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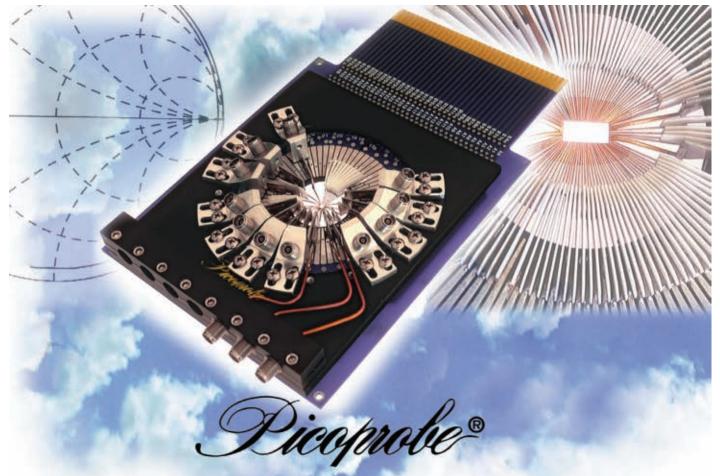
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What's Nat





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Custom Microstrip Filters

DLI has expanded its filter capability beyond microstrip bandpass designs. Notch filters, lowpass and highpass filters, ceramic cavity filters, and various other filter types are now available. All filters employ DLI's high-K ceramics which allow for great size reduction, and unbelievable temperature stability compared to alumina and PWB materials. Solder surface mount and chip and wire filters are all possible.

Notch Filter

- · Greater than -20dB attenuation typical
- Low loss in passband regions [better than -1.5dB]
- Typical size: .25 x .196 x .02 inches
- Solder surface mount device

Typical Lowpass Filter

- Low loss in passband [better than -1.0dB]
- Greater than -40dB attenuation in stopband
- Typical size: .4 x .25 x .015 inches
- Chip and wire filter [mounted on PCB with epoxy or SMT]
- Designs possible from S to Ku band

Typical Highpass Filter

- Low loss in passband region [better than -2.0dB]
- Greater than -35dB attenuation in stopband
- Typical size: .3 x .2 x .015 inches
- Chip and wire filter [mounted to PCB with epoxy]
- Corner frequencies possible from 1GHz to 67GHz

#Örlts Rotch Filter + 9 Barrights

L1/L2 GPS Notch Filters

- Greater than -20dB attenuation typical
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- Typical size: .25 x .25 x .075 inches
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DLI is now offering our proprietary NA dielectric formulation in a variety of MLC case sizes. With its negative temperature coefficient of capacitance (N30+/-15ppm/ $^{\circ}$ C), this high-Q porcelain dielectric is ideal for temperature compensating situations. NA is offered as a drop-in replacement for most AH/CF part numbers.

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When design engineers told us they'd like a termination that would allow them the freedom to use harsh solder profiles and multiple reworks, we listened! DLI has qualified enhanced versions of its RoHS compliant terminations designed to handle both the rigors of the test bench and the production floor with ease. The enhanced terminations are available in both standard (term code: E) and non-magnetic (term code: H) finishes. Please contact our Sales Representatives for more details.

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DLI is pleased to introduce the new C18 series of enhanced voltage high-Q porcelain capacitors. With voltage ratings up to 2000V, the C18 is designed to be the most robust "1111" high-Q capacitor available today. The C18 is available in both our ultra stable (0 ± 15 ppm/°C) CF and temperature compensating (+90ppm/°C) AH dielectrics, and is form-factor compatible with our existing line of C17"1111" capacitors.

Tuning Rod Kits

DLI designed tuning rods to utilize our C11 or C17 capacitors of a specified value attached to High-Q insulating holder to find the optimum capacitor for a particular circuit or application without soldering capacitors.





















Product Spotlight

KEL SEV-7500/E500-SMT

Surface Mount Cavity Filter Series

Patent Pending

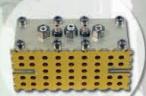
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- · Simplified electronic PWB mounting/assembly
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- · Option to hermetically seal
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AUGUST 2009 VOL. 52 • NO. 8

FEATURES

COVER FEATURE

22 Mil SatCom Capacity Crunch: The BUC Stops Here

Pat Hindle, Editor, Microwave Journal

Current trends in expanding military satellite communications capacity to meet current and future needs

TECHNICAL FEATURES

56 Multi-beam Scanning Lens Antenna for Satellite Communications to Trains

John Thornton, Andy White and Graham Long, University of York

Development of a mechanically scanned, two-beam hemispherical antenna for two-way satellite communications to trains

72 MM-waves in the Living Room: The Future of Wireless High Definition Multimedia

Jonathan Wells, AJIS LLC

Introduction to the standards, industry groups and commercial players currently defining the wireless high definition landscape

SPECIAL REPORT

86 UltraCMOS RFICs Ease the Complexity of Satellite Designs

Dale Robinette, Peregrine Semiconductor Inc.

Use of a complementary metal-oxide-semiconductor technology in the manufacture of high-performance radio frequency devices

Cover: US soldier with Falcon III AN/PRC-152 handheld radio; photo courtesy of Harris



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FEATURES

PRODUCT FEATURES

100 Two-stage Ultra Low Noise Amplifiers

Skyworks Solutions Inc.

Development of a family of two-stage low noise amplifiers covering the frequency range of 0.7 to 2.7 GHz

106 Rotary Joints for SatCom Applications

Spinner GmbH

Introduction to two rotary joint product families for fixed and mobile SatCom systems

112 X-band 100 W Block Upconverter

Locus Microwave

Design of an X-band 100 W block upconverter for outdoor military communication applications

DEPARTMENTS

17 ... Mark Your Calendar

18 ... Coming Events

39 ... Defense News

43 ... International Report

47 ... Commercial Market

50 ... Around the Circuit

116 ... Software Update

118 ... New Products

132 ... The Book End

134 ... Ad Index

136 ... Sales Reps

138 ... MWJ Puzzler

Hi David,

Wikipedia's reference about my manager not liking me working on CAD is incorrect. HP was one of the early-day proponents of computerizing design. I left HP for a better job opportunity. It was my father-in-law, a life-long Standard Oil executive, who was very concerned when I told him about leaving my latter employer to work full time with COMPACT. I still recall his worried statement, "How could anyone make a living on selling computer programs?" History proved him wrong, because now it is harder to make a living on selling hardware!

Thanks. Les Besser

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Skyworks Solutions Inc.

How to Specify RF and Microwave Filters Application Note, Anatech Electronics Inc.

Spacecraft Payload for MSC Networks

St. D. Ilcev, Durban University of Technology

Executive Interview

Klaus-Dieter Beck, Head of Sales and Marketing, Radar and Satellite Division at Spinner, sheds light on establishing the company in Germany in 1946, its evolution since then, development of new rotary joints for SatCom applications and future goals.



Expert Advice

Dr. Jonathan Wells, President of **AJIS LLC**, writes about the Gigabit Ethernet Superhighway, its need for broad spectrum in order to deliver the desired high data rates wirelessly and how that will impact component designers. Wells provides some insight into the organizations that are setting the standards behind Wireless HDTV.



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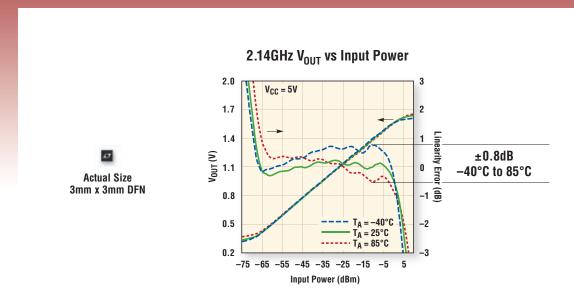


Events

Microwave Journal will be attending the **IEEE EMC Society Symposium** on Electromagnetic Compatibility in Austin, TX, August 17-21, to meet with exhibitors and conference attendees, eat some BBQ and report on the event. Read all about it at www.mwjournal.com/emc2009.

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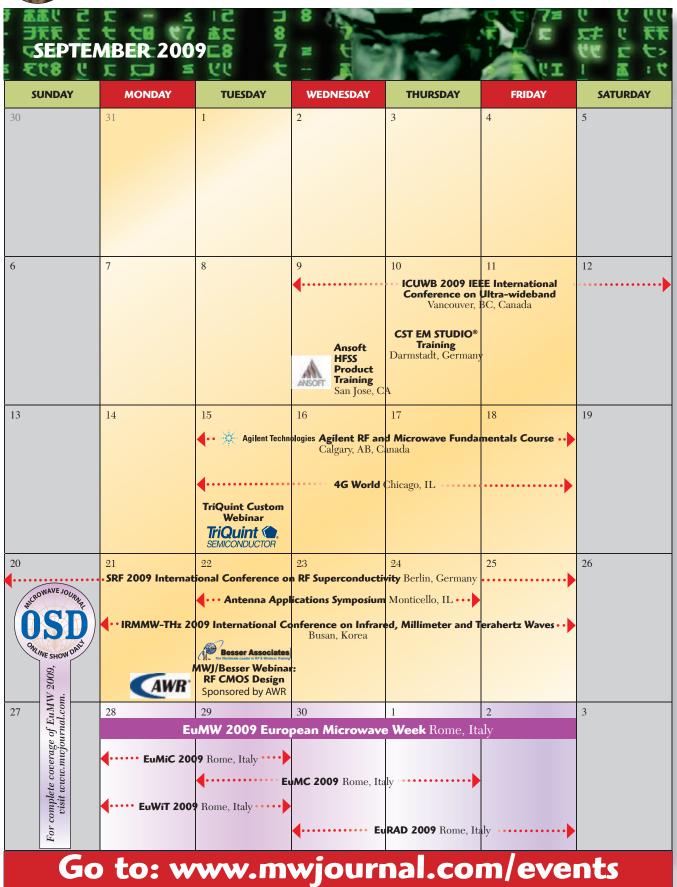




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www.ece.ubc.ca/~lampe/ICUWB2009/

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JANUARY

RWS2010

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

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January 24–28, 2010 • Hong Kong, China www.ieeemems.org

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MIL SATCOM CAPACITY CRUNCH: THE BUC STOPS HERE

dvances in military technology such as unmanned autonomous vehicles (UAV), real time video surveillance, networked communication systems, real time targeting and battlefield mapping are demanding much more capacity in satellite communications than is available today. A large amount of data needs to be transmitted in real time and via secure and protected communication systems, further compounding the capacity problem. In the Middle East conflicts, the military realized its lack of communications capacity was a critical issue and has used commercial systems to help carry the load. The current fleet of military communications satellites uses technology that is more than a decade old except for the two WGS satellites recently launched. The need to expand the capacity of these systems is great, but it is difficult to accomplish quickly due to the cost and long lead times to approve, build and launch systems.

Satellite communications play a vital role in providing voice and data to the warfighter and strategic command. The initial trend was for the military to use commercially available bandwidth to offset its demands. But with future militaries using a network-centric architecture that will integrate information from many sources and direct them in real time to the appropriate locations, it is clear they need additional dedicated and secure capacity. Future warfighter communication systems will be small, light and low enough in cost to al-

low most soldiers to carry their own communication devices and transmit monitored data collected from their individual sensors. Real time video is growing into wide use with various devices and sensors available in the field and on UAVs. Other surveillance sensors along with battlefield mapping and targeting data are quickly pushing the demand for more bandwidth in current and future systems at an astounding rate.

Microwave Journal surveyed some of the companies in our industry who supply components and subsystems to the satellite communications market about their participation in programs, new products and trends in the industry. Responding to our questions were Cobham Defense, Ducommun, e2v, Jersey Microwave, Microsemi, Micronetics, MITEQ and Xicom.

MIL SATCOM PROGRAMS

In order to meet the emerging needs for more capable systems, the US military is deploying new systems such as Wideband Global SatCom (WGS – formerly Wideband Gapfiller Satellite), Warfighter Information Network – Tactical (WIN-T), Advanced Extremely High Frequency (AEHF) satellites and the Mobile User Objective System (MUOS). These new initiatives (along with some others) will greatly

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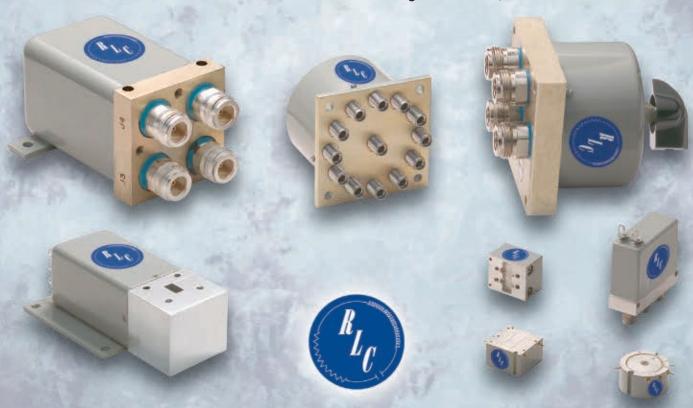
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expand the capacity of military SatCom systems, but it might not be enough to meet current and future needs.

