

Vol. 59 • No. 7

July 2016

Microwave Journal

.com

A Shift in the Industry

MVP
NI
Simplifying
Antenna
Design

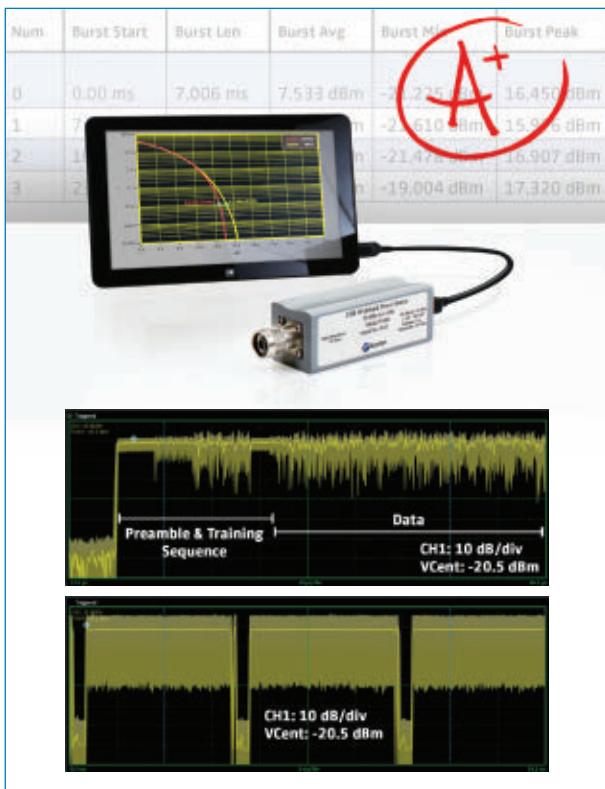


Founded in 1958

Don't Settle for Average.



Demand Peak Performance.



The 55 Series USB Peak Power Sensor *Real-Time Power Measurements for Complex Communications Signals*

Others claim to have fast average measurements, but only the 55 Series measures continuous and burst average power faster than anyone in the industry. It adds wide-band peak and crest factor measurements, allowing you to see all aspects of your device's performance. This USB Sensor delivers results 100 times faster than conventional meters and with its *Real-Time Power Processing™* technology captures all glitches with 100ps resolution.

- 195 MHz Video Bandwidth
- 3 ns risetime
- 100,000 measurements/sec
- 100 MHz Sample Rate
- Multi-channel synchronized measurements

For more information visit us at www.boonton.com or call +1 973-386-9696.



Public Safety



Satcom, mmWave
& Military



Aeronautical/Space
Transportation



AMER, EMEA,
& D.A.S

MECA 5G Products & Equipment

MECA Electronics designs and manufactures an extensive line of RF/Microwave Equipment and Components with industry leading performance including D.A.S. Equipment, Low PIM Products, supports 5G & Millimeter-Wave, Power Dividers & Combiners, Directional & Hybrid Couplers, Fixed & Variable Attenuators, RF Terminations, Circulators/Isolators, DC Blocks & Bias Tees, Adapters & Jumpers. Models available in industry common connector styles:

N, SMA, 2.92mm, TNC, BNC, 7/16, 4.1/9.5 & 4.3/10.0 DIN as well as QMA, Reverse Polarity SMA, TNC and various mounting solutions. Since 1961 MECA Electronics (Microwave Equipment & Components of America) has served the RF/Microwave industry with equipment and passive components covering Hz to 40 GHz. MECA is a privately held ISO9001:2008 Certified, global designer and manufacturer for the communications industry with products manufactured in the United States of America.



Low PIM Adapters



Low PIM Attenuators



Low PIM Terminations



Circulators/Isolators



Low PIM & D.A.S. Equipment



Dr. D.A.S.® Prescribes...



Power Divider/Combiner



Directional Couplers/Hybrids



Attenuators/Terminations



e-MECA.com
Since 1961

MECA Electronics, Inc.

Microwave Equipment & Components of America

The Professional's Choice for RF/Microwave Passive Components

459 E. Main St., Denville, NJ 07834

Tel: 973-625-0661 • Fax: 973-625-9277 • Sales@e-MECA.com



(Bwave)





POWER SPLITTERS/ COMBINERS

from **2 kHz to 26.5 GHz** as low as **94¢** ea. (qty. 1000)

NEW!

**THE WIDEST BANDWIDTH IN THE INDUSTRY
IN A SINGLE MODEL!**

EP2K1+ 2 to 26.5 GHz

EP2W1+ 0.5 to 9.5 GHz

EP2C+ 1.8 to 12.5 GHz


The industry's largest selection includes THOUSANDS of models from 2 kHz to 26.5 GHz, with up to 300 W power handling, in coaxial, flat-pack, surface mount and rack mount housings for 50 and 75Ω systems.

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

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

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

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

 **RoHS Compliant**
Product availability is listed on our website.

 **Mini-Circuits®**

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

448 rev R

Solid State Power Amplifiers

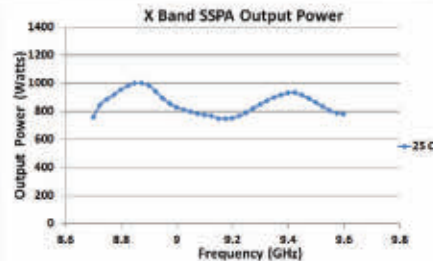
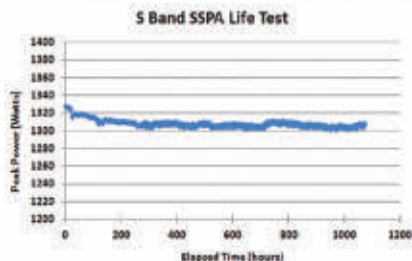
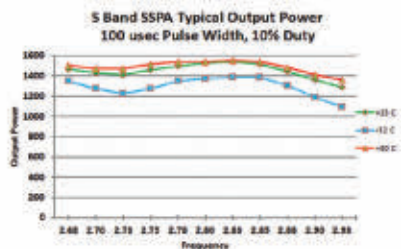
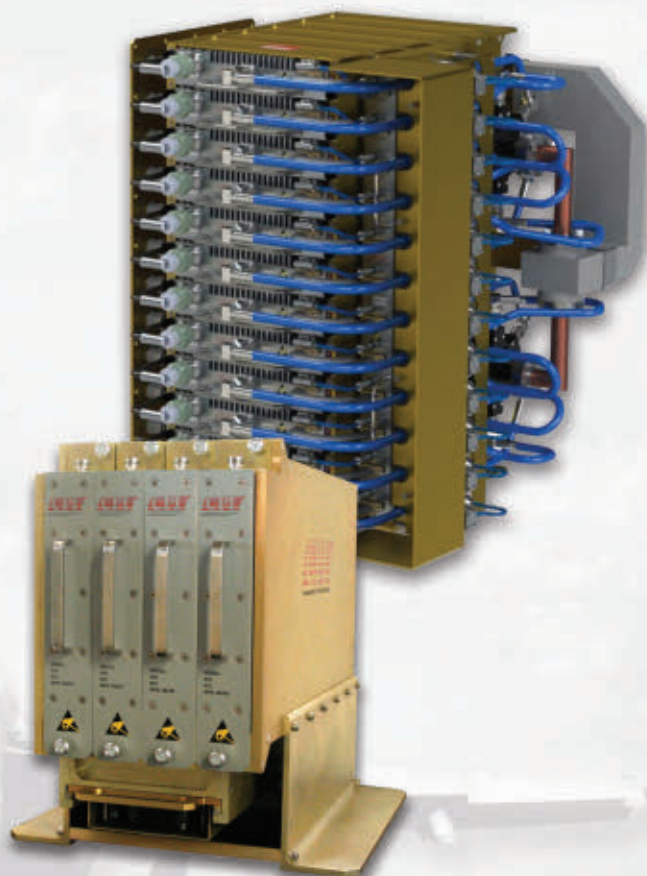
State of the art GaN technology

Features:

- High efficiency pulsed modules (10% duty)
- BIT and controls via EIA-422
- Compact light weight
- 9.0 - 9.2 GHz X-Band: 1 kW modules
- 5.2 - 5.9 GHz C-Band: 1.1 kW modules
- 2.7 - 2.9 GHz S-Band: 1.3 kW modules
- 1.2 - 1.4 GHz L-Band: 700 W modules
- Power combine modules up to 25 kW

Benefits:

- High reliability
- Field replaceable modules

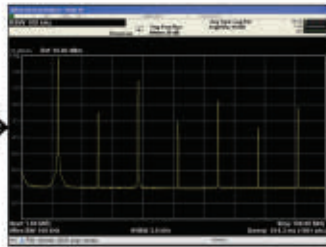
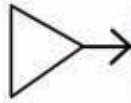


• Solid State Power Amplifiers • Integrated Microwave Assemblies • Receiver Protectors
• Control Components • Transmitters • Amplifiers • Modulators • Magnetrons • Crossed Field Amplifiers
• Ring Loop Traveling Wave Tubes • Power Couplers

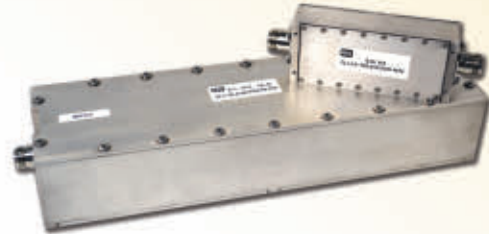
SUPERIOR HIGH-POWER LOWPASS FILTERS



+60 dBm
Amplifier



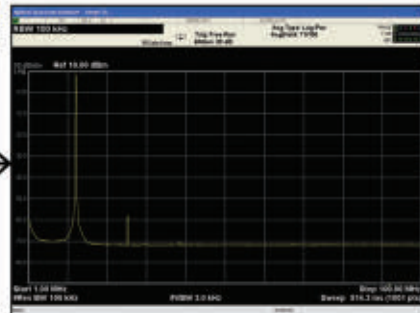
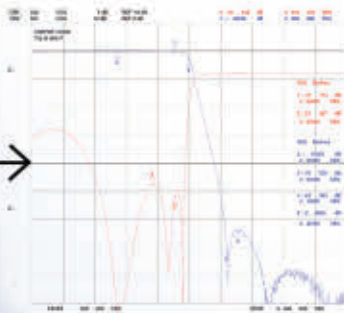
+60 dBm at Fundamental
Multiple Spurious Responses



WHICH WOULD BE
BETTER
FOR YOUR CUSTOMER?

+59 dBm at Fundamental
No Spurious Responses

+60 dBm
Amplifier



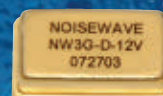
K&L HAS THE ANSWERS.



ENABLING COMMUNICATIONS AND SIGNAL CONTROL

www.klmicrowave.com • www.klfilterwizard.com • 410-749-2424 • sales@klmicrowave.com

New Wave in Noise



NoiseWave

your supplier of high performance, precise equipment for AWGN



NOISEWAVE
The new wave in NOISE

Ph. (973) 386-1119 • Fax (973) 386-1131 • info@noisewave.com • www.noisewave.com

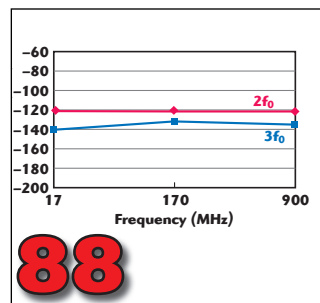
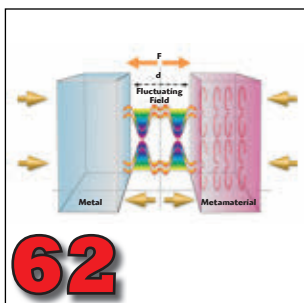
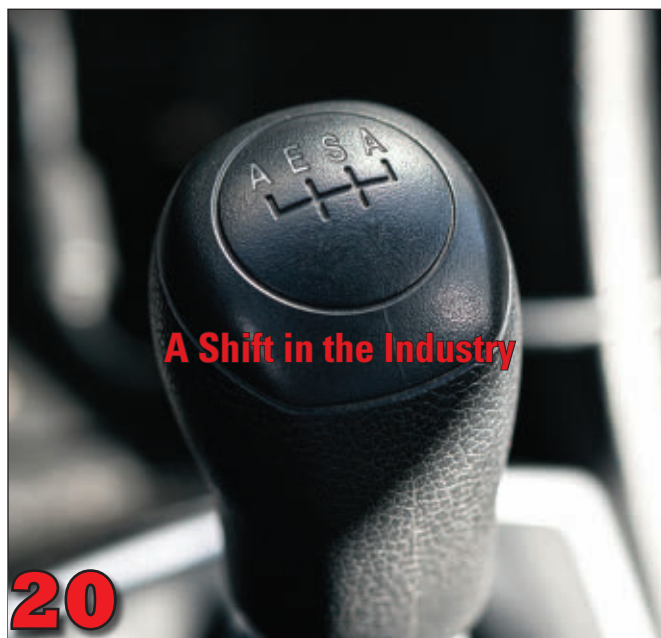
SMART DEVICES REQUIRE SMARTER AUTOMATED TEST SYSTEMS

The old approach to automated test isn't scaling, but you already knew that. Look at your balance sheet. To test smart devices, you need a smarter test system built on a platform of NI PXI, LabVIEW, and TestStand. More than 35,000 companies deploy NI technology to lower their cost of test—what are you waiting for?

Prepare for the future at ni.com/smarter-test



NI PXI, LabVIEW, and TestStand



Cover Feature

20 E Pluribus Unum: An Integrated Design Flow for Phased Arrays

Daren McClearnon, EEsof EDA, Keysight Technologies

MVP: Most Valuable Product

36 Simplifying Antenna Design Without Compromise

National Instruments, AWR Group

Technical Features

62 Möbius Metamaterial Strips: Opportunity, Trends, Challenges and Future

Ulrich L. Rohde, Federal Armed Forces University;
Ajay K. Poddar, Synergy Microwave

88 High Linearity RF Switches for DOCSIS 3.1 Applications

Peter Bacon and Kinana Hussain, Peregrine Semiconductor

Application Note

96 Using Model-Based Design for Software-Defined Radio

Mike Donovan, MathWorks; Andrei Cozma and Di Pu, Analog Devices Inc.

AUGMENTED REALITY: HOW IT WORKS

STEP 1

Download the free Layar app from the iTunes (iOS) or Google Play (Android) store.

STEP 2

Launch the app to view enhanced content on any page with the **layar** logo.

STEP 3

Frame the entire page in the screen and tap to experience enhancements (tap screen again for full screen view).

Look for the Layar logo on participating pages.

AR pages may expire after 30 days.

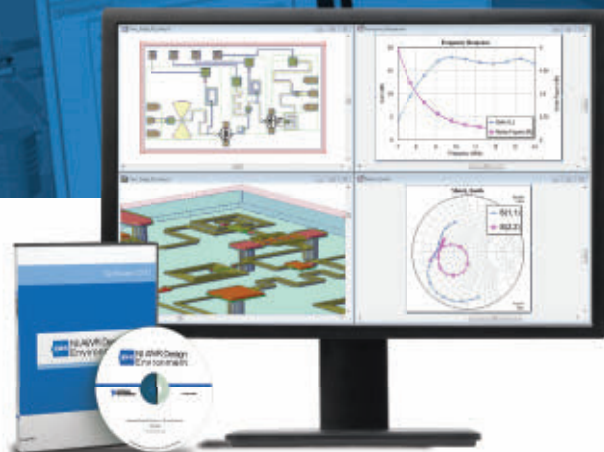
ONE PLATFORM, ZERO BARRIERS

SIMPLY SMARTER

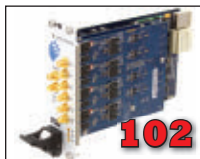
NI AWR DESIGN ENVIRONMENT

NI AWR Design Environment™ is one platform — integrating system, circuit, and electromagnetic analysis — for the design of today's advanced wireless products from base stations to cellphones to satellite communications. Its intuitive use model, proven simulation technologies, and open architecture supporting third-party solutions translates to zero barriers for your design success. Simply smarter design.

Learn more at ni.com/awr



Microwave Office | Visual System Simulator™ | Analog Office | AXIEM | Analyst™



Product Feature

102 High Speed PXle Digitizers

Spectrum Systementwicklung Microelectronic GmbH

Tech Briefs

106 225 to 450 MHz Low Loss Coupler Handles 200 W

Mini-Circuits

106 CS-ESA Software for EMC Analysis with Spectrum Analyzer

Langer EMV-Technik GmbH

108 PADS Adds DC Drop and Thermal Analysis

Mentor Graphics Corp.

Departments

17	Mark Your Calendar	110	Catalog Update
18	Coming Events	112	New Products
43	Defense News	118	Book End
47	International Report	120	Advertising Index
51	Commercial Market	120	Sales Reps
54	Around the Circuit	122	Fabs and Labs

Errata: Please note the following correction to "A Compact Balanced-to-Unbalanced Diplexer Using Interdigital Line Resonators," published in the April 2016 issue. In the right-hand column on page 156, 11 lines under the heading "Balanced-to-Unbalanced Diplexer," the text "low return loss" should be "high return loss." Also, Equation 3 below the text should read:

$$\left| \Gamma_2^{dd}(f_{CH1}) \right| \approx 0, \left| \Gamma_2^{dd}(f_{CH2}) \right| \approx 1, \left| \Gamma_3^{dd}(f_{CH2}) \right| \approx 0 \text{ and } \left| \Gamma_3^{dd}(f_{CH1}) \right| \approx 1$$

Microwave Journal (USPS 396-250) (ISSN 0192-6225) is published monthly by Horizon House Publications Inc., 685 Canton St., Norwood, MA 02062. Periodicals postage paid at Norwood, MA 02062 and additional mailing offices.

Photocopy Rights: Permission to photocopy for internal or personal use, or the internal or personal use of specific clients, is granted by *Microwave Journal* for users through Copyright Clearance Center provided that the base fee of \$5.00 per copy of the article, plus \$1.00 per page, is paid directly to the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923 USA (978) 750-8400. For government and/or educational classroom use, the Copyright Clearance Center should be contacted. The rate for this use is 0.03 cents per page. Please specify ISSN 0192-6225 *Microwave Journal* International. *Microwave Journal* can also be purchased on 35 mm film from University Microfilms, Periodic Entry Department, 300 N. Zeeb Rd., Ann Arbor, MI 48106 (313) 761-4700. Reprints: For requests of 100 or more reprints, contact Barbara Walsh at (781) 769-9750.

POSTMASTER: Send address corrections to *Microwave Journal*, PO Box 1143, Skokie, IL 60076 or e-mail mwj@halldata.com. Subscription information: (847) 763-4943. This journal is issued without charge upon written request to qualified persons working in the RF & microwave industry. Other subscriptions are: domestic, \$120.00 per year, two-year subscriptions, \$185.00; foreign, \$200.00 per year, two-year subscriptions, \$370.00; back issues (if available) and single copies, \$10.00 domestic and \$20.00 foreign. Claims for missing issues must be filed within 90 days of date of issue for complimentary replacement.

©2016 by Horizon House Publications Inc.
Posted under Canadian international publications mail agreement #PM40612608

STAFF

PUBLISHER: CARL SHEFFRES
EDITOR: PATRICK HINDLE
TECHNICAL EDITOR: GARY LERUDE
MANAGING EDITOR: JENNIFER DiMARCO
ASSOCIATE TECHNICAL EDITOR: CLIFF DRUBIN
MULTIMEDIA STAFF EDITOR: LESLIE NIKOU
MULTIMEDIA STAFF EDITOR: BARBARA WALSH
CONTRIBUTING EDITOR: JANINE LOVE
CONSULTING EDITOR: HARLAN HOWE, JR.
CONSULTING EDITOR: FRANK BASHORE
CONSULTING EDITOR: DAVID VYE
CONSULTING EDITOR: RAYMOND PENGELLY
ELECTRONIC MARKETING MANAGER:
 CHRIS STANFA
DIGITAL CONTENT PRODUCTION SPECIALIST:
 LAUREN TULLY
AUDIENCE DEVELOPMENT MANAGER:
 CAROL SPACH
TRAFFIC MANAGER: EDWARD KIESSLING
DIRECTOR OF PRODUCTION & DISTRIBUTION:
 ROBERT BASS
ART DIRECTOR: JANICE LEVENSON
GRAPHIC DESIGNER: SACHIKO STIGLITZ

EUROPE

INTERNATIONAL EDITOR: RICHARD MUMFORD
OFFICE MANAGER: NINA PLESU

CORPORATE STAFF

CEO: WILLIAM M. BAZZY
PRESIDENT: IVAR BAZZY
VICE PRESIDENT: JARED BAZZY

EDITORIAL REVIEW BOARD

Dr. I.J. Bahl	Dr. J.M. Osepchuk
F.M. Bashore	R. Pengelly
Dr. C.R. Boyd	Dr. Ajay K. Poddar
M. Goldfarb	Dr. J. Rautio
J.L. Heaton	Dr. U. Rohde
Dr. G. Heiter	Dr. P. Staecker
H. Howe, Jr.	F. Sullivan
Dr. T. Itoh	D. Swanson
Dr. J. Lasker	Dr. R.J. Trew
Dr. S. Maas	G.D. Vendelin
Dr. G.L. Matthaei	D. Vye
Dr. D.N. McQuiddy	Prof. K. Wu

EXECUTIVE EDITORIAL OFFICE

685 Canton Street, Norwood, MA 02062
 Tel: (781) 769-9750
 FAX: (781) 769-5037
 e-mail: mwj@mwjournal.com

EUROPEAN EDITORIAL OFFICE

16 Sussex Street, London SW1V 4RW, England
 Tel: Editorial: +44 207 596 8730 Sales: +44 207 596 8740
 FAX: +44 207 596 8749

SUBSCRIPTION SERVICES

Send subscription inquiries and address changes to:
 Tel: (847) 763-4943
 e-mail: mwj@halldata.com



www.mwjournal.com

Printed in the USA



High performance VNAs for any application

In the Lab | On the Manufacturing Floor | In the Field

With a wide variety of Vector Network Analyzers (VNAs) to suit your application and budget, Anritsu has the perfect solution to your VNA needs.

From RF and broadband VNAs, to premium VNAs with the highest performance and no compromises and value VNAs that offer solid performance with suitable measurement speeds for an R&D environment, we have the perfect solution for your application.

Our extensive range of VNAs now includes the NEW 2 or 4-port ShockLine performance line and the world's first 40 GHz USB VNA.

No matter what your application, Anritsu has your VNA needs covered.

Learn more: www.goanritsu.com/vnaguide15

eLEARNING free webinars

Improving Base Station Design - RF INNOVATIONS

Sponsored by: IDT

7/20

Access webinars on-demand from the archived webinars and events page at www.mwjournal.com



Liam Griffin, newly appointed president and CEO of **Skyworks Solutions**, discusses the future of connectivity, the seeds of Skyworks' success and how the company plans to stay in the lead.



Sailesh Chittipeddi, CTO and VP of operations at **IDT**, talks about the company's decision to enter RF, the markets they serve and their unique portfolio of products.

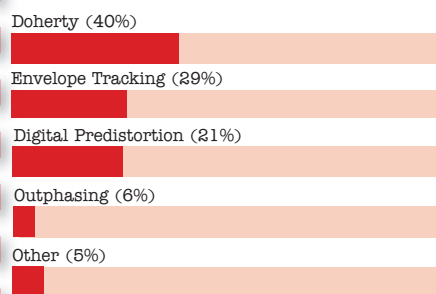
Web Survey

What is the biggest shift underway in the RF industry?

Look for our multiple choice survey online at mwjournal.com

May Survey

Which technology offers the greatest increase in amplifier efficiency?



WHITE PAPERS



Integrating EM Simulation Technologies within an RFIC Design Flow



PXI Interoperability – How to Achieve Multi-Vendor Interoperability in PXI Systems



Optimizing IP3 and ACPR Measurements



Catch **Frequency Matters**, the industry update from **Microwave Journal**, www.microwavejournal.com/FrequencyMatters

MWO

Introducing our new Common Mode Choke Finder



There's nothing common about it!

Search and compare hundreds of common mode choke options in four easy steps.

Step 1: Search by Impedance, Attenuation or Inductance at your operating frequency.

Step 2: View a sortable results table with complete performance specifications and select parts for further analysis.

Step 3: Make direct comparisons of up to six components on single impedance and attenuation graphs

Step 4: Request free samples of the most interesting parts for evaluation and testing.

It's that Simple!

Get started at coilcraft.com/CMCfinder



WWW.COILCRAFT.COM





photo courtesy of the
U.S. Military & NASA



ULTRA-REL[®] 10 MHz to 7GHz **CERAMIC MMIC AMPLIFIERS**

Low NF from 0.5 dB High IP3 up to +42 dBm Low DC current 65 mA **\$4.95** from ea. (qty 20)

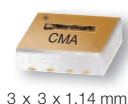
When failure is not an option. Our CMA family of ceramic MMIC amplifiers is expanding to meet your needs for more critical applications. Designed into a nitrogen-filled, hermetic LTCC package just 0.045" high, these rugged models have been qualified to meet MIL standards for a whole battery of harsh environmental conditions:

Qualified for: (see website for complete list and details)

Gross and Fine Leak	HTOL (1700 hours @ +105°C)
Mechanical Shock	Steam Aging
Vibration	Solder Heat Resistance
Acceleration	Autoclave
PIND	And More!

Robust performance across wide bandwidths makes them ideal for instrumentation, or anywhere long-term reliability adds bottom-line value. Go to minicircuits.com for all the details today, and have them in your hands as soon as tomorrow!

Electrical Specifications (-55 to +105°C)



3 x 3 x 1.14 mm

Model	Freq. (GHz)	Gain (dB)	P _{OUT} (dBm)	IP3 (dBm)	NF (dB)	DC (V)	Price \$ea. (qty 20)
New CMA-81+	DC-6	10	19.5	38	7.5	5	6.45
New CMA-82+	DC-7	15	20	42	6.8	5	6.45
New CMA-84+	DC-7	24	21	38	5.5	5	6.45
CMA-62+	0.01-6	15	19	33	5	5	4.95
CMA-63+	0.01-6	20	18	32	4	5	4.95
CMA-545+	0.05-6	15	20	37	1	3	4.95
CMA-5043+	0.05-4	18	20	33	0.8	5	4.95
CMA-545G1+	0.4-2.2	32	23	36	0.9	5	5.45
CMA-162LN+	0.7-1.6	23	19	30	0.5	4	4.95
CMA-252LN+	1.5-2.5	17	18	30	1	4	4.95

RoHS compliant





AUGUST

MARK YOUR CALENDAR

1



Initial Call for Abstracts

www.ediconchina.com

10



Call for Papers Deadline

www.ieee-iedm.org

24-26

RFIT 2016
Taipei, Taiwan



The 2016 IEEE International Symposium on Radio-Frequency Integration Technology (RFIT 2016) is a focused yet interdisciplinary advanced forum for microwave and

microelectronics technologies. RFIT provides a forum for the integrated circuit and technology communities to meet and present the latest developments in integrated circuit design, technology and system integration, with emphasis on wireless communication systems and emerging applications such as biology and healthcare, as well as THz and 3D integration technologies.

www.rfit2016.org

1-4



NIWeek 2016

Austin, Texas

The 22nd annual NIWeek conference presented by NI brings together the brightest minds in engineering and science.

More than 3,200 innovators representing a wide spectrum of industries, from automotive and telecommunications to robotics and energy, will discover the latest technology to accelerate productivity for software-defined systems in test, measurement and control.

www.ni.com/niweek

17-18



Multiphysics Intensive Training

Albuquerque, N.M.

www.comsol.com/events

29-9/2

EUSIPCO 2016
Budapest, Hungary



The 2016 European Signal Processing Conference will feature a comprehensive technical program addressing all

the latest developments in research and technology for signal processing. EUSIPCO 2016 will feature world-class speakers, oral and poster sessions, keynotes, exhibitions, demonstrations and tutorials, and is expected to attract many leading researchers and industry figures from all over the world.

www.eusipco2016.org

COMING SOON



September 20-22

**Hynes Convention Center
Boston, Mass.**

Register Now!

www.ediconusa.com

FOR DETAILS, VISIT MWJOURNAL.COM/EVENTS

HIGH POWER BROAD BAND LIMITERS 0.5 - 12 GHz

New 40 WATT CW



- Low Limiting Threshold (+6 dBm Typical)
- 40 Watt CW and 200 Watt Peak (1 microsec) power handling capability
- Built-In DC Block @ input and output
- Hermetically Sealed Module
- Typical Recovery Time is less than 10 Microsec

Typical Performance @ + 25 Deg. C

MODEL	FREQ. RANGE (GHz)	MAXIMUM INSERTION LOSS (dB)	MAX VSWR	MAX LEAKAGE @ 40 W CW INPUT (dBm)
LS0510 P40B	0.5 - 1.0	0.5	1.4:1	+21
LS0520 P40B	0.5 - 2.0	0.6	1.4:1	+21
LS0540 P40B	0.5 - 4.0	0.8	1.4:1	+21
LS0560 P40B	0.5 - 6.0	1.3	1.5:1	+21
LS05012P40B	0.5 - 12.0	1.7	1.7:1	+21
LS1020 P40B	1.0 - 2.0	0.6	1.4:1	+21
LS1060 P40B	1.0 - 6.0	1.2	1.5:1	+21
LS1012P40B	1.0 - 12.0	1.7	1.7:1	+21
LS2040P40B	2.0 - 4.0	0.7	1.4:1	+20
LS2060P40B	2.0 - 6.0	1.3	1.5:1	+20
LS2080P40B	2.0 - 8.0	1.5	1.6:1	+20
LS4080P40B	4.0 - 8.0	1.5	1.6:1	+20
LS7012P40B	7.0 - 12.0	1.7	1.7:1	+18

Note: 1. Insertion Loss and VSWR tested at -10 dBm.

Note: 2. Typical limiting threshold: +6 dBm.

Note: 3. Power rating derated to 20% @ +125 Deg. C.

Other Products: Detectors, Amplifiers, Switches, Comb Generators, Impulse Generators, Multipliers, Integrated Subassemblies

Please call for Detailed Brochures



155 Baytech Drive, San Jose, CA 95134
Tel: (408) 941-8399 . Fax: (408) 941-8388
Email: info@herotek.com
Website: www.herotek.com
Visa/Mastercard Accepted

Coming Events

CALL FOR PAPERS

EDI CON China 2017
August 1, 2016

LAMC 2016
August 1, 2016

DesignCon 2017
August 16, 2016

88th ARFTG Conference
October 7, 2016
mwjournal.com

AUGUST

NIWeek 2016

August 1-4, 2016 • Austin, Texas
www.ni.com/niweek

RFIT 2016

August 24-26, 2016 • Taipei, Taiwan
www.rfit2016.org



SEPTEMBER

CTIA Super Mobility

September 7-9, 2016 • Las Vegas, Nev.
www.ctiasupermobility2016.com

Tower and Small Cell Summit

September 7-9, 2016 • Las Vegas, Nev.
www.towersummit.com

IEEE AUTOTESTCON 2016

September 12-15, 2016 • Anaheim, Calif.
www.autotestcon.com

ION GNSS+ 2016

September 12-16, 2016 • Portland, Ore.
www.ion.org/gnss

Metamaterials 2016

September 17-22, 2016 • Crete, Greece
http://congress2016.metamorphose-vi.org

EDI CON USA

September 20-22, 2016 • Boston, Mass.
www.ediconusa.com

IRMMW-THz 2016

September 25-30, 2016 • Copenhagen, Denmark
www.irmmw-thz2016.org



OCTOBER

EuMW 2016

October 3-7, 2016 • London, UK
www.eumweek.com

The 2016 Defence, Security and Space Forum at EuMW

October 5, 2016 • London, UK
www.eumweek.com

ICUWB 2016

October 16-19, 2016 • Nanjing, China
http://icuwb2016.njupt.edu.cn

Phased Array 2016

October 18-21, 2016 • Waltham, Mass.
www.array2016.org

IME/China 2016

October 19-21, 2016 • Shanghai, China
www.imwexpo.com/siteengine.php?do=en/index

IEEE CSICS 2016

October 23-26, 2016 • Austin, Texas
www.csics.org

AMTA 2016

October 30-November 4, 2016 • Austin, Texas
www.amta2016.org



NOVEMBER

MILCOM 2016

November 1-3, 2016 • Baltimore, Md.
www.milcom.org

ITC/USA

November 7-10, 2016 • Glendale, Ariz.
www.telemetry.org



DECEMBER

IEEE International Electron Devices Meeting (IEDM)

December 3-7, 2016 • San Francisco, Calif.
www.ieee-iedm.org

APMC 2016

December 5-9, 2016 • New Delhi, India
www.apmc2016.org

88th ARFTG Microwave Measurement Conference

December 6-9, 2016 • Austin, Texas
www.arftg.org

IEEE MTT-S Latin America Microwave Conference (LAMC 2016)

December 12-14, 2016 • Puerto Vallarta, Mexico
www.lamc-ieee.org



JANUARY

RWW2017

January 15-18, 2017 • Phoenix, Ariz.
www.radiowirelessweek.org

DesignCon 2017

January 31-February 2, 2017 • Santa Clara, Calif.
www.designcon.com

FEBRUARY

Mobile World Congress 2017

February 27-March 2, 2017 • Barcelona, Spain
www.mobileworldcongress.com



COLLABORATION IS EVERYTHING.

Richardson RFPD and Microsemi proudly support RF Wireless, Energy and Power markets worldwide

For a relay team to win gold in Rio, skill and performance must be flawless.

Richardson RFPD and Microsemi strive to match those levels of dedication and teamwork with our combined support of worldwide A&D, industrial, energy storage, and power conversion applications needs.

When timing is critical, turn to Richardson RFPD and Microsemi for high-performance RF Wireless, Energy and Power solutions.

Learn more at www.richardsonrfpd.com/Microsemi.



Scan me to
LEARN MORE
www.richardsonrfpd.com/Microsemi



Your Global Source for RF, Wireless, Energy & Power Technologies

www.richardsonrfpd.com | 800.737.6937 | 630.262.6800

E Pluribus Unum: An Integrated Design Flow for Phased Arrays

Daren McClearnon
EEsof EDA, Keysight Technologies, Santa Rosa, Calif.

Multichannel antenna arrays are key enablers in the next generation of defense and wireless communications systems, for beam steering and multiple-input-multiple-output (MIMO) architectures. They allow both electronic warfare (EW) and consumer systems to provide precise, dynamically allocated and robust service levels, supporting mobility business models that were unthinkable a few years ago. Approaching this new technological complexity begins in R&D, where similar breakthroughs in design tools and verification methodologies can address phased array beam forming challenges efficiently, in a lean commercial environment. This article shows how a connected suite of standard tools can streamline the design process while enabling trade-offs in RF and digital beam forming performance.

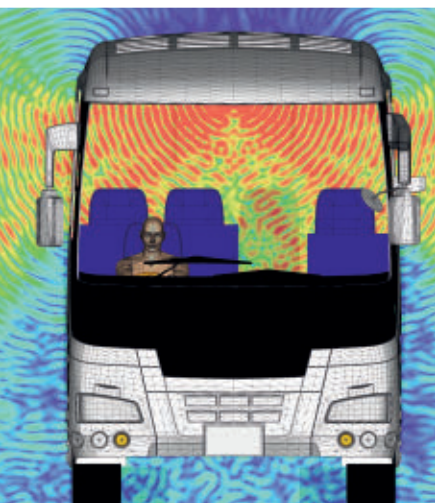
Multi-antenna techniques such as beam forming (RF, digital and hybrid) and massive MIMO are now major trends in 5G and satellite communications systems and EW, thanks to their ability to provide precise, dynamically allocated and robust service levels. These techniques solve different problems at the system level and can be used together to deliver more bits per Hz in a crowded area, with less interference. What has enabled these elaborate technologies to advance from their use in

specialized military applications to low cost, high volume consumer-oriented platforms, over the course of just a few years? The answer lies with semiconductor improvements gained in keeping with Moore's Law, specifically reduced cost, size and power and increased bandwidth and microwave performance. Consumer demand is playing a role in driving beam forming and MIMO into the commercial sector, leading to mobility business models that were unthinkable only a few years ago.



Make the Connection

Find the simple way through complex EM systems with CST STUDIO SUITE



Components don't exist in electromagnetic isolation. They influence their neighbors' performance. They are affected by the enclosure or structure around them. They are susceptible to outside influences. With System Assembly and Modeling, CST STUDIO SUITE helps optimize component and system performance.

Involved in antenna development? You can read about how CST technology is used to simulate antenna performance at www.cst.com/antenna.

If you're more interested in filters, couplers, planar and multilayer structures, we've a wide variety of worked application examples live on our website at www.cst.com/apps.

Get the big picture of what's really going on. Ensure your product and components perform in the toughest of environments.

**Choose CST STUDIO SUITE –
Complete Technology for 3D EM.**



For all the good that comes with these technologies, their complexity creates challenges, especially with the design of phased arrays. Overcoming these challenges to achieve an optimal system design requires a new, top-down system-level methodology, one that streamlines the design process, from assessing beam forming strategies and system-level scenarios to system implementation.

PHASED ARRAY DESIGN CHALLENGES

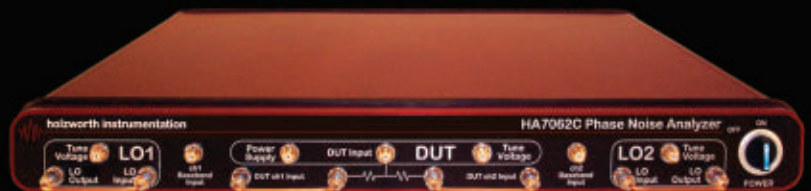
When designing phased array systems, several design flow challenges — both technical and economic — must be addressed. For example, to gain a system perspective of the economic and service-level trade-offs, the impact of realistic analog, electromagnetic (EM) and digital signal processing (DSP) performance must be considered. However, a system perspective is often hard to achieve. One challenge is the sheer number of engineering disciplines required to develop a phased array, most operat-

ing independently. Different toolsets are used for analyzing antennas and EM, RF transceivers and manifolds (which can take the form of ICs, modules and boards), as well as the integration of RF, digital and hybrid beam forming architectures — which cross boundaries between the base-band ASIC/FPGA and RF architectures.

While beamwidth and sidelobe levels are typical measures of array performance, the larger goal of any phased array subsystem is delivering higher system-level performance. Beam forming is used to concentrate RF power in specific directions, which reduces the RF power needed to achieve a given link quality (e.g., data throughput). Secondly, this also reduces interference for other users while improving their link quality and conserving battery life. At a higher level, the underlying RF impairments of the array affect the final sidelobe levels and beam patterns, reducing system-level performance.

In phased array transmitters, sidelobe levels from imperfectly formed beams may interfere with external devices or make the transmitter visible to countermeasures. In radar systems, sidelobes may also cause a form of self-induced multipath, where multiple copies of the same radar signal arrive from different sidelobe directions. These additional propagation paths can exaggerate ground clutter and must be removed with sophisticated DSP algorithms. Degraded RF array performance can also misdirect the main beam, widen it or reduce its directivity. Examples of this are “squinting,” (e.g., frequency dependent beam distortion that occurs during each radar chirp, as shown in **Figure 1**) and AM-AM/AM-PM distortion. In a military system, the reduction in effective radiated power (ERP) reduces the power illuminating a distant target and its probability of detection and effective standoff range. For communication link budgets, the effect

IT DOES EXIST...



HA7062C PHASE NOISE ANALYZER

- >> FAST: Real Time Data Analysis
- >> 10MHz - >20GHz DUT Input Range
- >> 0.1Hz - 40MHz Measurement Offsets
- >> ANSI z540 NIST Traceable Data
- >> 3 YEAR PRODUCT WARRANTY

ACCURATE PHASE NOISE MEASUREMENTS ARE NO LONGER A MYSTERY

YOUR COMPLETE MILLIMETER WAVE **SOLUTION**

new

Low-Cost
VNA Extender



MANY ITEMS IN STOCK



MADE IN USA

www.sagemillimeter.com | 3043 Kashiwa Street, Torrance, CA 90505
T: 424-757-0168 | F: 424-757-0188 | sales@sagemillimeter.com



SAGE

Millimeter, Inc.

is on the signal-to-noise ratio (SNR) and coverage area.

In phased array receivers, poor RF array performance may add noise. It may also increase reception from unwanted directions, from sidelobes and misplaced nulls, or wid-

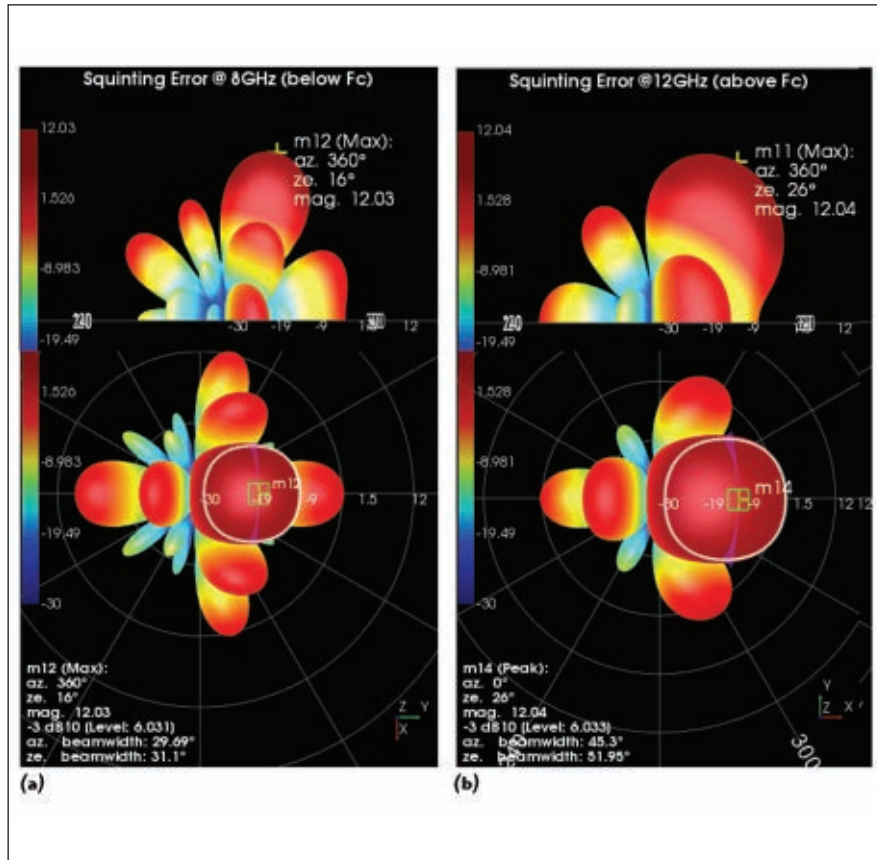
ened beams from overloading. These effects reduce sensitivity and range, increase susceptibility to interferers or jammers and degrade the overall error vector magnitude (EVM), bit error rate (BER) and throughput (or probability of detection). Gain/Tem-

perature (G/T) is a common measurement for receiver arrays, combining several underlying degradations into a composite figure-of-merit (similar to SNR) over a range of received spherical angles (see **Figure 2**). The array may be programmed to “listen” in a certain direction, yet how well does it achieve that goal?

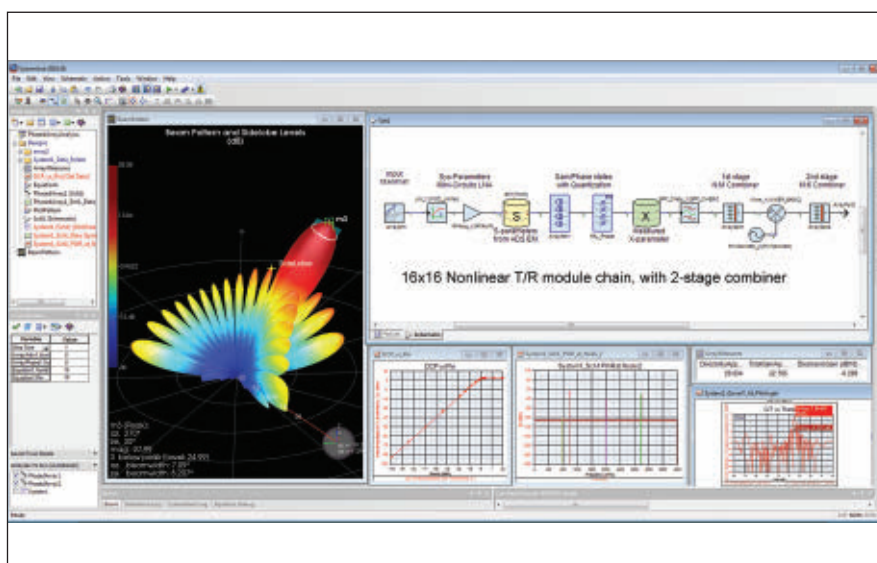
Although MIMO techniques are related to beam forming, they have subtly different issues from forms of crosstalk and correlation. Depending on the architecture, these techniques may be used in tandem on the same platform. MIMO improves the robustness of communication links in dense mobility environments, while improving spectral efficiency. Since MIMO requires individually-addressable signal paths for each “stream,” the cost and power of the digital-to-analog and analog-to-digital converters (DAC and ADC) and dedicated signal processing adds dramatically to the size, weight and power (SWaP) of the array subsystem. Functionally, analyzing multiple data streams from a single user (MIMO), compared to individual data streams from multiple users in a multi-function array, requires the array and its impairments to be accessed at the higher system-level.

In hybrid beam forming (HBF) and composite arrays comprised of multiple single-function sub-arrays, the likelihood of self-interference increases. HBF is gaining popularity in the 5G community as it allows cost-benefit trades between analog beam forming (ABF) and digital beam forming (DBF). In HBF, there are still multiple distinct baseband signals, but they drive ganged sub-arrays at the RF beam forming levels; these sub-arrays perform phase shifting at the transmit carrier frequency. Splitting the functionality achieves both directionality (beam forming) and throughput (MIMO) at lower cost and power from RF ASICs, ADCs and DACs.

