Military Microwave DIGEST

In This Issue

DARPA explores the microwave frontier

JTRS at General Dynamics: SDR writ small

Analysis: The microwave industry and defense

BAE Systems focuses on SoCs

Sage advice from Preston Marshall

VOLUME 1 MARCH 2009

A Supplement to Microwave Product Digest

The perfect synthesis of low noise, speed, and wide bandwidth

Wide bandwidth: 10 MHz to 20.48 GHz

Step sizes: down to 1Hz

1-Hz full-band coherent switching

Low phase noise: -120 dBc/Hz, typical at 10-kHz offset at 10 GHz

Harmonic filters

100-ns switching speed available

Industry-standard BCD programming

Locks to an external or internal reference

Modulation options: FM, Pulse, I&Q

Four FM modes

Digital frequency sweep

Digital attenuator option

Touch screen front-panel display

Low-profile chassis or compact modular package configurations

2U height configurations available

Ethernet capability

HERLEY-CTI

Series DS Direct Synthesizer

With ultra-low phase noise that rivals premium fixed-frequency sources, the DS Series offers very fast switching, extremely broad bandwidth in a single unit, and step sizes down to 1 Hz. Get the performance, speed, and flexibility you need for radar, RCS, EW, simulators, automatic test equipment, and frequency-agile equipment. Plus, 1-Hz coherent switching allows improved signature measurements.

For direct synthesizers, count on Herley for performance, reliability, service, and delivery.

For more information or to speak to a marketing representative, call **973-884-2580**. Or e-mail us at **sales@herley-cti.com**.

Frequency Range (MHz)	Phase Noise (dBc/Hz)				
	100 Hz	1 kHz	10 kHz	100 kHz	1 MHz
10 GHz	-92	-109	-120	-120	-128
1 GHz	-111	-127	-137	-139	-147
100 MHz	-125	-135	-145	-150	-153

HERLEY Industries, Inc.

Proven Microwave Performance

www.herley.com

Herley-CTI, 9 Whippany Rd, Whippany, NJ 07981 • **Telephone:** 973-884-2580
FAX: 973-887-6245 • www.herley.com • sales@herley-cti.com

WWW.MPDIGEST.COM ➤ 400

Military Microwave DIGEST

A Supplement to MPD

Editorial Statement of Purpose

Military Microwave Digest serves RF and microwave design engineers, engineering managers in research through production roles who design, manufacture, and specify components and subsystems used in aerospace and defense systems. Its editorial mission is to provide practical information about aerospace and defense markets, programs, and current and emerging technologies that are or will be critical for the development of rapidly-evolving defense systems.

Editor
Barry Manz
manzcom@gmail.com

Senior Production Editor
Erin Almaleh
eperry@mpdigest.com

Production Editor
Michele McGinn
mmcginn@mpdigest.com

Circulation Manager
Claire Ferrante
subscription@mpdigest.com

Director of Marketing
Rosalind Markhouse
rmarkhouse@aol.com

Publishing Coordinator
Eileen Rocco
eerrocco@aol.com

Publisher
Doug Markhouse
douglasmeow@aol.com

Editorial Council
Mark Perhacs, ACC
Harvey Kaylie, Mini-Circuits
Robert Pinato, RFMD®

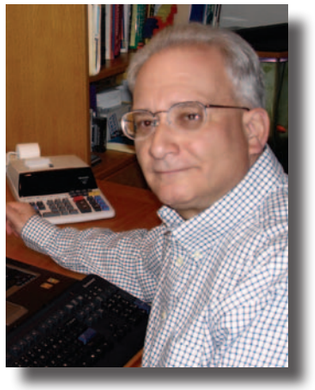
Publisher's Council
Robert Badami, Herley-CTI
Mark Andrews, TriQuint Semiconductor
Jim Price, Lorch Microwave
Arthur Nixon, Insulated Wire

OCTAGON COMMUNICATIONS, INC.
President — Douglas Markhouse
Secretary/Treasurer — Rosalind Markhouse
Controller — Eileen Rocco

This publication is issued without charge, upon written request, to qualified persons.

Pub. Agree. # 40112540
Return Undeliverable Canadian addresses to:
IMEX
P.O. Box 4332 Station Road
Toronto, ON M5W3J4

Now the real battle begins...



Barry Manz, Editor,
Military Microwave Digest

When President Barack Obama unveiled his proposed 2010 federal budget, the great fear among many in the defense community was that it would emasculate defense programs. That does not appear to have been the case – at least not yet. With an "all-inclusive" total of $633 billion (including the formerly separate appropriations for Iraq and Afghanistan), it's 4.63% of gross domestic product, and the base budget is up 4% from 2009. Obviously, it's way too early to hazard a guess about the fate of the Joint Strike Fighter, Future Combat Systems, Littoral combat ships, or other big-ticket, controversial programs. However, the pork fighters have already sounded the opening gun.

In fact, days before the budget was announced, Sen. John McCain ("we're facing a train wreck") and Carl Levin, (D-Michigan), the chairman of the Senate Armed Services Committee, singled out the aforementioned programs for scrutiny, among others. Even Defense Secretary Robert Gates, widely respected on both sides of the aisle, told Congress in January that "this moment presents an opportunity, one of those rare chances to match virtue to necessity, to critically and ruthlessly separate appetites from real requirements".

Unfortunately, "real requirements" is currently taken by many to mean asymmetric threats coming not from nation states but from small groups using archaic weaponry and electronic equipment. However, such a view is myopic, because while the U.S. was breathing a sigh of relief after the end of the Cold War and subsequently battling terrorism on multiple fronts, Russia and particularly China were advancing their defense systems. So today our threats are not just asymmetric but traditional in nature, making development of systems to counter them a "real requirement".

Dealing with both types of threats requires the expertise that the microwave industry has long provided. In fact, it's arguable that the applications that require RF and microwave technology have never been greater, as the nation's experience in both Iraq and Afghanistan have graphically demonstrated. The undisputed usefulness of UAVs, while an obvious example, is enabled by the information which is gathered and delivered in part by RF and microwave technology. Next-generation unattended ground sensors will be required in huge numbers (although at rock-bottom cost), as will networked communications equipment at all levels, to name just a few examples. With this in mind, it's hard to imagine that the coming years will be lean ones for microwave manufacturers serving the defense industry.

WWW.MPDIGEST.COM ➤ 500

In This Issue

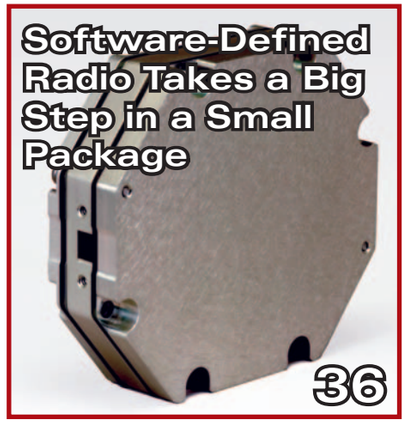
An Analyst's View 6

An interview with Brad Curran, at Frost & Sullivan.

28

Opportunities for Those with Vision

by Douglas Raymond



Software-Defined Radio Takes a Big Step in a Small Package 36

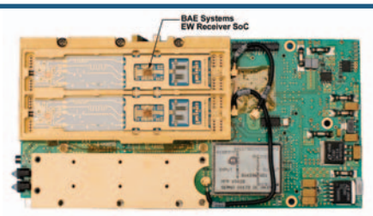
12 **DARPA and Microwave Technology, Part 1**

Research At the Edge

18 **DARPA and Microwave Technology, Part 2**

Into the Sub-millimeter-Wave Frontier

Reducing Size, Weight, and Cost at BAE Systems 42



45

A New Paradigm

A conversation with Preston Marshall, DARPA.

"We Started With A Dream, And It's Grown Into A Reality."

We've come a long way from that first amplifier built in my basement almost 40 years ago. Today we're recognized as the ultimate source for testing and communications solutions in the worlds of EMC, military, wireless, and beyond. And our products are everywhere. They're boosting the power of military radios for our troops in battle; driving the most sophisticated industrial/medical/scientific equipment; testing the emissions and susceptibility of electronic equipment; and helping new electronic products get to market faster.

We've become the industry leader by continually setting the bar a little higher. By raising quality. And increasing cost-efficiency. With innovations like "subampability" – the ability to add power to existing amps; and test systems that can be upgraded from the Internet to adapt to changing specs.

With the combined resources of all the AR companies, AR is your source for everything from RF power amplifiers, antennas, complete test systems, probes, monitors, software and receivers to military booster amps, and RF amplifier modules that can be customized to meet the toughest specs. We take great pride in the support & service we deliver to our customers anywhere in the world, whenever they need it.

"AR is truly the source for infinite solutions, combining the innovations of all AR companies worldwide with the products & services to manage today's needs, meet tomorrow's challenges, and turn their dream into realities."

To learn more, visit us at ar-worldwide.com or call 215-723-8181.

WWW.MPDIGEST.COM ➤ 401

ar®

rf/microwave instrumentation • modular rf • receiver systems • ar europe

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

In Europe, call ar emv United Kingdom 441-908-282766 • ar emv France 33 -1-47-91-75-30 • emv Germany 89-614-1710 • emv Netherlands 31-172-423-000

Copyright© 2008 AR. The orange stripe on AR products is Reg. U.S. Pat. & TM. Off.

An Analyst's View

Brad Curran is senior industry analyst, aerospace & defense, at Frost & Sullivan (www.frost-com). He can be reached at brad.curran@frost.com, (210) 477-8496.

While the electronics industry in general grapples with the diminishing fortunes of consumers, the prospects for manufacturers of products destined for defense applications that serve current threats remains strong. That's the overall feeling expressed Brad Curran, a senior industry analyst who covers aerospace and defense for Frost & Sullivan. His only caveat is for programs that are in their early stages of development and involve technology that is far from mature, which he feels are the most vulnerable to increased scrutiny.

MMD: What are your feelings concerning budgets for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) programs?

Curran: I believe C4ISR will continue to be very robust. In my opinion, budgets for C4ISR and tactical communications are going to go up even if the overall defense budget decreases and programs such as space-based technologies that are expensive and not relevant to current threats are reduced or eliminated. If you're working in procurement programs that are relevant to the current fight, your components will continue to be in demand. The new administration has not indicated there will be any reduction in forces, and these forces must be outfitted with communications and other equipment. DoD is not only concerned with cost but with the ability to get a technology deployed that is small, lightweight, and reliable, as well.

Secretary Gates has stated his commitment to a so-called 75% to 80% solution. That is, getting 75 or 80% of what's needed into the field soon is a lot better than 100% later when it may be outdated. Older equipment is worn out and gear with the newest technology will not be ready for years, so there's a gap that has to be filled now. The administration has stated it would rather build more of what we currently have than wait for new equipment. That isn't great news for RDT&E programs that are immature, but good for contractors and their suppliers who are delivering or will soon deliver proven solutions.

MMD: Seems like the Joint Tactical Radio System (JTRS) program and software-defined radio in general may fall into both categories.

Curran: That's true. In terms of JTRS, if you are not Software Communications Architecture (SCA) compliant, you're not going to be relevant in the long term. However, SDR is still the trend, although it probably will not look like the original JTRS blueprint. There are interim solutions from General Dynamics, Thales, Harris, and ITT that are addressing the need to have backward and forward waveform compatibility, while addressing size, weight, and power issues.

SCA was supposed to solve the interoperability problem, but in reality new stovepipes have been created that did not exist before. So instead, manufacturers have developed their own ways to take advantage of the benefits COTS can provide. It's a response to the need I mentioned about DoD's need for hardware that can be delivered now. As for JTRS in its current form, I'm not holding my breath. It started with dozens of waveforms and is now much less. We tend to rush technology into programs when it should still be in the research phase.

MMD: High-frequency (HF) systems have long been the backbone for defense communications. Has their day come and gone, or is there a future for HF systems in the military?

Curran: HF programs for long-distance communications went through a low ebb as more satellite transponders came online. However, much of DoD's satcom capacity is delivered via commercial transponders, which are expensive, and DoD does not want to depend on non-DoD resources. Getting access to satellite communications remains a problem for troops at the battalion level and below, so HF remains an important method of over-the-horizon transmission. HF also remains a backup for the Navy and Air Force. For base communications, troposcatter is still used mostly as a backup to landlines, Intranets, and satcom. HF also has a better chance

Curran, Con't on page 8

Aethercomm salutes our armed forces!

Another industry first from Aethercomm: a 20 MHz to 6000 MHz 10 Watt RF amplifier in a single module!

Aethercomm thanks the U.S. Military for a job well done.

We design & manufacture RF amplifiers and systems used for Force Protection and other life saving missions. Aethercomm products are combat proven and operate in the harshest environments on the earth.

Featured Product : SSPA 0.02-6.00-10

- GaN technology
- 20 MHz to 6000 MHz bandwidth
- 10 Watts PSat output power typical
- 50 dB small signal gain typical
- 28 Vdc operation
- +/- 3 dB gain flatness typical
- -40C to +85C base plate operation
- 2.5" (w) x 6.4" (l) x 1.0" (h)

Applications:
- EW Jamming
- Broadband Communications
- Test and Measurement

Contact Aethercomm with your RF amplifier requirements.

WWW.MPDIGEST.COM ➤ 402

BSI REGISTERED ISO 9001:2000 FM 89386

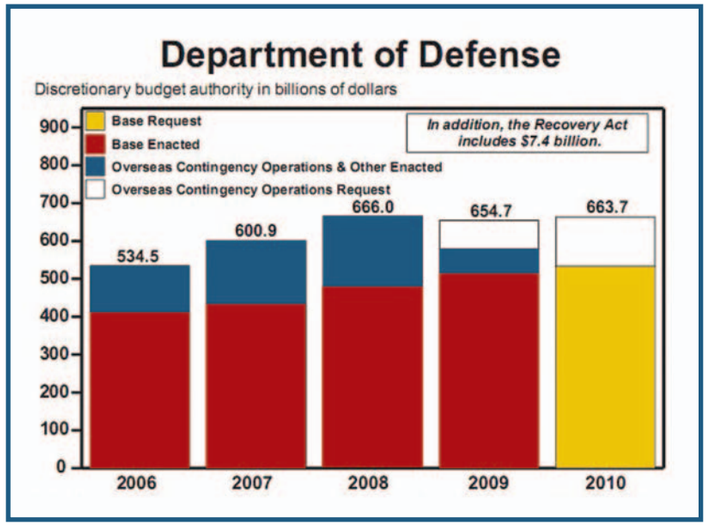
Tel 760.598.4340
Fax 760.598.4342
sales@aethercomm.com
www.aethercomm.com

Aethercomm®

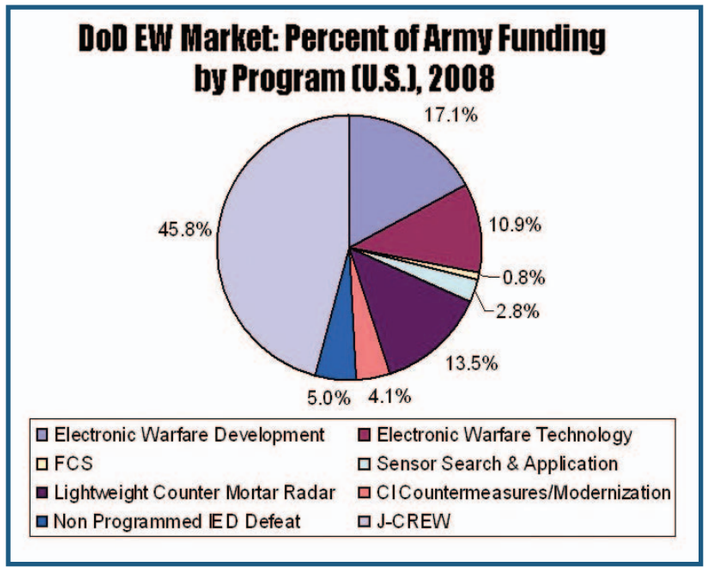
Curran, Con't from page 6

of hammering through EMP to provide a minimum level of communications.

