Multi-Beam Antennas: Increased Capacity, Enhanced Spectral Efficiency

Tom Perkins: Less Dielectric Can Be Good

Analog Devices Announces 24 GHz to 44 GHz Wideband Integrated Microwave Up & Downconverter

New Products

Product Highlights

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Including These Connector Series

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Frequency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.85mm</td>
<td>DC-65 GHz</td>
</tr>
<tr>
<td>2.92mm</td>
<td>DC-40 GHz</td>
</tr>
<tr>
<td>7mm</td>
<td>DC-18 GHz</td>
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<tr>
<td>2.4mm</td>
<td>DC-50 GHz</td>
</tr>
<tr>
<td>3.5mm</td>
<td>DC-34 GHz</td>
</tr>
<tr>
<td>SSMA</td>
<td>DC-40 GHz</td>
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</tbody>
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ISO 9001:2008

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Kaman Precision Products announced the AMADEUS – the Advanced Memory and Data Exchange Universal System. The AMADEUS includes the Model 9740 Multi-Port® data transfer unit which includes four removable memory cards (RMC) and a mini-Ground Station Adapter (GSA). The Model 9740 provides simultaneous data interface over 10GB Ethernet, Mil-Std 1553, RS-232/422 as well as options to record multiple SMPTE 292 and NTSC (RS-170) video/audio channels.

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OML has developed an economical sub-harmonic pumped mixer down-converter module for the 5G market. M28H2ADC operates from 24 to 40 GHz with an IF bandwidth >5 GHz. Its compact size is well suited for both field and lab uses. The M28H2ADC can be connected directly to portable handheld instruments such as Keysight FieldFox and Anritsu Spectrum Master or it can be configured to use with bench-top instruments. It is powered via USB port.

Located in the Silicon Valley, the staff at OML are pioneers in microwave and millimeter wave products. Our test equipment expertise is traceable to the pioneering spirit at Varian Associates (Solid State Microwave Division), which is globally recognized for the innovative design and manufacture of many of the first microwave products.

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22: Feature Article

**Multi-Beam Antennas: Increased Wireless Capacity with Enhanced Spectral Efficiency**

By John Howard and Steve Jalil

Multi-beam antennas provide increased wireless capacity with enhanced spectral efficiency. Typically, wireless providers use three sectors in a 360° coverage area. With multibeam antenna systems, spectrum and capacity are multiplied. In this paper, a 5GHz, 6-dual polarized beam system is presented. The system covers 90 degrees in the azimuth and was deployed at the Sky Tower in Auckland, New Zealand. Live data was gathered at street level and presented.

ETI has designed as many as 32 dual polarized beams within 120° coverage, providing 96 sectors in 360°. The benefits of such a system are higher data throughput, higher customer capacity, increased spectral efficiency, and reduced number of cell sites versus traditional antennas. With the use of multiplexers, several frequency channels can be merged and transmitted into a single beam producing a multi-channel sector. For every channel that is transmitted into the beam, an increase in capacity and throughput factor is obtained.
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The term Substrate Integrated Waveguide (SIW) was apparently first introduced in an *IEEE Microwave and Wireless Components Letters* paper by Dominic Deslandes and Ke Wu in 2001. This technique involves parallel plate waveguide integrated into substrate structures. Metallization is incorporated to form boundaries using various processing techniques that are not uncommon for multilayer and microstrip structures. The primary advantages of this technique are touted to be ease of manufacture with ordinary printed circuit fabrication equipment with an associated low cost. Other advantages are small size compared with conventional waveguide, moderate power handling, low insertion loss, and compatibility with other printed circuit mediums.

Many forms of passive microwave circuits have been developed using this technique including filters, couplers, hybrid ring (rat race), and phase shifters. The technique is particularly amenable to feeding or forming certain types of end-fed antennas such as tapered slot, circular cavity arrays, Vivaldis and horns. Performance can be accurately predicted using mature modelling/simulation software suites.

**Not a Panacea**

Note the emphasis on passive components and circuitry. This technique will find its place among other mature microwave circuit formats and obviously is not a “one size fits all” solution for future circuitry.

Planar microstrip remains a favored technique where active circuitry is involved. As an example, for ease of installation, discrete chips, surface mount, and MMIC devices are more amenable to a single-layered microwave integrated circuit (MIC) format. This reminds me of my own experience. Circa 1972, I was assigned to a new Navy program (which continues even today) where it was mandated that the entire microwave transmitter module assembly would be designed in a new alumina (Al₂O₃) MIC format. No exceptions for any sub-portions employing techniques such as waveguide, slab-line, or stripline were permitted.

The circuitry consisted of amplifiers, step recovery diode frequency multipliers, ferrite isolators, filters, and PIN diode switches. This mandate presented significant challenges at the time, particularly with achieving good rejection in microwave filters as high quality factors were not easily realized. Challenges abounded in electrical, mechanical and assembly techniques. We resorted to all sorts of unique innovations. For example, end-coupled resonator bandpass filters on narrow alumina substrates in metal walled and covered tunnels to achieve bandwidths on the order of a few percent. Another was
CTE match, so we soldered the alumina circuits to kovar carriers, which in turn were fastened with adequate grounding in aluminum housings. In later years the latter problem was solved by many means, not the least being the introduction of Rogers RT/duroid® 6010 laminate.

Looking back on this, the difficulties suffered paid off greatly as many lessons were learned about specific limitations of microstrip, how to reliably package such, and workarounds. My point is: I do not recommend mandating use of SIW throughout a complex assembly, particularly if active circuitry is contemplated.

Variants

SIW has many variants. These include: Air Filled Substrate-Integrated Waveguide (AFSIW), Dielectric-less Substrate-Integrated Waveguide (DSIW), Empty Substrate Integrated Coaxial Line Transition (ESICL), Empty Substrate Integrated Waveguide (ESIW), Hollow Substrate Integrated Waveguide (HSIW), Substrate Integrated Slab Waveguide (SISW), Ridged Substrate Integrated Waveguide (RSIW) and Millimeter-wave Substrate Integrated Waveguide (MSIW).

