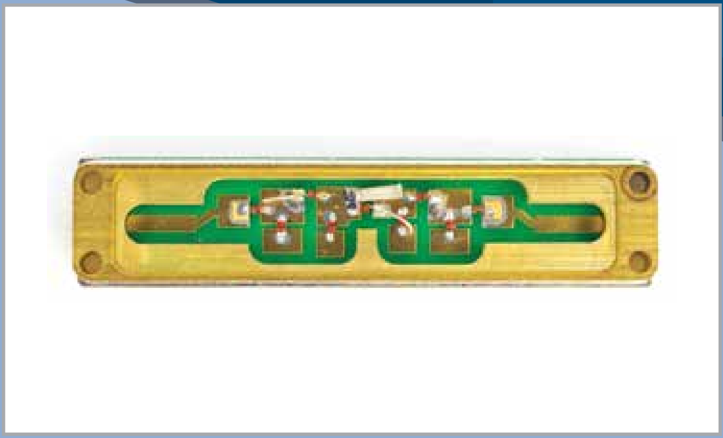
MPD MICROWAVE PRODUCT DIGEST
RF TO LIGHT
OCTOBER 2022

WEB DIRECTORY
pgs. 19 & 21



High-speed Oscilloscope

The R&S®MXO 4 Series is the first oscilloscope in its class with an update rate greater than 4.5 million waveforms per second that allows designers to view more signal detail and infrequent events. The 12 bit ADC in the instrument has 16 times the resolution of traditional 8 bit oscilloscopes at all sample rates, and standard acquisition memory is 400 Mpts on all four channels. They are available in four-channel models with bandwidths of 200 MHz, 350 MHz, 500 MHz, 1 GHz, and 1.5 GHz.

ROHDE & SCHWARZ

X Band Low Profile LC Filter

This X-band low profile LC bandpass filter covers 5.8 to 9.2 GHz with low passband insertion loss and high selectivity in a package measuring 1.6 x 0.36 x 0.1 in. The filter is built with high-temperature solder and can meet standard reflow temperatures up to 215° C. Other filter topologies include lumped constant types from 1 MHz to 10 GHz, crystal from 1 MHz to 250 MHz, ceramic from 300 MHz to 6 GHz, and cavity from 300 MHz to 26 GHz.

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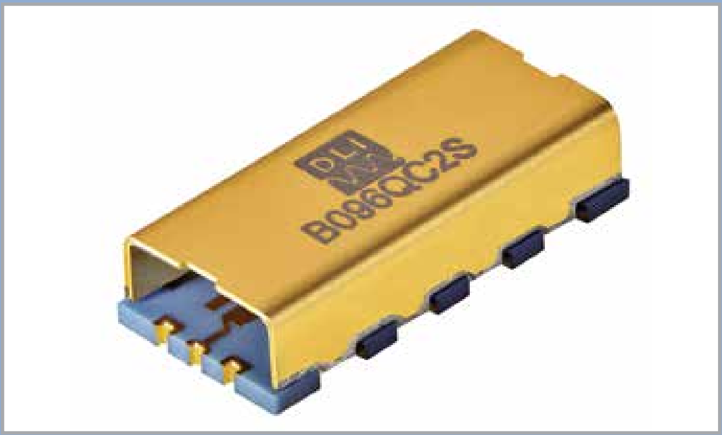

Temperature Stable Bandpass Filter

The B096QC2S ceramic bandpass filter has a center frequency of 10 GHz and a bandwidth of 2.5 to 12 GHz. It utilizes the company's high-permittivity ceramic that allows for a small footprint and a high level of temperature stability. VSWR is 2:1, insertion loss is 2.5 dB, and return loss is 10 dB. The filter operates over a temperature range of -55° to +125° C and out-of-band rejection is 50 dB.

KNOWLES ELECTRONICS

70 MHz Bandpass Filter

2924-SMA-SMA is a 50 ohm 70 MHz group delay equalized elliptic bandpass filter with a 1 dB bandwidth of 31 MHz and maximum 40 dB bandwidth of 49 MHz. Insertion loss is no more than 4 dB and group delay variation between 58 MHz and 82 MHz is 4 ns or less. It uses female SMA connectors. Other center frequencies, bandwidths, and surface-mount packaging are available. The filter's enclosure measures 2.2 x 0.6 x 0.6 mm.