A final concern is whether physically imperfect arrays really work across their intended bandwidths at their microwave or millimeter wave carrier frequencies and in their propagation environments. Until recently, this has been difficult for a disjointed set of simulation tools to predict, requiring dependence on hardware prototyping. Each engineering group has its own

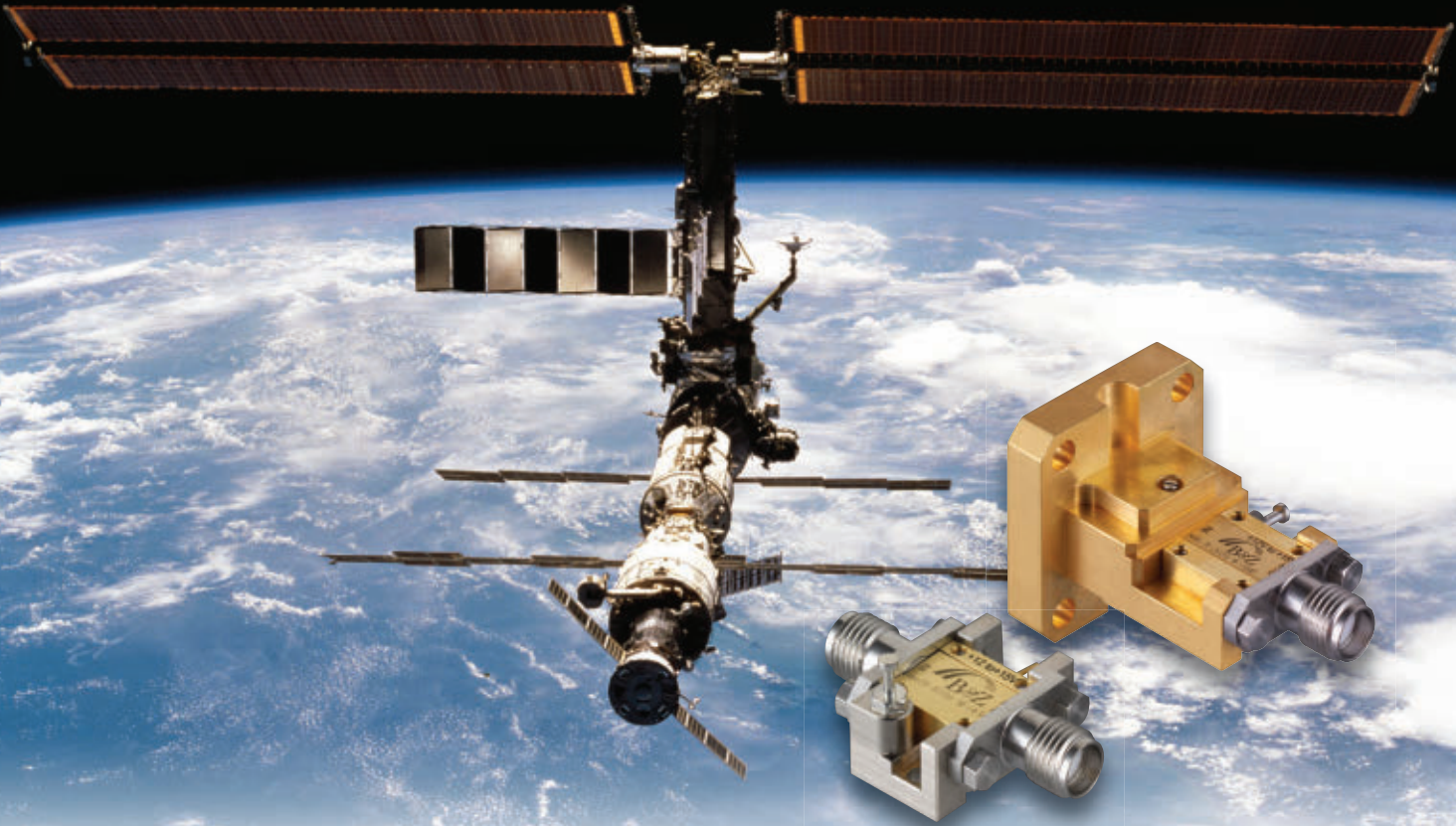


▲ Fig. 1 Array antenna patterns at 8 GHz (a) and 12 GHz (b) showing beam squinting and sidelobe variation.

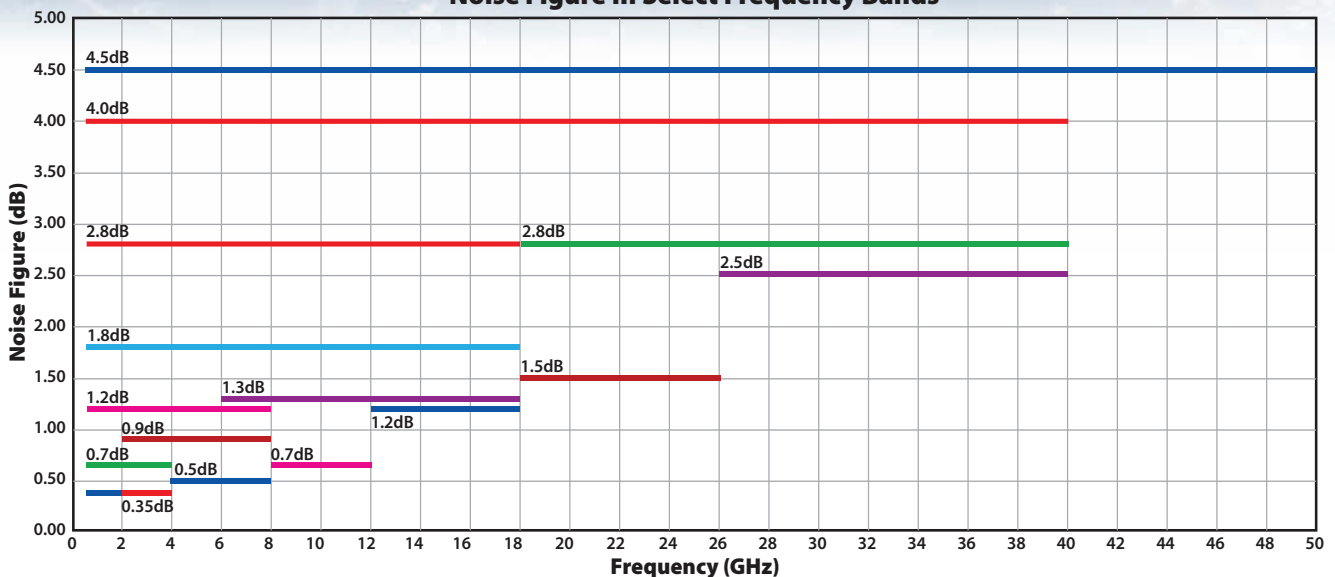


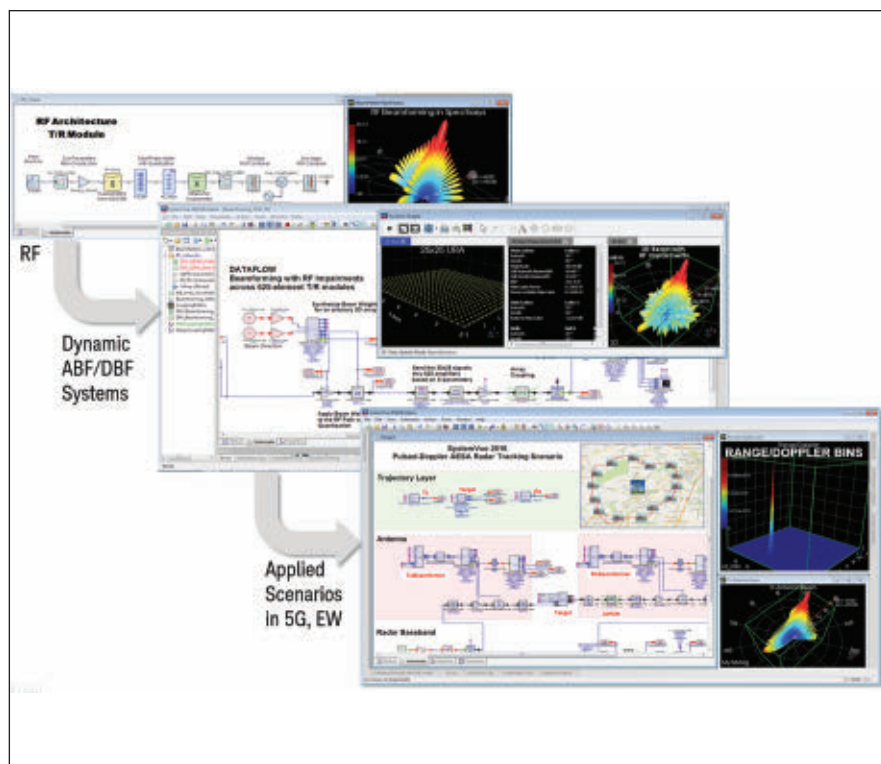
▲ Fig. 2 G/T analysis for a T/R module, showing sidelobes and directivity.

Has Amplifier Performance or Delivery Stalled Your Program?



Noise Figure In Select Frequency Bands





▲ Fig. 3 System analysis using multiple platforms, from the RF components to end use scenarios.

established tool chains and methodologies which are difficult to combine across disciplines. Back annotating engineering changes up to the system level is also difficult.

Collectively, the number of toolsets for architecting and validating phased arrays is daunting and needs much investigation and improvement. Given these challenges, a predictive, system-level design flow can greatly reduce iterations and the need for hardware validation, indoor/outdoor antenna ranges and flight time.

In addition to these design flow challenges, there are softer design flow risks to consider: In some environments, intellectual property (IP) is concentrated in people rather than tools. Preserving and re-using design experience and project IP is a strategic concern. Issues like controlling R&D “overhead” costs not assigned to a contract, technology turnover, time-to-deployment and high skill requirements add to the demand for streamlined model-based engineering (MBE) across multiple domains.

Power Amplifiers for

Introducing the Element of Portability
Uncompromising Solid State Performance and Protection

HIGH POWER

SKU	Frequency [MHz]	Pout [Watt]	Size
2126	20 ---- 500	1000	R5U
2162	20 ---- 1000	1000	R5U
2066	500 -- 1000	1000	R5U
2185	1000 - 1200	10000	R9U
2180	1000 - 2500	2000	R8U
2187	1000 - 3000	500	R5U
2170	1000 - 3000	1000	R5U
2186	2000 - 6000	150	R3U
2179	2000 - 6000	250	R4U

LOW POWER

SKU	Frequency [MHz]	Pout [Watt]	Size
2191	20 ---- 1000	100	R3U
2192	20 ---- 1000	250	R3U
2175	80 ---- 1000	500	R3U
2193	1000 - 3000	100	R3U
2194	1000 - 3000	250	R3U
2198	20 ---- 6000	100	R3U
2195	2000 - 6000	50	R3U
2196	2000 - 6000	80	R3U
2197	2000 - 6000	130	R3U

EMC TESTING

Selectable User Output Power Control
Automatic Gain Control (AGC)
Automatic Level Control (ALC)
Manual Gain Control (MGC)

Protection
Load VSWR 3:1
Input Overdrive Protection
Thermal Overload Protection
AC Power Supply Protection
Out of Band Drive Protection

Built in Peak Detectors
Input and Output Detectors
Selectable Peak and RMS

25 - 29 July 2016 | Ottawa, Canada

Certified to ISO 9001:2008
TUV Rheinland
Prescribed Right

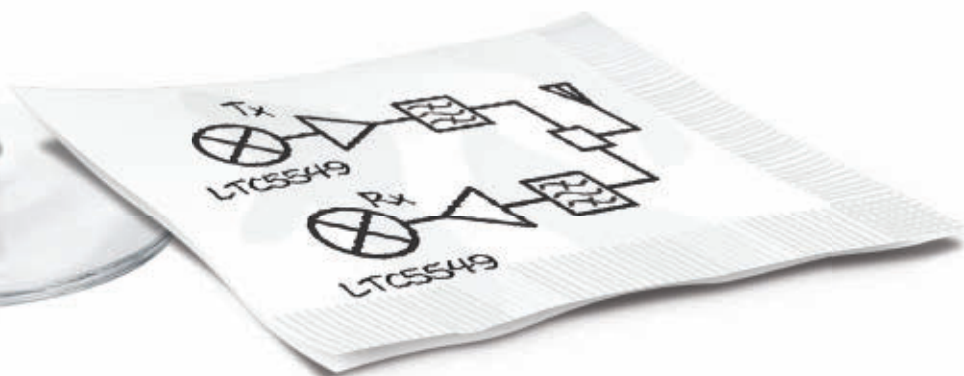
1(310)412-8100

www.EmpowerRF.com

EMPOWER
RF SYSTEMS, INC.

Upgrade Your Mixer

2GHz–14GHz, 0dBm LO Drive

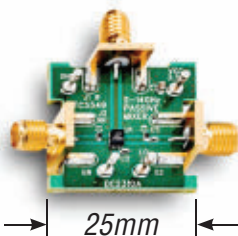


The LTC5549 microwave mixer upgrades your transmitter and receiver performance with a +22.8dBm IIP3 at 12GHz. Its 0dBm LO drive and an on-chip frequency doubler eliminate the need for an external LO power amplifier and allow use of commonly available low frequency PLL/synthesizers, reducing power consumption and solution costs — all in a tiny 3mm x 2mm package that keeps your solution size small.

▼ Features

- +22.8dBm IIP3 at 12GHz
- 0dBm LO Drive
- Upconversion or Downconversion
- –30dBm LO Leakage
- Tiny 3mm x 2mm Package

Demo Board



▼ Info & Free Samples

www.linear.com/product/LTC5549
1-800-4-LINEAR

LT, LT, LTC, LTM, Linear Technology and the Linear logo are registered trademarks of Linear Technology Corporation. All other trademarks are the property of their respective owners.

ADDRESSING THE CHALLENGES

Established electronic design automation (EDA) tool chains from companies like Keysight are being expanded to improve coverage for systems that use phased arrays and beam forming. These expanded tool chains help address several issues that arise from the use of disjointed design flows:

Choosing the right level of abstraction. Finding the right level of

simulation abstraction, especially in the RF design flow, can be difficult. If the models are too idealized for speed, then the simulations will not be accurate. That leads to increased hardware validation and cost. On the other hand, if excessive physical detail is included, the huge simulations will be too slow to validate meaningful portions of a “test plan” and not very scalable beyond 100-element arrays.

Fortunately, there is a middle ground. Behavioral modeling balances the many orders of simulation magnitude between multi-user 5G and radar system scenarios, with active signaling, beam forming algorithms, nonlinear RF T/R modules and EM solver physical design details. Intelligent choices about “which powers of 10” to combine can make the flow scalable to thousands of array elements and unite the teams, while still preserving essential accuracy.

Scaling up to size. Once the right level of abstraction is found, the next step is applying it to larger arrays (>1000 elements). Although spreadsheets are often used for architecture studies, they give up too much flexibility and do not consider noise, nonlinearities, X-parameters®, component variations and statistics, frequency dependence, mismatch or other factors. Circuit-level tools can be “brute forced” into array analysis, but that comes at a huge price for usability and speed. Instead, an intermediate modeling level can be used where nonlinear, multi-stage arrays are modeled in seconds using a simple use model, preserving the idea of “predictive” accuracy (i.e., a simulation that will tell you something you didn’t already know).

Validating the rendered beam (baseband with realistic RF). The ability to drive the accurate RF array model, from the previous steps, with realistic baseband beam forming algorithms is necessary to validate the beam integrity of the array under a range of 3D array configurations, scan angles, windowing tapers, sub-array partitioning, operating frequencies and other conditions. MATLAB algorithms by themselves do not save design iterations without some level of RF accuracy informed from the actual design process. Conversely, without complex algorithmic behaviors and baseband corrections, the benefit of static RF models can only be inferred at the array subsystem. Both domains must work together to predict the performance of the whole subsystem and reduce the cost of prototyping and test.

Handling dynamic, system-level scenarios. Array subsystems are designed to deliver a certain level

Powerful Multipath/Link Emulator

Multipath Rayleigh & Rician Fading
Unmanned Aerial Vehicle (UAV) testing
Sophisticated Satellite link emulation
Mobile Comm's on the move testing

250 MHz bandwidth

Test solutions for

- WIN-T** - warfare information networks, tactical
- MUOS** - mobile user objective system
- JTRS** - Joint Tactical Radio System
- IRIS** - Internet routing in space

Software showing mobile link setup



RF Test Equipment for Wireless Communications

dBm Corp, Inc

32A Spruce Street ♦ Oakland, NJ 07436

Tel (201) 677-0008 ♦ Fax (201) 677-9444

www.dbmcorp.com

If your 5G idea works here...



it will work here.

Autonomous vehicles navigating through traffic. Hands free.

Soon it will be reality. A world connected as never before. Always available. Low latency. Ultra reliable. That's the promise of 5G. New spectrum. New waveforms. Millimeter-waves. More. Keysight offers the world's first 5G simulation, design and test environment able to emulate your real-world 5G wireless thesis. With deep expertise to help you navigate 5G risk and complexity. So you can go from 5G ideas to 5G reality faster.

HARDWARE + SOFTWARE + PEOPLE = 5G INSIGHTS

5G

Get the latest app notes,
white papers and tutorials
www.keysight.com/find/5G-Insight

USA: 800 829 4444 CAN: 877 894 4414

© Keysight Technologies, Inc. 2016



Unlocking Measurement Insights

Agilent's Electronic Measurement Group is now **Keysight Technologies**.

of system performance, whether a 5G, EW or emerging satellite platform. A given array subsystem must be validated with format-realistic signaling and receiver processing in dynamic scenarios to ensure it is compliant with published standards, interoperable with other equipment under specified conditions and meets other performance minimums. Most organizations wait

until operational hardware prototypes are available to do this validation, which typically requires access to indoor and outdoor test ranges, flight time and other expensive assets. This leads to late discovery and troubleshooting of architectural flaws at the pilot production stage. A connected, top-down, system-level design flow enables diagnosing and quickly addressing

“preventable” errors before requiring more rigorous testing; expensive assets are only needed at the end. The connection of “proposal” to “final design,” in the terms of the customer’s own delivered performance, makes this step worth pulling into the R&D phase, as part of a soft, simulation-based test plan.

This final point has a large economic payoff. However, the following three capabilities are required to realize the benefits of a unified phased-array workflow:

- **Exchanging design information** — From an MBE perspective, a team works from the top down within a single discipline, such as moving beam forming algorithms from floating point into working FPGAs or ASICs. From the system perspective, maintaining this MBE approach across disciplines requires additional tool connectivity that is less common. Humans become the design flow bridge, often using word processors and spreadsheets in lieu of design files; however, this requires interpretation that inserts risk into the process. Direct exchange of design information enables faster cross-validation and engineering changes to back-propagate to the system architect, in the event of a lower level technical (or material) change. Design information formats include MATLAB models, System C/C++, VHDL and Verilog, S- and X-parameters, SysParameters, 3DEM far field pattern files and waveform files.
- **External scripting and automation for formalized cross-validation** — An environment like Keysight’s SystemVue can be used to assemble meaningful baseband-RF co-validation scenarios. These scenarios are automated with external applications to run a regular regression harness of automated verifications, such as for a nightly build process. The ability to cross-validate a project continuously, from the very first day, improves transparency, enables better project management and lowers risk.
- **Integration with test** — Finally, design simulation is helpful, yet it often remains separate from real world integration, variations and results. The ability to connect the

Invisipin®

ULTRA Hi RF - Compliant Connector



INFINITELY CONFIGURABLE • INDIVIDUALLY SOLDERABLE • HI COMPLIANCE RANGE

Specifications

- > 50 GHz Bandwidth @1 dB
- 20 mΩ C-Res (typical)
- Up to 4 Amps

Configurations

- 0.23mm to 0.64mm diameter pins
- Pitches from 0.4mm to >1mm



(Coaxial Configuration)

*Available in tape and reel (machine placeable) or fully integrated into custom products.

R&D
Interconnect Solutions®

www.RDIS.com/MJ

MJ@RDIS.com

610-443-2299

©2015 R&D Interconnect Solutions. All rights reserved. R&D Interconnect Solutions, Invisipin, and RDIS.com are trademarks of R&D Interconnect Solutions.

RF-LAMBDA
THE LEADER OF RF BROADBAND SOLUTIONS

Made in USA

BROADBAND SSPA SOLID STATE POWER AMPLIFIERS

0.1-22GHZ ULTRA BROADBAND SSPA



RFLUPA01M22GA
4W 0.1-22GHZ



RFLUPA0218GA
10W 2-18GHZ

0.01-6GHZ VHF, UHF, L, S, C BAND



RFLUPA0706GD
30W 0.7-6GHZ



RFLUPA02G06GC
100W 2-6GHZ

6-18GHZ C, X, KU BAND



RFLUPA0618GC
25W 6-18GHZ



RFLUPA08G11GA
50W 8-11GHZ



RFLUPA06G12GB
25W 6-12GHZ

18-50GHZ K, KA, V BAND



RFLUPA18G47GC
2W 18-47GHZ



RFLUPA27G34GB
15W 27-34GHZ



RFLUPA28G42GA
2W 28-42GHZ



RFLUPA32G38GB
8W 32-38GHZ

BENCHTOP RF MICROWAVE SYSTEM POWER AMPLIFIER



RAMP00G06GA - 30W 0.01-6GHZ



RAMP39G48GA - 4W 39-48GHZ



RAMP01G22GA - 8W 1-22GHZ



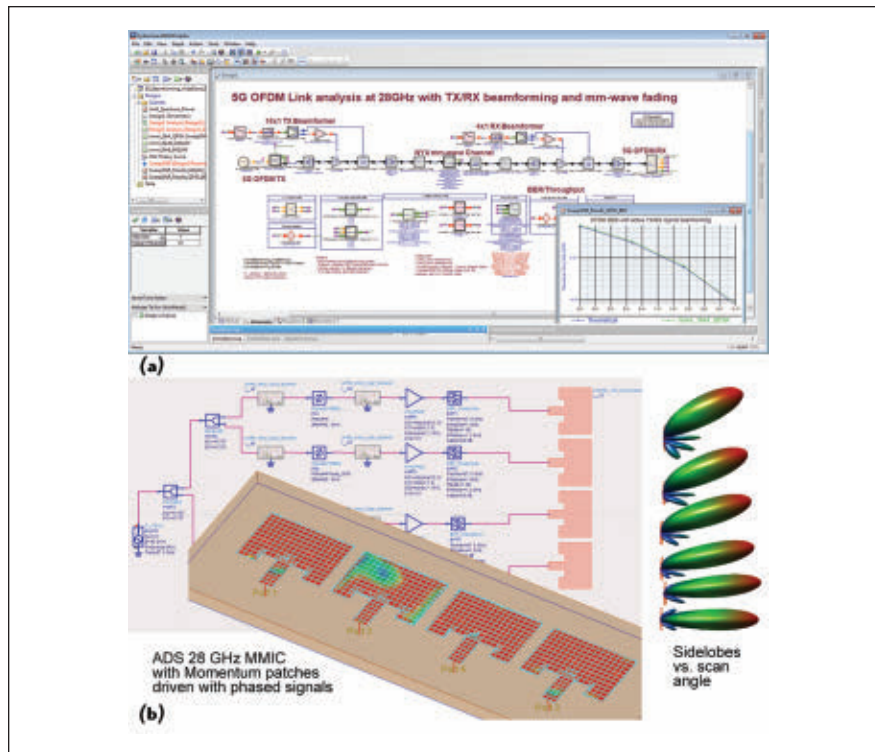
RAMP27G34GA - 8W 27-34GHZ

www.rflambda.com
sales@rflambda.com

1-888-976-8880
1-972-767-5998

San Diego, CA, US
Plano, TX, US
Ottawa, ONT, Canada





▲ Fig. 4 Link analysis of 28 GHz 5G OFDM link (a) and 4×1 receive array modeled in Momentum (b).

EDA world directly to wideband, multi-channel test and measurement, with support for real-time prototyping and instrument personalities, means that design insight can be preserved in a closed modeling loop using a consistent approach, from proposal into hardware. Combining simulation with versatile software-defined measurement platforms allows earlier architecture validation and enables flexible verification strategies that reduce project cost and increase utilization of test assets.

Progress in each of these areas is possible using a design flow that connects tools and reference IP in several domains into an open flow. Keysight SystemVue, for example, provides a phased-array design personality and can also operate as a co-validation backplane. The following case studies show how a unified, model-based design approach for phased arrays might work in the real world.

EW ARRAY

Consider a basic EW scenario in which a central monostatic radar beam forms in “tracking” mode to follow a radar cross section (RCS) target, such as an aircraft, as it flies in a path around a city, using latitude, longitude, altitude waypoints. As the position of the RCS target moves, both the transmitter and receiver arrays are steered to follow its direction. The arrays are each 25×25 uniform rectangular with a Taylor taper, whose complex weights are dynamically updated at the system level using adaptive algorithms. The arrays can either be purely behavioral or incorporate some effects from a T/R module chain modeled in an RF simulation domain. In **Figure 3**, the range-Doppler bins are shown at the system level, along with the beam quality.

In the RF array, it is possible to account for the X-parameters of components, designed in ADS or measured on the bench. It is also possible to account for noise, nonlinearities, mismatch and frequency response, as well as the use of quantized phase, delay or amplitude states. Coupling between array elements, based on a true EM simula-

EXODUS

ADVANCED COMMUNICATIONS

EXIT OUT OF ORDINARY

High Power SSPA
Chip & Wire, Assemblies, Modules & Systems
Broadband, CW, Pulse & Linear Applications
1MHz to 47GHz, 3KW CW, 10KW Pulse
Block Up Converters
Low Noise Amplifiers

Sales contacts
Inside Sales : Christy Strahan Anderson
Domestic/International Sales : Bill Liebman
Technical Sales : Effi Bainvill

Exodus Advanced Communications, Corp.
3674 E. Sunset Road, Suite 100,
Las Vegas, Nevada 89120 USA
Tel : 1-702-534-6564
Fax : 1-702-441-7016
Email : sales@exoduscomm.com
Web : www.exoduscomm.com

Silicon Quad Core ICs for K/Ka-Band SATCOM

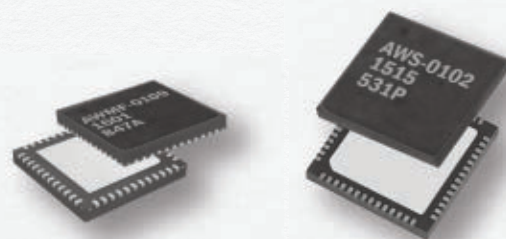
Market	Product Family	Part Number	Description
Satellite Communications AESA	K-and Ka-Band Silicon Core IC Solutions	AWS-0102 AWMF-0109 AWMF-0112 AWMF-0113	4-element Rx Quad Core IC (K-Band) 4-element Tx Quad Core IC (Ka-Band) 8-element Rx Quad Core IC (K-Band) 8-element Tx Quad Core IC (Ka-Band)

Highly integrated silicon

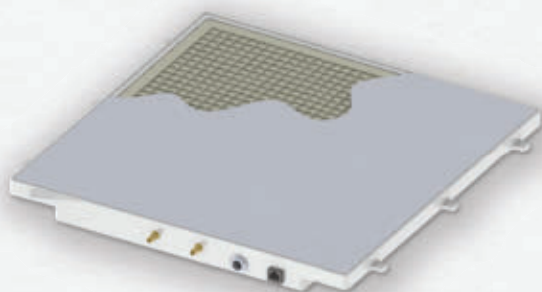
Supports 4 dual or 8 single pol elements

Linear or circular polarization

Enables complete K/Ka-band earth terminal solution



Surface mount QFN
sized to fit lattice spacing



Anokiwave - enabling your SATCOM
on the move terminals

mmW Si
Core ICs

AESA
ASICs

mmW
Front End ICs

tion, and realistic far field patterns for the radiating elements may be taken into account in the final, working beam patterns. As the array scans to more extreme angles, the scan loss and grating lobes degrade the performance. If the highest accuracy is needed for troubleshooting, a few key RF pieces may be directly co-simulated with the ADS circuit envelope/Ptolemy simulators — although for larger arrays, a comprehensive co-simulation approach can be impractical. For baseband, if FPGA algorithms are being co-verified, key algorithms can be co-simulated with either an HDL simulator, a Xilinx Virtex 7 FPGA board running in hardware-in-the-loop (HIL) mode or even an instrument. To account for atmospheric fading and terrain, SystemVue can be scripted to connect with the STK software from Analytical Graphics Inc. (AGI). This allows key time-varying quantities like range delay, Doppler shift and propagation loss to be rendered with accurate, fully-coded radar signaling.

With this verification backplane, it is possible to design the phased array and use it in a meaningful, scripted scenario that validates a range of conditions, statistical variations or countermeasures. In this way, an entire organization can contribute files and IP to a common tool and cross validate all the way to the test bench.

5G ARRAY

A likely 5G scenario comprises a wideband, 28 GHz MIMO OFDM link between a planar 4×4 array at the base station (i.e., eNodeB) and a 4×1 array at the user's equipment (UE). The beams are dynamically steered using hybrid beam forming (see **Figure 4**). The link is faded through a millimeter wave 3D MIMO fading model, based on 5G research at New York University. The baseband reference designs for the transmitter and receiver provide the OFDM framing and resource mapping on a flexible level; these designs go beyond LTE-A and include receiver synchronization and demodulation back to the

data payload. This complex BER/throughput example includes the effect of the array, beam forming accuracy and an industry-standard fading model. As more UEs and interferers are added, the adaptive beam forming algorithms, the modulation and coding strategy, as well as the RF architecture can be assessed. In this scenario, the flexibility to conduct system-level research, while using a practical RF basis to perform the modeling, allows the system architect to assess how large of an array is needed, the required performance and the risk to the company.

CONCLUSION

The practical design challenges for phased array subsystem design go beyond simple technical performance issues associated with individual RF component design. A view of the subsystem's performance can directly assess overall performance margins across baseband and RF and help designers make trade-offs between the domains, while delivering realistic performance. The critical capability is tying together the circuit simulators, beam forming and DSP algorithms, antenna patterns, system scenarios, FPGA implementations and test equipment in a unified model-based design flow. This can be accomplished using an electronic system-level platform like SystemVue. The resulting connected suite of standard tools helps to significantly streamline the design process. Adding a phased array beam forming personality adds more power, unlocking cross-functional insight. ■

Covering Your Spectrum

- Fixed Attenuators
- Variable Attenuators
- Terminations
- Power Dividers/Splitters
- RF Adapters
- DC Blocks
- RF Tuners
- DC to 50 GHz
- 1 Watt to 2000 Watts
- Custom Solutions



*Providing the highest quality and cost-competitive
Broadband RF and Microwave Products
in the Industry since 1989.*

Visit our new website with interactive catalog and online RFQ!

www.WeinschelAssociates.com

19212 Orbit Drive
Gaithersburg, MD 20879
Voice: 301.963.4630
Fax: 301.963.8640
RF@WeinschelAssociates.com



5G App Note:

For more information,
visit [http://literature.cdn.keysight.com/
litweb/pdf/5992-1448EN.pdf](http://literature.cdn.keysight.com/litweb/pdf/5992-1448EN.pdf)





New **0.5-8GHz** **Ultra-Wideband Low Noise Amplifiers...Matched!**

Low noise, high dynamic range, high output power, and flat gain from 0.5 to 8GHz, **all in a single model!** And it's very easy to use: all you need is a simple fixed inductor at the input and output to match impedance over the entire frequency band!ⁱ It's ideal for sensitive, high-dynamic-range receivers, instrumentation, defense systems, LTE, WiFi, S-Band and C-Band radar, SatCom and more! It operates on a single 5V supply and comes in a tiny 3x3mm MCLP package for excellent manufacturability. It's available off the shelf, so go to minicircuits.com and place your order today for delivery as soon as tomorrow!

ⁱ See datasheet for suggested application circuit.

ⁱⁱ Flatness specified over 0.5 to 7GHz.

Only **\$6⁹⁵**
(qty. 1000)

- **Matched over full frequency range!**
- Low Noise Figure, 1.3 dB
- High Gain, 21 dB
- Excellent Gain Flatness, ± 0.7 dBⁱⁱ
- High IP3, +35 dBm
- High Pout, +23.2 dBm

 **Tiny Size, 3x3 mm**





Simplifying Antenna Design Without Compromise

National Instruments
AWR Group, NI
El Segundo, Calif.

Growing demand for wireless connectivity relies more and more on integrated antenna solutions customized for optimal system performance, cost and size. Achieving multiple performance metrics such as impedance matching, gain, radiation efficiency and operating bandwidth is a time consuming process involving numerous iterative simulations and a significant amount of design knowledge. With the demand for design experience greatly exceeding the current supply of antenna engineers, an alternative approach is needed.

Fortunately, research into the use of the evolutionary algorithms (EA), a programmatic method to explore the design space and automatically locate superior antenna designs, offers a means to accelerate the overall design process. EA is proving to be highly effective at generating antenna structures with greater performance than would otherwise be developed by traditional methods. AntSyn™, a combination of EA with RF/microwave simulation, has been successful in the development of a variety of antenna types for

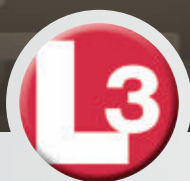
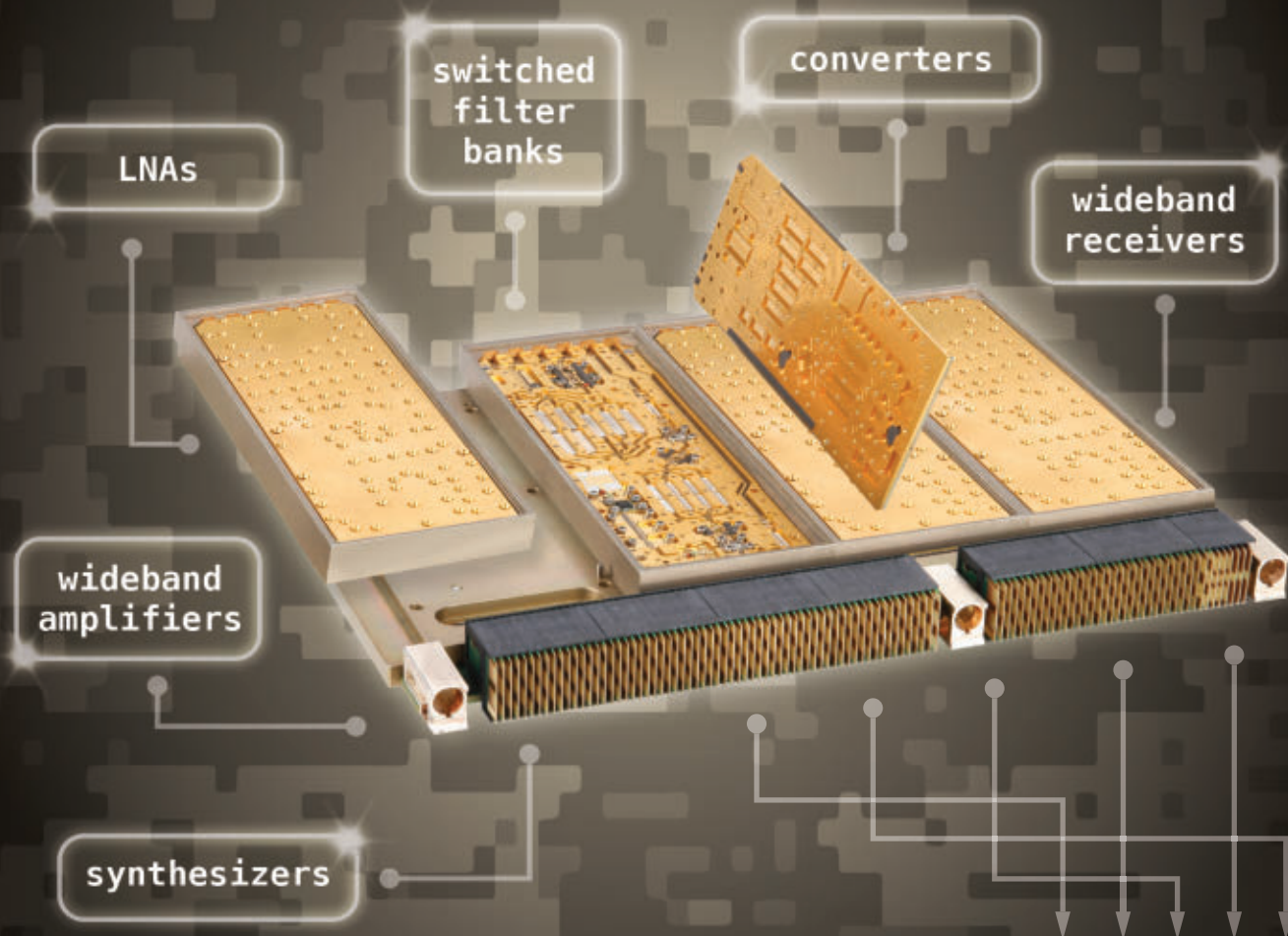
aerospace applications, and it is now available as a commercial product from National Instruments (NI).

AntSyn is an automated antenna design, synthesis and optimization tool that enables users to input antenna engineering requirements and output antenna designs. AntSyn was designed to be used both by experts and those who are relatively new to antenna design.

THE DESIGN BOTTLENECK

A properly designed antenna is typically characterized by a number of critical performance metrics that are driven by the target application. Chief concerns relate to the directional characteristics (as depicted in the antenna's radiation pattern) and the resulting gain. As a result, the range of antenna design types is extensive, with a very large number of shapes, sizes, requirements and applications. Designing and optimizing antennas by hand requires significant domain expertise. This time and labor intensive process depends on the aptitude or expertise of the designer to identify a suitable initial design that can

L-3 NARDA-MITEQ...NEXT-GENERATION INTEGRATED MICROWAVE ASSEMBLIES



Complex-Level
IMA Modular
Design

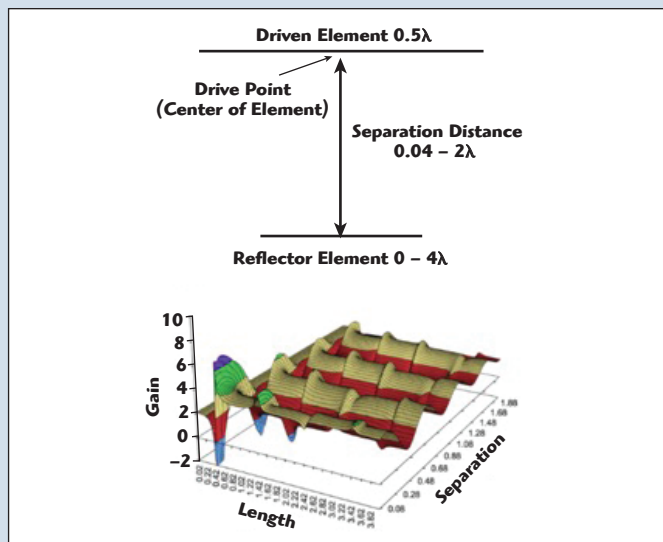
**OPEN VPX
TECHNOLOGY**

narda  **MITEQ**

Your Proven Source for IMAs With Open VPX Technology

L-3 Narda-MITEQ offers more than 60 years of innovative component-level expertise in microwave and RF technology, delivering both performance and packaging solutions not considered possible in the past. We are your proven source for complex-level IMA modular designs with open VPX technology for antenna interface modules, converters, wideband amplifiers, receivers, synthesizers, switched filter banks and more. Providing everything from design to production, we are ready to meet your most challenging requirements. When your next project demands a highly specialized IMA, count on L-3 Narda-MITEQ – *your best resource for advanced VPX solutions.*

Learn more about all we have to offer by visiting us at nardamiteq.com or call us at (631) 231-1700.



▲ Fig. 1 Antenna design complexity illustrated by the range of gain from varying the dipole length and reflector separation of a simple antenna.

be optimized to achieve the desired results (see **Figure 1**).

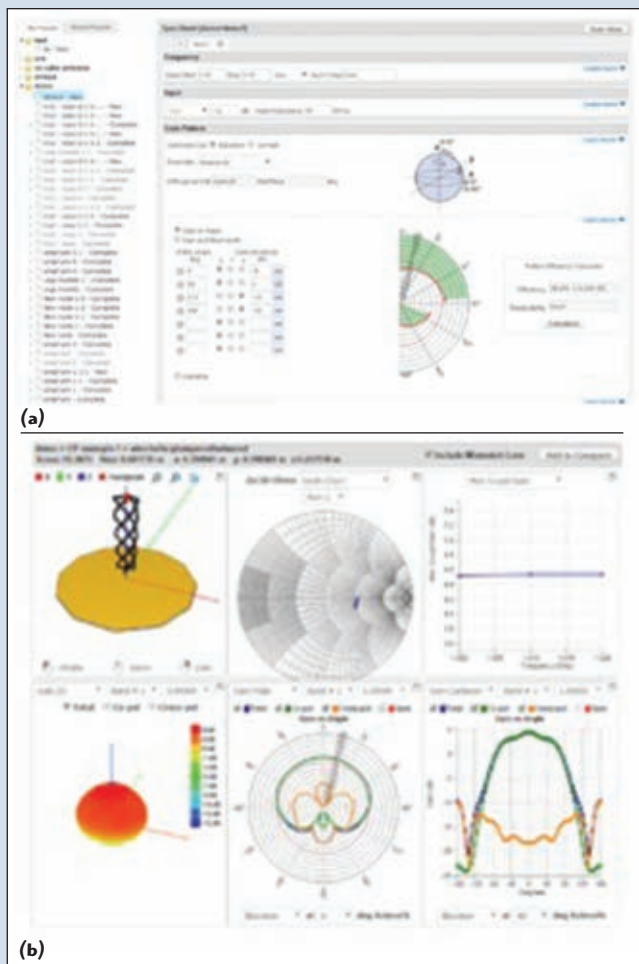
It is not uncommon for an experienced engineer to consume several months developing a new antenna design, depending on the level of difficulty defined by the antenna specifications. The time and effort invested increases significantly when addressing factors such as antenna interaction with the platform or wireless device and co-site interference. Design delays are compounded when program requirements change, such as in early stage development or where antenna integration requires in-situ optimization. The ability to conduct rapid antenna design and redesign is a growing concern as the number of wireless devices proliferates.

As an alternative or adjunct to designing by hand, since the early 1990s, researchers have been investigating methods based on evolutionary antenna design and optimization. One highly successful technique from NI is based on EA. This technology has been developed into a complete antenna synthesis tool, AntSyn, and has been used successfully by companies and government agencies operating in aerospace, communications and wireless electronics markets to design antennas operating at frequencies from below HF (2 MHz) to above Ka-Band (40 GHz). In contrast to the man-months of engineering time typically required for a final antenna design, AntSyn can generate a design in hours, optimizing trade-offs between criteria and often producing counter-intuitive designs that outperform traditional antennas.

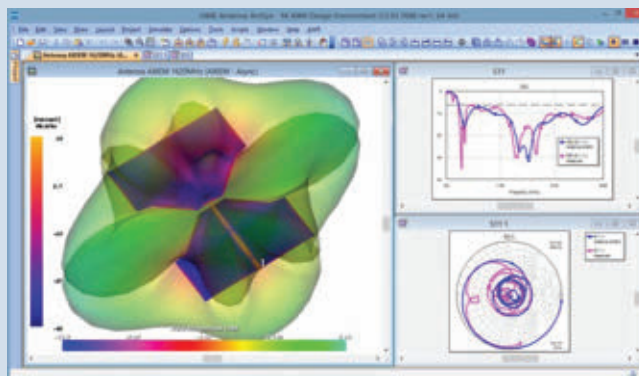
DESIGN BY REQUIREMENTS

AntSyn operates on a “what you want is what you get” principle, where the user inputs the antenna requirements, rather than a (parameterized) physical design. Antenna specifications such as frequency band, target impedance match (return loss), and gain pattern are input into the intuitive “spec sheet” user interface, which is automatically organized into a project file (see **Figure 2a**). By running the spec sheet, AntSyn returns one or more optimized antenna designs, the results of which are viewed using a customizable dashboard for rapid evaluation (see **Figure 2b**).

The user-specified dashboard can be set to view the proposed 3D model, input impedance (match) versus frequency in several formats, maximum gain versus frequency, radiation pattern cuts and qualitative star rating, all of which help identify good performers quickly. AntSyn has been used to develop a wide range of antenna types: single band, dual band, multiband, broadband and ultra-wideband (>100:1),



▲ Fig. 2 The AntSyn user interface spec sheet (a) defines the antenna requirements and the AntSyn results dashboard (b) enables rapid evaluation.



▲ Fig. 3 The AntSyn design is easily exported for final verification, whether to AXIEM or Analyst, within NI AWR Design Environment, or other 3D EM simulators.

high efficiency, loaded, electrically small, phased array, wire, patch, conformal, handset, multifunction and multiport.

EXAMPLES

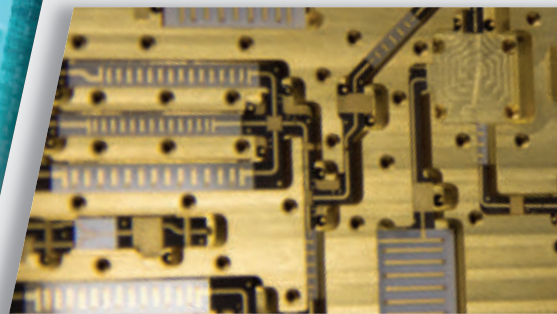
Several types of antennas that generate modest gains with good linear or circular polarization over significant bandwidths include:

- Microstrip patch, which is made up of one or more “patches” of metal, separated from a ground plane by a dielectric substrate

Innovation **That's Open.**

INTRODUCING *OpenRFM*™

MEETING NEW GOVERNMENT INTEROPERABILITY AND AFFORDABILITY REQUIREMENTS IN RADAR, ELECTRONIC WARFARE AND SIGNALS INTELLIGENCE, REQUIRES INNOVATIVE APPROACHES IN ADVANCED RF/MICROWAVE AND DIGITAL SIGNAL PROCESSING. OPENRFM IS THE FIRST RF/MICROWAVE OPEN SYSTEM APPROACH THAT LEVERAGES BEST AVAILABLE COMMERCIAL-ITEM TECHNOLOGY TO DELIVER SOPHISTICATED, INTEROPERABLE SENSOR PROCESSING SUBSYSTEMS TO DOMINATE THE ELECTROMAGNETIC SPECTRUM. OPENRFM IS THE BETTER ALTERNATIVE FOR AFFORDABLE RF SUBSYSTEMS FOR OUR WAR FIGHTERS AND ALLIES ALIKE.



MERCURY
SYSTEMS™

INNOVATION THAT MATTERS™

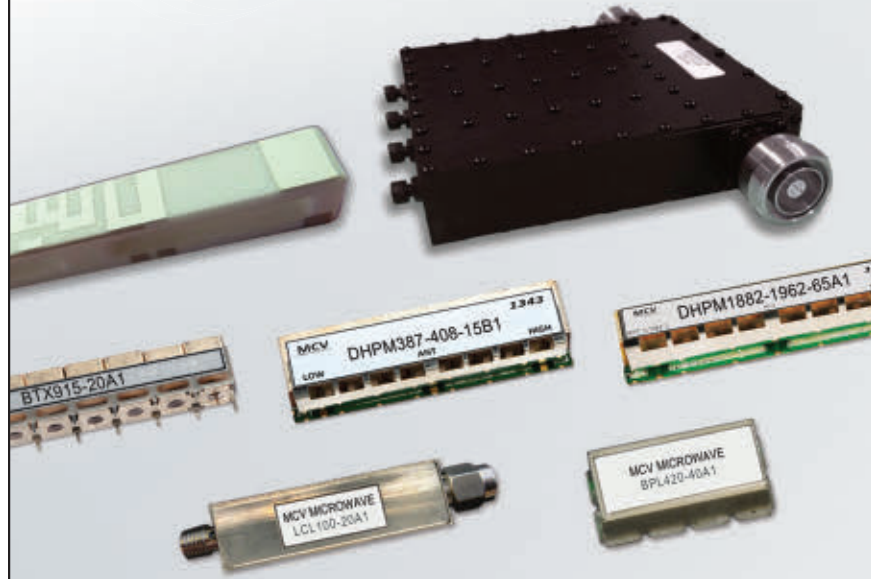


Visit mrcy.com/OpenRFM and download our technical whitepaper:
Advantages and Benefits of OpenRFM™





MCV
MICROWAVE



QUICK-TURN

CUSTOM PROTOTYPE RF/MICROWAVE FILTERS & ANTENNAS

WIRELESS INFRASTRUCTURE
PUBLIC SAFETY
MILITARY & SPACE
SATELLITE RECEIVER

PRODUCTS

LTE DAS and In-Building Network Filter Solutions
High Power/Low PIM Filters and Duplexers
Bandpass, Band Reject Filters, Highpass, Lowpass Filters, Multiplexers
Ultra-high Q Dielectric Resonators and Meta Materials
Narrow Band and Broad Band Antennas

Call for a FREE Consultation

858.450.0468

mcv-microwave.com

Most Valuable Product

- Helix antenna, a helical wire wound with a circumference of about one wavelength (1λ) and a pitch of $\lambda/4$ over a ground plane with a 1λ minimum diameter
- Single or crossed dipoles, which are center-fed radiating elements, each about $\lambda/2$ long with rods that are parallel to and over a ground plane of about $\lambda/4$ minimum diameter
- Quadrifilar antenna, similar to short helix, and slot, which uses a small cutout in a ground plane and can conform to the skin of a satellite
- Spiral antenna, which is wideband and may be cavity backed, two or three dimensional
- Horn antenna, either used as the "feed" for reflector antennas or stand-alone.