Most configurations of SIW resemble H-plane rectangular waveguide. Substrate integrated approaches using metalized vias dictate this format. However, there is also E-plane SIW (ESIW) which has continuous vertical and horizontal walls. An interesting transition has been developed that goes from H to E-plane SIW. It consists of 8 layers and was inspired by traditional coax to waveguide transition design.

Materials used can be many, much like those used in microstrip. This would include FR4, RO3003™, RO4003C™, RO6002™, RO5880™, and low temperature co-fired ceramic (LTCC).

Transitions between SIW mediums and to other mediums such as microstrip have been successfully developed. The reported measured phase constant of ESIW vs. WR-62 waveguide is essentially identical. The attenuation constant is less than 0.02 Nepers/meter higher than rectangular waveguide.

Significant power levels can be handled in some of these SIW techniques, particularly dielectric-filled SIWs for peak power. Average powers of approximately 50 to 100 watts can be sustained while peak powers of over 2 megawatts in some filled SIWs have been reported. Thus SIW is quite attractive for transmitters allowing interesting possibilities for miniaturizing radar.
Meetings and Events

WAMICON 2019
April 8 - 9, 2019
Cocoa Beach, FL
http://www.wamicon.org/

ICMIM
April 15 – 16, 2019
Detroit, MI
https://www.icmim-ieee.org/index.html

IWS
May 19 – 22, 2019
Guangzhou, China

IMS 2019
June 3 - 7, 2019
Boston
https://ims-ieee.org/

IEEE Wireless Power Transfer Conference
June 18 - 21, 2019
London
https://www.mtt.org/conference-calendar

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Object-Oriented Design and Programming in LabVIEW
Online
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Free, online LabVIEW training for students and teachers.
http://sine.ni.com/nievents/app/results/p/country/us/type/webcasts/

IEEE Women in Engineering International Leadership Summits (WIE ILS) provide regional opportunities to foster networking, mentorship, and collaboration. IEEE WIE will continue the WIE ILS program in 2019 as part of the portfolio of global initiatives that focus on Empowerment, Entrepreneurship, Leadership, and Emerging/Future Technology. https://wie.ieee.org/leadership-summits2019/

2019 IEEE WIE Leadership Summits

IEEE Women in Engineering International Leadership Summits (WIE ILS) provide regional opportunities to foster networking, mentorship, and collaboration. IEEE WIE will continue the WIE ILS program in 2019 as part of the portfolio of global initiatives that focus on Empowerment, Entrepreneurship, Leadership, and Emerging/Future Technology. https://wie.ieee.org/leadership-summits2019/

HFE’s April Issue

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“Look to the leader in YIG-Technology”
**Mission Critical Applications to Drive the Adoption of 5G sUAVs**

Public safety agencies in big markets have started to deploy mobile broadband communication networks to replace their existing narrowband technology, such as FirstNet in the United States and the Emergency Services Network in the United Kingdom. The adoption of Long-Term Evolution (LTE) will lead to 5G New Radio (NR) and unlock a myriad of civil use cases for small Unmanned Aerial Vehicles (sUAVs), according to a report by ABI Research, a market-foresight advisory firm providing strategic guidance on the most compelling transformative technologies.

As compared to a few years ago, sUAVs have been widely deployed in various public safety applications. This includes asset surveillance and monitoring, traffic management, crowd surveillance, and control, as well as search and rescue. However, all these applications are performed using remote control and within visual line of sight. Existing communication technologies, such as LTE, Wi-Fi, Bluetooth, and unlicensed spectrum, all have their limitations and restrictions.

“The biggest strengths of 5G are high throughput and low latency,” said Lian Jye Su, a Principal Analyst at ABI Research. “The high throughput enables the seamless transmission of high-resolution images and videos that are critical for search and rescue missions. Low latency, on the other hand, allows sUAVs to be controlled by a centralized command and control in beyond visual line of sight (BVLOS) flight. Path and route control, sensor information, geospatial, and telemetry data can be exchanged with the command and control almost instantaneously.”

With the increasing number of sUAVs sharing the airspace, public safety agencies will need UAV Traffic Management (UTM) system to control and manage national airspace. Each sUAV that is connected to the network will have a unique identifier which allows tracking and tracing across all kinds of terrains and environments. This will help public safety agencies track down rogue sUAVs and preserve the safety and security of the airspace.

In addition, 5G also enhances existing geo-positioning technology. Currently, satellite communications such as GPS and GLONASS are used for sUAV tracking, but satellite signals face a canyoning effect in dense urban landscapes and are subjected to interruption by buildings and natural landscapes. In indoor environments, sUAVs rely on optical flow and ultrasonic sensors for positioning and navigation, but this system is limited to the hardware available on the sUAVs. Cellular technology can augment satellite by using a radio fingerprinting technique, which matches cellular signal measurements against a central calibrated database and does not require an extra device or upgrade to the public safety network.

“The mission critical nature of public safety use cases demands a high level of reliability, scalability, and redundancy. Despite still being in the early stage of deployment, 5G has strong potential to solve the pain-points of public safety use cases. The telecommunications industry will start to roll out 5G equipment and devices in 2019 and it is just a matter of time before we start to see 5G sUAVs being deployed by public safety agencies,” concluded Su.

—ABI Research

**Moving AI Processing to the Edge Will Shake Up the Semiconductor Industry**

Revenue from the sale of Artificial Intelligence (AI) chipsets for edge inference and inference training will grow at 65% and 137% respectively between 2018 and 2023, creating massive new potential revenue streams for chip vendors. According to ABI Research, in 2018 shipment revenues from edge AI processing was US$1.3 billion, by 2023 this figure will grow to US$23 billion, a massive increase, but one that doesn’t necessarily favor current market leaders Intel and NVIDIA. There will be intense competition to capture this revenue between established players and several prominent startups.

