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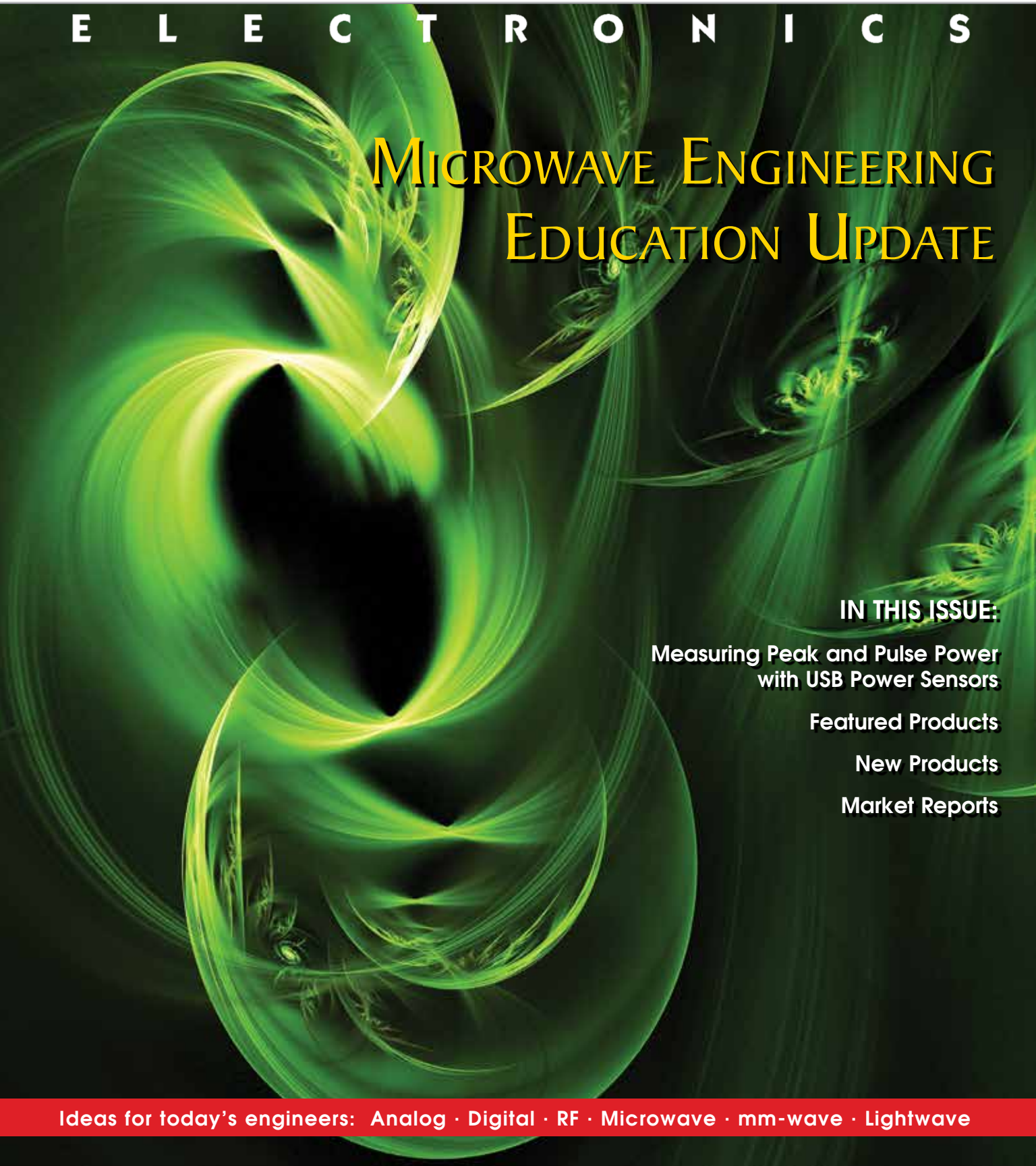

Microwave Engineering Education Update

IN THIS ISSUE:

Measuring Peak and Pulse Power with USB Power Sensors

Featured Products

New Products

Market Reports

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

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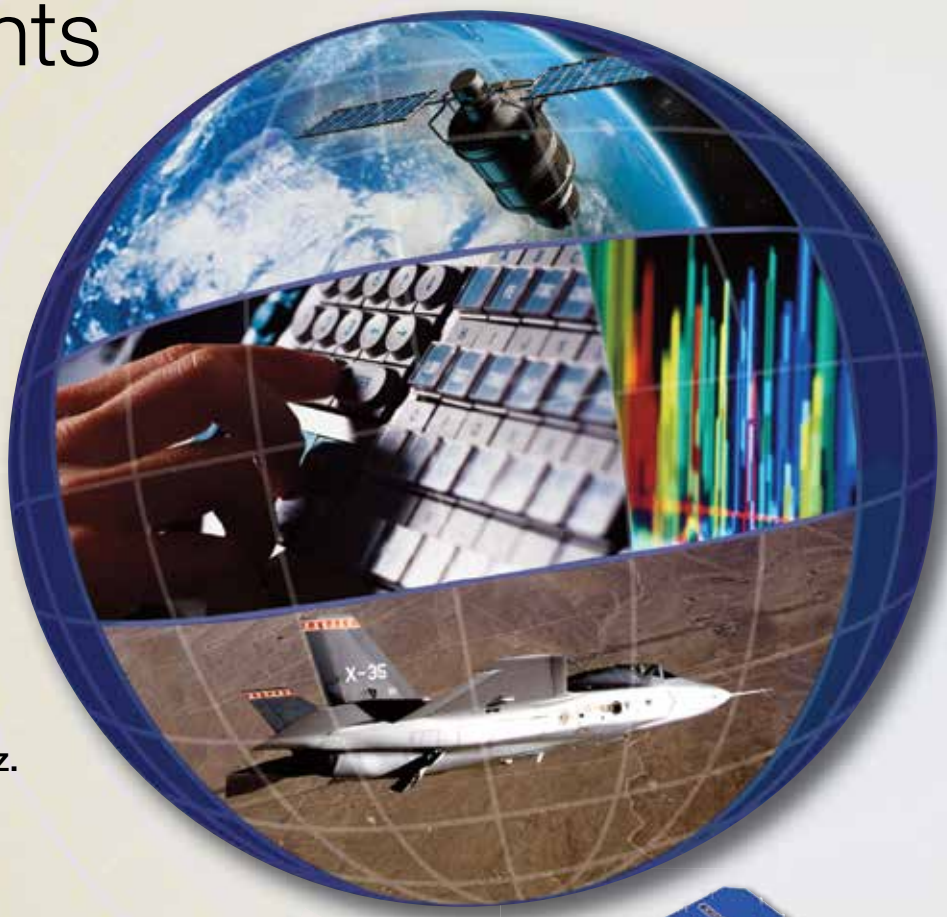

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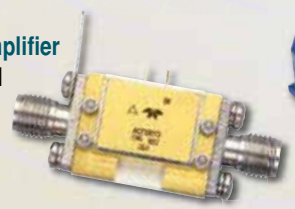

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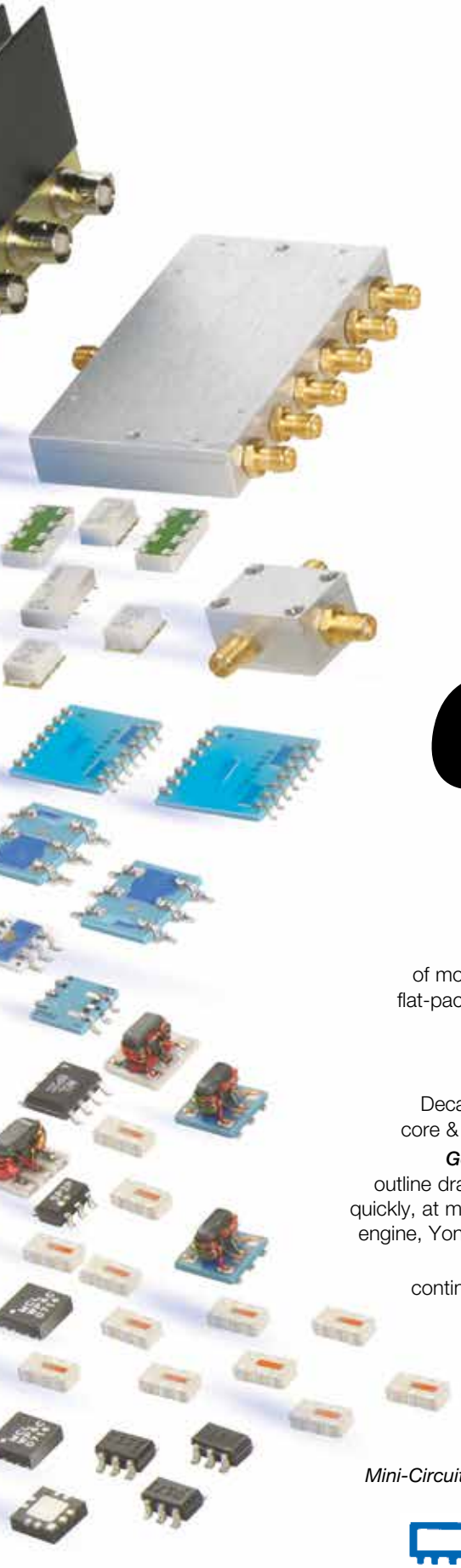

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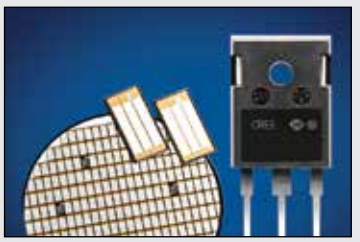

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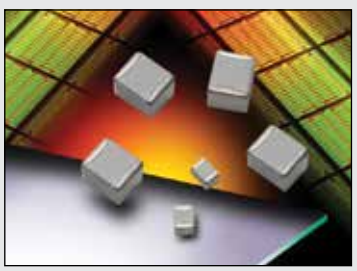
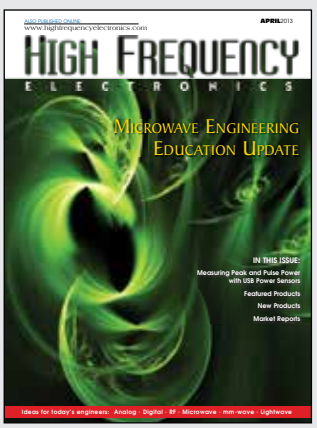


Featuring AVX Corp., Mixed Signal Integration Corp., AtlanTecRF, Agilent Technologies, RFMW, Ltd., AR RF/Microwave Instrumentation.

Highlighting Chuck Swift, Dielectric Laboratories, AWR Corp., Lime Microsystems, Insitu Inc., Raytheon Co., Aero Thermo Technology.



Commentary by Sr. Technical Editor Tom Perkins.

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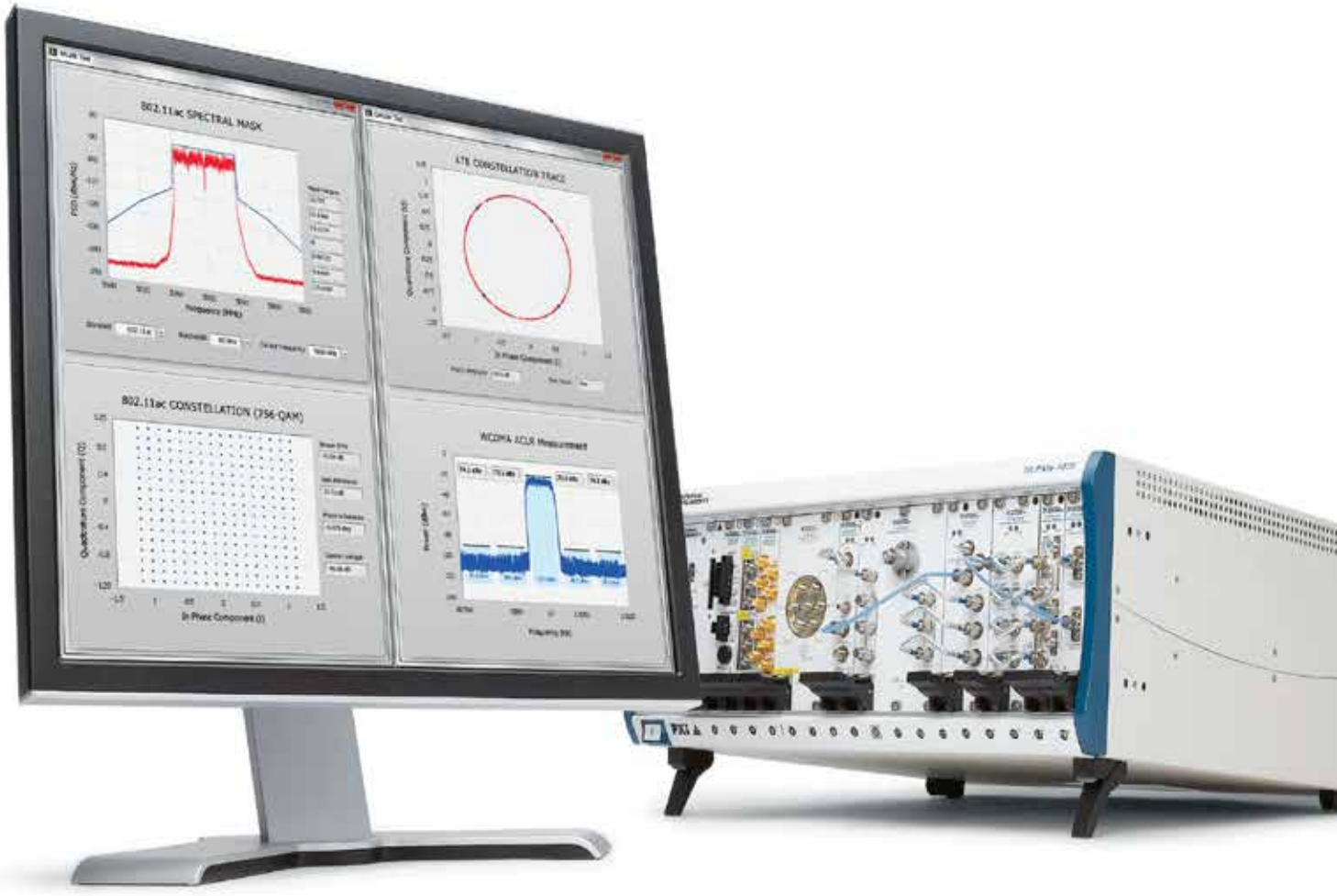

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Scott Spencer
scott@highfrequencyelectronics.com
Tel: 603-472-8261

Associate Publisher/Managing Editor
Tim Burkhard
tim@highfrequencyelectronics.com
Tel: 707-544-9977

Senior Technical Editor
Tom Perkins
tom@highfrequencyelectronics.com
Tel: 603-472-8261

Vice President, Sales
Gary Rhodes
grhodes@highfrequencyelectronics.com
Tel: 631-274-9530

Business Office
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Spotlight on Passive Components

Tom Perkins
Sr. Technical Editor

Have you noticed the proliferation of technical webinars in recent years? These webcasts usually require advance registration, and allow sign-in with an event password about 10 minutes before start time. There is usually a host who introduces the speaker(s). Questions are encouraged and can be entered in an on-line "chat" during the lecture. At the end there is usually about 10 minutes for the host to read questions and solicit answers. If a panel of experts is available, questions are often answered in greater depth than if the burden is placed strictly on the speaker. While these presentations are generally skewed towards promotion for the products described, such as test instruments, technology tutorials such as radar, LTE, MIMO, electronic warfare, etc. are sometimes sponsored by parties not directly hyped in the presentation. An engineer, technician or other interested party can get valuable information without leaving the workplace and consuming costly travel, lodging, and time. Missing, however, is the interaction with peer groups, although viewing with a group is certainly feasible.

