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MAY 2013

HIGH FREQUENCY ELECTRONICS

LDMOS Power Modules for Two Way Mobile Radios

IN THIS ISSUE:

Input Third Order Intercept Point for Crystal Filters

Featured Products

New Products

Market Reports

IMS 2013 SHOW ISSUE

Ideas for today's engineers: Analog · Digital · RF · Microwave · mm-wave · Lightwave

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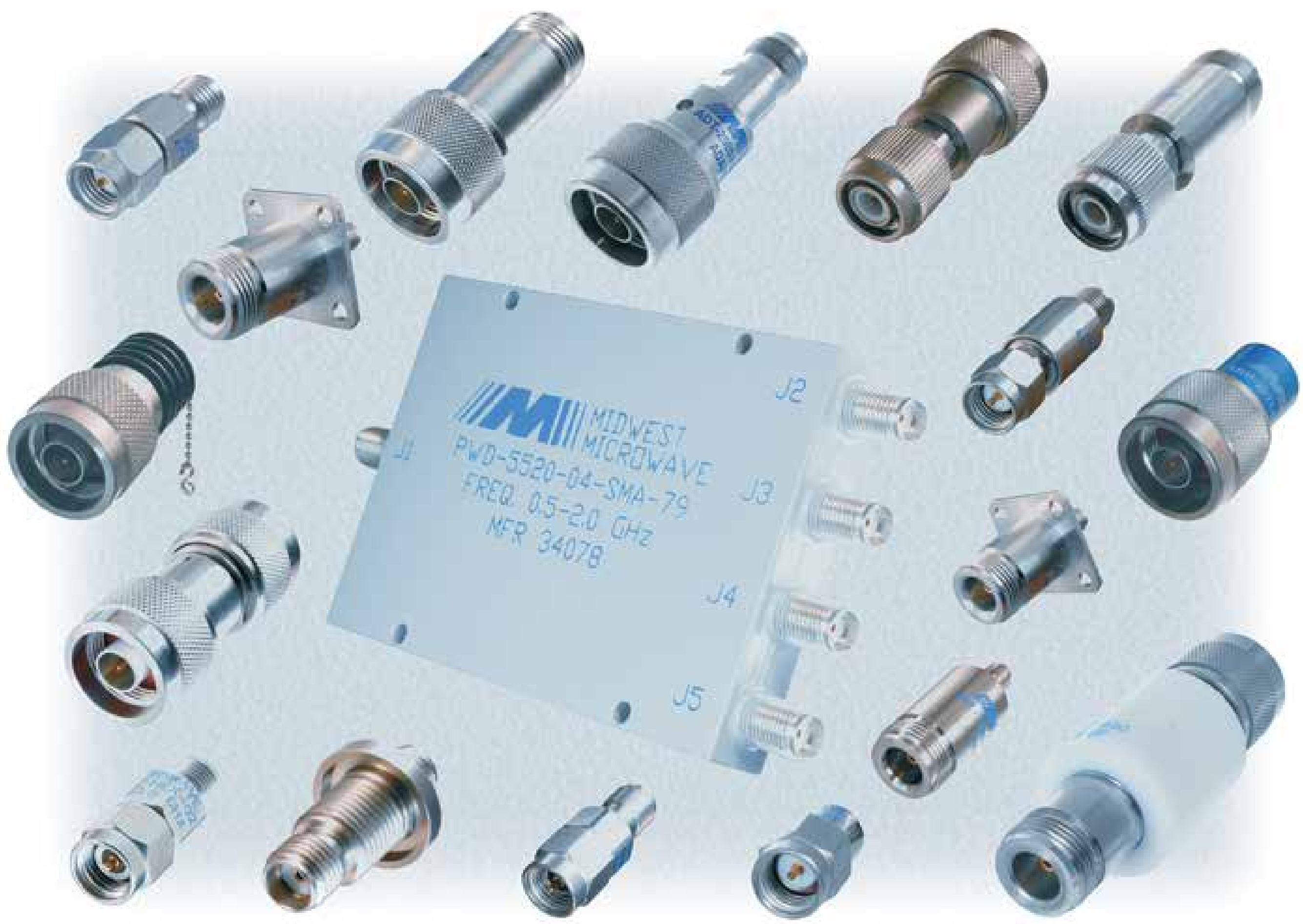

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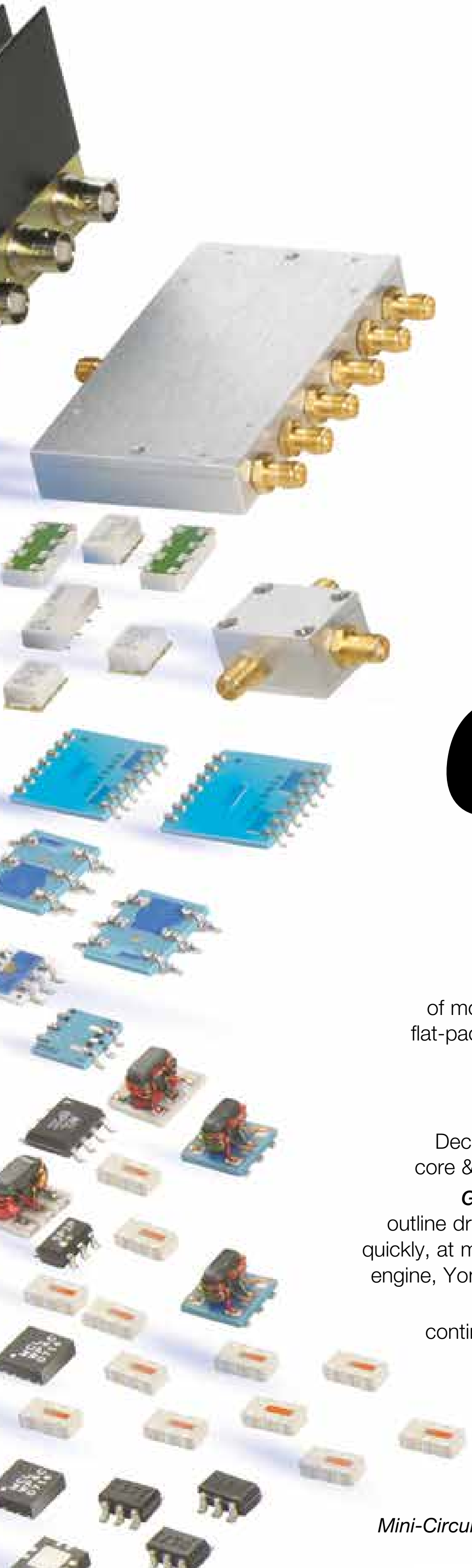

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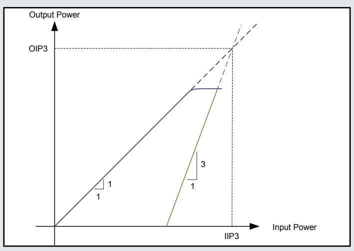
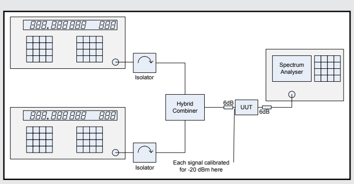
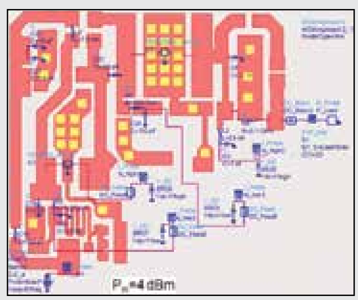
HIGH FREQUENCY ELECTRONICS

22
Crystal Filters
Input Third Order Intercept Point for Crystal Filters
By Dennis Layne





30
LDMOS Power Modules
LDMOS Power Modules for Two Way Mobile Radios
By Alfio Scuto



52
New Products

Including CST, Z-Communications, Rohde & Schwarz, AWT Global, Radio Frequency Systems, Agilent Technologies, Florida RF Labs.

16
Featured Products

Featuring Murata Power Solutions, EMC Technology, GT Microwave, Bliley Technologies, M/A-COM Technology Solutions.

12
In The News

Highlighting Lockheed Martin, Rockwell Collins, TECOM Industries, Cubic Corp., Nitronex, Texas Instruments, RFMW, CST.

87
Interview

Sherry Hess, Vice President of Marketing, AWR Corp.

6 Editorial
12 In the News
16 Featured Products
8 Meetings & Events
52 New Products
88 Advertiser Index

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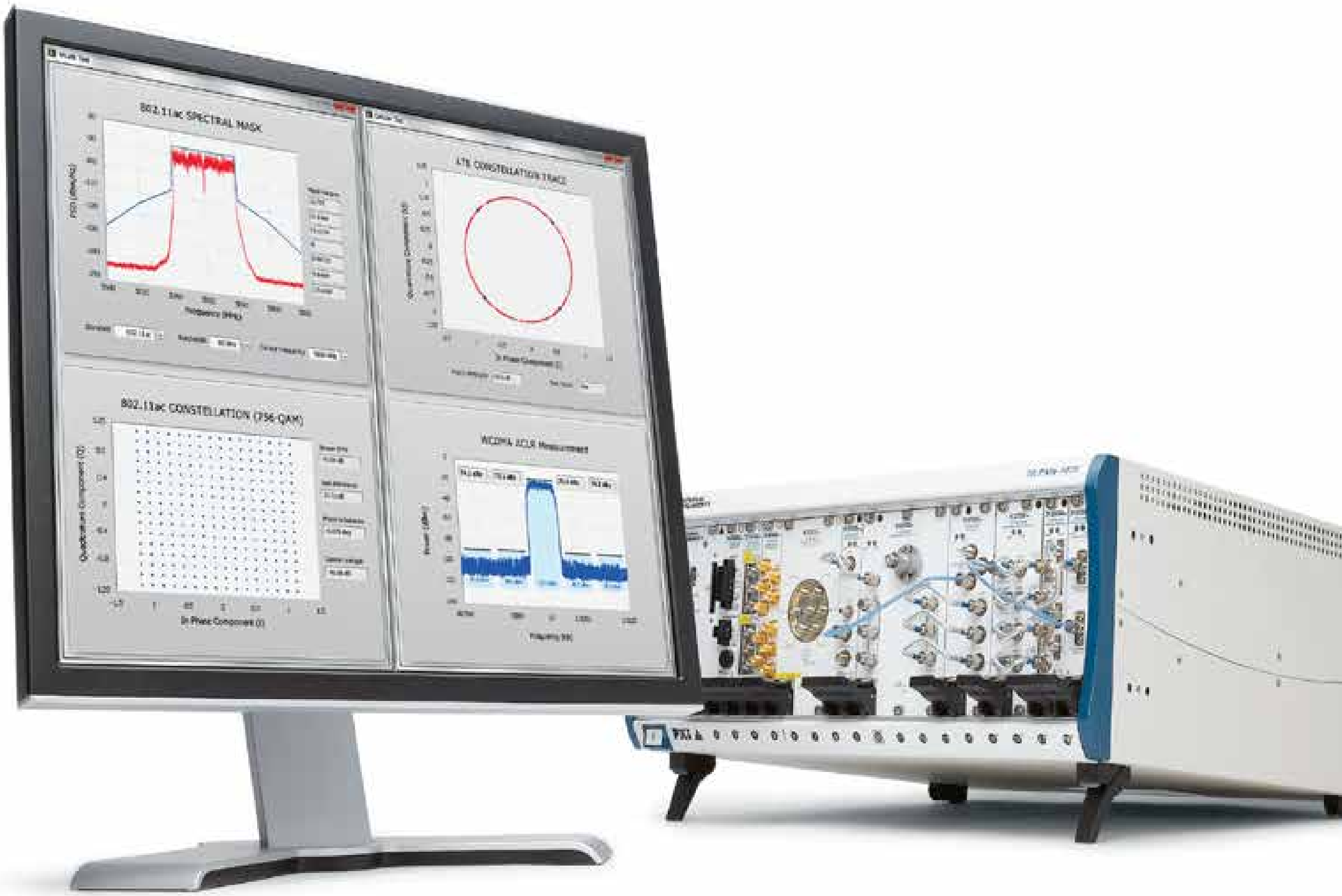
with open software and modular hardware



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Return to the Emerald City

Scott L. Spencer
Publisher

Seattle, Wash., sits on a strip of land between the salt waters of Puget Sound and the fresh waters of Lake Washington. A city built on hills and surrounded by water, Seattle will provide the backdrop for the IEEE MTT International Microwave Symposium (IMS2013) to be held June 2-7. Sometimes referred to as "The Queen City," its official nickname until 1982, or by its current nickname "The Emerald City," Seattle has always exhibited a spirit of enterprise and optimism often called "the Seattle Spirit." Seattle is home to many arts and cultural institutions, live theaters, and art museums. With its beautiful parks, Pioneer Square, and the Pike Place Market, Seattle will provide a terrific venue for this year's Symposium. It is worth noting that *High Frequency Electronics* was "launched" at the 2002 MTT-S in Seattle to provide "Information Resources for a New World of Technology." The first issue was mailed and posted online shortly after the Seattle meeting on July 19, 2002.

IMS 2013 is the premier event of its type in the world, focusing on all aspects of microwave theory and practice. Packed with top quality technical presentations, workshops, and tutorials, the conference offers an unparalleled opportunity for learning and gaining insight into new ideas, techniques and possibilities.

RFIC, ARFTG

The RFIC Symposium and the ARFTG Conference are two key elements of Microwave Week.

The RFIC Symposium highlights achievements in RF circuits, systems, and devices. This year's program will showcase innovations in RF integrated circuit design. Sessions will cover topics including cellular and wireless-connectivity system ICs, low power transceivers, reconfigurable and digital RF, broadband wireless communications, silicon millimeter-wave ICs, power amplifier technology, and RF device modeling and characterization.

ARFTG (Automatic RF Techniques Group) is a conference that provides participants an opportunity to speak "one-on-one" with experts in the RF and microwave test and measurement community covering diverse topics including high-throughput production, one-of-a-kind metrology measurements, complex systems or simple circuit modeling, small signal S-parameter or large-signal non-linear measurements, phase noise or noise figure, DC to light.

One of the best additions in recent years in the exhibit hall is the inclusion of the series of Microwave Applications Seminars or MicroApps, a series of seminars describing state-of-the-art products and processes of interest to conference attendees.

While MicroApps can provide useful information about products and technology, the exhibits themselves offer an opportunity to meet with suppliers that provide goods and services you need or meet a potential customer that would benefit from a solution you can provide. The exhibit floor is an excellent place to network. I always plan to spend some dedicated time to learn about new companies, some of whom will exhibit for the first time in Seattle. And, although it is not talked about much, many important career changes have been spawned at Microwave Week over the past 61 years.

If you are coming to Seattle, here is some sage advice from this year's IMS2013 General Chairman Tom Raschko's Welcoming Message:

• *Investment in yourself – Learn.* Now more than ever, we must invest in our careers. At IMS you will have an opportunity to see new circuit architectures, to experience new techniques in analysis and design, and to learn about new technologies. Take new knowledge and techniques home. Both you and your organization will gain from what you have learned

• *Network.* Mingle with leaders and luminaries of academia, industry and government. They will be on hand to instruct, listen, and discuss new products.

• *Have your work recognized.* Submit a technical paper. There is a huge benefit to have this kind of global exposure in your field. If you run or speak in a workshop your name is listed in the technical program. Now you are an industry leader that put the experts together or speaks with authority on a topic.

• *Enjoy Seattle.* Above all else, stay a little longer and have fun. We have a full calendar of social activities and guest programs.

For the second straight year *High Frequency Electronics* is proud to be the exclusive sponsor of the Monday evening Welcome Reception. All Microwave Week attendees and exhibitors are invited to attend from 7 to 8:30 p.m. in the Washington State Convention Center (WSSC) Ballroom 6E. I hope to see many of you there. I am excited about returning to Seattle and look forward to seeing old friends and making new ones, too. Please stop by Booth 607 to say hello and meet the people that bring you *High Frequency Electronics* each month.

Conferences

June 2 – 7, 2013
IMS 2013
Seattle, Wash.
http://www.ims2013.org/

June 2 – 4, 2013
IEEE RFIC 2013
Seattle, Wash.
http://www.rfic-ieee.org

September 1 – 6, 2013
International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz)
Mainz, Germany
www.irmmw-thz.com

October 15 – 18, 2013
IEEE International Symposium on Phased Array Systems & Technology
Waltham, Mass.
www.array2013.org

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Webcasts on demand.
http://search.ni.com/nisearch/app/main/p/bot/no/ap/tech/lang/en/pg/1/sn/catnav:mm,n15:WebcastsOnDemand,ssnav:dzn/
LabVIEW user groups.
https://decibel.ni.com/content/community/zone/labviewusergroups

Call for Papers

2013 Topical Symposium on Power Amplifiers for Wireless Communications (PAWC)
September 9 – 10, 2013, San Diego, Calif.
Abstract Submission Deadline: July 1, 2013
Final Paper Submission Deadline: August 12, 2013

2013 IEEE International Conference on Ultra-Wideband (ICUWB)
September 15 – 18, 2013, Sydney, Australia
Abstract Submission Deadline: March 8, 2013
Final Paper Submission Deadline: June 14, 2013

2013 IEEE International Symposium on Phased Array Systems and Technology (ARRAY 2013)
October 15 – 18, 2013, Waltham, Mass.
Final Paper Submission Deadline: June 1, 2013

2013 IEEE International Topical Meeting on Microwave Photonics (MWP 2013)
October 28 – 31, 2013, Alexandria, Va.
Abstract Submission Deadline: May 1, 2013

Defense Contract Activity Robust for Start of 2013

Financial reporting at the beginning of 2013 saw most companies in the defense sector unveiling largely stable revenue results for 2012 with only minor increases or declines year-on-year. The Strategy Analytics Advanced Defense Systems (ADS) service reports, "Defense Electronics Industry Review: January 2013," and "Defense Electronics Industry Review: February 2013," detail significant defense industry news, including product announcements, milestones, contract activity and defense industry financial performance for the beginning of 2013.

Company results reflected a slowing defense market, but contract activity was surprisingly good in January with new contracts across all sectors including radar, communications and EW. A number of international shows including IDEX and the Aero India exhibition in February provided the stage for companies to establish strategic relationships, form joint ventures and highlight their capabilities as well as sign major contracts.

"Boeing's financial performance was the exception with revenues growing 19 percent year-on-year." noted Eric Higham, ADS Service Director North America. "However, this was largely on the back of the company's commercial business."

"February deals included Saab partnering with Tawazun to create a new UAE-based radar company and Boeing and Elbit Systems signing a MoU leveraging Elbit's Directional Infrared Counter Measures (DIRCM) capabilities for Boeing's fixed and rotor platforms," said Asif Anwar Director of the ADS service at Strategy Analytics. "Other business activity included the O'Gara Group, completing its purchase agreement to acquire BAE Systems Commercial Armored Vehicles."

—Strategy Analytics
strategyanalytics.com

GaAs Device Revenue Grows in 2012

Growth in the last quarter of 2012 pulled GaAs device revenue to a slight gain for 2012. The Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) Insight, "GaAs Device Industry Closes up in 2012," explores GaAs device revenue growth and trends. It also presents the revenue performance of leading GaAs device manufacturers and foundries like RFMD, Skyworks, TriQuint Semiconductor, Avago Technologies and WIN Semiconductors.

The Insight concludes that handset growth, particularly smartphones, is responsible for most of the revenue growth in the GaAs device market. As data consumption continues to soar, handsets will remain the primary driver for GaAs device growth. In the short-term, revenue in the GaAs device market is expected to exceed the historical average. In the longer term, the Insight points out that recent developments in CMOS multi-mode, multi-band handset PAs from Qualcomm and others will pose a significant threat to the GaAs device market.

"Smartphones continue to grow faster than the overall handset market. This growth, coupled with more bands and increased GaAs device content remains the single biggest driver for revenue growth in the GaAs device market," noted Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "In the short-term, we anticipate this combination of factors will drive GaAs device revenue growth above historical averages".

Asif Anwar, Director, Strategy Analytics Strategic Technologies Practice, added, "Strong growth in the last quarter of 2012 provides a good starting point for the GaAs industry in 2013. However, recent announcements about CMOS multi-mode, multi-band PAs and envelope tracking will threaten the GaAs device market and these developments will be monitored closely."

—Strategy Analytics
strategyanalytics.com

Analysis: MOTS Equipment a Growth Area in Defense

New analysis from Frost & Sullivan, US Future Defense Market Opportunities, finds that the market earned revenue of $687 billion in 2011 and estimates this to decline to $459 billion in 2025 if a full sequestration remains in place.

By the end of 2013, if large numbers of troops depart from Afghanistan as planned, a return to more traditional peacetime testing, validation, and supply-chain integrity will be more strictly enforced. The Department of Defense budget emphasis will be to acquire large numbers of cost-efficient, general-purpose equipment. This general purpose equipment may use modular, swappable mission packages.

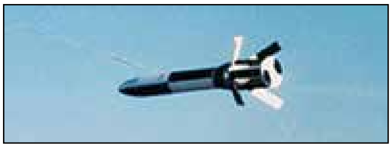
"Over the period between 2011 and 2025, many of the traditional procurement areas will remain viable but at a lower rate of acquisition," noted Frost & Sullivan Industry Manager Wayne Plucker. "Future weapons purchases will require that the weapons have reliable supply, training, maintenance, and repair systems."