“Companies are looking to the edge because it allows them to perform AI inference without transferring their data. The act of transferring data is inherently costly and in business-critical use cases where latency and accuracy are key, and constant connectivity is lacking, applications can’t be fulfilled. Locating AI inference processing at the edge also means that companies don’t have to share private or sensitive data with cloud providers, something that is problematic in the healthcare and consumer sectors,” said Jack Vernon, Industry Analyst at ABI Research.

What’s clear is that edge AI is going to have a significant impact on the semiconductor industry. The biggest winners from the growth in edge AI are going to be those vendors that either own or are currently building intellectual properties for AI-related Application-Specific Integrated Circuits (ASICs). Traditional processing architectures based on the Skallar approach to processing, like CPUs, are set to lose out to Tensor-based processing architecture in fulfilling the demand for edge AI processing, as they are far more efficient and scalable at performing Deep Learning (DL) tasks.

—ABI Research

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Defending Against Adversarial Artificial Intelligence

Today, machine learning (ML) is coming into its own, ready to serve mankind in a diverse array of applications – from highly efficient manufacturing, medicine and massive information analysis to self-driving transportation, and beyond. However, if misapplied, misused or subverted, ML holds the potential for great harm – this is the double-edged sword of machine learning.

“Over the last decade, researchers have focused on realizing practical ML capable of accomplishing real-world tasks and making them more efficient,” said Dr. Hava Siegelmann, program manager in DARPA’s Information Innovation Office (I2O). “We’re already benefitting from that work, and rapidly incorporating ML into a number of enterprises. But, in a very real way, we’ve rushed ahead, paying little attention to vulnerabilities inherent in ML platforms – particularly in terms of altering, corrupting or deceiving these systems.”

In a commonly cited example, ML used by a self-driving car was tricked by visual alterations to a stop sign. While a human viewing the altered sign would have no difficulty interpreting its meaning, the ML erroneously interpreted the stop sign as a 45 mph speed limit posting. In a real-world attack like this, the self-driving car would accelerate through the stop sign, potentially causing a disastrous outcome. This is just one of many recently discovered attacks applicable to virtually any ML application.

To get ahead of this acute safety challenge, DARPA created the Guaranteeing AI Robustness against Deception (GARD) program. GARD aims to develop a new generation of defenses against adversarial deception attacks on ML models. Current defense efforts were designed to protect against specific, pre-defined adversarial attacks and, remained vulnerable to attacks outside their design parameters when tested. GARD seeks to approach ML defense differently – by developing broad-based defenses that address the numerous possible attacks in a given scenario.

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GARD's novel response to adversarial AI will focus on three main objectives: 1) the development of theoretical foundations for defensible ML and a lexicon of new defense mechanisms based on them; 2) the creation and testing of defensible systems in a diverse range of settings; and 3) the construction of a new testbed for characterizing ML defensibility relative to threat scenarios. Through these interdependent program elements, GARD aims to create deception-resistant ML technologies with stringent criteria for evaluating their robustness.

GARD will explore many research directions for potential defenses, including biology. “The kind of broad scenario-based defense we’re looking to generate can be seen, for example, in the immune system, which identifies attacks, wins and remembers the attack to create a more effective response during future engagements,” said Siegelmann.

GARD will work on addressing present needs, but is keeping future challenges in mind as well. The program will initially concentrate on state-of-the-art image-based ML, then progress to video, audio and more complex systems – including multi-sensor and multi-modality variations. It will also seek to address ML capable of predictions, decisions and adapting during its lifetime.

—DARPA

Intelligent Healing for Complex Wounds

Blast injuries, burns, and other wounds experienced by warfighters often catastrophically damage their bones, skin, and nerves, resulting in months to years of recovery for the most severe injuries and often returning imperfect results. This long and limited healing process means prolonged pain and hardship for the patient, and a drop in readiness for the military. However, DARPA
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Paul Sheehan, the BETR program manager, described his vision for the technology as “not just personalized medicine, but dynamic, adaptive, and precise human therapies” that adjust to the wound state moment by moment to provide greater resilience to wounded warfighters.

“Wounds are living environments and the conditions change quickly as cells and tissues communicate and attempt to repair,” Sheehan said. “An ideal treatment would sense, process, and respond to these changes in the wound state and intervene to correct and speed recovery. For example, we anticipate interventions that modulate immune response, recruit necessary cell types to the wound, or direct how stem cells differentiate to expedite healing.”

—DARPA

**Electro Technik Industries, Inc. announced the acquisition of RF Techniques, Inc., San Jose, Calif. The newly acquired company will be part of the Electro Technik, RF/Microwave Group and report to Alen Fejzuli, Group President. RF Techniques has been in business for over 30 years and has developed an outstanding reputation in the industry for designing and delivering high reliability microwave components. Its products will compliment Res-net Microwave’s existing offerings by adding a family of brazed attenuators, resistors, and terminations, as well as thin film capabilities.**

**Mini-Circuits welcomed Spectrum Sales to its roster of authorized sales representatives. Spectrum Sales will provide service and technical support to Mini-Circuits customers in New York, northern New Jersey, and southern Connecticut. Spectrum’s team brings deep expertise and extensive background in the RF/microwave industry, and will provide industry-leading service to customers in the greater New York metro area. Spectrum Sales: Phone: (516) 921-5750; Fax: (516) 921-5776; spectrumsales.com.**
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- Remote control: GUI software or Standard Serial Communications Software

Integrated strip chart recorder (optional)
- Applications
  - Switch cycling

Ducommun
ducommun.com

24 GHz to 44 GHz Wideband Up & Downconverter
Analog Devices announced the ADMV1013 and ADMV1014, a paired highly integrated microwave upconverter and downconverter, respectively. These ICs operate over a very wide frequency range with 50 Ω-match from 24 GHz up to 44 GHz, facilitating ease of design and reducing the costs of building a single platform that can cover all 5G mmWave frequency bands including 28 GHz and 39 GHz.

