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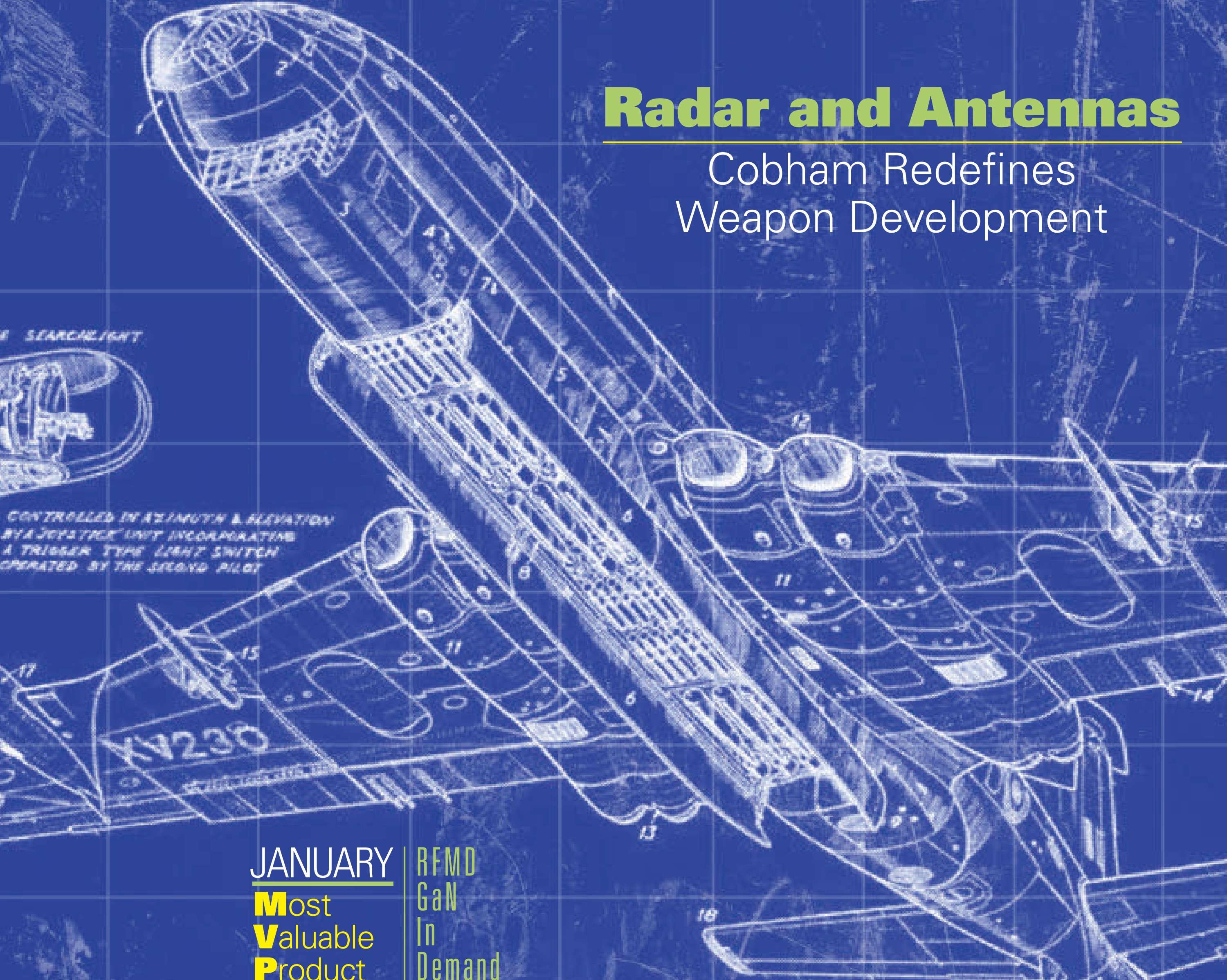
Microwave Journal



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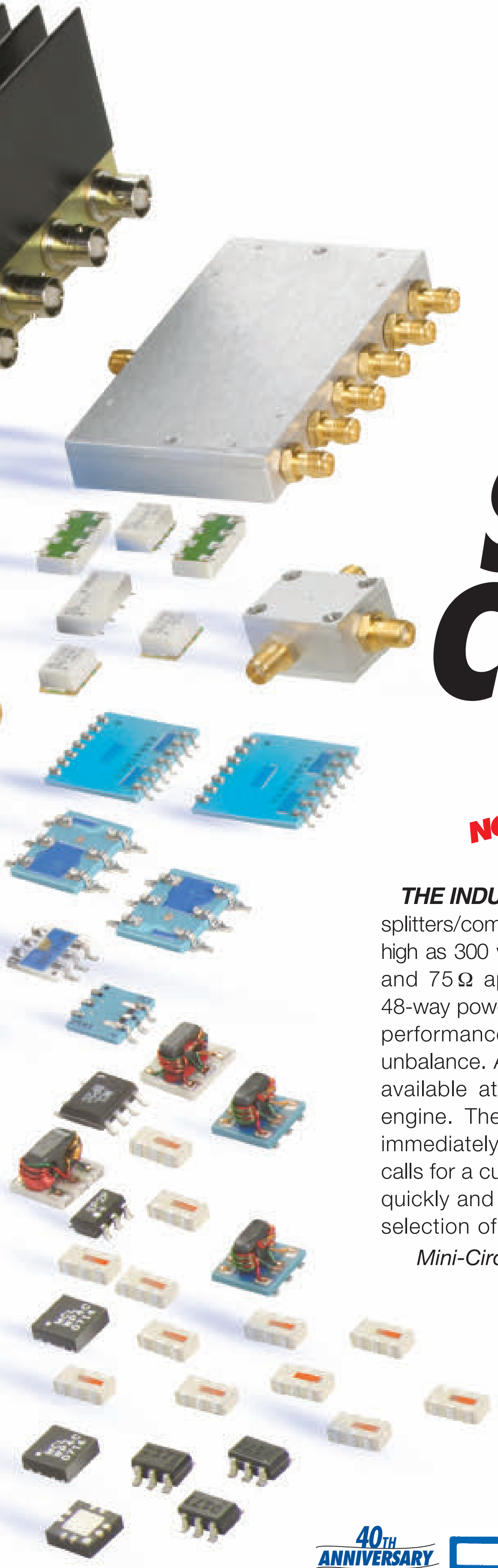

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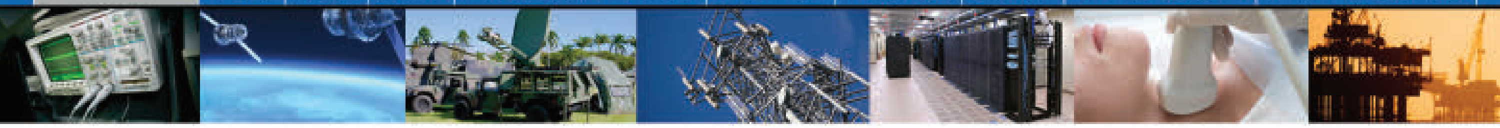

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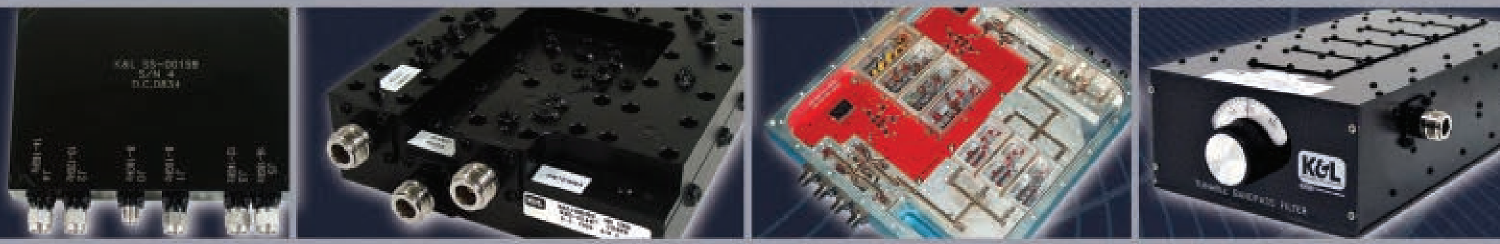


Microwave Journal

JANUARY 2010 VOL. 53 • NO. 1

FEATURES

NOTE FROM THE PUBLISHER

16 William Bazzy: 1920–2009

Carl Sheffres, Microwave Journal *Publisher*

A look back at the legacy of William Bazzy, the man who co-founded *Microwave Journal* more than 50 years ago

COVER FEATURE

24 Supporting the Warfighter: Adapting to the Changing Paradigm of the Defense Market

Jeremy Wensinger, Cobham Defense Systems

Ways in which solution providers and military users must collaborate to sustain and support national defense interests

MVP: MOST VALUABLE PRODUCT

40 The First in a Family of Versatile High Power GaN Transistors

RFMD

Introduction to a portfolio of gallium nitride unmatched power transistors ranging in power from 30 to 120 W

TUTORIAL

62 Automating Radar Measurement Tasks throughout the Lifecycle of a Radar System

Darren McCarthy, Tektronix Inc.

Use of automated signal generation and test software in helping engineers establish reliable and repeatable measurements

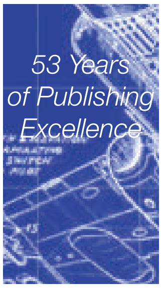
TECHNICAL FEATURES

76 Performance Improvement of Power Amplifiers Using an Asymmetrical Spurline Structure

Haiwen Liu, East China Jiaotong University; Fu Tong, Chinese Academy of Sciences

Introduction to an asymmetrical spurline structure used to reduce the higher harmonics of microwave power amplifiers

This month's cover image is courtesy of www.flightglobal.com



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MICROWAVE OFFICE

Microwave Journal

FEATURES

82 A Compact, Omni-directional, Circularly Polarized Microstrip Antenna

Jian An, Guang-ming Wang, Chen-xin Zhang and Hui-yong Zeng, Air Force Engineering University

Presentation of an omni-directional, circularly polarized antenna using a zero-order resonator with arc-shaped stubs

92 A Small Size, High Gain Antenna for Wireless Base Station Applications

Debatosh Guha, University of Calcutta; Yahia M.M. Antar, Royal Military College of Canada; P. Beland and M. Roper, Spotwave Wireless Inc.

Demonstration of a single-element high gain microstrip antenna operating over a wireless band covering eight percent impedance bandwidth

100 A Compact Planar Monopole Antenna for Ultra-wideband Operation

Jinwoo Jung and Yeongseog Lim, Chonnam National University; Hyeonjin Lee, Dongkang College

Proposed use of a planar monopole antenna with a subminiature version A connector for ultra-wideband operation

PRODUCT FEATURES

108 Switchable W-CDMA Power Amplifier Modules Supporting LTE

Mitsubishi Electric Corp.

Design of a series of power amplifier modules for current and future cell phone handset applications

116 Arch Roll Spherical Nearfield Scanner

Nearfield Systems Inc.

Development of a spherical scanner designed for wide angle satellite and radar antenna testing

DEPARTMENTS

19... Mark Your Calendar
20... Coming Events
45... Defense News
49... International Report
53... Commercial Market
56... Around the Circuit
124... Catalog Update
134... New Products
146... The Book End
148... Career Corner
152... Ad Index
152... Sales Reps
154... MWJ Puzzler

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Christopher Penney and Yong Wang, Remcom Inc.

Millimeter-wave Measurements Using Converters of the R&S ZVA Family
Michael Hiebel, Rohde & Schwarz

Setting Strategies for 4 x 4 Printed Beam Forming Networks
Leo G. Maloratsky, Aerospace Electronics Co.

Executive Interview

Shoiki Nakagawa, Division Manager of Semiconductor European Business Group at **Mitsubishi Electric Europe**, outlines the company's evolution from its inception in 1921, the Seven Guiding Principles that underpin its operation, environmental issues and how breakthrough technologies are identified and developed.

Expert Advice

Mike Lincoln of **TriQuint Semiconductor** discusses the advantages of GaN RF technology available through modules and other packaged products, die-level devices and foundry services, the technological alternatives to GaN and why engineers should consider Gallium Nitride for their next design.

EDA Focus

The latest release of Ansoft HFSS™ (v12.1) introduces a new integral equation solver option, based on 3-D full-wave method of moments (MoM) for large-scale, open, radiating and scattering simulations required by aircraft system integrators interested in antenna placement or radar cross section (RCS) studies.

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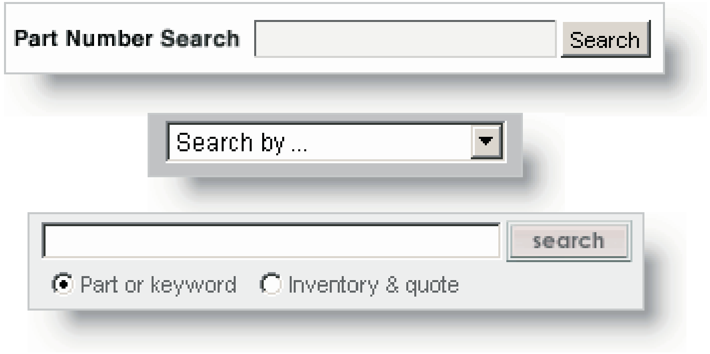

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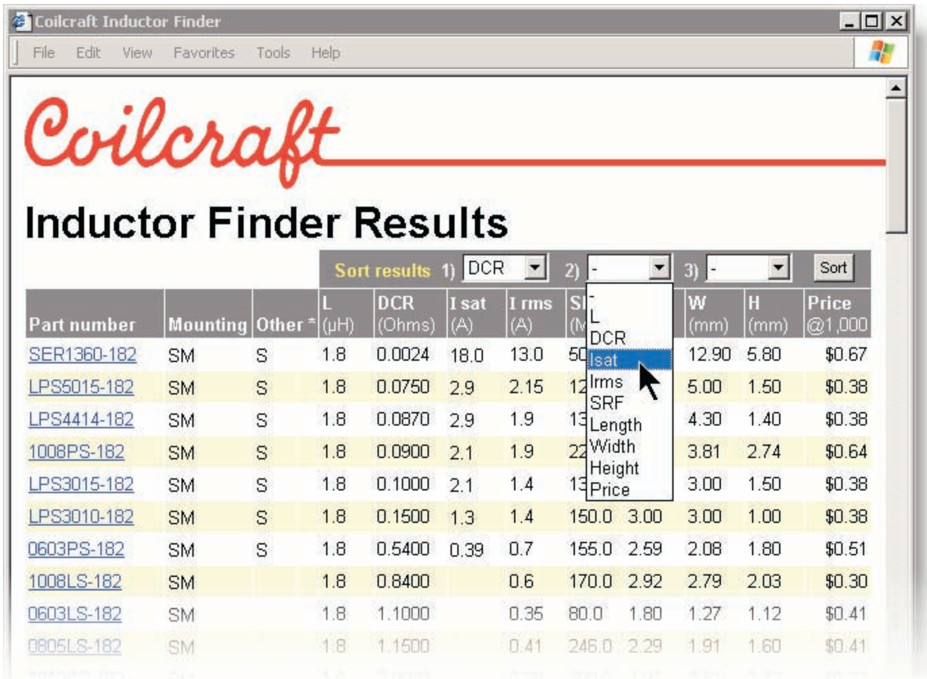

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William Bazzy: 1920-2009

Co-founder of Horizon House Inc./*Microwave Journal*

Microwave Journal mourns the passing last month of William "Leo" Bazzy, co-founder of Horizon House Inc. and *Microwave Journal,* at the age of 89. Mr. Bazzy was this magazine's first publisher, and served as president and chairman of Horizon House for more than 50 years. He also founded and served as publisher of *Telecommunications Magazine* and other specialty publications dedicated to advanced business practices in multimedia communications and wireless engineering for commercial, civil and defense industries.

William learned the basics of electrical engineering and wireless communications from the Army Signal Corps, where he served as a noncombat engineer during WWII, upon graduating from high school. After serving his country, he became an integral member of WBZ's radio engineering team. He led the technical team in the successful launch of WBZ TV in 1948, a first for New England, followed by a number of other innovations including live Red Sox games, in-studio debates featuring future-President Kennedy, and the area's first live daily news. He then worked for NBC's parent company RCA and other manufacturers to draft specifications in 1956 that became the universal standard for transmission of color television.

William left WBZ to found Horizon House in 1958. By joining in business with his brother Emil, who operated a printing press, they raised $10,000 to launch a new magazine called *Microwave Journal*. Ted Saad, an accomplished microwave engineer and industry entrepreneur, joined the two as a co-founder and served as the magazine's first technical editor. Together, they worked with the IEEE to establish and grow what is now the annual exhibition aligned with the MTT-S International Microwave Symposium. Horizon House remains a family owned and operated business, located in Norwood, MA, the town in which William spent most of his life, along with his loving wife Salwa.

In his "Publisher's Editorial", appearing in the debut issue of *Microwave Journal*, William wrote: "Our objective is simply to offer a forum to the industry and be the means of communication for the people in this segment of the electronic field". The idea was to create a magazine written for and by microwave engineers, covering not only the rapidly evolving technology, but also the people and companies driving that technology. William took a deep interest in what was going on throughout the industry, enjoyed meeting people and building the long-lasting relationships that ensured a stable supply of top-notch contributors and advertising support. He ended his editorial by saying "… we hope that this [the *Journal*] will enable the industry to keep in touch with one another, to keep the channels of communication open for the benefit of all".

William could have never imagined at the time how vastly those channels of communication would evolve.

For most of the fifty two year history of *Microwave Journal*, there was only one distribution mechanism to transmit information to readers—the print publication. Then came the internet, and it provided our readers with the ability to access content not only via print, but also our websites, newsletters and webinars. Social media and blogs have encouraged our community to interact like never before. As an example, *Microwave Journal* webinars have attracted thousands of viewers, and the social networks have added thousands of members. The channels of communication have never been more robust.

The magazine continues to evolve, while adhering to its core mission of delivering practical design information and market analysis to its microwave engineering audience. This month's cover feature on "Supporting the Warfighter: Adapting to the Changing Paradigm of the Defense Market" from Jeremy Wensinger of Cobham Defense Systems serves as an example of how the *Journal* continues to be a sounding board for industry leaders. It also illustrates how microwave companies continue to adapt the technology to meet current demands.

William Bazzy left a legacy that we're all proud of here at the *Journal*. At a time when a fledgling microwave industry was recovering from the post-war economic downturn in the defense sector, he launched a publication dedicated to the technology, businesses and entrepreneurs he believed were poised for great success. Today, as we face another challenging economy, we're committed to continuing his legacy and his mission, armed with an array of communication channels and poised for continued industry success.

Carl Sheffres
Publisher, *Microwave Journal*

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SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
31	1 **DesignCon 2010** Santa Clara, CA	2	3	4	5	6
7 **ISSCC 2010** **IEEE International Solid-state Circuits Conference** San Francisco, CA	8	9 **CST MICROWAVE STUDIO Training for EMC/Signal Integrity** Darmstadt, Germany	10	11	12	13
14	15 **GSMA Mobile World Congress** Barcelona, Spain **NATE 2010 National Association of Tower Erectors** Orlando, FL	16 **MWJ/Besser Webinar: LTE Focus** Sponsored by: AWR ROHDE & SCHWARZ	17	18	19	20
21	22 **IEEE International Microwave Workshop Series on RF Front-ends for Software Defined and Cognitive Radio Solutions** Aveiro, Portugal	23 Agilent Technologies **Agilent Technologies RF and Microwave Measurement Fundamentals** Westlake Village, CA	24	25	26	27
28	1	2	3	4	5	6

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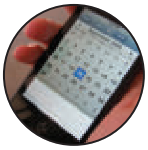

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Deadline: February 7, 2010
MILCOM 2010
Deadline: March 12, 2010
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JANUARY

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January 10–14, 2010 • New Orleans, LA
www.radiowirelessweek.org

MEMS 2010
IEEE International Conference on Micro Electromechanical Systems
January 24–28, 2010 • Hong Kong, China
www.ieeemems.org

FEBRUARY

DesignCon 2010
February 1–4, 2010 • Santa Clara, CA
www.designcon.com/2010

ISSCC 2010
IEEE International Solid-state Circuits Conference
February 7–11, 2010 • San Francisco, CA
www.isscc.org

GSMA Mobile World Congress
February 15–18, 2010 • Barcelona, Spain
www.mobileworldcongress.com

Nate 2010
National Association of Tower Erectors
February 15–18, 2010 • Orlando, FL
www.natehome.com

MARCH

EMV 2010
International Exhibition and Conference on Electromagnetic Compatibility
March 9–11, 2010 • Dusseldorf, Germany
www.e-emc.com

SATELLITE 2010
March 15–18, 2010 • National Harbor, MD
www.satellite2010.com

CTIA with RF/Microwave and M2M Zones
March 23–25, 2010 • Las Vegas, NV
www.ctiawireless.com

APRIL

WAMICON 2010
IEEE Wireless and Microwave Technology Conference
April 12–13, 2010 • Melbourne, FL
www.wamicon.org

APEMC 2010
Asia-Pacific Symposium on Electromagnetic Compatibility
April 12–16, 2010 • Beijing, China
www.apemc2010.org

MAY

MIE 2010 and ICMMT 2010
2010 Microwave Industry Exhibition in China (MIE 2010)

2010 International Conference on Microwave and Millimeter Wave Technology in China (ICMMT 2010)
May 8–11, 2010 • Chengdu, China
www.cnmw.org

RFIC 2010
IEEE Radio Frequency Integrated Circuits Symposium
May 23–25, 2010 • Anaheim, CA
www.rfic2010.org

IMS 2010
IEEE MTT-S International Microwave Symposium
May 23–28, 2010 • Anaheim, CA
www.ims2010.org

ARFTG 2010
75th ARFTG Microwave Measurement Conference
May 28, 2010 • Anaheim, CA
www.arftg.org

JULY

EMC 2010
IEEE International Symposium on Electromagnetic Compatibility
July 25–31, 2010 • Fort Lauderdale, FL
www.emc2010.org

SEPTEMBER

EuMW 2010
European Microwave Week
September 26–October 1, 2010
Paris, France
www.eumweek.com

OCTOBER

AMTA 2010
Antenna Measurement Techniques Association
October 10–15, 2010 • Atlanta, GA
www.amta2010.com

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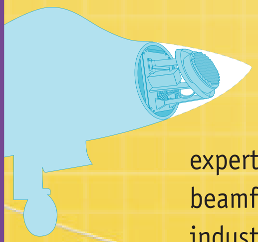

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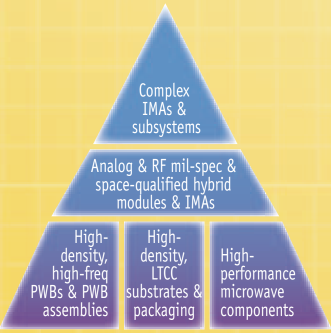

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SUPPORTING THE WARFIGHTER: ADAPTING TO THE CHANGING PARADIGM OF THE DEFENSE MARKET

It is a whole new world out there for defense companies. Department of Defense (DoD) budgets are under greater scrutiny, and pressure is mounting to reduce spending and change the way the US military does business. Yet new requirements and increasing demands are placed on the military every day, and the Global War on Terrorism continues into its eighth year. As a result, there is just not enough funding or resources to do everything that is being asked of our military. As the DoD formulates its plans to address these challenges, our business environment is becoming fundamentally different and increasingly complex.

I submit that these fundamental changes require each company to assess how we will adapt to meet rapidly evolving customer needs. It is a risky business situation, but some real trends are emerging to help us understand how to change the way we operate. We must make some "course heading" vector corrections in order to provide the most-affordable, best-technology and value-added solutions to meet DoD requirements.

This article explores these issues and their implications for defense programs, procurement policies and the way we suppliers must move forward. It sets the stage by looking at key economic issues framing the debate. It discusses changing priorities in defense spending and procurement and explores the paradigm shifts in modern warfare that drives DoD thinking about fighting in new environments. It looks at the emergence of the complex Battlefield of the Future, which is all about the networked warfighter. It also outlines the need for advanced sensors, net-centric operations, tactical communications and electronic warfare, which give the warfighter the 360° Mission Perspective necessary to meet the challenges of the modern and future battlefield. It evaluates issues central to the warfighter's needs, discusses implications for RF and microwave technology and our industry, and suggests how we must adapt to satisfy customer needs. It also shares some of our own Cobham Defense Systems insights and plans for growth and success by providing best-value solutions to assist the warfighter.

JEREMY WENSINGER
Cobham Defense Systems, Washington, DC

FRAMING THE ECONOMIC DEBATE

We clearly are living in challenging economic times. Access to credit markets is tight, institutional and private investors are wary of financial markets, and most economic projections are stagnant at best. Corporate leaders are asking themselves two questions: "How can we grow market share, provide opportunities for valued employees, and satisfy customers with reliable products and services?" and "How can we do more with less?"

The defense market faces similar economic issues. The DoD's budget will not be increasing in the out years, and it likely will decline for years to come. Supplemental Budget Requests—previously used to fund contingency operations in Operation Enduring Freedom/Operation Iraqi Freedom—will become part of the annual DoD appropriations process. In the past, supplementals sometimes funded programs not directly related to the fight on the ground, such as congressional "plus ups," specific earmarks for directed spending, additional quantity buys of certain weapon systems, and monies for "Not Funded Service Priority Items" for the three military services. For good or bad, those supplementals are now history.

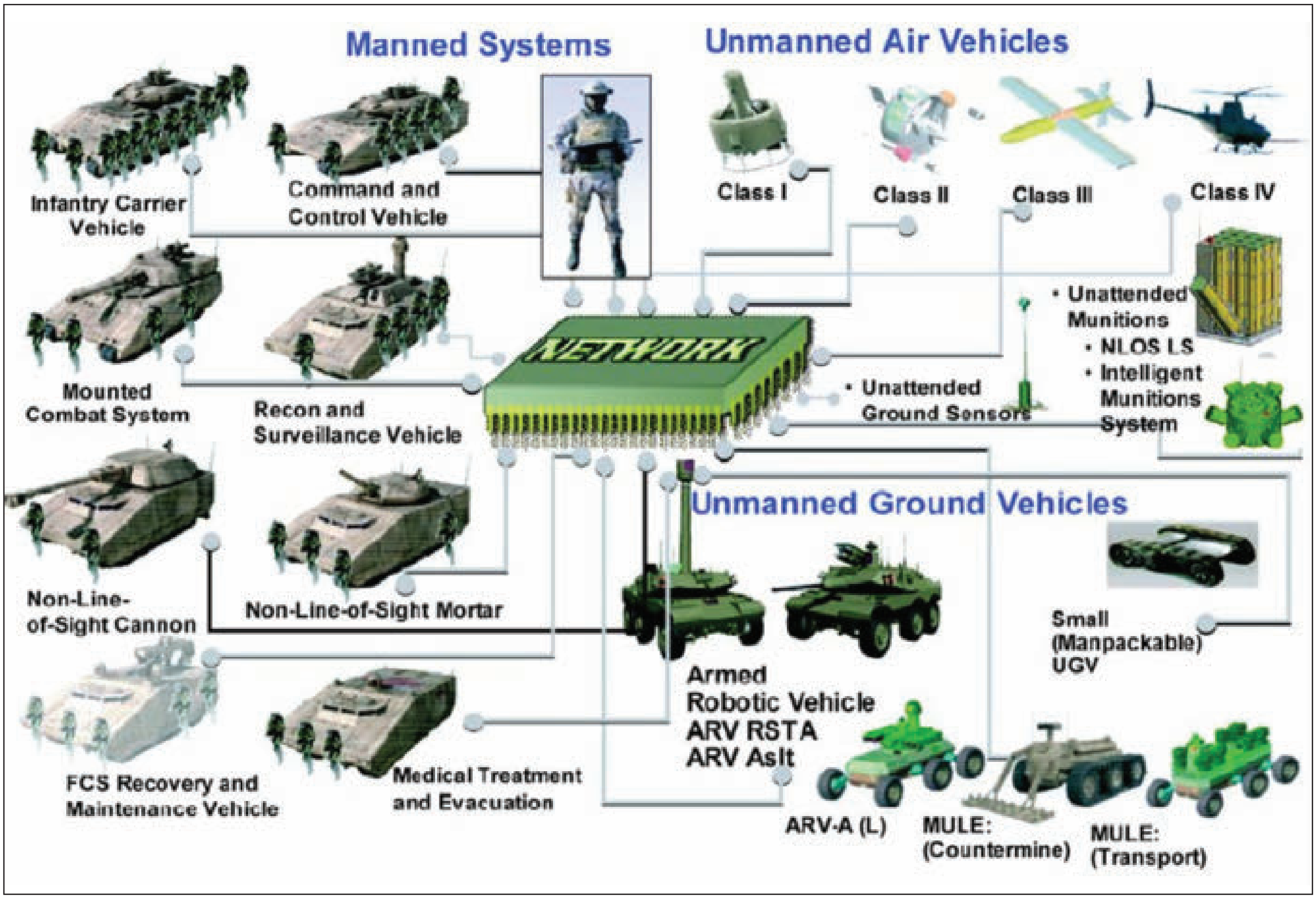
A NEW ERA IN DEFENSE PRIORITIES

A change in thinking is moving across the DoD and all the services. Secretary of Defense Robert Gates is leading the charge for reform. His "revolutionary and evolutionary" approach embodies strengthening such management concepts as accountability, performance to task and individual contractor responsibility. Gates is supported in these efforts by Deputy Secretary of Defense Bill Lynn and Under Secretary of Defense for Acquisition, Technology and Logistics, Ashton Carter. All share a common mindset for driving change. Congress has stepped up to the plate with the passing of a new public law last May giving Pentagon leadership the right language and legal authority to move forward with real and meaningful reforms in the way the DoD does business, directs its acquisition process and manages its weapons programs.

Certain programs are being canceled and contractors are being held more accountable for meeting requirements. As an example, the Army's massive Future Combat System (FCS) will likely be replaced with smaller modernization efforts because of escalating program costs, lack of a performance-based contract and, in large part, because the manned combat vehicle portion failed to reflect anti-insurgency lessons learned in Iraq and Afghanistan (see ***Figure 1***). On the acquisition side, new DoD procurement guidelines and acquisition reforms reflect changing priorities in which urgency is a factor in determining risk (i.e., going with an existing solution available to save lives today versus waiting for the promise of something better much later).

CAN WE AFFORD THE DEFENSE WE NEED?

Budget pressures, deficits, public bailouts of financial institutions and increased oversight of defense



▲ *Fig. 1 Future Combat Systems was envisioned to be a System of Systems solution set.*

spending, along with heated debate over healthcare reform costs, have the "pot of public opinion" on financial restraint bubbling over. At the same time, the Iraq and Afghanistan wars, potential for added resources and troop deployments, global terrorist threats, high-seas pirates and some bad state actors have all combined to create a "perfect storm complex threat environment." As a result, the burning questions facing our industry include:

- How can we get the DoD funding necessary to answer these threats given the economic climate?
- What will it take to equip, train and protect our warfighters with the advanced sensors, weapons and communications tools they need to successfully execute their missions?
- How do we ensure the safe return of all our brave men and women who go into harm's way in support of our national interests?
- How can the DoD and the defense industry, specifically those of us in the microwave technology community, come together to support the warfighter's technology and program needs?
- How can we address the political problems associated with affordability and cost growth reported on programs like F-22 Raptor, F-35 JSF and the Littoral Combat Ship?

THE NEED TO ADDRESS WHAT IS URGENT

Generational Defense programs are going away. Life cycles will be much shorter as the Services speed the way things are procured. Therefore, the defense industry must become more commercially oriented in bringing products to market quickly, and bringing technology development spirals into products faster.

General Peter W. Chiarelli, Vice Chief of Staff of the US Army, is highly critical of the "out of date ways" the Army buys weapons and equipment and believes soldiers are being shortchanged. "We have to find better ways to keep up with technology. It doesn't do us any good to have a procurement cycle that takes 10 to 15 years," he said recently in Washington at the October AUSA meetings.

Consider the evolution of the Joint Tactical Radio System (JTRS) program for the US Army. Initial radios took a very long time to design, configure and test. The development faced huge technological and manufacturing challenges. These radios are technologically complex and state-of-the-art and were very costly. As production approaches and trades are being made on how to use and deploy these radios, unit recurring costs are increasing even more. Some of these "follow on models" are becoming far more expensive than anticipated. There is no way every soldier will get a JTRS radio due to the cost. In addition, their ultimate deployment will

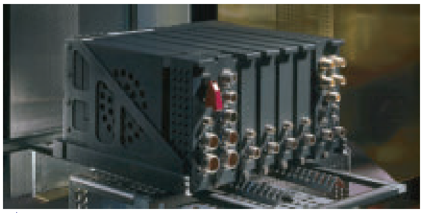
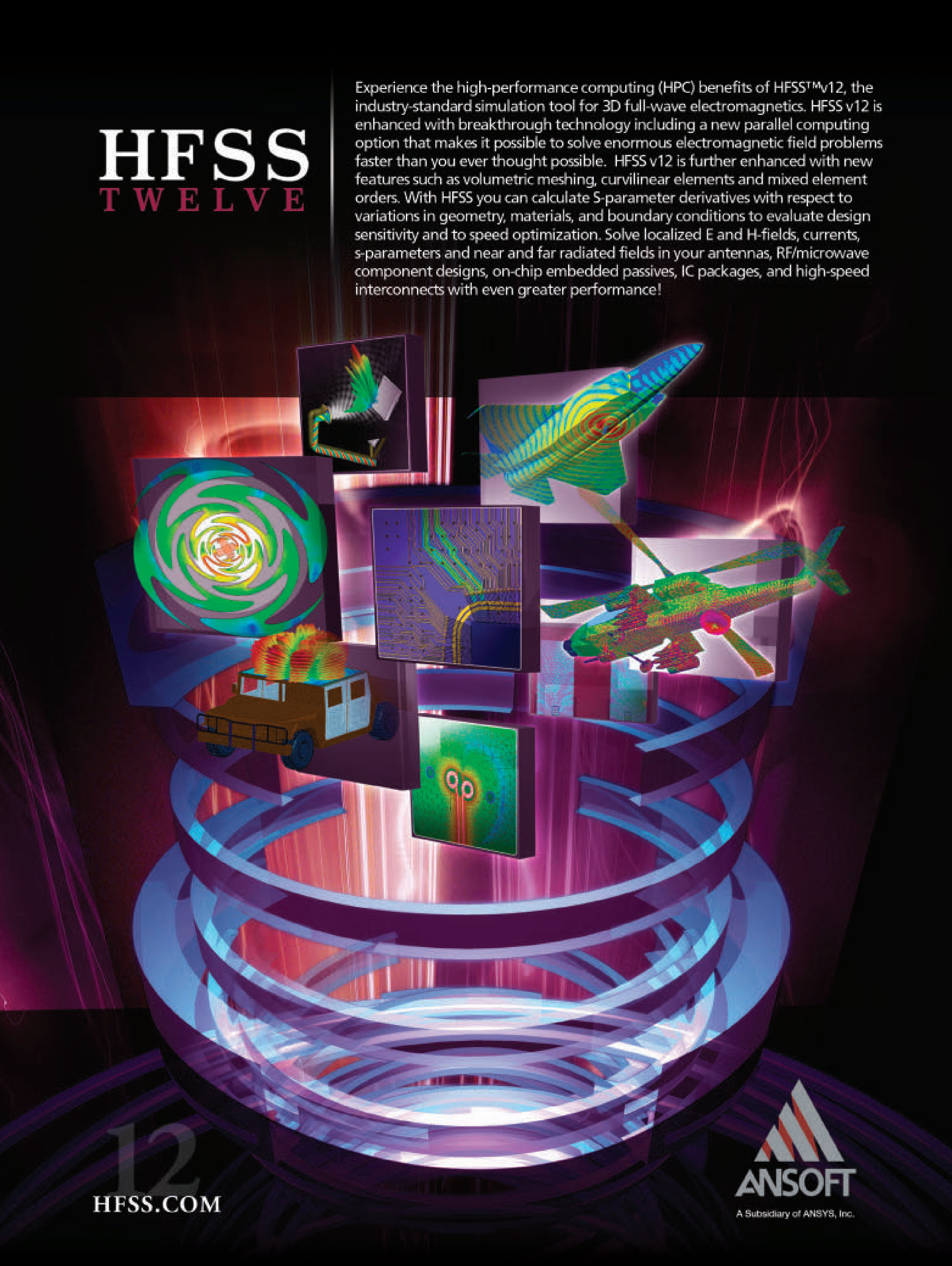


Fig. 2 The Joint Tactical Radio System enables state-of-the-art radio connectivity.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not be as widespread as originally anticipated (see ***Figure 2***).

The DoD Chief Technologist, Zachary Lemnios, recently conducted a study on bringing technology from the lab to the battlefield quickly. The purpose of the study was to identify lessons learned as well as effective tools and catalog best practices used by innovative defense firms. The study group was briefed on specific examples of how industry players rose to the challenge to meet urgent warfighter needs, such as Cobham Defense's efforts to deliver nearly 10,000 jamming devices to theater in less than 60 days to aid in the fight against insurgent Improvised Explosive Device (IED) attacks (see ***Figure 3***).

CHANGES IN MODERN WARFARE

The nature of the threat has fundamentally changed. Instead of international disputes that gradually escalate into major hostilities between nations, today's wars are often region-

▲ *Fig. 3 IED defeat activity is critical to today's threats.*

al conflicts that may erupt with little warning. Rather than facing only conventional military forces, warfighters must be informed and highly mobile to engage and defeat elusive bands of guerrillas, insurgents or terrorists anywhere around the globe. Military operations often are smaller in scale, becoming opportunistic missions waged by special operational forces against a shadowy enemy, as opposed to organized battles that match traditional forces against one another in a conventional cold war scenario.

In addition to the new rules of engagement, there are new military requirements. Victory has a less-concrete definition that depends more on efficient, real-time surveillance, quicker analysis of intelligence and swifter deployment of assets to engage and defeat the enemy. It is all about highly mobile forces, enhanced sensors and information networks, and greater precision and accuracy of deployed weapons. All information is required in all phases of the engagement. Communications and data flow in the battle is essential for all concepts of operation. Battle damage assessment has become critical to knowing the accuracy of weapons, the extent of damage, and any corresponding collateral effects. Contentious international issues arise when enemy propaganda accuses the US of "reckless deployment" of lethal force on unintended civilian areas. We have to get it right every time and be ready to show and prove the truth about how we engaged the enemy.