As the U.S. military continues its transformation into a more modular expeditionary force, the majority of the opportunities for defense contractors will be around modifications of existing technologies in order to offer a revised capabilities set. Independent and integrated sensors, "greener" equipment, modular scalable platforms, non-line-of-sight weapons, data handling and analysis, and unmanned systems are growth areas.

"The need to reduce defense spending and restructure military forces is expected to direct military procurement toward more solution-centric and fixed price contracts," added Plucker.

—Frost & Sullivan
frost.com

Rockwell Collins Inc., Cedar Rapids, Iowa, was awarded contract (FA8523-04-D-0002XE29). The award is a firm-fixed-price, sole-source contract for a maximum $16,214,717 for spares supporting **C-17** production. Location of performance is Iowa with a Jan. 31, 2018 performance completion date. Using military service is Air Force. Type of appropriation is fiscal 2013 Air Force funds. The contracting activity is the Defense Logistics Agency Aviation, Warner Robins, Ga.



Raytheon Co., Goleta, Calif. is being awarded a $35,166,810 firm-fixed delivery order for AN/ALE-50 **towed decoys**. Work will be performed at Forest, Miss., and is expected to be completed by March 31, 2015. This award is the result of a sole-source acquisition. Type of appropriation is fiscal 2011. Delivery order is multiyear. AFLCMC/WNKCB, Robins Air Force Base, Ga. is the contracting activity; (FA8523-04-D-0001-0087).

RAMSYS GmbH, Ottobrunn, Germany, is being awarded a $343,550,330 firm-fixed-price contract for the production of 445 Block 2 MK-44 Mod 4 **Rolling Airframe Missile** (RAM) Guided Missile Round Pack (GMRP) All-Up-Rounds (AURs). The RAM Guided Missile Weapon System is co-developed and co-produced under an International Cooperative Program between the United States and Federal Republic of Germany's governments. RAM is a missile system designed to provide anti-ship missile defense for multiple ship platforms. This contract involves a purchase by the German government as a result of an international agreement between the governments of the United States and Germany.

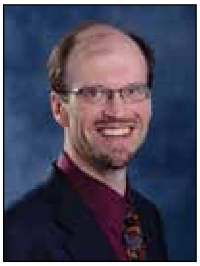
Lockheed Martin Corp., Marietta, Ga., is being awarded a $7,340,724 contract modification (FA8625-11-C-6597 P00197) for incorporation of **Large Aircraft Infrared Countermeasures** (LAIRCM) NexGen Sensors onto HC/MC-130J aircraft. Work will be performed in Marietta, Ga., and is expected to be completed by Oct.15, 2015. Type of appropriation is fiscal 2012. The contracting activity is AFLMC/WISK, Wright-Patterson Air Force Base, Ohio.

The **Laser Weapon System** (LaWS) temporarily installed aboard the guided-missile destroyer **USS Dewey** (DDG 105) in San Diego, Calif., is a technology demonstrator built by the **Naval Sea Systems Command** from commercial fiber solid state lasers, utilizing combination methods developed at the Naval Research Laboratory. LaWS can be directed onto targets from the radar track obtained from a MK 15 Phalanx Close-In Weapon system or other targeting source. The Office of Naval Research's Solid State Laser portfolio includes LaWS development and upgrades providing a quick reaction capability for the fleet with an affordable SSL weapon prototype. This capability provides Navy ships a method for sailors to easily defeat small boat threats and aerial targets without using bullets.

TECOM Industries, Inc. announced that its space qualified **S-Band Antenna** model 401163 was successfully deployed on the **Landsat Data Continuity Mission** (LDCM) satellite launched via an Atlas V rocket on February 11, 2013 from Vandenberg Air Force Base. The LDCM satellite deploys four (4) TECOM 401163 antennas, enabling satellite telemetry. The 401163 Antenna operates in the S-Band frequency with hemispherical coverage. TECOM's unique design provides a broad beam pattern for optimal telemetry control of satellites in all orientation.

Cubic Corporation announced the appointment of **Dave Schmitz** as president of Cubic Defense Applications (CDA). He succeeds **Brad Feldmann**, who was recently promoted to president and chief operating officer. Most recently, he was vice president and general manager of **Cobham Sensor**

Systems involved in technology applications supporting a variety of critical military platforms and systems. Schmitz received his bachelor's degree in applied mechanics from Harvard University, as well his master's degree in aeronautics and astronautics from Stanford University.



Nitronex named **David W. Runton** as its new Vice President of **Engineering**. Mr. Runton has almost 20 years of RF power semiconductor experience with six years in GaN specific product development, including design, assembly, qualification and packaging. Mr. Runton most recently served as Director of High Power Engineering for **RFMD** where he led an engineering product release team and developed long term product strategy. He has also held engineering leadership positions at **Freescale** and **Motorola Semiconductor.**

Mini-Circuits and **Modelithics** Inc. have agreed to collaborate in the development of high-accuracy **EDA simulation models** of Mini-Circuits' surface-mount microwave precision fixed attenuators YAT and RCAT series. The high-frequency substrate-scalable models are currently in development and will be available later this quarter for free download from the Modelithics website: http://www.modelithics.com/mvp/Mini-Circuits/. The models will also be included in the Modelithics free SELECT PLUS version of its Library of advanced RF and MW simulation models. Harvey Kaylie, Mini-Circuits Founder and President **Harvey Kaylie** commented as follows: "I have watched Modelithics grow from inception to become a trusted source of high quality models and data for design use. We are pleased to launch this collaboration for the benefit of our customers."

Texas Instruments Inc. announced several design updates to the TI E2ETM Community, http://www.ti.com/e2ejoin-pr, its popular **engineer-to-engineer online design community** that now connects more than 120,000 engineers. TI has expanded the site's search and navigation capability to make it easier for users to quickly find answers to their questions, engage with other engineers, and link to related technical content, such as application notes, user guides, and technical articles.

TI E2E™ Community

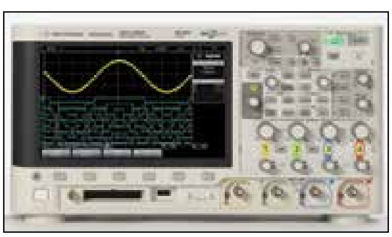
July 1, 2013 will mark the **10-year anniversary of RFMW**, Ltd. With headquarters in San Jose, Calif., and sales offices throughout North America, Europe and the Middle East, the company has seen a continual acceptance of its "niche" philosophy in that "RFMW, Ltd. is a specialty electronics distribution company focused on RF and microwave technology." "We're truly humbled by the trust our customers and suppliers have in RFMW. It's been an exciting 10 years that's gone by very fast and has seen tremendous changes in our organization and the industry," said RFMW President **Joel Levine**.

Computer Simulation Technology AG (CST) announced the incorporation of its office in Bengaluru, **India.** The founding of Computer Simulation Technology India Private Limited is a major milestone in CST's operations in India. CST software products have been available in India for over a decade through official distributors Step Electronics Pvt. Ltd. and Jyoti Electronics. Employees in the newly established company will continue to work together with distributors for the sale and support of CST software products.

Inductors

The 3000A and 3000B series of low profile power inductors are for use in noise reduction circuits of high frequency and high current switching power supplies, DC-DC converters and voltage regulator modules. The 3000A series is available with 80, 100, 150 or 200 nH inductance values. Maximum rated peak current is 57 Amps for the 80 nH device. Typical Rdc is only 0.20 mOhm across the series. The 3000B series has inductance values of 85, 100, 120, 150 or 200 nH and a maximum rated current of 78 A for the 85 nH inductor.

Murata Power Solutions
murata-ps.com



Oscilloscopes

Enhancements were added to the InfiniiVision 2000 X-Series oscilloscopes that provide more performance at a lower cost, making them ideal for educational institutions, manufacturing test environments and R&D benches. The new capabilities bring more memory—up to 1 M per channel—and a variety of low-cost serial decoding options for computer and embedded systems designers, as well as automotive and aerospace manufacturers.

Agilent Technologies
agilent.com

Attenuator

EMC Technology introduced the new 42UW series of high performance coaxial fixed attenuators, manufactured to meet the envi-

ronmental requirements of MIL-DLT-3933. They offer superior attenuation accuracy and VSWR, with extended broadband frequency operation from DC to 26 GHz.
EMC offers both commercial and high reliability versions for all applications. High reliability versions are offered with a standard test plan or up-screened to custom requirements.

EMC Technology
emc-rflabs.com

Polarizer

Model SAS-693-14115-F1 is a 66 to 72 GHz Linear to Circular Polarizer. The polarizer exhibits 1.0 dB maximum insertion loss, 1.3:1 VSWR and 1.2 dB axial ratio. The RF interface is 0.141” diameter circular waveguide with UG385/U flange for standard WR-15 waveguide interface. Various polarizers in different frequency range up to 110 GHz are also offered under different model numbers.

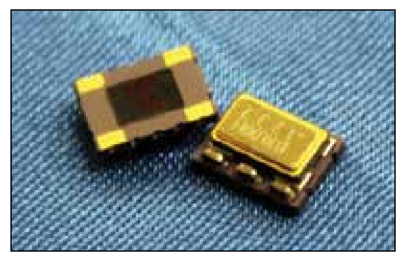
SAGE Millimeter
sagemillimeter.com

Switch

Model SA-50-0JK is a 4.385 to 4.885 GHz, SP32T, Reflective, PIN Diode Switch. This sub-assembly consists of two SP16T switches, one SPDT

switch and a power/logic connector all mounted together on a single plate. It exhibits an insertion loss less than 3.0 dB, a V.S.W.R. less than 1.5:1 in 50 Ohms and a minimum isolation of 60 dB. This SP32T Switch is capable of handling 10 W CW, hot switching, 200 W Peak, a 5% duty cycle and a 1.0 µSec pulse width.

GT Microwave
gtmicrowave.com



TCXO

Bliley Technologies released an industry standard 5 mm x 7 mm TCXO in a SMD hermetically sealed package. This series of TCXOs threatens OCXO Frequency vs. Temperature stability without the power consumption or cost. The Frequency vs. Temperature stability starts as low as ±50 ppb. Options available for customer selection include supply voltage; +3.3 VDC or +5 VDC, HCMOS, LVCOS, or Clipped Sine Wave output, and operating temperatures as wide as -40 ºC to +85 ºC.

Bliley Technologies
bliley.com

Resistor

Vishay Precision Group’s Vishay Foil Resistors brand (VFR) has released a new ultra-high-precision Z-Foil surface-mount current sensing chip resistor that is the industry's first such device to combine a high power rating of 1 W at +70°C and low TCR of ±0.2 ppm/°C typical from -55°C to +125°C, +25°C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ref. By dissipating up to 1 W in the 1625 package size, the VCS1625ZP allows designers to use a single device to measure larger currents than previously possible.

Vishay Precision Group
vishaypg.com

Driver

The MADR-009269 is a high performance single channel CMOS Driver that is used to translate TTL control inputs into complementary gate control voltages for GaAs FET microwave switches and attenuators. The device boasts high voltage CMOS technology, lower power dissipation and positive voltage control; making it an excellent solution for customers. Packaged in a low cost SOIC-8 package, it is ideal for customers looking for a low price driver with convenient implementation.

M/A-COM Technology Solutions
macomtech.com

Signal Analyzer

Rohde & Schwarz has upgraded its R&S FSW signal and spectrum analyzer with a new option to include analog baseband inputs covering a bandwidth of 80 MHz for I and Q signals. This makes it the only signal and spectrum analyzer on the market that can analyze signals with up to 160 MHz bandwidth in the baseband. The new feature will be beneficial to developers of transmitter modules for complex signals such as WLAN IEEE 802.11ac and LTE if different chipsets are used to generate the baseband signal and convert it to the RF.

Rohde & Schwarz
rohde-schwarz.com

OCXO

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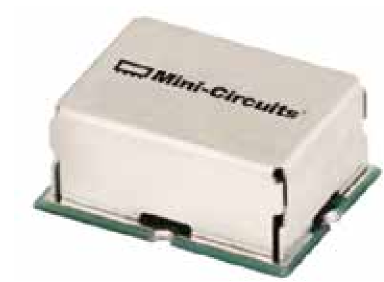

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Input Third Order Intercept Point for Crystal Filters

By Dennis Layne

A key performance requirement for crystal IF filters is the linearity of the filter.

Introduction

The heart of a dual conversion super heterodyne receiver is the Intermediate frequency (IF) filter or filters. This filter has to be approximately one channel wide. Crystal IF filters are typically used in order to achieve this bandwidth. A key performance requirement for crystal IF filters is the linearity of the filter. The IF filter is often subjected to multiple strong signals that are not in the pass band of the filter. In order to predict the receiver's linear dynamic range it is common to calculate the overall cascaded input third order intercept point (IIP3). From this value an estimate of the receiver intermodulation rejection can be calculated. Since crystal filters are passive components and by design, the interfering signals are not in the pass band of the filter, it is very challenging to measure the IIP3 of a crystal filter.

Third Order Intercept Point

The "third order intercept point" is the imaginary extrapolated point where the amplitude of a desired signal output from a device is equal to the amplitude of an unwanted output. The output intercept point equals the input intercept point plus the device gain. If the distortion products at the output are known for one particular input level then the intercept point can be predicted as follows:

$$IP_n = A + \frac{\Delta}{n-1}$$

IPn = n^{th} order intercept point
A = Signal power level at the input for IIP3 or output for OIP3 (dBm)
Δ = difference between desired signal and unwanted distortion (dB)
n = order of distortion

Two Tone Test

The Two-Tone test measures the third-order distortion products produced by a non-linear device when two tones closely spaced in frequency are fed into its input. In the case of an IF crystal filter, the two tones may be spaced the same as the industry standard intermodulation rejection test. These tones are outside of the filter passband. As a result of frequency spacing, the difference between the "test signal" and the "unwanted distortion" cannot be measured directly in one step.

The power of the distortion product is only meaningful at the output of the device under test and the gain of the device is defined as the loss in the passband of the filter. Therefore the power in the "test signal" in this case is defined as the power of one of the two test tones at the filter input minus the passband loss of the filter.

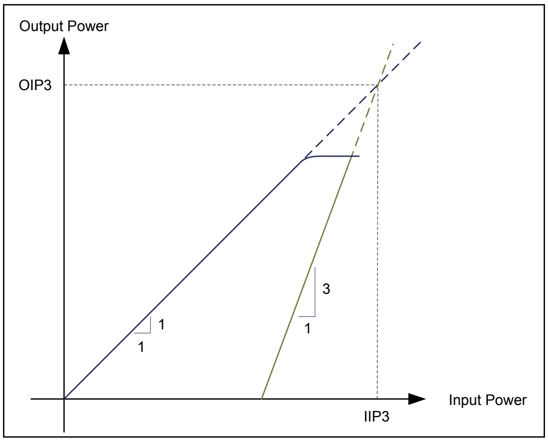

Figure 1 • Graphic definition of Intercept Point.

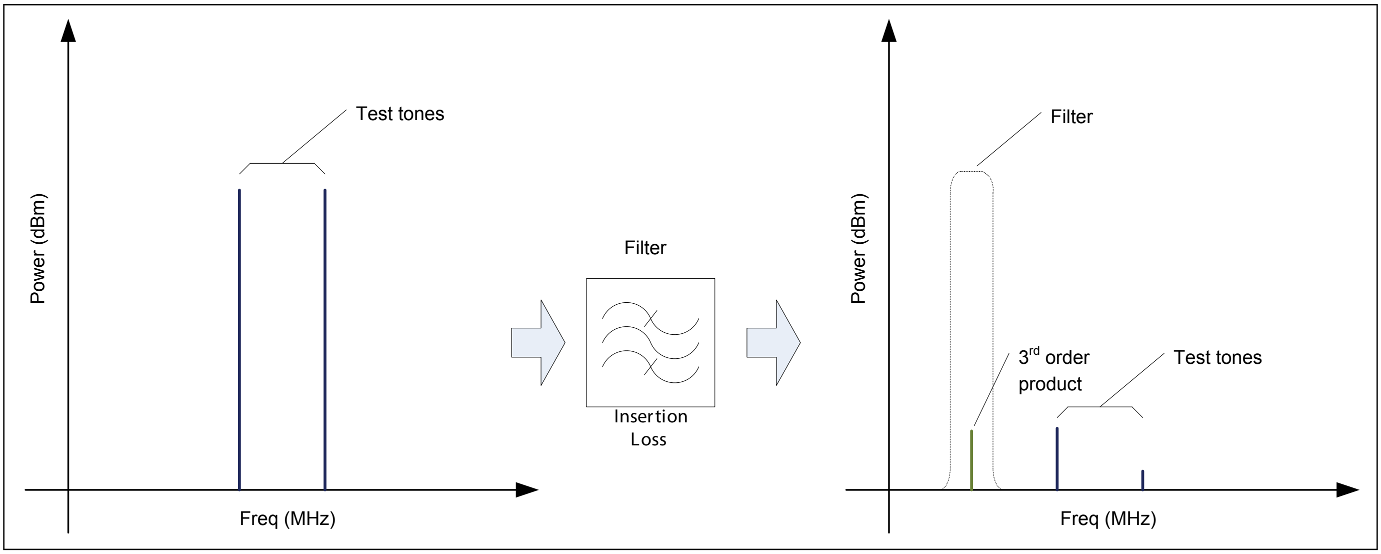

Figure 2 • Spectrum before and after Bandpass filter.

$$\Delta\ (\text{delta}) = (P_{test\_tone} - I_{loss}) - P3_{rd\_OP}$$

For example:

P_{test_tone} = -20 dBm

I_{loss} = 5 dB

$P3_{rd\_OP}$ = -100 dBm

Δ (delta) = -20 - 5 - -100 = 75 dB

Or, conversely if one considers the 3rd order product that would be imagined present at the input, then the power in the 3rd order product would be higher at the input of the filter by the insertion loss.

$$\Delta\ (\text{delta}) = P_{test\_tone} - (P3_{rd\_OP} + I_{loss})$$

For example:

P_{test_tone} = -20 dBm

I_{loss} = 5 dB

$P3_{rd\_OP}$ = -100 dBm

Δ (delta) = -20 – (-100 + 5) = 75 dB

Either way the result is the same.

Test Equipment Configuration

The goal when configuring the test setup is to get the lowest loss combining network that provides the best isolation between the signal generators and the best broad band termination at the input and output of the fixture. The setup is optimized so that the output power of the signal generators is as low as possible. In order to achieve this, there are two possible combining networks. First, one may use an isolator on the output of each signal generator. This will provide isolation between the signal generators with a low loss of signal to the filter under test. It is also best to use a hybrid combiner for the addition isolation between the inputs. Resistive attenuators are used at the input and output of the fixture for broadband termination. The output of the signal generators should be set to the lowest power that will result in a third order product within the dynamic range of the spectrum analyzer that is used.

An alternate combining network uses high isolation lab amplifiers at the output of each signal generator. This allows the signal generator to operate at a low output power but still have excellent isolation. The addition of

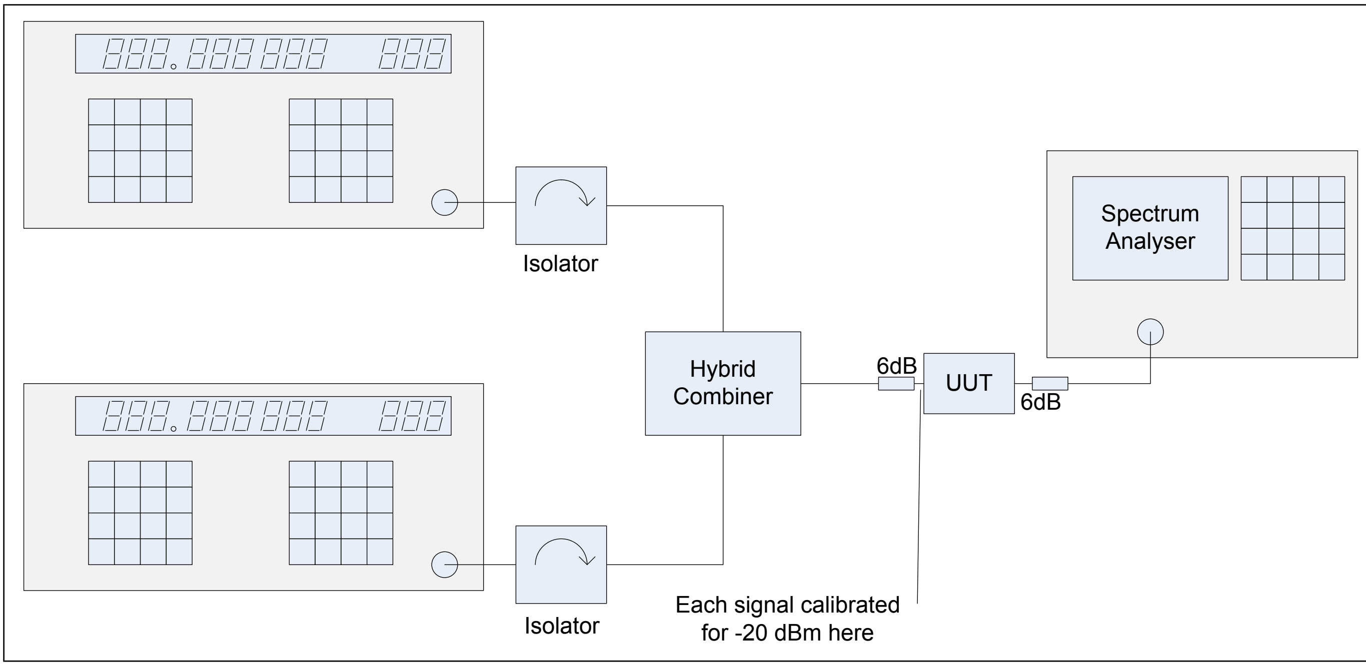

Figure 3 • Passive combining network.

low pass filters helps to remove harmonics from the generators and the amplifiers.