Additionally, the chipset is capable of flat 1 GHz RF instantaneous bandwidth supporting all broadband services as well as other ultra-wide bandwidth transceiver applications. Each upconverter and downconverter is highly integrated, comprising I (in-phase) and Q (quadrature-phase) mixers with on-chip programmable quadrature phase-shifter configurable for direct conversion to/from baseband (operable from DC to 6 GHz) or to an IF (operable from 800 MHz to 6 GHz). Also included on-chip are voltage variable attenuators, transmit PA driver (in the upconverter) and a receive LNA (in the downconverter), LO buffers with x4 frequency multiplier and programmable tracking filters.

Most programmability functions are controlled via an SPI serial interface. Through this port, these chips also provide a unique capability for each upconverter and downconverter to correct its respective quadrature phase imbalance, hence the usually difficult to suppress sideband emission can be improved from a typical value of 32 dBc, by 10 dB or more. This results in an unmatched level of microwave radio performance. The combination of features provides unprecedented flexibility and ease of use while minimizing external components, enabling implementation of small form factor systems such as small cells.

Analog Devices
analog.com

YIG Tech Brief
Using small conductive “loops,” a YIG filter is coupled to and from a YIG sphere’s resonant magnetic field. The closer the loop, the wider the bandwidth. Bandwidth can also be expanded by increasing the number of YIG resonators and carefully “tuning” the RF coupling loops. In this brief, RF engineers will learn the three basic methods in which this coupling is applied: signal transfer; signal reflection; and oscillation feedback, and how this differentiates a bandpass from a band-reject filter.

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The latest release of the antenna design, synthesis and optimization module, AntSyn™ 3.1, is now available for use by current customers and evaluators. IoT accounts, like Striiv, have found this innovative EM-based synthesis tool valuable for designing antenna solutions for their products.

Highlights of the release include:

Additional antennas added to the library bringing the total number of templates to 537. New antenna types for series-fed patch arrays, as well as new waveguide-fed, dualridge, transverse electromagnetic (TEM) and multifunction horn antennas. Ability to specify waveguide feeds, enabling the use of dozens of different commercially-available waveguides to feed many types of horns. Timing information to guide users on expected simulation times for certain classes of antennas and the ability to sort/queue by expected time run. Advance library search feature to narrow the number of displayed antennas according to user-specified attributes and/or descriptions.

National Instruments
awrcorp.com

Power Dividers: 0.698 - 2.700 GHz

VidaRF introduced Power Dividers covering 0.698 - 2.700 GHz for all wireless applications from cellular through UMTS. Available in 2, 3, 4, 6 and 8-way with SMA, N, QMA, or alternative connector configurations. VidaRF is a North Carolina-based company that is focused on being a solution provider by building to customer specs and offering zero days lead time for custom parts through its stock and ship program.

VidaRF
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Power Amp

Richardson RFPD, Inc. announced a new power amplifier from Microsemi Corporation, a Microchip Company. The MMA053AA is a gallium arsenide (GaAs) monolithic microwave integrated circuit (MMIC) pHEMT
Planar Monolithics Industries, Inc.

**Broad-Band Phase Shifters**

PMI offers the highest quality phase shifters for industrial and military applications in the frequency range up to 40 GHz. These models offer a 360° phase shift, fast switching speed, low insertion loss, high phase accuracy with various options available. View our standard phase shifter design capabilities at: https://www.pmi-rf.com/categories/phase-shifters

### PMI Model No. | FREQ Range (GHz) | Insertion Loss (dB) | Switching Speed | Phase Shift Range | Analog or Digital | Power Supply | Size (Inches) / Connectors
--- | --- | --- | --- | --- | --- | --- | ---
PS-85M4G-9B-SFF | 0.085 - 4 | 8.3 dB | 300 ns | 360° | Digital (9-bit) | +15 VDC @ 250 mA, -15 VDC @ 100 mA | 4.95” x 3.36” x 1.00” SMA Female
PS-200M10G-8B-SFF | 0.2 - 10 | 8.0 dB | 250 ns | 360° | Digital (8-bit) | +15 VDC @ 189 mA, -15 VDC @ 21 mA | 3.25” X 3.25” X 0.84” SMA Female
PS-2G18G-360-12D-TS | 2 - 18 | 17.7 dB | 410 ns | 360° | Digital (12-bit) | +12 VDC to ±15 VDC @ ±100 mA | 4.25 X 3.50 X 1.00 SMA Female
PS-360-3237-8-292FF | 32 - 37 | 13.4 dB | 450 ns | 360° | Digital (8-bit) | +15 VDC @ 90 mA, -15 VDC @ 60 mA | 1.15” X 1.8” X 0.4” 2.92mm Female

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Richardson RFPD
richardsonrfpd.com

Skew Matched Cable Pairs

Fairview Microwave expanded its line of skew matched cable pairs to include 40 GHz and 67 GHz versions that are ideal for the development of high-data-rate digital systems.

Fairview’s extended line of skew matched cables consists of seven models, three original and four new, available in 40 GHz and 67 GHz versions. These delay matched cables are offered with 2.92 mm or 1.85 mm connectors and polarity indicators for matched cable ends. Performance specs include an impressive VSWR of 1.4:1 and delay match as low as 1 ps. These extremely flexible cable pair models are 100% tested for skew match and available for same-day shipping.

Fairview Microwave
fairviewmicrowave.com

Broadband Conicals: 10 Amps

Gowanda Electronics introduced broadband microwave RF conical inductors that provide DC current handling up to 10 Amps - the highest level in the industry - and low insertion loss. These flying lead series were developed to address market needs and industry trends calling for ever-increasing performance from broadband conical components. Gowanda’s new series will be utilized in communication applications for bias T’s, broadband chip manufacturing, high frequency, and much more.

