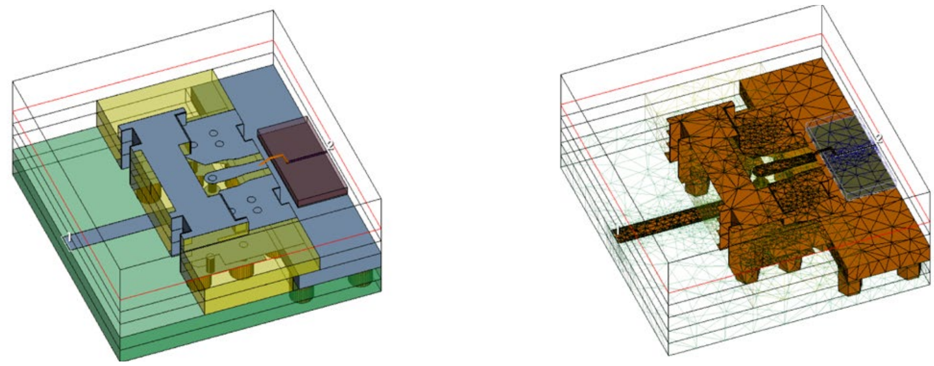


Figure 5: Details of package model I/O port simulation setup (left) and resulting mesh in Analyst software.

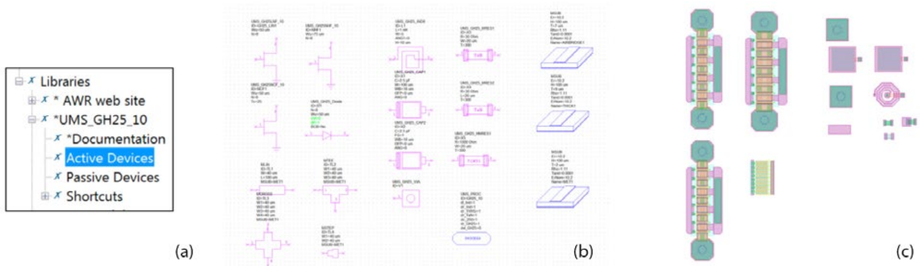


Figure 6: NI AWR software UMS PDK (a) element browser view, (b) schematic view, and (c) layout view.

Trade-offs When Selecting the Optimum Transmission Line for Frequencies up to 110 GHz

By Daniel Barnett, Teledyne Storm Microwave, Woodridge, Illinois, USA
and Dr. Robert Elliot, MIEEE, SMIET

INTRODUCTION

In the RF world a transmission line is used to transport RF energy from a source to a destination – an example being from a radio transmitter to an antenna. There are different types of transmission media and perhaps two of the most frequently used types are coaxial cable and waveguide.

At a macro level, coaxial cable is a 2-conductor transmission line compromised an inner conductor located centrally within a cylindrical outer conductor, separated by a dielectric. The dielectric material ranges from an air dielectric with the inner conductor supported by a series of dielectric posts (e.g. FEP, PTFE, PE) to a solid core extruded PTFE (i.e. material with no air injected). Many other options are available.

Waveguide, on the other hand, can be thought of as a single conductor transmission line that typically takes the form of a rectangular or circular cross section. In many cases, a complete transmission line is comprised of straight lengths of waveguide connected in series together with formed components that allow bends to be introduced in order for the complete transmission path to be enabled. Many other options exist, such as semi-flexible or flexible waveguide where, as supplied, the waveguide can be installed directly to a site from a large cable reel that is transported to site by a conventional truck. Almost invariably air is the dielectric material used. Other variants exist such as pressurizing the air, or using an inert gas for particular applications.

At a high level view, the choice between coax and waveguide is most often determined by the following parameters: frequency of operation, power, attenuation, and length of the transmission line. This article will explore some of factors behind the decision to use coax or waveguide in a particular application throughout the frequency band.

BASIC THEORY

[1] COAXIAL CABLE

In a coaxial cable the RF energy is contained within the outside of the inner conductor and the inside of the outer conductor. If the outer conductor is made of solid material, then all energy is contained within the coaxial region. This means that no RF energy can penetrate nor radiate from this transmission line. However most coaxial cable is flexible and the outer conductor can take the form of interwoven braid or a helically wound metal tape. The construction of the outer conductor leaves micro-gaps through which RF can radiate from or penetrate into the coaxial cable.

For the purposes of this article, in communications applications (e.g. 5G), the focus will concentrate on power, attenuation and length as applications move to higher frequency, millimeter wave bands. To increase the power (and additionally decrease the attenuation), the inner conductor has to be increased in diameter. In order to maintain the impedance, the outer conductor diameter has to change proportionally. As the diameters of the inner and outer conductors increase, the construction of the flexible cable outer conductor changes from an interwoven braid to a corrugated solid outer conductor (e.g. Heliax®). The corrugated construction allows the coaxial cable to be bent to accommodate normal installations. This range of inner and outer conductor construction and material choices give coaxial cable to ability to transmit from HF and VHF (e.g. Wireless Broadcast 1 MHz – 30 MHz, TV signals 56 MHz – 100 MHz) to millimeter frequencies (e.g. 5G at E-band 60 GHz – 90 GHz). Practical flexible coaxial cable can be up to 5” (12.7 cm) in diameter and can support transmission as low as 1 MHz. As cable diameters increase, the upper frequency of operation decreases. For example, in 0.047” (1.19-cm) diameter flexible cable the upper frequency is 110 GHz and for a 5” (12.7 cm) diameter corrugated cable the upper frequency is slightly over 1 GHz. In both cases though the lower frequencies are only limited by practical considerations. Typically, the larger corrugated outer conductor cables can be manufactured up to 500 ft (152 m) which meets practical considerations for handling and installation.

[2] WAVEGUIDE

Waveguides support RF transmission within a hollow metal tube. Similar to solid outer conductor coax cable, no RF energy can penetrate nor radiate from the waveguide. While coaxial cable can increase power and decrease attenuation by changing size, the power and attenuation of waveguide is determined by its dimensions which in turn determines the frequency range of operation. This means for a certain frequency range of operation; the power and attenuation levels are set. Typically, rigid (non-flexible) waveguide is manufactured in up to 20 ft (6.1 m) lengths and these must then connected in series for longer application lengths which presents many practical and logistical challenges. Also, there is practical side as to the lower frequency of a waveguide. Most commercial manufacturers of waveguide have a lower frequency of 1 GHz (WR650) which is supported in a waveguide with a rectangular cross section of 6.5” by 3.25” (16.51 by 8.26 cm). Manufacturing larger size for lower frequencies is only done for special applications – and when compared to the typical dimensions seen for coaxial cable presents some formidable size, installation and cost concerns. In this particular case, consideration of waveguide at these low frequencies versus coax would be made with consideration of the required operating power very much a prime concern.

COMPARISONS OF PERFORMANCE PARAMETERS

[1] IMPEDANCE

The impedance is an important consideration because a part of the power is reflected if the line is not terminated with the characteristic impedance. The reflected power may cause faults in the system or, if it is too big, even damage of parts of it.

The likelihood of an impedance mismatch is higher with coax cable as opposed to waveguide. Coax is trying to

mimic the structure of a circular waveguide: seamless tube with excellent concentricity. In practice though diameter of a coax cable varies in micro instances – a series of tolerance stack-ups of the center conductor, the dielectric (which in many instances consists of multiple layers of PTFE dielectric tape) and in many constructions a helical wrap. The connector for coax though is impedance matched to the coax and a well-matched connector impedance-wise, does a good job in mitigating the impedances variances of the cable. What is highly variable is the manufacture of the cable assembly – the joining of the coax to the connector. This manufacture is art and science: science in that most times the preparation of cable (cutting and stripping of cable layers to precise tolerances) is done by computerized machines and/or lasers and art in the amount of solder and heat to apply the solder is dictated but the experience and skill of the technician.

In a waveguide made from rigid material, e.g. high conductivity copper, brass, plated conductors, etc., a connector (flange) is braised or soldered on to the waveguide to a tight tolerance specification. Great attention has to be paid to the dimensional tolerances associated with concentricity, how perpendicular to the waveguide axis the flange face is, etc. Impedance mismatches will arise from many areas seen for coaxial transmission lines. These include factors such as dimensional tolerances associated with the cross section of the waveguide, denting or damage to the waveguide, incorrect installation of joined flanges, dirt or particulate matter on the flanges before connecting, etc.

A matching of 10 dB (VSWR 1.92:1) means that 10% of the power is reflected while with a matching of 20 dB (VSWR 1.22:1), this drops to 1%.

[2] FREQUENCY

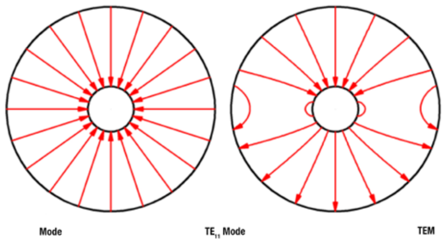
The construction of a coaxial cable is such that the frequency response is from DC to the cut-off frequency of the particular size cable. The most desirable propagation RF energy is Transverse Electro-Magnetic (TEM) mode and that has no upper frequency limitations. TEM mode has no electrical nor magnetic fields in the direction of propagation. Above a certain frequency known as the cut-off frequency (f_c), a higher order TE_{11} mode (TE has no magnetic field in the direction of propagation) also propagates. The TE_{11} causes interference with TEM mode due in part to a different Velocity of Propagation (Vp) and thus Return Loss (RL) and Insertion Loss (IL) are degraded. For all practical purposes then, the f_c is the highest frequency that can be achieved for a particular sized cable.

The most fundamental way to determine the cable size is by the following formula for cut-off frequency:

f_c = speed of light (c) / (average circumference of cable * square root of dielectric constant "E")

reducing this formula to the simplest terms ($Vp = 1/\sqrt{E}$);

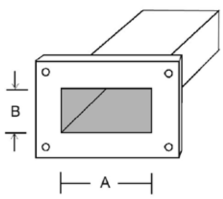
then f_c = Vp * 190.85/(Diameter of inner conductor + Diameter of outer conductor), with *Diameter in mm.*



In contrast, waveguide will most often be used over a much narrower range of frequencies. For rigid rectangular waveguide the ratio of the upper frequency limit to lower frequency limit found in typical applications will be approximately 1.5. In a rectangular cross section waveguide, the lower frequency limit is determined by the dimensions of the cross section of the waveguide. If the broad dimension of the guide is denoted as A, the narrow dimension of the guide is denoted by B then the lower cut off frequency the lowest order waveguide mode that propagates (the TE_{10} mode) is given by:

$f_c = c / 2A$ where:
f_c = cut off frequency in Hz;
c = speed of light in the dielectric contained in the waveguide, in meters/second;
A = broad dimension of the waveguide in meters.