Note that the isolators on the signal generators have ~ 30 dB of isolation. The combiner is an M/A-Com H-8-4 hybrid combiner and has ~25 dB of isolation. The 6 dB attenuators on either side of the fixture ensure a broadband termination to the filter under test.

Crystal Filter Input Third Order Intercept Point Test Procedure

1. Apply a signal at the IF frequency that is calibrated to be -20 dBm at the input to the filter (UUT).
2. Measure the output of the UUT and set a reference marker (this offsets the delta marker by the insertion loss).
3. Apply signals at even channel frequency offsets (i.e. 2 channels and 4 channels) above the filter center frequency (IF frequency). Or some other uniform spacing may be chosen as long as the signals are evenly spaced apart. These are also calibrated to –20 dBm at the input to the filter.
4. Measure the power of the resulting third order product at the center frequency (IF frequency) of the filter. The delta marker now reads the change in filter output power from the signal generators and the third order product at the output. This is the “delta”.
5. Apply signals at even channel frequency offsets below the filter center frequency (IF frequency). Repeat step 4. The third order product with the highest power reading is the worst case. Use it to calculate the input third order intercept point.

Then the input third order intercept point

$$= IIP_3 = Pin + \frac{\Delta}{2}$$

So, if the delta is 100 dB then the IIP3 = -20 dBm + (0.5 * 100 dB) = +30 dBm

If the insertion loss is 5 db then the output intercept point would be = Pout + 0.5* delta = -25 dBm + (0.5 * 100 dB) = +25 dBm

Test Setup Linearity

In order to determine if the test equipment is operating in a linear mode, one can test the response of the intermodulation product to changes in input power. Reduce the power of the “test signals” by on e dB. This should result in a three dB drop in the intermodulation product power on the spectrum analyzer. Repeat this test by increasing the “test signals” by one dB and observe a 3 dB increase in the intermodulation product power. If the intermodulation product does not change by exactly three (3) dB then some component of the measurement network is producing distortion.

Conclusion

With careful attention to the power levels in each part of the test network, the dynamic range of the measurement system can be optimized. This allows for accurate measurement of the device. This is challenging to achieve because non-linearity in any element of the

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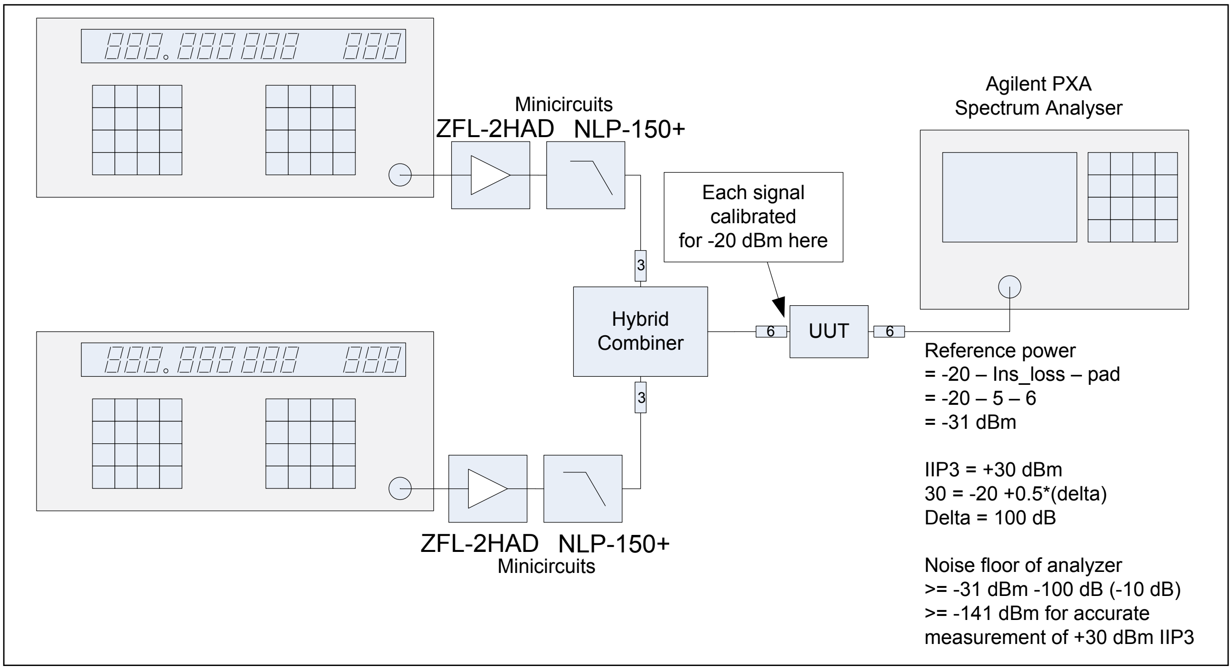

Figure 4 • Active combining network.

test network is difficult to distinguish from nonlinearity of the device under test. Once the input third order intercept point is accurately measured then the overall IIP3 cascade will result in an accurate Intermodulation rejection performance calculation.

About the Author:

Dennis Layne is a Principal RF Engineer at Harris Corp. Dennis has a BS in Physics from Lynchburg College in Virginia and has designed Land Mobile Radio receivers for 17 years.

LDMOS Power Modules for Two Way Mobile Radios

By Alfio Scuto

> Providing both amateurs and professionals with the tools needed to create their own "two-way radio."

Abstract: Two-way radios are today present in almost every area of our public life. They are an invaluable tool supporting professionals in a wide range of industries ranging from transportation to energy, government and others. With two-way radios, there's no need to deploy supporting infrastructure in the field. In fact, two-way radios can offer an instant communication (private and cost-effective) anywhere and anytime. Nevertheless, there is a vast and growing market among non-professional users who demand high-quality yet affordable equipment. The purpose of this article is to provide both amateurs and professionals with the tools needed to create their own " two-way radio" not linked to any specific standard product present in the market. This allows greater integration in radio systems currently in development, and in general, a considerable saving on production costs.

Introduction

The article shows the design flow for two RF power amplifier modules working in the UHF band with the output power being the only main difference.

The name and target specifications of each project are the following:

SYMBOL	PARAMETER	MIN	TYP	MAX	UNIT
VDD	Supply Voltage		12.5		V
F	Frequency Range	400	-	470	MHz
Pin	Input Power		5		dBm
η_T	Total Efficiency	50			%
2fo	2nd Harmonic			-45	dBc
ρ_{in}	Input Return Loss			-3	dB

Pout	Project's Name
45 W	STEVAL-TDR031V1
70 W	STEVAL-TDR034V1

Table 1 • Target specifications.

Both designs use Laterally Diffused MOS (LDMOS) devices respectively housed in three different packages: SOT-89, PowerFLAT, PSO-10.

In order to meet the above targets, a line-up topology with three power stages 2 has been used.

The basic idea was to consider the two projects as being a single project (Figure 1), where the cascade 1st and 2nd stage should have enough power to drive the final stage of the two devices in parallel.

Depending on the output power (see Fig: 1 project's name) the final stage has been designed with two devices in parallel, respectively: 2xPD85035S-E or 2xPD85050S.

Based on the two devices' datasheets (PD85035S-E and PD85050) we calculated that a 36 dBm power level is required to achieve a 45W or 70W output power.

Similarly, for the drive stage (cascade 1st and 2nd stage), using the datasheets for PD84002 and PD85006L-E, we obtained the following power level chain.

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LZY-22+	0.1-200	43	16	32	1495	1470
ZHL-5W-1	5-500	44	8	11	995	970
• ZHL-100W-GAN+	20-500	42	79	100	2395	2320
• ZHL-50W-52	50-500	50	40	63	1395	1320
• ZHL-100W-52	50-500	50	63	79	1995	1920
LZY-1+	20-512	43	37	50	1995	1895
• ZHL-20W-13+	20-1000	50	13	20	1395	1320
• ZHL-20W-13SW+	20-1000	50	13	20	1445	1370
LZY-2+	500-1000	46	32	38	1995	1895
NEW ZHL-100W-13+	800-1000	50	79	100	2195	2095
ZHL-5W-2G+	800-2000	45	5	6	995	945
ZHL-10W-2G	800-2000	43	10	13	1295	1220
ZHL-30W-252+	700-2500	50	25	40	2995	2920
ZHL-30W-262+	2300-2550	50	20	32	1995	1920
ZHL-16W-43+	1800-4000	45	13	16	1595	1545
ZVE-3W-83+	2000-8000	36	2	3	1295	1220
ZVE-3W-183+	5900-18000	35	2	3	1295	1220

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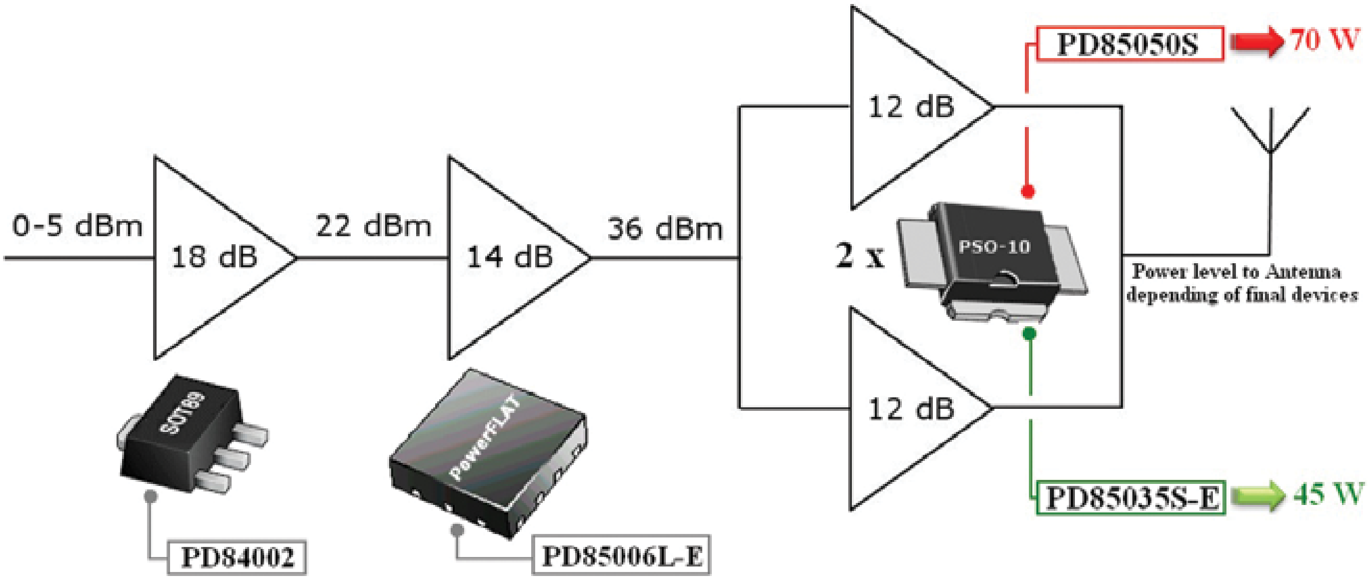


Figure 1 • Power level chain.

Each stage was simulated using the ADS software from Agilent. The intent was to get the right output impedance level to guarantee the desired power level all along the line-up.

Using library models available for each product employed (www.st.com/rf), several simulations were performed cascading the 1st and the 2nd stage in order to get a power level greater than 36dBm.

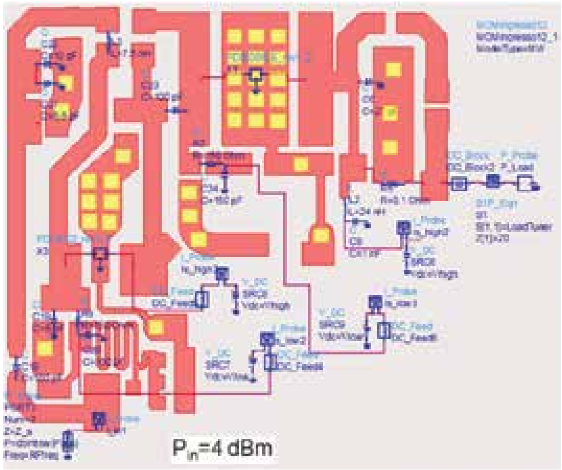


Figure 2 • 1st and 2nd stage.

Following the simulations at central frequency (435 MHz), the optimum load impedance for the final stage (2nd stage) is:

$$\begin{cases} Z_{source} = 50\ \Omega \\ Z_{lopt} = (3.818 - j * 1.189)\ \Omega \\ P_{delmax} = 38\ dBm\ (\approx 6.3\ W) \end{cases}$$

Using this impedance value at 435MHz (Zlopt) performance was optimized along the required frequency band. In Figure 4 we can observe that the level of the output power is higher than required. Later the level might drop due the effects of mismatching losses and/or losses in the stabilization network between the 2nd and 3rd stage.

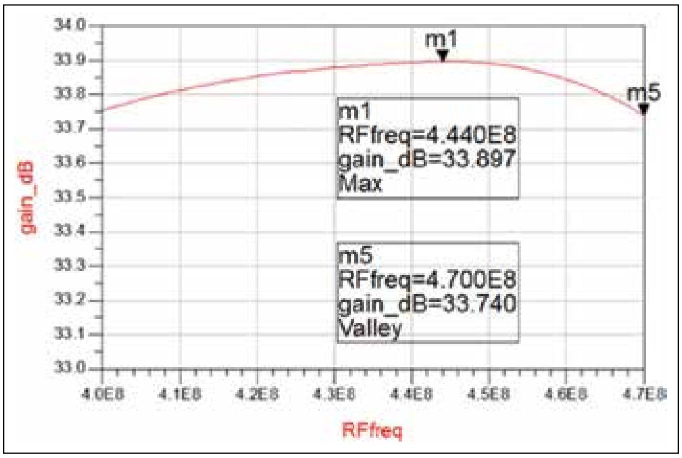


Figure 3 • Gain vs Frequency.

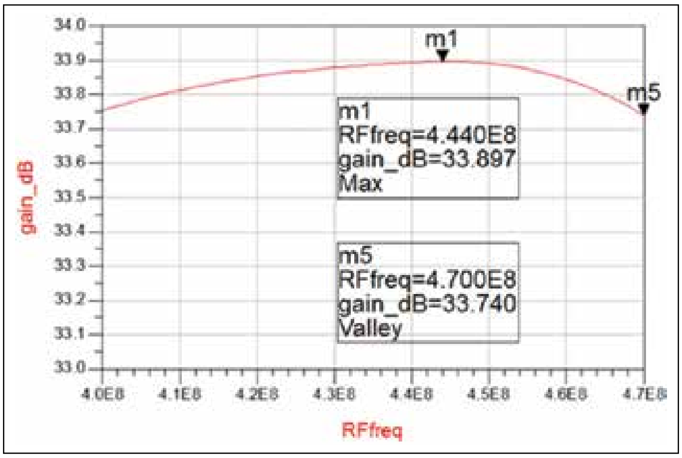


Figure 4 • Power vs Frequency.

Designing the Final Stage: Preliminary Trials Using Chip On Board

The two target projects (Table 1) were done using packaged LDMOS. Nevertheless it has been valuable to explore all the potential capabilities offered by the technology directly using the dice (no package). In this section we will analyze a hybrid combination between chip-on-board (COB) as final stage and two packaged products for 1st and 2nd stages.

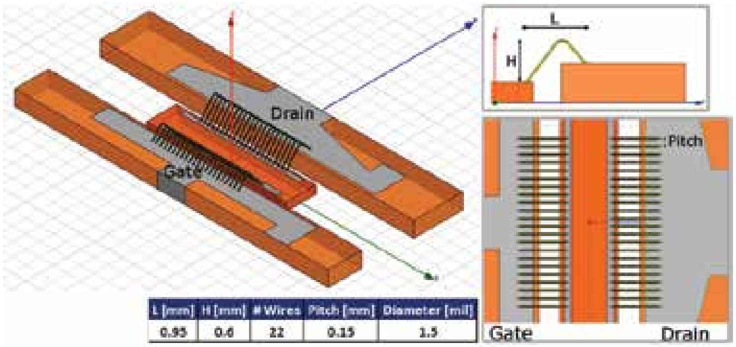
Thanks to the COB solution analysis we have a better understanding of all the thermal aspects which are essential for this power stage.

To realize the module we have used the FR-4 substrate as dielectric (20 mils) bonded with a Copper metal plate (1.6mm) which ensures a very stable thermal condition for the power amplifier.

Figure 5 • Substrate.

On the top of the substrate FR-4 (dielectric) there are two openings where the two dice have been directly bonded on copper metal gold finished layer.

The wire bond diagram and dimensions (Figure 6) are similar to those used for the PD85035-E.



L [mm]	H [mm]	# Wires	Pitch [mm]	Diameter [mil]
0.95	0.6	22	0.15	1.5

Figure 6 • Wire bond diagram.

The structure, dice and wire-bonding (Figure 6) has been simulated with HFSS to extract the equivalent lumped inductors on the gate and drain sides (Figure 7 and Figure 8).

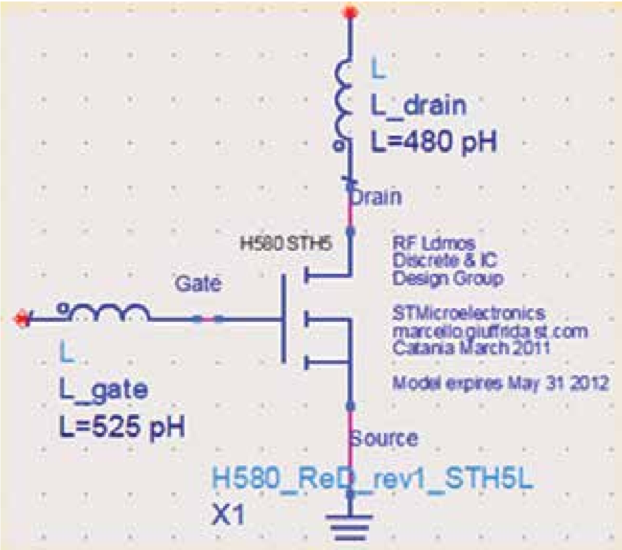


Figure 7 • Equivalent lumped inductors.

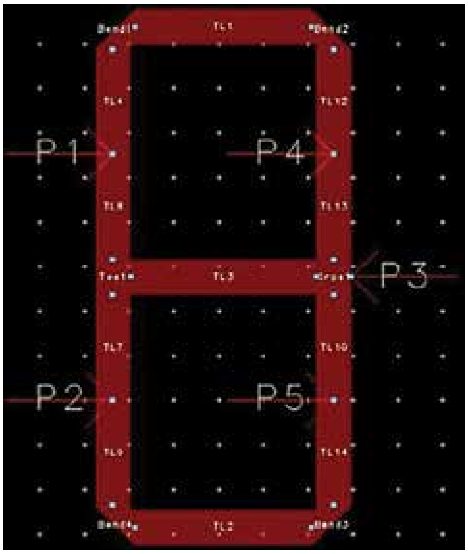


Figure 8 • CIT.

Another important aspect concerned the power combination of the two dice in parallel.

We had to look for a structure to accomplish a dual intent: increase the impedance level (impedance matching) and, at the same time, reduce the inevitable losses (power combination)

The idea was to combine the dice with the microstrip topology depicted in Figure 9. We will refer to this structure as Combiner and Impedance Transformer (CIT). Through simulation (Momentum) the physical dimensions have been optimized in order to get a symmetric structure and a good impedance transformation.

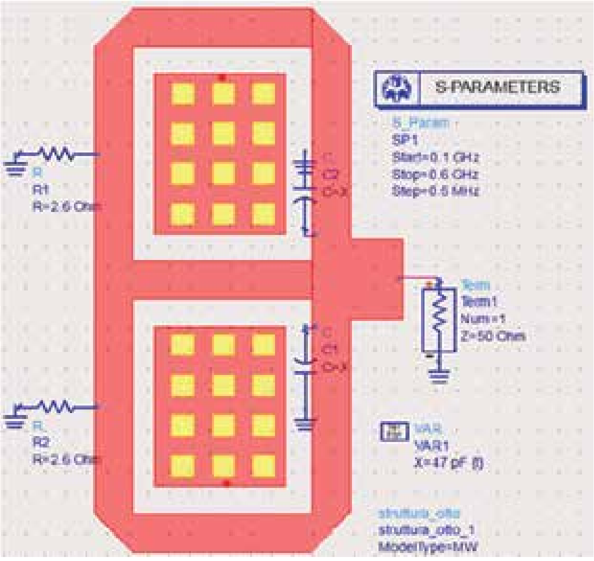


Figure 9 • CIT transformer.