Both HF and really low frequencies, such as ELF, which has long been used for submarines for many years, suffer from two problems. The first is that while voice communications can obviously be reliable at HF and ELF, the huge amounts of data required for the maps, imagery, and tactical and field reports required today is difficult to reliably transmit and receive at HF and ELF. The second is in providing encrypted information, for the same reason. To solve these problems, submarines, which have used ELF communications for many, many years, now use buoys that house satellite communications antennas that are connected to the sub's receivers and signal processing equipment via fiber-optic links. The buoys have no radar signature so they're secure, and they float on the surface to provide satellite communications without the sub having to reach periscope depth. Since optical links have the ability to deliver the enormous amounts of data and video information to and from the sub, they're very appealing. So in general, there's still a place for HF communications, but it's not 1952 anymore, so to speak.



The President's proposed 2010 defense budget includes a $533.7 billion "base" amount (up 4% over 2009) and $130 billion in supplemental funding for operations in Iraq and Afghanistan for a total of $663.7 billion.



MMD: What about electronic warfare funding as we go forward? The threats have changed since the Cold War when the prime adversary was the Soviet Union. Now some threats are as embarrassingly simple as TV remote controls and mobile phones used to trigger IEDs.

Curran: Asymmetrical threats have certainly changed the EW landscape, and it took awhile before physical protection from IEDs and jamming them were recognized as critical. However, once that occurred, equipment was deployed to provide both. Conventional threats are nevertheless still extremely important because while the U.S. has been immersed in simultaneously fighting two wars, the Chinese, for example, have deployed at least two new generations of anti-ship and anti-aircraft missiles and have increased the number of attack submarines.

Naval and airborne EW have been neglected while the ground side has been and continues to be the priority, since that's where the current problem exists. The Air Force used to lead airborne EW, but has essentially quit that business, and the Navy has been executive agent. There will be upgrades, in the F-18 Growler, for example, which is beginning to come into service, and others that will get attention. However, in my opinion air and naval EW need to be rapidly addressed. The airborne/seaborne EW threat will have more emphasis, and will hopefully be caught up in 3 to 4 years.

Curran, Con't on page 10

MECA DELIVERS HIGH FREQUENCY COMPONENTS OFF THE SHELF!
Most models available from STOCK - 4 weeks ARO
- Microwave Radio
- Mobile Satellite
- Earth Station
- Instrumentation
- Telemetry
- Radar
- Aviation

- Multi-Octave Power Divider/Combiners
- Octave Band Directional & Hybrid Couplers
- Attenuators, Terminations, Isolators/Circulators
- L, S, C, X and Ku Bands

WWW.MPDIGEST.COM ➤ 403

New Catalog Supplement Focus on High Frequency

START YOUR CRITICAL PROJECTS ON TIME – EVERYTIME!

e-MECA.com

Microwave Electronic Components of America
866-444-6322 | sales@e-MECA.com | www.e-MECA.com
459 East Main Street, Denville, NJ 07834 T. 973-625-0661 F. 973-625-9277

Rugged and Reliable RF/Microwave Components Since 1961 - Made in USA

Northrop Grumman's RQ-4 Global Hawk used by the Air Force is perhaps the best known UAV.

Curran, Con't from page 8

MMD: What about radar systems? Is there continued development in this vital area?

Curran: Absolutely. There are many upgrade programs in place at the prime contractor level and new systems as well. The Marines are developing the GATOR system and the Army continues to upgrade its theater air defense radars. A high growth area is for incoming round detection systems that use changes in air pressure to quickly detect and determine the direction and distance of mortar and even rifle fire. There are also upgrades for the Navy Hawkeye, for AWACS, and for JSTARS.

Northrop Grumman is upgrading the F16 radar, Raytheon the Patriot, and the Navy is adding a synthetic radar function to some of its Boeing/BAE Systems T-45C Goshawks to support crew training requirements, and is also considering a possible requirement to place a follow-on order for the advanced jet trainer. There is also the APQ-170 radar upgrade being conducted by DRS Technologies (now part of Finmeccanica) for the FC-130. Another growth area is in upgrades for air traffic control radars, such as the joint DoD/FAA digital airport surveillance radar system – and this is far from a complete list.

MMD: UAVs have been extremely important in Iraq and Afghanistan. What do you believe the future holds for these programs?

Curran: We're very bullish on UAVs of all types. There is a lot of work being conducted to improve UAV sensor and communications packages and ground controls. Although UAV platforms are dominated by just a few major suppliers such as General Atomics, Northrop Grumman, and Aerovironment, the sensor package, data links, ground controls, collaboration, analysis and dissemination tools provide lots of room for other firms to upgrade and participate. UAVs are well funded because troops just cannot get enough of what these platforms deliver.

MMD: So to summarize your comments, it appears that in your opinion the defense market for RF and microwave equipment manufacturers should continue to be strong, primarily in programs that are in production and relevant to current needs. Conversely, programs reliant on emerging or unproven technology, are less secure.

Curran: I would say that's a fair assessment. After the end of the Cold War, many people felt that the U.S. could finally relax to some degree after so many decades spending huge sums to counter threats principally from one or two large adversaries. Now these conventional threats not only still exist but have been joined by asymmetric types that require a whole range of new technological solutions, if not a wholly different approach to warfare. These threats along with the need to replenish and upgrade our current inventory makes it obvious, I believe, that there are exceptional opportunities for innovative companies that can deliver cost-effective, technically formidable solutions in the shortest possible time. Having said that, I also believe that manufacturers should still pay close attention to programs in early development because some will unquestionably be fielded in the future. ■

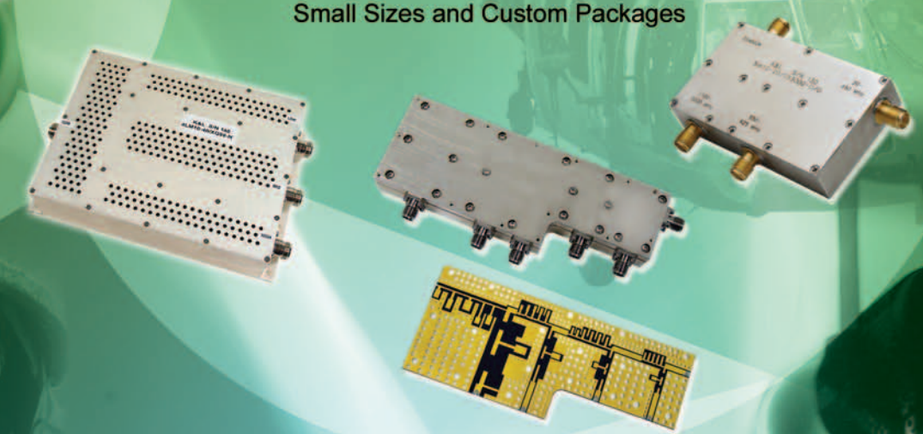
"We're very bullish on UAVs of all types."

WWW.MPDIGEST.COM ➤ 501

K&L MICROWAVE A DOVER COMPANY CMP

Filter Solutions

Passbands from 8 to 18 GHz
Combines Several Filters to a Common Port
Small Sizes and Custom Packages



Product Spotlight

8-18 GHz Multiplexer with Overlapping Bands

For wideband receiver applications, the 8 to 18 GHz spectrum is divided into 2 GHz segments prior to the amplification stage. The multiplexer passes each band with flat insertion loss of 1.25 dB and provides isolation of 70 dB between channels, directly affecting the dynamic range of signal detection equipment.

Other features of the multiplexer include:

- Overlapping Channels
- Resonators Machined Directly into the Housing for High Reliability
- Laser Welded Cover to Meet Fine Leak Requirements
- 4" x 3" x .5" with SMA Connectors on One Side

Filter Wizard℠

K&L Microwave's Filter Wizard℠ software simplifies selection of the right filter product for your application from a vast number of designs. Provide desired specifications, and Filter Wizard℠ returns response data, downloadable S-parameter data, and outline drawings for matching products. Visit www.klfilterwizard.com today!

WWW.MPDIGEST.COM ➤ 404

AS 9100 ISO 14001

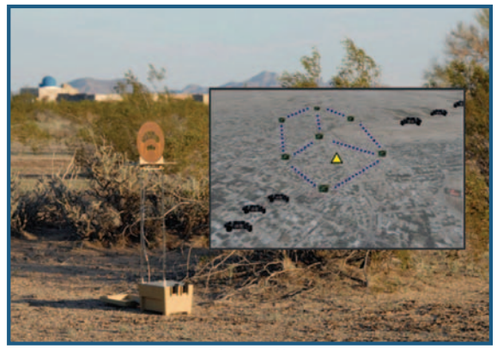
CERAMIC & MICROWAVE PRODUCTS
Electronic Components & Microwave Solutions

K&L Microwave, Inc. • 2250 Northwood Drive • Salisbury • MD • 21801 • P: 410-749-2424
F: 443-260-2268 • www.klmicrowave.com • www.klfilterwizard.com • sales@klmicrowave.com • sales@kleurope.com

Research At the Edge, Part 1

As DoD's largest research organization, The Defense Advanced Research Projects Agency (DARPA) sits at the leading edge of technological development in virtually every area of interest to the U. S. government. Think of it as a sort of federally-funded Bell Laboratories whose goal it is to "press the envelope" philosophically, politically, and scientifically by proposing and helping to develop completely new ways to reduce or eliminate limitations in current systems. The scope of DARPA's work is immense, ranging from biology and medicine to computer science, chemistry, physics, engineering, mathematics, materials sciences, social sciences, and neuroscience. However, most people would recognize it only for its DARPA Grand Challenge, a "pilotless road rally" that dangled the prospect before organizations worldwide of winning up to $2 million by developing autonomous ground vehicles that race to complete an arduous course in the shortest time. It became more and more popular since it first running in 2004, and the final event in 2007 was even televised live on the Web.

The two articles in this issue exploring research at DARPA cover activities at both the Microsystems Technology Office (MTO), in which Preston Marshall is a program manager, and the Strategic Technology Office (STO), in which Dr. Mark Rosker is a program manager. The two offices have different objectives, the latter being oriented toward research into integrated microsystems as "platforms-on-a-chip" to sense, process, and act on data in the battlespace. The STO focuses on technologies that have a potentially global or theater-wide impact on multiple military services. Among the array of programs under both of these organizations are many that either include or are based entirely on the use of microwave technology. This first article discusses programs within the MTO.



WolfPack's small unit support scenario

View From MTO: RUFAS

The Retro-Directive Ultra-Fast Radar (RUFAS) program is, in the words of Preston Marshall, "a completely different operating science for radars". RUFAS is based on correlations of the Gaussian noise received by an antenna array from a small object located in the antennas' far field, and the "retro-directive" re-radiation of the correlated noise by interconnecting the receive elements to transmit elements in a conjugate fashion.

This concept of combining and tailoring noise-correlating interferometry and retro-directive antenna arrays results in a radar with an omnidirectional search mode. This is achieved by broadcasting white noise over a specified search angle determined by the beam pattern of the elements. Once a target of adequate cross section enters the beam, correlations appear in the noise between neighboring antennas. The received noise power is then amplified by the transceiver and retransmitted directly toward the target in a feedback loop.

"It essentially lets the target focus be based on a spatial correlation on the return signal," says Marshall. "It gives us very low acquisition time and lets us build relatively small arrays that become highly accurate by self-focusing. We replace the accuracy of an array with a-priori knowledge via Kalman filters, for example. A conventional radar that can see bullets is lucky to get a couple of hits as the bullet passes through the beam, but with this system we get hundreds of hits."

The technique allows a very small, inaccurate array to be used that can nevertheless still achieve a highly accurate estimate of trajectory. It could be used to build inexpensive sniper protection without resorting to expensive phased arrays. The principle, says Marshall, is analog resonance, using the effect of an object in the propagation path to focus the beam. "The normal approach would be to focus the beam in all directions and interrogate with pulses to see if anything is there. This goes the other way: We don't focus it at all but radiate omnidirectionally and amplify and reinforce the correlated part of the return, which represents an object. Over successive round trips the array focuses on the object without having to do true time delay in a conventional TR module.

A breadboard version of RUFAS has undergone a variety of tests using "a small army of RPGs, mortars, and high-velocity rifles that we are throwing at it," says Mar-

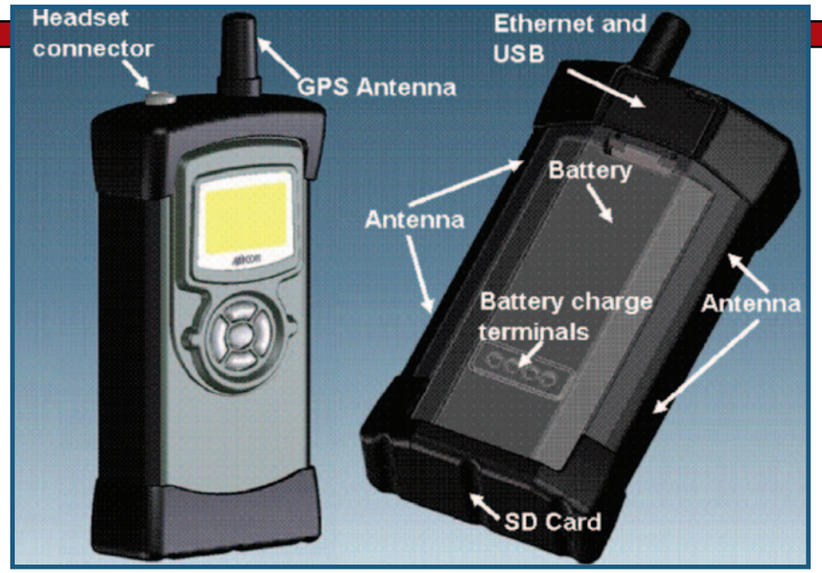
DARPA Part 1, Con't on page 14

DARPA Part 1, Con't from page 12

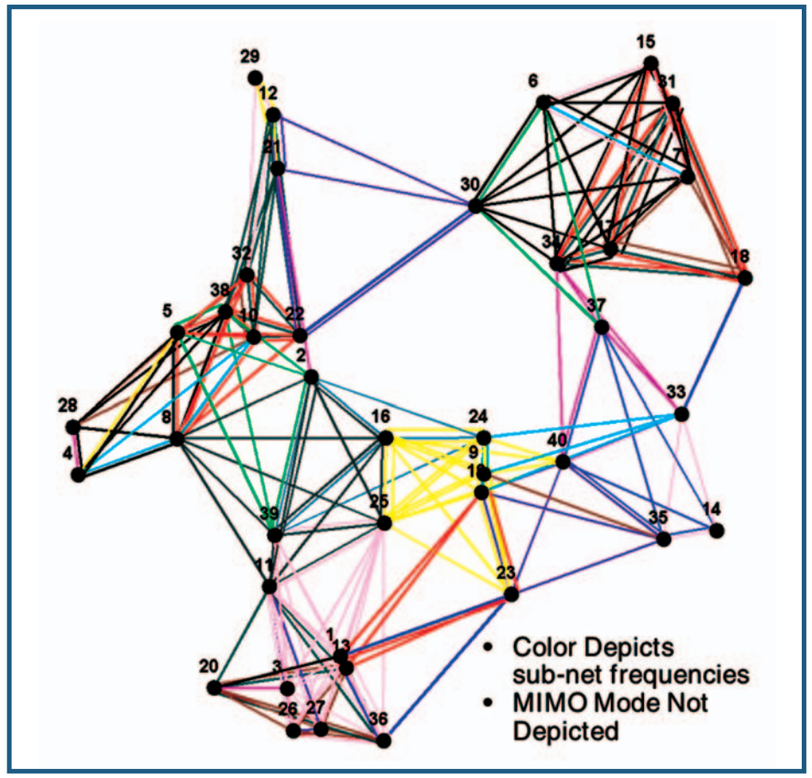
shall. "Now we're trying to understand what the real system advantages are and if they fundamentally enable new kinds of military capability." In the next phase, the program will move closer toward something that could be evaluated in real military scenarios. As is the recurring theme in all of Marshall's programs, "it's cost-sensitive. The market for radar sensing is not in the F-22 side, it's providing that level of protection to troops and vehicles."

