Navigating LNA Microwave Integrated Circuits

In the News
Market Reports
Editorial: Microwave Cooking Market was Slow to Mature

Ideas for Today’s Engineers: Analog · Digital · RF · Microwave · MM-Wave · Lightwave
C.W. SWIFT & Associates, Inc.

C.W. SWIFT & Associates distributes our extensive inventory of SGMC Microwave’s quality products ... OFF THE SHELF!

SGMC Microwave Components are in Stock — Call Today for a Quote!

ADAPTERS • CABLE CONNECTORS • RECEPTACLES • CUSTOM DESIGNS

Including These Connector Series

<table>
<thead>
<tr>
<th>Connector Series</th>
<th>Frequency Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.85mm</td>
<td>DC-65 GHz</td>
</tr>
<tr>
<td>2.4mm</td>
<td>DC-50 GHz</td>
</tr>
<tr>
<td>2.92mm</td>
<td>DC-40 GHz</td>
</tr>
<tr>
<td>3.5mm</td>
<td>DC-34 GHz</td>
</tr>
<tr>
<td>7mm</td>
<td>DC-18 GHz</td>
</tr>
<tr>
<td>SSMA</td>
<td>DC-40 GHz</td>
</tr>
</tbody>
</table>

ISO 9001:2008

C.W. SWIFT & Associates, Inc.
15216 Burbank Blvd., Van Nuys, CA 91411
Tel: 800-642-7692 or 818-989-1133 or Fax: 818-989-4784
sales@cwswift.com •www.cwswift.com

CLOSED EVERY ST. PATRICK’S DAY!
RF, Microwave, Microelectronics & Power Solutions

Components, Modules, Integrated Assemblies & Subsystems

- Amplifiers, Filters, and Passive & Active Components
- Integrated Microwave Assemblies
- SAW Filters & Oscillators
- Optoelectronic Solutions
- High Temperature Microelectronics
- Power Conversion & Distribution

Call +1 (855) 294 3800 or visit micro.apitech.com | Check us out on social:
The industry's largest selection includes THOUSANDS of models from 2 kHz to 65 GHz, with up to 300 W power handling, in coaxial, flat-pack, surface mount and rack mount housings for 50 and 75 Ω systems.

From 2-way through 48-way designs, with 0°, 90°, or 180° phase configurations, Mini-Circuits' power splitter/combiners offer a vast selection of features and capabilities to meet your needs from high power and low insertion loss to ultra-tiny LTCC units and much more.

Need to find the right models fast? Visit minicircuits.com and use Yoni2®! It's our patented search engine that searches actual test data for the models that meet your specific requirements! You'll find test data, S-parameters, PCB layouts, pricing, real-time availability, and everything you need to make a smart decision fast!

All Mini-Circuits' catalog models are available off the shelf for immediate shipment, so check out our website today for delivery as soon as tomorrow!

POWER SPLITTERS
COMBINERS

as low as 89¢ from 2 kHz to 65 GHz ea. (qty. 1000)

RoHS Compliant

Product availability is listed on our website.

COVERING 10 to 65 GHz IN A SINGLE MODEL

ZN2PD-E653+

NEW!
The industry’s largest selection includes THOUSANDS of models from 2 kHz to 65 GHz, with up to 300W power handling, in coaxial, flat-pack, surface mount and rack mount housings for 50 and 75Ω systems.

From 2-way through 48-way designs, with 0°, 90°, or 180° phase configurations, Mini-Circuits’ power splitter/combiners offer a vast selection of features and capabilities to meet your needs from high power and low insertion loss to ultra-tiny LTCC units and much more.

Need to find the right models fast? Visit minicircuits.com and use Yoni2®!

It’s our patented search engine that searches actual test data for the models that meet your specific requirements! You’ll find test data, S-parameters, PCB layouts, pricing, real-time availability, and everything you need to make a smart decision fast!

All Mini-Circuits’ catalog models are available off the shelf for immediate shipment, so check out our website today for delivery as soon as tomorrow!
22: Feature Article
Navigating LNA Microwave Integrated Circuits
By Peter McNeil

Low Noise Amplifiers (LNAs) are among the fundamental building blocks of wireless communications systems, along with power amplifiers (PA), oscillators, and mixers. These components serve as the medium that takes a received signal and amplifies it with a sufficient amount of gain while adding minimal noise. This typically occurs before mixing the signal with a local oscillator (LO) and converting it to analog baseband for signal processing to occur.

From semiconductor substrate type, to integrated circuit implementation (i.e.: MMIC or MIC), to the packaging, the specific function of the LNA along with the scenario it is applied in, allow for a fairly wide array of LNA design combinations. This article attempts to navigate through some of the current technologies used in various LNA architectures.

28: Industry Products
A Rundown of the Industry’s Latest Product Innovations
By HFE Staff

Including SAGE Millimeter, NuWaves Engineering, Ironwood Electronics, Besser Associates, LadyBug Technologies, Spacek Labs, and more.
NI AWR DESIGN ENVIRONMENT

SIMPLY SMARTER
POWER AMPLIFIER DESIGN

NI AWR Design Environment is one platform integrating system, circuit, and electromagnetic analysis that provides robust harmonic-balance simulation for fast and accurate nonlinear analysis of power amplifiers. With highly accurate semiconductor device and circuit element models, load-pull analysis, and design automation, the software empowers amplifier designers to successfully bring their products to market.

Simply smarter amplifier design.

Learn more at awrcorp.com/amplifier
I have seen numerous accounts concerning the invention of the microwave oven. It is true that my grandfather, Percy L. Spencer, filed for a patent, #2,495,429 Method of Treating Foodstuffs, in October 1945, and it was granted in January 1950. At the time he was employed by Raytheon Manufacturing Corp. The story goes that he stood in front of a burn-in rack of magnetrons when he noticed a candy bar in his pocket had melted, and came up with the idea of cooking with radio waves.

Whether or not the candy bar incident is true, the real story behind the microwave oven is that Raytheon Company was in transition, trying to survive in an era of uncertainty. It was 1945, World War II would soon end, and many firms’ vital defense contracts would soon dry up. In anticipation of a steep decline in revenue, Raytheon knew it had to leverage its core competencies (radar and power tube technologies) into the civilian marketplace.

The notion that electromagnetic energy could be used for heating materials including food was known to companies like Westinghouse, RCA, and General Electric, all of which were conducting research in this area. Technical papers of the time referred to the use of radio waves for the “sterilization, blanching, and cooking of food stuffs.”

Prototype Ovens

Raytheon took the task to hand and began developing prototype ovens. Early versions weighed in at nearly 700 lbs., were over five feet tall, used a conveyor belt to move food past the radiating source, needed running water to cool the power tubes, and required a 220 volt electrical source. With a price tag of nearly $2,000, the microwave oven fell low on the list of in-demand consumer products.

A young Raytheon engineer named Marvin Bock was chosen to spearhead the effort to make the microwave oven consumer-friendly. Early microwave ovens operated at 915 MHz, producing a wavelength of about 12 centimeters. Because the cavity size was comparable to the wavelength, there was a tendency to form standing waves which caused the food to heat unevenly – a major impediment. Bock scrapped the 915 MHz power source, settling on 2450 MHz, on the theory that the shorter wavelength would produce smaller standing waves, thus more even heating. Bock experimented with varying the size of the cavity using motors to move one wall in and out. He tried rotating the food on a turntable. Another engineer sug-
gested that rotating metal rods sus-
pended from the upper wall of the
oven would function as a “mode stir-
rer.” The mode-stirring rods were not
perfect, but sufficient to put the
uneven cooking problem to rest. Still,
market demand was soft, and in
1948 Raytheon stopped making
microwave ovens.

In 1953 Raytheon relaunched the
“Radarange,” a new unit smaller and
more powerful than its predecessors.
The company sold about 10,000 units
between 1953 and 1967. The lacklu-
ter sales figures were tied directly to
manufacturing costs and market
expectations: the market wanted a
$500 oven and the tube alone cost
$300. Speculating that having the
ability to package the microwave
oven with other major appliances
would be an advantage, Raytheon
acquired Amana, a manufacturer of
high-quality refrigeration equip-
ment. Amana founder and President
George Foerstner and his son Richard
were soon involved with the reshap-
ing of the microwave oven to meet
the needs of everyday households.

They focused on the magnetron
just as Marvin Bock had done earli-
er. By this time Japan had emerged
as a low-cost provider of a wide
range of electronic devices. New
Japan Radio Company (NJRC)
offered to supply magnetrons and
power supplies for a tenth of
Raytheon’s tube cost. The NJRC
tubes were not as powerful as
Raytheon’s and food took longer to
cook. However, the smaller NJRC
tubes meant the need for 220 volt
electrical was gone. Now, Amana
could offer an affordable unit that
the consumer could take home, plug
in, and immediately enjoy micro-
wave cooking. In 1970 about 40,000
ovens were sold, most under $400.
Once the Japanese entered the mar-
ket, now as direct competitors, sales
took off, with one million units sold
in 1975, and later 10 million per year
by 1985. It is expected that about
13.5 million units per year will be
sold in 2018 and 2019.

Technology advances will likely
change how these ovens are pro-
duced in the future. One example is
Dutch based Ampleon, which is
leveraging its 2.45 GHz LDMOS
transistor expertise in collaboration
with the major consumer appliance
manufacturer Midea to supply the
first commercially available solid-
state microwave ovens. The solid-
state approach allows for precise
control over output power, frequency,
and phase; virtually eliminates the
formation of standing waves; and
results in a much more uniform tem-
perature in cooked foods.

It wasn’t long ago that the con-
cept of generating the power needed
to cook food at microwave frequen-
cies via a solid-state source seemed
inconceivable.
Meetings and Events

IEEE Radio Wireless Symposium 2019
January 20 – 23, 2019
Orlando
https://www.radiowirelessweek.org/

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

Company-Sponsored
Training & Tools

Analog Devices
Training, tutorials and seminars.

NI AWR
On-site and online training, and open training courses on design software.

National Instruments
LabVIEW Core 1
Online
http://sine.ni.com/tacs/app/fp/p/ap/ov/pg/1/
LabVIEW Core 2
Online
http://sine.ni.com/tacs/app/fp/p/ap/ov/pg/1/
Object-Oriented Design and Programming in LabVIEW
Online
http://sine.ni.com/tacs/app/fp/p/ap/ov/pg/1/
Free, online LabVIEW training for students and teachers.
http://sine.ni.com/nievents/app/results/p/country/us/type/webcasts/

2018 IEEE WIE International Leadership Summits
El Salvador November 9, 2018
Tokyo November 9 - 10, 2018

Was Your Paper Rejected by a Symposium?

HFE Wants to See It
Email Summary to:
tim@highfrequencyelectronics.com

HFE's December Issue
Passives Oscillators VCOs

CONTACT YOUR SALES REP TODAY!
Industry Leading Performance!

The LUXYN™ MLVS-Series Frequency Synthesizers from Micro Lambda Wireless is one of the fastest and quietest synthesizers on the market. Standard frequency models are available covering 500 MHz to 20 GHz and 500 MHz to 10 GHz with options to cover down to 50 MHz and up to 21 GHz in a single unit.

With the lowest noise in the industry, (phase noise at 5 GHz is -130 dBc/Hz @ 10 kHz offset and at 10 GHz is -125 dBc/Hz @ 10 kHz offset), these synthesizers are designed for low noise & fast tune applications such as Receiving Systems, Frequency Converters and Test & Measurement Equipment.

For more information contact Micro Lambda Wireless.

www.microlambdawireless.com

Micro Lambda is a ISO 9001:2015 Registered Company

“Look to the leader in YIG-Technology”
High Frequency Electronics

Market Reports

Study: 5G Device Prices Will Decline More slowly than 3G, 4G

5G smartphones will carry wholesale costs of more than $750 when they are introduced in 2019, translating to retail prices of as much as $1,000 or more. According to a series of newly published reports from the Strategy Analytics Device Technologies practice, 5G device prices will decline at a much slower pace compared to 3G and 4G handsets. Subsidies will be necessary to make 5G smartphones affordable to the mass market.

• The report “5G’s Dirty Little Secret: Subsidies Must Return,” concludes:
  • 5G is not a panacea for the industry ills whether one is an operator or a device vendor. There is a lot of hard work, experimentation and failure likely over the next 5 years.
  • There is every reason to think that the transition to 5G will result in a reordering of the current list of top smartphone makers just as happened with 2G, 3G and 4G.
  • Vendors must strive to be global and minimize market specific SKUs where possible, building from a global platform or be local, focused and niche. The profit drain zone is positioned at the bottom of the U-curve with volume between 40 and 60M where profits are almost impossible to realize.
  • Lenovo-Motorola, LG, and ZTE to name a few are in perilous positions and must carefully execute a pragmatic 5G strategy or risk surging losses.
  • Samsung and Huawei each have challenges to maintain growth with 5G due to their limited presence in China and USA respectively.

Senior Analyst Ville-Petterri Ukonaho commented “5G has many more risks than rewards for most vendors in the short term. We believe caution about the speed of 5G ramp up and slope of the price/performance curve for devices is critical. Unlike current generation smartphones, 5G devices will require a number of changes in order to provide the best performance, including new chipsets and additional antennas. 5G devices will be the most complex and expensive ever.”

