MPD MICROWAVE PRODUCT DIGEST
RF TO LIGHT — APRIL 2020

5G Ready MillimeterWave Products

An entire family of components covers the various proposed bands for 5G and millimeterWave bands. Included are power dividers and couplers covering 6 to 40 and 10 to 50 GHz with 2.92 and 2.4mm interfaces, along with supporting components such as attenuators, terminations, bias tees, DC blocks, and adapters. This includes octave and multi-octave units covering MHz to GHz with SMA interfaces. Models covering 40 to 50 and 26 to 65 GHz are now available.

MECA ELECTRONICS

Isolation Transformers for Medical Applications

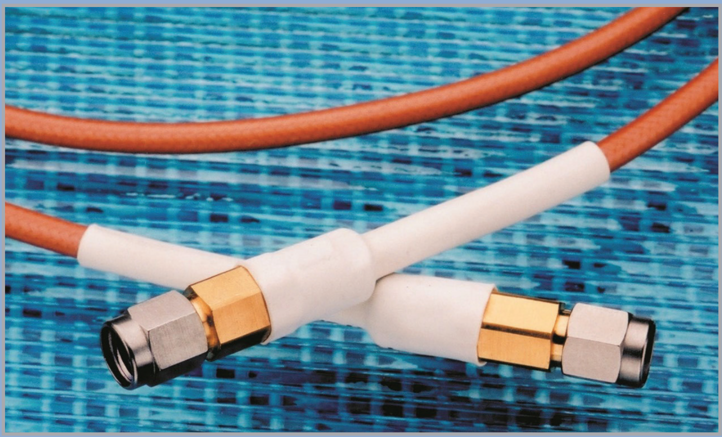
A new series of data isolators, also known as isolation transformers, are fully self-contained devices that protect valuable network equipment and personnel from damaging surges and power anomalies that commonly occur across network cabling. Installation and operation is easy and efficient—simply plug the device inline between two 10/100/1000 Ethernet cables and equipment on each end is effectively protected.

TRANSTECTOR

Dual Directional Coupler

Model 526550010 is a multipurpose, stripline design that exhibits excellent coupling over the 26.5 to 50 GHz frequency bands (Ka- and Q-bands). This new coupler is uniquely designed for system applications where external leveling, precise monitoring, signal mixing, or swept transmission and reflection measurements are required. Its superior performance ratings include nominal coupling (with respect to input) of 10 dB, +/-1.8 dB, and frequency sensitivity of +/-1.0 dB. Insertion loss (including coupled power) is less than 3.0 dB.

KRYTAR



RF Interconnects for 5G Infrastructure and Applications

The interconnect requirements at mmWave are completely different than what we see at traditional telecom frequencies of sub 6 GHz. Whereas, coaxial cable used in traditional telecom infrastructure is often heavy and stiff with bulky interfaces that were optimized for ruggedness, power handling and PIM performance, mmWave assemblies are a whole different animal.

TIMES MICROWAVE SYSTEMS

Read the full article starting on pg. 8

Advances in MMW Isolator Design Launch Manufacturers into Stratospheric Operating Frequencies

by Dave Rizzo, Micro Harmonics

Improvements in the five critical characteristics of isolators benefit electronics manufacturers in the new path towards next-gen wireless

Figure 1: Without control, standing waves can attenuate power output, distort the digital information on the carrier and, in extreme cases, damage internal components

It doesn't take a crystal ball to know where the future of wireless is heading. With inexhaustible demand driven by 5G, 6G and beyond, ultra-high definition video, autonomous driving cars, security applications and IoT, the sky's the limit for utilizing the higher ends of the electromagnetic (EM) spectrum.

Meeting this demand requires products capable of capitalizing on the millimeterWave (MMW) bands which presently cover the frequencies between 30 GHz to 500 GHz. However, these higher frequencies present a significant problem that design engineers must address: that of standing waves. Without control, these unwanted waves can attenuate power output, distort the digital information on the carrier and, in extreme cases, damage internal components.

To counteract the problem of standing waves at lower microwave frequencies, engineers rely on Faraday rotation isolators—more commonly referred to simply as isolators. At their very basic level, an isolator is a two-port, input and output, component that allows EM signals to pass in one direction, but absorbs them in the opposite direction. However, traditional isolators fall short at the higher frequencies required for next-gen wireless applications.