I mention this resource because a recent presentation by Agilent Technologies was particularly well done and demonstrates the value of such media. The title is: *Signal Analyzer Fundamentals and New Applications.* The speaker, Erik Diez, in this case a Senior Product Manager, explained spectrum analyzers in a succinct manner. Signal analyzer measurement techniques and the abilities of modern equipment with digitizing were very enlightening. The discussion explained resolution, sensitivity, distortion products, dynamic range and more. His explanation of Second Order Intercept (SOI) and Third Order Intercept (TOI) and relation to harmonic distortion from non-linear devices was the best I've ever heard or read on that subject matter.

These webinars are generally well prepared and scripted to sync with the graphics shown. The speaker is often never seen, only heard—maybe something to be tweaked a bit.

Passive Components

On another subject, we have occasionally received comments that more should be said about passive components. As I pointed out in my February editorial, passive products seem to be a bit more enduring and stable relative to longevity of suppliers. In March I spent some time with Ralph Baer who is generally credited with inventing early video games, and still is inventing and developing children's toys at the young age of 91. He was recently made a 2013 IEEE Fellow, something that should probably have happened 30 years ago. Louis Terman, son of the acclaimed Frederick

Emmons Terman and IEEE President in 2008, played a role in making this honor happen for Ralph. Having discussed the tremendous influence of Terman's texts with Mr. Baer, I pulled the 1947 Third Edition of Louis' father's book, *Radio Engineering,* off my not-so-current bookshelf. In the Preface this late edition states: "In particular, greatly increased attention is given to ultra-high-frequency and microwave techniques, also to wide-band and pulse methods such as encountered by television and radar. A chapter on circuits with distributed constants has been added that summarizes the principal properties of transmission lines, wave guides and cavity resonators."

In the Beginning

In the two decades commencing shortly before WWII, passive circuitry dominated the then-called "ultra highs" and microwaves. The new Chapter 4 discussing "Circuits with Distributed Constants" immediately followed the previous chapter describing lumped constant circuits. So, over a brief span of 15 years since Terman's 1st edition, in 1932, high frequency electronics took on significant importance. Tube oscillators, klystrons, and magnetrons found their way into the third edition also, in a later chapter.

Great Technical Advances

I must admit that I tend to discuss, maybe too much, the latest and greatest active circuitry. Much of the hype in our industry is placed on the newest III-V semiconductor technology and high speed circuit processing. Often ignored are passive circuit components that make up parts of just about every circuit in our business. We have some wonderful companies that advertise with HFE that manufacture power dividers, attenuators, terminations, couplers, chip resistors, chip capacitors, inductors, passive mixers, coaxial connectors, cables, filters, circulators, isolators, waveguide components, switches, antennas, circuit boards, frequency multipliers, rack assemblies, absorptive materials, metamaterials and more.

There have been significant advances in many of these component technologies. An explosion in varieties of connectors, advances in bandwidth coverage of passive chips, a plethora of dielectric substrate choices, improved filter performance, much improved reliability, and new materials and automated fabrication techniques have enabled improved and smaller components and subsystems. The engineering discipline involved is sometimes now called "mechatronics." More later …

See you at RFIC and IMS 2013, Seattle, June 2 – 7. More than a webinar!

Conferences

April 10 – 11, 2013
Microwave & RF
Paris
microwave-rf.com

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
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Webcasts on demand.
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LabVIEW user groups.
https://decibel.ni.com/content/community/zone/labviewusergroups

Call for Papers

2013 IEEE International Topical Meeting on Microwave Photonics (MWP 2013)
October 28 – 31, 2013, Annapolis, Md.
Abstract Deadline: May 1, 2013
www.mwp2013.org

2013 IEEE International Symposium on Phased Array Systems
October 15 – 18, 2013, Waltham, Mass.
Summary Deadline: December 15, 2012
Final Paper Deadline: June 1, 2013
www.array2013.org

2013 38th International Conference on Infrared, Millimeter, and Terahertz Waves (IRMMW-THz)
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Short-Range Wireless Technology IC Market to Reach Almost 5 Billion Units Shipped in 2013

The total market for open short-range wireless (SRW) technology based ICs, i.e. Bluetooth, Wi-Fi, ZigBee, NFC, and GPS, is expected to reach almost 5 billion units in 2013 and grow to nearly 8 billion by 2018. This includes standalone wireless connectivity ICs, wireless connectivity combo ICs, and also platforms with integrated wireless connectivity.

"In the year where cumulative Bluetooth enabled device shipments will reach 10 billion and cumulative Wi-Fi enabled device shipments will reach 7 billion, we will also see total wireless connectivity IC shipments break through 5 billion per annum," said Peter Cooney, practice director. "It is truly a momentous year for short-range wireless technology."

Consumer devices such as mobile phones, laptops, media tablets, games consoles, etc. have been the major driver of SRW technology growth but as many of these devices start to peak it is newer applications such as automotive, home automation, smart energy, retail, and many more that will be the major growth drivers over the next 10 years.

SRW technologies are enabling simple, low-cost connections to be made between multitude devices and helping to make 2013 the year that the Internet of Everything (IoE) hits an inflection point and starts to become a reality. Bluetooth, Wi-Fi, and ZigBee are just a few of many technologies that will enable growth in this market, coupled with proprietary SRW, cellular, white space, and fixed communication technologies, also.

—ABI Research
abiresearch.com

Report: Mediatek Delivers World's Smallest Multimode Transceiver

ABI Research finds that Mediatek has delivered the world's smallest multimode transceiver. Coming just after Qualcomm announced intentions to produce RF front ends for high tier LTE smartphones, Mediatek releases the world's smallest RF transceiver which is also the world's first 40nm transceiver.

The transceiver (MT6167) accompanies the widely publicized MT6589 quad-core application processor/3G modem and the MT6320 power management unit (PMU). The transceiver measures less than 7sq mm and supports 2G and 3G protocols. The norm for transceivers with this functionality is above 20 sq. mm. Qualcomm's current solution measures in slightly above 25 sq.mm.

The MT6589 chips also perform well. The chipset measured 40% less power in 2G talk modes and 30% less in 3G talk modes compared to the prior MT6577 solution (as measured in ABI Research's teardown laboratory). The quad core A7's provide a smooth UI and plenty of mobile power.

—ABI Research
abiresearch.com

Demand for Conventional Submarines to Remain Healthy

The modern non-nuclear, conventional diesel-electric submarine (SSK) with air-independent propulsion systems (AIP) is a complex, multi-role and extremely powerful weapon system. The submarine is able to deploy a wide range of weapons and conducting various missions ranging from anti-submarine, anti-surface vessels warfare to intelligence, surveillance and reconnaissance.

According to Frost & Sullivan, despite the implementation of austerity measures and defense budget reductions in many countries, the demand for conventional submarines, mainly with AIP on board, will grow at a compound annual growth rate (CAGR) of 1.8 per cent globally during 2013–2022 and present revenue opportunities of up to USD 34.80 billion.

"The naval operations environment has changed significantly; operations at sea have moved from the 'blue water' open ocean to the 'brown water' shallow costal environment," noted Frost & Sullivan Aerospace, Defense & Security Industry Analyst, Dominik Kimla. "The importance of smaller and quieter conventional submarines, rather than larger, nuclear-powered, has increased significantly."

—Frost & Sullivan
frost.com

Move Toward Digital Necessitates Bit Error Rate Testing

Advances in key technologies such as synchronous optical networking (SONET)/synchronous digital hierarchy (SDH) and Ethernet over SONET (EoS), as well as the deployment of 40 and 100 gigabit networks are expected to considerably boost the demand for bit error rate testers (BERTs) globally. The market will particularly benefit from the communication and IT industries' increasing adoption of digital technologies such as high definition multimedia interface (HDMI) and digital audio.

"As digital interfaces are complex in nature, testing them is challenging," said Frost & Sullivan Measurement & Instrumentation Industry Manager Sujan Sami. "BERT vendors are expected to develop innovative test solutions to address these complexities, as the current products do not fully satisfy the testing needs of some high-speed digital interfaces."

—Frost & Sullivan
frost.com

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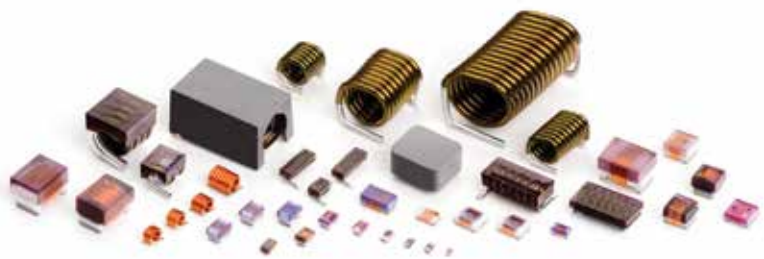

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Insitu, Inc., Bingen, Wash., is being awarded a $7,826,247 modification to a previously awarded firm-fixed-price contract (N00019-11-C-0061) to exercise an option for operational and maintenance servicesin support of the **ScanEagle Unmanned Aerial Systems.** These services will provide electro-optical/infrared and mid-wave infrared imagery in support of land based operations in Operation Enduring Freedom to provide real-time imagery and data. Work will be performed in Bingen, Wash., and is expected to be completed in January 2014. Contract funds in the amount of $3,557,385 will be obligated at time of award, all of which will expire at the end of the current fiscal year. The Naval Air Systems Command, Patuxent River, Md., is the contracting activity.

Raytheon Co., Tucson, Ariz., is being awarded a $12,773,553 firm-fixed-price, indefinite-delivery/indefinite-quantity contract for services in support of **Tomahawk missile** depot maintenance, including direct fleet support for resolving technical issues with forward deployed, in-theater weapons and inventory management for the U.S. Navy and the United Kingdom. Work will be performed in Tucson, Ariz. (70 percent); Camden, Ark. (24 percent); Commerce Township, Mich. (4 percent); Indianapolis, Ind. (1 percent); and various other continental U.S. (CONUS) and outside CONUS locations (1 percent).

Aero Thermo Technology, Inc., Huntsville, Ala., is being awarded a $6,779,733 cost-plus-fixed-fee contract to provide guidance systems, technical, analytical and program services to support the **TRIDENT II Submarine Launched Ballistic Missile** guidance systems requirements for strategic systems programs. They will support key guidance system technology development and coordination between the Navy and the Air Force for current and next generation strategic systems. The Navy and Air Force will conduct closely coordinated strategic ballistic missile technology development and application programs based on recommendations of the U.S. Strategic Command, Defense Planning Guidance, and Nuclear Posture Reviews.

Lingel

Nagle

Dielectric Laboratories, Inc. named **Thomas Lingel**, Ph.D., as Director of Engineering. Dr. Lingel joined DLI in January after spending the past 13-plus years at Anaren Microwave in progressively responsible positions. Prior to that he was with Dornier Satellite Systems GmbH and Siemens, while obtaining his Ph.D. in Electrical Engineering, graduating Summa Cum Laude from Ilmenau University of Technology, Ilmenau Germany. Dr. Lingel was active as a guest lecturer at Syracuse University and is currently the Chair of the IEEE MTTS-13 Committee "Microwave Ferrites and Ferroelectrics," and Vice Chair of the Syracuse Section of the IEEE. He has also served on different conference paper review committees. **DLI** also announced the appointment of **Brian G. Nagle** as Applications Engineer Manager. Nagle has over 11 years' experience at DLI with his most recent position as Quality Engineer. He will be serving customers globally with technical application inquires providing insight and guidance in the application and use of DLI's capacitor products.

Microwave-industry distribution pioneer **Chuck Swift** of **C.W. Swift & Associates** celebrated his 86th birthday last month in Van Nuys, Calif., with his family and employees. Many will recognize that as a redundant statement. Founded in 1958 as one of the industry's first microwave distributors, C.W. Swift focuses on a wide selection of RF, microwave and millimeter-wave transmission line connectors and components, "as well ultra-low VSWR pistachio nuts," Chuck added. In addition to his business responsibilities, Chuck, the original "Ol' Peddler," and the Swift crew have volunteered their time, talents, and energy to countless industry activities and events across five-plus decades. In 2010 the **International Microwave Symposium** and the **MTT-S Los Angeles Chapters** held a special luncheon in his honor to recognize Chuck's 55 years of service to the IEEE MTT-S. Happy Birthday, Chuck.

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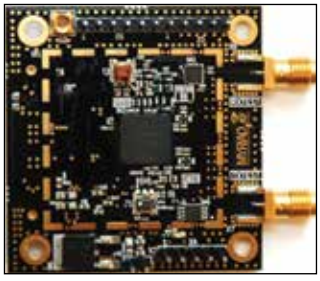
AWR Corp. recently co-sponsored the **University Student Design Competition** in China at Nanjing Postal University and SouthEast University, offering cash prizes to the first, second, and third place winners. The winning papers and an interview with design competition winner Wang Lei from SouthEast University are available on AWR's Chinese language site at http://www.awrcorp.com/cn/china-university-design-competition-2012. AWR is also sponsoring the **student design contest** at the IEEE **International Wireless Symposium 2013** (IWS2013) in Beijing, April 14-16, 2013. Eleven candidates have submitted papers for this competition and AWR will award the winners with cash prizes in the amount of $1,000 for first place, $750 for second place, and $500 for third place, to be shared among members of each team.

The Association for Unmanned Vehicle Systems International (**AUVSI**) unveiled a study that finds that the **unmanned aircraft industry** is poised to create more than **70,000 new American jobs** in the first three years following the integration of unmanned aircraft systems (UAS) into U.S. national airspace system (NAS). Integration is scheduled to take place in 2015. Beyond the first three years, the study projects that more than 100,000 new jobs will be created by 2025. "This is an incredibly exciting time for an industry developing technology that will benefit society, as well as the economy," said **Michael Toscano**, president & CEO of AUVSI. "In recent years, unmanned aircraft technology has grown remarkably and is already proving useful in a range of domestic applications. Integrating UAS into the national airspace will lead to new and expanded uses, which means the creation of quality, high-paying American jobs."



Lime Microsystems has launched an **open-source RF initiative** to widen the community of developers and aid RF innovation. Launched as a non-profit initiative, **Myriad-RF** aims to give both hobbyists and experienced design engineers a range of low-cost RF boards and free design files available for general use. Future board designs will come from the wider Myriad-RF community, with the first board (Myriad-RF 1) designed by Taiwanese distributor Azio Electronics. Myriad-RF boards use field programmable RF (FP-RF) transceivers to operate on all mobile broadband standards - LTE, HSPA+, CDMA, 2G - including all regional variants; and any wireless communications frequency between 0.3 and 3.8GHz. This includes the regulated, licensed bands and unlicensed/whitespace spectra. Lime has also beta-launched the Myriad-RF community website and forum, **www.myriadrf.org**. This resource will also house the board design files and example projects with how-to guides and the ability for users to contribute extra content.