Ken Hyers, Director of Emerging Device Technologies agrees “It requires magical thinking to expect that consumers are going to rush to buy 5G smartphones that are bigger, and more expensive than any phone that they’ve ever bought before. Only 9% of Chinese customers, for example, buy phones whose wholesale prices start at US$500 and up. Without scale from China to drive device prices lower, can 5G forecasts from operators and device vendors really live up to their lofty ambitions? Slower uptake is a real threat unless someone closes the gap to 4G performance.”

David Kerr, SVP adds “The history of the mobile industry teaches us that with every transition from one wireless generation to the next at least one top vendor has found itself wrong-footed by the transition and has seen its market share collapse (i.e. Motorola and Nokia). Could Huawei be the next? Or will Samsung’s lack of presence in China see it vulnerable?”

—Strategy Analytics
strategyanalytics.com

* * *

New defense platforms and major upgrades are reaching the production phase and while the radar segment will remain the dominant application, all the defense segments will experience growth.

Cellular Applications Propel RF GaAs Revenue Past $800M

After a relatively flat year in 2016, revenue in the RF GaAs device market grew by more than 7 percent in 2017. While a wide variety of commercial and defense applications use GaAs devices, the wireless market continues to be the dominant user of this technology. Mobile handsets will continue to define the revenue trajectory, but emerging 5G network deployments will contribute to future growth. The Strategy Analytics Advanced Semiconductor Applications (ASA) service report, “RF GaAs Device Industry Forecast: 2017 - 2022,” forecasts that RF GaAs revenues will push past the $9 billion milestone by the end of the forecast timeframe.

“Despite the dominance of the wireless segment, the RF GaAs market has been notable for the breadth of applications using the technology,” noted Eric Higham, Service Director, Advanced Semiconductor Applications (ASA) service. “However, GaAs devices are facing challenges from other technologies and they are being commoditized in many of these applications. Future growth is going to depend heavily on LTE and emerging 5G networks.”

“The situation for RF GaAs growth in the defense market is different,” observed Asif Anwar, Director of the Advanced Defense Systems (ADS) service. “New defense platforms and major upgrades are reaching the production phase and while the radar segment will remain the dominant application, all the defense segments will experience growth.”

—Strategy Analytics
strategyanalytics.com
The Smart Choice for Small Spaces

Coilcraft is the brand engineers trust most when specifying tiny inductors for wearable technology.

Boost the performance and battery life of your wearable products with these tiny RF and power inductors from Coilcraft:
- Wirewound chip inductors as small as 0201 size for wireless communications
- Shielded power inductors as thin as 0.5 mm for power management
- Coupled inductors as small as 2.2 x 1.45 mm for LED display drivers

You can get started by using our suite of web tools to quickly locate the perfect inductors for your design. Compare and analyze multiple parts based on your true operating conditions, and then order free evaluation samples with just a click.


Coilcraft
WWW.COILCRAFT.COM
In the News

Discovering New Molecules for Military Applications
The efficient discovery and production of new molecules is essential for a range of military capabilities—from developing safe chemical warfare agent simulants and medicines to counter emerging threats, to coatings, dyes, and specialty fuels for advanced performance. Current approaches to develop molecules for specific applications, however, are intuition-driven, mired in slow iterative design and test cycles, and ultimately limited by the specific molecular expertise of the chemist who has to test each candidate molecule by hand.

Today, DARPA announced the Accelerated Molecular Discovery (AMD) program, which aims to develop new, AI-based systematic approaches that increase the pace of discovery and optimization of high-performance molecules.

“The ultimate goal of AMD is to speed the time to design, validate, and optimize new molecules with defined properties from several years to a few months, or even several weeks,” said Anne Fischer, program manager in DARPA’s Defense Sciences Office. “We aim to develop the AI tools, models and experimental systems to enable autonomous design of molecules to quickly meet DoD needs.”

The program calls for teams of researchers to develop AI-based, closed-loop systems that automatically extract existing chemistry data from databases and text, perform autonomous experimental measurement and optimization, and use computational approaches to develop physics-based representations and predictive tools.

AMD performers will develop tools, models, and experimental capabilities to rapidly design, validate, and optimize molecules. Government partners will evaluate performer developments and test their ability to identify new molecules with specific combinations of functional properties that may be relevant to specific DoD application requirements.

“There are currently around 140 million known molecules, but the space of potential molecules is vastly larger than that, upwards of $10^{60}$,” Fischer said. “In DARPA’s Make-It program, we’ve developed advanced ways to efficiently synthesize known molecules. AMD is taking the next step, where we will rapidly be able to explore the unknown molecular universe to design and produce completely new molecules with specific desired functions.”

—DARPA

DARPA Seeks Proposals for Third OFFSET Swarm Sprint
DARPA’s OFFensive Swarm-Enabled Tactics (OFFSET) envisions swarms of 250 collaborative autonomous systems providing critical insights to small ground military units in urban areas where vertical structures, tight spaces, and limited sight lines constrain communications and mobility. DARPA is soliciting proposals for its third swarm sprint, which will focus on the topics of human-swarm teaming and swarm tactics.

Swarm sprints allow for incorporation of emerging technology and new performers throughout the life of the program. Each of five core sprints focuses on one or more of the key OFFSET thrusts – or topic areas: swarm tactics, swarm autonomy, human-swarm teaming, virtual environment, and physical testbed. Each topic emphasizes slightly different perspectives, but ultimately aims to enable breakthroughs in swarm capabilities.

“What makes autonomous swarm research challenging and compelling is the rapid pace at which swarm technologies and associated capabilities are advancing,” says Timothy Chung, program manager in DARPA’s Tactical Technology Office (TTO). “OFFSET is designed around the idea of incorporating core swarm sprints at regular intervals.”

The first of two topic areas covered in the third sprint is human-swarm teaming, which refers to the design, development, and demonstration of novel frameworks to
Ultra-Broadband Performance from 16 KHz to 40+ GHz

Advantages:
- Ultra-Broadband Performance
- Ultra-Low Insertion Loss
- Flat Frequency Response
- Excellent Return Loss
- Rugged Ceramic Construction
- Unit-to-Unit Performance Repeatability

Features:
- EIA 00402 Case Size
- Capacitance: 100 nF
- Operating Frequency: 16 KHz to 40+ GHz
- Insertion Loss: <0.6 dB typ.
- Orientation Insensitive
- One Piece Construction
- Voltage Rating: 16 WVDC
- Gold Complaint Terminations
- RoHS Compliant

Applications:
- Optoelectronics / High Speed Data
- Transimpedance Amplifiers
- ROSA / TOSA†
- SONETTT†
- Broadband Test Equipment
- Broadband Microwave Millimeter-wave

† Receive and Transmit Optical Sub-Assembly
TT Synchronous Optical Network

New ATC 560L Ultra-Broadband UBC™ SMT Capacitors

560L Insertion Loss (S21)

Magnitude (dB)

Frequency (GHz)
enhance how humans interact with autonomous swarms. This topic area recognizes and seeks to address the complexity of the swarm systems themselves, as well as the cognitive, physical, and contextual needs of human teammates or tacticians when conducting urban operations.

The third swarm sprint also seeks to increase the collection of swarm tactics found in the OFFSET swarm tactics exchange, a repository of tools and tactics – or approaches – sprinters can employ. Selected swarm sprinters will design and implement additional sophisticated swarm tactics employing a heterogeneous swarm of air and ground robots, and addressing the mission context of “conducting an urban raid” within four square city blocks over a mission duration of one-to-two hours.

Swarm sprinters in either topic area, whether for human-swarm teaming or advanced swarm tactics, will integrate their technologies into one or both of the OFFSET swarm systems architectures, and will have the chance to further develop and demonstrate their innovative solutions in relevant field tests to showcase breakthrough swarm capabilities in urban settings.

DARPA also has awarded contracts to the following organizations for the second Swarm Sprint:
- Carnegie Mellon University
- Corenova Technologies, Inc.
- Cornell University
- Heron Systems Inc.
- Michigan Technological University
- Siemens Corporation, Corporate Technology
- University of Colorado, Boulder
- University of North Carolina, Charlotte

This cohort of sprinters for the second swarm will leverage existing technologies or develop new ones leading to enhancements in swarm autonomy, highlighting enriched foundations in swarm primitives and/or swarm algorithms. These contributions to the overarching OFFSET swarm systems architectures will offer additional building blocks for novel capabilities that spotlight the potentially disruptive advantages of autonomous swarms for complex urban operations.

—DARPA

Infinite Electronics announced the appointment of Penny Cotner as President and Chief Executive Officer. Former Chief Executive Officer Terry Jarnigan has transitioned to the role of Executive Chairman. Cotner joined Infinite in 2013 as Vice President of Sales and Service for Pasternack, the original Infinite brand. She most recently served as Chief Revenue Officer.

Under Jarnigan’s leadership, Infinite Electronics has experienced explosive growth driven by major expansion of product lines, deep investments in technical resources and multichannel marketing to communicate with engineers worldwide. “Infinite has a unique and compelling customer value proposition, and has maintained a solid business model to deliver it over many years. We’ve been fortunate to have a private equity partner like Genstar Capital who has fully supported our accelerated growth plans 100 percent,” Jarnigan commented.

The company has grown from a single brand and one location with less than 100 employees, to over 1,000 employees offering 12 highly recognized brands to more than 175,000 customers.
Whether your coaxial application is at the tower top, GPS or in the base station, RF products designed and manufactured by PolyPhaser set the standard for the industry.

赦 Superior Protection
PolyPhaser’s superior RF designs and platforms include system level protection, DC Pass, DC Block, Bias-T and Ultra-Low PIM products.

赦 Patented Technology
Our patented designs are engineered for low voltage let-through and superior RF integrity, offering the industry’s best performing surge arrestors.

赦 Guaranteed Performance
PolyPhaser’s field-tested product platform, is backed by a ten-year warranty and can be found in mission-critical communication applications in more than 160 countries.

an INFINIT® company

When RF network reliability is a requirement, the only choice is PolyPhaser! Learn more at PolyPhaser.com or call us 208 772 8515.
**Featured Products**

**High Power Pulsed Microwave Amp**

Series 2004 Amplifier Systems provide the latest in high power, low noise operation for high performance instrumentation radar requirements. This state-of-the-art product delivers incomparable pulsed RF performance with exceptional low phase noise for operation in benign laboratory or hostile field environments. Microprocessors provide the operator, and or computer, access to monitor TWT conditions, fault latching, and control of power supply and modulator parameters. An RS-232 interface provides the ability to remotely operate, monitor, control and adjust the system. The optional 10/100 Base Ethernet provides the ability to remotely operate, monitor & control operation of the amplifier. Any fault condition latches information. Software is provided to operate with MS Windows.

**Quarterwave**

quarterwave.com

**Push-On Contacts**

SSBP push-on contacts are designed to be used in industry standard multi-contact connectors or can be arrayed in a custom envelope for maximum flexibility. The SSBP interface engagement starts with a low insertion force mate, then the spring loaded sleeve is compressed when the multi-contact connector is fully engaged.

**Common Mode Chokes**

Coilcraft’s new 1812CAN Series common mode chokes provide noise suppression on CAN (1 Mbps) or CAN FD (5 Mbps) data lines in automotive and industrial automation applications. CAN Common Mode Chokes are the most commonly-used filter component to attenuate common mode noise at the CAN bus (Controller Area Network) transceiver’s output. The 1812CAN Series can also be used for the FlexRay automotive bus system.

**Coilcraft**

coilcraft.com

**Waveguide Calibration Kit**

Model STQ-TO-12-U3-CKIT1 is an E-band waveguide vector network analyzer (VNA) calibration kit designed to work with industry standard network analyzers in the frequency range of 60 to 90 GHz. The kit consists of two straight waveguide sections, one fixed short, one fixed matching load, one sliding load, one ¼ wavelength offset, two waveguide quick connects, ten 3/32 hex head waveguide screws, a 3/32” hex waveguide screw driver and one calibration data USB drive. The calibration kit is collected in a wooden box and is an ideal higher performance metrology-grade calibration set for VNA system calibrations.

**SAGE Millimeter**

Sagemillimeter.com

**Precision N-Type Adapters**

- Frequency Range: DC to 18 GHz (Mode FREE)
- Electrical: 50 Ohm, Low VSWR & Low Insertion Loss
- Straight Adapters VSWR: 1.15:1 Max @ 18 GHz (Typical VSWR 1.05:1 through 18 GHz)
- Internally Swept Right Angle Adapter VSWR: 1.25:1 Max @ 18 GHz (Consult Factory for plots)
- Materials: Passivated 303 Stainless Steel Robust Construction / Beryllium Copper Gold Plated
- Dielectrics Fluorocarbon (PTFE)

Reliability you can count on, from SGMC Microwave.