KR ELECTRONICS

Top Research Institutions Try to Unlock 6G

by Greg Rankin

While the rollout of 5G is still in its infancy, bleeding-edge research around the world is now heavily focused on solving a significant problem that is expected to arise within the next few years. Antenna-to-antenna links or the "backhaul of the network" are essentially limited to frequencies under 100 GHz. However, experts are predicting that by around 2025 these lower frequencies, under 80 GHz, will no longer be enough to support the evolution of 5G or 5G plus, especially within densely populated areas.

"For 5G networks, at some point, every user will expect to have at least 1 GB/s or higher," says Dr. Guillaume Ducournau. "So, if you're running 5G in a crowded place, like a commercial center or a big city, we have to be able to manage the huge data rates at the antenna collecting point."

Dr. Ducournau is a professor at Université de Lille in France and a top academic researcher in THz communications. He has authored over 100 peer-reviewed papers published in international journals and developed several experimental setups dedicated to the characterization of THz devices for communications in the Lille THz communication cluster.

Figure 1: Currently there is a dearth of components capable of operating in excess of 100 GHz and then even fewer when you push into the THz regime where 6G is expected to excel. Unless the industry can come up with better components the problem is going to grow exponentially.

"Currently there is a dearth of components capable of operating in excess of 100 GHz and then even fewer when you push into the THz regime where 6G is expected to excel," continues Dr. Ducournau. "So, unless the industry can come up with better components the problem is going to grow exponentially."

6G is not yet a functioning technology, but will deliver data rates that are 100 times faster than 5G and shift from primarily connecting people and things to connecting intelligence. Connected Robotic and Autonomous Systems (CRAS), Unmanned Aerial Vehicles (UAVs), artificial intelligence, and even remote robotic surgery. However, without resolving the issue of working at millimeter wave (mmWave) and THz frequencies, 6G could be greatly delayed.

"There is an urgent need right now to develop components, devices, testbeds, and concepts to operate at higher frequencies because, by 2030 or so, 6G will require these things," says Dr. Ducournau.

Pushing Towards THz Components

The issue with creating components at frequencies above 100 GHz comes down to physics.

As you move up the electromagnetic (EM) spectrum the wavelengths get shorter. In fact, at a frequency of 300 GHz, the wavelength shrinks to just one millimeter. At these higher frequencies, the constituent parts are tiny and even small alignment errors can significantly degrade performance.

At such a small scale, available power and device power handling become a big challenge. Therefore, components at these frequencies must operate with exceptionally low insertion loss and extremely high performance to allow engineers

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to develop effective signal chains.

In addition to sufficient device power handling, high isolation between active components becomes of critical importance to minimize signal degradation and potential device destruction from signal reflections between components.

For example, Faraday rotation isolators—more commonly referred to simply as isolators—are two-port components that allow EM signals to pass in one direction but absorb them in the opposite direction. Isolators are often used in communication systems because they do a good job of suppressing standing waves.

"Isolators have low insertion loss within the microwave bands, but at mm-wave frequencies, where we were working at, the loss becomes increasingly problematic," explains Dr. Ducournau.