HFE

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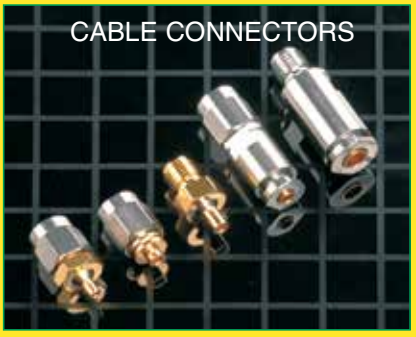

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Mixer

The MSMXVHF mixer with selectable high frequency lowpass/bandpass filter is a CMOS switched-capacitor integrated circuit that has an independent 500 MHz mixer and 1 MHz lowpass or band-pass filter. The selections are 6 poles Butterworth, Elliptic, Bessel lowpass or six pole full, 1/3 or 1/6 octave bandpass filter. Price is $7.05 each at 1,000 pieces for a SOIC-16 plastic package.

Mixed Signal Integration Corp.
mix-sig.com

Combiner

Model SWP-27340304-28-S1 is a Ka band waveguide 4 way power combiner offering minimum 5 GHz operational bandwidth in the frequency range of 26.5 to 40 GHz. It exhibits less than 0.5 dB insertion loss and more than 20 dB port isolation in the operation bandwidth. It features excellent phase and amplitude balance and is equipped with self-locking phase trimming tuners to further enhance phase balance fine adjustment capacity for some phase balance critical applications. With slight isolation performance degradation, the power combiner is suitable for full waveguide operation.

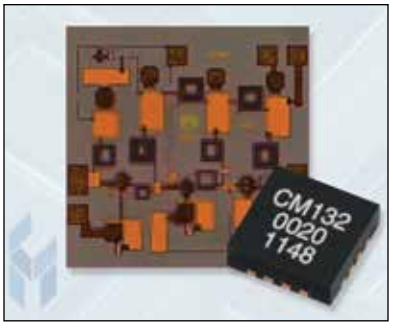
SAGE Millimeter
sagemillimeter.com

Cable Assemblies

AtlanTecRF now has stock of Low PIM cable assemblies designed specifically for applications where it is

essential to have a low level of passive intermodulation products. This newly launched series is available in two convenient diameters and a large range of lengths. In order to achieve the low intermodulation level of -155 dBm at 6 GHz with 2 tones of +26 dBm, the cable material consists of a silver plated copper center conductor with PTFE dielectric and a copper/tin composite outer conductor. Connector bodies are of tri-metal plated brass with no ferrous parts.

AtlanTecRF
atlantecrf.com



LNA

Custom MMIC announced a 5-11 GHz ultra-low noise amplifier. The CMD132P3 presents an ultra-low noise figure of 1.3 dB, delivers greater than 20 dB of gain across the entire bandwidth, and has a corresponding output 1 dB compression point of +10 dBm. It is housed in a RoHS-compliant, 3 x 3 mm QFN plastic surface mount package, requires a single supply voltage of +3.6 V at 30 mA. Ideal for microwave radios and C- and X-band applications where small size and low power consumption are needed, it is also suitable for point-to-point radios, point-to-multipoint radios, military and space applications, and test instrumentation.

Custom MMIC
custommmic.com

Power Sensor

Rohde & Schwarz added the R&S NRP-Z58 to its portfolio of power sensors. The sensor's high measuring speed of over 300 measurements per second in buffered mode allows especially fast power measurements. Range is 55 dB (–35 dBm to 20 dBm). When performing relative measurements such as amplification and reflection measurements, the R&S NRP-Z58 delivers extremely precise measurement results thanks to its high linearity of 0.01 dB.

Rohde & Schwarz
rohde-schwarz.com

Amp

AR RF/Microwave Instrumentation introduced the Model 350AH1 solid state amplifier. This portable, self-contained, 350 watt/10 Hz - 1 MHz unit provides power, durability and dependability along with the versatility for a wide range of applications. Designed for test and other laboratory applications where instantaneous bandwidth, high gain and moderate power output are required, the potential uses for Model 350AH1 are many and varied.

AR RF/Microwave Instrumentation
arworld.us

Capacitors

AVX Corp. introduced a new series of microwave MLCCs with near-pure silver (Ag) electrodes, which both enhance performance and mitigate cost. Exhibiting higher conductivity than competing non-precious metal RF capacitors, AVX's new UQ Series MLCCs feature ultra-low

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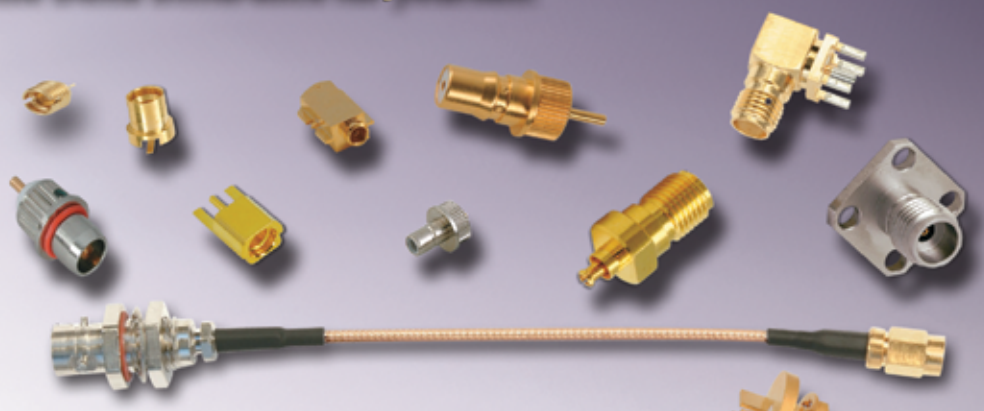

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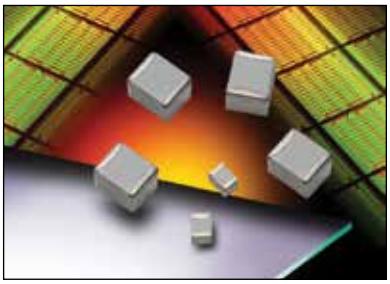

ESR, high Q, high self-resonance, and a capacitance range spanning 0.1pF to 1000pF. Ideal applications for the UQ Series include RF power amplifiers, low noise amplifiers, filter networks, and MRI systems.

AVX Corp.
avx.com

Optical Power Meter

Agilent Technologies Inc. introduced the latest addition to its extensive optical power-meter portfolio. The two-channel N7747A and four-channel N7748A bring the industry-leading sensitivity of the 81634B sensor module to the compact multichannel N77 platform, with updated memory size and data-transfer speed. These optical power meters enable engineers to make parallel multiport measurements and monitor weak signals and small signal changes with high precision in communications or sensing applications. The meters can detect power levels down to -110 dBm and log data at intervals down to 25 µs with up to 1 million points per channel.

Agilent Technologies
agilent.com

Switch

Mini-Circuits' model MSP4TA-18+ SP4T switch features low insertion loss, 0.2 dB typ.; high isolation, 85 dB typ.; ultra-reliable; break-before-make configuration; absorptive failsafe switch. Applications: (ATE) automatic test equipment; reliable

"sleeptime" switching; redundancy switching for microwave radio.

Mini-Circuits
minicircuits.com

Filters

RFMW, Ltd. announced design and sales support for 6 GHz broadband wireless filters from Sangshin Elecom. The MBP33RC6162S525A is an excellent choice for wireless backhaul applications where flexibility in channel planning and selection is critical. It covers from 5.9 GHz to 6.425 GHz in a small 8.5 mm x 5.6 mm package. It exhibits insertion loss of 2.0 dB, 25 dB of rejection at 5.5 GHz and return loss of 12 dB while operating from -40 deg C to +85 deg C. A complementary filter, the MBP33RC5212S525A covers the frequency band of 4950 to 5475 MHz and offers comparable performance to the MBP33RC-6162S525A.

RFMW, Ltd.
rfmw.com

LNA

PMI Model No. PE2-25-218-20-12-SFF is a 2.0 to 18.0 GHz low noise amplifier that provides greater than 25 dB of gain while maintaining a maximum gain flatness of ±1.5 dB maximum over the operat-

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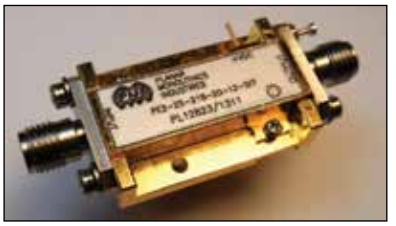

ing frequency. The noise figure is 4.5 dB typical and offers an OP1dB of +20 dBm minimum. The operating voltage is +12 to 15VDC and the current draw is 300 mA maximum. This amplifier is supplied in a PE2 package that measures 1.08" x 0.71" x 0.29".

Planar Monolithics Industries
pmi-rf.com

Power Splitter

Mini-Circuits' model SEPS-4-272+ surface-mount power splitter/combiner features good isolation, 20 dB typ.; good output matching, VSWR 1.1 typ.; shielded case; aqueous washable; good coplanarity. Applications include: cellular, GPS, PCS, CATV, ISM, wireless communications systems.

Mini-Circuits
minicircuits.com

Power Amp

RFMW Ltd. announced design and sales support for the RFPA2026, 700 to 2700 MHz, 2W power amplifier module from RFMD. It is a 3-stage module with independent bias control for each stage plus the ability to bypass the first stage to reduce gain and power consumption. With all stages active, it provides 38 dB of gain at 2140 MHz with a corresponding P1dB of 33 dBm. External matching and bias control allows the RFPA2026 to be optimized for various applications including small-cell power amplifiers and ultra-linear driver amplifiers. A power-down capability decreases power consumption and improves system sensitivity.

RFMW
rfmw.com

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Measuring Peak and Pulse Power with USB Power Sensors

By Orwill Hawkins

This paper will compare Pulse Power measurement using new, accurate USB Sensor technology to traditional measurement methods.

Advances in computing and measurement technology have increased the capabilities of USB RF Power Sensors. These advances have made measurement capabilities possible at modest costs that were previously out of reach. Capabilities like direct measurement of pulse power can now be done with low cost USB power sensors, such as those used in the example below. This paper will compare Pulse Power measurement using new, accurate USB Sensor technology to traditional measurement methods.

Traditionally, Microwave Pulse Power has been measured using average power and applying the pulse's duty cycle using the long time accepted formula:

Pulse Power = Average Power / Duty Cycle.

This method uses total measured power over time and produces a computed Pulse Power result based on assumed pulse information. Unfortunately, additional information such as peak power, droop, and crest factor may remain unknown, rendering the measurement limited in value. Significant errors are also possible with this method due to errors in the assumed pulse width and duty cycle. Errors caused by discrepancies between actual and assumed pulse shape or malfunctioning equipment may also occur.

Given the rapid advances in modulation technology, it is important to recognize the need for the additional information and accuracy that is now available with today's Power Sensor technology.

Modern Power Sensors

Modern USB Power Sensors utilize cutting-edge processing technology and are capable of rapidly measuring and digitizing the demodulated waveform. These sensors integrate the measurement data over time and provide the user with actual pulse power, and provide additional measured parameters such as peak power, crest factor and duty cycle, in addition to average power. This information is often very useful for the engineer, designer and technician. Figure 1 depicts a microwave pulse stream and indicates some of the desirable information that can be measured with a USB Power Sensor.

To deliver the necessary measurements, USB Peak and Pulse sensors use advanced trigger schemes that accurately locate the pulse mesial's and process the digitized data

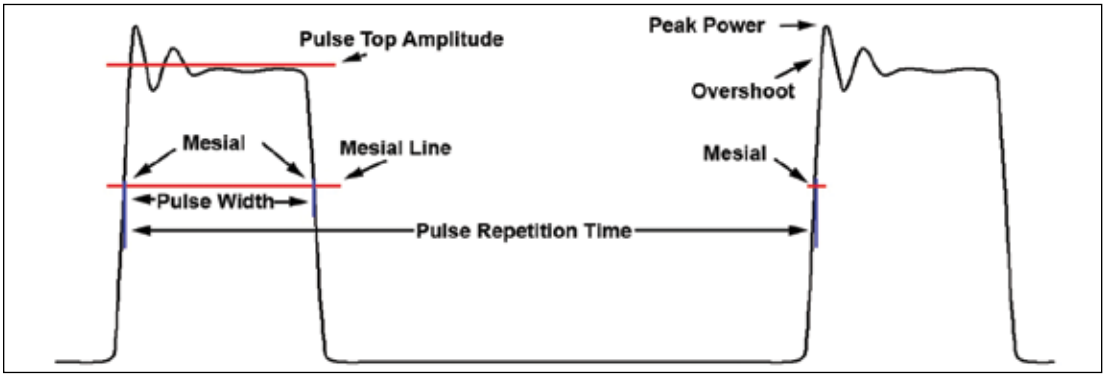

Figure 1 • Pulse Waveform Detail.

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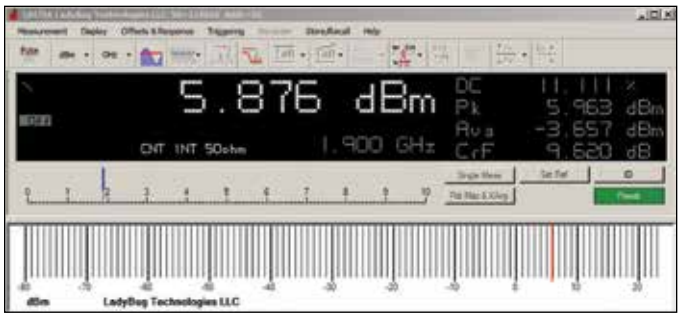

Figure 2 • Power Measured with a LadyBug LB479A.

from the measured power. These sensors provide accurate Peak Power, Pulse Width, Pulse Power, Pulse Repetition Rate, Duty Cycle, Crest Factor and more. As an alternative, some USB sensors, such as the LadyBug LB480A PowerSensor+™ that was used in the example below, support external triggering. This allows control of the measurement timing and can be particularly useful with very low power measurements where the signal might be near the noise floor. Averaging repetitive signals improves measurement accuracy.

Pulse Power Example

For example purposes, pulse power was measured from a small test source. The pulse modulating waveform has an

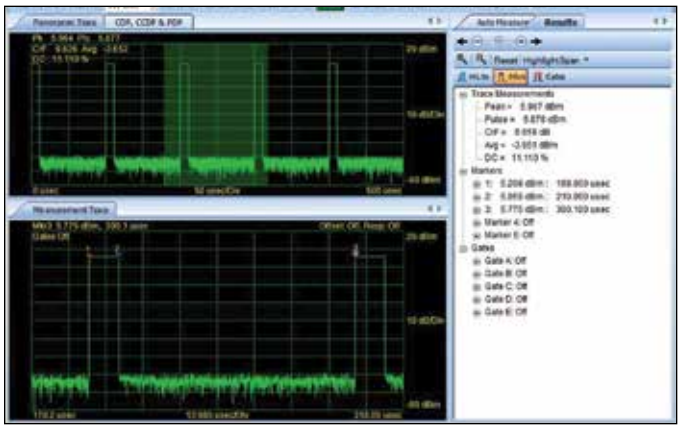

Figure 3 • Pulse Profile Measurement.