WGS is a high capacity system that will greatly increase the capacity available to the USAF to help meet the growing demand for military satellite communications. Boeing is the lead contractor for the program that includes three Block I and three Block II WGS satellites. WGS-1 was launched in October 2007 and WGS-2 in April 2009. WGS satellites have flexible coverage areas and the ability to connect X-band and Ka-band users via reconfigurable antennas and a digital channelizer. These are the first military satellites available with dual mode capability. The Block II satellites will include RF bypass to support airborne intelligence, surveillance and reconnaissance platforms requiring additional ultra-high bandwidth and data rates demanded by UAVs. Each unit is capable of routing 2.1 to 3.6 Gbps of data; that is more than 10 times the communications capacity of the previous Defense Satellite Communications Systems (DSCS) III satellite and provides more flexible coverage to any user in the field of view.¹

WIN-T is the Army's on-the-move, high-speed, high-capacity backbone communications network, linking warfighters on the battlefield with the Global Information Grid (GIG). The Joint Network Node (JNN) is now WIN-T Increment 1. WIN-T Increment 1 is defined as providing "networking at-the-halt" and is further divided into two sub increments defined as WIN-T Increment 1a, "extended networking at-the-halt", and WIN-T Increment 1b, "enhanced networking at-the-halt". WIN-T Increment 1a upgrades the former JNN satellite capability to access the Ka-band defense WGS, reducing reliance on commercial Ku-band satellite, while increment 1b introduces the Net Centric Waveform (NCW), a dynamic waveform that optimizes bandwidth and satellite utilization.

The AEHF System is a joint service satellite communications system that provides near-worldwide, secure, survivable and jam-resistant communications for high-priority military ground, sea and air assets. The AEHF satellites will have 12 times more communications capacity than the previous Milstar system it replaces. It will also

usher in a new era of cooperation and interoperability with Canada, the Netherlands and the United Kingdom, under cooperative development partnerships and support tactical and strategic communications. The expected launch

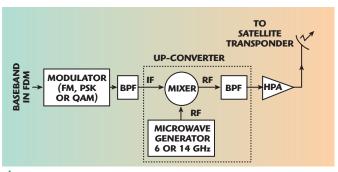
of the first satellite is 2010 and launch of the third and final satellite in 2012.

The MUOS communications satellite network is designed to replace the US Navy UHF Follow-On (UFO) satellite system. The MUOS system will provide UHF secure voice, data, video, network-centric communications in real-time to US and Allied mobile warfighters through 2030, and will be fully interoperable with the Joint Tactical Radio System (JTRS) and current radio systems. It is designed to provide global SatCom narrowband (64 kpbs and below) connectivity for voice, video and data.

Many of the companies we surveyed are involved in these critical programs along with others in the industry. Jersey Microwave stated that they are the first company qualified to provide Ka-band block upconverters into the amplifiers to support WGS and have delivered over 1100 block upconverters in support of the WIN-T program. Cobham Defense builds the space-based antenna unit for WGS and is supporting the space qualified units to meet their current demand. Microsemi is supplying frequency converters to the WIN-T program, while Xicom, Micronetics and MITEQ are supplying various components to the WGS program and related equipment. In April, CPI was awarded a contract for Ka-band highpower satellite communications amplifiers to upgrade DataPath's existing unit hub SatCom truck terminals used for the WIN-T program. These terminals were originally configured solely for Ku-band communications.

SATELLITE LINKS

Satellite communication systems consist of an uplink from an Earth station to the satellite transponder and back to the Earth downlink. The up-



▲ Fig. 1 Simplified satellite uplink block diagram.

link signal is generated from the transmitter that can be a solid-state power amplifier (SSPA), travelling wave tube amplifier (TWTA), or klystron power amplifier (KPA). The power amplifier units are typically mounted on the dish as close to the feed as possible to minimize losses. These dish mounted units are commonly called block upconverters (BUC), which typically up convert the incoming L-band cable signal to the microwave frequency for transmission to the satellite (typically C-, X-, Ku- or Ka-band). See **Figure 1** for a typical simplified uplink block diagram.² The output power and small size of the BUC unit are important so the transmission energy can be maximized. The combination of the BUC output power and antenna gain produces equivalent isotropic radiated power (EIRP) for link budget estimates.

We asked companies how SSPAs were progressing against the TWTs, which have been the mainstay of the high power industry for years. Many companies see the SSPAs going higher in power and becoming a more reliable solution eating away the market share of TWTs for low to medium power applications. Some see the newer GaNbased SSPAs growing while others see them as an unfulfilled promise. Microsemi commented that GaN is gaining traction to further extend the power range of SSPAs, and combined with more efficient spatial and waveguide power combining techniques, they are forcing TWT suppliers to share more of the market. The new spatial combining techniques also offer a "graceful" failure mechanism. If one or two devices in the combiner fail, the component still operates (at reduced power level), giving the system greater reliability but just not at the initial power level. GaN does require much higher voltages than previously used GaAs devices for these applications so associated regula-



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CHANGING THE STANDARDS

tion circuitry has to change and thermal handling is more of an issue. This can be more critical in space applications where it is difficult to remove the heat. Micronetics on the other hand said they have seen little effect from GaN on the high performance SatCom systems because of poor linearity, but are planning on reviewing higher frequency GaN devices in the near future for possible use in systems.

However, MITEQ points out that

there has been an emotional response to some decisions between SSPAs and TWTs. TWTs are still lighter in weight, more cost effective and have higher efficiency than SSPAs. They went on to say that with continuous and incremental improvements, TWTs have been proven over and over again that they are a viable alternative to solid state; in some cases a better alternative. With the advances in particle physics and material sciences, the TWT will con-

tinue to be a state-of-the-art technology in the high power, high frequency RF amplification market. In actuality, there has been a resurgence in lower frequencies due to the re-understanding that both technologies are viable depending on the application. Graham Gooday, e2v's General Manager of Defence, commented, "Watt for watt, lower efficiency solid-state amplifiers are still broadly much larger and heavier than TWT amplifiers. Looking at it the other way, in power or size limited situations a TWT amplifier will still give you more signal power for the available space or power supply, with less waste heat to remove. That's not a complacent position. Solid-state amplifiers can satisfy lower power, lower frequency requirements, but with programmes to improve the ruggedness, efficiency and operational life of TWT amplifiers we believe that we maintain a positive performance differentiation."

Xicom offered an opinion somewhere in between as they use both technologies. They see growing demand for both. The power level at which the transition point between choosing a TWTA versus a SSPA has risen, in sync with the available power from a single transistor. However, the demands for high data rates still push many systems to require TWTAs in order to support the link budgets. This is also very frequency band dependent, as the amount of power achieved from a transistor is very different at C-band than at Ka-band.

For the GaAs-based device outlook, Strategy Analytics recently issued a market report indicating the demand for GaAs devices in SatCom/VSAT market will grow 4 percent through 2013 with steady demand due to long design cycles and pent up demand driven mostly by the consumer sector.³ Since GaAs is still used extensively in the space and ground segments, they expect a compound annual average growth rate of over 4 percent from 2008-2013 with MMICs being the majority of volume and GaAs revenue. The largest opportunities are for Kuand Ka-band power amplifiers despite the threats from other technologies and they expect GaAs to remain the dominant technology solution.

The Earth station uplink signal is received by the satellite transponder and transmitted back to the Earth downlink station. *Figure 2* shows a typical simplified block diagram of a





SYSTEMS UCCESS

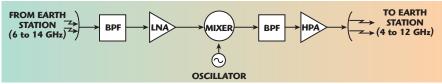
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▲ Fig. 2 Simplified C-band satellite transponder block diagram.

C-band satellite transponder.² The components and subsystems must be small, light weight, highly reliable and as efficient as possible to minimize the energy needed and heat dis-

sipated. Every extra pound of weight is very costly to launch and it is very difficult to dissipate the heat in space. Efficiency is critical to reduce energy consumption as much as possible.

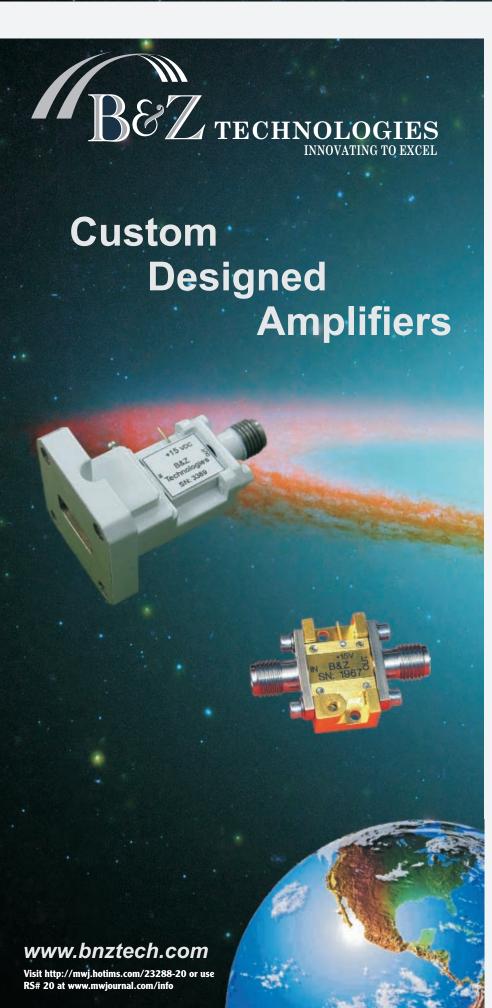


On the receive side, the downlink Earth station receives the signal from the satellite, amplifies it and downconverts it to the L-band cable transmission frequency. *Figure 3* shows a typical simplified block diagram.² The low noise amplifier is critical to the performance/sensitivity of the downlink so the low noise block (LNB) downconverter is the critical component in the system. The BUC and LNB along with the dish antenna make a two-way ground station system called a Very Small Aperture Terminal (VSAT).

REQUIREMENTS AND CHALLENGES

Commercial satellites currently provide capacity for military applications such as communications, video and UAV missions. Many commercial satellites provide wider bandwidths and there are a much larger number of them compared to military satellites, making the capacity capability even broader. e2v commented, "Whilst there is some crossover traffic from military to commercial channels there remains a defined market for intheatre defence specific equipment and there is no reason to think that is going to change. In fact, if anything, this market is becoming more demanding of the supplier base and of system performance, giving companies like e2v opportunities to shine." However, it is likely that the military will continue to make extensive use of commercial capacity even after many of these new systems come online due to growing data needs in many areas.

The main difference between commercial and military satellites is that military systems provide highly secure, survivable, protected, global communications for the warfighter. Commercial systems are more vulnerable to security attacks, jamming and destructive events including nuclear attacks or other severe environmental situations. Military systems can resist these severe conditions and prevent jamming, interference, hacking, etc. Military systems are often optimized for certain types of data and capacity needs so they can offer a better fit to their specific mission. Another area where commercial systems cannot help is with polar coverage. Since there is little need for services in these areas, they do not have coverage there. Military systems need



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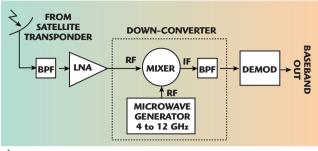


Fig. 3 Simplified satellite downlink block diagram.

to have global coverage and AEHF will feature an Advanced Polar System for wideband, protected coverage. Commercial systems should be able to complement capacity, but cannot be relied on for all situations and needs.

USA

There is a need to use higher frequency transmitters to provide more bandwidth and capacity, but the higher frequencies in general are attenuated more by the atmosphere (especially at 60 GHz where the 0_2 attenuation is high) and are more expensive and difficult to design. While there is a big push to use the higher frequencies to meet the growing capacity needs, the cost and design issues need to be overcome as these systems are realized. There is always a push for more power and more linear amplifier systems to improve performance.

TRENDS AND SOLUTIONS

Euroconsult estimates that 1185 satellites will be built and launched between 2009 and 2018, which is an increase of about 50 percent compared to the previous decade of 1999 to 2008.⁴ Not all of these will be communications satellites and while there is ongoing defense and security concerns, demand for proprietary military satellite systems remains concentrated in a limited number of countries. But countries like the US that need to maintain a modern military must expand capacity to meet current and future needs.

Most agree that the current demand for Ku-band communications is strong, while the C-band is fading as broader bandwidth needs are met. Ka-band is growing quickly as military SatCom is increasing its bandwidth capabilities and pushing for higher frequencies. Jersey Microwave is developing a Ka-band Test Loop Translator to support upcoming Ka-band hardware in anticipation of the growing Ka-band market. As evidenced by WGS, future systems will use higher frequencies (Ka-band and above) plus dual- or tri-band systems to utilize current technology and add higher bandwidth capabilities. X-band for commercial systems has been slow, but military use should pick up over the new few years. A couple of the companies we surveyed also see some future demand for even higher frequency, higher bandwidth systems using Q- and V-bands.

In order to achieve these higher bandwidth needs, suppliers are designing higher frequency and broader bandwidth devices and subsystems. To increase efficiency with a given bandwidth, complex modulation schemes



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have evolved, which in turn requires more linear power requirements. Digital pre-distortion (DPD) has improved the linearity of SSPA designs and better broadband matching networks are now available. Microwave Journal reviewed some of the newer SSPA hardware at Satellite 2009 in late March in Washington, DC. Micronetics had its Ku-band high power transceivers on display, which are available with transmit powers of 10, 16, 20 and 40 W. MITEQ was featuring its SSPA systems, including X-band configurations with up to 70 W for satellite uplink applications that come in outdoor antenna mount and rack mount systems. And Locus Microwave (now part of the Codan family) was displaying its 100 W Ku-band SSPA in a lightweight package of 7 lbs (also see the company's 100 W X-band BUC product feature in this issue). On the LNB side there was Teledyne Microwave featuring a Ka-band high performance LNB with a typical noise figure of 1.5 dB.

Also at Satellite 2009 were the latest TWT components, including MCL with its antenna mount TWT low power amplifier with 175 or 200 W at X-band. NEC had a 500 W Ka-band peak high power TWT featuring low power consumption and lightweight construction. Thales had on display a new line of TWTs (Periodic Permanent Magnet focused) that provide 750 W for DBS applications and is widely used in ground uplink systems. And e2v has its new StellarMini, which is the latest generation of the company's high power TWTs. Xicom introduced a new suite of X- and Ka-band uplink amplifiers including both SSPA and TWTA designs for WGS satellites. The product offerings covered

power levels from 35 to 2500 W in X-band and 10 to 500 W in Ka-band.