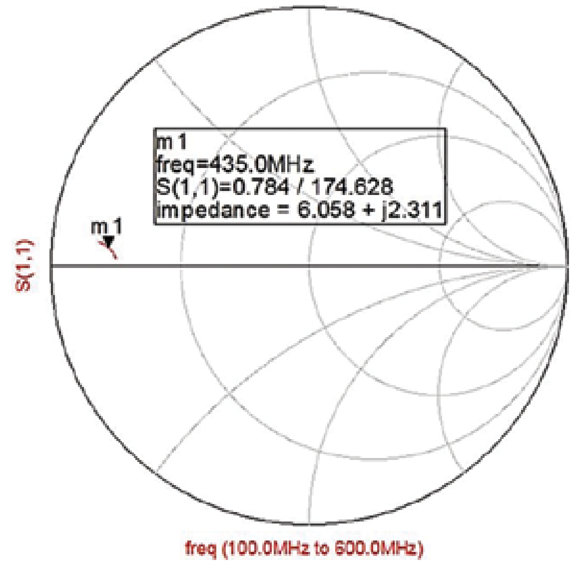


Figure 10 • Impedance Transformation of CIT.

To prove the benefits of the CIT as impedance transformer, it was employed in a simulation using as starting point the impedance at drain level of two LDMOS devices in parallel.

Using the Cripps' method 1 (load-line analysis) the impedance transformation of the structure was tested. For a single device, the power capability is:

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$$P = \frac{V_{dc}^2}{2R_L} \rightarrow R_L = \frac{V_{dc}^2}{2P} = \frac{(13.6)^2}{2 \cdot 35} = 2.6\,\Omega$$

For two LDMOS devices in parallel the value must be divided by two.

The Smith chart confirms the good impedance transformation obtained (Figure 10).

At this point the CIT has been considered part of the active devices and simulated at 435 MHz with the load-pull (Figure 11).

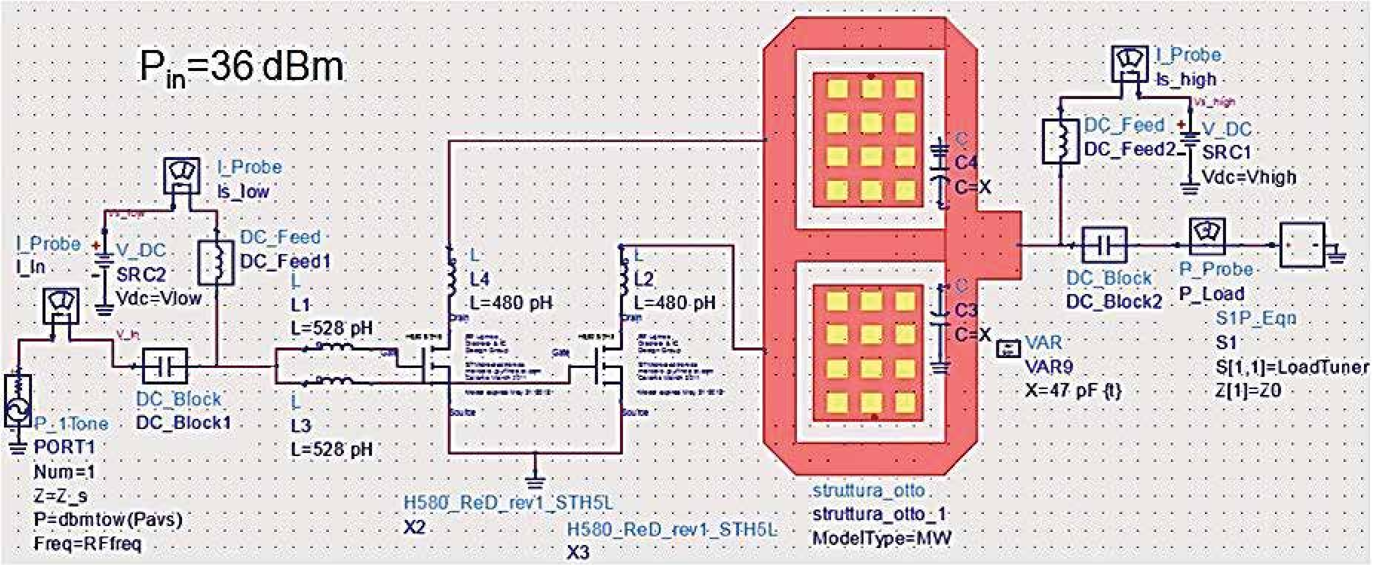


Figure 11 • Final stage simulation.

In the equation below ZLopt is the impedance to obtain Pdelmax.

$$\begin{cases} Z_{source} = 50\,\Omega \\ Z_{lopt} = (3.818 - j * 1.189)\,\Omega \\ P_{delmax} = 38\,dBm\ (\approx 6.3\,W) \end{cases}$$

Using the ZLopt just found, we did an optimization work to equalize the gain in band (Figure 12) and a power sweep at central frequency (Figure 13) in order to achieve more than 60 W at P3dB.

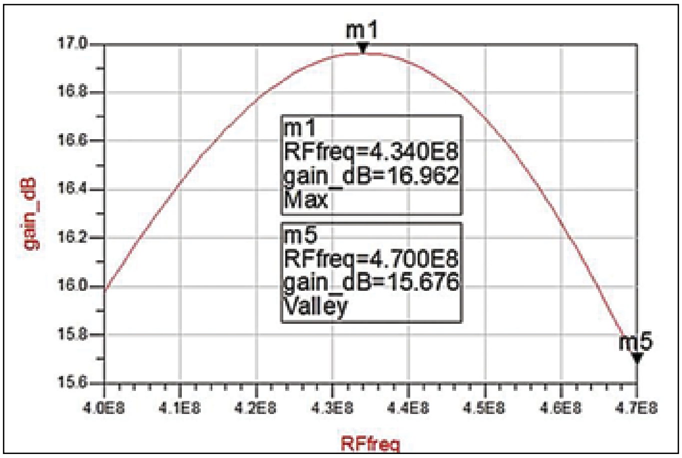


Figure 12 • Gain vs Frequency.

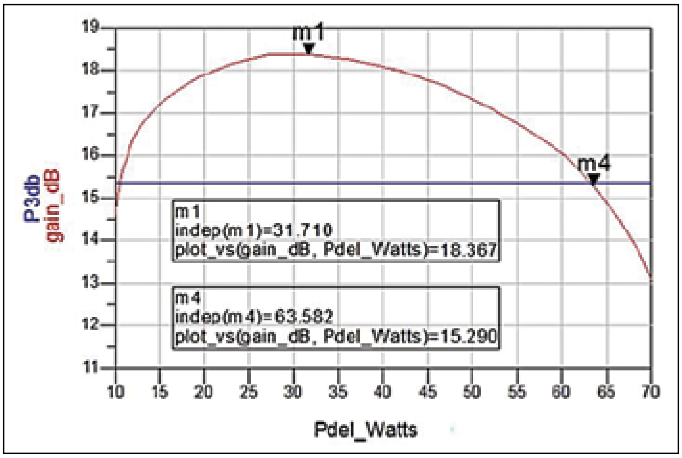


Figure 13 • Power vs Frequency.

The ZLot was then synthesized using lumped elements and microstrip lines.

Similarly the 1st stage has been matched at central frequency in order to get a good input return loss (IRL) along the band.

Finally all the stages were assembled and the final circuit with COB is hereafter displayed:

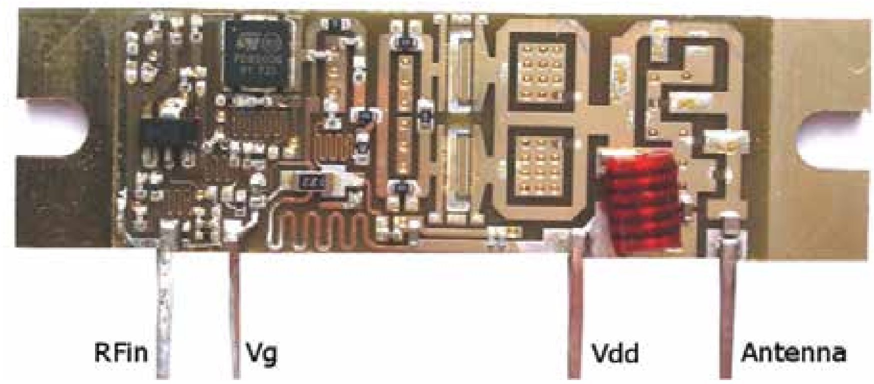


Figure 14 • COB module.

The prototype (Figure14) has been then measured in order to verify all the RF performances (see test-bench Figure 20).

On the RF bench the prototype has been optimized and in some part re-tuned. The measurements are hereafter presented:

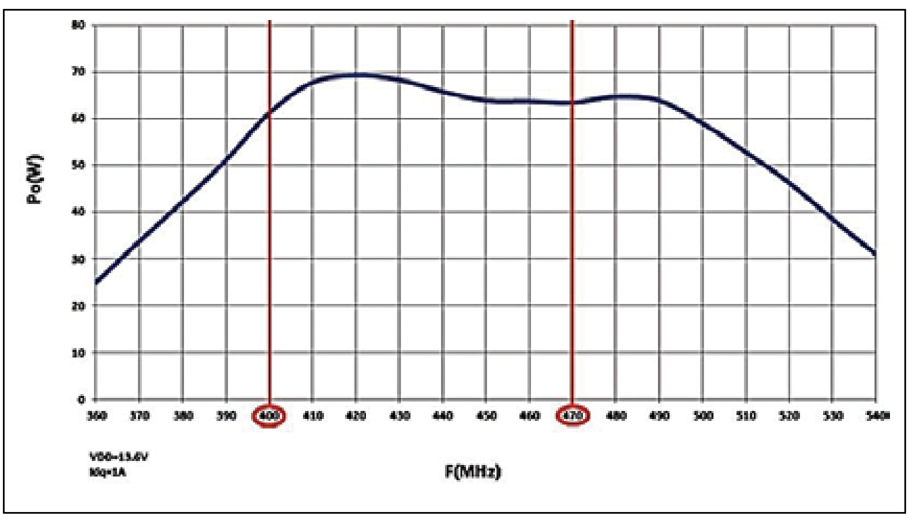


Figure 15 • Po vs frequency of COB.

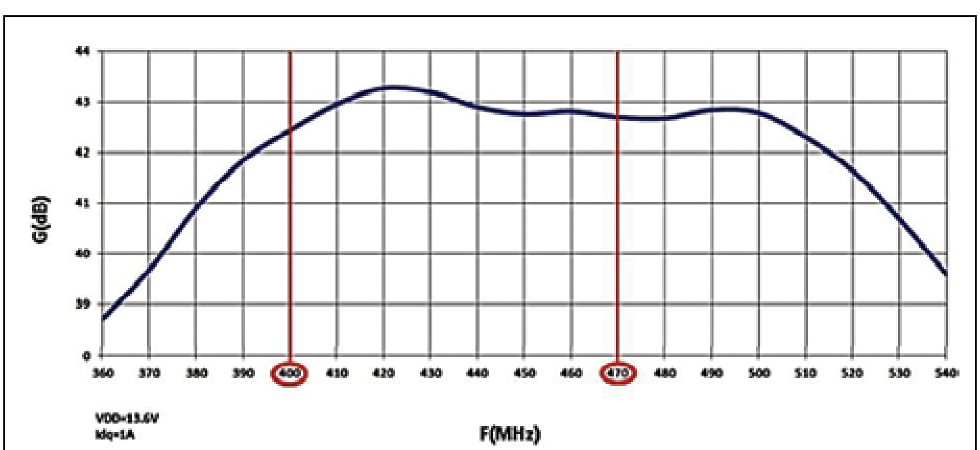


Figure 16 • Gain vs Frequency of COB.

In conclusion, the preliminary design done with COB has delivered better than expected results. This was possible thanks to the synergy between simulations and the RF bench re-works.

At this point, in order to verify if both parallel dice were working in a balanced way (i.e. if they carried half of the total power present in the output) a thermo analysis was performed.

A thermal map of the dice's surfaces could unveil hot spots and potential failures. Moreover it's a good way to check the solder joint between PCB and the area beneath the dice.

The thermal measurements (Figure 17) showed about 10 °C of difference between the two average temperatures, proving that both devices are working properly.

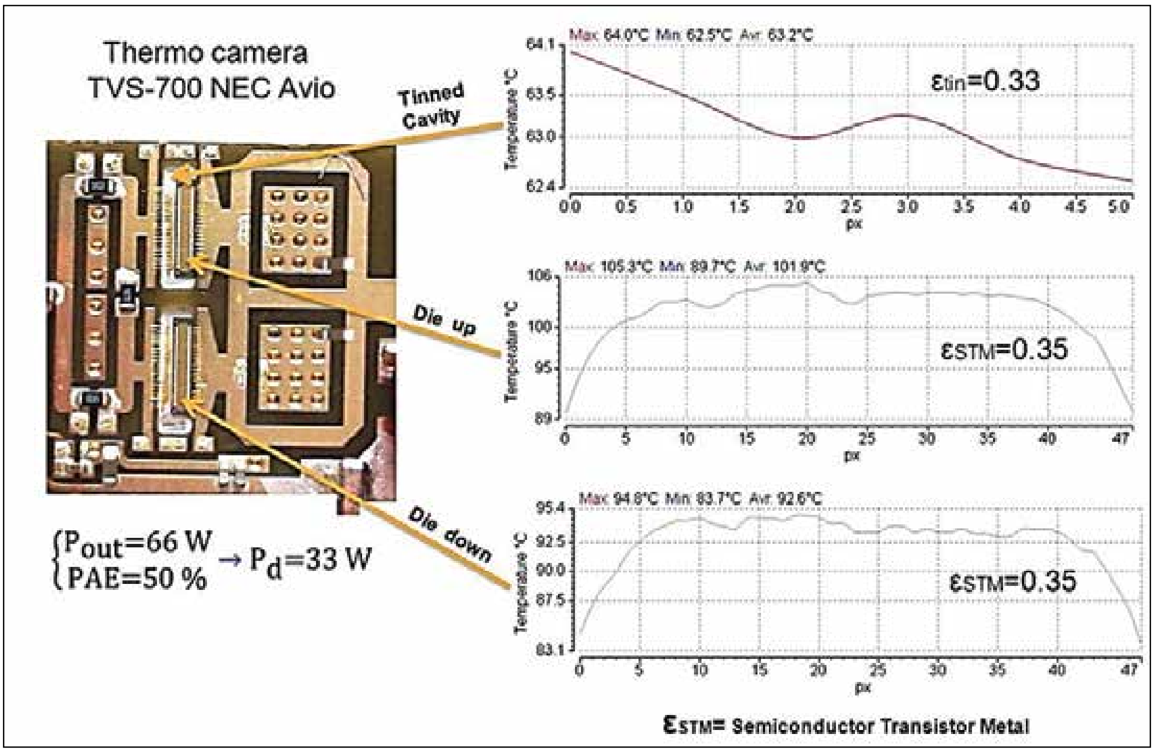


Figure 17 • Thermal map.

Design of the Discrete Modules

After the preliminary design made in COB we are now able to set up the cascade 1st and 2nd stage. Moreover, we have a better understanding of the power capabilities of the two dice. Now it's time to move on making the prototypes stated in Table 1.

For both projects we have used the same topology of PCB shown in Figure 18. Moreover, to test the amplifiers, we have developed a special test board and heat-sink (Figure 19). Their BOM is presented in Table 4.

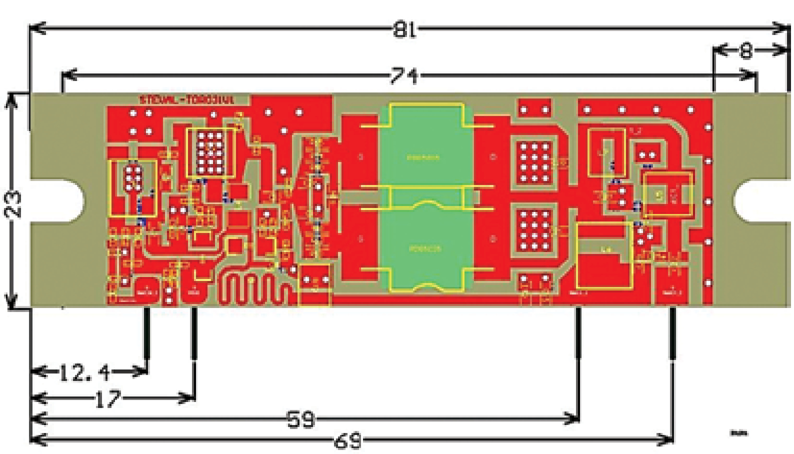


Figure 18 • PCB for modules.

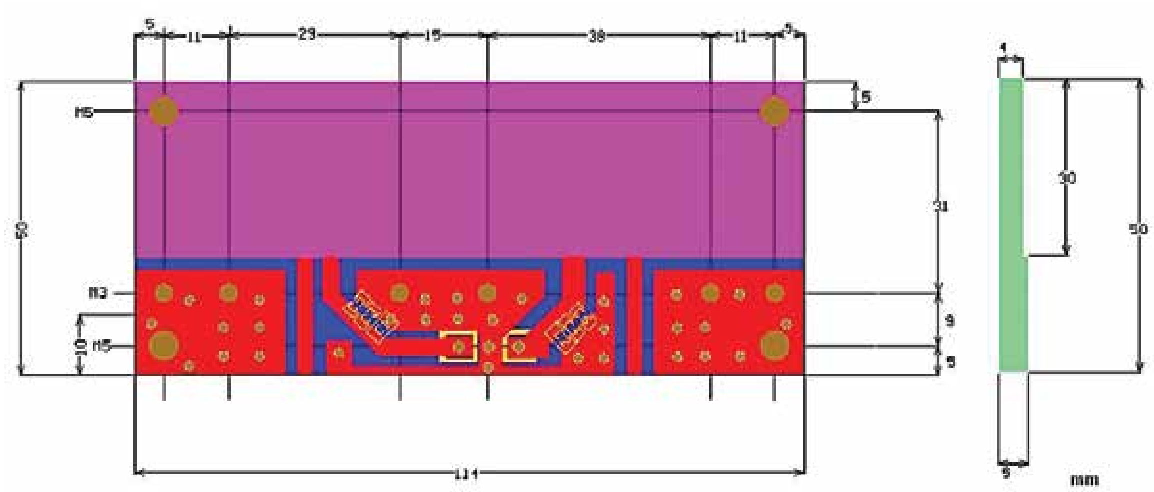
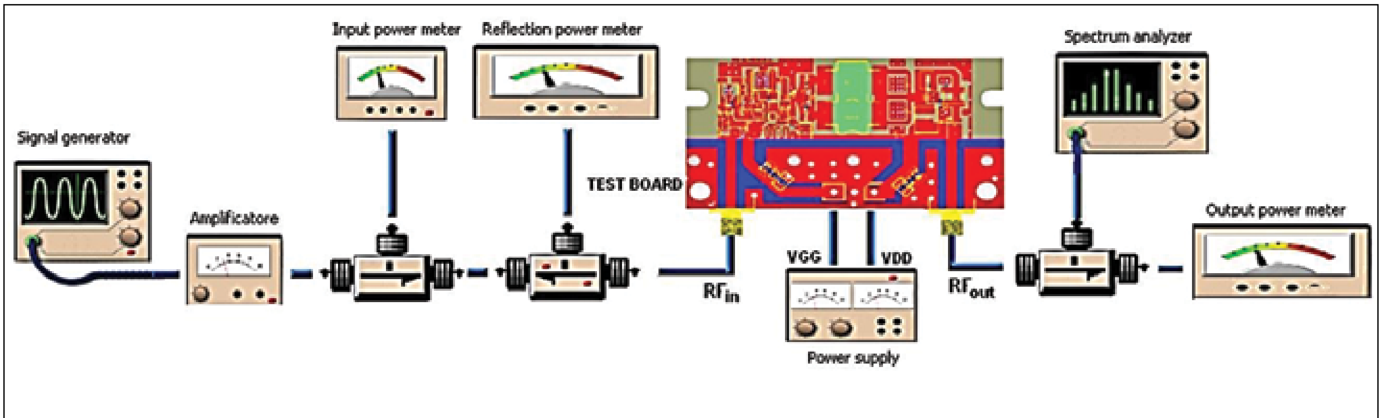


Figure 19 • Test board.

All the measures were done with test bench as shown in Figure 20.



TEST BOARD : All the measures have been done including 50Ω lines input and output with IL = 0.06 dB into 380MHz - 500MHz

Figure 20 • Test bench.

STEVAL-TDR031V1

This design moved along the same lines previously adopted for the COB version.

No big changes concerning the 1st and the 2nd stage. All the activity was focused on searching for the optimum load impedance at central frequency.

The load was then used to optimize the RF behaviors along the frequency band.

The result of this work is presented in the following images.

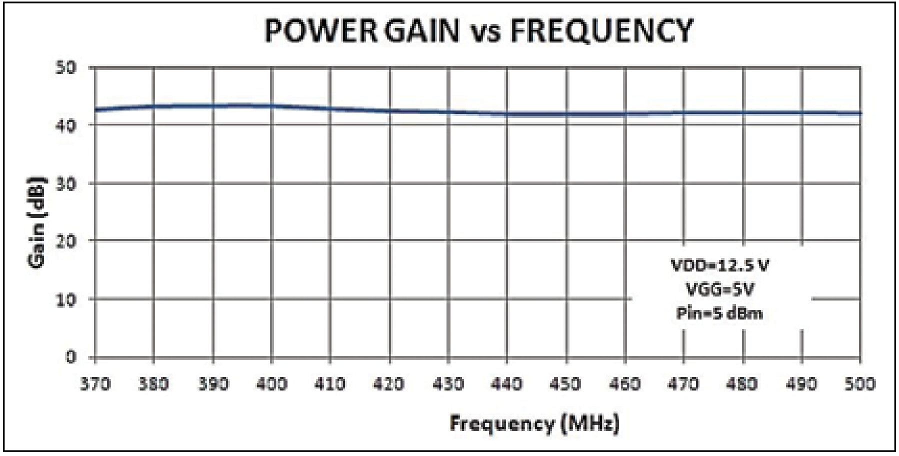


Figure 21 • Power Gain vs Frequency.