BATTLEFIELD OF THE FUTURE

The concept of warfighting is evolving from conventional conflicts with organized armies to irregular warfare with groups of insurgents, terrorists and non-state actors. It will be waged in multiple domains—land, sea, air, space and cyberspace. It will be directed against enemies both seen

and unseen with bullets, electrons, software, computers, network-centric information activities, advanced wireless technologies, unmanned vehicles, lethal force and real-time intelligence.

Success on the new battlefield requires what we at Cobham Defense Systems call 360° Mission Perspective—the ability to gather, manage and secure information from every angle in order to provide the warfighter with secure situational awareness and ultimate mission success. For example, we must deliver networked communications at the soldier level along with real-time imagery to identify enemy forces and coordinate operations. Our warfighters must be able to clearly understand their battle space and mission objectives, and how to achieve those objectives with the limited resources at hand. Battlefield information must be collected, analyzed and updated in real time to track an enemy that is highly mobile and hiding from view.

The warfighter also needs greater agility and mobility, and must be able to deploy the right assets to the right place at the right time. This means having the best weapons, communications and sensors available to detect, target and engage the enemy. In addition, because new threats also represent greater risks to both armed forces and civilians, our forces need advanced electronic sensors that can be used reliably as decision aides for accurate weapons engagement that minimizes any non-combatant casualties.

SENSOR REQUIREMENTS FOR FINDING COMBATANTS

The warfighter will face shadow enemies who seek to inflict the most harm whenever and wherever they can, in the shortest time possible and without regard to collateral damage, and then vanish as quickly as they appeared. These combatants want to move freely and operate with impunity. So how do we find them, track their movements, and anticipate their next moves and counter planned activities? What types of electronic sensors and systems will it take to ensure victory against these new and emerging threats?

For real-time intelligence, precise location information and accurate targeting data, warfighters need advanced radar and imagery sensor information. The tools must include the best radar sensors, radios and RF-directed weapons possible, enabled by RF, microwave and millimeter-wave technologies. Advanced sensors will help our forces target the "bad guys" and avoid the unintended consequences of injuring non-combatants. Today's solution providers must get the "electronic smarts" into battlefield weapons, communications gear and EW/radar sensors, quickly and affordably (see ***Figure 4***).

FOCUS ON THE WARFIGHTER

Everything today must be warfighter focused. Whether it is on the ground or in a helicopter, if it helps warfighters accomplish their missions, it is very relevant. As a nation, we must ask whether we are spending on things that do not assist the warfighter. As Secretary Gates has said, the DoD must buy the hardware to fight the wars we are fighting now; the futuristic stuff does not help today's soldier.

▲ *Fig. 4 Sensors like the US Army's EQ-36 will track back to launch enemy rockets, shells and grenades for counter fire.*

Our spending priorities must change to reflect the new paradigm. It is no longer just about tanks, bullets, guns, ships and fighters. Rather, it is about fighting with intelligence and focused lethality. It is about situational awareness, whether around a tank, a ship, a plane, or even a single soldier. Reform and political resolve are needed around defense appropriations so the military can focus on the mission and survivability of the warfighter.

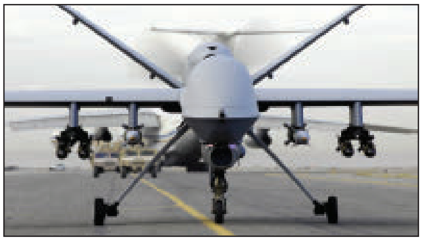
IMPLICATIONS FOR THE RF/MW INDUSTRY

How can we fight the battle in the physical domain as well as the electronic domain via satellites, sensors and imagery? Today, drones can be flown from bases in Nevada to the battlefields in Afghanistan, Iraq and anywhere else. The complexity of enabling specialized unmanned aerial vehicles (UAV) like the Global Hawk or Predator to be flown, controlled, engaged with the enemy and firing ordnance is very impressive (see ***Figure 5***).

Using more UAVs requires a new class of sensors, communication links and EW. Systems will require smaller, more agile platforms including microwave sensors. More and better sensors also are needed on the battlefield, along with a greater ability to use computer networks. Game changers will include specialized EW to protect the warfighter from IEDs.

It is getting to the point where the age of cyber warfare is upon us. When you consider the recent Israeli strike on the Syrian Nuclear Reactor in which all electronic systems went down (as reported by *Time* magazine and other media)—all military and computer networks, radar and surface-to-air missile sites, all communication and information operations—you realize that we are now going to battle with networks and "electrons."

The US Navy is taking on the affordability question as it views and develops



▲ *Fig. 5 UAVs for combat air support missions total on average 37 simultaneous flights at any one time.*

▲ *Fig. 6 The future of Navy Littoral Warfare—fighting the enemy close to the shore on land—will be defined by the LCS program.*

next-generation phased-array technology for its new fleet of warships (see ***Figure 6***). This includes radar, communications, EW, and other RF and microwave-related functions. It is proceeding under a Modular Open Systems Architecture (MOSA) approach in a program called Integrated Topside (InTOP) that is funded out of ONR, and supported by NRL, NAVSEA and others in the Navy. The idea is that these complex sensor systems can have well-defined interfaces between the various aspects of the system—antennas, T/R modules, beamforming networks, digital and advanced signal processors. Is it possible on a warship for these elements to function in a "plug and play" environment, similar to a desktop PC? If such a system architecture can be realized, it can be procured and maintained by the Navy in a far more cost-effective way than a single OEM that just has a systems specification for shipboard electronic systems. Today, the cost of electronics on a ship approximately equals the cost of the ship itself. This InTOP combat electronics program is geared to address that affordability problem.

ADAPTING TO CHANGE

Change never comes easy. The new defense marketplace requires all stakeholder organizations and their employees to rethink how they conduct their DoD business and operate to support the warfighter. Our customers cannot afford to keep developing new systems. The view forward is agility and affordability via sharing, reuse and modification. We must challenge conventional technology, wisdom and approaches to achieve true affordability of next-generation solutions.

All of us can benefit from this new approach, and we all have a stake in its success; whether it is military planners defining requirements more realistically (i.e., an 80 percent solution that is effective), DoD procurement leadership demanding strict cost realism in estimates and bids (i.e., expenditure planning that minimizes cost growth), or holding government and industry program managers more accountable for schedule and cost performance (i.e., terminating troubled and non-performing programs).

Successful solution providers will be those that can meet customer needs in a more efficient and nimble way. Everyone must work together in the best interest of the nation. By becoming facilitators of the process, we will find ways to compete and win in the new environment. Instead of being gatekeepers longing for the old ways and hoping to outlast the people with new ideas, we must adapt. Change is already in the building.

HOW COBHAM IS INNOVATING TO ASSIST THE CUSTOMER

Cobham Defense Systems has many sophisticated customers who

take on difficult technology and system challenges to improve military capabilities. To support these efforts, we have established a world-class technology and innovation business area that challenges traditional technology and manufacturing approaches. What is most unique about this area is its up-front focus on the process of innovation to achieve true affordability of next-generation sensor solutions.

Our engineers and scientists are tasked with challenging conventional wisdom and traditional thinking on hardware approaches. Their job is to define a workable solution that is more cost-effective and affordable than a traditional approach. This requires having a thorough knowledge of advanced microwave and millimeter-wave technology, advanced semiconductors and system engineering, and knowing how these issues affect system performance.

The new world of defense demands greater affordability, higher reliability and lower maintenance costs. It also opens the door for innovative companies with a common interest to team up on new opportunities. The best way defense OEMs and their partners can achieve the affordability and performance goals is to share their combined expertise in an integrated product team environment that can deliver full systems, individual components, and fully integrated subsystems, on time and on cost.

NEXT STEPS FOR OUR INDUSTRY

While it will be a difficult financial and management challenge to succeed in the new defense environment, we all have a stake in the outcome. Solution providers, military users and the DoD must collaborate to address requirements to sustain and support our warfighters and ensure our national defense interests.

We can help our customers get the warfighter a step ahead by improving combat efficiency and survivability, providing faster and more agile defense systems development, and delivering the technology, hardware, communications and information networks that are critical to victory on new and emerging battlefields.

We must be prepared for the engagements that are entered into today and tomorrow, not those of yesterday. We also must keep a laser-like focus on affordability and cost reduction and strive to implement extensive design reuse. Most importantly, we must employ a spirit of constant innovation for problem solving.

All of us at Cobham Defense Systems welcome the challenge of this dynamic defense marketplace. We commit to working with all stakeholders to provide the effective and affordable technology solutions and the 360° Mission Perspective our warfighters need to succeed. ■

Jeremy Wensinger *has served as President of Cobham Defense Systems since September 2008. Cobham Defense Systems is a division of Cobham Plc, which has been a valued technology partner and solutions provider to the aerospace and defense industries for 75 years. With more than 125,000 systems fielded with 18 allied armies around the world, Cobham Defense Systems is the world's ubiquitous supplier of advanced mission subsystems that move information between sensors and decision makers, delivering 360° Mission Perspective.*

THE FIRST IN A FAMILY OF VERSATILE HIGH POWER GaN TRANSISTORS

RFMD has developed a portfolio of Gallium Nitride (GaN) on Silicon Carbide (SiC) high power amplifiers and just recently released the first product from a family of discrete unmatched power transistors. The RF3931 is a 48 V, 30 W high power discrete transistor that operates in the DC to 3 GHz frequency range and is designed for commercial wireless infrastructure, defense/military, industrial/scientific/medical, test instrumentation and general purpose broadband amplifier applications.

Using an advanced high power density 0.5 µm GaN high electron mobility transistor (HEMT) semiconductor process, these high-performance amplifiers achieve high efficiency and flat gain over a broad frequency range in a single amplifier design. The RF3931 is an unmatched GaN transistor packaged in a hermetic, flanged ceramic package. This package provides excellent thermal stability through the use of advanced heat sink and power dissipation technologies. Ease of integration is accomplished through the incorporation of simple, optimized matching networks external to the package that provide wideband gain and power performance in a single amplifier. This is the first product released from a family of four unmatched power transistors ranging in power levels from 30 to 120 W.

DESIGN

The RF3931 utilizes RFMD's advanced 0.5 µm GaN1 process optimized for high-power and high-efficiency performance with the following process parameters: 28 to 48 V operation, Vbd>200 V, Pd 6-8 W/mm and Ft ~11 GHz. The RFMD GaN1 process is fully qualified and has a predicted Activation Energy E_a=2.3 with Mean Time to Failure (MTTF) of 9.2×10^6 at 200°C channel temperature. The GaN high-voltage process delivers lower output capacitance and higher impedance, enabling device designs that provide wider bandwidth and simpler matching circuits versus incumbent silicon processes.

RFMD's RF3931 is a depletion mode device and therefore requires a typical -5 to -6 V gate pinch-off voltage. The Vgsq to bias the transistor for nominal class AB operation is between -3 to -4 V. Even though the transistor is optimized for 48 V operation, it has been demonstrated to work at drain voltages as low as 28 V and as high as 65 V. The input capacitance is 9.5 pF or 0.3 pF/W; the output capacitance is 5.5 pF or 0.15 pF/W. The RF3931 is optimized for the DC to 3 GHz frequency range and is incorporated into an advanced, high thermal conductivity package that is required to support the higher power density of GaN. The bolt-down, 2-leaded-flange, hermetically sealed solution provides a robust, packaged designed to operate over temperature ranges from -40° to 85°C.

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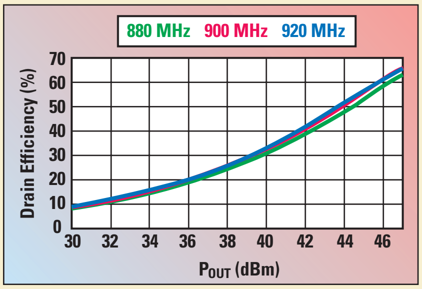

Fig. 1 RF3931 drain efficiency vs. output power at 900 MHz (Vds = 48 V, Idq = 130 mA).

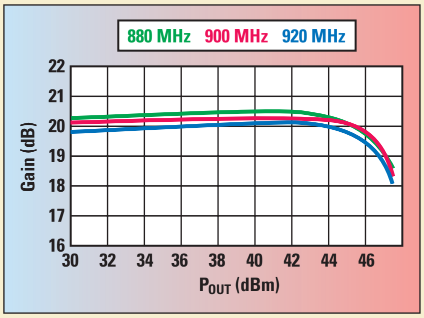

Fig. 2 RF3931 gain vs. output power at 900 MHz (Vds = 48 V, Idq = 130 mA).

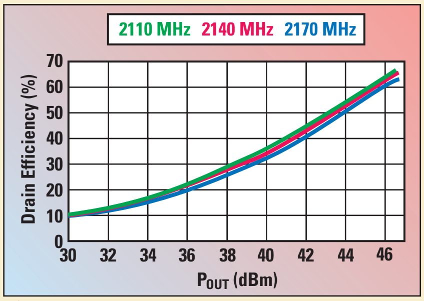

Fig. 3 RF3931 drain efficiency vs. output power at 2.1 GHz (Vds = 48 V, Idq = 130 mA).

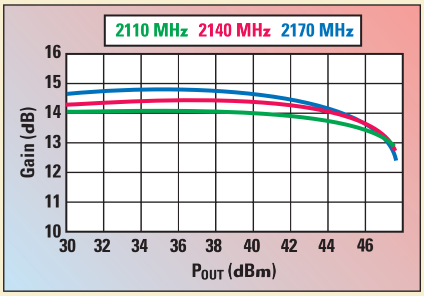

Fig. 4 RF3931 gain vs. output power at 2.1 GHz (Vds = 48 V, Idq = 130 mA).

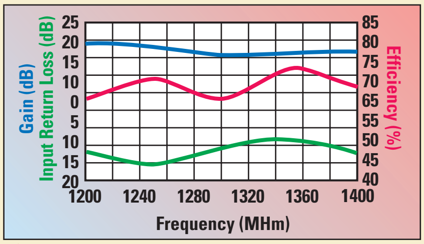

Fig. 5 RF3931 L-band (1200 to 1400 MHz) performance.

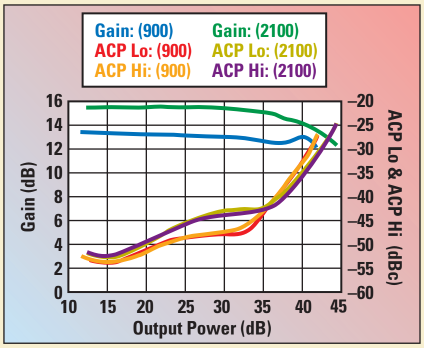

Fig. 6 RF3931 ACP measurements.

A summary of the RF3931's features include: 28 to 48 V operation; DC to 3 GHz broadband tunable frequency range. Performance at 900 MHz (see ***Figures 1*** and ***2***): 50 W typical peak power; 65% power added efficiency; 20 dB linear gain. Performance at 2.1 GHz (see ***Figures 3*** and ***4***): 40 W typical peak power; 62% power added efficiency; 15 dB linear gain. Common to both: 0.012 dB/°C gain variation over temperature; -40° to 85°C operating temperature range; 100 percent RF and DC tested; industry-standard 2-leaded flange ceramic package; RoHS compliant and lead-free; EAR99 export control.

Nonlinear models were developed to enable the design community to predict performance of the RF3931 in both linear and compressed applications. Efforts to improve the model performance over temperature at specific frequencies and power convergence are ongoing. Upgrades to the models will be made available to the market periodically.

NUMEROUS APPLICATIONS

Suitable for both linear and compressed end products, the RF3931 is an ideal solution for a multitude of applications requiring bandwidth, power and efficiency. Such applications include public mobile radios (PMR), military communications, civilian and military radar, military jamming, test instrumentation, commercial/cellular wireless infrastructure, and general purpose broadband amplifiers. End customers incorporating the RF3931 into next-generation systems will benefit from utilizing this advanced technology due to its ability to enable higher efficiency, higher power and wider bandwidth solutions versus the incumbent technology. These enhanced capabilities enable the RF3931 to provide value proposition(s) of reduced components, reduced cooling/thermal requirements, reduced weight/size, and ultimately, reduced installed costs.

The RF3931 performs well for both pulse and CW constant envelope applications. Optimum performance is highlighted by the results of a RF3931 fixture tuned for L-band 1200 to 1400 MHz frequency under pulse conditions. The RF3931, operating at Vdd=48 V and Idsq= 130 mA, provides 45 W output power with ~65 percent drain efficiency and ~17 dB gain over the full 200 MHz bandwidth when a 100 usec pulse width, 10 percent duty cycle waveform, is introduced to the fixture (see ***Figure 5***). The RF3931 L-band results were accomplished through simple, optimized matching networks external to the package.

Linear performance in high power amplifiers is important for applications using complex waveforms with high peak to average ratios (PAR). The RF3931 demonstrates respectable linear performance and can be used in both corrected and un-corrected linear architectures. The linear performance of the RF3931 achieves better than -40 and -45 dBc ACP for 2.1 GHz and 900 MHz, respectively, using 0 percent clipping on a 3G 64-channel test model to 34 dBm (see ***Figure 6***). Both examples demonstrate that the RF3931 is a versatile power amplifier that provides a range of power, efficiency, bandwidth and linearity from a single device. The inherent attributes in RFMD's GaN1 process and end product design allow for ease of implementation and superior performance in end customer applications.

CONCLUSION

RF3931 is the first product released in RFMD's new family of GaN unmatched power transistors ranging in power from 30 to 120 W. The design is incorporated in an advanced, high thermal conductivity flange ceramic package and has been developed to meet the needs of customers requiring optimal power performance for both compressed and linear applications. Based on RFMD's robust GaN1 HEMT process technology, the RF3931 offers customers high power and high efficiency broadband power amplification in a low-cost, green solution.

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VENDORVIEW

RS No. 300

Northrop Grumman Receives Contract to Supply Radar to Submarines

Northrop Grumman Corp.'s Sperry Marine business unit has been awarded a contract to supply navigation radar systems for eight new US Navy nuclear attack submarines. The firm, fixed-price contract, valued at $20.9 M, was awarded to Sperry Marine by Naval Sea Systems Command, Washington, DC.

The contract calls for Sperry Marine to produce and deliver eight AN/BPS-16(v)5 radar sets to be installed on eight Virginia-class Block III submarines. The scope of work will include manufacturing, fabrication, assembly and testing. The AN/BPS-16(v)5 is an advanced submarine navigation radar and electronic navigation system, which provides naval electronic chart display and information system (ECDIS-N) capability running on Sperry Marine's Voyage Management System (VMS) software.

...The contract calls for Sperry Marine to produce and deliver eight AN/BPS-16(v)5 radar sets...

"The AN/BPS-16(v)5 with VMS software will permit the new submarines to be certified to use ECDIS-N as their primary navigation tool," said J. Nolasco DaCunha, Vice President of Northrop Grumman Sperry Marine. "With this contract, the submarine community continues to make rapid progress toward the US Navy's goal of converting the entire fleet to ECDIS-N."

The Virginia-class Block III submarines are being built by Northrop Grumman Shipbuilding and General Dynamics Electric Boat. The lead submarine in the Block III build, North Dakota (SSN 784), is scheduled to be delivered in 2014.

Lockheed Martin Awarded $1 B Contract for Aegis Ballistic Missile Defense

The US Department of Defense's Missile Defense Agency (MDA) awarded Lockheed Martin a $1 B contract for continued development and evolution of the Aegis Ballistic Missile Defense (BMD) Weapon System. Under the contract, Lockheed Martin's Surface-Sea Based Missile Defense line of business, in Moorestown, NJ, will design, develop, integrate, test, deliver and install further Aegis BMD capability for the US and allied navies.

"This contract will both continue the spiral development of Aegis BMD capability to meet expanding global security threats and increase the number of BMD-capable ships at sea by integrating Aegis BMD into the Aegis Modernization program," explained Orlando Carvalho, Vice President and General Manager of the Lockheed Martin business completing the work. "This further supports the increasing demand for Aegis BMD capability worldwide, especially in light of the Administration's recent shift in policy in European Missile Defense."

Currently, a total of 21 Aegis BMD-equipped warships —19 in the US Navy and two in the Japanese Maritime Self-Defense Force—have the certified capability to engage ballistic missiles and perform long-range surveillance and tracking missions. The US Navy is modifying two additional US East Coast-based Aegis-equipped ships to perform ballistic missile defense.

The Aegis Weapon System is the world's premier naval defense system and the sea-based element of the US Ballistic Missile Defense System (BMDS). Its precision SPY-1 radar and integrated command and control system seamlessly guides the interceptor and uplinks target track information to the missile for terminal homing. Its ability to detect, track and engage targets ranging from sea-skimming cruise missiles to ballistic missiles in space is proven. The Aegis BMD Weapon System also integrates with the BMDS, receiving track data from and providing track information to other BMDS elements.

The 92 Aegis-equipped ships currently in service around the globe have more than 950 years of at-sea operational experience and have launched more than 3,500 missiles in tests and real-world operations. In addition to the US, Aegis is the maritime weapon system of choice for Australia, Japan, Norway, South Korea and Spain.

Raytheon Eyes International Contract Award for F-16 AESA Radar

Raytheon Co. moves closer to its first international sale of RACR (Raytheon Advanced Combat Radar) following approval for the company to move forward with technical discussions with at least two potential customers. Both countries are looking to upgrade their F-16 fleets within the next two years in order to keep their force structure at the cutting edge of today's complex battlespace. RACR is designed for all F-16s and is approved for export. The program is on schedule to fly production hardware on an F-16 during the first half of 2010.

"RACR continues to exceed expectations in meeting key production and integration milestones and has just wrapped up a series of validation tests at Lockheed Martin's system integration laboratory," said Tom Kennedy, Vice President of the Tactical Airborne Systems business division. The program demonstrated various radar capabilities in both air-to-air and air-to-ground modes as well as integration with Raytheon's F-16 center pedestal display. The new color display allows pilots to conduct simultaneous operations and provides a clearer picture of the overall battlespace.

"RACR has 90 percent software and hardware commonality with our combat-proven AESA radar for the F/A-18 Super Hornet. Several US Navy squadrons are already operational in theater with this technology today, while the Royal Austra-

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lian Air Force is also in flight training with our AESA radar system. This active production line allows us to provide F-16 customers with a high-performing, affordable but low-risk solution while also addressing obsolescence challenges they currently face with mechanical scanned radars," added Kennedy.

Microwave Journal partners with Strategy Analytics in a free webinar focused on AESA Radars. Live webcast: 1/28/2010, 11:00 am (ET)

Within the past year Raytheon has also installed the RACR radar twice on F-16s at both Lockheed Martin and Edwards Air Force Base. The seamless installation process demonstrated Raytheon's proven modular radar design resulting in an easy upgrade path for customers who need AESA radar capability.

Harris Completes Major Review for GOES-R Satellite

Harris Corp., an international communications and information technology company, successfully completed the first milestone in a National Oceanic and Atmospheric Administration (NOAA) program that will process 40 times more data than is possible today, and deliver weather images to more than 10,000 direct users. The Systems Requirements Review of the Geostationary Operational Environmental Satellite — Series R Ground Segment (GOES-R GS) program was completed recently in Melbourne, FL. The review ensures the system's functional and performance requirements and its preliminary program plan satisfy the GOES-R mission.

The ground segment of the GOES-R program encompasses receiving and processing of satellite data, generating and distributing of products from satellite data, and command and control of operational satellites. Harris is the prime contractor and systems integrator for the 10-year, potential $736 M contract.

"This milestone establishes a common understanding of all of the requirements the GOES-R ground segment must meet during development, deployment and operation," said Ray Thorpe, Vice President of GOES-R programs at Harris Government Communications Systems.

Today's GOES satellites provide the images and time-lapse sequences familiar to most Americans in television weather forecasts. They are the primary tool used by NOAA to detect and track hurricanes, thunderstorms, tornadoes and other severe weather in the continental US and western hemisphere. The next-generation GOES-R system will provide significantly improved image resolution.

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20 - 45 MHz, minimum	≥ 40 dB @ 60 MHz & ≥ 50 dB @ 90 - 600 MHz
20 - 75 MHz, minimum	≥ 40 dB @ 90 MHz & ≥ 50 dB @ 135 - 600 MHz
20 - 115 MHz, minimum	≥ 40 dB @ 150 MHz & ≥ 50 dB @ 250 - 600 MHz
20 - 150 MHz, minimum	≥ 40 dB @ 200 MHz & ≥ 50 dB @ 300 - 600 MHz
20 - 220 MHz, minimum	≥ 40 dB @ 300 MHz & ≥ 50 dB @ 450 - 900 MHz
20 - 335 MHz, minimum	≥ 40 dB @ 440 MHz & ≥ 50 dB @ 660 - 1400 MHz
20 - 500 MHz, minimum	≥ 35 dB @ 670 MHz & ≥ 50 dB @ 1005 - 2000 MHz
20 - 700 MHz, minimum	≥ 40 dB @ 980 MHz & ≥ 50 dB @ 1470 - 2000 MHz
20 - 1010 MHz, minimum	≥ 35 dB @ 1400 MHz & ≥ 50 dB @ 2100 - 3000 MHz
20 - 1400 MHz, minimum	≥ 40 dB @ 2000 MHz & ≥ 50 dB @ 3000 - 4200 MHz
20 - 2000 MHz, minimum	≥ 40 dB @ 2800 MHz & ≥ 50 dB @ 4200 - 5000 MHz
20 - 3000 MHz, minimum	≥ 40 dB @ 3940 MHz & ≥ 50 dB @ 5910 - 6000 MHz

Common Specifications

- IL: ≤ 0.3 dB @ PB
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Butterfly Wings Project Takes Off

Over the next three years scientists from QinetiQ and the University of Exeter, UK, will build on a portfolio of patented technology to develop new anti-counterfeit and RF technologies. The work will be based on groundbreaking physical sciences research in the field of tailored electromagnetic materials—made by studying the wings of butterflies.

By understanding how the wing surfaces control light to produce iridescence, the team will apply the same physics to control infrared, microwave or radio wave radiation to develop new anti-counterfeit technology, radio-frequency identification technology, WiFi efficiency and security applications.

The £3.2 M project is funded through the Engineering and Physical Sciences Research Council's (EPSRC) Knowledge Transfer Accounts (KTA), which were established to help translate research into business innovation. The initial product targets are in the growth markets of Radio Frequency Identification (RFID) and Anti-Counterfeiting measures (ACF). The team aims to launch its first innovation in spring 2010 and will be hosting a number of investor forum events at the university and in London.

"Butterfly wings create a myriad of visual effects through subtle changes... on their surface"

"Butterfly wings create a myriad of visual effects through subtle changes in the size, shape or structure of fine scales on their surface which can refract or absorb light and produce vivid colours," said Andrew Treen, QinetiQ's entrepreneur within the project. "By understanding the underlying optical properties, we can develop and apply the principles to a variety of other commercial applications in the infrared, microwave and radio wave segments of the spectrum and develop solutions that will help society. The natural world still holds many secrets, but this project will hopefully unlock a few more of them."

Galileo Ground Station Inaugurated

The site of a ground station for Galileo, Europe's global navigation satellite system, inside the Guiana Space Centre (CSG), near Kourou in French Guiana, has been inaugurated. The site, which was made available by France's Centre National d'Études Spatiales (CNES), will play an essential role in the setting up of the Galileo system, since it will accommodate the most comprehensive of the Galileo ground segment stations.

The Kourou station will consist of a telemetry, tracking and command (TT&C) station to monitor and control the Galileo constellation satellites, a sensor station (GSS) for acquisition of the satellite navigation signals, and two uplink stations (ULS) for transmission of navigation and integrity messages to the satellites. In all, the Galileo ground segment for the in-orbit validation phase (IOV) will comprise 18 sensor stations, five uplink stations, two telemetry, tracking and command stations, and two Galileo Control Centres (GCC).

The Kourou station will consist of a telemetry, tracking and command (TT&C) station

The Control Centres will be situated at Fucino in Italy and Oberpfaffenhofen in Germany. The data gathered by the sensor stations will be continuously transmitted to the GCCs where they will be processed by mission control in order to determine the navigation and integrity messages to be sent back to the satellites via the uplink stations. The Galileo system's capability to directly inform its users of the integrity level of its signal represents a major advance compared to other satellite navigation systems.

The inauguration of the Kourou site marks an important stage in the in-orbit validation phase of the Galileo programme developed by the European Space Agency (ESA) in cooperation with the European Commission. The first of the Galileo constellation satellites will be launched at the end of 2010. Subsequently, the Galileo ground station at Kourou will evolve as the system—which will consist of 30 satellites—is built up to full deployment, with the addition of two ULS antennas and two further redundant GSS channels, producing the final configuration.

EADS Opens R&T Branch in Bangalore

EADS Innovation Works, the European aerospace and defence group's research and development network, is opening a branch in Bangalore, India. Located within the Airbus Engineering Centre India's premises, EADS Innovation Works India will manage and broker R&T projects for the EADS Business Units and the Corporate R&T Organisation.

"The opening of EADS Innovation Works India is a part of our global research and technology strategy"

Some of the projects carried out will be performed in collaboration with Indian partners such as the Indian Institute of Science and the Indian Institutes of Technology. EADS Innovation Works India will also run its own projects using internal resources at its own facilities. The projects will capitalise on Indian capabilities identified by EADS in various fields: numerical simulation of complex physical systems, multi-disciplinary

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optimisation, high-performance computing and radar technology.

"The opening of EADS Innovation Works India is a part of our global research and technology strategy," said EADS CTO Jean Botti. "EADS is developing international R&T capabilities in order to access new technologies and engineering resources efficiently close to our strategic markets. India is an important part of our vision for research and technology growth and India has highly educated people that will offer tremendous value to our R & T capabilities."

Yann Barbaux, head of EADS Innovation Works, added: "Bangalore is India's aerospace and IT hub; it was important for us to be present. The opening of this new branch of EADS Innovation Works, the third one outside of Europe, will again put some fresh ideas in our innovation process."

SMS Wins Award for Microwave Source Development

Specialist Microwave Solutions Ltd. (SMS) has been awarded a two-year Knowledge Transfer Partnership (KTP) sponsored by the UK Technology Strategy Board. As a result, SMS will work together with Cranfield University's Manufacturing Department, within the School of Applied Sciences and with their microwave experts from the Defence and Security academy in Shrivenham, to develop cost-effective microwave sources and associated technologies for radar, secure communications and electronic sensing system applications.

SMS Ltd. enjoys a strong market presence in the UK for microwave components, assemblies and sub-systems for the aerospace, defence and industrial sectors; successful achievement of the KTP will expand the company's capability to include complex state-of-the-art microwave sources.

...successful achievement of the KTP will expand the company's capability

Benefits will include increased value added within their existing component and sub-system business as a result of the ability to reduce costs by higher levels of integration and less reliance on bought-in parts. Cranfield University has strong expertise in microwave engineering, design optimisation, cost engineering, value engineering, and obsolescence management, across a range of industry sectors and has successfully conducted a number of projects in these areas.

WiFi Hotspot Market Stages Revival in 2009

The Wi-Fi hotspot market is entering a revival period marked by renewed interest from communication providers and increased usage among both business and leisure users, reports In-Stat. In-Stat estimates that hotspot usage will increase in 2009 by 47 percent, bringing total worldwide connects to 1.2 billion.

"A market that appeared to be languishing due to revenue shortcomings has found a renewed life force," says Frank Dickson, In-Stat Analyst. "Mobile operators have become increasingly involved in the hotspot market globally as they assess the potential of hotspots to offload wireless data traffic from overburdened 3G networks. Also, mass market adoption of Wi-Fi-enabled smartphones has significantly altered hotspot usage, with these devices accounting for the majority of access sessions in some locations." Recent research by In-Stat found the following:

...hotspot usage will increase in 2009 by 47 percent...

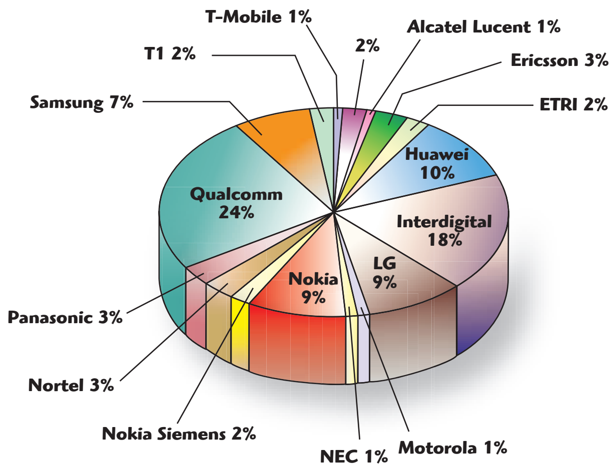
- Total worldwide hotspot venues will reach 245,000 locations in 2009.
- AT&T is on course to experience 500 percent usage growth for 2008 vs. 2009.
- Asia-Pacific will experience the greatest growth in venue deployments over the next few years, largely driven by large-scale deployments in China.
- Survey results suggest that security concerns by individuals, not corporate users, are limiting hotspot usage.

The research, "Wi-Fi Hotspots: Cellular Handsets and Portable Devices Drive a Market Renaissance," covers the worldwide market for Wi-Fi hotspots. It includes:

- Forecasts of mobile handsets with embedded Wi-Fi sales through 2013.
- Forecasts of hotspot venue and usage growth for North America, Asia and Europe through 2013.
- Results and analysis of an In-Stat consumer survey.
- Provider segmentation and deployment analysis.
- Profiles of major players, including AT&T, Swisscom, Boingo, iPass and WeRoam.
- Discussion of emerging applications.

Qualcomm Takes Lead as 4G Patent Holder

Qualcomm looks set to be the leading patent holder in 4G wireless communications after recording 24 percent of ETSI declarations surrounding LTE, as well as 16 percent of the 26,000 patents that have potential relevance to 4G technologies generally, including WiMAX. Other notable players in the LTE field include Interdigital (18 percent), Huawei (10 percent), LG (9 percent), Nokia (9 percent) and Samsung (7 percent). When considering the whole 4G environment Samsung takes second spot



Source: ABI Research

with 12 percent of all patent filings, and Nokia takes third with 6 percent.

Stuart Carlaw, Chief Research Officer at ABI Research, comments, "Innovation in this space continues unabated. Given that these declarations reflect work completed 18 months ago, it is very feasible that this landscape could shift again during the coming two years as we see the 4G market ramp up. We see no major reason why the licensing situation in 4G will be significantly different from that for 3G. There is still a big list of 'haves' but also a large list of 'have-nots'. The only major change is that the list of haves has changed significantly to embrace newly active patent holders such as Samsung and Huawei."

These data are contained in ABI Research's database product "LTE and WiMAX Intellectual Landscapes." The research was compiled through analysis of IEEE declarations of essentiality as well as a full search of patents relating to OFDM, OFDMA, Beamforming, SDMA, HARQ, SC-FDMA, MIMO and Fast Power Control. It forms part of the firm's 4G Research Service, which also includes Research Reports, Research Briefs, ABI Insights, ABI Vendor Matrices and analyst inquiry support.

Shipments of WiMAX Chipsets Reach Four Million

Shipments of mobile WiMAX chipsets were predicted to reach four million by the end of 2009 according to the latest research by Maravedis, who in partnership with Reveal Wireless released its new report "WiMAX Wave2 Subscriber Station Chipset Vendors Competitive Analysis." Maravedis and Reveal Wireless found that the WiMAX subscriber station chipset ecosystem is acutely fragmented, with more than 14 chipset vendors competing for market share. "This puts pressure on vendors with insufficient customer traction, lacking funding or scale, or offering only partial chipset solutions," said Adlane Fellah, Maravedis CEO and Founder and Co-author of the report.

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Several early movers that entered the WiMAX market with fixed or Wave1 mobile solutions are now shipping Wave2 compliant chipsets, mainly composed of a baseband chip and companion RF transceiver IC. "However, most of the available chipsets are not highly optimized because they were compelled to cover a broad range of application segments," noted Pascal Deriot, Senior Analyst and Co-author of the report. "We believe that WiMAX mass market adoption requires ubiquitous coverage and IOT mature, sub $10 chipsets that are power and performance optimized for each application-specific segment."

...the WiMAX subscriber station chipset ecosystem is acutely fragmented, with more than 14 chipset vendors competing for market share

This research provides a detailed comparison of the key WiMAX chipset vendors, identifying system architectures, estimating chipset and system BOM, cost of available devices, such as CPEs, USB dongles or Express Cards, and researching vendor product roadmaps and SWOT. The report covers over 29 baseband, RF IC and module solutions from 14 WiMAX vendors, and profiles the five key players—Beceem, GCT, Intel, Samsung and Sequans—offering an in-depth analysis of each chipset.

Select Key Findings:

- The five key players have introduced differentiated chipset solutions, enabling them to gain significant leadership in their target market segments.
- Few WiMAX chipset players have the scale to effectively address all segments; no global leader has emerged in 2009.
- Mixed process technologies and packaging approach have been launched in 2009, from monolithic solutions to System-in-Package implementations to save cost and space.
- Similar to WiFi or 3GPP/3GPP2 platforms, vendors leverage their first or second generations to further reduce chipset cost and improve footprint, Bill of Material and performance.
- Three chipset vendors are best positioned to achieve the US$10 price target through baseband and RF monolithic die integration in 65-nm.
- The WiMAX market is not large enough to support 14 chipset vendors. Consolidations, exits and transitions toward LTE are expected in the next two years.

The report also analyzes the difficult choices faced by small chipset players with limited budgets. The next challenge for most WiMAX chipset vendors will be to find the right balance of R&D investments in an LTE transition and a more integrated and cost-effective path for their WiMAX solution.