Another program, also with a cost driver, is WolfPack, which was created to enable the military to deny the enemy use of communications and radars throughout the battlespace. The networked system is comprised of autonomous, ground-based monitors and jammers that are cooperatively linked to avoid disruption of friendly military and protected commercial radio communications and radars. WolfPack relies on high-efficiency subresonant antennas, networking algorithms that allow coordinated access to the spectrum by communications systems, jammers, and signals intelligence (SIGINT) systems. It focuses on methods of easily deploying systems in "RF advantaged" sites, and algorithms to rapidly and autonomously detect, classify, identify, and jam target signals with low-power electronics. DARPA is developing long-term plans with the Army for deployment via airborne and deep-launch devices, and is working with the Air Force in a distributed suppression of enemy air defense role. Initial discussions with the Navy are taking place for littoral and force protection missions.

"We wanted to demonstrate that you can do ELINT and SIGINT in an unclassified framework and make it part of an operational unit, for example a company that wants to know who is shooting at them," says Marshall. "That is, you could change the tactical outcome by devolving these capabilities close to the edge and modify them rapidly as the threat evolves. They could just set it up in a couple of days and make use of the information without having to request high-demand assets. It would be a $500 unit, disposable and unclassified."



The WNaN radio



Simulated WNaN 40-node assignment

"The enemy relies on off-the-shelf equipment in some cases, and you don't learn about it with a EP-3 overflight. So we envision EW in this case as something that can respond to how the enemy attacks and make use of high-volume COTS parts to provide a proliferated response rather than to depend on high-demand assets like we do today," Marshall continues. "The threat has changed and we can be responsive to

DARPA Part 1, Con't on page 16

RF & Microwave Filters for the most advanced

Integrated Assemblies

LORCH delivers custom solutions for demanding applications

- high-level integration capabilities
- latest component technology
- optimized for performance and value
- all hardware designed, manufactured and assembled in-house
- time-tested baseline designs ready for customization

LORCH MICROWAVE

Salisbury, Maryland 21802 · USA
800.780.2169 · 410.860.5100

Brackenholme Y08 6EL. UK
Tel/Fax +44 (0) 1757 633 755

www.lorch.com

WWW.MPDIGEST.COM ➤ 406

smiths
bringing technology to life

DARPA Part 1, Con't from page 14

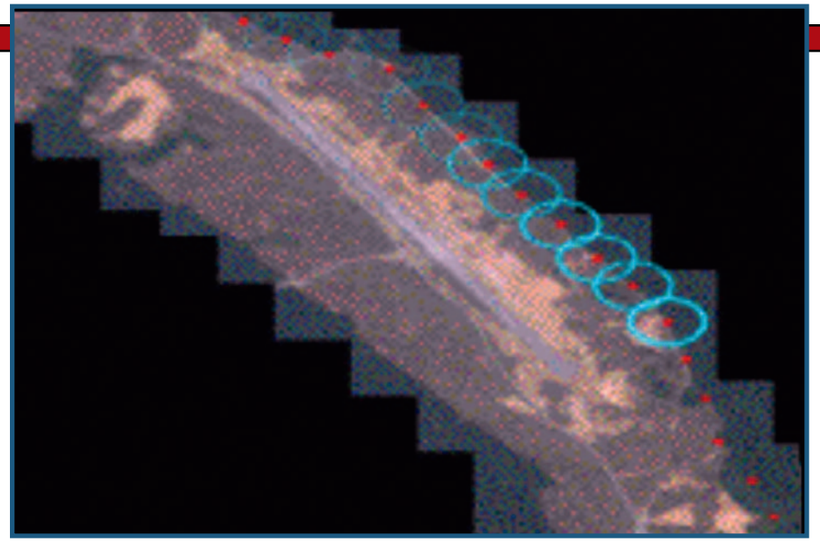
it without a long timeline. We're talking about things we are bolting onto vehicles rather than onto an aircraft, so we can respond very rapidly."

The Wireless Network after Next (WNaN) program is dedicated to developing wireless nodes and adaptive network technologies that enable the nodes to autonomously form ad-hoc networks. The nodes are inexpensive, which makes them deployable with all mounted and dismounted warfighters. In combat environments, the communications capabilities provided by the WNaN network are designed to provide superior throughput, robustness, scalability, and ease of use when compared to current networks.

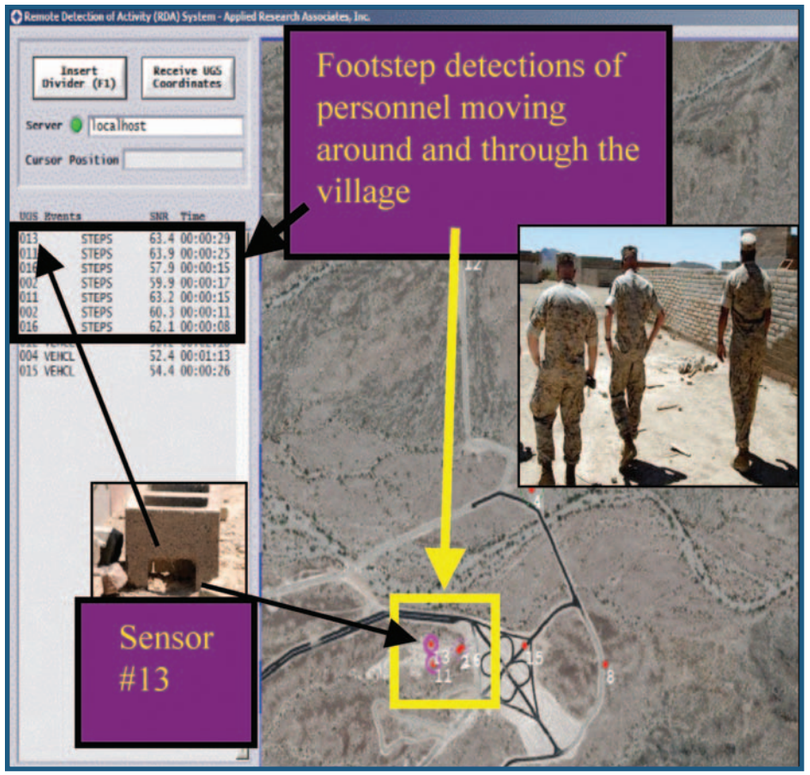
WNaN technologies will give the military an affordable way to communicate with every person and device at the tactical level of command and control. Its scaleable design allows future increases in node densities and network capabilities to be achieved while reducing size, weight, and cost. Specifically, WNaN:

- Integrates spectrum agility and spectrum sharing capabilities
- Uses disruption-tolerant networking techniques to knit together heterogeneous networks
- Incorporates advanced front-end filtering
- Employs Multiple Input Multiple Output (MIMO) technology

The WNaN nodes are optimized for operation with the network, which adapts to changing conditions by adjusting its topology and the operational mode of the nodes to reduce demands at the physical and link layers. The concept has two complementary components: low-cost, multichannel, spectrum-agile, MIMO-capable wireless radio nodes built with inexpensive RF circuit technology, and a network with densely-deployed, low-cost wireless nodes and adaptive network layers that mitigates RF limitations by leveraging rich connection topologies. The wireless nodes should be producible at $500 per node in large quantities, offer four channels per node, and operate from 900 MHz to 6 GHz. The network will be scalable to tens of thousands of nodes, adapt to the environment and mission, increase spectrum access, sense impairments and mitigate their effects, and interface with legacy radios and non-WNaN IP systems.



Typical RDA screen view



Depiction of RDA detection

Toward the Ultimate "Disposable" Sensor

The goal of the Remote Detection of Activities (RDA) program is to create an extremely inexpensive (less than $250 in quantity), unattended ground sensor (UGS) network with long RF communication ranges and specialized algorithms. It features a high link margin that permits

DARPA Part 1, Con't on page 20

Research At the Edge, Part 2

Into the Sub-millimeter Wave Frontier

The programs managed by Dr. Mark Rosker are, in contrast to those of Preston Marshall at MTO, often centered around technologies and regions of the electromagnetic spectrum well beyond what any commercial or military service is currently using. That is, the "terahertz domain." The benefits Rosker and his teams hope to derive from this work may not only allow entirely new systems to be created that circumvent the problems encountered using conventional technologies and frequencies, but improve device technology and fabrication in general. The projects are collectively at a more basic research level than what manufacturers typically devote their resources to. Like so many DARPA programs before them, they have the potential to change current paradigms.

The Sub-millimeter Wave Imaging Focal-plane Technology (SWIFT) program is a prime example of these programs. It was designed to explore the sub-millimeter-wave region above 300 GHz that offers unique opportunities for sensors and communications systems. The goal was to demonstrate an active sub-aperture operating at 340 GHz, enabling systems for imaging at sub-millimeter frequencies in all-weather environments and platforms. A specific objective was development of a compact, coherent source at 340 GHz capable of producing at least 50 mW from a single MMIC and 1 W when power-combined across the aperture.

Other objectives included development of sensitive MMIC low-noise amplifiers with a noise figure of 8 dB at 340 GHz, and to achieve an integrated imaging system consisting of a 1x128-pixel active array. The imaging system would produce a two-dimensional image in which each pixel records the relative intensity of the sub-millimeter-wave radiation received on the focal plane within the field of view of the scene being sensed.

The SWIFT program and a complementary program called Terahertz Imaging Focal-plane Technology (TIFT) were synergistic. The TIFT program demonstrates large multi-element detector receiver focal plane arrays that respond to radiation in the terahertz region. The resulting man-portable sensor system operates effectively at standoff range with high spatial resolution limited only by beam diffraction. The imaging receiver is designed to produce a two-dimensional (2D) image in which each pixel records the relative intensity of the terahertz radiation received on the focal plane within the appropriate section of the field of view of the scene being sensed. The program achieves intensity sensitivities as close as possible to the thermal background limit at room temperature. The size, weight, and electrical power requirements are consistent with portability.

An objective was to demonstrate a compact terahertz source achieving at least 10 mW of average power and 1% efficiency, which is considered a requirement for active illumination and local oscillators in heterodyne or homodyne detection schemes. The team also worked to develop and demonstrate a terahertz receiver with noise equivalent power of less than 1 pW/Hz with an integration acquisition time of no more than 30 ms and a pre-detection bandwidth of no more than 50 GHz. Both programs have concluded with impressive results, and this success has spawned another program, currently at an early stage, called Terrahertz Electronics.

The imagers in the TIFT and SWIFT programs were developed in part to provide the ability to "see" through weather or sandstorms, which is vital for helicopters that need to image a short distance in front of the aircraft in hostile environmental conditions.

"This is difficult to do even with infrared," says Rosker. "When you can use infrared you will, but sometimes it's not available. Millimeter-wave systems operating at 100 GHz are currently being used but even though they can penetrate through dust

DARPA Part 2, Con't on page 24

SATCOM Test Equipment

Typical application...

Payload communications testing
V-SAT earth station development
Mobile terminal testing

Solutions provided for...

WIN-T - warfare information networks, tactical
MUOS - mobile user objective system
IRIS - Internet routing in space
Terrestar - mobile communications

Satellite RF Link emulation and link budget testing for payload and terminal development. System allows phase continuous Doppler, delay, path loss, phase shift and flat fading to be independently programmed for each channel. Multiple channels permits satellite or earthstation handoff emulation for full constellation testing. Capable of supporting L, C, S, Ku, Ka band RF links (with appropriate RF frequency converters).

WWW.MPDIGEST.COM ➤ 408

dBm

RF Test Equipment for Wireless Communications

dBm, LLC
32A Spruce Street ◆ Oakland, NJ 07436
Tel (201) 677-0008 ◆ Fax (201) 677-9444
www.dbmcorp.com

DARPA Part 1, Con't from page 16

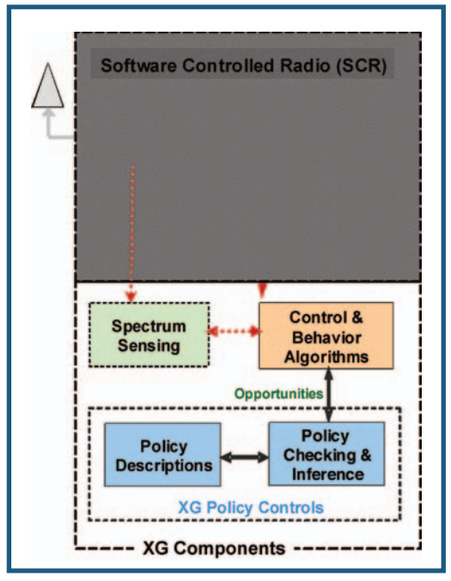
signals to be transmitted between buildings and walls to command and control radios including UAVs. The results of this effort will provide the tactical warfighter the ability to detect activities of interest and determine appropriate courses of action to minimize loss of life and assist in mission accomplishment. It will detect vehicles and human footsteps, provide early warning in a variety of geographical settings, and will be simple to operate. RDA applications include monitoring lines of communication, perimeters, and border intrusions, as well as monitoring enemy activity near buildings or around urban and rural environments.

The units will measure less than 3 x 3 in., have a battery life of more than 4 months, and have a range of about 5 miles with an RF output power of 100 mW. It will have to operate unattended for weeks to several months and be producible in high volumes.

"Think of it as a 3-in., tuna-can-sized unattended sensor," says Marshall. "We have been providing a large number of them for people to experiment with. It's not exotic technology, but moves us to the idea that low-cost persistent sensing is of value, particularly if it is deployable and controllable by organic units. A soldier could carry 10 of them with a total weight of 2 lb., so he lays them on places of interest and sees what is tripped. If you don't get them back, you've only lost a couple hundred dollars each, so you don't have to go pick them up -- and be ambushed."