Navigating which of these antenna configurations achieves the best overall performance for the reduced size, weight and cost demands is a challenging task, especially as non-traditional companies jump into wireless-enabled devices called for by the Internet of Things (IoT) and small satellite (NanoSat or CubeSat) markets. NI is addressing this challenge with smarter design and test solutions spanning early concept through final verification.

Designers can expect to benefit from easily comparing the trade-offs between these different antenna types and then exploring more of the design space through smarter, knowledge-guided optimization. After achieving satisfactory design results, AntSyn antenna data can be transferred for verification in NI AWR Design Environment™, specifically AXIEM planar EM simulator, Analyst™ 3D finite element method (FEM) simulator or other third-party EM tools from Sonnet, ANSYS HFSS and CST Microwave Studio (see **Figure 3**). This ability further extends design capabilities and the assurance of optimum results.

AntSyn provides an automated antenna design, synthesis and optimization tool that is well suited for helping designers of antennas, RF components and system engineers of many skill levels to address the challenges of next-generation antenna design and integration.



National Instruments
AWR Group, NI
El Segundo, Calif.
awrcorp.com/antsyn



FLAT, STABLE GAIN



SINGLE POSITIVE SUPPLY



LOW NOISE FIGURE



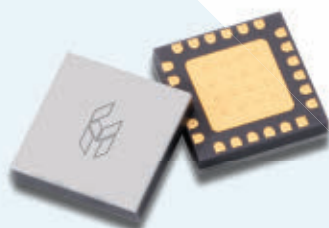
HIGH POWER HANDLING



LOW POWER CONSUMPTION



SMALLEST FORM FACTOR



Low Noise Amplifiers

- Frequencies from 2 to 45 GHz
- Noise figures as low as 1 dB
- Gain from 15 to 30 dB
- +20 dBm Input Power Handling
- Stable from -55 to +85°C

Think of what you'll save with an LNA you can design with instead of design around.

With everything we've built into our LNAs, you'll be wondering what to do with the extra power and board space. Not to mention the time and money.

Download fully characterized datasheets and S-parameters, and start engineering your next chain today.

[CustomMMIC.com](https://www.custommmic.com)

RF Amplifiers and Sub-Assemblies for Every Application

Delivery from Stock to 2 Weeks ARO from the catalog or built to your specifications!

- Competitive Pricing & Fast Delivery
- Military Reliability & Qualification
- Various Options: Temperature Compensation, Input Limiter Protection, Detectors/TTL & More
- Unconditionally Stable (100% tested)

ISO 9001:2000
and AS9100B
CERTIFIED

OCTAVE BAND LOW NOISE AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2110	0.5-1.0	28	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111	4.0-8.0	29	1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA812-3111	8.0-12.0	27	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA1218-4111	12.0-18.0	25	1.9 MAX, 1.7 TYP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

CA01-2111	0.4-0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8-1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2-1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2-2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7-2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7-4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4-5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25-7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0-10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75-15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35-1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1-3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9-6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0-12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0-12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2-13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0-15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0-22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA0102-3111	0.1-2.0	28	1.6 Max, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA0106-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max, 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112	0.1-8.0	32	3.0 MAX, 1.8 TYP	+22 MIN	+32 dBm	2.0:1
CA02-3112	0.5-2.0	36	4.5 MAX, 2.5 TYP	+30 MIN	+40 dBm	2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0	22	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA618-4112	6.0-18.0	25	5.0 MAX, 3.5 TYP	+23 MIN	+33 dBm	2.0:1
CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110	2.0-18.0	30	5.0 MAX, 3.5 TYP	+20 MIN	+30 dBm	2.0:1
CA218-4112	2.0-18.0	29	5.0 MAX, 3.5 TYP	+24 MIN	+34 dBm	2.0:1

LIMITING AMPLIFIERS

Model No.	Freq (GHz)	Input Dynamic Range	Output Power Range Psat	Power Flatness dB	VSWR
CLA24-4001	2.0-4.0	-28 to +10 dBm	+7 to +11 dBm	+/- 1.5 MAX	2.0:1
CLA26-8001	2.0-6.0	-50 to +20 dBm	+14 to +18 dBm	+/- 1.5 MAX	2.0:1
CLA712-5001	7.0-12.4	-21 to +10 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1
CLA618-1201	6.0-18.0	-50 to +20 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	6.0-12.0	24	2.5 MAX, 1.5 TYP	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25	2.2 MAX, 1.6 TYP	+16 MIN	20 dB MIN	1.8:1
CA1518-4110A	15.0-18.0	30	3.0 MAX, 2.0 TYP	+18 MIN	20 dB MIN	1.85:1

LOW FREQUENCY AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

CIAO Wireless can easily modify any of its standard models to meet your "exact" requirements at the Catalog Pricing.

Visit our web site at www.ciaowireless.com for our complete product offering.

Ciao Wireless, Inc. 4000 Via Pescador, Camarillo, CA 93012

Tel (805) 389-3224 Fax (805) 389-3629 sales@ciaowireless.com





CODE Moves Toward Sophisticated, Resilient and Collaborative UAS



DARPA's Collaborative Operations in Denied Environment (CODE) program seeks to help the U.S. military's unmanned aircraft systems (UAS) conduct dynamic, long-distance engagements of highly mobile ground and maritime targets in denied or contested electromagnetic airspace, all while reducing required communication bandwidth and cognitive burden on human supervisors. In an important step toward that goal, DARPA recently awarded Phase 2 system integration contracts to Lockheed Martin Corp. (Orlando, Fla.) and Raytheon Co. (Tucson, Ariz.).

Further, the following six companies, all of which had Phase 1 contracts with DARPA to develop supporting technologies, will collaborate in various ways with the two prime contractors: Daniel H. Wagner Assoc. (Hampton, Va.), Scientific Systems Co., Inc. (Woburn, Mass.), Smart Information Flow Technologies, LLC (Minneapolis, Minn.), Soar Technology, Inc. (Ann Arbor, Mich.), SRI International (Menlo Park, Calif.), and Vencore Labs dba Applied Communication Sciences (Basking Ridge, N.J.)

CODE's main objective is to develop and demonstrate the value of collaborative autonomy, in which UAS perform sophisticated tasks both individually and in teams under the supervision of a single human mission commander. CODE-equipped UAS perform their mission by sharing data, negotiating assignments, and synchronizing actions and communications among team members and with the commander. CODE's modular open software architecture on board the UAS enable multiple CODE-equipped unmanned aircraft to navigate to their destinations and find, track, identify and engage targets under established rules of engagement. The UAS also recruit other CODE-equipped UAS from nearby friendly forces to augment their own capabilities and adapt to dynamic situations such as attrition of friendly forces or the emergence of unanticipated threats.

"During Phase 1, we successfully demonstrated, in simulation, the potential value of collaborative autonomy among UAS at the tactical edge, and worked with our performers to draft transition plans for possible future operational systems," said Jean-Charles Ledé, DARPA program manager. "Between the two teams, we have selected about 20 autonomous behaviors that greatly increase the mission capabilities of our legacy UAS and enable them to perform complex missions in denied or contested environments in which communications, navigation and other critical elements of the targeting chain are compromised."

CODE's prototype human-system interface (HSI) is designed to allow a single person to visualize, supervise, and command a team of unmanned systems in an intuitive manner. Mission commanders can know their team's status and tactical situation, see pre-planned and alternative courses of action, and alter the UAS' activities in real time.



Source: DARPA

Top Three Subcontractors Selected by OneWeb Satellites

OneWeb Satellites, a joint venture equally owned by Airbus Defence and Space and OneWeb, has selected the first three top-tier subcontractors. The supply contracts have been signed with MacDonald, Dettwiler and Associates Ltd. (MDA) from Canada, Sodern from France and Teledyne Defence (a business unit of Teledyne Microwave Solutions) from the UK.

To equip each of the 900 satellites forming the OneWeb fleet, MDA will provide on board antenna systems, Sodern has customized to constellation its star tracker technology, while Teledyne Defence has designed communications repeater equipment derived from its high volume manufacturing heritage.

With this milestone OneWeb Satellites is pursuing its industrial development and rapidly moving forward. In April, Florida was announced as the site for its high volume satellite manufacturing factory.

The space segment of OneWeb will initially comprise a constellation of 648 operational satellites and replacement satellites, all of which will be identical. Each satellite will weigh approximately 150 kg and will operate in low Earth orbit. Arianespace and Virgin Galactic will begin launching the spacecraft in 2018 after which the satellites will be moved to their operational orbits using electrical propulsion.

The constellation to be operated by OneWeb will provide high-speed internet services with global coverage. The joint venture will also be able to produce satellites, platforms or equipment to be marketed by Airbus Defence and Space for the benefit of other operators of future constellations.

NRL Invokes Cost Effective Approach to Improve Joint ISR Missions

The U.S. Naval Research Laboratory (NRL) Radar Division has teamed with San Diego-based General Atomics Aeronautical Systems Inc. to integrate maritime mode inverse synthetic aperture radar (maritime-ISAR) imaging capability with GA-ASI's Lynx Multi-Mode

Radar deployed on its Unmanned Aerial Systems (UAS).

Developed for the U.S. Air Force (USAF) through funding by General Atomics Aeronautical Systems Inc. (GA-ASI), the MQ-9 unmanned aerial vehicle (UAV) is designed to execute time-sensitive targets with persistence and precision, and destroy or disable those targets. GA-ASI has teamed with the U.S. Naval Research Laboratory to implement an Inverse Synthetic Aperture Radar (ISAR) imaging capability in the GA-ASI's Lynx Multi Mode Radar currently deployed on UASAF MQ-9 UAVs.

"Because ships and small watercraft at sea are usually in motion — having both forward velocity and other linear and angular motions, for example, pitch and roll and heave and sway — this creates a problem for typical ISAR platforms," said Thomas Pizzillo, head, NRL Radar Analysis Branch. "The addition of a maritime-ISAR mode to the General Atomics Lynx radar, as a software only upgrade, is the most cost effective alternative to introduce this capability to the MQ-9 fleet."


Synthetic Aperture Radar (SAR) is a radar imaging method using multiple pulses transmitted from a moving platform. The received signals are combined to form a high quality two-dimensional (2D) image of the ground-terrain of interest. Classical SAR algorithms assume the target scene (background) is stationary and any motion in the scene shows up as a smear or streak in the image. ISAR



Courtesy U.S. Air Force/Lt. Col. Leslie Pratt

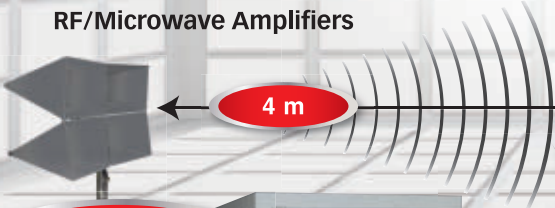
algorithms assume the target itself is moving, and through a set of complex algorithms, calculates enhanced angular or cross-range resolution by analyzing subtle differences in range-rates caused by the target motion. The net effect is to focus the image of a moving target without smearing.

"NRL has successfully adapted the necessary changes to ISAR image formation in which the rotational motion of the target is not known beforehand," Pizzillo says. "This provides the end-user with an imaging software tool that can produce high-quality imagery in conditions with significantly complex target motion."



YOUR COMPLETE SOLUTION FOR RADAR PULSE TESTING


RF/Microwave Amplifiers



4 m


Broad Field High Gain Area Antenna

300 v/m & 600 v/m
1.2 GHz - 1.4 GHz
2.7 GHz - 3.1 GHz



1.75 m
5.5 m

300 or 600 VOLTS per meter




.5 kW - 8 kW+ Pulse Amps

Model	Frequency Range	Power
S1412 - 500P	1.2 - 1.4 GHz	500 Watts Pulse
S1412 - 1 kW	1.2 - 1.4 GHz	1 kW Pulse
S1412 - 2 kW	1.2 - 1.4 GHz	2 kW Pulse
S1412 - 4 kW	1.2 - 1.4 GHz	4 kW Pulse
S1412 - 8 kW	1.2 - 1.4 GHz	8 kW Pulse
S1412 - XX kW	1.2 - 1.4 GHz	XX kW Pulse
S3127 - 500P	2.7 - 3.1 GHz	500 Watts Pulse
S3127 - 1 kW	2.7 - 3.1 GHz	1 kW Pulse
S3127 - 2 kW	2.7 - 3.1 GHz	2 kW Pulse
S3127 - 4 kW	2.7 - 3.1 GHz	4 kW Pulse
S3127 - 8 kW	2.7 - 3.1 GHz	8 kW Pulse
S3127 - XX kW	2.7 - 3.1 GHz	XX kW Pulse

INSTRUMENTS FOR INDUSTRY

903 South 2nd Street • Ronkonkoma, NY 11779
 Tel: 631-467-8400 • Fax: 631-467-8558 • sales@ifi.com • www.ifl.com



COMPLIANCE TEST SOLUTIONS

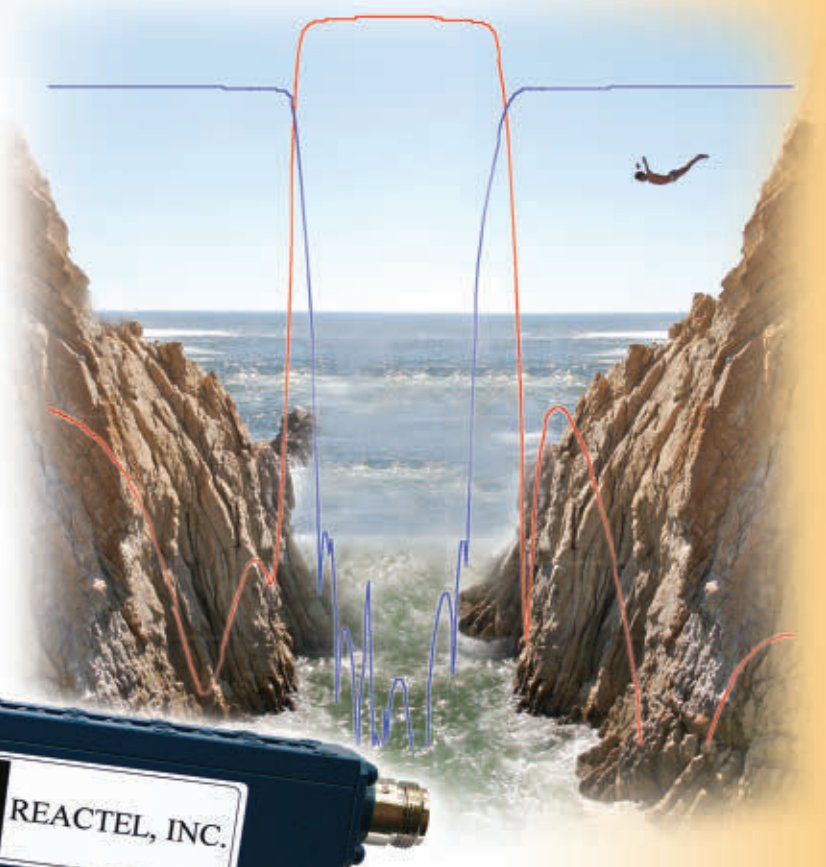
Reactel, Incorporated

Reacting First to All Your Filter Needs.

A SHEER DESCENT INTO THE NOISE

High Performance Notch Filters

- High Q
- Bandwidths as low as 0.5%
- Frequency range up to 20 GHz
- Power levels up to 1000 W



Reactel manufactures a variety of notch filters suitable for most any application. Utilizing Discrete Component, Ceramic, Cavity, Waveguide or Microstrip technologies, we can create a unit which has extremely low pass band loss, contain up to 16 sections, and can have connectors or surface mount launch options. Contact us with your requirement and let us show you how sharp our notch filters can be.

- Submitting a request for immediate attention will never be easier.
- Full featured App contains expanded RFQ capability, catalog, data sheets and more.
- Available for iPad, iPod and Android devices via the App Store and Google Play.



8031 Cessna Avenue • Gaithersburg, Maryland 20879 • Phone: (301) 519-3660 • Fax: (301) 519-2447
For general inquiries, please email reactel@reactel.com • <http://twitter.com/reacteljim> • Go online to www.reactel.com to download your Reactel catalog today.



@reacteljim



The 2016 Defence, Security and Space Forum At European Microwave Week



Wednesday, 5 October – ExCel, London – Rooms 8 to 11

A focused Forum addressing the application of RF and microwave technology to Complex Urban Environments.

The emphasis will be on complex urban environments, encompassing the challenges and opportunities for indoor/enclosed and urban communications and sensing technologies. The Forum has the scope to cover topics including: Smart City initiatives; 3D tracking technologies in complex and indoor environments; sensing complex targets in dense target environments; congested spectrum and network issues.

Programme:

09:00 – 10:40 EuRAD Opening Session

11:20 – 13:00 Complex Urban Sensing and Communication

Speakers from industry and academia will present RF solutions and systems that address the challenges imposed by operation in complex urban environments. Confirmed speakers include:

- New Transceiver Technology Applied to Standoff Submillimetre-Wave Imaging Radar – *Ken Cooper, JPL*
- Indoor and Urban Environment Location of Moving People and Vehicles Using Signals of Opportunity – *Pierfrancesco Lombardo, University of Rome*
- Communication Satellite Impact on TV and Data Broadcasting Through Urban Environments – *Erdem Demircioğlu, Turksat International*

13:10 – 14:10 Strategy Analytics Lunch & Learn Session

This session will add a further dimension by offering a market analysis perspective, illustrating the status, development and potential of the market.

14:20 – 16:00 Microwave Journal Industry Panel Session

The session offers an industrial perspective on the key issues facing the defence, security and space sector. In accordance with the theme for 2016, the Panel will address: *Complex Urban environments, encompassing the challenges and opportunities for indoor/enclosed and urban communications and sensing technologies*. Confirmed speakers include:

- Spectral Detection and Visualisation with Distributed RF Receivers – *Raymond Shen, Keysight Technologies*
- How do Mobiles Develop the 6th Sense? – An Introduction to LTE-based Device-to-Device (D2D) Communication Principles – *Meik Kottkamp, Rohde & Schwarz*

16:40 – 18:20 EuMW Defence & Security Executive Forum

High-level speakers from leading defence and security companies present their views and experiences on RF microwave technology trends and its use in urban environments. Confirmed presentations include:

- Challenges for Maritime Border Surveillance Radar – *Tony Brown, EASAT*
- Challenges in the 'Future Borders' Concept - Combining Technology, People and Processes – *Roger Cumming, Fenley-Martel (ex UK Home Office)*
- Challenges in Urban Sensing and Communications [Preliminary Title] – *Ian Beresford, QinetiQ*

18:20 – 19:00 Cocktail Reception

Registration and Programme Updates

Registration fees are £10 for those who have registered for a conference and £40 for those not registered for a conference.

As information is formalized, the Conference Special Events section of the EuMW website will be updated on a regular basis.

**Register online at
www.eumweek.com**



Sponsors:





LTE Networks Pass 500 Milestone

The Global mobile Suppliers Association (GSA) confirmed that the number of commercially launched LTE networks passed the 500 milestone during May 2016. The historic milestone was reached in 77 months from first service launch, almost five years less than the time taken by 3G/WCDMA systems, and six months faster than HSPA systems.

GSA data for Q1 2016 LTE subscriptions revealed that LTE gained 182 million connections in Q1 2016, almost four times faster than 3G/HSPA systems. 3G/HSPA subscriptions grew by 48 million, while GSM subscriptions fell by 120 million in the same quarter. The number of LTE and LTE-Advanced subscriptions is expected to pass the 3G/WCDMA-HSPA global total in 2020, and possibly sooner.

The Asia region, with over 734 million LTE subscriptions, further grew its share of global LTE subscriptions quarter on quarter to reach 56.9 percent. By March 2016

“...LTE is now connecting over 1 in 6 mobile subscribers worldwide...”

China had passed 511 million LTE subscriptions, adding 96.3 million in the quarter. North America remains the second largest LTE market with 253 million, though its share of the world market further

declined 2.6 percent in the quarter to 19.6 percent of the global total. The European share of the global total is 14 percent.

Strong growth was recorded again in the Latin America and Caribbean region to reach 67 million 4G/LTE subscriptions. 11.1 million LTE subscriptions were added in the Middle East region in Q1 to reach 46.6 million. Russia has 16.7 million LTE subscriptions, Africa has 9 million LTE subscriptions and India has almost four million.

Alan Hadden, vice president, GSA said, “LTE subscriptions were signed up during Q1 2016 at an average of two million per day and the rate is accelerating. LTE is now connecting over 1 in 6 mobile subscribers worldwide.”

Project Lifts Cloud from European Telecommunication Companies

The EU-funded MOBILE CLOUD NETWORKING project, which was officially completed at the end of April 2016, has effectively integrated domains, cloud computing services and mobile networks in order to provide the canvas upon which Europe’s future mobile network services can be run. This is vitally important. If European companies are to take advantage of the technologies offered by cloud computing, then communication networks must be appropriately redesigned.

EU action in the telecommunications sector has in recent decades led to greater consumer choice, falling call

costs and higher standards of service. However, mobile services have yet to fully tap the vast commercial potential offered by cloud computing, which is why the results of the MOBILE CLOUD NETWORKING project could be of great industry interest.

By leveraging Europe’s excellence in mobile communications and extending this into the cloud arena—at present almost exclusively in the hands of US companies — the project will help European telecommunication companies remain globally competitive in an industry worth around €300 billion in the EU alone.

The proliferation of mobile internet access and services has driven huge increase in mobile data traffic. The internet now performs millions of tasks, from online banking to tsunami monitoring, and data traffic volumes are expected to grow 12-fold by 2018. Tapping the full potential of the cloud, as this EU-funded project has done, is a key way of reducing infrastructure expenditure, achieving efficiencies and creating space for further anticipated data growth.

...the project will help European telecommunication companies remain globally competitive...

GLIS 2016 Focuses on Space and ‘Connected’ World

The Global Conference on Space and the Information Society (GLIS 2016), organized by the International Astronautical Federation (IAF), and held at the International Telecommunication Union (ITU) in Geneva, Switzerland in June, drew attention to the fact that space and space applications have a major role to play in the shaping of a future ‘connected’ world.

The international community faces substantial challenges: digital divide, disaster management, cybersecurity, big data analysis and climate change, to name a few. The next years will see governments, industry, academia and NGOs work together in a new era of connectivity. A combination of factors, such as the implementation of the UN Space Development Goals, the deployment of new mega constellations and the launch of new digitalized systems will strongly contribute to reaching this goal. International organizations, such as the United Nations and its agencies, ITU and UNOOSA, along with the IAF, aim to extend cooperation in space to achieve a better connected world.

“ITU is committed to maintaining right of access to the radio-frequency spectrum and satellite-orbit resources, and to ensuring their rational, equitable, efficient and economical use, free from harmful interference,” said ITU Secretary-General Houlin Zhao. “Through our concerted efforts, we can help remove the obstacles that impede the development of new satellite networks and applications and bring them into operation to connect the unconnected around the world.”

For More Information

Visit mwjournal.com for more international news

“...connect the
unconnected around
the world.”

“Activities in space contribute enormously towards shaping the information society,” said François Rancy, director of the ITU Radiocommunication

Bureau. “These involve the production of big data, the provision of global positioning information, the distribution of television programmes, the provision of emergency services, the prevention and mitigation of natural and man-made disasters, the forecasting of weather, the understanding, monitoring and protection of Earth natural resources and the connection of the world population to broadband services. Indeed, satellite systems play a critical role in supporting each and every one of the 17 sustainable development goals adopted last year by the United Nations.”

Mobile and Broadcast Converge in New ETSI Specification Group

The European Telecommunications Standards Institute (ETSI) has unveiled a new Industry Specification Group, the Mobile and Broadcast Convergence (MBC) ISG. It will explore the deployment and business models of converged networks from the perspectives of all interested parties. The group will study the means to support delivery of media including linear and nonlinear

elements over converged networks, taking into account the potential benefits and challenges from a commercial and technical perspective.

TV delivery has traditionally been dependent on one-way, one-to-many delivery networks to fixed TV sets (i.e., broadcasting). Nowadays, an increasing number of consumers watch linear or non-linear content on their traditional home screens as well as on their smartphones and tablets. Although much of this content is currently delivered via Wi-Fi networks, these new forms of media consumption dramatically increase the load on mobile networks. This situation may require new solutions, such as the leveraging of a one-to-many broadcasting approach.

“Increasingly consumers are using smartphones and tablets to access linear and nonlinear content interchangeably and the old model of a screen in the living room to watch TV broadcasting is becoming more and more irrelevant. Broadcasters and mobile operators will have to adapt their business models to these changed bandwidth flows and there is uncertainty about the optimum technology choices. This ISG is to allow all interested parties to engage with the technical debate now, ahead of whatever standardization work will be needed subsequently,” said David Hendon, convenor of the MBC ISG.

While the ISG will not make recommendations about spectrum allocation, spectrum authorization models, which impact the regulatory framework and/or business model, may need to be considered in the ISG work.



Spectrum Compact

2 - 40 GHz and 70 - 87 GHz

World's smallest microwave spectrum analyzers for 2GHz - 40GHz and 70GHz - 86GHz frequency bands! An irreplaceable tool for every field engineer performing link alignment, troubleshooting, interference detection and many other tasks.

For more information, please visit:

www.saftehnika.com/en/spectrumanalyzer



100W POWER AMPLIFIERS

700-2700 MHz



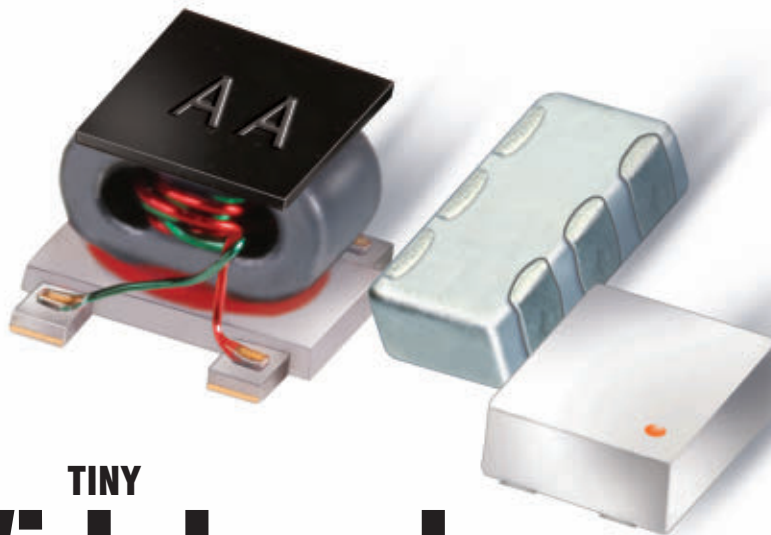
\$8,995_{each}

48 dB Gain, ± 1.7 dB Flatness

Output power up to 100W with consistent performance across a wide frequency range for a fraction of the cost of competitive products! Mini-Circuits' new HPA-272+ high power rack mount amplifiers are ideal for a wide variety of high power test applications including EMI, reliability testing, power stress testing, and burn-in of multiple units at once. This model provides 48 dB gain with ± 1.7 dB gain flatness over its entire frequency range and 89 dB reverse isolation. Housed in a rugged, 19-inch rack-mountable chassis, the amplifier operates on a self-contained 110/220V power supply and includes internal cooling, making it easy to use in most lab environments. Extensive built-in safety features include over-temperature protection and the ability to withstand opens and shorts at the output.* They're available off the shelf for an outstanding value, so place your order on minicircuits.com today for delivery as soon as tomorrow!

*at 3 dB compression point.





TINY Wideband Transformers & Baluns!

NOW!
4 kHz - 18 GHz From **99¢**
ea. (qty. 20)

To support an even wider range of applications, Mini-Circuits tiny surface-mount transformers and baluns now cover frequencies from 4 kHz up to 18 GHz! Our latest designs achieve consistent performance across very wide frequency bands, and our baluns have demonstrated great utility for use with chipsets. With over 250 trusted models in stock representing a wide selection of circuit topologies and impedance ratios, chances are, we have a solution for your needs!

Our Low Temperature Co-Fired Ceramic (LTCC) models provide reliable performance in tough operating conditions, tiny size – as small as 0805 – and very low cost. All core-and-wire models are available with our exclusive Top Hat® feature, improving pick-and-place accuracy and throughput. We even manufacture our own transmission wire under rigorous control and use all-welded connections to ensure reliability and repeatability you can count on.

Visit minicircuits.com and use **Yoni2®**, our patented search engine to search our entire model database by performance criteria and find the models that meet your requirements. Order today and have them in hand as soon as tomorrow! Cost-effective custom designs and simulations with fast turnarounds are just a phone call away!



TC
0.15" x 0.15"



NC
0.08 x 0.05"
Ceramic



NCR2
0.08 x 0.10"
Ceramic

 **RoHS compliant.**





Internet of Things to Overtake Mobile Phones by 2018

The latest edition of the Ericsson Mobility Report reveals that the Internet of Things (IoT) is set to overtake mobile phones as the largest category of connected devices by 2018.

Between 2015 and 2021, the number of IoT connected devices is expected to grow 23 percent annually, of which cellular IoT is forecast to have the highest growth rate. Of the 28 billion total devices that will be connected by 2021, close to 16 billion will be IoT devices.

Western Europe will lead the way in adding IoT connection — the number of IoT devices in this market is projected to grow 400 percent by 2021. This will principally be driven by regulatory requirements, for example for intelligent utility meters, and a growing demand for connected cars including the EU e-call directive to be implemented in 2018.

Rima Qureshi, senior vice president and chief strategy officer, Ericsson, says, “IoT is now accelerating as device costs fall and innovative applications emerge. From 2020, commercial deployment of 5G networks will provide additional capabilities that are critical for IoT, such as network slicing and the capacity to connect exponentially more devices than is possible today.”

Smartphone subscriptions continue to increase and are forecast to surpass those for basic phones in Q3 this year. By 2021, smartphone subscriptions will almost double from 3.4 to 6.3 billion. Also revealed in the report, there are now 5 billion mobile subscribers — unique users — in the world today, which is testament to the phenomenal growth of mobile technology in a relatively short period of time.

16 billion connected devices forecast to join the Internet of Things by the end of 2021.

Detailed in the report is a dramatic shift in teen viewing habits: use of cellular data for smartphone video grew 127 percent in just 15 months (2014-15). Over a period of four years (2011-15) there has been a 50 percent drop in

the time teens spend watching TV/video on a TV screen, and in contrast an 85 percent increase in those viewing TV/video on a smartphone. This, and the fact that the upcoming generation of mobile users are the heaviest consumers of data for smartphone video streaming (Wi-Fi and cellular combined), makes them the most important group for cellular operators to monitor.

In 2016, a long anticipated milestone is being passed with commercial LTE networks supporting downlink peak data speeds of 1 Gbps. Devices that support 1 Gbps are expected in the second half of 2016, initially in markets such as Japan, U.S., South Korea and China, but rapidly spreading to other regions. Mobile users will enjoy extremely fast

time to content thanks to this enhanced technology, which will enable up to two thirds faster download speeds compared with the fastest technology available today. Further highlights include:

A global growth story: mobile broadband subscriptions will grow fourfold in the Middle East and Africa between 2015 and 2021; mobile data traffic in India will grow fifteen times by 2021; and despite being the most mature market, mobile traffic in North America will grow 50 percent in 2016 alone.

Data traffic continues unabated growth: global mobile data traffic grew 60 percent between Q1 2015 and Q1 2016, due to rising numbers of smartphone subscriptions and increasing data consumption per subscriber. By the end of 2021, around 90 percent of mobile data traffic will be from smartphones.

LTE subscriptions grew at a high rate during Q1 2016: there were 150 million new subscriptions during the quarter — driven by demand for improved user experience and faster networks — reaching a total of 1.2 billion worldwide. LTE peak data speeds of 1 Gbps are anticipated to be commercially available in 2016.

Additional spectrum harmonization needed between countries planning early 5G deployment: 5G is expected to start more quickly than anticipated, and spectrum harmonization is needed between countries planning early roll-outs. This is in addition to the current process for WRC-19, which focuses on spectrum for commercial 5G deployments beyond 2020.

5G Key Technology in Enabling V2X Communication in Future Cars



By 2025, 67 million automotive 5G vehicle subscriptions will be active—three million of which will be low latency connections mainly deployed in autonomous and driverless cars. ABI Research highlights that 5G will unify connectivity in autonomous vehicles; enabling broadband multimedia streaming, cloud services for vehicle lifecycle management, the capturing and uploading of huge volumes of sensor data, and cooperative mobility through V2X (vehicle-to-vehicle and vehicle-to-infrastructure) communication.

“V2X is a key requirement for the connected and autonomous vehicle of the future,” says Dominique Bonte, managing director and vice president at ABI Research. “It is closely linked to the concept of cooperative mobility, allowing vehicles to exchange both status and event information with each other via reliable, low-latency communication technologies. With it, vehicles can be proactive, capturing and sharing critical events happening locally with each other, ultimately ensuring safer driving practices.”

But for V2X to become a reality, the automotive and transportation industries must first expand the scope and relevance of 5G cellular connectivity. ABI Research anticipates this to dramatically increase through 2025, allowing

connectivity providers to bring more value-added services to the table and better position themselves in the automotive ecosystem. From there, new business models will emerge and ultimately more closely align the automotive and telecom industries.

ABI Research suggests that 5G's most promising capability for automotive will be its low latency, which could be as low as one millisecond. However, Bonte says that this will require underlying ultra reliable low latency 5G capabilities based on the use of millimeter wave bands, latency reduction techniques, and advanced device-to-device communication.

V2X is a key requirement for the connected and autonomous vehicle of the future, but 5G is needed to make it a reality.

"The extent to which these latencies will be achieved will heavily depend on the 5G standards and deployment strategies, but the question is not so much if, but when the industry will embrace the disruptive approach," continues Bonte. "While right now, the industry is leveraging and upgrading

current LTE/4G networks, it will eventually build new RAN networks based on millimeter waves. Once this happens, starting from the second half of the next decade,

very low-latency capabilities will be achievable and V2X-enabled smart mobility applications will be possible."

Retail Sees 400 Percent Growth in Wi-Fi Indoor Analytics Installations



Calculations show that total Wi-Fi location technology installations in retail were up almost 400 percent YoY in 2015. Driving the growth is a combination of start-ups and access point vendors, such as Cisco Systems, Ruckus Wireless and Zebra Technologies that are adopting new pricing models, technologies and a large number of platform partners to help them win new business.

"Previous iterations of Wi-Fi location platforms were expensive and not ideal for customer engagement," says Patrick Connolly, principal analyst at ABI Research. "But retailers and vendors quickly grasped that Wi-Fi's role in this space centers on gathering customer analytics."

"The ongoing challenge is a simple one: there is always new technology around the corner," concludes Connolly. "Retailers are only beginning to grow accustomed to Wi-Fi and iBeacons, yet the industry is already shifting toward a new generation of technologies, such as magnetic field, sensor fusion, and Google's Project Tango. Many Wi-Fi and beacon vendors are also developing their own high accuracy proprietary solutions, which will start to penetrate the market in 2016."



Frequency Matters.

www.mwjjournal.com/freqmatters

SIMPLIFYING ANTENNA
DESIGN WITHOUT
COMPROMISE

AN INTEGRATED
DESIGN FLOW FOR
PHASED ARRAYS

MÖBIUS METAMATERIAL
INSPIRED SIGNAL
SOURCES AND SENSORS

INDUSTRY NEWS AND
EVENTS



Catch up on the latest industry news with the bi-weekly video update
Frequency Matters
from
Microwave Journal



Scan page
using **layar** app

Sponsored By





TMS

Your Single Source for Advanced Microwave & RF Technologies

From microwave components to integrated assemblies, Teledyne Microwave Solutions (TMS) brings 50+ years of experience to the design, development, and manufacture of advanced microwave technologies.

SSPAs | Modems | Mixers
Receivers | Detectors
HPAs | Converters
Linearizers | Synthesizers
Integrated Assemblies
Circuit Board & Packaging
TWTs | Space | SATCOM
Filters | Amplifiers | YIG & BAW
Components | Isolators & Circulators
Attenuators | Value Added Services



TELEDYNE MICROWAVE SOLUTIONS
Everywhere you look™

800.832.6869 | Microwave@Teledyne.com | TeledyneMicrowave.com

Teledyne Microwave Solutions



The Power of Consolidation

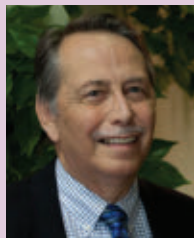
Cougar • Defence • Labtech • MEC • Microwave • Paradise Datacom



Around the Circuit

Barbara Walsh, Multimedia Staff Editor

The Industry Mourns Anthony S. Tirollo



▲ Anthony S. Tirollo

Anthony S. Tirollo, founder, owner and chief technology officer at TRM Microwave in Bedford, N.H., passed away on May 21, 2016. He founded the company in 1970 and guided its growth through the company's 45th anniversary in 2015, when it became a woman-owned small business. He was born on December 4, 1940 in New Haven, Conn. the son of Joseph Tirollo, Sr. and Angelina Tirollo, father to 3 daughters, Robin Tirollo, Tracy Erdahl and Maureen Corriea. He was the husband of Wendy D. Tirollo. They were married on February 14, 1998 in Key West, Fla. Tony graduated from New Haven School of Electronics in New Haven, Conn. He had a wonderful sense of humor and shared many jokes with his family, friends and employees. Tony loved spending winters at his home in Bonita Springs, Fla. He enjoyed utilizing his God given engineering talents for many projects, as well as entertaining family and friends. His contributions to family, friends, colleagues, animals and TRM are lasting. He will be missed.

MERGERS & ACQUISITIONS

Mercury Systems Inc. announced the completion of its previously reported acquisition of the embedded security, RF and microwave, and custom microelectronics businesses from **Microsemi Corp.** Pursuant to the terms of the stock purchase agreement applicable to the acquisition, Mercury acquired these businesses for a total purchase price of \$300 million, subject to adjustment for certain working capital items. The acquisition and associated transaction expenses were funded with a combination of a new \$200 million bank term loan A facility and Mercury cash on hand, which includes net proceeds of approximately \$94 million from Mercury's recent issuance of common stock in an underwritten public offering.

COLLABORATIONS

Keysight Technologies Inc. and **Datang Telecom Group** announced the signing of a Memorandum of Understanding (MOU) to establish a strategic partnership on research and development of 5G communication technologies. 5G is the next generation of wireless communication technologies, featured as big data, massive connections and diverse user scenarios. Both companies are committed to co-work on the 5G enabling technologies, standardization, prototype verification and evaluations, aiming to move 5G innovations forward.

X-Microwave LLC and **Peregrine Semiconductor Corp.** announced their collaboration and the addition of Peregrine's RF products to X-Microwave's online simulation tool and hardware prototyping system. X-Microwave's building-block system simplifies the modular design process and enables RF engineers to easily simulate and prototype RF and microwave circuits. To kick off this relationship, 16 Peregrine products are being added to the X-Microwave system as drop-in X-MWblock™ components.

Sivers IMA announced it has signed an agreement with **Blu Wireless Technology**, a company that designs and licenses baseband modem IP for mmWave applications — including the 802.11ad standard within the Wi-Fi Alliance (also known as WiGig®). Under the agreement, Blu will integrate and optimize its WiGig Hydra baseband modem IP with Sivers IMA's WiGig RFIC. This will enable Sivers IMA to market a complete WiGig solution compliant with the 802.11ad standard. This includes a baseband modem and a transceiver with steerable antennas.

NEW STARTS

Richardson RFPD Inc. announced that its distribution of a large portfolio of serial digital interface (SDI) video and optoelectronics products from **M/A-COM Technology Solutions** has expanded into Europe. MACOM's high-performance analog portfolio grew significantly as a result of the company's 2013 acquisition of Mindspeed Technologies. The product range features SDI video and optoelectronics products, including crosspoints, signal conditioners, redrivers, CDRs and SDI reclockers, SDI cable equalizers and SDI cable drivers.

Delta Electronics Manufacturing Corp. unveiled a new brand identity and website that captures the company's position as a leading global provider of precision interconnect and innovative solutions. The company will also launch a redesigned website at www.deltarf.com.

CONTRACTS

Harris Corp. has received an eight-year, \$96 million ceiling, single-award IDIQ contract from the **U.S. Naval Air Systems Command** to supply precision approach radars (PAR) to the U.S. Navy, Air Force and Army. The contract was awarded during the fourth quarter of Harris' fiscal 2016. Under the contract, Harris will supply high-performance PAR systems to help the three services upgrade their precision approach and military air traffic management capabilities. Harris has produced sophisticated radar technology for more than 70 years, pioneering the development of air traffic control and 3-D air defense radars for tactical applications.

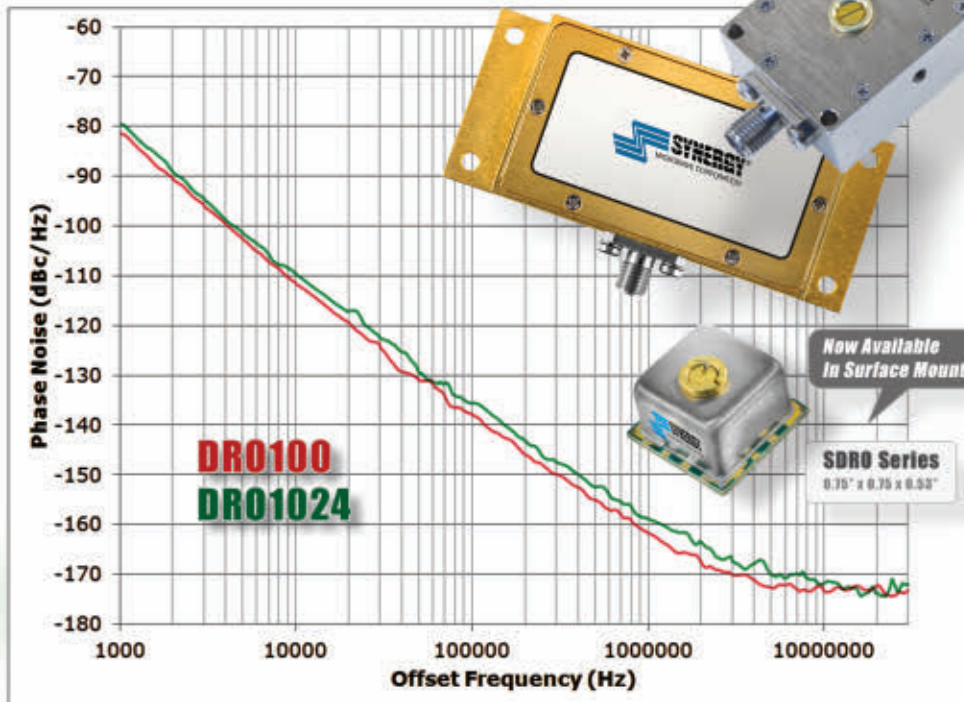
AT&T is the sole awardee of a contract worth up to \$74.6 million over five years, if all options are exercised, from the **Defense Information Systems Agency**. AT&T will provide

For More
Information

For up-to-date news briefs, visit mwjournal.com

Exceptional Phase Noise Performance Dielectric Resonator Oscillator

RoHS Patented
Technology




Model	Frequency (GHz)	Tuning Voltage (VDC)	DC Bias (VDC)	Typical Phase Noise @ 10 kHz (dBc/Hz)
Surface Mount Models				
SDRO1000-8	10	1 - 15	+8 @ 25 mA	-107
SDRO1024-8	10.24	1 - 15	+8 @ 25 mA	-111
SDRO1250-8	12.50	1 - 15	+8 @ 25 mA	-105
Connectorized Models				
DRO100	10	1 - 15	+7 - 10 @ 70 mA	-111
DRO1024	10.24	1 - 15	+7 - 10 @ 70 mA	-109

Model	Center Frequency (GHz)	Mechanical Tuning (MHz)	Supply Voltage (VDC / Current)	Typical Phase Noise @ 10 kHz (dBc/Hz)
Mechanical Tuning Connectorized Model				
KDRO145-15-411M	14.5	±4 MHz	7.5 V / 90 mA (Max.)	-88

Talk To Us About Your Custom Requirements.



Phone: (973) 881-8800 | Fax: (973) 881-8361
E-mail: sales@synergymwave.com
Web: WWW.SYNERGYMWAVE.COM
Mail: 201 McLean Boulevard, Paterson, NJ 07504



ProtoTx

Everything you need to
upconvert I/Q or IF signals to RF

4 Programmable Operating Modes:

- I/Q upconverter
- RF = LO - IF upconverter
- RF = LO + IF upconverter
- Synthesizer


Polyphase Microwave
A Technology Service Corporation Company

812-323-8708 • sales@polyphasemicrowave.com
polyphasemicrowave.com/mj

BIRD® DIAGNOSTIC SYSTEM (BDS)

Total Reliability for Complex Applications!

Bird has long provided RF reliability through power sensors capable of 1% accuracy for the calibration of the process tools and now also offers a diagnostic system that not only enables an extremely precise characterization in non-50 Ohm environments, but also provides active feedback for process control.



- ▶ Chamber to Chamber Matching
- ▶ Impedance Matching
- ▶ Harmonics up to 500 MHz
- ▶ Waveform Reconstruction

Learn More @ www.birdrf.com

Bird Technologies®
You're heard, loud and clear.

sales@birdrf.com
440.248.1200
+01 866.695.4569

© 2016 Bird Technologies. Bird Technologies, Bird®, DeltaNode and TXRX are registered trademarks of Bird Technologies. All rights reserved.

Around the Circuit

highly secure telecom services that support U.S. senior leadership communications between select Department of Defense aircraft and ground stations across the continental U.S. and around the world. AT&T will provide long-haul telecommunications and related transmission circuits. These support the government's restricted-use, ultra-high frequency communications platform. The services are highly reliable and resilient to keep continuous communications under duress.

BAE Systems has received a \$29.4 million competitively awarded contract from the **U.S. Navy** to maintain the USS Gettysburg (CG 64), a Ticonderoga-class guided missile cruiser. The contract includes options that if exercised would raise the total value to \$31.8 million. The special selected restricted availability of the Gettysburg will begin in June and be completed in December. BAE Systems' Norfolk, Va. shipyard will perform the repair, maintenance, and modernization work aboard the 567-foot-long ship. The Gettysburg is equipped with the Aegis Combat System, which provides air defense for aircraft carrier battle groups. The ship was commissioned in 1991.

Comtech Telecommunications Corp. announced that during its fourth quarter of fiscal 2016, its subsidiary, **Comtech Systems Inc.**, received an order from a foreign prime contractor for approximately \$7 million to design and install a number of fixed troposcatter terminals. The systems will be used by a foreign military end-customer for communications between off-shore islands. It was also announced that during its third quarter of fiscal 2016, its subsidiary, Comtech Systems Inc., received an order from a foreign military totaling approximately \$1.5 million to provide troposcatter equipment to a prime contractor for use in early testing, characterization and network integration activities as part of an upcoming deployable communications network for an Asia Pacific military.

Cobham recently received a series of orders for electronic warfare components and subsystems for an airborne electronic intelligence (ELINT) platform totaling approximately \$5.5 million. Cobham's electronics are integrated into a sensor suite that provides intelligence, surveillance and reconnaissance (ISR) capability. The work will be performed by Cobham Microelectronic Solutions, a business unit of the Cobham Advanced Electronics Solutions sector. Cobham Advanced Electronic Solutions' ISR related products include microelectronics, waveguide, rotary joints, and integrated assemblies for radar and electronic warfare applications.