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INDUSTRY NEWS

Keithley Instruments Inc., a leader in advanced electrical test instruments and systems, announced that it has signed a definitive agreement with **Agilent Technologies Inc.** to sell substantially all of its RF product line to Agilent. Following the closing, it is anticipated that the majority of the RF team will become Agilent employees. Under the terms of the agreement, the company will transfer substantially all of the assets associated with the RF product line and Agilent will assume certain related liabilities. Agilent will provide global sales, service and support for the existing RF product line. The company expects to receive cash proceeds of approximately $9 M and to realize a pre-tax gain in the range of $2.5 to $3.5 M during its first quarter ended December 31, 2009, as a result of the sale.

Molex Inc., an electronic components company, announced that it has completed the acquisition of China-based Zhenjiang Tean Telecom & Appliance Co. Ltd. (Tean), located in Jiangsu Province. Tean designs and manufactures a variety of radio frequency (RF) and microwave products for the telecom and base station/wireless markets globally.

AWR®, an innovation leader in high-frequency electronic design automation (EDA), and AMPSA, a supplier of RF and microwave amplifier design software, announced a relationship that enables AWR to incorporate AMPSA's Multimatch amplifier design technology as an optional module into its industry-leading Microwave Office high-frequency design software. By making the Multimatch Amplifier Design Wizard (Multimatch ADW) readily available to Microwave Office software users, designers gain ready access to design technology for realizing state-of-the-art, high-dynamic-range RF and microwave amplifiers (Class A and Class B).

Cobham has opened a new facility in Exeter, NH, that will immediately accommodate 80 new jobs related to the manufacture of cable systems sold to the US Government and major aerospace and defense companies. Cobham Sensor Systems products manufactured at this facility support electronics warfare and command, control, communications, computers, intelligence, surveillance and reconnaissance (C4ISR) applications, as well as a wide variety of major airborne, shipboard, ground-based, space-based and homeland security-related radar platforms.

Rochester Electronics, a comprehensive and authorized source for discontinued semiconductors, is actively expanding its mission critical product manufacturing capabilities to ensure a continuous supply of certified radiation hardened space-level semiconductors. An approved member of the Class V Qualified Manufacturer List (QML) by the Defense Supply Center Columbus (DSCC), Rochester Electronics is contractually licensed by National Semiconductor, TI, Fairchild and other leading semiconductor firms, to provide a continuing manufacturing source for products they no longer make.

DragonWave Inc., a supplier of packet microwave radio systems for mobile and access networks, announced that it has received Metro Ethernet Forum (MEF) certification for its Horizon Compact packet microwave radio solution. The MEF certification program provides service level benchmarks for manufacturers' equipment and service provider performance in complex Ethernet-based networks. Horizon Compact is now MEF 9 and MEF 14 certified.

Cobham SATCOM, a manufacturer of Inmarsat satellite communications equipment, announced that the HGA-7001 High Gain Antenna subsystem has been certified on the Airbus A320 (Single Aisle) family of airframes. This complements an ever growing range of airframes on which the system is deployed and confirms the general appeal and acceptance that this product enjoys in the aeronautical market. Cobham also confirmed the first deliveries of this product to Airbus for installation on airline aircraft.

Skyworks Solutions Inc., an innovator of high reliability analog and mixed signal semiconductors enabling a broad range of end markets, announced that the company's expanded ISO/TS 16949 certification now includes its entire Mexicali, Mexico manufacturing facility. Skyworks' 2007 ISO/TS 16949 certification previously covered only certain facets of its Mexicali operations.

Rodelco Electronics Corp. has received an AS9100B supplier certification for the design, development and manufacture of RF/microwave assemblies, microelectronic circuits and electronic assemblies. The certificate was issued by National Quality Assurance, USA. Rodelco is a manufacturer of high quality, custom developed, RF and microwave components and assemblies for the military and OEM market.

Gowanda Electronics installed two cleanrooms at its facilities in upstate New York. It is the first inductor manufacturer to install multiple cleanrooms. The cleanrooms are Class 100,000, but can be upgraded to Class 10,000 as needed to meet customer requirements. The installation of these cleanrooms reflects Gowanda's commitment to the electronics industry and to the increasing demands/requirements of its customers.

CONTRACTS

Comtech Telecommunications Corp. announced that its Tempe, Arizona-based subsidiary, **Comtech EF Data Corp.**, received $2.4 M in orders for satellite modems and redundancy switches. The equipment will be employed by the United States government to support an ongoing military communications program. The order includes the DMD2050 Universal Satellite Modem and corresponding redundancy switches.

RF Micro Devices Inc. (RFMD) announced that RFMD has been selected by a leading manufacturer of smartphones to support two upcoming CDMA smartphones. RFMD will supply its high performance RF1130 single-pole three-throw (SP3T) cellular switch into two upcoming

models targeting the consumer smartphone market. The first device is expected to launch in the first half of calendar 2010, and shipments of the RF1130 are expected to commence in the March 2010 quarter.

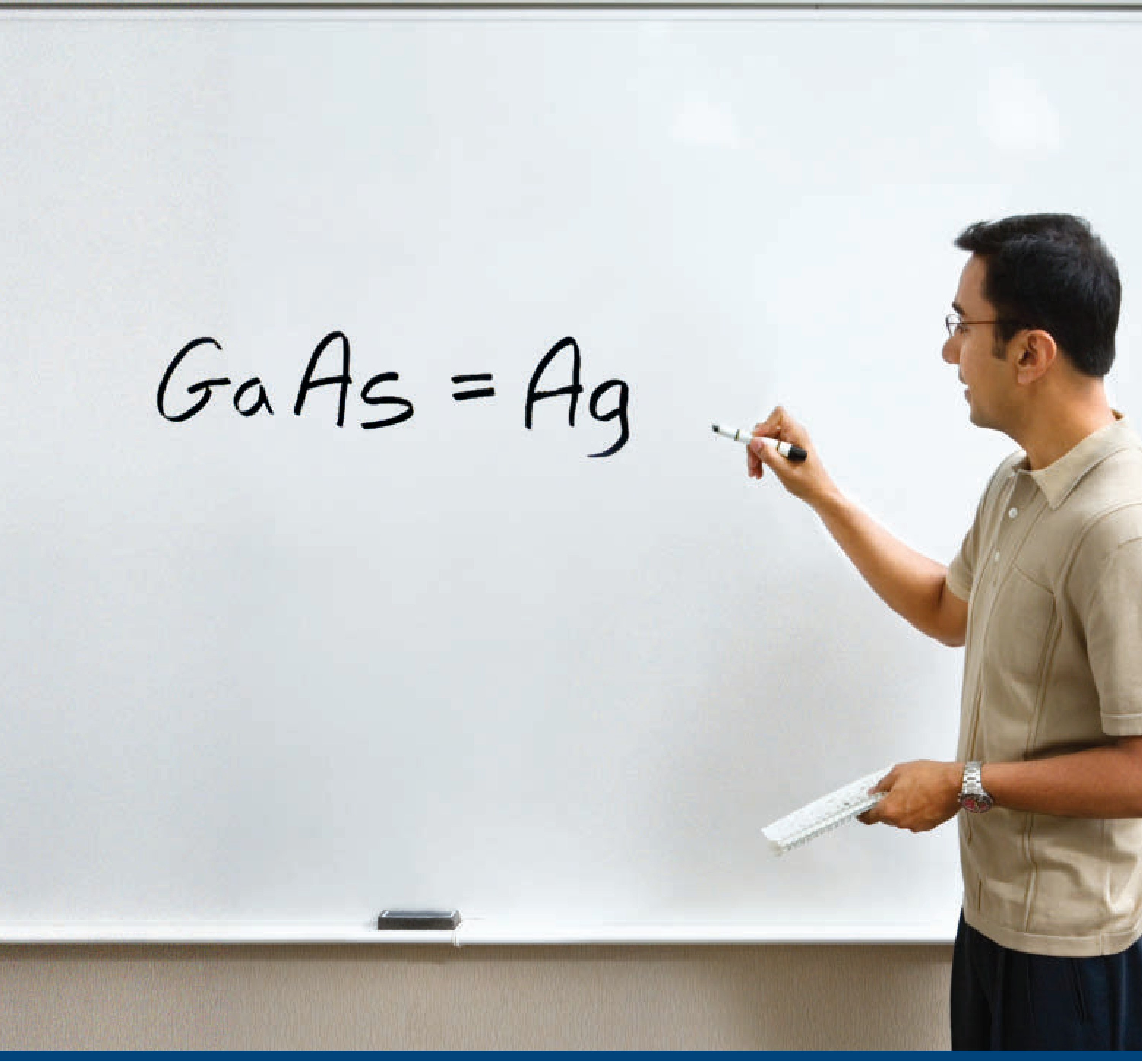
Ball Aerospace & Technologies Corp. has been selected by NASA's Goddard Space Flight Center to build a second Global Precipitation Measurement Microwave Imager (GMI) in support of the Global Precipitation Measurement (GPM) mission. The identical GMI 1 and GMI 2 Microwave Imagers are multi-channel, conical-scanning, microwave radiometers serving an essential role in the near-global-coverage and frequent-revisit-time requirements of GPM, a mission designed to improve climate, weather and hydrological predictions by providing more accurate precipitation measurements from space. GMI 1 is scheduled to begin full instrument testing at Ball Aerospace by mid-2010. Following completion, the radiometer will fly aboard the GPM space-borne core observatory scheduled to launch in 2013.

PERSONNEL

Electronic Assembly Manufacturing Inc. (EAM) has announced the hiring of a new Director of Sales, **Mary Terribile**. With more than 31 years of management and customer service experience, Terribile will fulfill the role of Director of Sales by developing and managing field sales representative teams for the growing cable assembly company. She previously worked at Radiall USA Inc. (formally Applied Engineering Products), located in New Haven, CT, in a variety of roles including Inside Sales Manager, National Sales Manager and Product Manager. She also has experience working for Cablewave Systems and Times Wire and Cable as an inside sales representative.

Spartech-South, an RF and microwave manufactures rep firm covering the southeast, announced that **Scott Brooks** has recently joined the Spartech team as territory Sales Manager. Brooks has 25 years experience selling RF and microwave components and interconnects with companies such as W.L. Gore, Precision Marketing Inc., M/A-COM, Adams-Russell and most recently with Brooks Associates, a manufacturing rep firm he started in 1991. Brooks will be covering commercial and military customers in Eastern and Southern Florida. His new contact info is as follows: Office (321) 727-8045, Cell (321) 615-1454, e-mail: Scott@Spartech-South.com.

Analog Devices Inc. (ADI) announced new, expanded roles for Vice Presidents **Robert (Robbie) McAdam** and **Vincent Roche**, as part of an organizational change that strengthens the company's focus on delivering world-class signal processing products and support to customers. McAdam and Roche will lead two new groups, reporting to President and CEO Jerry Fishman. Vice President Robbie McAdam leads the Core Products and Technologies (CPT) group, which focuses on strengthening ADI's number-one market share position in converters and high performance amplifiers, and growing the portfolio of RF, power, MEMS



Impossible? But it all adds up. TriQuint Semiconductor is celebrating its silver anniversary. Since 1985, we've worked hand-in-hand with engineers and scientists around the world using innovative technologies like GaAs in mobile device, defense, aerospace and networking communications. Join in the celebration of our future together, and you may even win a cool gadget powered by TriQuint technology. **Get into the equation at www.triquint.com/innovation.**

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and DSP products. Vice President Vincent Roche leads the new Strategic Market Segments (SMS) group, which focuses on integrating ADI technology into optimized solutions for automotive, industrial, medical, consumer and communications infrastructure customers.

▲ Mitch Gaudyn

D.L.S. Electronic Systems Inc., Wheeling, IL, names **Mitch Gaudyn** Manager of its Conformity Assessment Compliance Testing Group. Gaudyn will oversee the day-to-day operations and management of the Product Safety testing arm of D.L.S., covering UL, CSA, CE, CCC, C Tick, BSMI and other global testing standards and requirements. Gaudyn comes from Charles Industries, where he has been the Product Manager for OSP Telecom and Other Electronic Products.

REP APPOINTMENTS

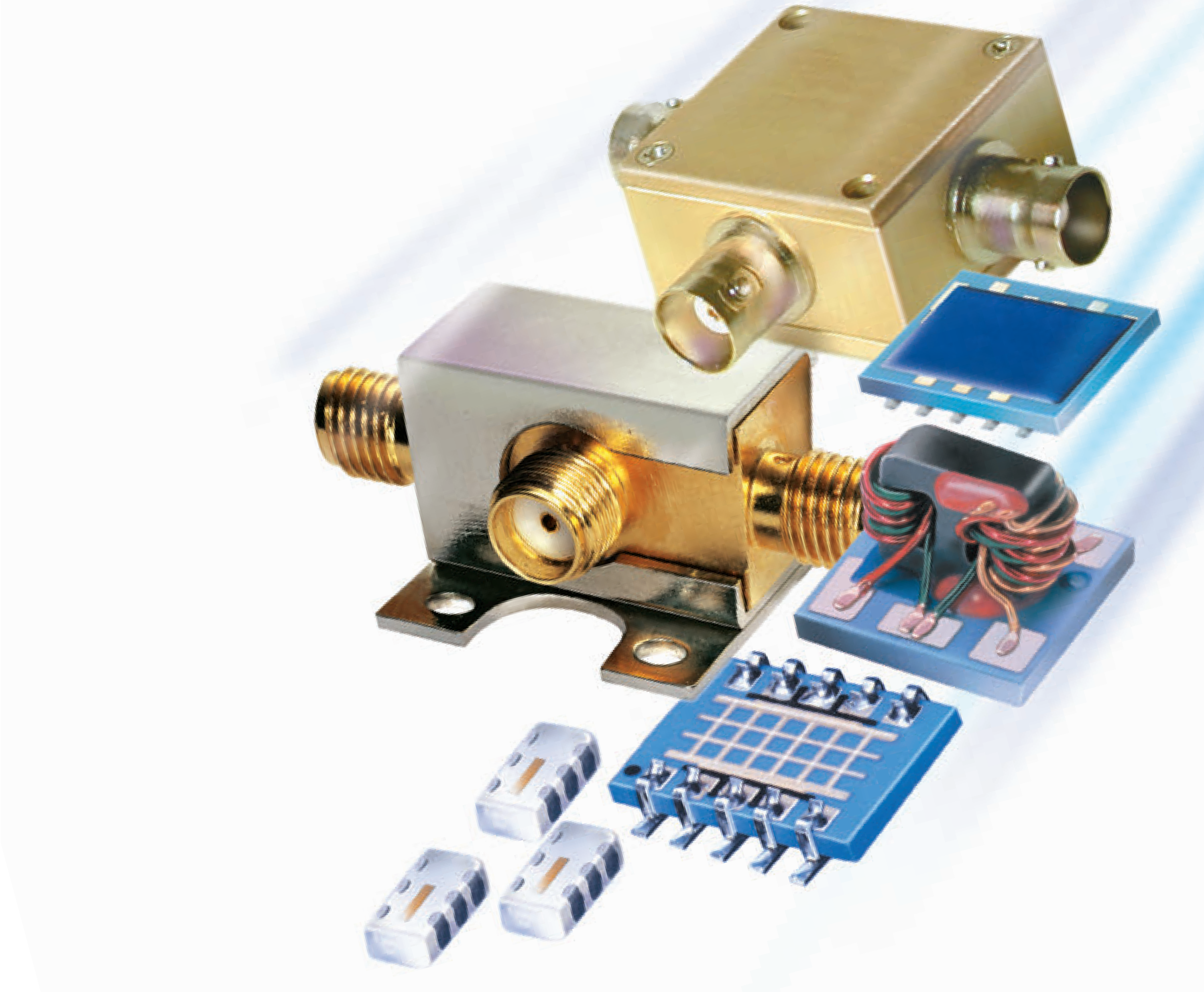
Richardson Electronics Ltd., whose new website features the latest products from the top suppliers for the most important RF/Wireless and Power Conversion applications, announced it has signed a global distribution agreement with **Sarantel**, a manufacturer of filtering antennas for mobile and wireless devices. As a leading distributor of RF and microwave components, Richardson Electronics offers technical expertise, value-added customer service, and a global sales footprint, which provides OEM/ODM companies with streamlined new product introduction and shorter design cycles.

Vaunix Technology Corp., a manufacturer of USB controlled and powered test equipment, has announced the hiring of two new sales representatives to handle customer relationships in the UK and Japan. **MCS Test Equipment** is a supplier of wireless test and measurement equipment in the UK. Located in North Wales, MCS covers all territory within the UK. Vaunix representative Bill Beck can be reached by phone 08453 62 63 65 or e-mail: info@mcs-testequipment.com. For more information, visit the MCS website at www.mcs-testequipment.co.uk.

Electronic components distributor **Digi-Key Corp.**, recognized by design engineers as having the industry's broadest selection of electronic components available for immediate shipment, announced it has expanded its agreement with **CTS Corp.** to include the Tusonix line of EMI/RFI filters, capacitor assemblies and related components.

Reactel Inc., a manufacturer of RF and microwave filters, multiplexers, and multi-function assemblies for the commercial, military, industrial, and medical industries, announced the appointment of **Trembly Associates** as the company's exclusive representative in Arizona, New Mexico, Colorado and Utah. For more information about Trembly Associates, please visit www.trembly.com or telephone Gary Mulryan at (505) 266-8616.

Linx Technologies Inc. announced the appointment of **World Micro Inc.** as a stocking distributor.



AUTOMATING RADAR MEASUREMENT TASKS THROUGHOUT THE LIFECYCLE OF A RADAR SYSTEM

The measurements needed for radar differ depending on the job to be done and the type or radar to be characterized. Modern radar designs incorporate complicated pulses that present significant measurement challenges. Improvements to range, resolution and immunity to interference have implemented complex technologies such as phase modulated pulses, frequency hopping, frequency chirped pulses and very narrow pulses, with many of these exhibiting high bandwidth.

The latest commercial test equipment has enough bandwidth, resolution, timing accuracy and RF performance that when coupled with automatic signal generation and analysis software can reduce development costs and speed time-to-market for emerging radar designs. While radars can internally test their own function, radars cannot tell themselves why they do not work or in many cases when they are not functioning properly. Further, the validation and verification of emissions and immunity to the anticipated environment require independent test tools.

The radar measurements discussed here are all pulse measurements. Although there are several continuous transmission types of radar, primarily Doppler and passive radar technologies, the great majority of radars are pulsed. This article addresses the needs for pulse generation and measurements, the automated pulses are detected and the measurements that are available, explanation of just how several automated measurements are made, and pulse generation. The three main phases of the radar measurement lifecycles are design and verification, production, and signal monitoring.

RADAR DESIGN AND VERIFICATION MEASUREMENT

During the verification of the design of radar, there is a need to assure that the transmitted signal is correct, that the receiver responds to correct signals, and that there are no unexpected signals emitted from the transmitter. Unexpected outputs can range from unintended signals that are related to the desired pulse (such as harmonics, sub-harmonics, images and mixing products, etc.), as well as spurious outputs unrelated to the desired pulse, such as radiation of internal local oscillators, coupling from digital clocks, spurious oscillations within RF circuitry, pulse errors due to component distortions and mismatch, and so forth.

In the modern world of "software-defined" radar, modulated pulses, chirps, and other waveforms are often created not with traditional analog circuitry, but with Digital Signal Processing

DARREN MCCARTHY
Tektronix Inc., Beaverton, OR

(DSP) and Direct Digital Synthesis techniques that digitally synthesize complicated signals directly at IF or RF frequencies. These only become analog when the synthesized digital data is put through a D/A converter.

Within the DSP, subtle computer code errors such as illegal filter values or numeric expressions can create very short-duration signals that may bear little or no relation to the desired output. A single incorrect computer instruction can create momentarily incorrect RF output. This can play havoc when filtered, amplified and transmitted. Spurious emissions can interfere with other services as well as provide a distinctive signature if they are specific to a particular transmitter design.

PRODUCTION TESTING MEASUREMENTS

Production testing requires verification that each unit meets its specifications. Tasks include tuning and calibrating assemblies, as well as compensating and calibrating analog modules, linearizers and amplifier components. Results must be accurate and repeatable to assure that the final product will function as intended. As component and subsystem vendors make changes to their processes, continued verification of performance is required without varying the tests throughout the production life.

Automated testing reduces the chance for operator error, which is a drawback of manually operated and interpreted testing equipment. Reproducibility of test results can be maintained regardless of production personnel, environment, or equipment changes, and training requirements can be significantly reduced.

SIGNAL MONITORING

In situ signal monitoring presents a somewhat different challenge, particularly in defense and military applications. There is less need to verify a specification, but more to identify signals that may be present in a local area, or may show themselves only very rarely. This type of interference can jam or reduce the effectiveness of the radar.

When searching for pulsed or interfering signals, an automated continuously searching analyzer must not blink just when the signal appears. Discovering, triggering and capturing infrequent signals or transient characteristics of signals are required before analysis can be performed. Interference may be manifested not only as an infrequent problem, but may be an issue of multiple signals sharing a frequency, either intentionally or unintentionally.

RADAR PULSE CREATION

For the design and production phases of the radar lifecycle, both transmitter and the receiver test are required coupled with appropriate signal generation solutions. On the transmitter side, modern radars often generate pulses at an Intermediate Frequency (IF) where the processing is easier. They then convert that frequency to the final operating frequency before amplifying it to the necessary high power. When testing an up-converter from the IF system, or testing the power amplifier, a radar pulse generator is needed as well as the pulse analyzer.

There are several solutions for generation of radar pulses. Arbitrary Function Generators (AFG), Arbitrary Waveform Generators (AWG), and software to create the necessary pulses can generate digital and analog baseband, IF, RF, or microwave signals using direct synthesis. Test waveforms can be imported into the generators, synthesized, or replayed. Signal generation is often required in the selection and verification of analog transmitter components to test the margin of design and manufacturing processes.

Testing the receiver portion of a radar system when the companion transmitter is not yet available requires pulse generation equipment with the capability to add impairments and distortions to generated pulses. This will verify the limits of receiver functionality. A generator of waveforms with arbitrary variation of any part of a digitally created waveform fills this need. Common impairments are in-channel and out-of-channel signals and noise to test desensitization or blocking.

There are many different varieties of wideband AFG and AWG instruments that are capable of generating complex radar signals as baseband or IF signals. For the lower radar frequencies, even fully modulated RF signals can be directly generated. Some models also have digital data outputs in addition to the analog signals. ***Figure 1*** illustrates where the test tools can be applied for radar transmitter or receiver analysis.

SYNTHESIZING SIGNALS IN SOFTWARE

The latest development is signal generation software that delivers advanced capabilities for direct synthesis and generation of complex radar signals using an AWG to generate the actual signal. The user enters into the software a description of the desired RF signal and the software will compile the necessary waveform file. It will also use the waveform sequencing ability of the signal generator to create longer length waveforms. The software provides the

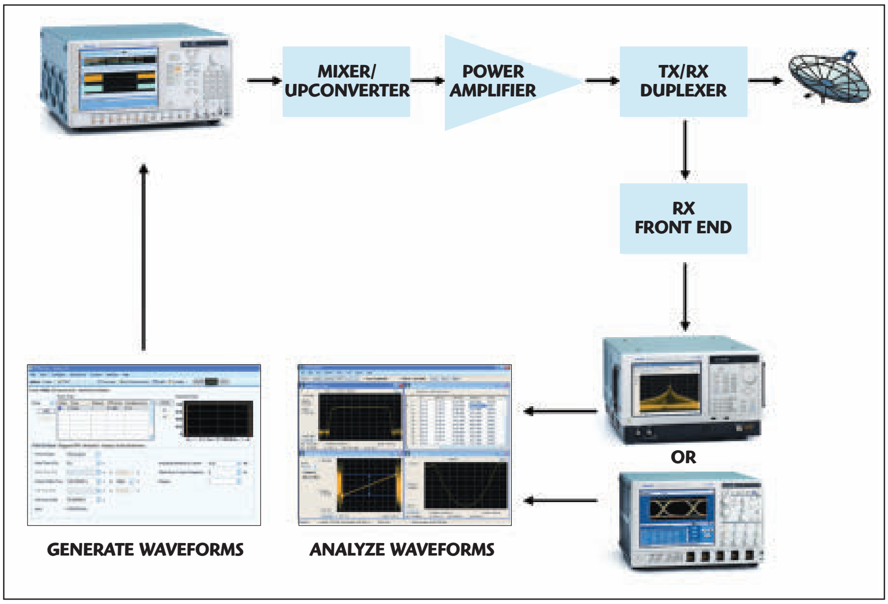


Fig. 1 Radar test tool overview.

flexibility to create independent single or multiple pulse groups to form a coherent or a non-coherent pulse train. It is also possible to define inter and intra pulse hopping patterns in both frequency and amplitude and to visualize defined radar pulse patterns graphically in spectrogram view.

PULSE MEASUREMENTS

The traditional measurements of a pulse are timing. The width and period are the most basic, and convert to repetition rate and duty cycle. Pulse shaping may be used to contain the transmitted spectrum. Pulse shape includes the rise time, fall time and aberrations. The aberrations include overshoot, undershoot, ringing and droop. A challenge is to measure the transient splatter and spectral re-growth if the pulse shaping is not correct.

Timing variations from one pulse to another is the next more advanced timing measurement. These may be intentional variations or unintentional ones, which may degrade system functionality. Radar signals, however, may contain modulation within a pulse. Such modulations can be simple or very complex. There are several ways to measure different modulations within a pulse.

- Amplitude-versus Time
- Phase-versus Time
- Frequency-versus Time
- General Purpose Modulation Measurements, such as BPSK, QPSK, QAM, etc.
- Chirp measurements

Amplitude, Phase and Frequency versus Time are all single parameter measurements and operate on a sample by sample basis. The amplitude measurement plots the magnitude envelope detection. The magnitude is calculated for each sample by squaring both In-phase (I) and Quadrature (Q) values for each sample, summing them and then taking the square root of the sum.

Analysis of digitally modulated signals is more complex. The desired plot includes the amplitude, the phase, or both plotted against the transmitted "symbols" (the data words transmitted). This requires entering the modulation type, symbol rate and the measurement and reference filter parameters. This measurement can display constellation, error plots, signal quality and a demodulated symbol table.

AUTOMATED RF PULSE MEASUREMENTS

As radar signals have become more complex, it is increasingly beneficial for engineering whether in design, production or monitoring stages, to have automated tools for completing RF pulse measurements. This ensures both greater reliability and repeatability. The following descriptions of pulse measurement techniques generally apply to spectrum analyzers and oscilloscopes with vector signal analysis software.

Measurements made of a single pulse (sometimes called short frame measurements) depend on the intended use of the pulse. The applied modulation will determine the needed measurements. For simple single-frequency (CW) pulses the measurements may include power (or voltage), timing, shape, RF carrier frequency and RF Spectrum occupancy.

For modulated pulses, additional measurements are required. The accuracy of modulation contained within the pulse is needed. Parameters such as phase or frequency modulation, frequency extent of a chirp, and phase linearity of a chirp are crucial to the performance of the radar system. Modulation accuracy of digitally modulated pulses is also important.

FINDING THE PULSE

Before any parameters can be measured, an automated system must identify that a pulse exists and further locate some critical features of the pulse, from which the timing, amplitude and frequency measurements will be referenced. Algorithms used for finding pulses require at least seven samples between the rising and falling edges to be assured of good reliability of pulse detection. If there are fewer points, then the detector will be less reliable and the pulse measurement specifications will all degrade. For a 40 MHz bandwidth digitizer, 7 samples is equivalent to 150 nanoseconds. And for a 110 MHz digitizer it is 50 nanoseconds. For a 20 GHz bandwidth oscilloscope it is roughly 140 picoseconds.

The actual detection of pulses is complicated by the extremes of some of the parameters and variations encountered in modern pulsed radars. The duty cycle may be very small, which leaves the pulse detector look-

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Our Productivity Goals

IKE Micro owner Scott MacKenzie discusses his latest fashion choices.

MWJ: I guess the first obvious question is, why the outfit?

SM: I promised to dress up like a woman if we beat our productivity goal in 2008. We did, so here I am in all my glory!

MWJ: How does IKE Micro produce at such a high level?

SM: We have a veteran, low-turnover workforce, and a good balance of automated and manual assembly capability. Because of our 100% focus on build-to-print manufacturing, design and market issues don't get in the way of the delivery schedule.

MWJ: Are your company's assembly capabilities comprehensive?

SM: Yes, from DC to 100GHz. Our capabilities include surface mount, epoxy and solder board mount, feedthru installation, die attach, wire/ribbon bond, coil and beam lead bonding, and all the crazy RF soldering and bonding needed so our units make it through test with minimal tuning.

MWJ: What types of customers take advantage of IKE's experience and capabilities?

SM: It's a good mix. It includes the big systems companies and many of the small to mid-sized module suppliers. Many of these companies advertise with you. We do complex modules and pretty basic subassemblies. Our domestic and international customer mix is 65% defense and 35% commercial.

MWJ: What are your goals for 2009?

SM: I want to continue to produce at high levels and exceed customer expectations. More importantly, I plan to steer clear of the EE design guys, some of those guys freak me out, especially when I'm wearing this dress.

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ing at only noise for most of the pulse interval. The pulse timing may vary from pulse to pulse, or the frequency of each pulse may hop in an unpredictable sequence. Even the amplitude may vary between pulses leaving a detection analysis based solely on modal histogram distribution unusable.

Other difficulties arise if the pulses exhibit real-world characteristics shown in ***Figure 2*** such as ringing, droop, carrier leakage, unequal rise and fall times, or even amplitude variations such as a dip in the middle of a pulse. The greatest difficulty to overcome is poor signal-to-noise ratio. Particularly as the pulse width gets smaller, the rise time gets faster, or as a frequency chirp gets wider, the bandwidth of the measuring system must also get greater. As the bandwidth increases, the noise increases with it.

FINDING THE PULSE CARRIER AMPLITUDE

The basic tradeoff in the pulse amplitude algorithm is between the reliability of the detection versus the speed of the algorithm. The method used in the advanced pulse analysis includes four separate pulse detection algorithms. Each of these algorithms is called within the DSP processor one at a time. They are called in order of the simplest and fastest first. Then the next detector with increasing complexity will be tried. This will continue, and if at any time a pulse is found, then the process ends. In this manner the finding of the pulse and its amplitude is completed in the least amount of time required.

The pulse Carrier Detection Algorithm reports "no Pulse Found" only if all four methods fail to find a pulse. All of the carrier level detection algorithms use envelope detection. With this method, a simple CW pulse will be represented by a voltage waveform that represents the baseband pulse that modulated an RF carrier. The actual mechanism is to take the square root of the sum of the squares of the (I) and (Q) values at each digital sample of the IF signal.

Once the pulse has been found, the magnitude can be determined from the samples now known to be inside the pulse and the reference points (cardinal points) can then be located.

LOCATING THE PULSE CARDINAL POINTS

Once it has been determined that a pulse does exist, a model of the pulse will be constructed with four cardinal points and four lines. These points and lines are the fundamentals from which all of the measurements are referenced. ***Figure 3*** shows a set of magnitude samples with the lines drawn through the samples. Then the points are shown at the intersection of the lines. When a pulse view is selected on-screen with a linear scaled display, these calculated pulse lines will be shown overlaid on the actual plot of the measured pulse.

To construct the model, the instrument first performs a re-iterative least squares fit in the pulse points to determine the best-fit position for these lines. The process starts with the top line. For greatest likelihood of good fit, the line-fit is started with only the center 50 percent of the points at the top. This is done to minimize errors from any overshoot or ringing at the transitions.

ESTIMATING THE CARRIER FREQUENCY

All frequency and phase measurements within pulses are made with

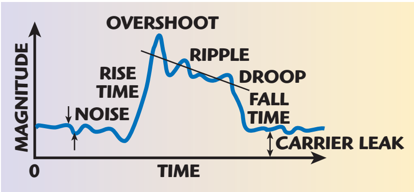

Fig. 2 A real-world pulse can have many distortions.

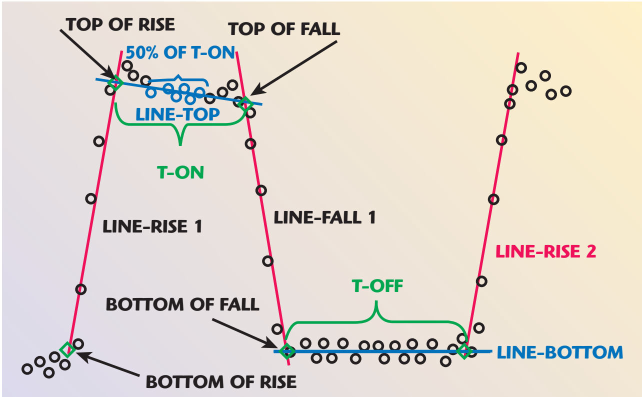

Fig. 3 The cardinal points and connecting lines of the pulse model.

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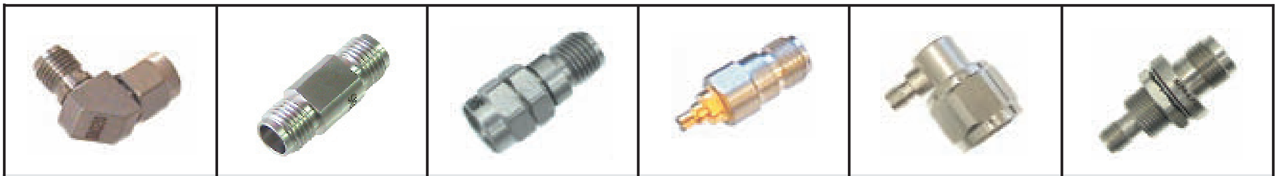

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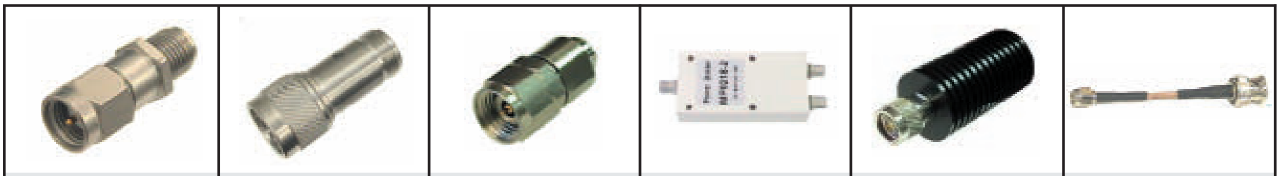

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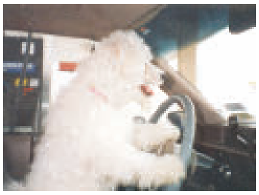

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Visit http://mwj.hotims.com/28484-32 or use RS# 32 at www.mwjournal.com/info respect to the carrier frequency of the pulse. This frequency can be entered manually by the user if the frequency is known. Or the instrument can automatically estimate the carrier frequency. If the frequency is to be estimated internally, there are some settings that the user can enter to help with the estimation. The frequency estimations are performed based on the user entry of the type of pulse and improve the time to results for measurements.

If the carrier were ON constantly, then there would be little difficulty determining the frequency. But for these pulses the carrier is ON and visible for only a small fraction of the time. These fractions are discontinuous as well. This makes the determination much more difficult.

TIMING MEASUREMENTS

Once the cardinal points have been located, the timing measurements can be calculated. All measurements are made with reference to these points. The first measurements are the rise and fall times. The best-fit lines were found as part of the pulse and cardinal points location process. While a good approximation would be to simply measure the time between the lower and upper points at each transition, this would be slightly incorrect. The specified time is between the two points that lie on the actual pulse and are also at the specified amplitudes.

In this case, the amplitudes were specified as either the 10 and 90 percent voltage or 20 and 80 percent. In ***Figure 4*** the pulse trace window shows the measured pulse, the best-fit lines, the cardinal points and the arrow with the vertical lines shows the exact points of the rise time of the pulse.

Other timing measurements include pulse width, repetition interval/duty cycle, peak amplitude, average ON power, average transmit power, droop and pulse top ripple. The ripple is defined as the difference between the peak positive and negative excursions from the best-fit line (which was already found to be the droop). This ripple, as seen in ***Figure 5***, is expressed in percent of the pulse-top voltage.

FREQUENCY AND PHASE MEASUREMENTS

For CW pulses only, a frequency measurement can be made using the marker on a spectrum display, but this method has limitations due to the PRF lines that are an artifact of swept spectrum analysis and the difficulty of locating the center one to place the marker depending on the space interpolation and signal repeatability. The software uses a variety of methods to find the carrier frequency within pulses in preparation for automated measurement of phase and frequency parameters.

Pulse-to-pulse carrier phase difference is made using I/Q processing as other phase measurements. The accuracy of this measurement is subject to four major influences: signal-to-noise ratio, phase noise, estimation of the pulse rising edge, and finally the overshoot present on the pulse as measured.

The pulse-to-pulse frequency measurement is just like the corresponding phase measurement, except that the error effects are far less pronounced. Frequency measurement is a relative phase-change measurement made locally on the pulse, from which the frequency is calculated. Then the measured pulse frequency is compared to the reference pulse frequency, which was found locally within the first pulse.

CHIRP MEASUREMENTS

There are specialized measurements required for verification of the performance of frequency chirped pulses. For simple time-of-flight

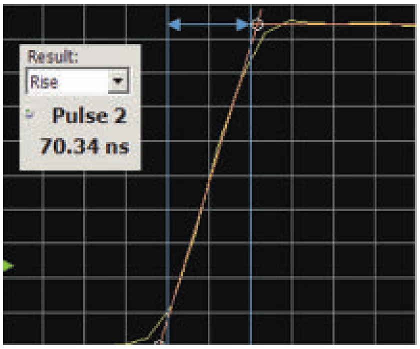

Fig. 4 The rise time measurement with measurement points shown on the pulse trace.

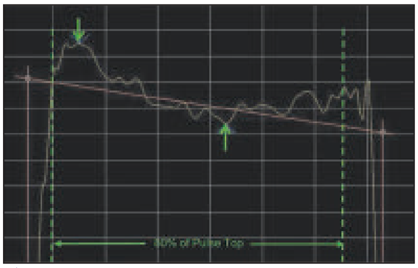

Fig. 5 The pulse ripple measurement.