**SGMC Microwave**

sgmcmicrowave.com
We’re RF On Demand, with over one million RF and microwave components in stock and ready to ship. You can count on us to stock the RF parts you need and reliably ship them when you need them. Add Fairview Microwave to your team and consider it done.
Diplexer

Response Microwave announced a new diplexer for use in specific tele-com 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

Direct Digital Synthesizer: 10 MHz to 1 GHz

Avid Systems announces the AVS-1012, a coherent direct digital synthesizer capable of output frequencies from 10MHz to 1 GHz. The AVS-1012 uses a multi-modulus NCO to provide an exact frequency output and can switch to any frequency in 160 nS. The AVS-1012 produces a spectrally pure output with spurious less than -75 dBC as well as outstanding phase noise characteristics. The modular design allows customers to specify output power and operating frequency.

Avid Systems
avid-systems.com

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

Wideband Transceiver

Norden Millimeter model NUDC2-18/1.3-2.3 is a Wideband Microwave Transceiver in a low-SWaP 3U module.

The NUDC2-18/1.3-2.3 is a dual conversion transceiver providing 2-18 GHz operation in a versatile OpenVPX platform. The NUDC2-18/1.3-2.3 includes internal LOs
Planar Monolithics Industries, Inc.

Integrated RF/Microwave Assemblies
PMI offers the highest quality multi-function modules and integrated microwave assemblies for commercial and military applications in frequency ranges up to 40 GHz. Built to your specifications, functions can include amplification, attenuation, filtering, switching, phase shifting, power detection, modulation, coupling, limiting and digital/analog control. PMI offers many other standard models with various options that are available at: https://www.pmi-rf.com/categories/integrated-mic-mmic-assemblies

3U Open VPX Transceiver
PTRAN-100M18G-SFB-3UVPX-10HP-MAH
http://www.pmi-rf.com/model-ptran-100m18g-sfb-3uvpx-10hp-mah

- 100 MHz to 18.0 GHz Transceiver
- Integrated Up and Down Converters
- IF up to 4 GHz
- Time Gated SDLVA for Pulse Blanking
- ±80 to -10 dBm Input Dynamic Range
- Customizable Switched Filter Banks
- 0 to +10 dBm Transmit Power
- 100 ns Switching Speed
- Fits into a 3U open VPX form factor utilizing the high speed VITA 67 RF connector.
- CW Immunity

Amplified RF Downconverter Modules
LCM-7R7G8R2G-CD-1 & LCM-16G100MBW-CD-1
https://www.pmi-rf.com/model-no-lcm-7r7g8r2g-cd-1
https://www.pmi-rf.com/model-no-lcm-16g100mbw-cd-1

- Customized Frequency Ranges:
  LCM-7R7G8R2G-CD-1: 7.7 to 8.2 GHz
  LCM-16G100MBW-CD-1: 16.0 GHz ± 50 MHz
- IF range of DC to 10 kHz
- Features a 20 dB voltage programmable attenuator and a 360° phase shifter.
- Designed for low spectral noise and high reverse isolation
- Slim line housing measuring only 2.5” x 1.75” x 0.4”

Phase and Amplitude Matched Integrated Modules in sets of four
PCAM-05G18G-INT-S5F
https://www.pmi-rf.com/products-details/pcam-05g18g-int-s5f

- Operating Frequency Range of 0.5 to 18.0 GHz.
- Built in sets of four, phase and amplitude matched to industry leading levels of ±10º and ±1.5 dB over the frequency range.
- Incorporates limiters, LNAs, switches, and variable digital attenuators.
- These units allow for high and low gain paths, a calibration input, and an auxiliary channel.
- A low noise figure and high output P1dB of +15 dBm are achieved by utilizing system analysis software and in-house hybrid/MIC processes.
- SMA Female connectors and small housing configuration.

Quad Phase and Amplitude Matched Diplexer Gain Module
DGM-18G40G-292FF-DS
https://www.pmi-rf.com/model-dgm-18g40g-292ff-ds

- Operating Frequency Range: 18.0 to 40 GHz.
- Switched output and an integrated power divider feeding the four antenna inputs via a 20 dB coupler for ease of system integration.
- Band select function not only switches bands, but allows the amplified bands not in use to be turned off to reduce power consumption.
- Designed to have better than 60 dB harmonic suppression.

Planar Monolithics Industries, Inc.

Amplifiers – Solid State
Attenuators – Variable/Programmable
Couplers (Quadrature, 180° & Directional)
Detectors – RF/Microwave
DLVAs, ERDLVAs & SDLVAs
DTOs, VCOs, PLO, DROs, & Frequency Synthesizers
Filters & Switched Filter Banks
Form, Fit, Functional Products & Services
Frequency Discriminators & IFMs
Integrated MIC/MMIC Assemblies (IMAs)
IQ Vector Modulators
Limiters – RF/Microwave
Log Amplifiers
Millimeter Wave Components (Up to 50 GHz)
Miscellaneous Products
Multifunction Integrated Assemblies (MIAs)
Phase Shifters & Bi-Phase Modulators
Power Dividers/Combiners (Passive & Active)
Pulse Modulators (SPST)
Rack & Chassis Mount Products
Receiver Front Ends & Transceivers
SDLVAs, ERDLVAs & DLVAs
Single Side Band Modulators
SMT & QFN Products
Switch Matrices
Switched Filter Banks
Switches – Solid State
Systems – Fly Eye Radars
Threshold Detectors
USB Products

West Coast Operation:
4921 Robert J. Mathews Pkwy, Suite 1
El Dorado Hills, CA 95762 USA
Tel: 916-542-1401, Fax: 916-265-2597

East Coast Operation:
7311-F Grove Road
Frederick, MD 21704 USA
Tel: 301-662-5019, Fax: 301-662-1731

sales@pmi-rf.com • www.pmi-rf.com

ISO9001-2015 REGISTERED
Featured Products

Norden Millimeter
nordengroup.com

which provide an instantaneous IF bandwidth of 1 GHz and exceptional Noise Figure: Down Converter NF=6dB max, Up Converter NF=15dB max.

Herotek
herotek.com

Comb Generators and More

Herotek 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. Herotek offers Detectors, Comb Generators, Limiters, Switches, GaAsFet Amplifiers (Broadband, Low Noise, and Power) and integrated subsystems of many types, including up and down converters, multipliers, harmonic mixers, and transeivers.

MECA Electronics
e-meca.com

Power Module

Ampleon announced a compact dual-stage 250 Watt LDMOS RF power module BPC2425M9X2S250-1. Designed for high power continuous wave (CW) industrial, scientific and medical (ISM) applications operating in the 2,400 MHz to 2,500 MHz frequency band, the high efficiency module measures 72 mm x 34 mm.

Ampleon
ampleon.com

MECA Electronics' latest offerings include broadband (SMA) Isolators & Circulators covering 2.000 - 6.000 GHz encompassing S & C bands with typical VSWRs of 1.45:1, Isolation 15 dB Typ and Insertion loss of 0.7 dB Typ.

Get info at www.HFeLink.com
RF TEST SYSTEMS
Expandable for Multiple Inputs & Outputs

• Programmable attenuators, multi-throw switches, power splitters and more!

• Simply add more to your existing system to increase capacity and capability!

Mini-Circuits®
www.minicircuits.com (718) 934-4500 testsolutions@minicircuits.com
Navigating LNA Microwave Integrated Circuits

By Peter McNeil

Low Noise Amplifiers (LNAs) are among the fundamental building blocks of wireless communications systems, along with power amplifiers (PA), oscillators, and mixers. These components serve as the medium that takes a received signal and amplifies it with a sufficient amount of gain while adding minimal noise. This typically occurs before mixing the signal with a local oscillator (LO) and converting it to analog baseband for signal processing to occur.

From semiconductor substrate type, to integrated circuit implementation (i.e.: MMIC or MIC), to the packaging, the specific function of the LNA along with the scenario it is applied in, allow for a fairly wide array of LNA design combinations. This article attempts to navigate through some of the current technologies used in various LNA architectures.

Brief Overview of LNA Parameters and Topologies

The LNA is used in the RF front-end receiver and is meant to amplify the received signal with adequate gain while maintaining a low noise figure (NF). The importance of these can be seen in Friis equation (below) for the cascading noise figure in a receiver chain:

$$F_{Total} = F_1 + F_2 - 1G_1 + F_3 - 1G_1G_2 + F_4 - 1G_1G_2G_3$$

Where $F_1$, $F_2$, and $F_3$ are the noise factor for the first, second, and third component in the receiver signal chain. While $G_1$, $G_2$, and $G_3$ are the gain for the first, second, and third component in the receiver signal chain.

There are several design considerations that are made apparent with this equation. Namely, that the noise factor of the first component accounts for the bulk of the noise factor for the receiver and, finally, that the gain of the first component can rapidly deteriorate the noise factor down the chain if it is sufficiently high. Oftentimes, the LNA is the first or second component and as stated earlier it important that the noise factor of this component remains low with as high amount of gain as possible. The noise factor of the receiver is directly correlated to its signal-to-noise ratio (SNR) which is, in turn, related to the critical parameter of bit error rate (BER) of the receiver. There are also other parameters that are important including bandwidth, linearity (IP3), power consumption, and impedance matching.

Noise figure is just the noise factor (F) expressed in decibels (dB) where the noise factor is a ratio of signal-to-noise ratio (SNR) at the input and output of a device. NF can consist of a number of different types of noise including shot noise, thermal noise, and flicker noise. The gain is the ratio of the output power to the input power in dB. There is always a tradeoff between gain and NF for an LNA.

The input and output of the LNA must also be matched with a matching network from source to the load to minimize any reflections and loss of signal through the LNA. This means that the input must be matched to the antenna while the output is matched to the demodulation circuit so maximum power transfer can occur. External passive components such as inductors are also necessary for biasing but are kept to a minimum due to their size and cost.

There are several transistor LNA configurations including single-transistor common-source, cascode common-source, and a common-gate amplifier. The cascode configuration facilitates...
independent matching networks at the input and output with the setback of a reduced linearity. The single-transistor topologies are more ideal for low power applications. Common-gate topologies have the significant downside of a noise figure that grows with frequency and are therefore more ideal for low frequency applications. The cascode topology is often employed due to its robustness in terms of noise figure, gain, stability, and linearity. These transistor configurations can all be employed in stages to meet gain requirements with the trade-off of a marginally higher noise figure.

Transistor Geometries and Substrates

There are two main high frequency transistors employed for LNAs: GaAs pHEMT and SiGe BiCMOS HBT. These are relatively new transistor topologies that are a result of recent advancements in bandgap engineering. For some background, there are a number of substrates that can be utilized for high frequency components including Gallium Arsenide (GaAs), Silicon Germanium (SiGe), Gallium Nitride (GaN), and Indium Phosphide (InP). Table 1 lists some properties of these materials.

While GaN lists high (H) on practically all the parameters in the table, it is not necessary for the ideal functionality of an LNA. In terms of cost, the GaAs and SiGe substrates are best with moderate to high, high frequency performance. There are GaN LNAs that are implemented for their resistance to high incident powers, potentially eliminating the need for a protective circulator before the LNA. The InP substrate has the highest electron mobility is most often used for extremely fast transistors in sub-millimeter applications. Still, the InP substrate is often the most expensive to implement and so is less often used than GaAs and Si-based substrates.

There have been several studies comparing the GaAs pseudomorphic High Electron Mobility Transistors (pHEMT) and SiGe BiCMOS Heterojunction Bipolar Transistors (HBT) for LNA applications. The general consensus is that the GaAs pHEMT LNA and SiGe BiCMOS LNA has comparable performance in terms of linearity but the pHEMT technology exhibits a lower NF. Still, the SiGe BiCMOS offers a much higher gain with relatively low current consumption whereas the pHEMT requires a much higher current consumption for the same level of gain. Moreover, the silicon-based technology is generally more cost-effective. The GaAs pHEMT LNA is therefore more often leveraged for its low noise figure and broadband performance while the SiGe...
BiCMOS LNA can be used for its ideal narrow-band characteristics.

**LNA: MMIC or HMIC**

LNAs can be implemented as either monolithic microwave integrated circuits (MMIC) or Hybrid Microwave Integrated Circuits (HMIC). A MMIC allows for the integration of passive devices (e.g.: attenuator, coupler, filter, etc.) and active devices (e.g.: oscillator, mixer, amplifier, etc.) as well as their connected transmission lines to be grown in situ on one planar substrate such as a silicon wafer. The main benefit of MMICs is their cost-effectiveness for somewhat generic, volume production circuits with the added benefit of a very small dimensions (1 mm² to 10 mm²). The fabrication of MMICs becomes cost-prohibitive at smaller scales where the time it takes to design, simulate, fabricate, test, debug, and repeat is not justifiable. Many LNAs are manufactured this way and are sold as either as bare dies, or, in Quad Flat No-leads (QFN) packaging. It should be noted that LNA parameters such as gain and NF will degrade from die to packaging.