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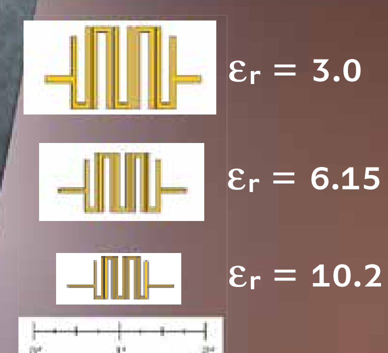

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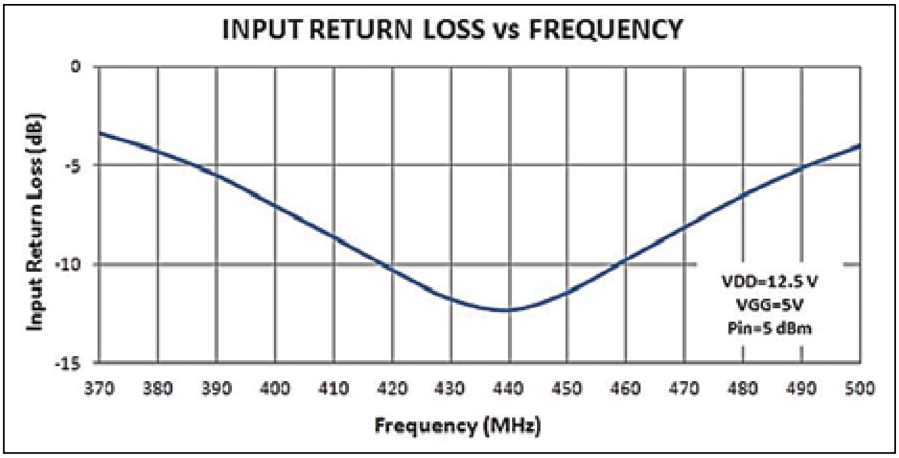

Figure 22 • IRL vs Frequency.

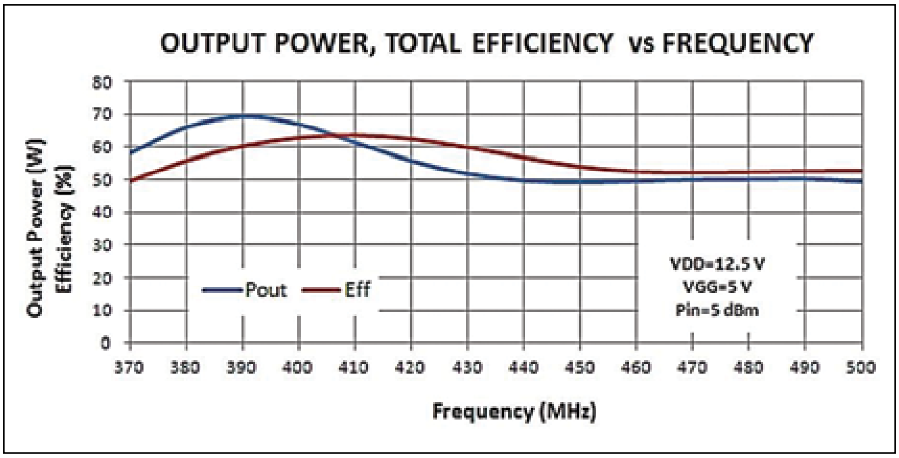

Figure 23 • Po, eff. Vs Frequency.

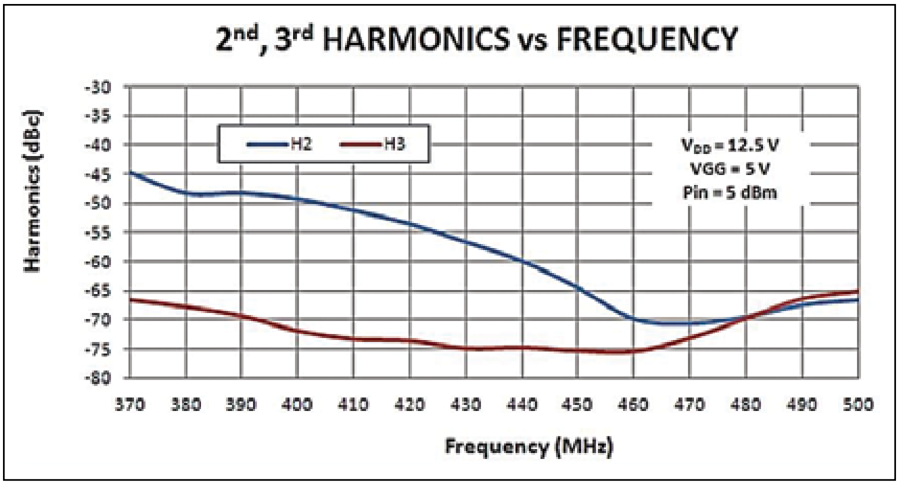

Figure 24 • Harmonics.

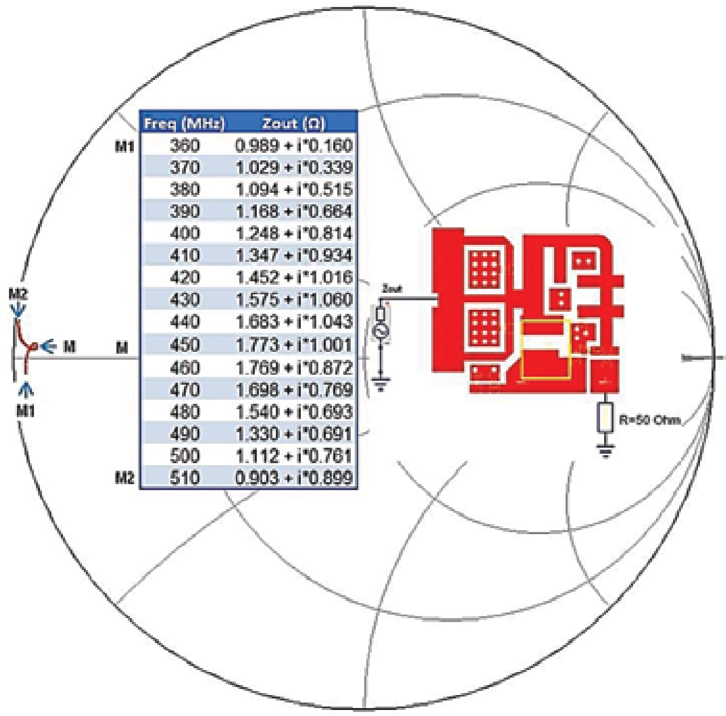

Figure 25 • Output impedance of STEVAL-TDR031V1

In Figure 25 we see the equivalent drains' impedances for the two PD85035S-E measured at the midpoint between the two drains. The small circle around the mark M (Figure 25) proves the achievement of broadband impedance.

The STEVAL-TDR031V1 is visible in Figure 26 while for the schematic and BOM refer to Figure 27 and Table 2.

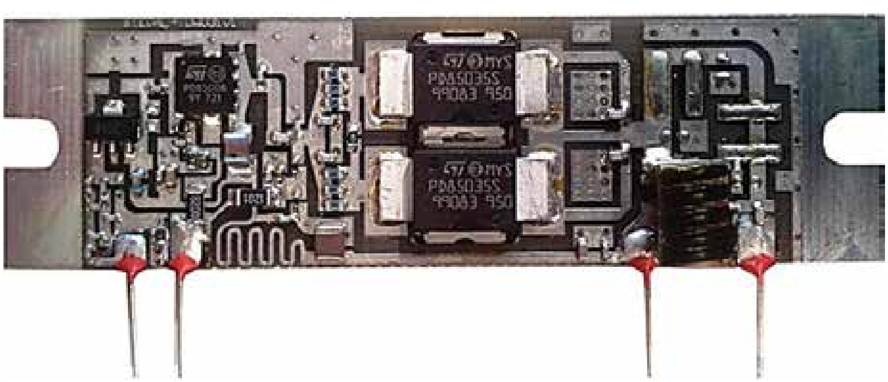

Figure 26 • STEVAL-TDR031V1.

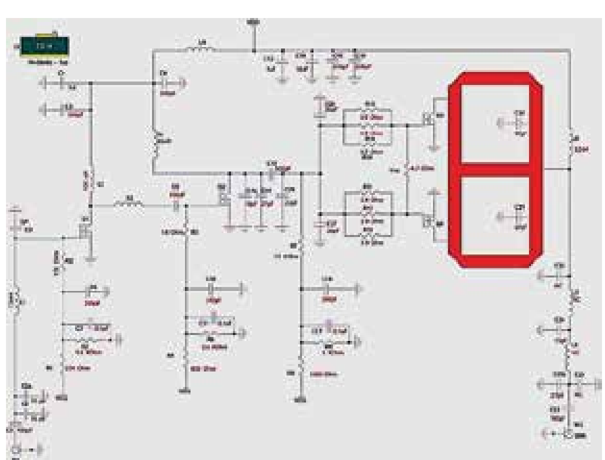

Figure 27 • Schematic of STEVAL-TDR031V1.

Designator	Manufacturer	Quantity	Value	Manufacturer Part Number	Footprint
C1, C9	Murata	2	100pF	GRM1555C1H101JA01	402
C2	Murata	1	16 pF	GJM1555C1H160GB01#	402
C2a	Murata	1	10 pF	GJM1555C1H100JZ01#	402
C3	Murata	1	5pF	GRM1555C1H5R0GA01#	402
C4	Murata	1	1uF	GRM188R61E105KA12#	603
C5, C6, C8, C10, C15, C16, C19	Murata	7	240pF	GRM1555C1H241JA01#	402
C7, C11, C17	Murata	3	0.1uF	GRM155C81E104KA12#	402
C12	Murata	1	1uF	GRM188B31E105KA75#	603
C13	Murata	2	100pF	GQM1885C1H101GB01#	603
C22	Murata	2	100pF	GQM2195C1H101JB01#	805
C14	Murata	1	27pF	GRM1555C1H270FA01#	402
C14a	Murata	1	18pF	GRM1555C1H180JZ01#	402
C18	Murata	1	10uF	GRM32ER71H106KA12#	1210
C20, C21	Murata	2	47pF	GQM1875C2E470GB12#	603
C24	Murata	1	15pF	GQM1875C2E150GB12#	603
C25a	Murata	1	2.7pF	GCM1885C2A2R7CB01#	603
C26, C27	Murata	2	36pF	GRM1555C1H360GA01#	603
C29	Murata	1	22pF	GRM1555C1H220FA01#	402
L1	Coilcraft	1	7.5nH	0402CS-7N5XJLW	402
L2	Coilcraft	1	100 nH	0603HP-R10X_LU	603
L3, L4	NA	2	NA	NA	402
L5	Coilcraft	1	10.2nH	0807SQ-10N_LC	Mini A
L6	Coilcraft	1	52nH	NA5778-AE	
L7	Coilcraft	1	3.7nH	GA3092-ALC	Mini A
La	Coilcraft	1	68nH	1008HQ-68NX_LC	402
Q1	STM	1	SOT89	PD84002	SOT89
Q2	STM	1	PowerFlat	PD85006L	PowerFlat
Q3, Q4	STM	2	PSO-10	PD85035S	PSO-10
R1	Vishay	1	220 Ohm	CRCW0402220RFKED	402
R2	Vishay	1	150 Ohm	CRCW0402150RFKED	402
R3, R6	Vishay	2	5.6 KOhm	CRCW04025K60FKED	402
R4	Vishay	1	820 Ohm	CRCW1206820RFKEA	1206
R5	Vishay	1	18 Ohm	CRCW040218R0FKED	402
R7	Vishay	1	15 KOhm	CRCW040215K0FKED	402
R8	Vishay	1	1200 Ohm	CRCW12061K20FKEA	1206
R9	Vishay	1	4,99 Kohm	CRCW04024K99FKED	402
R10, R11, R12, R13, R14, R15	KOA Speer	6	3.9 Ohm	RK73H1JTTD3R90F	603
R16	Vishay	1	4.7 Ohm	CRCW06034R70FKEA	603
Substrate			FR-4	20 mils 1oz copper	

Table 2 • BOM of STEVAL-TDR031V1.

STEVAL-TDR034V1

The final stage of this amplifier employs two PD85050S. Based on the latest low voltage LDMOS technology, these devices satisfy the increasing demand for power in the context of UHF mobile radios. In applications for digital communications, sometimes the linearity must be obtained with some dB of back-off from the power saturation. Using the PD85050S device model, some load-pull simulations were performed in order to get the optimum load impedance that allowed the max output power. The value has been then divided by 2 (parallel of two PD85050S) and considered as the starting point during the synthesis of the output network. The RF results and the impedance level measured at the drain level are shown in the below figures.

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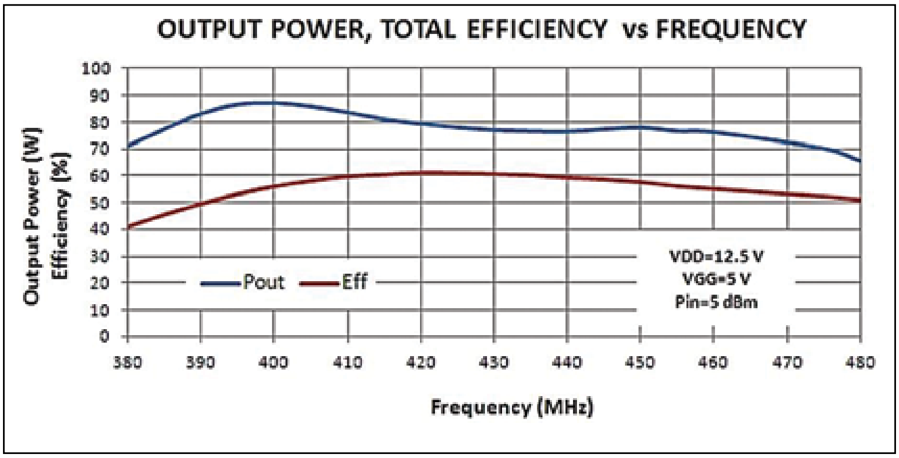

Figure 28 • Po, Eff. Vs Frequency.

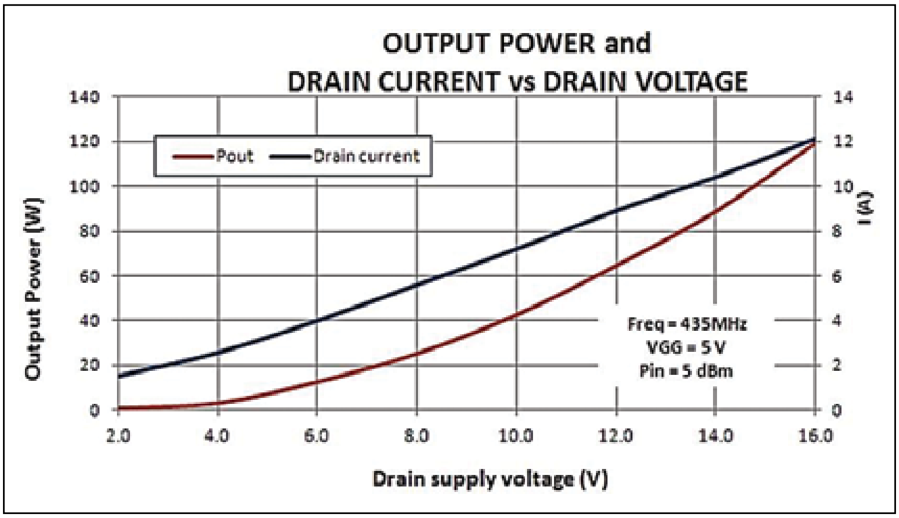

Figure 29 • Po, Id vs Voltage supply.

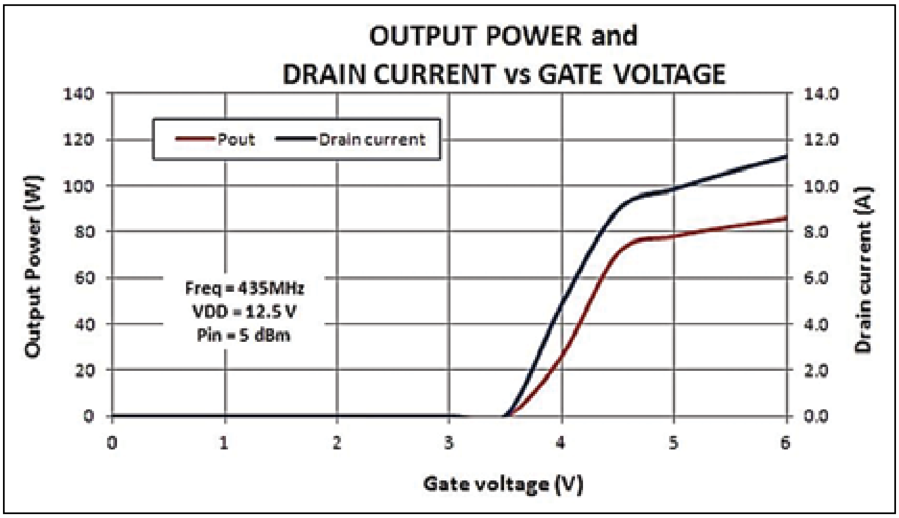

Figure 30 • Po, Id vs gate supply.

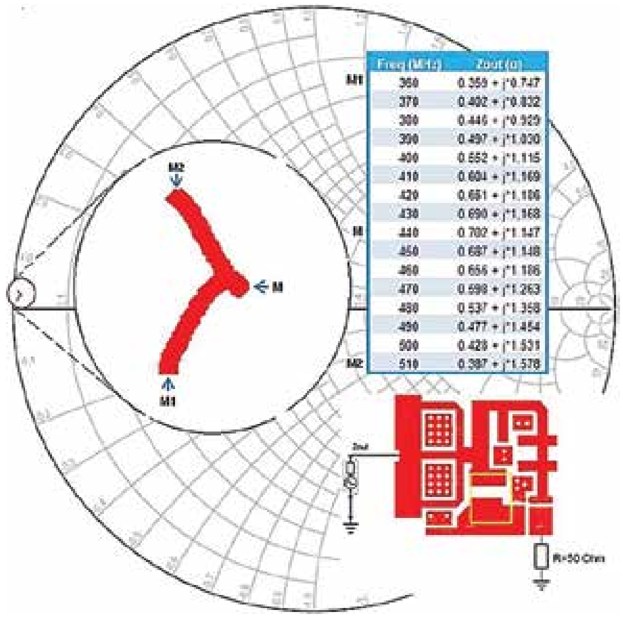

Figure 31 • Output impedance of STEVAL-TDR034V1.

The STEVAL-TDR034V1 is visible in Figure 32 while for the schematic and BOM refer to Figure 33 and in Table 3.

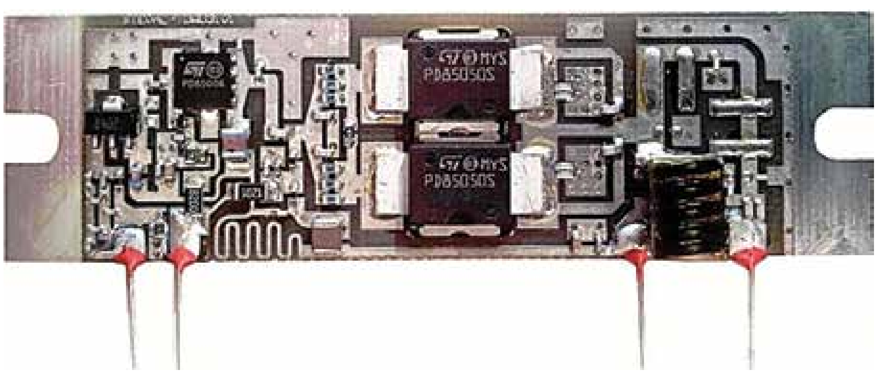

Figure 32 • STEVAL-TDR034V1.

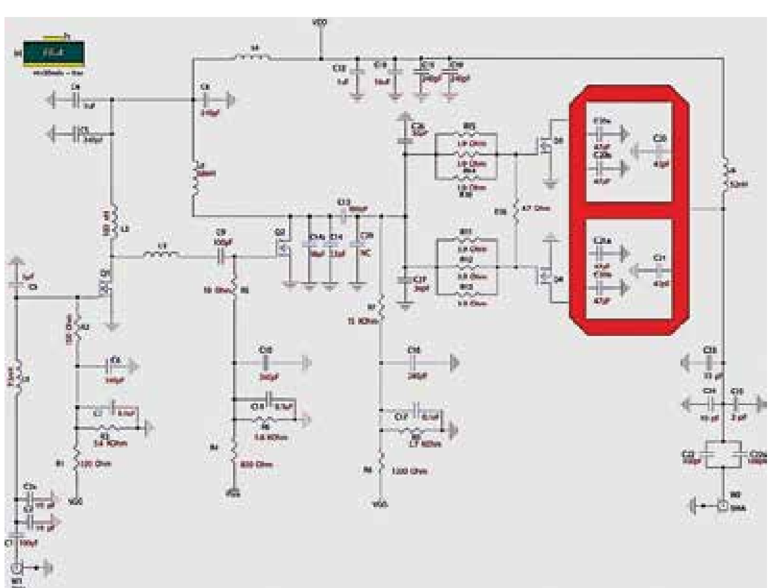

Figure 33 • Schematic of STEVAL-TDR034V1.