The goal of the Next Generation (XG) program is to develop the enabling technologies and system concepts to dynamically redistribute allocated spectrum and novel waveforms to improve military communications. It is driven by the fact that U.S. forces face unique spectrum access issues everywhere they operate because of competing civilian or government users of spectrum. This fact must be reflected in force planning and has the potential to preclude operation of critical systems.

To achieve its goals, the XG program develops

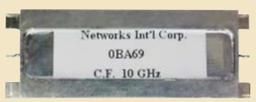


XG system configuration

DARPA Part 1, Con't on page 22

NETWORKS INTERNATIONAL CORPORATION

CAVITY FILTERS



NEW PRODUCTS*

NIC introduces its CV series line of cavity filters designed to support ruggedized applications. Features include:

- High "Q" & Low Loss
- Narrow bandwidths and high selectivity
- Custom designs (combline & interdigital) available
- Surface Mount & Connectorized options available

Typical Specifications

C.F.	3 to 14 GHz
3-dB BW	1 to 10 %
I.L.	0.5 to 4 dB
Return Loss	16 dB (Typical)
Operating Temp.	-40 °C to +90 °C

Standard & Custom Packages Available

NIC

20+ Years of Excellence

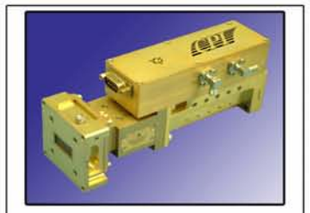
913.685.3400

15237 Broadmoor
Overland Park, KS 66223

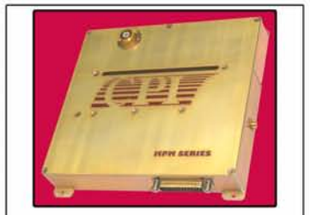
www.nickc.com
e-mail: sales@nickc.com

WWW.MPDIGEST.COM ➤ 409

Transmitter
CPI BMD has produced many transmitters for military and commercial radars and for electronic warfare systems. technology includes coherent radar transmitters with helix and coupled cavity TWTs or with klystrons, as well as magnetron based transmitters at all frequencies and power levels.
CPI / BMD ➤ 410



Receiver Protectors
CPI BMD's current designs span the complete spectrum from low-frequency coaxial limiters to complete pre-TR, TR limiters with attenuation and phase control at Ka-Band. These products are manufactured in all transmission line types, including waveguide, coax, stripline and microstrip.
CPI / BMD ➤ 411



MPMs
A broadband, Compact Amplifier wieghing under 5 pounds.
Solid State Amplifier for the first stage of RF amplification with booster TWT for final power stage. State of the art design; designed for all military environments.
CPI / BMD ➤ 412

Upconverters
CPI BMD upconverters frequency translates a wideband linear chirp from VHF to L-Band and then to X-Band. The unit is designed to minimize spurious emissions at the X-Band output while maintaining the transmitted waveform integrity.
CPI / BMD ➤ 413

Integrated Microwave Assemblies

Advanced Technology - Extensive Experience - Superior Performance

CPI
Communications & Power Industries

Communications & Power Industries' Beverly Microwave Division (BMD) offers product technology that includes Integrated Microwave Assemblies and Control Components. BMD's broad experience and extensive capabilities in the areas of high power microwave component design for military and non-military radar, satellite, communications, and EW systems makes it uniquely suited to design and manufacture a wide range of components and multi-function assemblies in small, lightweight packages. Coupling that with our experience in other transmission lines and technologies gives us a technical capability that is unparalleled in the microwave industry.

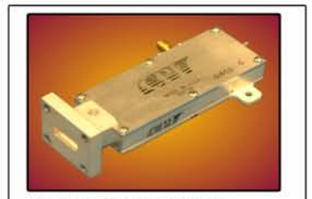
- Multi-function components
- RF front ends
- Switches & attenuators
- High level assemblies & modules
- Design capability up to 40 GHz
- Power handling to 1 MW+ peak
- Integral driver & associated electronics
- The industry's most extensive high power test facility

Communications & Power Industries
Beverly Microwave Division

150 Sohier Road
Beverly, MA 01915
Phone: (978) 922-6000
Fax: (978) 922-2736

marketing@bmd.cpii.com
www.cpii.com/bmd

WWW.MPDIGEST.COM ➤ 417



Limiter / Attenuators
CPI BMD utilizes solid state technology to provide passive high power limiting capability as well as integrated STC attenuation control. Products available from as low as L-Band to as high as Ka-Band.
CPI / BMD ➤ 414

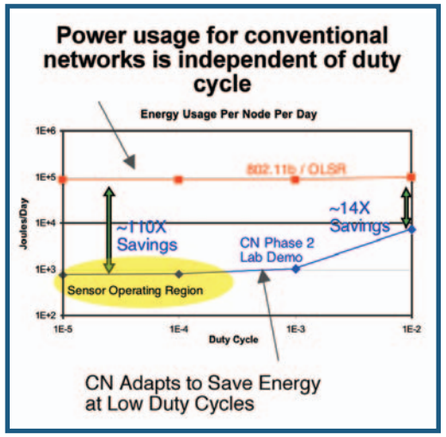
Receivers
A dual-conversion X-Band radar receiver. The receiver can be selected to output the first IF, wide-band L-band signal or the second IF signal converted to VHF. The receiver is designed to have a very high dynamic range to operate in a multiple-system airborne environment.
CPI / BMD ➤ 415

Magnetrons
CPI BMD is a major designer and manufacturer of pulsed, frequency agile and beacon magnetrons for military, commercial, industrial and university users worldwide.
CPI / BMD ➤ 416

DARPA Part 1, Con't from page 20

the theoretical underpinnings for dynamic spectrum control, the technologies and subsystems that enable spectrum reallocation, and the system prototypes to demonstrate applicability to legacy and future DoD RF emitters. Technology in commercial microelectronics will be supplemented with new waveforms and medium access and control protocol technologies to construct an integrated system. The proposed program goals are to develop, integrate, and evaluate the technology to enable equipment to automatically select spectrum and operating modes to minimize disruption of existing users, and to ensure operation of U.S. systems.

"The technology we started here 7 years ago has really taken off," says Marshall. "There is an NTIA working group, a DoD executive steering group, and XG is now being placed into production for the Army's Enhanced Position and Location Reporting System (EPLRS) radio. It has effectively left DARPA, which of course is always our goal, since we measure success by whether the world takes the project over. That's success for a DARPA program manager." The program has implications for the microwave community, according to Marshall, because it indicates that DoD should build equipment that is not tied to any particular regulatory regime, but rather be dynamically modified. A frequency band may be needed for communications today but a commander might need it later for radar, or vice versa. "Our ability to maintain regulations worldwide is not what it used to be because there are so many demands for spectrum," Marshall continues. "Even in the military we have to rebalance how we use spectrum based on the tactical and strategic environment. We have to build more spectrally-agile solutions in the future because the assumption that you will always have dedicated spectrum will be difficult to maintain over the next decades."



Connectionless Networks energy savings

Computing, the Analog Way

Marshall says the Analog Logic program is "the most significant thing I have -- if it works." The program will develop and demonstrate architec-

DARPA Part 1, Con't on page 34

True FM L-Band and S-Band Telemetry Transmitters with RS232 Programmable Carrier Frequency

Volume:	Less than 0.5 cubic inches
Weight:	Less than 0.5 ounces
Frequency Selection:	HyperTerminal compatible
Modulation Types:	Analog, Digital, and Video
Output Power:	300 mW nominal at 3.3 Vdc; 500 mW nominal at 5.0 Vdc
Environmental:	Ruggedized for high vibration/high shock operation
Input Voltage:	3.3 Vdc to 5.0 Vdc
Input Current:	400 mA max @ 3.3 Vdc; 550 mA max @ 5.0 Vdc

With over 30 years of experience in developing Space, Airborne and Ground-Based telemetry products, Emhiser is a tested and reliable source for the Aerospace and Defense industries.

EMHISER RESEARCH, INC.

For additional information please contact Emhiser Research:

U.S.A. Emhiser Research, Inc., T: 775-345-2705 / F: 775 345-2484 / info@emhiser.com
Canada Emhiser Research, Ltd., T: 705-746-4268 / F: 705-746-4414 / erl@emhiser.com

WWW.MPDIGEST.COM ➤ 418

Dressed and Ready for Action

Wideband Military Components

MLFR-Series Band Reject Filters
- 2-18 GHz and 2-20 GHz coverage
- 1.4" & 1.7" packages
- 40 dB rejection notches

MLFP-Series Band pass Filters
- 2-18 GHz and 2-20 GHz coverage
- 2, 4, 6, & 7 stage designs
- 1.7", 1.4" & 1.0" cube packages

MLXS and MLXS-T Series Oscillators
- 2-18 GHz and 2-20 GHz coverage
- Fundamental or Switched band designs
- 2" cylinder package

MLHG-Series Harmonic Generators
- 2-18 GHz and 2-20 GHz coverage
- -28 dBm to -44 dBm output power
- Integrated 4 stage YIG filter

Full 2-20 GHz & 2-18 GHz Frequency Coverage in Single Units

www.microlambdawireless.com

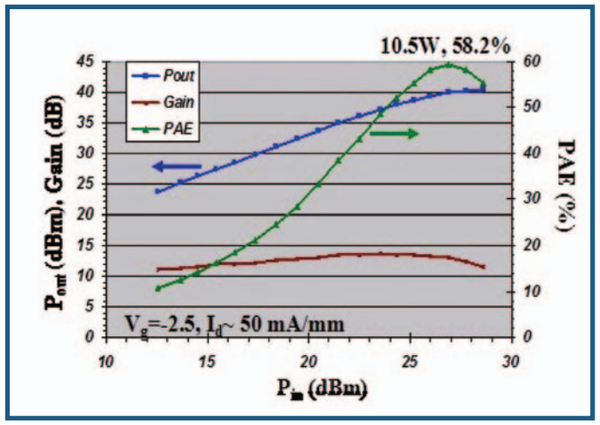
MICRO LAMBDA WIRELESS, INC.

"Look to the leader in YIG-Technology"

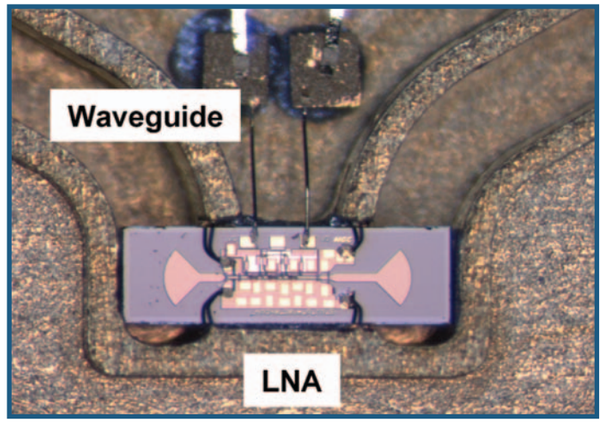
WWW.MPDIGEST.COM ➤ 419

46515 Landing Parkway, Fremont CA 94538 • (510) 770-9221 • sales@microlambdawireless.com

DARPA Part 2, Con't from page 18



Improvement in power-added efficiency achieved WBGS-RF program



340 GHz low-noise amplifier designed in SWIFT program has noise figure of less than 8.7 dB

and smoke, they require too large an antenna for many applications. So it's a trade-off between smaller apertures and acceptance range and resolution."

Beyond the application level, Rosker believes the programs had merit because they pushed transistors to the limit of their capabilities by raising their cutoff frequencies, which improves device performance at lower frequencies as well in terms of noise figure, for example.

"When I pitched the SWIFT and TIFT programs, I thought there was a clear line of demarcation between the two technologies," Rosker continues. "I thought that with a reasonable amount of work we could get a transistor to operate at 340 GHz but not at 650 GHz, which is the next absorption window." However, the SWIFT program showed that there was indeed potential for higher frequencies, so the team continued to improve the transistor technology to reach 650 GHz or higher.

The new Terrahertz Electronics program is currently in Phase 1 at 670 GHz and will produce a significant amount of output from a single device. Subsequent phases will work toward 850 GHz and 1 THz by the end of Phase 3. "By end of the program we have to produce a transistor with gain at 1 THz, which means we will need technology with a cutoff frequency of 3 THz," he continues. In all cases, the semiconductor compound is indium phosphide (InP) fabricated as heterojunction bipolar transistors and high electron mobility transistors.

Getting SMART

The Scalable Millimeter-wave Architectures for Reconfigurable Transceivers (SMART) program is focused on developing an integrated, surface-emitting panel architecture for millimeter wave transceiver arrays. The program will ultimately demonstrate a coherent, active, electronically steerable array (AESA) of at least 400 elements with an output power density of 5 W/cm^2 and a total layer thickness of less than 1 cm. This is a much greater functional density than is achievable with current millimeter-wave architectures such as slats or bricks, and should be accomplished without compromising performance in areas such as receiver noise figure. The resulting heterogeneously-integrated, batch-fabricated, RF sub-array "building blocks" will be designed to be combined to large arrays.

Since SMART focuses not on building an entire array, it has the potential advantage of driving down cost while reducing size and weight and increasing performance. By using a three-dimensional approach, it is hoped that a high level of functionality will result not just from a single element but in fabricating an entire array in a single process.

"The real accomplishment," says Rosker, "is showing a 4x4 element array composed of six mostly-GaAs layers each 650 µm in thickness for the whole array. Phase 1 covered only the transmit section, and Phase 2 covers both transmit and receive. In Phase 3, the goal will be to begin tiling them together to make larger arrays. The team developed a 3D MMIC achieved through wafer-scale assembly – building two wafers and integrating them together. The expectation is to make a 6-in. array, for example, in a single step. "One day, millimeter-wave tiled arrays will be everywhere," says Rosker. "Around the end of this year we should be able to show a 4x4 transmit/receive element. We've already demonstrated a transmit element that could move beams around and perform the expected functions. It included phase shifters but not attenuators, which will be added in Phase 2.