A big part of the problem is that the first isolators were designed more than a half century ago, with very few modifications since the original concept. With recent advancements, however, companies at the cutting edge of MMW technologies are gaining the ability to launch products

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Figure 2: An isolator is a two-port, input and output, component that allows electromagnetic signals to pass in one direction but, absorbs them in the opposite direction. However, traditional isolators fall short at the higher frequencies required for next-gen wireless applications.

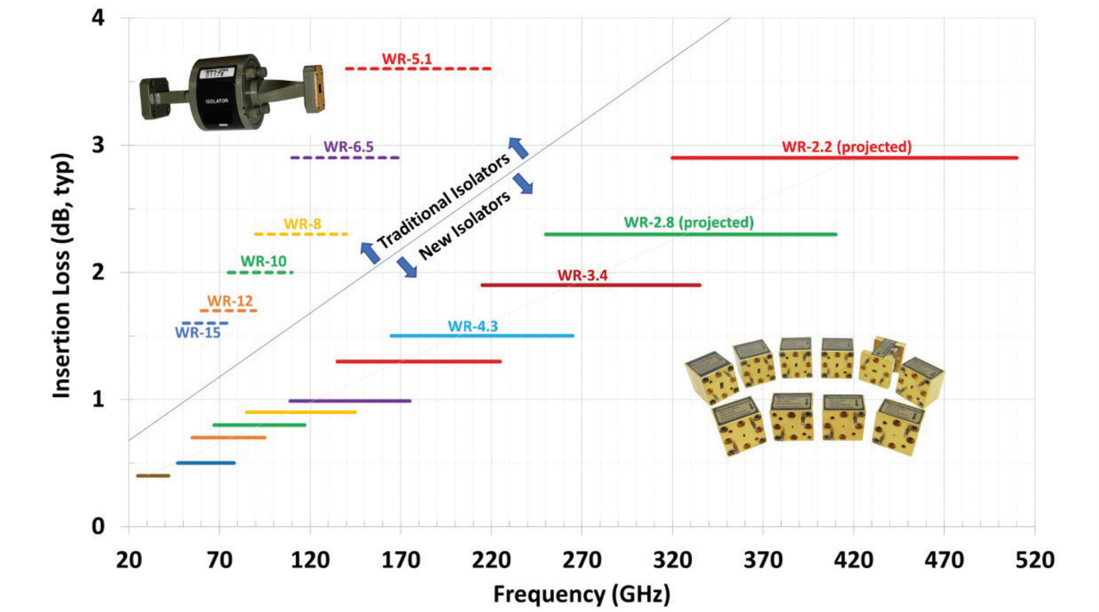

Figure 3: A big part of the problem is that the first isolators were designed more than a half century ago, with very few modifications since the original concept. These isolators had good isolation, but very high attenuation of the forward, input signal.

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that operate optimally at stratospheric frequencies.

"The new series of waveguide isolators have been a key enabling technology for VDI, and a large advance from what was previously available," says Jeffrey Hesler, PhD, CTO of Virginia Diodes, Inc.

VDI is a Virginia-based manufacturer of state-of-the-art test and measurement equipment—such as vector network analyzer, spectrum analyzer and signal generator extension modules—for MMW and THz applications.

"The compact size, extremely low insertion loss, and the wide bandwidth have allowed us to use isolators in a wider variety of our systems than was previously possible, and have led to significant improvements in key system performance metrics such as source power and sensitivity," says Hesler.

By understanding these advancements in each of the five properties of isolator functionality, designers can better harness isolators to improve their MMW products.

High Isolation

Isolation is a measure of how much of the signal traveling in the reverse direction passes back through the isolator. Because isolators are intended to prevent, or minimize this from happening, the higher the isolation, the better.

"The issue that MMW system designers face is impedance mismatches and the resulting reflections between components," states David Porterfield, Founder and CEO of Micro Harmonics Corporation (MHC).

Headquartered in Virginia, MHC (www.Micro Harmonics.com) specializes in design solutions for components used in MMW products. Under a two-phased NASA contract awarded in 2015, the company successfully developed an advanced line of isolators for WR-15 through WR-3.4 (50 GHz to 330 GHz) applications.