11 microsecond pulse width and a pulse repetition time of 100 microseconds. The Pulse carrier frequency is 1.9 GHz, and the on/off ratio for the test signal is better than 80 dB. Pulse power is just under 6 dBm. The test source was connected directly to the LadyBug LB479A Peak, Pulse and Average Sensor. The LB479A operates from 10 MHz to 8GHz and over a dynamic range of - 60dBm to +20dBm.

A screen shot of the measurement is shown in Figure 2. All of these measurements were made simply by connecting the sensor to the signal source and entering the carrier frequency. This greatly simplifies and speeds up the measurement process whether it is in a bench, ATE, or service environment.

Analyzing the Results

The traditional method requires the user to know the signal's Duty Cycle in order to calculate Pulse Power. Because Average only Sensors are not capable of measuring Duty Cycle, it must be calculated using the formula below. In many cases the Duty Cycle is given or assumed, not measured, adding suspicion to the measurement's accuracy. In this case the Duty Cycle is given as 11.0%

Duty Cycle=Pulse Width / Pulse Repetition Rate.

Calculated Duty Cycle is 11% (=11us/100us)

Note that the calculated 11% Duty Cycle is close to the 11.1% actual Duty Cycle measured by the sensor. This method can lead to other inaccuracies in the measurement caused by errors in the assumed pulse parameters, amplifier or modulator distortion, failing components etc.

The sensor measured -3.657 dBm average power. Prior to applying the traditional method of determining Pulse Power, the measured average power must be converted from dBm to a linear scale, in this case mW. The following equation was used:

P mW=10^(PdBm/10) = 10^(-3.657/10) = 0.431 mW.

Now that linear power and Duty Cycle are known, Pulse Power can be calculated using the standard traditional formula:

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Pulse Power = Average Power / Duty Cycle as mentioned earlier.

Plugging in the numbers results in a pulse power of 3.92 mW or 0.431 mW/0.11. This can now be converted back to dBm using

$PdBm=10*\log_{10}(PmW)$

The result is 5.933 dBm, and is very close to the more precisely measured 5.879 dBm.

For further comparison, the Sensor was replaced with a LadyBug LB480A with pulse profiling time domain analysis capability as shown in Figure 3.

Zoom was utilized to expand the data and three markers were placed to determine the pulse width and repetition rate. Start time is shown by Marker #1 at 199.950us, Marker #2 marks the pulse's end time at 210.950us, and Marker #3 marks the end of the cycle at 311.100us. The results visually and mathematically confirm previous measurements.

Conclusion

USB Peak, Pulse and Average Power Sensors, provide a lot of the valuable information that a Time Domain, Pulse Profiling sensor provides, at less cost. These sensors accurately measure Peak, Pulse & Average Power plus Duty Cycle along with analysis such as Crest Factor. The Sensors can expose unexpected system faults that cannot be found using an Average Power Sensor. These facts make them a very good alternative to traditional methods that utilize average only Sensors and combine the readings with the assumed pulse parameters. Today's modern Peak, Pulse and Average Power Sensors such as the LadyBug Technologies LB479A that was used in the example above, are cost-competitive solutions for RF engineers and technicians.

About the Author:

Orwill Hawkins, Vice President of Marketing at LadyBug Technologies, has over three decades of management, marketing, engineering and manufacturing experience. He also has extensive hands-on design experience in the RF, analog and digital fields. Among the many products he has designed and marketed are a self-contained RF field disturbance burglar alarm system, a sailboat speedometer, and various robotic servo systems. Additional inventions include a prototype oscilloscope, a CNC cutting system, and various other analog, digital and RF inventions.

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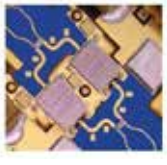

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Microwave Engineering Education

By Tom Perkins
Senior Technical Editor

Exploring some of the history, current trends, and what the classroom of the future may look like.

Abstract

According to recently released statistics by The Alliance for Science and Technology Research in America, slightly over 25 percent of high school students in the United States are interested in Science, Technology, Engineering, Mathematics and Statistics (STEM). According to the US Department of Education the percentage of bachelor's degrees conferred in STEM fields in the United States was lower in 2008-2009 (24.2 percent) than it was in 1998-1999 (25.6 percent). Engineering education and particularly majors in microwave electronics have gone through significant change in the past 60 years. Our *High Frequency Electronics* Editorial Calendar for April 2013 includes the topic of Engineering Education. Having an increasing interest in this general topic and having both taken and taught courses in microwaves, I decided to tackle this topic. This article explores some of the history, current trends, and what the classroom of the future may look like.

At the Campus Bookstore

The first textbooks available for the budding microwave technology field, which was often considered more of an art than a science in the middle of the 20th century, were 1) the incredibly comprehensive and still useful 28 volume *MIT Radiation Laboratory Series,* 2) a book titled *Waveguide Handbook* edited by Nathan Marcuvitz which famously became Volume 10 of the Rad Lab Series, and a few others such as 3) *Theory and Application of Microwaves* by Arthur Bronwell and Robert Beam, 1947. Interestingly, Dr. Marcuvitz died at age 96 in 2010, so he got to see and experience incredible advances. The addition of circuits with distributed constants in Fred Terman's *Radio Handbook* is certainly noteworthy. As time went by a number of contemporary textbooks became available such as *Foundations of Microwave Engineering* by Robert E. Collin, 1966; *Microwave Engineering Passive Circuits* by Peter A. Rizzi, 1988; and *Microwave Engineering* by David M. Pozar, 3rd Edition, 2004. The latter book, originally published in the 1990s, is widely used today. Numerous books devoted to specialized technology within our field have been published over the years. I would guess that active microwave amplifier and oscillator devices would top the list, including lots of material devoted to monolithic microwave integrated circuits (MMICs).

Prerequisites

The problem with many current EE curriculums is that only one Emag course is required. One reason that students hesitate to take other electives in this area is because they are intimidated by the mathematics. Defense-centric companies do little to promote their work and therefore students are generally unaware of the excitement and fulfillment derived from designing and building a radar system, satellite hardware, MMICs, antennas, etc. They generally pursue digital and computer courses, thinking perhaps if they go down another path they will miss out on the lucrative future opportunities. Now that A/D's are sampling at 5 GHz and higher, digital technology will play a large role, but there has to be an understanding that signals travelling on the digital signal lines are at GHz frequencies and hence a good knowledge of microwave transmission

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lines, radiation, noise, and signal isolation will be required. Most credible microwave courses require prerequisites, in addition lots of basic math and physics courses, such as Electro-Magnetic Fields and Solid State Device Physics. Because of heavy emphasis on materials technology and semiconductor foundry activity since the 1980s, there may be a necessity for materials science and chemistry courses, also. A downside is that a number of schools have dropped microwave engineering courses or relegated them to post-graduate status. The reasons are not clear, but likely the lack of interested students coupled with relatively high costs, particularly in maintaining laboratories, are factors.

There are approximately two dozen schools in the United States that offer microwave courses in the undergraduate curriculum. Examples are Ohio State University, University of Illinois at Urbana-Champaign, Penn State University, Georgia Tech, Arizona State, University of Colorado, University of Massachusetts, University of Mississippi, and the University of Michigan. There are very good schools worldwide with some emerging opportunities now in places like Brazil, India, and China. Schools offering both undergraduate and graduate level courses worldwide (not complete) can be found at:

http://www.microwaves101.com/encyclopedia/colleges.cfm

Example of a Comprehensive Study Program

The University of Michigan at Ann Arbor, has traditionally offered many in-depth courses in our field. The University of Michigan offers fundamental courses such as Microwave Circuits I focusing on CAD tools, passive and active circuits and use of modern laboratory equipment. CAD software providers often provide universities with free programs recognizing that the student user will grow into and request the products in the work environment later. The same goes for test equipment which is sometimes offered to institutions at a reduced rate or even donated.

Years ago this was often not the case. Labs were usually equipped with left-overs and discarded equipment even going back to WWII surplus gear. Not necessarily a bad thing—I once took advantage of the fact that I had worked with klystrons (Figure 1) in college. In the early 1970's, I was asked to make some time-consuming phase shifter measurements for a new project. All the then-modern microwave signal sources (like Alford sweepers) were in high demand. So I spotted a klystron with its somewhat draconian power supply on the shelf, hooked it up, and made my measurements. No one bothered my set-up for weeks, because most didn't know what it was—or maybe were afraid of high voltages. Speaking of old equipment, I have found that many recent graduates of microwave curriculums seem to have no idea of what Lecher wires or slotted line (Figure 2) is. This is a bit unfortunate because basic laboratory devices give one a "visual" feel for standing waves and related phenomenon. The Smith Chart may be going the same way.

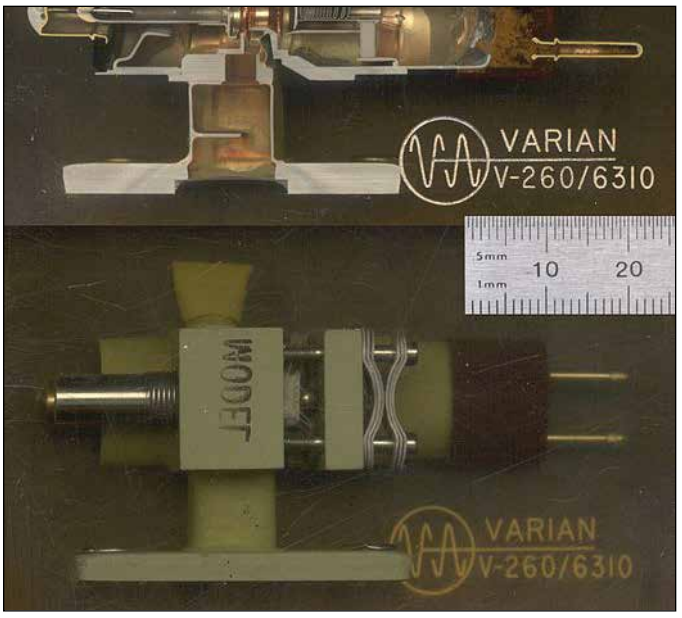

Figure 1 • Reflex klystron including cutaway view.

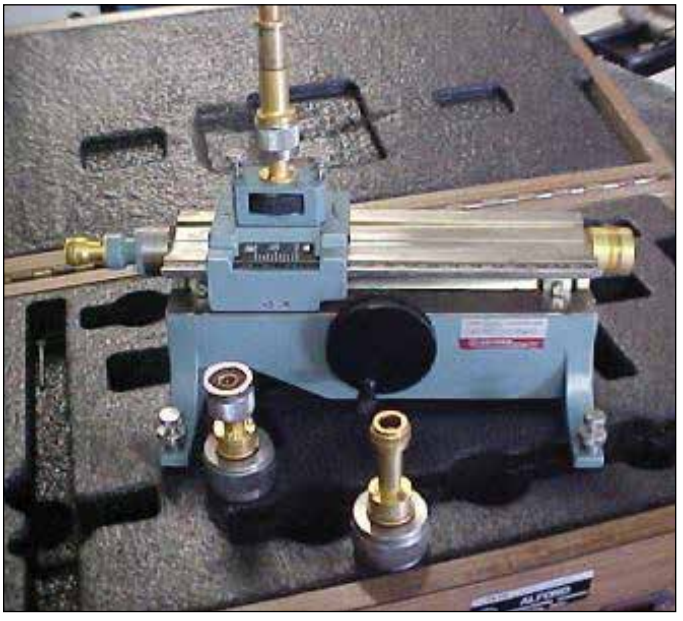

Figure 2 • Alford Model 3300 slotted line.

Now back to the University of Michigan example. They have a Radiation Laboratory (RAD). Quoting from the University's webpage:

"Areas of focus include antennas, from HF to terahertz frequencies; computational electromagnetics and modeling techniques; electromagnetic wave interactions

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Obviously the cost for all this is significant and may explain why some schools have dropped actual hands-on laboratory activity completely from their curriculum.

Coming of Computers

Starting over four decades ago, computers have had an impact on how and what is taught in engineering programs at the college and university level. No longer does a student have to walk to some remote campus computer building with no windows – yes, pun intended - to submit punch cards for processing in an IBM 1620 or similar system. Now we have portable devices that can be taken virtually anywhere that have far more calculating power than imagined back then. We can access just about any information instantly, greatly eliminating the need for a conventional book library. While technology has made incredible advancements that impact most people's lives, the use of this technology in engineering education offers a great challenge. Students can perform significantly complicated calculations accurately in a very short time with fantastically high fidelity visual data results. RF and microwave courses compete for funding and students with more popular computer courses and other technologies such as medical electronics, nanotechnology, robotics, etc.

Analytical tools have improved significantly over the past ten years. Finite Element analysis, which was mechanical engineering's foremost analysis tool, made its way into the microwave/EM arena. This has made possible the design and then simulation of devices. The advanced adaptive meshers and matrix solvers in combination with the large computer memories have driven the development of tools such as ANSYS HFSS, FEKO, Microwave Office™, Sonnet, CST and COMSOL, to name a few, for microwave EM analysis. Without these tools, the development cycle of new circuits and devices would be much slower and therefore more expensive.

Modern Classroom Amenities

Classrooms of old were typically equipped with black or green chalkboards, chalk, and erasers. Now they are equipped with white boards, computer projection systems, internet connections, and Wi-Fi services. Even more recent are electronic white boards with lecture capture cameras. According to Dr. Robert Henry of the University of New Hampshire, these amenities introduce higher costs, including 3 to 4 year replacement cycles for hardware, cost for new software, more square footage per student, more initial course development time, training faculty in use of the equipment and software, and additional IT support personnel. Students often bring devices such as iPods, laptop computer, and smart phones into the modern classroom. Resources now available include electronic textbooks, Wikipedia, YouTube, search engines, Skype, and free content lectures on radar, electronic warfare, LTE, etc.

Instructional Delivery

Prior to the advent of electronic media, it was generally accepted that face-to-face delivery was the best method. Increasingly, we now have on-line delivery augmented by incredibly well orchestrated graphics and possibilities for demonstration of wave motion, electron flow and other realism. Blended means for instruction are now a strong possiblility. The actual classroom experience and opportunity for questions is still hard to beat. We will likely see a progression from less use of the white board to more use of PowerPoint slides and animated videos. Use of programs like Blackboard (ironic name) can provide the student with posted class notes, assignments, solutions, electronic submission of homework, listing of links/web sites, chat sessions and blogs. Teachers can e-mail comments on homework or lab reports back to the student rapidly. Also, material can easily be archived. The availability of all these tools should not be an excuse to sleep, miss class or surf the web when one should be paying attention to the instructor. Unfortunately, this can be a downside of these technology advancements.