As an example, WR284 is the standardized nomenclature for a rigid rectangular waveguide that has dimensions 2.84 x 1.42 inches (7.21- x 3.61-cm). Note that in most cases, the narrow dimension is one half of the broad dimension for standardized rectangular waveguide.



The calculation of the cut-off frequency for the lowest supported mode, the TE_{10} mode, then is:

$$f_c = 3 \times 10^8 / (2 \times 0.0721) = 2.079 \text{ GHz}$$

The upper frequency limit is determined by the appearance of the next higher order mode, which will depend upon the dimensions of the waveguide. For the typical 2:1 ratio of A to B, the next higher order mode in WR284 is the TE_{20} mode with a cut-off frequency of 4.158 GHz. It is to be noted here that these two cut off frequencies define the theoretical frequency band of operation. They do not take into account practical considerations such as – what is the waveguide attenuation per meter at these two frequencies? Further examination of this question shows that at the lower frequency cut-off, the attenuation per meter is infinite. The attenuation reduces rapidly as the operating frequency is raised above the low frequency cut-off. As the frequency of operation increases, then concerns turn to the cut-off frequency of the TE_{20} mode. Weighing these considerations, the practical frequency band of operation for the example above, WR284, is typically taken as 2.60 to 3.95 GHz. Taking the ratio of these two practical limits gives 1.52 – supporting the comment above regarding the 50% bandwidth.

Table 1 shows the various coax and waveguide (WG) sizes and corresponding frequency ranges. To illustrate a reasonable comparison, upper limits of popular frequency bands are used. Because coax is broadband, the largest size coax whose fc is at the upper frequency range of the band is used. Flexible coax also has many options for dielectric material from Polyethylene (used mainly in high power corrugated coax, for example Heliax®, applications to extruded and tape PTFE (used in radar, satellite and 5G applications). In the table below, the PTFE dielectric versions of flexible coax is used.

[3] CONNECTORS

The choice of connector styles begins for coax connectors in 1942 when Paul Neill of Bell Labs developed the N (for Neill) connector with a frequency range of DC – 11 GHz. Since that time, mainly connector vendors (e.g. Amphenol or Gilbert) or Analyzer manufacturers (e.g. Anritsu or Hewlett-Packard – now Keysight) have designed connectors. There are 2 main connection philosophies: thread-on with a coupling nut and push-on where the male connection is

either smooth-bore (no retention mechanism) or limited detent (partial retention mechanism or full detent (full retention mechanism). Most of the privately thread-on developed connectors have become defacto standards and are defined by either MIL-PRF-39012 and MIL-STD-348 (e.g. SMA, N, TNC, SSMA) or IEEE (g. 3.5 mm, 2.92 mm, 1.85 mm and 1.00 mm). The non-proprietary push-on connectors standardized typically by MIL-STD-348 (e.g. SMP, SMPM) or an industry coalition (e.g. MCX, MMCX).

There are sexless connectors (e.g. 7 mm) that are used in laboratory setting. Most of the coaxial connectors use a male and female design strategy which is more complex. All the connector styles with male and female contacts have a finite number of mating cycles: each cycle degrading slightly the plating on both contacts. The tines in the female socket are not designed such that the male pin may be subjected to a rotary motion.

The design of the connector dictates how many individually components there are, each with its own tolerance stack up. Having all the tolerances line up, either on the high side or the low side, can cause a performance degradation with the connector still being within specification. The design though is guided by the frequency so higher frequencies necessitate smaller parts, thinner component walls and mechanical couplings that can be easily over-torqued. The fine line between over and under torqueing creates a scenario that can easily create lower RF Shielding effectiveness and Insertion Loss suck-outs if the reference planes of the male and female connectors are not mated per the design.

Rectangular or circular cross section waveguides most often use flanges attached to both ends of lengths of waveguide to allow connection of the assembly to further lengths of waveguide or to equipment. The profile of the flange has to be as planar as possible, but can be machined to have slots, for example to accommodate with flexible gasket materials depending on whether the application needs to be pressurized (e.g. due to a long run to eliminate moisture) or highly sensitive to RF interference (e.g. any imaging application – MRI). Other options include resonant slots to provide an RF 'choking' effect to improve the shielding effectiveness of the mated flange connection. These flanges, when machined properly, are a highly efficient and repeatable method of transporting a signal through junctions and bends in the signal path. See Table 2.

Band	Freq (GHz)	WG size (mm)	WG Freq Range (GHz)	Coax size (mm)	Coax Freq Range (GHz)
UHF	.3 – 1	292 x 146	.5 – 1	17.8	0 – 7.3
S-band	2 – 4	72 X 36	2.1 – 4.1	17.8	0 – 7.3
X-band	8 – 12	23 X 11.5	6.6 – 13	10.5	0 – 12.8
K-band	18 – 27	10.8 X 5.4	14 – 28	5.2	0 – 27.4
V-band	40 – 75	3.8 X 1.9	40 – 78	2.4	0 – 79.2
W-band	75 – 110	2.5 X 1.25	60 – 118	1.4	0 – 110

Table 1: Coax and waveguide (WG) sizes versus frequency bands.

Band	Freq (GHz)	WG Style	Coax connectors (*partial list*)
UHF	.3 – 1	Rectangular, circular, square, with gasket, gasketless, 4 connecting screws, 8 connecting screws, use of precision dowel pins to assist alignment at higher frequencies	N, TNC, SMB, BNC, MCX
S-band	2 – 4		
X-band	8 – 12		
K-band	18 – 27		SMA, SMP, 3.5 mm
V-band	40 – 75		1.85 mm (67 GHz), SMPS (65 GHz)
W-band	75 – 110		1.0 mm

Table 2: Coax connectors and waveguide (WG) styles.

[4] RF SHIELDING AND LEAKAGE

RF Shielding is the measurement (in dB) of the ability of the cable construction to reject any spurious signal from becoming part of the waveguide's or coax's resident signal. RF Leakage is the measurement of any coax's or waveguide's signal that escapes the transmission path. The goal is that both these measurements are as small as possible.

Coax assemblies consist of the cable and the connectors. For a coax construction where the outer conductor is a solid tube – either semi-rigid or corrugated – there is no opportunity for any RF energy to escape or penetrate the cable. For this construction the areas of concern are the connector itself and the mated connector. A flexible coax is typically made of many layers of braided round wire and/or helically wrapped flat wire. More layers will provide greater RF Shielding/Leakage protection. At 5 GHz with the wavelength being 60 mm there is little opportunity for any RF energy that ½ or ¼ wavelength to escape. At 110 GHz the wavelength being 2.7 mm there is plenty of opportunity for RF energy that ½ or ¼ wavelength to escape. At these frequencies there are micro gaps in braid or helical in the cable where RF energy can escape or penetrate. In the connector, the various components have tolerances so there can fit together, and those small areas offer a path for RF energy to escape or penetrate.

Waveguide has the superior design to keep these measurements small with highly machined (and thus well-fitting) surfaces, a transmission path where are the signal is inside the transmission path and availability of special RF resistant gasket material that would further inhibit the radiation or penetration of RF signals.

[5] POWER

The power a coax cable assembly can support is typically limited by the power the connector is able to handle. While it is shown in the Frequency table above that a 5.2 mm diameter coax has a frequency range of 26 GHz and can handle 140 Watts, if the connectors are SMP then that cable assembly can handle 42 Watts; and if the connectors are SMA then the value is 80 Watts. In general, the lower frequency connectors (e.g. TNC, N - <18 GHz) can handle much more power than the corresponding cable so the cable will then be the limiting factor. There is not much need for power when the frequencies reach W-band though and there is no power requirement in the 1.00 mm IEEE standard.

In table 3 above, the waveguide chosen is WR187. This has a broad dimension of 1.87 inches (47.5 mm). In addition, the power denoted in the table is the peak power – that is generally the term used to define when arcing / voltage breakdown effects will occur. The power limit is determined by the average power that can be supported by the transmission line and referred to as the CW power. In this case, the highest power that can be supported is determined by RF heating effects determined, again, by conductor and dielectric losses. For waveguide and coax, the CW power rating is much lower than the peak power rating, and may have to be taken into account. As an example, the CW power rating of the WR187 example is 18 kW, versus the peak power rating of 3300 kW cited.

Frequency	Waveguide	Corrugated	Coax
5 GHz	3,300 Kilowatts	91 Kilowatts	2.2 Kilowatts
110 GHz	15.5 Kilowatts	NA	5.5 watts

Table 3: WR187 waveguide power parameters.

Band	Freq (GHz)	WG size (mm)	WG Loss (dB/M)	Coax size (mm)	Coax Loss (dB/M)
UHF	.3 – 1	292 x 146	0.0043	17.8	0.07
S-band	2 – 4	72 X 36	0.0367	17.8	0.153
X-band	8 – 12	23 X 11.5	0.215	10.5	0.476
K-band	18 – 27	10.8 X 5.4	0.69	5.2	1.47
V-band	40 – 75	3.8 X 1.9	1.763	2.4	6.203
W-band	75 – 110	2.5 X 1.25	4.43	1.4	16.07

Table 4: Attenuation characteristics for coax and waveguides with respect to size.

[[6] ATTENUATION

The attenuation of a coax assembly is directly proportional to the size of the center conductor. From the formula in the “Frequency” section above, the cut-off frequency (f_c) is inversely proportional to the combined diameters of the inner and outer conductors: as the cable becomes smaller the frequency increases along with a proportional attenuation increase.

Waveguide also follows the paradigm of “higher frequency means smaller size and higher attenuation” but since there is no center conductor and the supported fundamental mode (the TE_{10} mode), the attenuation behavior in practical waveguide is determined by the need to keep the operating frequency as high above the TE_{10} cut-off frequency as possible, but a practical amount below the cut-off frequency of the TE_{20} mode. This consideration leads to choices made in standards bodies for the practical operating frequency limits. At the two frequencies given for the WR284 waveguide above, the attenuation in high conductivity copper waveguide is 2.44 and 1.67 dB / 100 meters at 2.6 and 3.95 GHz respectively.