Gowanda Electronics
gowanda.com

<table>
<thead>
<tr>
<th>Frequency Range (MHz)</th>
<th>Coupling (dB)</th>
<th>I.L. Loss (dB)</th>
<th>Coupling Flatness max.</th>
<th>Directivity (dB) min.</th>
<th>Input Power (watts) max.</th>
<th>Model Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0-32.0</td>
<td>50 ± 1</td>
<td>0.06</td>
<td>0.25</td>
<td>25</td>
<td>2500</td>
<td>C50-101</td>
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<tr>
<td>0.5-50</td>
<td>50 ± 1</td>
<td>0.10</td>
<td>0.50</td>
<td>20</td>
<td>2000</td>
<td>C50-100</td>
</tr>
<tr>
<td>0.5-100</td>
<td>30 ± 1</td>
<td>0.30</td>
<td>0.50</td>
<td>25</td>
<td>200</td>
<td>C30-102</td>
</tr>
<tr>
<td>0.5-100</td>
<td>40 ± 1</td>
<td>0.20</td>
<td>0.30</td>
<td>20</td>
<td>200</td>
<td>C40-103</td>
</tr>
<tr>
<td>1.0-100</td>
<td>50 ± 1</td>
<td>0.20</td>
<td>1.00</td>
<td>20</td>
<td>500</td>
<td>C50-109</td>
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<tr>
<td>20.0-200</td>
<td>50 ± 1</td>
<td>0.20</td>
<td>0.75</td>
<td>20</td>
<td>500</td>
<td>C50-108</td>
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<tr>
<td>0.1-250</td>
<td>40 ± 1</td>
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<td>0.50</td>
<td>20</td>
<td>250</td>
<td>C40-111</td>
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<tr>
<td>50-500</td>
<td>40 ± 1</td>
<td>0.20</td>
<td>1.00</td>
<td>20</td>
<td>500</td>
<td>C40-21</td>
</tr>
<tr>
<td>50-500</td>
<td>50 ± 1</td>
<td>0.20</td>
<td>1.00</td>
<td>20</td>
<td>500</td>
<td>C50-21</td>
</tr>
<tr>
<td>100-1000</td>
<td>40 ± 1</td>
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<td>1.00</td>
<td>20</td>
<td>500</td>
<td>C40-20</td>
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<td>500-1000</td>
<td>50 ± 1</td>
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<td>500</td>
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<tr>
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<td>1.00</td>
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<td>80-1000</td>
<td>50 ± 1</td>
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<td>1000</td>
<td>C50-27</td>
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<tr>
<td>80-1000</td>
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<td>1.00</td>
<td>20</td>
<td>1500</td>
<td>C40-31</td>
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<tr>
<td>80-1000</td>
<td>50 ± 1</td>
<td>0.30</td>
<td>1.00</td>
<td>20</td>
<td>1500</td>
<td>C50-31</td>
</tr>
</tbody>
</table>

IN-OUT ports: Type N connectors standard, SMA connectors optional. Coupled ports: SMA connectors standard. See website for details.

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48 Industrial West, Clifton, NJ 07012 | Tel: 973-779-6202 • Fax: 973-779-2727 | sales@pulsarmicrowave.com

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Multi-Beam Antennas: Increased Wireless Capacity with Enhanced Spectral Efficiency

By John Howard and Steve Jalil

Multi-beam antennas provide increased wireless capacity with enhanced spectral efficiency. Typically, wireless providers use three sectors in a 360° coverage area. With multibeam antenna systems, spectrum and capacity are multiplied. In this paper, a 5GHz, 6-dual polarized beam system is presented. The system covers 90 degrees in the azimuth and was deployed at the Sky Tower in Auckland, New Zealand. Live data was gathered at street level and presented.

Introduction

ET Industries has been in production of 5G Antenna Systems since 2006. The antenna systems of the 2006 production covering the CBRS band are shown in figures 1 and 2. The system has a total of 48 beams in 360 degrees. Frequency was repeated three times per 90
degrees thus providing 12 times higher spectral capacity from a single cell.

ETI has designed as many as 32 dual polarized beams within 120° coverage, providing 96 sectors in 360°. The benefits of such a system are higher data throughput, higher customer capacity, increased spectral efficiency, and reduced number of cell sites versus traditional antennas. With the use of multiplexers, several frequency channels can be merged and transmitted into a single beam producing a multi-channel sector. For every channel that is transmitted into the beam, an increase in capacity and throughput factor is obtained.

In this paper, a 6-dual polarized beam system is presented. The system covers 90 degrees in the azimuth and was deployed at the Sky Tower in Auckland, New Zealand.

**Deployment**

The architecture of the ETI 5G Antenna System deployed at the Sky Tower in Auckland, NZ is detailed in figure 3. The system deployment consisted of six MIMO access points interfaced with two beamforming networks, one per polarization. The 5 GHz phased array had a 128-element geometry per polarization. The 5G antenna system provided a radiation pattern of six dual polarized beams in a 90-degree azimuth footprint.

**Results**

Measurements were taken at street level in the city of Auckland up to 10 km from the transmission point. Speeds of 200Mbps per 20MHz channel per beam were witnessed. Modulations of 256QAM were produced in the field. This resulted in 1.2Gbps aggregate from one antenna across the 90-degree azimuth coverage. The Smart MIMO Switching capabilities of the system were also witnessed. The links automatically changed from MIMO-A (Diversity) to MIMO-B (Multiple Streams) based on link conditions to increase efficiency, link stability, as well as increased data capacity.

During the deployment, ETI repeated the same frequency on beams 3 and 8, essentially doubling this channel’s speed. Simultaneous readings at the same channel were taken demonstrating no interference and a substantial increase of capacity by repeating the channel. See figure 6 for frequency reuse of beams 3 and 8 carrying the same channel.