Additional Advantages of Electronic Media

Mostly obvious other advantages are help available to all students, ease of making announcements such as special events or guest speakers, student-to-student interaction via various media, growing access to industry events, remote access from anywhere and secure access to grades. Finally, we will likely see increased *Asynchronous Learning*. According to Wikipedia, this is a student-centered teaching method that uses online learning resources to facilitate information-sharing out-

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A Different Approach

In researching this topic a bit, I stumbled upon a paper written by Maryland-based educators describing an innovative microwave engineering course with a concurrent laboratory. The paper states: "This course is offered in the context of a collaborative electrical engineering program among Salisbury University (SU), University of Maryland Eastern Shore (UMES), and University of Maryland at College Park (UMCP). In contrast to the traditional lineup of topics, we develop the course using circuit theory all the way through ABCD and Scattering matrices, transmission lines and impedance matching. Only then, about mid-semester, do we make our first reference to Maxwell's Equations and develop the theory of waveguides. In order to address the pedagogical concern expressed in the literature, we have retained the almost moribund slotted lines while concomitantly introducing the snazzy network analyzers in the laboratory experience. The need for designing such a course was motivated by the inexplicable - but welcome - presence of over half a dozen microwave companies concentrated in a narrow rural corridor on the lower eastern shore of Maryland coupled with a severe shortage of qualified engineers desperately sought by these companies."

There is indeed a unique concentration of competitive microwave companies, mostly who design and produce filters in this area. These companies must compete for talent with areas such as greater Atlanta, Boston, Silicon Valley, Long Island, etc., having multiple schools geared for microwave training.

Student Group Projects, Student Papers and Hardware Competitions

Worth mention is the emergence of on-campus sponsored hands-on projects, student paper and hardware competitions. In recent years a feature of the IEEE Microwave Theory and Techniques Symposium has been dedicated contests in papers, poster sessions and competitions between school campus teams. The hardware competitions might include building amplifiers with lowest noise figure or highest efficiency, filters with highest Q, just to name a couple. This encourages activity beyond the classroom only experience that ruled the past. Obviously a lot of team spirit, much like a sports event, goes with this. Hurray for the nerds!

Universities have become smarter by requiring capstone projects for seniors. These often get industrial sponsorship. The sponsor company often participates in on-campus evaluation of the projects. This provides the opportunity for companies to get to know students and possibly invite them for interviews.

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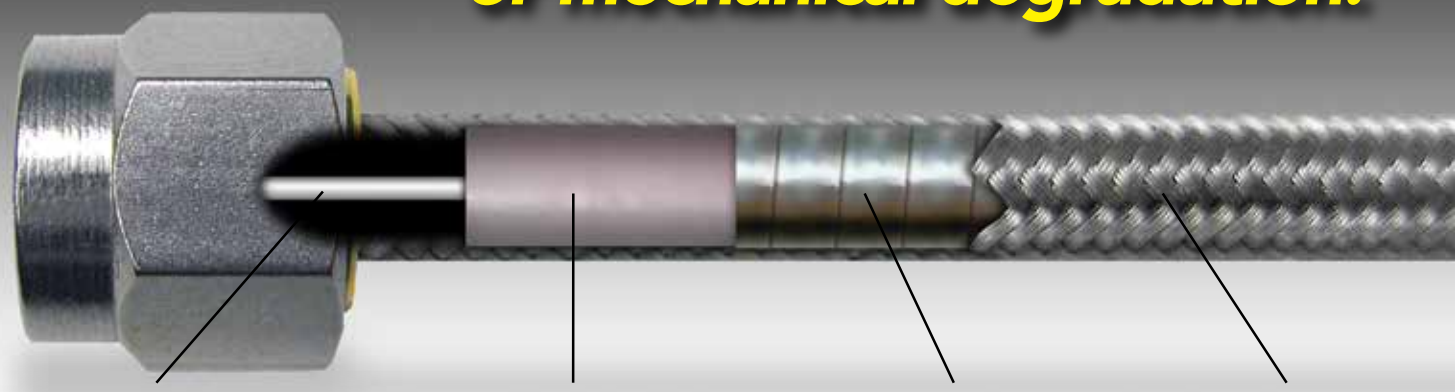

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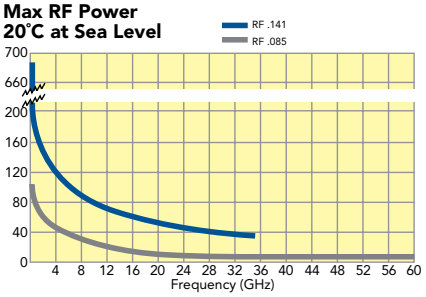

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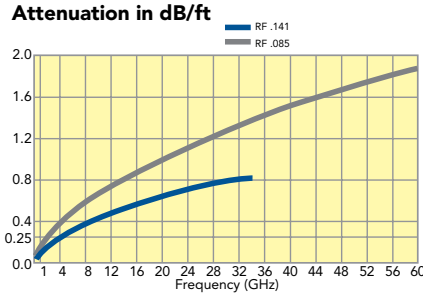

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Beyond the College Classroom

Certainly worth mention are focused microwave courses taught with the purpose of providing updated or new knowledge to the engineering or industry-related professional beyond the formal college education. These courses are often company-sponsored (perhaps to a lesser extent than in the past due to financial constraints) or taught by outside entities such as Besser Associates. This approach serves to fill a partial void and can be adapted to the audience background, level of expertise and depth of need for understanding. I have personally taught many microwave courses to engineers who weren't sure whether they wanted to pursue microwave engineering, support personnel such as mechanical engineers who wanted to better understand the technology, and sales people who often are intimidated by technical details because no one ever explained even basic terminology. Of course the depth of the material has to be tailored for the particular class audience. This activity can be very rewarding for both student and instructor.

Conclusion

The instruction in high frequency electronics, like many other disciplines, is undergoing a paradigm shift mostly influenced by the explosion of electronic media, computer-aided design and sophisticated test equipment. One question is whether schools are preparing students adequately for the confluence of high frequency analog and digital technology. The basic one semester EM course is insufficient background for the next generation of EE students. Because the push is for ultra-wide bandwidth, driven by the internet and smart phone services, etc., many students must deal with frequencies above 1 GHz. A basic inductor, capacitor, resistor (lumped devices) electronics background is not sufficient to solve high frequency problems. There should be a push to include at least two EM requirements in the undergraduate curriculum: basic EM and microwave techniques. It's interesting to contemplate that many of the microwave technology advancements of the last two decades have enabled changes in the way courses are taught, e.g., wireless internet access, thus being self benefiting for our high frequency trade.

About the Author:

Tom Perkins is the Senior Technical Editor for *High Frequency Electronics*. He wishes to thank *HFE* Editorial Advisors Dr. A. Abedi and Dr. R. Gilbert for review and advice.

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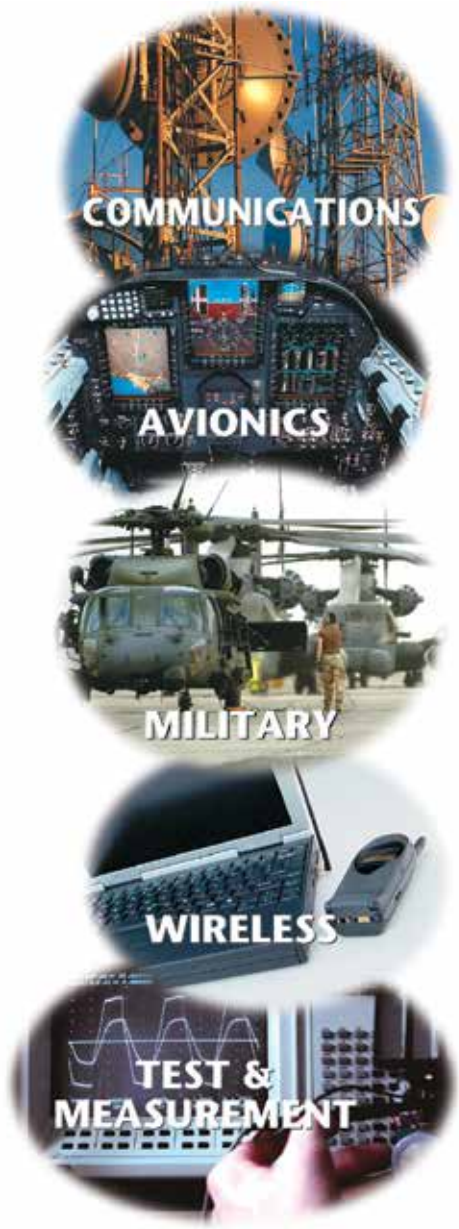

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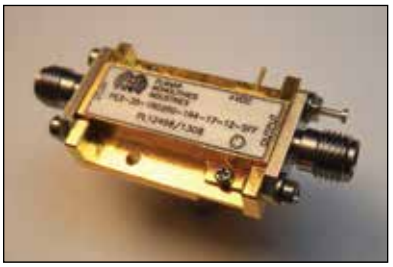

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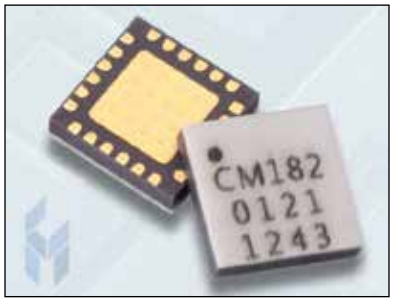

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Contacts:

Scott Spencer, Publisher
scott@highfrequencyelectronics.com

Tim Burkhard,
Associate Publisher-Managing Editor
tim@highfrequencyelectronics.com

Tom Perkins, Senior Technical Editor
tom@highfrequencyelectronics.com

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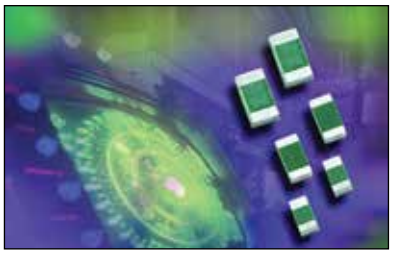


Resistor

Vishay Intertechnology, Inc. announced that it has extended its E/H series of MIL-PRF-55342-qualified thin film surface-mount resistor chips to offer an "S" level failure rate of 0.001 % per 1,000 hours in 12 case sizes. The QPL devices are qualified to TCR characteristics E, H, K, L, and M. The enhanced resistors' established reliability is assured through 100 % screening and extensive environmental testing that includes 100 % group A, power conditioning, and Group B lot testing, through which the devices have been rated and approved for an "S" failure rate level.

Vishay Intertechnology
vishay.com

Thermistor

API Technologies Corp. announced its latest development in NTC thermistors, Surge-Gard™ inrush current limiting devices. Designed to limit the inrush current that occurs when power is applied to a system, Surge-Gard NTC thermistors help reduce circuit failures and lower rectifier costs by reducing required peak forward surge current ratings. Featuring steady state current ratings ranging from 1 to 36 amps and resistance values from 0.5Ω to 220Ω, Surge-Gard is manufactured using specially formulated metal oxide ceramic materials that allow the thermistors to suppress high inrush current surges.

API Technologies Corp.
apitech.com

Amplifier

The R&S BBA150 amplifier family covers a wide range of applications. The amplifiers can be used for EMC testing up to 3 GHz in line with common standards, for instance for EMS measurements in line with the basic EN 61000 4 3 standard

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

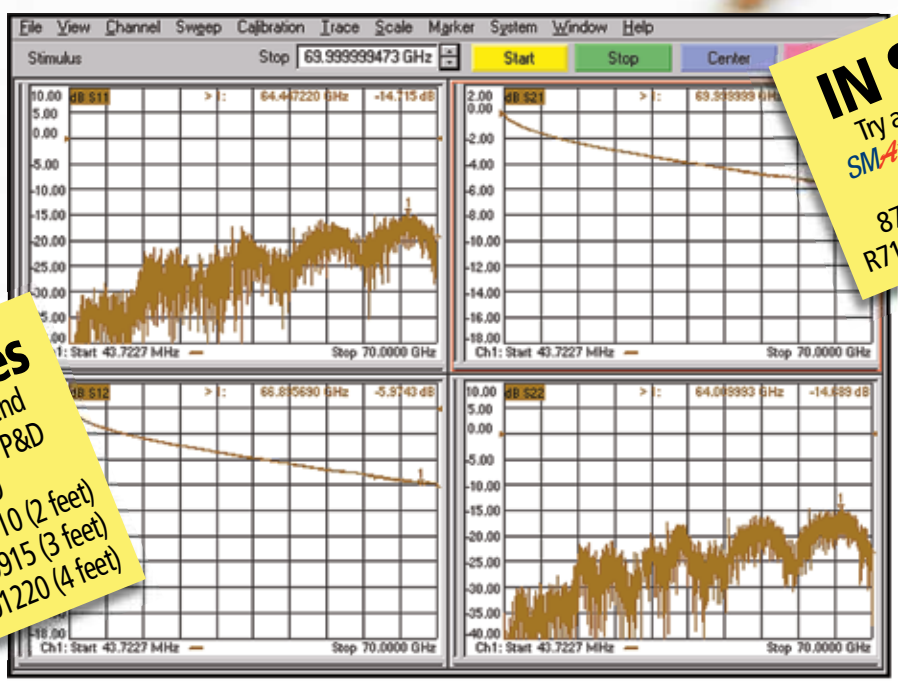
MECHANICAL SPECIFICATION

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

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)
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PH: 408.414.1450 or 877.367.7369 Email: sales@rfmw.com
Website: www.rfmw.com/Rosenberger

and referencing product standards. Manufacturers can also use these amplifiers for non-EMC applications in component production and quality assurance. The amplifiers are suitable for research, physical engineering and communications applications as well.

Rohde & Schwarz
rohde-schwarz.com

Filter

PMI Model 7CL5125-1490-CD-SFF is a band pass filter centered at 5125 MHz and has a nominal bandwidth of 1490 MHz. This filter provides over 40 dB of rejection between 3.0 to 3.658 GHz and between 6.65 to 7.3 GHz and over 65 dBc of rejection between 1.5 to 2.5 GHz. This filter has a low insertion loss of less than 1 dB and measures 1.9" x 0.875" x 0.5".

Planar Monolithics Industries
pmi-rf.com

Circulator

The HMC15-385-60.0-2.0 ferrite junction circulator utilizes a low loss H-plane structure in a modified Y-junction format to provide minimum loss with maximum isolation and bandwidth. The circulator is commonly employed as a signal duplexer on transceivers having a single antenna. The in-line port orientation makes the mechanical interface more convenient than standard Y-junction types. Access pockets on the top and bottom allow for blind flange mating, eliminating the need for interconnecting waveguide in many cases.

Renaissance Electronics/HXI
rec-usa.com

VHF/UHF Receiver

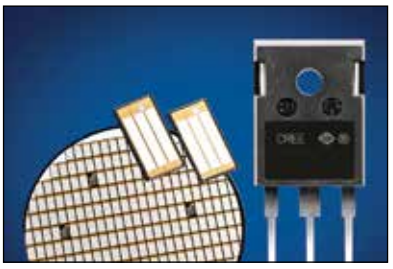
Elcom's SIR-3200 receiver, covering 20 to 3000 MHz, is designed to deliver the high-level of performance required in today's most demanding VHF/UHF signal monitoring applications. The RF analog front-end architecture of the SIR 3000 offers exceptional dynamic range and low spurious. High-speed, high-resolution digital signal processing provides fourteen selectable IF bandwidths ranging from 3.2 KHz to 10 MHz. Additional IF bandwidths of 20 MHz and 40 MHz are available as options.

FEI-Elcom Tech
elcom-tech.com

RF Transformer

Mini-Circuits' model TCM1-43X+ surface-mount RF transformer features: wide bandwidth 10 to 4000 MHz; balanced transmission line; low insertion loss, 1.1 dB typ.; excellent return loss; aqueous washable. Applications include: PCS, wideband push-pull amplifiers, cellular.