Mercury Systems Inc. announced it received a \$4.2 million follow-on order from a leading defense prime contractor for high-performance digital signal processing modules for an unmanned airborne synthetic aperture radar (SAR) application. The order was booked in the company's fiscal 2016 fourth quarter and is expected to be shipped by its fiscal 2017 second quarter.

The **U.S. Navy** awarded a contract modification to **General Dynamics Mission Systems** to build and deliver more than 30 new AN/USC-61(C) Digital Modular Radios (DMR), along with related materials and equipment for new Navy surface vessels and submarines. The software-



We've been traveling safely at speeds up to **79 GHz** for many years



Circuit boards are being pushed harder, with frequencies for automotive radar systems and mobile backhaul communications links climbing to 79 GHz and beyond. Just as designers of satellite communication systems have for decades, now designers of these commercial applications are counting on the circuit boards and materials used within them for consistent, reliable operation at millimeter wave frequencies. History proves that Circuit Materials from Rogers Corporation are the ideal choice.

Whether they are based on Rogers RO4835™ LoPro® circuit materials or RO3003™ laminates, these higher-frequency applications depend on reliable substrates with consistent performance in the 79 GHz range. Both RO4835 LoPro and RO3003 circuit materials feature best in class electrical performance across diverse environments including a wide temperature range and elevated humidity.

Future electronics systems are making greater use of millimeter wave frequencies, through 79 GHz and higher. Make sure those systems provide consistent, reliable performance essential to millions of users, with low-loss RO4835 LoPro and RO3003 circuit materials from Rogers.



Advanced Connectivity Solutions

Learn more at www.rogerscorp.com/79

USA - AZ, tel. +1 480-961-1382
EUROPE - BELGIUM, tel. +32 9 235 3611



Z-Communications, Inc.

High Performance PLO Solutions

RFS Series Fixed Frequency PLLs | 1 GHz - 6 GHz

Reference Signal Included • No External Programming • Fixed Frequency

Part Number	Freq (MHz)	Output Power (dBm) (typ)	Spurs (dBc)	PN @1kHz (dBc/Hz) (typ)	PN @10kHz (dBc/Hz) (typ)
RFS1030-LF	1030	3	-65	-93	-98
RFS2450-LF	2450	3	-65	-85	-95
RFS3500A-LF	3500	3	-65	-85	-93
RFS4500A-LF	4500	2	-65	-85	-86
RFS5900A-LF	5900	3	-65	-80	-86

SFS Series Fixed Frequency PLLs | 500 MHz - 15 GHz

No External Programming • Ultra-Low Noise • Small Size

Part Number	Freq (MHz)	Output Power (dBm) (typ)	Spurs (dBc)	PN @1kHz (dBc/Hz) (typ)	PN @10kHz (dBc/Hz) (typ)
SFS1600E-LF	1600	5	-65	-85	-120
SFS2500C-LF	2500	6	-70	-84	-111
SFS6400A-LF	6400	6	-65	-88	-88
SFS10625H-LF	10625	0	-70	-99	-105
SFS12000H-LF	12000	0	-65	-97	-103

WWW.ZCOMM.COM

14118 Stowe Drive, Suite B, Poway, CA 92064
P: (858) 621-2700 E: sales@zcomm.com

ISO 9001:2008



Around the Circuit

defined radios are a mission critical communications hub for Navy vessels and submarines. A majority of the work will be done at General Dynamics' Scottsdale, Ariz. location.

PEOPLE



▲ Liam K. Griffin



▲ David J. Aldrich

Skyworks Solutions Inc. announced that its board of directors has appointed **Liam K. Griffin** as chief executive officer. Griffin was also elected to the board of directors of Skyworks effective May 11, 2016. **David J.**

Aldrich, Skyworks' chief executive officer since 2000, will assume the newly established role of executive chairman and, in that position, will continue to serve as the chairman of Skyworks' board of directors. Skyworks has substantially outpaced the broader semiconductor market: growing the top line at a 25 percent annual rate from \$1.1 billion in fiscal 2010 to over \$3.2 billion in fiscal 2015.



▲ Barry Black



▲ Jodie Davoll

IMS announced the promotion of **Barry Black** to sr. manager of sales and marketing. Black will be responsible for worldwide sales operations including overall direction and strategy of the company's global sales initiative. **Jodie Davoll** has been appointed as marketing coordinator. Davoll will focus on maintaining the website and marketing communications programs. **Dale**



▲ Dale Azuma



▲ Peter Leary

Azuma has been appointed as regional sales manager. Azuma will be responsible for day to day sales operations in the Western territory. **Peter Leary** has been appointed as sales applications engineer. Leary is customer oriented, Solidworks certified and loves using Sonnet EM software.



▲ Jason Smith

Teseq, now a unit of **AMETEK Compliance Test Solutions** and a developer of instrumentation and systems for electromagnetic compatibility (EMC) emission and immunity testing, has hired **Jason Smith** as regional sales manager. Smith, a veteran in EMC sales and marketing, will use his extensive industry experience to help the AMETEK CTS growing sales force support its customers, representatives and factory teams. Before joining AMETEK CTS, Smith worked for HV Technologies,

FEATURED

WHITE PAPERS

The information you need, from industry experts



Integrating EM Simulation Technologies within an RFIC Design Flow



PXI Interoperability – How to Achieve Multi-Vendor Interoperability in PXI Systems



Optimizing IP3 and ACPR Measurements

Check out these new online Technical Papers featured at **MWJournal.com**

Frequency Matters.

ATC 100 Series Superchips® and 700 Series Case Sizes A, B, C & E

Supports a Wide Range of Critical Large and Small Signal Minimal Drift Applications

Building on over 50 years experience in MLC performance, ATC offers 100 Series P90 Superchips and 700 Series NPO MLCs with Q greater than 10,000.

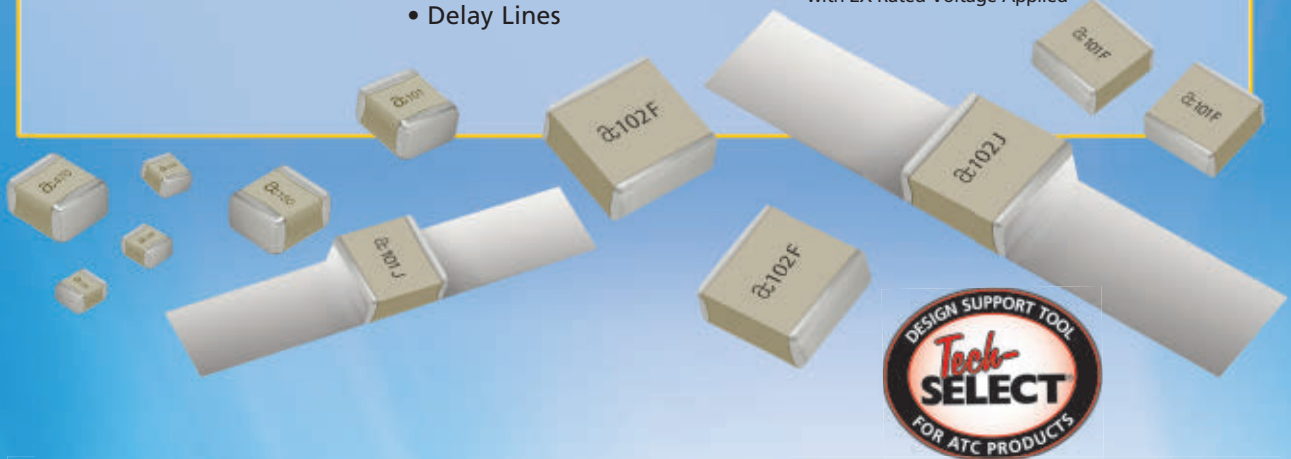
Typical Applications:

- High RF Power Amplifiers
- High RF Power Switching
- Impedance Matching
- Induction Heating
- Filter Networks
- Antenna Matching
- Transceiver Modules
- Medical MRI Imaging Coils
- Low Noise Amplifiers
- Synthesizers
- Mixers
- Delay Lines

High Reliability

- Qualified to MIL-PRF-55681
- S-Level Reliability*
- QPL Approved (CDR Availability)
- Supported by COTS

*ATC Capacitors are Qualified to S-Level Failure Rate = 0.001%/1000 Hrs. @ 125°C with 2X Rated Voltage Applied



ATC Series		Dimensions	Capacitance Range (pF)		Working Voltage (WVDC) max.
			100 Series	700 Series	
100A	700A	.055 X .055 (1.40 X 1.40)	0.1 to 100	0.1 to 1000	Up to 250
100B	700B	.110 X .110 (2.79 X 2.79)	0.1 to 1000	0.1 to 5100	Up to 1500
100C	700C	.250 X .250 (6.35 X 6.35)	1 to 2700	1 to 2700	100C: Up to 3600 / 700C: Up to 2500
100E	700E	.380 X .380 (9.65 X 9.65)	1 to 5100	1 to 2200	Up to 7200

inches (mm)



AMERICAN
ATC North America
sales@atceramics.com

TECHNICAL
ATC Europe
saleseur@atceramics.com

CERAMICS
ATC Asia
sales@atceramics-asia.com

THE ENGINEERS' CHOICE®
ISO 9001 REGISTERED COMPANY



THE ENGINEERS' CHOICE®

www.atceramics.com



Electronic Design Innovation Conference 电子设计创新大会

April 25-27, 2017

Shanghai Convention
&
Exhibition
Center of International
Sourcing

Shanghai, China

EDICONCHINA.com

Host Sponsor:



Diamond Sponsor:



Corporate Sponsor:



Organized by:



Around the Circuit

Manassas, Va., where he served for more than four years as EMC sales and marketing manager.



▲ Dave Kendall

Link Electronics announced the retirement of founder **Bob Henson**, and new ownership by industry veteran **Dave Kendall**. With 30 plus years in the technology and electronics industry, along with electrical engineering experience as an officer in the U.S. Navy, Kendall brings a wealth of insight and perspective to his new role. He started in sales and marketing and worked his way into executive roles, bringing extensive knowledge, passion, leadership and drive for innovation.

REP APPOINTMENTS

Anritsu Corp. announced that they have signed a distribution agreement with **Electro Rent UK**. The distribution agreement extends Electro Rent's existing relationship with Anritsu as a preferred reseller and rental partner in the United States and Canada. Under the terms of the new agreement, Anritsu's field analyzers will be now also be available in the UK through Electro Rent.

Richardson Electronics Ltd. announced a new global distribution agreement with **Anaren Inc.**, a designer, manufacturer and seller of custom high-frequency solutions and standard components for the wireless communications, space and defense electronics, wireless consumer electronics, and IoT markets. The agreement aligns with both companies' commitment to finding innovative ways to create and provide solutions for customers.

PLACES

Arrow Electronics Inc., a global leader in IT asset disposition, announced it upgraded its Columbus, Ohio-area value recovery facility, adding state-of-the-art automated equipment and a new layout to further increase processing efficiency and chain-of-custody security. As a result of the upgrades, the facility's IT asset processing capacity has increased 500 percent.

Lockheed Martin Canada opened the doors of its IMPACT Centre in Ottawa, with a ribbon cutting event showcasing the innovative demonstration centre. The centre is designed to be a significant economic driver across Canada, bringing Canadian industry and academia together for critical research, development and advancement of technology. Lockheed Martin created the IMPACT Centre with a vision to promote the growth of small Canadian businesses, advance research, support sustainability and enhance Canada's capability for major exports in defence and technology sectors. At the heart of the IMPACT Centre, is an initial core focus on naval systems and the competitive naval combat systems world market.



Programmable ATTENUATORS

0 to 120 dB 0.25 dB Step* 1 to 8000 MHz† from **\$395**

FEATURES

- 0–30, 60, 63, 90, 110, and 120 dB
- USB, Ethernet & RS232 control options
- User-friendly GUI and DLLs included
- Sweeping and hopping capability
- Available from stock!

Perfect for...

- Fading simulators
- Handover system evaluation
- Automated test equipment
- And MORE!

Visit minicircuits.com for detailed model specs, application notes, and more!
Place your order today and have them on your test bench as soon as tomorrow!

* Model RCDAT-3000-63W2+ specified step size 1 dB

† Model RCDAT-3000-63W2+ specified from 50–3000 MHz; 120 dB models specified from 1–4000 MHz

†† No drivers required. DLL objects for 32/64 bit Windows® environments using ActiveX® and .NET® frameworks.



EDITOR'S NOTE

This is the concluding article of the three part series exploring the theory and applications of Möbius metamaterials. The previous articles appeared in *Microwave Journal's* May and June 2016 issues.

Möbius Metamaterial Strips: Opportunity, Trends, Challenges and Future

Ulrich L. Rohde

Federal Armed Forces University, Munich, Germany

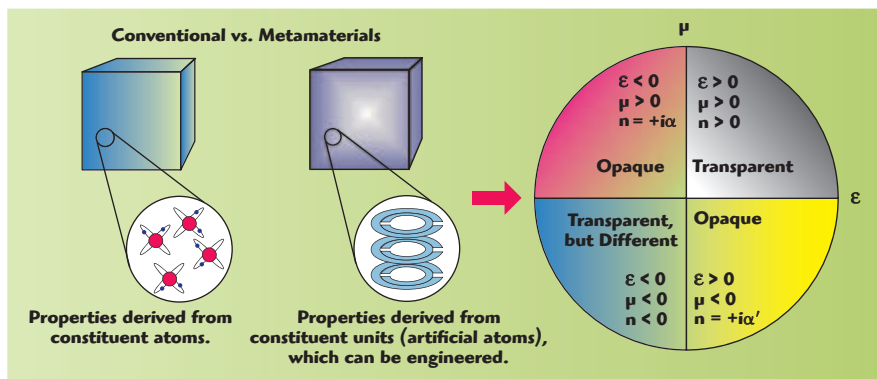
Ajay K. Poddar

Synergy Microwave, Paterson, N.J.

The MMS (Metamaterial Möbius Strip) is an artificial composite structure with a negative index of refraction ($n = -\sqrt{\epsilon\mu}$; $\epsilon < 0$, $\mu < 0$), where n is the refractive index, ϵ is the electrical permittivity and μ is the magnetic permeability of the medium. It has emerged as a cutting edge of science relating physics, chemistry, biology, material science, optics, acoustics and electronics. For most naturally existing materials, μ is close to 1; hence, magnetic susceptibility of natural materials is small as compared to the electric/dielectric susceptibility. This phenomenon limits the interaction of atoms to the electric component of the electromagnetic (EM) wave, leaving the magnetic component mostly unexploited. Magnetism is primarily weak at optical frequencies as well, because the relaxation times of paramagnetic and ferromag-

netic processes are considerably longer than an optical period, electron movement in atoms is the only mechanism for creating the magnetic response. This is why the magnetic field component is usually not involved in light-matter interactions. The reason for weak magnetism is mainly due to limitations of the material properties imposed by chemical composition and constituent components (atoms and molecules). On the contrary, MMS resonant nanostructures, in principle, can exhibit a broad range of magnetic permeability values.¹⁻⁷⁵ A number of stimulating phenomena and applications associated with MMS structures are discussed in part 1 (MWJ May 2016) and part 2 (MWJ June 2016) of this series. This issue addresses the prospects, challenges and future directions of MMS inspired components for various applications including the Gravitational Casimir Effect.

Recent research in the field of metamaterials⁶⁹⁻⁷⁵ has not only established interesting physical phenomena but also lead to opportunities for utilizing negative index components and devices for next generation energy-efficient electronic circuits and systems. **Figure 1** compares the properties of natural and artificially engineered composite materials.¹ Unlike conventional materials that interact with EM waves based on their chemical compositions, the properties of metamaterials are derived from their topologies and geometric structures.



▲ Fig. 1 Characteristics of conventional materials vs. metamaterials.

Making the Connection to Millimeter Wave Solutions



OML can extend the frequency of your Vector Network Analyzer so that you can conduct industry-leading millimeter wave measurements. Offering three configurations (T/R, T & S) ranging from 50 to 500 GHz these modules allow capabilities to measure full S-parameters. With options such as variable attenuation, amplification in RF & LO paths, low power and Intermodulation; OML frequency extension modules can help you with your solution.

Innovation in Millimeter Wave Solutions
www.omlinc.com
(408) 779-2698



INNOVATION IN FREQUENCY CONTROL

Pletronics Inc.

Ultra Low Jitter Oscillator-LVDS;PECL; HCSSL
Improved Signal to Noise Ratio and Bit Error Rate
100G-400G Optical Transport Networks
10/40/100 Gbe
PCI Express

GypSync®
GPS Synchronized TCXO Module
NEMA Output & Evaluation Board - 1pps output
GypSync® TCXO utilizing the Pletronics OeM4 (pictured) is suitable for use in high end design applications

NEW PRODUCT OeM8



Improved TCVCXO technology!
±50ppb OTR, -40°C to +85°C

Test & Measurement Equipment
SDR
Small Cell

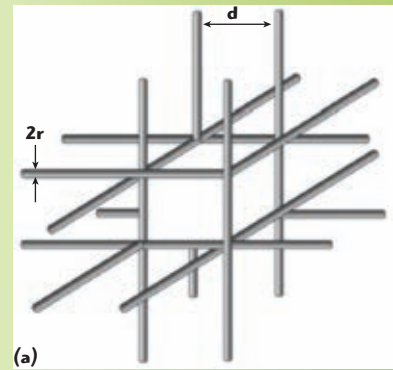
For more product information
www.Pletronics.com
or call (425) 776-1880

Customizable Solutions for
Different Applications

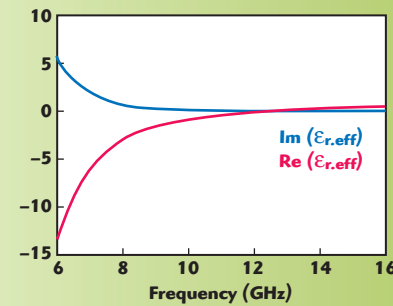


Technical Feature

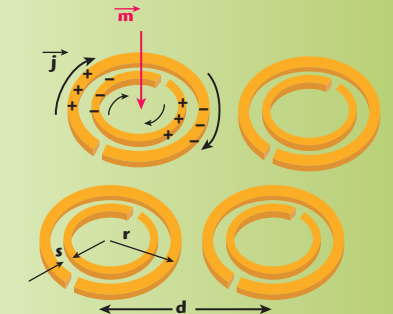
The typical metamaterial consists of periodically or arbitrarily dissemi-



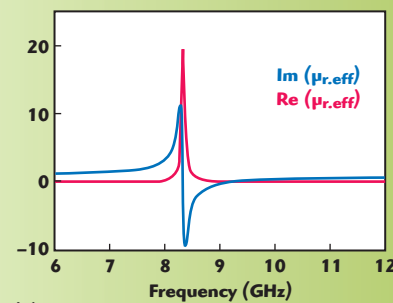
(a)



(b)



(c)



(d)

▲ Fig. 2 Typical negative index structure for the realization of artificial electric and magnetic responses; periodic wires arranged in a simple cubic lattice (a) effective permittivity of wire medium, acting as dilute metal with extremely low plasma frequency (b) a magnetic field penetrating an SRR induces a current, and hence, a magnetic moment (c) and SRR effective permeability at resonance (d).⁸

nated structured cells with dimensions and spacings much smaller than a wavelength of the incident EM waves.¹⁻³ As a consequence, the microscopic detail of each unit cell structure cannot be sensed by EM waves. What is important to understand is the average result of the collective response of the entire assemblage, comprised of inhomogeneous matter. In other words, such a collection of inhomogeneous matter can be characterized by an equivalent homogenous material with effective constitutive relative permittivity ($\epsilon_{r,eff}$) and permeability ($\mu_{r,eff}$) at the macroscopic level. The key aspect of an MMS inspired structure is that effective permittivity ($\epsilon_{r,eff}$) and permeability ($\mu_{r,eff}$) can be controlled and tuned by a suitably designed disseminated element for broadband operation.

In classical EM theory, the characteristics of matter illustrated in Figure 1 can be described by the Drude-Lorentz model⁶ as

$$\epsilon_r(\omega) = \left[1 - \left(\frac{\omega_{p,e}^2}{\omega^2 - \omega_{0,e}^2 + i\omega\gamma_e} \right) \right] \quad (1)$$

$$\mu_r(\omega) = \left[1 - \left(\frac{\omega_{p,m}^2}{\omega^2 - \omega_{0,m}^2 + i\omega\gamma_e} \right) \right] \quad (2)$$

where ω_p is the plasma frequency, ω_0 is the resonant frequency, subscripts 'e' and 'm' represent electric and magnetic response, and γ is the damping factor associated with material losses.

Figure 2 shows a typical metamaterial structure,^{4,5} realized by the combination of split ring resonators (SRR) and thin metallic wires. The effective relative permittivity ($\epsilon_{r,eff}$) and effective relative permeability ($\mu_{r,eff}$) obey the Drude-Lorentz⁶⁻⁹ model as

$$\epsilon_{r,eff}(\omega) = \left[1 - \left(\frac{\omega_{p,eff}^2}{\omega(\omega + i\omega\gamma_{eff})} \right) \right],$$

$$\omega_{p,eff}(\omega) = \frac{e^2}{\epsilon_0} \left(\frac{n_{e,eff}}{m_{e,eff}} \right) = \frac{2\pi c^2}{d^2 \left(\ln \frac{d}{r} \right)},$$

$$\gamma_{eff} = \epsilon_0 \left(\frac{d^2 \omega_p^2}{\pi r^2 \sigma} \right) \cong 0.1 \omega_{p,eff} \quad (3)$$



Planar Monolithics Industries, Inc.

18 to 40 GHz Minature DLVAs & SDLVAs

PMI offers a variety of DLVAs and SDLVAs covering the 18 to 40 GHz frequency range. PMI's DLVAs and SDLVAs offer high dynamic range along with excellent temperature stability.

Amplifiers – Solid State

**Attenuators – Variable/
Programmable**

**Couplers (Quadrature,
180° & Directional)**

Detectors – RF/Microwave

**DLVAs, ERDLVAs
& SDLVAs**

**DTOs, VCOs, PLO, DROs,
& Frequency Synthesizers**

**Filters & Switched
Filter Banks**

**Form, Fit, Functional
Products & Services**

**Frequency Discriminators
& IFMs**

**Integrated MIC/MMIC
Assemblies (IMAs)**

IQ Vector Modulators

Limiters – RF/Microwave

Log Amplifiers

**Millimeter Wave
Components
(Up to 50 GHz)**

Miscellaneous Products

**Multifunction Integrated
Assemblies (MIAs)**

**Phase Shifters & Bi-Phase
Modulators**

**Power Dividers/Combiners
(Passive & Active)**

Pulse Modulators (SPST)

**Rack & Chassis Mount
Products**

**Receiver Front Ends
& Transceivers**

**SDLVAs, ERDLVAs
& DLVAs**

**Single Side Band
Modulators**

SMT & QFN Products

Switch Matrices

Switched Filter Banks

Switches – Solid State

Systems – Fly Eye Radars

Threshold Detectors

USB Products

- Hermetic Sealing
- Temperature Compensation
- Small Quantity Requirements Accepted
- Military or Stringent Screening
- CW Immunity & Matched Sets
- Specialized Testing & Custom designs welcome!

Model DLVA-18G40G-42-50-CD-1 Detection Log Video Amplifiers (DLVA)

Frequency Range	18.0 to 40.0 GHz (Operational) 30.0 to 31.0 GHz (Full Performance)
Flatness @ -23 dBm	±0.25 dB - Measured ±0.1 dB
VSWR (In/Out)	1.5:1 Max - Measured 1.18
TSS	-34 dBm @ 25 °C - Measured -39.8 dBm
Logging Range	-32 to +10 dBm
Log Slope	50 ± 3 mV/dB - Measured 51.83 mV/dB
Log Linearity	±0.5 dB - Measured +0.4, -0.35 dB
DC Offset	0 to ±75 mV - Measured +45 / -4 mV
Output Stability (-54 to +85 °C)	±0.75 dB



- Package Size:
1.86" x 1.69" x 0.40"
- DC Voltage:
+15 VDC @ 37 mA - Measured
-15 VDC @ 42 mA - Measured



Model SDLVA-18G40G-65-CD-292FF-A15 Successive Detection Log Video Amplifier (SDLVA)

Frequency Range	18.0 to 40.0 GHz
TSS	-67 dBm @ 25 °C - Measured -68 dBm
Input Power Handling	10 dBm Max
Video Log Range	-63 dBm to +2 dBm
Video Log Linearity	±1.5 dB Max - Measured +1.27, -1.48 dB ±3.0 over Temp Max
Video Log Slope	25 mV/dB nominal - Measured 24.4 mV/dB
Video Freq Flatness	±2.5 dB Max @ 25°C - Measured ±2.10 dB
Pulse Width Range	30 ns to CW
Video Rise Time	11 ns (8 ns typ) - Measured 10.04 ns
Recovery Time	60 ns (40 ns Typ) - Measured 60 ns
Delay Time	15 ns (5 ns Typ) - Measured 14.6 ns 7 ns Over Temp Typ
Video Output Impedance	50 Ohm
Input VSWR (50 Ohm)	2.5:1 - Measured 2.34:1
Operating Temperature	-55 to +85 °C



- Package Size:
2.37" x 1.80" x 0.42"
- DC Voltage:
+12 VDC @ 310 mA - Measured
-12 VDC @ 150 mA - Measured



West Coast Operation:

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

East Coast Operation:

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

sales@pmi-rf.com • www.pmi-rf.com
ISO9001 REGISTERED

$$\mu_r(\omega) = 1 = \frac{F\omega^2}{\omega^2 - \omega_0^2 + i\Gamma\omega},$$

$$F = \frac{\pi \times r^2}{d^2},$$

$$\omega_0 = \sqrt{\frac{3sc^2}{\pi^2 r^3}}, \Gamma = \frac{2}{r^\sigma \mu_0} \quad (4)$$

where σ is the conductivity of metal wire, d is the lattice constant, ω_0 represents the resonant frequency, $\omega_{p,eff}$ is the effective plasma frequency, F is the filling ratio of the SRR, and Γ is the damping term. From (3), the effective plasma frequency is $\omega_{p,eff} = 7.52 \times 10^{10}$ rad/sec; assuming that the metal wire conductivity $\sigma = 10^7 \Omega^{-1} m^{-1}$, the metal wire radius $r = 1 \times 10^{-6}$ meters and the lattice constant $d = 3.5 \times 10^{-3}$ meters. From (4), the

resonant frequency $f_0 = 8.324$ GHz; assuming that for the SRR, $d = 4 \times 10^{-3}$ meters, $r = 1 \times 10^{-3}$ meters, and $s = 1 \times 10^{-4}$ meters. This corresponds to a free space wavelength of 3.6×10^{-2} meters which is about 10 times larger than d .

From (3) and (4), $\epsilon_{r,eff}$ of metallic wire and $\mu_{r,eff}$ of the SRR exhibit the typical Drude-Lorentz characteristics,⁸ plotted in **Figures 2b** and **d**. Equations (3) and (4) provide approximate analytical solutions for the effective constitutive parameters (permittivity, permeability) with reasonable accuracy, valid for the simple structure shown in Figure 2. For a complex structure, however, and especially for an MMS inspired negative index metasurface, this is not true.

The alternative approach is to retrieve the effective parameters from numerical simulations⁹⁻¹² described in detail.⁷⁰ The first step of the retrieval procedure is to calculate the transmission and reflection of the composite MMS based on numerical algorithms, such as finite-difference time-domain (FDTD) and finite element method (FEM). Some commercial software, including ADS, Ansys HFSS, CST Microwave Studio, COMSOL Multiphysics and SONNET are widely used but none of these provide error free solutions. The refractive index and impedance are related to the transmission coefficient (t) and reflection coefficient (r) by equations⁹

$$Z_{eff} = \pm \left[\frac{(1+r)^2 - t^2}{(1-r)^2 - t^2} \right]^{1/2} \quad (5)$$

$$n_{eff} = \pm \cos^{-1} \left[\frac{1}{k_0 L} \left(\frac{1-r^2 + t^2}{2t} \right) \right] + \frac{2\pi m}{k_0 L},$$

$$k_0 = \frac{2\pi}{\lambda_0} \quad (6)$$

$$\epsilon_{r,eff}(\omega) = \frac{n_{eff}(\omega)}{Z_{eff}(\omega)} \quad (7)$$

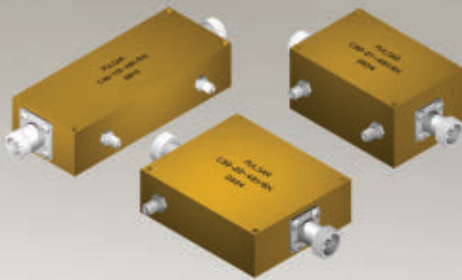
$$\mu_{r,eff}(\omega) = n_{eff}(\omega) \times Z_{eff}(\omega) \quad (8)$$

where k_0 is the wave vector in vacuum, L is the thickness of the metamaterial, and m is an integer.

From Equations (5) and (6), effective impedance and refractive index can be determined provided that the metamaterial structures act like a passive medium; this implies that the real part of z_{eff} and the imaginary part of

Dual High Power Directional Couplers

Up to 2500 Watts



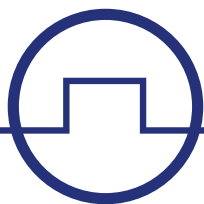
Frequency Range (MHz)	Coupling (dB)	I.L. Loss (dB) max.	Coupling Flatness max.	Directivity (dB) min.	Input Power (watts) max.	Model Number
2.0-32.0	50 ± 1	0.06	0.25	25	2500	C50-101
0.5-50	50 ± 1	0.10	0.50	20	2000	C50-100
0.5-100	30 ± 1	0.30	0.50	25	200	C30-102
0.5-100	40 ± 1	0.20	0.30	20	200	C40-103
1.0-100	50 ± 1	0.20	1.00	20	500	C50-109
20.0-200	50 ± 1	0.20	0.75	20	500	C50-108
0.1-250	40 ± 1	0.40	0.50	20	250	C40-111
50-500	40 ± 1	0.20	1.00	20	500	C40-21
50-500	50 ± 1	0.20	1.00	20	500	C50-21
100-1000	40 ± 1	0.40	1.00	20	500	C40-20
500-1000	50 ± 1	0.20	0.50	20	500	C50-106
80-1000	40 ± 1	0.30	1.00	20	1000	C40-27
80-1000	50 ± 1	0.30	1.00	20	1000	C50-27
80-1000	40 ± 1	0.30	1.00	20	1500	C40-31
80-1000	50 ± 1	0.30	1.00	20	1500	C50-31

IN-OUT ports: Type N connectors standard, SMA connectors optional.
Coupled ports: SMA connectors standard. See website for details.

PULSAR
MICROWAVE CORPORATION

www.pulsarmicrowave.com

48 Industrial West, Clifton, NJ 07012 | Tel: 973-779-6262 · Fax: 973-779-2727 | sales@pulsarmicrowave.com

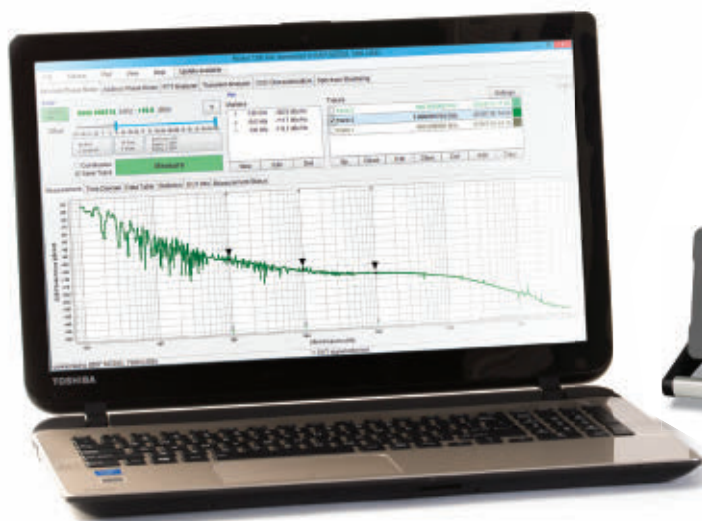


BNC Berkeley Nucleonics Corp

Berkeley Nucleonics Corp., 2955 Kerner Blvd. San Rafael CA 94901

Email RFsales@berkeleynucleonics.com, Call 800-234-7858 or LIVE-Chat @ www.berkeleynucleonics.com

We've changed the face (or at least the front panel) of RF and Microwave Instrumentation



Phase Noise Test Systems

**Less than
\$50k**

"Not all good things come in big packages"

Phase Noise Measurement & Signal Sources Analysis from 2 MHz to 26.5 GHz

- Instrument noise floor down to -185 dBc/Hz
- Absolute AND Residual measurements, .01 Hz to 50 MHz offset
- Super fast ATE optimized measurements
- External or ultra-low noise internal references w/ industry leading sensitivity



RF / Microwave Signal Sources



Real-Time Spectrum Analyzers

n_{eff} are positive.⁹ Note that the effective parameter retrieval process is a challenging task, especially when metamaterial structures fall into the category of anisotropic or bi-anisotropic, and EM wave is obliquely incident.¹² Parameter retrieval becomes even more complex for nonlinear metamaterial composite structures.

The metamaterial structure shown in **Figure 3a** is a combination of metallic wires and SRRs; however, these

artificially engineered structures pose fabrication problems. A simplified structure reported in literature is the Fishnet structure¹⁴⁻¹⁶ that consists of two layers of metal meshes separated by a dielectric layer (see **Figures 3b** and **3c**). Paired stripes oriented parallel to the electric field provide negative $\epsilon_{\text{r,eff}}(\omega)$, while the other pairs of stripes parallel to the magnetic field support negative $\mu_{\text{r,eff}}(\omega)$. Since the dielectric thickness of the fishnet

structure is easy to control, the fabrication burden is significantly eased as compared to the conventional approach of using SRRs and metallic wires.⁸ Moreover, in order to produce a negative refractive index, EM waves are incident normal to the fishnet surface, whereas the structure fabricated by SRRs and wires requires oblique incidence to excite SRRs with out-of-plane magnetic fields for strong magnetic resonances.

FASTER, QUIETER, SMALLER SIGNAL SOURCES QUICKSYN SYNTHESIZERS

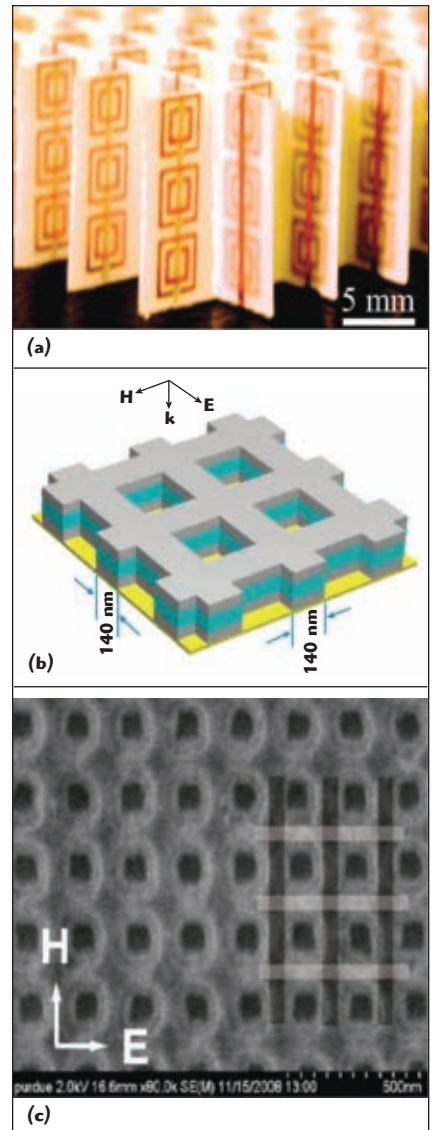
Design smaller and more efficiently with National Instruments QuickSyn synthesizers. The revolutionary phase-refining technology used in QuickSyn synthesizers enables blazing fast switching speeds, very low spurious and phase noise performance, wide frequency range, and small footprint.

ni-microwavecomponents.com/quicksyn



QuickSyn Lite Synthesizer

© 2016 National Instruments. All rights reserved.



▲ **Fig. 3** Typical arrangement of artificially engineered negative index medium; copper SRRs and wires deposited lithographically on standard circuit boards for microwave frequencies where the size of the unit cell is 5×10^{-3} meters (a)¹³ NIM fishnet structure for the visible region (yellow) where two layers of metal mesh (gray) are separated by a dielectric layer (cyan) (b) and a scanning electron microscope (SEM) image of the fishnet structure fabricated by electron beam lithography (c).¹⁴

2 GHz Clock Generator



- Square wave clocks from DC to 2.05 GHz
- Random jitter <1 ps (rms)
- 80 ps rise and fall times
- 16-digit frequency resolution
- CMOS, LVDS, ECL, PECL, RS-485
- Phase adjustment & time modulation

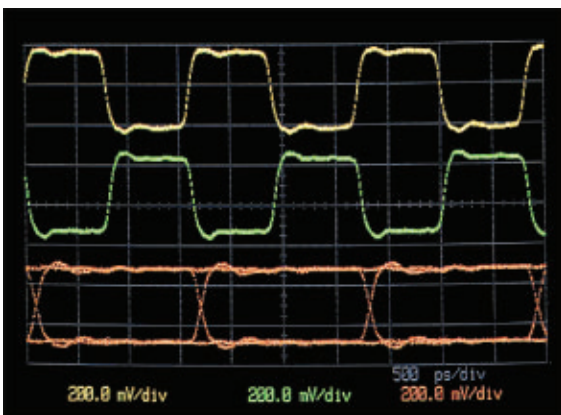
The CG635 generates clock signals—flawlessly. The clock signals are fast, clean and accurate, and can be set to standard logic levels.

How fast? Frequency to 2.05 GHz with rise and fall times as short as 80 ps.

How clean? Jitter is less than 1 ps and phase noise is better than -90 dBc/Hz (100 Hz offset) at 622.08 MHz.

How accurate? Using the optional rubidium timebase, aging is better than 0.0005 ppm/yr, and temperature stability is better than 0.0001 ppm.

You would expect an instrument this good to be expensive, but it isn't. You no longer have to buy an rf synthesizer to generate clock signals. The CG635 does the job better—at a fraction of the cost.

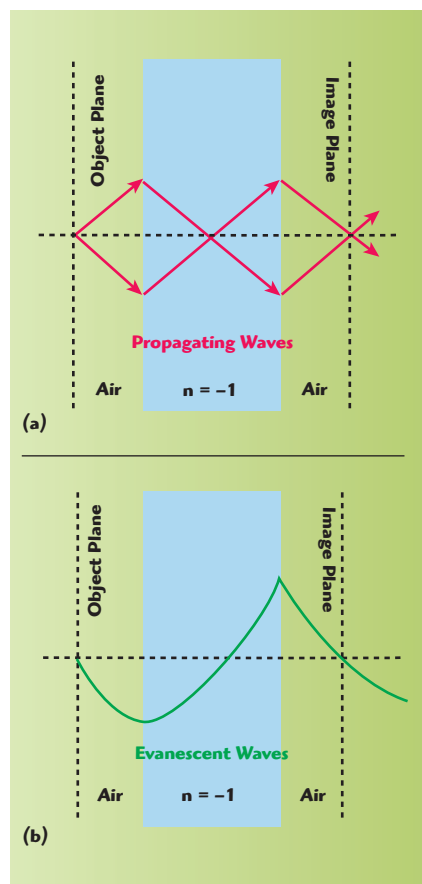


Plot shows complementary clocks and PRBS (opt. 01) outputs at 622.08 Mb/s with LVDS levels. Traces have transition times of 80 ps and jitter less than 1 ps (rms).

Stanford Research Systems



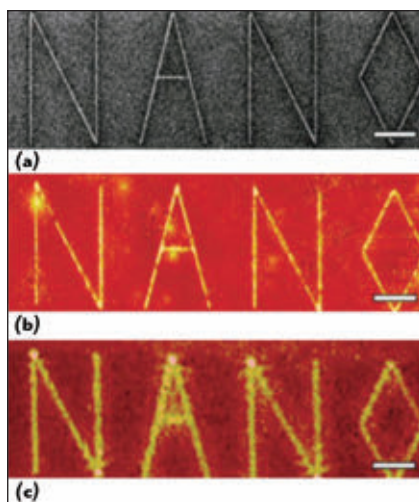
Phone: (408)744-9040 • Fax: (408)744-9049 • info@thinkSRS.com • www.thinkSRS.com



▲ Fig. 4 Metamaterial slab shows the properties of a perfect lens; focusing all light rays from a point source (a) and amplifying evanescent waves (b) to provide perfect imaging at the image plane.

METAMATERIAL OPPORTUNITIES AND EMERGING TRENDS

The aerospace, defense and biomedical electronics sectors are viewed



▲ Fig. 5 Experimental demonstration of an optical silver superlens; object mask (a) metamaterial superlens image (b) and conventionally focused image (c).

as the most vibrant market areas for metamaterial products applications. The rise of drones and related weight considerations, the need for improved military communications, and the burgeoning demand for new and more sophisticated biosensors are all areas where metamaterial technology can help propel things forward.

Imaging

Metamaterial structures have been used in magnetic imaging, microwave circuit components, antennas, and perfect lenses with imaging resolutions beyond the diffraction limit.¹⁻²¹ In conventional optical systems, it is not possible to determine two points separated

less than $1/2n$, where n is the refractive index of the ambient medium. This fundamental limitation exists because the information of the object's fine features and textures are carried by evanescent waves, which exponentially decay in space. All the information relevant to the sub-wavelength details of the object is lost, before reaching the imaging plane. It is interesting to note that a metamaterial slab acts as a perfect lens to recover all the lost information.²⁰ This extraordinary property of perfect lens arises from the fact that the initially decayed evanescent waves are now amplified through the slab. Meanwhile, the propagating waves are focused due to the negative refraction and reversed phase front. As a result, a metamaterial slab, incredibly, brings both propagating and evanescent waves to a perfect focus (see **Figures 4a** and **4b**), without suffering the traditional constraint imposed by the diffraction limit.

This shows promise in the realization of metamaterial super lenses, which are lenses that are almost free of aberrations and that can focus images below the diffraction limit. The recorded image "NANO" (see **Figure 5b**) reproduces the fine features from the object mask (see **Figure 5a**) in all directions with good fidelity, while the image in the control experiment without the super lens (see **Figure 5c**) shows a much wider line width.²² In the seminal paper, Pendry et al.,⁵ predicted the enhanced nonlinear optical properties by inserting nonlinear

Look to Norden for your Radar Component Needs



**77 Ghz
RADAR TxRx**



**12-Channel 10 Watt
X-Band TxRx**



**KA-Band
Transceiver**



**NORDEN
MILLIMETER**

For more information on these products go to:
www.nordengroup.com or
 call **530.642.9123**





Why AR Solid State Pulsed Amplifiers Should Be On Your Radar



For automotive and military EMC radiated immunity susceptibility testing, as well as radar and communication applications, there is now a very attractive alternative to Traveling Wave Tube Amplifiers (TWTAs).

AR's new offerings include various frequency ranges and output power levels to meet several standards, or designs can be tailored to suit your specific application. These amplifiers feature a touchscreen control panel, GPIB interface, TTL gating, fault monitoring, and forced air cooling.

Features & Benefits For These Rugged Amplifiers Are:

- Octave Frequencies: 1-2 GHz and 2-4 GHz
- Narrowband Frequencies: 1.2-1.4 GHz & 2.7-3.1 GHz
- Power Levels: 1 kW to 150 kW
- Harmonic Distortion of -18dBc @ 1dB compression point
- Pulse Widths to 100 μ sec. & Duty Cycles to 10%
- High Mean Time To Failure (MTTF)
- Mismatch Tolerance - Will operate without damage or oscillation with any magnitude and phase of source and load impedance.
- Numerous Applications Possible - Automotive, MIL STD 464, DO-160 and Military Radar



To learn more, visit www.arworld.us/pulsedamps or call us at 215-723-8181.

Come See Us at IEEE EMC Ottawa
The Shaw Centre, Ottawa, Canada, July 25-29, 2016, Booth 400

ISO 9001:2008
Certified

We don't just build great products.
We build great products that last.



rf/microwave instrumentation

Other **ar** divisions: modular rf • receiver systems • ar europe

USA 215-723-8181. For an applications engineer, call 800-933-8181.

In Europe, call ar United Kingdom +44 1908 282766 • ar France +33147917530 • ar Deutschland +49 6101 802700 • ar Benelux +31 172 423000

Download the AR RF/Microwave Mobile App: www.arworld.us/arApp

Copyright © 2016 AR.

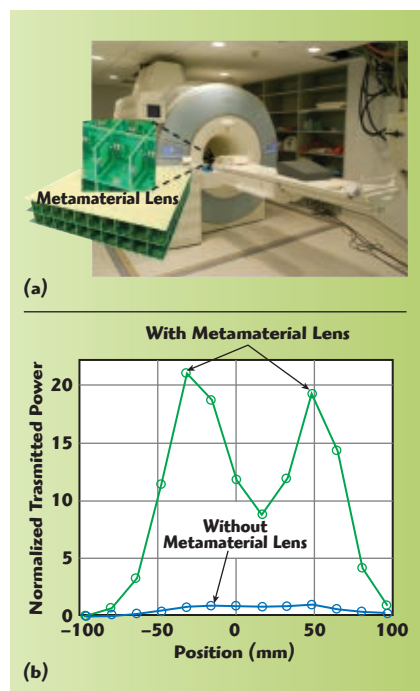
The orange stripe on AR products is
Reg. U.S. Pat. & TM. Off.



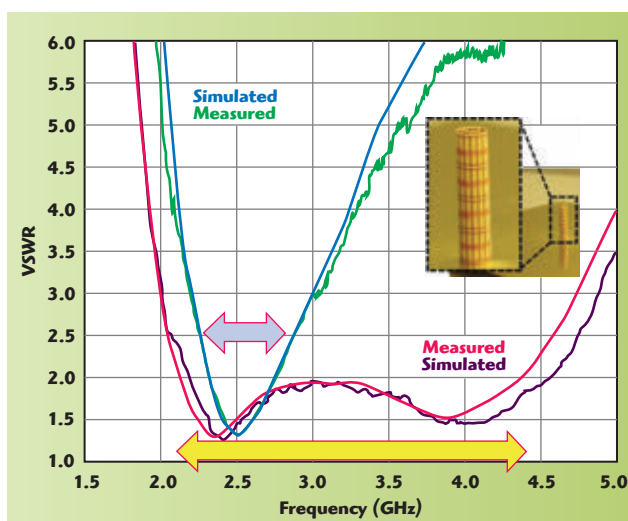
Technical Feature

elements into the gap of SRRs, arising from the giant local-field amplification.

Figure 6 shows the typical measurement setup for an MRI measurement at 8.5 MHz for prostate cancer detection. Metamaterial inspired ($\mu = -1$) split ring resonators loaded with capacitors and inductors enabled a 20 times increase in the magnetic field. As shown in **Figure 6b**, the lens resolves two magnetic sources indistinguishable without the lens.⁷⁶



▲ Fig. 6 MRI measurement setup shows the use of metamaterial lens for imaging (a) and the measurement response with and without the lens (b).⁷⁶



▲ Fig. 7 Data showing increased antenna bandwidth using metamaterial.⁷⁷ Simulated monopole alone (blue line), measured monopole alone (green line), simulated monopole with metamaterial (red line), measured monopole with metamaterial (purple line).