For more complex circuits Hybrid Microwave Integrated Circuits (HMICs) are often employed where the hybrid integration can be realized using various types of materials and manufacturing processes combined on a single package. This is generally accomplished by attaching highly optimized ICs on a low-loss dielectric substrate, as shown in Figure 1, the term HMIC typically means one of three substrates/processes are employed: PCBs, thick-film, or thin-film. Printed circuit boards will often leverage the FR4 material with supplemental laminates that exhibit low dielectric constants for circuits up to 4 GHz while PTFE (Teflon) and Rogers substrates can be used for higher frequencies. PCBs have the benefit of accessibility on a macro scale components from a variety

---

<table>
<thead>
<tr>
<th>Properties</th>
<th>Description</th>
<th>GaAs</th>
<th>SiGe</th>
<th>GaN</th>
<th>InP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band Gap</td>
<td>Material's performance at high temperatures and large voltages.</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Breakdown Electric Field</td>
<td>Determines power handling capabilities.</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Electron Mobility</td>
<td>Material's performance at high frequencies.</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>Material's ability to dissipate heat</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>M</td>
</tr>
<tr>
<td>Power Density</td>
<td>Material's ability to handle higher powers in smaller packages.</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
</tbody>
</table>

Table 1 • A Comparison of High Frequency Semiconductors.

---

Figure 1 • HMICs could involve the use of a PCB, thick-film substrate, or a thin-film substrate (left to right) [3].
Low Noise Amplifiers

0.5-15 GHz

Noise Figure as low as 1.5 dB
50Ω Matched over >1 Decade Bandwidths

Mini-Circuits
www.minicircuits.com  (718) 934-4500  sales@minicircuits.com
of vendors can be put together and a circuit can be prototyped rapidly with low cost and a quick turnaround time.

The thick-film process includes printing circuits by pushing a conductive epoxy through a patterned screen on a ceramic substrate that is often 95% pure alumina. High precision conductors are around 25 μm in trace width as opposed to the 15 μm average for thin film processes. A thin-film process will generally involve a higher purity of alumina (99%) and, as opposed to the additive thick-film process, a photolithographic, subtractive process is leveraged for thin-film technologies.

The chemical etching technique in the thin-film process allows for much thinner achievable trace widths and ultimately smaller dimensions. While the large trace thickness of PCBs and thick-film technologies are not relevant at the microwave frequencies, they are not a practical option up to the millimeter-wave frequencies. Furthermore, since line impedance is a function of thickness and space to ground, HMICs are more often employed through thin-film technologies as it enables more flexibility in line width in a scenario where an engineer has a preset requirement for space to ground.

A Variety of LNA Implementations

Depending on the transistor topology used, most LNAs will require the use of biasing circuitry to avoid damaging the device. For both p-channel and n-channel FETs, for instance, current will flow from drain to source when the gate voltage is set at 0V. In these cases, the gate voltage must be applied before the drain voltage to prevent transistor damage. A bias sequencing circuit allows for the proper pinch-off voltage to be applied to the gate before applying voltage to the drain, then finally adjusts the gate voltage before turning on the RF signal. For a MMIC-based LNA, the bias circuitry is often implemented external to the die. This implementation is invariably some form of a HMIC which can be as follows:

- Integrated into a thin-film process
- In a chip-and-wire topology with MMIC-based LNA wedge-bonded to thin-film ceramic boards
- In a flip chip attachment onto a ceramic (thin-film) substrate
- MMIC packaged as a SMD component and soldered onto substrate

In the chip-and-wire topology, a LNA MMIC is wedge bonded to custom thin-film alumina boards with biasing circuitry. The LNA MMIC can also be attached in a flip chip style (Figure 2) where the die itself incorporates an array of metal bumps that is then soldered onto the ceramic board. This way, the chip-to-substrate transition is minimized allowing for better RF and mm-wave performance. The MMIC itself can also be packaged to be handled like any SMD component for simpler manufacturability. The main setback of this approach comes from the performance degradation due to packaging, there is also a limit on thermal dissipation as the die cannot be mounted directly on a ground plane (this is not a major concern for LNAs). Integrated thin-film LNAs have the benefit of including the respective biasing circuitry as well as simplified packaging without the parasitics of wire bonds but they are limited in frequency and customizability.

These variations can also be applied at the, larger, receiver front-end level where there is a trend towards

---

**Figure 2** • Chip-and-wire interconnections utilize bare dies often from a variety of vendors along with thin-film boards for interconnect in metal casing. Flip chip topologies uses an array of metal connections on the chip to solder to the substrate. [2]
higher integration. For instance, a SoC can integrate an entire RF transceiver with digital, analog, and RF blocks on a single die—granted, these are for low powered, microwave applications.

**Receiver Implementation: MCM, SiP, or SoC?**

From the systems perspective, the LNA is obviously not an isolated element but instead a component in a chain of other components. Therefore, design, fabrication, and packaging at the transistor level to the systems level must be considered. Whether the receiver is being implemented in cellular-based user equipment, a radar transponder, a satellite ground terminal, or a base station, the design constraints and thus packaging vary. Many receivers are implemented as multi-chip modules (MCM) as it allows for flexibility in sub-components and assembly. Integrating an entire system on a chip (SoC) is limited in choice of substrate and is thus severely limited in frequency range as well as power handling. There is also the perspective that more integrated the device, the more specialized the function of the IC which can be a risky inflexibility as technology evolves.

**Conclusion**

From transistor geometries and design layouts to hardware implementation and packaging, there are many variables to consider in the making of an LNA. Many LNAs have a cascode topology and are fabricated as either GaAs pHEMTs or SiGe BiCMOS HBTs. These MMICs are then implemented in a HMIC layout with custom, thin-film boards. At this level, the packaging can vary where many HMICs are either chip-and-wire or flip chip. Packaged MMICs can also be used as SMD components for more modular manufacturing but have a degraded gain and noise figure.

**About the Author**

Peter McNeil serves as marketing manager for Fairview Microwave.

**References**

Doppler Measuring System

Spacek Labs Model DS-940HD is a cost-effective Doppler measuring system. The center frequency of the model shown is 94 GHz with +/- 50 MHz of bias tuning. The output power of the DS-940HD is 20 mW at the horn antenna. The Gunn oscillator incorporates a GaAs Gunn diode with an input bias of +4.5 to +5.5 VDC @ 1.0A typ. Heat is dissipated with an integrated heatsink. This assembly is delivered with a WR-10 horn antenna, an integrated isolator, circulator and a Spacek Labs W band detector, Model DW-2. It allows real-time Doppler measurements including direction (to and from radar) up to a distance of 10 feet depending on size of object. These systems are available from 18 to 110 GHz in all standard waveguide bands.

Spacek Labs
spaceklabs.com

BGA Pocket Adapter

Ironwood Electronics’ new high performance BGA Socket Adapter, LS-BGA256E-15, allows user to convert compression mount BGA socket which needs mounting holes (in target PCB) into conventional through hole soldering options. The adapter consists of machined Brass pins pressed into an FR4 wafer. The top side of adapter has gold plated pads to receive socket interconnect and the bottom side has 0.008” diameter pin tails. The adapter can be soldered to any thru-hole pattern using conventional soldering methods or plugged into mating female receptacle.

Ironwood Electronics
ironwoodelectronics.com
RF SWITCH MATRICES

DC to 18GHz

1 SPDT
2 SPDT
3 SPDT
8 SPDT
2 SP4T
1 SP6T
2 SP6T
4 SPDT

SWITCH STATUS INDICATOR LIGHTS
• Activated
• Non Activated

USB & Ethernet Control Options
models from $405 ea.

• 0.25 dB Insertion Loss
• 85 dB Isolation
• 1.2 VSWR
• up to 10W Power Handling
• Extra-Long Switch Life
  Up to 100 Million Cycles*
• Switch Cycle Counting Feature
  with Automatic Calibration Alerts
• User-Friendly GUI and DLLs Included
• Compatible with Most Third Party Lab Software†
• Small size fits in your Laptop Case!
• Available from Stock

Visit minicircuits.com for detailed model specs, application notes, and more!
Place your order today for delivery as soon as tomorrow!

* With factory cleaning service. Switches protected by US patents 5,272,458; 6,650,210; 6,414,577; 7,843,289; and additional patents pending.
† See data sheet for a full list of compatible software.
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.

Besser Associates instructors are recognized experts in their field. They are top-notch design engineers, skilled in both technology and the art of instructing. With an average of more than 20 years of education and practical first-hand experience, our instructors bring a wealth of training and information to the courses they present. Equally important, our trainers communicate effectively; they know how to reach both novice and veteran professionals.

RF Technology Certification
Next session starts December 3 – online

Applied RF Engineering I
Next session starts January 14 – online

Radio Systems: RF Transceiver Design from Antenna to Bits & Back
February 25 – March 1, San Diego, CA - Dr. Waleed Khalil

mm-Wave RFIC and MMIC Design Techniques
February 25-27, 2019, San Diego, CA - Dr. Ali Darwish

Transceiver and Systems Design for Digital Communications
February 25-27, 2019, San Diego, CA - Scott Bullock

Cognitive Radios, Networks, & Systems for Digital Communications
February 28 – March 1, San Diego

Get info at www.HFeLink.com
Innovative Manufacturing Solutions for Aerospace, Defense, and Industrial Markets

Ducommun serves the avionics, communications, defense, industrial, intelligent traffic systems, medical, and test equipment markets with millimeter wave products. We design and manufacture products including amplifiers, antennas (horn and patch), mixers, oscillators, multipliers, radar sensors, industrial grade phase shifters, lab components, up/down-converters, along with sub-systems and integrated assemblies.

Ducommun is a global provider of manufacturing and engineering services, developing innovative electronic, engineered and structural solutions for complex applications in aerospace, defense and industrial markets. Our full-service collaborative approach, broad capabilities and value-added services like new product introduction, supply chain strategies and program management deliver value for our customers and innovative solutions for their complex electronic and structural needs.

Founded in 1849, Ducommun is the oldest company in California. Evolving from a hardware supply store opened by Charles Ducommun in Los Angeles during the California Gold Rush, the company assisted in the birth of the aerospace industry in Southern California by providing aircraft aluminum to early aerospace pioneers like Lindbergh, Douglas and Lockheed.

Today, Ducommun is a global provider of innovative manufacturing solutions for customers in the aerospace, defense and industrial markets. We specialize in two core areas – Electronic Systems and Structural Systems – to produce complex products and components for commercial aircraft platforms, mission-critical military and space programs, and sophisticated industrial applications.

Our company is organized to leverage our full spectrum of capabilities through common, companywide processes and value-added services like new product introduction, supply chain strategies, and program management that create value for the customer and to facilitate ease of doing business.

Ducommun
ducommun.com
ARE YOU 5G-READY?

LET US BE YOUR ONE-STOP SHOP
FOR MMWAVE COMPONENTS & SUBASSEMBLIES.

SAGE Millimeter, Inc.

WWW.SAGEMILLIMETER.COM
MADE IN USA
VIEW PRICING, LEADTIME, AND INVENTORY

NEW SAGE WEBSITE

Over 2,500 millimeter wave components off-the-shelf, in stock, and ready to ship guaranteed in only 1-3 days.
Edge Launch Connectors

- 1.85mm, 2.4mm, 2.92mm, 3.5mm, & SMA Series readily available for 0.062” thick PCB’s.
- Electrical: 50 Ohm, Low VSWR, Low Insertion Loss, Mode Free through 65 GHz.
- Materials: Beryllium Copper Gold plated Components.
- Dielectrics are PCTFE (PolyChloroTriFluoroEthylene) (SMA Fluorocarbon (PTFE))
- Available for immediate delivery – Same day shipping for all stock items.

SGMC Microwave is a registered ISO 9001:2015 manufacturer of precision coaxial connectors including cable connectors, adapters, and receptacles.

SGMC Microwave
sgmcmicrowave.com

Flexible Waveguide (Flexguide) Section

Model SWG-15020-FB-F is a 2” (50.8 mm) long, V-band flexible waveguide section with a WR-15 waveguide and UG-385/U flange. It also has a polysulfide rubber jacket for robustness applications. The waveguide features a flexible bend to be long-term stress free when it is integrated into systems. The waveguide is manufactured with a precision manufacturing process to ensure high quality. The waveguide has low insertion loss in the frequency range of 50 to 75 GHz. Various standard and custom length options are available under different model numbers.

SAGE Millimeter
sagemillimeter.com
Bidirectional Amplifier

The NuPower Xtender™ VU4GX01 VHF/UHF Bidirectional Amplifier module is a small, broadband, high-performance RF embedded OEM amplifier that generates 4 watts of linear RF power across the 225 to 512 MHz frequency range. It is ideal for extending the communication range of half-duplex transceivers with constant-envelope waveforms (i.e. PSK- and FSK-based modulations, such as SOQPSK and GFSK), and generates 10 Watts of RF transmit power. The module accepts a +5 dBm input level and provides 35 dB of transmit gain, all while operating with 30% or better power efficiency at most frequencies. In receive mode, it offers a low noise figure of 3.5 dB and incorporates a low noise amplifier that provides 15 dB of gain.