On the higher level product side at Satellite 2009, Cobham had its Micro-Atlantic wave antenna systems on display including the SAT Series Ka/ Ku-band transportable SatCom Antenna system that uses a 1 meter multi-piece lightweight dual reflector. It can acquire and track a Ka- or Com antenna system. Ku-band satellite



A Fig. 4 Transportable Ka-/Ku-band Sat-Com antenna system.

and pass the data signal from the satellite to an external data receiver (see *Figure 4*).

Another part of this improving technology is better software to model 3D structures and package parasitics to design higher performing devices. Modeling becomes even more critical at the higher frequencies and the transitions between coax, CPW and microstrip need to be carefully de-

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NEW!	DC - 1	HBT Gain Block, 75 Ohm	14	38	5.5	21	+5V @ 160mA	S8G	HMC754S8GE
NEW!	0.05 - 3.0	HBT Gain Block	15	40	3.5	18	+5V @ 88mA	ST89	HMC740ST89E
NEW!	0.05 - 3.0	HBT Gain Block	20	42	2.5	18	+5V @ 96mA	ST89	HMC741ST89E
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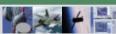
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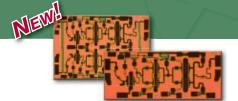
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	6 - 9.5	Power Amplifier, 1 Watt	21	40	-	30.5	+7V @ 820mA	LP5	HMC590LP5E
	6 - 9.5	Power Amplifier, 2 Watt	18	41	-	33	+7V @ 1340mA	LP5	HMC591LP5E
	7 - 9	Power Amplifier, 2 Watt	26	40	6.5	33.5	+7V @ 1.3A	Chip	HMC486
	7 - 9	Power Amplifier, 2 Watt	22	40	7	32	+7V @ 1.3A	LP5	HMC486LP5E
	9 - 12	Power Amplifier, 2 Watt	20	36	8	32	+7V @ 1.3A	LP5	HMC487LP5E
	10 - 13	Power Amplifier, 1 Watt	19	38	-	31	+7V @ 750mA	Chip	HMC592
	12 - 16	Power Amplifier, 1 Watt	13	34	9	31	+7V @ 1.3A	LP5	HMC489LP5E
NEW!	16 - 24	Power Amplifier, 1 Watt	23	41	-	31	+7V @ 790mA	Chip	HMC756
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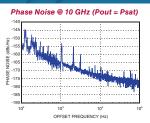


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	2 - 18	Wideband, Low Phase Noise	14 / 4.5	27	-160	15 / 18	+5V @ 64mA	Chip	HMC606
	2 - 18	Wideband, Low Phase Noise	13.5 / 7	27	-160	15 / 17	+5V @ 64mA	LC5	HMC606LC5
	2 - 18	Wideband, Low Phase Noise	13.5 / 5	22.5	-160	15 / 18.5	+5V @ 80mA	C-1 / SMA	HMC-C050
NEW!	6 - 12	Wideband, Low Phase Noise	11 / 4.5	34	-167	20 / 22	+7V @ 170mA	C-16 / SMA	HMC-C072

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signed using powerful finite element analysis tools. Microsemi emphasized that they build circuits using automated equipment to reduce variation in critical component placement and wire bonding. This automation supports tighter phase matching between power-combined channels reducing critical combiner losses.

There is always a trend for smaller, lighter weight and more efficient components and subsystems for SatCom systems especially for mobile and space applications. Jersey Microwave has recently developed a single module that contains a Ku-band block up and down converter for a custom military requirement in a $3.5 \times 2.9 \times 0.66$ inch package. This small, lightweight, low power consumption unit is ideal for man-pack and airborne applications.

Packaging is another critical area for lighter more compact components and designs are much more sensitive at the higher frequencies. Rogers has developed a RT/duroid 5880LZ laminate with a new filler system that results in a low density (1.37 gm/cm³), lightweight material for high performance, weight sensitive applications. The 1.96 dielectric constant is among the lowest available for any microwave PCB material and ideal for antenna applications. Microsemi is now leveraging its Epsilon™ packaging technology for military use. It is essentially a laminate of soft board and FR4 coupled with palladium-doped plating to eliminate most of the metal packaging while simultaneously accommodating both surface-mount soldering and gold wire bonding. This greatly reduces the weight and cost of traditionally machined housings.

CONCLUSION

There is a large capacity crunch in military SatCom systems as current demands such as real time video surveillance, UAV monitoring, networked communications, real time targeting and battlefield mapping are demanding much more capacity. This is compounded by the future plans to convert the military to a network-centric force that will demand even more capacity. The military has responded with new programs such as WGS, WIN-T, AEHF and MUOS, while the microwave component and subsystem companies are responding with higher frequency, lower cost, lighter and more efficient products. The current demand is strong for Ku-band products with a growing demand for Ka-band products to increase the bandwidth of SatCom systems. X-band could see significant growth for small tactical and transportable terminals as mobile units find expanded roles that could change the nature of SatCom again. The BUC stops here with the government and industry as they respond to these current and future needs for capacity.

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	Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package / Connector	Part Number
	DC - 20	SPST, Hi Isolation	3.0	100	23	0 / +5V	C-9 / SMA	HMC-C019
NEW	DC - 18	SPDT, Hi Isolation	2.5	60	27	0 / +5V	C-14 / SMA	HMC-C058
	DC - 20	SPDT, Hi Isolation	2.0	40	23	0 / +5V	C-5 / SMA	HMC-C011
NEW	DC - 20	SP4T, Hi Isolation	3.0	40	24	0 / +5V	C-15 / SMA	HMC-C071

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	Frequency	Maximu Frequency Function PFD Frequ (MHz)		Maximum Reference Frequency (MHz)	Figure of Merit (Frac / Int) (dBc/Hz)	Frequency Resolution w/ 50 MHz Ref.	lution w/ Supply		Part Number
NEW!	10 kHz to 8 GHz	Fractional-N w/ Int. Sweeper	75	200	-221 / -227	3 Hz	+5V @ 37mA +3.3V @ 90mA	LP6C	HMC701LP6CE
NEW!	10 kHz to 14 GHz	Fractional-N w/ Int. Sweeper	75	200	-221 / -227	6 Hz	+5V @ 37mA +3.3V @ 136mA	LP6C	HMC702LP6CE
	10 MHz to 8 GHz	Fractional-N	70	200	-221 / -226	3 Hz	+5V @ 7mA +3.3V @ 95mA	LP4	HMC700LP4E
	80 MHz to 7 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 310mA	LP5	HMC698LP5E
	160 MHz to 7 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 310mA	LP5	HMC699LP5E
	10 MHz to 2.8 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 250mA	QS16G	HMC440QS16GE

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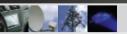
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	Frequency (GHz)	Function	Frequency Resolution	Maxi Power Out	mum tput (dBm)	100kH Phase Nois	lz SSB se (dBc/Hz)	Spurious @ 1 GHz	Switching Speed @ 100 MHz	Part Number
	(G112)		(MHz)	@ 2 GHz	@ 6 GHz	@ 1 GHz	@ 4 GHz	(dBc)	Steps (µs)	Number
NEW!	0.01 - 20	Signal Generator	0.01	+27	+27	-113	-101	-80	<300	HMC-T2100
	0.7 - 8.0	Signal Generator	1	+20	+15	-78	-87	-57	<200	HMC-T2000

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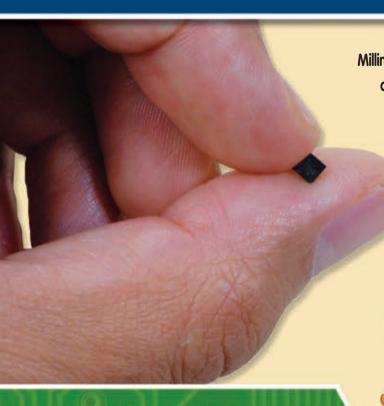


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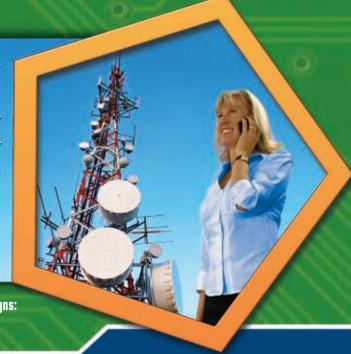
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PtP Radio Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	Voltage / Current (V / mA)	Part Number
2W HPA	5.5 - 8.5	32 (34) / 41	30	6 / 1260	TGA2706-SM
Driver Amp, SB	11 - 17	17 / –	23	6 / 75	TGA2507-SM
2W HPA	12.5 - 16	(32) / 37	32	6 - 7 / 680	TGA2503-SM
1W HPA, PD	17 - 21	29 (31) / 41	21	6 / 825	TGA4530-SM
HPA, AGC, PD	17 - 24	(29) / 38	22	5 / 712	TGA2522-SM
HPA	17 - 24	31 (32) / 40	23	7 / 720	TGA4531
1W HPA	28 - 31	30 / –	19	6 / 420	TGA4509-SM
Driver Amp	29 - 31	16 (17) / 22	15	6 / 60	TGA4510-SM
2W HPA	30 - 40	31.5 (33) / –	20	6 / 1050	TGA4516
MPA	32 - 45	24 (25) / 33	16	6 / 175	TGA4521
MPA	33 - 47	27 (27.5) / 36	18	6 / 400	TGA4522

NOTES: SB = Self Biased, AGC = Automatic Gain Control, PD = Power Detector

PtP Radio Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Part Number
LNA, AGC	2 - 20	19 / –	17.5	2.5	5 / 100	TGA2526
LNA, AGC	2 - 20	16 / –	17	2.5	5 / 75	TGA2513-SM
LNA, SB, AGC	4 - 14	6 / 16	22	2.3	5 / 90	TGA2512-1-SM
LNA	21 - 27	10 / –	21	2.5	3.5 / 60	TGA4506-SM
LNA	28 - 36	12 / 21	22	2.3	3 / 60	TGA4507
LNA	30 - 42	14 / –	21	2.8	3 / 40	TGA4508

NOTES: SB = Self Biased, AGC = Automatic Gain Control, GB = Gate Bias

PtP Radio Frequency Converters & Control Products

	RF Frequency Range (GHz)				Voltage / Current (V / mA)	Part Number
Doubler with Amplifier	16 - 30	18	30	19	5 / 150	TGC4403-SM
Upconverting Mixer	17 - 26	-9	40	-	-0.9 / 0	TGC4402-SM
Gain Block & 2x / 3x Multiplier	17 - 40	9	N/A	2	5 / 140	TGA4031-SM



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OCTAVE BA	ND LOW N			_		
Model No. CA01-2110	Freq (GHz) 0.5-1.0	Gain (dB) MIN	Noise Figure (dB) 1.0 MAX, 0.7 TYP	Power -out @ P1-dB +10 MIN	3rd Order ICP +20 dBm	VSWR 2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP 1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111 CA812-3111	4.0-8.0 8.0-12.0	29 27	1.3 MAX, 1.0 TYP 1.6 MAX, 1.4 TYP	+10 MIN +10 MIN	+20 dBm +20 dBm	2.0:1 2.0:1
CA012-3111 CA1218-4111	12.0-18.0	25	1.9 MAX, 1.4 TTP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2111	0.4 - 0.5	NOISE AND	MEDIUM POV	VER AMPLIFI +10 MIN	IERS +20 dBm	2.0.1
CA01-2111 CA01-2113	0.4 - 0.5	28	0.6 MAX, 0.4 TYP 0.6 MAX, 0.4 TYP	+10 MIN +10 MIN	+20 dBm	2.0:1 2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4 2.7 - 2.9	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116 CA34-2110	3.7 - 4.2	29 28	0.7 MAX, 0.5 TYP 1.0 MAX, 0.5 TYP	+10 MIN +10 MIN	+20 dBm +20 dBm	2.0:1 2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75 9.0 - 10.6	32 25	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110 CA1315-3110	13.75 - 15.4	25	1.4 MAX, 1.2 TYP 1.6 MAX, 1.4 TYP	+10 MIN +10 MIN	+20 dBm +20 dBm	2.0.1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5 5.9 - 6.4	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm +40 dBm	2.0:1 2.0:1
CA56-5114 CA812-6115	8.0 - 12.0	30 30	5.0 MAX, 4.0 TYP 4.5 MAX, 3.5 TYP	+30 MIN +30 MIN	+40 dBm	2.0.1
CA812-6116	8.0 - 12.0	30	4.5 MAX, 3.5 TYP 5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25 14.0 - 15.0	28	6.0 MAX, 5.5 TYP 5.0 MAX, 4.0 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110 CA1722-4110	17.0 - 22.0	30 25	3.5 MAX, 2.8 TYP	+30 MIN +21 MIN	+40 dBm +31 dBm	2.0:1 2.0:1
ULTRA-BRO	ADBAND &	MULTI-OC	TAVE BAND AN	APLIFIERS		
Model No. CA0102-3111	Freq (GHz) 0.1-2.0	Gain (dB) MIN 28	Noise Figure (dB) 1.6 Max, 1.2 TYP	Power -out @ P1-dB +10 MIN	3rd Order ICP +20 dBm	VSWR 2.0:1
CA0102-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max. 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112 CA02-3112	0.1-8.0 0.5-2.0	32 36	3.0 MAX, 1.8 TYP 4.5 MAX, 2.5 TYP	+22 MIN +30 MIN	+32 dBm +40 dBm	2.0:1 2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX. 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0 6.0-18.0	22 25	5.0 MAX, 3.5 TYP	+30 MIN +23 MIN	+40 dBm +33 dBm	2.0:1 2.0:1
CA618-4112 CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP 5.0 MAX, 3.5 TYP	+30 MIN	+33 dBm	2.0.1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110 CA218-4112	2.0-18.0 2.0-18.0	30 29	5.0 MAX, 3.5 TYP 5.0 MAX, 3.5 TYP	+20 MIN +24 MIN	+30 dBm +34 dBm	2.0:1 2.0:1
LIMITING A		27	J.U MAX, J.J 111	+24 /VIIIV	+34 UDIII	
Model No.		nput Dynamic Ro			er Flatness dB	VSWR
CLA24-4001 CLA26-8001	2.0 - 4.0 2.0 - 6.0	-28 to +10 dB -50 to +20 dB		8 dBm +,	/- 1.5 MAX /- 1.5 MAX	2.0:1 2.0:1
CLA712-5001	7.0 - 12.4	-21 to +10 dB	m + 14 to +1	9 dBm +,	/- 1.5 MAX	2.0:1
CLA618-1201 AMPLIFIERS \	6.0 - 18.0	-50 to +20 dB		9 dBm +,	/- 1.5 MAX	2.0:1
Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB) Pow	er-out@P1-dB Gain	Attenuation Ranae	VSWR
CA001-2511A	0.025-0.150	21 5	.0 MAX. 3.5 TYP -	+12 MIN	30 dB MIN	2.0:1
CA05-3110A CA56-3110A	0.5-5.5 5.85-6.425	23 2. 28 2.			20 dB MIN 22 dB MIN	2.0:1 1.8:1
CA612-4110A	6.0-12.0	24 2.	.5 MAX, 1.5 TYP -	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25 2.			20 dB MIN	1.8:1
CA1518-4110A LOW FREQUE	15.0-18.0 NCY AMPLIFI		.0 MAX, 2.0 TYP -	+18 MIN	20 dB MIN	1.85:1
Model No.	Freq (GHz) (Gain (dB) MIN			3rd Order ICP	VSWR
CA001-2110 CA001-2211	0.01-0.10 0.04-0.15	18 24	4.0 MAX, 2.2 TYP 3.5 MAX, 2.2 TYP	+10 MIN +13 MIN	+20 dBm +23 dBm	2.0:1 2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP 4.0 MAX, 2.8 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114 CA003-3116	0.01-2.0 0.01-3.0	27 18	4.0 MAX, 2.8 TYP 4.0 MAX, 2.8 TYP	+20 MIN +25 MIN	+30 dBm +35 dBm	2.0:1 2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1
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DEFENSE NEWS