Designator	Manufacturer	Quantity	Value	Manufacturer Part Number	Footprint
C1, C9	Murata	2	100pF	GRM1555C1H101JA01	402
C2	Murata	1	16 pF	GJM1555C1H160GB01#	402
C2a	Murata	1	10 pF	GJM1555C1H100JZ01#	402
C3	Murata	1	5pF	GRM1555C1H5R0GA01#	402
C4	Murata	1	1uF	GRM188R61E105KA12#	603
C5, C6, C8, C10, C15, C16, C19	Murata	7	240pF	GRM1555C1H241JA01#	402
C7, C11, C17	Murata	3	0.1uF	GRM155C81E104KA12#	402
C12	Murata	1	1uF	GRM188B31E105KA75#	603
C13	Murata	1	100pF	GQM1885C1H101GB01#	603
C22, C22a	Murata	2	100pF	GQM2195C1H101JB01#	805
C14	Murata	1	27pF	GRM1555C1H270FA01#	402
C14a	Murata	1	18pF	GRM1555C1H180JZ01#	402
C18	Murata	1	10uF	GRM32ER71H106KA12#	1210
C20, C20a, C20b, C21,C21a, C21b	Murata	6	47pF	GQM1875C2E470GB12#	603
C23, C24	Murata	2	10pF	GQM1875C2E100JB12#	603
C25	Murata	1	2pF	GCM1885C2A2R0CB01#	603
C26, C27	Murata	2	36pF	GRM1555C1H360GA01#	603
C29	Murata	1	NC		
L1	Coilcraft	1	7.5nH	0402CS-7N5XJLW	402
L2	Coilcraft	1	100 nH	0603HP-R10X_LU	603
L6	Coilcraft	1	52nH	NA5778-AE	
La	Coilcraft	1	68nH	1008HQ-68NX_LC	402
Q1	STM	1	SOT89	PD84002	SOT89
Q2	STM	1	PowerFlat	PD85006L	PowerFlat
Q3, Q4	STM	2	PSO-10	PD85050S	PSO-10
R1	Vishay	1	220 Ohm	CRCW0402220RFKED	402
R2	Vishay	1	150 Ohm	CRCW0402150RFKED	402
R3, R6	Vishay	2	5.6 KOhm	CRCW04025K60FKED	402
R4	Vishay	1	820 Ohm	CRCW1206820RFKEA	1206
R5	Vishay	1	18 Ohm	CRCW040218R0FKED	402
R7	Vishay	1	15 KOhm	CRCW040215K0FKED	402
R8	Vishay	1	1200 Ohm	CRCW12061K20FKEA	1206
R9	Vishay	1	2,7 Kohm	CRCW04022K7CEED	402
R10, R11, R12, R13, R14, R15	KOA Speer	6	3.9 Ohm	RK73H1JTTD3R90F	603
R16	Vishay	1	4.7 Ohm	CRCW06034R70FKEA	603
Substrate			FR-4	20 mils 1oz copper	

Table 3 • BOM of STEVAL-TDR034V1.

Designator	Manufacturer	Quantity	Value	Manufacturer Part Number	Type
C1, C2		2	100µF		Tantalum
C3, C4	Murata	2	10µF	GRM42-6X7R225K25D52K	402
C5, C6	Murata	2	2.2uF	GRM42-6X5R106K25D539	603
Substrate			FR-4	60 mils 1oz copper	

Table 4 • BOM Test Board.

Conclusion

This article has described a design procedure and some practical solutions to build a multistage power amplifier. The intent was to show a low-cost and reliable way to design and produce customizable amplifiers.

The STEVAL-TDR031V1 and STEVAL-TDR034V1 were designed with plastic packaged LDMOS devices, resulting in amplifiers with a high moisture sensitivity level typically not achievable with similar modules using chip-on-board technology.

STMicroelectronics can provide all the LDMOS devices mentioned in this article, and if necessary, can also provide the technical support to revise the layout (gerbers) for system integration and/or the components for cost reduction (BOM) .

Standard design support includes: device models, PCB gerbers, BOM and demo board, for further information please visit www.st.com/rf.

References

1. Cripps, S. C., RF Power Amplifiers for Wireless Communications, Norwood, MA: Artech House, 1999.
2. Andrei Grebennikov, RF and Microwave Power Amplifier Design, McGraw Hill,2005.

About the Author:

Alfio Scuto was born in Acireale, Italy, in 1967. He received a Master's degree in Electronics Engineering with Microelectronics from the University of Catania, Italy, in 1998. In 1999, he joined STMicroelectronics and, for two years, worked in the RF power design center based in Montgomeryville, PA. Since then he has been involved in the device characterization of high-power high-frequency transistors, such as DMOS and LDMOS. He is currently working in STMicroelectronics in Catania (Italy) as a Senior RF Engineer supporting the product marketing group. For many years he has designed and developed RF power amplifiers to evaluate and verify product performance in reference to customer requirements.


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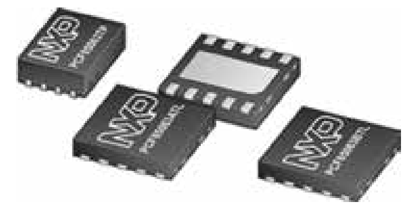

to 0.9 V. With a size of 2 x 3 x 0.75 mm and a pin pitch of 0.5 mm, the PCF85063TP tracks time and date from seconds to years, and is one of the smallest RTCs in the world. In addition to electronic frequency tuning, the RTCs can also be programmed to generate an interrupt every 30 or 60 seconds, communicating via a Fast-mode I2C-bus operating up to 400 kHz.

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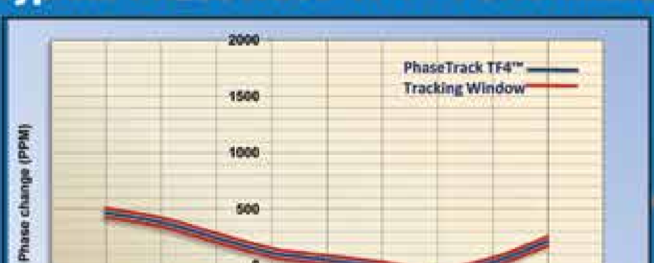

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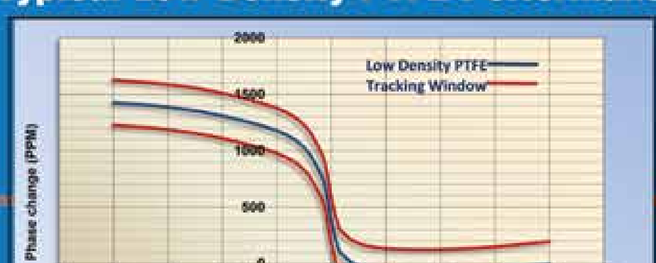

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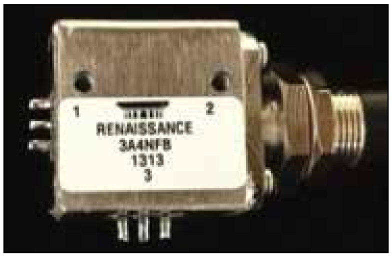
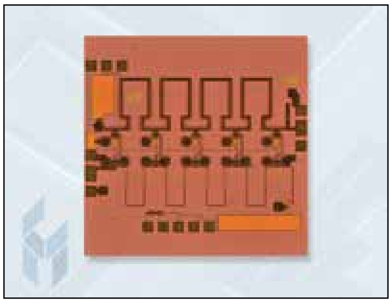
Times Microwave Systems
timesmicrowave.com



Circulator

Renaissance has developed a new S band drop-in circulator that is designed for amplifiers used in space applications. The isolator can operate between 2.2 – 2.4 GHz with 0.5 dB insertion loss and 20 dB isolation and return loss. The design can handle 75 W over -40 to +95 C. Port 2 has an extended TNC female connector and the other two ports are coplanar drop-in tab style.

Renaissance Electronics Corp.
rec-usa.com



Amplifiers

Custom MMIC added four new amplifiers in die form: the CMD164, 165, and 173 distributed amplifiers, and the CMD166 driver amplifier. The CMD164 (DC-30 GHz) and the CMD165 (2-30 GHz) each deliver greater than 12 dB of gain with

ClearPlex™ Ceramic Filter

ClearPlex™ is a ceramic waveguide filter with high performance attributes. Its power rating peak exceeds 500 Watts. The high Q factor is 30% greater than a ceramic coaxial filter, allowing for better insertion loss and rejection rate. It is ideal for replacing air-cavity filters where space is limited. Applications may include remote radio heads and small cells.

Tight Stability Quartz Crystal

The ATSSMTS crystal series offers excellent long-term stability (±10 ppm to ±50 ppm) and reliability in a proven resistance-weld metal package. The excellent shock performance makes it suitable for microprocessor, telecommunication, industrial, consumer electronics and networking applications.

Disc Ceramic WEECON® Capacitors

With a capacitance range of 1 pF to 0.082 mF, these disc ceramic capacitors offer a variety of TC materials and tolerances. The capacitors operates efficiently at -55°C to 125°C, which makes the WEECON® suitable for high reliability applications, as well as, the ultra stable requirements of tuned circuits to the general purpose needs for coupling and by-passing.

Forged & Extruded Heat Sinks

Critical components running at maximum speeds will generate and create thermal management challenges that can be addressed by using CTS heat sinks. They offer excellent thermal resistance (as low as 1.2°C/Watt at 200 LFPM convection flow conditions), while various attachment methods provide optimal convenience. These heat sinks are applicable for BGA, PGA, PLCC, QFP and other IC packages.

Ultra-Low Power Shock Resistant

The Model 148 is an ultra-low power shock resistant miniature OCXO. It has very low power consumption of <0.23 Watts. Its strong mechanical construction enables durability of up to 500G of mechanical shock. The part is highly stable (up to 10 ppb) while maintaining exceptional performance (-166dBc/Hz floor at 10MHz).

an output 1 dB compression point of +15 dBm and noise figure of 2.4 dB at 10 GHz. The CMD173 operates from DC-20 GHz and delivers greater than 15 dB of gain with an output 1 dB compression point of +18 dBm and noise figure of 2 dB at 10 GHz. The CMD166 operates from 20-40 GHz with 9 dB of gain and an output 1 dB compression point of +17 dBm.

Custom MMIC
custommmic.com

Web Portal

Agilent Technologies announced enhancements to its myAgilent Web portal, providing a personalized online experience and quick, easy and timely access to the most relevant and useful electronic test and measurement product, service and support information. Enhancements include: Single sign-on with one user name and password for easy access to multiple Agilent Web services; Easier management of Agilent Web capabilities and preferences via a single, combined user profile; Increased visibility and a seamless view into both product and service information, and more.

Agilent Technologies
agilent.com

Signal Generator

The new R&S SMW200A high-end vector signal generator combines a baseband generator, RF generator and MIMO fading simulator in a

The Industry's Leading DTOs & DROs, Synthesizers and Switch Filter Banks

PLEASE VISIT PMI IN BOOTH NO. 1802 AT THE ANNUAL IEEE IMS2013 SYMPOSIUM JUNE 2nd - 7th IN SEATTLE, WA

- Amplifiers
- Attenuators - Variable
- DLVA & ERDLVA & SDLVA's
- DTO's
- Filters
- Form, Fit & Function Products
- Hybrids, Dividers & Couplers
- IFM's & Frequency Discriminators
- Integrated MIC/MMIC Modules
- I/Q Vector Modulators
- Limiters & Detectors
- Log Amplifiers
- Pulse & Bi-Phase Modulators
- Phase Shifters
- Rack & Chassis Mount Products
- Receiver Front Ends
- Single Sideband Modulators
- SMT & QFN Products
- Solid-State Switches
- Switch Matrices
- Switch Filter Banks
- Threshold Detectors
- USB Products

Digitally Tuned Oscillators (DTOs):

- Standard Model DTOs available from:
- 50 to 100MHz / 100MHz to 1GHz / 500MHz to 2GHz 500MHz to 2.5GHz / 2 to 6GHz / 6 to 18GHz / 2 to 18GHz
- Frequency Accuracy of +/-2.0 MHz Average
- Frequency Drift of <0.1 MHz/degree C
- Phase Noise of -60dBc/Hz @ 100kHz Offset
- RF Output +10dBm Average and with Low Harmonic Output
- Analog Modulation of DC to 9MHz

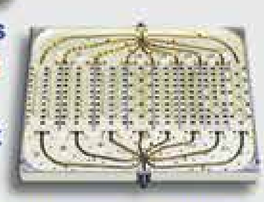
Dielectric Resonator Oscillators (DROs & PLDRO's):

- Frequency Ranges from 2 to 40GHz Available
- Phase Locked Models (Internal or External Reference)
- Low Phase Noise Performance of -120dBc/Hz @ 100kHz
- Designed for Operating in High Vibration Environments
- Multiple Output Options Available
- Integrated Independent Phase and Amplitude Control Available

Frequency Synthesizer, PMI Model PFS-618-CD-1

- Frequency Range: 6.0 to 18.0 GHz in 100kHz Steps
- Output Power: +10dBm minimum
- Settling Time: 1usec maximum
- Harmonics -30 dBc max. & Sub-Harmonics -55dBc max.
- Frequency Modulation Bandwidth: DC to 10 MHz
- Small Size 6.23" x 6.48" x 1.6"

Switch Filter Banks:



- 10MHz to 40GHz Frequency Ranges
- Solid State Switches Using PMI Proven Designs
- Bandpass / Low Pass / High Pass / Band Reject
- Quickly Designed To Your Specifications
- TTL, LVTTL, PECL, LVPECL, RS-232 or Ethernet
- Ultra-Small Sizes Available

Hermetic Sealing, High Reliability to Mil-Std-883, Small Quantity Requirements accepted. We offer Custom Designs at low prices.

PMI

PLANAR MONOLITHICS INDUSTRIES, INC.

7311-F Grove Road, Frederick, Maryland 21704 USA
Tel: 301-662-5019 | Fax: 301-662-1731
Email: sales@pmi-rf.com | www.pmi-rf.com

ISO9001:2008 Certified

single instrument. It covers the frequency range from 100 kHz to 3 GHz or 6 GHz and features an I/Q modulation bandwidth of 160 MHz with internal baseband. Exceptional modulation and RF characteristics make it ideal for developing high-end components, modules and complete products for wideband communications systems.

Rohde & Schwarz
rohde-schwarz.com

Analyzer

AWT Global launched a line of field strength meters with spectrum analyzer capability: The UBA 9290 Series. The battery operated, hand-held analyzers are well suited for wireless field applications but are also a very useful tool in the RF laboratory. UBA 9290 analyzers cover a frequency range from 100 kHz to 2.9 GHz and with a sensitivity of -117 dBm, they are capable of evaluating even weak RF signals. A frequency counter with separate input allows to measure frequencies from 9 MHz to 2.1 GHz.

AWT Global
awt-global.com

Filter

The NBP-1560+ is a band pass filter built in a rugged, connectorized package. Covering a pass band of 1500 to 1620 MHz, these units offer good matching within the pass band and high rejection. This will find its application in Transmitters/receivers and harmonic rejection. It has repeatable performance across production lots and consistent performance across temperature.

Mini-Circuits
minicircuits.com

Antenna

Radio Frequency Systems plans to release a new omnidirectional antenna designed for broadband in-building distribution of modern wireless communication systems such as LTE,

GSM, CDMA, PCS, 3G, WiFi, WLAN services in Q2 to the North American market. The addition of this new PIM-certified Omni antenna, I-ATO2-698/2700JPL, for 698-2700 MHz, rounds out RFS's portfolio of products for indoor applications, which includes plenum-rated cables, connectors, tools and jumpers.

Radio Frequency Systems
rfsworld.com

Isolator

Renaissance has developed a new Ka band waveguide isolator that is designed for downconverters used in space applications. The isolator can operate between 27.5 – 31 GHz with 0.15 dB insertion loss over 5% bandwidth and 20 dB isolation and return loss. The isolators can handle 1 W forward and reflected RF power levels. All epoxy and RTV used are space qualified.

Renaissance Electronics Corp.
rec-usa.com

SDLVA

PMI Model No. SDLVA-100M700M-70 is a Successive Detection Video Log Amplifier (SDLVA) that operates over the 100 to 700 MHz Frequency Range. It has a Dynamic Range of >55 dB, a TSS of -60 dBm typical and a Nominal Video Bandwidth of 20 MHz. It has been designed using cutting edge GaAs Technology which provides stunning performance and reliability in a compact package.

Planar Monolithics Industries
pmi-rf.com

Oscilloscope

The R&S RTM provides time domain, logic, protocol and frequency analysis functions in a single box, making it the ideal instrument for the testing and development of electronic circuits. The R&S RTM scores points with its color-coded controls, logically grouped menus with flat structures and dedicated keys for frequently used functions. The undo/redo function, for example,

makes it possible to easily restore previous settings – making the correction of mistakes no trouble at all.

Rohde & Schwarz
rohde-schwarz.com

App Notes

Agilent's new application notes show users of the low cost N9322C basic spectrum analyzer (BSA) how to use the tracking generator and reflection measurement application options. The application notes show how to achieve specific capabilities

suited for performance characterization of components, antennae, RFID tags, and RF Tx modules, delivering more value when using the N9322C.

Agilent Technologies
agilent.com

Cable Assembly

Lab-Flex® AF, a modified version of the popular Lab-Flex® series, is now available from Florida RF Labs. This new family of cables has been enhanced to perform in typical harsh environments associated with airborne, shipboard and ground-based applications. A proprietary cable assembly design utilizes a redundant sealing system to prevent water ingress in both cable and connector interfaces and it employs a very durable dielectric design which is able to withstand crushing or kinking.

Florida RF Labs
rflabs.com

Power Amps

TriQuint's new GaAs PAs include the 3.2W TGA2501-GSG, 6-18 GHz, with 26 dB of small-signal gain and 23% efficiency; the 5.5W TGA2536-FL, 13.5-16 GHz, with 25 dB gain

Best in Class!

2801 Series

Flexible/High Frequency/Low Loss Cable Assemblies

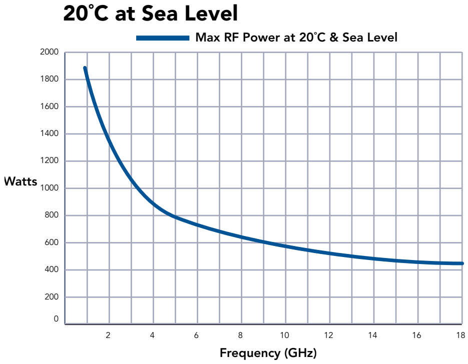
The **2801 Series** cable assemblies offer the "lowest loss in the industry" at frequencies up to 18 GHz. The cable features a multi-ply concentrically laminated dielectric of expanded PTFE, double shielding and a standard FEP jacket per ASTM D-2116. Options including LOW SMOKE/ZERO HALOGEN polyurethane jacketing and TUF-FLEX internal armoring are available for applications requiring enhanced mechanical protection. SMA, precision TNC and N Type connectors are standard for frequencies up to 18 GHz. C, SC and 7-16 connectors are also offered.

Visit Us At **IMS 2013** Booth #946

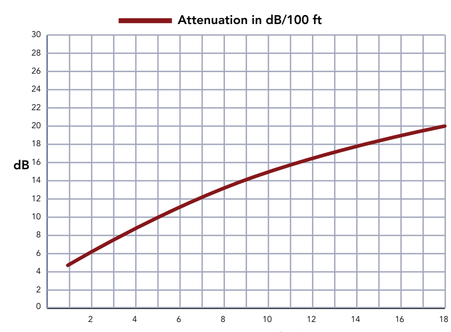
Specifications

Impedance:	50 ohmΩ	**RF leakage, min:**	-100 dB to 18 GHz
Time delay:	1.2 ns/ft.	**Temp range:**	-65°C to +165°C
Cut off frequency:	18 GHz	**Cable outer diameter:**	0.31″
Capacitance:	24 pf/ft.	**Velocity of propagation:**	83%
Weight:	7.8 lb./100 ft.	**UL flame retardant rating:**	VO

Max RF Power in Watts 20°C at Sea Level



Attenuation in dB/100 ft



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and 20% efficiency; and the 14W TGA2517-GSG, 7.5-11.5 GHz, with 30 dB gain and 25% efficiency.

TriQuint Semiconductor
triquint.com

RF Connectors

Coaxicom announced a commercial RF connector series that delivers uncompromised performance, produced through a high-volume manufacturing solution. “I’ve heard from many of our best customers that a commercial line of products would fill a void in the industry,” says Julian Andrews, Operations Manager for Coaxial Components Corp. “As a result, our team developed a G-series of microwave components that will be priced competitively with imported connectors. This product line will meet the superior design standards established in our current Coaxicom line.”

Coaxicom
coaxicom.com

Module

PMI Model Number PEC-1227/1575-IAFS-SFF is a multi-function, integrated module that provides amplification and dual passband filtering within the GPS L1 & L2 frequency bands of 1575.42 MHz and 1227.60 MHz. Two input channels are switchable to a common output. This product is designed to handle exposure to extreme environmental conditions including airborne and launch rocket environments.