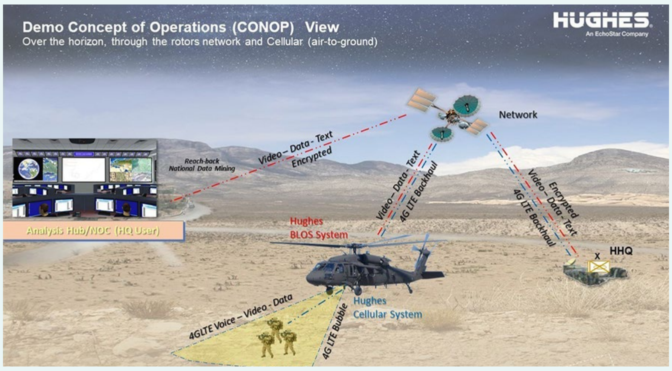
CONCLUSIONS

While the major characteristics of coaxial cable and waveguide have been compared in this article, this is not a complete comparison. There are obvious aspects such as flexibility, ruggedness and cost that are subjective in nature and the application proscribes either coax or waveguide.

Using a coax application sphere and a waveguide application sphere in a Venn Diagram approach; at lower frequencies (e.g. UHF – K-band) the two spheres would be separate whereas at high frequencies (e.g. V-band – W-band) the two spheres would closer and in some instances slightly overlapping. The article is meant to give some quantitative data and background for making a RF transmission transport decision for higher frequency applications.

As use of the millimeter wave bands increases due to applications such as 5G, consideration of the merits of transmission line options becomes necessary. This article has described two common transmission line options, some of the defining characteristics and when these and factors such as cost, flexibility, connector options, manufacturability and ease of installation are taken into account a very good case is made for the use of coaxial cable assemblies as a front runner for V-band, W-band, etc. applications.

LTE coverage using helicopters and UAVs



Hughes Network Systems in partnership with Virtual Network Communications (VNC) will extend mobile network connectivity using an integrated combination of deployable LTE technology from VNC with Hughes JUPITER™ and HM satellite systems. The new systems support various global LTE applications for government, militaries, first responders, and commercial Mobile Network Operators (MNOs).

"VNC developed this innovative, edge-centric approach to positively impact lives and keep critical missions connected. Additionally, a new 5G solution is on our development roadmap and we look forward to integrating it with the Hughes JUPITER platform," said Mohan Tammisetti, chief executive officer of VNC.

GOVERNMENT AND MILITARY

Designed to provide wireless coverage for soldiers or first responders, the new Hughes HeloCell™ integrates LTE technology from VNC with the Hughes HeloSat™, which provides Beyond Line of Sight (BLoS) communications on rotary-wing aircraft. For military and emergency applications, the Hughes and VNC technologies combine to form an "airborne cell tower" when installed aboard a helicopter or an Unmanned Aerial Vehicle (UAV). The system provides an extended cellular coverage radius of tens of kilometers, with the satellite terminal backhauling the mobile traffic to and from the network core. It can also scale to support more than 100 simultaneous active users on a single, layered system architecture.

"Adaptable for rotary-wing aircraft and UAVs, the HeloCell Solution is ideal for extending mobile connectivity in a disaster area or warzone," said Wayne Marhefka, senior director of business development for Hughes Defense Division. "Together with VNC, Hughes can extend connectivity to soldiers and first response teams who need wireless communications to carry out their missions, especially in remote and disconnected environments. Integrating with our innovative HM and JUPITER Systems technology, these new cellular capabilities will help the DoD build a layered and unified communications network architecture for faster and more-informed decision-making."

The VNC LTE technology can also be integrated with the JUPITER System to backhaul mobile traffic, enabling MNOs to quickly and cost-effectively provide 4G access to people in areas unserved or underserved by terrestrial connectivity.

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Material Properties to Consider when Choosing PCB Materials for 5G Base Stations

By John Hendricks, Market Segment Manager,
John Coonrod, Technical Marketing Manager, Rogers Corp

Wireless cellular communications have become a way of life for millions if not billions of users worldwide—so many users, in fact, that the demand for wireless services has created a need for the next, fifth generation (5G) of wireless cellular communications networks. Users no longer simply use their cell phones for voice communications. They have become essential components in wireless communications networks, linking users with voice, video, data, and all the functionality of a modern personal computer. This ever-increasing use of multiple wireless services, along with the growing number of cell phone users worldwide, is spurring the development of 5G wireless networks to fortify (and eventually replace) the cellular communications networks built before 5G, including Third Generation (3G), Fourth Generation (4G), and Fourth Generation Long Term Evolution (4G LTE) systems. Providers of 5G wireless services are already promising better, faster, more reliable performance.

Countless Internet of Things (IoT) wireless devices for commercial and industrial applications, such as in "smart" homes, offices, and factories, will be part of those 5G wireless networks, adding demands for wider bandwidths and higher data rates to support instant access to millions if not billions of IoT sensors. 5G technology will serve as a gateway for remote data access and control of anything connected to an IoT device, and as part of industrial automation systems and massive machine-type-communications (mMTC) applications. The International Telecoms Union radio communications sector (ITU-R), for example, has identified three main applications areas for 5G systems: enhanced mobile broadband (eMBB) communications, ultra-reliable low-latency (URLLC) communications, massive machine type communications (mMTC).

But first, 5G base stations must be constructed. In contrast to 4G wireless networks (Fig. 1), 5G cell sites will be smaller and more numerous, relying on lower-power transmissions over shorter distances to achieve widespread coverage. The use of higher frequencies and wider bandwidths in 5G compared to 4G will enable higher data rates and faster upload/download speeds. As with 4G. 5G wireless networks will depend on the military-like reliability of advanced cellular base stations, built on foundations provided by high-quality printed-circuit-board (PCB) materials. For many of the components in those base stations, such as power amplifiers (PAs) and antennas, a better understanding of PCB parameters can lead to an optimum choice of circuit materials for 5G base stations.

Figure 1: Base stations are being designed and constructed to bring advanced 5G wireless services around the world.

MATERIAL MATTERS

Differences between 4G and 5G systems (see table 1) require a fresh look when specifying the PCB materials for the building-block components of those systems, such as PAs and antennas. One of the most glaring differences between the two cellular wireless communication systems approaches is in their use of frequencies and bandwidths, with 5G taking advantage of available bandwidth at millimeter-wave frequencies. Millimeter-wave frequencies, so named for their actual physical wavelengths, extend from 30 to 300 GHz; 5G systems are also making use of microwave frequencies from 24 to 39 GHz and 0.6 to 4.9 GHz. The high millimeter-wave frequencies have traditionally been the domain of limited-user applications, such as in astronomy and satellite communications (satcom), although the pent-up demand for 5G services promises to bring millimeter-wave frequencies to the masses. The small circuit dimensions required at millimeter-wave frequencies have long represented difficult challenges for component and circuit designers, but improvements in PCB materials are helping to overcome those challenges.

These wide bandwidths at higher frequencies will also be accessed differently in 5G networks than in 4G systems, with 5G relying mainly on time-division duplex (TDD) methods for transmitting and receiving signals rather than the largely frequency-division-duplex (FDD) techniques used in 4G systems. The smaller 5G base stations will employ different architectures than 4G systems, with generally smaller components (including antennas and amplifiers) and higher levels of integration making miniaturization possible.

The different system-level design approaches applied in 5G require PCB materials that help optimize the performance of those approaches. For example, 5G systems will incorporate more active antennas than 4G systems, often integrated with other components such as couplers, attenuators, and PAs to achieve miniaturization. Multilayer circuit boards will also be used rather than simpler PCBs with double-sided conductive metallization to achieve miniaturization. The closely spaced sources of heat dissipation, such as active antennas and PAs, within such compact circuits will typically require

the use of flame-retardant (UL94-V0) circuit materials for safety and reliability.

The use of FDD transmissions in 4G systems requires tight control of generated signals and signal by-products, such as harmonic, spurious, and intermodulation to allow effective use of FDD techniques. As a result, many 4G systems targeted minimal passive-intermodulation (PIM) levels as essential requirements for any PCB materials used in 4G base stations, often calling for circuit materials based on extremely low-loss polytetrafluoroethylene (PTFE) dielectric materials to meet challenging minimum PIM performance levels, typically -163 dBc.

Several PCB material parameters provide insights into how well a material will perform at millimeter-wave frequencies, including dielectric constant (Dk), dissipation factor (Df), coefficient of thermal expansion (CTE), and temperature coefficient of dielectric constant (TCDk). Because of the high frequencies and small wavelengths at millimeter-wave frequencies, even excessive variations in PCB material thickness, copper conductor thickness, and uneven or rough surfaces of a PCB material's copper conductors can translate into performance variations for circuits fabricated on those materials.

Because of their small dimensions, circuits for millimeter-wave frequencies have traditionally been fabricated on low-Dk circuit materials, with Dk values of typically around 3. In special cases demanding miniaturization, circuit designers may require PCB materials with higher Dk values.

Due to the small wavelengths at millimeter-wave frequencies, the Dk must be controlled within the tightest tolerance possible across a PCB material to maintain consistemt impedance (usually 50 Ω) for the transmission lines of circuits fabricated on that PCB material. The Dk must also remain consistent with changes in environmental conditions, such as relative humidity (RH) and temperature since any variations in Dk will result in variations in transmission-line performance, with variations typically increasing with increasing frequency. A circuit material's TCDk parameter provides details on the consistency of the material's Dk across a measured temperature range, with low TCDk values representing the stable Dk with temperature needed for consistent transmission-line impedance at millimeter-wave frequencies.

When selecting PCB materials for multilayer assemblies, as in compact 5G base stations, CTE provides a means of estimating the effects of temperature on a multilayer hybrid circuit assembly, such as how each copper and dielectric layer will change across a designated temperature range. Ideally, all circuit dielectric and metal layers would have the same or similar CTE values, so that materials would expand and contract with changes of temperature by the same amounts and at the same rates. A goal is to keep differences in PCB material CTE values to a minimum.

The CTE of copper is about 17 ppm/°C, so an ideal dielectric layer would have the same CTE value or close. As an example, RO3003G2™ circuit material from Rogers Corp. (www.rogerscorp.com) is available with CTE values of 16, 17, and 18 ppm/°C in the x, y, and z axes of the PCB material, respectively. This close match to copper for all three axes results in high reliability of circuit features, such as plated through holes (PTHs) at high temperatures (such as in PAs) and across wide operating temperature ranges.