High Frequency Integrated Vacuum Electronics (HiFIVE)

The objective of the HiFIVE program is to develop an integrated, microfabricated vacuum electronic (VE) high-power amplifier (HPA) circuit for use in high-bandwidth, high-power transmitters. The program will demonstrate the circuit over a 5 GHz fre-

DARPA Part 2, Con't on page 26

Solid State Tetrode Tube and Combination Amplifiers

Model Number	Freq Range (MHz)	Min Pwr Out (Watts)	Min Sat Gain (dB)
M/TCCX/SCCX Series • .01-220 MHz			
SCCX300	.01-220	300	55
SCCX500	.01-220	500	57
M404	.01-220	500	57
M406	.01-220	1000	60
TCCX2000	.01-220	2000	63
TCCX2200	.01-220	2200	63
TCCX2500	.01-220	2500	64
CMX/SMX Series • .01-1000 MHz			
SMX301	.01-1000	300/100	55/50
SMX302	.01-1000	300/200	55/53
SMX303	.01-1000	300/300	55/55
SMX501	.01-1000	500/100	57/50
SMX502	.01-1000	500/200	57/53
SMX503	.01-1000	500/300	57/55
CMX10001	.01-1000	1000/100	60/50
CMX100010	.01-1000	1000/1000	60/60

Microwave Solid State and TWT Amplifiers

Model Number	Freq Range (GHz)	Min Pwr Out (Watts)	Min Sat Gain (dB)
T-200 Series • 200-300 Watts CW 1-21.5 GHz			
T251-250	1-2.5	250	54
T82-250	2-8	250	54
T188-250	7.5-18	250	54
T2118-250	18.0-21.7	250	54
T-500 Series • 500 Watts CW 1-18 GHz			
T251-500	1-2.5	500	57
T7525-500	2.5-7.5	500	57
T188-500	7.5-18	500	57
MMT Series • 5-150 Watts, 18-40 GHz			
T2618-40	18-26.5	40	46
T4026-40	26.5-40	40	46
S/T-50 Series • 40-60 Watts CW 1-18 GHz			
S21-50	1-2	50	47
T82-50	2-8	50	47
T188-50	8-18	50	47

Solid State Amplifiers

Model Number	Freq Range (MHz)	Min Pwr Out (Watts)	Min Sat Gain (dB)
SMCC Series • 200-1000 MHz			
SMCC350	200-1000	350	55
SMCC600	200-1000	600	58
SMCC1000	200-1000	1000	60
SMCC2000	200-1000	2000	63
SMC Series • 80-1000 MHz			
SMC250	80-1000	250	54
SMC500	80-1000	500	57
SMC1000	80-1000	1000	60
SMX-CMX Series • .01-1000 MHz			
SMX100	.01-1000	100	50
SMX200	.01-1000	200	53
SMX500	.01-1000	500	57
SVC-SMV Series • 100-1000 MHz			
SVC500	100-500	500	57
SMV500	500-1000	500	57

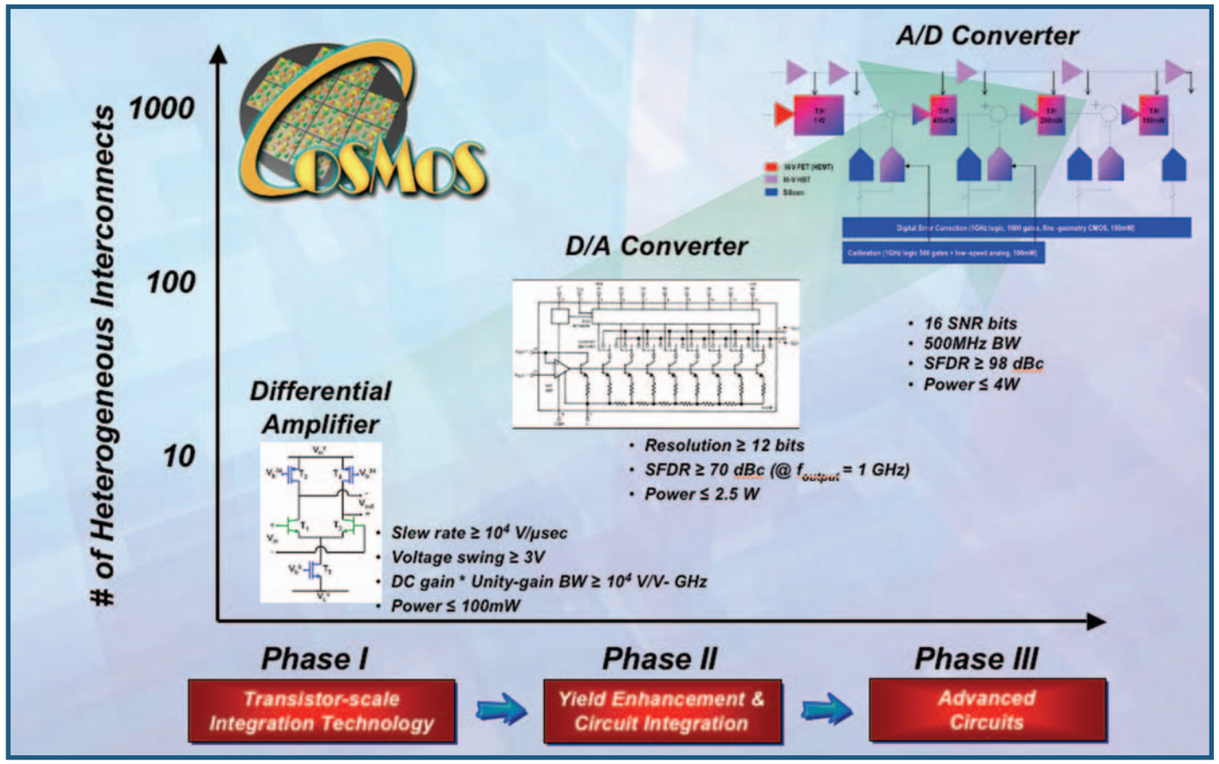
Visit IFI.com for additional amplifier models and products.

INSTRUMENTS FOR INDUSTRY

903 South Second Street • Ronkonkoma, NY 11779
Tel: 631-467-8400 • Fax: 631-467-8558 • E mail: sales@ifi.com • www.ifi.com

WWW.MPDIGEST.COM ➤ 420

DARPA Part 2, Con't from page 24



Stages of the COSMOS program

quency band centered at 220 GHz. The program consists of three phases. The first phase focuses on HPA design, development of a stable, high-power electron beam transport, microfabrication of the interaction structure, and development of a high-current-density cathode. In the second phase the HPA design will be validated. The end result of the program in Phase 3 will be operation without degradation for at least 103 hr. An additional goal is to create a microwave power module (MPM) with an integrated solid-state driver amplifier.

The spectrum at 220 GHz is an atmospheric transparency band, but not all that transparent, since above 300 GHz there is no region at which there is as much transmission as at the lower end of the 60 GHz absorption band. "So transmission should be used in quotes," notes Rosker. The first challenge of this program was to manufacture such a device, since dimensions at this frequency are very small. The program will rely on reactive ion etching or another technique to achieve the tiny required tolerances.

"To get a lot of RF power you have to have a high aspect ratio beam rather than a single pencil beam – actually a large number of precisely-aligned pencil beams," says Rosker. "You will not achieve as much gain and coupling of the e-beam and RF wave going down the structure as you can at lower frequencies, but we are compensating for physics by increasing the beam's aspect ratio." Rosker says the device looks indistinguishable from a solid-state source because it is so small, but in its purest sense is a tube-type device, since it operates in a vacuum.

Where GaN Got Its Big Break

The Wide Bandgap Semiconductor Technology Initiative (WBGS-RF) is arguably one of the key reasons why reliable GaN-based devices are today being manufactured and employed in RF power amplifiers. One of the fundamental problems with GaN was its limited operating life. At the beginning of the program "you could measure performance of the transistor and literally watch it degrade in front of you," says Rosker. There are perhaps 10 possible mechanisms that can cause the degradation, most of which are "traps", in which a defect causes the charge to be trapped in a certain place. The team thought the substrate must be responsible for the degradation be-

DARPA Part 2, Con't on page 32

SELECTION SUPPORT SERVICE

When you need it most

All are key when purchasing high performance microwave transmission lines. Currently a **SELECTION** of IW products are employed on the Navy's latest platforms in a variety of systems including the AIMS ATC/IFF radar, PHALANX close in defense system, HDR and MILSTAR.

IW's **SUPPORT** for these systems includes a wide range of flexible microwave cable assemblies. Extremely low loss cables are optimized for operation up to 11 GHz, 18 GHz 26.5 GHz, 40 GHz, 50 GHz, and 65GHz. These cables are available with optional internal and external ruggedization and a selection of jacket materials to meet specific environmental requirements. IW supports these cables with a wide selection of connectors including SMA, TNC, N, SC, 1.65mm, 2.4mm, 3.5mm, and 7mm.

IW's **SERVICE** is second to none. Most quotes are provided within 24 hours. Additionally, your calls are handled personally, not through voice mail!

ISO 9001:2000 CERTIFIED

20 East Franklin Street • Danbury, CT 06810 • T: 203-791-1999 • F: 203-748-5217 • E: sales@iw-microwave.com • W: iw-microwave.com

WWW.MPDIGEST.COM ➤ 421

Opportunities for Those with Vision

By Douglas Raymond

This current economic environment presents the test and measurement industry with both uncertainty (i.e. risk) and opportunity, and while these times are not for the faint of heart, risk and opportunity go hand in hand. Uncertainty benefits companies that take action, reevaluate their objectives, adjust accordingly, and move forward. It will harm companies that hesitate, stay in place, or retreat to a "safe" posture, and continue apace as if the market in 2009 is the same as it was in 2007.

In my career I have lived through four critical economic cycles. I have heard people tell me that test equipment was "dead" and soon to be replaced by software and design tools. The reality every time was that test equipment continued to be critically important, and what changed was how and where it was used. The test and measurement industry has kept pace with the dramatic evolution of communication, defense, manufacturing, design, and semiconductor systems, and it will continue to be a critical and fundamental element in technological progress as we go forward.

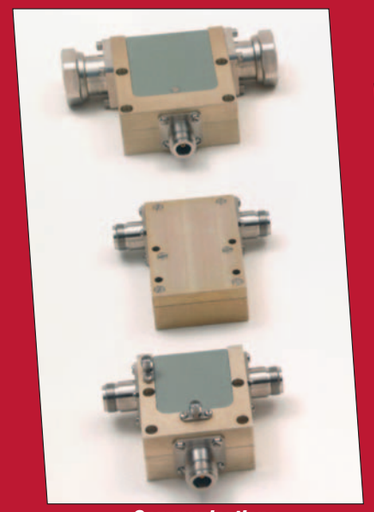
For the defense industry, it is clear that test equipment will play an even greater role in securing our safety and indirectly our very existence. The world is a tumultuous and dangerous place. We are at war with terrorists and terrorist states, and regardless of your political position, stance on the root causes, or who is to blame, the threat is nevertheless real. Today, defense systems are more complex, farther reaching, and more demanding than ever. As in the commercial world of mobile phones, computers, and communication systems, defense systems must work the first time and be strictly maintained to ensure that they are calibrated and operating within their specified performance.

The general purpose, ATE, communication test equipment market is about $23 billion and is expected to continue to grow at a compound adjusted growth rate of 3% to 6%. While the commercial market may be flat or slightly decline, there should be growth in the defense test equipment market. The reasons for this are based on the need to maintain and support war-weary defense systems and to continue to develop new defense capabilities.

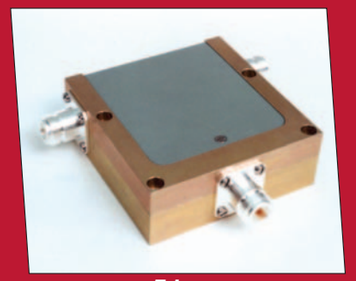
Growth for defense test systems will be in traditional test equipment and systems, and programs like MATE and CASE will continue to evolve. Prime contractors and subcontractors will continue to build new and replacement systems and components for the defense industry that will require full testing. There will be growth in nontraditional test equipment, and advances in test technologies will continue to be integrated into defense systems and components, not only for test but for system operation. The vast wealth of intellectual property developed by test equipment manufacturers has great value to the defense industry, so much so that it is now being viewed as fundamental to defense systems.

The overlap of the commercial and defense industries is having a profound effect on the supply side of the test and measurement community. Companies that have developed creative system performance monitoring test tools now have direct opportunities to be important players in the defense communication segment. Companies like Ixia, Spirent, MuDynamics, and many more have tools that can play a critical role in defense communication. Other companies like LUNA Technologies that have developed optical vector network analyzers may change the very way the navy maintains, troubleshoots, and repairs its complex shipboard communication infrastructure. Other proven test technologies, such as boundary scan, will have

Raymond, Con't on page 30



Communications



Telecom

Scientific – Medical

HIGH POWER

Isolators / Circulators For Military / Radar Applications.

Drop-in Model CT-3885-S

Military and Radar

100 MHz to 20 GHz

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

SEE US AT MTT-s BOOTH #510

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

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

WWW.MPDIGEST.COM ➤ 422

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

Raymond, Con't from page 28

potential impact on defense systems and subsystems.

Today's defense systems find and identify threats, communicate, and take action, and RF, microwave, and infrared technology are at the core of this capability. The need for smart munitions, extremely accurate avionics, radar, and many other systems will continue to drive the need for signal generators, spectrum analyzers, and network analyzers with increasing accuracy, sensitivity, and overall capability. Companies such as Agilent Technologies, Rohde & Schwarz, Anritsu, and Giga-Tronics, have the opportunity to go beyond simply providing equipment, to supply IP and expertise that is directly applicable to defense systems.

Growth will also come from the legacy defense test equipment infrastructure. Renewing and replacing old, outdated test systems and software is a significant opportunity – and challenge. Many defense test systems today are 30 to 40 or more years old. Maintaining this older equipment is imperative but costly. Renewing, updating, and replacing it provides opportunities in software and hardware development, training, and new logistic support strategies.

In short, regardless of what happens in the commercial market during 2009, there will continue to be substantial opportunities for the test equipment community in nearly all sectors of defense. To paraphrase Mark Twain, "The report of the death of test and measurement has been greatly exaggerated". As long as there is technology there will be test, for without it nothing can advance.

Douglas Raymond is a strategic development consultant and founder of Arjs Group (www.arjsgroup.com) based in Livermore, CA, which provides business, market, product, and distribution strategies for a wide range of companies. He was formerly vice president of Frost & Sullivan's Measurement and Instrumentation Business Unit, and has held many positions in the electronics community. He began his career as a microwave engineer in the aerospace industry. He was a program manager and engineering R&D manager at M/A-COM, Varian Associates, and Raytheon, and spent 19 years at Hewlett-Packard/Agilent Technologies, where among other assignments he was general manager of Agilent's Knowledge Services Division. He also founded All Ways On Wireless, Inc, a WiFi infrastructure/solution provider. He can be reached at (978) 846-0039. ■

WWW.MPDIGEST.COM ➤ 504

Infusing new technology into legacy systems.

Whenever legacy systems are upgraded, whether to address new threats or to benefit from improved technology, you can count on CTT's twenty-five years of experience in microwave amplification and subsystem integration.

CTT offers not only form, fit, function of microwave amplifier replacements for many mature systems, but also incorporates leading-edge technology components such as GaN and SiC.

CTT is well positioned to offer engineering and production technology solutions – including high-rel manufacturing – to infuse new technology into legacy systems for improved reliability and life cycle costs.

- Multi-Band Communications
- Simulators
- Line Test Equipment
- EW: ECM, ECCM & ESM
- Jammers: Radar & IEDs
- Radar Systems

More than twenty-five years ago CTT, Inc. made a strong commitment to serve the defense electronics market with a simple goal: quality, performance, reliability, service and on-time delivery of our products.

Give us a call to find out how our commitment can support your success. It's that simple.

Microwave Technology Leadership

- **Low-Noise Amplifiers**
  - **NEW** Compact Low-Noise
  - 0.5–20 GHz
  - Broadband 0.2–20 GHz
  - Broadband 17–40 GHz
  - Narrowband Up to 18 GHz
- **Custom Engineered Options**
- **Hi-Reliability Capability**
- **Power Amplifiers**
  - **NEW** GaN Broadband
  - Broadband 0.2–100W
  - Narrowband Up to 100W
  - Rack-Mount 0.5–40 GHz
- **Special Purpose Amplifiers**
  - Equalizer Amplifiers
  - Frequency Doubler/Triplers
  - Limiting Amplifiers
  - Temperature Compensated
- **Subsystems**
- **Contract Manufacturing**

USA-based thin-film microwave production facility

ISO 9001:2000 QUALITY

CTT INC.