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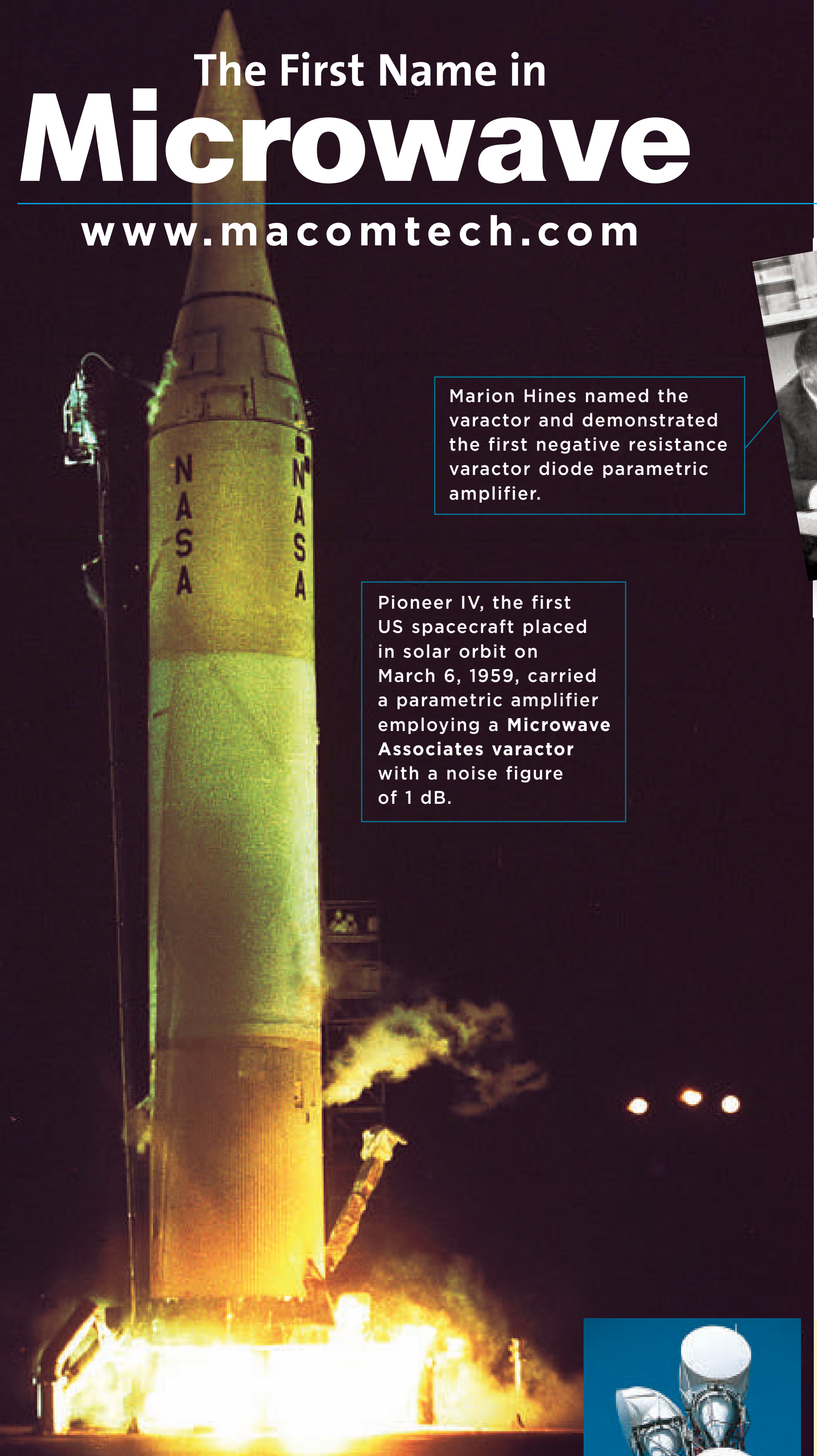

Marion Hines named the varactor and demonstrated the first negative resistance varactor diode parametric amplifier.

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Marion Hines with Microwave Associates CEO Dr. Lawrence Gould and varactor inventor Dr. Arthur Uhlir (photo circa 1961)

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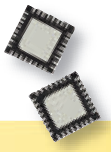
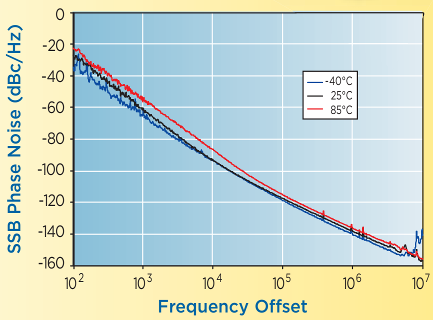




For information on VCOs and other products from M/A-COM Technology Solutions, visit **macomtech.com** pulsed CW radar, the main concern is that the timing parameters of the pulse be as designed. For chirp radar, the possible transmitted errors that will cause errors in the receiver can be much more subtle. While parameters such as pulse timing, center frequency, chirp frequency width and frequency errors across the chirp will all certainly cause problems when the transmitter adds these to the radiated signal, the phase errors across each pulse as well as from one pulse to another are the more subtle contributors to the success of chirped radar.

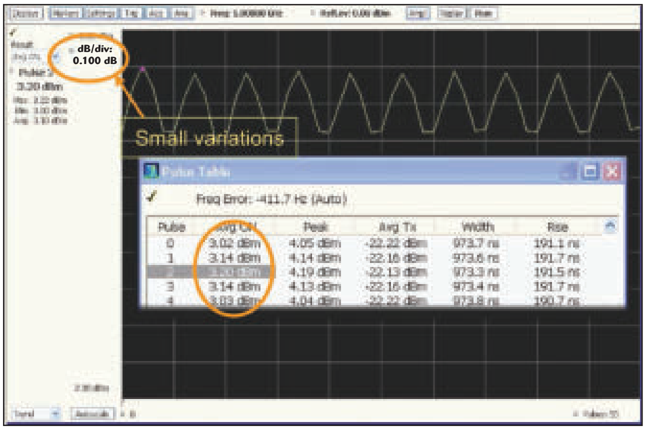
LONG FRAME MEASUREMENTS (MULTIPLE PULSES)

Measurement of a single pulse is not usually sufficient to assure transmitter performance. Many pulses can be measured. If there are differences from one pulse to another, this by itself can be used to diagnose problems that may be otherwise difficult to find.

The first view into such variations is the pulse table. When there are many pulses in one acquisition, the measured values can be arranged into a table where the numeric values of all measurements are calculated for each acquisition. The user can select which measurements will be shown in the table. Each column contains the results from one parameter displayed sequentially for all the pulses which were measured. A new column is added for each additional parameter selected by the user.

The results table shows variations in the pulse power of only about one tenth of a dB amongst the pulses. Even though this is only an extremely slight variation, it may be significant. To see if there is some regularity to the results, the trend of results is plotted. The trend plot plots one point for each pulse. This effectively removes the long time in between the pulses and gives a readable trend plot.

Figure 6 shows such a plot for the results of Average ON Power of a series of pulses. There is a pronounced periodicity in the pulse power being produced by this transmitter. If the variations were random, then, as small as they are, they might well be ignored by the receiver. But a periodic variation may well produce false target information, so there is a need to find the nature of the periodicity as well as the cause.



▲ *Fig. 6 Plot of the trend of average ON power in a series of pulses.*

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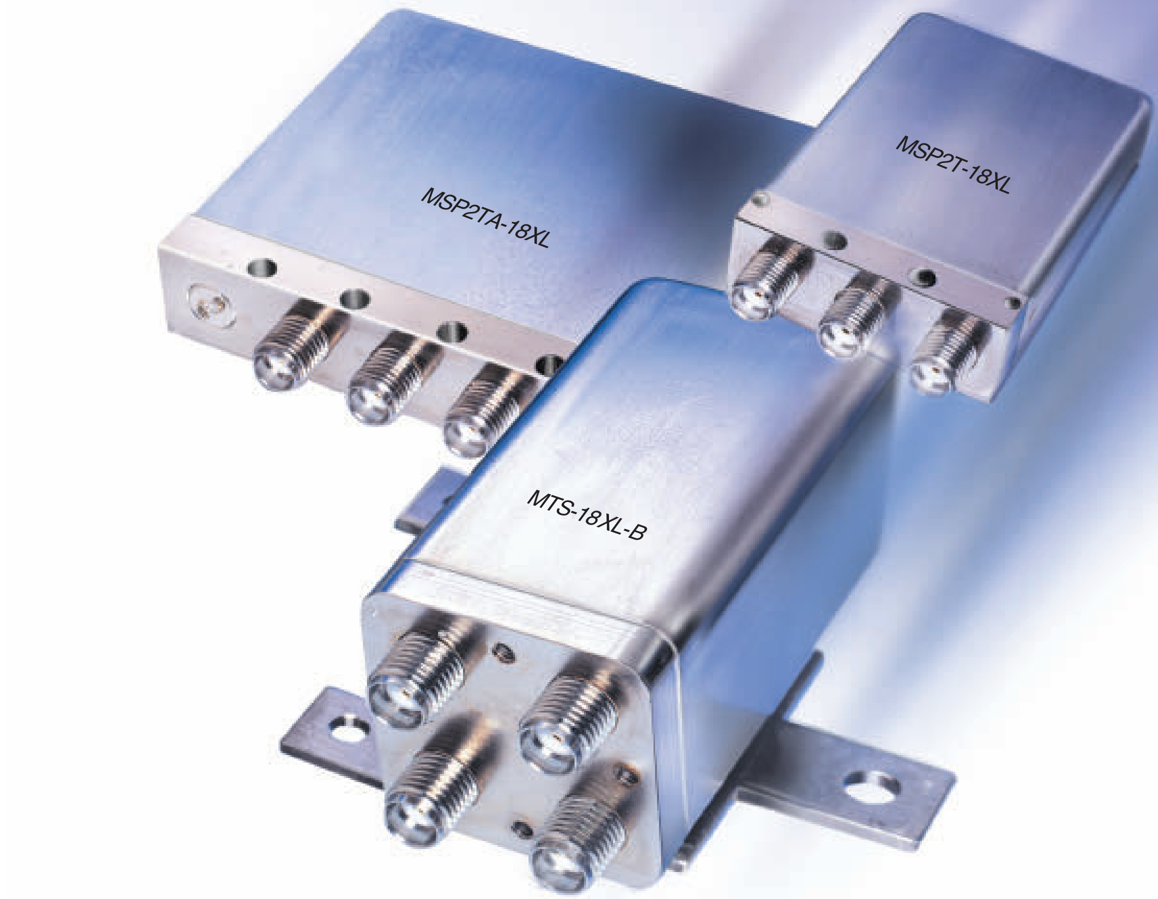

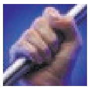

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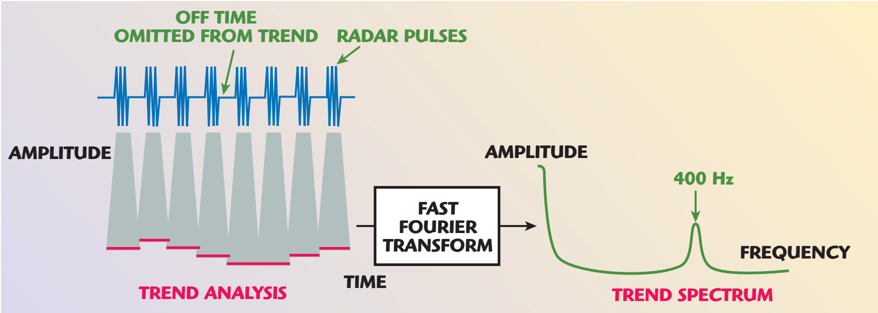

▲ *Fig. 7 The process of performing a FFT on measurement results of multiple pulses.*

The table of values is useful to manually see if there are anomalous readings for some pulses. The pulse trend plot graphically shows the character and magnitude of such variations. But to analyze these results and make a possible determination of the root cause for such variations requires further computations. The method provided is a Fast Fourier Transform (FFT) of the tabular pulse measurement results. ***Figure 7*** shows the process.

The drawing illustrates how the FFT might well have been from the previous trend plot. In this case, by analyzing just the ON samples of the Average ON measurements, and eliminating the OFF time samples, an FFT of the Average ON trend can be calculated. Here the 400 Hz primary power supply is modulating the transmit power. Having found a correlation between the variations and a possible cause, remedial action can now be taken.

CONCLUSION

The complicated pulses used in modern radar systems present significant measurement challenges in military and defense environments. The need for testing solutions extends throughout the lifecycle of a radar system from initial design, to production and through to signal monitoring. While there are somewhat different requirements at each phase, automated signal generation and test software help engineers make reliable and repeatable measurements.

Using AWG and signal creation software, signals can be inserted at any point in the radar chain to verify performance or to simulate a range of signal conditions. Using software together with oscilloscopes and spectrum analyzers, engineers can perform a full range of automated pulsed radar measurements including timing, frequency and phase, chirp and long frame measurements involving multiple pulses. No longer is it necessary for radar development teams to develop custom test benches to fully characterize and validate their designs due to a lack of suitable test solutions. ■

PERFORMANCE IMPROVEMENT OF POWER AMPLIFIERS USING AN ASYMMETRICAL SPURLINE STRUCTURE

In this article, an asymmetrical spurline structure with dual rejection bands is proposed to reduce the higher harmonics of microwave power amplifiers. To evaluate the effect of an asymmetrical spurline structure on microwave amplifiers, two InGaP HBT power amplifiers were designed and fabricated. One of them has an asymmetrical spurline structure at the output section, while the other has a conventional 50 Ω microstrip line only. The results show that the asymmetrical spurline structure suppresses the second and third harmonics by more than 27 dB at the output and yields an improved power added efficiency (PAE) and output power by 6 to 8 percent and 1 to 4 percent, respectively.

Microstrip bandgap structures, such as photonic bandgap (PBG), electromagnetic bandgap (EBG) and defected ground structure (DGS), have recently been used to suppress high-order harmonics in antennas, amplifiers and oscillators[1-4] because they are simple to fabricate and have excellent filtering performance. For example, Radisic[1] introduced a wideband power amplifier using a dielectric PBG structure for higher harmonics suppression and improvement in power-added efficiency (PAE), while Lim[2] reported a power amplifier with efficiency and output power improvements using a defected ground structure. However, slotted ground planes are required in the above-mentioned applications, which result in a large circuit size and higher insertion loss. Woo demonstrated that a single asymmetric slotted ground plane with compact size was excellent for second and third harmonics suppression simultaneously.[5] Nevertheless, a slotted ground plane needs an etching process on the backside ground plane and an accurate position calibration, which increases cost and complexity.

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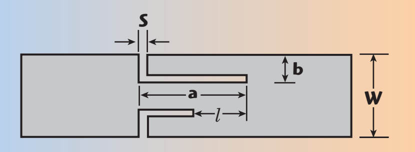
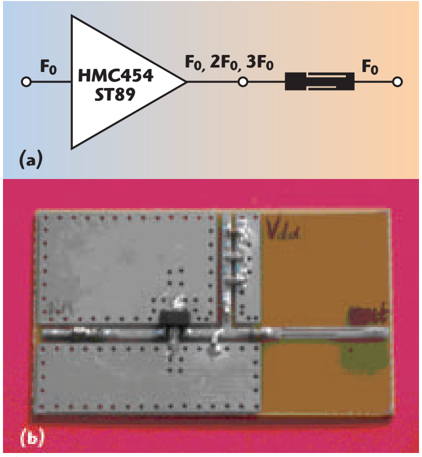


▲ *Fig. 1 Layout of the proposed asymmetrical spurline structure.*



▲ *Fig. 2 Schematic of the power amplifier with the asymmetrical spurline structure (a) and photograph of the fabricated amplifier (b).*

A spurline structure is a simple slotted structure that is embedded directly into a microstrip line. Without any stubs and etch processing on the backside ground plane, it is a convenient process for dense integrated circuits because of their inherently compact design and ease of integration. Also, spurline structures can provide excellent bandgap characteristics and have been applied in antenna and filter designs.[6,7] However, the reported spurline structures only provide a single bandgap to suppress one higher-order harmonic component.

Based on previous work about asymmetrical spurlines,[8,9] a new method to suppress harmonics in a power amplifier is proposed, using an asymmetrical spurline structure. An asymmetrical spurline structure with dual rejection bands was designed and can be applied to the second and third harmonics suppression. Measured results are given and the improved output power and PAE performances of the power amplifiers are discussed.

ASYMMETRICAL SPURLINE STRUCTURE AND POWER AMPLIFIER DESIGN

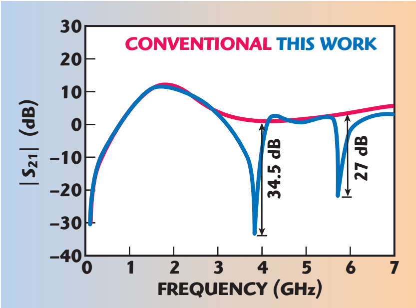
An asymmetrical spurline structure is shown in ***Figure 1***. It consists of two asymmetrical L-shaped slots embedded into the microstrip line. The length difference between the upper spurline and lower spurline is denoted by l. The configuration of the spurline structure is defined by three parameters: the slot width s, the slot length a and the slot height b. Because of the dimensional asymmetry, different inductance and capacitance effects of the asymmetrical spurline structure are expected and dual bandgap characteristics could be obtained.

A MMIC InGaP HBT amplifier (HMC454ST89 from Hittite) combined with the proposed asymmetrical spurline structure is employed to realize a Class A power amplifier operating over the 1.7 to 2.2 GHz band. It is shown in ***Figure 2***. The required drain bias voltage is set to +5 V. Choke inductors and shunt MIM capacitors are used in the bias circuit. The matching circuits are made of a microstrip impedance transformer, DC block capacitors and shunt capacitors. The asymmetrical spurline structure is etched in the output microstrip line to implement the second and third harmonics suppression. The proposed asymmetrical spurline structure's dimensions are chosen as follows: s = 0.2 mm, a = 11.3 mm, l = 3.5 mm, b = 0.4 mm, w = 1.48 mm. A substrate with a relative dielectric constant of 4.5 and a thickness of 0.8 mm is used in the simulation and measurements. The amplifier circuit and the spurline patterns can be realized at the same time by a simple etching process.

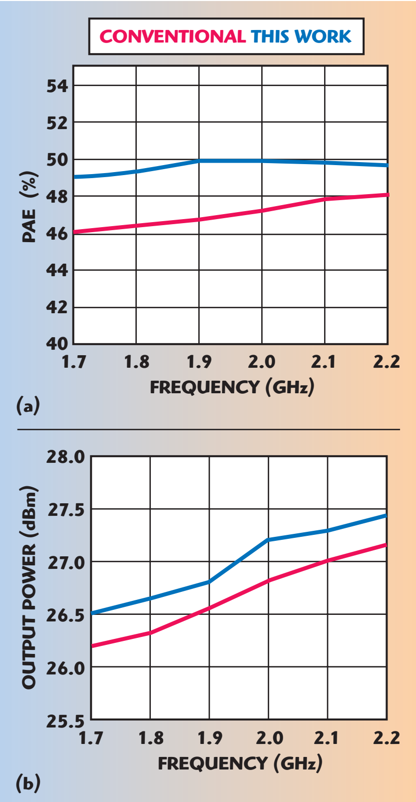
The signals at the output of the amplifier are terminated by the asymmetrical spurline structure. Only the fundamental component F_0 at 1.91 GHz passes through; the higher harmonic components ($2F_0$ and $3F_0$) are suppressed, resulting in improved linearity and an increase in fundamental power.

In order to investigate the performance improvement of the amplifiers, two kinds of power amplifiers have been fabricated. One is a conventional design without the spurline structure, while the other is the proposed design. The simulated transmission characteristics of the amplifiers are shown in ***Figure 3***. As shown, it is demonstrated that the optimum load impedance at the fundamental frequency (F_0) is changed slightly after adding the asymmetrical spurline structure. Furthermore, it is found that the harmonics suppressions at the second and third harmonics are approximately 34.5 and 27 dB, respectively.

A comparison of the measured output power and PAE of the two amplifiers is shown in ***Figure 4***. From the measured results, it is clearly observed that the asymmetrical spurline structure has improved the PAE of the power amplifier by 6 to 8 percent. Additionally, the improvement in output power is 0.4 to 1.0 dBm and is not appreciable because the magnitudes of the second and third harmonics are very small. The output power is improved by 1 to 4 percent.



▲ *Fig. 3 Simulated amplifier performance.*



▲ *Fig. 4 Measured performance of the two amplifiers: (a) power added efficiency (PAE) and (b) output power.*

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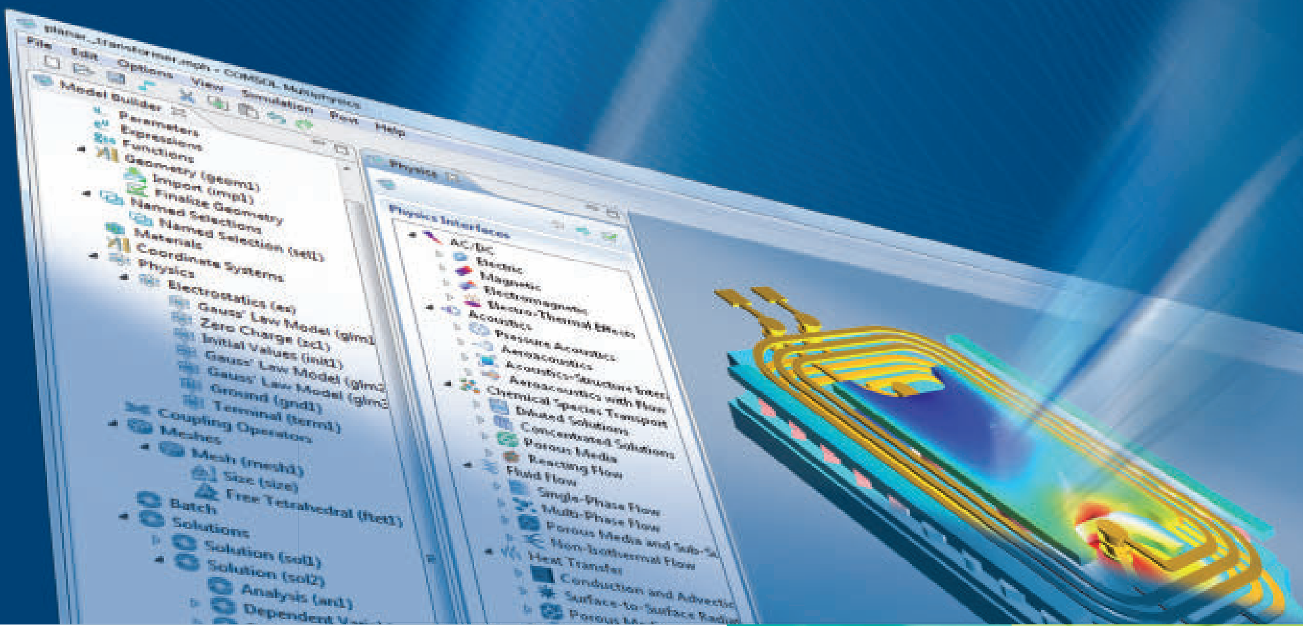

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CONCLUSION

A new method of adopting an asymmetrical spurline structure for higher harmonics rejection in microwave amplifiers is verified in this article. At the output of the proposed amplifier, an asymmetrical spurline structure with dual rejection bands is introduced to tune out the second and third harmonics. Compared to the conventional amplifier design, the asymmetrical spurline structure suppresses the second and third harmonics by more than 27 dB and yields an improved PAE by 6 to 8 percent. It is expected that the asymmetrical spurline structure can be widely used in other microstrip circuits and systems for tuning harmonics and improve performance while the design is compact and easy to integrate. ■

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A Compact, Omni-directional, Circularly Polarized Microstrip Antenna

A new type of omni-directional, circularly polarized microstrip antenna employing a zero-order resonator (ZOR) loaded with arc-shaped stubs along the patch is presented. The concept of the proposed antenna uses a configuration of the horizontal magnetic and electric loop currents that act as electric and magnetic monopole antennas, respectively. By adjusting the relevant dimensions of the loaded stubs, an omni-directional, circularly polarized operation can be realized. The operational frequency of the proposed antenna is 1.9 GHz. According to the measured results, the proposed antenna provides a 10 dB input return loss and bandwidth of 11.8 percent. The simulation and measurement radiation patterns show that the proposed antenna radiates the electromagnetic wave omni-directionally. The simulated axial ratios of the proposed antenna indicate that it has a good circular polarization performance.

As a result of further research, antennas using metamaterials have been published. Planar leaky-wave antennas using transmission-line metamaterials have been reported with continuous beam scanning.[1-3] Feeding networks of microstrip patch arrays using transmission-line metamaterials have been designed,[4] which removes the inherent pattern squint resulting from the traditional series feeding network. Iizuka and Hall have shown how left-handed transmission lines can be incorporated into dipole antennas and found that the antenna shows a reduced wavelength with decreasing frequency.[5] Microstrip patch antennas, loaded with a miniaturized multilayered left-handed (LH) transmission line that increases the effective wavelength of the antenna and thus lowers the resonant frequency of the radiating mode, have been realized.[6] As a new type of antenna, zero-order resonator antennas have been explored.[7-10] These antennas radiate electromagnetic waves like monopole antennas and simultaneously maintain the inherent advantage of a low profile microstrip patch. However, these antennas are all linearly polarized and, to the authors' knowledge, omni-directional circularly polarized structures using ZORs have not been reported so far.

In this article, the design, fabrication and measurement of a novel type of an omni-directional, circularly-polarized microstrip antenna are described. The proposed antenna uses a zero order resonance loaded with four identi-

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cal arc-shaped stubs, which maintains the advantage of a low profile microstrip patch antenna and possess a monopole-like radiation pattern.

THEORY

Antennas using a ZOR based on a periodic design approach have been studied in detail.[9,10] In the circuit model of these antennas, the series capacitance between unit ZORs is needed to represent the electromagnetic coupling, and provides the capacitance realizing the left-handed part of the composite right-/left-handed transmission line. A mushroom ZOR, which consists of a square metallic patch connected to the ground plane by a shorting post, has been considered.[9,10] This structure, employing unit ZORs, realizes an omnidirectional linear polarization operation. The equivalent circuit model of a ZOR is shown in ***Figure 1***. L_R', C_L', L_L' and C_R' are series inductance and capacitance per unit length and parallel inductance and capacitance per unit length, when the periodic ZORs can be seen as homogeneous media.

By applying the periodic boundary related to the Bloch-Floquet theorem, the unit ZOR dispersion is determined to be:

$$\beta(\omega) = \cos^{-1}\left(1 + \frac{ZY}{2}\right) \tag{1}$$

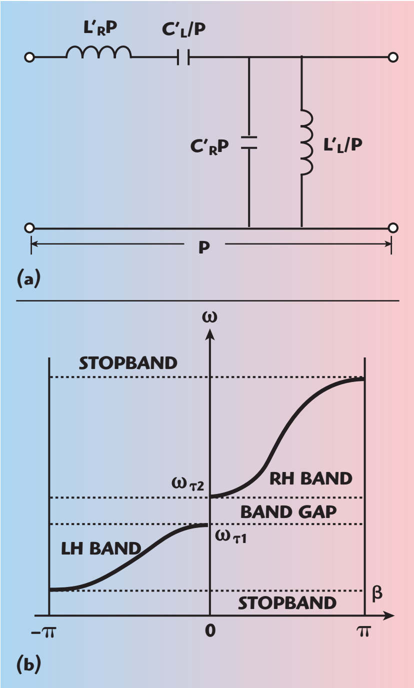

Fig. 1 Equivalent circuit of a unit ZOR (a) and its dispersion diagram (b).

where the series impedance and shunt admittance are

$$Z(\omega) = j\left(\omega L_R - \frac{1}{\omega C_L}\right) \tag{2}$$

$$Y(\omega) = j\left(\omega C_R - \frac{1}{\omega L_L}\right) \tag{3}$$

The series resonance angular frequency and the shunt resonance angular frequency of the unit ZOR are defined as follows:

$$\omega_{se} = \frac{1}{\sqrt{L_R C_L}} \tag{4}$$

$$\omega_{sh} = \frac{1}{\sqrt{L_L C_R}} \tag{5}$$

In general, the series and shunt resonance angular frequencies are not equal. The balance condition is not satisfied and a bandgap exits between the left-handed low pass band and the right-handed high pass band. The bandgap can be described by two cut-off frequencies following:

$$\omega_{\tau 1} = \min(\omega_{se}, \omega_{sh}) \tag{6}$$

$$\omega_{\tau 2} = \max(\omega_{se}, \omega_{sh}) \tag{7}$$

The dispersion diagram is also shown in the figure. The unit ZOR supports a fundamental left-handed wave (phase advance) at lower frequencies and a right-handed wave (phase delay) at higher frequencies. By periodically cascading unit ZORs of length p, N times, the final structure can still be considered a resonator under the resonance condition

$$\beta_n = \frac{n\pi}{Np} \tag{8}$$

where n is the resonance mode number, which can be zero, or a positive or negative integer.[11] In the case of open boundary conditions, the zero-order resonance angular frequency is determined by the shunt resonance angular frequency ω_{sh}.[10] When the ZOR operates in the zero order mode, the ZOR antenna radiates the electromagnetic wave omni-directionally, like a monopole antenna with finite ground plane.

In this article, a circular mushroom ZOR is considered. By loading the patch with four identical arc-shaped stubs along the patch perimeter, a circumfluent current can be obtained and thus omni-directional, circularly po-

larized radiation can also be realized. ***Figure 2*** shows the equivalent circuit model of the proposed structure. The loaded arc-shaped stubs extend the current path of the patch of the ZOR and act as an increase in the area of the patch, which can be further considered as increasing the shunt capacitance and series inductance. The series capacitance between unit ZORs is not included in the circuit model of the proposed antenna, since only one unit ZOR is used. The resonant frequency of the proposed ZOR antenna is determined by the shunt resonance as follows:

$$f_0 = \frac{1}{2\pi\sqrt{L_L C_R}} \tag{9}$$

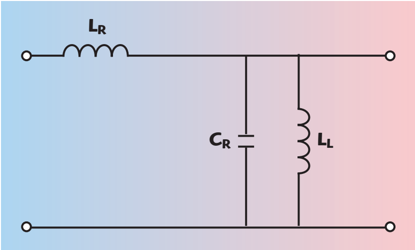

Fig. 2 Equivalent circuit of the proposed antenna.

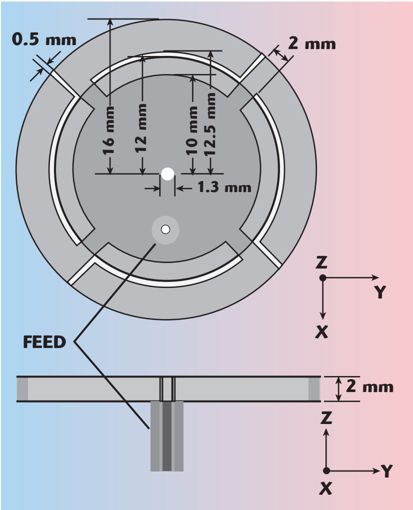

Fig. 3 Layout of the proposed antenna.

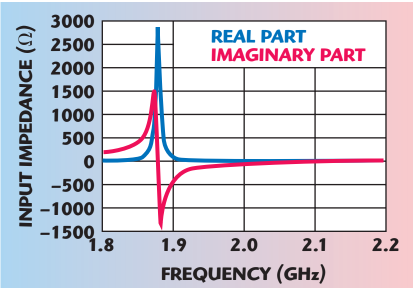

Fig. 4 Input impedance of the proposed antenna without ring slot.

DESIGN OF THE OMNI-DIRECTIONAL, CIRCULARLY POLARIZED ANTENNA

The layout of the proposed ZOR antenna is shown in ***Figure 3***. The feed point is located at (6 mm, 0 mm, 0 mm). The four stubs extend the current on the patch, increasing the patch area that is the shunt capacitance. Based on Equation 9, the resonant frequency will be lower than that of the ZOR antenna without the four loaded stubs.

Input Impedance and Matching

The input impedance of the ZOR antenna without any matching is shown in ***Figure 4***. It can be seen that the real part of the input impedance is very large at the resonance frequency and the ZOR antenna is badly mismatched to the 50 Ω feed line. Appropriate matching means must be added to match to the 50 Ω feed line. Here, a ring slot is adopted to improve the matching of the ZOR antenna, whose dimensions are optimized by using HFSS. A ring slot with an outer radius of 2.1 mm and an inner radius of 1.7 mm is used. ***Figure 5*** shows the input impedance of the ZOR antenna with the matching ring slot. It can be seen that the matching of the ZOR antenna is greatly improved after adopting the ring slot.

Effect of Dimensions of the Loaded Stubs on the Axial Ratio

The current distribution in the patch of the ZOR antenna is plotted in ***Figure 6***. The in-phase current distribution on the patch and loaded stubs can be observed. The radiation of the radial current simulates the function of the electric monopole antenna and the radiation of the circumfluent current simulates the function of the magnetic monopole antenna. The electric and magnetic monopole antenna have the same phase center, that is the geometrical center of the ZOR antenna, but they have not the same original phase. If the electric and magnetic monopole antenna are equal in terms of magnitude and orthogonal in terms of phase, the circularly polarized operation can be realized. The magnitude of circumfluent current has relevant relations with the dimensions of the loaded stubs. The difference of the original phase of the radial and circumfluent current is determined by the distance between the

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SPST								
0.2 – 2	SW1-002020RN1NF	1.7	70	1.6:1	10/10	20	35	35/70
2 – 8	SW1-020080RN1NF	2	80	1.7:1	10/10	20	35	35/70
4 – 12	SW1-040120RN1NF	2.2	80	1.7:1	10/10	20	35	35/70
2 – 18	SW1-020180RN1NF	3	80	2:1	10/10	20	35	35/70
1 – 18	SW1-010180RN1NF	3	70	2:1	10/10	20	35	35/70
SP2T								
0.2 – 2	SW2-002020RN1NF	1.5	70	1.6:1	10/10	20	35	60/60
2 – 8	SW2-020080RN1NF	1.8	80	1.7:1	10/10	20	35	60/60
4 – 12	SW2-040120RN1NF	2.2	80	1.7:1	10/10	20	35	60/60
2 – 18	SW2-020180RN1NF	2.8	80	2:1	10/10	20	35	60/60
1 – 18	SW2-010180RN1NF	3	70	2:1	10/10	20	35	60/60
SP3T								
0.2 – 2	SW3-002020RN1NF	1.6	70	1.6:1	20/20	150	180	85/85
2 – 8	SW3-020080RN1NF	1.9	80	1.7:1	20/20	150	180	85/85
4 – 12	SW3-040120RN1NF	2.4	90	1.7:1	20/20	150	180	85/85
2 – 18	SW3-020180RN1NF	3	80	2:1	20/20	150	180	85/85
1 – 18	SW3-010180RN1NF	3.1	70	2:1	20/20	150	180	85/85

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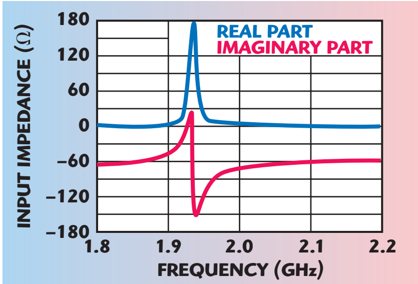


Fig. 5 Input impedance of the proposed antenna with ring slot.

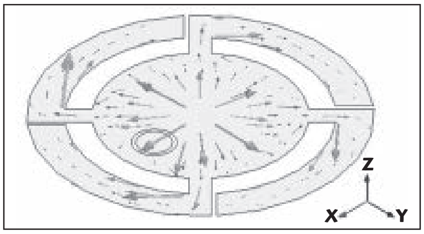


Fig. 6 Current distribution.

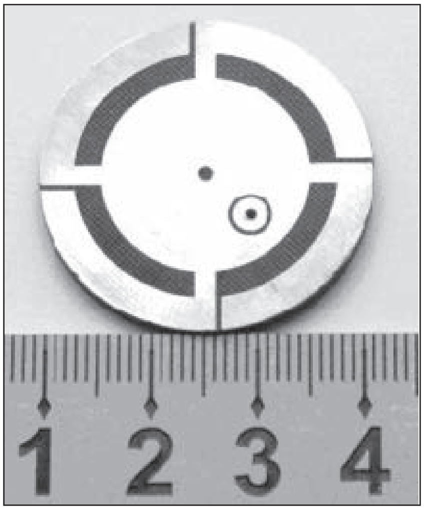


Fig. 7 Prototype of the proposed antenna.

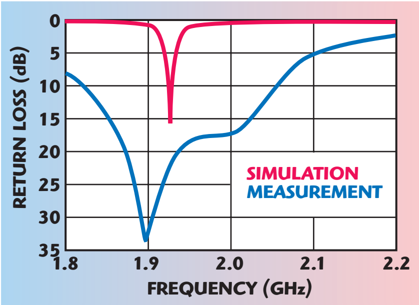


Fig. 8 Simulated and measured return loss.

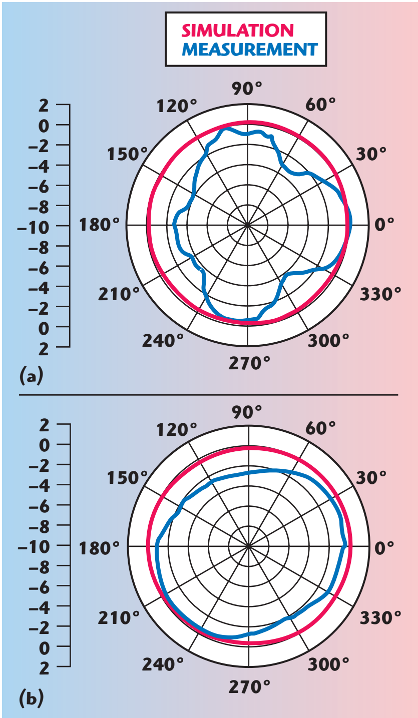


Fig. 9 Simulated and measured radiation patterns in the x-y plane: (a) horizontal component and (b) vertical components.