RO3003™ circuit material has been a regular choice of millimeter-wave circuit designers of automotive radar systems at 77 GHz for some time. RO3003G2 material (Fig. 2) is the optimized version of RO3003 laminate, formulated specifically for millimeter-wave applications. RO3003G2 laminate exhibits a low Dk of 3.00 that is maintained across a circuit board to a tight tolerance of ± 0.04 that is also stable with frequency to maintain consistent impedance of transmission lines at millimeter-wave frequencies. The material exhibits extremely low insertion loss when tested with microstrip transmission lines, even when compared to RO3003 laminate (Fig. 3). RO3003 and RO3003G2 laminates have low TCDk, indicating a minimal change in Dk with temperature changes. RO3003G2 laminate features low moisture absorption of 0.06% (water has a Dk of about 70, so even a

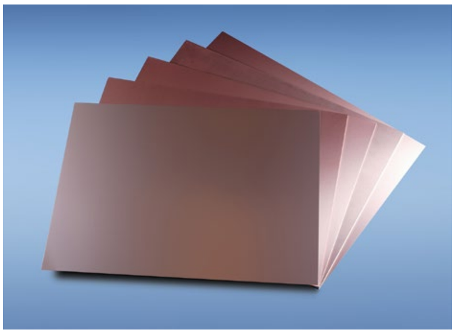


Figure 2: RO3003G2™ circuit materials provide the essential performance requirements needed for high performance at millimeter-wave frequencies.

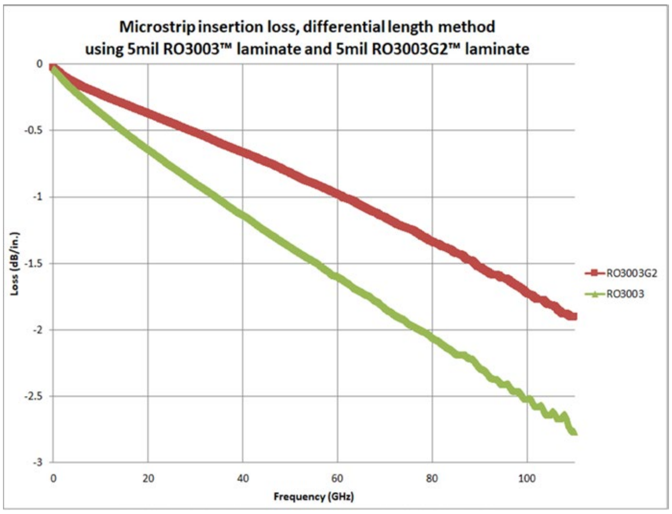


Figure 3: Both RO3003™ and RO3003G2™ circuit materials exhibit low insertion loss through 110 GHz when tested with microstrip transmission lines.

	4G and 4G LTE Wireless	5G Wireless
Frequency range	700 to 900 MHz 1800 to 2600 MHz	600 to 4900 MHz 24 to 39 GHz
Antennas	double-sided PCBs	multilayer PCBs
Antenna configuration	simple MIMO	massive MIMO
Duplex approach	FDD	TDD

Table 1: Comparing 4G and 5G wireless communications systems.

Material	Dk (at 10 GHz)	Df (at 10 GHz)	Key applications
RO3003G2™ laminate	3.00±0.04 (at 10 GHz)	0.0011	5G, automotive radar sensors
RO4003C™ laminate	3.38±0.05 (at 10 GHz)	0.0027	5G, wireless comms
RO4350B™ laminate	3.48±0.05 (at 10 GHz)	0.0037	5G, wireless comms
RO4450T™ laminate	3.35±0.05 (at 10 GHz)	0.0040	5G multilayer PCBs
RO4835T™ laminate	3.33 (at 10 GHz)	0.0034	phased-array radar, microwave links
TC350™ Plus	3.62 (at 10 GHz)	0.0017	sub-6-GHz amps, active antennas

Table 2: Sampling millimeter-wave circuit materials.

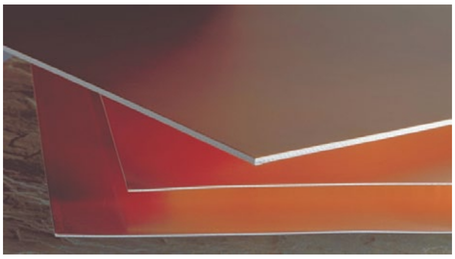


Figure 4: TC350™ Plus laminates provide outstanding thermal conductivity for the PAs and active antennas required for 5G base stations.

small amount of absorbed moisture can raise a PCB's Dk value).

Also effective at millimeter-wave frequencies, RO4835T™ ceramic-filled, hydrocarbon-based laminates exhibit stable Dk of 3.33 when tested at 10 GHz (see table 2). These low-loss materials have a Df of 0.0034. With low moisture absorption of 0.15%, these RoHS-compliant materials feature high resistance to the effects of oxidation, maintaining the consistent Dk needed at millimeter-wave frequencies, even in environments with high relative humidity (RH). RO4835T laminates serve as low-loss, high-frequency circuit layers in multilayer circuit assemblies, for example with FR-4 circuit layers. When used to combine circuit layers, RO4450T™ materials are low-loss bonding materials that can be used in conjunction with RO4835T laminates

At lower frequencies in 5G base stations, TC350™ Plus laminates from Rogers Corp. are well suited for PAs and active antennas (Fig. 4). They combine PTFE, thermally conductive ceramic fillers, and woven glass reinforcement into circuit materials with outstanding thermal conductivity, for use in high-power, high-temperature circuits at high frequencies. TC350 Plus materials feature a strong bond between dielectric materials and low-profile copper layers, achieving thermal conductivity of 1.24 W/mK with a Dk of 3.50 at 10 GHz.

These materials defy the usual tradeoff of sacrificing loss performance for improved thermal conductivity by delivering low Df (loss tangent) of 0.0017 at 10 GHz. TC350 Plus circuit materials maintain the consistent Dk characteristics needed for consistent impedance at millimeter-wave frequencies, with low water absorption of 0.05% and TCDk of -42 ppm/°C. The materials have CTE of 38 ppm/°C to achieve reliable PTHs and low-stress solder joints even for PAs exhibiting large temperature variations. Well suited for thermally sensitive active and passive microwave and millimeter-wave circuits and components, the circuit materials are available in panel sizes as large as 48 × 54 inches for design and production flexibility.

For the lowest loss applications at millimeter-wave frequencies, circuit materials such as RO3003™ and RO3003G2™ substrates provide the unmatched Df behavior needed to minimize loss especially at such high frequencies. At lower frequencies, such as 6 GHz and below, TC350™ Plus materials offer the enhanced thermal conductivity needed for the high levels of integration of active antennas and PAs needed to ensure that 5G base stations will be small enough to be "heard and not seen."

Virtual Antenna™: Easy Design of IoT Devices with Embedded Antennas

By J. Anguera, A. Andújar, C. Puente, Fractus Antennas, Barcelona, Spain

INTRODUCTION

Smart sensors, smart meters, smart tracking, smart factories, smart agriculture and all possible smart things you can imagine need to be connected. IoT enables connecting things with other things, in consequence a relevant player is needed which transmits and receives data to and from each thing: an IoT antenna.

Wireless engineers working on the development of the all the new bunch of IoT devices are looking for the best IoT antenna: the one covering all desired bands, with the smallest footprint and with the highest efficiency. On top of this, the antenna needs to be integrated in the design with other radiofrequency components such as modules, amplifiers, and filters, therefore, why not treat it as just another component?

Virtual Antenna™ technology enables one antenna component to cover all IoT frequency bands. The antenna called antenna booster is a very small chip antenna component able to be tuned to any frequency worldwide as needed. And because it is off the shelf, no customization on the antenna part will be needed so the IoT architecture becomes predictable from day one and is the ideal solution for mass production.

This paper presents the main features of Virtual Antenna™ technology and shows a simple design flow comprising only three simple steps on how wireless design engineers can embed Virtual Antenna™ in IoT devices.

VIRTUAL ANTENNA™ FEATURES

Virtual Antenna™ technology is based on replacing a complex and usually customized antenna designs with an off-the-shelf, miniature and multiband component called an antenna booster (Figure 1). Being surface-mount and chip-like in nature, the antenna booster fits seamlessly in an electronic printed circuit board the same way any other electronic component (an amplifier, filter or switch, to name a few) does. Virtual Antenna™ gets this name from the fact that an antenna booster, when is strategically placed on a device's PCB (Printed Circuit Board), can boost currents on the ground plane of the PCB to make it an effective radiator [1]-[6]. Consequently, the size of an antenna booster can be very small compared to other conventional multiband antennas (Figure 1). For example, the antenna booster shown in Figure 2 has a size of 12 mm x 3 mm x 2.4 mm which in terms of the wavelength, represents only λ/30 at 824 MHz referred to its longest dimension of 12 mm. This tiny and versatile component has been recently adopted, among other IoT devices, in the open-source hardware platform mangOH™ Yellow, a super sensor for cellular industrial IoT.

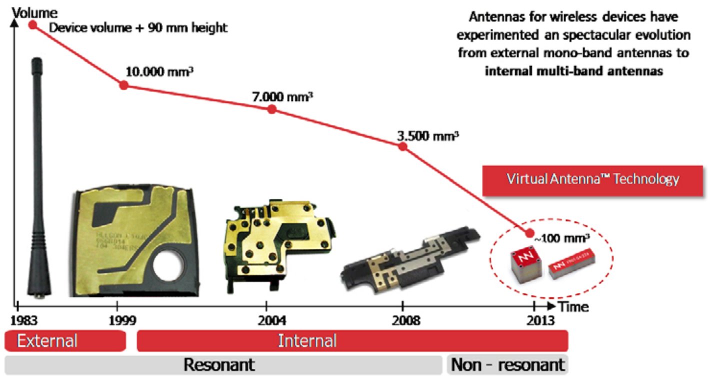


Figure 1: Antenna boosters are tiny SMD antenna components featuring small size about 100mm^3 and able to operate at any band within the frequency range from 698 MHz to 6 GHz.

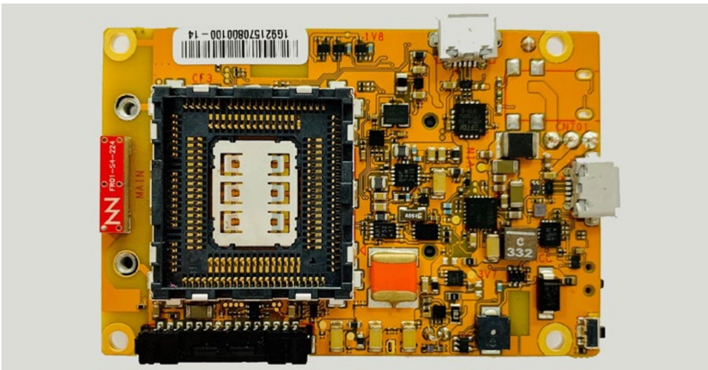


Figure 2: Antenna booster RUN mXTEND™ embedded in the IoT platform mangOH™ yellow. The antenna booster being an SMD component means it can be easily assembled with a conventional pick-and-place machine.