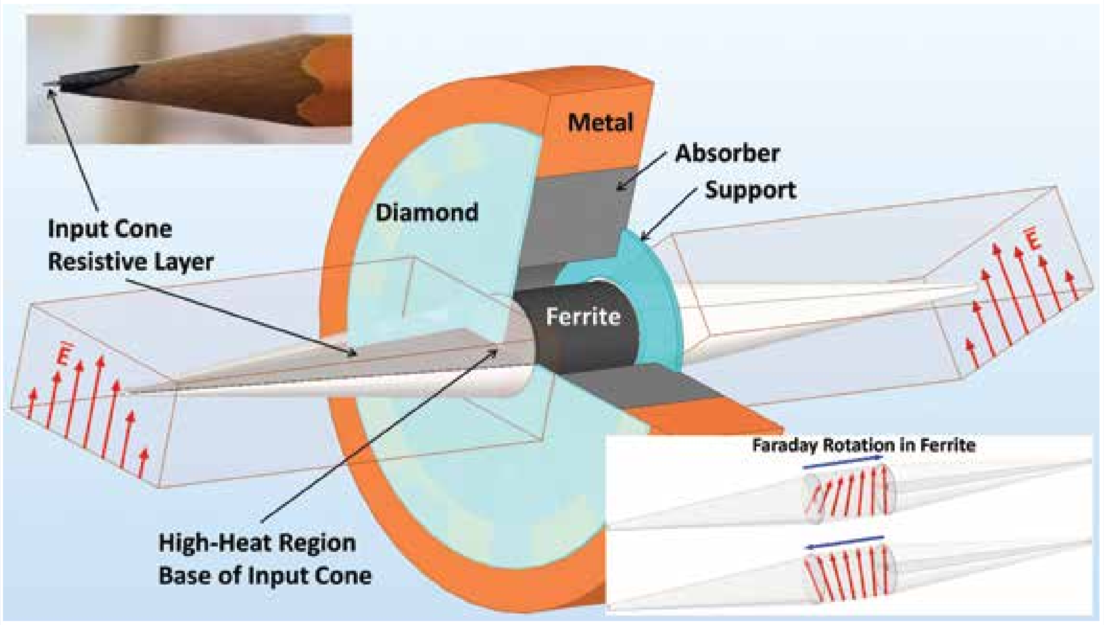

Figure 2: To minimize insertion loss, it is essential that the ferrite length be reduced as much as possible. The Micro Harmonics design saturates the ferrite with a strong magnetic bias field, which allows for the shortest possible length of ferrite to achieve the ideal 45° of rotation.

A Boost for mmWave Components

"After doing significant research a few years ago, I discovered NASA had awarded a project to Micro Harmonics to develop mmWave isolators all the way to 300 GHz, and they showed very good performance," recalls Dr. Ducournau. "I immediately called them up."

Micro Harmonics Corporation (www.MicroHarmonics.com) specializes in components for mmWave applications and successfully developed an advanced line of commercial off-the-shelf (COTS) circulators, isolators, and hybrid circulators, many of which can operate well into the THz regime.

Professor Ducournau selected an isolator that operates with WR-3.4 (220-325 GHz) and features a large usable bandwidth of dozens of GHz on either side of the center frequency.

"This allowed us to get the first-ever device characterization of a low noise amplifier operating at 300 GHz," states Dr. Ducournau.

His research team successfully characterized the noise floor (NF) along with the IP3 and IP5 of the amplifier, which are measurements of nonlinear frequency performance.

In addition to isolators, "there's also a need for circulators at these very high frequencies," explains Dr. Ducournau. "Circulators form part of the core system for communication applications but also for radar. Having these available could be a big boost for system implementation of early prototypes."

For example, a new hybrid circulator recently developed operates in the 100+ GHz range, which will be crucial to solving many of the 6G bottlenecks within the backhaul of the network.

The hybrid circulator has a much larger working bandwidth from 150 GHz to 190 GHz. The current state-of-the-art Y-junction circulator has a bandwidth of only a few GHz at these frequencies. The bandwidths required for 6G are not remotely possible using a Y-junction approach.

"Looking at the D-band development for backhauling, such devices would be very useful as duplex links targeted in such applications," says Prof. Ducournau.

A Small Footprint

Simply attaining higher frequencies is not the only consideration when moving new research from the lab to commercial production. An overriding theme in commercialization is the drive to reduce the size, weight, power, and cost (SWaP-C) of components.

Minimizing the size and weight of mmWave components is especially important in today's wireless applications. A standard traditional-style isolator in the WR10 band is about 3 inches long, with a cylindrical section in the center that's about 1.3 inches in diameter. While that may seem small, new designs are only 0.75 inches per side and 0.45 inches thick and are packaged in a designer-friendly

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- Noise power after the analog combiner is larger
- The NF of components after the analog combiner has less impact
- IIP3 decreases as signals combine due to larger signals at devices after the analog combiner
- Spurs are generally correlated within the analog subarray. This is because the source is after the analog combiners and so the same spur is measured regardless of whether the microwave channel is enabled.

As subarrays are combined digitally:

- SNR increases 10logN
- Signal power remains constant
- The noise power in dBFS/Hz decreases
- IIP3 approaches the average
- Spurs observed are uncorrelated across digital channels

Correlated phase noise terms are worth noting. Correlated phase noise is observed in this test configuration. This can be seen with the close-in noise in **Figure 8** where the frequency axis is zoomed enough to show the effect. A common microwave input and LO input from test equipment is used. This means the microwave signals and LO phase noise are correlated. Shared power can also cause a correlated contribution and voltages are shared in this test configuration. In this test configuration we did not debug the dominant sources of correlated phase noise during receiver testing. However, this point is noted and remains an area for future investigation in this hardware.