Lightweight Metamaterial

Metamaterial technology is an enabler to build lighter and more compact antenna systems. **Figure 7** shows the performance of the typical light weight inspired monopole antenna. The data shows that the bandwidth increased to over an octave while preserving the radiation characteristics of a simple monopole.

Light Manipulation

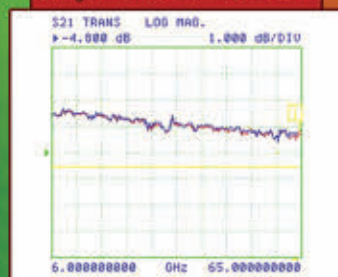
Metamaterial technology offers unparalleled opportunities for light manipulation. Recent developments in the field have fueled new opportunities for light propagation, establishing a new paradigm for spin and quantum related phenomena in optical physics. Nonlinear metamaterials, with properties depending on the intensity of EM waves, is an emerging research topic with novel phenomena such as hysteretic transition,²³ unusual wave mixing²⁴ and solitary wave propagation.²⁵⁻²⁶

The other interesting phenomenon is the reversed Manley-Rowe relation and backward phase matching condition for second-harmonic generation (SHG) or optical parametric amplification (OPA).²⁷ Suppose a metamaterial has a negative refractive index at the fundamental frequency ω_1 and a positive refractive index at the second-harmonic frequency ω_2 . At ω_1 the energy flow (Poynting vector) points from left to right, for example; then the wave vector \vec{k}_1 must point from right to left arising from negative index sample

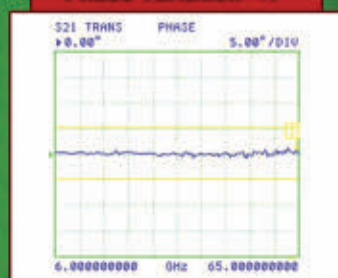
at ω_1 . The phase matching condition i.e. $\vec{k}_2 = 2\vec{k}_1$ requires that the wave vector \vec{k}_2 at the second harmonic frequency ω_2 also travels from the right to the left. Since the metamaterial possesses a positive refractive index at ω_2 , the energy flow is at the same direction as the wave vector. As a result, the second harmonic signal is maximal at the incident interface rather than at the exit interface of the metamaterial slab, in sharp

6 - 65 GHz Power Dividers

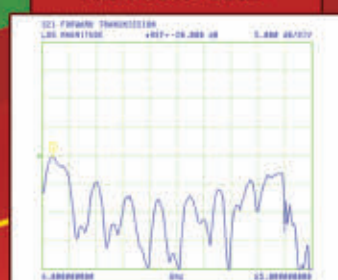
Amplitude Balance <.3dB



Phase Variation <1°



Isolation >20dB



VSWR <1.6:1

For hot air, ask our competitors.
For advanced microwave products, call ETI.



Tel: 973-394-1719
Fax: 973-394-1710

Electromagnetic Technologies Industries, Inc.
50 Intervale Rd. Boonton, NJ 07005 U.S.A.
sales@etiworld.com • www.ETIworld.com



ISO 9001

RF-LAMBDA

THE LEADER OF RF BROADBAND SOLUTIONS

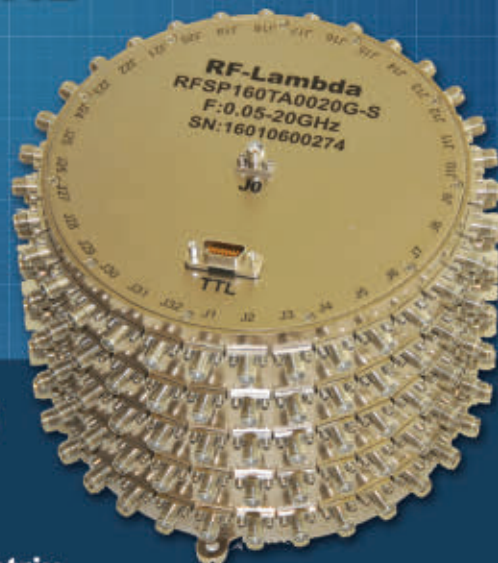
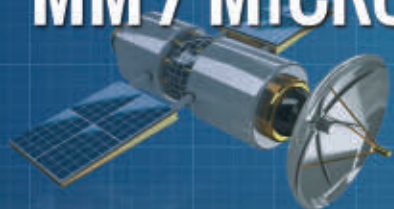
WWW.RFLAMBDA.COM

ITAR & ISO9000
Registered Manufacture



Thousand
in stock

RF SWITCHES MM / MICROWAVE DC-50GHz



160 CHANNELS
mm/Microwave

0.05-20GHz

Filter Bank Switch Matrix

For Phase Array Radar Application Satellite communication.



PN: RFSP32TA5M43G

SP32T SWITCH 0.5-43.5GHz

PN: RFSP16TA5M43G

SP16T SWITCH 0.5-43.5GHz

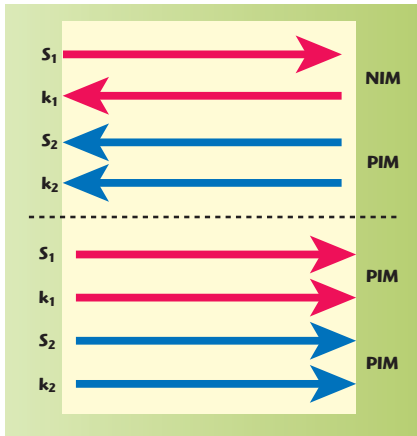


www.rflambda.com
sales@rflambda.com

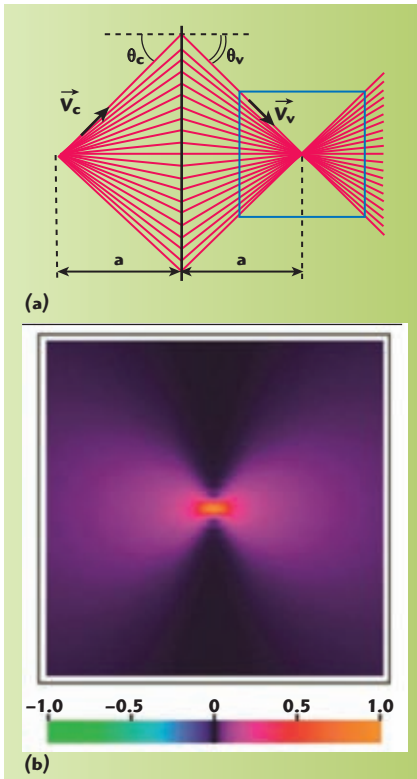
1-888-976-8880
1-972-767-5998

Plano, TX, US
San Diego, CA, US
Ottawa, ONT, Canada



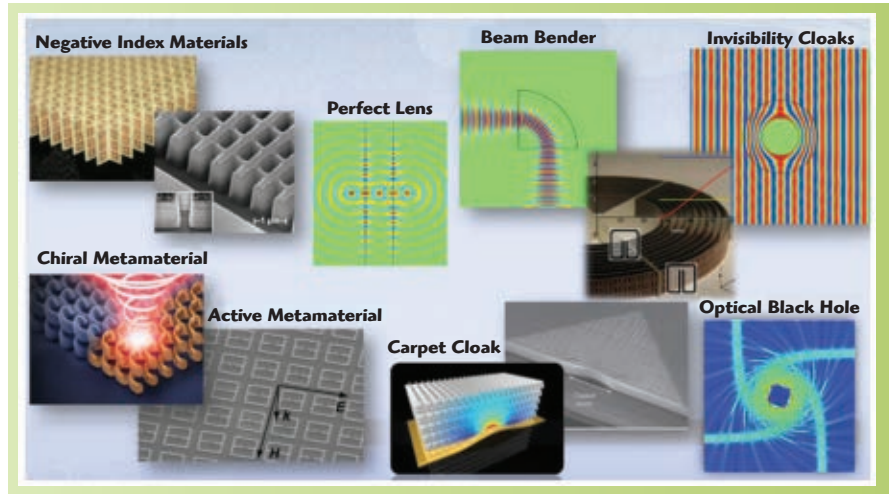


▲ Fig. 8 Schematic of a second harmonic generation with negative index materials in comparison with normal SHG with only positive index materials.



▲ Fig. 9 Focusing of electrons by a grapheme p-n junction; trajectories of electrons diverging from a source at distance a from the junction and becoming convergent after negative refraction (a) and the interference-induced pattern in the charge current near the focal image (b).³²

contrast to SHG in normal dielectric materials (see **Figure 8**). Moreover, artificial magnetic metamaterials could provide additional ways to boost the nonlinear process.²⁸ In terms of applications, tunable metamaterials²⁹⁻³⁰ and memory devices³¹ have been experimentally demonstrated based on nonlinear metamaterial composites.



▲ Fig. 10 Metamaterial technology and transformation optics approaches.

Metamaterials may manifest fascinating phenomena in the quantum world. In principle, the metamaterial concept could be applied to any wave at any scale, including the matter wave which is the wave description of particles, such as electrons and neutrons, in quantum mechanics. Indeed, researchers have made theoretical efforts in this direction. Cheianov et al.,³² theoretically demonstrated that negative refraction and focusing of electrons can be achieved in graphene (see **Figure 9**), a monolayer of graphite.

Figure 10 illustrates the technology and transformation optics approach that enables unprecedented design flexibility and novel device applications.

TECHNOLOGY CHALLENGES

The metamaterial technology and transformation optics shown in **Figure 10** promise unparalleled opportunities; but at the same time, metamaterial composites fabrication is challenging. The real challenge is to predict the topology and geometry of negative index microstructures even though they tend to have simple shapes. The topology optimization method allows selection of geometric and topological configuration of multi-physical functional materials while taking into account the MMS material composition. Commercialization is primarily a manufacturing problem due to the lack of effective tools to economically pattern large volumes of material.

The immediate step is to improve the homogenization methodology for the design of multi-function nonlinear metamaterial devices, improving

the bandwidth, and providing smaller/more compact structures. More investigation of pulse propagation in optical fiber and speed control by means of nonlinear refractive index for the space-time cloak, solitons and their variants is needed in negative refractive index composites.

FUTURISTIC OUTLOOK

The emerging future is likely to be in the area of the Gravitational Casimir effect and signal processing where the space-time cloak acts as a means of prioritizing data channels, rather than theoretically attempting to combine space-time and spatial cloaks. In addition to this, Möbius transformations that exploit hyperbolic characteristics could be interesting for a variety of Minkowski-based relativistic scenarios including spinning cosmic strings.

Gravitational Casimir Effect

Figure 11 shows the practical evidence of the Casimir force 'F' on parallel plates kept in vacuum. The effective force $F \propto A/d^4$, where A is the area of plate and d is the distance between the plates. The Casimir force⁶⁷ (see **Figure 12**) arises from the interaction of the surfaces with the surrounding electromagnetic spectrum, and includes a complex dependence on the full dielectric function of both surfaces and the region between. On the more theoretical side, the MMI structure can produce a powerful Casimir effect (force from nothing), which will allow the transport of matter; this implies the ability to attract or push away physical matter.

As shown in **Figure (12)**,⁵⁶ the polaritonic contribution is responsible



SMP connectors with great performance up to 40 GHz

HUBER+SUHNER SMP snap-on connectors provide a robust, proven and fully compatible plug-in solution for applications up to 40 GHz. Interface design and materials provide true compatibility with all MIL-STD-348 SMP connectors in the market.

The broadband characteristics, the small size, MIL-STD-348 compliance and the good performance make this product the ideal standard snap-on solution for Aerospace+Defense and Test+Measurement applications.

hubersuhner.com

The Largest Selection of Waveguide Components For Same-Day Shipping



Waveguide Bandpass Filters



Waveguide Detectors



Waveguide Power Amplifiers



Waveguide Sections



Waveguide Standard Gain Horns



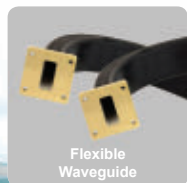
Waveguide Terminations



Waveguide Variable Attenuators



Waveguide to Coax Adapters



Flexible Waveguide



Waveguide Up/Down Converters

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

PE PASTERNAK
THE ENGINEER'S RF SOURCE

Technical Feature

for the change in sign of the Casimir force between a metallic and a metamaterial mirror. For $L \geq \lambda_r/5$ the binding TM polariton, which dominates at short distance, is overwhelmed by the joint repulsion due to the anti-binding TM and TE polaritons. This shows that, for mixed configurations as well, surface plasmons are crucial in determining both the strength and the sign of the Casimir interaction.

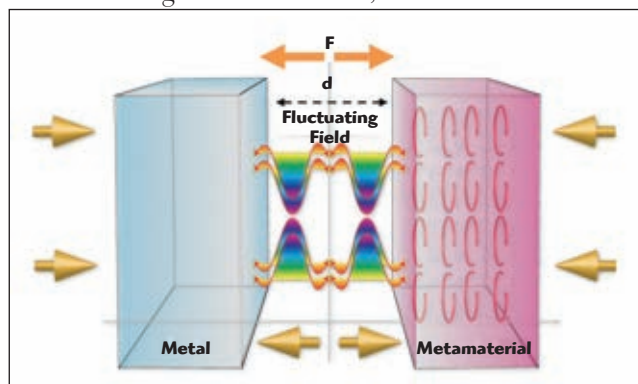
One of the exciting properties of MMI structures is that they can bend light in a way that is mathematically equivalent to the way space-time bends light, enabling topological exploration for the realization of low cost gravitational wave detector. **Figure 13** shows the gravitational Casimir effect, with a two plate setup. The change in the refractive index of the plates causes the gravitational wave to refract, where k represents the wave vector of the incident, transmitted, and reflected gravitational waves, and

γ is the corresponding angle with respect to the surface normal.⁶⁸ The Casimir effect has also been investigated in weak gravitational fields to see the effect the slightly curved space time background would have on the Casimir energy.⁶⁸

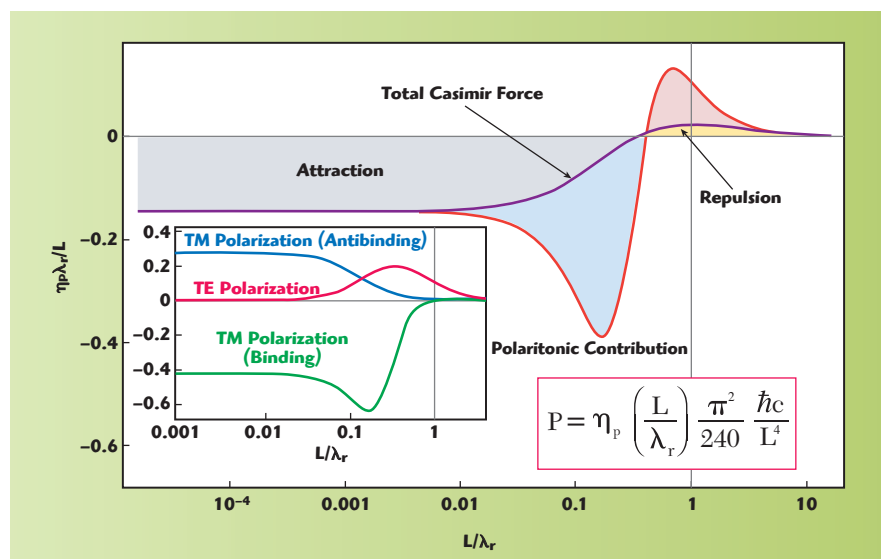
Gravitational Wave Reflector and the Gravitational Characteristic Impedance of Free Space

Thin metamaterial superconducting films are predicted to be highly reflective mirrors for gravitational waves at microwave frequencies. There are four conventionally accepted fundamental forces of nature: (i) gravitational, (ii) electromagnetic, (iii) strong nuclear, and (iv) weak nuclear. Each one is understood as the dynamics of a field. The gravitational force is modeled as a continuous classical field. Interestingly, of the four fundamental forces of nature, only gravity and electricity have long range, inverse square laws.

The Maxwell-like representation of Einstein's equations of general relativity describe the coupling of weak gravitational fields to slowly moving matter. In the asymptotically flat space-time coordinate system of a distant inertial observer, the four equations in SI units are:



▲ Fig. 11 The repulsive Casimir force F on parallel plate kept in vacuum.⁵⁶



▲ Fig. 12 The polaritonic contribution is responsible for the change in sign of the Casimir force between a metallic and a metamaterial mirror.⁵⁶

Design & Buy Online with

The Pasternack Cable Creator™

***Over 250,000 Possible Cable Assembly Configurations
Available – All Shipped the Same Day.***



Customize RF cable assemblies to your exact specifications with the new Pasternack Cable Creator. This easy to use tool provides instant pricing, detailed datasheets, and online ordering with same day shipping on any cable assembly built from our inventory of 1,300 connectors and 120 cable types. Another RF solution brought to you by the RF engineers at Pasternack.

866.727.8376
visit pasternack.com today!

PE PASTERNAK®
THE ENGINEER'S RF SOURCE

$$\nabla \times \bar{\mathbf{E}}_G = -\frac{\partial \bar{\mathbf{E}}_G}{\partial t} \quad (9)$$

$$\nabla \times \bar{\mathbf{B}}_G = \mu_G \left(-\mathbf{j}_G + \epsilon_G \frac{\partial \bar{\mathbf{E}}_G}{\partial t} \right) \quad (10)$$

$$\nabla \cdot \bar{\mathbf{E}}_G = -\frac{\rho_G}{\epsilon_G} \quad (11)$$

$$\nabla \cdot \bar{\mathbf{B}}_G = 0 \quad (12)$$

where the gravitational analog of the electric permittivity ϵ_G and magnetic permeability μ_G of free space is given by

$$\mu_G = \frac{4\pi G}{c^2} = 9.3 \times 10^{-27} \quad (13)$$

$$\epsilon_G = \frac{1}{4\pi G} = 1.2 \times 10^9 \quad (14)$$

The value of ϵ_G is fixed by demanding that Newton's law of gravitation be recovered from the Gauss-like law (12), whereas the value of μ_G is fixed by the linearization procedure from Einstein's field equations. These two constants ex-

press the strengths of the coupling between sources (i.e., of masses and mass currents, respectively) and gravitational fields, and are analogous to the two constants ϵ_0 (the permittivity of free space) and μ_0 (the permeability of free space), which express the strengths of coupling between sources (charges and charge currents, respectively) and electromagnetic fields in Maxwell's theory.

In the above set of equations, the field $\bar{\mathbf{E}}_G$ is the gravito-electric field, which is to be identified with the local acceleration \mathbf{g} of a test particle produced by the mass density ρ_G , in the Newtonian limit of general relativity. The field $\bar{\mathbf{B}}$ is the gravito-magnetic field produced by the mass current density \mathbf{j}_G and by the gravitational analog of the Maxwell displacement current density

$$\epsilon_G \left(\frac{\partial \bar{\mathbf{E}}_G}{\partial t} \right)$$

of the Ampere-like law (10). The resulting magnetic-like field $\bar{\mathbf{B}}_G$ can be regarded as a generalization of the Lense-Thirring field of general relativ-

ity. Because these equations are linear, all fields will obey the superposition principle not only outside the source (i.e., in the vacuum), but also within the matter inside the source, provided the field strengths are sufficiently weak and the matter is sufficiently slowly moving. Note that the fields $\bar{\mathbf{E}}_G$ and $\bar{\mathbf{B}}_G$ in the above Maxwell-like equations will be treated as classical fields, just like the fields $\bar{\mathbf{E}}_G$ and $\bar{\mathbf{B}}_G$ in the classical Maxwell's equations.

An important physical property follows from the above Maxwell-like equations, namely, the characteristic gravitational impedance of free space Z_G .⁶³⁻⁶⁵

$$Z_G = \sqrt{\frac{\mu_G}{\epsilon_G}} = \frac{4\pi G}{C} = 2.8 \times 10^{-18} \quad (15)$$

This quantity is a characteristic of the vacuum, i.e., it is a property of space-time itself, and it is independent of any of the properties of matter per se. As with

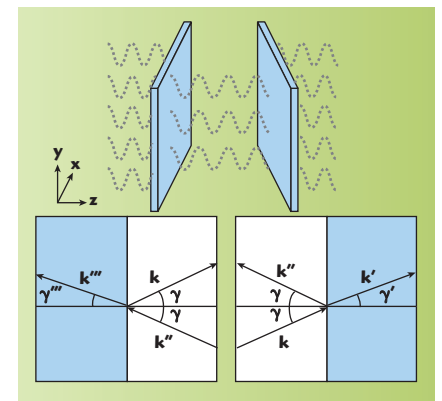
$$Z_0 = \sqrt{\frac{\mu_0}{\epsilon_0}} = 377$$

ohms in the EM case,

$$Z_G = \sqrt{\frac{\mu_G}{\epsilon_G}} = 2.8 \times 10^{-28}$$

will play a central role in all gravitational radiation coupling problems.

In practice, the impedance of a material object must be much smaller than this extremely small quantity before any significant portion of the incident gravitational-wave (GW) power can be reflected. In other words, conditions must be highly unfavorable for dissipation into heat. Because all classical material objects have extremely high levels of dissipation compared to Z_G ,



▲ Fig. 13 The Gravitational Casimir effect.⁶⁸



ISO 9001:2008 **RoHS COMPLIANT** **25** **Made in USA**

MICROWAVE OSCILLATORS

DIELECTRIC RESONATOR TECHNOLOGY

Designing and Manufacturing microwave & mm-wave components and sub-assemblies ranging from 10 MHz to 50 GHz for 25 years, Exodus Dynamics has become a proud supplier to many of the nation's top aerospace and defense companies. With rugged designs, supported by a 2 year warranty, our products are designed, built and test-proven to last a lifetime. Typical features include:

- Ultra Low Phase Noise for Radar Applications
- Optional Operating of -55° to +105°C
- Vibration/Shock Upgrades
- 24 Hour Turnaround (standard products)
- Optional Output Power up to +30 dBm





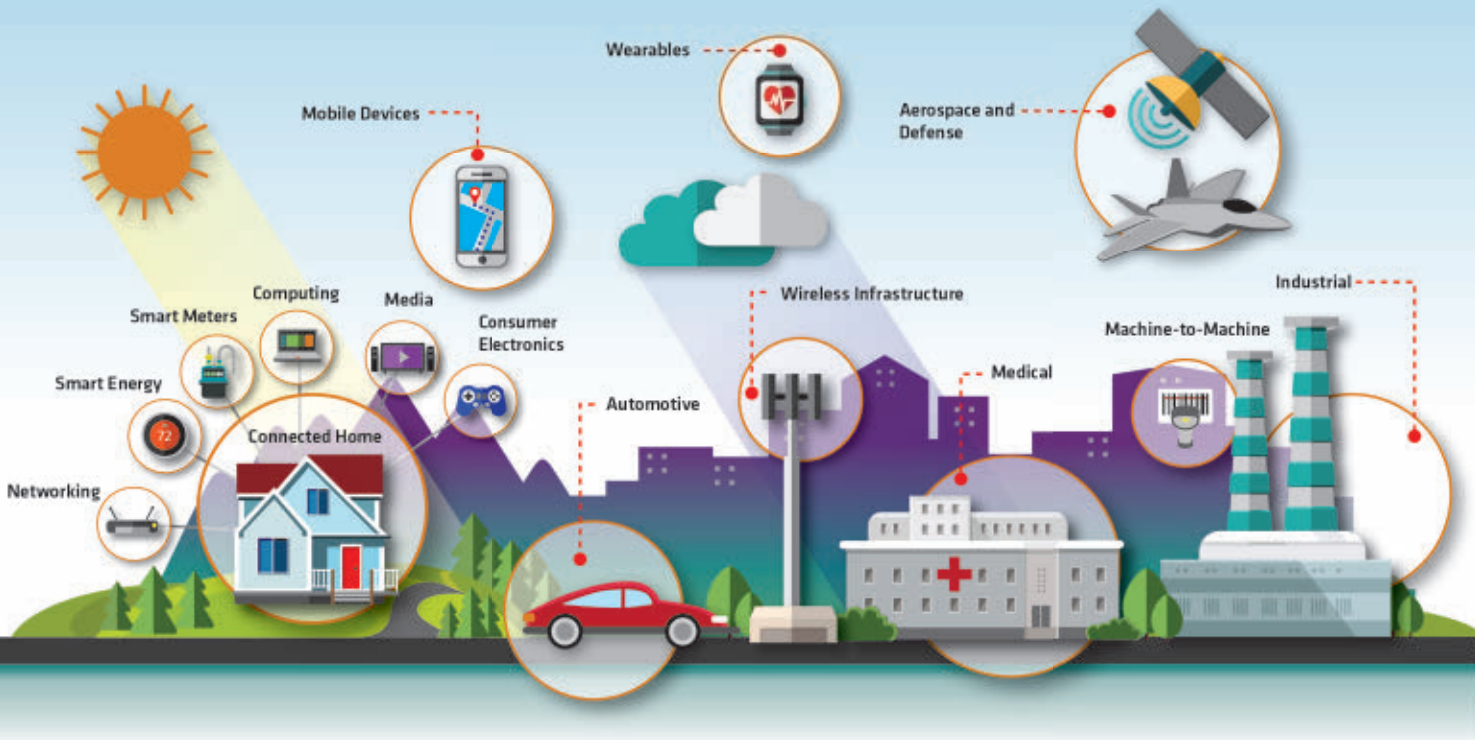
Dielectric Resonator Oscillators | Frequency Amplifiers | Frequency Converters | Frequency Multipliers

AEROSPACE | INDUSTRIAL | DEFENSE | TELECOM | GOVERNMENT

www.exodusdynamics.com | Phone: 719-445-2999 | Sales@ExodusDynamics.com



Enabling the Internet of Things



| Automotive

AEC-Q100 Qualified 20 MHz to 3 GHz SPDT RF Switch: SKYA21001
For wireless control applications

| Connected Home

0.1 to 6 GHz SP3T Switch (-40 to +105 °C Operating Temperature Range): SKY13588-460LF
For LTE (band, mode), multimode antenna switching, Wi-Fi networks and embedded lighting

| Industrial

470 to 510 MHz Front-end Module: SKY66115-11
For low-power range extension in industrial, smart meter, tracking and RFID applications

| Machine-to-Machine (M2M)

Step-down Regulator with Auto Bypass: SKY87000-13
For machine-to-machine and mobile devices

| Medical

Ultra Broadband Low-noise Amplifier: SKY67159-396LF
For magnetic resonance imaging, monitoring equipment and telemetry

| Mobile Devices

Multimode Multiband Power Amplifier Module for Penta-Band (1, 2, 4, 5, 8) WCDMA / HSDPA / HSUPA / HSPA+ / LTE Bands 1, 2, 4, 5, 8, 26, 27, 34, 39: SKY77759-51
For multiband handsets

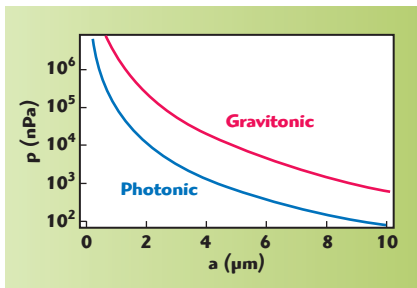
| Smart Energy

Transmit/Receive Front-end Module: SKY66100-11
For automated meter reading, advanced metering infrastructure and ISM systems

| Wearables

20 MHz to 6 GHz SPDT Switch: SKY13587-378LF
For low-power transmit/receive systems

Please visit our Internet of Things site at www.skyworksinc.com/IoT



▲ Fig. 14 Typical CAD simulated plots of gravitonic (red line) and photonic (blue line) contributions to the Casimir pressure of parallel plates kept in vacuum.⁶⁸

even at very low temperatures, they are inevitably very poor GW reflectors.⁶⁵⁻⁶⁶ The question of GW reflection from macroscopically coherent quantum systems such as superconductors requires a separate analysis due to the effectively zero resistance associated with superconductors, i.e., the lack of dissipation exhibited by matter in this unique state, at temperatures near absolute zero.

Peters⁷⁸ reported on the gravitational refractive index n_G , which was much larger than that generated by just considering induced quadrupole moments, suggesting that his model

encapsulates the dominant GW interaction with matter, given as

$$n_G = 1 + \frac{2\pi G \rho}{\omega^2} \quad (16)$$

where ρ is the density of the medium.

Minter⁵⁷ et al., give the reflection coefficient of a superconducting film from an incident GW as

$$r_G = \frac{1}{1 + \frac{2\delta^2}{c \times d} \xi} \quad (17)$$

where δ is the EM skin depth of the superconducting film and d is the film thickness.

From (17), the gravitonic contribution to the Casimir pressure for superconducting lead (Pb) of thickness $d = 2$ nm at zero temperature is plotted in **Figure 14**.⁶⁸ The EM skin depth of Pb is $\delta = 37$ nm. This result is compared with the photonic contribution to the Casimir pressure of superconducting lead. The EM reflection coefficient is⁷⁹

$$r_E = \frac{1}{1 + \frac{2\lambda\delta^2}{c \times d} \xi} \quad (18)$$

where $\lambda = 83$ nm is the coherence length. The photonic contribution to the Casimir pressure is calculated by using Equation (18).

James⁶⁸ claims that Casimir pressure is an order of magnitude larger than that predicted from the photonic contribution alone. This would be the first experimental evidence for the validity of the H-C theory and the existence of gravitons. This would open a new field in the way of graviton detection.

CONCLUSION

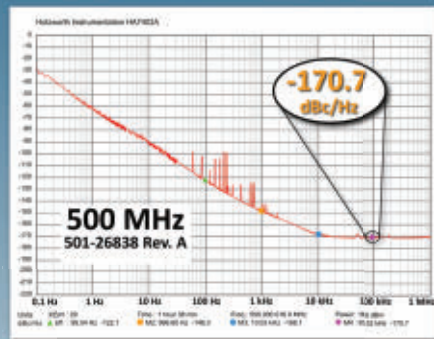
This series of articles discussed the opportunities, emerging trends, challenges and future direction promoted by the scientists, experimentalists and technologists whose focus is in translating metamaterials into practical systems and devices. Their unique electromagnetic properties have attracted considerable attention from researchers across multiple disciplines. With the complete degree of freedom to control over material properties, what is possible is limited only by our imagination. Magneto electric couplings can be a source of new behavior in Casimir systems, metamaterial Casimir repulsive effects can lead to anti-gravity and low cost solution for levitation. As a final comment, the authors acknowledge that MMS metasurfaces can provide nearly infinite group delay, which is very helpful in understanding Einstein precession, geodetic effects and provides new evidence for refining our understanding of the relativistic corrections to Newtonian celestial mechanics. For example, multi-knots Möbius strips can be considered as tiny strings that can vibrate in multiple dimensions, and depending on how they vibrate, they might be seen in 3-dimensional space as matter, light or gravity. The vibration of the string which determines whether it appears to be matter or energy, and every form of matter or energy is the result of the vibration of the string. The authors consciously set out to describe a model of the universe as a “Möbius Universe,” unbounded in the form of Möbius loop along the plane of space-time fabrics.

ACKNOWLEDGMENTS

The authors would like to thank Dr. Ignaz Eisele (EMFT Fraunhofer Institute, Munich, Germany) for developing prototypes and custom structures, Dr. Karl-Heinz Hoffmann

MULTIPLIED CRYSTAL OSCILLATORS (MXO Series) EXTREMELY LOW PHASE NOISE


- 100 MHz to 12 GHz, Fixed
- OCXO & Integrated Multipliers
- Noise Floors to -190 dBc/Hz
- Excellent Spectral Purity
- Very Low Jitter Option
- Phase Lock Options
- Easily Customized



"Quietly the Best"



Wenzel Associates, Inc.
2215 Kramer Lane, Austin, Texas 78758
512-835-2038 • sales@wenzel.com
www.wenzel.com



The spark is in you.
(We're just here to help you ignite it.)



Keysight X-Series Signal Analyzers	UXA	PXA	MXA	EXA	CXA
Max. Frequency	50 GHz	50 GHz	26.5 GHz	44 GHz	26.5 GHz
Max. Bandwidth	1 GHz	510 MHz	160 MHz	40 MHz	25 MHz
Multi-touch UI	Yes	Yes	Yes	Yes	Yes

Your next breakthrough. It's what drives Keysight X-Series signal analyzers. With multi-touch, they're the benchmark for accessible performance—easily linking cause and effect to put you closer to the answer. Plus with apps, software and upgradability, you'll be ready to make inspired connections for years to come.

See the video and get inspired.
www.keysight.com/find/X-Series-inspired

USA: 800 829 4444 CAN: 877 894 4414

© Keysight Technologies, Inc. 2016.



Unlocking Measurement Insights

Agilent's Electronic Measurement Group is now **Keysight Technologies**.

(Bavarian Academy of Science, Germany), Dr. Shiban Koul (IIT-Delhi, India), Dr. Tatsuo Itoh (UCLA, USA), Dr. Matthias Rudolph (BTU Cottbus, Germany), Dr. Afshin Daryoush (Drexel University, Philadelphia, USA) and Dr. Arye Rosen (Rowan University, NJ, USA) for their valuable inputs, technical discussions and developing prototype for the theoretical proof and experimental validation. The authors would also like to thank the Indian Government in 1990s for supporting the negative index Möbius strips based RF&MW components for space applications. A special heartfelt thank you goes to our close friend Prof. D. Sundararajan who passed away on 22nd September 2014. Prof. Sundararajan and Dr. Poddar had been working on this mysterious Metamaterial Möbius strips since 1990 and were the first ones to demonstrate Möbius strips sensors for the applications in underground mine detections, memory devices, RFID for the detection of chemical explosives and weapons made of plastics, and composite materials which were often missed and undetected by RADAR. ■

References

1. D. R. Smith, S. Schultz, P. Markoš and C. M. Soukoulis, "Determination of Effective Permittivity and Permeability of Metamaterials from Reflection and Transmission Coefficients," *Physical Review B*, Vol. 65, No. 19, April 2002, pp. 195104-1-5.
2. D. R. Smith, D. C. Vier, Th. Koschny and C. M. Soukoulis, "Electromagnetic Parameter Retrieval from Inhomogeneous Metamaterials," *Physical Review E*, Vol. 71, No. 3, March 2005, pp. 36617-1-11.
3. J. B. Pendry, A. J. Holden, D. J. Robbins and W. J. Stewart, "Low Frequency Plasmons in Thin-Wire Structures," *Journal of Physics: Condensed Matter*, Vol. 10, No. 22, June 1998, pp. 4785-4809.
4. J. B. Pendry, A. J. Holden, W. J. Stewart and I. Youngs, "Extremely Low Frequency Plasmons in Metallic Mesostructures," *Physical Review Letters*, Vol. 76, No. 25, June 1996, pp. 4773-4776.
5. J. B. Pendry, A. J. Holden, D. J. Robbins and W. J. Stewart, "Magnetism From Conductors and Enhanced Nonlinear Phenomena," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 47, No. 11, November 1999, pp. 2075-2084.
6. J. D. Jackson, "Classical Electromagnetics," John Wiley & Sons, 3rd Edition, New York, 1999.
7. V. G. Veselago, "Electrodynamics of Substances with Simultaneously Negative Values of Sigma and Mu," *Soviet Physics Uspekhi*, Vol. 10, 1968, pp. 509-514.
8. Y. Liu and X. Zhang, "Metamaterials: A New Frontier of Science and Technology," *Chemical Society Reviews*, Vol. 40, January 2011, pp. 2494-2507.
9. D. R. Smith, S. Schultz, P. Markoš and C. M.

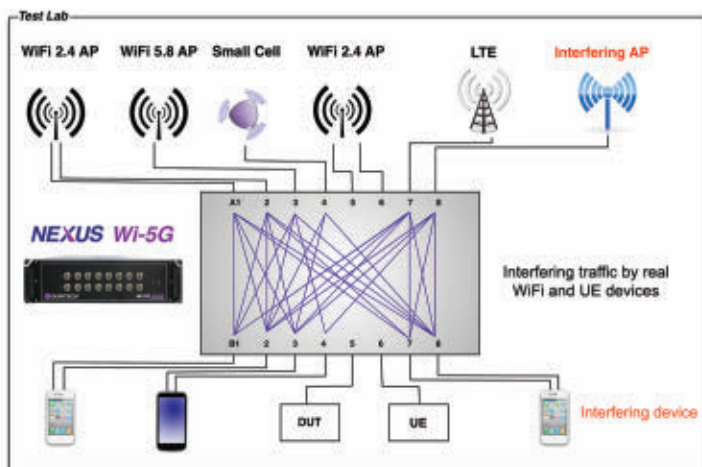
- Soukoulis, "Determination of Effective Permittivity and Permeability of Metamaterials from Reflection and Transmission Coefficients," *Physical Review B: Condensed Matter*, April 2002, Vol. 65, April 2002, pp. 195104-1-5.
10. X. Chen, B. I. Wu, J. A. Kong and T. M. Grzegorzczak, "Retrieval of the Effective Constitutive Parameters of Bianisotropic Metamaterials," *Physical Review E: Statistical Physics, Plasmas, Fluids, and Related Interdisciplinary Topics*, Vol. 71, No. 4, April 2005, pp. 046610.
11. D. R. Smith, D. C. Vier, Th. Koschny and C. M. Soukoulis, "Electromagnetic Parameter Retrieval from Inhomogeneous Metamaterials," *Physical Review E: Statistical, Nonlinear, Biological, and Soft Matter Physics*, Vol. 71, March 2005, pp. 036617-1-11.
12. C. Menzel, T. Paul, C. Rockstuhl, T. Pertsch, S. Tretakov and F. Lederer, "Validity of Effective Material Parameters for Optical Fishnet Material," *Physical Review B: Condensed Matter*, Vol. 81, No. 3, January 2010, pp. 035320/1-5.
13. R. A. Shelby, D. R. Smith and S. Schultz, "Experimental Verification of a Negative Index of Refraction," *Science*, Vol. 292, No. 5514, April 2001, 292, pp. 77-79.
14. S. Xiao, U. K. Chettiar, A. V. Kildishev, V. P. Drachev and V. M. Shalaev, "Yellow-Light Negative-Index Metamaterials," *Optics Letters*, Vol. 34, No. 22, 2009, pp. 3478-3480.
15. S. Zhang, W. Fan, N. C. Panoiu, K. J. Malloy, R. M. Osgood and S. R. J. Brueck, "Experimental Demonstration of Near-Infrared Negative-Index Metamaterials," *Physical Review Letters*, Vol. 95, September 2005, pp. 137404.
16. G. Dolling, C. Enkrich, M. Wegener, C. M. Soukoulis and S. Linden, "Simultaneous Negative Phase and Group Velocity of Light in a Metamaterial," *Science*, 2006, Vol. 312, No. 5775, May 2006, pp. 892-894.
17. M. C. K. Wiltshire, J. B. Pendry, I. R. Young, D. J. Larkman, D. J. Gilderdale and J. V. Hajnal, "Microstructured Magnetic Materials for RF Flux Guides in Magnetic Resonance Imaging," *Science*, Vol. 291, No. 5505, February 2001, pp. 849-851.
18. C. Caloz, A. Sanada, and T. Itoh, "A Novel Composite Right/Left-Handed Coupled-Line Directional Coupler with Arbitrary Coupling Level and Broad Bandwidth," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 52, No. 3, March 2004, pp. 980-992.
19. A. Kurs, A. Karalis, R. Moffatt, J. D. Joannopoulos, P. Fisher and M. Soljačić, *Science*, Vol. 317, No. 5834, July 2007, pp. 83-86.
20. J. B. Pendry, "Negative Refraction Makes a Perfect Lens," *Physical Review Letters*, Vol. 85, October 2000, pp. 3966-3969.
21. X. Zhang and Z. W. Liu, "Superlenses to Overcome the Diffraction Limit," *Nature Materials*, Vol. 7, June 2008, pp. 435-441.
22. N. Fang, H. Lee, C. Sun and X. Zhang, "Sub-Diffraction-Limited Optical Imaging with a Silver Superlens," *Science*, Vol. 308, No. 5721, April 2005, pp. 534-537.
23. A. A. Zharov, I. V. Shadrivov and Yu. S. Kivshar, "Nonlinear Properties of Left-Handed Metamaterials," *Physical Review Letters*, Vol. 91, No. 3, July 2003, pp. 037401-1-4.
24. V. M. Agranovich, Y. R. Shen, R. H. Baughman and A. A. Zakhidov, "Linear and Nonlinear Wave Propagation in Negative Refraction Metamaterials," *Physical Review B: Condensed Matter*, Vol. 69, No. 16, April 2004, pp. 165112.
25. N. Lazarides, M. Eleftheriou and G. P. Tsironis, "Discrete Breathers in Nonlinear Magnetic Metamaterials," *Physical Review Letters*, Vol. 97, October 2006, pp. 157406.
26. Y. Liu, G. Bartal, D. A. Genov and X. Zhang, "Subwavelength Discrete Solutions in Nonlinear Metamaterials," *Physical Review Letters*, Vol. 99, October 2007, pp. 153901.
27. N.M. Litchinitser and V.M. Shalaev, "Photonic

Testing Tomorrow's Wireless Technologies for Today's Connected World: The NEXUS WI-5G VoLTE and VoWiFi for Automated Testing Applications

With evermore demanding QoE and Carrier Service Level Agreements, quality of voice transmission offerings become increasingly challenging due to complex multi-frequency handoffs between cellular (LTE) and WiFi networks.

Quintech Electronics **NEXUS WI-5G** wideband Attenuator Matrix passes signals between 600-6000 MHz providing end-to-end test capabilities. Continuous and seamless VoLTE/VoWiFi transmissions are set, validated and verified before field deployment. HD voice transmission can be passed through any cellular frequency for quality assurance of these coexisting technologies:

Efficient network simplification, lower maintenance, improved time to market and return on your investment.



QUINTECH
The Source for RF Reliability

Toll Free: 1-800-839-3658 Office: 724-349-1412

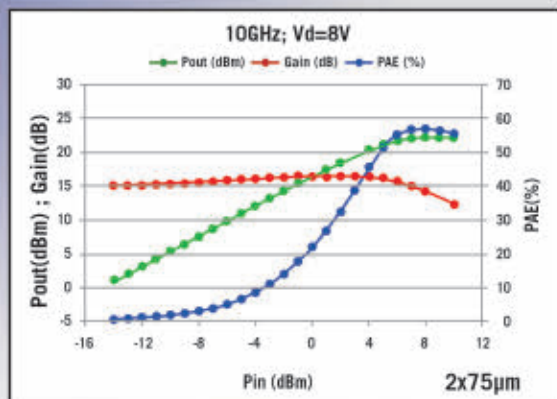
www.quintechelectronics.com/NEXUS_WI-5G



PP25/-21 0.25 μ m Power pHEMT

- 0.25 μ m PHEMT process on 100 μ m substrates
- Power performance at 8V and 10GHz: >1W/mm, PAE 56%, 14dB Gain

PP25-21 (Class-AB) Tuned for Pout



Gain (dB)	P1dB (dBm)	P1dB (mW/mm)	Psat (dBm)	Psat (mW/mm)	PAE Max(%)
15.0	22.1	1086	22.2	1114	56.8

2x75 μ m device @8V, 10GHz, 150 mA/mm

Summary of WIN mmWave pHEMT portfolio

	PP25-21	PP15-50/51	PL15-12	PP10-10/11
Gate length	0.25 μ m	0.15 μ m	0.15 μ m	0.1 μ m
Max Drain Bias	8 V	6 V	4 V	4 V
Idmax (Vg=0.5V)	490 mA/mm	620 mA/mm	525 mA/mm	760 mA/mm
Peak Gm	410 mS/mm	460 mS/mm	580 mS/mm	725 mS/mm
Vto	-1.15 V	-1.3 V	-0.7 V	-0.95 V
BVGD	20V(18V min)	16V(14V min)	9V(8V min)	10V(8V min)
f _T	65 GHz	90 GHz	100 GHz	130 GHz
f _{max}	190 GHz	185 GHz	150 GHz	180 GHz
Power Density (2x75 μ m)	1100 mW/mm @ 8V, 10GHz	870 mW/mm @ 6V, 29GHz	580 mW/mm @ 4V, 29GHz	860 mW/mm @ 4V, 29GHz (2x50 μ m)

- Metamaterials," *Laser Physics Letters*, Vol. 5, 2008, pp. 411–420.
28. M. W. Klein, C. Enkrich, M. Wegener and S. Linden, "Second-Harmonic Generation from Magnetic Metamaterials," *Science*, Vol. 313, No. 5786, July 2006, pp. 502–504.
 29. I. V. Shadrivov, S. K. Morrison and Y. S. Kivshar, "Tunable Split-Ring Resonators for Nonlinear Negative-Index Metamaterials," *Optics Express*, Vol. 14, No. 20, October 2006, pp. 9344–9349.
 30. B. N. Wang, J. F. Zhou, T. Koschny and C. M. Soukoulis, "Nonlinear Properties of Split-Ring Resonators," *Optics Express*, Vol. 16, No. 20, 2008, pp. 16058–16063.
 31. T. Driscoll, H. T. Kim, B. G. Chae, B. J. Kim, Y.

- W. Lee, N. M. Jokerst, S. Palit, D. R. Smith, M. Di Ventra and D. N. Basov, "Memory Metamaterials," *Science*, Vol. 325, No. 5947, September 2009, pp. 1518–1521.
32. V. V. Cheianov, V. Fal'ko and B. L. Altshuler, "The Focusing of Electron Flow and a Veselago Lens in Graphene P-N Junctions," *Science*, Vol. 315, No. 5816, March 2007, pp. 1252–1255.
33. S. Zhang, D. A. Genov, C. Sun and X. Zhang, "Cloaking of Matter Waves," *Physical Review Letters*, Vol. 100, No. 12, March 2008, pp. 123002-1-4.
34. Z. Jacob, J. Y. Kim, G. V. Naik, A. Boltasseva, E. E. Narimanov and V. M. Shalae, "Engineering Photonic Density of States Using Metamaterials," *Applied Physics B: Lasers and Optics*, Vol.