The Lockheed Martin team developing the US Air Force's next-generation Global Positioning System (GPS) spacecraft, known as GPS III, has successfully completed the Preliminary Design Review (PDR) phase, a major program milestone that allows the team to begin the Critical Design Review (CDR) stage.

Lockheed Martin, Newtown, PA, along with teammates ITT, Clifton, NJ, and General Dynamics, Gilbert, AZ, completed a comprehensive spacecraft segment PDR, which represented the culmination of 70 subsystem and assembly PDRs, executed over the past six months.

Nearly 150 representatives from the US Air Force Global Positioning Systems Wing and user communities, including representatives from the Department of Defense, the Joint Chiefs of Staff, Air Force Space Command, the Department of Transportation, and the Federal Aviation Agency participated in the four-day Space Vehicle PDR at Lockheed Martin Space Systems facilities in Newtown, PA. Completion of the PDR milestone validates that the design meets warfighter and civil requirements and advances the GPS III program into the Critical Design Review phase.

GPS III will improve position, navigation and timing services and provide advanced anti-jam capabilities yielding superior system security, accuracy and reliability. The team is working under a \$3 B Development and Production contract awarded in May 2008 to produce up to 12 GPS IIIA satellites, with first launch projected for 2014.

The next generation GPS IIIA satellites will deliver significant improvements over current GPS space vehicles, including a new international civil signal (L1C) and increased M-Code anti-jam power with full earth coverage for military users.

Through precision location and timing information, the GPS constellation provides critical situational awareness and precision weapon guidance for the military and supports a wide range of civil, scientific and commercial functions, including air traffic control, ATM banking and the Internet. Air Force Space Command's 2nd Space Operations Squadron (2SOPS), based at Schriever Air Force Base, CO, manages and operates the GPS constellation for both civil and military users.

EADS Selects Harris
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arris Stratex Networks Inc., a specialist in backhaul solutions for mobility and broadband networks, announced EADS Defence and Security (DS), a systems solutions provider for armed forces and civil security worldwide, selected its end-to-end wireless broadband microwave

transmission equipment and network service assurance solutions to support deployments of secured communications networks for the defense and security industries. Under the two-year contract, Harris Stratex will supply EADS DS with products and services, including the EclipseTM radio platform, NetBoss® network management solutions and associated support services.

"Global defense and security organizations are increasingly moving to IP-based networks as an efficient means to seamlessly and securely exchange highly-sensitive information," said Harald Braun, Harris Stratex President and CEO. "As one of the largest global suppliers of wireless transmission systems and network service assurance solutions, Harris Stratex is excited to supply our end-to-end networking technology and services to EADS DS, which have some of the most stringent technology and security requirements out there."

Harris Stratex Eclipse technology provides scalable capacity, TDM and IP network intelligence, and key security features required for mission critical networks. The high-capacity Eclipse radios are optimized for networks with flexible, high-bandwidth capabilities. The Eclipse platform, which features a number of TDM wireless transport capabilities, including Super-PDHTM transport and compact nodal networking, will help EADS deploy increasingly stable, secure and future-proof communications networks.

Harris Receives \$13.5 M from US Air Force

arris Corp., an international communications and information technology company, has been awarded a \$13.5 M order to provide the US Air Force with both vehicular radios and the new Harris digital tactical intercom system. The equipment will be installed in high mobility

multi-purpose wheeled vehicles or humvees (HMMWV) in support of Air Force ground missions.

The Air Force is acquiring Harris Falcon III® AN/VRC-110 multiband, multimode vehicular radios, along with the recently introduced RF-7800I Tactical Intercom System. The RF-7800I provides modular, interoperable in-vehicle voice and data connectivity among vehicle crew members, while also creating a network backbone that centralizes access to and control of vehicular communication assets, including the AN/VRC-110.

The AN/VRC-110 is a high-performance, multiband vehicular tactical radio system that offers users a wide range of capabilities such as SINCGARS interoperability, APCO P25, ultra high-frequency (UHF) ground-toground line-of-sight communications, close-air support and programmable encryption. The JTRS-approved AN/PRC-152(C) serves as the handheld transceiver in the AN/VRC-110 system.

Northrop Grumman
BLOS Capability for
US Air Force Paying
Dividends

DEFENSE NEWS

ike the advertisement that speaks to the value of a product, Northrop Grumman's Beyond-Line-of-Sight (BLOS) communications capability is priceless for troops on the ground. That is the sentiment coming from the 116th Air Control Wing, which flies the US Air Force E-8C Joint STARS.

The company completed delivery of the new airborne broadband and Internet Protocol (IP) communications capability on the E-8C earlier this year. The ground stations, trainers and the full fleet of aircraft have been equipped with the IP-based BLOS communications system, which provides chat, e-mail and web-browsing capabilities across the US Department of Defense secure network.

The BLOS capability upgrade was developed in response to an Urgent Operational Need (UON) program request received in September 2007 to support the warfighter's requirement to communicate on a global scale using Internet-based technology. Included in the BLOS product are critical information assurance (IA) designs, which ensure the integrity, security and correct accessibility of classified communications.

"The BLOS capability allows Joint STARS operators to connect with personnel anywhere in the world using either data or voice communications via existing satellite and IP infrastructures," said Stu Schreiber, Northrop Grumman's BLOS Program Manager.

"Our development team pulled together a detailed design, developed software and customized networking protocols, and integrated the system within four months," said Dale Burton, Vice President of Northrop Grumman's Intelligence, Surveillance and Reconnaissance programs for the company's Aerospace Systems sector. "This precedent-setting effort also included a parallel retrofit/fielding effort, resulting in a complete fleet-wide design to install upgrade within 14 months and within the constraints of aircraft availability, as Joint STARS continues to support key warfighting efforts overseas.

"This type of system design and development (SDD) program would normally take 20 to 22 months to complete, but the entire effort was condensed into a nine-month effort through an incredible level of contractor and government focus and dedication," continued Burton. "Now we're looking for ways we can improve the jet's connectivity even more."

"In a time when delivering programs on cost and on schedule can be challenging, BLOS is a success in both respects, coming in early and on cost while also meeting an urgent warfighter need," said Capt. Kate Stowe, Air Force BLOS Program Manager.



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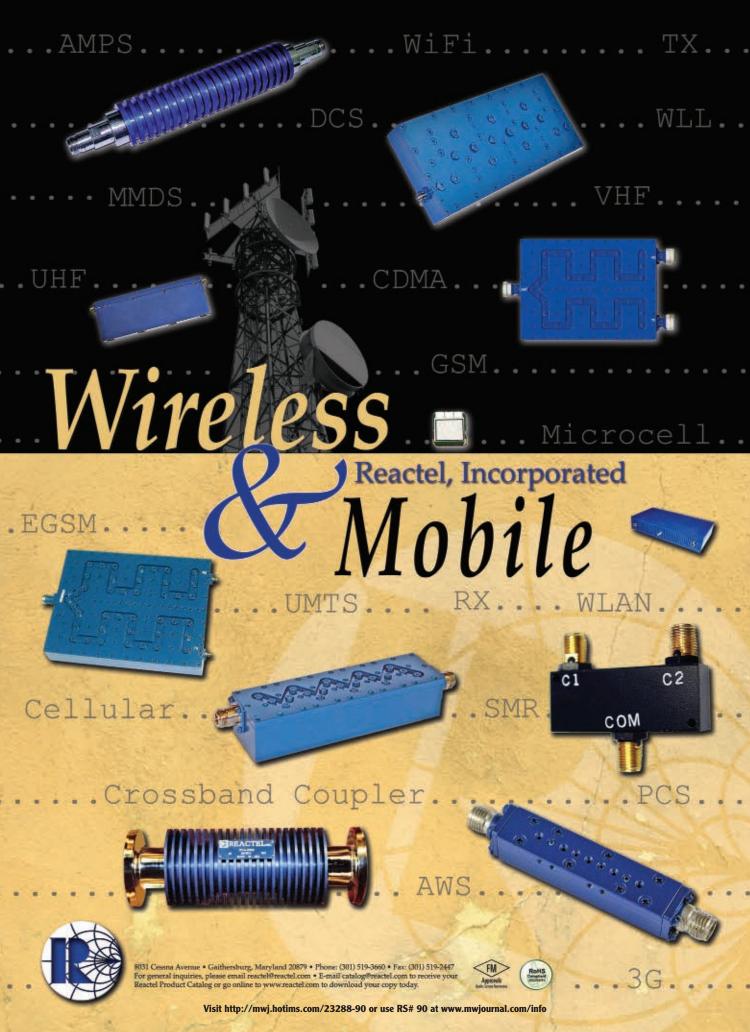
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International Report

Richard Mumford, International Editor

ETSI Creates
Aeronautical
Technical
Committee

•he European Telecommunications Standards Institute (ETSI) has established a new Technical Committee (TC AERO), whose work will focus primarily on supporting European initiatives in the Air Traffic Management sector. This committee will deal with interoperability aspects of the European Air Traffic Man-

agement Network (EATMN) under the Single European Sky regulation.

Under mandates from the European Commission it will be responsible for developing European standards satisfying the essential requirements and/or Implementing Rules of the Single European Sky Interoperability Regulation (552/2004/EC). This Regulation gives standards a central role in achieving its objectives, and the standards to be produced by the new committee will be given the status of Community Specifications when referenced by the EC in the Official Journal of the European Union (OJEU).

In addition to its role in creating candidate Community Specifications, the Aeronautical Technical Committee will produce other technical standards and reports related to interoperability in EATMN. It will liaise as necessary with other standards organizations, including CEN and CENELEC, and with relevant civil and military aeronautical organizations (such as ICAO and NATO). Specifically, the committee will work in close co-operation with the European Organization for Civil Aviation Equipment (EUROCAE), as explicitly required by the Interoperability Regulation, the European Organisation for the Safety of Air Navigation (EUROCONTROL) and the European Aviation Safety Agency (EASA).

It will also take into account the requirements of the International Telecommunication Union (ITU) and the European Conference of Posts & Telecommunications Administrations (CEPT) in the production of standards, studies and reports for radio communication, navigation and surveillance systems.

SESAR Injects €1.9 B into ATM Research

The Single European Sky ATM Research (SESAR) Joint Undertaking, a public-private partnership in air traffic management (ATM) research and development founded by the European Commission and EURO-CONTROL, has signed 16 contracts, totalling €1.9 B for the creation of Europe's future ATM system. These

contracts mark the beginning of the execution of the SES-AR programme.

Based on the Single European Sky legislative package, the mission of the SESAR Joint Undertaking (SJU) is to ensure the modernisation of the European air traffic management system by coordinating and concentrating all relevant research and development efforts in Europe. By 2020, SESAR aims to create the capability to handle a threefold increase in traffic in Europe, while improving safety by a factor of ten.

"In the context of a global recession, the financing and timely development of SESAR has become literally vital," commented Antonio Tajani, Commission Vice-president in charge of transport. "Public-private funding kicks in to support ATM research and development at a time when global economic uncertainty is prompting businesses to manage their cash with extreme caution. On top of green and safety objectives, SESAR will also contribute to the viability of the entire sector, as it will cut air transport operating costs in the longer term."

Shorter KTPs Launched in UK

programme of shorter Knowledge Transfer Partnerships (KTP), which enable collaboration between business, third sector organisations and academia, has been launched by the Technology Strategy Board, the government body responsible for promoting business innovation in the UK.