241 East Java Drive • Sunnyvale • California 94089
Phone: 408-541-0596 • Fax: 408-541-0794 • www.cttinc.com • E-mail: sales@cttinc.com

WWW.MPDIGEST.COM ➤ 423

CARLISLE INTERCONNECT TECHNOLOGIES

GOING THROUGH A PHASE?

Carlisle's family of precision coaxial phase adjusters is ideally suited for **Electronically Scanned Arrays** (ESAs) as well as other military and space applications.

FEATURES and BENEFITS:

- Multiple configurations include box models, coaxial airlines with mounting brackets and models that terminate at the end of a cable assembly.
- Carlisle offers a variety of interface options including SMA, TNC, SSMA, SMP and SSMP®.
- Covers frequency range from DC to 26 GHz.
- Allows for continuous adjustment of phase over the entire operating frequency range.
- All phase adjusters have mechanisms that allow for locking the device at a desired phase length.
- Phase adjustments are done in airlines to maintain 50-Ohm impedance and phase stability over temperature.

(866) 282-4708 Tel
(562) 494-0955 Fax

For more information:
rf@carlisleit.com
www.carlisleit.com

WWW.MPDIGEST.COM ➤ 424

DARPA Part 2, Con't from page 26

cause of imperfect matching, different lattice matching, and lattice dislocations. However, it was ultimately learned that other factors were the root cause, which the program then addressed. "Around here, factor of ten increases in the performance of a specific parameter are typical," says Rosker. "We made a 10^{10} improvement in operating lifetime, from minutes to 10^7 hours". The long-running effort began in 2001 and is currently in Phase 3, which will demonstrate GaN MMIC capability. See plot, page 24. Specific goals include demonstration of a more than 100-mm, semi-insulating, high-quality substrate, epitaxial material technologies with extremely tight control of composition, thickness, and doping, robust RF and analog devices with cutoff frequencies greater than 150 GHz, and millimeter-wave circuits operating up to 35 GHz, as well as high-power (more than 1 kW/cm^2) assemblies.

Compound Semiconductor Materials on Silicon (COSMOS)

While compound semiconductor technology has unique properties that make it highly appealing for many applications, the vast majority of devices are based on silicon and the CMOS process in particular. With this as a core consideration, DARPA set out to heterogeneously integrate compound semiconductor materials with silicon. The program's goal is to develop a viable process for integration of compound semiconductor devices with silicon CMOS and to demonstrate superior performance in mixed-signal circuits. COSMOS will culminate in a heterogeneously-integrated 16-b analog-to-digital converter that will be accomplished by placing compound semiconductor and silicon transistors in proximity of 5 µm or less with 5 µm or less minimum pitch of the heterogeneous interconnect vias. See plot, page 26.

"Everything today uses wire bonds," says Rosker. "You have a circuit in silicon and one in another material, not two different materials in the same signal path. We'd like to change that, so you can combine different materials – junctions – on a microscopic scale. We chose the mixed-signal class of circuits because they are the best examples of where you have this intimacy, and because the ultimate payoff could be the greatest. What we're trying to achieve simply cannot be done using wire bonds.

"If we succeed", he continues, "we will demonstrate that you can use the best junction for any application, mixing and matching across devices to choose the best one. Think of having a GaN-based amplifier in a mobile phone directly in the silicon." ■

WWW.MPDIGEST.COM ➤ 503

Receive-transmit Integrated Subassembly Products and Stabilized RF Sources with Modulation Capability

Standalone Set-on Receiver products provide wideband, fast tuning and programmable set-on capability for EW applications. These higher level assemblies have been developed using basic bulding blocks consisting of Digitally Tuned Oscillators (DTO), Instantaneous Frequency Measurement receivers (IFM), and Frequency Locked Source (FLO) technology in addition to digital pocessing, microprocessor control and digital signal analysis.

Receiver-jammer unit utilizes a self calibrating IFM and DTO to make an accurate Set-on Receiver (SOR), response time <250µs. The unit is microprocessor controlled to program various mission profiles for signal identifications and jamming parameters.

Frequency Locked Source (FLO) covers 6-18 GHz band, and tunes to any frequency in less than 1µs with <1 MHz frequency accuracy. Includes pulse, FM, amplitude and phase modulators.

Wideband RF Front End Subsystem for multiple SOR and/or deception jammers. Unit capable of covering 2 to 18 GHz and millimeter wave in desired frequency blocks. Modular assembly offers Up and Down frequency conversion, signal identification, emitter priority, signal tracking, predictor gates and transmitter power management.

Teledyne Cougar is your source for Integrated Subassemblies, RF & Microwave Components, Integrated Assemblies and Value-added Service needs.

TELEDYNE COUGAR
A Teledyne Technologies Company
ISO 9001:2000 • AS9100 • MIL-PRF-38534 • Class H & Class K Certified
927 Thompson Place • Sunnyvale, CA 94085
408-522-3838 • Fax 408-522-3839
www.teledyne-cougar.com • email: cougar@teledyne.com

WWW.MPDIGEST.COM ➤ 425

WHEN "OFF THE SHELF" DOESN'T MAKE IT...

THE GOLD STANDARD OF CUSTOM ENGINEERING DOES!

The designers and makers of

AMPLIFIERS
CONTROL PRODUCTS
SUPER COMPONENTS
CONTRACT MANUFACTURING
MULTIFUNCTIONAL ASSEMBLIES

We make a world of difference

ISO 9001:2000 CERTIFIED

In our forty-year history, we at Daico have developed a broad range of IF/RF and microwave control products, amplifiers and multifunction assemblies operating from DC to 18 GHz. We provide the Defense, Aerospace and other high-end electronic industries with custom-designed products to meet ever-increasing requirements.

In addition, Daico has the resources and capacity to provide the integration and assembly work needed to incorporate your many other components and subsystems. We offer comprehensive contract manufacturing, which includes complete mechanical and electrical engineering services, manufacturing for product improvement/redesign and production efficiency.

And for production assistance in the form of Build-to-Print and RF assembly work or manufacture of legacy products, Daico engineering and complete testing are geared to conserve your company resources.

Moreover, this financially stable organization is uniquely positioned for small- to medium-size complex production assignments. Visit our web site, then let's talk about how we can make a difference on your next project.

DAICO Industries

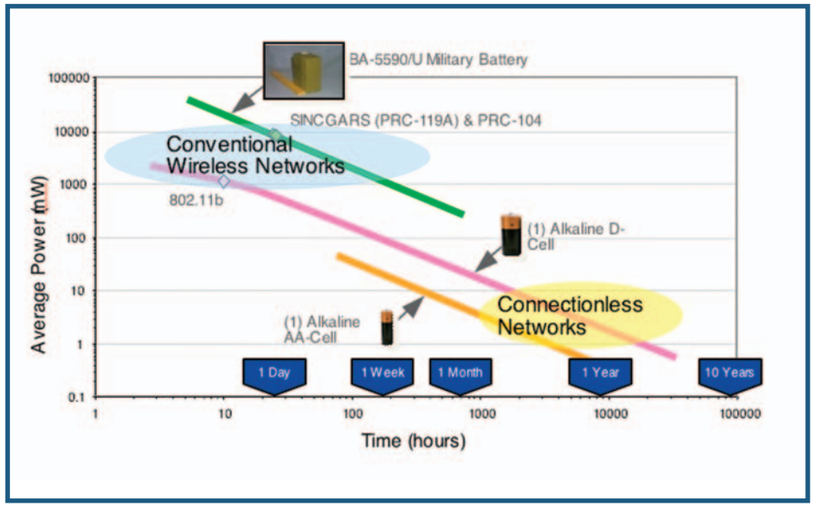
DAICO Industries, Inc.
1070 East 233rd Street
Carson, California 90745
Phone 310 507 3242
Fax 310 507 5701
www.daico.com

PERFORMANCE • VALUE • RELIABILITY • QUALITY
40 YEARS
1967 & 2007

WWW.MPDIGEST.COM ➤ 426

WWW.MPDIGEST.COM ➤ 427

DARPA Part 1, Con't from page 22



Connectionless Networks potential benefits to DoD

tures, designs, and development tools for implementing computational functions in analog circuitry to overcome performance limitations inherent in digital designs. Applications that could benefit from its results include wideband signal spreading, spectrum utilization, multiple input multiple output channels, and radar. The program applies analog technology to signal processing functions that are typically performed digitally and are complex, require high levels of power, have low dynamic range, limit computational speed, and are susceptible to manufacturing variances. The goal is to demonstrate analog-only signal processing capability with no local oscillator, down conversion, or analog-to-digital conversion.

Marshall believes the program has the potential to reduce complexity and power requirements for signal processing functions while improving performance in comparison with digital implementations in FPGA, DSPs, and general-purpose processors. The result is hoped to be a significant reduction in system cost, increased battery life, and higher system reliability. The program will also create the algorithm libraries and automated development tools needed for developing algorithms at low cost similar to Very High Level Design Language (VHDL).

Connectionless Networks

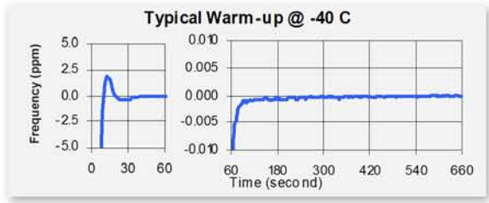
Bringing data efficiently from high value, energy-limited sensors (such as unattended ground sensors), into system architectures like that of the Airborne Communications Node (ACN) require emphasis on how these kinds of sensor networks communicate. The Connectionless Networks (CN) program is tasked to develop technology that allows networks to send and receive information as much as 100 to 1,000 times more efficiently than with conventional and near-term deployable communications systems. See chart on page 22.

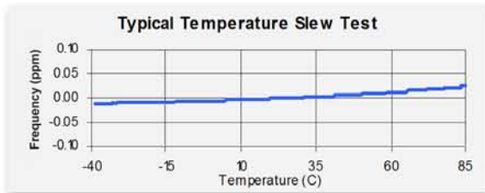
Current energy inefficiency not only limits the lifetime of energy-limited (i.e., battery-operated) systems, it severely impacts communications between sensors or remotely-operated weapons. Eliminating the need to maintain a continuous network linkage would enable these platforms to provide continuous connectivity without consumption of power. The CN program will exploit the current signal processing components, intelligent (processing and memory intensive) routing, and availability of situational information to demonstrate a total energy savings of at least 100 times versus typical connection oriented network applications. ■

WWW.MPDIGEST.COM ➤ 502

Next Generation EX-420 EMXO™ Provides customers advanced stability performance and fast warm-up with low power consumption.

The EX-420 provides exceptionally low aging rates and tight temperature stabilities in an extremely small package over a wide range of environmental conditions. This EMXO™ series bridges the gap between current large, high precision OCXO's and smaller TCXO's. The EX-420 Series becomes the most economical choice where there is a need for spectral purity, short and long term stability, along with small size and dramatically reduced power consumption.





Additional Features Include

- Temperature Stability to +/-75x10^{-9} over -20° to +70°C
- Low Power Consumption: <0.35W @ 25°C, 0.7W @ -40°C
- Fast Warm-up: Two Minutes at 25°C
- Weight: <3gm
- Available in Thru Hole and Surface Mount Package
- 13 mm x 13 mm Half DIP Package

Applications

- SONET/SDH, DWDM, FDM, ATM, 3G
- Test & Measurement Equipment
- Wireless Communication Equipment
- Military Airborne and Mobile Systems

For more information on the new EX-420 or any Vectron products, please contact a customer service representative at 1-88-VECTRON-1 or visit www.vectron.com

OCXO/EMXO | TCXO | VCSO | VCXO | Frequency Translation | SAW Filter | Clocks/XO | Crystals | Timing Solutions | Hi-Temp Electronics

Precision Timing Solutions

With over 50 years of experience, we are the leader in providing frequency control and hybrid solutions to our customers around the world. Our innovative approach to design and manufacture has resulted in the most advanced product offering of any Frequency Control Supplier in the world.

Helping Customers Innovate, Improve & Grow

VECTRON INTERNATIONAL A DOVER COMPANY

WWW.MPDIGEST.COM ➤ 428

Software-Defined Radio Takes a Big Step in a Small Package

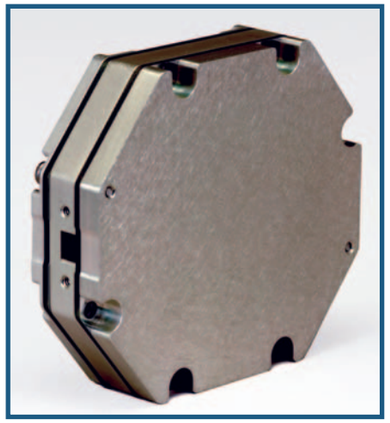


Figure 1: The core radio architecture combines far more functionality than current radios that operate at limited frequency ranges, have only one waveform, and no networking capability.

The Joint Tactical Radio System (JTRS) Handheld, Manpack, Small Form Fit (HMS) program lead by General Dynamics C4 Systems has as its goal production of miniaturized software-defined radio (SDR) systems for unattended ground sensors through soldier systems. Team members include BAE Systems, Rockwell Collins, and Thales Communications. The program's approach is to build a family of radios around a single architecture with core modules that are combined, configured, and packaged according to the platform in which they will be deployed.

Like JTRS itself, the HMS program poses a formidable set of challenges, all of which need to be met inside very small enclosures that will be deployed in intelligent munitions, unattended ground sensors and gateway radios, unattended ground vehicles, soldier systems, small UAVs, and hand-held and manpack radios. Not surprisingly, achieving all this requires prodigious amounts of signal processing and processor power, as well as complex software for controlling and programming the units (the operating system alone has nearly 1 million lines of code), as well as for the required levels of overall encryption and waveform-specific encryption.

Nevertheless, Joe Miller, director of JTRS programs in the Communication Networks Division of C4 Systems, says that RF technology presents an equal or greater challenge than its digital counterpart. "The baseband uses advanced technology but the commercial market has taken care of that," says Miller. "Advanced general-purpose processors, DSPs, and FPGAs are all available thanks to the commercial market, although we had to get the vendors to be more sensitive to power constraints, especially in the area of FPGAs. The real advances we have brought forward are in the RF area."

HMS was not the company's first foray into SDR. In fact, the Digital Modular Radio (DMR) developed by General Dynamics, now in its sixth production run, was the first SDR radio to become a communications system standard for DoD. The multi-channel unit provides multiple waveforms and multi-level information security for voice and data communications and currently operates aboard U.S. Navy surface ships and submarines, fixed-sites, and other DoD communication platforms. The four-channel, full-duplex, 2 MHz to 2 GHz radio has more than 12 waveforms.

The focus of JTRS has changed from DoD's initial plan to make it a panacea for radio communications across the board. "To some degree that has gone by the wayside," says Miller, "and today the focus is on networking. While our radios include some legacy waveforms, the biggest thing they bring to DoD is networking, which is not done effectively or efficiently now."