Besides its small size, Virtual Antenna™ features multiband operation in the frequency range from 0.698 GHz up to 6 GHz. To achieve either single or multiband operation, a matching network is combined with an antenna booster with a totally passive solution since the matching network comprises lumped components (inductors and capacitors). In some particular devices where the size of the device is small (~50 mm), architectures using smart matching networks can be combined with Virtual Antenna™ as well [7]. A recent IoT platform adopting this technology is the Thingy:91 by Nordic Semiconductor which is a multi-sensor prototyping kit ideal for kick starting cellular IoT projects.

An antenna booster can be assembled with a conventional pick-and-place machine, making the manufacture and design of the new generation of IoT wireless devices simpler, faster and more cost effective (Figure 2).

EASY DESIGN OF IOT DEVICES WITH EMBEDDED ANTENNAS IN THREE STEPS

Virtual Antenna™ enables the integration of embedded antennas in IoT devices in three simple steps. Following these basic steps, wireless engineers designing IoT devices, can easily embed an antenna.

#Step 1: The first step is to place the antenna booster in the PCB of the device. As a recommended rule, the preferred positions are the corners of the ground plane of the device (Figure 3). In this situation, bandwidth and efficiency can be maximized which is especially attractive for multiband applications such as for example devices operating at 698 MHz - 960 MHz and 1710 - 2690 MHz for instance. However, in other situations, where bandwidth is not a constraint, such as in single band applications, for example ISM (BW~3%), GNSS (BW~3%), Bluetooth (BW~3%), others positions different than the corners can be used as well.

It is important to emphasize that antenna location should be determined at the very beginning of a device design project in order to optimize performance of the antenna within the device. Otherwise, performance can be poor and difficult to improve in more advanced phases of a project. This means that the antenna performance should not consider the antenna only: the performance depends on the antenna in combination with the device. Therefore, a correct selection of the antenna booster location will optimize radiofrequency performance in terms of transmitted and received power.

#Step 2: The next step, step 2, is to design a matching network. Since the input impedance of an antenna booster is mainly reactive across the frequency bands of operation, a matching network is needed to maximize the radiated power into space and maximize the received power from space (Figure 4). This design flow differs from the traditional antenna design where the antenna geometry is customized depending on the frequency bands of operation [8]. For Virtual Antenna™ instead, the only customization needed is for the matching network, resulting in a faster and easier design flow. In effect, the design of a matching network can be fully automatized by using network synthesis tools available in most of microwave circuit simulators used in the wireless industry such as the following synthesis network tools: the NI AWR software offered by National Instruments and the Optenni-Lab offered by Optenni [9]-[10].

Thanks to this design flow, an antenna booster can operate at any band and in any device by just designing a suitable matching network. For example, if we have an IoT device that needs operation at the NB-IoT 900 MHz band, a simple L-type matching network can work (Figure 5). However, if the device needs to operate at several LTE bands, the same antenna booster as previous case is used but with a different matching network (Figure 6).

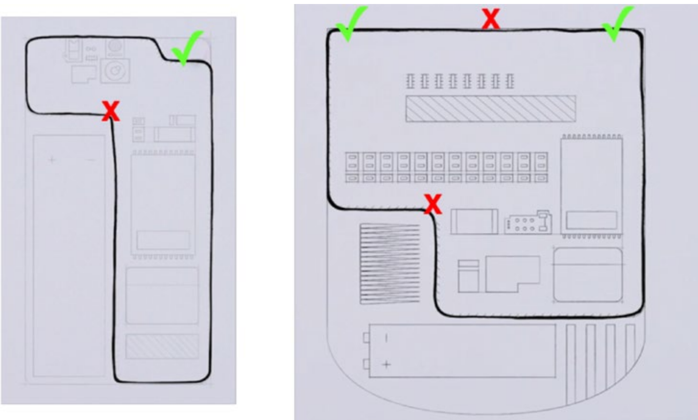


Figure 3 Illustrations showing the preferred (✓) and non-preferred locations (X) for an antenna booster.

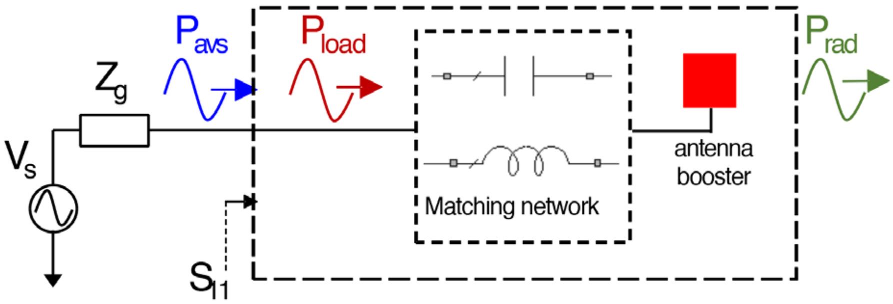
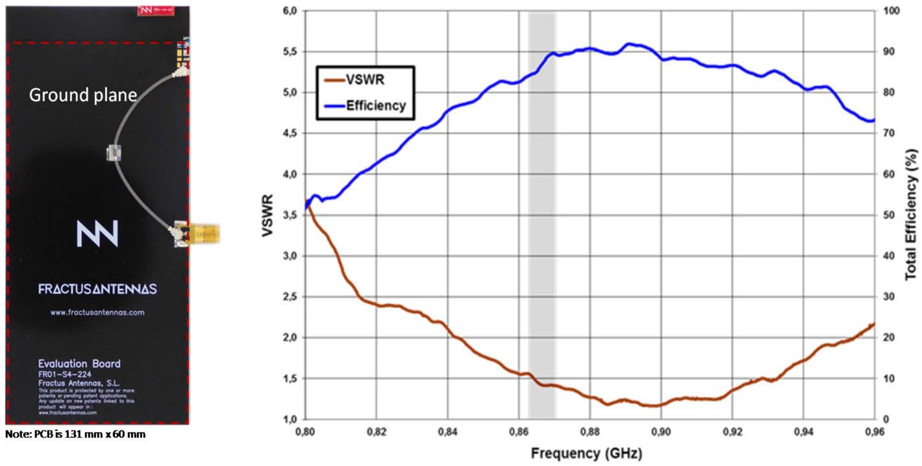


Figure 4: A matching network is designed and located between a radiofrequency module (represented by the source Vs and impedance Zg) and the antenna booster.

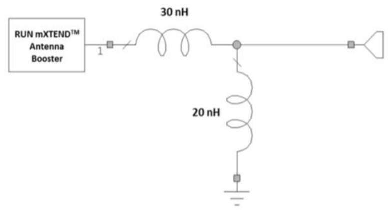
As seen from these two examples, the antenna booster is the same component for both cases, and the only part that changes is the matching network design for each case. Therefore, a new antenna design is not needed for each situation since the same antenna booster can be used for any band. Furthermore, if the PCB size changes, the same design flow applies, that is, the antenna booster can be the same and only the matching network is designed to operate at the desired number of bands [11]. Consequently, this is an advantage for wireless engineers that need to embed an antenna in their devices since the antenna booster remains the same and there is no need to choose a different antenna to integrate in all their different devices. Also, this represents an economy of scale advantage since same antenna booster can be integrated across different platforms.

#Step 3: The third step in the design flow is to test the device. Once the matching network has been implemented into the device's PCB, VSWR and efficiency must be tested. VSWR can be tested with a vector network analyzer (VNA) providing information about VSWR (or S_{11}). By measuring VSWR (see examples at Figure 5 and Figure 6), the wireless designer knows how well the matching network and the antenna booster behave. Usually the VSWR results of less than three are preferred across the frequency bands of operation. Compact VNA are available in the market for testing VSWR such as those offered by Rohde&Schwarz.

Once, the VSWR achieves a specified target, total efficiency must be tested which is carried out with the device inside an anechoic chamber (Figure 7). Total efficiency is the ratio between the power radiated into space (P_{rad}) over the available power of the radiofrequency module (P_{avs}) – (Figure 4). Although VSWR measurement provides a good sense on how well then antenna system is behaving, total efficiency will inform on how much power from the module is radiated into space and how much is lost in nearby components, materials, and components of the matching network. Total efficiency is, therefore, a relevant figure of merit to be sure that the device will be competitive in the market. Moreover, when total efficiency is measured taking the full device parts (the PCB including the antenna booster, the matching network as well as battery, displays, casing, etc.)

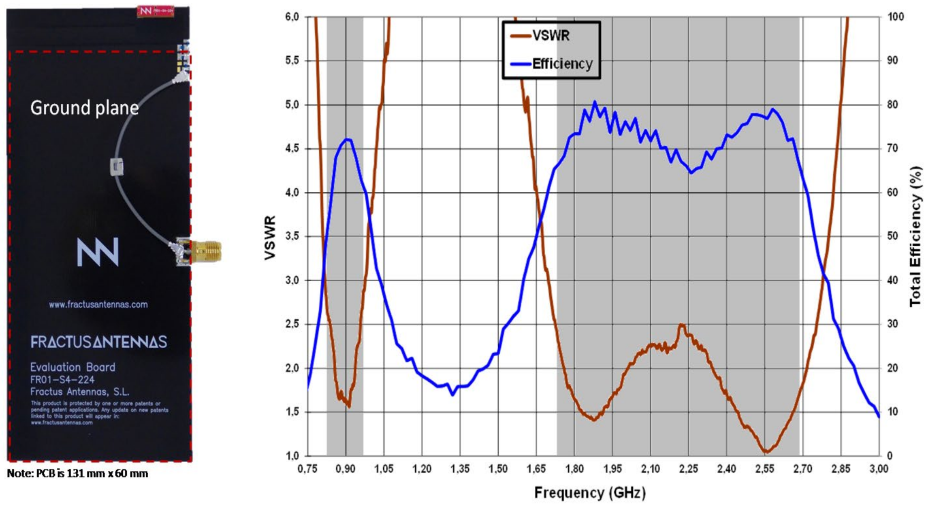


863 – 870 MHz

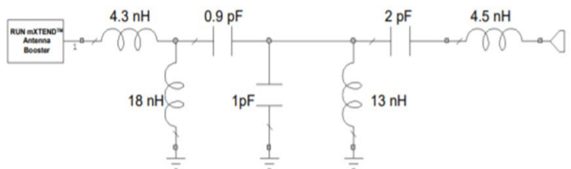


Value	Part Number
30 nH	LQW18AN30NG00
20 nH	LQW18AN20NG00

Figure 5: (Top left) An antenna booster (12 mm x 3 mm x 2.4 mm) with a matching network comprising two lumped SMD components for operation at 900 MHz (Bottom). (Top right) Measured VSWR and total efficiency.