Building on shorter KTP

schemes already being offered by Regional Development Agencies and the Devolved Administrations, the existing national KTP Programme is expanding to offer organisations throughout the UK the opportunity to undertake shorter-term projects than have previously been available.

The new shorter KTP initiative is designed to be flexible and act as a stepping-stone for those businesses that may not have worked with higher or further education institutions before. It is expected to play a key role in enabling small organisations, in particular, to explore the benefits of collaboration.

Anglo-China Nanotechnology Collaboration

The UK Engineering and Physical Sciences Research Council (ESPRC) and the National Science Foundation of China have jointly awarded a team of researchers from the University of Surrey, UK, and two other institutions a grant of around £430,000 to develop ultrasmall-scale silicon structures for 'spintronic' semiconduc-

tors. It is hoped that the work could eventually lead to cheaper and more sophisticated processing technologies for use in computer technology.

Called 'Silicon-Based Nanospintronics', the grant brings together experts from the London Centre for Nanotech-

International Report



nology at University College London (UCL), the Institute of Microelectronics at Peking University and the University of Surrey's Advanced Technology Institute. The Institute for Plasma Physics in Utrecht, the Netherlands, with whom the University of Surrey has long-standing links, is an additional but informal partner for the project.

The proposal exploits the combination of Chinese excellence in silicon fabrication nanotechnology and UK expertise in observing and controlling the way electrons spin within semiconductors. It will last for approximately three years, and will involve several student exchanges between the University of Surrey and Peking University.

Silicon has not been highly studied for 'spintronic' purposes to date because of its very weak magnetic properties. This makes it difficult for researchers to manipulate the spins from clockwise to anti-clockwise and vice-versa. The 'Silicon-Based Nanospintronics' team has, however, proposed a new way of manipulating electron spins with laser beams, and the research programme has the objective of building a prototype device for this.

Eudyna/Sumitomo Restructure Business

With effect from 1 August, Sumitomo Electric Industries Ltd. and Eudyna Devices Inc. have reorganised their optical and electronic devices business by way of an absorption-type corporate split. On that date Eudyna also changed its corporate name to Sumitomo Electric Device Innovations Inc., while Excelight Communications Inc., the overseas sales base for optical and electronic devices, has changed its corporate name to Sumitomo Electric Device Innovations USA Inc. and integrated the business with Eudyna Devices USA.

Eudyna was established on 1 April 2004 as a 50-50 joint venture between Sumitomo Electric and Fujitsu Ltd. On 1 April 2009 Sumitomo Electric acquired the remaining 50 per cent of Eudyna stocks from Fujitsu, prompting the decision to combine the two companies' managerial resources and utilise them effectively.

Sumitomo Electric will succeed Eudyna's sales and marketing, strategic planning and research and development of the entire optical and electronic device business, while Eudyna, under its new name, will assume product development, manufacturing, sales engineering, quality assurance and purchasing (Japanese domestic procurement only) activities.

The restructuring is also intended to gear up Sumitomo Electric to meet more sophisticated and diversified needs for technology development and achieve synergy in its electronic device related study and network related product development.

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COMMERCIAL MARKET

Crystal Oscillator
Veterans Face
Challenge from
Silicon Upstarts

Vendors of crystal oscillators are the guardians of a design and manufacturing tradition going back to the early 20th century, and some of today's market participants trace their origins to those early days. Their products, evolved over more than 75 years, require craftsmanship and exacting fabrication skills to pro-

duce, and are found in a vast array of electronic equipment to this day.

Yet now, the market position of the crystal oscillator is threatened by a new set of devices grouped under the label "silicon timing solutions." The fortunes of these two contenders are tracked in a new study from ABI Research.

Virtually every device that contains an IC or generates a radio signal needs these devices. The incentives for equipment manufacturers to switch to silicon timing solutions? They are generally less expensive, more robust and can integrate other functions onto the chip. But although great strides have been and will be made, they do not yet equal crystal oscillators in accuracy and stability.

In order to maximize their long-term chances of holding market share, many crystal oscillator vendors are focusing on military, aerospace and industrial markets where accuracy is at a premium and buyers are somewhat less price-obsessed. Silicon timing solution vendors, on the other hand, see fertile territories in mainstream computing and consumer electronics with MIDs and netbooks, two particularly active new segments.

ABI Research's new study, "The Timing Solutions Market," examines the major categories of timing solutions and presents both market share data for the major device vendors and five-year forecasts in a multiple scenario context. It offers detailed discussions of both the applications and the timing solutions for those applications. The report also reviews the transition from quartz crystal controlled oscillators to complex silicon timing solutions ICs.

VSAT Weathers Economic Storm

The Strategy Analytics GaAs and Compound Semiconductor Technologies (GaAs) service report, "GaAs Device Opportunities from the SATCOM/VSAT Market: 2008-2013," concludes that long design cycles and pent-up demand driven by the consumer

sector will allow the very small aperture terminals (VSAT) market to weather the current economic storm better than most communications markets, translating into steady demand for GaAs devices.

GaAs semiconductor technology is used extensively in VSAT satellite communications systems for both the space and ground segments of the market. Strategy Analytics forecasts that GaAs device demand will grow at a CAAGR (compound annual average growth rate) of over 4 percent from 2008 to 2013. MMICs will dominate the volume and represent 57 percent of total GaAs revenues.

"The VSAT industry has had to learn some tough lessons over the past decade, but the result is a model focused on value-added services which is now being augmented by growth prospects in the broadband access arena," noted Asif Anwar at Strategy Analytics. "Advances in technology and economies of scale have combined to increase data rates while simultaneously reducing prices, opening up the opportunities for satellite communications to compete against other wireless and wired broadband technologies."

Anwar concluded, "We believe the demand for broadband services will fuel the rollout of VSAT systems through 2013, creating steady demand for GaAs semiconductors. The largest opportunities are for Ku- and Ka-band power amplifiers, where despite some threats from alternative technologies, GaAs will remain the dominant solution."

Space Systems/ Loral to Provide Satellites to Intelsat

Space Systems/Loral (SS/L), a subsidiary of Loral Space & Communications and a provider of commercial satellites, announced that it has been awarded a contract to provide two new satellites to Intelsat, a provider of fixed satellite services (FSS) worldwide. The two satellites, Intelsat-19 and Intel-

sat-20, will be among the most powerful FSS satellites ever built with unprecedented capacity to provide services for broadband, video and voice applications.

Intelsat-19 and Intelsat-20 will replace existing satellites that currently provide services to five continents and will offer services for broadcast television and telecommunications. The satellites also will have the capacity to support mobile communications and higher data rate network services.

Intelsat-19 is the 36th satellite that Space Systems/Loral will provide to Intelsat and is scheduled for launch in 2011. It will replace the Intelsat-8 satellite at 166 degrees east longitude. The satellite's C-band capacity will provide enhanced distribution of content throughout Asia-Pacific with reach to the Western United States. The increased Ku-band capacity, optimized to distribute services to Australia, will also support demand for mobility and enterprise network applications across the Asia-Pacific region.

Intelsat-20 is the 37th satellite that Space Systems/Loral will provide to Intelsat and is scheduled for launch in 2012. The Intelsat-20 satellite will replace the Intelsat-7 and Intelsat-10 satellites, which are co-located at 68.5 degrees east longitude. The new satellite's C- and Ku-band payload is optimized for high-power distribution of video, voice and data network services.

Both satellites are built on the highly reliable Space Systems/Loral 1300 satellite platform, which provides the flex-



COMMERCIAL MARKET

ibility for a broad range of applications. They are designed to provide service for at least 15 years.

With Intelsat-19 and Intelsat-20, Space Systems/Loral will have a total of four Intelsat spacecraft in its manufacturing facility with a record breaking 288 36 MHz transponder equivalents of capacity under construction for Intelsat.

Escape Communications Announces Alldigital Gigabit Ethernet Modem

Escape Communications Inc., a developer of signal processing solutions for wireless communication products and systems, announced completion of a Gigabit Ethernet modem for millimeterwave wireless transmission systems. This reconfigurable single chip modem is an all-digital modem specifically designed for compatibility

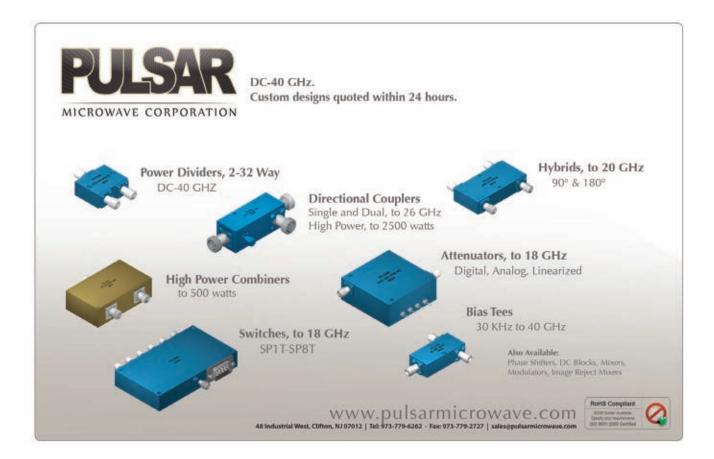
with the European 250 MHz channel allocations for the 60, 70 and 80 GHz mm-wave V- and E-bands. The Gigabit Ethernet modem features a vector-based signal processing architecture originally developed by Escape in support of the very high volume market of wireless fiber-to-the-home. Earlier this year, Escape announced another derivative of this technology: the Multi-rate Multi-mode Demodulator, which operates over variable rates of 1 Mbps to 4 Gbps and modulation

types of QPSK, MSK, 8-PSK, 16-APSK and 32-APSK (APSK per DVB-S2).

Visant Strategies recently reported that applications in the mobile backhaul and consumer electronics markets will drive the creation of a mm-wave market with revenues in excess of \$1.5 B by 2014. According to the 2009 Visant report, the most promising mm-wave segment is 71 to 86 GHz E-band backhaul for rapidly expanding LTE, WiMAX and HSPA+wireless networks. Nearly 50 times the number of 60 GHz V-band and 70/80 GHz E-band point-to-point radios are predicted to be shipped in 2014 compared to 2008.

The Escape Gigabit Ethernet all-digital modem module supports full duplex operation in the 250 MHz mm-wave channels defined by European CEPT rules. The all-digital design accommodates configurable high-order modulation types, arbitrary symbol rates, and configurable forward error-correction schemes. It includes advanced carrier tracking to compensate for low-cost mm-wave sources with poor phase noise. The modem is implemented in a single FPGA and supports field upgradeability.

"We are extremely proud to announce the completion of our all-digital modem for the emerging mm-wave market-place," said Co-founder and CEO, Michael Stewart. "We have focused early on compliance with the CEPT-defined 250 MHz channels and have succeeded in developing a reconfigurable modem module that is available now, but can be readily scaled to support higher data rates and more comprehensive feature sets as the market emerges and grows."



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AROUND THE CIRCUIT

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INDUSTRY NEWS

- Aeroflex and w2bi (Wireless to Business Integration) announced that they have entered into an agreement to pool their test expertise and technology for the joint development of a network certification platform for LTE mobile devices. The combination of Aeroflex's highly successful 7100 LTE test system integrated with w2bi's Q-GENERIC automated test solution will create a versatile LTE handset certification platform for network operators, device manufacturers and test labs worldwide.
- Lockheed Martin has entered into a US Department of Defense Mentor-Protégé Agreement with M2 Global Technology Ltd., San Antonio, TX, a small business supplier to Lockheed Martin's F-16, F-22 and F-35 programs. Over the one-year period of the Mentor-Protégé relationship, Lockheed Martin Aeronautics will assist and guide M2 Global, a service disabled veteran-owned small business, in the further development and refinement of the manufacturing and management processes needed to better serve its key aerospace, defense and commercial markets.
- Peregrine Semiconductor Corp., a supplier of highperformance RF CMOS and mixed-signal communications ICs, and MagnaChip Semiconductor Ltd., an Asia-based designer and manufacturer of analog and mixed-signal semiconductor products for high volume consumer applications, announced that the companies have completed the final qualification phase in the process technology transfer of Peregrine's UltraCMOSTM SOS (Silicon-On-Sapphire) technology to MagnaChip's Cheongju wafer manufacturing facility. Peregrine and MagnaChip began the final qualification phase of the technology transfer in July 2008 and released it to production eight weeks ago. The 10-month qualification cycle of UltraCMOS technology is exceptionally short due to its standard CMOS foundation.
- The University of California, San Diego (UCSD), provider of a program in microwave and millimeter-wave RF-ICs and mixed-signal, and Jazz Semiconductor®, a Tower Group company, announced that they have collaborated to develop a two-antenna quad-beam RFIC phased-array receiver covering the 11 to 15 GHz frequency range. First time success was achieved using Jazz Semiconductor's high performance 0.18-micron SiGe BiCMOS process and its own proprietary models, kit and DIRECT Multiproject Wafer (MPW) program. The chip was designed and tested by the Electrical and Computer Engineering School at UCSD, and was sponsored by the DARPA RF VLSI program, Mark Rosker, Program Monitor.
- RF Micro Devices Inc. (RFMD) announced the company has formed a gallium nitride (GaN) Foundry Services business unit to supply high reliability, high performance and price-competitive GaN semiconductor technology into

multiple RF power markets. The RFMD GaN Foundry Services business unit will leverage the company's industry leadership in gallium arsenide (GaAs) manufacturing capacity and cycle times, as well as a range of new customer services, to drive shorter time-to-market and minimize time between initial wafer order and final delivery. RFMD's GaN manufacturing is interchangeable with its GaAs manufacturing and directly benefits from the scale and demonstrated expertise of RFMD's industry-leading wafer fabrication capability.