Mini-Circuits
minicircuits.com



MOSFET

Cree, Inc. released its second generation SiC MOSFET enabling systems to have higher efficiency and smaller size at cost parity with silicon-based solutions. These 1200V MOSFETs deliver industry-leading power density and switching efficiency at half the cost per amp of Cree's previous generation MOSFETs. At this price-performance point, they enable lower system costs for OEMs and provide additional savings to the end-user through increased efficiency and lower installation costs due to the lower size and weight of SiC-based systems.

Cree, Inc.
cree.com

Phase Shifter

Model P2P-68T-5 is a broadband digitally controlled PIN 360 degree diode phase shifter operating from 6.0 – 18.0 GHz. This device offers up to 0.088 degree resolution with 12 BITs of TTL compatible binary logic and switches in less than 500 nSec. Across the entire band, phase accuracy is +/-10 degrees, amplitude balance +/-1.0 dB, and VSWR 1.9:1 in 50 Ohms. Input power is up to +15 dBm CW or 1.0 Watt max. The operating temperature range is extended from -55 to +85 degrees C. Package size is 3.00 x 3.00 x 1.00 in.

GT Microwave Inc.
gtmicrowave.com

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25 MHz to 6 GHz
SIGNAL GENERATORS

70 dB Power Range

only $2695 ea.

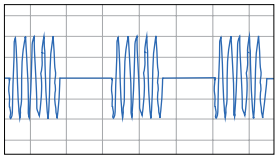
Rugged, portable, USB-controlled generators for production test

Sweep or hop across wide frequency and power bands, trigger a single pulse or a continuous pulse train, use a pair for third-order intercept tests, or slip one into your laptop case and take it on the road! Our simple-to-use GUI will have you up and running in minutes, with almost any PC.* Like all of our portable test equipment, the new SSG-6000 is compatible with most test software,* adding capabilities and increasing efficiency without busting your budget!

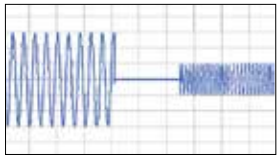
* See data sheets for an extensive list of compatible hardware and software.

Synthesized signal source for accurate, reliable testing

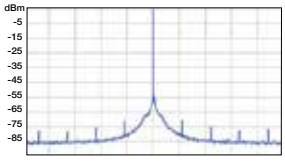
Signals within 1 ppm for frequency and 0.25 dBm for power (-60 to +10 dBm), low harmonics (-50 dBc), frequency resolution from 3 Hz, trigger and reference ports in and out, and a 3-msec settling time help you get the data you need from complex, high-speed testing plans. Just go to minicircuits.com for specifications, performance data, and everything you need to make your choice — and get it in your hands as soon as tomorrow!



NOW! Pulse widths from 1µS.



Frequency and power hopping.



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U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

NEW PRODUCTS

Filter

Mini-Circuits' new high pass filter HFCN-103+ is an LTCC based 7 section design that extends the upper frequency cutoff range of the existing HFCN series to 10 GHz. Systems that previously relied on large distributed filter elements to support these lower frequencies can save space and system complexity by integrating the HFCN-103+ into new designs. These filters are offered in an EIA 1206 package size and have a typical stop band rejection of 30 dB.

Mini-Circuits
minicircuits.com

Sensors

E-UGS Unattended Ground Sensors are seismic sensors that can be deployed in seconds and provide live seismic sensing for up to six months to protect the perimeter of any area without endangering personnel. Capable of the early detection of people walking and vehicles, the sensors are disposable and the controller/receiver operates with a PC or laptop and shows maps with sensor locations and status alerts for activated sensors.

Applied Research Associates
ara.com

Power Amp

Solid-state power amplifiers covering the 1 - 6 GHz frequency band require dual bands (two separate amplifiers) to provide high output power. AR created single band Models 15S1G6 & 50S1G6, providing 15 & 50 watts of linear output power across the 1 – 6 GHz frequency band with excellent gain flatness.

AR RF/Microwave Instrumentation
arworld.us

EMERSON
Network Power
Connectivity Solutions

Cable Assemblies

Emerson Network Power Connectivity Solutions announced the Semflex Quick Turn Cable Assembly program, which offers the precision low-loss Semflex HP series cable assemblies to ship from the factory within 48 hours of receipt of order. The cable assemblies offered consist of the HP120, 160, 190 and 305 series with available connectors of SMA, 2.92 mm, 2.4 mm and Type N. Performance is up to 50 GHz.

Emerson Network Power
emersonconnectivity.com

Connector

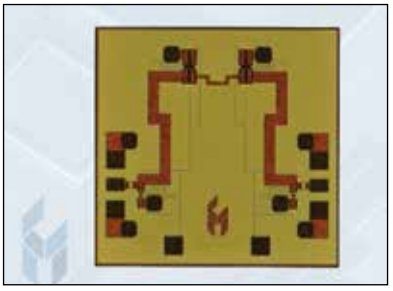
The 7 mm interface is a hermaphroditic precision coaxial connector available in panel mount, cable mount and between-series adapter configurations. Constructed of polished passivated 303 stainless steel coupling mechanisms and outer shells with gold plated beryllium copper inner contacts, the 7 mm operates over a DC to 18 GHz frequency range. Panel mount offers solid probe contact and extended dielectrics and tab contacts. Cable connectors are available for .141 and .250 inch diameter semi-rigid as well as popular high-frequency low-loss flexible cables. Adapters to 2.4 mm, 2.9 mm, 3.5 mm, SMA, SSMA, N Type and TNC connector types are all standard and available for immediate shipment.

SGMC Microwave
sgmcmicrowave.com

Power Amplifiers

AR now complements its line of 4-18 GHz Hybrid Power Modules (HPM's) with new designs covering the 1-6 GHz frequency range in one amplifier module.

AR RF/Microwave Instrumentation
arworld.us



Attenuator

Custom MMIC introduced the CMD172, a new Voltage-Variable Attenuator (VVA) in die form operating from 18 to 40 GHz. Fabricated in GaAs with a small footprint, it is a wideband absorptive VVA die that uses a single DC control voltage between -3V and 0V to vary the RF signal level over a 37 dB dynamic range. The insertion loss

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Custom MMIC
custommmic.com

DF System

Anritsu Company introduced the MA2700A InterferenceHunter handheld direction finding system that enhances interference mapping and simplifies locating interference sources in wireless networks. Designed for use with Anritsu's BTS Master™, Cell Master™, and Spectrum Master™ handheld analyzers, the InterferenceHunter can be used by field engineers and technicians during deployment, installation, and maintenance of wireless networks. It is ideally suited for use in spectrum clearing and interference mitigation.

Anritsu Company
anritsu.com

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Product Releases to HFE

To be considered for publication, please submit text in Word along with a 300 dpi min. color JPG image of your product. *Submit to:*

tim@
highfrequencyelectronics.com

Product Showcase

Product Showcase

Product Highlights

Waveform Generator

Tektronix, Inc. unveiled its next generation of arbitrary waveform generators that offer up to 50 GS/s sample rate performance. With the industry's best combination of high sample rate, long waveform memory and deep dynamic range, the new series supports a wide range of demanding signal generation requirements in defense electronics, high-speed serial, optical networking and advanced research applications.

Tektronix
tek.com

Capacitors

Passive Plus, Inc. (PPI) and Modelithics, Inc. collaborated to develop Global™ Models for four series of PPI's ultra-low ESR capacitors. These models are substrate scalable, part-value scalable, pad scalable, and some are orientation selectable (vertical or horizontal surface-mount). These models are currently available and included in the 2013 Modelithics Library releases. They are compatible with Agilent ADS and Genesys and AWR's Microwave Office™ simulators.

Passive Plus, passiveplus.com
Modelithics, modelithics.com

Noise Source

Model STZ-12-I1 is an E Band full waveguide noise source. It is a silicon IMPATT diode based solid state source that employs high performance diode and priority circuit design to offer nominal 14 dB ENR with extreme flatness in entire waveguide bandwidth from 60 to 90 GHz. It is integrated with Faraday isolator to improve the port VSWR and load pull to result more reliable and accurate noise figure measurement. Operating voltage is at +28 Vdc via a BNC(F) connector, which offers immediate interface requirement with an industry-standard noise meter. It can work in either CW or pulse AM mode by applying TTL triggering signal via an SMA(F) connector.

SAGE Millimeter
sagemillimeter.com

Reliability matters.

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Mission-critical applications have relied on Rogers' microwave materials for years. The superior electrical & mechanical characteristics of Rogers' high reliability laminates provide the stable, consistent performance over time and temperature that's so critical for aerospace and defense applications.

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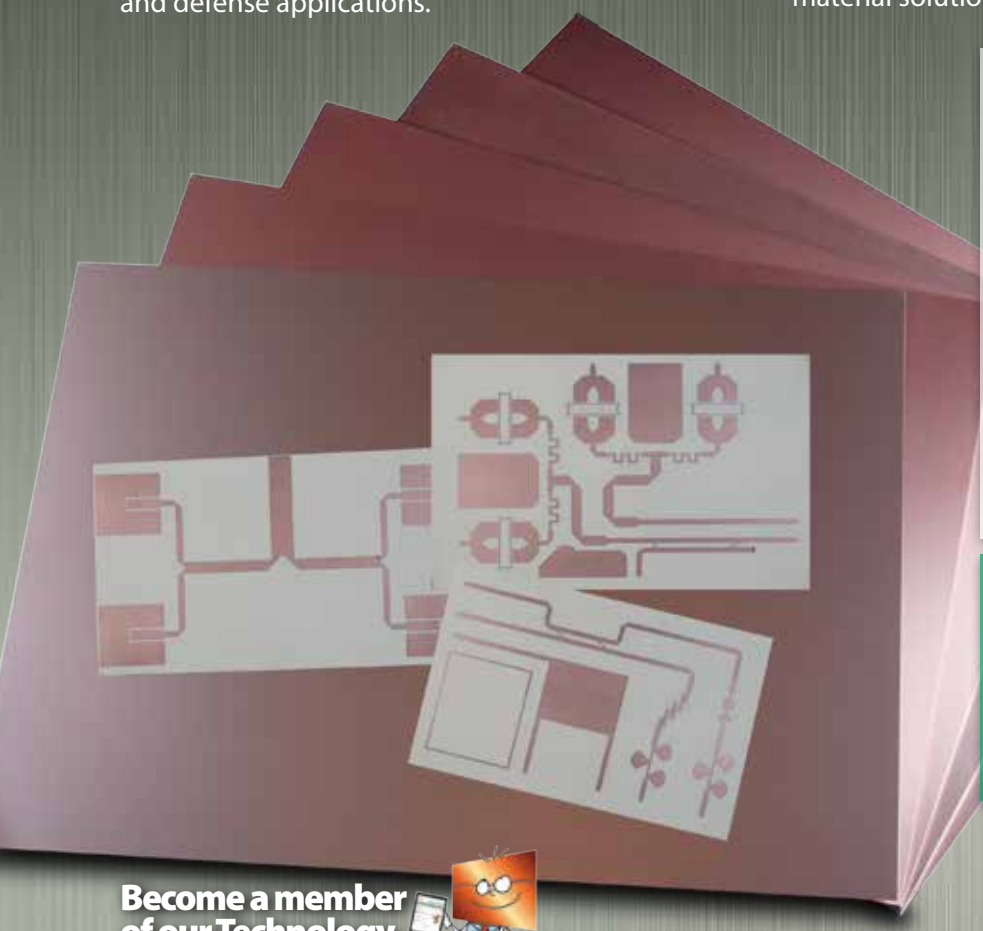
Visit **www.rogerscorp.com/military** to learn more about Rogers' aerospace and defense microwave material solutions.



RT/duroid® 6202PR laminates

- Reduced planar resistor variation
- Low thermal coefficient of dielectric constant
- Low coefficient of thermal expansion

RT/duroid 5880LZ laminates

- Dielectric constant of 1.96
- Low z-axis coefficient of thermal expansion
- Light weight

RT/duroid 6035HTC laminates

- Highest thermal conductivity (1.44 W/mk) for 3.5Dk printed circuit board laminates
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- Low profile, thermally stable copper options

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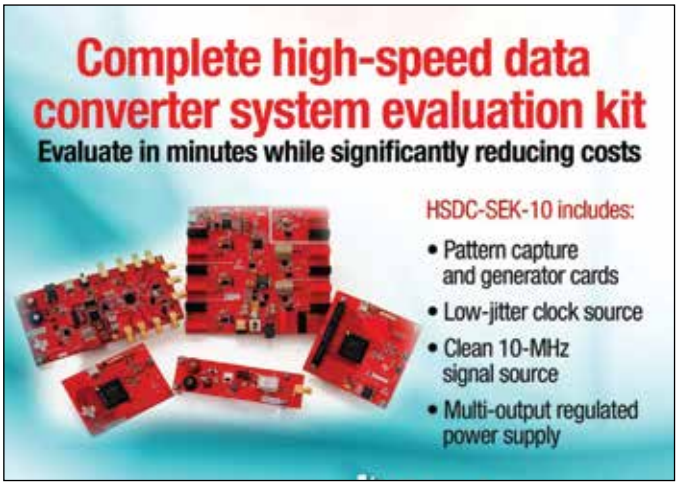
Product Highlights



Connectors

VidaRF is offering a new line of precision coaxial connectors for semi-rigid and flexible cables. Interfaces include Type N, Type N Right Angle, SMA and TNC connectors that provide excellent VSWR from DC -18 GHz. S/Steel passivated construction.

VidaRF
vidarf.com

Evaluation Kit

Texas Instruments Inc. introduced the industry's first complete high-speed data converter system evaluation kit that significantly reduces system evaluation costs and enables designers to get their system running in minutes. The HSDC-SEK-10 includes a pattern capture card, pattern generator card, low-jitter clock source, clean 10-MHz signal source and a multi-output regulated power supply. It can significantly reduce evaluation time and costs for a host of demanding applications. Examples include test and measurement, communications, defense, and medical equipment.

Texas Instruments
ti.com

Bit Error Ratio Tester

Agilent Technologies introduced a 32-Gb/s bit error ratio tester with four-tap de-emphasis. New high-speed data transfer standards such as 100-Gb Ethernet and 32-Gb Fibre Channel create new testing challenges for designers of servers, network interface cards, backplanes and communication ICs, because quality degrades when signals are transmitted over backplanes, printed circuit board traces and long cables. To address the issue, Agilent created remotely mountable pattern-generator heads for use with its N4960A BERTs (bit error ratio testers). The heads feature integrated four-tap de-emphasis (one precursor, two post-cursors) operating up to 32 Gb/s, providing designers the signal compensation required for transmitter emulation when they characterize receivers and systems.

Agilent Technologies
agilent.com

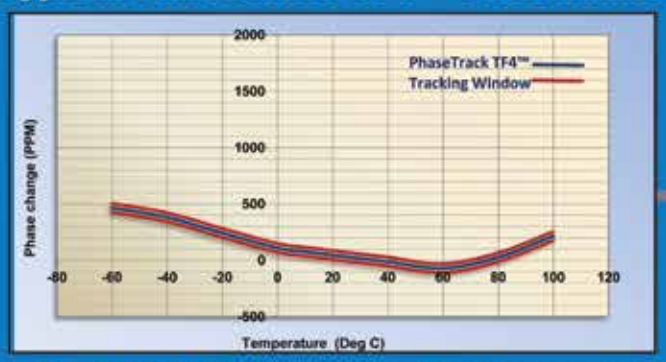
Instantly Improve the Performance of Your Phased Array Radar!