The actual measurements are too numerous to present herein, but representative measurements are shown in Tables 1 and 2. Table 1 consists of the readings in beam mode 3 and table 2 of beam mode 1. RF 1 and RF 2 are the two paths for the dual polarization in downlink and uplink. During the trial different measurements at
5G

different distances were gathered as follows: received signal strength (RSSI), Signal-to-noise and distortion ratio (SINADR), data rates in Mb/s and MIMO for both uplink and downlink.

Some areas where there is MIMO-A is because of non-optimized street level positions of the subscriber module. This in turn decreased the link efficiency.
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Fig. 5 • View from behind the 21 dB gain antenna system. 6 beams, M3 (left outermost beam), M2, M1, M8, M7 and M6 (right outermost beam).

Fig. 6 • Repeated channels beams M3 and M8.
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Proper planning and optimization of the subscriber modules’ position will allow for MIMO-B links everywhere.

**Conclusion**

Traditional 360° cells sites are divided into three sectors. With the multi-beam antenna system, spectrum and capacity can be multiplied. The benefit of such a system is higher data throughput, higher customer capacity and increased spectral efficiency. The beam crossing can be designed to cross between 3 to 10 dB with side lobe levels of 25dB. As the number of beams increases, so does the capacity and throughput. With the use of multiplexers, multi-channel sectors can be created to further enhance the benefits of the system. The multi-beam antenna system is clearly the solution to the ever-growing demand of data usage and network capacity for the finite amount of spectrum.

<table>
<thead>
<tr>
<th>Location</th>
<th>RSSI (dBm)</th>
<th>SINADR (dB)</th>
<th>Data Rate (Mb/s)</th>
<th>MIMO</th>
<th>Distance (km)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>RF1 DL</td>
<td>RF2 DL</td>
<td>RF3 DL</td>
<td>RF1 UL</td>
<td>RF2 UL</td>
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<tr>
<td>Michael Joseph Savage</td>
<td>-76</td>
<td>-74</td>
<td>-75</td>
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<td>Memorial</td>
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<td>-78</td>
<td>-79</td>
<td>-77</td>
<td>16</td>
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</tbody>
</table>

**Table 1** • Beam mode 3 street level results.
### About the Authors

John Howard and Steve Jalil are with Electromagnetics Technologies Industries, Boonton, New Jersey.

### References


---

**Table 2 • Beam mode 1 street level results.**

<table>
<thead>
<tr>
<th>Location</th>
<th>RSSI (dBm)</th>
<th>SINADR (dB)</th>
<th>Data Rate (Mb/s)</th>
<th>MIMO</th>
<th>Distance (km)</th>
</tr>
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<tr>
<td></td>
<td>RF1 DL</td>
<td>RF2 DL</td>
<td>RF1 UL</td>
<td>RF2 UL</td>
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<td>Victoria Ave School</td>
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<tr>
<td>Mt. Wellington</td>
<td>-84</td>
<td>-80</td>
<td>-83</td>
<td>-78</td>
<td>12</td>
</tr>
</tbody>
</table>
Precision SMA Panel Cable Connectors
SMA Female/Jack 2 and 4 Hole configurations for .085 Semi-Rigid Cable (Direct Solder)
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PN: 190-32-34-000  2.4mm MALE (NMD) to 2.92mm MALE (STD)
PN: 190-34-35-001  2.92mm MALE (STD) to 2.92mm FEMALE (NMD)
PN: 190-32-35-000  2.4mm MALE (NMD) to 2.92mm FEMALE (STD)

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App Note: Automating Matching-Circuit Design

This application note highlights the network synthesis module within the NI AWR Design Environment platform, an electronic design automation (EDA) software technology that reduces design time in the domain of network synthesis by automating the development of impedance-matching circuits.

Network synthesis is helpful at the earliest stages of a design to help determine reasonable performance targets based on device performance limits, device sizing (decisions on active device periphery), part selection for discrete packaged transistors, and other early design decisions.

National Instruments awrcorp.com

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MM-Wave Active Doubler

The new mmwave ADA-2052 active doubler will frequency extend your <26 GHz synthesizer up to 52 GHz with high output power and high harmonic suppressions. +20 dBm output power is provided over 30 to 52 GHz, and at least +16 dBm from 20 to 30 GHz, with an input from -6 to +2 dBm. This high performance GaAs MMIC chipset consists of an ADM-5974CH input buffer amplifier, MMD-2060HCH doubler, and AMM-6702CH output buffer amplifier. ADA-2052 is a RoHS connectorized module ideal for lab use, test and measurement, and prototype systems.

Marki Microwave markimicrowave.com
**Product Highlights**

**Wideband Power Amp Brochure**

AMCOM’s products are as categorized in its new online product brochure:

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- Products: (many are for wideband applications) 1) Discrete devices (GaN/SiC HEMT, GaAs FET, GaAs PHEMT): packaged and bare die DC-18GHz and up to 40W 2) MMIC power amplifiers (based on GaN/SiC HEMT, GaAs FET, GaAs PHEMT): wideband DC-17GHz and 1W-20W 3) SSPA modules and pallets: 30MHz-17GHz and up to 100W. 4) Microwave T/R switches, phase shifters, attenuators, and bias tees 5) Custom design: MMIC power amplifiers, module power amplifiers, as well as T/R modules with frequencies ranging from 10KHz to 60GHz with output power from 1W to 100W.

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Herotek, Inc. has been a quality supplier of RF and Microwave components since 1982. Herotek is a broad-based, high technology company supplying parts for the Military, Industrial and Commercial markets with designs from DC to 75 GHz. It offers standard products as well as thousands of custom designs, and is happy to match existing products.