- Empower RF Systems, a manufacturer of solid-state power amplifiers and amplifier-based solutions, announced the opening of a Regional Design Center located in Holbrook, NY. The establishment of the Regional Design Center expands the company's engineering capabilities and will play a key role in product development, device evaluation, customer technical support and business development initiatives. Robert Lauria, Engineering Director and 25-year RF industry veteran, is responsible for leading the Regional Design Center technical team. Bill Liebman manages the overall operation and is also responsible for assigned business development activities.
- **Phonon Corp.**, a privately-held corporation, broke ground May 6th to construct a 15,000 square foot addition to its headquarters to provide more space for engineering and to expand manufacturing capacity to support future revenue growth. Phonon Corp. designs, manufactures and markets a broad range of signal processing products for defense and satellite markets including the emerging Homeland Security initiatives for communications, surveillance and information gathering based on surface acoustic wave technology.
- Trilithic Inc. announced that it is among the first companies to achieve the coveted and recently released International Organization for Standardization (ISO) ISO 9001:2008 certification requirements. By completing the certification to the ISO 9001:2008 standard, Trilithic demonstrates highly effective business processes, commitment to continuous quality improvement and a focus on customer satisfaction.
- TriQuint Semiconductor, an RF product manufacturer and foundry services provider, has been accredited by the Department of Defense (DoD) as a Category 1A 'Trusted Foundry' for its 100 mm gallium arsenide (GaAs) facilities in Richardson, TX. Accreditation expands Tri-Quint's wide-ranging GaAs circuit fabrication capabilities by including classified programs; a Category 1A designation is the highest awarded by the DoD.

CONTRACTS

■ L-3 Communications announced that its MPRI division has been awarded a follow-on contract by the US Air Forces Europe (USAFE). This five-year IDIQ contract consists of a base year plus four option years, with a total contract potential of \$375 M. Under this contract, L-3 will

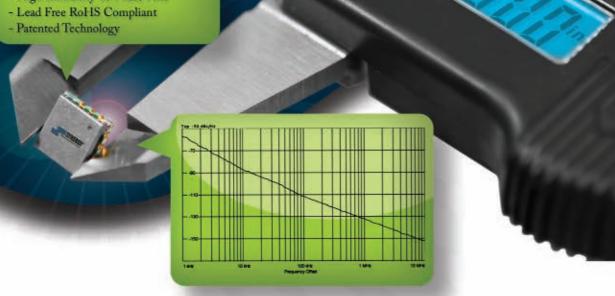


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DCO Series					M
DCO1198-8	1198.4 - 1198.7	0.5 - 7.5	+8 @ 30 mA	-116	wiew/
DCO170340-5	1700 - 3400	0.5 - 24	+5 @ 24 mA	-90	
DC0200400-5 DC0200400-3	2000 - 4000	0.5 - 18	+5 @ 35 mA +3 @ 35 mA	-90 -89	Models 0.3 x v
DCO300600-5 DCO300600-3	3000 - 6000	0.5 - 18	+5 @ 35 mA +3 @ 35 mA	-80 -78	0.3 x 0.3 x 0.1
DCO400800-5 DCO400800-3	4000 - 8000	0.5 - 18	+5 @ 35 mA +3 @ 35 mA	-78 -76	0.3 x 0.3 x 0.1
DCO432493-5 DCO432493-3	4325 - 4950	0.5 - 11	+5 @ 17 mA +3 @ 17 mA	-88 -86	0.3 x 0.3 x 0.1
DCO473542-5 DCO473542-3	4730 - 5420	0.5 - 22	+5 @ 20 mA +3 @ 20 mA	-88 -86	0.3 × 0.3 × 0.1
DCO490517-5 DCO490517-3	4900 - 5175	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 × 0.3 × 0.1
DCO495550-5 DCO495550-3	4950 - 5500	0.5 - 12	+5 @ 22 mA +3 @ 22 mA	-87 -85	0.3 x 0.3 x 0.1
DCO608634-5 DCO608634-3	6080 - 6340	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-86 -84	0.3 x 0.3 x 0.1
DCO615712-5 DCO615712-3	6150 - 7120	0.5 - 18	+5 @ 22 mA +3 @ 22 mA	-85 -83	0.3 x 0.3 x 0.1
DXO Series			t	2396	
DXO810900-5 DXO810900-3	8100 - 8800	0.5 - 16	+5 @ 22 mA +3 @ 22 mA	-82 -80	0.3 x 0.3 x 0.1
DXO900965-5 DXO900965-3	9000 - 9650	0.5 - 16	+5 @ 22 mA +3 @ 22 mA	-80 -78	0.3 x 0.3 x 0.1

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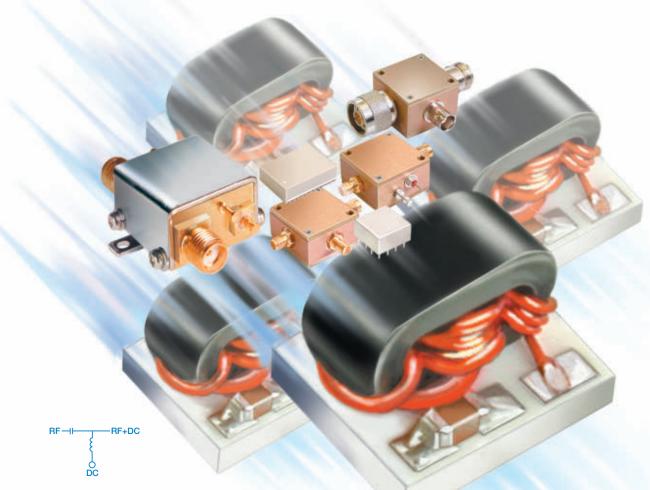
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provide the USAFE with a variety of advisory and assistance services (A&AS), including engineering and technical services; management and professional support; and studies, analysis and evaluation services to maintain and enhance government owned computer software and provide intelligence analysis support. These activities will be provided to the headquarters of the European Command and its subordinate commands throughout Europe.

- OEwaves Inc. has been awarded phase II of an earlier contract by Lockheed Martin Maritime Systems & Sensors, in support of a Science and Technology contract from the US Army Research Development and Development Command's Aviation and Missile Research Development and Engineering Center to develop and demonstrate critical technologies that bridge the gap between existing capabilities and the Army vision for future protection capabilities. In this phase, OEwaves will deliver multiple brass board hardware as part of a complete program with a potential total value of approximately \$5 M.
- **Tahoe RF Semiconductor Inc.** announced that it has received an STTR Phase I award from the US Navy for the development of Novel Phase Shifterless RF Phase Array Antenna Systems (N09-T035). The STTR Program provides up to \$850,000 in early-stage R&D funding directly to small companies working cooperatively with researchers at universities and other research institutions. Tahoe RF will conduct the development in cooperation with Professor James Buckwalter's team at the University of California San Diego.
- HRL Laboratories LLC announced it received a Phase II, 18-month contract from the Defense Advanced Research Projects Agency (DARPA) to continue its groundbreaking work on the COSMOS program, or COmpound Semiconductor Materials on Silicon. The goal of the DAR-PA/Air Force Research Laboratory program is to develop new methods to tightly integrate compound semiconductor technologies with state-of-the-art CMOS circuits in order to achieve unprecedented levels of circuit performance.

PERSONNEL

■ M/A-COM Technology Solutions announced the appointment of Joseph G. Thomas to Chief Executive Officer. He previously served as President. Thomas has been with the company for 35 years, serving in a number of senior management positions. He has led growth teams addressing multiple markets, ranging from consumer entertainment to strategic defense applications. Prior to joining the company, Thomas was an Engineering Manager with Micro Dynamics in Woburn, MA. In related news, M/A-COM Technology Solutions recently announced the appointment of **Conrad Gagnon** to Chief Financial Officer. Gagnon has been with the company for more than 25 years and has served in a number of leadership roles in finance, sales and marketing, acquisitions, new ventures and portfolio management. Prior to joining the company, Gagnon was Cost and Budget Manager at Ingersoll-Rand.



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Model	Freq	Insertion	Isolation	VSWR	Price \$ea.		
	(MHz)	Loss (dB)	(dB)	(:1)	Qty.10		
TCBT-2R5G TCBT-6G TCBT: LTCC, Actua	20-2500 50-6000 Size .15"x.15	0.35 0.7 5". U.S. Pate	44 28 ent 7.012.4	1.10 1.20	6.95 * 9.95		
					Qty.1-9		
JEBT-4R2G	10-4200	0.6	40	1.10	39.95		
JEBT-4R2GW	0.1-4200	0.6	40	1.10	59.95		
PBTC-1G	10-1000	0.3	33	1.10	25.95		
PBTC-3G	10-3000	0.3	30	1.13	35.95		
PBTC-1GW	0.1-1000	0.3	33	1.10	35.95		
PBTC-3GW	0.1-3000	0.3	30	1.13	46.95		
ZFBT-4R2G	10-4200	0.6	40	1.13	59.95		
ZFBT-6G	10-6000	0.6	40	1.13	79.95		
ZFBT-4R2GW	0.1-4200	0.6	40	1.13	79.95		
ZFBT-6GW	0.1-6000	0.6	40	1.13	89.95		
ZFBT-4R2G-FT	10-4200	0.6	N/A	1.13	59.95		
ZFBT-6G-FT	10-6000	0.6	N/A	1.13	79.95		
ZFBT-4R2GW-FT	0.1-4200	0.6	N/A	1.13	79.95		
ZFBT-6GW-FT	0.1-6000	0.6	N/A	1.13	89.95		
ZNBT-60-1W	2.5-6000	0.6	45	1.10	82.95		
ZX85-12G+ ZX85: U.S. Patent 6,		0.6	N/A	1.20	99.95		

Note: Isolation dB applies to DC to (RF) and DC to (RF+DC) ports.







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■ ANADIGICS Inc. announced that it has appointed **Russ Wagner** as Vice President, Operations. Wagner joined the company in September, 2007, as part of ANADIGIC's acquisition of Fairchild Semiconductor's RF design team. Wagner brings over 15 years of valuable semiconductor industry experience to the position. At both Fairchild and Raytheon RF Components he was responsible for strategic and tactical management of engineering and product development, operations, foundries and world-class supply chain management.

■ Akon Inc., a leader in RF microwave components and subsystems for military, space, and commercial applications,



▲ Dennis Tuccori

is pleased to announce the appointment of **Dennis Tuccori** as a Director of Sales and Marketing. Tuccori brings with him years of experience working for companies such as Celeritek, Loral-Narda West and Aydin Microwave. He joined Akon in April, 2009. He will be responsible for sales in the United States and Asia

Ducommun Technologies announced **Michael Cronin** has joined Ducommun Technologies as a Business



Michael Cronii

Development Manager. Cronin's primary responsibilities will be the sale of Ducommun's microwave and millimeterwave products. Cronin was previously with First Alliance Electronics in Denver, CO as a manufacturer's representative. His background encompasses progressively responsible positions with National Semiconductor, Front Range Microwave and Vari-L Corp. During this time, he sold RF and microwave

products into the aerospace and commercial business. Cronin brings over 20 years of sales and marketing experience.

REP APPOINTMENTS

■ Linx Technologies Inc. announced the appointment of Future Electronics Inc. as a worldwide stocking distributor for its full product line, including RF modules, OEM products, antennas, connectors, ICs, interface modules and development systems. Linx products simplify challenging areas of electronics, such as RF, by providing solutions, which can be quickly and easily applied by engineers of all skill levels. Future's strong application engineering, marketing and volume OEM orientation will provide Linx with a differentiated partner and the opportunity to better serve customers globally.

■ Reactel Inc., a manufacturer of RF and microwave filters, multiplexers, switched filter banks and subassemblies to the commercial, military, industrial and medical industries, announced the appointment of **Comp-Tech Sales** as the company's exclusive representative in New York and New Jersey. For more information about Comp-Tech Sales, please visit www.comp-techsales.com or telephone Buss Muniz at (201) 288-7400.

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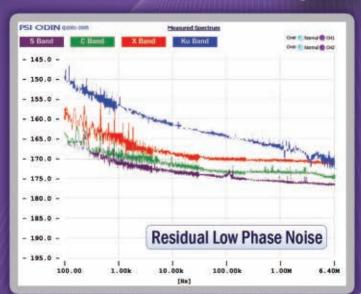
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MULTI-BEAM SCANNING LENS ANTENNA FOR SATELLITE COMMUNICATIONS TO TRAINS

Internet and wireless communications services whether they are at home, at the work desk, or on the move. Wireless connectivity is increasingly being offered to rail passengers where it is also often cited as an incentive to attract travelers to choose rail over other transport modalities.

When rail passengers use a wireless local area network (LAN) within the vehicle compartment, the connection of this LAN to the Internet backbone can present a significant technical challenge. Numerous competing requirements include the need for good geographical coverage and availability; quality of service; sufficient bandwidth; and a cost that

is acceptable to the consumer. Solutions have included uni- or bi-directional satbundled cell phone lines; wireless hotspots in stations: and combinations of these measures.1 Proposed solutions include WiMAX, for which a good deal of terrestrial

infrastructure would be needed, high altitude platforms, for which the aeronautical technology is not sufficiently mature, and 3G mobile networks, which tend to lack sufficient geographical coverage. Satellite has emerged as offering the winning combination of coverage and bandwidth, either in isolation or as part of a multi-bearer solution.