824 – 960 MHz and 1710 – 2690 MHz



Value	Part Number
4.3 nH	LQW15AN4N3B80
18 nH	LQW18AN18NG10
0.9 pF	GJM1555C1HR90WB01
1 pF	GJM1555C1H1R0WB01
13 nH	LQW15AN13NG00
2 pF	GJM1555C1H2R0WB01
4.5 nH	LQW15AN4N5B80

Figure 6: (Top left) An antenna booster with a multiband matching network comprising seven SMD lumped components for operation at 824 MHz - 960 MHz and 1710 MHz - 2690 MHz (Bottom). (Top right) Measured VSWR and total efficiency.

provides information about the TRP (Total Radiated Power) which is used in many wireless device certifications (eq. 1) such as PTCRB certification. TRP is linked to total efficiency as shown in eq.(1):

$$TRP(dBm) = P_{out}(dBm) + 10\cdot\log(\text{total efficiency}) \quad eq(1)$$

where Pout is the nominal output power from the radiofrequency module.

For example, imagine we have a radiofrequency module with a nominal output power of 23 dBm and to certify the product, the TRP should be above 18 dBm, this means that the total efficiency must be above 31.6%.

This reveals that total efficiency is a parameter of paramount relevance. In this sense, Virtual Antenna™ can easily control how to optimize total efficiency in a product certification since if any adjustment needs to be done, this can be addressed by adjusting the matching network. Adjusting the antenna design in this situation will put the project at risk since a new design takes weeks of works which is critical at this stage. On the contrary, Virtual Antenna™ has the flexibility to simply adjust the matching network, which is faster and easier and at the end, this is an efficient process which is very convenient for wireless design engineers developing IoT devices.

Figure 7: Anechoic chamber for testing total efficiency - full 3D pattern is measured.

CONCLUSIONS

Virtual Antenna™ enables the wireless designer to easily embed a tiny antenna component in IoT devices. This tiny antenna component is called antenna booster being around 100 mm^3, up to ten times smaller than traditional customized antennas. Besides being very small, an antenna booster can operate at any band in the range 0.698 GHz - 6 GHz by only designing a matching network.

A simple design process comprising three steps enables to embed antenna booster in IoT devices: antenna booster placement, design of the matching network, and testing the full device with the embedded antenna booster.

Antenna placement is an important decision that need to be taken at the very beginning of a device design in order to optimize performance. The performance of an embedded antenna should be considered along with the device and not by considering the antenna only; the behavior is at the end, determined by the antenna and the device together.

The design of a matching network is easily systematized with a microwave circuit simulator which makes the design flow the same procedure as a matching network for an amplifier. This facilitates wireless engineers to embed an antenna into an IoT device since it does not require antenna expertise but circuit design skills instead. This design flow is very flexible since if any mechanical change on the device affects the antenna performance, the antenna does not need to be redesigned but only the matching network must be tuned. This is a faster, easier and cheaper design flow.

Finally, an antenna booster is an off-the-shelf component ready to be used and being a SMD component is compatible with typical pick-and-place mounting machines.

REFERENCES

[1] J. Anguera, A. Andújar, C. Puente, J. Mumbrú, "Antennaless Wireless Device", US Patent 8,203,492, August 2008.

[2] J. Anguera, A. Andújar, C. Puente, and J. Mumbrú, "Antennaless Wireless Device capable of Operation in Multiple Frequency regions," US. Patent 8,736,497, August 4, 2008.

[3] A. Andújar, J. Anguera, and C. Puente, "Ground Plane Boosters as a Compact Antenna Technology for Wireless Handheld Devices," IEEE Trans. Antennas Propag., vol.59, no.5, pp.1668-1677, May 2011.

[4] J. Anguera, N. Toporcer, and A. Andújar, "Slim bar booster for electronics devices," US Patent 9960478 (B2), July 2014.

[5] J. Anguera, A. Andújar, and C. Puente, "Antenna-Less Wireless: A Marriage Between Antenna and Microwave Engineering," Microwave Journal, vol.60, no.10, October 2017, pp.22-36.

[6] A. Andújar and J. Anguera, "Integration of a Non-Resonant Antenna in a Smartphone for Multiband Operation," European Conference on Antennas and Propagation, EUCAP 2018, London, UK, April 2018.

[7] J. Anguera, A. Andújar, J. L. Leiva, C. Schepens, R. Gaddi, and S. Kahng, "Multiband Antenna Operation with a Non-Resonant Element Using a Reconfigurable Matching Network," European Conference on Antennas and Propagation, EUCAP 2018, London, UK, April 2018.

[8] J. Anguera, C. Picher, A. Bujalance, and A. Andújar, "Ground Plane Booster Antenna Technology for Smartphones and Tablets," Microwave and Optical Technology Letters, vol.58, no. 6, pp.1289-1294, June 2016.

[9] D. Vye, "Network Synthesis Wizard Automates Interactive Matching-Circuit Design", Microwave Journal, Nov. 2018, pp.96-102.

[10] J. Juntunen, J. Järveläinen, and D. Linden, "MIMO Dual-Band WiFi Antenna Using NI AWR Software, Optenni Lab, and Premix PREPERM Materials," MMee, March-April 2019, pp.12-14.

[11] A. Andújar, J. Anguera, and R. Mª Mateo, "Multiband Non-Resonant Antenna System with Reduced Ground Clearance," European Conference on Antennas and Propagation, EUCAP 2017, Paris, France, April 2017.

First Rust programming language app for IoT SiP

Product design and engineering consultancy 42 Technology has announced what it claims to be the world's first Rust programming language application for a single-chip Internet of Things (IoT) device.

This software achievement could accelerate the development of more robust and secure low cost, low powered cellular IoT products and systems, and play a critical role in unlocking significant new markets for smart industrial and consumer products. For example in areas such as real-time asset tracking and monitoring, utility metering and smart city technology.

Rust is a very-high-performance alternative to systems programming languages such C and C++, which avoids the memory safety issues that plague those languages, and without the complexity and overhead of Java.

42 Technology's application demo is based around the recently launched Nordic Semiconductor nRF9160 System in Package (SiP) device, which features a full multimode LTE-M/NB-IoT modem to connect to the mobile network, assisted GPS and an ARM Cortex-M33 processor. The ARMv8-M architecture's TrustZone security features are particularly exciting, allowing applications and associated services to operate securely, protected from hacking, misuse and corruption.

In recent field trials, 42 Technology's Rust application made secure encrypted connections to Amazon cloud services via an early LTE Cat-M network that is being rolled out across the UK by O2, the mobile network operator. The board also supports NB-IoT which is being launched by Vodafone and other operators.

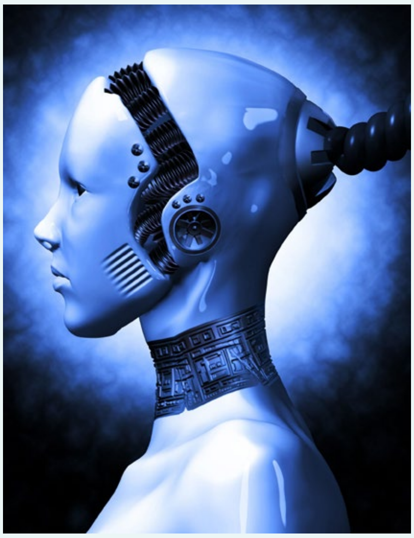
"42 Technology has specifically developed its Rust-based application to demonstrate an easier and faster way for companies to develop new products for the cellular IoT revolution but without inadvertently compromising on security. Our aim is to help eliminate the security vulnerabilities that too many people have seen, for example, with low cost home security cameras, smart hubs and with medical equipment such as insulin pumps," said Jonathan Pallant, the senior consultant who led the application development programme at 42 Technology and is also a founding member of the Rust Embedded Working Group.

Rust is the perfect programming language to run on very small and low-cost hardware, and was specifically designed from the outset with a focus on memory-safety. It gives developers modern, powerful tools to allow them to be highly productive – without incurring significant run-time overhead – and because of the strict type-checking and borrow-checking, the Rust compiler is able to highlight potential issues early in the development process.

www.42technology.com

Next gen video codec standard for machines

Gyrfalcon Technology Inc., along with China Telecom, have proposed a next generation video codec called, "video coding for machines" (VCM), which provides compression coding for machine vision, as well as compression for human-machine hybrid vision.



A new group will establish the VCM standard. Patrick Dong of Gyrfalcon Technology was appointed as the Co-Chair of the new group, with Yuan Zhang, of China Telecom, who was appointed as the Chair of the new group. Together they will lead VCM group to establish a new video codec standard that will improve the previous generation video coding and decoding standard H.26x.

According to sources at China Telecom, they will rapidly promote this new VCM standard, develop chips based on it and deepen the application for its broad use in the Internet of Things ecosystem.

There is a growing awareness that the majority of video traffic will be used by machines. According to recent information published by Cisco in 2018, Machine-to-Machine applications will represent the greatest usage of Internet video traffic over the next four years. This means that optimizing video data for machine use will be a key driver for commercializing new solutions and enabling mass adoption and innovation.

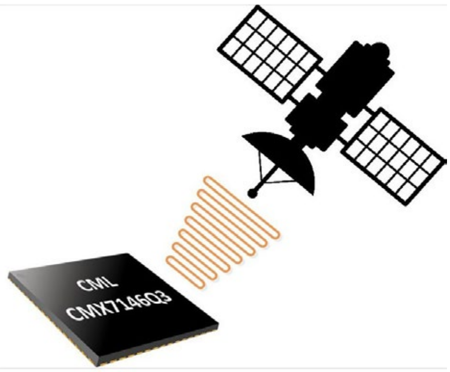
This is a critical step for many industries, as for more than 40 years, MPEG has taken the global lead in producing mainstream digital media standards and enabled the development and success of digital media products, services and applications. From inception, MPEG has spawned nearly 180 standards, including the well known, H.264 (AVC), H.265 (HEVC) and H.266 (VVC) (under development, launched in 2020) standards. The value generated by these essential MPEG standard patents with core codecs is quite high.

Gyrfalcon Technology has been active in the MPEG standards for more than two years, and has been recognized by industry analysts for technology innovations leveraging artificial intelligence and deep learning. In addition, China Telecom conducted extensive research on various video-coding technologies for machine vision and human-machine hybrid vision. China Telecom looked at the data intensive environment of wireless and the emergence of 5G, together with AI, deep learning, feature extraction and video analysis together with existing video processing and coding technologies.

www.gyrfalcontech.ai

BPSK wireless data modulator

simplifies design



CML Microcircuits Ltd has introduced the CMX7146, a flexible data modulator that simplifies the design of transmit-only solutions using BPSK (binary phase shift keying) and differential BPSK modulation (also referred to as PRK, phase reversal keying, or 2PSK).