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---

**AMCOM offers a variety of GaN MMICs with different power levels and operating frequencies. Our GaN MMICS are offered in different forms such as bare die and packaged. This table summarizes AMCOM’s recent releases:**

<table>
<thead>
<tr>
<th>Model</th>
<th>Freq.</th>
<th>Vd</th>
<th>Gain</th>
<th>P1dB</th>
<th>Psat</th>
<th>PAE</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM00010037WN-XX-R</td>
<td>DC-10 GHz</td>
<td>28V</td>
<td>13dB</td>
<td>30dBm</td>
<td>37dBm</td>
<td>23%</td>
<td>Packaged, Die</td>
</tr>
<tr>
<td>AM206041WN-XX-R</td>
<td>1.8-6.5 GHz</td>
<td>28V</td>
<td>30dB</td>
<td>38dBm</td>
<td>41dBm</td>
<td>20%</td>
<td>Packaged, Die</td>
</tr>
<tr>
<td>AM408041WN-XX-R</td>
<td>3.75-8.25 GHz</td>
<td>28V</td>
<td>33dB</td>
<td>38dBm</td>
<td>42dBm</td>
<td>26%</td>
<td>Packaged, Die</td>
</tr>
<tr>
<td>AM07512041WN-XX-R</td>
<td>7.5-12.5 GHz</td>
<td>28V</td>
<td>27dB</td>
<td>37.5dBm</td>
<td>41dBm</td>
<td>20%</td>
<td>Packaged, Die</td>
</tr>
</tbody>
</table>

For more detailed information please visit: [www.amcomusa.com](http://www.amcomusa.com)

AMCOM

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XGL4020 Series inductors are qualified to AEC-Q200 Grade 1 standards (-40° to +125°C ambient) with a maximum part temperature of +165°C and exhibit no thermal aging issues, making them suitable for automotive and other harsh-environment applications. They feature RoHS-compliant, tin-silver-over-copper terminations and are halogen free. Their composite construction also minimizes audible buzzing.

As with all Coilcraft parts, free evaluation samples of the XGL4020 Series are available online at www.coilcraft.com.

Headquartered outside of Chicago in Cary, Illinois, Coilcraft is a leading global supplier of magnetic components including high performance RF chip inductors, power magnetics and filters.

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Product Highlights

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For precompliance tests, R&S ELEKTRA controls the R&S FPC1000 spectrum analyzer, which developers can also use for many other applications. The R&S FPC1000 offers numerous options such as frequency extensions or RF preamplifiers, which can be enabled with a keycode if needed. The R&S FPL1007 spectrum analyzer with the R&S FPL1-K54 measurement application is the perfect diagnostic tool for detecting EMI emissions. Disturbance maxima and critical frequencies are automatically entered in a peak list. Using the CISPR detectors, users can then carry out a final evaluation with respect to official EMI emission limits.

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Studies reveal that within each 3-5 year period, one-half of an engineer’s technical knowledge becomes obsolete. New graduates soon discover that university education provides only the foundation of knowledge that is realistically needed to perform well in the industry. Continued education is a must for survival in today’s competitive market. Application of modern computer-aided engineering to RF and microwave circuit and system design is vital to manufacturing products with high quality and yield. Modernization of the design laboratory and production floor is critical to maintaining a competitive edge.

A well-planned continuing education program will enable your company to meet these goals. As a recognized international leader in continuing education, Besser Associates is dedicated to serving the needs of RF and wireless professionals.

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Besser Associates
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Education Update

Get info at www.HFeLink.com
For more than 50 years, Gowanda has been a leading manufacturer of board-level magnetic inductive components for the OEM electronics marketplace. Our extensive product line includes axial-lead & surface mount RF and power inductors, chip coils, conicals, lead and lead-free designs, pot cores, qualified product list (QPL) components, shielded/unshielded designs, switching power supply magnetics, toroids, transformers, tunable coils, and application-specific configurations.

Dramatic changes have occurred in electronic technology over the years, and Gowanda has kept pace with - and in many cases stayed ahead of - these changes via ongoing research and development. The steady stream of new products, new technology and engineering advancements at Gowanda has resulted in the company becoming the “supplier of choice” for Fortune 500 and Global 1000 companies around the world. For these companies the need for a component solution, not just a product, has made Gowanda an essential partner in their corporate product development teams.

Over the years, Gowanda has earned the reputation of being a customer-driven supplier of high quality, highly reliable, ruggedized electronic components. Our time-tested ability to support our customers is the key reason that Gowanda continues to enjoy long-term contract relationships with these major companies.

Precision magnetic components from Gowanda - and all the expertise and service that come with them - offer OEMs the unique opportunity to address their power supply management and RF signal challenges supported by a partner with a long-term view and commitment to excellence. Such a relationship is especially important when off-the-shelf, mass produced components do not address the quality and performance requirements of demanding applications.

Gowanda
gowanda.com
RelComm Technologies, Inc. designs and builds RF relay component products for the communications and instrumentation marketplace.

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Over the last 40+ years, a lot has changed in the RF and Microwave industries. However, some things remain the same, like Customers’ demand for a reliable source of quality products supported by superior technical and customer service.

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Today, Pasternack is a global supplier of RF and Microwave components supported by a growing list of 19 International Distributors who service customers in more than 35 countries worldwide and partner with us in pursuit of our vision to be the world’s most recognized and trusted provider of urgently needed RF/Microwave components and assemblies.

Pasternack continues its mission to provide the users of RF and Microwave components and assemblies the broadest and deepest selection of products available for same-day shipment worldwide.

“Since 1972, Pasternack has steadily grown by aligning its offerings to match the needs of our Customers.”

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Pasternack
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Compact, Economical Test Equipment

DS Instruments is dedicated to the design and manufacturing of compact and economical Microwave Test Equipment without compromising quality. We focus on providing clean and simple interfaces with the flexibility to make equipment into the financial reach of small business on a modest budget. Our first product was a unique RF tracking generator that brought existing signal analyzers increased functionality and renewed utility. The following two years of full-time research and design lead to an entire line of compact RF Test Equipment built to be simple and reliable. We now have more active products than the founding engineers ever expected, and are reaching customers of all sizes all over the world.