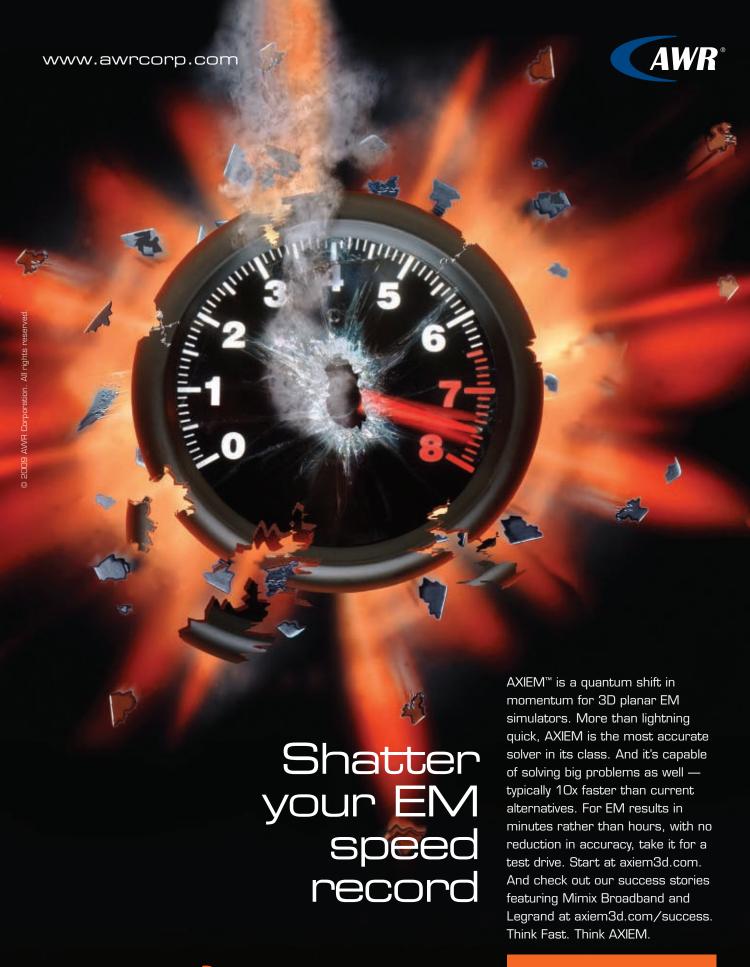
A broadband access service launched fully in Europe in 2008, following a trial phase supported by the European Space Agency² and led by Thales and 21Net Ltd., uses a two-way satellite link in Ku-band. This relies entirely on a tracking reflector antenna on the train's roof (see *Figure 1*). The radome height is 72 cm; this limits the number of railway routes where services can be offered due to the need for this headroom. Clearly, a lower profile scanning antenna would open up the scope for wider geographical availability of this service.

LENS ANTENNA

Solutions for scanning antennas are too numerous for a proper review to be feasible in this article but are often based on array techniques, either through mechanically scanned sub-

▲ Fig. 1 Legacy satellite antenna on train (source: European Space Agency).

JOHN THORNTON, ANDY WHITE AND GRAHAM LONG University of York, UK



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50 - 1000	22	2.2	-67/-60
50 - 1000	23	2.0	-68/-60
50 - 1000	11	4	-75/-62
50 ~ 2200	20	2.0	-71/-60
50 ~ 1000	25	2.0	-70/-55
	50 - 1000 50 - 2200 50 - 1000 50 - 1000 50 - 1000 50 - 2200 50 - 1000	50 - 1000 20 50 - 2200 19 50 - 1000 22 50 - 1000 23 50 - 1000 11 50 - 2200 20 50 - 1000 25	50 - 1000 20 1.0 50 - 2200 19 3.2 50 - 1000 22 2.2 50 - 1000 23 2.0 50 - 1000 11 4 50 - 2200 20 2.0

Push Pull MMIC (75Q)

Part Number	Freq. (MHz)	Gain (dB)	NF (dB)			
AE514***	50 ~ 2200	18	2,5	-63/-70		
AE617***	50 ~ 1000	22	2,3	-64/-63		
AE627***	50 ~ 1000	19	3,7	-67/-73		
AE618***	50 ~ 1000	20,8	3	-68/-73		
*** 79 Channels, +39dBmV/ch, Single						

Active Divider (75Q)

Part Number		Freq.	Gain (dB)		CTB/CSO (dBc)
AD311	50	~ 1000	4.2	4.2	-71/-63
AD412	50	~ 1000	4.3	5	-71/-65
* 135 Channels, Input +15dBmV/ch, Single					



arrays or phased array/beamforming techniques, and so inevitably suffer to some extent from scanning loss. Thus, arrays don't always offer an acceptable combination of efficiency, scan performance and cost. This led to a re-evaluation of the scanning lens antenna as a lower profile solution while offering comparable efficiency to a reflector, i.e. a similar gain for a given aperture area. The spherical lens antenna is well-known for its scanning and multiple beam capabilities, and chief variants are the constantindex lens and the stepped-index or Luneburg lens. The former works well for modest aperture size, but the efficiency falls off for an electrically large lens. The latter offers very high efficiency in theory, but is problematic to manufacture: The use of many concentric dielectric layers and eradication air gaps between them are difficult to achieve. A beneficial variant is the use of a hemispherical lens above a ground plane since this yields an equivalent aperture diameter, but in half the height. The current work was particularly inspired by a twolayer stepped-index hemispherical lens antenna that was developed for Ka-band.^{3,4} This used readily available dielectric polymers and achieved a measured gain in the region 35 dBi at 28 to 31 GHz from a diameter of 236 mm, being an estimated aperture efficiency of 68 percent. This article will describe how this lens design was scaled in size and frequency and combined with a mechanical scanning system to allow independent beam steering of two primary feeds, thus offering satellite diversity.

FIRST DESIGN PHASE

The project comprised two main strands: The development of a 61 cm stepped-index lens based on the electromagnetic design of the Ka-band scale model; and development of the

TABLE I					
MECHANICAL SCAN REQUIREMENTS					
Elevation scan range	13° to 62°				
Pointing error no worse than	0.2° RMS, 0.4° peak				
Maximum rate of roll, pitch and yaw	5°/s				
Maximum elevation acceleration	1°/s²				
Maximum azimuth acceleration	4°/s²				

mechanical scanning system. To a large extent these two strands were pursued independently and brought together towards the end of the program. This also de-risked the problem of fabricating the polymer lens, since the mechanical system could also be used with a commercially available Luneburg-type lens. The end goal was a prototype suitable for demonstration of proof-of-concept and feasibility of use rather than a commercial offering.

The mechanical design began with a 'clean sheet' and a number of configurations were considered. A key driver was minimizing the antenna height and so any geometries where components were placed below the ground plane were rejected. Accelerometer data from earlier railway trials were examined so as to derive the required maximum beam steering acceleration and velocity; these figures are summarized in **Table 1**.

The elevation scan range was derived from the anticipated extremes of latitude for rail routes within Europe, to which was added 7° to accommodate maximum train pitch and roll angles. The initial mechanical concept is sketched in Figure 2 where some basic features were established:

- Each feed runs along an elevation rail, driven by a timing belt
- Two elevation arms attached to a shared azimuth rail
- Elevation and azimuth motors fixed

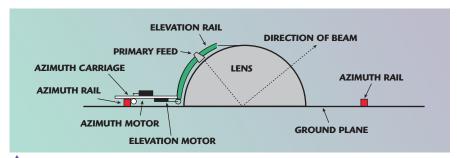


Fig. 2 Basic mechanical scanning concept, elevation view.



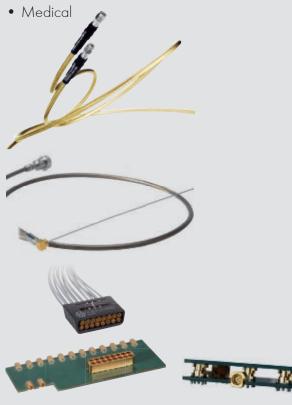


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RWP03080-10 *	38	80
RWP03160-10 *	22	160

20-1000MHz products

Part Number	Gain (dB)	Psat (W)
RWP05020-10	37	20
RWP05040-10	37	40

450-870MHz products

Part Number	Gain (48)	Psat:
RWP06040-10	37	40
RWF05080-10 *	35	85
RWF05150-10 *	22	150
# Halasica critical/last VIIII)	CE .	



500-2500MHz products

Part Number	Gain (dB)	Psat (W)	Size (MM)
RUP15010-10	14	10	55x30
RUP15010-11	57	10	120x80
RUP15020-10	15	20	60.4x30.2
RUP15020-11	57	20	120x80
RUP15030-10	14	30	90x50
RUP15050-10	- 11	50	100x50
RUP15100-10	55	100	130x60

2500-6000MHz products*

Gain (dB)	Psat (W)	Size (MM)
8	10	70x35
7	20	75×35
	(dB)	(dB) (W) 8 10

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RRP29080-11	2.7-3.1	35	80
RRP29250-11	2.7-3.1	32	250
RRP29300-10	2.7-3.1	9	300
RRP31080-11	2.9-3.3	34	80
RRP31250-11	2.9-3.3	32	250
RRP31300-10	29-33	8.5	300
RRP33080-11	3.1-3.5	33	80
RRP33250-11	3,1-3,5	31	250
RRP33300-10	3.1-3.5	- 8	300

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In this configuration the major components move with the azimuth carriage and thus never obstruct the opposite side of the lens and ground plane. In contrast, fixing components such as motors to the ground plane would lead to aperture blockage for certain azimuth beam steering angles. Thus, only the azimuth rail blocks the aperture, and so it is advantageous to place it at a reasonable distance from the lens edge.

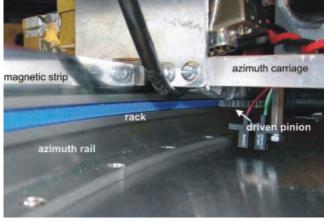
DETAILED MECHANICAL DESIGN

Having established a basic geometry, this was worked out in proper detail. The mechanical and RF requirements were often competing and thus compromises had to be established. The elevation and azimuth rails are among the most complex and important geometries, being curved components that perform numerous functions. The azimuth rail in par-

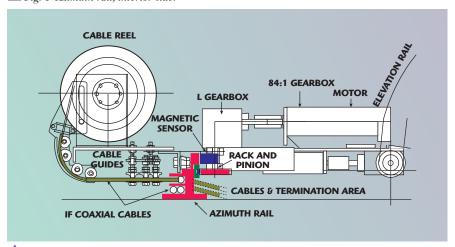
ticular houses the toothed rack and magnetic sensor strip on the interior side (see Figure 3) and vertically stacked cable guides on the outside face. Routing a number of flexible cables proved challenging since there are three IF circuits (one for Ku-band receive, one each for Kaband transmit and receive) and one control circuit. Accordingly, each of the two azimuth carriages carry two cable spools and the cables are guided into the slots on the azimuth rail by a system of small pulley wheels, illustrated in the lower left region of the elevation view drawing of Figure 4. The first iteration of the cable feed system is also shown in the photograph of Figure 5, here shown parked opposite the aperture where the cables are routed through the azimuth rail. As the carriage scans to the left or right of this region, the cables are laid in the grooves in the azimuth rail. Also just visible in this image (lower right) are four holes through which coaxial cables are routed to the exterior, thus avoiding

placing any components below the ground plane. Figure 6 shows the slip ring (left) and RF rotary joint (right) installed and connected in the final version of the cable spools.

The aperture blockage caused by the azimuth rail (highlighted red in Figure 4) gave some concern, since this



📤 Fig. 3 Azimuth rail, interior side.



lacktriangle Fig. 4 Elevation schematic of components carried by carriage and azimuth rail.

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XC0900P-10	0.8-1.0	55
XC0900A-05	0.8-1.0	250
XC0900A-10	0.8-1.0	250
XC0900A-20	0.8-1.0	200
XC0900B-30	0.8-1.0	355
XC1500A-20	1.0-2.0	150
1P510	1.7-2.0	20
1P520	1.7-2.0	25
XC1900E-10	1.7-2.0	175
XC1900A-05	1.7-2.0	200
XC1900A-10	1.7-2.0	175
XC1900A-20	1.7-2.0	150
JP506	2.0-2.3	20
JP510	2.0-2.3	20

Part Number	Frequency (GHz)	Power (W)
JP520	2.0-2.3	25
XC2100E-10	2.0-2.3	165
XC2100A-05	2.0-2.3	175
XC2100A-10	2.0-2.3	175
XC2100A-20	2.0-2.3	150
XC2100A-30	2.0-2.3	120
XC2100B-30	1.8-2.7	300
1P610	2.3-2.7	20
1P620	2.3-2.7	25
XC2500P-20	2.3-2.7	20
XC2500E-10	2.3-2.7	145
1M710	3.3-3.7	22
XC3500P-20	3.3-3.8	45
XC3500M-20	3.3-3.8	60
1M810	5.0-6.0	15



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LL0120-1 LL0120-2 LL0120-3 LL0120-4	0.1 - 2.0	-10 - 5 0 + 5		-11 - 6 - 1 + 4
LL2018-1 LL2018-2 LL2018-3	2-18	*	-10 TO -5 - 5 TO 0 0 TO+5	-10 - 5 0

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would introduce a scanning loss at low elevation angles. However, these components had to be procured very early in the design and construction phase and hence for this first iteration had a conservative design that can accommodate a range of cable thicknesses and the magnetic sensor which ultimately may be dispensed with. Measurements on a scale model at 30 GHz indicate that the scanning loss caused by this version of the azimuth rail is only measurable as the elevation angle approaches 30° or less, and at 18° would be about 1.5 dB. This could be reduced by slimming down the height of the rail. A more elegant solution could use optical IF distribution for the aggregate 5 GHz of IF bandwidth, thus reducing the reliance on coaxial cable. This approach has been studied for a future

Figure 7 shows the electromechanical system fully assembled, shown around a dummy lens. The main components and

phase.

features are labeled. The two independently steered beams allow for the operator to use satellite diversity. The minimum relative satellite azimuth is limited by the relative positions of the two primary feeds and increases with increasing elevation angle, the worst case being an azimuth spacing of 21°. Thus, satellites more closely spaced than this cannot always be used simultaneously.