The data modulator generates precise baseband analogue in-phase and quadrature signals with programmable signal filtering. This generates with high accuracy a signal ready for transmission and suitable for up-conversion to an RF carrier of the user's choice.

Compared to other BPSK systems, the CMX7146 offers greater flexibility, with better support for low speed BPSK modulation. It provides extensive configuration in terms of data rates and modulation shaping, while enabling users to customize transmit frequencies and channel bandwidths using an external RF modulator.

By contrast, alternative products on the market leave customers to develop their own discrete systems, which requires both RF and DSP programming knowledge. The integrated approach provided by the CMX7146 data modulator accelerates time to market, without the need for specialist knowledge.

BPSK is often used when durable, long range communication is needed. Its benefits include being relatively simple to demodulate and also extremely power efficient. These features have seen BPSK widely adopted for satellite applications (most recently in CubeSats), marine search and rescue (SAR) beacons and Industrial Internet of Things (IIoT) transmitters.

The CMX7146 data modulator supports raw (bits in, modulation data out) and preloaded (messages in, modulation data out) transmissions and features a transmit trigger input to enable precisely timed data transfers. A power amplifier ramping DAC can be employed to control transmission bursts, which can be synchronized as part of the transmit sequence. To increase flexibility in sensor interfacing and IIoT solutions, the CMX7146 integrates low power analogue to digital converters and four GPIO interfaces.

The CMX7146 is based on CML's proven FirmASIC® technology, where device functionality is defined by a small configuration file that is loaded at power-up. This increases the flexibility and lifetime of an end-product, by taking advantage of future functionality upgrades provided by CML, such as alternative modulation schemes or over air protocols.

The CMX7146 operates from a single 3.3V supply and is provided in a space-saving 48 lead QFN package.

www.cmlmicro.com

Armored VNA test cables

target instrumentation

SAGE Millimeter has released a new line of cost effective, instrumentation grade, flexible, armored VNA test cables in either 1.85 mm, 2.4 mm, 2.92 mm, or 3.5 mm with an NMD female and a female or NMD male connector.

The coaxial test cables are especially designed and manufactured for VNA applications with greater than 10,000 connections. The coaxial cable utilizes the highest quality test instrumentation grade cable and a precision manufacturing process to guarantee superior microwave performance and mechanical durability. The impedance of these cables is 50 ohms.

The models offered can form a VNA test cable pair for custom test set applications:

- STQ-CW-VFVF025-F1 and STQ-CW-VFVM025-F1 cover DC to 67 GHz with a 1.85 mm NMD female and a 1.85 mm female or NMD male connector.
- STQ-CW-2F2F025-F1 and STQ-CW-2F2M025-F1 cover DC to 50 GHz with a 2.4 mm NMD female and a 2.4 mm female or NMD male connector.
- STQ-CW-KFKF025-F1 and STQ-CW-KFKM025-F1 cover DC to 40 GHz with a 2.92 mm NMD female and a 2.92 mm female or NMD male connector.
- STQ-CW-3F3F025-F1 and STQ-CW-3F3M025-F1 cover DC to 26.5 GHz with a 3.5 mm NMD female and a 3.5 mm female or NMD male connector.

Other connector type combinations and lengths are offered under different models.

www.sagemillimeter.com

Front-end modules

for Bluetooth® IoT applications

Skyworks has introduced the SKY66118-11 and the SKY66407-11, which are 2.4 GHz front-end modules (FEMs) for Bluetooth® Internet of Things (IoT) applications including smartwatches, trackers, connected home systems, wireless and gaming headsets and more.

These low power FEMs significantly improve range (more than 2X) when compared to standalone system-on-chip (SoC) implementations, and efficiently deliver more power to the antenna, thereby minimizing or potentially eliminating any required antenna matching network. The FEMs also integrate power amplifier output matching, harmonic filtering, and bypass path switching which enable flexible and innovative end product designs for space-constrained IoT applications.

The SKY66118-11 is a high-performance, fully integrated RF front-end module (FEM) designed for Bluetooth, Zigbee®, and Thread applications.

It is designed for ease of use and maximum flexibility. The device integrates a +20 dBm power amplifier, RF switches, output matching, and harmonic filtering. Using simple 2-pin GPIO control, the FEM supports three modes of operation (transmit mode, bypass mode, and an ALL OFF sleep mode). The output power can also be externally adjusted through the VCTRL pin.

A low transmit current consumption and operation over a wide supply range enable the FEM to be used with a direct battery connection, supporting a wide range of battery discharge voltages.

The SKY66407-11 is a highly integrated front-end module (FEM) designed for Bluetooth IoT applications operating in the 2.4 to 2.4835 GHz range. The device is provided in a 1.2 x 1.2 x 0.35 mm 9-pin CSP package.

www.skyworksinc.com

Phase shifters

cover nearly any requirement up to 40 GHz

A comprehensive range of coaxial and waveguide phase shifters manufactured by L3 Narda-ATM is now available to microwave design engineers through Basingstoke-based Link Microtek.

Covering microwave frequency bands all the way up to 40 GHz, the phase shifters come in both coaxial and waveguide styles and can be specified with digital counting dial, direct reading dial and servo motor control options. A number of models are specifically designed for use in Ka-band systems.

Ideal for adjusting the phases of elements within a phased array antenna system, the devices are primarily aimed at military or commercial radar applications and can also be used for drive feed balancing on high power amplifiers, as well as general test-and-measurement applications.

The coaxial phase shifter line includes units with minimum adjustable phase shifts of 30, 40, 60, 90, 180 and 360 degrees/GHz. Featuring low insertion loss, the devices have maximum VSWRs ranging from 1.3:1 to 2.0:1, while power-handling capability is specified as 100-W average and 3-kW peak.

They are housed in sturdy aluminium enclosures with a corrosion-resistant epoxy coating and use SMA, Type N or 2.92-mm stainless-steel coaxial connectors. On standard models the phase shift is adjusted via a rotating control knob, with the position fixed by means of a lock nut.

The waveguide phase shifters, meanwhile, are available in both low-power and high-power versions offering minimum phase adjustment from 0 to 360 degrees, with low insertion loss and low VSWR. Covering waveguide sizes from WR28 to WR137, the low-power models feature a maximum RF power rating of 100-W (CW), while the high-power models can handle maximum average powers ranging from 160 to 11500-W and peak powers from 18 to 2500-kW, depending on waveguide size.

www.linkmicrotek.com

Digital scope

boasts 2GHz bandwidth for real time eye diagrams

The MSO8000 digital oscilloscope series from Rigol offers bandwidths from 600 MHz, 1 GHz and 2 GHz and a maximum sampling rate of 10 GS/s. Ideal for high speed and instantaneous signal acquisition and analysis, the instruments feature a 10.1 inch capacitive color touch screen with 256 intensity levels and color grade for precise and clear signal presentation. For recording and processing of measuring large amounts of data, a memory depth of up to 500 million points is available, and with a waveform capture rate of up to 600,000 wfms/second, the user can capture, display and evaluate fast signal sequences with up to 450,000 frames.

The MSO version of the high-end digital oscilloscope has also been extended with additional professional functions. The instruments feature a new integrated measurement method with real-time eye diagram and jitter analysis software, highlighting the jitter trend for digital analysis. Versatile Trigger, Math and Displaying features and integrated signal search function are available.

All Serial Bus protocol analysis (Decode/Trigger-Options), build-in voltmeter, counter, totalizer, protocol analyzer and an 2-channel arbitrary function generator complete the integration of 7 in 1 instruments. Various interfaces such as USB Host, USB Device, HDMI, LAN, USB-GPIB (adapter), and AUX OUT are available.

A full range of active and passive probes, high-voltage probes and 19-inch mounting frames, software drivers for popular packages and high-level languages, as well as free UltraScope operating software and web remote control are also available.

www.rigol.eu

Largest FPGA

with 9-million system logic cells

Xilinx has expanded its 16-nm Virtex® UltraScale+™ family to now include the largest FPGA, the Virtex UltraScale+ VU19P, which features 35 billion transistors.

The VU19P FPGA provides the highest logic density and I/O count on a single device ever built, enabling emulation and prototyping of the most advanced ASIC and SoC technologies, as well as test, measurement, compute, networking, aerospace and defense-related applications.

The VU19P sets a new standard in FPGAs, featuring 9 million system logic cells, up to 1.5 terabits per-second of DDR4 memory bandwidth and up to 4.5 terabits per-second of transceiver bandwidth, and over 2,000 user I/Os. It enables the prototyping and emulation of the most complex SoCs being designed by engineers today as well as the development of emerging, complex algorithms such as those used for artificial intelligence, machine learning, video processing and sensor fusion. The VU19P is 1.6X larger than its predecessor and what was previously the industry's largest FPGA — the 20 nm Virtex UltraScale 440 FPGA.

The FPGA is supported by an extensive set of debug, visibility tools, and IP, providing customers with a comprehensive development platform to quickly design and validate next-generation applications and technologies. Hardware and software co-validation allows for developers to bring up software and implement custom features before physical parts are available. Moreover, the design flow can be co-optimized by using the Xilinx Vivado® Design Suite, which reduces cost and tape-out risk, and improves efficiency and time-to-market.

The VU19P will be generally available in the fall of 2020.

www.xilinx.com

Reference kit speeds LoRa IoT development

Smart Building Reference Kit from Semtech is a collection of tools designed to accelerate the development of smart building systems based on LoRa devices and the LoRaWAN protocol.

The kit will allow users to monitor doors and windows, desk and room presence, environmental conditions, and detect water intrusion. It comes complete with more than 20 sensors, two gateways and a global 4G hotspot for simplified setup.

The portable nature of the kit allows users to move sensor locations to assess completeness of network coverage. LoRa's ability to cover deep indoor locations within a building's structure and offer long battery life make it the preferred technology for today's smart building projects.

Through the creation of a self-contained kit, Semtech aims to simplify the testing of LoRa-based products in a smart building environment and continue to support LoRa-based developers and end users.

www.semtech.com

LXI-based portable 16 channel AWG

The latest Arbitrary Waveform Generator (AWG) family from Spectrum Instrumentation is based on the LXI instrumentation standard and has been created for engineers and scientists that need to simultaneously generate up to 16 precise electronic signals. Small and compact, the AWG units are well suited for automated testing or remote-control type applications that need portability.