DS Instruments
dsinstruments.com

We pride ourselves in using genuine, cutting-edge components from the top semiconductor manufacturers.

our equipment attractive to engineers working in design, testing, lab settings, defense, government, universities, and overseas. All hardware design, firmware development, and assembly is based in the United States. We pride ourselves in using genuine, cutting-edge components from the top semiconductor manufacturers.

Our current products include Microwave & RF Signal Generators, Digital RF Step Attenuators, Signal Power Meters, Phase Shifters, Gain Blocks, Tracking Generators, and Frequency Counters. We are always developing new products and welcome ideas at any time! Direct sales, minimal advertising, and a lean business environment enable us to pass significant savings on to our satisfied customers.

DS Instruments was founded by two engineers with the vision of bringing critical high frequency lab...
Test Solution: Bluetooth 5.1

Devices with BLE 5.1 functionality are suitable for tasks such as indoor asset tracking and for navigation services at airports.

Rohde & Schwarz is now launching the first test solution as a software upgrade for the R&S CMW test platform. The test solution for Bluetooth® 5.1 can be used to verify the performance of the location services that have been significantly improved with the new Bluetooth® specification.

With the new Bluetooth® core specification version 5.1 (BT 5.1), Bluetooth® Low Energy (BLE) devices can optionally offer improved navigation services. Additional functionality for direction finding (angle estimation) using the angle of arrival (AoA) and angle of departure (AoD) methods enables position determination with accuracy down to centimeter level in both the transmit and receive direction.

Previous solutions could only provide meter level accuracy. Devices with BLE 5.1 functionality are suitable for tasks such as indoor asset tracking and for navigation services at airports. Beacons are already being used to call attention to specific nearby products, sights and attractions in public spaces. BLE 5.1 now makes it possible to guide interested parties precisely to these points of interest. The Bluetooth® Special Interest Group (SIG) expects that by 2022 around 400 million additional devices will use the Bluetooth® 5.1 location services solutions.

To enable device manufacturers to test their products in line with Bluetooth® 5.1, Rohde & Schwarz has expanded its BLE test solution to include 23 new test cases in direct test mode (DTM) defined in the new RF-PHY.TS.5.1.0 test specification. With these tests, manufacturers can demonstrate that their products are RF interoperable with other devices and that direction finding meets the requirements of the BT 5.1 specification.

Rohde & Schwarz
rohde-schwarz.com
PIM Finder: Pinpoint and Detect External PIM Sources

Kaelus’s PIM Finder software is designed to accurately identify and locate external PIM sources outside antenna infrastructure.

Used in combination with the Kaelus iVA Cable & Antenna analyzer and the iPA portable PIM analyzer, PIM finder is a software option available through Kaelus Unify, used to pinpoint and detect external PIM sources such as loose mounting and cable brackets, fasteners, parapet walls and more, while allowing for the elimination of key causes of PIM interference.

Kaelus
kaelus.com

44GHz SPDT Switches

Analog Devices announced its 44 GHz single-pole, double-throw (SPDT) switches, the ADRF5024 and ADRF5025 in advanced Silicon-on-Insulator (SOI) technology. They are broadband, with the ADRF5024 yielding flat frequency response from 100 MHz to 44 GHz, while the ADRF5025 from 9 kHz to 44 GHz, with repeatable characteristics better than 1.7 dB insertion loss and 35 dB channel to channel isolation. Both parts support 27 dBm power handling for both through and hot-switching conditions. The switches come in a compact, highly reliable, 2.25 mm x 2.25 mm surface-mount-technology (SMT) compatible package, exhibiting electrical performance beyond incumbent solutions.

Analog Devices
analog.com
Product Highlights

VNA Cal Kit
For vector error correction procedures with your existing vector network analyzers, OML offers precision millimeter waveguide calibration kits with coverage from 50 GHz to 0.5 THz in three configurations: Universal, Standard, and Standard plus Sliding Load (except WR-02.2).

Universal
The VxxCAL is the premium calibration kit that supports the most calibration techniques.

OML
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Spectrum Analyzer Extension Modules
OML can extend the frequency range of your existing spectrum analyzer to millimeter wave frequencies with our single diode unbalanced harmonic mixers. Harmonic mixers are available for the waveguide bands between 18 and 325 GHz. These frequency extension modules are compatible with most spectrum analyzers that offer optional external mixer access. By substituting the harmonic mixer for the existing microwave input, you can expand your spectrum analyzer frequency coverage for millimeter wave measurements.

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E-Band Mixer

Spacek Labs model M80 5X2B is an E-band mixer covering the two radio bands of 71 to 76 GHz and 81 to 86 GHz. The mixer includes an integrated LO doubler, so that the customer need only supply a 39 GHz source with +16 dBm of power. Spacek Labs can also supply a phase locked source with the assembly. The conversion loss over the band is 6 dB typ and 9 dB max, with an IF frequency range of 2 to 8 GHz. The input P1dB is 6 dBm typ, and the bias is +12 VDC at 10 mA. The RF ports is WR-12 waveguide, LO input port is 2.92mm coax connector and the IF port connector is SMA (f).

Spacek Labs
spaceklabs.com

Diplexer

Response Microwave features a diplexer for use in specific telecom antenna applications. The new RMDU.0-25004310f offers Tx band of DC-1GHz and Rx band of 1.5-2.5GHz, with typical electrical performance of 0.5dB max insertion loss, 14db min return loss and 35dB minimum rejection over the band. Power handling is 50W CW and PIM is -150dBc. The unit is operational over the -10° to +85° C range and mechanical package is 2.4 x 7.30 x 1.3inches, plus 4.3/10 female connectors. Alternate bands and connectors are available on request.

Response Microwave
responsemicrowave.com
LTCC
WIDEBAND XFORMERS & BALUNS

240 MHz - 18 GHz
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- Power Handling up to 3W
- Rugged Construction for Harsh Environments
- Outstanding Repeatability
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