"In MMW systems, the distance between components is often more than a wavelength, putting reflected signals out of phase," continues Porterfield. "The out-of-phase reflected signal can perturb the operating point of the

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Figure 4: To counteract the problem of standing waves at higher MMW frequencies, engineers are turning to isolators that were recently redesigned for NASA

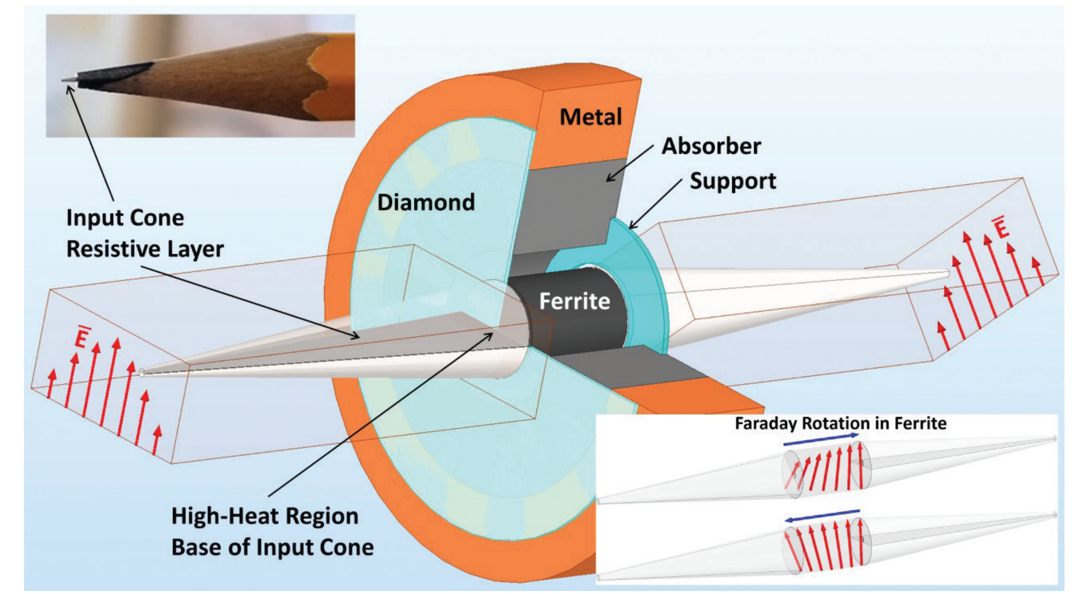

Figure 5: Micro Harmonics revolutionized the design of the Faraday rotation isolator. The new design delivers extremely low insertion loss at very high frequencies and a wide bandwidth, all within a more compact size.

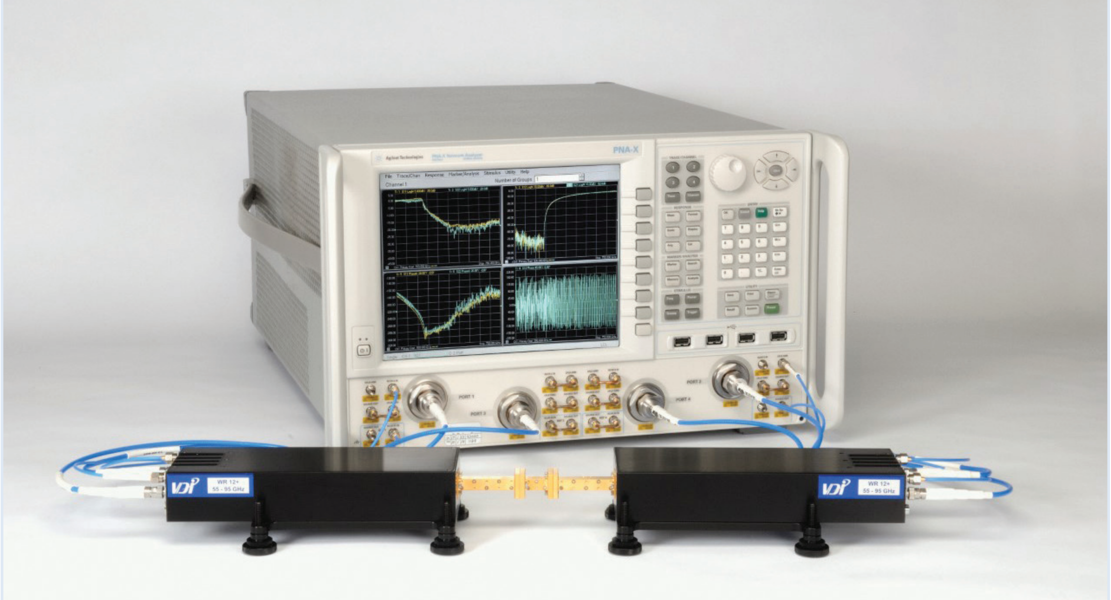

Figure 6: Virginia Diodes, a manufacturer of state-of-the-art test and measurement equipment, has utilized the new isolators from Micro Harmonics to launch products that operate optimally at stratospheric frequencies

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upstream component. As you sweep frequencies, the phase changes and you get nulls, dips and degraded performance. However, when you insert an isolator between components, the reflected signal gets absorbed and the problem goes away."