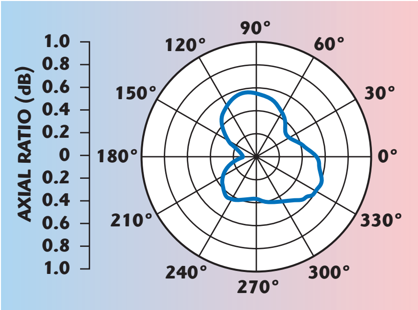
stubs and the patch sides. The axial ratio changes with the dimensions of the loaded stubs and the distance between the stubs and the patch sides. The proposed antenna realizes left hand circular polarization. If the stubs are loaded inversely along the patch perimeter, right hand circular polarization can be realized.

Antenna Realization

In order to obtain good circular polarized performance, the relevant parameters of loaded stubs are optimized by using HFSS and are shown in the layout figure. ***Figure 7*** shows the prototype of the proposed antenna. It uses a Teflon substrate with a dielectric constant of 2.65 and a height of 2 mm.

SIMULATION AND MEASUREMENT RESULTS

The simulated and measured return losses are displayed in ***Figure 8***. The operational frequency of the proposed antenna is 1.9 GHz. The difference between the two curves may be due to the fact that the top patch is loaded with stubs and the current path is extended. However, the ground plane is not large enough and the current on it may flow on the outer surface and even on the outer surface of the coaxial line. This acts as an effective impedance matching. The proposed antenna provides a 10 dB input return loss and bandwidth of 11.8 percent. ***Figure 9*** shows the simulated and measured radiation patterns of the vertical and horizontal polarization components in the x-y plane. It can be seen that omni-directional radiation is obtained for the proposed antenna. The radiation non-circularity of the proposed antenna may be attributed to fabrication errors and measurement environ-



▲ *Fig. 10 Simulated axial ratio of the proposed antenna in the x-y plane.*

ment. ***Figure 10*** plots the simulated axial ratio of the proposed antenna in the x-y plane. It can be observed that the proposed antenna has a good omni-directional axial ratio performance. By using the gain comparison method, the measured gain of the proposed antenna is 0.2 dB.

CONCLUSION

A new type of low profile omni-directional, circularly polarized antenna is designed, fabricated and measured. The proposed antenna has a good performance in size, a radiation pattern similar to a monopole antenna and can provide a large service area. The proposed antenna can find wide applications in the mobile and wireless local area network (WLAN) systems due to its good performance in axial ratio, size and service area. ■

ACKNOWLEDGMENT

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A Small Size, High Gain Antenna for Wireless Base Station Applications

A single-element high gain compact microstrip antenna has been experimentally demonstrated to operate over a wireless band covering 8 percent impedance bandwidth. As much as 11 dBi peak gain with linearly polarized radiation has been achieved using a prototype designed for personal communication systems (PCS: 1850 to 1990 MHz). The prototype occupies only $0.15\lambda_0 \times 1.0\lambda_0^2$ space, λ_0 being the wavelength corresponding to the center frequency. This antenna is aimed to communicating with the wireless base stations as a booster/repeater device to serve a microcell in a weak signal zone.

In view of the compact and portable nature of the wireless equipment, their compact size and configuration have been a big issue to the wireless industry. Some challenges in realizing miniaturized wireless antennas have been discussed by Cantrell[1] and some new useful candidates using dielectric resonators and microstrips have been recently reported.[2-4]

Of all the possible structures investigated so far, microstrip appears to be the most advantageous for various reasons, including simplicity, cost, weight and fabrication. However, a microstrip patch having a rectangular or circular shape suffers from an inherent limitation of narrow impedance bandwidth (≈2 to 3 percent with VSWR < 2) and the peak gain is limited to 6 to 7 dBi. Several techniques are known to increase the impedance bandwidth of a microstrip antenna, but they usually reduce the antenna gain. Several gain enhancement techniques like using a planar array or superstrate layers are also known, but they could significantly reduce the antenna bandwidth.

In this work, the combination of some useful techniques have been explored to demonstrate a small size, high gain antenna with a considerably large impedance bandwidth accommodating a commercial wireless band. The techniques employed here were studied earlier by different groups individually to investigate a mechanically tunable patch,[5,6] to compensate probe reactance[7] and to study improved radiation properties using a shaped ground plane.[8-11]

Here, all of them have been employed in one structure for the first time, to realize a commercially viable high gain wireless antenna. As much as 11 dBi peak gain has been experimentally demonstrated using a prototype operating over the 1850 to 1990 MHz band (VSWR < 2 over 8 percent impedance bandwidth) for the PCS band. The antenna occupies only $0.15\lambda_0$ by $1.0\lambda_0^2$ space, λ_0 being the wavelength corresponding to the center of the frequency band. The antenna, backed by a transmit-receive unit, can be packed together in a compact plastic enclosure and should be ideal for both indoor and outdoor installations. This is basically aimed to microcell applications to communicate with a base station as a booster/repeater device in a weak signal zone like an airport, large building, shopping mall, etc.

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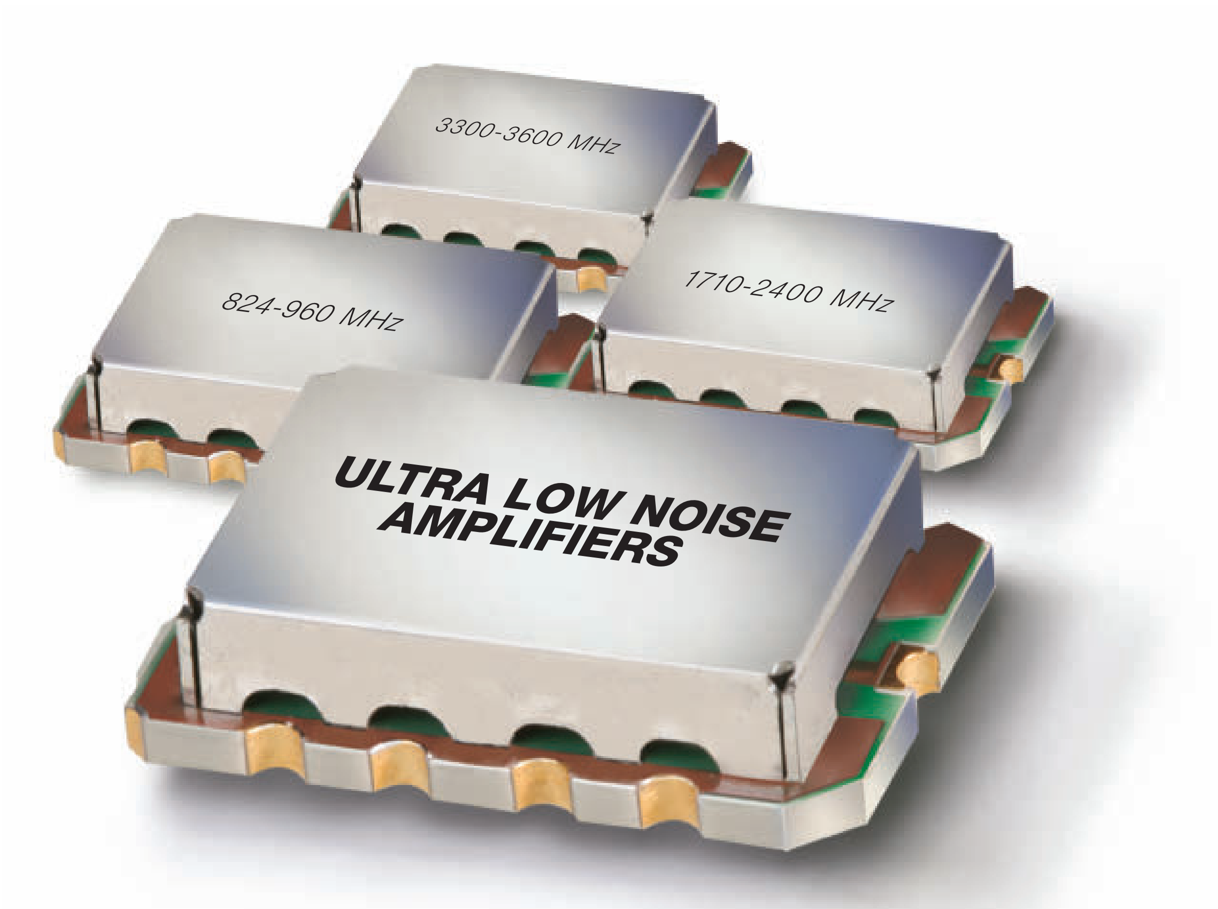
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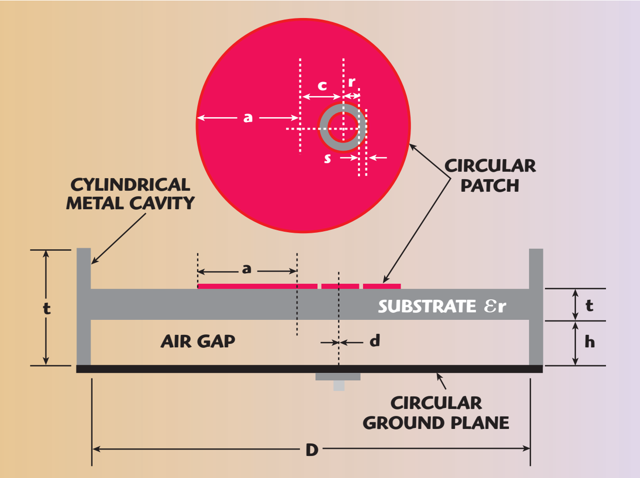
DESIGN APPROACH

A schematic diagram of the antenna is shown in ***Figure 1***. A coaxial-fed circular patch, etched on a microstrip substrate, is used as the radiating element where the substrate is fitted within a circular cylindrical cavity having its diameter D equal to approximately the resonant wavelength and the depth $l \approx 0.15D$. The substrate maintains a variable air gap h with the ground plane, which is the floor of the metal cavity. An annular slot is introduced surrounding the feed point. This design approach, aimed at achieving a high gain performance over a wide impedance bandwidth using a compact ground plane, is provided below:

(i) An increase in the substrate thickness and decrease in its relative permittivity are two suitable choices to enhance the impedance bandwidth of a microstrip patch. This was implemented by introducing an air gap below the substrate.[5,6] In the original work with an air gap,[5] the objective was to tune the antenna by varying the gap height h. In the present structure, the air gap results in increased electric fringing fields; hence, a considerable increment in the effective radius of the radiating patch is obtained, which can be estimated.[6] This increment in the effective patch radius causes the enhancement in the antenna gain.

(ii) Feeding through a coaxial probe has been chosen since it is simple, less expensive and efficient for integrating with the transceiver front end. However, the long center conductor penetrating through the substrate with air gap results in a large value of feed inductance, which degrades the impedance matching at the input. A capacitive loading by an annular slot on the patch, surrounding the feed, was demonstrated by Hall[7] as a probe compensation technique for a thick substrate. Here, for the first time, that technique has been applied to the proposed geometry with an air-gap to simultaneously achieve the high gain along with a wide matching bandwidth.

(iii) Maintaining the ground plane size as small as possible is another requirement for a compact wireless antenna, which in turn, for a microstrip element, degrades the radiation pattern and the antenna gain. This aspect has been taken care of by introducing a metal cavity surrounding



▲ *Fig. 1 Schematic diagram of the proposed wireless antenna.*

the patch, which also prevents diffraction at the edge of the ground plane. Some earlier studies employing cavity and shaped ground plane[8-11] also addressed the possibility of reduction in patch size and improvement in radiation characteristics.

For the present design, the optimum parameters like the patch radius a, the air gap h and the feed location c have been directly calculated from previously published formulas,[6,12] for the center frequency of the band. The antenna has been designed to operate over an approximately 8 percent matching bandwidth; the matching parameters r and s of the annular slot have been optimized through a series of simulation studies.[13] The other important parameters like the cavity diameter D and depth l were thoroughly studied in view of achieving optimized radiation properties. Further details of the design parameters are also available.[14]

MEASURED AND SIMULATED RESULTS

A prototype, operating in the PCS band, was fabricated and measured using an HP 8510 B network analyzer and a fully automated anechoic chamber. Some representative results are presented. ***Figure 2*** shows the measured and simulated return loss characteristics of the prototype. The antenna parameters are: ε_r = 4.5, t = 1.575 mm, l = 25 mm, d = 1.275 mm, a = 33 mm, r = 5 mm, s = 0.8 mm, c = 14 mm, h = 5 mm and D = 160 mm. The measurements show close agreement with the optimum simulated return loss values. The measured S_{11} values rather indicate a comparatively improved impedance matching at the antenna input.

The diameter of the ground plane has been initially chosen to be approximately $1.0\lambda_0$ (D ≈ 160 mm). The effect

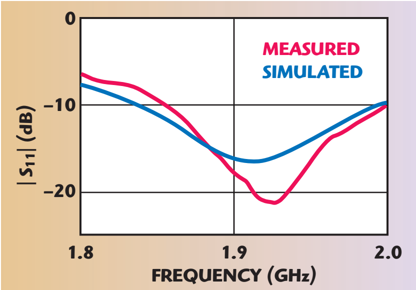


Fig. 2 Measured and simulated return loss of the prototype antenna.

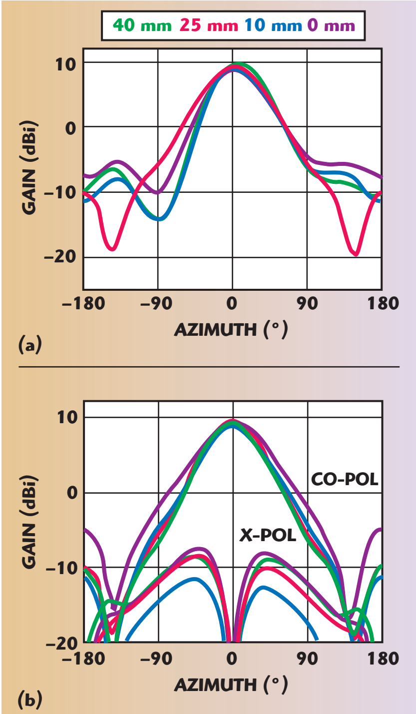


Fig. 3 Simulated radiation patterns for different heights of the cavity wall: (a) E-plane and (b) H-plane.

of the cavity height l on the radiation characteristics has been examined and is shown in ***Figure 3***. Those corresponding to l = 25 mm indicate the best possible response in view of the optimum beam shape and minimum backward radiation. The effect of change in D value above and below D = 160 mm has also been examined and is shown in ***Figure 4***, keeping l = 25 mm. A decrease in D by 20 mm (that is D = 140 mm) results in relatively 1 dB down in the peak gain. Again, an increase of D by 20 mm (D = 180 mm) is found to enhance the peak gain by approximately 1 dB, but with a considerable back radiation, particularly in the E-plane pattern. Therefore, D = 160 mm with l = 25 mm appears to be the best choice to achieve a good radiation pattern with an optimum peak gain of approximately 11 dBi.

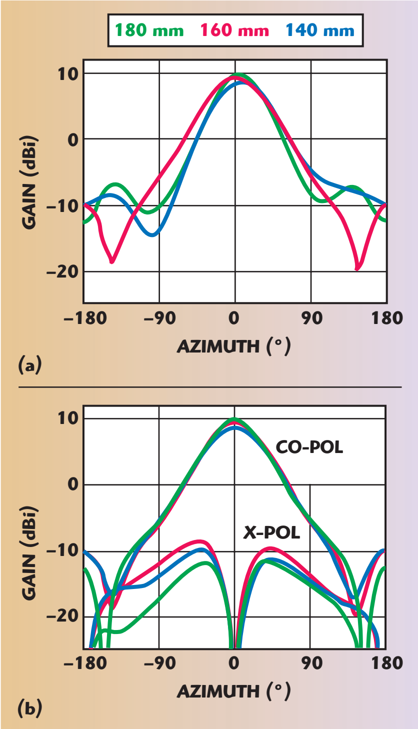


Fig. 4 Simulated radiation pattern for different cavity diameters.

Figure 5 shows the measured values of the peak gain along with the simulated data. The simulated data have been generated in two sets: over 1.85 to 1.9 GHz, using 1.9 GHz as the 'solution frequency', and over 1.92 to 2 GHz, using 2 GHz as the 'solution frequency'. The simulation shows close agreement with the measurements indicating a maximum relative deviation of the order of 0.5 dB.

The measured radiation characteristics of the PCS antenna are shown in ***Figure 6*** near the centers of its two sub-bands called uplink (1.85 to 1.91 GHz) and downlink (1.93 to 1.99 GHz) frequencies. Both the co- and cross-polarized patterns at these two frequencies are identical. As much as 11 dBi peak gain with its main lobe aligned to the bore sight is revealed. The simulated gain, shown previously, closely corresponds to the measured values except for the E-plane cross-polarized level. Though no significant cross-polarized radiation above -25 dB is obtained theoretically, the measurements show this as much as -10 dB near bore sight.

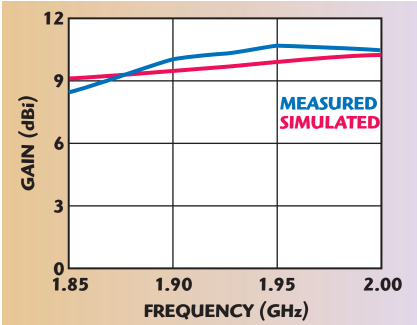
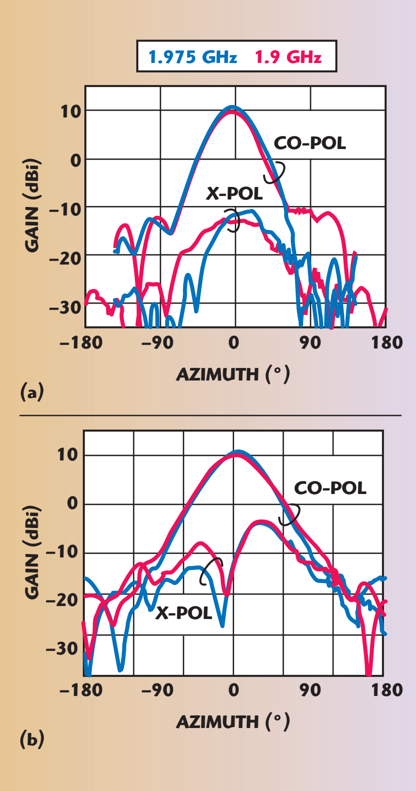


Fig. 5 Measured and simulated peak gain of the prototype antenna.



▲ *Fig. 6 Measured radiation characteristics of the proposed antenna: (a) E-plane and (b) H-plane.*

Such an experimental observation was also indicated and discussed in a previous paper.[15]

CONCLUSION

A new design of an antenna suitable for certain wireless applications is presented. The performance of the antenna is demonstrated based on theoretical and experimental studies. This antenna is simple, less expensive, compact in size and with relatively high gain, operating over the PCS frequencies. As much as 11 dBi peak gain with linear polarization and 8 percent impedance bandwidth have been experimentally demonstrated. ■

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A Compact Planar Monopole Antenna for Ultra-wideband Operation

A novel planar monopole antenna of small dimensions is proposed for ultra-wideband (UWB) operation. With the use of a planar monopole microstrip feed and a subminiature version A (SMA) connector, the proposed antenna has a very wide impedance bandwidth from 3.06 to 10.80 GHz, defined by a VSWR less than 2:1. The transmission loss and group delay are also measured and discussed.

The United States Federal Communications Commission (FCC) has opened the radio spectrum from 3.1 to 10.6 GHz, permitting the use of a new unlicensed radio transmission technology, the UWB system. UWB systems entail sharp sub-nanosecond pulses, and occupy a wide band with the only restriction being a limit on the radiated emissions levels. The European Commission is following the same road and has been allocating the bands from 3.4 to 9 GHz for UWB systems.[1] Several compact UWB antennas have been reported.[2-5,7]

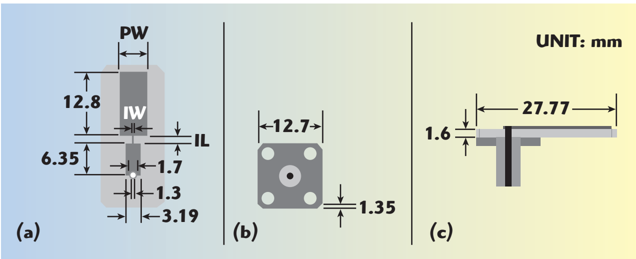

Fig. 1 Geometry of the proposed antenna: (a) top view, (b) SMA connector and (c) sectional view.

In this article, a compact planar monopole antenna is proposed for UWB operation. The proposed antenna uses an SMA connector in place of a ground plane. Details of the antenna design and experimental results are presented and discussed.

ANTENNA DESIGN

Figure 1 shows the geometry of the proposed antenna. The antenna is printed on a FR4 substrate, with a relative permittivity of 4.4 and a thickness of 1.6 mm, and mounted on the square flange of an SMA connector, with a width of 12.7 mm. The antenna consists of three sections: a planar monopole, a microstrip line and an SMA connector.

Planar monopole antennas, featuring broad bandwidth, small size, omni-directional radiation pattern and low cost, have been pro-

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*Chonnam National University
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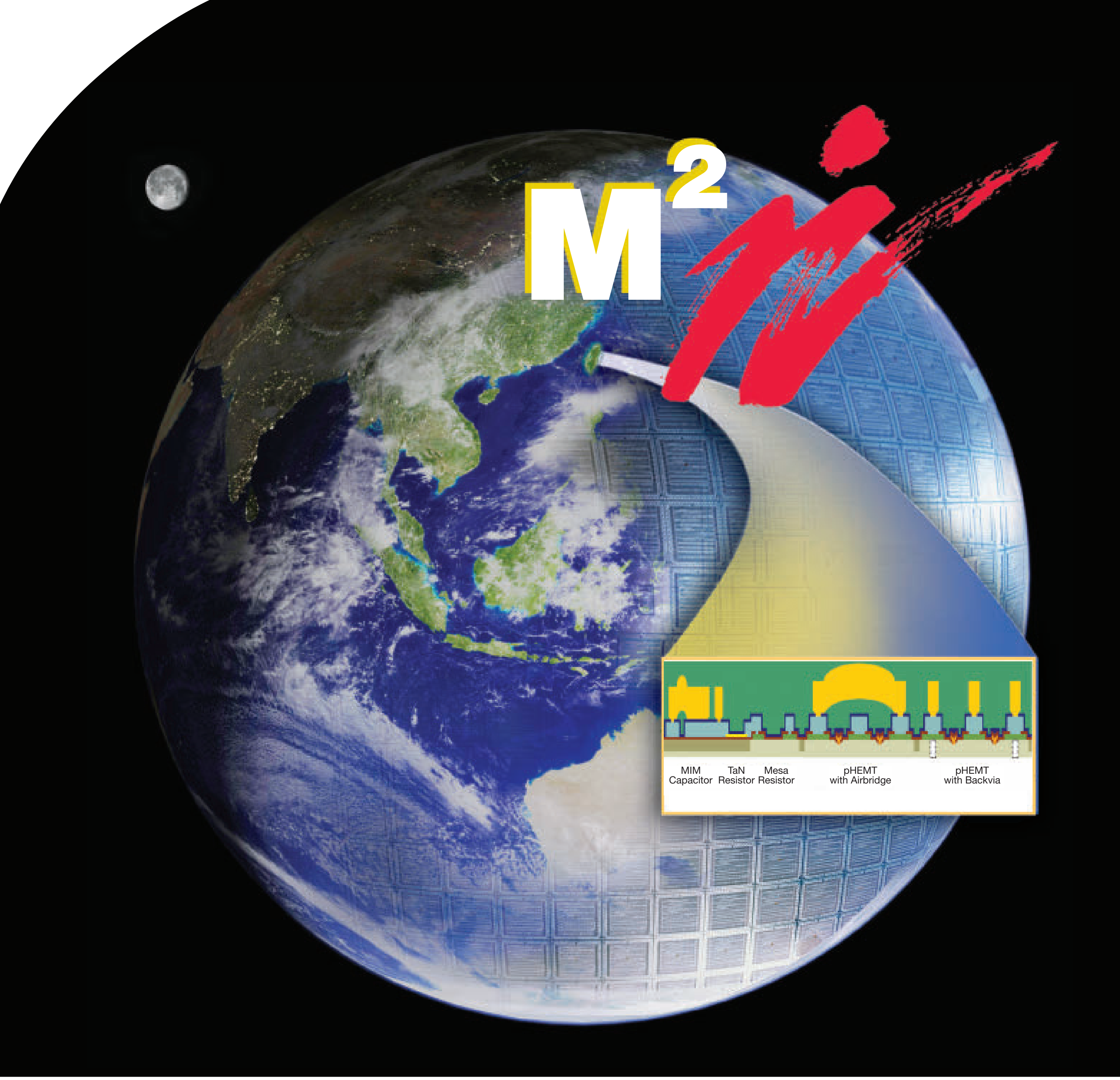

M2
MIM Capacitor
TaN Resistor
Mesa Resistor
pHEMT with Airbridge
pHEMT with Backvia

posed and investigated for UWB applications.[2,3] Therefore, a rectangular planar monopole (12.8 mm × PW) is used. In addition, a line (IL × IW) is situated between the planar monopole and the microstrip line to achieve good impedance matching.

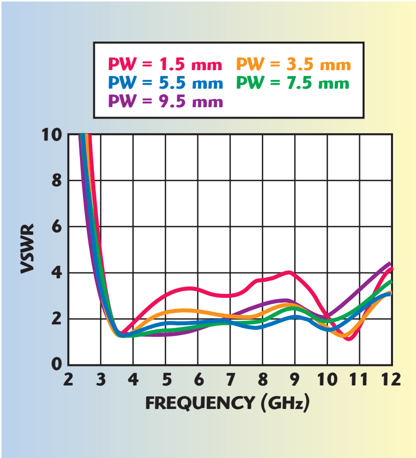
The antenna is fed by a microstrip line 3.19 mm wide. The microstrip line is connected to the 1.3 mm diameter inner conductor of an SMA connector and a 1.7 mm diameter circular patch is printed around the via-hole for a smooth connection. The ground plane of the antenna is the ground flange of the SMA connector that has the dimensions of 12.7 × 12.7 mm. Therefore, the proposed antenna is designed to connect the main radiator directly to the SMA connector without a special ground plane.

Planar antennas with a modified ground plane (beveling and notch) have been proposed and investigated for UWB operation.[4,5,7] In the case of the proposed antenna, the SMA connector has bevels (with a width of 1.35 mm and a 45-degree angle) at each corner for broadband operation. Incorporation of the four circular holes of the SMA connector does not have a significant influence on the operating performance of the antenna.

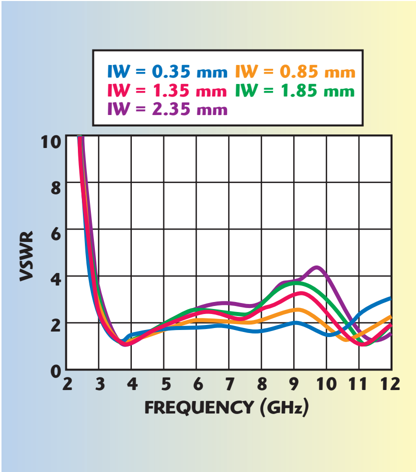
DISCUSSION AND EXPERIMENTAL RESULTS

For a printed rectangular planar monopole antenna, the impedance bandwidth is heavily dependent on the width of the monopole.[6] ***Figure 2*** shows the simulated voltage standing wave ratio (VSWR) of the antennas for various widths PW, keeping IW = 0.35 mm and IL = 1.3 mm constant. Varying PW from 1.5 to 9.5 mm yields results similar to those of Jhon and Amman.[6] Good impedance matching can generally be implemented only when PW is equal to 5.5 mm, at which value the impedance bandwidth covers the UWB band (3.1 to 10.6 GHz).

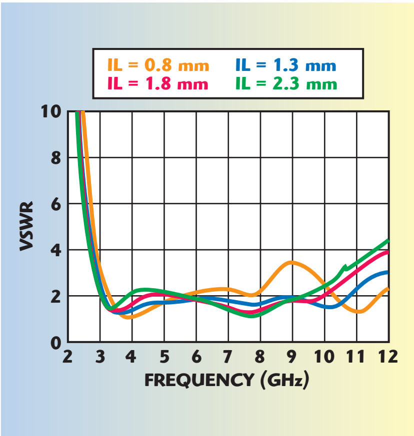
A small transmission line is located between the planar monopole and the microstrip line to achieve good impedance matching. ***Figure 3*** shows the VSWR of the antennas with various widths IW, keeping PW = 5.5 mm and IL = 1.3 mm constant. ***Figure 4*** shows the VSWR of the antennas with various lengths IL, keeping PW = 5.5 mm and IW = 0.35 mm constant. The final dimensions IW and IL are set at 0.35 and 1.3 mm, respectively, in order to cover the UWB band.



▲ *Fig. 2 Simulated VSWR for various widths PW.*

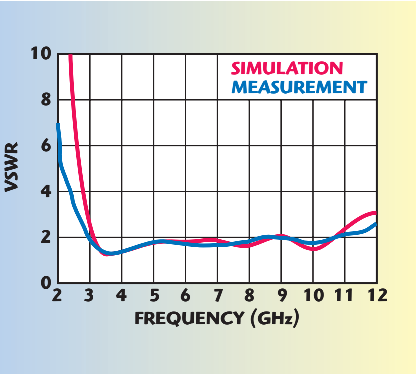


▲ *Fig. 3 Simulated VSWR for various widths IW.*



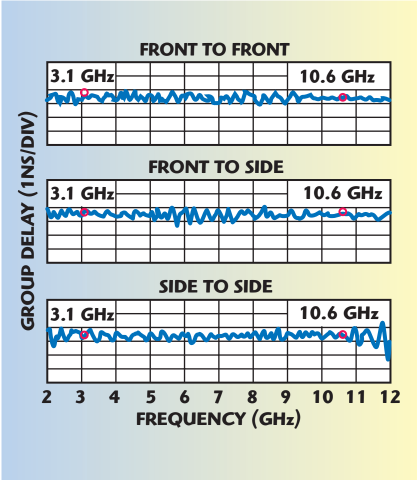
▲ *Fig. 4 Simulated VSWR for various lengths IL.*

▲ *Fig. 5 Photograph of the fabricated antenna.*

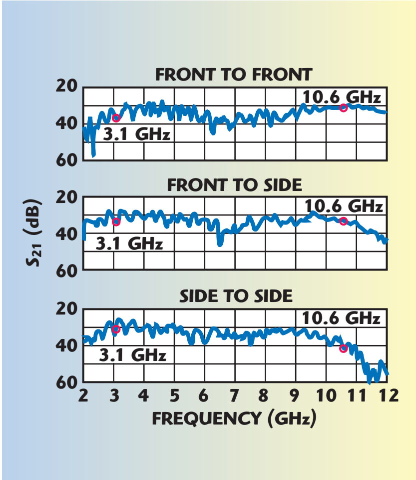


▲ *Fig. 6 Simulated and measured VSWR of the fabricated antenna.*

The antenna was fabricated and measured. ***Figure 5*** shows a photograph of the fabricated antenna. ***Figure 6***, which shows the simulated and measured VSWR for the given dimensions, confirms the good agreement between the measured and simulated results. The simulated and the measured bandwidth, defined by VSWR less than 2:1, were 7.63 GHz (3.09 to 10.72 GHz) and 7.74 GHz (3.06 to 10.80 GHz), respectively.



▲ *Fig. 7 Group delay measured in the time domain.*

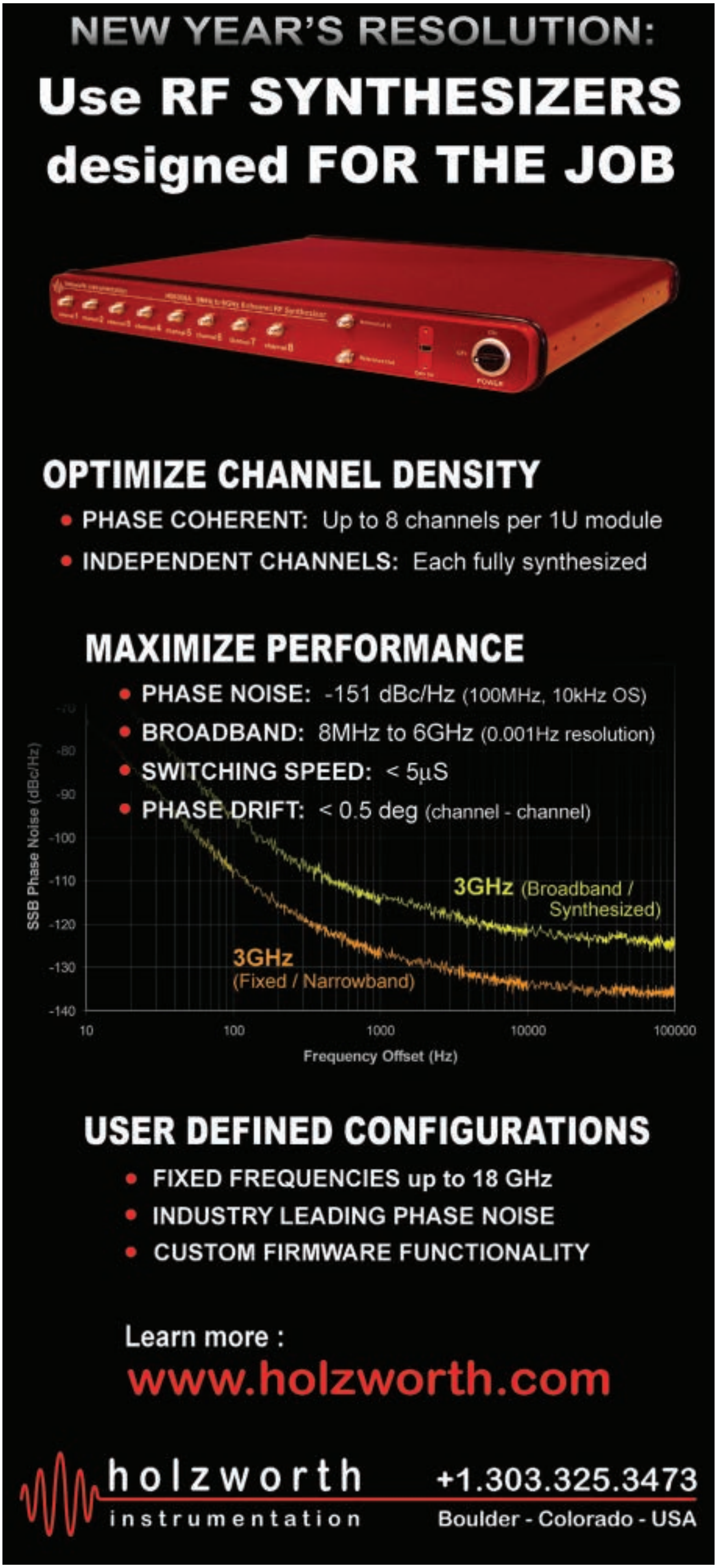


▲ *Fig. 8 Measured transmission loss.*

Figure 7 shows the measured group delay in the time domain. The antennas were separated by a distance of 50 mm due to the low output power of the network analyzer. The group delay is not well detected by the network analyzer at a significant distance, without a low noise amplifier (LNA).[7] Considering the measured values in an available range of UWB communication, from 3.1 to 10.6 GHz, the group delay variation was less than approximately 1 ns. This performance should allow for communication through enhanced phase linearity, and a pulse template transmitted or received by the antenna will retain its shape without serious distortion. The magnitude of transmission loss (S_{21}) between two identical antennas separated by 100 mm was also measured and is plotted in ***Figure 8***. For measurement of group delay and S_{21}, an antenna was connected to each port of the network analyzer, and both identical antenna pairs were placed front to front, front to side, and side to side. In the figures, the markers indicate the frequency points at 3.1 and 10.6 GHz, respectively.

CONCLUSION

A compact planar monopole antenna with an SMA connector has been proposed for UWB operation. The proposed antenna uses an SMA connector in place of a ground plane. As a result, broad impedance bandwidth and compact antenna dimensions are achieved. The measured VSWR, transmission loss and group delay demonstrate that



the antenna can serve for UWB operations. The proposed antenna has small dimensions, broad impedance bandwidth, small group delay, and is suitable for UWB antenna applications. ■

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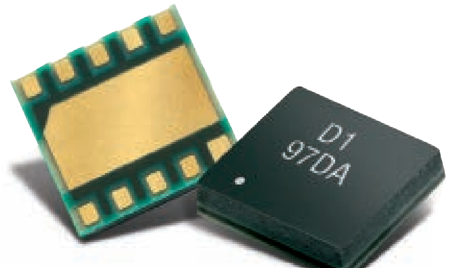

SWITCHABLE W-CDMA POWER AMPLIFIER MODULES SUPPORTING LTE

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In many quarters it is expected that Long Term Evolution (LTE) will be the next generation standard or the 3.9 generation (3.9G) mobile phone standard, which could be introduced as early as this year. The LTE advantage is a very high-speed data transfer capability of up to 326 Mbps and can utilize quite a few existing base stations, compared to other emerging high-speed data link systems such as WiMAX.

Key devices needed to realize longer talk time and lighter handsets are power amplifier modules (PAM). Because they consume a large amount of the current available from the power supply in a handset, it is essential to operate the PAM with high efficiency under the various modulation schemes.

In addition, it is important for the PAM to incorporate a simple digital input/output (I/O) interface and have reference voltage generation, as the reference voltage often plays an important role in the accurate bias feeding of HBT-based power amplifiers. The self-reference generation of the PAM allows a discrete low-voltage-drop-out regulator (LDO) to be removed on the printed-circuit board (PCB) and a digital I/O enables direct control of the PAM by advanced Si-based RF-LSIs or baseband LSIs. Thus, increased functionality as well as improved performance is a key requirement for the PAM.

BA012DX SERIES

These requirements are more than satisfied by Mitsubishi Electric's new BA012Dx series of power amplifier modules, which incorporate cutting-edge device and circuit technologies. These PAMs support current and near future cell phone handset applications from W-CDMA systems up to LTE systems. The applications include the latest fast data transfer systems—High Speed Downlink Packet Access (HSDPA), High Speed Uplink Packet Access (HSUPA) and High Speed Packet Access Plus (HSPA+).