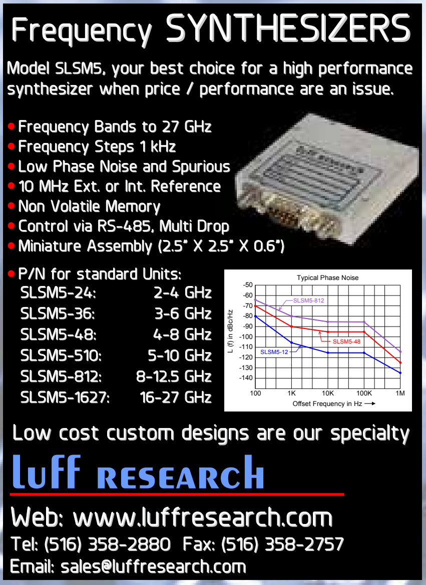
Planar Monolithics Industries
pmi-rf.com

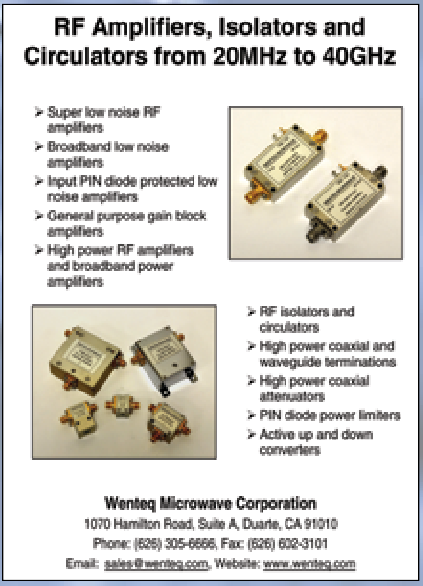
Isolators

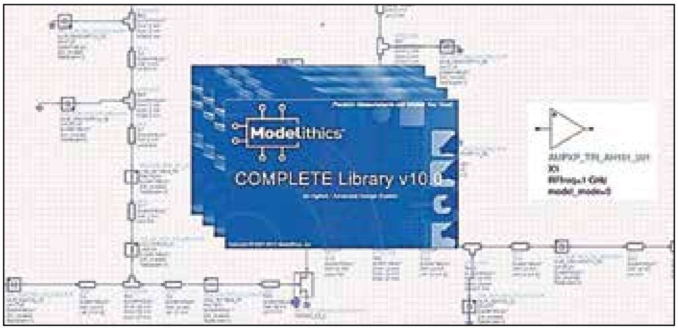
VidaRF offers a wide selection of Drop-In Isolators and Circulators designed to cover 80 MHz to 40 GHz. Tab’s configured to gull wing or straight. Magnetically shielded, clockwise or counter-clock wise rotation (CCW), LOW IMD -80dBc, reflected power from 1(W) to 200(W) on pending models, single or double junction and RoHS compliant.

VidaRF
vidarf.com

Product Showcase



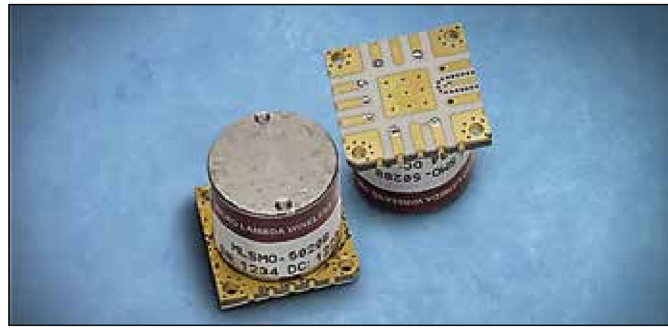




ADS Library

The latest release of Modelithics' COMPLETE Library for Agilent Technologies' Advanced Design System (ADS), now represents over 8600 individual microwave devices. New models have been added to version 10.0 including devices from Passive Plus, AVX, Aeroflex/Inmet, Chilisin, Piconics, Murata, Mini-Circuits and TriQuint Semiconductor. Visit the website below to explore the extensive selection of passive Global Models™, non-linear transistor and diode models, attenuator models, X-parameter* amplifier models and more.

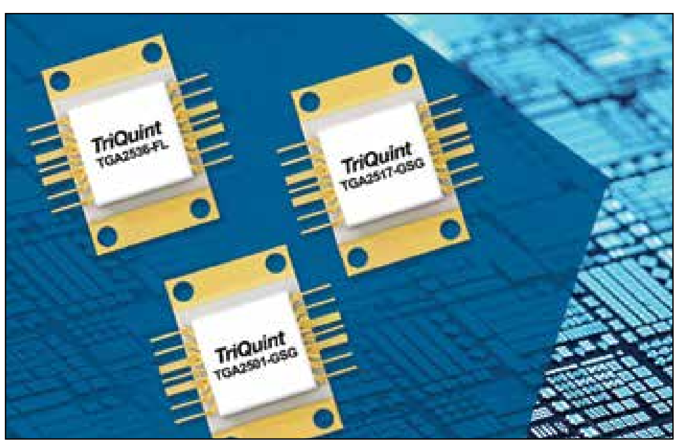
Modelithics
modelithics.com



Surface Mount YTOs

Micro Lambda Wireless, Inc. announced new surface mount YIG-Tuned oscillators covering 2 to 13 GHz. Utilizing new permanent magnets and SiGe transistors, these units are available in octave and multi-octave frequency bands. The units are packaged in a standard surface mount package size utilizing the production sized .500" tall TO-8 package. They provide +8 to +9 dBm power output levels and operate over the 0 to +65 C commercial temperature ranges. Extended temperature models covering -40 to +85 deg C are available for all models.

Micro Lambda Wireless
microlambdawireless.com



Power Amps

TriQuint Semiconductor released three new packaged gallium arsenide (GaAs) RF power amplifiers that deliver high output, gain and efficiency for commercial and defense applications including point-to-point microwave radio, radar, VSAT and related applications. The new amplifiers feature low-loss, ground-signal-ground (GSG) RF transitions designed to interface with a coplanar waveguide multilayer PC circuit board for superior grounding.

TriQuint Semiconductor
tqs.com

Amphenol®
SV MICROWAVE

ATTENUATORS & TERMINATIONS...

SV Microwave offers the most comprehensive line of standard and QPL (Mil-Approved) Coaxial Attenuators and terminations in the industry today. Microwave Components Inc. has been delivering SV Microwave precision components from stock for more than a decade !!!

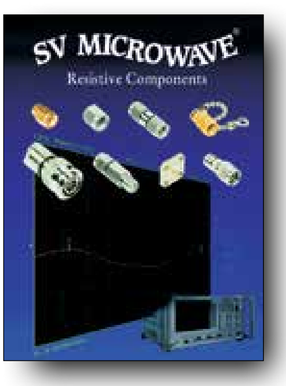
Call us today and put our experience to work for you...

Attenuators

- SMA, TNC, N, 2.4 mm, 2.9 mm
- Nominal Impedance: 50 ohms
- Frequency Range: DC-50 GHz
- Interfaces IAW MIL-PRF-39012
- Meet requirements of MIL-A-3933
- Environmental Standards per MIL-STD-202

Terminations

- SMA, TNC, N, 2.4 mm, 2.9 mm, ZMA
- Nominal Impedance: 50 ohms
- Frequency Range: DC-50 GHz
- Interfaces IAW MIL-PRF-39012
- Meet requirements of MIL-DTL-39030
- Environmental Standards per MIL-STD-202



Mil Approved Products in Stock:

- M39012 – Connectors
- M3933 – Attenuators
- M39030 – Terminations
- M55339 – Adapters
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Waveguide Switch

RLC Electronics' electromechanical waveguide switches offer a compact design utilizing a proprietary non-contacting actuator mechanism that requires low current. These units are available in SPDT and transfer configurations, manual or remote, with a choice of coil voltages, frequency options and optional indicator contacts. Solid state de-energizing circuiting insures high reliability and is available with common positive, common negative, and TTL control options.

RLC Electronics
rlcelectronics.com

I/Q Mixers

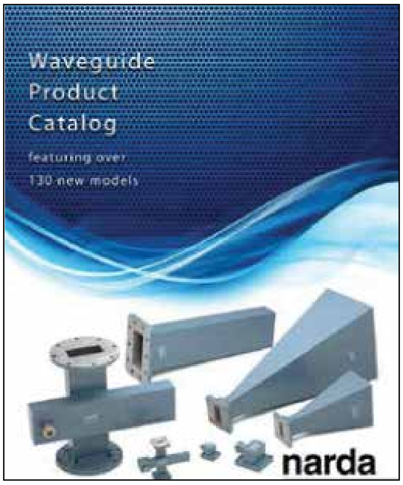
The HMC1063LP3E and the HMC1056LP4BE are GaAs MMIC I/Q mixers in compact leadless "Pb free" SMT packages, which can be used as either image reject mixers or as single sideband upconverters. The mixers utilize two standard Hittite double balanced mixer cells and a 90 degree hybrid fabricated in a GaAs Schottky diode process. A low frequency quadrature hybrid is used to produce a 1000 MHz LSB IF output.

Hittite Microwave Corp.
hittite.com

Cable Assemblies

These new formable RF cable assemblies are hand formable semi-rigid replacements that are an ideal alternative to costly preformed coaxial assemblies. These formable semi-rigid cables are dimensionally and electrically similar to their semi-rigid counterpart and have a tinned-copper-braid outer shield that provides excellent RF shielding, greater than 100 dB. The cable assemblies do not require special tooling to shape or reshape and can be formed more than once without damaging the outer conductor.

Pasternack Enterprises
pasternack.com



Catalog

Narda Microwave-East announces the availability of its new Waveguide Product Catalog. The catalog includes specifications for its expanded waveguide product line and features 130 new models in four distinct catagories: • Waveguide-to-Coaxial Adapters (Right Angle and End Launch); • Gain Horns; • Low and Medium Power Terminations; • Crossguide Directional Couplers.

Narda Microwave-East
nardamicrowave.com

Signal Generators

Agilent Technologies Inc. introduced several key enhancements to its high-performance MXG and cost-effective EXG X-Series vector signal generators. They are designed to improve measurement accuracy, accelerate research and development, and provide in-depth signal simulation for even the most comprehensive receiver verification. These enhancements make these systems ideal for component and receiver development in RADAR, military communications and consumer wireless applications.

Agilent Technologies
agilent.com

IFE Unit

PMI Model No. IFE-DRS-KIT is an Integrated Front End (IFE) unit that consists of a low noise amplifier, RF Log Detector, and a low noise video amplifier. This integrated unit was designed to support a phased array radar automated test set.

Planar Monolithics Industries
pmi-rf.com

5 – 500 MHz Power Divider/Splitters

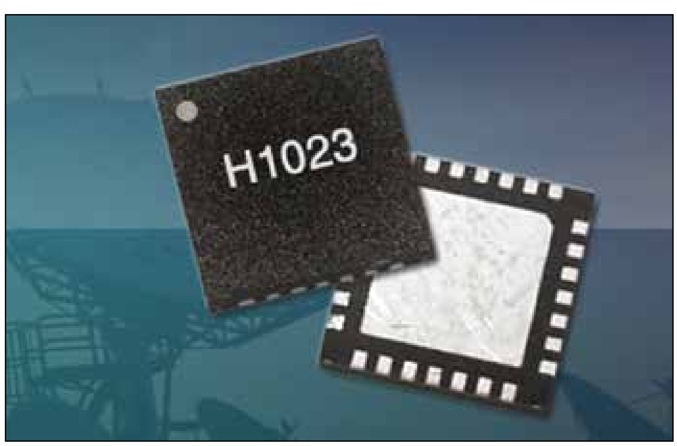
MECA Electronics introduced a new frequency range to its RUGGED & RELIABLE Power Divider line. 5 – 500 MHz available in 2, 3, 4, and 9-Way splits. Optimized for excellent performance across the entire band. Their rugged construction makes them ideal for all low frequency systems. Available in N, SMA, TNC, and BNC connector types. ALWAYS available from stock – 4 weeks ARO. Made in USA & 36-month warranty.

MECA Electronics
e-meca.com

Couplers

Response Microwave, Inc. announced a new series of RoHS compliant octave and multi-octave band, couplers and hybrids for use in telecom and ATE applications. Part of the new GreenLine™ series of economical RoHS compliant control components, the new series covers the 0.5 – 20 GHz band offering typical electrical performance of 0.6 dB insertion loss, VSWR of 1.25:1, minimum directivity of 20 dB . Units are operational over the -35 to +85 deg C range. Mechanical package sizes are very compact.

Response Microwave
responsemicrowave.com



Filter

A 6th order, programmable bandwidth, fully calibrated dual Low Pass Filter (LPF), the HMC1023LP5E features programmable 0 or 10 dB gain and supports arbitrary user programmable, bandwidths from 5 MHz to 72 MHz. When calibrated, the programmed bandwidth is accurate to within ±2.5%. A built-in filter bypass option enables wider bandwidth while maintaining programmed gain and common mode control settings.

Hittite Microwave Corp.
hittite.com


dynawave
Single Path to Optimum Performance
We make our own cable
DynaCore® Technology
We make our own connectors
standard and custom
We supply the highest performance assemblies
DC to 65 GHz
We invite you to find out more about DynaCore® and our complete capabilities
Scan the QR code to instantly access our new website to see the most comprehensive line of high performance, low loss bulk cable, connectors and cable assemblies.
Visit us at IMS 2013
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www.dynawave.com • 978.469.0555
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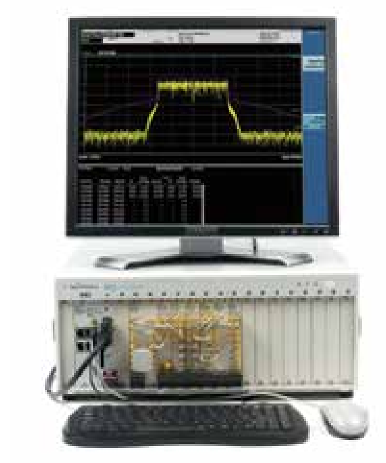
Product Highlights



Power Amp

API Technologies Corp. expanded its Power Amplifier line of products to include the latest in GaN technology driven designs. This expanded line is specially intended for use in electronic warfare, RCIED countermeasures, and national security jammer applications where the use of rugged and highly reliable power amplifier designs is mission critical.

API Technologies Corp.
apitech.com

Test Solution

Agilent Technologies Inc. announced a wireless connectivity test set and multiport adapter to help wireless device manufacturers quickly and accurately test 802.11a/b/g/n/ac WLAN, Bluetooth® 1.0 to 4.0, and Global Navigation Satellite Systems (GNSS) technologies. It supports multiple wireless connectivity formats: 802.11a/b/g/n/ac WLAN, Bluetooth 1.0 to 4.0, and GNSS (GPS, Galileo, GLONASS, etc.).

Agilent Technologies
agilent.com

Ceramic Notch Filter

NIC introduces a high performance Ceramic Notch filter in the 900 MHz band. This band rejection filter is suitable for applications ranging from commercial wireless to military. Custom designs are available upon request.

Networks International Corp.
nickc.com

Rosenberger® Rmor™ Cables Assembly

PHASE STABLE THROUGH 70GHz

Rosenberger Rmor™ cables are designed for rugged environments for indoor and outdoor applications. Each shielded coaxial cable is protected with flexible, SPIRAL-wound 304 Stainless Steel armor coated with extruded Polyurethane. The connector ends are sealed and encapsulated with a pressure injection-molded polymer strain relief.

This combination of materials and technology provides superior ruggedization, environmental resistance, RF shielding effectiveness and stability under flexure and vibration.

Additional connector interfaces and armor/cable diameters are available on request.

DESCRIPTION

Rosenberger connectors, cable assembly, standard length 915mm or 36 inches

GENERAL ELECTRICAL SPECIFICATIONS

Impedance:	50 +/- 1 Ohms
Operating frequency:	DC to 70 GHz
Return loss:	14 dB minimum up to 70 GHz
Cable insertion loss:	.67 dB/ft @ 10.0 GHz
Velocity of propagation (%):	78 % nominal
Capacitance:	24.7 pf/ft. nominal
Shielding effectiveness:	< -90 dB
Dielectric withstand voltage:	1000 Vrms
Amplitude & phase stable:	+/- .03dB & +/- 1° @10GHz

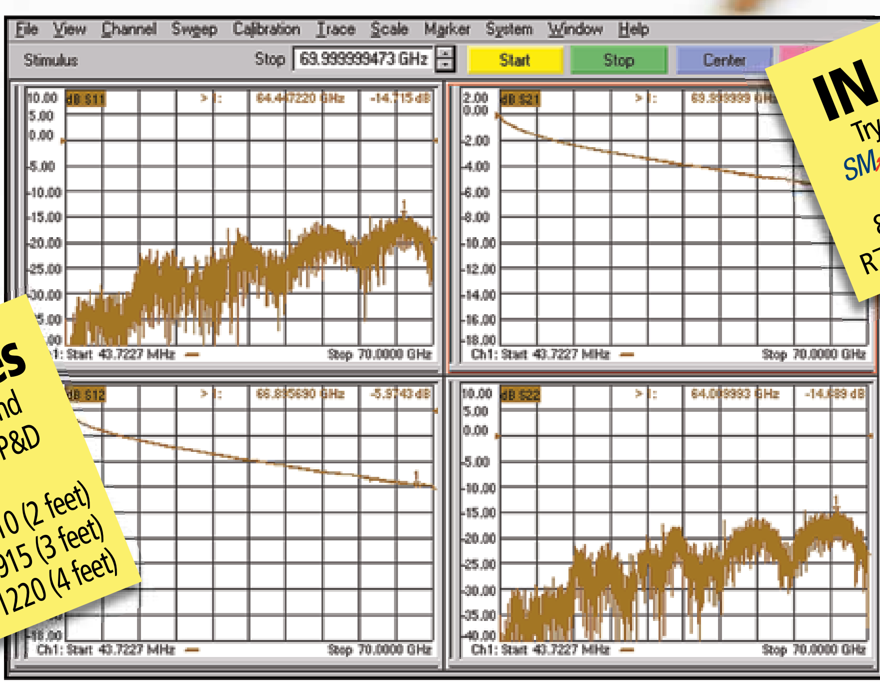
MECHANICAL SPECIFICATION

Cable jacket & armor outer diameter:	092 inches nominal & .250 inches nominal
Minimum bend radius:	.5 inches
Armor crush strength:	450 lbs/in (min)
Connector retention:	≥25 lbs.
Mating torque:	7-10 inch pounds

MATERIALS AND FINISHES

Armor type:	SPIRAL-wound 304 SS & Polyurethane blue jacket
Connector environmental testing:	Per MIL-STD-202, Meth 101,106,107,204 & 213
Connector interface dimension:	IEC 60169-17 Per MIL-PRF-39012 DINEN122200

Note: Cable assemblies also available with interfaces such as 1.85mm, 2.4mm, 2.92mm, SMA +, SMA, N.



Example of typical 36 inches assembly up to 70 GHz

IN STOCK!
Try an Rmor cable with SMA+™ (operates to 36 GHz)
Call RFMW today
877.367.7369. Ask for p/n
R71-32+S132+S1-00457 (18")

70GHz Cables
1.85mm males each end
Call RFMW today for P&D
877.367.7369
RU5-08S1-08S1-00610 (2 feet)
RU5-08S1-08S1-00915 (3 feet)
RU5-08S1-08S1-01220 (4 feet)

RfMW

RFMW is the exclusive stocking distributor for Rosenberger® Connectors and Cable Assemblies
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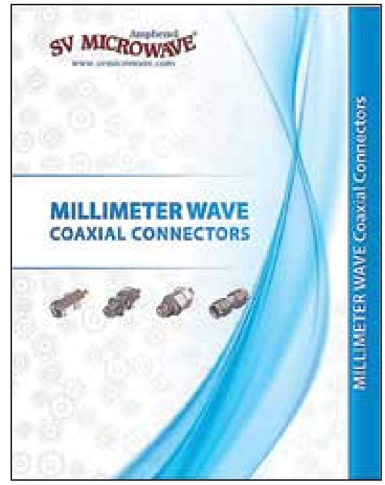
PH: 408.414.1450 or 877.367.7369 Email: sales@rfmw.com
Website: www.rfmw.com/Rosenberger



USB Power Sensor w/Secure Cable

LadyBug Technologies announced a new secure connector system for its USB Power Sensors. The connector system is designed to meet customer requirements for assured connectivity in a variety of testing environments. In ATE systems, the connector is a perfect complement to LadyBug's patented No-Zero No-Cal capability. The Sensor can remain hidden away from view with the assurance that it will work reliably and will not become disconnected if the cabling is disturbed. The secure cable fits the full line of LadyBug Technologies USB Power Sensors.

LadyBug Technologies
ladybug-tech.com

MM-Wave Connectors

SV Microwave has released a new Catalog for its Millimeter Wave connector series. SV's line has the precision, quality and performance needed for the millimeter wave spectrum through 67 GHz. Products include 2.92 mm, 2.4 mm and 1.85 mm.

SV Microwave
svmicro.com

White Paper: RF Switch Matrix Basics

RF and microwave switch matrix solutions play a key role in a variety of test systems. SenarioTek designs and configures signal routing solutions that are often unique to a specific application. The company has identified some basic steps that help facilitate the design process and ensure that the finished product meets the needs of the test system. This white paper covers the most important initial steps in the process.