NuWaves Engineering
nuwaves.com

RF Downconverter

The ConvertaWave™ model RF225-500DCV1, is a robust RF downconverter, providing high dynamic range performance over the 225-500 MHz frequency range. The 70 MHz IF output is band-limited to 500 kHz. The downconverter provides superior rejection of out of band signals, Automatic Gain Control (AGC) / Manual Gain Control (MGC) operation, and operates over VHF and UHF frequencies in 100 kHz steps. The ConvertaWave has extremely low noise figure and user selectable features.

NuWaves Engineering
nuwaves.com

---

NuPower® Broadband Power Amplifiers

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Freq (MHz)</th>
<th>Gain (dB)</th>
<th>Power Out (W)</th>
<th>Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW-PA-11B02A</td>
<td>200 - 2600</td>
<td>40</td>
<td>10</td>
<td>2.34 x 1.96 x 0.62</td>
</tr>
<tr>
<td>NW-PA-VU-4-G01</td>
<td>225 - 512</td>
<td>35</td>
<td>10</td>
<td>2.34 x 2.34 x 0.70</td>
</tr>
<tr>
<td>NW-PA-11C01A</td>
<td>225 - 2400</td>
<td>40</td>
<td>15</td>
<td>3.00 x 2.00 x 0.65</td>
</tr>
<tr>
<td>NW-PA-13G05A</td>
<td>800 - 2000</td>
<td>45</td>
<td>50</td>
<td>4.50 x 3.50 x 0.61</td>
</tr>
<tr>
<td>NW-PA-15D05A</td>
<td>800 - 2000</td>
<td>44</td>
<td>20</td>
<td>4.50 x 3.50 x 0.61</td>
</tr>
<tr>
<td>NW-PA-12B01A</td>
<td>1000 - 2500</td>
<td>42</td>
<td>20</td>
<td>3.00 x 2.00 x 0.65</td>
</tr>
<tr>
<td>NW-PA-12B01A-D30</td>
<td>1000 - 2500</td>
<td>37</td>
<td>5</td>
<td>3.00 x 1.80 x 0.50</td>
</tr>
<tr>
<td>NW-PA-12A03A</td>
<td>1000 - 2500</td>
<td>40</td>
<td>4</td>
<td>3.00 x 2.00 x 0.65</td>
</tr>
<tr>
<td>NW-PA-12A03A-D30</td>
<td>1000 - 2500</td>
<td>37</td>
<td>5</td>
<td>3.00 x 1.80 x 0.50</td>
</tr>
<tr>
<td>NW-PA-12A01A</td>
<td>1000 - 2500</td>
<td>40</td>
<td>4</td>
<td>3.00 x 2.00 x 0.65</td>
</tr>
<tr>
<td>NW-PA-12A01A-D30</td>
<td>1000 - 2500</td>
<td>37</td>
<td>5</td>
<td>3.00 x 1.80 x 0.50</td>
</tr>
<tr>
<td>NW-PA-12E05A</td>
<td>2000 - 2600</td>
<td>44</td>
<td>30</td>
<td>4.50 x 1.50 x 0.61</td>
</tr>
<tr>
<td>NW-PA-C-10-R01</td>
<td>4400 - 5100</td>
<td>40</td>
<td>20</td>
<td>4.50 x 3.50 x 0.61</td>
</tr>
<tr>
<td>NW-PA-C-20-R01</td>
<td>4400 - 4900</td>
<td>43</td>
<td>20</td>
<td>4.50 x 3.50 x 0.61</td>
</tr>
</tbody>
</table>

NuPower Xtender® Broadband Bidirectional Amplifiers

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Freq (MHz)</th>
<th>Gain (dB)</th>
<th>Power Out (W)</th>
<th>Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW-BA-VU-4-G02</td>
<td>225 - 512</td>
<td>35</td>
<td>10</td>
<td>2.34 x 2.34 x 0.70</td>
</tr>
<tr>
<td>NW-BA-12B04A</td>
<td>1000 - 2500</td>
<td>35</td>
<td>15</td>
<td>3.00 x 2.00 x 1.16</td>
</tr>
<tr>
<td>NW-BA-12C04A</td>
<td>1000 - 2500</td>
<td>35</td>
<td>15</td>
<td>3.00 x 2.00 x 1.16</td>
</tr>
<tr>
<td>NW-BA-C-10-RX01</td>
<td>4400 - 5100</td>
<td>10</td>
<td>10</td>
<td>3.57 x 2.57 x 0.50</td>
</tr>
<tr>
<td>NW-BA-C-20-RX01</td>
<td>4400 - 4900</td>
<td>43</td>
<td>20</td>
<td>5.50 x 4.50 x 0.71</td>
</tr>
</tbody>
</table>

Broadband High Intercept Low Noise Amplifiers (HILNA™)

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Freq (MHz)</th>
<th>Gain (dB)</th>
<th>OIP3 (dBm)</th>
<th>Size (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HILNA-HF</td>
<td>2 - 50</td>
<td>30</td>
<td>30</td>
<td>3.15 x 2.50 x 1.18</td>
</tr>
<tr>
<td>HILNA-V1</td>
<td>50 - 1500</td>
<td>35</td>
<td>30</td>
<td>1.00 x 0.75 x 0.50</td>
</tr>
<tr>
<td>HILNA-V1</td>
<td>50 - 1000</td>
<td>30</td>
<td>32</td>
<td>3.15 x 2.50 x 1.18</td>
</tr>
<tr>
<td>HILNA-G2V1</td>
<td>50 - 1500</td>
<td>31</td>
<td>30</td>
<td>3.15 x 2.50 x 1.18</td>
</tr>
<tr>
<td>HILNA-LS</td>
<td>1000 - 3000</td>
<td>50</td>
<td>33</td>
<td>2.50 x 1.75 x 0.75</td>
</tr>
<tr>
<td>HILNA-GPS</td>
<td>1200 - 1600</td>
<td>32</td>
<td>30</td>
<td>3.15 x 2.50 x 1.18</td>
</tr>
<tr>
<td>HILNA-CX</td>
<td>5000 - 10000</td>
<td>35</td>
<td>21</td>
<td>1.77 x 1.52 x 0.45</td>
</tr>
</tbody>
</table>

Get info at www.HFeLink.com
Pasternack’s new series of vertical launch connectors consists of 12 models that provide VSWR as low as 1.3:1 and maximum operating frequency of up to 50 GHz, depending on the model. These launches boast a reusable clamp attachment and can be used for microstrip or stripline. They are offered in male and female versions, covering 2.4mm, 2.92mm and SMA interfaces, and all models provide solderless installation. These removable vertical launches feature a stainless steel outer conductor, gold-plated beryllium copper center contact and Polyetherimide (PEI) insulators. They are ideal for high-speed backplanes, signal integrity measurements, semiconductor verification boards, multi-channel tests and SERDES applications.

Pasternack
pasternack.com

RF Probes
Pasternack’s extended line of coaxial RF probes now includes 4 models that deliver 10 dB maximum return loss over the broad frequency range of DC-40 GHz. These probes are offered in GS and GSG configurations with a pitch of 800 or 1500 microns and a 2.92mm interface. They are gold-plated and have compliant pogo pin contacts that allow for a wide range of probing angles. These RF coaxial probes can be used by hand, with or without a probe positioner, and can be cable mounted or mounted with Pasternack’s multi-axis probe positioner. They are ideal for signal integrity measurement, chip evaluation, coplanar waveguide, Gigabit SERDES, substrate characterization and test fixture applications.

Pasternack
pasternack.com

Product Highlights

The Largest Selection of Waveguide Components For Same-Day Shipping

- Frequencies from L-band to W-band
- Leading Edge Performance
- Sizes from WR-10 to WR-430
- High Precision Machining
- Multiple Flange Styles
- All In-Stock and Ready to Ship

Get info at www.HFeLink.com

RF Probes
Pasternack’s extended line of coaxial RF probes now includes 4 models that deliver 10 dB maximum return loss over the broad frequency range of DC-40 GHz. These probes are offered in GS and GSG configurations with a pitch of 800 or 1500 microns and a 2.92mm interface. They are gold-plated and have compliant pogo pin contacts that allow for a wide range of probing angles. These RF coaxial probes can be used by hand, with or without a probe positioner, and can be cable mounted or mounted with Pasternack’s multi-axis probe positioner. They are ideal for signal integrity measurement, chip evaluation, coplanar waveguide, Gigabit SERDES, substrate characterization and test fixture applications.

Pasternack
pasternack.com

Vertical Launch Connectors
Pasternack’s new series of vertical launch connectors consists of 12 models that provide VSWR as low as 1.3:1 and maximum operating frequency of up to 50 GHz, depending on the model. These launches boast a reusable clamp attachment and can be used for microstrip or stripline. They are offered in male and female versions, covering 2.4mm, 2.92mm and SMA interfaces, and all models provide solderless installation. These removable vertical launches feature a stainless steel outer conductor, gold-plated beryllium copper center contact and Polyetherimide (PEI) insulators. They are ideal for high-speed backplanes, signal integrity measurements, semiconductor verification boards, multi-channel tests and SERDES applications.

Pasternack
pasternack.com
LadyBug Technologies, a leader in RF Power measurement, announced its LB5900 Series Power Sensors Security Options for commercial and military applications. Models with frequency coverage up to 40 GHz are available. Security options include Option SEC -- secure erase -- and Option MIL -- memory write prohibited. For the highest level of security, Option MIL prevents any user information from being stored in the sensor but still allows a very high level of usability, including programmatic control. Items such as presets, internal user cal tables, simple and frequency dependent offsets, will be lost when the power is removed. Each time the sensor is powered, it will appear as it did when it was first delivered. Option SAN provides a secure erase of all data stored by the user in the sensor. This includes all offsets, presets, user cal tables, FDO tables, and other data not placed in the sensor by the factory. Initial factory calibration is not erased.

We manufacture a broad line of high quality first tier NIST traceable USB power sensors. Our sensors are compatible with Windows XP, Win 7, 8 & Win 10; in 32 and 64 bit systems. We offer LINUX compatible sensors along with the only Optional SPI & I2C power sensor available. With our patented NoZero NoCal feature, it is not necessary to zero or calibrate before making measurements, even for low level measurements requiring high accuracy. Simply connect and measure. The Sensors are housed in a robust metal enclosure for durability and offer a variety of connectors including N, SMA, 3.5mm and 2.92mm so that you can obtain the best possible match. We include limit free, flexible applications for use with our products at no additional cost. We cover the RF and microwave market with three sensor types.

- General Purpose: Our True RMS sensors make highly accurate measurements on any signal with any modulation format or bandwidth.
- We manufacture pulse sensors that will provide statistical pulse information such as peak and pulse power, duty cycle and crest factor on pulse modulated signals as well as average CW power.
- Our Pulse Profiling sensors provide time domain trace visibility of modulation information in addition to the measurements made by our pulse sensors.

LadyBug Technologies
ladybug-tech.com
Modular RF Switch Control System

With intuitive configuration commands, the EOM can quickly configure a switch matrix of up to 100 x 100 with up to 6 levels of switches in each path.

Modular System Controls has developed a modular system for OEMs to control RF switches, attenuators, synthesizers and other devices. The traditional OEM approach has been to use generic commercial off-the-shelf serial, Ethernet or GPIB digital interface boards to control their systems. These boards typically have up to 16 8-bit ports with 128 total I/O lines with a control format that may only support byte oriented commands.

Most multi-position switches have one control line per pole and if indicator contacts are used there will be an additional line for each contact. If one byte is used to control each switch, a typical interface board is only capable of controlling 16 switches without indicator feedback or 8 switches with indicators. As there are up to 14 lines (including power and ground) for a common 6-position switch, an eight switch system could have a bundle of up to 112 wires which have to be hand routed and connected. Additional interface boards could be added to increase the number of switches, but this only complicates any control software and there is no simple provision for local front panel control. To add to the complexity, if the switches do not have TTL compatible inputs, additional driver circuitry will need to be added to handle the coil voltages and inductive spikes.

Some OEMs have built backplane boards to handle decoding, interconnections and interfacing using ribbon cables to connect to the interface board. However there are reliability issues with ribbon cables, especially in military or other high-reliability systems. The Modular System Controls approach is to use distributed processing. A small module about the size of a credit card containing a low cost microcontroller is placed on each backplane board and is connected to the System Control Board via a standard off-the-shelf Ethernet cables using the industry standard I2C protocol. The modules have 2 connectors to support daisy chaining of the cables.

An example switch driver board is shown. Each I2C bus can support up to 112 modules. The modules use a standard SPI bus to control 16-bit I/O expander chips on the backplane boards which will support up to 32 expander chips or 512 I/O lines per module. The System Control
Board has 3 I2C interfaces which results in a practically unlimited number of I/O lines. The module’s standard firmware supports 1-of-N type switches, binary encoded switches, latching switches (pulsed outputs), attenuators and parallel I/O for relays, LEDs, front panel switches, and many others. Verification of switch connections can be enabled using indicator lines. Synthesizers and other devices can be controlled via the SPI bus, a serial port or a second I2C interface on the module.