The BA012Dx series has been specifically developed to address the requirements mentioned above and is a family of single-band

MITSUBISHI ELECTRIC CORPORATION
Tokyo, Japan

PAMs for use in cell phone handsets or data cards for mobile applications. Compared to multi-band PAMs, the single-band PAM configuration gives customers the freedom for a more flexible PCB design. In the series, the BA012D1 is for band I, BA012D2 for band V, BA012D3 for band XI, BA012D4 for band II, BA012D5 for band VIII and BA012D6 for band III (IV). PAMs for other bands are currently being considered.

INTEGRATED COUPLER

A block diagram of the PAM is shown in ***Figure 1***. One of the key features is an integrated coupler for monitoring output power to simplify the layout of the handset. Other features are the integrated reference voltage generator and the control logic circuit, which address recent Si I/O level requirements. To achieve this level of integration, an advanced in-house BiFET technology has been employed for the BA012Dx

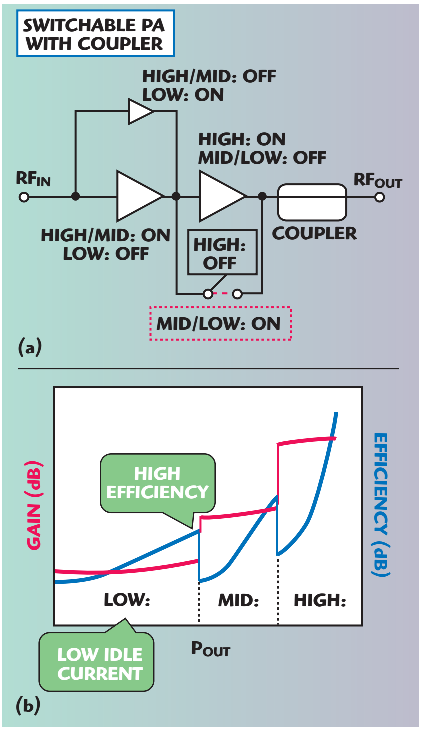

Fig. 1 Simplified block diagram of the BA012Dx (a) and gain/efficiency vs. P_{out} (b).

series, which allows for both HBTs and FETs to be fabricated on the same die. In this process FET-based topologies can be used for the DC bias circuits and the analog RF switches, and these can be incorporated together with a conventional HBT power amplifier block. Thanks to the BiFET process, the BA012Dx series can be operated in three different power modes depending on the required output power level. These three power modes can be used to reduce the average current consumption and extend battery life. In the high power mode, the PAM works as a two-stage amplifier, delivering sufficient output power and linearity.

In contrast, the mid-power mode is implemented by switching the second stage off and bypassing it, leading to very high efficiency operation. In the low-power mode, only an additional small-size power stage is active while the other stages are kept in the off-state. As a result, the BA012Dx series is capable of delivering very high efficiency in each power mode.

POWER-ADDED EFFICIENCY

Figure 2 shows an example of the power measurement for the BA012D1 module under W-CDMA modulation test conditions. This PAM achieves power-added efficiencies (PAE) of 36


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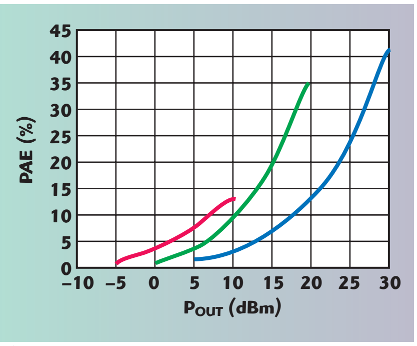
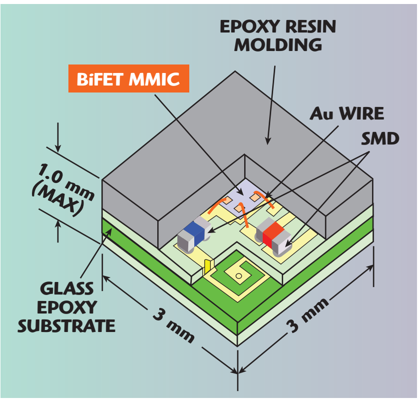
percent, 26 percent (or higher), and 10 percent in the high, mid, and low power modes, respectively, while maintaining adjacent channel leakage power ratio (ACLR) of less than -41 dBc and next adjacent channel leakage power ratio (NACLR) of less than -55 dBc.

Under the LTE (3rd Generation Partnership Project [3GPP] TS36.101) modulation condition of resource blocks (RB), 25 and 100, the PAEs of 31.3 and 31.4 percent can be achieved in the high power mode. The efficiency drop is minimized due to circuit parameter optimization for various modulation schemes from W-CDMA to LTE. The 3GPP compliant, probability distribution function (PDF)-based average current is as low as 27.7 mA, which is very effective in saving battery current consumption and consequently extending talk time in everyday cell phone use.

The cross-section of a BA012Dx device is shown in ***Figure 3***. The BiFET MMIC die is assembled on a small 3 × 3 mm glass epoxy substrate, together with several surface-mount devices (SMD) such as capacitors and inductors, used for matching and decoupling. The height of the package is less than 1 mm, which is suitable for realizing low-height cell phones and thin data cards.



▲ *Fig. 2 Typical performance of the BA012Dx under W-CDMA modulation.*



▲ *Fig. 3 Cross-section view of a BA012Dx device.*

CONCLUSION

Mitsubishi Electric has utilized the company's wealth of manufacturing experience in producing very high reliability products to develop the BA012Dx series, which has been produced in order to satisfy the current and future mobile phone and data-card market requirements. Cutting-edge design and fabrication techniques have produced a range of PAMs that are expected to contribute to the realization of even smaller, lighter cell phone handsets.

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RS No. 310

ARCH ROLL SPHERICAL NEARFIELD SCANNER

Nearfield Systems Inc. (NSI) has developed a new spherical near-field scanner, NSI-700S-300, that is capable of testing stationary antennas over wide angles with accuracies and speeds that historically were only available from planar near-field systems. It is ideal for wide angle satellite and radar antenna testing.

The planar near-field technique is often used for testing antennas of higher directivity (typically >15 dBi), and allow the antenna to remain in a fixed orientation. However, planar near-field scanning cannot provide good sidelobe coverage out to beyond about ±70 or ±80 degrees. Spherical near-field measurement systems can avoid that limitation, but until now have required that the antenna be moved about one or both axes to accomplish the measurement. NSI, in introducing the NSI-700S-300 Arch Roll Spherical Near-field Scanner, has overcome this limitation, allowing high precision spherical near-field measurements beyond ±90 degrees, without the need to move the antenna (see ***Figure 1***).

The challenge was to design a spherical antenna measurement system that would allow fast and accurate electromagnetic field measurements for a stationary antenna by using only probe motion. The advantages of testing a stationary antenna include:

- The antenna can be measured in the orientation in which it will be used. This way antenna flexure due to a changing gravity vector does not corrupt the measured patterns.
- Manufacturing support hardware costs for the antenna can be greatly reduced. For in-

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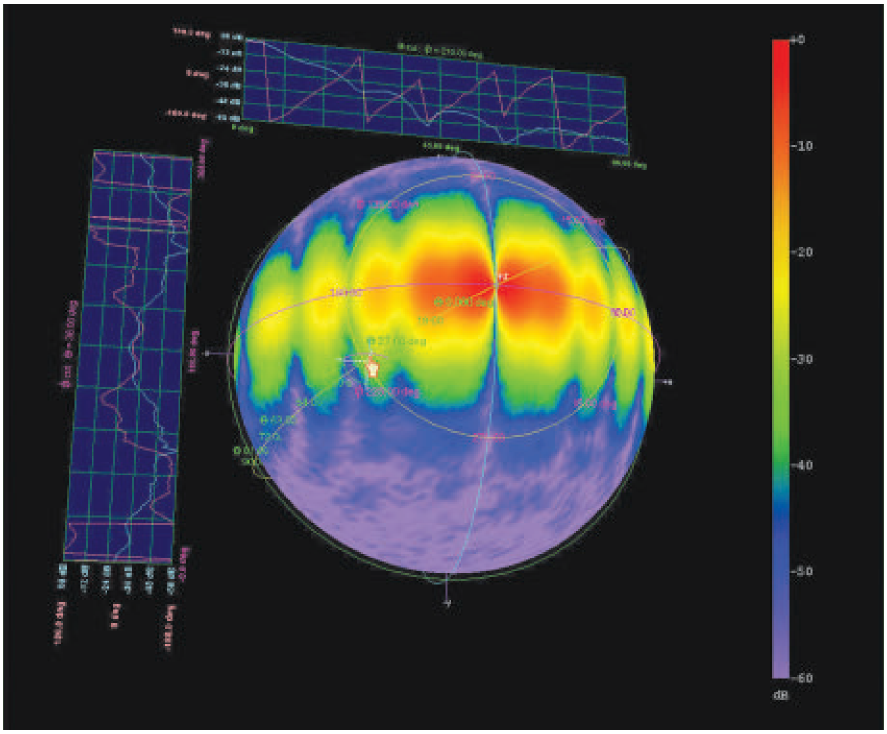

Fig. 1 *Typical hemispherical near-field data plot measured on NSI-700S-300.*

Fig. 2 *Pictorial of NSI-700S-300 arch roll spherical scanner with inset image.*

stance, expensive slip ring assemblies and flexing power control cabling used for active thermal control are no longer necessary.

- The antenna alignment support equipment is much simpler and can be set up in the manufacturing assembly area, and simply rolled in to the test range without elaborate fixtures, mounting procedures, or alignment steps.

The stationary antenna approach requires an electromagnetic field sensing probe that moves over a hyper-hemispheric surface enveloping the antenna (see **Figure 2**). The probe is precisely positioned in space by a high precision structure augmented by dynamic motion compensation. The scanner can complete a hyper-hemispherical multi-beam, multi-frequency antenna measurement set of up to

TABLE I

NSI-700S-300 SPECIFICATIONS

Construction	Steel support column, Phi and Theta "C" shaped structure
Drive System	Precision Stepper Motors
Scan Area	360° Phi and 95° in Theta°
Maximum Antenna Diameter	96" (2.4 m)
Resolution	0.0015° Phi and Theta
Position Repeatability	0.015°
Rotational Speed	30°/s Phi
System Controller	NSI Panther Motion Controller with serial and parallel I/O interfaces
Measurement Workstation	Measurement workstation computer with large LCD monitor
Stepper Motor Power Amplifier	EIA 19" rack mount (7" high x 14" deep)
Motor Cables	Quick-connect; 40' (12 m)
Scanner Absorber	Absorber Kit (12" pyramidal cone), Flat
Probe	WR90 Open-ended Waveguide Probe SMA (f) transition and Pyramidal Absorber (3")
RF Cables	20 GHz RF Cables
Rotary Joints	Qty. 3 - DC-26.5 GHz, (Phi, Theta, Pol)
Supported RF Devices	NSI Panther 9000 Receiver or selection of Agilent, Rohde & Schwarz, and Anritsu VNAs (contact NSI for a complete list)
Power	100-240 VAC switchable, 50/60 Hz, 500 W

eight feet in diameter in less than one hour. The arch rotates continuously at 30 degrees per second during the measurement process.

The new Arch Roll scanner product line opens the door for accurate wide angle hyper-hemispherical measurements of stationary antennas. Its design not only eliminates the need for slip ring assemblies to the antenna, but simplifies the meticulous alignment procedure required for accurate measurements on traditional spherical scanners.

The NSI-700S-300 Arch Roll Scanner's proven design allows for frequency expansion to millimeter-wave measurements. The design is also adaptable for symmetrical 1g loading measurement requirements. It is ideally suited for satellite and radar antennas that require precision testing of a fixed antenna that cannot be moved or rotated during a test cycle.

Other unique features of the Arch Roll Scanner include (see ***Table 1*** for a full list):

- Sub arc second encoders combined with structural deformation correction.
- A 4" travel radial stage for accommodating a variety of probes.
- Specially designed algorithms for dynamic probe position correction of the arch roll configuration that allow 'on-the-fly' probe position correction to maintain a probe position accuracy on the order of 0.0025 inches rms.
- An RF subsystem that is capable of measuring thousands of frequencies and beam configurations.

The NSI-700S-300 Arch Roll Spherical Near-field Scanner together with NSI's Panther 9000 RF subsystem and NSI 2000 antenna measurement software deliver spherical measurement with unprecedented accuracies and speeds.

Nearfield Systems Inc. (NSI), Torrance, CA, e-mail: sales@nearfield.com, www.nearfield.com.

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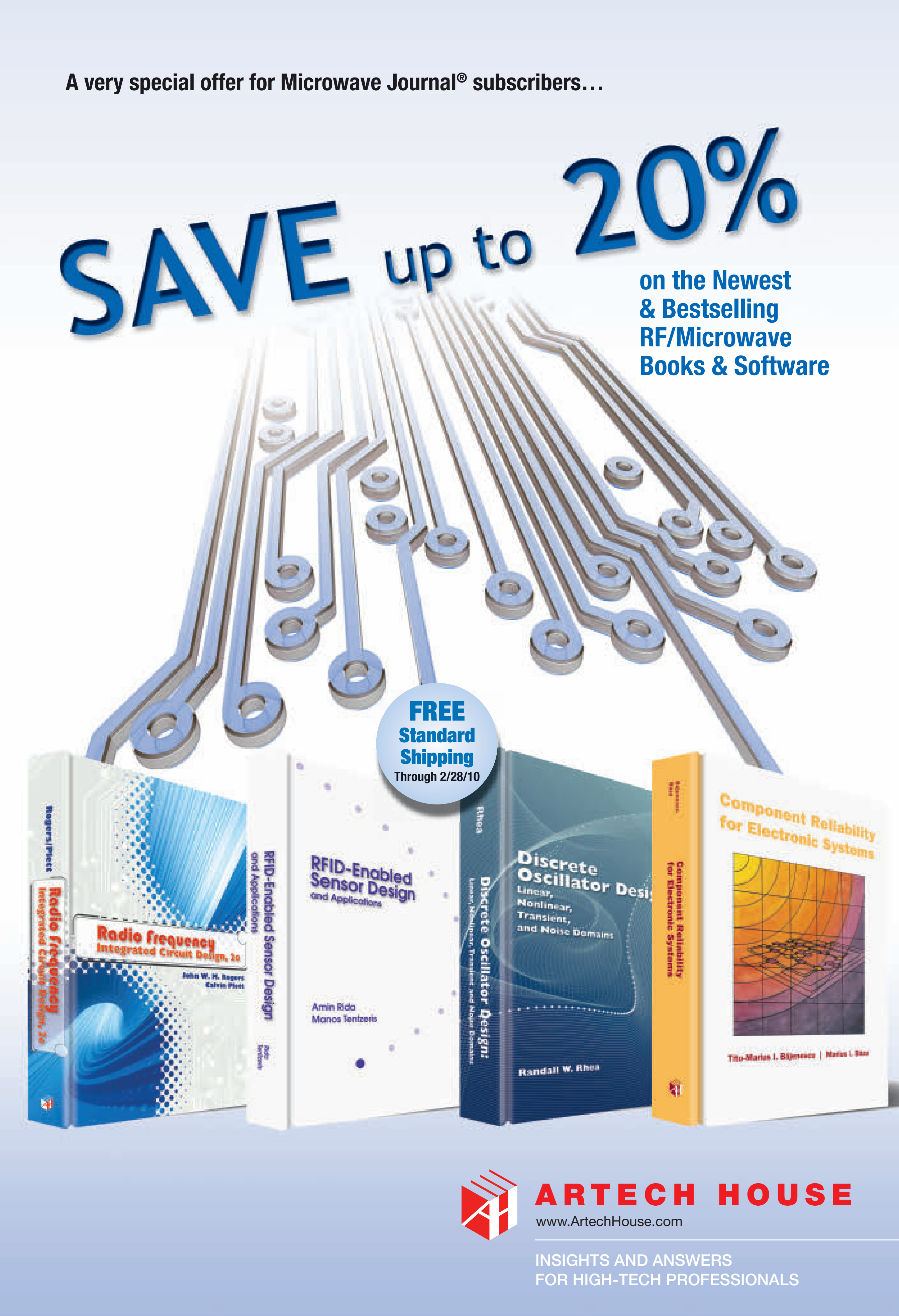
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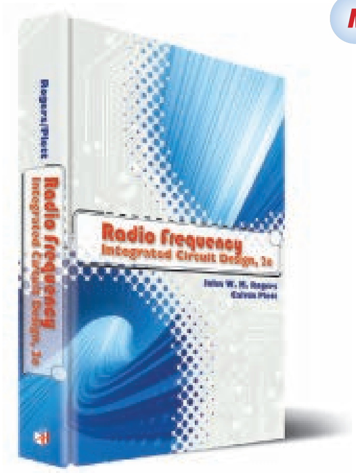

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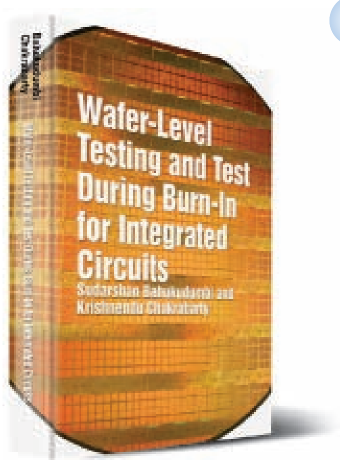

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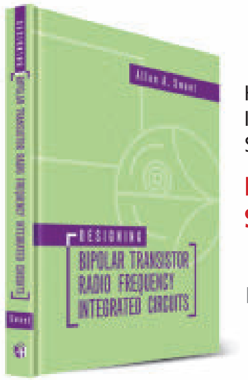

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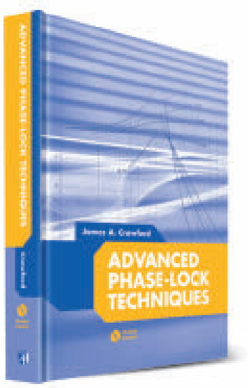

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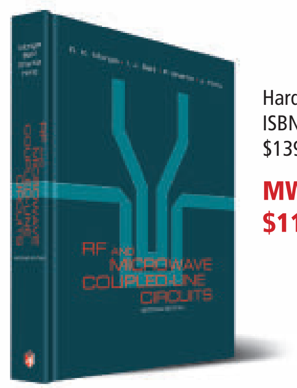

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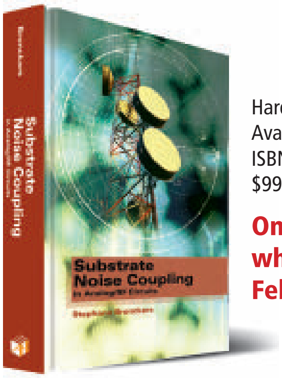

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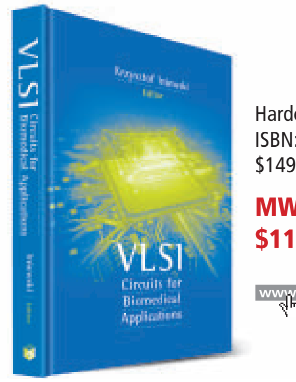

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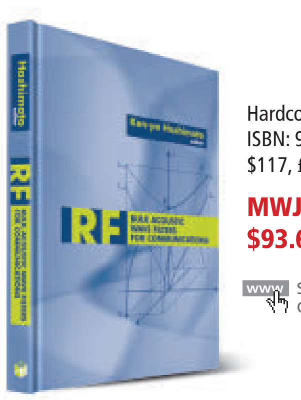

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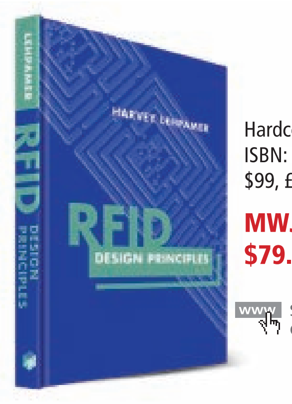

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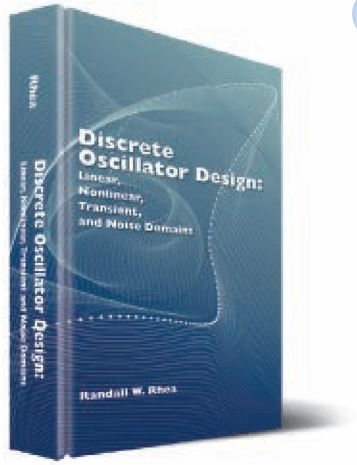

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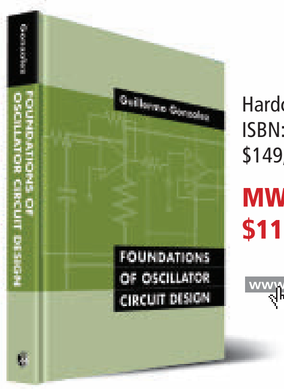

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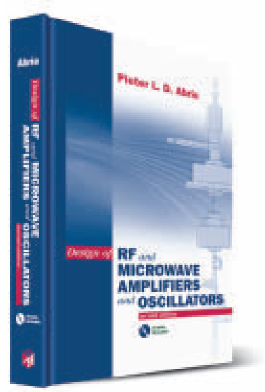

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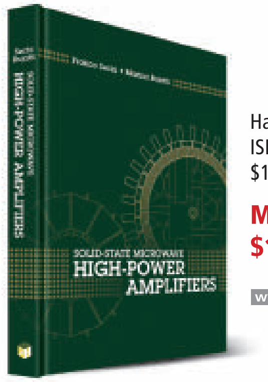

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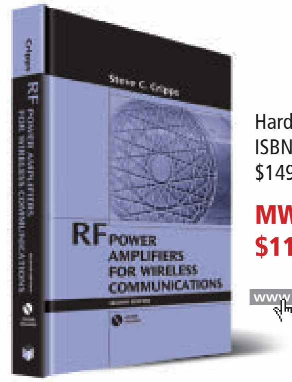

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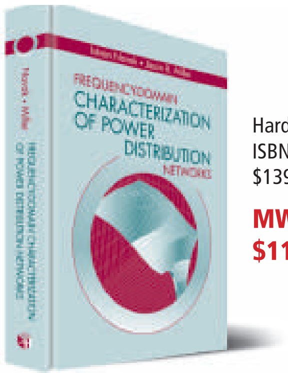

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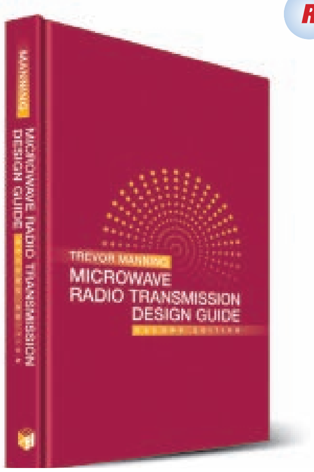

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Microwave Radio Transmission Design Guide, Second Edition

Trevor Manning, *TMC Global*

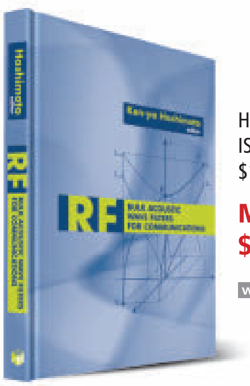
This newly revised edition of the classic Artech House book, *Microwave Radio Transmission Design*, provides a current, comprehensive treatment of the subject with a focus on applying practical knowledge to real-world networks. The second edition includes a wealth of important updates, including discussions on backhaul capacity limitations, ethernet over radio, details on the latest cellular radio standards (2.5G, 3G, and 4G). You also learn about recent changes in spectrum management, including the availability of unlicensed bands and new mm band frequencies between 70 and 90 GHz. Additionally, you find more details on the fundamentals of antennas, especially at VHF/UHF levels.

Contents: Forward. Preface. Introduction. Link Planning. Reliability Standards. Transport Technologies. Radio Equipment Characteristics. Microwave Propagation. Antenna Considerations. Frequency Planning. Link Design. Useful Formulae. List Acronyms and Abbreviations. About the Author. Index.

Hardcover. 298 pp. 2009
ISBN: 978-1-59693-456-6
$109, £68

MWJ Discount Price
$87.20, £54.40

www SAMPLE CHAPTER



Hardcover. 294 pp. 2009
ISBN: 978-1-59693-321-7
$139, £75

MWJ Discount Price
$111.20, £60.00

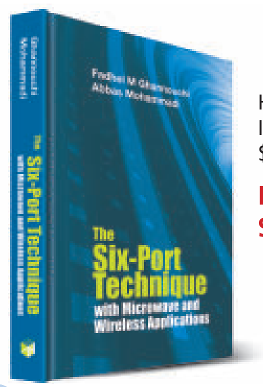
www SAMPLE CHAPTER

RF Bulk Acoustic Wave Filters for Communications

Ken-ya Hashimoto, *Chiba University*

For years, surface acoustic wave (SAW) filters have been widely used as radio frequency front-end filters and duplexers for mobile communication systems. Recently, bulk acoustic wave (BAW) filters are gaining more popularly for their performance benefits and are being utilized more and more in the design of today's cutting-edge mobile devices and systems. This timely book presents a thorough overview of RF BAW filters, covering a vast range of technologies, optimal device design, filter topologies, packaging, fabrication processes, and high quality piezoelectric thin films. Moreover, the book discusses the integration of BAW filters in RF systems.

Contents: Background and History. Resonator and Filter Topologies. Baw Device Basics. Design and Fabrication of BAW Devices. FBAR Resonators and Filters. Comparison with SAW Devices. Films Deposition for BAW Devices. Characterization of BAW Devices. Monolithic Integration. System-in-Package (SiP) Integration. Index.



Hardcover. 252 pp. 2009
ISBN: 978-1-60807-033-6
$89, £55

MWJ Discount Price
$71.20, £44.00

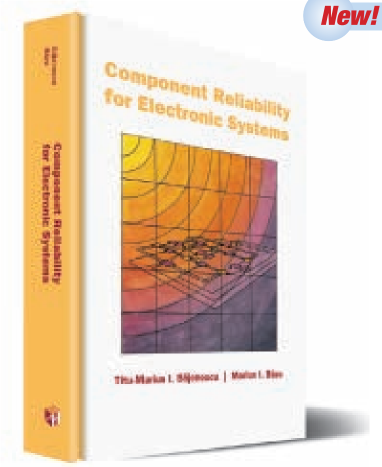
Recent Release

The Six-Port Technique with Microwave and Wireless Applications

Fadhel M. Ghannouchi *University of Calgary* **and Abbas Mohammadi,** *Amirkabir University of Technology*

One of the main issues in microwave and wireless system design is to ensure high performance with low cost techniques. The six-port technique helps allow for this in critical network design areas. This practical resource offers you a thorough overview the six-port technique, from basic principles of RF measurement based techniques and multiport design, to coverage of key applications, such as vector network analyzers, software defined radio, and radar. The first book dedicated to six-port applications and principles, this volume serves as a current, one-stop guide offering you cost-effective solutions for your challenging projects in the field.

Contents: Introduction. Six-Port Fundamentals. Design of Six-Port Junctions. Calibration Techniques. Load-Pull Measurements Using Six-Port Technique. Six-Port Network Analyzer. Six-Port Wireless Applications. Six-Port Microwave Applications. Index.



New!

Component Reliability for Electronic Systems

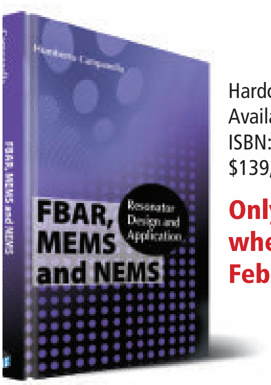
Titu-Marius I. Bajenescu and Marius I. Bazu

This practical book offers you specific guidance on how to design more reliable components and build more reliable electronic systems. You learn how to optimize a virtual component prototype, accurately monitor product reliability during the entire production process, and add the burn-in and selection procedures that are the most appropriate for the intended applications. Moreover, the book helps you ensure that all components are correctly applied, margins are adequate, wear-out failure modes are prevented during the expected duration of life, and system interfaces cannot lead to failure.

Contents: *Part I: Reliability* – Reliability Building. Reliability Assessment. Package and Reliability. Failure Analysis. Test and Testability. *Part II: Reliability of Electronic Components* – Reliability of Passive Electronic Parts. Reliability of Diodes. Reliability of Silicon Power Transistors. Reliability of Optoelectronic Components. Reliability of Thyristors and Triacs. Reliability of Monolithic Integrated Circuits. Reliability of Memories and Microprocessors. Reliability of Hybrid Integrated Circuits. Reliability of Micro- and Nano-Systems.

Hardcover. 694 pp. 2010
ISBN: 978-1-59693-436-8
$129, £79

MWJ Discount Price
$103.20, £63.20



Hardcover. Approx. 390 pp.
Available March 2010
ISBN: 978-1-60783-977-4
$139, £85

Only $118, £72 when you order before February 28, 2010

Coming Soon! Save 15%

FBAR, MEMS and NEMS Resonator Design and Applications

Humberto Campanella,
Instituto Microelectronica de Barcelona

This groundbreaking book provides you with a comprehensive understanding of FBAR (thin-film bulk acoustic wave resonator), MEMS (microelectomechanical system), and NEMS (nanoelectromechanical system) resonators. For the first time anywhere, you find extensive coverage of these devices at both the technology and application levels. This practical reference offers you guidance in design, fabrication, and characterization of FBARs, MEMS and NEBS. It discusses the integration of these devices with standard CMOS (complementary-metal-oxide-semiconductor) technologies, and their application to sensing and RF systems.

Contents: Part I: Introduction to Thin-Film Bulk Acoustic Wave Resonators (FBAR), Micro and Nano Electro Mechanical System (M/NEMS) Resonators. Part II: Fabrication Technologies and CMOS Integration. Part III: Applications of FBAR, MEMS, NEMS Resonators. Case Studies: Modeling, Design and Fabrication of FBAR and MEMS-Based Systems.

Hardcover. Approx. 425 pp.
Available May 2010
ISBN: 978-1-60783-983-5
$139, £84

Only $118, £71 when you order before April 30, 2010

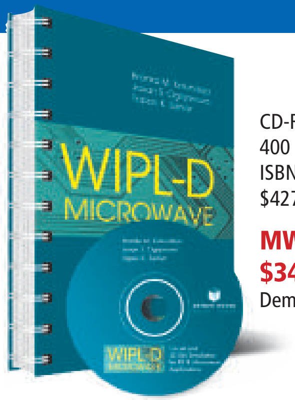
Coming Soon! Save 15%

Automated Testing of High-Speed Digital Interfaces

Jose Moreira, *Verigy*, **Hubert Werkmann,** *Verigy* **and Heidi Barnes,** *Agilent*

Providing a complete introduction to the state-of-the-art in high-speed digital testing with automated test equipment (ATE), this practical resource is the first book focus exclusively on this increasingly important topic. Featuring clear examples, this one-stop reference covers all critical aspects of the subject, from high-speed digital basics, ATE instrumentation for digital applications, and test and measurements, to production testing, support instrumentation and text fixture design. This in-depth volume also discusses at advanced ATE topics, such as multiplexing of ATE pin channels and testing of high-speed bi-directional interfaces with fly-by approaches.

Contents: Introduction. High-Speed Digital Basics. High-Speed Interfaces Standards. ATE Instrumentation for Digital Applications. Tests and Measurements. Production Testing. Support Instrumentation. Test Fixture Design. Advanced ATE Topics.



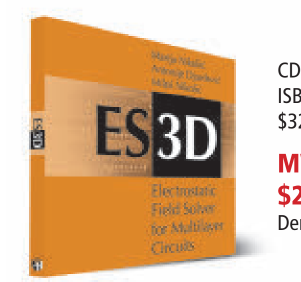
CD-ROM with User's Manual.
400 pp. 2005
ISBN: 1-58053-965-3
$427, £266

MWJ Discount Price
$341.60, £212.80
Demo available at ArtechHouse.com

WIPL-D Microwave: Circuit and 3D EM Simulation for RF & Microwave Applications — Software and User's Manual

Branko M. Kolundzija, Jovan S. Ognjanovic, Tapan K. Sarkar

Offering you the performance and time-saving features of software costing many times more, this software package serves as fast and accurate design & simulation tool for your projects involving microwave circuits, components, and antennas. It includes an easy-to-use circuit solver and schematic capture, component library, and an optimizer that automates the design of microwave devices and antennas. As a product from the well-know WIPL-D family, it inherits a full-wave 3D EM (electromagnetic) solver.



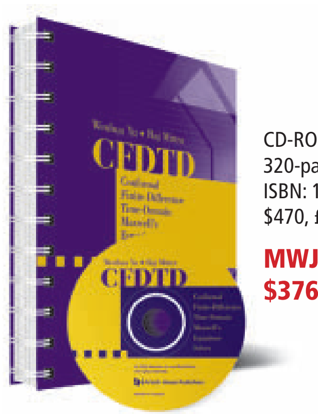
CD-ROM. 2007
ISBN: 978-1-59693-026-1
$320, £200

MWJ Discount Price
$256.00, £160.00
Demo available at ArtechHouse.com

ES3D: Electrostatic Field Solver for Multilayer Circuits

Marija Nikolić, Antonije Djordević, and Miloš Nikolić, *University of Belgrade*

Analyze electrostatic properties of arbitrary 3-D metallic and dielectric structures with ES3D, a powerful software package created exclusively to aid you in evaluating circuit performance or designing power devices. *ES3D* calculates self and mutual capacitances, as well as circuit (y) parameters of networks formed by these capacitances. This output can be seamlessly exported to software that analyzes microwave and RF circuits.



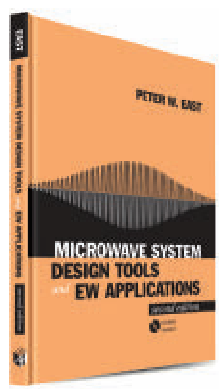
CD-ROM set with
320-page user's guide. 2004.
ISBN: 1-58053-731-6
$470, £298

MWJ Discount Price
$376.00, £238.40

CFDTD: Conformal Finite Difference Time Domain Maxwell's Equations Solver, Software and User's Guide

Wenhua Yu and Raj Mittra,
Pennsylvania State University

Here's a powerful, full three-dimensional Maxwell's equations solver that serves as a fast and accurate tool for modeling a wide variety of antenna and arrays, waveguides, cavities, microwave circuits, as well as a useful resource for Radar Cross Section analysis. This cutting-edge CFDTD software package combines visual languages and advanced techniques in computational electromagnetics to simulate the behaviors of complex microwave systems. Designed to handle 220 x 220 x 220 nodes, the software is well-equipped for large-size and high-frequency problems.



Hardcover. 248 pp./CD-ROM. 2008
ISBN: 978-1-59693-256-2
$129, £81

MWJ Discount Price
$103.20, £64.80
Demo available at ArtechHouse.com

Book and CD-ROM package!

Microwave System Design Tools and EW Applications, Second Edition

Peter W. East, *Private Consultant*

Previously available only as a CD-ROM, this popular electronic warfare (EW) and microwave design resource has now been transformed and expanded into a practical, fully-integrated book and CD-ROM package. More than ever, in this dynamic second edition, you find a wealth of practical tools and guidance to help you speed up design, evaluation, and specification of EW systems and microwave components. ***The book*** covers a broad range of essential topics in the field. ***The CD-ROM*** contains a number of independent software applications that parallel and build on the topics presented in the book and help you calculate accurate design performance data.

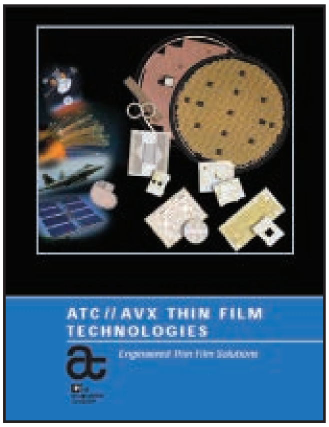
Signal Analyzer Migration Brochure

VENDORVIEW

Agilent's new technical brochure and website now address the transition details when upgrading from the PSA signal analyzer to the new PXA high-performance signal analyzer. The brochure also highlights the 12 top reasons why the PXA is the ideal and direct form, fit and functional replacement for the PSA, while offering more performance, capability and flexibility. For more information, visit http://cp.literature.agilent.com/litweb/pdf/5990-3990EN.pdf.

Agilent Technologies Inc., Santa Clara, CA (800) 829-4444, www.agilent.com.

RS No. 310

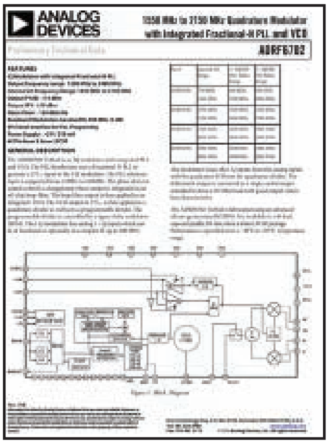


Thin Film Technologies Catalog

The 16-page ATC//AVX Thin Film Technologies/Engineered Thin Film Solutions Catalog highlights the combined capabilities of the Jacksonville, FL and Myrtle Beach, SC design and manufacturing facilities. The catalog details the Thin Film capabilities and lists primary markets and applications for these products. Included are tables for substrate properties, sputtered and electroplated materials, wafer construction, resistors, capacitors and inductors, and typical metalizations.

American Technical Ceramics, Huntington Station, NY (631) 622-4700, www.atceramics.com.

RS No. 311



Product Data Sheets

Analog Devices introduces a series of datasheets for the company's highly integrated RFICs designed for LTE and 4G cellular base stations. As worldwide mobile carriers evolve toward 4G technologies, small higher-density radio card form factors are needed to support the delivery of continuous voice and high-data-rate services. ADI's new ADRF670x series of modulators enable these high-density radio cards by combining multiple discrete functional blocks into a single device, while meeting the demanding performance required by higher-capacity base stations.

Analog Devices Inc., Norwood, MA (781) 329-4700, www.analog.com.