With six new instruments being released, users are offered a wide choice of configurations and performance levels. All the units feature the latest 16 bit digital-to-analog converter (DAC) technology and combine this with low-noise flexible outputs; allowing them to generate almost any test signal in the DC to 60 MHz frequency range. Furthermore, full remote control of the AWG is achieved through a simple Ethernet connection to any PC or local area network (LAN) making them easy to integrate into virtually every test system.

The DN2.65x series of generator NETBOX instruments are available with 4, 8 or 16 fully synchronous channels and offer output rates of 40 MS/s or 125 MS/s. Signals with a programmable output swing of up to ±6 V into high impedance or ±3 V into 50 Ohms can be generated. The units also include large on-board memories of up to 2 x 512 MSamples that can be utilized in a number of different operating modes to allow the generation of long and complex waveforms. This includes Single-Shot, Loop, FIFO, Gated and Sequence Replay modes. Signals can even be generated while new waveform data is being loaded to the on-board memory.

For perfect waveform generation, each channel of the AWG is clocked using a phase locked loop (PLL) control system that can be generated internally or from an external clock or reference. Four different filters are available to optimize the output signal quality and help ensure excellent dynamic performance. For example, Noise Spectral Density (NSD) is as low as -142 dBm/Hz, Total Harmonic Distortion (THD) is down to -74 dB, Signal to Noise Ratio (SNR) is as high as 90 dB and Spurious Free Dynamic Range (SFDR) is up to 97 dB. It's a total performance level that allows users to generate the highest quality test signals.

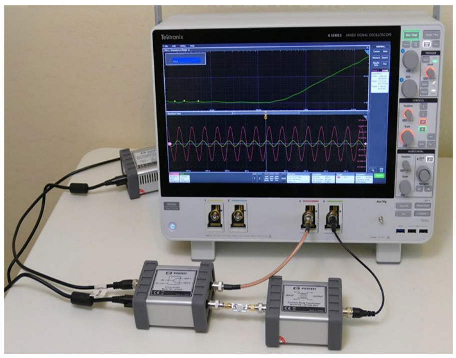
The AWG flexibility is further enhanced by front-panel, multi-purpose I/O connectors that allow access to synchronous digital (marker) outputs, trigger output, run and arm status, the PLL reference clock or asynchronous I/O lines.

Weighing as little as 6.3 kg, the generator NETBOX products are easily portable and can work almost anywhere: freestanding on a test bench, rack mounted with other equipment or even mobile (when powered by the optional 12 or 24 V DC sources).

www.spectrum-instrumentation.com

Wideband active splitter

for oscilloscope impedance measurements



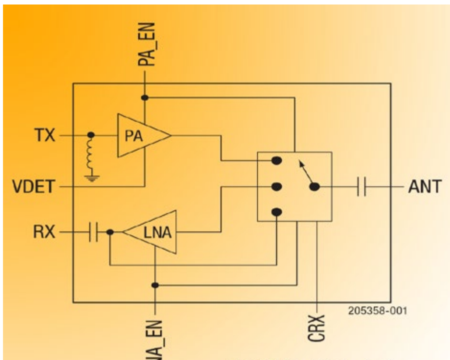
Picotest has released the J2161A, 2-way wideband active splitter. This accessory enables the 2-port shunt-through impedance measurement on oscilloscopes.

Traditionally, this measurement has been performed on Vector Network Analyzers (VNAs) or Frequency Response Analyzers (FRAs). But oscilloscopes, such as the Tektronix Series 5 and 6 scopes, offers a software add-on to enable this and other FRA type measurements in the frequency domain.

The 2-port measurement is the 'Gold Standard' test for Power Distribution Network impedance in the microohm and milliOhm region used for power integrity verification. The J2161A, and J2102B ground loop breaker (needed for the 2-port measurement), are unique because they are the only solution designed for this test and for all scopes with FRA software features that support 2-port measurement.

www.picotest.com

Integrated 2.4 GHz and 5 GHz 802.11ax FEMs



SKY85748-11 Block Diagram

Skyworks has introduced the SKY85330-21, a 2.4 GHz front-end module (FEM) and the SKY85748-11, a 5 GHz FEM for enterprise 802.11ax (Wi-Fi 6) applications including access points, routers and gateways. These fully-integrated FEMs feature a logarithmic power detector supporting wide dynamic ranges and low power consumption enabling improved thermal management. They also deliver industry leading efficiency, which is ideal for POE applications.

The SKY85330-21 is a complete 802.11b/g/n/ac/ax 1024 QAM WLAN RF front-end module (FEM. The device provides all the functionality of a fully matched power amplifier (PA), power detector, low-noise amplifier (LNA), and single-pole, double-throw (SPDT) switch. The FEM provides a complete 2.4 GHz WLAN RF solution from the output of the transceiver to the antenna, and from the antenna to the input of the transceiver. The LNA increases the receive sensitivity of embedded solutions to improve range or to overcome the insertion loss of cellular filters (often included for mobile applications). The SKY85330-21 also includes a transmitter power detector with 20 dB of dynamic range, and a digital enable control for transmitter power ramp on/off control. It is provided in an ultra-compact, 16-pin 2.5- x 2.5-mm Quad Flat No-Lead (QFN) package.

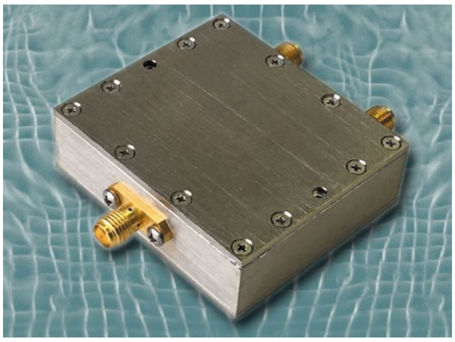
The SKY85748-11 is a highly integrated, 5 GHz front-end module (FEM) incorporating a 5 GHz single-pole, double-throw (SPDT) transmit/receive (T/R) switch, a 5 GHz low-noise amplifier (LNA) with bypass, and a 5 GHz power amplifier (PA) intended for mobile/portable 802.11ax applications and systems. The integrated logarithmic power detector provides closed-loop power control within the system. The device is provided in a compact, 16-pin 2.5- x 2.5-mm Quad Flat No-Lead (QFN) laminate package.

Both FEMs can be paired with leading enterprise 802.11ax reference designs.

www.skyworksinc.com

Resistive power divider series

covers DC to 7 GHz



BroadWave Technologies has announced a resistive power divider series with an operating frequency range of DC to 7 GHz.

Models 151-271-002 and 151-271-004 are 50-Ohm 2- and 4-way power dividers. These devices have an average power rating of 2-W with 1.50:1 maximum VSWR. The insertion loss above theoretical loss is ±1.5 dB nominal, amplitude tracking is ±0.5 dB maximum, and the operating temperature range is - 20°C to +100°C. RF connectors on the power divider are SMA female.

www.broadwavetechnologies.com

Dual-band WiFi/WLAN antenna

for surface-mount applications

Linx Technologies has introduced the nanoSplatch™ nSP250 dual-band WiFi/WLAN antenna for embedded applications. These antennas are a reduced-size evolution of the company's successful surface-mount embedded Splatch™ and microSplatch™ antennas.

The nanoSplatch™ nSP250 is an ideal embedded antenna for use in compact or portable devices targeting WiFi/WLAN and other 2.4 GHz or 5.8 GHz ISM frequency band technologies such as Bluetooth® and ZigBee®. The surface-mount nSP250 antenna uses just 80.6 mm 2 of board space and costs under one dollar in volume.

The antenna uses a grounded-line technique to achieve outstanding performance in a tiny surface-mount package. The nSP250 exhibits low proximity effect with a very hemispherical radiation pattern, making it ideal for handheld devices and applications typically subject to interference. This makes it especially well-suited for IoT and low-power wide-area (LPWA) network applications. The nSP250 also covers the U-NII frequency bands from 5.15 GHz to 5.85 GHz.

The nanoSplatch nSP250 is available today in tape and reel packaging and is designed for reflow-solder mounting directly to a printed circuit board for high-volume application.

www.linxtechnologies.com

Wi-Fi HaLow development platform

targets IIoT applicfations

A member of the Wi-Fi Alliance, Adapt has announced a Wi-Fi HaLow Development Platform (HDP) family for system integrators and application developers targeting the industrial IoT market.

The HDP-100 and HDP-200 systems support the IEEE 802.11ah (Wi-Fi HaLow) standard and are offered as providing a complete hardware and software development environment in a small-form factor for use across multiple industry segments including agriculture, construction, logistics, retail, security, smart home, and transportation.

Wi-Fi HaLow operates in the sub-gigahertz, license-free frequencies of the ISM (Industrial, Scientific and Medical) bands, enabling a longer range of more than 1 km while using less power than existing Wi-Fi technologies, including operation on a coin cell battery. Additional benefits of the 802.11ah standard, says the company, include better penetration through buildings, support for up to 8191 stations (STA) per Access Point (AP), and support for WPA3 for authentication and encryption. The HDP family includes:

- HDP-100 - Targeted at in-house development teams, includes the FPGA-based systems, software drivers, digital signal processing and radio transceiver for limited range communication, and API to connect to targeted software applications.
- HDP-200 - Useful for initial pilot project deployments, includes all of the HDP-100 functionality, plus an integrated power amplifier which supports the >1km communication range.

www.adapt-ip.com

Automotive tuner with SDR technology

Silicon Labs has introduced hybrid software-defined radio (SDR) tuners, expanding its portfolio to meet the growing need of automotive radio manufacturers to support all global digital radio standards with a common platform.

The latest Si479x7 devices are the company's first automotive radio tuners supporting the Digital Radio Mondiale (DRM) standard. The Si479x7 tuners are an extension of the popular family of Global Eagle and Dual Eagle AM/FM receivers and digital radio tuners, providing the same outstanding field performance, pin and package compatibility between single and dual tuners, and bill of materials (BOM) cost advantages.

In addition to introducing new DRM-capable tuners, Silicon Labs is enhancing its Si4790x/5x/6x automotive tuners with unique "SDR-friendly" technology, effectively transforming these devices into hybrid SDR tuners. The hybrid SDR technology includes advanced DSP-based automotive features such as Maximal Ratio Combining (MRC), Digital Automatic Gain Control (AGC), Digital Radio Fast Detect and Dynamic Zero-IF (ZIF) I/Q. These features enable automotive radio manufacturers to support global digital radio standards with a common radio hardware and software design. This added flexibility helps OEM and Tier 1 customers reduce design, qualification, sourcing and inventory costs while avoiding the complexity and inefficiency of supporting multiple automotive radio platforms.

www.silabs.com