From an RF perspective, the challenge includes accommodating multiple frequencies, narrow and wideband waveforms, as well as multiple modulation schemes from FM to frequency-hopping, Orthogonal Frequency Division Multiplexing (OFDM), a heavily-modified variant of W-CDMA, and single sideband. All require different RF characteristics, and each waveform has different signal-to-noise, phase noise, spectral, and filtering requirements. "Our architecture puts the radio functionality in the RF transceiver and baseband," says Miller. "In the size and weight of an existing UHF radio, we had to build something that operates from 2 MHz to 2.5 GHz. It had never been done before, and you could not do it with standard technology."

Taking a New Approach

The company hired engineers with

General Dynamics, Con't on page 38

We're Delivering
POWER SUPPLIES *and* POWER AMPLIFIERS
From the Ground Up…

To learn more, visit us at
www.bcpowersys.com
call us at
(631) 751-9370
or send an e-mail to
sales@bcpowersys.com
WWW.MPDIGEST.COM ➤ 429

Whether you're application is on the ground, on the sea, or in the air BC Power Systems has a DC or RF power solution to meet your needs. Since 1985, we've been delivering rugged, innovative products to prime defense contractors and the U. S. government with a proven record of success.

Our highly-efficient switching power supply portfolio ranges from tens of watts to kilowatts in numerous form factors. And our solid-state RF power amplifiers based on LDMOS and GaN devices operate up to 6 GHz and deliver up to several kilowatts of RF output power. Design teams for both product lines work together to ensure that every custom solution meets or exceeds expectations.

So whether you're building IED jammers, or EW, ECM, avionics, or communications systems – bring us your design challenge. We'll show you how BC Power Systems' integrated design approach provides the highest levels of performance and ruggedness.

BC power systems

BC Power Systems, Inc.
200 Belle Mead Road
Setauket, New York 11733
www.bcpowersys.com

General Dynamics, Con't from page 36

expertise in developing wireless systems, and in particular Low-Temperature Cofired Ceramic (LTCC) packaging and High-Density Interconnect (HDI) technology. The LTCC three-dimensional ceramic substrate embeds inductance and capacitance in the Z axis and the active device die in the X/Y substrate. "What this allowed us to do was create a circuit the size of a quarter or even a dime that would occupy a large circuit board using conventional technology," says Miller.

The design incorporates 16 of these RF circuits into the core architecture, which includes a 12-W power amplifier, synthesizer, and filters. The entire 2 MHz to 2.5 GHz radio is now about the size of a credit card. "While this technology is mature in the cellular industry, we applied it to a military system over wide bandwidths for the first time," says Miller. "For cellular systems, it's comparatively easy because they are typically dealing with a single waveform, and a narrow bandwidth. In ours, we not only provide a bandwidth from HF through L-band but with multiple waveforms that are wide and narrowband, each with stringent spectral requirements."

There are two basic versions of the "core" subsystem. The first version, called Core Radio 1, is designed for use in UAVs or sensors and covers UHF or UHF and L band, takes up less than 8.8 in.^{3}, and weighs less than 0.55 lb. It delivers 2 W at UHF and 5 W at L band, and has an embedded communications security module. Core Radio 2 covers 2.2 MHz to 2.5 GHz, measures less than 8.5 in.^{3}, and delivers 5 W. The transceiver and baseband modules are combined with a 20 W power amplifiers with full security as well as Ethernet and USB interfaces to form the complete radio.

The complete manpack radio has embedded GPS and weighs about 14.5 lb. with battery, which is about the same or less as current single-channel manpacks that do not have the multiple waveform capability or operate from HF through 2.5 GHz. More channels can be implemented by daisy chaining an additional radio to make a four-channel system.

Figure 3: The complete manpack radio includes all functions and technology within its compact footprint.

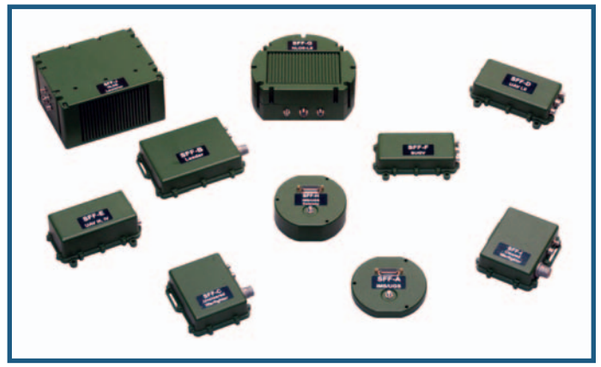


Figure 2: The radios will ultimately be produced in an array of forms, some including greater functionality than others.

The Core Radio 2 is currently in the integration stage with prototypes of four radios undergoing integration and importing of waveforms. Prototypes of these should be ready around summer's end, according to Miller. The team is building its first deliverable manpack radio now, which will begin a series of NSA certification and government field tests that should take about a year. Limited initial production is not expected until the first quarter of 2011.

The radio incorporates six waveforms, some of which are legacy types and some new networking schemes. For example, the radio handles fast-hopping SINCGARS from 30 to 88 MHz, as well as a satellite communications waveform, the Army's EPLRS networking waveform, and the HF waveform. The new soldier radio networking waveform has variants that are included depending on the application, such as in sensors and munitions or dismounted soldier radios. It accommodates data, video, and voice communications, and operates on more than one band. The sixth is the next-generation satellite waveform for the new Mobile User Objective System (MUOS) geosynchronous satellites, which will replace the existing UHF Follow-On (UFO) spacecraft. The waveform is based on W-CDMA and was developed by General Dynamics. The team started with commercial W-CDMA and significantly modified it for military applications. Nineteen other waveforms are options on contract that can be added if DoD requires them.

At the amplifier level, the team chose GaN HEMT devices for the final stages, and the amplifiers are in some cases delivering 50% efficiency. The team performed exhaustive testing of the devices before being convinced that GaN was reliable, producible, and had a long enough operating life to meet requirements. "GaN has been a significant contributor to meeting size, weight, power constraints," says Miller. "Unless you increase efficiency, you have to add mass to dissipate thermal energy, which is unacceptable in the small form factor we're working in."

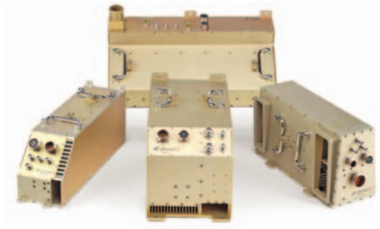
General Dynamics, Con't on page 40

Any spec. Any platform. Any time. dB Control delivers.

When split-second decisions are made under adverse conditions, a failure of the countermeasure system can jeopardize missions and cost lives. Reliable performance of the transmitter in an ECM system cannot be compromised. dB Control keeps you in control by building high performance into every product we deliver.

dB Control provides production-quantity Traveling Wave Tube (TWT) Amplifiers, Microwave Power Modules (MPMs), fully integrated transmitters and power supplies for ground-based, shipborne and high-altitude military manned and unmanned aircraft platforms. And our modular designs enable us to quickly configure custom products to your exact specifications.

We design and manufacture rugged, reliable microwave power systems for the U.S. Armed Forces and key OEMs – customers that demand performance. If your expectations are just as high, contact us today.



dB Control
Reliability by Design™

WWW.MPDIGEST.COM ➤ 430

1120 Auburn Street, Fremont, CA 94538 | +1 (510) 656-2325 | marketing@dBControl.com | www.dBControl.com

General Dynamics,
Con't from page 36

To increase operating time, the radio employs sophisticated power management techniques as well as circuits that put the radio into various sleep modes beginning at the device level and continuing to complete functions. Certain devices are turned off while others remain active depending on the activities the radio is performing at a specific time, while also ensuring that full functionality can be rapidly restored so communications are not missed.

The program supports 14 radios, each one with unique characteristics, but all sharing the same underlying circuitry and modules. For example, some radios will be deployed on UAVs and embedded radios in platforms that supply control, power, RF power amplifiers, and other functions that the radio need not have onboard. In contrast, the two-channel, 20-W manpack radio must have its own internal power system as well as controls, displays, and other elements.

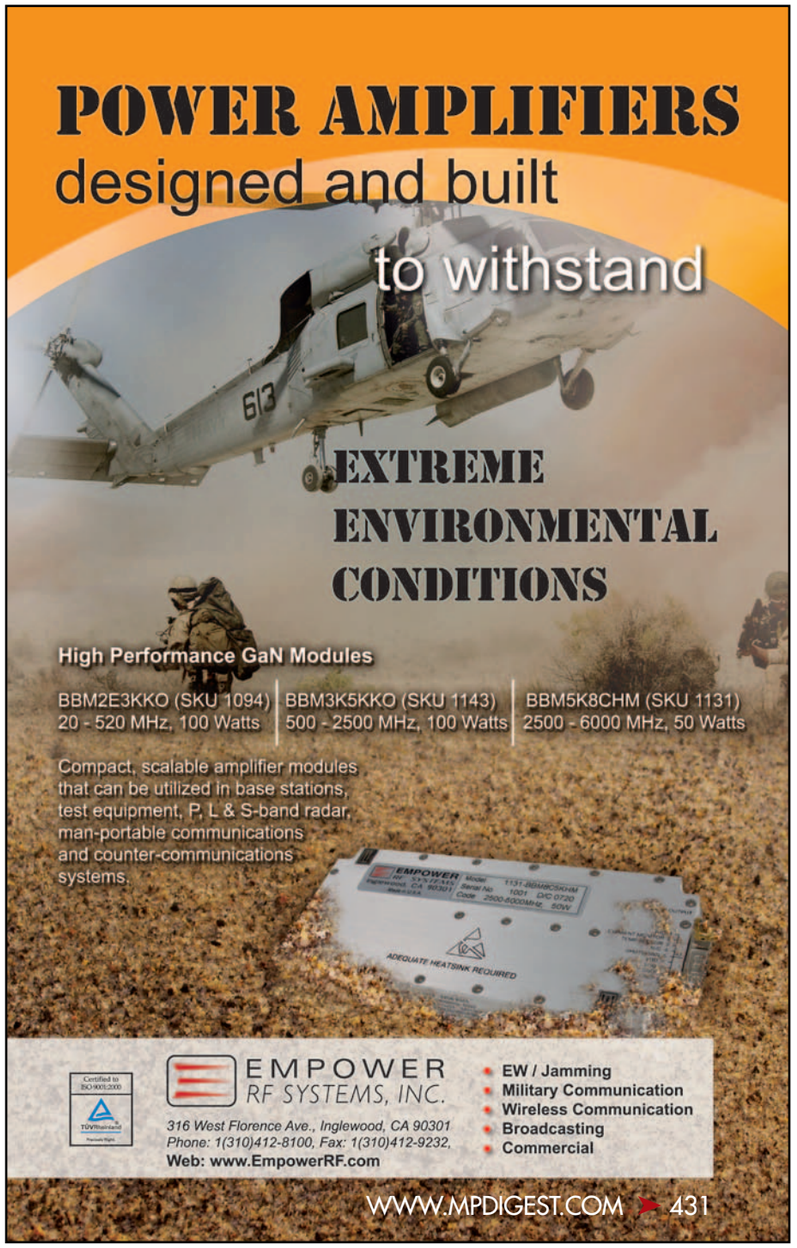
The team has thus far delivered more than 500 radios primarily for test and integration purposes, although they will ultimately be used in the Future Combat System, Land Warrior, and Ground Soldier programs, as well as the Unattended Ground Sensor and other sensor programs. The Navy and Air Force will generally require the manpack handheld radios, while the Army requires the embedded form factor.

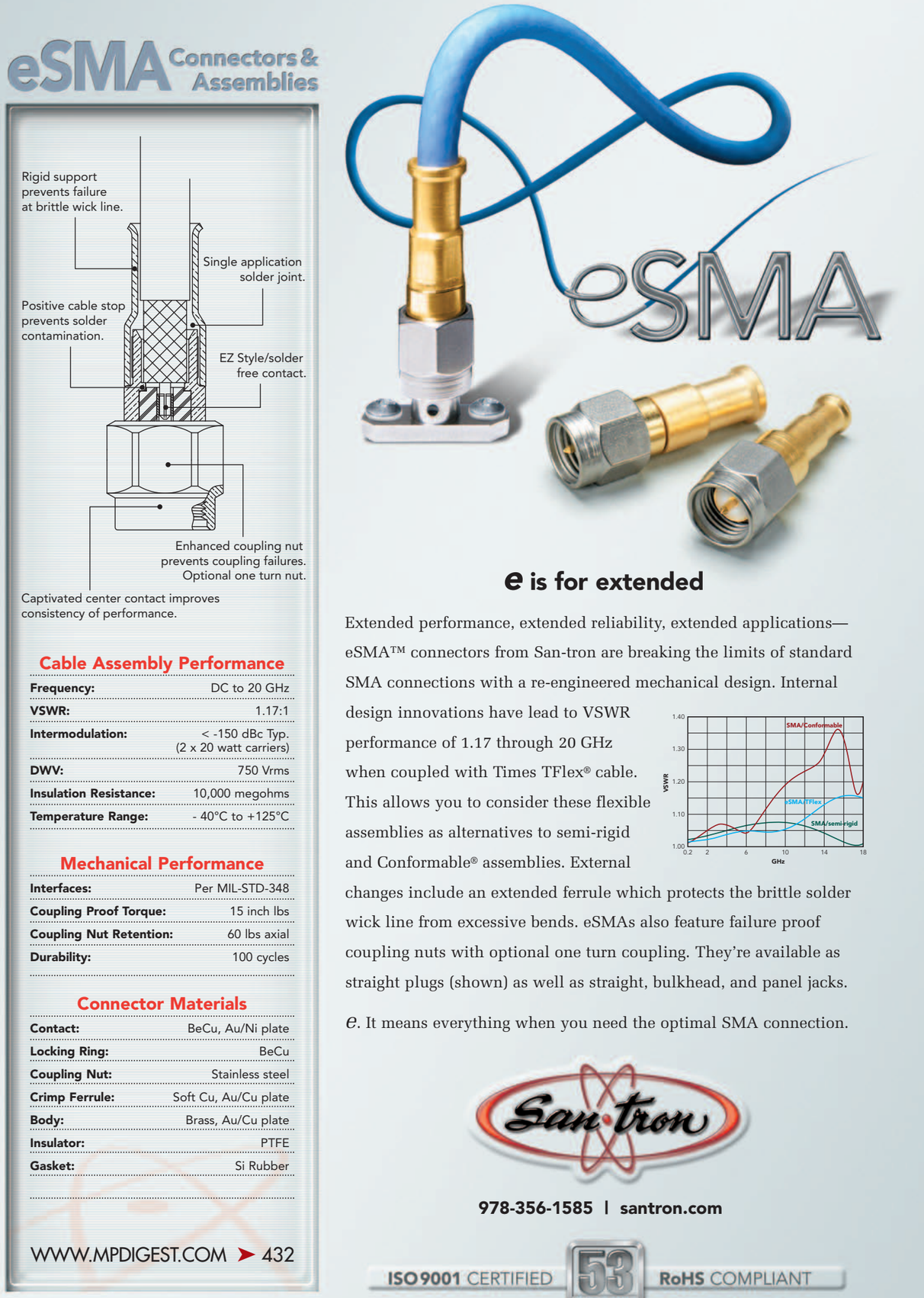
The radios used in sensing applications still must transmit and receive both sound and video, with information sent through the network to a command and control center or in some cases even to dismounted soldiers. The sensor radio is a network transceiver, operates with the soldier radio waveform, and must be expendable (e.g., inexpensive). To achieve this, the radios typically operate over limited frequencies, do not employ the advanced LTCC or HDI technology, and do not have the highest level of communications security, all of which reduce cost.