The MSC02 System Control Board is the heart of the system. In addition to the 3 I2C buses, it supports TCP/IP Ethernet, USB and serial (RS232, RS422 & RS485) remote control using IEEE-488.2, SCPI and MODBUS protocols. Local HMI control is provided by an optional full color 800 x 400 pixel touchscreen panel which is also controlled by the I2C bus to provide individual switch control, matrix control, attenuator control and setup from the front panel. In addition, an embedded web server provides configuration and control via a web browser. With intuitive configuration commands, the EOM can quickly configure a switch matrix of up to 100 x 100 with up to 6 levels of switches in each path. The matrix connections are then made with a simple high level SCPI command: ROUTe:MATrix x,y. The System Controller Board runs off of the system power supply (9-40VDC) and provides logic power for the I/O boards. Additional chassis can be controlled by the Controller’s RS422 or RS485 ports.

**Modular System Controls**
modularsystemcontrols.com
ESR Capacitors

Passive Plus, Inc. (PPI) now offers extended-values for the Traditional NP0, Hi-Q 0505 (.055" x .055") -- now available up to 1,000pF. The 0505 has increased Operational Temperature up to 200°C. These parts exhibit Low ESR/ESL, Low Noise, High Self-Resonance as well as ultra-stable performance over temperature. Used in wireless broadcasting equipment, mobile base stations, GPS, MRI, and radar applications, these capacitors are offered in magnetic and non-magnetic terminations.

Passive Plus
passiveplus.com

---

Broad Bandwidth Digital Step Attenuator

RFMW announced design and sales support for a broad bandwidth digital step attenuator (DSA). The pSemi PE43508 offers 6-bit control with 0.5dB LSB step accuracy for 31.5 dB attenuation range from 9kHz to 55GHz. Ideal for test and measurement, point-to-point communication systems, and very small aperture terminals (VSAT), the PE43508 features glitch-safe attenuation state transitions to protect circuits. An integrated digital control interface supports both serial addressable and parallel attenuation programming. Offered as flip-chip die, this DSA is manufactured on a variation of silicon-on-insulator (SOI) technology and requires no external blocking capacitors if 0 VDC is present on the RF ports.

RFMW
rfmw.com
Mixer: Handheld Spectrum Analyzers
OML’s mixer series, MxxHxDC, is specifically designed for handheld spectrum analyzers as a portable solution for millimeter wave spectrum analysis measurement. Utilizing the handheld spectrum analyzer tracking generator as an LO source and the built-in DC supply; this harmonic mixer provides you the ease of portable field measurement in a one box solution.

Available in waveguide bands WR-12 (60-90 GHz), WR-15 (50-75 GHz) WR-10 (75-110 GHz). OML’s innovative millimeter wave frequency extension products can help you with your testing in the emerging application areas such as WiGig, 5G, collision avoidance radar systems, E-Band backhaul and military & defense.

OML
omlin.com

Frequency Extension Modules
OML’s Signal Generator Frequency Extension Module can extend the frequency range of your existing 20 GHz microwave synthesizer to millimeter wave frequencies. Modules are available to span the waveguide bands between 50 and 500 GHz. These source modules are RoHS compliant. In addition, an option is available for manual power sweeps using a micrometer as a tuning mechanism. The standard source module has a prerequisite for +12V that is easily satisfied with many commercially available power supplies. As an alternative, a specialized option is available (SxxMS-AG) that enables the the Keysight PSG to satisfy the source module’s power supply prerequisite.

OML
omlin.com
60 to 90 GHz Feed Horn Antenna

Model SAF-6039031340-141-S1-122-DP is a dual polarized, WR-12 scalar feed horn antenna assembly that covers several popular 5G bands in the frequency range of 60 to 90 GHz. The antenna features an integrated orthomode transducer (OMT) that provides high port isolation and cross-polarization cancellation and a broad band scalar horn that provides low sidelobe levels. The OMT enables the antenna to separate a circular or elliptical polarized waveform into two linear, orthogonal waveforms or vice versa. The dual polarized horn also supports either vertical or horizontal polarized waveguide forms with more than 30 dB cross polarization rejections. At center frequency, the horn antenna exhibits 13 dBi nominal gain and a typical half power beamwidth of 40 degrees and -25 dB sidelobe levels, respectively. The antenna exhibits 35 dB typical port isolation between the horizontal and vertical ports. The horizontal and vertical ports are WR-12 waveguides with UG-387/U flanges and 4-40 threaded holes.

SAGE Millimeter
sagemillimeter.com

RF, Microwave Stocking Distributor

Microwave Components, Inc., was established in 1980 as a specialized RF Microwave and more recently, millimeter wave stocking distributor. We specialize in interconnect products and low loss cable /cable assemblies and several other RF components from antennas to board level components. More recently, we offer customers an avenue to integrated microwave assemblies for a custom designed solution for evolving market needs for miniaturized multi-function devices. The markets we serve include aerospace /defense, telecommunications, test & instrumentation and others. We hold preferred status from many Government Prime Contractors and support their contractual flow downs passed on. We are franchised from the industry’s leading manufacturers to offer our customers a broad range of products needed in today’s applications and programs.

Microwave Components
mwc-llc.com
• TE Connectivity RF connectors provide the right solution for your application.
• Crimp, solder, and clamp terminations offer ease in cable termination and impedance-matched designs.
• MIL-Standard products are qualified to M39012, M55339, and M83517.

For more than 25 years, Microwave Components has been delivering these quality products and superior technical support to the industry with an extensive inventory of commercial and MIL–Approved products.

Call us today and put our experience to work for you...

DISTRIBUTED BY:

MICROWAVE COMPONENTS LLC

3171 SE DOMINICA TERRACE, STUART, FLORIDA 34997-5994 USA
TELEPHONE 772.286.4455 | TOLL FREE 800.282.4771 | FAX 772.286.4496
email: admin@mwc-llc.com | website: www.mwc-llc.com
CAGE Code: 10933

New !!!
Compression Coax Connector for parallel board-board blind mate applications

Ultra-miniature Coax Connector and Cable Assembly Series for Wireless Communication Systems

AS 9120
ISO 9001:200
CERTIFIED

TE Connectivity, TE and TE connectivity (logo) are registered trade marks
71 to 76 GHz E Band Junction Isolator & Circulator

Model SNW-7137630818-12-I1 is an E band waveguide junction isolator that covers the frequency range of 71 to 76 GHz. Compared with a Faraday isolator, the waveguide junction isolator offers an insertion loss of 0.8 dB typical and a much shorter insertion length for system integration. As a tradeoff, the waveguide junction isolator only offers a nominal isolation of 18 dB. Model SNW-7137630818-12-C1 is an E band, waveguide junction circulator that covers the frequency range of 71 to 76 GHz. The waveguide junction circulator is designed and manufactured to provide a low insertion loss of 0.8 dB maximum, a minimum isolation of 18 dB, and a much shorter insertion length for system integration. Both devices have input and output ports that are WR-12 waveguides with UG-387/U flanges.

SAGE Millimeter
sagemillimeter.com

81 to 86 GHz E Band Junction Isolator & Circulator

Model SNW-8138630818-12-I1 is an E band waveguide junction isolator that covers the frequency range of 81 to 86 GHz. Compared with a Faraday isolator, the waveguide junction isolator offers an insertion loss of 0.8 dB typical and a much shorter insertion length for system integration. As a tradeoff, the waveguide junction isolator only offers a nominal isolation of 18 dB. Model SNW-8138630818-12-C1 is an E band, waveguide junction circulator that covers the frequency range of 81 to 86 GHz. The waveguide junction circulator is designed and manufactured to provide a low insertion loss of 0.8 dB maximum, a minimum isolation of 18 dB, and a much shorter insertion length for system integration. Both devices have input and output ports that are WR-12 waveguides with UG-387/U flanges.

SAGE Millimeter
sagemillimeter.com
USB Pulse Profiling Sensors

In addition to statistical information, pulse profiling sensors provide time domain trace measurements. The sensor measures RF power, converts and sends data points fast enough to build a time domain trace. The measurement can be triggered and the signals detail can be plotted for on-screen viewing as shown above. This was made with a LadyBug LB480A sensor. Additionally, these sensors can make triggered pulse measurements such as pulse width and pulse repetition time along with all of the measurements made by our peak and pulse sensors. LadyBug’s Pulse Profiling Sensors also provides a full complement of statistical information such as CDF, CCDF and PDF.

LadyBug Technologies
ladybug-tech.com

Design Software on Display

NI AWR software will be on display at the Microwave Workshops and Exhibition (MWE), later this month in Yokohama, Japan. Demonstrations in Booth #I-03 will highlight the V14 release of NI AWR Design Environment, inclusive of Microwave Office circuit design software, Visual System Simulator™ (VSS) system design software and AXIEM and Analyst™ 3D electromagnetic (EM) software, as well as AntSyn™ antenna design, synthesis and optimization software.

NI AWR
awrcorp.com
Bandpass Filter

Spacek Labs model Fc2-625-9 is a broadband bandpass filter in WR-15 waveguide. This series of filters operate from 18 to 110 GHz in the standard or custom waveguide bands and have bandwidths from 30 to 100% of the waveguide band. These waveguide filters are a combination of our exceptional performance low pass filter technology along with our high pass filter in series, with both filters designed to meet your exacting passband requirements. Model Fc2-625-9 has a passband from 48 to 72 GHz. The lower and upper 20 dB reject points are 45 and 74 GHz respectively. The filter has a rejection of >30 dB out to 110 GHz. Insertion loss is 1 dB typ and 2 dB max.

Spacek Labs
spaceklabs.com

Radiation Measurement System

Saelig introduced the portable, compact MegiQ RMS-0640/0660 Radiation Measurement Systems, turnkey systems that can measure antenna and equipment radiation patterns and Total Radiated Power (TRP) of an RF device from 600MHz to 4/6GHz. The RMS-06x0 system consists of a measurement antenna, a measurement receiver with optional signal generator, a motorized turntable, and application software for system control and calculations. This system removes the need for an expensive anechoic chamber for most applications. Moderate lab space is all that is needed in order to obtain accurate 3-axis radiation patterns and TRP calculations. Extensive testing and comparison with anechoic test lab measurements has shown that the measurement accuracy of the RMS-06x0 approximates very well to anechoic measurements.

Saelig
saelig.com
AMCOM has all the expertise, manpower, space, and equipment for manufacturing state-of-the-art products. Some of our capabilities are: active device design, MMIC design, and power amplifier module design. In addition, we are experts in device/MMIC packaging, module assembly and RF/DC testing. For active devices, we either procure parts such as silicon LDMOS, or GaN HEMT, or we use a semiconductor foundry to fabricate our own proprietary device/MMIC.

One of AMCOM's specialties is custom designing MMICs and modules for our customers' specific needs. The custom products include all front-end components such as low-noise amplifiers, power amplifiers, switches, attenuators, phase shifters, and up/down converters. We make every effort to meet our customers' performance requirements including size and weight.

The company has a dedicated customer support team and takes pride in its tradition of identifying cost-effective solutions for its customers. Please contact us with your microwave component needs.

AMCOM Communications is a leading edge microwave design organization that provides power FETs, MMIC power amplifiers, as well as high-power amplifier modules with RF and DC connectors.

AMCOM
amcomusa.com

AMCOM offers a variety of Solid State Power Amplifiers (SSPA) for different power levels and operating frequencies. The connectorized modules are offered in compact sizes and are suitable for many applications such as radar, instrumentation and broadband jamming. Also, AMCOM offers a custom design service to meet customers' requirements for their own specific applications. The table below shows some of AMCOM's standard products:

<table>
<thead>
<tr>
<th>Model</th>
<th>Frequency</th>
<th>V_supply</th>
<th>I_dq</th>
<th>Gain</th>
<th>P1dB</th>
<th>Psat</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM003040SF-4H</td>
<td>0.05-3GHz</td>
<td>24-28V</td>
<td>3.5A</td>
<td>43dB</td>
<td>41dBm</td>
<td>42dBm</td>
</tr>
<tr>
<td>AM004042SF-2H</td>
<td>0.05-4GHz</td>
<td>40-50V</td>
<td>1.5A</td>
<td>24dB</td>
<td>40dBm</td>
<td>42dBm</td>
</tr>
<tr>
<td>AM042644SF-3H</td>
<td>0.3-2.6GHz</td>
<td>28-32V</td>
<td>2.7A</td>
<td>35dB</td>
<td>43dBm</td>
<td>44dBm</td>
</tr>
<tr>
<td>AM153042SF-4H</td>
<td>1.3-3.4GHz</td>
<td>15-20V</td>
<td>6A</td>
<td>36dB</td>
<td>42dBm</td>
<td>43dBm</td>
</tr>
<tr>
<td>AM206545SF-3H</td>
<td>2-6.5GHz</td>
<td>32-40V</td>
<td>2.5A</td>
<td>28dB</td>
<td>38.5dBm</td>
<td>45dBm</td>
</tr>
<tr>
<td>AM02018041SF-3H</td>
<td>2-18GHz</td>
<td>32-40V</td>
<td>3.4A</td>
<td>26dB</td>
<td>36.5dBm</td>
<td>41dBm</td>
</tr>
<tr>
<td>AM07511242SF-3H</td>
<td>7.5-11.2GHz</td>
<td>12-15V</td>
<td>5.5A</td>
<td>23dB</td>
<td>40.5dBm</td>
<td>41.5dBm</td>
</tr>
<tr>
<td>AM08513241SF-3H</td>
<td>8.5-13.2GHz</td>
<td>12-15V</td>
<td>6A</td>
<td>25dB</td>
<td>40.5dBm</td>
<td>41.5dBm</td>
</tr>
<tr>
<td>AM00010037UM-1H</td>
<td>0.05-10GHz</td>
<td>+28, -2V</td>
<td>0.3A</td>
<td>13dB</td>
<td>30dBm</td>
<td>37dBm</td>
</tr>
<tr>
<td>AM30040031SF-3H</td>
<td>30-40GHz</td>
<td>+6, -0.6V</td>
<td>1A</td>
<td>17dB</td>
<td>27dBm</td>
<td>31dBm</td>
</tr>
</tbody>
</table>

For more detailed information please visit:
www.amcomusa.com

Get info at www.HFeLink.com
5G Primer: Amplifier, Filter Design

This primer examines some of the challenges engineers face when designing filters and power amplifiers for 5G New Radio (NR) communication systems.