- 100, No. 1, July 2010, pp. 215–218.
35. M. A. Noginov, H. Li, Y. A. Barnakov, D. Dryden, G. Nataraj, G. Zhu, C. E. Bonner, M. Mayy, Z. Jacob and E. E. Narimanov, "Controlling Spontaneous Emission with Metamaterials," *Optics Letters*, Vol. 35, No. 11, 2010, pp. 1863–1865.
36. C. Henkel and K. Joulain, "Casimir Force Between Designed Materials: What is Possible and What Not," *Europhysics Letters*, Vol. 72, No. 6, December 2005, pp. 929–935.
37. U. Leonhardt and T. G. Philbin, "Quantum Levitation by Left-Handed Metamaterials," *New Journal of Physics*, Vol. 9, August 2007, pp. 010254-1-11.
38. F.S.S. Rosa, D.A.R. Dalvit and P.W. Milonni, "Casimir-Lifshitz Theory and Metamaterials," *Physical Review Letters*, Vol. 100, No. 18, May 2008, pp. 183602.
39. R. Zhao, J. Zhou, T. Koschny, E. N. Economou and C. M. Soukoulis, "Repulsive Casimir Force in Chiral Metamaterials," *Physical Review Letters*, Vol. 103, No. 10, September 2009, pp. 103602.
40. V. Yannopapas and N. V. Vitanov, "First-Principles Study of Casimir Repulsion in Metamaterials," *Physical Review Letters*, Vol. 103, No. 12, September 2009, pp. 120401.
41. S. I. Maslovski and M. G. Silveirinha, "Ultralong-range Casimir-Lifshitz Forces Mediated by Nanowire Materials," *Physical Review A*, No. 82, No. 2, August 2010, pp. 022511.
42. Y. Yang, H. Zhang, J. Zhu, G. Wang, T. -R. Tzeng, X. Xuan, K. Huang and P. Wang, "Distinguishing the Viability of a Single Yeast Cell with an Ultra-Sensitive Radio Frequency Sensor," *Lab Chip*, Vol. 10, January 2010, pp. 553–555.
43. Y. Cui and P. Wang, "The Design and Operation of Ultra-Sensitive and Tunable Radio-Frequency Interferometers," *IEEE Transactions on Microwave Theory and Techniques*, Vol. 62, No. 12, December 2014, pp. 3172–3182.
44. G. P. Agrawal, *Fiber-Optic Communication Systems*, 3rd ed., Wiley, 2010.
45. A. H. Gnauck, R. W. Tkach, A. R. Chraplyvy and T. Li, "High-Capacity Optical Transmission Systems," *Journal of Lightwave Technology*, Vol. 26, No. 9, May 2008, pp. 1032–1045.
46. R. J. Essiambre and R. W. Tkach, "Capacity Trends and Limits of Optical Communication Networks," *Proceedings of the IEEE*, Vol. 100, No. 5, May 2012, pp. 1035–1055.
47. A. H. Gnauck, P. J. Winzer, S. Chandrasekhar, X. Liu, B. Zhu and D. W. Peckham, "Spectrally Efficient Long-Haul WDM Transmission Using 224-Gb/s Polarization-Multiplexed 16-QAM," *Journal of Lightwave Technology*, Vol. 29, No. 4, February 2011, pp. 373–377.
48. D. J. Richardson, J. M. Fini and L. E. Nelson, "Space-Division Multiplexing in Optical Fibres," *Nature Photonics*, Vol. 7, No. 5, April 2013, pp. 354–362.
49. B. Zhu, J. M. Fini, M. F. Yan, X. Liu, S. Chandrasekhar, T. F. Taunay, M. Fishteyn, E. Monberg and F. V. Dimarcello, "High-Capacity Space-Division-Multiplexed DWDM Transmissions Using Multi Core Fiber," *Journal of Lightwave Technology*, Vol. 30, No. 4, February 2012, pp. 486–492.
50. X. Liu, S. Chandrasekhar, X. Chen, P. J. Winzer, Y. Pan, T. Taunay, B. Zhu, M. Fishteyn, M. F. Yan, J. Fini, E. M. Monberg and F. V. Dimarcello, "1.12-Tb/s 32-QAM-OFDM Superchannel with 8.6-b/s/Hz Intrachannel Spectral Efficiency and Space-Division Multiplexing with 60-b/s/Hz Aggregate Spectral Efficiency," *Optical Express*, Vol. 19, No. 26, December 2011, pp. B955–B964.
51. R. Ryf, S. Randel, A. H. Gnauck, C. Bolle, A. Sierra, S. Mumtaz, M. Esmacpour, E. C. Burrows, R. J. Essiambre, P. J. Winzer, D. W. Peckham, A. H. McCurdy and R. Lingle, "Mode-Division Multiplexing Over 96 km of

G.T. Microwave

Cutting Edge Technology for Mission Critical Applications

Phase Shifters, I & Q Vector Modulators & Frequency Translators

ULTRA BROADBAND 20 dB/360°

Features

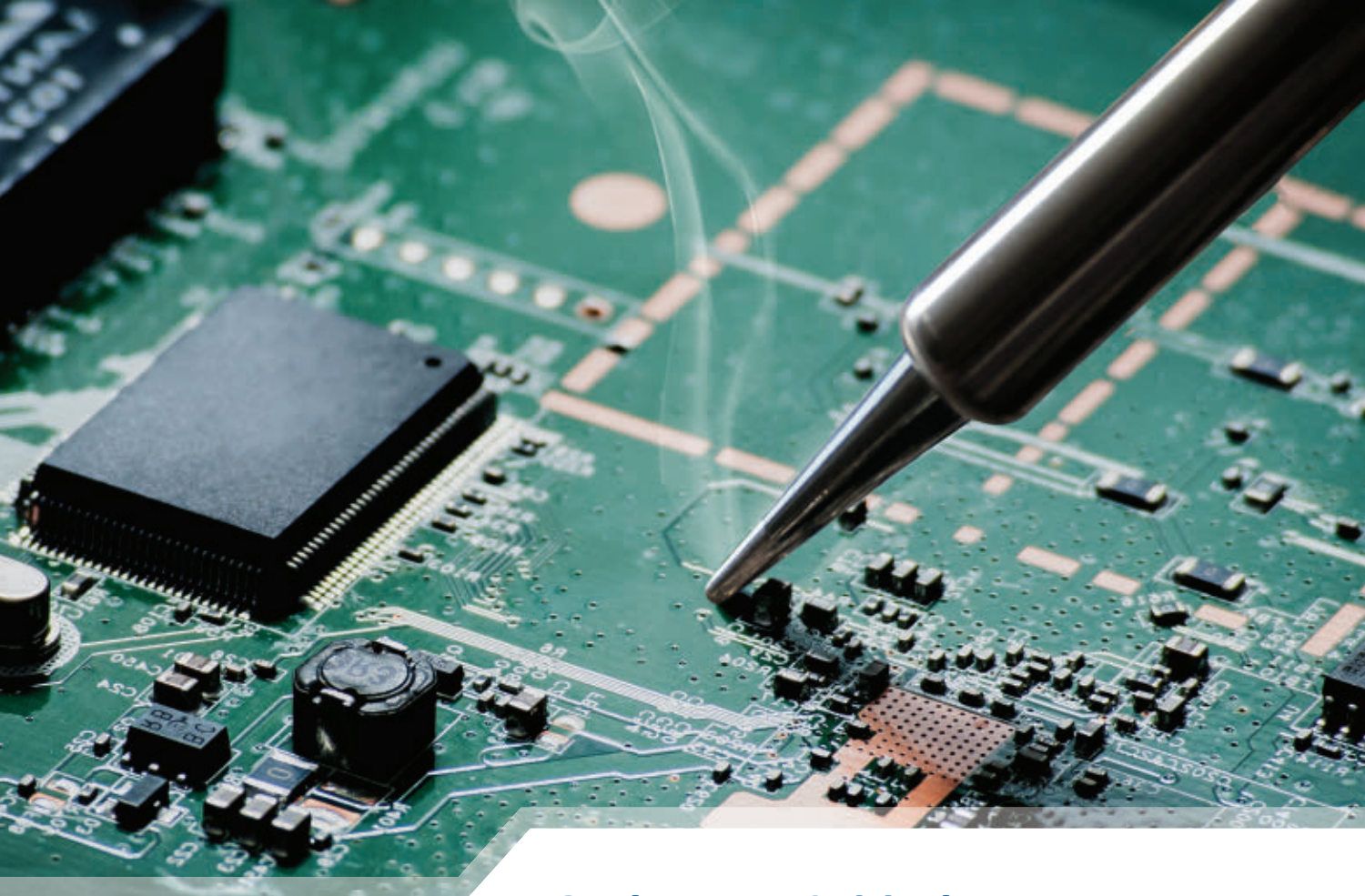
- 2 - 18 GHz Bandwidth.
- Simultaneous Control of Phase & Amplitude
- Faster Switching Speed 500 NSec.
- Digital/Analog Models Available

2 Emery Avenue,
Randolph, NJ 07869 USA
Fax: 973-361-5722
sales@gtmicrowave.com
Call @ 973-361-5700

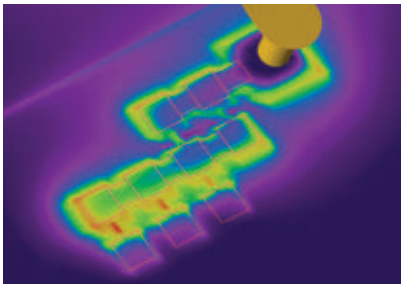
www.gtmicrowave.com

Electrical Specifications				
Frequency Range GHz	Phase Error Vs Frequency MAX	Attenuation Error MAX	Insertion Loss MAX	V.S.W.R MAX
0.5-2.0	±10.0°	±1.5dB	13.0dB	1.70:1
1.0-3.0	±10.0°	±1.5dB	13.0dB	1.70:1
2.0-6.0	±10.0°	±1.5dB	12.0dB	1.90:1
6.0-18.0	±10.0°	±1.5dB	12.0dB	1.90:1
12.0-22.0	±15.0°	±3.50dB	17.0dB	2.20:1
2.0-18.0	±22.0°	±3.00dB	16.0dB	2.20:1

For substantial improvement in performance; ask for OPTIMIZED NARROWBAND models
2.0-18 GHz models have 15 dB/360° of dynamic range



Retire Your Soldering Iron ... XFtdt's Circuit Element Optimizer Offers a Brand New Approach



3D EM fields are analyzed when
selecting the lumped component
values in **Full-Wave Matching
Circuit Optimization**

Gone are the days of soldering components in and out of a prototype, trying to achieve the desired performance.

XFtdt's Circuit Element Optimizer uses a new technology that combines full-wave 3D EM simulation with circuit optimization to solve an age-old RF problem: determining which component values provide the desired match for a given matching network layout.

**And there's only one EM simulation solver
that makes it possible: XFtdt®.**

Download our Discovery Kit to get started | www.remcom.com/no-soldering >>>

REMC  **M**®



+1.888.7.REMCOM (US/CAN) | +1.814.861.1299 | www.remcom.com

Few-Mode Fiber Using Coherent 6×6 MIMO Processing," *Journal of Lightwave Technology*, Vol. 30, No. 4, February 2012, pp. 521–531.

52. N. Bozinovic, Y. Yue, Y. Ren, M. Tur, P. Kristensen, H. Huang, A. E. Willner and S. Ramachandran, "Terabit-Scale Orbital Angular Momentum Mode Division Multiplexing in Fibers," *Science*, Vol. 340, No. 6140, June 2013, pp. 1545–1548.
53. N. Bozinovic, S. Golowich, P. Kristensen and S. Ramachandran, "Control of Orbital Angular Momentum of Light, with Optical Fibers," *Optics Letters*, Vol. 37, No. 13, 2012, pp. 2451–2453.
54. P. Gregg, P. Kristensen, S. Golowich, J. Olsen, P. Steinvurzel and S. Ramachandran, "Stable Transmission of 12 OAM States in Air-Core

Fiber," *Optical Society of America CLEO 2013 Technical Digest*, June 2013, pp. 1–2.

55. J. Zeng, X. Wang, J. Sun, A. Pandey, A. N. Cartwright and N. M. Litchinitser, "Manipulating Complex Light with Metamaterial," *Scientific Reports*, Vol. 3, No. 2826, October 2013.
56. F. Intravaia and C. Henkel, "Can Surface Plasmons Tune the Casimir Forces Between Metamaterials?" *Institut fuer Physik und Astronomie*, Poster, <http://cnls.lanl.gov/casimir/PostersSF/Intravaia-SantaFe-poster.pdf>.
57. S. Minter, K. Wegter-McNelly and R. Chiao, "Do Mirrors for Gravitational Wave Exist?" *Physica E: Low-dimensional Systems and Nanostructures*, Vol. 42, No. 3, January 2010, pp. 234–255.

58. R.E. Glover and M. Tinkham, "Transmission of Superconducting Films at Millimeter-Microwave and Far Infrared Frequencies," *Physical Review*, Vol. 104, No. 3, November 1956, pp. 844.
59. M. Tinkham, "Introduction to Superconductivity," 2nd ed., Dover, New York, 2004.
60. R. M. Wald, "General Relativity," University of Chicago Press, Chicago, 1984.
61. W.H. Zurek, "Decoherence, Einselection, and the Quantum Origins of the Classical," *Reviews of Modern Physics*, Vol. 75, No. 3, September 2003, pp. 715.
62. B.S. DeWitt, "Superconductors and Gravitational Drag," *Physical Review Letters*, Vol. 16, No. 24, June 1966, pp. 1092.
63. R. Y. Chiao, "Science and Ultimate Reality," J. D. Barrow, P. C. W. Davies, and C. L. Harper (eds.) Jr. (Cambridge University Press, Cambridge, 2004), p. 254.
64. C. Kiefer and C. Weber, "On the Interaction of Mesoscopic Quantum Systems with Gravity," *Annalen der Physik*, Vol. 14, No. 4, April 2005, pp. 253–278.
65. R.Y. Chiao and W. J. Fitelson, "Time and Matter in the Interaction Between Gravity and Quantum Fluids: Are there Macroscopic Quantum Transducers Between Gravitational and Electromagnetic Waves?" *arXiv:gr-qc/0303089*, March 2003.
66. S. Weinberg, "Gravitation and Cosmology," Wiley, New York, 1972.
67. A. Lambrecht, "The Casimir Effect: a Force From Nothing," *Physics World*, September 2002.
68. J. Q. Quach, "Gravitational Casimir Effect," *Physical Review Letters*, Vol. 114, No. 8, February 2015, pp. 081104–1–5.
69. U. L. Rohde and A. K. Poddar, "Möbius Metamaterial Inspired Next Generation Circuits and Systems," *Microwave Journal*, Vol. 59, No. 5, May 2016, pp. 62–88.
70. U. L. Rohde and A. K. Poddar, "Möbius Metamaterial Inspired: Signal Sources and Sensors," *Microwave Journal*, Vol. 59, No. 6, June 2016.
71. U. L. Rohde and A. K. Poddar, "Ka-Band Metamaterial Möbius Oscillator (MMO) Circuit," *IEEE International Microwave Symposium Digest*, May 2016, pp. 1–4.
72. U. L. Rohde and A. K. Poddar, "Möbius Metamaterial Strips Resonator: Tunable Oscillators for Modern Communication Systems," *Microwave Journal*, Vol. 58, No. 1, January 2015.
73. U. L. Rohde and A. K. Poddar, "Metamaterial Resonators: Theory and Applications," *Microwave Journal*, Vol. 57, No. 12, December 2014, pp. 74–86.
74. U. L. Rohde and A. K. Poddar, "Möbius Strips and Metamaterial Symmetry: Theory and Applications," *Microwave Journal*, Vol. 57, No. 11, November 2014, pp. 76–88.
75. U. L. Rohde, A. K. Poddar and D. Sundararajan, "Printed Resonators: Möbius Strips Theory and Applications," *Microwave Journal*, Vol. 56, No. 11, November 2013, pp. 24–54.
76. C. P. Scarborough, Z. H. Jiang, D. H. Werner, C. Rivero-Baleine and C. Drake, "Experimental Demonstration of an Isotropic Metamaterial Super Lens with Negative Unity Permeability at 8.5 MHz," *Applied Physics Letters*, Vol. 101, No. 1, July 2012, pp. 014101–1–3.
77. Z. H. Jiang, M. D. Gregory and D. H. Werner, "A Broadband Monopole Antenna Enabled by an Ultrathin Anisotropic Metamaterial Coating," *IEEE Antennas and Wireless Propagation Letters*, Vol. 10, 2011, pp. 1543–1546.
78. P. C. Peters, "Index of Refraction for Scalar, Electromagnetic, and Gravitational Waves in Weak Gravitational Fields," *Physical Review D*, Vol. 9, April 1974, pp. 2207–2218.
79. S. J. Minter, K. Wegter-McNelly and R. Y. Chiao, "Do Mirrors for Gravitational Waves Exist?" *Physica E* 42, 2010.

Complete Connections for Your 5G Applications!



Frontlynk®
Bridging Gaps





1.0mm Series



Multi Coax & Phase Matched Cables



Test Cables



Frontlynk Technologies Inc.
 Tel: +886-6-356-2626 Fax: +886-356-6268
 E-mail: info@frontlynk.com

www.frontlynk.com

TINY! **Ultra-Wideband** **MMIC SPLITTER/COMBINERS**



Single Unit Coverage as Wide as **2 to 26.5 GHz**

Models from **\$5⁵⁶**
ea. (qty. 1000)

THE WIDEST BANDWIDTH IN THE INDUSTRY IN A SINGLE MODEL!

Our new EP-series ultra-wideband MMIC splitter/combiners are perfect for wide-band systems like defense, instrumentation, and all cellular bands through LTE and WiFi. These models deliver consistent performance across the whole range, so you can reduce component counts on your bill of materials by using one part instead of many! They utilize GaAs IPD technology to achieve industry-leading performance, high power handling capability and efficient heat dissipation in a tiny device size, giving you a new level of capability and the flexibility to use them almost anywhere on your PCB! They're available off the shelf, so place your order on minicircuits.com today, and have them in hand as soon as tomorrow!

- Series coverage from 0.5 to 26.5 GHz
- Power handling up to 2.5W
- Insertion loss, 1.1 dB typ.
- Isolation, 20 dB typ.
- Low phase and amplitude unbalance
- DC passing up to 1.2A

 EP2K-Series, 4x4x1mm
 EP2W-Series, 5x5x1mm



High Linearity RF Switches for DOCSIS 3.1 Applications

Peter Bacon and Kinana Hussain
Peregrine Semiconductor, San Diego, Calif.

Driven by consumer demand and the proliferation of electronic devices, data consumption is rising rapidly. The Cisco Visual Networking Index (VNI) predicts that from 2014 to 2019, networked devices and connections will grow globally from 14.2 to 24.4 billion. The report forecasts that global Internet traffic will grow 3.2 fold from 2014 to 2019 at a compound annual growth rate of 26 percent.

The rapid adoption of higher resolution, video-streaming services has further increased demand for faster connections. In fact, the VNI estimates global Internet video traffic will be 77 percent of all Internet traffic in 2019. It predicts that five million years of video content will cross the Internet each month in 2019. This estimate means nearly a million minutes of video will be streamed or downloaded every second.

The cable industry faces the challenge of supporting this increasing demand for more high-speed home data. The VNI forecasts that 62.8 percent of global Internet traffic in 2019 will be fixed Wi-Fi and 19 percent will be fixed wired.¹ Consumers and businesses are demanding faster connections, which is putting enormous strain on the broadband system.

From customer premise equipment (CPE) devices to multi-service operators (MSO) head-end infrastructure, the cable industry is in a race with data consumption.

DOCSIS 3.1 TECHNOLOGY

To meet these growing data requirements, the cable industry developed the DOCSIS 3.1 cable industry standard. The Data Over Cable Service Interface Specification (DOCSIS) is an industry-wide collaboration that is issued by research and development consortium Cable-Labs. The DOCSIS specifications are used by the cable market to define how the cable modem interacts with the overall data delivery infrastructure, from the back office network to the hybrid fiber/coaxial (HFC) system to the cable modem itself, which delivers services to the end-user. DOCSIS 3.1 is the latest generation. The first standard, DOCSIS 1.0, came out in 1997; past specifications include DOCSIS 3.0, DOCSIS 2.0 and DOCSIS 1.1.

DOCSIS 3.1 technology offers many improvements over its precursor, the DOCSIS 3.0 standard. DOCSIS 3.1 increases speeds up to 10 Gbps downstream and up to 1 Gbps upstream. It allows for greater system capacity with the ability to support up to 4,096 quadra-

TACONIC®

Finding a better way

EZ-10

**Nanotechnology Based PTFE
Laminate**

- DF @ 10 GHZ = 0.0012
- For emerging high speed digital and E/W frequencies
- Near FR-4 fabrication

fastRise™

**Multilayer Non-Reinforced
Prepreg**

- DF @ 10 GHZ = 0.0014
- Low temperature thermosetting prepreg/alternative to thermo-plastic film
- Lowest loss RF prepreg

***Lowest Loss Materials
for Multilayer, Power
Amplifier & Rigid/Flex***

RF-35TC

**Thermally Conductive Low
Loss Laminate**

- DF @ 10 GHZ = 0.0011
- High adhesion to low profile coppers
- Diffuses heat away from transmission lines and surface mount components



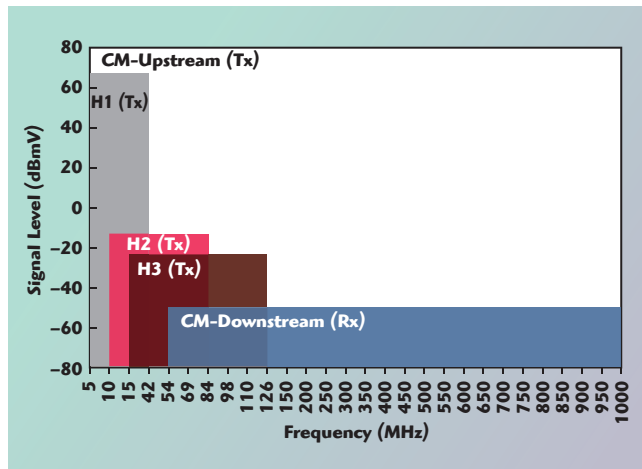
Scan for more information

TSM-DS3

**Dimensionally Stable Low
Loss Laminate**

- DF @ 10 GHZ = 0.0011
- Enables large format high layer count PWBs
- Diffuses heat away from heat sources in PWBs

www.4taconic.com
1-800-833-1805



▲ Fig. 1 Nonlinearities of the cable modem upstream can block the downstream receiver from capturing the desired signal.

ture amplitude modulation (QAM), which is 12 bits/symbol. This is a vast improvement over DOCSIS 3.0, which only supported up to 256 QAM (8 bits/symbol). DOCSIS 3.1 reduces network delays and improves responsiveness with Active Queue Management. Additionally, it is more energy efficient and enables companies to improve their current energy metrics.

One of the main benefits of DOCSIS 3.1 is that it does not require upgrades to existing data-delivery infrastructure. The current HFC network does not need to be modified to work with DOCSIS 3.1 technology; therefore, network capacity can be increased without extensive adjustments. Furthermore, DOCSIS 3.1 maintains backward compatibility with DOCSIS 3.0 technology.

DOCSIS 3.1 allows the cable industry to increase network capacity by more than 50 percent over the same spectrum. It enables cable companies to offer consumers and businesses higher download and upload speeds without sacrificing quality in any way. Consumers not only benefit from higher speeds, but they can enjoy the reduction in network delays and receive higher resolution images. It is also designed to support the latest innovations, such as 4K video and ultra-high definition movies.²

LINEARITY & HARMONICS CHALLENGE

The new specification sets an ambitious goal for the cable industry. From an RF perspective, one of the toughest challenges is to comply with the new

key factor in assuring that any device that is simultaneously handling both upstream and downstream signals is able to maintain its spectral separation and purity. It is detrimental to have spurious levels from one signal stream overriding the desired signal of the other data stream. Therefore, any switch that is in a position of routing both upstream and downstream signals will have stringent second and third harmonic requirements.

In DOCSIS 3.1, there is a move to orthogonal frequency division modulation (OFDM) for downstream data transmission and orthogonal frequency division multiple access (OFDMA) for upstream data delivery. The frequency range is increasing from 1.002 GHz to at least 1.218 GHz and maybe even 1.794 GHz. Additionally, the number of possible frequency partitions has increased from three to four and the ability to select between partitions has been added. QAM has increased from a maximum of 1,024 to 4,096, with an interleaved option for 16,384 QAM. In general, greater implementation flexibility has been incorporated in the entire specification.

Regarding channel impairments, as QAM level increases the signal-to-noise ratio (SNR) requirement also increases. Thus, implementation of DOCSIS 3.1 implies ever-increasing signal integrity requirements. To maintain a low symbol error rate the SNR must continue to increase as the modulation scheme grows in complexity. For 4,096 QAM an SNR of 45.4 dB is needed to obtain a 10^{-6} probability of a symbol error compared to 13.7 dB

linearity requirements. For DOCSIS 3.1 technology, high linearity is necessary to support the increased data rates and the upstream/downstream spectral integrity. When transmitting higher data rates, linearity preserves the integrity of the in-band complex modulated waveform. Increased linearity also shows itself in reduced out-of-band harmonic spurious generation—a

for the same error probability using a much simpler QPSK scheme.

Further, nonlinearities of the cable modem upstream can block the downstream receiver from capturing the desired signal. **Figure 1** shows signal level vs. frequency for the upstream Tx signal, the downstream Rx signal and the second (H2) and third harmonic (H3) of the Tx upstream signal. The Tx signal level is much higher than the minimum Rx downstream signal the cable modem will receive at its F-connector. If the harmonic generation levels are not considered (H2 and H3), they can be greater than the downstream Rx signal and can block the downstream signal from being received.

A single cable must support both downstream and upstream paths, so bandwidth is frequency divided. The challenge is to ensure that spurious out-of-band emissions of the upstream transmitter do not corrupt the signal of the receiver downstream. Prior to DOCSIS 3.1, there had not been a need to perform frequency selectivity during the operation of the cable modem—a fixed frequency partitioning was sufficient. Now there is a need for greater upstream/downstream frequency band flexibility.

RF SWITCHES ENABLE DUAL-BAND ARCHITECTURE

In response to the DOCSIS 3.1 linearity and harmonic requirements, many companies set out to create a solution. In October 2014, Peregrine introduced a high linearity RF switch with excellent harmonic performance. Subsequently in March 2016, they set a new record for high linearity and introduced an upgraded version switch that reportedly boasts the highest linearity specifications on the market today.

The switches offer to solve the DOCSIS 3.1 linearity challenge even when supporting a dual upstream/downstream band architecture. They are currently the only RF switches that enable dual upstream/downstream bands to reside in the same CPE device. CPE devices, such as set-top boxes, cable modems and home gateways, had previously supported only one upstream/downstream band combination. By using this dual-band architecture, CPEs can comply with the DOCSIS 3.1 cable industry stan-



Electronic Design Innovation Conference
Workshops & Exhibition

EDICON COMES TO THE USA!

September 20-22, 2016

Hynes Convention Center ■ Boston, MA

www.ediconusa.com

In-depth Technical Training



**100+ Exhibitors Including the
New Signal Integrity Zone**



Networking



Register Today for **EDICON USA 2016!**

Microwave Journal Subscribers
Save 20% with discount code: MWJREADER20

THE Industry Event for
RF, Microwave, EMC/EMI and high speed digital designers

Scan here to go
directly to registration



- Short Courses
- Workshops
- Technical Sessions
- RF Back to Basics Training
- Expo Hall Demos
- Frequency Matters Theatre
- Signal Integrity Zone
- Free Hands-on Training
- Poster Session
- Networking Events
- Plenary Keynotes

www.ediconusa.com

Image: Joseph Sohm / Shutterstock.com

Host Sponsor:



Diamond Sponsor:



Corporate Sponsor:



Conference Sponsors:



Sponsored By:



Attention: RF, Microwave & High-Speed Digital Designers



2016

Registration is OPEN
for

EDI CON USA 2016

**September 20-22, Hynes Convention
Center, Boston, MA**

**Industry-Driven Technical
Conference with:**

Technical Sessions
Panels
Workshops
Short Courses
Plenary & Keynote Talks

Exhibition features:

120+ Exhibitors
Demonstrations
Poster Sessions
Hands On Training
Networking

Come to EDI CON USA to find solutions, products, and techniques that you can put to immediate use in communication, defense, consumer electronics, aerospace, and medical designs.

Hot Topics: 5G, SOI, EMC/EMI, Test & Measurement, Modeling & Simulation, Signal Integrity, Power Integrity, EDA, Space-Qualified ICs, Ultra Low Power, MIMO, Radar, GaN, IoT

Register Online Today!

(Early Bird discount ends July 31, 2016)

<http://www.ediconusa.com/registration.asp>

www.ediconusa.com

standard, and MSOs have the flexibility to offer their customers new and expanded services. A dual-band architecture eliminates an extra step in giving customers higher speeds. At the flip of a switch, a cable service provider can repartition its frequency plan when it desires in order to better match the data consumption needs.

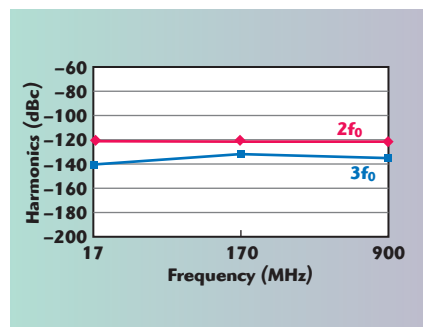
Before the introduction of these products, no switch had been released that met the linearity requirements necessary to support a dual upstream/downstream band architecture. To create this full-frequency architecture, the switch is placed directly at the cable modem (CM) F-connector between the filters and cable input. This switch must maintain frequency duplexing established by the two low-pass and high-pass filters and must de-

liver high linearity to avoid corruption of the downstream band. Additionally, this switch must comply with the stringent DOCSIS 3.1 CM integrated spurious emissions requirements of -50 dBmV. Such a low spurious level requires the switch harmonic performance to be greater than -115 dBc. An example product that exceeds this specification is the Peregrine PE42723 switch where the second harmonic is -121 dBc and the third harmonic is -140 dBc at 17 MHz. **Figure 2** shows the second and third harmonic for this switch when the input power (P_{IN}) is 65 dBmV.

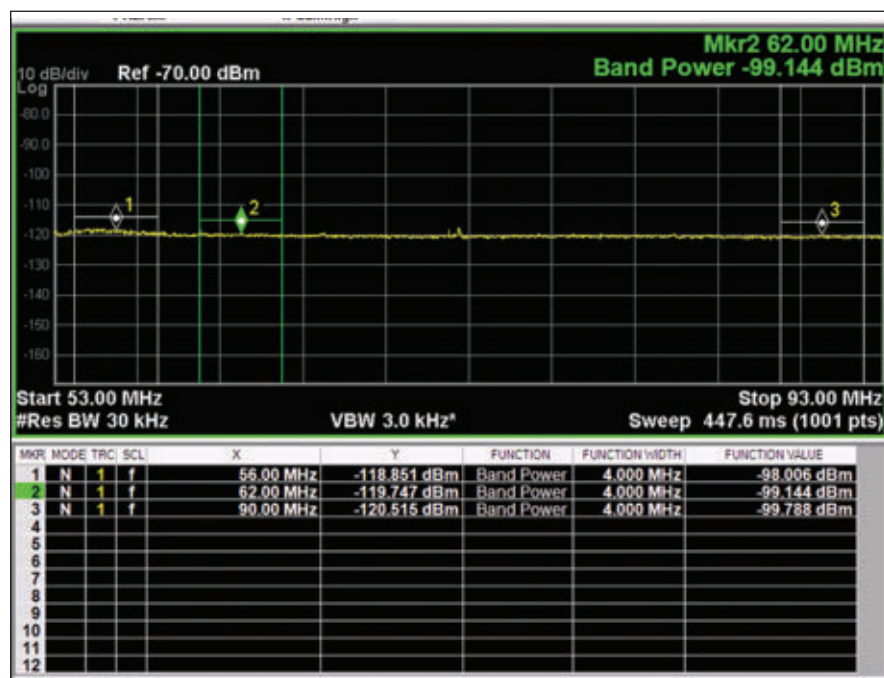
Figure 3 reveals the integrated spurious emissions of the switch in a Murata DOCSIS 3.1 module. The switch was tested with a Keysight signal generator and spectrum analyzer using a DOCSIS OFDMA upstream waveform, an input power of $+71.8$ dBmV, 24 MHz BW and utilizing $4,096$ QAM. The integrated spurious levels were measured across the low end of the downstream band at 56 , 62 and 90 MHz center frequencies and over a 4 MHz integration bandwidth. Even with this over-stressed condition of being driven by 71.8 dBmV and delivering more than 69 dBmV to the F-connector, the integrated spurious level for this module remained below the -50 dBmV requirement.

Switches that can meet these strin-

gent requirements are manufactured on the UltraCMOS® process, a patented variation of silicon-on-insulator (SOI) technology on a sapphire substrate. Sapphire is a near perfect insulator, offers excellent RF and microwave properties and has a mature supply chain. UltraCMOS silicon-on-sapphire (SOS) chips feature low defect density for simpler construction; dielectrically isolated transistors for excellent power handling and multiple thresholds; inherent CMOS logic levels; and high ESD ratings. Nonlinear effects from the substrate and metallization are an advantage in meeting strict linearity requirements. The sapphire substrate demonstrates consistent behavior with respect to insertion loss vs. input power. Further, a sapphire substrate demonstrates excellent characteristics with respect to second and third harmonics versus input power. Specifically, a through-line measurement on a sapphire substrate at a fundamental power level of $+18$ dBm ($+65$ dBmV) results in harmonic levels of -102 dBm for the second harmonic and -122 dBm for the third harmonic, translating to -120 dBc and -140 dBc, respectively. From a substrate perspective, merely meeting these requirements represents a substantial challenge for other technologies.



▲ Fig. 2 Typical harmonic performance of SOI switch. At 17 MHz, the second harmonic is -121 dBc, and the third harmonic is -140 dBc ($P_{IN} = 65$ dBmV).



▲ Fig. 3 Integrated spurious emissions of the SOI switch in a DOCSIS 3.1 module, measuring -50.3 dBmV.

TECHNOLOGY TRANSITIONS FROM CONCEPT TO REALITY

Introduced in 2013, DOCSIS 3.1 implementation is an ongoing process. In previous generations of the DOCSIS standard, implementation has taken several years to go from a concept to deployment. However, the cable industry has made a collaborative effort to rapidly develop and deploy DOCSIS 3.1 technology. ABI Research predicts that nine million broadband subscribers will be using DOCSIS 3.1 equipment by 2017. This represents over one percent of total fixed broadband subscribers worldwide.³

In January 2016, CableLabs announced that five cable modem products had received DOCSIS 3.1 certification. Cable modems from CastleNet, Technicolor, Askey, Ubee Interactive and Netgear proved that they could comply with the latest specifications. This product certification announcement was an important milestone for CableLabs. Compared



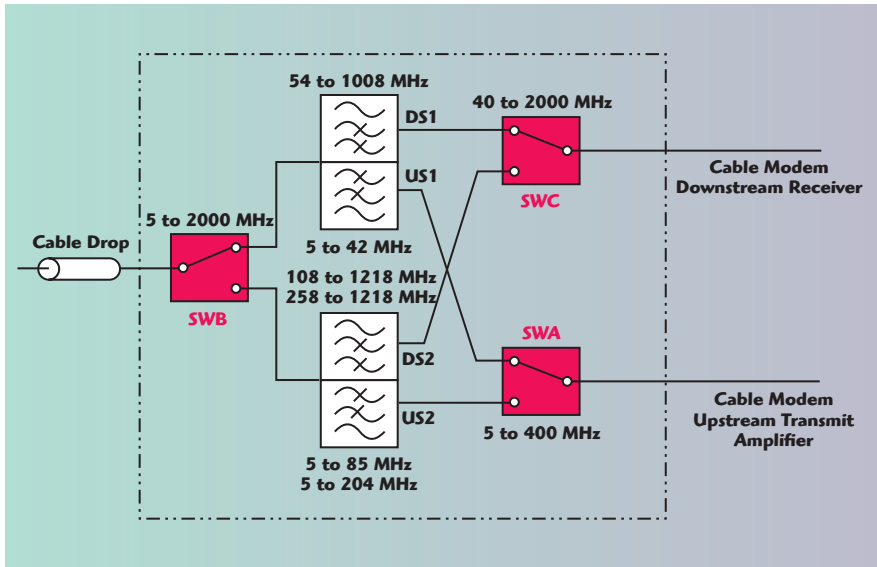
www.rosenberger.com/aerospace

Aerospace Products

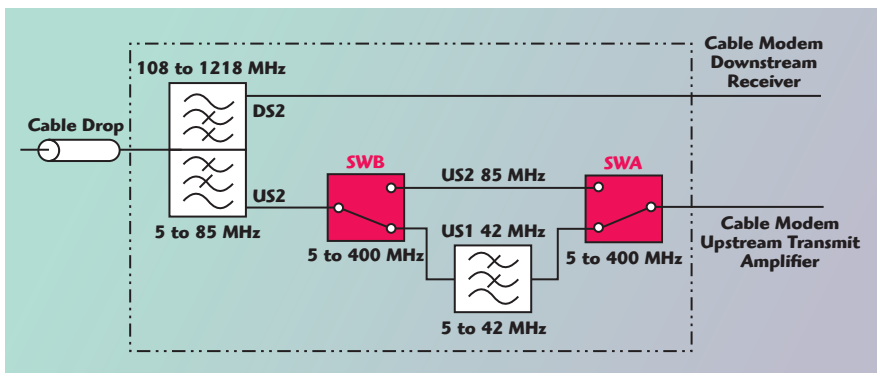
Whether aviation or spaceflight applications – Rosenberger is a qualified and trusted supplier of connectors and cable assemblies to the aerospace industry. Our aerospace products are designed and manufactured in accordance with ESCC, MIL-PRF 39012, or DIN EN 9100.

PRODUCT RANGE

- Cable assemblies
- Board-to-Board connections
- Board-to-Cable connections
- SMD types
- PCB connectors



▲ Fig. 4 Dual upstream/downstream band architecture with full frequency coverage. The switches must provide high linearity (SWB), high isolation and linearity (SWA) and low insertion loss (SWC).



▲ Fig. 5 Dual-band architecture with an optimized upstream band using high isolation switches (SWA and SWB).

to previous DOCSIS generations, the time from specification development to product certification occurred in half the time.⁴

MSOs are also preparing their systems for the new standard. In December 2015, Comcast announced that they had successfully tested a DOCSIS 3.1 modem at a Philadelphia home. This initial test marked the world's first DOCSIS 3.1 modem on a customer-facing network and proved that DOCSIS 3.1 technology could work on Comcast's existing HFC network. While the technology trials started in Philadelphia, Comcast plans to expand testing to other locations in Pennsylvania, Atlanta, Georgia and Northern California.⁵

As the worldwide cable industry transitions from DOCSIS 3.0 to 3.1 technologies, MSOs need to future-proof their CPE devices with high flexibility in addition to backward

compatibility. One of the main benefits of these switches is that they support both DOCSIS 3.0 and 3.1 requirements, allowing for a simple and cost-effective transition to the new standard. In fact, this is a key selling feature for cable modem vendors. Of the five DOCSIS 3.1 certified cable modems, these switches are designed into three of the five cable modems—the three that feature a switchable band-select feature.

DOCSIS 3.1/3.0 DUAL-BAND ARCHITECTURE

Beyond the F-connector switch, there are other critical switch sockets in a DOCSIS 3.1/3.0 cable modem dual-band architecture. **Figure 4** shows a dual upstream/downstream band architecture at full frequency. In this example, high performance switches must be placed at sockets SWA, SWB and SWC. As discussed, the switch at

the SWB socket must generate near zero out-of-band emissions to mitigate harmonic spurious falling in the DS1 legacy band. These switches can be placed in the SWB switch socket, which is between the cable drop and the filters. Socket SWA in the upstream band requires high isolation and high linearity. Finally, switch socket SWC in the downstream band requires a switch with low insertion loss.

Optionally, **Figure 5** depicts a dual-band architecture with an optimized upstream band. In this example, the switch can be placed in the SWB switch socket, which is after the filters on the upstream band. Switch socket SWA on the upstream band requires high isolation.

CONCLUSION

The ability to meet DOCSIS 3.1 standards is crucial for the cable industry. There are currently few switches that are able to meet the DOCSIS 3.1 linearity and harmonics requirements and enable a dual upstream/downstream band architecture, but new UltraCMOS switches from Peregrine Semiconductor are able to meet the stringent requirements. This ability to support dual-upstream/downstream bands in the same CPE device is a critical enabler in making DOCSIS 3.1 a reality. ■

References

1. "Visual Networking Index (VNI) – VNI Forecast Highlights," Cisco, 2016, www.cisco.com/c/en/us/solutions/service-provider/visual-networking-index-vni-forecast.html. [Accessed: 31- March 2016].
2. "Featured Technology" CableLabs, 2016, www.cablelabs.com/innovations/featured-technology/. [Accessed: 31- March 2016].
3. "ABI Research Forecasts 9 Million Broadband Subscribers to Use DOCSIS 3.1 Equipment by 2017," ABI Research, 2016, <https://www.abiresearch.com/press/abi-research-forecasts-9-million-broadband-subscribers-to-use-docsis-3-1-equipment-by-2017>. [Accessed: 30-March 2016].
4. "Five New CableLabs Certified DOCSIS 3.1 Cable Modem Products Usher in a New Generation of Broadband Services," CableLabs, 2016, www.cablelabs.com/news/five-new-cablelabs-certified-docsis-3-1-cable-modem-products-usher-in-a-new-generation-of-broadband-services/. [Accessed: 31-March 2016].
5. "World's First Live DOCSIS 3.1 Gigabit-Class Modem Goes Online in Philadelphia," Comcast, 2016, <http://corporate.comcast.com/comcast-voices/worlds-first-live-docsis-3-1-gigabit-class-modem-goes-online-in-philadelphia>. [Accessed: 31-March 2016].

The MegaPhase logo is a stylized, abstract 'S' or 'M' shape in white and yellow, set against a circular background that transitions from orange to purple. It is positioned in the upper left quadrant of the advertisement.

MegaPhase®

The background of the top half of the advertisement is a photograph of a long line of military vehicles, possibly armored trucks or tanks, parked in a row. The image is tinted with a purple hue.

Our Warrior Cable® Comes With Its Own Set Of Armor

Some jobs are just too tough for ordinary RF cables. That's why our Warrior Cable features internally armored GrooveTube® technology – super flexible copper outer conductor tubing. The protective shielding enables the Warrior Cable to provide long-term repeatable performance in even the most extreme conditions.

It's ideal for use in electronic countermeasures, electronic warfare, and field-deployed communication systems ... or in commercial/ industrial situations where tough handling or demanding conditions exist.

No job is too tough for the MegaPhase Warrior Cable.

For more information, visit MegaPhase.com or call us at (570) 424-8400.



**With the right connections,
anything is possible.**



122 Banner Road, Stroudsburg, PA 18360-6433

Tel: 1-877-634-2742 | 570-424-8400

Solutions@MegaPhase.com | www.MegaPhase.com

Using Model-Based Design for Software-Defined Radio

Mike Donovan

MathWorks, Natick, Mass.

Andrei Cozma and Di Pu

Analog Devices Inc., Norwood, Mass.

This article outlines, in four steps, how a small team of engineers reduced design delays and failures through an alternative approach that uses a combination of Model-Based Design and Software Defined Radio (SDR) hardware to design signal processing algorithms, configure RF hardware, generate C and HDL code, and integrate the software with radio hardware. Tools used in this example include MATLAB and Simulink from MathWorks, along with hardware from Analog Devices and Avnet.

Building a wireless receiver is a challenging task that requires a diverse set of skills that are often distributed among many different design teams. In a traditional design methodology, these skills include RF design, HDL programming, system on chip (SoC) development, device driver configuration, and hardware/software integration. With a dependency upon multiple groups, the possibility that the design will fail grows as more team members become involved in the project.

Common challenges in wireless receiver design often lead to a design process that has a high potential for miscommunicated specifications and interfaces, incompatible design ideas, and unexplored trade-offs.

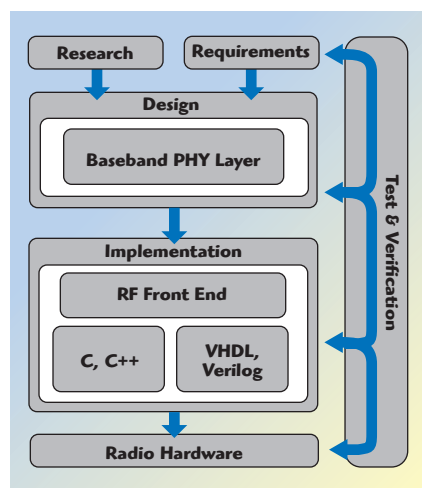
Figure 1 shows the steps used to design a receiver using Model-Based Design and SDR hardware. In this approach, a majority of the development effort is spent in the design stage to create a Simulink model of the baseband receiver algorithms. The implementation stage of this process happens quickly because software errors are reduced using code generation,

and the SDR hardware provides a configurable RF front-end. Verification time of the code and hardware significantly decreases because the detailed design developed in Simulink accurately reflects the final SDR implementation. An additional benefit of using Model-Based Design is that communication between the engineers is enhanced by working with an executable specification in Simulink, leading to fewer misunderstandings of the overall design and expected performance of the receiver.

EXAMPLE FRAMEWORK

To demonstrate this approach, a team of three engineers used Model-Based Design to develop an Automatic Dependent Surveillance – Broadcast (ADS-B) receiver running on an Analog Devices AD9361 integrated RF Agile Transceiver™/Xilinx Zynq®-7000 All Programmable SoC Software Defined Radio (SDR) platform. This receiver was developed in a relatively short time with minimal obstacles, drawing on the following resources:

- A comprehensive user interface to configure the Analog Devices AD9361 RF Agile Transceiver to receive ADS-B transmissions and obtain a high quality signal.
- The ability to build a model of an ADS-B receiver in MATLAB and Simulink that generates functional C and HDL source code



▲ Fig. 1 Model-based design flow for a wireless receiver.

GHz

powerfilm™



*Microwave Global
Models™ Available*

Meet the magic number for two-watt temperature-variable attenuators

Push the limits of frequency without sacrificing performance. Powerfilm surface-mount attenuators from Inmet, part of API Technologies Corp., vary with temperature and are the perfect balance of price, power, and dependability. They offer the flattest broadband performance of their kind and allow you to create automatic- and passive-link margin compensation on a wider variety of transmit and receive chain circuit applications.

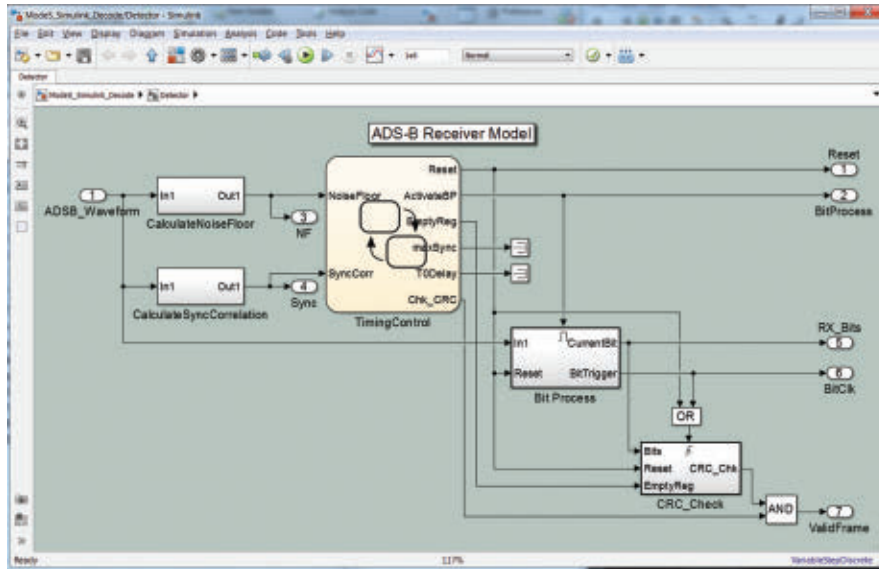
Save money and space by throwing out your complicated gain-control circuitry and required bias and control voltages. Visit our website for complete details and request a sample today.

- **-0.005 dB/dB/°C shift models available from stock**
- **New higher shift models feature -0.009 dB/dB/°C**
- **DC to 12 GHz operation**
- **Superior RF attenuation vs. temperature**
- **Excellent return loss vs. frequency**
- **Design kits available**

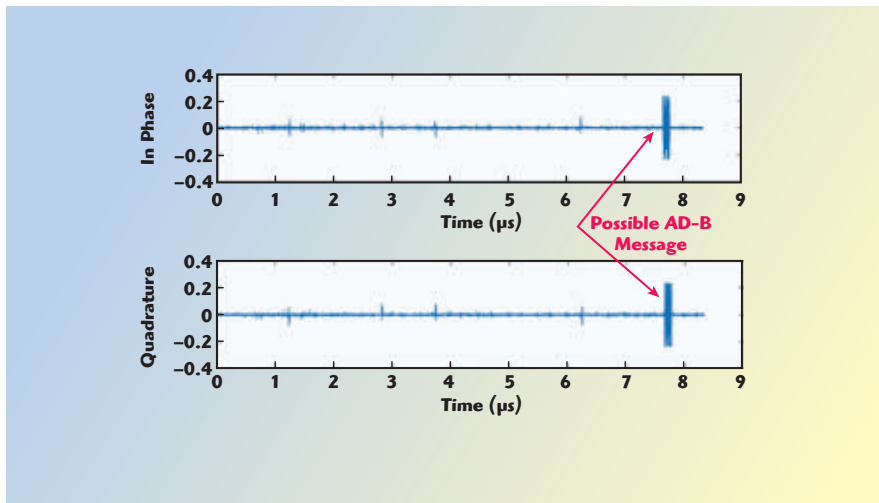
api 
technologies corp.
▶ INMET

734-426-5553 | 888-244-6638 | inmet.apitech.com

Inmet is now part of API Technologies Corp.