SenarioTek
senariotek.com

Connector Video

San-tron, Inc. describes engineering parameters, design and manufacturing challenges, and performance characteristics of the 40 GHz S292 series of 2.92 mm connectors and plugs in the video “An Introduction to San-tron S292 Connectors.” Developed for RF/microwave engineers designing components for demanding applications in the 40 GHz or K-band ranges, San-tron S292 40 GHz connectors offer VSWR of <1.18 through 40 GHz.

San-tron
santron.com

Equalizer

The VAEQ-1000+ is a 50Ω voltage variable equalizer built into a shielded case. (size of .394” x .394” x .150”). This model offers excellent performance over a wide frequency range of 50 to 1000 MHz with the variable slope pro¬viding great flexibility in a small package. The VAEQ-1000+ is often used to compensate RF chain gain flatness or cable loss versus frequency.

Mini-Circuits
minicircuits.com

Capacitors

Passive Plus has developed a series of broadband and ultra-broadband capacitors, the 0402BB103, 0402BB104, and 0201BB104, intended primarily for coupling RF signals or bypassing them to ground over extraordinarily large RF bandwidths. Applications for which they are intended require small, surface-mount (SMT) devices with low insertion losses and reflections across RF frequencies extending from the tens of kHz to the tens of GHz.

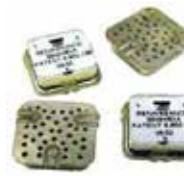
Passive Plus
passiveplus.com

Components and Integrated Assemblies up to 140 GHz

Industries served - Avionics, Defense, Telecommunications, Space, Broadcasting, VSAT, 4G/LTE, Medical, Homeland Security and more

For over two decades **Renaissance Electronics Corporation (REC)** has been servicing the RF, Microwave, and Millimeter Wave community **Creating Shared Value (CSV)** for economic success. We have created policies and practices that enhance the competitiveness of our business.

We are prepared to meet the needs and challenges of our customers through our four product groups that service Military and Commercial applications. With over 350 years of combined higher level engineering expertise, we can provide a wide range of products from individual standard components to custom integrated sub-systems and systems.



Ferrite Product Group

(Isolators and Circulators)

Provides Coaxial, Drop-in, Strip-line, Micro-strip, Surface Mount and Waveguide configurations. We specialize in broad bandwidth, miniature, magnetically shielded, high power, low inter-modulation distortion (IMD) and low insertion loss ferrite devices. Standard product delivery is immediate (from stock) to six weeks.

Switch Product Group

Provides Electromechanical Switches, Custom Broadband Digital Switches and Switch Matrices, with high MTBF. Renaissance is the first in the industry to produce a truly hermetic electromechanical space qualified SPDT switch.

Base Station Product Group

(Telecommunication products)

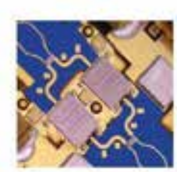
Provides Receiver Multicouplers, High Power Transmitter Combiners, Multiband Combiners, Power Dividers, Power Combiners, Duplexers, Triplexers, Couplers, LNAs, Rack Mount Systems, 60 GHz Wireless Radio Links, E-Band Wireless Radio Links and more.

Millimeter Wave Product Group

Provides ultra high speed data transmission Radio Links, Wireless Video Distribution Systems with HD capabilities, Power Amplifiers, Radar Solutions, Sensors, Detection and Imaging Systems, Transceivers, LNAs, PIN Switches, VCOs, Gunn Oscillators, Multipliers, Combiners, Mixers, Attenuators, FPGA and more.

Other General Information

- **Our Vision -** "To be the world's preferred supplier of RF, Microwave and Millimeter Wave products."
- **Quality Standards** - ISO 9001:2008 and AS9100:2009 certified, MIL-I-45208A, MIL-STD-883, MIL-DTL-28791, MIL-STD-1285, ASTM E595, MIL-DTL-3928F, NHB 5300.4.
- **Space Heritage -** Involved in various space programs.
- **Financial and Credit Status -** High D&B rating (DUNS #78-1555-6600).
- **Location -** 12 Lancaster County Road, Harvard, MA 01451, USA.



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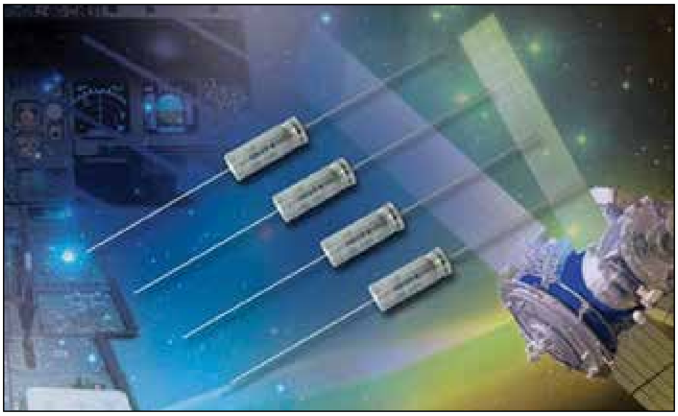
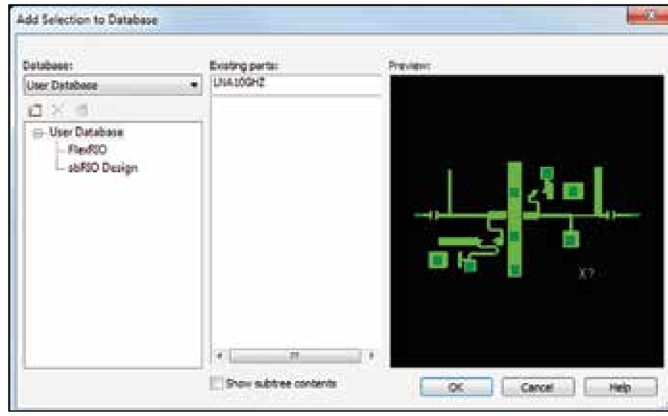
Product Highlights



Capacitors

Vishay Intertechnology announced that its T16 series of tantalum-cased wet tantalum capacitors with glass-to-tantalum hermetic seals is now available in the A, B, C, and D case codes. For avionics and aerospace applications, the devices have been enhanced with improved vibration (sine: 50 g; random: 27.7 g) capability. The capacitors provide all the advantages of the company's SuperTan® series devices while offering reverse voltage of 1.5 V at +85 °C, thermal shock of 300 cycles, and high vibration capability.

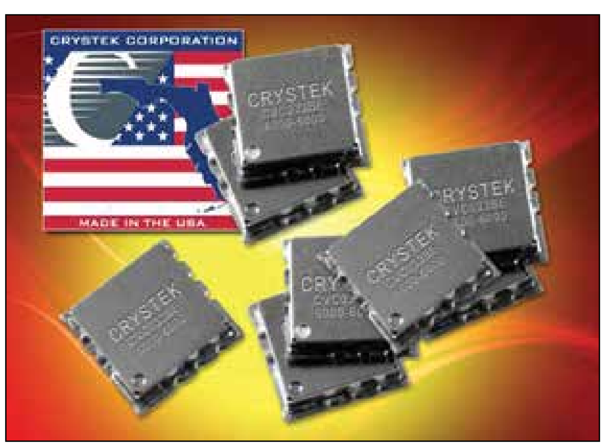
Vishay Intertechnology
vishay.com



App Note

AWR's new application note titled, 'Multisim/Ultiboard for Low-Frequency Simulation and Layout' details how to complement Microwave Office® circuit design software with National Instrument's Multisim circuit simulation software and Ultiboard printed circuit board (PCB) layout software for a comprehensive design flow spanning from DC to microwave frequencies.

AWR Corp.
awrcorp.com



VCO

Crystek's CVCO33BE-6000-6000 VCO (Voltage Controlled Oscillator) operates at 6000 MHz with a control voltage range of 0.5V~4.5 V. This VCO features a typical phase noise of -85 dBc/Hz @ 10KHz offset and has excellent linearity. Output power is typically +5 dBm. Engineered and manufactured in the USA, the model CVCO33BE-6000-6000 is packaged in the industry-standard 0.5-in. x 0.5-in. SMD package. Input voltage is 5 V, with a max. current consumption of 40 mA.

Crystek Corp.
crystek.com

Product Highlights

Capacitors

Vishay Intertechnology, Inc. introduced a new high-performance metallized polypropylene film snubber capacitor. Configurable for direct mounting on insulated gate bipolar transistor (IGBT) modules, the Vishay Roederstein MKP386M features a wide capacitance range from 0.047 µF up to 10 µF, high-temperature operation to + 105 °C, and seven voltage ratings from 700 VDC to 2500 VDC and 420 VAC to 800 VAC.

Vishay Intertechnology
vishay.com

Power Amp

L-3 Electron Devices announced the introduction of its 50-watt NanoMPM® Ka-Band power amplifier, the world's smallest commercially available millimeter wave module. At just 6.5 inches x 4 inches x 1 inch, the new NanoMPM is designed for emerging Ka-Band global communications systems used in smaller-scale satellite programs. It can also be reconfigured to operate over a broader frequency range for compact electronic warfare programs.

L-3 Electron Devices
L-3com.com

Capacitors

AVX Corp. introduced a new ultra-broadband capacitor series. Designed to address DC blocking from 16KHz to 40GHz, AVX's new GX03 Series Ultra-Broadband Capacitors exhibit ultra-broadband performance, extremely low insertion loss, excellent return loss, and X7R characteristics. Ideal applications for the GX03 Series include: semiconductor data communications, receiver optical subassemblies, transimpedance amplifiers, and test equipment.

AVX Corp.
avx.com

+20 dBm Power Amplifiers with a choice of gain

GVA AMPLIFIERS

DC* to 7 GHz

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2 New Models!

The GVA-62+ and -63+ add ultra-flat gain to our GVA lineup, as low as ±0.7 dB across the entire 100 MHz-6 GHz band! All of our GVA models are extremely broadband, with a wide dynamic range and the right gain to fit your application. Based on high-performance InGaP HBT technology, these patented amplifiers cover DC* to 7 GHz, with a gain selection of 10, 15, 20 or 24 dB (at 1 GHz). They all provide better than +20 dBm typical output power, with typical IP3 performance as high as +41 dBm at 1 GHz. Supplied in RoHS-compliant, SOT-89 housings, low-cost GVA amplifiers feature excellent input/output return loss and high reverse isolation. With built-in ESD protection, GVA amplifiers are unconditionally stable and designed for a single 5V supply. Just go to minicircuits.com for technical specifications, performance data, export info, pricing, and everything you need to choose your GVA today!

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**Low frequency cut-off determined by coupling cap, except for GVA-62+ and GVA-63+ low cutoff at 10 MHz.*

US patent 6,943,629

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U.S. Patents 7739260, 7761442

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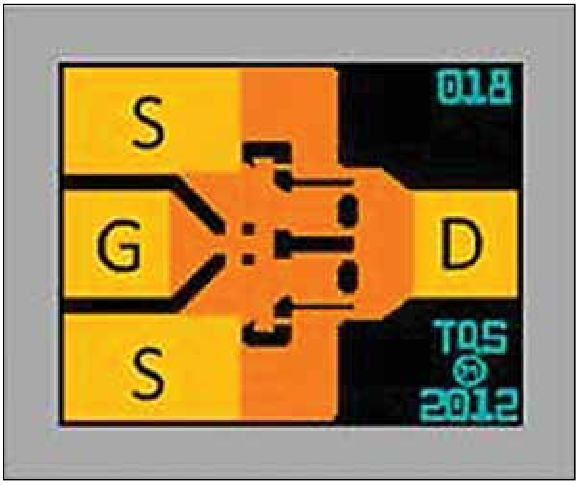


pHEMT

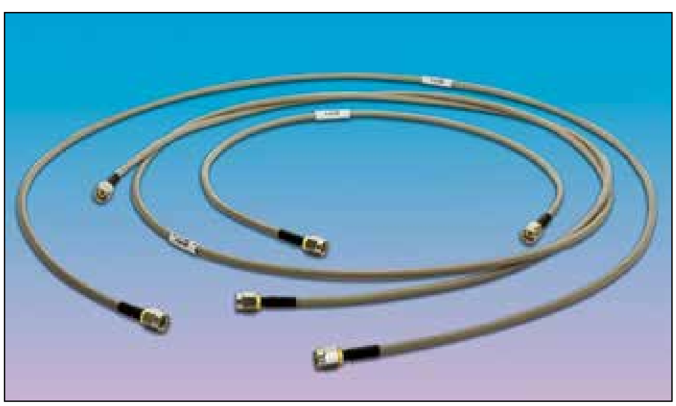
RFMW, Ltd. announced design and sales support for TriQuint Semiconductor's TGF2018, a discrete 180-Micron pHEMT which operates from DC to 20 GHz. The TGF2018 is designed using TriQuint's proven standard 0.25um power pHEMT production process. This process features advanced techniques to optimize microwave power and efficiency at high drain bias operating conditions.

RFMW
rfmw.com

Amplifiers

MITEQ's new TTA Series are high performance Broadband Low Noise Amplifiers specially developed for Electromagnetic (EMC) compliance testing. Complete frequency coverage from 1 MHz to 40 GHz is possible with three separate TTA amplifiers. They are enclosed in a small [5.1" L x 3.5" W x 1.9" H] lightweight EMI/RFI case and can be used easily in the EMC test setup. A universal wall plug in power supply is included with each TTA which operates from 50-60 Hz / 100-240 VAC.

MITEQ
miteq.com



Cable Assemblies

AtlanTecRF introduced a comprehensive range of fully flexible test cable assemblies particularly suited to extensive test set-ups either in the laboratory or automatic test equipment. Grey in color and only 0.168 inches in diameter the standard connector types are SMA male with the well-known and reliable anti-torque feature for which AtlanTecRF assemblies are renowned. Frequency performance is to 26.5GHz and standard stock lengths range from 2 to 60 inches with other connector options available.

AtlanTecRF
atlantecrf.com

Product Highlights

User Interface

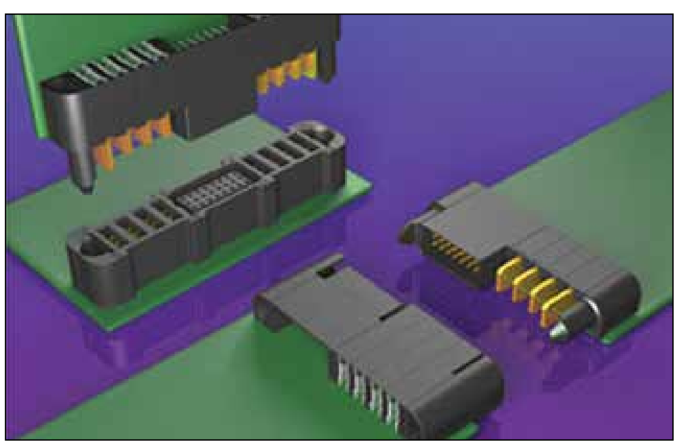
Comtech Xicom Technology, Inc., announced a Web-based interface for the company's LCD touch screen amplifiers. The new graphical user interface (GUI) displays the identical images on a computer screen as that shown on the amplifier's LDC control panel, offering an easy-to-use off-site interface for monitoring and controlling multiple amplifiers and switches.

Comtech Xicom Technology
xicomtech.com

Filter

LCR Electronics Inc. announced their FH Series HEMP Power Line Filters, designed to meet or exceed the requirements of MIL-STD-220 with 100dB attenuation from 14kHz to 1GHz. Designed to meet the point-of-entry requirements of MIL-STD-188-125-1 & MIL-STD-188-125-2 for short and intermediate pulses, LCR's FH1960 HEMP filters also meet high insertion loss performance for SCIF, TEMPEST and other applications.

LCR Electronics
lcr-inc.com



Interconnects

Samtec's line of PowerStrip™ interconnects now includes the EXTreme Ten60Power™ socket and terminal system that delivers high current power performance of up to 60A per power blade (1 blade powered at 75ºC; 30ºC Temperature Rise) with a low 10 mm profile design for enhanced system airflow. This system is an ideal solution for board-to-board power applications in industries such as Networking, Telecommunications, Data communications, and Military/Aerospace.

Samtec
Samtec.com

HFE Interview: Sherry Hess

Sherry Hess, Vice President of Marketing, AWR Corp.

HFE: Statistics from the Society of Women Engineers show that women are definitely in the minority in the engineering population, and not increasing. What are your thoughts on encouraging more women to enter the field of engineering?

Hess: With women numbering about 43 percent of engineers in the Asia Pacific region, 23 percent in Europe/Middle East/Africa and only 10 percent in the USA—and the numbers are not growing—we women have to find novel ways to stay connected to our brethren who have already chosen RF and microwave as their path, and work together to uncover ways to bring even more females into the domain of engineering.

It is definitely a struggle to make engineering appear more inspiring for either gender, but it cannot hurt for all of us, as engineers, to stretch a little bit outside of our comfort zone and talk about our profession. Our field of RF and microwave literally brought us the wireless revolution. This is an exciting field to be in, and we should be more outspoken about the part we play in shaping future products and technologies. In addition, I believe those of us who are well established in the engineering world in positions of authority need to work at both putting ourselves out there as role models and also creating and promoting opportunities for women that will encourage them to choose engineering and aspire to high level positions.

When you took on the organization of the Women in Microwaves reception at IMS in 2010 as your first step in supporting the cause of increasing the numbers of women in engineering, you were previously unaware of that event, even though you had been prominent in the IMS conference for years. What steps have you taken to communicate more closely with women in the microwave community?

The Women in Microwaves reception is a premier event within the RF and microwave community's biggest gathering of the year—the International Microwave Symposium (IMS). I was surprised to find when I took on the WIM event that it was very poorly promoted and therefore not well attended. I worked hard at creating awareness of the event and spreading the word among men and women alike about this unique opportunity to network among colleagues from around the world. In the two years I chaired the event (2010-2011), attendance doubled and has continued to grow. We now have women from all facets of IMS, regardless of their registration status, attend the event. The WIM group associated with European Microwave Week has become much more active, as well.

You have just been named to co-chair Women in Engineering within the IEEE Microwave Theory & Techniques Society (MTT-S) by the Membership and Geographic Activities committee. How do you plan to leverage this position to further raise awareness among women of career opportunities in engineering?

I learned from my experience with WIM that we have to be aggressive with our outreach in order to increase awareness and fully promote the many benefits and opportunities that the RF and microwave industry offers women.

My theory is that in order to encourage more women to become engineers we need to work towards *creating* them through both a concerted communications program to foster awareness and a focus on programs such as grants, scholarships, educational gifts, free training, design competitions, etc., that provide economical opportunities to further learning and experience in engineering. Hopefully if there are more opportunities to help women jump-start a career in engineering, and they understand from a younger age the excitement of our field, more women will set their sights on engineering.

To this point, I participated last year in the Women in Electronic Design panel at DAC (Design Automation Conference). The theme of the panel was "the Mechanics of Creativity." In preparing to debate this topic, I realized that engineering is a topic engineers don't often talk about. I think if we can find a way to communicate to young people out there, especially women, how incredibly creative engineering can be, and, additionally, provide them with advantageous real-world experiences that can impact their careers, we can encourage more to enter the profession.

Additionally, this April (14-18th) I'll be attending IEEE International Wireless Symposium (IWS) in China and meeting with female engineers there. The dialogues are beginning online and I'm quickly learning that the ratio of female to male engineers in China is far healthier than in the USA. I'd like to understand why that is and bring any wisdom back to the USA, as well. I also plan to get to EuMW in October and initiate a dialogue with our European counterparts.

And, last but by no means least, my co-chair, Dr. Rashuanda Henderson of the University of Texas at Dallas, and I have a busy schedule planned for our two-year tenure that includes not only speaking at major microwave shows worldwide and meeting with fellow women engineers at these gatherings, but various and frequent local IEEE MTT-S chapter meetings throughout the USA. These events should be a great starting point for broadening awareness and fostering communication.

Advertiser Index

Company	Page
Advanced Switch Technology	67
Aeroflex Inmet	60
Aethercomm	25
AR RF/Microwave Instrumentation	37
AWR Corp.	17
CDM Electronics	56
Cernex	18
Coilcraft	11
CST	51
CTS Electronic Components	39, 57
C.W. Swift & Associates	C2
C.W. Swift/SRI Connector Gage	47
Damaskos	67
Delta Electronics	61
Dielectric Laboratories	77
Dynawave	73
Emerson Network Power	33, C4
GT Microwave	62
Herotek	14
IMS 2013	85
IW Microwave	65
JFW Industries	54
Luff Research	66, 67
MDL	29
MECA Electronics	19
Micro Lambda Wireless	9
Microwave Components	69
Mini-Circuits	2, 3
Mini-Circuits	15
Mini-Circuits	23
Mini-Circuits	31
Mini-Circuits	53
Mini-Circuits	82, 83
Miteq	7
Molex	C3
National Instruments	5
NIC	1
NXP	35
Passive Plus	58
Planar Monolithics Industries	59
Pulsar Microwave	28
Renaissance Electronics	79
RF Bay	67
RFMW	75
Rogers Corp.	43
SAGE Millimeter	24
Satellink	66
Sector Microwave	66
SGMC Microwave	21
SignalCore	58
State of the Art	64
SV Microwave	63
Times Microwave Systems	55
TRU Corp.	27
VidaRF	20
Wenteq Microwave Corp.	67
Wenzel Associates	52
Wilmanco	67

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