Available for download via registration at:


Registration is required to download the listed white papers. If you already have registration for AWR Downloads site you only need to enter your email address.

National Instruments
awrcorp.com

17-40 GHz Block Up and Down Converters

Norden Millimeter's next generation of broader band block up and down converters are used for extending the frequency range of existing ELINT, COMINT, RADAR, and Testing systems. These converters cover the 17-26.5 GHz and 25.5-40 GHz bands with a full 1 GHz overlap with existing 18GHz systems and at the transition between bands.

The Upconverter has independent input IF and output RF attenuation for over 60 dB of gain control. These attenuators are controlled by parallel attenuation bits on a rear power/control multi-pin connector. Both converters offer best in class spur free dynamic range. The units use a single frequency external LO signal of 14.4 GHz.

Norden Millimeter
nordengroup.com
Passives, Connectivity Products Catalog

Response Microwave announced the availability of its new product selection guide. The 108 page catalog provides an overview of corporate capabilities and selection tables of the companies passive component and connectivity product offering which operates from DC to 65GHz, and also selective optical products.

It also offers application notes on the company’s unique HYBRIDLINE™ series of drop-in quad hybrids and couplers.

The company website is currently in a re-design process and once complete, the catalog will be available in a downloadable PDF format.

Response Microwave
responsemicrowave.com

---

Diplexer: Telecom Bands

Response Microwave announced the availability of a new 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 1.3 inches, plus 4.3/10 female connectors. Alternate bands and connectors are available on request.

Response Microwave
responsemicrowave.com
Power Amps and More

Exodus Advanced Communications is a multinational RF communication equipment and engineering service company serving both commercial and government entities and their affiliates worldwide. Headquartered in Las Vegas, Nevada, the company utilizes its global network of resources to effectively serve customer requirements.

As a unique original equipment manufacturer of power amplifiers ranging from 500KHz to 51GHz with various output power levels and noise figure ranges, we fully support custom designs and manufacturing requirements for both small and large volume levels. We bring decades of combined experience in the RF field for numerous applications including military jamming, communications, radar, EMI/EMC and various commercial projects with all designing and manufacturing of our HPA, MPA, and LNA products in-house.

Exodus Advanced Communications
exoduscomm.com

YIG-Tuned Components: Trust the Leader

YIG technology is the most effective solution to a variety of RF and microwave frequency generation and filtering challenges — especially when the absolute lowest phase noise and multi-octave tuning is required. At Micro Lambda we’ve dedicated ourselves to the art of YIG-tuned designs and perfecting the science of manipulating YIG behavior. We offer you the latest suite of standard products, customization capabilities, and the best customer support.

Established in 1990, no company has done more in the last 25 years to launch new products and revolutionize the field of YIG design. Taking what was once a technology reserved for only the most far-reaching programs, Micro Lambda has developed commercially viable and standardly packaged components to give every RF and microwave engineer the chance to consider the difference a YIG-based device or system can make.

Micro Lambda Wireless
microlambdawireless.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.

Such applications include high-performance equipment and instrumentation in the fields of aerospace, communication, computers & peripherals, consumer products, diagnostic, education, industrial automation, control & monitoring, medical, military/defense, security, space, and test & measurement.

Gowanda participates in Ship-to-Stock programs with many of its customers in support of their JIT and Lean Manufacturing programs. We fully recognize the critical need for product quality, reliability, and on-time delivery in the support of these customers’ programs. Our on time, world-wide delivery performance record historically is above 95%, while our product return record historically is less than ½ of 1%.

We recognize what it takes to be a world-class supplier to the best manufacturers in the business. We are ranked in that elite group of supply partners by our customers, and are committed to maintaining that status.

Gowanda Electronics
gowanda.com
26.5 GHz RF Downconverter

The SC5318A is a C to K broadband single-stage downconverter, converting frequencies from 6 GHz to 26.5 GHz down to 50 MHz to 3 GHz. The LO frequency range is from 6 to 26.5 GHz with an input LO range from 6 to 14 GHz. An internal frequency doubler multiplies the input LO range up to 26.5 GHz. This module also features an internal 26.5 GHz synthesized LO, RF preamplifier, and variable gain control, making it a standalone module. The SC5318A may be paired together for MIMO applications such as ground-based satellite communications, point-to-point radio, and test instrument systems.

SignalCore
signalcore.com

Power Sensors for IoT Bluetooth Testing

LadyBug Technologies’ LB479A and LB480A are ideal for testing Bluetooth devices. The sensors have very good dynamic range and are suitable for measuring radiated power as well as direct connectivity to the Bluetooth DUT. Both sensors provide statistical pulse measurement capability. This capability is ideal for manufacturing test systems where a quick numerical measurement of average and pulse power is required without complex measurement set up. The LB480A includes triggering features along with pulse profiling capability. LadyBug sensors can be ordered with a variety of connectors reducing or eliminating adaptor requirements, thereby increasing measurement accuracy.

LadyBug Technologies
ladybug-tech.com
**FREQUENCY SYNTHESIZERS**  
**to 34 GHz**

Model SLSM5
- Great performance to 34 GHz (in bands)
- 1 kHz step size
- Good phase noise
- Frequency control
  - RS485 (multiprotocol)
  - USB via converter
- Supplied with evaluation GUI
- Reference ext 10 MHz or int (±0.5 PPM)
- Miniature package (2.5”x2.5”x0.63”)
- DC power single 5V
- Affordable and a great value

In short we build so much performance into the SLSM5 that the only surprise is its price and affordability!

---

**Product Showcase**

**Waveguide Components**
from 2.6GHz to 110GHz

- Waveguide straight sections, bends and twists
- Waveguide Range adapters
- Waveguide Tees
- Waveguide switches
- Multi-hole directional couplers
- Cross directional couplers
- Fixed and variable waveguide attenuators
- Variable waveguide shorts

** Wentep Microwave Corporation**  
107 Hamilton Road, Suite A, Duarte, CA 91010  
Phone: (626) 305-6699, Fax: (626) 620-3101  
Email: sales@wentep.com  
Website: www.wentep.com

---

**We are going to the edge and beyond**

Our next stop is **PLUTO!**

**NEW HORIZONS**

**Sector Microwave Ind., Inc.**  
(651) 242-2300  Phone: (651) 242-8158  Fax: www.sectormicrowave.com

---

**RF Bay, Inc.**

- 10GHz Divide-by-13 Prescaler  
- 850-950MHz 10W Power Amplifier  
- 10KHz - 1GHz RF Amplifier

**RF Bay, Inc.**  
19225 Orbit Drive, Gaithersburg, MD 20879  
Tel: (301) 880-9921, Fax: (301) 560-8007, Mobile: (240) 645-8591  
Email: sales@rfbayinc.com, Website: www.rfbayinc.com

---

**Hi-Rel by Design**

In business since 1986, Special Hermetic Products, Inc. has been a leader in the hermetic seal business for over 20 years. In addition to hermetic feedthroughs, capacitors, connectors, headers and related products & services, SHP offers solutions for all your custom hermetic design requirements. SHP is ISO 9001:2008 Certified.

**SPECIAL HERMETIC PRODUCTS, INC.**  
PO Box 269 – Wilton – NH – 03066  
Tel: (603) 651-2005 – FAX: (603) 654-4265  
Email: sales@shp-seals.com

---

**LOW NOISE AMPLIFIERS**

**www.satellink.com**

---

**30 Years**

**Satellink, Inc.**  
3272 Miller Park Dr.  
Garland, TX 75042  
Call: (972) 487-1434  Fax: (972) 487-1204

---
Multicoax Connector

Amphenol Ardent Concepts has released a new form factor of its TR Multicoax connector. The connector was designed specifically for solving signal integrity issues caused by serpentine trace routing from high speed devices. TR Equal Trace delivers superior signal integrity from multiple high-speed channels in an arched footprint, making it ideal for applications where equal and short trace lengths are imperative for performance tuning. In these cases, TR Equal Trace can eliminate the need to create complicated serpentine traces, helping to ensure signals reach their destination at the same time in data and clock routing for peak performance. The tight pitch of TR Equal Trace gets the connector closer to the device to reduce signal loss.

Amphenol Ardent Concepts
ardentconcepts.com

Broadband LNA

The HILNA™ GPS C034 is a broadband low noise amplifier designed to achieve high gain while maintaining low noise and a high third order intercept point, and is specifically targeted for the L1 (1575.43 MHz) and L2 (1227.6 MHz) GPS signals. This ruggedized, high-performance module delivers 32 dB of gain across the frequency range of 1200 MHz to 1600 MHz with an OIP3 of +30 dBm and less than 1 dB of noise figure. The HILNA™ GPS C034 is also usable up to 2000 MHz with over 28 dB of gain. The module’s robust power supply also operates over a broad 22-34 VDC range, easily allowing the unit to be integrated into systems without regard to power supply precision.

NuWaves Engineering
nuwaves.com
Band Reject Filter

Model JTIDS-0001-TNS is an ultra-small band reject filter centered at 1085 MHz. This filter rejects frequencies from 960 to 1210 MHz and was specifically designed for Military JDITS applications. Other specifications include notch Bandwidth of 250 MHz; passband insertion loss 6.0 dB; and VSWR of 2.0:1. Physical size is 1.5”L x 0.5”W x 0.5”H and contains TNC female IN/OUT connectors.

Planar Monolithics Industries
pmi-rf.com

MLCC Capacitors

The AEC-Q200 series of MLCC capacitors has had a range extension increasing the available working voltage from 2kV up to a maximum of 4kV. Designed for EV applications where ever higher voltages are needed, but where a margin for derating has to be accommodated for - ideal for power train use, like battery management and inverters. Available in X7R dielectric, and with capacitance up to 22nF, this extension joins an already comprehensive offering of Syfer AEC-Q200 qualified MLCC capacitors and complements the extensive AEC-Q200 qualified components KPD offer. Available as standard with KPD’s lead-free, RoHS and REACH compliant, FlexiCap termination for crack prevention and high number thermal cycle withstand.

Knowles Precision Devices
knowles.com
A Leading Provider of RF Coaxial Relays

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

EXCELLENCE BY DESIGN

Design Enhanced Application Specific RF Coaxial Relays
Military Defense Fixed/Mobile/Shipboard
Commercial Telecommunications Infrastructure
Satellite Communications Ground Stations
Test and Measurement Instrumentation from DC to 40 GHz

RF Relay Store

www.rfrelaystore.com

The RF Relay Store provides the most convenient, dependable and cost effective way to procure small quantities of RF coaxial relays. RelComm Technologies now makes available standard building block part types for shipment from stock.

RF Coaxial Relays - Extremely low loss from DC to 18GHz.
1P1T, 1P2T, 2P2T, Transfer, and Multi-Throw.
PCB Mount, SMA, and N-Type Connectorized

RelComm Technologies, Inc. - 610 Beam Street, Salisbury, MD 21801
P: (410) 749-4488 - F: (410) 860-2327 - www.relcommtech.com - sales@relcommtech.com
**Wirewound Ferrite Beads**

Coilcraft offers a broad range of wirewound ferrite beads in standard package sizes from 0201 (0603) to 1812 (4532). Superior attenuation and frequency performance enable smaller solution sizes compared to traditional thick-film chip ferrite beads. Ferrite beads are used as low pass filters to eliminate high frequency noise while allowing low frequency signals or DC current to pass through a circuit. Coilcraft wirewound ferrite beads feature a ferrite construction and heavy gauge wire for high current handling. They provide extremely low DCR while maintaining high filtering impedance across a wide bandwidth – up to GHz band. These features enhance the performance of the choke circuit while potentially reducing board space by replacing a larger chip ferrite bead with an equivalent, or higher-performing wirewound ferrite bead.

Coilcraft  
coilcraft.com

---

**Millimeter Wave Products**

Ducommun serves the avionics, communications, defense, industrial, intelligent traffic systems, medical, and test equipment markets with millimeter wave products. We design and manufacture products including amplifiers, antennas (horn and patch), mixers, oscillators, multipliers, radar sensors, industrial grade phase shifters, lab components, up/down-converters, along with sub-systems and integrated assemblies.