▲ Fig. 2 Simulink model of an ADS-B receiver.



▲ Fig. 3 Captured waveform containing possible ADS-B messages.

```
Aircraft ID: 4005a5 is at altitude 40300
Aircraft ID: 4005a5 is at latitude 42.398, longitude -71.112

Aircraft ID: 4005a5 is travelling at 427.375713 knots
Direction West at 205.000000 knots, direction South at 375.000000 knots
Aircraft ID: 4005a5 is going Down at 1216.000000 feet/min

Aircraft ID: 4005a5 is at altitude 40275
Aircraft ID: 4005a5 is at latitude 42.396, longitude -71.113

Aircraft ID: 4005a5 is at altitude 40250
Aircraft ID: 4005a5 is at latitude 42.393, longitude -71.115

Aircraft ID: 4005a5 is travelling at 428.253430 knots
Direction West at 205.000000 knots, direction South at 376.000000 knots
Aircraft ID: 4005a5 is going Down at 1344.000000 feet/min

Aircraft ID: 4005a5 is at altitude 40150
Aircraft ID: 4005a5 is at latitude 42.386, longitude -71.121

Aircraft ID: 4005a5 is at altitude 40025
Aircraft ID: 4005a5 is at latitude 42.375, longitude -71.128
```

▲ Fig. 4 Live data results from the ADS-B receiver implemented on the Zynq radio platform.

(see **Figure 2**).

- HDL code generation tools that automate many of the hardware/software integration steps.
- Libraries from Analog Devices that enable data communications between the host computer and SDR platform.

THE FOUR STEP PROCESS TO PRODUCTION:

Step 1 – Select the Radio Platform

The SDR platform was composed of two key devices. The Analog Devices AD9361 RF Agile Transceiver is a highly flexible, highly programmable device with the tuning range and bandwidth to support a large number of wireless standards, all in a single integrated IC. The Zynq-7000 All Programmable SoC from Xilinx integrates a dual-core ARM Cortex-A9 processor with a large array of programmable logic. Combined, the Zynq and AD9361 produce a versatile radio platform. The transceiver is capable of acquiring many simple and complex radio waveforms, and the Zynq SoC can be programmed to demodulate and decode a wide variety of digital communication protocols.

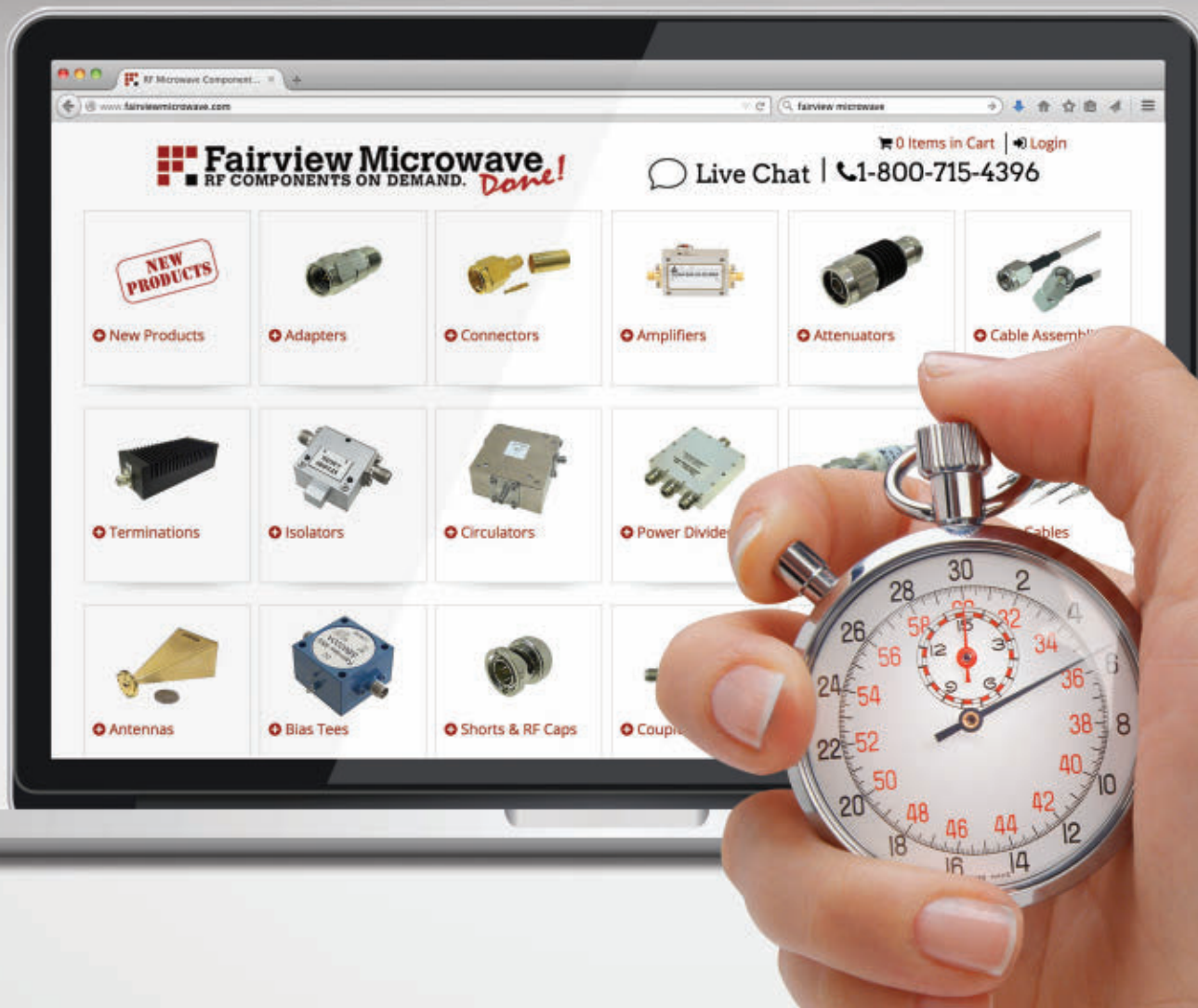
Step 2 – Design the Receiver Algorithms in MATLAB and Simulink

MATLAB and Simulink were used to design signal processing algorithms that receive and decode wireless transmissions. ADS-B uses short messages of 112 bits transmitted at 1 Mb/sec and a form of amplitude modulation called pulse position modulation. Detecting and decoding these messages presents several challenges typical in wireless receiver design, including:

- Detecting transmissions of interest using a message preamble
- Aligning the bit detection algorithm to the first message bit
- Making bit decisions based on modulated waveforms
- Calculating a checksum to verify the message is valid
- Decoding the individual bit fields.

The engineers used MATLAB to test a number of design ideas which allowed them to find a promising solution quickly. The design was then converted to Simulink and elaborations were made to the model to increase the clock rate and reduce the area of design.

The Right RF Parts. Right Away.



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

fairviewmicrowave.com
1.800.715.4396

Fairview Microwave
RF COMPONENTS ON DEMAND. *Done!*

Step 3 – Verify the Design with Live RF Signals

Hardware-in-the-loop testing provided a good intermediate step to verify that the radio could be configured correctly and the software design remained error-free. Analog Devices provided an IIO System object that enabled the RF signal captured by the Zynq radio platform to be streamed directly into the Simulink model of the ADS-B receiver.

This incremental step was useful for verifying that the AD9361 transceiver was configured correctly, proving that the Simulink model could successfully demodulate the live ADS-B transmissions, and confirming that the algorithm design would work over the range of environmental conditions experienced by the radio interface. **Figure 3** shows an example of ADS-B waveform data captured off the air.

Step 4 – Generate Code and Verify Real-Time Performance

The C and HDL code needed to program the Zynq SoC was generated from the Simulink model of the ADS-B receiver using HDL Coder and MATLAB Coder. The Xilinx Vivado Design Suite was scripted behind the scenes to download the code to the Zynq radio platform, and then tests were run with pre-recorded IQ data to verify the Zynq code was functioning correctly.

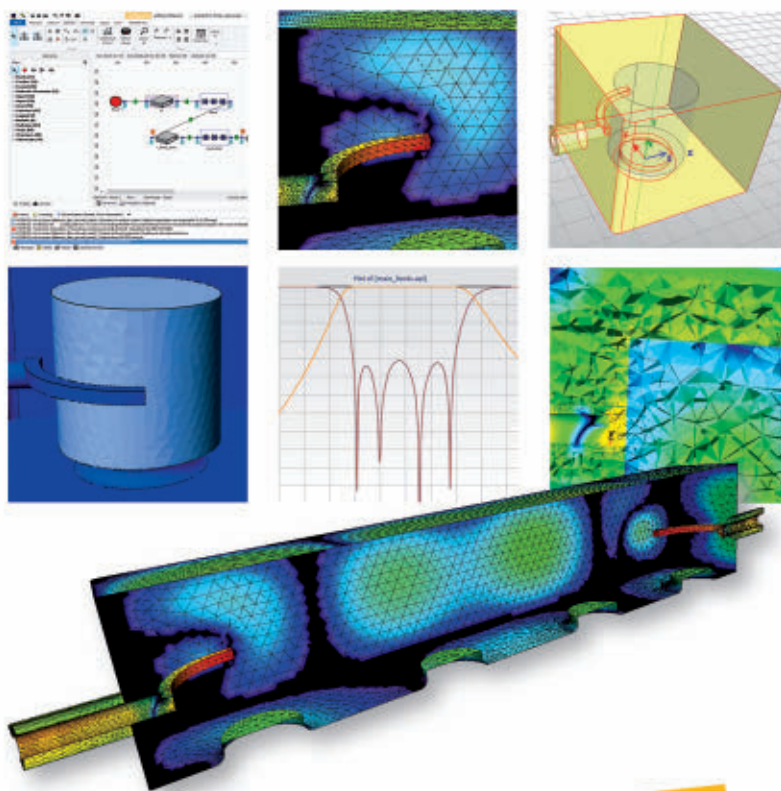
The last step in the design-to-production process was to disconnect from the host PC and verify that the ADS-B receiver would run in real-time on the Zynq radio platform. In this demonstration, the receiver successfully decoded ADS-B transmissions from aircraft at a distance of over 50 miles, as shown in **Figure 4**.

CONCLUSION

There were a number of elements that contributed to the successful design and deployment of the wireless receiver, including:

- The AD9361 transceiver used in this project is a high performance device that is easy to configure, which eliminated the need to develop a custom RF front-end design.
- MATLAB and Simulink provide a complete signal processing design environment for designing and simulating wireless receiver algorithms.
- The C and HDL code used to program the Zynq SoC were generated from a Simulink model, allowing the engineering team to dedicate most of their development time to the design of the receiver.
- Minimal debugging was required because the software code matched the design model, and small, incremental steps could be taken to move the design off the host PC and onto the embedded radio platform.

ADS-B is a relatively simple standard that provides a good test case to demonstrate the Model-Based Design approach to building a wireless receiver. Engineers who adopt Model-Based Design and the Zynq SDR platform should be able to follow this workflow to develop more complex and powerful QPSK-, QAM-, and LTE-based SDR systems. ■



THERE'S MAGIC IN FAST AND ACCURATE RF DESIGNS



µWave Wizard™: The hybrid full-wave EM-tool for sophisticated designs of antennas, filters, couplers, multiplexers, ...
MiCIAN GmbH, Schlachte 21, 28195 Bremen, Germany, Tel.: +49 42116899351, Fax: +49 42116899352, www.mician.com



Ultra Small 2x2mm

2W ATTENUATORS DC-20GHz **\$1⁹⁹** ea. (qty. 1000)


Save PC board space with our new tiny 2W fixed value absorptive attenuators, available in molded plastic or high-rel hermetic nitrogen-filled ceramic packages. They are perfect building blocks, reducing effects of mismatches, harmonics, and intermodulation, improving isolation, and meeting other circuit level requirements. These units will deliver the precise attenuation you need, and are stocked in 1-dB steps from 0 to 10 dB, and 12, 15, 20 and 30 dB.

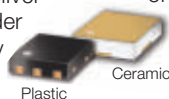
The ceramic hermetic **RCAT** family is built to deliver reliable, repeatable performance from DC-20GHz under the harshest conditions. With prices starting at only

\$4.95 ea. (qty. 20), these units are qualified to meet MIL requirements including vibration, PIND, thermal shock, gross and fine leak and more, at up to 125°C!

The molded plastic **YAT** family uses an industry proven, high thermal conductivity case and has excellent electrical performance over the frequency range of DC to 18 GHz, for prices starting at \$2.99 ea. (qty. 20).

For more details, just go to minicircuits.com – place your order today, and you can have these products in your hands as soon as tomorrow!

 RoHS compliant



FREE Simulation Models!



<http://www.modelithics.com/mvp/Mini-Circuits/>





High Speed PXIe Digitizers

Spectrum Systementwicklung Microelectronic GmbH
Grosshansdorf, Germany

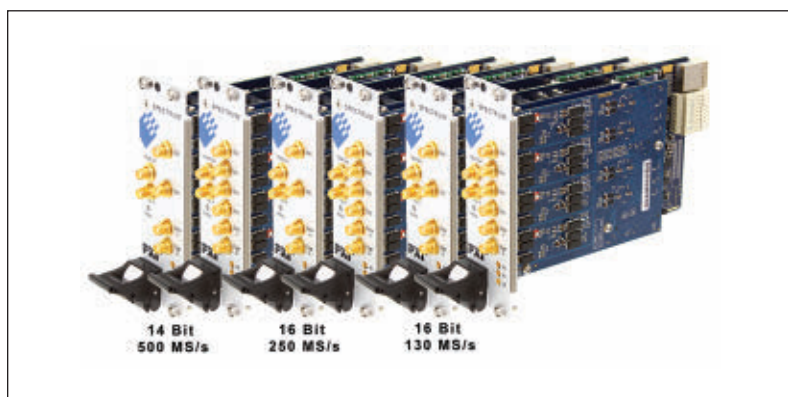
When it comes to modular instrumentation the PXI standard has become today's most popular choice for the automated test industry. With its high quality mechanical and electrical design, and wide range of suppliers and modules, PXI has proven to be the ideal platform for many industrial and mobile applications. Constantly evolving, the latest PXI Express (PXIe) systems are now based on PCI Express (PCIe) technology that provides data throughputs some 10 to 20 times

faster than the earlier generation of PXI products. Faster throughput means shorter testing times and improved system productivity.

To allow users to harness these capabilities, Spectrum GmbH has released its first high-speed digitizer product line based on the PXIe standard. The M4x.44xx series consists of six new digitizers (shown in **Figure 1**) each packaged in a dual width 3U PXIe module and incorporating a four lane PCI Express Generation 2 interface. With data transfer speeds in excess of 1.7 GB/s the high-performance interface allows the new modules to be used in today's fastest PXIe mainframe systems (see **Figure 2**).

However, it's not just data transfer speed that makes these new PXIe digitizers stand out. They also set new standards for sampling rate, resolution and channel density. Versions come with either two or four fully synchronous channels and resolutions of 14 bits, for sampling at rates up to 500 MS/s, or 16 bits for sampling at rates up to 130 or 250 MS/s.

With analog bandwidth up to 250 MHz the digitizers are ideally suited for use in ATE systems where electronic signals in the 1 to 200 MHz range need to be acquired and measured



▲ Fig. 1 The M4x series includes six new PXIe modules featuring two or four channels, 14- and 16-bit resolution and sampling rates of 130, 250 and 500 MSPS.

4205 Series

USB/TTL controlled

Available in 0-31.5,
63.5, and 95 dB



DC to 6 GHz Programmable Attenuator Solutions



8320, 8321, 8331 Series

Ethernet controlled

Configurations up to 12 channels

Electromechanical & solid-state designs

Bring your 3G/4G testing to a solid state

If it's time to bring your test systems to the digital age, look to the leaders in solid-state programmable attenuation.

With 60 years of industry leadership and product development, Weinschel, part of API Technologies Corp., offers DC to 6 GHz MMIC digital attenuation solutions including USB/TTL controlled attenuators and Ethernet controlled rack mountable subsystems.

Designed with budget and performance concerns in mind, these devices offer superior RF characteristics suitable for automated bench testing in wireless backhaul, fading simulation, and other high-performance wireless applications.

- **Excellent solid-state repeatability and performance**
- **Uninterrupted RF when changing attenuation value**
- **Labview based USB Control Center Software included**



api 
technologies corp.
WEINSCHTEL

301-846-9222 | 800-638-2048 | weinschel-sales@apitech.com | weinschel.apitech.com

Weinschel is now part of API Technologies Corp.

with the best possible speed and precision. Typical applications include semiconductor and component testing, radar, wireless communications, medical science, transportation, power, physics, surveillance, aerospace and military.

Designed to handle the widest range of input signals the modules incorporate an oscilloscope style front-end. Each channel has its own separate monolithic ADC and low noise signal conditioning circuitry. Fully programmable, the cards provide six gain input ranges (from ± 200 mV up to ± 10 V), selectable input impedance

of $50\ \Omega$ or $1\ \text{M}\Omega$ and AC or DC coupling. A powerful trigger system and versatile clock adds to the overall flexibility. The trigger source can be any of the input channels, either of the two external trigger inputs, any of the eight PXI trigger lines or the PXI star trigger. Trigger modes include positive or negative edge, window (both edges), logical multi-source (pattern), software and rearm.

The clocking system of the digitizers is cutting edge. The clock can be internally or externally generated (including using the 100 MHz PXIe differential clock and the 10 MHz PXI clock as a source). It has a built-in 10 MHz reference which, if required, can be synchronized with other reference sources. A fine-resolution mode is also available that allows clock rates to be selected with 1 Hz resolution. This useful feature makes it possible to program the sampling rate to match that of other devices or specific input signals.

Each module is equipped with a generous 4 GByte (2 Giga Samples) of on-board acquisition memory, making it simple to acquire long and complex signals. The capability is further enhanced by a variety of data acquisition and readout modes. These include single-shot capture (transient recording), streaming (FIFO), segmented (multiple recording), gated (gated sampling), or the combination of segmented acquisition of fast signals in parallel with slow continuous data recording (ABA mode). A trigger time stamp feature even identifies when events occurred and makes it easy to measure the time between them.

The high-resolution ADCs combine with the low noise front-end electronics and accurate clocks to ensure the digitizers deliver outstanding dynamic range and performance. For example, signal-to-noise

ratios (SNR) are typically over 70 dB, spurious free dynamic range (SFDR) is better than 90 dB and total harmonic distortion (THD) is less than -70 dB. These specifications make it possible to detect small signal variations on larger ones and also allow better measurement repeatability, precision and accuracy.

The new PXIe modules are based on Spectrum's proven M4i series of PCIe cards and deliver the same advanced features and signal quality. As the PXIe modules have a smaller footprint than their equivalent PCIe cards, a new base board was designed (see **Figure 3**). A modular concept was used so that different digitizer or generator front-ends can be shared by both PCIe and PXIe platforms. This modularity will also enable the release of several new PXIe products within a short time — all sharing a common software interface that's similar to existing PCIe, PCI and PXIe products.

Those users wanting out-of-the-box operation of the digitizers can utilize the powerful SBench 6 program, which supports all the key functions of the digitizer as well as providing data display, storage, analysis and documentation. The program allows both oscilloscope and transient recording modes, including continuous data streaming. A base version of SBench 6 is provided free of charge.

Customers who need to develop their own programs can use the proven Spectrum drivers (available for Windows and Linux), which are included as standard. A set of programming examples is provided to illustrate the card's main signal capture functions. Support covers programming in Visual C++, Borland C++, Gnu C++, LabVIEW, MATLAB, Visual Basic, VB.NET, C#, J# and Delphi code.

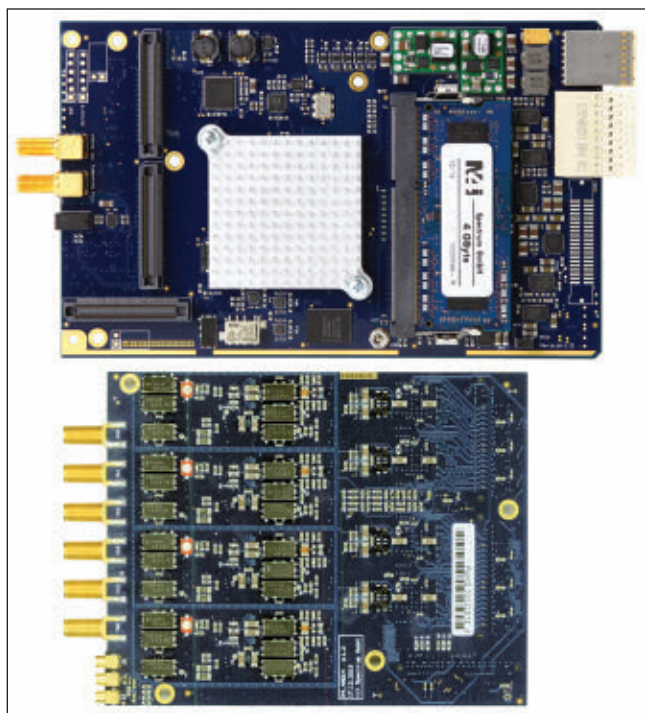
The new M4x series modules come complete with software drivers and a two year manufacturer's warranty, together with free technical support, including software and firmware updates.

VENDORVIEW

**Spectrum Systementwicklung
Microelectronic GmbH
Grosshansdorf, Germany
www.spectrum-instrumentation.
com/en**

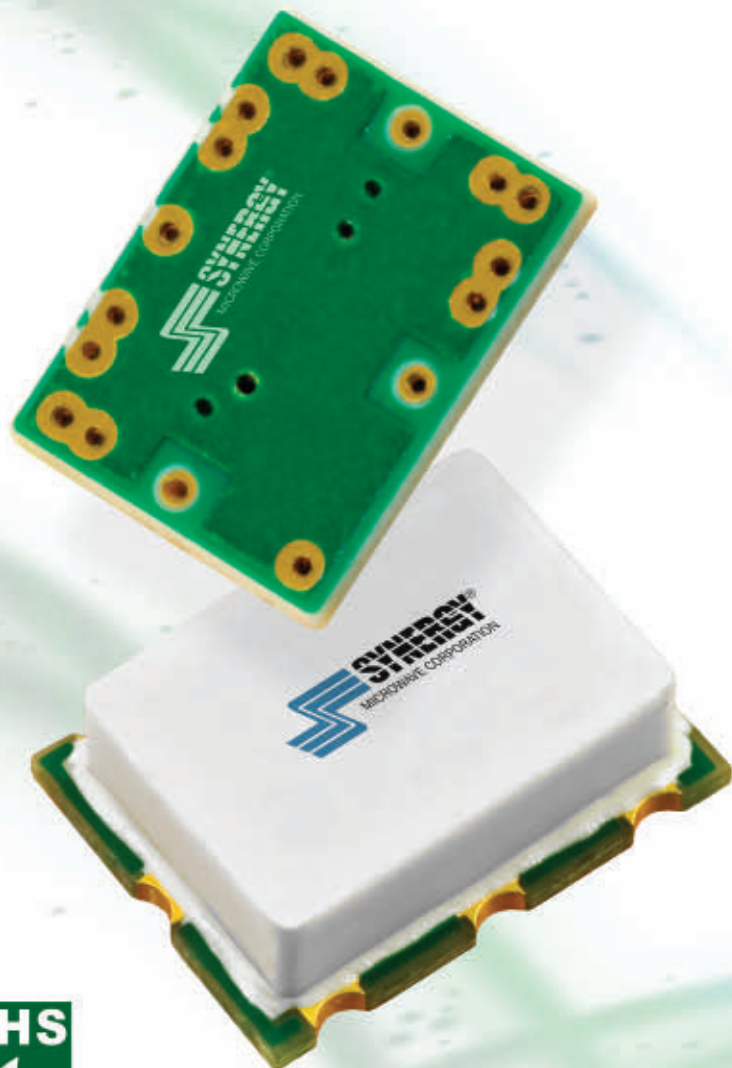


▲ Fig. 2 The M4x.44xx series fits into any PXIe system with two free slots.



▲ Fig. 3 The M4x.44xx series has a new base board (top) that accommodates the existing M4i series digitizer (bottom) and generator hardware, allowing rapid product development.

STM (SPUR TAMER) WIDEBAND MIXER SERIES



Features

- | Low Spurs
- | High Isolation
- | Good Linearity
- | Small Size

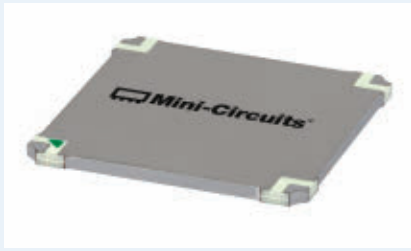
Up to
**18.0
GHz**



Talk To Us About Your Custom Requirements.



Phone: (973) 881-8800 | Fax: (973) 881-8361
E-mail: sales@synergymwave.com
Web: WWW.SYNERGYMWAVE.COM
Mail: 201 McLean Boulevard, Paterson, NJ 07504



225 to 450 MHz Low Loss Coupler Handles 200 W

For high power RF systems, such as military and VHF/UHF radio, Mini-Circuits developed a bidirectional coupler that handles 200 W of combined DC and RF power. Covering 225 to 450 MHz, the MBDA-30-451HP provides a 30.5 dB coupled signal with ± 0.85 dB flatness across the full band. Coupler directivity is typically 28 dB and mainline loss is 0.15 dB. The typical return loss for input, output and coupled ports is 30 dB. The high directivity ensures accurate sampling from the coupled port, and the good return loss extends over

the entire frequency range.

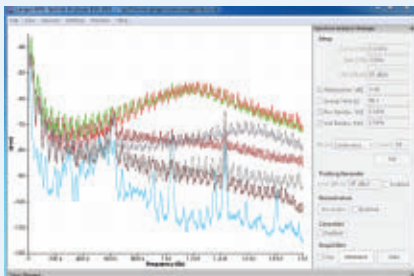
The surface-mount, stripline design operates from -55° to $+105^{\circ}\text{C}$ and measures only $1.0" \times 1.0" \times 0.05"$. The coupler is fabricated using a laminated PCB process that includes wrap-around terminations for good solderability and easy visual inspection.

This coupler is a recent addition to Mini-Circuits' new series of stripline-based models that provide extremely high power handling in a miniature, low profile printed laminate form factor. The series is designed for use in

power amplifiers and antenna feeds and where high temperature is common. The MBDA-30-451HP is available off-the-shelf.



Mini-Circuits
Brooklyn, N.Y.
www.minicircuits.com



CS-ESA Software for EMC Analysis with Spectrum Analyzer

The ChipScan-ESA analysis software has been designed to record spectrum analyzer measurement curves. It has been custom-designed for EMC measurements in the field and utilizes Langer EMV-Technik GmbH's ESA1 emissions development system. The software allows users to record the type and properties of any number of near-field emission measurements and compare the curves quickly and easily. It is particularly suitable for pre- and post measurements during the EMC optimization of the device under test.

Features include a Trace Manager that allows users to annotate, color or offset the measurement curves, while the Spectrum Analyzer Manager enables users to control the most important spectrum analyzer functions

via the user interface. The software enables a random number of measurement curves to be recorded at any one time, which are shown in one diagram for precise analysis. Also, individual measurement curves can be shown or hidden and each curve can be assigned a specific color and extensive comments added. The comments can be used to provide information about the measurement conditions that led to the respective curve.

The Live Trace feature allows a continuous display of the spectrum analyzer's measurements in the relevant window. During the live transmission, previously recorded measurement curves can be shown for comparison. Users can select this feature to check and further optimize the effect of an

EMC countermeasure directly.

The ChipScan-ESA software can be used to record any number of measurements from a spectrum analyzer and store them. Measurement curves can be compared directly and user-defined correction curves can be created. Existing correction curves can be imported and applied.

The software can also be used to generate and export image data that may be required for documentation or for presentation. In addition, all measurement curves can be exported to R, Matlab or Excel as a comma separated value (CSV) list for further processing.

Langer EMV-Technik GmbH
Bannewitz, Germany
www.langer-emv.com

FIVE DAYS



THREE CONFERENCES



ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2016
EXCEL LONDON, UK
3 - 7 OCTOBER 2016



**EUROPEAN
MICROWAVE WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

EUROPEAN MICROWAVE WEEK 2016 REGISTRATION INFORMATION

EUROPE'S PREMIER MICROWAVE,
RF, WIRELESS AND RADAR EVENT

EuMA

European Microwave Association

Official Publication:



The 11th European Microwave
Integrated Circuits Conference

Co-sponsored by:



Organised by:



Supported by:



Co-sponsored by:



Co-sponsored by:



The 46th European Microwave Conference

Co-sponsored by:



The 13th European Radar Conference

Co-sponsored by:



Register online at
www.eumweek.com



RETURNING TO LONDON FOR THE FIRST TIME IN 15 YEARS

THE ONLY EUROPEAN EVENT DEDICATED TO THE MICROWAVE AND RF INDUSTRY

EuMW 2016 will be held in the dynamic and historically rich city of London. Bringing industry and academia together, European Microwave Week 2016 is a FIVE day event, including THREE cutting edge conferences and ONE exciting trade and technology exhibition featuring leading players from across the globe. Concentrating on the needs of engineers, the event showcases the latest trends and developments that are widening the field of applied microwaves. It also offers you the opportunity for face-to-face interaction with those driving the future of microwave technology.

EuMW 2016 will see an estimated 1,700 - 2,000 conference delegates, over 4,000 visitors and in excess of 300 international exhibitors (inc. Asia & US).

REGISTRATION TO THE EXHIBITION IS FREE!

Pivotal to the week is the European Microwave Exhibition, which offers YOU the opportunity to see, first hand, the latest technological developments from global leaders in microwave technology.

The exhibition will provide an unrivalled opportunity for visitors to view and ask questions related to the latest products, components and materials from our extensive selection of international exhibitors. It will also feature exhibitor demonstrations, Industrial Workshops and the annual European Microwave Week Microwave Application Seminars (MicroApps).

- **International Companies** - meet the industry's biggest names and network on a global scale
- **Cutting-edge Technology** - exhibitors showcase the latest product innovations, offer hands-on demonstrations and provide the opportunity to talk technical with the experts
- **Technical Workshops** - get first hand technical advice and guidance from some of the industry's leading innovators

BE THERE

Exhibition Dates

Tuesday 4th October
Wednesday 5th October
Thursday 6th October

Opening Times

09:30 - 18:00
09:30 - 17:30
09:30 - 16:30

FAST TRACK BADGE RETRIEVAL

Entrance to the Exhibition is FREE and attending couldn't be easier.

VISITORS

Registering for the Exhibition

- Register as an Exhibition Visitor online at www.eumweek.com
- Receive a confirmation email with barcode
- Bring your barcode with you to the Exhibition
- Go to the Fast Track Check In Desk and print out your visitor badge
- Alternatively, you can register onsite at the self service terminals during the Exhibition

Please note NO visitor badges will be mailed out prior to the Exhibition.



**EUROPEAN
MICROWAVE
WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

EUROPEAN MICROWAVE WEEK 2016 THE CONFERENCES

Don't miss Europe's premier microwave conference event. The 2016 week consists of three conferences and associated workshops:

- European Microwave Integrated Circuits Conference (EuMIC) 3rd – 4th October 2016
- European Microwave Conference (EuMC) 4th – 6th October 2016
- European Radar Conference (EuRAD) 5th – 7th October 2016
- Plus Workshops and Short Courses (From 3rd October 2016)
- In addition, EuMW 2016 will include the 'Defence, Security and Space Forum' on 5th October 2016

The three conferences specifically target ground breaking innovation in microwave research through a call for papers explicitly inviting the submission of presentations on the latest trends in the field, driven by industry roadmaps. The result is three superb conferences created from the very best papers. For a detailed description of the conferences, workshops and short courses please visit www.eumweek.com. The full conference programme can be downloaded from there.

FAST TRACK BADGE RETRIEVAL

Register online and print out your badge in seconds onsite at the Fast Track Check In Desk

CONFERENCE PRICES

There are TWO different rates available for the EuMW conferences:

- **ADVANCE DISCOUNTED RATE** – for all registrations up to and including 3rd September
- **STANDARD RATE** – for all registrations made after 3rd September

Please see the Conference Registration Rates table on the back page for complete pricing information.

All payments must be in £ Sterling – cards will be debited in £ Sterling.

Online registration is open now, up to and during the event until 7th October 2016

DELEGATES

Registering for the Conference

- Register online at www.eumweek.com
- Receive an email receipt with barcode
- Bring your email, barcode and photo ID with you to the event
- Go to the Fast Track Check In Desk and print out your delegate badge
- Alternatively, you can register onsite at the self service terminals during the registration opening times below:

- | | |
|--|---|
| - Sunday 2nd October (16:00 - 19:00) | - Monday 3rd October (08:00 – 17.00) |
| - Tuesday 4th October (08:00 – 18.00) | - Wednesday 5th October (08:00 – 17.00) |
| - Thursday 6th October (08:00 – 17.00) | - Friday 7th October (08:00 – 10.00) |

Once you have collected your badge, you can collect the conference proceedings on USB stick and delegate bag for the conferences from the specified delegate bag area by scanning your badge.

CONFERENCE REGISTRATION INFORMATION

EUROPEAN MICROWAVE WEEK 2016, 3rd - 7th October, London, UK

Register Online at www.eumweek.com

ONLINE registration is open from 1st June 2016 up to and during the event until 7th October 2016.

ONSITE registration is open from 16:00 on 2nd October 2016.

ADVANCE DISCOUNTED RATE (up to and including 3rd September) **STANDARD RATE** (from 4th September & Onsite)

Reduced rates are offered if you have society membership to any of the following*: EuMA, GAAS, IET or IEEE.

EuMA membership fees: Professional £19/year, Student £11/year.

If you register for membership through the EuMW registration system, you will automatically be entitled to discounted member rates.

Reduced Rates for the conferences are also offered if you are a Student/Senior (Full-time students 30 years or younger and Seniors 65 or older as of 1st August 2016).

ADVANCE REGISTRATION CONFERENCE FEES (UP TO AND INCLUDING 3RD SEPT.)

CONFERENCE FEES	ADVANCE DISCOUNTED RATE			
	Society Member (*any of above)		Non Member	
	Standard	Student/Sr.	Standard	Student/Sr.
<i>1 Conference</i>				
EuMC	£355	£100	£500	£140
EuMIC	£270	£90	£380	£130
EuRAD	£240	£80	£340	£120
<i>2 Conferences</i>				
EuMC + EuMIC	£500	£190	£710	£270
EuMC + EuRAD	£480	£180	£680	£260
EuMIC + EuRAD	£410	£170	£580	£250
<i>3 Conferences</i>				
EuMC + EuMIC + EuRAD	£610	£270	£860	£390

STANDARD REGISTRATION CONFERENCE FEES (FROM 4TH SEPT. AND ONSITE)

CONFERENCE FEES	STANDARD RATE			
	Society Member (*any of above)		Non Member	
	Standard	Student/Sr.	Standard	Student/Sr.
<i>1 Conference</i>				
EuMC	£500	£140	£700	£200
EuMIC	£380	£130	£540	£190
EuRAD	£340	£120	£480	£170
<i>2 Conferences</i>				
EuMC + EuMIC	£710	£270	£1,000	£390
EuMC + EuRAD	£680	£260	£950	£370
EuMIC + EuRAD	£580	£250	£820	£360
<i>3 Conferences</i>				
EuMC + EuMIC + EuRAD	£860	£390	£1,210	£560

WORKSHOP AND SHORT COURSE FEES (ONE STANDARD RATE THROUGHOUT)

FEES	STANDARD RATE			
	Society Member (*any of above)		Non Member	
	Standard	Student/Sr.	Standard	Student/Sr.
Half day WITH Conference registration	£75	£60	£100	£75
Half day WITHOUT Conference registration	£100	£75	£130	£100
Full day WITH Conference registration	£105	£80	£135	£100
Full day WITHOUT Conference registration	£135	£105	£180	£130

THE EUMW CRUISE ON THE RIVER THAMES - 5th Oct 16

Tickets for the cruise are limited and are available on a first-come first-served basis at the price of £25.00 for EuMW Delegates and £36.00 for guests.

Proceedings on USB Stick

All papers published for presentation at each conference will be on a USB stick, given out FREE with the delegate bags to those attending conferences. For additional USB sticks the cost is £50.

International Journal of Microwave and Wireless Technologies (8 issues per year)

International Journal combined with EuMA membership: £50 for Professionals or £43 for Students.

Partner Programme and Social Events

Full Details and contacts for the Partner Programme and other Social Events can be obtained via the EuMW website www.eumweek.com

SPECIAL FORUMS & SESSIONS

Date	Time	Title	Location	No. of Days	Fee	
Wednesday 5th October	11:20 - 19:00	Defence, Security & Space Forum	Rooms 8 to 11	1	£10 for delegates (those registered for EuMC, EuMIC or EuRAD)	£40 for all others (those not registered for a conference)

FIVE DAYS

THREE CONFERENCES

ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2016
EXCEL LONDON, UK
3 - 7 OCTOBER 2016



**EUROPEAN
MICROWAVE
WEEK**
LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

EUROPE'S PREMIER MICROWAVE, RF, WIRELESS AND RADAR EVENT

The Exhibition (4th - 6th October 2016)

- 8,000 sqm of gross exhibition space
- 4,000 key visitors from around the globe
- 1,700 - 2,000 conference delegates
- In excess of 300 international exhibitors (including Asia and US as well as Europe)

Scan page
using [layar](#) app

The Conferences:

- European Microwave Integrated Circuits Conference (EuMIC)
- European Microwave Conference (EuMC)
- European Radar Conference (EuRAD)
- Plus Workshops and Short Courses
- In addition EuMW 2016 will include the 'Defence, Security and Space Forum'

EuMA
European Microwave Association

Official Publication:
**Microwave
Journal**

Organised by:
**h horizon
house**

Supported by:
IET The Institution of
Engineering and Technology

Co-sponsored by:
MTT-S

Co-sponsored by:
IEEE

**EuMIC
2016**
The 11th European Microwave
Integrated Circuits Conference
Co-sponsored by:



46TH EUROPEAN MICROWAVE CONFERENCE 2016
The 46th European Microwave Conference
Co-sponsored by:



**EuRAD
2016**
The 13th European Radar Conference
Co-sponsored by:



INTERESTED IN EXHIBITING?

For International Sales:

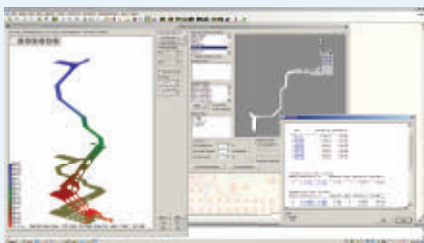
Richard Vaughan
International Sales Manager
E: rvaughan@horizonhouse.co.uk
Tel: +44 20 7596 8742

For US Sales:

Alyssa Connell
Event Coordinator
E: aconnell@mwjournal.com
Tel: +1 781 619 1930

For more information visit:

www.eumweek.com



PADS Adds DC Drop and Thermal Analysis

Recognizing that product development is much more than schematic capture and board layout, Mentor Graphics has extended its PADS printed circuit board (PCB) design capabilities by adding HyperLynx® DC Drop and FloTHERM® XT tools to their PADS® PCB software, creating a comprehensive product development platform.

HyperLynx DC Drop enables designers to optimize the power distribution network on the PCB. The software can quickly analyze voltage drops caused by insufficient copper across power supply rails and identify layout areas that contain excessive current density. The HyperLynx DC Drop tool

identifies problem areas in the design which would be difficult to find in the lab on a prototype, providing solutions in an easy-to-use environment. Results can be validated in layout to ensure that appropriate guidelines were followed, reducing prototype spins.

FloTHERM XT is a thermal simulation tool that considers all thermal aspects of the design: package, PCB layout, board structure and enclosure. As circuitry becomes faster, smaller and more densely packed, designers need to analyze thermal performance to ensure product reliability; physical testing is not always possible due to time and cost. FloTHERM XT interfaces with all major MCAD vendors and is

compatible with all vendor-neutral file formats. The tool can be used as early as placement to identify the thermal effects of the entire system. Using the SmartParts™ feature, designers can build simple models in minutes, apply complex mechanical parts directly from MCAD, create custom CAD geometry and import detailed electronic assemblies from EDA tools.

The PADS HyperLynx DC Drop tool starts at \$4,995, and the PADS FloTHERM XT tool starts at \$12,500.

Mentor Graphics Corp.
Wilsonville, Ore.
(800) 547-3000
www.pads.com

AMTA 2016

Antenna Measurement Techniques Association
38th Annual Symposium

October 31-November 4, 2016
Austin, Texas USA
Hyatt Regency Austin Hotel

www.amta2016.org



Host:



Co-Hosts:



ETS-Lindgren is proud to host the 38th Annual Symposium of the Antenna Measurement Techniques Association (AMTA), a non-profit, international organization dedicated to the development and dissemination of theory, best practices and applications of antenna, radar signature, and related electromagnetic measurement technologies. To learn more about AMTA, visit www.amta.org.

SYMPOSIUM HIGHLIGHTS

- High-quality Papers Presented on a Continuous Basis Over Four Days – No Parallel Sessions
- Practical Full Day Short Course – *New Frontiers in RF Material Measurements*
- Exhibits Showcasing Antenna and Measurement Related Products and Services
- Technical Tours, Social Events, and Daytime Companion Tours to Austin Highlights

Paper Topics Include:

Advances in near-field, far-field, compact, and RCS range measurements; measurement imaging and processing; phased array, adaptive/smart antenna application and measurement; GNSS, PCS, cellular, satellite, and automotive antennas and measurement; multi-link MIMO and cooperative channels; and applied computational electromagnetics – to name a few.

View the preliminary technical program online after July 1 at www.amta2016.org

You need the special Product, and best Quality?

**At www.spectrum-et.com you will find the best,
from Connectors to Super Components.**



 **Spectrum**
Elektrotechnik GmbH

when Quality is needed

80905 Munich, Germany
Telephone: +49-89-3548-040
WWW.SPECTRUM-ET.COM

P.O. Box 450533
Facsimile: +49-89-3548-0490
Email: sales@spectrum-et.com

RF Power Reference Guide

Ampleon announced the launch of its "24/7 RF" e-book manual. This first edition guide is an essential reference for any engineer working on RF power amplifier designs and is available for free download at www.ampleon.com/24-7rf. Composed of RF applications, technologies and RF product portfolio sections, the 24/7 RF highlights design concepts and example schematic diagrams for each specific application sector. The 24/7 RF manual also includes sections on design support, cross references and packaging.

Ampleon

www.ampleon.com



RF Test Systems Brochure

JFW Industries' new RF Test Systems Brochure showcases the company's custom capabilities in RF attenuation and switching systems as well as off-the-shelf automated testing solutions. JFW Industries Inc. designs and manufactures a wide range of attenuators, RF switches, power dividers, test accessories and systems within an ISO 9001:2008 certified quality system. These products meet or exceed the requirements of the most demanding applications. All JFW products are designed to the most exacting standards to provide innovative, high quality and cost effective solutions in a wide variety of global applications.

JFW Industries Inc.

www.jfwindustries.com



Signal Integrity App Notes

VENDORVIEW

"How do I...? Quick Answers to Your Signal Integrity Questions," is a new collection of six application notes from Keysight Technologies. Each application note is an independent list of questions and answers targeting a specific topic related to signal integrity. Find answers to FAQs such as, "How do I start learning about SI simulation?" — "What are the architectures of the high speed SERDES transmitter and receiver?"— and much more. Download all six application notes today.

Keysight Technologies Inc.

www.keysight.com/find/eesof-ads-si-examples



Millimeter Wave Supplement Catalog

VENDORVIEW

MECA's newest publication, Millimeter Wave Supplement (Issue 2) includes their latest 5G ready components operating up to 40 GHz. Since 1961 MECA Electronics (Microwave Equipment & Components of America) has served the RF/microwave industry with equipment and passive components covering Hz to 40 GHz. MECA is a privately-held ISO9001:2008 certified global designer and manufacturer for the communications industry. Products are manufactured in the U.S. with 36-month warranty.

MECA Electronics Inc.

www.e-MECA.com



New Product Brochures

VENDORVIEW

Modelithics has developed new brochures for recently released inaugural model libraries. The first Modelithics® CLR Library for ANSYS® HFSS™ was released in November 2015 and the first Modelithics® CLR Library for Sonnet® Suites™ was released in May 2016. New brochures for these libraries are now available along with those for the Modelithics COMPLETE Library for Keysight ADS, Keysight Genesys and NI AWR Design Environment. The brochures include advanced model feature highlights and an extensive list of commercial electronic parts available as Microwave Global Models™.

Modelithics Inc.

www.modelithics.com/Literature/Brochure



2016 Product Catalog

Request your new 2016 Tektronix and Keithley product catalog with product highlights covering general test and measurement, bench products and video test. This comprehensive catalog provides key product specifications, application details, links to primers, application notes, videos and online demos. Quick-reference selection charts on the complete range products including: oscilloscopes, logic analyzers, signal generators, real-time spectrum analyzers, digital multimeters, power analyzers, power supplies, frequency counter/timers and signal generators, and software solutions.