Acknowledgements

The authors would like to acknowledge the many engineers at Analog Devices who made this work possible. This includes IC designers, circuit board designers, software developers, and technicians who assembled the prototype hardware. We would also like to thank the application-oriented managers who demonstrated foresight in the value of the test platform and showed patience during the lengthy process to bring the test platform to reality. Our description documents the receiver test results, but without the work of many others this description would not have been possible.

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rectangular cuboid.

These types of improvements in commercial components, along with leading researchers in the field, are pushing towards widespread commercial 6G technologies potentially by the end of this decade.

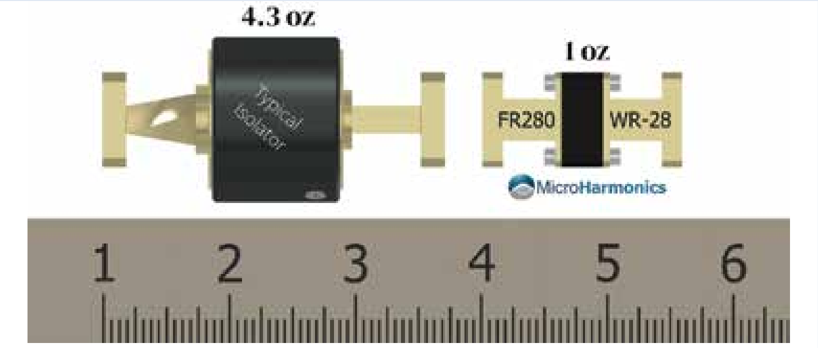

Figure 3: Minimizing the size and weight of mmWave components is especially important in today's wireless applications. A standard traditional-style isolator is about 3 inches long, and while that may seem small, new designs are only 0.75 inches per side and 0.45 inches thick.

Unlocking New Technologies

Of particular interest to Professor Ducournau is the development of remote robotic surgery where a very low time-latency transmission system would be required. This is where the development of new components for systems with 6G speeds and high-reliability low latency communications are opening the door for the world's best doctors to perform operations on people anywhere on the planet.

"If the energy consumption is low and the devices can be mass produced at low cost, the possibilities for new techniques for medical procedures would be endless."

The technical challenges to implementing 6G systems are enormous. There is a good chance that the push to higher frequencies will halt near this point due to the practical limits of physics, health and safety.

"There is a strong argument to stay within the mmWave or lower THz frequencies because these wavelengths keep the radiated power densities within the bounds of what most people consider safe," concludes Prof. Ducournau.

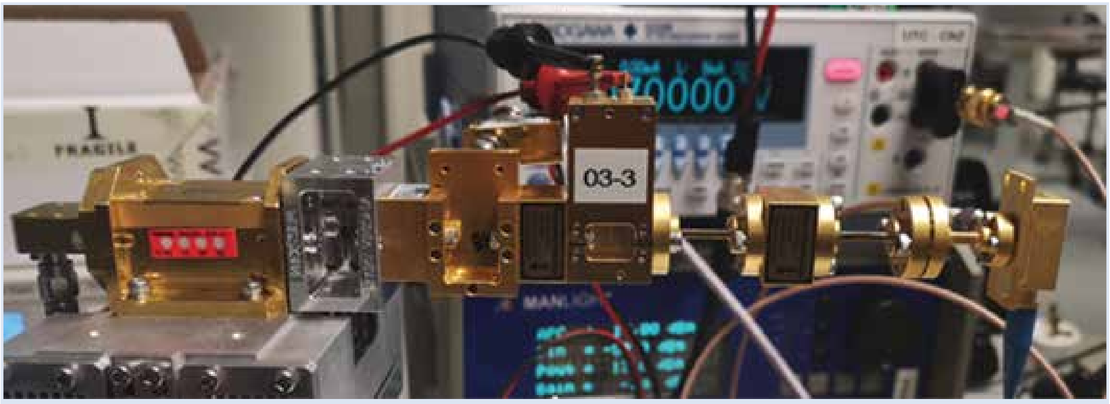

Figure 4: Professor Ducournau, from Université de Lille in France, selected a Micro Harmonics isolator that operates with WR-3.4 (220-325 GHz) and features a large usable bandwidth of dozens of GHz on either side of the center frequency to get the first-ever device characterization of a low noise amplifier operating at 300 GHz

For more information contact Micro Harmonics: 540.473.9983, sales@mhc1.com, or visit www.MicroHarmonics.com

• GREG RANKIN •