The Future

The team is currently in Phase 2 of the program, which began in 2005. The first, simpler UHF models for sensor applications were shipped for government field testing at Fort Bliss in November 2008. Testing will continue through the spring and will be completed after limited user tests that are expected to be conducted in April. After that a production decision is expected to be made in July and assuming all goes well, a low rate initial production award will follow this summer, resulting in delivery of the first radios at end of the year or early next year. ■

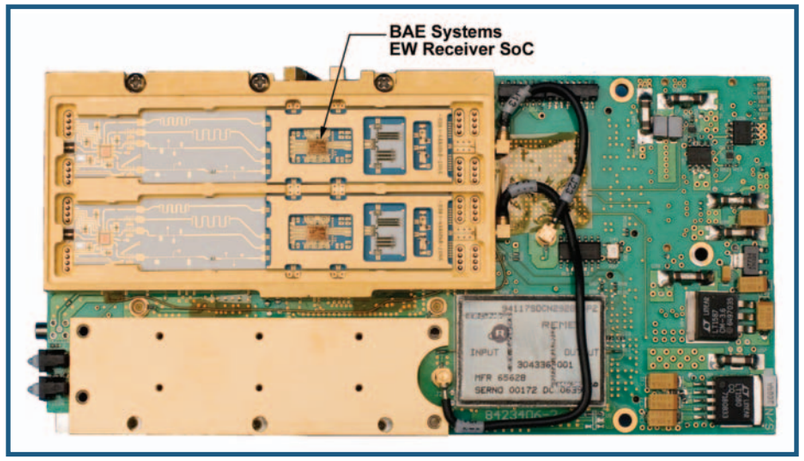
WWW.MPDIGEST.COM ➤ 505





Reducing Size, Weight, and Cost at BAE Systems

As a major defense prime contractor, BAE Systems must look out far beyond what it is currently delivering to what DoD will ultimately want and need if it is to meet future requirements. From the perspective of electronics technology, this almost invariably means hardware that is smaller, lighter, and less expensive than current systems, while being more highly integrated and delivering higher performance. To address that tall order, the Advanced Systems and Technology Group at BAE Systems is tasked with developing a vision for how the company's next-generation systems will be designed and produced. For Frank Stroili, director of the group, that means, among other things, integrating more of the electronics at or near the antenna.



One of BAE Systems' SoCs for an EW receiver application

"The Holy Grail is to have all RF electronics integrated into the antenna, whether the application is communications, EW, or radar," says Stroili. "A typical phased-array has some electronics near the antenna, including amplifiers and switches, for example. But there is a lot of cabling that must pass down an aircraft or ship to reach the microwave subsystems for downconversion in the receiver and the hardware related to that, such as local oscillators, synthesizers, mixers, amplifier stages, and analog-to-digital converters.

"The same is true in the transmit path, where you have upconversion and its related synthesizers and cable up to the array," Stroili continues. "The problems are the losses incurred by cabling, high cost, and the difficulty of making retrofits. So if you can get the electronics to the antenna, all you're left with may be some fiber-optic links that run from the antenna to the computer."

The technology needed to achieve this which the group is developing significant resources, is the System on Chip (SoC), that can reduce what would traditionally require dozens of discrete components to a few ICs. The group employs silicon germanium (SiGe), which offers the ability to perform microwave and digital processing on the same IC. "We have done quite a few SiGe ICs in last 5 years," says Stroili, "and have achieved a two to ten-times reduction in size, weight, and power. It opens up a huge application market in which you take capability that today is found only on large platforms and put it on small platforms."

One of the challenges is how to handle the coupling of digital noise into sensitive RF circuits, when digital circuits with millions of logic gates are located only a millimeter away. The team is tackling this by isolating circuits in wells on the IC, with insulating substrates to reduce substrate noise, and in some cases subtracting out the noise through digital and analog techniques.

"What ultimately dominates the size of many RF and microwave systems is filtering," Stroili continues. "So we're looking at MEMS-based filters and three-dimensional packaging to get filter volume smaller". The need for filtering is continually growing thanks to increasingly dense ambient signal environments whose constituent components include commercial emitters, as well as those attempting to intentionally deny transmission and reception, and even those from friendly sources such as neighboring ships. "Having preselection in front of these systems is becoming a necessity, and doing it in a small volume is key to accomplishing what we're trying to do." ■

WWW.MPDIGEST.COM ➤ 506

Broadband Power Amplifiers

For applications ranging from radar jamming to line-of-sight and satallite communications, OPHIR$_{RF}$ amplifiers are designed to achieve maximum performance for both standard and military applications. Standard, custom and COTS-adapted units available.

Ophir RF Broadband, High Power Amplifier Systems from 10 kHz-6 GHz and beyond!

Model 5087	0.01-230MHz,	250W
Model 5075	20-500MHz,	1000W
Model 5127	20-1000MHz,	200W
Model 5072	80-1000MHz,	500W
Model 5155	0.8-2.5GHz,	250W
Model 5174	1.0-3.0GHz,	100W
Model 5164	0.8-4.2GHz,	80W
Model 5165	0.8-4.2GHz	200W

New Broadband Family

Model 5190	2.0-6.0GHz,	9W
Model 5191	2.0-6.0GHz,	15W
Model 5192	2.0-6.0GHz,	25W
Model 5193	2.0-6.0GHz,	50W

Banded Power RF Amplifier Systems

Model 7000	1.0MHz-2.5GHz,	50/100W
Model 7001	20-3000MHz,	22W
Model 7002	20-2500MHz,	50W
Model 7003	20-6000MHz,	22-50W
Model 7004	20-2000MHz,	22W
Model 7005	80-6000MHz,	50-280W
Model 7006	1.0-6.0GHz,	50-80W
Model 7010	700-6000MHz	15W
Model 7011	20-1000MHz	500W/150W

OPHIR RF
THE ART OF WIRELESS™

www.ophirrf.com
5300 Beethoven St. Los Angeles, CA 90066
◆TEL: (310) 306-5556 ◆ Fax: (310) 821-7413
WWW.MPDIGEST.COM ➤ 433

GSA
info@ophirrf.com www.ophirrf.com

Advertiser's Index

Advanced Control Components	17
Aethercomm	7
AR	5
BC Power Systems	37
Carlisle Interconnect Technologies	31
Channel Microwave	34
Cobham	Cov 4
CPI/BMD	21
CTT	30
Daico	33
dB Control	39
dBm	19
Emhiser Research	22
Empower RF	40
Herley-CTI	Cov 2
IFI	25
IW	27
K&L Microwave	11
Lorch Microwave	15
MECA	9
Micro Lambda Wireless	23
NIC	20
OPHIR RF	43
Pole Zero	13
R&D Microwaves	44
San-tron	41
Teledyne Cougar	32
UTE	29
Vectron	35
Werlatone	Cov 3

EDITORIAL AND BUSINESS OFFICE

385 Sylvan Avenue, Suite 16, Englewood Cliffs, New Jersey 07632 • (201) 569-5870 • Fax: (201) 569-6684

A New Paradigm

At DARPA, "thinking out of the box" is more than a cliché, it's a job requirement. A conversation with Preston Marshall, a veteran DARPA program manager, makes it clear that when applied to many of the programs under his wing, out of the box thinking means finding ways to get reliable systems into the hands of soldiers in the field at affordable prices. To that end, his thoughts on the microwave industry provide insight into what manufacturers must do to ensure they have a place in supplying coming generations of battlefield systems. The following thoughts were excerpted from a conversation between Marshall and contributing editor Barry Manz.

In the microwave industry there are two kinds of markets, boutique and wireless. The boutique market, which has been the norm for defense products, is supplied by microwave companies that provide solutions for expensive, low-volume systems. Wireless suppliers provide highly-integrated, inexpensive components for inexpensive, high-volume consumer products. The problem we must solve is to find economic solutions that don't use boutique parts. Compare the level of integration in a typical military microwave system and that of a 3.5-GHz WiMAX device, for example. In the military device, you'll find parts from 15 or 20 suppliers, each with its own little specialty bolted into a frame and interconnected with cables. That's not how a 3.5 GHz WiMAX product is built, in which there are far fewer components, and they are surface-mounted on a small inexpensive circuit board. There must be middle ground between the two.

At DARPA, we're looking at how we can use $2 parts and deal with their limitations. We do not want to buy a $500 LNA and a $2,000 power amplifier for the RUFAS radar, for example. Manufacturers that can learn to embrace this challenge will have a real opportunity in the future. We are also working to use the same type of low-cost, highly-integrated components to deliver an acceptable (or better) solution, while also building networks that can compensate for the performance limitations of inexpensive commodity components. Granted, conventional military radios may have higher performance, but they are extremely expensive and unacceptable if the goal is to populate the "edge" with rich information.

Typical military screening makes sense if you are building a billion-dollar airplane where avionics cost is not critical. The military generally "flows down" technology developed for the airborne platforms, but it's not clear that we can create an immersive environment for soldiers by scaling down technologies from platforms like the F-22. For example, a key specification for a military receiver is the third order intermodulation performance of its front end. In the past we bought radios with incredibly high performance in this area. But they drain batteries, cost a lot of money, and nobody else wants them, so we are the only ones that pay for that development. We're striving to live with -8 dBm not with +20 dBm.

> *"At DARPA, we're looking at how we can use $2 parts and deal with their limitations."*

We can buy the parts inexpensively and use the dynamic spectrum technology we have developed so the radio will ignore spectral environments in which front end linearity will be exceeded. As a result, the radio will have a higher probability of operating effectively than if it had an incredibly robust front end. We have taken the radios developed for the Wireless Network after Next (WNaN) program into signal environments where even military radios could not function effectively, but the radios with our dynamic spectrum technolo-

Preston Marshall, Con't on page 46

Microwave Technology and Defense

***Preston Marshall** has 30 years' experience in communications, software, hardware, and system development. At DARPA, he is a program manager with the Advanced Technology Office (ATO), with responsibility for the neXt Generation (XG) Communications, WOLFPACK, Disruption Tolerant Networks, Connectionless Networking, Radio-Isotope Power Sources, Retro-Directive Ultra-Fast Acquisition Sensor, and Wireless Network after Next programs as well as many research initiatives.*

He was earlier employed in a range of leadership and technical positions in defense electronics companies, and participated in submarine, missile defense, B-1B, acoustic processing, and space sensors programs. Marshall holds BSEE and MS Information Science degrees from Lehigh University.

Preston Marshall,
Con't from page 45

gy worked well. Going forward, we will really force this challenge by using even lower-performance devices and try to get those same results. So far, it appears we can do that.

When we were platform-centric, the fighting elements (platforms) were a few hundred ships and not all that many types of airplanes. With the kind of engagements we face now, the soldier is the fighting element, so the economics of putting technology in the hands of every soldier are different than for a far fewer number of airframes. With an F-22 the focus is on capability, but if 200,000 soldiers must be equipped, affordability is just as important. It's simply the only way will get this equipment into soldiers' hands. DoD should be able to leverage the fact that the smartphone manufacturer is buying 10 million chips a month, which has driven parts prices of parts down dramatically.

Make no mistake, when there is a real commercial opportunity, DoD will make use of it. The military has pulled out of businesses when if found competing, less-expensive avenues, even if they were not quite as good. Remember when DoD had its own computer language, Ada? We abandoned it, and that's just one example. You cannot find a computer company today dedicated to DoD. But in lots of microwave companies DoD pays every dollar – there's a reserved parking space, so to speak. In electronics there ought to be no DoD parking space. We ought to be able to walk in and simply be "one week's run".

The microwave industry needs to break up the lines between hardware, software, and systems, rather than specifying parts that are so unique that they become unaffordable. The industry must find ways to morph into a reasonable middle ground to supply units in the tens of thousands, which is not something this industry is accustomed to. The industry must also be responsive. We used to buy jammers for airplanes that were replaced every 15 years. Now we're buying them for trucks and we recomplete for new generations every few years. It is a short product life cycle being pushed much deeper into the force structure, and manufacturers need to accommodate it.

> *"The economics of putting together in the hands of every soldier are different than for airframes."*

In short, the microwave industry has great opportunities to deliver all types of components and subsystems for use in hardware used by soldiers in the field. But they'll have to be inexpensive and manufacturable in large numbers, and that will truly require thinking out of the box. ■

WWW.MPDIGEST.COM ➤ 507

WERLATONE

SOPHISTICATED APPLICATIONS
- JAMMING
- COMMUNICATIONS
- CO-SITE MANAGEMENT

REQUIRE,

SOPHISTICATED SOLUTIONS
- MORE POWER
- GREATER BANDWIDTH
- LESS LOSS
- SMALLER PACKAGES

- POWER COMBINERS/DIVIDERS
- 90° HYBRID COUPLERS
- 0°/180° HYBRID JUNCTIONS
- DIRECTIONAL COUPLERS

DESIGNED TO MEET THE MOST STRINGENT OPERATING CONDITIONS.

Werlatone, Inc.
2095 Route 22
PO Box 47
Brewster, NY 10509
T. 845.279.6187
F. 845.279.7404
sales@werlatone.com

WWW.MPDIGEST.COM ➤ 435

www.werlatone.com

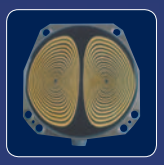
COBHAM SENSOR SYSTEMS

WHERE THE POWER OF INTEGRATION IS WORKING FOR YOU

Cobham Microwave Systems is comprised of the following groups: Sensor & Antenna Systems, Active Microwave Sub-systems, and Passive Microwave Sub-systems. For added assurance, all our products, from the smallest MMIC components to the largest antenna subsystems, are designed, manufactured, tested and inspected to meet the most stringent customer specifications.

Count on Cobham for all your product needs -- Electronic Warfare, Homeland Security, Radar, Ground & Mobile Communications, Smart Munitions, Search & Surveillance, Force Protection, Missiles, Space, Satellite Communication, SIGINT, and Overhaul & Repair.

From names you know and trust:
Atlantic Positioning Systems,
Atlantic Microwave,
Continental Microwave, Kevlin,
Lansdale, M/A-COM, Nurad,
REMEC Defense & Space,
Sivers Lab AB



COBHAM

www.cobhamdes.com

ATLANTIC POSITIONING SYSTEMS www.atlanticpositioners.com 727.299.0150 ATLANTIC MICROWAVE www.atlanticmicrowave.com 978.779.6963
CONTINENTAL MICROWAVE www.contmicro.com 603.775.5200 KEVLIN www.kevlin.com 978.557.2400 LANSDALE www.cobhamdes.com 215.996.2000
M/A-COM www.macom.com North America 800.366.2266 Europe +44 0 1908.574200 Asia / Pacific +81.44.844.8296 NURAD www.nurad.com 410.542.1700
REMEC DEFENSE & SPACE www.remecrds.com 858.560.1301 SIVERS LAB AB www.siverslab.se +46 8 477 6811