Ducommun  
ducommun.com
BGA Socket Design

Ironwood Electronics has recently introduced a new BGA socket design using high performance elastomer capable of 75GHz, very low inductance and wide temperature applications. The GT-BGA-2086 socket is designed for 21x21 mm package size and operates at bandwidths up to 75GHz with less than 1dB of insertion loss. The socket is designed to dissipate few watts using compression screw and can be customized up to 300 watts with modified fin design on top of the screw and adding axial flow fan. The contact resistance is typically 30 milliohms per pin. The socket is mounted on the target PCB with no soldering, and uses very small real estate allowing capacitors/resistors to be placed close by.

Ironwood Electronics
ironwoodelectronics.com

Fully Differential Amplifiers/ADC Drivers

Analog Devices announced the LTC6363-0.5, LTC6363-1 and LTC6363-2 Precision, Fixed-Gain, Fully Differential Amplifiers, creating a family of ultra-precision fixed-gain variants of the successful LTC6363 amplifier. The new offerings are available in fixed gains of 0.5, 1 and 2V/V which provide flexibility when scaling inputs to the full range of ADCs. The precision resistors, which are integrated in LTC6363-0.5, LTC6363-1 and LTC6363-2, have been designed with overall system performance in mind, striking a balance between noise and linearity, and utilizing laser trimmed factory calibration to achieve a level of precision which is difficult and costly to achieve discretely.

Analog Devices
analog.com
Coaxial Adapters, Amplifiers, Attenuators, Couplers, Splitters, Terminations & Test Cables

Breaking Through Barriers to the Next Generation of Wireless Applications
IMS2019
2-7 June 2019
Boston
The Hub of Microwaves
Boston Convention & Exhibition Center
Boston, Massachusetts
Submit your Paper Today!
Secure your Booth Space Now!
www.ims-ieee.org
Suspended Substrate Low Pass Filter Features Wide Passband of DC to 14 GHz

The ZLSS-14G+ 500 low pass filter has a broad, low-loss passband of DC to 14 GHz with sharp cutoff and high-rejection stopband that extends to 26.5 GHz. Fabricated with reliable suspended-substrate-stripline circuit technology, the RoHS-compliant filter has typical passband insertion loss of 2 dB with typical passband VSWR of 2.1:1. Typical stopband rejection is 30 dB from 16.5 to 18 GHz, 50 dB from 18 to 19.7 GHz, and 80 dB or more from 19.7 to 26.5 GHz. The low pass filter is suitable for rejection of unwanted harmonic signal content in transmitters and receivers. It is supplied in a compact coaxial package measuring 0.90 × 0.70 × 0.60 in. (22.86 × 17.78 × 15.24 mm) with female SMA connectors. The RoHS-compliant filter handles input power levels to 3W (+30 dBm). It is designed for operating temperatures from -40 to +85°C.

Wideband Digital Step Attenuator, 0 to 15.5 dB, DC to 4 GHz

Mini-Circuits ZX76-31R5A-PN+ is a coaxial digital step attenuator with an attenuation range from 0 to 31.5 dB in 0.5 dB steps and a wide frequency range from DC to 4 GHz. The device operates on a dual +3V / -3.3V supply and features a 6-bit parallel control interface. Its control lines are buffered by Schmitt triggers allowing a wide range of control voltage levels. The attenuator provides good return loss of 20 dB, IP3 of +52 dBm, and attenuation accuracy to within ±0.1 dB. The unit comes housed in a rugged, unibody case (1.2 x 1.18 x 0.46") with SMA connectors and base-mount brackets for easy mounting in your assembly.

Coaxial Directional Coupler Provides Flat Coupling from 2 to 18 GHz

Mini-Circuits ZUDC10-02183+ is a wideband, coaxial directional coupler supporting a wide variety of applications ranging from 2 to 18 GHz. This model provides 10 dB coupling with outstanding flatness of ±0.4 dB over its entire frequency range. The coupler can handle up to 20W RF input power and achieves mainline loss of 0.3 dB, 26 dB return loss, and 25 dB directivity. The unit comes housed in a rugged aluminum alloy case 2.25 x 0.73 x 0.50" with SMA-female connectors.

High-Rejection Reflectionless Bandpass Filter Passes 15.5 to 20.5 GHz

Mini-Circuits’ XBF-183+ is a reflectionless band pass filter with a passband from 15.5 to 20.5 GHz. The filter employs a patented filter topology, which absorbs and terminates stopband signals rather than reflecting them back to the source. This capability eliminates stopband reflections typical of traditional filter designs, minimizing intermodulation and other interferences. This model includes four sections, achieving rejection of 67 dB in the lower stopband and 56 dB in the upper stopband. It provides 4.9 dB insertion loss in the passband, 1.6:1 passband VSWR, and typical VSWR of 2.2 in the lower stopband and 3.0 in the upper stopband. The filter can handle RF input power up to 0.5W in the passband and 0.16W in the stopband, and it provides a wide operating temperature range from -55 to +105°C. Fabricated using GaAs IPD process technology, the filter comes housed in a tiny 4x4mm QFN package.

Wideband MMIC Amplifier Die Covers DC to 7 GHz

Mini-Circuits’ GALI-39-D+ is a wideband MMIC amplifier die with a wide operating frequency range from DC to 7 GHz. This model operates on a 35mA supply and provides 19.7 dB gain, +10.5 dBm output power at 1 dB compression, 2.4 dB noise figure, and +22.9 dBm IP3. Designed using a patented transient-protected Darlington configuration and fabricated with InGaP HBT technology, the amplifier provides outstanding reliability and repeatability. GALI-39-D+ is available in small quantity gel-paks of 10, 50, and 100 KGD (“Known Good Dice”) as well as partial and full production wafers.

Tiny LTCC Band Pass Filter, 3400 to 3850 MHz

The BFCV-3641+ LTCC band pass filter has a passband from 3400 to 3850 MHz, supporting a variety of applications such as software defined radio, WLAN, and more. This model provides 1.6 dB passband insertion loss, typical stopband rejection from 20 to 35 dB, and RF input power handling up to 0.5W. Its LTCC construction enables tiny size (0.12 x 0.10 x 0.06"), excellent thermal stability from -55 to +100°C, and outstanding reliability for tough operating conditions.
Up to 50 GHz!

TEST CABLES

Reliability You Can Trust...

Why do 10,000 customers trust Mini-Circuits test cables? Because they simply don’t fail! Our test cables have been performance qualified to 20,000 flexures* and come backed by our 6-month product guarantee, so you can be confident you’re getting rugged construction, reliability, and repeatable performance you can depend on. Order some for your test setup at minicircuits.com today, and you’ll quickly find that consistent long-term performance, less retesting and fewer false rejects really add up to bottom-line savings, test after test!

*Varies by model. See individual model data sheets for details.

www.minicircuits.com  P.O. Box 350166, Brooklyn, NY 11235-0003  (718) 934-4500  sales@minicircuits.com  507 Rev K
Hand Flex Cables conform to any shape required.

NOW! **DC-40 GHz!**  $12.95 ea. (qty. 1-9)

Get the performance of semi-rigid cable, and the versatility of a flexible assembly. Mini-Circuits Hand Flex cables offer the mechanical and electrical stability of semi-rigid cables, but they’re easily shaped by hand to quickly form any configuration needed for your assembly, system, or test rack. Wherever they’re used, the savings in time and materials really adds up!

**Excellent return loss, low insertion loss, DC-40 GHz.**
Hand Flex cables deliver excellent return loss (33 dB typ. at 9 GHz for a 3-inch cable) and low insertion loss (0.2 dB typ. at 9 GHz for a 3-inch cable). Why waste time measuring and bending semi-rigid cables when you can easily install a Hand Flex interconnect?

**Two popular diameters to fit your needs.**
Hand Flex cables are now available in 0.047", 0.086" and 0.141" diameters, with a tight bend radius of 3.2, 6 or 8 mm, respectively. Choose from SMA, SMA Right-Angle, SMA Bulkhead, SMP Right-Angle Snap-On and N-Type connectors to support a wide variety of system configurations.

**Standard lengths in stock, custom models available.**
Standard lengths from 3" to 50" are in stock for same-day shipping. You can even get a Designer’s Kit, so you always have a few on hand. Custom lengths and right-angle models are also available by preorder. Check out our website for details, and simplify your high-frequency connections with Hand Flex! ✨RoHS compliant
Advertiser Index

<table>
<thead>
<tr>
<th>Company</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMCOM</td>
<td>47</td>
</tr>
<tr>
<td>American Technical Ceramics</td>
<td>13</td>
</tr>
<tr>
<td>API Technologies</td>
<td>1</td>
</tr>
<tr>
<td>Besser Associates</td>
<td>30</td>
</tr>
<tr>
<td>Coilcraft</td>
<td>11</td>
</tr>
<tr>
<td>C. W. Swift &amp; Associates</td>
<td>C2</td>
</tr>
<tr>
<td>dBm</td>
<td>7</td>
</tr>
<tr>
<td>Ducomon</td>
<td>31</td>
</tr>
<tr>
<td>Ducomon</td>
<td>57</td>
</tr>
<tr>
<td>Exodus Advanced Communications</td>
<td>18</td>
</tr>
<tr>
<td>Fairview Microwave</td>
<td>17</td>
</tr>
<tr>
<td>Gowanda Electronics</td>
<td>51</td>
</tr>
<tr>
<td>Herotek</td>
<td>14</td>
</tr>
<tr>
<td>IMS2019</td>
<td>60</td>
</tr>
<tr>
<td>Luff Research</td>
<td>53</td>
</tr>
<tr>
<td>Micro Lambda Wireless</td>
<td>9</td>
</tr>
<tr>
<td>Microwave Components</td>
<td>43</td>
</tr>
<tr>
<td>Mini-Circuits</td>
<td>2, 3</td>
</tr>
<tr>
<td>Mini-Circuits</td>
<td>21</td>
</tr>
<tr>
<td>Mini-Circuits</td>
<td>25</td>
</tr>
<tr>
<td>Mini-Circuits</td>
<td>29</td>
</tr>
<tr>
<td>Mini-Circuits</td>
<td>59</td>
</tr>
<tr>
<td>National Instruments</td>
<td>5</td>
</tr>
<tr>
<td>Norden Millimeter</td>
<td>23</td>
</tr>
<tr>
<td>NuWaves Engineering</td>
<td>35</td>
</tr>
<tr>
<td>OML</td>
<td>41</td>
</tr>
<tr>
<td>Pasternack</td>
<td>36</td>
</tr>
<tr>
<td>Pasternack</td>
<td>C4</td>
</tr>
<tr>
<td>Planar Monolithics Industries</td>
<td>19</td>
</tr>
<tr>
<td>PolyPhaser</td>
<td>15</td>
</tr>
<tr>
<td>Pulsar Microwave</td>
<td>20</td>
</tr>
<tr>
<td>RelComm Technologies</td>
<td>56</td>
</tr>
<tr>
<td>RF Bay</td>
<td>53</td>
</tr>
<tr>
<td>SAGE Millimeter</td>
<td>32, 33</td>
</tr>
<tr>
<td>Satellink</td>
<td>53</td>
</tr>
<tr>
<td>Sector Microwave</td>
<td>53</td>
</tr>
<tr>
<td>SGMC Microwave</td>
<td>C3</td>
</tr>
<tr>
<td>Spacek Labs</td>
<td>27</td>
</tr>
<tr>
<td>Special Hermetic Products</td>
<td>53</td>
</tr>
<tr>
<td>Wenteq Microwave</td>
<td>53</td>
</tr>
</tbody>
</table>

The ad index is provided as an additional service by the publisher, who assumes no responsibility for errors or omissions.

**FIND OUR ADVERTISERS’ WEB SITES USING HFeLink™**
1. Go to our company information Web site:
   www.HFeLink.com, or
2. From www.highfrequencyelectronics.com, click on the HFeLink reminder on the home page
3. Companies in our current issue are listed, or you can choose one of our recent issues
4. Find the company you want ... and just click!
5. Or ... view our Online Edition and simply click on any ad!
QUALITY, PERFORMANCE AND RELIABILITY IN PRECISION COAXIAL CONNECTORS

SGMC Microwave — The name to count on for Quality, Performance and Reliability! Please contact us today by Phone, Fax or Email.

Manufacturer of Precision Coaxial Connectors
620 Atlantis Road, Melbourne, FL 32904
Phone: 321-409-0509    Fax: 321-409-0510
sales@sgmcmicrowave.com
www.sgmcmicrowave.com
Get info at www.HFeLink.com
Armed with the world’s largest selection of in-stock, ready to ship RF components, and the brains to back them up, Pasternack Applications Engineers stand ready to troubleshoot your technical issues and think creatively to deliver solutions for all your RF project needs. Whether you’ve hit a design snag, you’re looking for a hard to find part or simply need it by tomorrow, our Applications Engineers are at your service. Call or visit us at pasternack.com to learn more.

866.727.8376
Pasternack.com

You Engineer the Future. We’ll Supply the Components... Today!