Phased Array Radar system performance has long been limited by the phase change over temperature of coaxial cables.

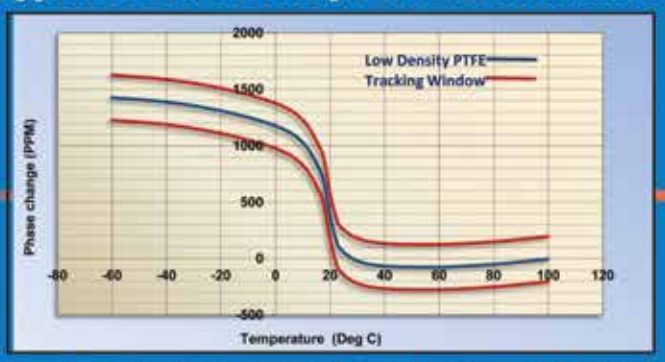
Not anymore!

TF4™ - our proprietary, ultra stable dielectric material significantly improves Phased Array Radar system performance by reducing the phase change of the interconnecting coaxial cables.

Typical PhaseTrack TF4™ Performance



Typical Low Density PTFE Performance



- Available NOW in various flexible coaxial cable and semi rigid coaxial cable assembly sizes
- Perfect for all Ground, Naval, Airborne or Spaceflight Phased Array Radar applications
- Frequency ranges to 40 GHz
- Wide range of connector types available
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www.timesmicrowave.com

Product Highlights

Amplifier

Comtech Xicom Technology introduced a compact and highly efficient GaN-based amplifier for X-band MILSATCOM service. Model XTSLIN-100X-B1 features 100W of WGS linear power in a compact, rugged 32-pound package. Drawing only 750 W of prime power while at linear RF output, this amplifier is ideal for transportable applications where robust, high efficiency, lightweight and high-temperature operation is required. In addition, this unit has demonstrated the ability to support critical multi-carrier X-Band operation with extremely low leakage levels in the receive band, even for the case with the SSPA in view of the antenna and feed.

Comtech Xicom Technology
xicomtech.com

Attenuator

Model A0P-73X-0KK is phase invariant PIN diode attenuator operating from 12.0 – 16.0 GHz. It is capable of a 45 dB dynamic range with monotonic 0.25 dB steps. The attenuation flatness is +/-2.0 dB and delta phase vs. attenuation is +/- 15 degrees. Maximum VSWR and insertion loss are 2.0:1 in 50 Ohms and 7.0 dB, respectively. The attenuator is digitally controlled via 8 BITs of TTL compatible binary logic with switching speed less than 1.0 µSec. The attenuator can handle +15 dBm CW or 1.0 Watt max. The operating temperature range extends from -33 to +63 degrees C. Package size is 2.00 x 3.50 x 0.97 in.

GT Microwave Inc.
gtmicrowave.com

Power Meter Software

LadyBug Technologies' latest Virtual Power Meter V4.5 supports a broad range of RF measurement solutions. The VPM is an ideal user interface for displaying time domain scope-like profiles of the modulated waveform. When used with LadyBug's Pulse Profiling Sensors, the software delivers clear and concise pulse details. A "pulse zoom" feature includes gates and markers that provide accurate measurement of selected details. Measurements such as Average Power, Droop, Crest Factor, Peak and Pulse Power, along with statistical information such as CDF, PDF and CCDF, are also provided with full scaling control.

LadyBug Technologies
ladybug-tech.com

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IEEE MTT-S

Product Highlights

Selection Guide

Hittite Microwave Corp. released its March 2013 Selection Guide summarizing over 1,075 products including 20 new offerings. New is a dual low pass filter in the IF Baseband Processing Product line featuring an integrated ADC driver, programmable input impedance, and adjustable output common mode voltage from 0.9 V to 3 V with a 2 Vpp signal. The guide is organized by RF & Microwave, Analog & Mixed Signal, Clocks & Timing and LO Frequency Generation IC sections along with Modules and Instrumentation.

Hittite Microwave Corp.
hittite.com

Connector App Note

SV Microwave has released a new application note for its QuarterBackTM connector series. The line utilizes a quarter-turn bayonet style coupling nut with a locking feature for standard SMP/SMPM interfaces. The QuarterBackTM connectors are ideal for high vibration and test applications that require a large number of mating cycles. The app note can be found at http://www.svmicrowave.com/index.cfm?fuseaction=pages.QuarterBack.

SV Microwave
svmicro.com

Switch

PMI Model No. P4T-100M40G-90-T-512-292FF-SP is a 100 MHz to 40 GHz, Ultra-Compact, High Speed, Single Pole, Four Throw, Absorptive Switch. It offers over 100 dB of port to port isolation from 100 MHz to 18 GHz, over 90 dB from 18 to 26.5 GHz and over 75 dB from 26.5 to 40 GHz. It has a typical insertion loss of 8.8 dB from 100 MHz to 18 GHz, 5.2 dB from 18 to 26.5 GHz and 5.6 dB from 26.5 to 40 GHz. Switching speed is less than 100 nsec and is controlled by 2-Bit decoded TTL. Maximum operating power is +20 dBm CW and the typical VSWR is 2.0:1. The housing measures only 2.0" x 1.0" x 0.4" and is supplied with 2.92 mm female connectors.

Planar Monolithics Industries
pmi-rf.com

Product Highlights

Isolator

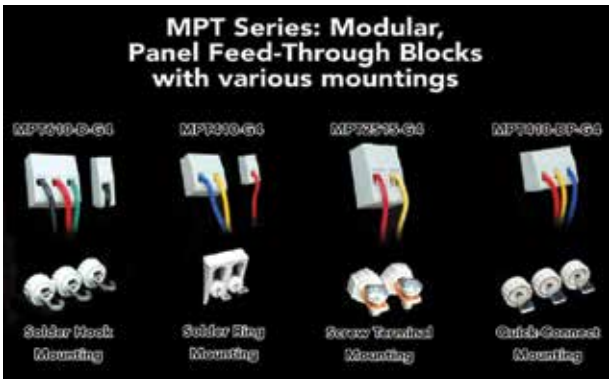
Renaissance has designed a new 20 kW peak power isolator designed to sustain 64 W CW operating at 2110 – 2750 MHz. The input and output connectors are 7/8" EIA and has a 5" long section for termination. With insertion loss of less than 0.6 dB and with return loss and isolation over 15 dB, the isolator is ideal to protect a HPA from unwanted reflections. This isolator is ideal for high peak pulsed radar applications.

Renaissance Electronics/HXI
rec-usa.com

Frequency Synthesizer Product Guide

Micro Lambda Wireless offers an extensive frequency synthesizer product line with standard designs covering from 500 MHz to 22 GHz. From low cost single-loop designs up to wideband configurations that outperform some test equipment, Micro Lambda leads the market today in YIG-based synthesizers. Standard product offerings include low-cost configurations covering 2 to 12 GHz in 2 or 3 GHz tuning ranges with as low as 100 kHz step size, narrowband multi-loop configurations covering the 2 to 16 GHz frequency range with 2 to 4 GHz tuning bands and low phase noise performance, wideband multi-loop configurations covering 600 MHz to 3 GHz and 2 – 10 GHz with 1 Hz step size and 2 to 20 GHz low noise PXI-based units with 1 kHz step size.

Micro Lambda Wireless
microlambdawireless.com



Terminal Blocks

BlockMaster Electronics introduced a series of panel feed thru terminal blocks that are versatile enough to be used in a variety power distribution and terminal applications. With products such as hi-power switching, motor control, medical imaging and power supplies, the MPT series can eliminate many problems. The new MPT series power handling ranges from 24A/450V to 150 A/1000V, and can accept wire ranges from 14 to 1 AWG stranded, and 12 to 2 AWG solid among 7 different sizes. Its modular design allows any number of positions to be easily assembled on the line or in the field as each position interlocks together providing seamless modular construction side by side or stackable.

BlockMaster Electronics
blockmaster.com

Product Highlights

Resistors

Vishay Intertechnology, Inc. announced a new surface-mount Power Metal Strip® resistor featuring a wide side terminal construction that yields a high 2 W power rating in the compact 1020 case size. The WSL1020 combines its high power-to-footprint-size ratio with extremely low resistance values down to 0.003 Ω and stable resistance tolerances to 0.5 %. The advanced construction of the Vishay Dale WSL1020 resistor incorporates a solid metal nickel-chrome alloy resistive element with low TCR (< 20 ppm/°C).

Vishay Intertechnology, Inc.
vishay.com

Spectrum Analyzer

Narda Test Solutions has added a number of new features to its NRA series rack-mount spectrum analyzer, most notably the ability to deliver I/Q data as a gapless real-time stream with a channel bandwidth of up to 400 kHz. This is especially useful for testing the quality and integrity of transmitted and received signals. Available in the UK from Link Microtek, the 1U-high 19 in. spectrum analyzer covers frequencies ranging from 9 kHz to 6 GHz and is suited to a wide variety of applications, including Satcom uplinks, broadcast systems and communications services such as GSM, UMTS, LTE and WiMAX.

Link Microtek
linkmicrotek.com

CRO

Crystek's new CVCO55CXT-5685-5780 Coaxial Resonator Oscillator (CRO) is a coaxial-based VCO with an internal proprietary frequency doubler. The CVCO55CXT family's frequency doubling, 2X fundamental technology reaches new performance levels of lower phase noise and much lower harmonics over the competition, while achieving lower current consumption in the process. The CVCO55CXT-5685-5780 operates from 5685 to 5780 MHz with a tuning voltage range of 0.3 Vdc to 4.7 Vdc.

Crystek
crystek.com

Product Highlights

Inductors

Pulse Electronics Corp. expanded its range of round-wire coil (RWC) surface mount power inductors to deliver higher inductance/current capability. Mechanical sizes from 7.6 x 7.4 x 6.4mm up to 21.7 x 21.5 x 12.5mm are now available with an inductance range from 0.3uH to 50uH and with a current rating up to 70A. These inductors use a ferrite core material which yields a 90% core loss reduction and 30% increase in maximum operating temperature when compared to standard iron powder material used in flat-coil inductors.

Pulse Electronics Corp.
pulseelectronics.com

Cable Fittings

The new, fourth generation of cable glands Euro-Top EMC not only prevents intrusion by dust and humidity, it also considerably reduces interference from electro-magnetic fields. This allows uninterrupted operation and prevents surges, circuit feedback, radio interference and interspersion in highly sensitive areas, such as those used for measurement and control technology. Interference from electro-magnetic fields is mainly created through improper assembly of shielded cables. Today housings, electronic modules, cables and control lines are regularly shielded; however, if control and supply lines are installed in housings and cabinets that have a higher voltage and more power, this often causes damage to the shield.

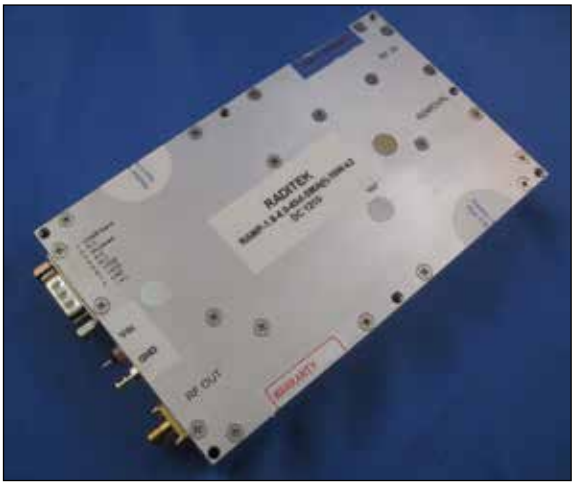
RST
rst.eu

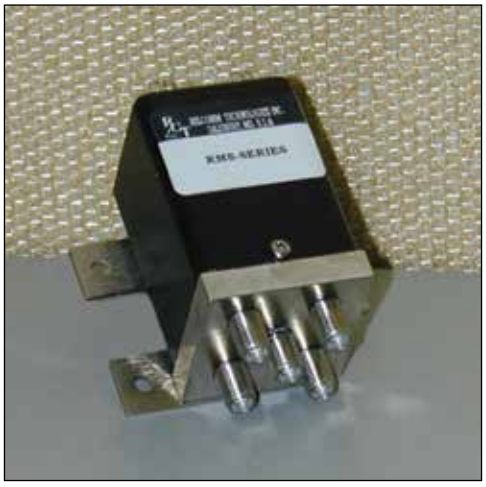
Sensor Catalog

SAGE Millimeter is a technology company with a focus on developing high performance microwave and millimeter-wave components and sub-assemblies in the frequency range up to 140 GHz for commercial and military system applications. SAGE Millimeter's new sensor catalog features oscillators, Doppler sensor modules, ranging sensor modules, Doppler sensor heads, ranging sensor heads, Doppler radar target simulators, and a sensor module and sensor head selection guide.

SAGE Millimeter, Inc.
sagemillimeter.com

Product Highlights





Amplifier

RADITEK's latest low gain block amplifier, (RAMP-1.8-4.0-45d-Sf-10W-k2) operates between 1.8 - 4.0 GHz with a RF gain of 45 dB and a noise figure of 10 dB max. Input and output connectors are SMA female. Dimensions: (W) 151 x (D) 91 x (H)30 mm.

RADITEK
raditek.com

Relay

RelComm Technologies, Inc. introduced a new 1P4T coaxial relay now available in a familiar style outline. This RMS Series boasts exceptional performance to 18 GHz - VSWR 1.50:1 maximum, Insertion Loss 0.50 dB maximum and Isolation better than -60 dB. This device exhibits a short electrical length and compact mechanical package measuring 1.30 sq. x 2.00. The bracket provides ease and versatility in mounting. Available in failsafe and latching configurations.

RelComm Technologies
relcommtech.com

Amp

The 1163/BBM2E3KLO is a 20 to 520 MHz amplifier which is guaranteed to deliver 125W output power and related RF performance under all specified temperature and environmental conditions. It uses high power LDMOS transistors and offers built-in control and monitoring, with protection functions that include non-volatile memory for event recording and factory setup recovery features. The 7" x 4" x 1.5" module is ideally-suited for broadband jamming and high power linear applications in the UHF and VHF bands.

Richardson RFPD
richardsonrfpd.com

Product Highlights

Phase Trimmers

Bracke Manufacturing, LLC released a series of Phase Trimmers with working frequency range from 50 MHz to 18 GHz, designed for applications where phase matching between cables or test equipment is critical to system performance. At elevated frequencies discrete changes in phase can require minute physical adjustment in the length of the electrical path. Phase trimmers enable the engineer or technician to make precise adjustment to the phase without otherwise degrading the signal.

Bracke Manufacturing LLC
brackemfg.com

Module

The RFFM6901 is a single-chip front end module for applications in the 868/915MHz ISM Band. It addresses the need for aggressive size reduction for typical portable equipment RF front end design and greatly reduces the number of components outside of the core chipset, thus minimizing the footprint and assembly cost of the overall solution. The RFFM6901 contains an integrated 1W PA, dual port diversity antenna switch, LNA with bypass mode, and matching components.