The highest possible isolation occurs when the reverse wave is rotated exactly 45° into the plane of the isolator's resistive layer. Isolation can degrade by as much as 10 dB when the signal rotation is off by just 1°.

"The only way to confirm such precision is to fully characterize each isolator on a vector network analyzer," says Porterfield. "This validates total compliance, as opposed to just spot-checking at a couple of frequencies in the band."

Low Insertion Loss

While isolation is the namesake of these components, the suppression of the reverse wave can't come at the expense of attenuating the forward, input signal. Insertion loss is a measure of how much loss a signal incurs as it passes through the isolator in the forward direction.

For traditional style isolators, insertion loss is low in the microwave bands, but at MMW frequencies the loss becomes increasingly problematic. For instance, in the WR-10 band (75-110 GHz) the insertion loss can exceed 3 dB, meaning half of the signal power is lost. In the WR-5.1 band (140-220 GHz) the loss climbs to more than 5 dB. Because of high losses, traditional isolators are often precluded for use in MMW systems.

"A designer's main fear is that the isolator will significantly degrade the strength of the final output," continues Porterfield. "It can be frustrating for engineers to try and tune the standing waves out of each system, usually with limited success. Many of the alternate methods used are narrow band in nature, so that the solution may work well only over an insufficiently narrow

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band of frequencies."

Faraday rotation isolators operate by using ferrite discs to rotate the signal. However, the traditional method to manufacture them has been to use ferrites that are substantially longer than the minimum required length, and then tune the magnetic bias field to achieve optimal performance. This delivers good isolation, but at a much higher insertion loss.

Porterfield points out a two-fold problem with this workaround. First, there is more of the lossy ferrite in the signal path, and second, the ferrite loss parameter increases at lower magnetization levels.

To minimize loss, it is essential that the ferrite length be reduced as much as possible. The design developed for NASA 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. This lowers the insertion loss to less than 1 dB at 75-110 GHz and only 2 dB at 220-330 GHz.

"The extension of isolator technology above 220 GHz is an impressive technical feat, and a key technology that enables us to deliver accurate measurements with higher sensitivity than we were previously able to achieve," notes VDI's Hesler.

Low Port Reflection

A good isolator must also have low port reflections. Voltage Standing Wave Ratio (VSWR) is a measure of the reflections at the input and output ports. A good range at MMW frequencies is 1.5:1 or less; 1:1 equals no reflection.

The importance of low port reflections is often overlooked. An isolator with high port reflections creates an alternate set of standing waves. The adjacent components are still adversely impacted by out-of-phase signals reflected back into their ports. High isolation and low insertion loss are of little value if the port reflections are large.

High Power Rating

Power in the reverse traveling signal is absorbed in the isolator, resulting in heat. The more heat it can handle, the higher the power rating. Historically, high heat was not an issue as there was very little power available at MMW frequencies. However, as higher power sources become available, the importance of power ratings increases.

To handle the problem of high heat loads, some newer isolators are already incorporating diamond heat sinks into their design. Diamond is the ultimate thermal conductor, approaching 2200 W/m•K (watts per meter-Kelvin), more than five times higher than copper. Diamond effectively channels heat from the resistive layer in the isolator to the metal waveguide block, and thus lowers operating temperatures for improved reliability.

Small Footprint

Minimizing the size and weight of MMW 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," observes Porterfield. "But the newest design shapes are rectangular and can be as small as 0.75 inches per side and 0.45 inches thick."

The same technology used to reduce insertion loss—utilizing the shortest possible length of ferrite—also partially accounts for the reduction in footprint.

In addition to the five critical characteristics, other properties of modern isolators improve their utility at MMW frequencies; for instance, wide bandwidth. Standard waveguide bands typically extend to 40% on either side of the center frequency. Newer, high-performing isolators operate over extended bandwidths exceeding 50% from center frequency, giving designers greater freedom to build more bandwidth into their systems.

Additional advances include isolators that operate in cryogenic conditions, which is critical because a traditional isolator designed for room temperature operation will perform poorly when cooled.

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

About the Author

Dave Rizzo is a Phoenix-based freelance writer and licensed ham radio operator who has over 25 years of experience writing on the latest trends in the microwave and RF industries.

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