RS No. 312

CD Catalog

Cobham Sensor Systems – Baltimore, MD (formerly Nurad Technologies Inc.) announces a new Antenna and Composite Products digital catalog. This new catalog contains a comprehensive detailing of company capabilities and products. Downloadable product datasheets include: broadband horn, conformal, log periodic and blade antennas. A representative listing of its radome and composite structure products is also available. Antenna and composite design aid information is available to help determine custom design needs. Since the catalog is web-based, all information in the catalog can be easily acquired using the interactive hyperlinks. To request a catalog, contact NuradSales@cobhamdes.com.

Cobham Sensor Systems – Sensor Electronics, Baltimore, MD (410) 542-1700, www.cobham.com.

RS No. 313

Custom Assembly Literature

Custom Assembly has developed a more efficient way to solder high power circuit boards. Using a single-pass reflow solder process, Custom Assembly can bond copper plate ground planes and components all at once, saving time and reducing costs. Features to note: minimal solder voids; quick and efficient single-pass process; ability to accommodate low-volume production runs; and is a cost-effective solution.

Custom Assembly LLC, Wood Dale, IL (630) 595-4855, www.customassemblyllc.com.

RS No. 314

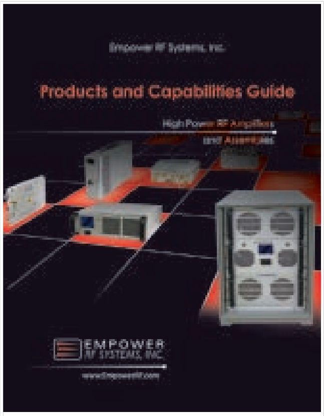
Defence CD ROM

This CD ROM reflects e2v's experience in the design, engineering and manufacture of specialised components and sub-systems for the defence and aerospace sectors. The company's key technologies and solutions include electronic warfare and radar, missiles, aircraft UAV and space, SATCOM and homeland security. The CD includes .pdfs of products under the headings: broadband converters, imaging, microprocessors, microwave products, MRAM magneto resistive RAM, QP semiconductors, SATCOM products, solid-state modulators, thermal imaging and TWTs.

e2v, Chelmsford, UK +44 1245 493493, www.e2v.com.

RS No. 315

Visit http://mwj.hotims.com/28484-30 or use RS# 30 at www.mwjournal.com/info



High-power Broadband RF Amplifiers

This updated Products and Capabilities Guide is a comprehensive overview of the company's capabilities and a listing of its most popular amplifier products. With products that cover from 150 kHz to 6 GHz and an extensive library of building block designs, there is an array of catalog standard and semi-custom solutions available to consider. This brochure will be especially useful for buyers, sales reps and engineers.

Empower RF Systems Inc.,
Inglewood, CA (310) 412-8100, www.empowerrf.com.

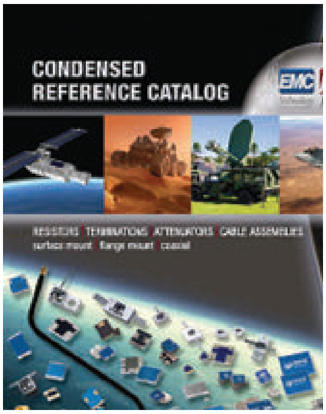
RS No. 316

2010 Microwave Products Catalog

This comprehensive 128-page catalog features standard and custom waveguide components, antennas, programmable instrumentation and systems from 320 MHz to 500 GHz in rectangular guide and 2 to 40 GHz in double ridged. New products featured include millimetric split block couplers, 1.0 mm waveguide to coax adaptors, high power terminations, switch drivers, commercial system switches, NRL horns and near field probes. The catalog also contains standard products up to 330 GHz.

Flann Microwave, Bodmin,
Cornwall, UK +44 (0) 1208 77777, www.flann.com.

RS No. 317



Condensed Reference Catalog

VENDORVIEW

This six-page short form Condensed Reference Catalog contains the most up-to date product and capability offerings from Florida RF Labs/EMC Technology, a Smiths business. The brochure highlights the company's broad product offering that includes RF and microwave resistors, terminations, attenuators (fixed and temperature variable), couplers, power dividers, equalizers and coaxial cable assembly solutions. Also included are the company's unique engineering design kits. Component details, datasheets and measured data can be downloaded from the websites.

Florida RF Labs/EMC Technology,
Stuart, FL (772) 286-9300, www.rflabs.com and www.emct.com.

RS No. 318

Product Literature

VENDORVIEW

Hittite's Off-the-Shelf Newsletter showcases 27 newly released products including several feature articles. Two new product lines are introduced: Synthesizers with Integrated VCOs and Dielectric Resonator Oscillators. Other features include an expanded product 'Applications by Market Table' for products throughout the newsletter. Hittite's 2009 Designer's Guide Catalog is also available on CD-ROM with full product specifications for over 760 products across 22 product lines.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343, www.hittite.com.

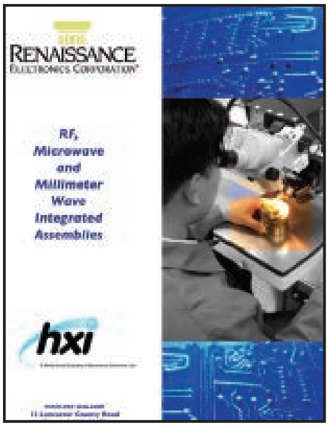
RS No. 319

Thin Film Microcircuits

A new data sheet from LEW Techniques, United Kingdom, describes the thin film microcircuit manufacturing capability of the company. The datasheet details the various materials, circuit geometries and intricate shapes available, the benefits of the metallisation schemes used, and covers special features such as pre-deposited Au/Sn for assembly efficiency, vias, multilayers and resistors. The data sheet is available at www.lewtec.co.uk.

LEW Techniques Ltd.,
Somerset, UK +44 (0) 1823 286698, www.lewtec.co.uk.

RS No. 320



Integrated Assemblies Brochure

Renaissance Electronics Corp. (REC) announced its new RF, Microwave and Millimeter Wave Integrated Assemblies Brochure is available for distribution. Renaissance/HXI is a turnkey solution provider of quality RF, microwave and millimeter-wave products. REC provides optimized cost and performance solutions for all RF, microwave and millimeter-wave-based components, sub-assemblies, integrated assemblies and sub-systems. This latest brochure shows its capabilities in partnering and manufacturing build-to-print integrated products assuring cost-effective solutions.

Renaissance Electronics Corp.,
Harvard, MA (978) 772-7774, www.rec-usa.com.

RS No. 321

CONSIDER

PHASE MASTER® ENHANCED 190E Series Cable Assemblies

Highly shielded, phase stable assemblies

Compared to similar phase stable cables, Phase Master® 190E's enhanced, multilayer shield construction yields:

- Increased shielding effectiveness (**120 dB @ 1GHz, min**)
- Increased mechanical durability, especially torsion resistance
- Greater connector retention (>40 lbs straight pull with SMA connectors).
- A high level of phase stability vs. temperature and flexure
- Reduced insertion loss & increased amplitude stability

▶ **Download the data sheet:** www.teledynestorm.com/PM190E

▶ Call us now for information on how Phase Master® Enhanced 190E Series cables can benefit your program: 630-754-3300

TELEDYNE
STORM PRODUCTS
A Teledyne Technologies Company

Microwave Business Unit
10221 Werch Drive
Woodridge, Illinois 60517

Tel 630.754.3300
Fax 630.754.3500
storm_microwave@teledyne.com

CATALOG UPDATE

LTCC Design Guide

This free, low temperature co-fired ceramic (LTCC) design guide offers information useful to any OEM engineer employing LTCC in the design of a new product. The 12-page illustration and table-rich guide includes information on conductor, via, multilayer and RF/microwave parameters; general design tips and insights of use when laying out LTCC circuits; and introductory information on Anaren's LTCC capabilities, which are offered out of the company's ceramics-focused operation in Salem, NH, and augmented by Anaren's RF/microwave engineering expertise at company headquarters in Syracuse, NY.

Anaren Inc.,
East Syracuse, NY (603) 898-2883, www.anaren.com.

RS No. 323

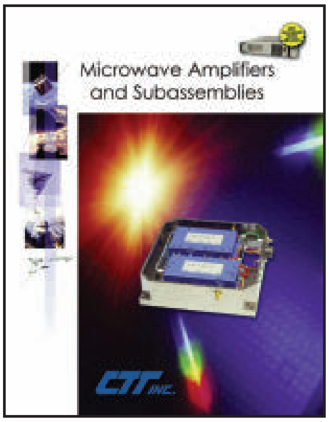
Microwave Amplifier Brochure

VENDORVIEW

The microwave amplifier brochure from AR RF/Microwave Instrumentation features a wide range of microwave amplifiers. The brochure highlights the "S" series (1 to 800 W, 0.8 to 18 GHz) and TWT amplifier series (1 to 10,000 W, 0.8 to 45 GHz). The brochure includes photographs, descriptions, specifications and performance graphs for each model.

AR RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181, www.ar-worldwide.com.

RS No. 324



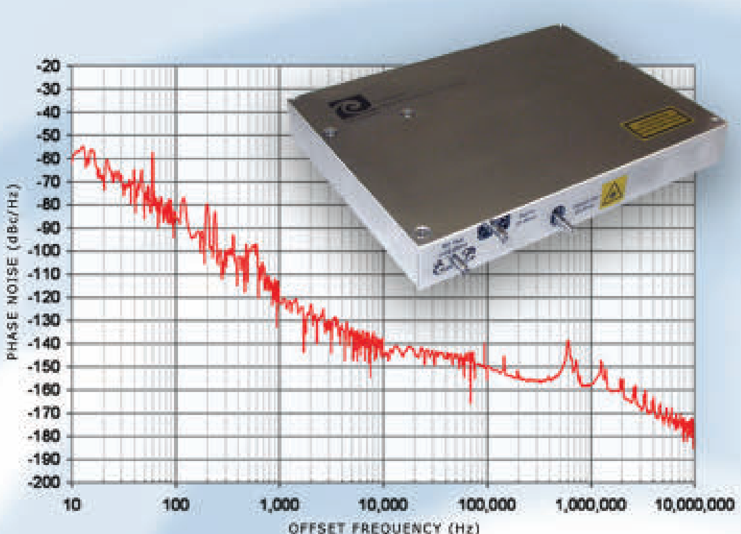
Product Catalog

This updated 36-page catalog features over 145 all-new amplifier products including lightweight and compact 0.5 to 20 GHz LNAs, 0.1 to 20 GHz broadband LNAs, and 0.5 to 31 GHz rack-mount power amplifiers employing GaN and GaAs technologies for UHF through Ka-band applications. CTT's extended product offering includes GaN-based power amplifiers for wideband applications (25 W from 0.5 to 2 GHz), as well as narrowband radar applications (80 W from 8.5 to 9.6 GHz). Additional offerings include high and medium power amplifiers, custom engineered options (CEO) and contract manufacturing services.

CTT Inc.,
Sunnyvale, CA (408) 541-0596, www.cttinc.com.

RS No. 325

Ultra-Low Phase Noise Microwave Oscillator AND Homodyne Phase Noise Measurement System



Phase Noise at 10 GHz

Based on patented opto-electronic oscillator (OEO) technology.

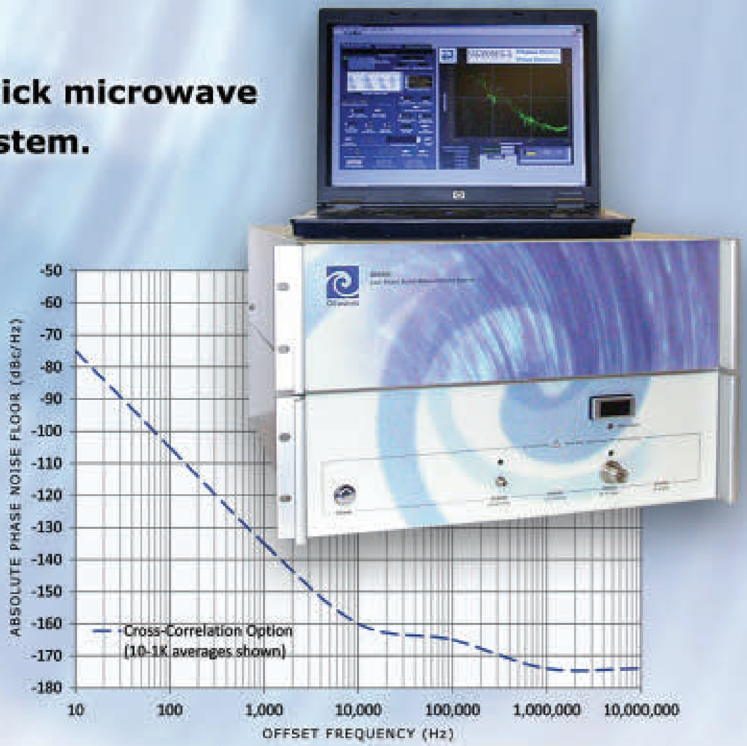
FEATURES

- -145 dBc/Hz at 10 kHz offset at 10 GHz
- Compact 4.5″ x 5.9″ x 0.94″ package
- Low spurious content
- Low vibration/acceleration sensitivity
- External phase locking option
- Pulsed optical output option
- EMI tolerant

Complete automated connect and click microwave phase noise/jitter measurement system.

FEATURES

- No reference source required
- No down converter or PLL required
- -174 dBc/Hz **absolute** phase noise measurement capability
- Frequency range option up to 68 GHz
- RMS and P-P jitter measurement option
- Unique microwave-photonic system takes seconds to operate
- Various performance levels, features, and future upgrade options available



Absolute Phase Noise Floor at 10 GHz

PLEASE CONTACT US FOR CUSTOM FEATURES

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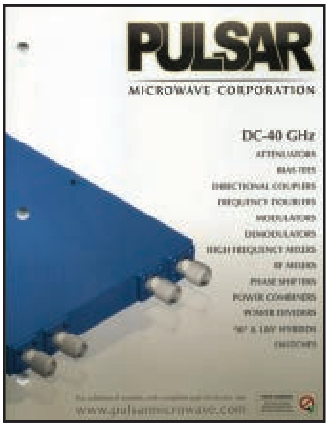
OEwaves

626.449.5000
www.oewaves.com

INVENT. DEVELOP. DELIVER.

Catalog Update



RF and Microwave Passive Components

Pulsar Microwave Corp. is a valued supplier of high quality RF and microwave passive components in the frequency range of DC to 40 GHz. Current catalog features attenuators, bias tees, directional couplers, frequency doublers, modulators and demodulators, mixers, phase shifters, power combiners, power dividers 90° and 180° hybrids and switches.

Pulsar Microwave Corp.,
Clifton, NJ (973) 779-6262, www.pulsarmicrowave.com.
RS No. 322

Product Selection Guide

VENDORVIEW

Response Microwave Inc. announced the availability of its new product selection guide. The 60-page catalog provides an overview of corporate capabilities and selection tables of the company's passive component and connectivity product offering that operates from DC to 65 GHz, and also selective optical products. It also offers application notes on the company's unique HYBRIDLINE series of drop-in quad hybrids and couplers. The catalog will also be available in a downloadable .pdf format at the company website.

Response Microwave Inc.,
Devens, MA (978) 772-3767, www.responsemicrowave.com.
RS No. 326

Precision Microwave Components

RLC, a designer and manufacturer of high quality, state-of-the-art coaxial switches, bandpass filters, precision attenuators and other transmission line components for the microwave industry, announced the arrival of its new catalog. The catalog can be downloaded from the RLC website to your desktop for easy access at www.rlcelectronics.com. This catalog describes RLC's standard product line.

RLC Electronics Inc.,
Mount Kisco, NY (914) 241-1334, www.rlcelectronics.com.
RS No. 327

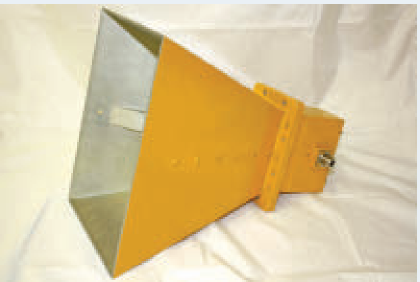
Compact Antenna

The HW Series 1/2-wave center-fed dipole antennas and 1/4-wave monopole antennas are now available with standard SMA connector terminations. HW Series antennas are ideal for applications requiring a compact, low-cost antenna solution. These antennas attach using an FCC-compliant RP-SMA connector or the newly available standard SMA connector. Alternate connectors and custom colors are available for volume OEM orders. The antennas are available in standard center frequencies of 315, 418, 433, 868 and 916 MHz. The 868 and 916 MHz versions are 1/2-wave center-fed dipoles, while the 315, 418 and 433 MHz are all 1/4 wave monopoles. HW Series antennas are immediately available at $4.98 in volume quantities.

Antenna Factor,
Merlin, OR (800) 489-1634,
www.antennafactor.com.

RS No. 216

Reference Antenna



Cobham Sensor Systems - Baltimore announces model 15RH1, a broadband linear horn gain reference antenna that operates in the frequency range of 0.75 to 3 GHz, has a VSWR of 2:1 maximum and nominal gain of 6 to 16 dBi. This antenna is primarily used in test chambers to accelerate gain measurements and minimize set-up errors. Units can be supplied with measured gain curve for enhanced gain accuracy over calculated values. Typical gain accuracy is better than 0.3 dB over the band of operation. Model 15RH1 is designed to meet NRL Report 4433 requirements.

Cobham Sensor Systems–Sensor Electronics,
Baltimore, MD (410) 542-1700,
www.cobham.com/baltimore.

RS No. 217

Comb Generator

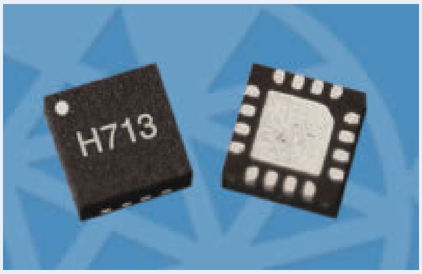
This comb generator is a complete system including power supply, synthesizer and comb generator head. It covers a wide input frequency range and has low input power requirement of only 0 dBm. The output harmonics reach up to 18 GHz. It is applicable with an internal (100 to 200 MHz) or an external synthesizer (30 MHz to 4 GHz). The features include two ECL compatible outputs, 400 kHz tuning step size and PC interface (serial/USB). It can be used for a wide range of applications like frequency multipliers, signal generators, EMC source, UWB applications and FMCW radars.

Heuermann HF-Technik GmbH,
Stolberg, Germany +49 2402/9749764,
www.hhft.de.

RS No. 218

Power Detector

VENDORVIEW



This new 54 dB Log detector/controller is primarily targeted to high volume automotive, broadband, cellular/3G and WiMAX/4G applications between 50 MHz and 8 GHz. The HMC713LP3E Logarithmic Detector/Controller is fabricated using a SiGe BiCMOS process and converts RF signals at its input to a proportional DC voltage at its output. The HMC713LP3E delivers 54 dB dynamic range up to 2700 MHz with ±1 dB accuracy. At input frequencies from 3.9 to 8 GHz, dynamic ranges up to 49 dB are achievable with ±1 dB accuracy. Stability over the -40° to +85°C operating temperature range is outstanding, while input return loss is better than 10 dB across the entire operating frequency range. The HMC713LP3E can also be used in the controller mode, making it ideal for applications such as RF transmitter power amplifier control, RSSI measurement in cellular base stations, radio links and radar.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343,
www.hittite.com.

RS No. 219

Noise Instrument

NoiseWave announces the immediate availability of the NW18G-MI noise instrument. The unit is a manual Additive White Gaussian Noise generator that features broadband frequency coverage from 2 to 18 GHz. Power out is -14 dBm and the unit features a flatness of ±2.5 dB. The NW18G-MI operates from standard line voltages. Applications for this instrument include system and component wireless testing, signal simulation, VSAT, defense and aerospace related testing.

NoiseWave Corp.,
East Hanover, NJ
(973) 386-1119,
www.noisewave.com.

RS No. 220

Low Phase Noise Oscillator

Model OSC049 is a multiplied crystal base source. This oscillator utilizes a fifth overtone SC cut crystal within a low-profile package that maintains excellent frequency stability of ±1 ppm maximum (±0.5 ppm typical) over -40° to +85°C at 400 MHz output. The device offers low-g sensitivity of 3×10^{-10} /g; a noise floor of -156 dBc/Hz; and SSB phase noise performance of: -116 dBc/Hz at 100 Hz; -145 dBc/Hz at 1 kHz; -150 dBc/Hz at 10 kHz; -154 dBc/Hz at 100 kHz and -155 dBc/Hz at 1 MHz. This model is ideal for electronic warfare, C4ISR as well as radar applications.

TRAK Microwave Corp.,
Tampa, FL
(813) 901-7200,
www.trak.com.

RS No. 221

Four-way Power Divider

VENDORVIEW

Model 3326B-4 is a four-way power divider that operates from 6 to 18 GHz and features precise phase and amplitude balance, high port-to-port isolation, and low input VSWR. The power divider is well suited for a broad array of commercial and military applications. The model 3326B-4 offers insertion loss of less than 2 dB, isolation of at least 18 dB, and input and output VSWR of less than 1.5:1 or less. Amplitude balance is maintained to 0.5 dB or less and phase balance is maintained to 7° or better. It can handle an average RF input power of 30 W into a VSWR of 1.2:1 or less and up to 10 W into a 2:1 VSWR. The Model 3326B-4 measures 4.3" × 1.4" × 0.5" and has Type-N female connectors.

Narda,
Hauppauge, NY
(631) 231-1700,
www.nardamicrowave.com/east.

RS No. 229

Now!

MULTIPLY UP TO 20 GHz

Frequency Multipliers from $5.95 qty. 10-49

For your leading-edge synthesizers, local oscillators, and Satellite up/down converters, Mini-Circuits offers a large selection of ***broadband doublers, triplers, quadruplers, and x12 frequency multipliers.***

Now generate output frequencies from 100 kHz to 20 GHz with excellent suppression of fundamental frequency and undesired harmonics, as well as spurious. All featuring low conversion loss and designed into a wide array of, off-the-shelf, rugged coaxial, and surface mount packages to meet your requirements.

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IF/RF MICROWAVE COMPONENTS

455 rev B

Visit http://mwj.hotims.com/28484-68 or use RS# 68 at www.mwjournal.com/info

New Products

Components

3 GHz SMA Attenuators

These low cost attenuators operate to 3 GHz and are designed for commercial applications where price is the primary concern. The AS398 series is RoHS compliant and is rated for use to 1 W maximum power. These SMA attenuators are priced below $6 in production quantities and are an excellent choice for in-building wireless applications. Standard attenuation values of 1-10, 15 and 20 dB versions are available.

Aeroflex/Inmet,
Ann Arbor, MI (734) 426-5553,
www.aeroflex.com.

RS No. 222

6 to 10 GHz Bandpass Filters

VENDORVIEW

AKON Inc.'s line of high selectivity bandpass filters includes model number A65-MH002. This filter offers a 6 to 10 GHz passband, with less than 1.0 dB insertion loss, 2.0:1 or better VSWR, +40 dBm maximum power handling capability and -70 dB stopband minimum, all in a 2.9" × 0.58" × 0.50" package.

AKON Inc.,
San Jose, CA (408) 432-8039,
www.akoninc.com.

RS No. 223

RF Coaxial Terminations

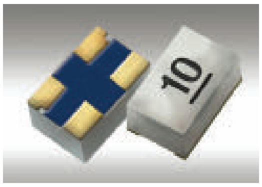
ANOISON Electronics announces the introduction of a full line of RF coaxial terminations. Included are terminations with SMA, QMA, Mini-QMA, 2.92 mm, TNC, N, HPQN and 7/16 interfaces. Frequency ranges are offered from DC to 40 GHz with power up to 5 W as standard products. Custom configurations are available on request.

ANOISON Electronics,
Portsmouth, NH (603) 431-0651,
www.anoison.com.

RS No. 224

Chip Attenuator

VENDORVIEW



EMC Technology introduces a new fixed attenuator TS07XXF, in a SMT planar style chip design. This new TS07XXF offers a small 0805 package size and has excellent frequency response from DC to 6 GHz. The TS07XXF is packaged on 1,000 piece tape and reels for high volume, pick & place and targeted for Telecom and WiMAX applications. The TS07XXF attenuator is available in values of 1 through 10 dB in one dB increments and handles an operating temperature range of -55° to +125°C. This cost-effective attenuator handles 100 mW of input power. The planar style chip size is 0.080" × 0.050". All values of the TS07XXF are available and are RoHS compliant.

EMC Technology,
Stuart, FL (772) 286-9300,
www.emct.com.

RS No. 225

Downconverting Mixers

This LTC554x family of four new high dynamic range downconverting mixers covers the 700 MHz to 4 GHz wireless infrastructure frequency range. The LTC554x mixers offer outstanding IIP3 of 26 dBm, low noise figures of 9 to 10 dB and high conversion gain of 8 dB, enabling excellent dynamic range performance for both main receivers and digital predistortion receivers. The LTC554x family of mixers provides best-in-class capability to maintain a low noise figure in the presence of strong blocking interferers, and significantly enhancing receiver sensitivity and robustness. The LTC554x family operates on a single 3.3 V supply without compromising performance, while reducing power consumption by 34 percent compared to the closest competing solution.

Linear Technology,
Milpitas, CA (408) 432-1900,
www.linear.com.

RS No. 226

Low Pass Filter

The 7LPX-R18000-S is a bi-directional low pass filter. The insertion loss is 2.0 dB maximum from 200 MHz to 18 GHz. The VSWR is 2.0:1 from 200 MHz to 18 GHz. The filter provides 35 dB rejection at 22 GHz and 55 dB rejection from 26 to 30 GHz. The physical size is 0.81" × 0.450" × 0.38" excluding SMA female removable connectors.

Lorch Microwave,
Salisbury, MD (410) 860-5100,
www.lorch.com.

RS No. 227

Drop-in Isolators

These two drop-in isolators are designed for the 921 to 960 and 1805 to 1880 MHz bands. The isolators offer 55 dB isolation over the whole frequency band, allowing OEM manufacturers to specify a single device for double isolation. For both isolators, insertion loss is better than 0.5 dB, and the VSWR is less than 1.14:1 over the operating temperature range of 0 to +85°C. These dual-junction devices are also available in many other frequency ranges. Dimensions: 2.17" × 1.25" × 0.36".

M2 Global Technology Ltd.,
San Antonio, TX (210) 561-4800,
www.m2global.com.

RS No. 228

QFN Packaged Up-converter

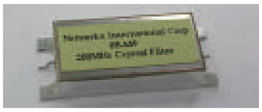
VENDORVIEW

This 37 to 40 GHz GaAs MMIC up-converter integrates an image reject balanced mixer, LO buffer amplifier, LO doubler and RF buffer amplifier within a fully molded 4×4 mm QFN package. This RoHS compliant, packaged up-converter has an input third order intercept point (IIP3) of +20 dBm, a conversion gain of 7 dB and an image rejection of greater than 15 dBc. The device can be tuned to give 2xLO leakage of less than -25 dBm; variable gain regulation can be achieved by adjusting the bias, with turn-down trajectories optimized to maintain linearity and minimal 2xLO leakage over the gain control range. The XU1019-QH is well suited for point-to-point (PTP) radio, LMDS, SATCOM and VSAT applications.

Mimix Broadband Inc.,
Houston, TX (281) 988-4600,
www.mimixbroadband.com.

RS No. 244

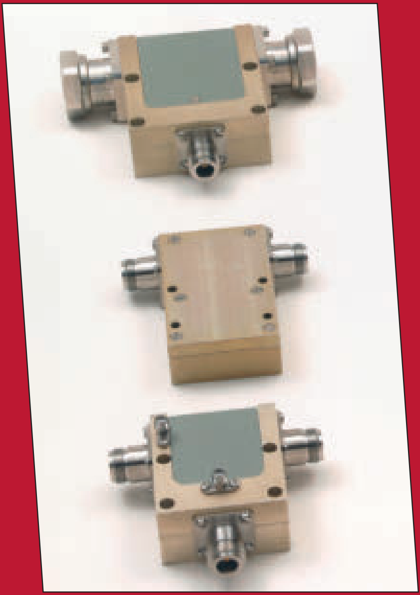
Crystal Filter



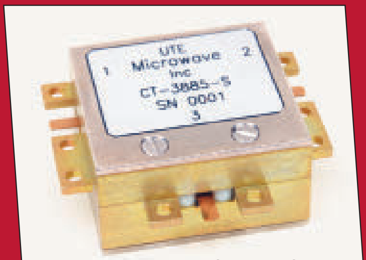
NIC introduces a 200 MHz Crystal filter used for spectrum clean up purposes in clock/timing applications. These filters are designed to reduce noise and other unwanted frequencies around a desired signal. Features include: a fundamental frequency Crystal filter; hermetic package complying with MIL-

HIGH POWER

Isolators / Circulators For Military / Radar Applications.



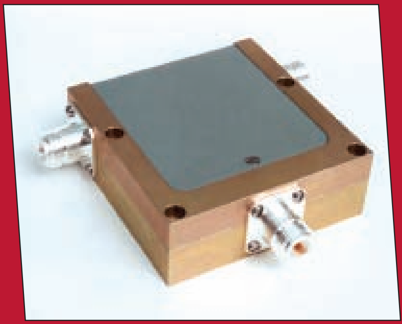
Communications



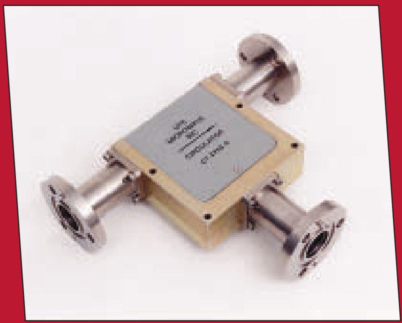
Drop-in Model CT-3885-S

Military and Radar

100 MHz to 20 GHz



Telecom



Scientific – Medical

UTE Microwave is one of the leading suppliers of ferrite components in the industry. We offer innovative engineering, reliability, custom design, standards...many off-the-shelf...plus superior service and over 35 years of know-how.

For Military and Radar applications our Drop-in Model CT-3885-S is designed to operate at 2.5 KW Peak and 250 Watts average power in the 3 GHz radar bands. Bandwidth is up to 12%. Typical specs are 20 dB Isolation. 0.3 dB max Insertion loss and 1.25 max VSWR. The 1-5/8 x 1-5/8 x 7/8 package provides for optimum RF grounding and heat transfer. Other stripline interface HIGH POWER units are available from VHF thru C band.

A broad line of low loss HIGH POWER coaxial and stripline mounting circulators are available. Typical coax units handle 3 KW CW, 10 KW peak at 120 MHz and 1 KW CW, 3 KW peak in the 400-800 MHz TV bands. 250 Watt stripline drop-in units are also available. In the 800-3.5 GHz spectrum, 0.15 dB loss stripline drop-in units operate at 200 Watts CW, 2 KW peak power levels.

Our **"POWER-LINE"** capability serves major markets...
Military and Commercial

FEATURES:

- **Power levels to 5 KW CW, 75 KW Pk.**
- **Low Intermod Units**
- **Low Loss Options**
- **Extended Octave Bandwidths**
- **Power Monitors and DC Blocks**
- **Iso Filter-Monitor Assemblies**

The following models are examples of our High Power units

Model No.	Power	Connectors	Freq. Range
CT-1542-D	10 Kw Pk 1 Kw Av	DIN 7/16	420–470 MHz
CT-2608-S	3 Kw Pk 300 W Av	"Drop-in"	1.2–1.4 GHz
CT-3877-S	2.5 Kw Pk 250 W Av	"Drop-in"	2.7–3.1 GHz
CT-3838-N	5 Kw Pk 500 W Av	N Conn.	2.7–3.1 GHz
CT-1645-N	250 W Satcom	N Conn.	240–320 MHz
CT-1739-D	20 Kw Pk 1 Kw Av	DIN 7/16	128 MHz Medical

Visit http://mwj.hotims.com/28484-115 or use RS# 115 at www.mwjournal.com/info

Broadband Units • Common Band Devices • High Isolation Units • Multiport Devices • Drop-In Devices • Wireless/PCN Devices • High-Power Industrial/Medical Iso Adaptors Waveguide Junctions • High-Power TV Units • VHF and UHF Devices

sales@utemicrowave.com

UTE MICROWAVE INC.

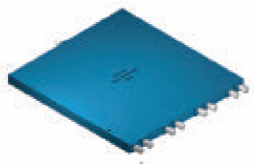
3500 Sunset Ave., Asbury Park, NJ 07712
Tel: 732-922-1009 Fax: 732-922-1848
E-mail: info@utemicrowave.com

Contact us for more information on our extensive product line and current catalog. We accept Visa, MC, Amex

STD-202; small package size; custom designs of fundamental frequency Crystal filters available up to 250 MHz; and custom package configurations—connectorized, surface-mount and PC mount packages are available.
Networks International Corp., Overland Park, KS (913) 685-3400, www.nickc.com.

RS No. 230

Eight-way Power Divider



Pulsar P/N PS8-16-454/8S is a new eight-way power divider covering the frequency range of 0.5 to 18 GHz with 16 dB isolation, 6.5 dB insertion loss and an input/output VSWR of 1.6:1. Maximum amplitude and phase balances are 1.2 and 15 degrees, respectively. Outline dimensions are 6.0" × 6.36" × 0.4". SMA female connectors are standard.
Pulsar Microwave Corp., Clifton, NJ (973) 779-6262, www.pulsarmicrowave.com.

RS No. 231

Bandpass Filter

VENDORVIEW

Reactel part number 6C9-1621.25-X10.5T11 is a bandpass filter for the Iridium band. This unit is specifically designed with a narrow bandwidth and high rejection to isolate Iridium frequencies from outside interference due to Inmarsat systems. This unit can be outfitted with any RF connector you may desire. Please contact the factory for this or any other Iridium filter requirement that you have.
Reactel Inc., Gaithersburg, MD (301) 519-3660, www.reactel.com.

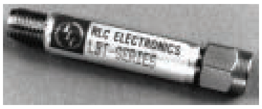
RS No. 232

Hermetically Sealed Switch

The hermetically sealed components require stringent quality control metrics and attention to detail. The test and assembly process is much more complex than the company's standard design. The 100 percent leak testing ensures a precision high reliability component that meets MIL-STD 202 method 112E. These current production components have seen increased demand in mission critical applications. The Renaissance RSMH series of switches offer the same dependability of its standard design in a hermetic laser welded package. All seals are glass to metal or metal to metal. These SPDT switches are laser welded in an argon environment (< 50 ppm moisture) and will operate at -55° to +85°C.
Renaissance Electronics Corp., Harvard, MA (978) 772-7774, www.rec-usa.com.

RS No. 233

Low Pass Filters



RLC Electronics now offers 4th order tubular Bessel low pass filters with 3 dB cutoffs from 1 to 22 GHz. Computer design and tubular construction allow RLC to maintain excellent group delay characteristics with reasonable rejection while extending its 3 dB cutoff approaching 30 Giga bits. These filters should be regarded as compromise designs for pulsed systems where truthful reproduction of the pulse shape is important. Primarily used on lightwave receivers to reduce the impact of higher order distortion and noise. These high frequency filters are essential for today's high bit rate applications.
RLC Electronics Inc., Mount Kisco, NY (914) 241-1334, www.rlcelectronics.com.

RS No. 234

Bundled Cable Products

Times Microwave Systems has developed a series of bundled cable products that are uniquely suited to WiMAX deployments using Alvarion BreezeMAX® equipment. These systems require four small coaxial cable runs per sector (typically LMR-240). Times LMR®-BC240-4 cable offers considerable labor savings over individual runs. It also adds mechanical protection and eliminates the potential for crossed cables since each inner cable is labeled every six inches along its length. This cable is very flexible, has an internal rip cord to assist with the removal of the outer jacket and can be deployed using standard ½" cable accessories.
Times Microwave Systems, Wallingford, CT (203) 949-8400, www.timesmicrowave.com.

RS No. 235

Amplifiers

GaN Broadband Power Amplifier

Model SSPA 1.71-1.88-69 is a high power, Gallium Nitride (GaN) amplifier that operates from 1710 to 1880 MHz minimum and is packaged in a very compact, high performance package. This amplifier is designed for operation in harsh environments. Typical output power is 70 W across the band at P3dB. Small-signal gain is 53 to 54 dB across the band typically. Power added efficiency in saturation is typically 40 to 50 percent across the band. Input and output VSWR is 2.0:1 maximum. This unit is equipped with DC switching circuitry that enables and disables the RF devices inside the amplifier in 2000 ns typical for turn on and 5000 ns typical for turn off time.
Aethercomm Inc., Carlsbad, CA (760) 208-6002, www.aethercomm.com.

RS No. 236

Whether you are looking for new cutting-edge technology, comparison-shopping for the latest applications or interested in taking next generation products for a test drive, the SATELLITE Exhibition Show Floor is the one place where you'll find solutions from more than 300 companies in the global communications via satellite market.

Exhibition Hours

Tuesday, March 16:
11:00 a.m. – 5:45 p.m.

Wednesday, March 17:
9:00 a.m. – 6:00 p.m.

Thursday, March 18:
9:00 a.m. – 1:00 p.m.

Register today for the SATELLITE Exhibition to experience first-hand:

- Solutions in every booth and down every aisle to help you overcome obstacles that lay in the road ahead
- **NEW FOR 2010!** Outdoor exhibits showcasing the latest Mobile Command Units, SNG Trucks, Large Antennas, Trailer and Truck-Mounted Satellite Systems and more!
- Networking opportunities with colleagues from every market of satellite-enabled communications

Back by popular demand! MSUA-7

The MSUA Pavilion features companies showcasing the latest products, technology and applications for mobile satellite services. The MSUA Pavilion is located on the SATELLITE Exhibition Show Floor and included with your Exhibit Hall Only registration.

Discover new solutions suited to your needs in these categories:

- Antennas
- Broadband Technology Provider
- Broadcast/Satellite Services
- Comms-on-the-Move
- Content Security/Encryption
- Data/Digital Audio Broadcasting
- Interactive TV Platforms
- IP Networking Services
- Launch Service Provider
- Mobile Media
- Networking Hardware/Software
- Receivers/Transceivers
- RF/Microwaves
- Telecommunications Carrier
- Test Equipment
- Transmission Services (Data, Video, Voice, Hybrid)
- Up/Down Converters
- And more!