Tektronix Inc.

www.tektronix.com



RF-LAMBDA

THE LEADER OF RF BROADBAND SOLUTIONS

ITAR & ISO9000
Registered Manufacture



PIN DIODE, GaAs AND GaN CONTROL PRODUCTS

SWITCH IN PIN DIODE, GaAs AND GaN TECHNOLOGY UP TO 67GHz



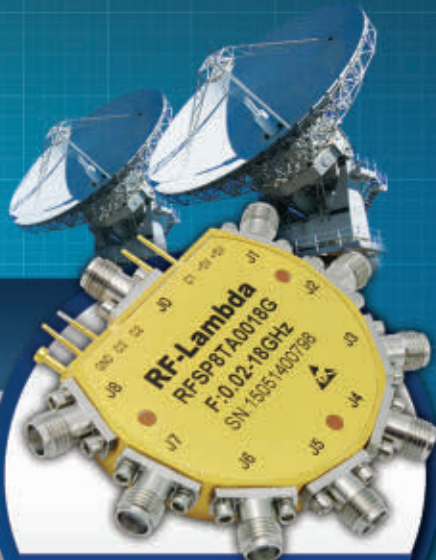
PN: RFSP4TA5M43G
FULL BAND 0.05-43.5GHz SP4T
SWITCH 50NS SPEED



PN: RFSP2TRDC18G
HIGH POWER 10W DC-18GHz HOT
SWITCHABLE SP2T SWITCH



PN: RFSP2TR5M06G
HIGH POWER 100W DC-6GHz HOT
SWITCHABLE SP2T SWITCH



PN: RFSP8TA0018G
HIGH IP3 500DBM 0.02-18GHz
SP8T PIN DIODE SWITCH



PN: RFPST1826N6
DIGITAL CONTROL PHASE SHIFTER 360
DEGREE 64 STEP 18-26GHz

DIGITAL AND VOLTAGE CONTROL PHASE SHIFTER UP TO 40GHz



PN: RFPST0618N6
DIGITAL CONTROL PHASE SHIFTER
360 DEGREE 64 STEP 6-18GHz



PN: RVPT0818GBC
VOLTAGE CONTROL PHASE
SHIFTER 360 DEGREE 8-18GHz



PN: RVPT0408GBC
VOLTAGE CONTROL PHASE
SHIFTER 360 DEGREE 4-8GHz

DIGITAL AND VOLTAGE CONTROL ATTENUATOR UP TO 50GHz



PN: RFDAT0040G5A
DIGITAL STEP ATTENUATOR
0.1-40GHz 5 BITS 31dB



PN: RFVAT0218A30
VOLTAGE CONTROL ATTENUATOR
2-18GHz 30dB IP3 500DBM



PN: RFVAT0050A17V
VOLTAGE CONTROL ATTENUATOR
0.01-50GHz 17dB



PN: RFDAT0018G8A
DIGITAL STEP ATTENUATOR 0.1-18GHz
8 BITS 128dB IP3 500DBM

www.rflambda.com
sales@rflambda.com

1-888-976-8880
1-972-767-5998

Plano, TX, US
San Diego, CA, US
Ottawa, ONT, Canada

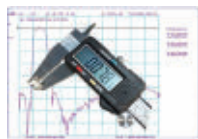


NEW PRODUCTS

FOR MORE NEW PRODUCTS, VISIT WWW.MWJOURNAL.COM/BUYERSGUIDE
FEATURING **VENDORVIEW** STOREFRONTS

COMPONENTS

L-Band Nano Filter



3H's new L-Band Nano bandpass filter offers low in-band insertion loss of <1.35 dB and >50 dB attenuation at 650 and 1700 MHz

while also meeting 45 dB attenuation at 3500 MHz to 7 GHz without the need for a lowpass filter. The filter size is 0.65" x 0.20" x 0.08" and is suitable for automated assembly, meets Mil-Std-202 conditions. For more information contact: sales@3hcomm.com or call (949) 529-1583

3H Communications

www.3hcommunicationsystems.com

Up/Down-Converter



A complete remote converter system using a computer network control including I/Os, USB, RS232 and Ethernet (RG45). This product can be utilized as an up-converter, down-converter or both, built per customer application using computer controlling the gain up to 30 dB with 0.5 dB LSB. The gain and frequency can be changed by an operator using any computer by typing gain or frequency. This product comes with instructions and hardware/software needed to operate the converter.

Advanced Microwave Inc.

www.advmic.com

Digitally Controlled Programmable Attenuators



Fairview Microwave Inc. announced the release of their new digitally controlled programmable attenuators with performance up to 40 GHz and up

to 60 dB attenuation range with 0.03 dB minimum step size. These programmable attenuators are commonly used in electronic warfare, military and space communication systems, radar and test and measurement applications. Fairview's digitally controlled attenuators perform the important function of adjusting the amplitude of signal levels in RF, microwave and millimeter wave systems. The designs utilize PIN diode semiconductor technology that generates extremely fast switching performance between attenuation states over wide frequency bands.

Fairview Microwave Inc.

www.fairviewmicrowave.com

LC Filters



MCV Microwave's LC filters feature center frequencies from 100 kHz to 10 GHz with excellent environmental performance in a rugged surface-mount and connectorized package.

It is available in standard and special enhanced performance packages. MCV offers solutions in LC bandpass filters, LC band reject filters, LC highpass filters, LC lowpass filters, LC duplexers, LC multiplexers and LC tunable filters.

MCV Microwave

www.mcv-microwave.com

Millimeter Wave Products



MECA announced its new family of 5G ready millimeter wave power dividers, couplers, isolators, attenuators and terminations covering C to V-Bands. Ideal for Satcom, 5G and back-

haul upgrade applications. Ranging from 2 and 4 way power dividers, 10 and 20 dB couplers, attenuators, terminations, isolators, bias tees and DC blocks covering up to 40 GHz with 2.92 mm connectors. Made in U.S. and 36-month warranty.

MECA Electronics Inc.

www.e-MECA.com

Programmable Attenuator



Mini-Circuits' RCDAT-8000-90 is a general purpose programmable RF attenuator supporting frequencies from 1 to 8000 MHz with attenuation from 0 to 90 dB in 0.25 dB steps.

Its unique design maintains linear attenuation change per dB, even at the highest attenuation settings. The attenuator is controlled via USB or Ethernet-



TCP/IP connections and supports both HTTP and Telnet network protocols. It comes housed in a rugged, shielded metal case with input/output SMA(F) RF ports (input/output ports are interchangeable), a standard Ethernet port, and a USB type Mini-B power and control port.

Mini-Circuits

www.minicircuits.com

Lowpass Filter



PMI Model No. 8LP7G-7050-CD-SFF is a low-pass filter with SMA female connectors in and out. All filters will be machined and silver plated to provide the highest possible Q.

Features include 0.5 passband DC to 7 GHz, VSWR in the passband 2.0:1 max., 1.5:1 goal - measured 1.4:1 and insertion loss (passband) 1 dB max. - measured 0.7 dB.

Planar Monolithics Industries Inc.

www.pmi-rf.com

High Power 18 GHz SPDT Switch



RLC Electronics announced the addition of a high power 18 GHz SPDT switch with N connectors to its product capabilities.

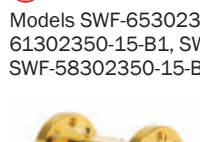
The switch can handle

1000 W at 100 MHz, 200 W at 4 GHz and 125 W at 18 GHz, and provides high-reliability, long life and excellent electrical performance characteristics over the frequency range (including high isolation). Options on the switch include operating mode (failsafe or latching) and coil voltage (12 or 28 VDC), as well as indicator circuitry and a TTL Driver. Control connector options include solder terminals, in addition to special power connectors such as MS and sub-D.

RLC Electronics

www.rlcelectronics.com

V-Band Waveguide Bandpass Filters



Models SWF-65302350-15-B1, SWF-61302350-15-B1, SWF-63302350-15-B1 and SWF-58302350-15-B1 are V-Band, waveguide

bandpass filters designed for WiGig applications. All four filters offer a 2 GHz passband with 50 dB typical rejection. The filters also have a nominal in-

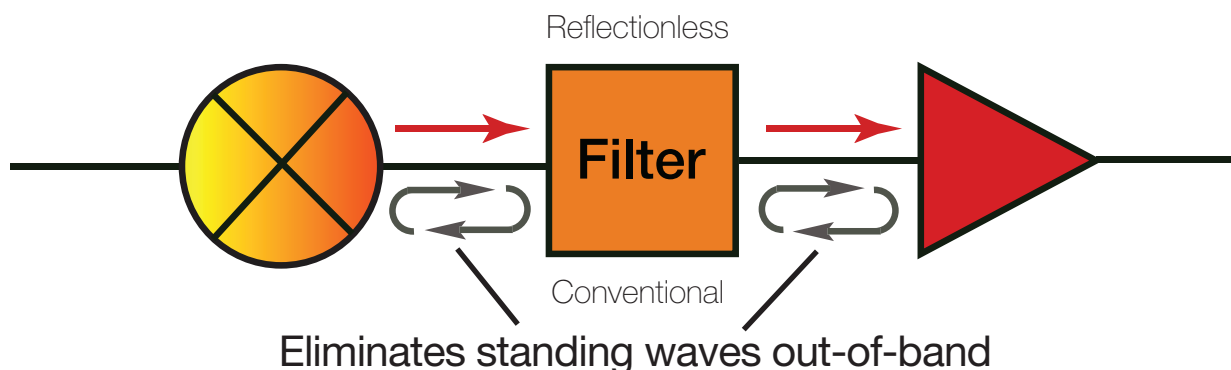
sertion loss of 2.5 dB. Since both low and high end cut off frequencies can be selected by modifying the design, custom models are available.

SAGE Millimeter

www.sagemillimeter.com

NOW! Revolutionary **ABSORPTIVE/REFLECTIONLESS FILTERS**

DC to 21 GHz!



Stops Signal Reflections Dead in Their Tracks!

\$6⁹⁵
ea. (qty. 1000)

Mini-Circuits is proud to bring the industry a revolutionary breakthrough in the longstanding problem of signal reflections when embedding filters in RF systems. Whereas conventional filters are fully reflective in the stopband, our new X-series reflectionless filters are matched to 50Ω in the passband, stopband and transition band, eliminating intermods, ripples and other problems caused by reflections in the signal chain. They're perfect for pairing with non-linear devices such as mixers and multipliers, significantly reducing unwanted signals generated due to non-linearity and increasing system dynamic range by eliminating matching attenuators². They'll change the way you think about using filters in your design!

Jump on the bandwagon, and place your order online today for delivery as soon as tomorrow. Need a custom design? Call us to talk to our engineers about a reflectionless filter for your system requirements.



- ✓ High pass, low pass and band pass models
- ✓ Patented design eliminates in-band spurs
- ✓ Absorbs stopband signal power rather than reflecting it
- ✓ Good impedance match in passband stopband and transition
- ✓ Intrinsically Cascadable³
- ✓ Passbands from DC – to 21 GHz⁴
- ✓ Stopbands up to 35 GHz

 **Tiny 3x3mm QFN**

¹ Small quantity samples available, \$9.95 ea. (qty. 20)

² See application note AN-75-007 on our website

³ See application note AN-75-008 on our website

⁴ Defined to 3 dB cutoff point

Protected by U.S. Patent No. 8,392,495 and Chinese Patent No. ZL201080014266.1. Patent applications 14/724976 (U.S.) and PCT/USIS/33118 (PCT) pending.



CERNEX, Inc.

RF, MICROWAVE & MILLIMETER-WAVE

COMPONENTS AND SUB-SYSTEMS

UP TO 325GHz

AMPLIFIERS UP TO 110GHz
FREQUENCY MULTIPLIERS/DIVIDERS
(UP TO 160GHz)

CONVERTERS UP TO 110GHz
ANTENNAS UP TO 220GHz

COUPLERS UP TO 220GHz
FERRITE PRODUCTS
(ISOLATORS/CIRCULATORS)
UP TO 160GHz

FILTERS/DIPLEXERS
SOURCES UP TO 160GHz

SWITCHES UP TO 160GHz
PHASESHIFTERS UP TO 160GHz

TRANSITIONS/ADAPTERS (UP TO 325GHz)
WAVEGUIDE PRODUCTS UP TO 325GHz

TERMINATIONS/LOADS UP TO 160GHz
MIXERS (UP TO 110GHz)

ATTENUATORS (UP TO 160GHz)
DETECTORS (UP TO 160GHz)

LIMITERS (UP TO 160GHz)
BLAS TEE (UP TO 100GHz)

POWER COMBINERS/DIVIDERS EQUALIZERS

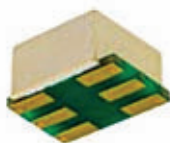
CABLES
ASSEMBLIES/CONNECTORS (UP TO 100GHz)
SUB-SYSTEMS (UP TO 100GHz)

Cernex, Inc.
1710 Zanker Road, Suite 103
San Jose, CA 95112
Tel: (408) 541-9226
Fax: (408) 541-9229

www.cernex.com
cernex@cernex.com

NewProducts

Hybrid Splitter



The SLQ-K04 is an octave bandwidth quadrature hybrid splitter that covers the frequency range of 100 to 200 MHz. This unit offers a typical

insertion loss across the band of 0.4 dB with a maximum amplitude unbalance of 1 dB. Other specifications include typical phase unbalance of 1 degree, isolation of 15 dB minimum and VSWR of 1.3:1 typical on all ports. Power handling capability is 1 W maximum. This 90 degree hybrid is available in a surface-mount package, 0.385" x 0.3" x 0.2" (L x W x H) with ENIG terminations and operates from -40° to + 85°C.

Synergy Microwave Corp.
www.synergymicrowave.com

CABLES & CONNECTORS

Waveguide Twists



Pasternack introduced a new family of precision waveguide twists operating from 18 to 110 GHz across seven frequency bands. Ideal for systems requiring a gradual turn in the polar

ization and waveform, these twists are designed and constructed to prevent unwanted distortion in the signal's transmission. Pasternack's new waveguide twists are useful components when building a waveguide system, as they allow the waveguide to be turned at a precise angle in order to meet the mechanical and electrical constraints of the overall system. These waveguide twists are also beneficial in applications to ensure correct polarization of the signal.

Pasternack
www.pasternack.com

Precision Right Angle Adapters

SGMC Microwave has an extensive line of 2.4 mm, 2.92 mm, 3.5 mm and SMA precision right angle in-series and between-series adapters suited for all your application needs.



All of SGMC's right angle connectors are internally swept and made free through their respective frequencies. Body components are manufac-

tured from corrosion resistant Type 303 stainless steel, passivated and SGMC's one piece center contacts are manufactured from beryllium copper, gold plated. Ready to ship today from the company's stocking distributor, C.W. Swift & Associates (sales@cwswift.com). Quality, performance and reliability you can count on, from SGMC Microwave.

SGMC Microwave
www.sgmcmicrowave.com

AMPLIFIERS

Solid-State Pulsed Amplifiers



There is now a very attractive alternative to Traveling Wave Tube Amplifiers (TWTAs) for automotive and military EMC radiated immunity susceptibility testing, as well as radar

and communication applications. AR's new offerings include the following frequency ranges: 1.2 to 1.4 GHz, 2.7 to 3.1 GHz, 1 to 2 GHz and 2 to 4 GHz. Output levels range from 1 to 150 kW. Designs can also be tailored to suit your specific application. Numerous applications include, but are not limited to automotive, MIL STD 464, DO-160 and military radar.

AR RF/Microwave Instrumentation
www.arworld.us/pulsedamps

8 W GaN Power Amplifier



Model AHP-29043925-G1 is one of Ducommun's newly developed amplifiers that utilize GaN technology in order to achieve high power

with small footprint. The amplifier operates within the frequency range of 27 to 31 GHz, with small signal gain at 25 dB and saturated power at 39 dBm. This high power amplifier in Ka-Band is ideal for satellite and ground communications. Ducommun also offers higher power models of this frequency range, contact Ducommun sales for more information.

Ducommun Inc.
www.ducommun.com

UltraCMOS® MPAC – Doherty



The UltraCMOS® PE46130 and PE46140 join the PE46120 MPAC product family in offering phase and amplitude control for Doherty power amplifier appli-

cations. The PE46130 provides excellent phase and amplitude accuracy from 2.3 to 2.7 GHz, and the PE46140 extends from 3.4 to 3.8 GHz. Each monolithic phase and amplitude controller (MPAC) integrates a 90-degree hybrid splitter, digital phase shifters, digital step attenuator and a digital SPI interface on a single die.

Peregrine Semiconductor
www.psemi.com

RF Power LDMOS Transistor



Richardson RFPD Inc. announced the availability and full design support capabilities for a new LDMOS transistor from NXP Semiconductors. The

MRF8VP13350NR3 is a 350 W CW transistor designed for industrial, scientific and medical (ISM) applications in the 700 to 1300 MHz frequency range. It is capable of 350 W CW or pulse power in narrowband operation. The new device is internally input matched for

FIVE DAYS



THREE CONFERENCES



ONE EXHIBITION

EUROPEAN MICROWAVE WEEK 2016
EXCEL LONDON, UK
3 - 7 OCTOBER 2016



**EUROPEAN
MICROWAVE
WEEK**
 LONDON, UK
3-7 OCTOBER 2016
www.eumweek.com

EUROPE'S PREMIER MICROWAVE, RF, WIRELESS AND RADAR EVENT

The Conferences (3rd - 7th October 2016)

- European Microwave Integrated Circuits Conference (EuMIC)
3rd – 4th October 2016
- European Microwave Conference (EuMC) 4th – 6th October 2016
- European Radar Conference (EuRAD) 5th – 7th October 2016
- Plus Workshops and Short Courses (From 3rd October 2016)
- In addition, EuMW 2016 will include the 'Defence, Security and Space Forum'
5th October 2016

DISCOUNTED CONFERENCE RATES

Discounted rates are available up to and including 3rd September 2016.

Register NOW and SAVE!

*Registration is available after this date and up to 7th October
at the standard rate.*

The FREE Exhibition (4th - 6th October 2016)

ENTRY TO THE EXHIBITION IS FREE! Register today to gain access to over 300 international exhibitors and take the opportunity of face-to-face interaction with those developing the future of microwave technology. The exhibition also features exhibitor demonstrations, industrial workshops and the annual European Microwave Week Microwave Application Seminars (MicroApps).

EuMA
European Microwave Association

Official Publication:



Organised by:



Supported by:



Co-sponsored by:



Co-sponsored by:



The 11th European Microwave
Integrated Circuits Conference
Co-sponsored by:



The 46th European Microwave Conference

Co-sponsored by:



The 13th European Radar Conference

Co-sponsored by:



Register online now as a delegate or visitor at: **www.eumweek.com**

PIN DIODE CONTROL DEVICES

PIN DIODE

ATTENUATORS

- 0.1–20GHz
- Broad & narrow band models
- Wide dynamic range
- Custom designs



Attenuator types offered are: Current Controlled, Voltage Controlled, Linearized Voltage Controlled, Digitally Controlled and Digital Diode Attenuators.

PIN DIODE

SWITCHES

- Broad & narrow band models
- 0.1–20GHz
- Small size
- Custom designs



SPST thru SP8T and Transfer type models are offered and all switches are low loss with isolation up to 100dB. Reflective and non-reflective models are available along with TTL compatible logic inputs. Switching speeds are 1μsec.—30nsec. and SMA connectors are standard. Custom designs including special logic inputs, voltages, connectors and package styles are available. All switches meet MIL-E-5400

PIN DIODE

PHASE SHIFTERS

- 0.5–20GHz
- Switched Line
- Varactor Controlled
- Vector Modulators
- Bi-Phase Modulators
- QPSK Modulators
- Custom Designs



SUBASSEMBLIES

Passive Components and Control Devices can be integrated into subassemblies to fit your special requirements. Call for more information and technical assistance.



NewProducts

ease of use, and it can be used single-ended or in a push-pull configuration. It is qualified up to a maximum of 50 VDD operation and includes integrated ESD protection.

Richardson RFPD
www.richardsonrfpd.com

SOURCES

Microwave Signal Generators



Berkeley Nucleonics released option "FS" for the 845 series microwave signal generators capable of providing extremely fast sweeps in frequency and power as low as 10 us. This performance offering, relative to the price and package, is unmatched within the industry and provide a distinct advantage in defense applications. In contrast to traditional analog sweeps, fast digital sweeps can be synchronized at any time during the sweep and yield very precise frequencies throughout the sweep.

Berkeley Nucleonics
www.berkeleynucleonics.com

Miniature Low Noise PLL Modules



CTS Corp. announced a new family of phase-lock-loop (PLL) modules, with two initial members, models VFJA1490 and

VFJA1491, both supplied in miniature surface-mount packages measuring just 9 mm × 14 mm. The VFJA1490 models work with LVPECL, LVCMOS, and sinewave inputs from 10 to 200 MHz and provide LVPECL outputs at frequencies to 1 GHz with extremely low jitter of 65 fs measured 12 kHz to 20 MHz from the carrier. The phase noise is also low, at just -145 dBc/Hz offset 100 kHz from a 500 MHz carrier.

CTS Corp.
www.ctscorp.com

Dielectric Resonator Oscillator



Exodus Dynamics introduced the EDRO-1035-10.00, a 1 W, 10 GHz ultra low noise dielectric resonator oscillator (DRO), with



TTL RF muting and variable attenuation feature. The unit draws only 360 mA with +12 VDC and provides 19 dB of attenuation with -3 VDC supply.

Voltage-Controlled Oscillator



Z-Communications Inc. announced a RoHS compliant voltage-controlled oscillator (VCO) model TR01800A-LF. The TR01800A-LF is the first in a line of ceramic resonator VCOs

which saves precious board space while delivering exceptional phase noise performance. This innovative VCO covers the frequency of 1800 MHz within a tuning voltage range of 0.5 to 4.5 VDC while featuring a spectrally clean signal of -117 dBc/Hz at 10 kHz offset.

Z-Communications Inc.
www.zcomm.com

ANTENNAS

Body Worn Antennas



Southwest Antennas offers a full line of body worn antennas for dismounted user applications or covert surveillance operations where the radio and antenna system needs to be concealed on the body. These antennas weigh less than an ounce, and are tuned specifically to be used next to or close to the human body. Southwest Antennas offers models designed to operate in the UHF, L, and S-Band frequency ranges.

Southwest Antennas
www.southwestantennas.com

TEST EQUIPMENT

Phase Noise Analyzer



The new HA7062C real time phase noise analyzer is a cross correlation analyzer offering blazing fast data acquisition speeds with 0.1 Hz to 40 MHz measurement offsets. Accuracy is critical and is backed by an ANSI z540 calibration for NIST traceable data. Simultaneous AM/PM measurements with AM/PM isolation. Intuitive absolute and residual measurements and so much more. Holzworth Instrumentation has been designing, manufacturing, and utilizing industry leading phase noise analysis tools for more than a decade. Ultra low phase noise is its business.

Holzworth Instrumentation
www.holzworth.com

Assembly and Test Equipment



Since 1966, West • Bond Inc. has been a design and manufacturer of assembly and test equipment for the microelec-

tronic industry in Southern California. Including automatic, semiautomatic and manual ESD protected bonders, with ultrasonic, thermosonic, and thermocompression wire/ribbon capability. Included in product line are eutectic and epoxy die bonders, insulated wire bonders, and pull testers with its patented X-Y-Z, 8/1 ratio micromanipulator.

West • Bond Inc.
www.westbond.com

Custom Designs

CALL OR WRITE

waveline
SOLID STATE INC.

P.O. Box 718, West Caldwell, NJ 07006
(973) 226-9100 Fax: 973-226-1565
E-mail: wavelineinc.com



WAVEGUIDE SWITCHES - COAXIAL SWITCHES - DUAL SWITCHES

WE ARE THE WAVEGUIDE & COAXIAL SWITCH EXPERTS
YOUR #1 SOURCE FOR MICROWAVE SWITCHES

QUALITY, SERVICE & QUICK DELIVERIES UNMATCHED IN THE INDUSTRY

754 Fortune Crescent, Kingston, ON, K7P 2T3, Canada
Tel: 613 384 3939 - Fax: 613 384 5026
e-mail: info@astswitch.com

www.astswitch.com



ES MICROWAVE LLC.

Since 1985 we have offered our custom design filters and sub-assemblies in combine, interdigital and suspended-substrate technologies.

Broadband

Suspended-Substrate

Filters, Diplexers, Triplexers, Quadruplexers,

Quintuplexers, Sextuplexers...



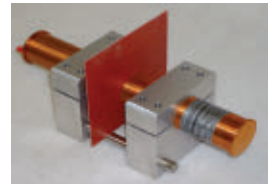
DC-40 GHz Filters
Multiplexers &
Switch Filter Banks

ES Microwave, LLC

8031 Cesana Avenue, Gaithersburg, MD 20879
P: 301-519-9407 F: 301-519-9418
www.esmicrowave.com

CIRCUIT BOARD TESTERS

- Standard Models-3 Octaves Each
 - From ~0.4 to ~20GHz
- Models-125HC, 08, 06, 03, 015
- Usable from -50 to +150° C



ϵ , $\tan \delta$ - Cavity™ sfwr

Thin Sheets, Substrates, Resins, Foams

www.damaskosinc.com

(610)358-0200 fax(610)558-1019

KR Electronics



www.krfilters.com
ISO 9001:2008 Certified

Custom & Standard Filters

40+ Years of Military & Commercial Applications

Bandpass
Anti-Aliasing
Highpass
Video Filters
Diplexers
Delay Equalized
Surface Mount

Lowpass
Notch
Root Cosine
Equalizers
Linear Phase
Absorptive
Matched

KR Electronics, Inc.
Avenel, NJ
www.krfilters.com

sales@krfilters.com
Phone 732.636.1900
Fax 732.636.1982

ELECTRICALLY CONDUCTIVE ADHESIVE SYSTEMS

- Epoxies
- Silicones
- Sodium silicate compounds

MASTERBOND

Celebrating our 40 year anniversary

+1.201.343.8983 • www.masterbond.com

SECTOR MICROWAVE
Don't sweat over your switching needs.

Our Waveguide and Coaxial switches are COOL!!



(631)242-2300 PHONE (631)242-8158 FAX
WWW.SECTORMICROWAVE.COM



REVOLUTIONARY HERMETIC SMP CONNECTORS

These SMPs meet the requirements of MIL-STD-348, but utilize unique housing interface features, which significantly improves reliability and production assembly yields. Proprietary techniques are used to independently control plating thickness on pin and housing.



For use with Aluminum, Kovar and other package materials

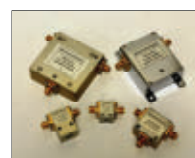


SPECIAL HERMETIC PRODUCTS, INC.

PO BOX 269 - WILTON - NH - 03086
(603) 654-2002 - Fax (603) 654-2533
E-mail: sales@shp-seals.com
Web: www.shp-seals.com

RF Amplifiers, Isolators and Circulators from 20MHz to 40GHz

- Super low noise RF amplifiers
- Broadband low noise amplifiers
- Input PIN diode protected low noise amplifiers
- General purpose gain block amplifiers
- High power RF amplifiers and broadband power amplifiers



- RF isolators and circulators
- High power coaxial and waveguide terminations
- High power coaxial attenuators
- PIN diode power limiters
- Active up and down converters

Wentek Microwave Corporation

138 W Pomona Ave, Monrovia, CA 91016

Phone: (626) 305-6666, Fax: (626) 602-3101

Email: sales@wentek.com, Website: www.wentek.com



Understanding Quartz Crystals and Oscillators

Ramón M. Cerda

Our world runs on quartz crystal oscillators. Every electronic system has one — or is locked to one — and every EE has “learned” about them in college and likely seen their schematics in countless block diagrams. Yet, unless you are designing crystal oscillators, you have probably relegated them to the black arts, like antennas. Even if you are tasked with specifying or designing one, learning how to do so is challenging. That’s what Ramón Cerda found, and that’s what prompted him to write an understandable text for the practicing engineer.

Cerda’s goal is to “demystify the field.” He does so in 15 chapters, beginning with a thorough discussion of

quartz crystals and their piezoelectric properties (discovered by Jacques and Pierre Curie in 1880), encompassing the nuances of flicker noise, drive level sensitivity and the effects of acceleration. Subsequent chapters address the design of crystal oscillators, including tutorials on oscillator theory and choosing the appropriate crystal for the application. A single chapter is devoted to phase noise and jitter, another to specifying performance based on the type of oscillator (clock, voltage controlled, temperature compensated, oven controlled and variations). The remaining chapters address specific oscillator types (Pierce-Gate, Colpitts and Butler), frequency multiplication techniques, characterization (Allan Variance) and testing (both electrical and environmental). For completeness, the book discusses MEMS resonators, given their widespread adoption and

use in oscillators. Cerda compares the performance obtained from MEMS to crystal oscillators, concluding that present MEMS oscillators, while having advantages and a “bright future,” have higher phase noise and jitter.

“Understanding Quartz Crystals and Oscillators” is understandable, thorough and a good reference to have on your bookshelf.

To order this book, contact:

Artech House

www.artechhouse.com

ISBN: 978-1-60807-118-0

299 pages

\$197

Available in hardcover and eBook formats

THE LATEST “WORDS” IN MICROWAVE DESIGN...



Microwave and RF Semiconductor Control Device Modeling

Robert H. Caverly

Hardcover • 290 pp. • 2016

ISBN: 978-1-63081-021-4

\$189 / £140



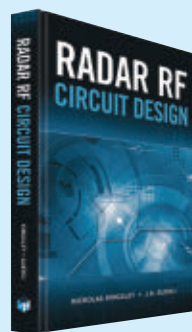
Electronics for Microwave Backhaul

Vittorio Camarchia, Roberto Quaglia, and Marco Pirola

Hardcover • 356 pp. • 2016

ISBN: 978-1-63081-015-3

\$179 / £133



Radar RF Circuit Design

Nickolas Kingsley and Joseph R. Guerri

Hardcover • 316 pp. • 2016

ISBN: 978-1-60807-970-4

\$169 / £128

US: Call 1-800-225-9977 (in the U.S. or Canada), or 1-781-769-9750, ext. 4030

Fax 1-781-769-6334

E-mail to: artech@ArtechHouse.com

UK: Call +44 (0)20 7596 8750

Fax +44 (0)20 7630-0166

E-mail artech-uk@ArtechHouse.com

For complete descriptions and to order, visit

ArtechHouse.com

All orders plus shipping/handling and applicable taxes.



ARTECH HOUSE
BOSTON | LONDON

685 Canton Street, Norwood, MA 02062 USA

16 Sussex Street, London SW1V 4RW UK

July Short Course Webinars

Technical Education Training Improving Base Station Design

Sponsored by: IDT

Live webcast: 7/20/16

**Register to attend at
mwjournal.com/webinars**

Past Webinars On Demand

Technical Education Training Series

- The Power of Testing IoT Devices in All Phases of the Product Lifecycle
- Radar Signal Generation with up to 2 GHz Bandwidth for Single-Channel and Multichannel Receiver Testing
- Faster Analysis of Complex RF Signals
- 802.11ax – High Efficiency Wireless Improving User Throughput in Dense User Environments
- Practical Antenna Design for Advanced Wireless Products
- Expanding the Possibilities of Cellular Wireless Infrastructure with GaN
- Designing Next-Gen Cellular and Wi-Fi Switches Using RF SOI Technology
- Improving Reliability and Efficiency with Solid State Spatial Combining Technology
- Effect of Conductor Profile Structure on Propagation in Transmission Lines
- Minimize Your Y-Factor Noise Figure Measurement Uncertainty
- Doherty at Eighty
- Millimeter Wave and E-Band Vector Network Analyzer Solutions
- Making Noise Work for You
- RF and Microwave Heating Simulation and Application Design
- Critical Aspects of Dielectric Constant Properties for High Frequency Circuit Design
- Demystifying MIMO Radar and Conventional Equivalents

RF/Microwave Training Series

Presented by: Besser Associates

- Introduction to Radar
- RF and Microwave Filters
- Mixers and Frequency Conversion

CST Webinar Series

- Hybrid Simulation for Electrically Large Aerospace Platforms
- Simulation of Implanted Medical Devices

Innovations in EDA

Presented by: Keysight Technologies

- Advances in High Power RF Design
- 5G Physical Layer Modeling: A Communication System Architect's Guide
- Designing X-Band PAs Using SMT Plastic Packaged GaN Transistors

Keysight Technologies Webcast

- LTE in the Unlicensed Spectrum
- Using a Multi-Touch UI to Streamline Signal Analyzer Measurements
- Testing Voice Over LTE on Your Device

Keysight RF and Microwave Basics Education Series

- Simulating, Generating and Analyzing Custom-Modulated Satellite Signals

Keysight FieldFox Series

- Wireless Site Survey, Spectrum Monitoring and Interference Analysis

ADVERTISER	PAGE No.	ADVERTISER	PAGE No.	ADVERTISER	PAGE No.
Advanced Switch Technology	117	Exodus Advanced Communications, Corp.....	32	Planar Monolithics Industries, Inc.....	65
American Technical Ceramics.....	59	Exodus Dynamics.....	78	Pletronics, Inc.....	64
AMTA 2016	108	Fairview Microwave.....	99	Polyphase Microwave, Inc.....	56
Anokiwave.....	33	Frontlynk Technologies Inc.	86	Pulsar Microwave Corporation	66
Anritsu Company.....	13	G.T. Microwave Inc.....	84	Quintech Electronics & Communications Inc. ..	82
API Technologies, Inmet.....	97	Herotek, Inc.....	18	R&D Interconnect Solutions	30
API Technologies, Weinschel	103	Holzworth Instrumentation.....	22	Reactel, Incorporated	45
AR RF/Microwave Instrumentation.....	71	Huber + Suhner AG.....	75	Remcom.....	85
Artech House.....	118	IFI, a unit of AMETEK CTS.....	44	RF-Lambda	31, 73, 111
B&Z Technologies, LLC	25	K&L Microwave, Inc.....	7	Richardson RFPD	19
Berkeley Nucleonics Corp.....	67	Keysight Technologies	29, 81	Rogers Corporation.....	57
Bird Technologies	56	KR Electronics, Inc.....	117	Rosenberger	93
Boonton Electronics (a Wireless Telecom Group Company).....	COV 2	L-3 Narda-MITEQ.....	37	SAF Tehnika	48
Cernex, Inc.....	114	Linear Technology Corporation	27	Sage Millimeter, Inc.....	23
Ciao Wireless, Inc.....	42	Master Bond Inc.	117	Sector Microwave Industries, Inc.	117
Coilcraft	15	MCV Microwave	40	Skyworks Solutions, Inc.....	79
CPI Beverly Microwave Division.....	6	MECA Electronics, Inc.	3	Special Hermetic Products, Inc.....	117
CST of America, Inc.....	21	MegaPhase.....	95	Spectrum Elektrotechnik GmbH	109
Custom MMIC	41	Mercury Systems, Inc.....	39	Stanford Research Systems.....	69
Damaskos Inc.....	117	MiCIAN GmbH	100	Synergy Microwave Corporation	55, 105
dBm Corp.....	28	Microwave Journal	52, 58, 117, 119	Taconic	89
EDI CON China 2017	60	Mini-Circuits	4-5, 16, 35, 49, 50, 61, 87, 101, 113, 121	Teledyne Microwave Solutions	53
EDI CON USA 2016.....	91, COV 3	National Instruments.....	9, 11	Waveline Inc.....	116
Empower RF Systems, Inc.....	26	NI Microwave Components	68	Weinschel Associates	34
ES Microwave, LLC.....	117	NoiseWave Corp.	8	Wenteq Microwave Corporation.....	117
ET Industries	72	Norden Millimeter Inc.	70	Wenzel Associates, Inc.	80
EuMW 2016	107, 115	OML Inc.	63	Werlatone, Inc.....	COV 4
EuMW Defence, Security and Space Forum 2016.....	46	Pasternack	76, 77	WIN Semiconductors Corp.	83
				Z-Communications, Inc.....	58

Sales Representatives



Frequency Matters.

**Eastern and
Central Time Zones**

Chuck Boyd
Northeast Reg. Sales Mgr.
(New England, New York,
Eastern Canada)
685 Canton Street
Norwood, MA 02062
Tel: (781) 619-1942
FAX: (781) 769-5037
cboyd@mwjournal.com

Michael Hallman
Eastern Reg. Sales Mgr.
(NJ, Mid-Atlantic, Southeast,
Midwest, TX)
4 Valley View Court
Middletown, MD 21769
Tel: (301) 371-8830
FAX: (301) 371-8832
mhallman@mwjournal.com

**Pacific and
Mountain Time Zones**

Brian Landy
Western Reg. Sales Mgr.
(CA, AZ, OR, WA, ID, NV, UT,
NM, CO, WY, MT, ND, SD, NE &
Western Canada)
144 Segre Place
Santa Cruz, CA 95060
Tel: (831) 426-4143
FAX: (831) 515-5444
blandy@mwjournal.com

International Sales

Richard Vaughan
International Sales Manager
16 Sussex Street
London SW1V 4RW, England
Tel: +44 207 596 8742
FAX: +44 207 596 8749
rvaughan@horizonhouse.co.uk

**Germany, Austria,
and Switzerland
(German-speaking)**

WMS Werbe- und Media Service
Brigitte Beranek
Gerhart-Hauptmann-Street 33,
D-72574 Bad Urach
Germany
Tel: +49 7125 407 31 18
FAX: +49 7125 407 31 08
bberanek@horizonhouse.com

Korea

Young-Seoh Chinn
JES Media International
2nd Floor, ANA Bldg.
257-1, Myungil-Dong
Kangdong-Gu
Seoul, 134-070 Korea
Tel: +82 2 481-3411
FAX: +82 2 481-3414
yschinn@horizonhouse.com

China

Shenzhen
Michael Tsui
ACT International
Tel: 86-755-25988571
FAX: 86-10-58607751
michaelt@actintl.com.hk

Shanghai

Linda Li
ACT International
Tel: 86-21-62511200
lindal@actintl.com.hk

Beijing

Oasis Guo
ACT International
Tel: 86-13011108861
oasisg@actintl.com.hk

Hong Kong, Taiwan, Singapore

Mark Mak
ACT International
Tel: 852-28386298
markm@actintl.com.hk

Japan

Katsuhiko Ishii
Ace Media Service Inc.
12-6, 4-Chome,
Nishiiko, Adachi-Ku
Tokyo 121-0824, Japan
Tel: +81 3 5691 3335
FAX: +81 3 5691 3336
amskatsu@dream.com

SUPER ULTRA WIDEBAND AMPLIFIERS

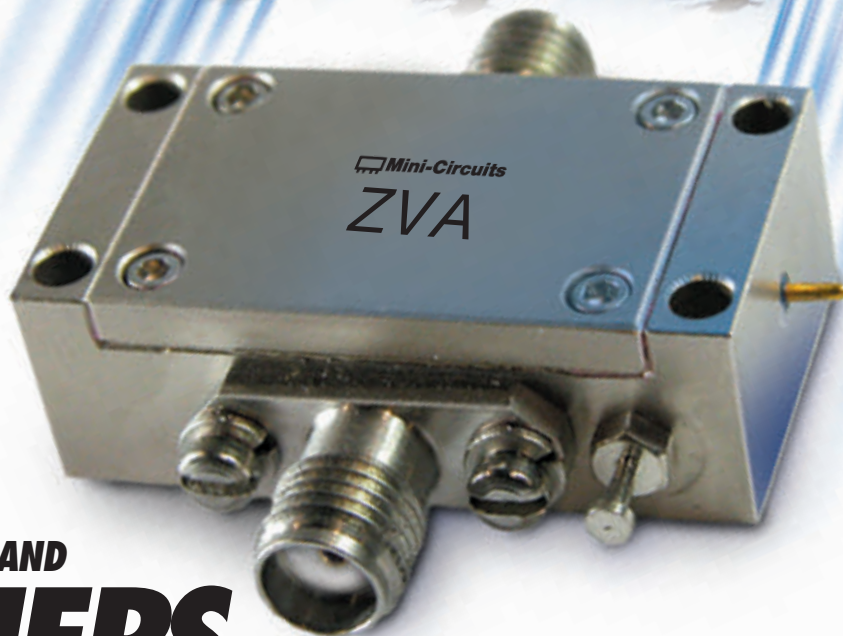
up to +27 dBm output... **0.1 to 21 GHz**

Ultra wide coverage and super flat gain make our ZVA family ideal for ECM, instrumentation, and test systems. With output power up to 0.5 Watts, they're simply some of the most usable amplifiers you'll find, for a wide range of applications and architectures!

All of our ZVA models are unconditionally stable, ruggedly constructed, and able to withstand open or short circuits at full output. For more details, from data sheets to environmental ratings, pricing, and real-time availability, just go to minicircuits.com!

All models IN STOCK!

 RoHS compliant



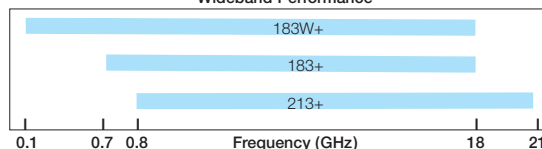
from **\$845** ea.

Electrical Specifications (-55 to +85°C base plate temperature)

Model	Frequency (GHz)	Gain (dB)	P1dB (dBm)	IP3 (dBm)	NF (dB)	Price \$ * (Qty. 1-9)
NEW ZVA-183WX+	0.1-18	28±2	27	35	3.0	1345.00
ZVA-183X+	0.7-18	26±1	24	33	3.0	845.00
ZVA-213X+	0.8-21	26±2	24	33	3.0	945.00

* Heat sink must be provided to limit base plate temperature. To order with heat sink, remove "X" from model number and add \$50 to price.

Wideband Performance



 **Mini-Circuits®**

www.minicircuits.com P.O. Box 350166, Brooklyn, NY 11235-0003 (718) 934-4500 sales@minicircuits.com

FAB\$ and LAB\$

From Powder to Product – Trans-Tech Does it All



Among the many world-class, high-volume manufacturing facilities located around the world within Skyworks, there is a small gem in Adamstown, Md. called Trans-Tech. Trans-Tech is a wholly owned subsidiary of Skyworks Solutions providing complementary state-of-the-art RF/microwave ceramic products. The company designs and manufactures a complete line of high quality, low cost ceramic based components for a number of applications within the RF/microwave business sector. Their product portfolio includes dielectric resonators and coaxial transmission line elements for DRO and VCO applications, ceramic bandpass filters, ferrite and garnet material for circulators/isolators. They also design and manufacture thermal barrier coatings and bio-ceramics. Trans-Tech services the wireless infrastructure, aerospace, automotive, military and medical markets — a broad reach for a small business.

The company was founded in Rockville, Md. by Dr. Herbert H. Greger in 1955 and was acquired by Alpha Industries, now Skyworks, in 1981. The company currently operates in 140,000 square feet of space in two locations employing about 240 people. Their locations include a circulator and isolator design team in Ireland, as well as sales, marketing engineering and quality workforce in China. Trans-Tech purchased MACOM's isolator business in 2011 and has been improving the ceramic resonator material by reducing its size while maintaining high RF performance levels. This has been accomplished using new ferrite material formulations producing a higher dielectric constant than previously achievable.

Trans-Tech's material expertise sets them apart from other manufacturers because they control the whole process from powder to finished product.

The company performs all of the processing from raw materials, forming, firing, finishing, to assembly and test. Trans-Tech uses about 75 different elements and more than 400 compositions of materials to produce these specialized, custom products that provide high performance end products to their customers. For ceramic processing, Trans-Tech does powder preparation via solid-state reactions, vibratory milling, ball milling and spray drying. Their forming processes include dry pressing, extrusion and isostatic presses that use up to 60,000 psi of pressure. Sintering is performed via tunnel, periodic, bottom load and air-fired/pressurized kilns and grinding is performed using many methods including CNC, surface, lapping, through-feed, ID and OD slicing and centerless. They also have extensive analysis equipment to measure the physical and electrical properties of their ceramics and end products.

Trans-Tech is working on replacing typical cavity style filters with a ceramic based SMT or connectorized filters with power handling > 100 W. They are also working to extend the typical 5.5 GHz frequency limit with ceramics, achieving designs up to 7 GHz. Work is ongoing to reduce resonator sizes and extend their frequency for 5G applications and others in the future.

As a small business within Skyworks, the culture is a family atmosphere driven to be agile. They respond quickly to customer needs and have an innovative spirit to solve problems with their materials expertise. Many workers have been there 30-plus years and some 40-plus years, demonstrating the close knit family environment. While they are a small group within Skyworks, their products are found in the most demanding wireless applications around the world as they continue to invent new material solutions for the wireless industry.

www.skyworksinc.com

Exhibition Space is Almost Sold Out. Book Your Booth Today!



September 20-22

**Hynes Convention Center
Boston, MA**

Join the Growing List of Exhibitors:

Keysight Technologies
Rohde & Schwarz
National Instruments
CST-Computer Simulation Technology AG
Mini-Circuits
A.J. Tuck Company
Accel-RF Instruments
Accurate Circuit Engineering
AdTech Ceramics
AEM
Agile Microwave Technology Inc.
Altair Engineering
Amplical Corp.
AmpliTech, Inc.
Analog Devices
Anokiwave
ANSYS
Applied Thin-Film Products
AR RF/Microwave Instrumentation
ARC Technologies
Ardent Concepts
ATE Systems
AWR
B & Z Technologies
Barry Industries, Inc.
Berkeley Nucleonics
Boonton
BSC Filters
CapeSym
Centerline Technologies

Colby Instruments
COMSOL Inc.
Copper Mountain Technologies
dBm Corp, Inc.
Dow-Key Microwave
Dynamic Engineers Inc.
Dynawave Incorporated
Electro Rent Corporation
EMSCAN
Essco Calibration Laboratory
Focus Microwaves
Fractal Antenna Systems
GEIB Refining Corp.
GigaTest Labs
Gowanda Electronics
High Frequency Electronics
Holzworth Instrumentation
Instec
Integra Technologies
Integrated Device Technology (IDT)
International Manufacturing Services
Ion Beam Milling
IW Microwave Product Division
JFW Industries, Inc.
K&L Microwave
Keysight EEsos EDA
L3 Narda - MITEQ
Lake Shore Cryotronics
Laser Services Inc.
Lighthouse Technical Sales

LPKF Laser and Electronics
MACOM
Marki Microwave
Massachusetts Bay Technologies
Mathworks
Maury Microwave
Mentor Graphics Corp.
Mercury Systems
Mician Inc.
MicroFab
Microlab
Microtech
Microwave Communications Laboratories,
MCLI
Microwave Development Laboratories
Microwave Product Digest
Microwave Products Group
Millitech
Mitsubishi Electric US
Modular Components National
MOSIS
Noise XT
Noisecom
Noisewave
Nuhertz Technologies, LLC
NXP Semiconductors
Ophir RF Inc.
Orban Microwave
Pickering Interfaces
Pico Technology

Piconics Inc.
Planar Monolithics Industries, Inc.
Pole/Zero
PPG Aerospace-Curing Microwave
Prosto Engineering
Queen Screw & Mfg. Inc.
Reactel Inc.
Response Microwave Inc.
Rogers Corp.
Semiconductor Enclosures, Inc.
SemiGen Inc.
Signal Integrity Software Inc (SiSoft)
SignalCore Inc.
Sonnet Software
Southwest Microwave, Inc.
SV Microwave
SW Filter Design
Synergy Microwave Corporation
Taconic
TechPlus Microwave, Inc.
Tech-X Corporation
Tektronix, Inc.
Times Microwave Systems
TowerJazz
Transline Technology Inc.
TTE Filters, LLC
T-Tech Inc.

Contact your MWJ Sales Representative

EDICONUSA.com

Premium Sponsors



BAE SYSTEMS

Raytheon

Organized By





WERLATONE®

Mismatch Tolerant®

High Power

Efficiency

Bandwidth

HIGH POWER COMBINERS

BIG STUFF!

- Power Levels to 20 kW CW
- Low Insertion Loss
- Isolated and Non-Isolated Designs
- Rack Mount, Drawer Mount, Radial Type
- Coherent and Non-Coherent Combining



A few of our Customer driven designs.

Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	Isolation (dB)	Size (Inches)
D8265	2-Way	1-50	5,000	0.3	20	15.5 x 11.75 x 5.25
D2075	2-Way	1.5-30	6,000	0.2	20	15.5 x 11.75 x 5.25
D8969	2-Way	1.5-30	12,500	0.2	20	17 x 17 x 8
D6139	4-Way	1.5-32	5,000	0.25	20	13 x 11 x 5
D6774	4-Way	1.5-32	20,000	0.3	20	21 x 17.25 x 11
D6846	6-Way	1.5-30	4,000	0.35	20	3U, 19" Rack
D8421	8-Way	1.5-30	12,000	0.3	20	22.5 x 19.5 x 8.75
D7685	4-Way	2-100	2,500	0.5	20	15 x 13 x 5.5
D2786	4-Way	20-150	4,000	0.5	20	18 x 17 x 5
D6078	2-Way	100-500	2,000	0.25	20	13 x 7 x 2.25
H7521	2-Way (180°)	200-400	2,500	0.3	20	15 x 10 x 2
D7502	2-Way	400-1000	2,500	0.25	NI*	9.38 x 3.38 x 1.25

*NI = No Isolating Terminations

Werlatone, Inc.
We Are High Power

17 Jon Barrett Road
Patterson, NY 12563
T 845 278 2220
F 845 278 3440
sales@werlatone.com
www.werlatone.com



Directional Couplers



Combiners/Dividers



90° Hybrids



180° Hybrids



Absorptive Filters