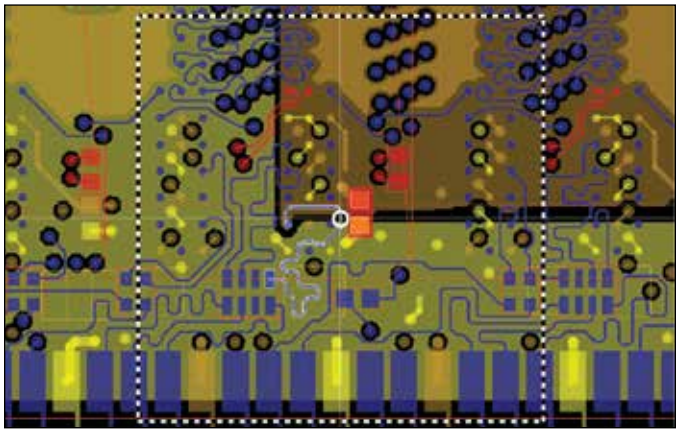
RFMD
rfmd.com

Synthesizer

The LNS-18 is a general-purpose synthesizer with outstanding phase noise performance. Its low noise oscillators generate a flexible frequency range up to 18 GHz. With -132 dBc/Hz at 10 GHz carrier and 20 kHz offset, it is designed to test components and systems for demanding applications in military and aerospace. Optional level control, pulse modulation, GPIB, and low frequency extension down to 8 MHz using ultra-low noise frequency dividers (-165 dBc/Hz) are available in addition to Ethernet and EFC input.

Noise XT
noisext.com

Product Highlights



PCB Analyzer

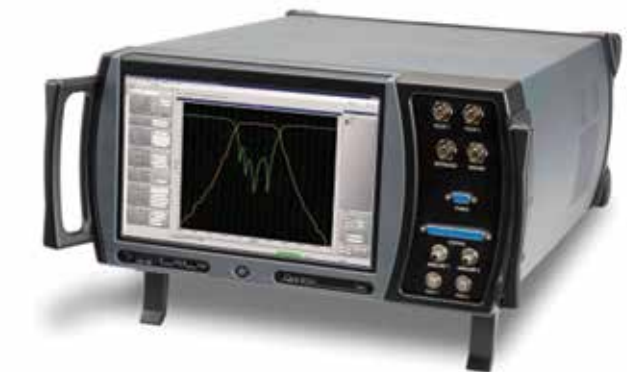
Design engineers dealing with electromagnetic compatibility (EMC) and signal integrity (SI) of PCBs can now employ CST BOARDCHECK™ to get a quick overview of potential problems in their layout. CST BOARDCHECK supports a multitude of popular layout formats such as CADENCE® ALLEGRO®, Zuken CR 5000, Mentor Graphics® Expedition® and ODB++, which are read-in using the sophisticated CST STUDIO SUITE® import filters.

CST
cst.com

Power Amps

Hittite's new HMC952 and the HMC952LP5GE are four stage GaAs pHEMT MMIC 2 Watt Medium Power Amplifiers with temperature compensated on chip power detectors that operate between 9 and 14 GHz. They provide 33 dB of gain, +35 dBm of saturated output power, and 27% PAE (Power Added Efficiency) from a +6V supply. With up to +43 dBm output IP3 the HMC952LP5GE is ideal for high linearity applications in military and space as well as high capacity point-to-point and point-to-multi-point radios.

Hittite Microwave Corp.
hittite.com

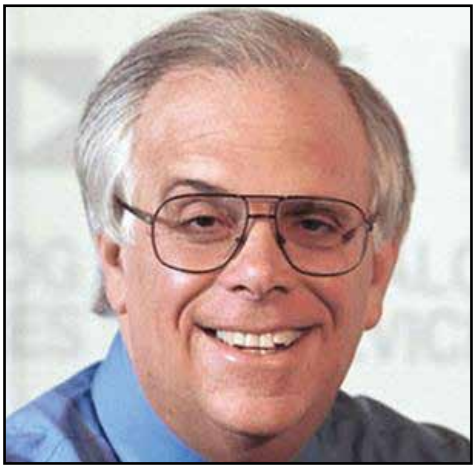


Test System

Aeroflex Inc. announced the 7700 integrated microwave test system, a complete turnkey ATE (Automated Test Equipment) system-in-a-box designed for rapid production testing of microwave and RF components and modules. It is a bench-sized instrument that utilizes Aeroflex's synthetic architecture and Common Platform hardware to achieve fast measurement throughput. It provides the functionality and measurements of a vector signal generator, spectrum analyzer, vector network analyzer, oscilloscope, power meter, frequency counter, noise figure meter, and a phase noise analyzer.

Aeroflex Inc.
aeroflex.com

In Memoriam: Jerald Fishman



Analog Devices Photo

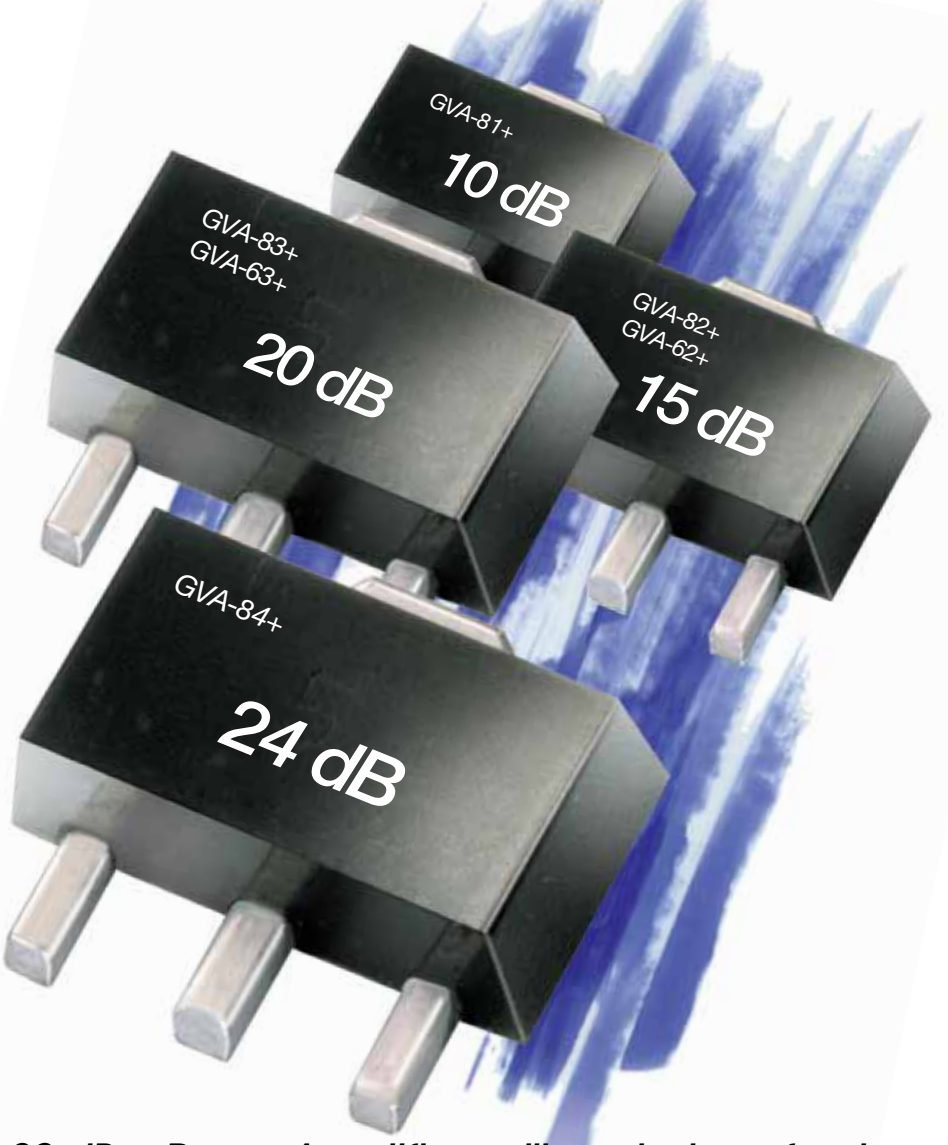
Analog Devices Inc. announced that CEO Jerald G. Fishman passed away suddenly from an apparent heart attack on March 28. Mr. Fishman was 67 years old.

"This is a terrible loss for me personally and for all of us here at ADI," said Ray Stata, Chairman of the Board. "Jerry dedicated his entire career to building ADI into a great company—one of which we all are enormously proud. Jerry's commitment to ADI occupied a central part of his life and his passion for success was infectious. Jerry not only developed enormous respect both inside and outside the company as one of our industry's greatest leaders, but also for those like me who knew him well, he engendered a sense of affection and loyalty through his candor, openness, and integrity and through his unique sense of humor. While Jerry was extraordinarily passionate about his work and ADI, his greatest pride was his family and our thoughts are with them at this time. We shall miss Jerry deeply."

Jerry was born in 1945 and grew up in Flushing, NY. He graduated from the City College of New York with a BSEE degree. He went on to earn an MSEE degree from Northeastern University, an MBA from Boston University, and Juris Doctor degree from Suffolk Law School.

Jerry joined Analog Devices in 1971 in product marketing. His responsibilities and his contributions expanded quickly as he rose through the ranks of the company, and in 1991 he was named President and Chief Operating Officer. In 1996, he was named President and Chief Executive Officer. Jerry's contributions to ADI and the industry were recognized throughout his career.

In accordance with the Company's bylaws, ADI's President Vincent Roche has been appointed Chief Executive Officer on an interim basis by ADI's Board of Directors.



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US patent 6,943,629

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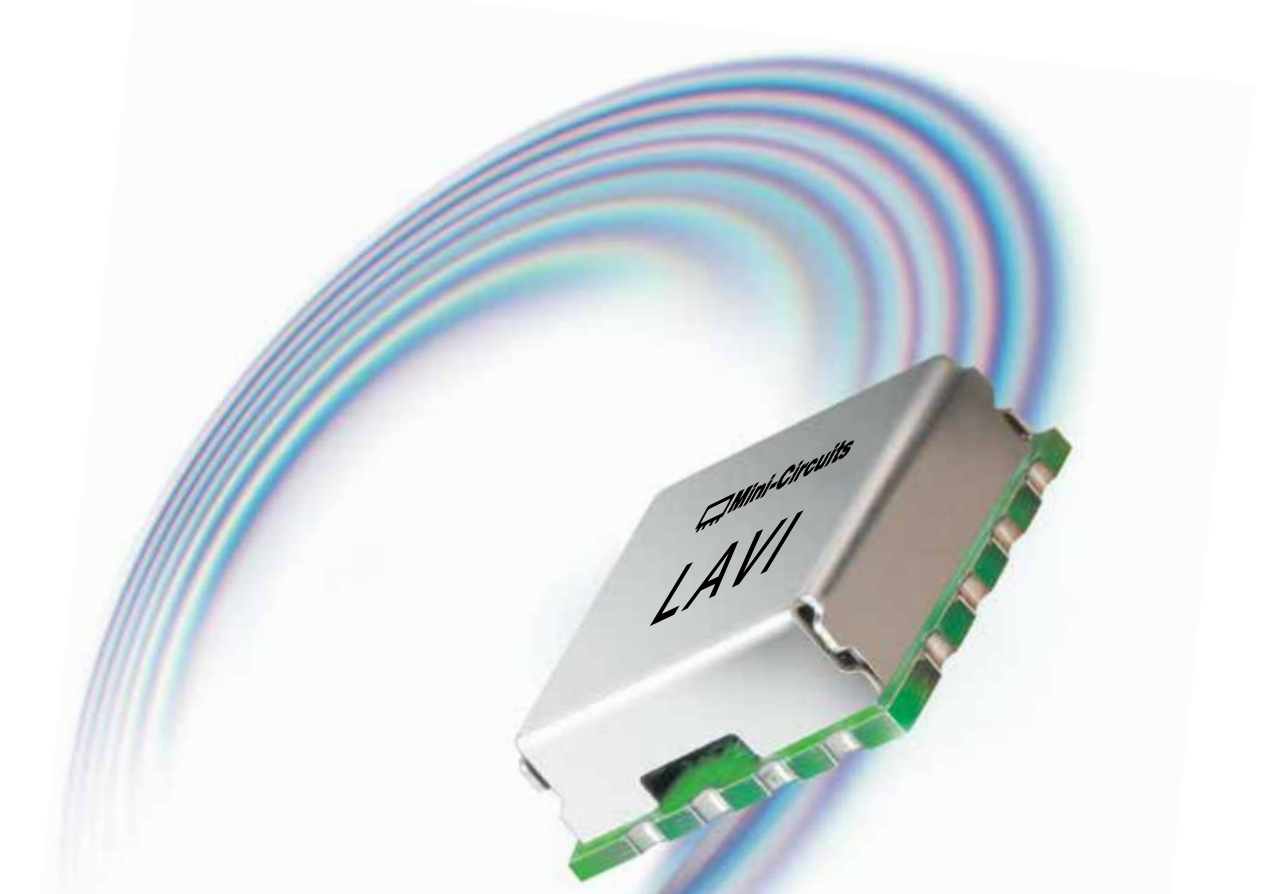

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Advertiser Index

Company	Page
Advanced Switch Technology	47
Avtech	47
CDM Electronics	26
Cernex	18
Coilcraft	11
C.W. Swift & Associates	C2
C.W. Swift/SRI Connector Gage	33
Delta Electronics	17
Dudley Lab	47
Emerson Network Power	C4
Emerson Network Power	13
Herotek	14
IMS 2013	53
IW Microwave	35
JFW Industries	40
Krytar	36
MECA Electronics	19
Micro Lambda Wireless	9
Microwave Components	37
Mini-Circuits	2, 3
Mini-Circuits	62, 63
Mini-Circuits	21
Mini-Circuits	25
Mini-Circuits	29
Mini-Circuits	43
Miteq	7
Molex	C3
National Instruments	5
Pulsar Microwave	34
RelComm Technologies	23
Renaissance Electronics	27
RF Bay	47
RFMW	41
Rogers Corp	49
SAGE Millimeter	24
Satellink	46
Sector Microwave	47
SGMC Microwave	15
SV Microwave	31
Teledyne Microwave Solutions	1
Times Microwave	51
TRU Corp	45
VidaRF	20
Wenteq Microwave Corp	47
Wilmanco	46

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PUBLISHER
Scott Spencer
Tel: 603-472-8261
Fax: 603-471-0716
scott@highfrequencyelectronics.com

ADVERTISING SALES — EAST
Gary Rhodes
Vice President, Sales
Tel: 631-274-9530
Fax: 631-667-2871
grhodes@highfrequencyelectronics.com

ADVERTISING SALES — WEST
Tim Burkhard
Associate Publisher
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Fax: 707-544-9375
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ADVERTISING SALES—WEST—NEW ACCOUNTS
Jeff Victor
Tel: 224-436-8044
Fax: 509-472-1888
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Tel: 201-666-6698
Fax: 201-666-6698
joanne@highfrequencyelectronics.com

U.K AND EUROPE
Sam Baird
Tel: +44 1883 715 697
Fax: +44 1883 715 697
sam@highfrequencyelectronics.com

U.K AND EUROPE
Zena Coupé
Tel: +44 1923 852 537
Fax: +44 1923 852 261
zena@highfrequencyelectronics.com

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