Join your fellow colleagues for the offi cial kick off of SATELLITE 2010!

Included with your Exhibit Hall Only registration is access to the Welcome Reception on Monday, March 15! Reconnect with old friends and form new relationships in what is consistently one of the most popular networking events at SATELLITE 2010!

Looking to maximize your experience?

Register for the SATELLITE 2010 Conference!

A perfect complement to the Exhibition, the SATELLITE 2010 Conference features sessions led by panels of experts and thought leaders of the global satellite community. You'll participate in engaging conversations and get our questions answered!

In addition to the conference program, you'll also receive access to the Satellite Executive of the Year Luncheon, Satellite Executive of the Year Reception and Conference Proceedings on CD-Rom with your conference registration!

Use your VIP Code located on the other side of this brochure to save hundreds on the Conference with the Early Bird discount.

Don't wait to register – the Early Bird discount ends December 16, 2009!

SATELLITE 2010 REGISTRATION FORM

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Mail this completed form to (forms must be received by February 26, 2010):
SATELLITE 2010
c/o CDS, 107 Waterhouse Road
Bourne, MA 02532

By registering you agree (opt-in) to receive email messages concerning the Conference and Exhibition unless you check the opt-out below. You may decide to opt-out at any time.
☐ Opt-out—I do not want to receive any information about the Conference and Exhibition via email.

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Country ____________________
Phone ____________ Ext ________ Fax ____________
Email ____________________
(Required to confirm registration)

☐ Check here if you have any disabilities that may require special services and attach an explanation of your requirements.

2. Select Your Registration Package

Registration Type	Early Bird Discount Register by Dec. 16, 2009	Late Advance Discount Register between Dec. 17, 2009 and Mar. 14, 2010	On-Site Register on Mar. 15-18, 2010
☐ **Full Conference**	**$2049**	**$2359**	**$2699**

Military Discount rate: $1499

Best Value! Includes:

- Your choice of one Pre-Conference Program on Monday, March 15
- ALL Conference sessions on Tuesday-Thursday, March 16-18
- Exhibit Hall with MSUA Pavilion on Tuesday-Thursday, March 16-18
- Welcome Reception, Monday, March 15
- Satellite Executive of the Year Luncheon on Wednesday, March 17
- Satellite Executive of the Year Reception on Wednesday, March 17
- SATELLITE 2010 Conference Proceedings

Please select your Pre-Conference Program (required):

☐ Satellite Finance Forum 2010
☐ Communications Via Satellite: The Basics
☐ IP Networking Over Satellite
☐ Space Principles
☐ Vertical SatCom Markets
☐ Engineering 2010: New Solutions for Satellite Services

Registration Type	Early Bird Discount	Late Advance Discount	On-Site
☐ **SATELLITE 2010 Individual Conference**	**$1499**	**$1729**	**$1999**

Military Discount rate: $999

Includes:

- ALL Conference sessions on Tuesday-Thursday, March 16-18
- Exhibit Hall with MSUA Pavilion on Tuesday-Thursday, March 16-18
- Welcome Reception, Monday, March 15
- Satellite Executive of the Year Luncheon on Wednesday, March 17
- Satellite Executive of the Year Reception on Wednesday, March 17
- SATELLITE 2010 Conference Proceedings

Registration Type	Early Bird Discount	Late Advance Discount	On-Site
☐ **Two-Day Forums**	**$1279**	**$1529**	**$1699**

Military Discount: $899

Includes:

- Your Choice of Two-Day Forum on Tuesday-Wednesday, March 16-17
- Exhibit Hall with MSUA Pavilion on Tuesday-Thursday, March 16-18
- General Sessions on Wednesday, March 17 and Thursday, March 18
- Welcome Reception, Monday, March 15
- Satellite Executive of the Year Luncheon on Wednesday, March 17
- Satellite Executive of the Year Reception on Wednesday, March 17
- SATELLITE 2010 Conference Proceedings

Please select your Two-Day Forum Program (required):

☐ Broadcast Forum
☐ Enterprise Forum
☐ Military Forum

Registration Type	Early Bird Discount Register by Dec. 16, 2009	Late Advance Discount Register between Dec. 17, 2009 and Mar. 14, 2010	On-Site Register on Mar. 15-18, 2010
☐ **Pre-Conference Program**	**$999**	**$1259**	**$1399**

Includes:

- Your Choice of One Pre-Conference Program on Monday, March 15
- Exhibit Hall with MSUA Pavilion on Tuesday-Thursday, March 16-18
- Opening General Session Tuesday, March 16
- Welcome Reception, Monday, March 15

Please select your Pre-Conference Program (required):

☐ Satellite Finance Forum 2010
☐ Communications Via Satellite: The Basics
☐ IP Networking Over Satellite
☐ Space Principles
☐ Vertical SatCom Markets
☐ Engineering 2010: New Solutions for Satellite Services

Registration Type	Early Bird Discount	Late Advance Discount	On-Site
☐ **Exhibit Hall Only**	**FREE**	**FREE**	**$89**

Includes:

- Exhibit Hall with MSUA Pavilion on Tuesday-Thursday, March 16-18
- Welcome Reception, Monday, March 15
- Opening General Session Tuesday, March 16

3. Co-Located Conference

	Early Bird	Late Advance	On-Site
☐ **MSUA-7**	**$525**	**$635**	**$745**

Tuesday, March 16-Wednesday, March 17

4. Networking Events

MSUA Innovation and Pioneer Awards Luncheon
11:45 a.m.–1:15 p.m.Tuesday, March 16, 2010
☐ $65*
**One ticket is included with MSUA-6 registration*

WTA 2009 Teleport Award Luncheon
11:45 a.m.–1:15 p.m.Tuesday, March 16, 2010
☐ $35

5. Order Conference Proceedings

Conference Proceedings CD-Rom (Includes shipping)
I would like to add the following Conference Proceedings to my registration:

☐ SATELLITE 2010 – Pre-order–will ship 6 weeks after event $535
☐ SATELLITE 2009 – ships within 1 week $535
☐ SATELLITE 2008 – ships within 1 week $435

6. Calculate Total Due

Registration Fee $______+ Networking Events $______+
Conference Proceedings $______= TOTAL $__________

7. Payment Information

☐ Check: #____________ is enclosed.
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16548

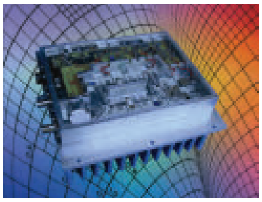
Solid-state Power Amplifier

The Empower RF model BBM2E4ALP 125 W rugged solid-state power amplifier module operates in a frequency range from 20 to 1000 MHz. The BBM2E4ALP high-power RF amplifier module is the latest in compact high-output broadband amplifier technology. The amplifier is compact at less than 6.75 inches long and 1.25-inch thick, has high gain (51 dB) and excellent linearity. It is built within a ruggedized CNC-machined housing for use in the most extreme conditions.

Empower RF Systems Inc.,
Inglewood, CA (310) 412-8100,
www.empowerrf.com.

RS No. 238

100 W Power Amplifier



Microwave Solutions announced its latest addition to its solid-state power amplifiers series, Model MSD-2X0X901-GC. With an operating frequency of 1.5 to 1.6 GHz, this PA has 100 W saturated output power with input power as low as -12 dBm. It offers 20 dB of gain control, precision RF power out detector circuitry and temperature compensation. This PA is also available in bandwidth range of 20 percent from 800 MHz to 2.1 GHz with saturated output power up to 150 W.

Microwave Solutions Inc.,
National City, CA (619) 474-7500,
www.microwavesolutions.com.

RS No. 239

Low Noise Amplifier

VENDORVIEW

The TAMP-72LN+ (RoHS compliant) is a low noise amplifier (LNA) that utilizes advanced E-PHEMT technology in a single stage low noise amplifier design built into a shielded case (size: 0.591" × 0.394" × 0.118"). The drop-in module offers low noise figure and moderate gain with good input and output return loss over the entire frequency range and without the need of external matching components. The LNA operates in a frequency range from 400 to 700 MHz, offers IP3 of 36 dBm typical, low noise figure of 1.0 dB typical and integrated bias matching and stability circuits. Price: $11.95 (Qty. 5-49).

Mini-Circuits,
Brooklyn, NY
(718) 934-4500,
www.minicircuits.com.

RS No. 240

COFDM Power Amplifiers

Stealth Microwave introduces the SM4450-37HS, a GaAs FET amplifier designed for COFDM video transmission in military bands. The unit operates from 4.4 to 5.0 GHz with a minimum P1dB and OIP3 of +37 and +48 dBm, respectively. Twenty to 38 dB of gain is available with a flatness of ±0.75 dB across the band. Standard features include a single +12 V DC supply, thermal protection with auto reset, and over/reverse voltage protection. In module form, the unit measures 4.7" × 2" × 0.54"; an integral heatsink is also available. This amplifier is also available in lab unit and 19" rack configurations.

Stealth Microwave Inc.
Trenton, NJ (609) 538-8586,
www.stealthmicrowave.com.

RS No. 241

Assemblies

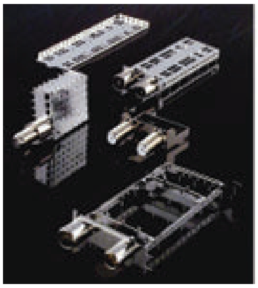
Solder Bonding

Custom Assembly has developed a more efficient way to solder high power circuit boards. Using a single-pass reflow solder process, Custom Assembly can bond copper plate ground planes and components all at once, saving time and reducing costs. Features include: minimal solder voids; quick and efficient single-pass process; ability to accommodate low-volume production runs and is a cost effective solution.

Custom Assembly LLC
Wood Dale, IL (630) 595-4855,
www.customassemblyllc.com.

RS No. 242

RF Shielding Products



Duplex CSA shielding products are designed to protect sensitive components from RF electromagnetic radiation by keeping it contained inside or sealed out of a device. In partnership with its metalwork division, Duplex has made a major investment in the design and fabrication of custom shielding products that complement its RF connector portfolio. This means Duplex can offer fast turnaround from design to delivery of completed components. Duplex can deliver solutions ranging from a single piece shield to complex multi compartment cases with snap on covers. An idea can be turned into reality quickly, utilizing a range of standard features that are tooled and ready to use. Prototypes and production runs can be produced with minimum tooling costs using photo etching techniques.

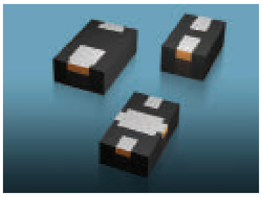
Duplex CSA Ltd.,
Cambridgeshire, UK
+44 1480 406206, www.duplexcsa.com.

RS No. 237

Mini-Circuits
ZVA-213X

Device

Switch and Attenuator Diodes



This suite of surface-mount PIN diode switch elements and attenuator diodes are designed for high volume pick and place applications. These control devices are delivered in plastic SMT packages with standard 31 mils high bodies. Their performance and mechanicals allow them to be easily dropped into existing designs. Aeroflex/Metelics' MS-family of medium and high power PIN diode SPST switch elements are available in series (SE), shunt (SH) and series shunt (SS) configurations, and offer maximum frequency options ranging from 1 to 10 GHz. Ten models are available that offer maximum rated power from 5 to 50 W, insertion losses at 1 GHz ranging from 0.15 through 0.40 dB and isolation at 1 GHz of 10 through 63 dB.

Aeroflex/Metelics,
Sunnyvale, CA (888) 641-7364,
www.aeroflex.com/metelics.

RS No. 243

Sources

Phase-locked Oscillators

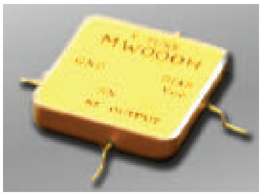
Serving as an augmentation of its standard product line, EM Research now introduces its LX-Series of fixed-frequency phase-locked oscillators and serially-programmable frequency synthesizers with optional internal references. The series is available fixed or in bands over the frequency range 50 MHz to 6 GHz with frequency stability of ±5 ppm (standard) or ±2.5 ppm (optional). It operates over the temperature range of -30° to +70°C with output power of +7 dBm ±2 dB, 50 Ohms. The oscillators feature low harmonics (<-20 dBc, typical), low spurs (<-60 dBc, typical) and exceptionally low phase noise characteristics (-105 dBc/Hz at 100 kHz, typical – Fout = 2.45 GHz). Supply voltage is +3.3, +5 or +8 V DC at 70 mA (typical). Housed in a miniature (0.75" × 0.75" × 0.15") surface-mount package, the LX Series is ideally used as a local oscillator in ISM Band up/down converter applications or as a system high frequency reference.

EM Research Inc.,
Reno, NV (775) 345-2411,
www.emresearch.com.

RS No. 245

Voltage-controlled Oscillator

The MW500-1828 is a 1/2" hermetic package voltage-controlled oscillator (VCO) with a fixed tuning of 1200 MHz from 2 to 4 V tuning using a 5 V supply. This VCO's rugged hermetic packaging makes it suitable in a range of military and other demanding applications.



Output power is +8 dBm ±2 dBm across the band over temperature while using less than 40 mA of current.

Micronetics Inc.,
Hudson, NH (603) 546-4167,
www.micronetics.com.

RS No. 246

GPS Frequency Reference

The E8-Y/E8000 is a GPS controlled frequency and timing source providing very low noise 10 MHz and 1 PPS timing mark, both synchronized to GPS time. Accurate and stable signals, locked to GPS are traceable, calibration free outputs that are without drift. The 10 MHz very low distortion sine wave 50 Ω, +12 dBm output has < 50 dBc harmonics and < 75 dBc spurii. Stability is 8×10^{-13}/s, accuracy is $\times 10^{-13}$ long term and phase noise is -110 dBc/Hz at 1 Hz offset. A noise floor of -156 dBc/Hz is exhibited and holdover is provided in the event of GPS signal failure. The 1 PPS output is 5 V CMOS with 4 ns standard deviation and measured RMS jitter is approximately 7 ns.

Quartzlock (UK) Ltd.,
Totnes, UK +44 (0) 1803 862062,
www.quartzlock.com.

RS No. 249

Voltage-controlled Oscillator

The model ZRO1860A1LF is an RoHS compliant voltage-controlled oscillator (VCO) in L-band. The ZRO1860A1LF operates at 1860 MHz with a tuning voltage range of 0.5 to 4.5 V DC. This VCO features a typical phase noise of -118 dBc/Hz at 10 kHz offset and a typical tuning sensitivity of 5 MHz/V. The ZRO1860A1LF is designed to deliver a typical output power of 3 dBm at 5 V DC supply while drawing 25 mA (typical) over the temperature range of -40° to 85°C. This VCO features typical second harmonic suppression of -25 dBc and comes in Z-Comm's standard MINI-16-SM package measuring 0.5" × 0.5" × 0.22".

Z-Communications Inc.,
San Diego, CA (858) 621-2700,
www.zcomm.com.

RS No. 247

Test Equipment

Pulse Generator

Model AVRF-7A-B is a fast high voltage pulse generator that generates amplitudes of up to 750 V, with 7.5 ns rise and fall times. The pulse

i2S® INTELLIGENT INTERACTIVE SYNTHESIZERS

FEATURES: Over an octave bandwidth tuning, Small step size resolution, Outstanding spectral purity, High spurious rejection, Fast lock settling time

MTS2500-110250-10

Output Frequency	1100 - 2500 MHz	
Bandwidth	1400 MHz	
External Reference	10 MHz	
Step Size	Programmable to 1 Hz	
Bias Voltage	+5 / +3.3 V	
Output Power	+9 dBm (Min.)	
Spurious Suppression	60 dB (Typ.)	
Harmonic Suppression	15 dB (Typ.)	
Typical Phase Noise	Offset	dBc/Hz.
	1 kHz	-93
	10 kHz	-95
	100 kHz	-110
Settling Time	Within 1 kHz	<22 mSec
	Within 10 Hz	<36 mSec
Operating Temperature Range	-20 to +70 °C	

MTS2500-200400-10

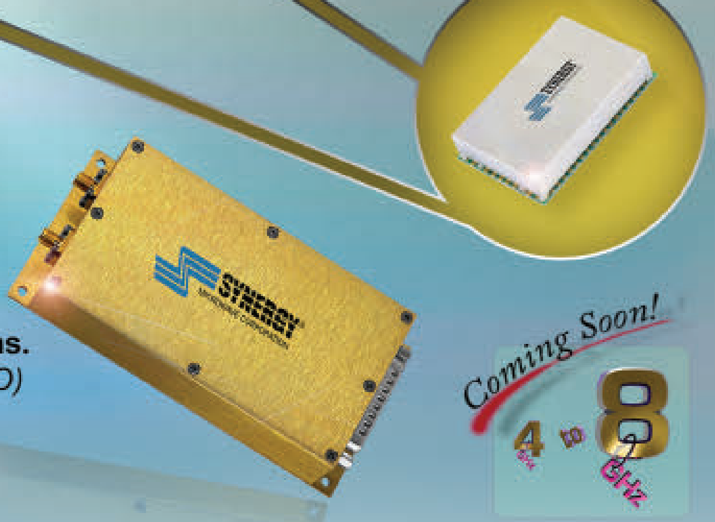
Output Frequency	2000 - 4000 MHz	
Bandwidth	2000 MHz	
External Reference	10 MHz	
Step Size	Programmable to 1 Hz	
Bias Voltage	+5 / +3.3 V	
Output Power	+5.5 dBm (Min.)	
Spurious Suppression	60 dB (Typ.)	
Harmonic Suppression	10 dB (Typ.)	
Typical Phase Noise	Offset	dBc/Hz.
	1 kHz	-88
	10 kHz	-87
	100 kHz	-100
Settling Time	Within 1 kHz	<10 mSec
	Within 10 Hz	<20 mSec
Operating Temperature Range	-20 to +70 °C	

MTS2500-300600-10

Output Frequency	3000 - 6000 MHz	
Bandwidth	3000 MHz	
External Reference	10 MHz	
Step Size	Programmable to 1 Hz	
Bias Voltage	+5 / +3.3 V	
Output Power	+2 dBm (Min.)	
Spurious Suppression	60 dB (Typ.)	
Harmonic Suppression	20 dB (Typ.)	
Typical Phase Noise	Offset	dBc/Hz.
	1 kHz	-87
	10 kHz	-83
	100 kHz	-108
Settling Time	Within 1 kHz	<6 mSec
	Within 10 Hz	<12 mSec
Operating Temperature Range	-20 to +70 °C	

Patented Technology

Programming Interface:
-- 3.3V SPI (Standard)
-- RS232



Also available in connectorized package with the following options.
-- Internal reference (TCXO & OCXO)
-- Divider output for lower bands
-- Low phase noise option

Available Frequencies Ranging Up To 8000 MHz

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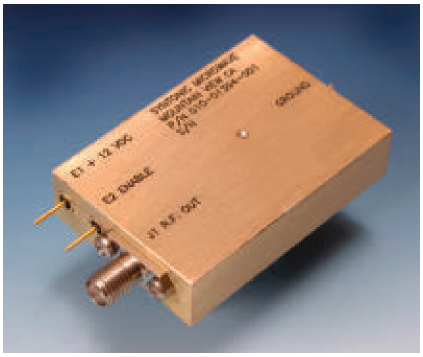
For additional information, contact Synergy's sales and application team.
201 McLean Boulevard, Paterson, NJ 07504 | Phone: (973) 881-8800
Fax: (973) 881-8361 | E-mail: sales@synergymwave.com

Visit Our Website At WWW.SYNERGYMWAVE.COM

width is variable from 0.15 to 10 us. The maximum PRF is 10 kHz, and the maximum duty cycle is 0.1 percent. Switchable polarity is optional. IEEE-488.2GPIB/RS-232 control.
Avtech Electrosystems Ltd.,
Ottawa, Ontario, Canada
(613) 686-6675,
www.avtechpulse.com.

RS No. 248

Comb Generator



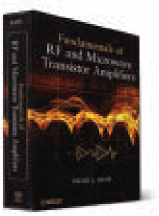
The CG1000 series comb generator provides a combline of CW outputs up to 26 GHz. Picket sizes of 500, 750 and 1000 MHz are available. A TCXO, PLO and integrated amplifier are all included in the compact design.
Syntonic Microwave,
Mountain View, CA
(650) 264-7884,
www.syntonicmicrowave.com.

RS No. 250

Spectrum Analyzers

This new 8853 series of 3 GHz spectrum analyzers is designed for the broadcast and wireless markets. This new series of spectrum analyzers has a wireless option package that includes channel power, adjacent channel power (ACP) and Complimentary Cumulative Distribution Function (CCDF) for testing CDMA2000, WCDMA, TD-SCDMA, 1x EV-DO and WiMAX. The new 8853 series from Trilithic allows wireless operators to put sophisticated analysis and troubleshooting capability in the hands of a wider range of technicians.
Trilithic,
Indianapolis, IN
(317) 895-3600,
www.trilithic.com.

RS No. 251



Fundamentals of RF and Microwave Transistor Amplifiers

Inder J. Bahl

Amplifiers are the heart of most transmitter designs and play a vital role in the development of high-performance, low cost and efficient designs. Inder Bahl is one of the industry's most respected experts in microwave design and has authored or co-authored over 150 papers and 12 books. In his most recent work he outlines the keys to successful transistor amplifier design from his 28 years of experience in the industry.

Fundamentals of RF and Microwave Transistor Amplifiers covers a comprehensive treatment of RF and microwave low-noise and power amplifier circuits including low noise, narrowband, broadband, linear, high power, high efficiency and high voltage. The topics include modeling, analysis, design, packaging, and thermal and fabrication considerations. Amplifier related design problems range from matching networks to biasing and stability, including examples to understand the concepts presented.

The book has 22 chapters covering basic principles, analysis, techniques and designs used in transistor amplifiers, and provide the foundation for the analysis and design of RF and microwave transistor amplifiers. Design procedures and examples are provided in each chapter including technical information and remarks on the most widely used microwave techniques. This book contains enough material for one year at the senior or graduate level including a set of problems in most chapters. Anyone reading this book should have some basic knowledge of solid state devices, theory of transmission lines, circuit theory and electromagnetics.

The unique features of this book include in-depth study of transistor amplifiers, extensive design equations and figures, treatment of the practical aspects of amplifier circuits, and description of fabrication technologies. It provides a broad view of solid state transistor amplifiers and covers essential background material in the fundamentals of amplifier design including both theoretical and practical aspects. RF and microwave circuits using Si bipolar and CMOS technologies have made tremendous progress in recent years, but are only covered on a limited scope in this book.

This book is recommended to anyone who wants to learn about amplifier design or master amplifier design techniques. The author's broad and extensive experience in the field enables him to clearly outline the keys to successful transistor amplifier design.

To order this book, contact:

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'Recession 101' and Your Career

There is no doubt that the economy has affected the industry. Jobs have been lost, careers changed and the financial status of many has been severely affected. The one good thing I have learned from the "Recession 101 Class" is that recessions test us, but are never final; recessions really do end.

If we had better monitoring and control over our economic/financial condition, we might not be in the precarious situation of the past several months. What have we learned from this? Could this ever happen again? If it did, what action would I take to ameliorate the consequences? These questions are very real and not only reflect the economy, but each of our careers. Most importantly, the answers to these questions are those that every individual should have readily available.

One can easily become a victim of the recession via layoffs and although we cannot always avoid them, there are steps we can take to minimize our job risk. The time to avert career set backs is well before they happen. Do you have a well-planned primary career objective with goals, time-lines, as well as a backup plan given the primary plan isn't achieved? The individuals most likely to be successful in achieving the goals and objectives are those with clearly defined career objectives who don't wait for success to come to them. They are not reactive; they are proactive. A career plan is not just for the unemployed; it is just as important for those individuals currently employed.

If you're fortunate enough to be employed, have you evaluated your employer's plan and status? So many people are surprised when they are told the 'company is in trouble' and their job is tenuous. A regularly scheduled assessment of the company's status and evaluation of your relationship to it is highly recommended. Ask questions of your employer and decide if the answers are those that indicate a mutual compatibility and probability of continued success. The assessment should include research on the company's financial condition, the market for the product/services produced, and whether or not your role within the company meets yours and your employer's needs.

Recessions require that employers evaluate who is an asset. Contributors whose work benefits the company will stay. Included in the evaluation is whether the contributor's personality continues to 'fit' the company's specific culture. While working on your plan ask yourself whether you are truly an asset. Be honest with yourself. Does the effectiveness of your individual personality, work habits, etc., 'fit in' with that of your employer? Your plan and answers to these questions can help you avert negative consequences.

Last, but not least, recessions are a test not an end!

Benson D. Evans, PhD
Managing Director
www.rfjobstoday.com

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Advertising Index

RS No.	Advertiser	Page No.	Web Address
1	Admotech	118	http://mwj.hotims.com/28484-1
2	Advanced Switch Technology	142	http://mwj.hotims.com/28484-2
3	Aeroflex / Inmet, Inc.	30	http://mwj.hotims.com/28484-3
4	Aethercomm	81	http://mwj.hotims.com/28484-4
5	Agilent Technologies, Inc.	17	http://mwj.hotims.com/28484-5
6	AML Communications Inc.	43	http://mwj.hotims.com/28484-6
7	Anaren Microwave	22-23	http://mwj.hotims.com/28484-7
8	Anatech Electronics, Inc.	104	http://mwj.hotims.com/28484-8
9	Ansoft Corporation	29	http://mwj.hotims.com/28484-9
10	Antenna Research Associates	80	http://mwj.hotims.com/28484-10
11	Applied Radar, Inc.	144	http://mwj.hotims.com/28484-11
12	AR RF/Microwave Instrumentation	75	http://mwj.hotims.com/28484-12
13,14	Artech House	123,146	http://mwj.hotims.com/28484-13
15	Astrolab, Inc.	131	http://mwj.hotims.com/28484-15
16	AWR	11	http://mwj.hotims.com/28484-16
17	B&Z Technologies, LLC	33	http://mwj.hotims.com/28484-17
18	Carlisle Interconnect Technologies	13	http://mwj.hotims.com/28484-18
19	Cernex, Inc.	88	http://mwj.hotims.com/28484-19
20	Channel Microwave Corporation	20	http://mwj.hotims.com/28484-20
21	Ciao Wireless, Inc.	44	http://mwj.hotims.com/28484-21
22	Cobham Defense Electronic Systems	37	http://mwj.hotims.com/28484-22
23	Coilcraft	15	http://mwj.hotims.com/28484-23
24	COMSOL, Inc.	79	http://mwj.hotims.com/28484-24
25	CPI Beverly Microwave Division	39	http://mwj.hotims.com/28484-25
26	CST of America, Inc.	27	http://mwj.hotims.com/28484-26
27	CTT Inc.	77	http://mwj.hotims.com/28484-27
28	Daico Industries, Inc.	35	http://mwj.hotims.com/28484-28
29	dBm, LLC	38	http://mwj.hotims.com/28484-29
	DesignCon 2010	96,122	www.designcon.com/2010
30	Eastern Wireless TeleComm, Inc.	125	http://mwj.hotims.com/28484-30
31	ES Microwave, LLC	96	http://mwj.hotims.com/28484-31
	EuMW 2010	132,150	www.eumweek.com
32	Fairview Microwave	69	http://mwj.hotims.com/28484-32
33	Feko	90	http://mwj.hotims.com/28484-33
34	Frontlynk Technologies Inc.	85	http://mwj.hotims.com/28484-34
35	G.T. Microwave Inc.	28	http://mwj.hotims.com/28484-35
36	HARTING North America	60	http://mwj.hotims.com/28484-36
37	Herotek, Inc.	86	http://mwj.hotims.com/28484-37
38,39,40,41	Hittite Microwave Corporation	94,95,97,99	http://mwj.hotims.com/28484-38
42	Holzworth Instrumentation	106	http://mwj.hotims.com/28484-42
43	Huber + Suhner AG	89	http://mwj.hotims.com/28484-43
	IEEE MTT-S International Microwave Symposium	114	www.ims2010.org
	IEEE WAMICON 2010	128	www.wamicon.org
44	IKE Micro	67	http://mwj.hotims.com/28484-44
45	ITT Microwave Systems	46	http://mwj.hotims.com/28484-45
46	JQL Electronics Inc.	55	http://mwj.hotims.com/28484-46
47	K&L Microwave, Inc.	7	http://mwj.hotims.com/28484-47
48	KR Electronics, Inc.	144	http://mwj.hotims.com/28484-48
49	Linear Technology Corporation	41	http://mwj.hotims.com/28484-49
50	Lorch Microwave	47	http://mwj.hotims.com/28484-50
51,52	M/A-COM Technology Solutions	70,71	http://mwj.hotims.com/28484-51
53	Maury Microwave Corporation	9	http://mwj.hotims.com/28484-53
54	MECA Electronics, Inc.	36	http://mwj.hotims.com/28484-54
55	MFG Galileo Composites	58	http://mwj.hotims.com/28484-55
56	MIcable Inc.	139	http://mwj.hotims.com/28484-56
57	Microphase Corporation	111	http://mwj.hotims.com/28484-57
58	Microsemi	54	http://mwj.hotims.com/28484-58
59	Microwave Development Laboratories	115	http://mwj.hotims.com/28484-59
	Microwave Journal	98,110,112, 130,144,148	www.mwjournal.com
60,61,62, 63,64,65, 66,67,68, 69,70, 71,72	Mini-Circuits	4-5,18,31, 51,52,61, 73,93,135, 141,145, 149,153	http://mwj.hotims.com/28484-60
73,74,75	MITEQ Inc.	3,87,147	http://mwj.hotims.com/28484-73
76,77	Modco, Inc.	142,144	http://mwj.hotims.com/28484-76
78	Narda Microwave-East, an L3 Communications Co.	91	http://mwj.hotims.com/28484-78
79	Networks International Corporation	105	http://mwj.hotims.com/28484-79
80	Nexyn Corporation	84	http://mwj.hotims.com/28484-80
81	Noisecom	COV 2	http://mwj.hotims.com/28484-81
82	NoiseWave Corp.	8	http://mwj.hotims.com/28484-82
83	OEwaves	129	http://mwj.hotims.com/28484-83
84	OML Inc.	109	http://mwj.hotims.com/28484-84
85	Pascall Electronics Limited	50	http://mwj.hotims.com/28484-85
86	Programmed Test Sources, Inc.	COV 3	http://mwj.hotims.com/28484-86
	QuinStar Technology, Inc.	117	www.quinstar.com
87	R&K Company Limited	136	http://mwj.hotims.com/28484-87
88	Radiall	142	http://mwj.hotims.com/28484-88
89	Radio Waves, Inc.	74	http://mwj.hotims.com/28484-89
90	Reactel, Incorporated	48	http://mwj.hotims.com/28484-90
91	Remcom	113	http://mwj.hotims.com/28484-91
92	RF TEC Mfg., Inc.	144	http://mwj.hotims.com/28484-92
93,94	RFHIC	66,68	http://mwj.hotims.com/28484-93
95	RFMD	119	http://mwj.hotims.com/28484-95
96	RLC Electronics, Inc.	25	http://mwj.hotims.com/28484-96
97	Rogers Corporation	103	http://mwj.hotims.com/28484-97
98	Rohde & Schwarz GmbH	65	http://mwj.hotims.com/28484-98
99	Rosenberger	121	http://mwj.hotims.com/28484-99
100	RT Logic	63	http://mwj.hotims.com/28484-100
101	Sector Microwave Industries, Inc.	144	http://mwj.hotims.com/28484-101
102	Skyworks	151	http://mwj.hotims.com/28484-102
103	Sonnet Software, Inc.	21	http://mwj.hotims.com/28484-103
104	Spacek Labs Inc.	34	http://mwj.hotims.com/28484-104
105	Spectrum Elektrotechnik GmbH	133	http://mwj.hotims.com/28484-105
06	Spinnaker Microwave, Inc.	138	http://mwj.hotims.com/28484-106
107	Spinner GmbH	72	http://mwj.hotims.com/28484-107
108	Sumitomo Electric USA Inc.	83	http://mwj.hotims.com/28484-108
109	SV Microwave, Inc.	107	http://mwj.hotims.com/28484-109
110,111	Synergy Microwave Corporation	57,143	http://mwj.hotims.com/28484-110
112	Teledyne Storm Products	127	http://mwj.hotims.com/28484-112
113	TriQuint Semiconductor, Inc.	59	http://mwj.hotims.com/28484-113
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CBL-3FT-SMSM+	SMA	3	1.5	27	72.95
CBL-4FT-SMSM+	SMA	4	1.9	27	75.95
CBL-5FT-SMSM+	SMA	5	2.5	27	77.95
CBL-6FT-SMSM+	SMA	6	3.0	27	79.95
CBL-10FT-SMSM+	SMA	10	4.8	27	87.95
CBL-12FT-SMSM+	SMA	12	5.9	27	91.95
CBL-15FT-SMSM+	SMA	15	7.3	27	100.95
CBL-25FT-SMSM+	SMA	25	11.7	27	139.95
CBL-2FT-SMNM+	SMA to N-Type	2	1.1	27	99.95
CBL-3FT-SMNM+	SMA to N-Type	3	1.5	27	104.95
CBL-4FT-SMNM+	SMA to N-Type	4	1.9	27	112.95
CBL-6FT-SMNM+	SMA to N-Type	6	3.0	27	114.95
CBL-15FT-SMNM+	SMA to N-Type	15	7.3	27	156.95
CBL-2FT-NMNM+	N-Type	2	1.1	27	102.95
CBL-3FT-NMNM+	N-Type	3	1.5	27	105.95
CBL-6FT-NMNM+	N-Type	6	3.0	27	112.95
CBL-10FT-NMNM+	N-Type	10	4.7	27	156.95
CBL-15FT-NMNM+	N-Type	15	7.3	27	164.95
CBL-20FT-NMNM+	N-Type	20	9.4	27	178.95
CBL-25FT-NMNM+	N-Type	25	11.7	27	199.95
		Female to Male			
CBL-3FT-SFSM+	SMA-F to SMA-M	3	1.5	27	93.95
CBL-2FT-SFNM+	SMA-F to N-M	2	1.1	27	119.95
CBL-3FT-SFNM+	SMA-F to N-M	3	1.5	27	124.95
CBL-6FT-SFNM+	SMA-F to N-M	6	3.0	27	146.95
ARMORED CABLES		Male to Male			
APC-6FT-NM-NM+	N-Type	6	3.0	27	181.95
APC-10FT-NM-NM+	N-Type	10	4.8	27	208.95
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ACROSS

4 The repeated switching of frequencies during radio transmission (2 words)
9 A measure of how an electric field affects, and is affected by, a dielectric medium
14 Radar system that uses the apparent shift in frequency of an incident wave to measure presence and velocity of a target (2 words)
15 Automatic Waveform Generator
16 Linear frequency sweep
17 Voltage Standing Wave Radio
18 The ratio of operating to non-operating time for a device (2 words)
19 Variation in magnitude of a waveform
20 90 degrees out of phase
22 Quadrature Phase Shift Key modulation
24 PAE (3 words)

DOWN

1 Joint Tactical Radio System
2 DGS (3 words)
3 Type of distributed element filter with band-stop (notch) characteristics
5 Improvised Explosive Device
6 The vector ratio of voltage to current, the reciprocal of admittance
7 Next generation system for the warfighter which will enable networked sensors (3 words)
8 Type of polarization when the plane of polarization rotates in a corkscrew pattern making one complete revolution during each wavelength
10 An unbalanced transmission line structure consisting of a ground plane, the dielectric material of the printed circuit board and a narrow strip on the top side of the circuit board
11 The ratio between the amplitude of the output signal of a device or circuit compared to the amplitude of its input signal (2 words)
12 The geometric shape of one period of an electric signal when it is plotted versus time
13 Energy at integral multiples of the frequency of the fundamental signal
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23 Digital Signal Processor

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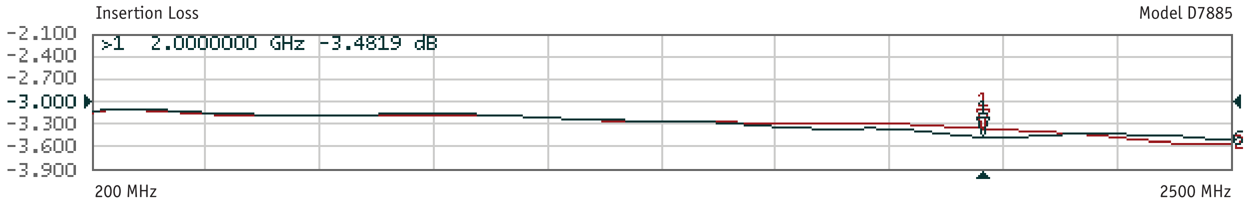

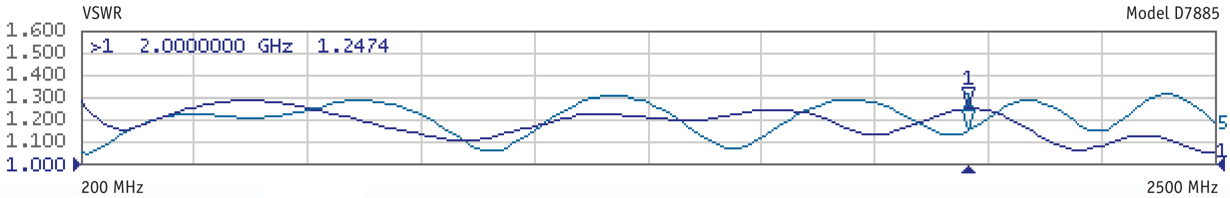

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Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	VSWR	Isolation (dB)	Size (Inches)
D7885	2-Way	200-2500	200	0.65	1.40:1	15	7.7 x 1.6 x 1.1
D7823	2-Way	500-2500	200	0.4	1.35:1	15	4.7 x 2.0 x 0.8
D7630	2-Way	800-3000	200	0.4	1.35:1	15	3.7 x 1.9 x 0.87
D7539	4-Way	800-2800	200	0.6	1.35:1	17	5.5 x 4.1 x 1.1
D7695	4-Way	900-1300	100	0.4	1.30:1	20	4.0 x 3.3 x 0.8