Fig. 5 Cable reel and guides on exterior side of azimuth rail.

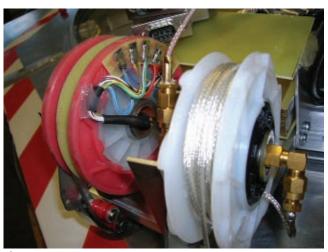


Fig. 6 Slip ring (left) and rotary joint (right) installed in cable

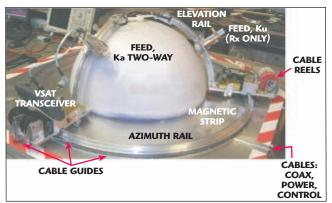


Fig. 7 Fully assembled electro-mechanical system.

In the present design, there is a Ku-band receive only beam, which is the most straightforward and uses a low cost domestic satellite TV low noise block converter as the feed. This produces an IF output at 900 to 2100 MHz, which is routed via spooled coaxial cable and RF rotary joint to an exterior receiver. The other beam is intended for two-way communications at Ka-band, namely a 20 GHz receive and 30 GHz transmit frequency plan,

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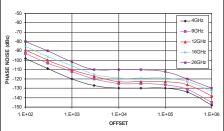
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as used in the US by domestic twoway satellite Internet services, and soon to be offered in Europe following the launch of HYLAS, the 'highly adaptive satellite's that will have both Ku- and Ka-band transponders. For the two-way beam, two IF circuits are needed and these are also distributed by spooled coaxial cables. A Ka-band VSAT transceiver was adapted, this being a convenient short cut to demonstrating the required functionality. This unit needs to be placed as close to the feed as possible to minimize interconnection losses, and has been housed on the azimuth carriage. Flexible cables route the 20/30 GHz signals to the feed and introduce a minimal loss of less than 1 dB. An orthomode transducer is used at the feed.

MOTORS AND INTERFACES, POWER AND CONTROL

Servo motors are used for the azimuth and elevation drive, i.e. where maximum torque and acceleration can be employed using feedback control rather than open-loop steppers. The azimuth motors carry more load and are thus higher power items than the elevation motors. In-line gearboxes are used. The Maxon motors are each controlled via a Maxon 'EPOS' unit, a modular-designed digital positioning system suitable for electronically commutated motors. Each motor is fitted with an incremental shaft encoder giving the ability for position resolution to 1/2000 of a turn. The EPOS units use auto-tuning software to enable the individual motor current, velocity and position gains to be adjusted for optimal regulation, which helped speed up the integration of the motor drive system to the antenna system.

The four individual EPOS control units connect to a common two-wire Controller Area Network (CAN) bus. The same CAN bus is also used for the interconnection of the other microcontroller systems so each unit becomes a CAN node. The CAN bus is ideal for this application, requiring very few conductors to form the bus; it is thus light weight and the cables can be both small and flexible minimizing motor load. In the present design the CAN cable is also spooled, which is why a total of four spools are used. Ultimately, the CAN signals could also be carried over RF and thus share one of the IF coaxial cables, which would reduce the total number of cables needed. The CAN bus was initially designed for use in motor vehicles and as such has a fast robust communication protocol that efficiently handles errors. The final deployment of this type of antenna system will be into an environment with a large amount of electrical noise due to the close proximity of the train pantograph and the overhead power line; the CAN bus is well suited to this environment. The protocol has several error detection strategies to avoid invalid data being acted upon. Individual CAN nodes also have the ability to determine fault conditions and transition to different modes based of the severity of the problems being encountered, if necessary even removing themselves from the bus in order to maintain bus integrity.

DC POWER

Power to each of the azimuth carriage assemblies is fed via a spooled multi-core cable and slip ring, the DC power being decoupled from the RF signals. The DC power is supplied at a voltage level of approximately 30 V. Although this level is not directly required with the antenna system, the use of the high level reduces the transmission losses in the feed cable. After filtering to remove electrical noise including transients, the high level DC is transformed to the various required low voltage levels by means of switch mode power supplies. The peak current drawn by the motor system does not exceed 600 mA.

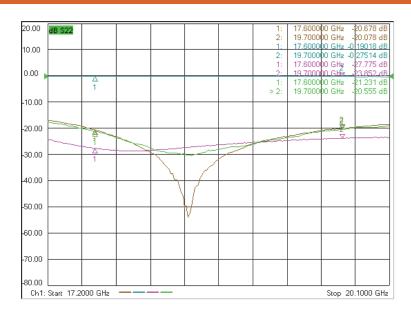
MAGNETIC LINEAR MEASUREMENT SYSTEM

In order to measure the overall accuracy of the Maxon motor control system and if necessary to provide an input to the final control loop, the prototype system incorporates an Elgo magnetic linear measurement system. This gives very precise (~micron) linear measurement and was used mainly to characterize the precision of the motor system. Ultimately, a magnetic system is probably not needed because the accuracy and reliability of the motor system is very good. Thus, a complex closed-loop control system, whereby a positional measurement is made after a command to move is is-

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TECDİA

Solution for GaN FET



Tecdia introduces the SBT-GF0702 high voltage Bias-T.

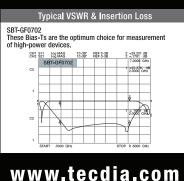
The SBT-GF0702 is capable of handling up to 10 amps of DC current at 150V to apply bias to RF signals within the range of $2\sim7$ GHz.

For many years Tecdia has produced top of the line high current (5, 10 and 20A) bias tee models capable of handling a DC bias voltage of 30V, and RF power of 50W. Now, to meet the higher voltage and power requirements of GaN devices, Tecdia is introducing this new design that has the following specifications:

SPECIFICATION

Series		SBT		
Model	Model		F0702	
Frequency Ra	nge	2~7	GHz	
Insertion Loss		0.5dB max.		
VSWR (Return	loss)	1.22 max. (20dB min.)		
Connectors RF		APC-7		
Connectors	DC		BNC-R (Female)	
RF Power		50W max.	100W max.	
Bias Current		20A max.	10A max.	
Bias Voltage		30V max.	150V max.	
Dimensions (n	nm)*	50 x 52 x 20		
Weight		200g		

* Excluding Connectors



sued and any necessary correction implemented, should not be necessary because of the high confidence that the magnitude of any such correction term will always be insignificant.

DEVELOPMENT OF 61 CM STEPPED-INDEX LENS

The two-layer hemispherical lens geometry, although conceptually ple, proved verv difficult to implement with the required dimensions. In parallel with the development of the mechanical system, various approaches to lens manufacture were examined. Specialist moldable (including syntactic foam) were investi-

gated, but they could not be obtained in an uncured state. Anticipating use of such materials, a set of aluminum molds was also acquired. Another promising lead was the use of polyurethane foam, where dielectric constant varies roughly linearly with the polymer-to-air ratio. For a while this looked like a solution that could be manufactured at low cost by molding. Ultimately, however, following a number of measurements on various samples of this material, the loss tangent appeared to be too high to meet the requirements so this line of enquiry also had to be abandoned. Possibly the best material for this application would be an "artificial dielectric" such as ceramic-loaded low loss foam,6 but these are not readily available and really need further development. Finally, the investigation returned full circle to pursue manufacture from polymer billets of polyethylene and Rexolite. As a polyethylene billet of sufficient thickness could not be obtained, a pseudo-billet was fabricated by bolting together two thick slabs. This was then turned into the lens



▲ Fig. 8 Receiving satellite TV at 11 GHz.



dielectric products A Fig. 9 Outdoor mobile test laboratory.

outer layer on a large CNC machine. The Rexolite inner hemisphere was machined from a single billet.

Figure 8 shows the lens in use with a domestic satellite TV receiver. Also shown is a conventional dish antenna of average diameter 62 cm. The received signal strength from 10.7 to 12.5 GHz was found to be equivalent for both dish and lens. A commercially available quasi-Luneburg lens was also used for comparison that comprises 7 layers of polystyrene foam according to traditional principles. While this worked reasonably well, the received power was on average 2 dB lower than for the dish and two-layer lens across this frequency band.

MEASUREMENTS AND RESULTS

To complete the antenna build, the two-layer lens was integrated with the mechanical scanning system. The gain was measured for various carrier frequencies using an outdoor range. The experimental arrangement is shown in *Figure 9* where the antenna can be seen inclined on a jig, which allows for alteration of





Microlab



the feed elevation with respect to the ground-plane.

Measured results are summarized in *Table 2*. The gain and sidelobe levels do vary slightly with the azimuth and elevation angle, and particularly at low elevation where the azimuth rail partially blocks the aperture, as described previously.

Typical radiation patterns are shown in *Figures 10* and *11*. The reguirement on sidelobe levels is from Eutelsat Standard M, which is known to be challenging. The Ka-band performance does drop off at 30 GHz, which is also expected from theory. At this wavelength the layered lens structure is very coarse, and could be improved by increasing the number of dielectric layers. This effect has been quantified from theory where the computational effort using the spherical wave expansion technique becomes quite intense. Nevertheless, a 3 layer structure has been identified that should offer 67 percent aperture efficiency in theory. Construction of such a lens was beyond the present scope, however. The measured gain at 20 and 30 GHz is at the OMT waveguide port and does not include the additional 1 dB of cable loss to the transceiver. However, this would be overcome by placing amplifier modules within the feed/OMT, an implementation detail that was also beyond the current scope.

The mechanical performance exceeds the requirements and positional accuracy is at least 0.1° in both azimuth and in elevation. Maximum angular speeds also exceed the requirement.

CONCLUSION

A mechanically scanned, two-beam hemispherical lens antenna has been successfully developed. The intended application is two-way satellite communications to trains, enabling wireless services to passengers. Effort was prioritized on the most novel aspects of the antenna that fall into two broad strands: Development of the 61 cm diameter stepped-index lens; and the two-axis scanning system for two independent feeds along with cable routing for concomitant IF circuits, power distribution and control bus. Other features that would be required for a final deployment of the antenna, but

TABLE II MEASURED ANTENNA GAIN AT 45° FEED ELEVATION ANGLE			
Frequency (GHz) Gain (dBi)			
10.8	35.0		
11.5	35.6		
12.5	36.3		
20.0	38.5		
30.0	40.0		

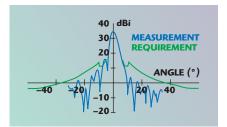


Fig. 10 Radiation pattern at 10.8 GHz, H-plane.

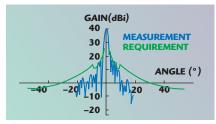


Fig. 11 Radiation pattern at 30 GHz, H-plane.

which were not considered to require particular innovation, include environmental housing, inertial control system, etc., and these fell out of the scope of this work.

The antenna's electrical efficiency met the requirements for Ku-band applications and here offers efficiency comparable to a 62 cm diameter parabolic reflector in a height profile that could be as low as 32 cm, offering advantages for deployment on high speed trains where headroom is constrained. Ka-band performance was adequate at the receiver frequency of 20 GHz, while for transmission at 30 GHz improvement would be sought on the measured gain by developing a three-layer lens for this frequency. The azimuth rail introduces a scanning loss at low elevation angles of 1 to 1.5 dB (depending on angle and polarization), an effect studied in some detail through scale model













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measurements so as to quantify improvements that could be made through slimming down the height of this structure.

Maximum achievable beam scan speeds exceed requirements by a factor of 2 and angular precision is excellent at 0.1°. In future work the goal is to add an inertial control system and demonstrate real-time satellite connectivity on a moving vehicle. ■

ACKNOWLEDGMENTS

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John Thornton is a Research Fellow in the Department of Electronics having moved to the University of York in 2000. Between 1995 and 2000, he did research work at Rutherford Appleton Laboratory (UK) and later at the University of Oxford (UK) on diverse projects related to microwave engineering, space science and communications, prior to which he worked in industry. He has a master's degree in physics and completed a PhD degree with the Open University in 2002. His current research includes scanning antennas for communications applications.

Andy White has over 25 years' experience in the electronics industry. He currently leads a team of engineering support staff in the Department of Electronics at the University of York. He focuses his time on the management of large electronics projects. His areas of expertise include embedded system design, microcontrollers, FPGA, HALT, high level communication systems, logistics and trials management.

Graham Long was the manager and founder of the York Electronics Centre, set up at the University of York in 1980. He has broad experience in electronics, industrial applications, machine vision systems and measurement instrumentation, and has also project managed collaborative EU research programmes. The Centre undertook feasibility studies and electronic product equipment design, and many projects were carried out in liaison with other university staff. Since his retirement in 2008, he has continued to work as a private consultant.



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MM-waves in the Living Room: The Future of Wireless High Definition Multimedia

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igh Definition Television (HDTV) is an already mature consumer electronics (CE) field. However, it is a field that is still cluttered by a rats nest of interconnecting wires. Home theatre systems are often built around a sleek, flat-panel audio-visual (AV) display hanging on a wall, often connected to a variety of high definition (HD) sources; for example, cable or satellite set-top boxes,

AV RECEIVER

HDTV

BLUE-RAY
DVD PLAYER

DIGITAL VIDEO
RECORDER (DVR)

SET TOP BOX #1

Fig. 1 Example of possible home theater setup.

blue-ray disc players, gaming consoles and/or broadband Internet connections. An example setup is shown in *Figure 1*. Connecting this display (or often multiple displays) to the many HD content sources requires a suite of specialist cables and switches, most of which are costly, bulky and unsightly. Although such cables are effective at carrying the high data rates required, many users would prefer a more elegant wireless solution, if available, especially if it eliminated the mass of wires, removed the interconnection headaches, and provided seamless networking capabilities between multiple sources and viewing devices.

HDMI™ (High Definition Multimedia Interface) has emerged in recent years as the enabling CE HD digital interface. HDMI permits data transfer at rates of 3 Gbps and higher; equivalent to 1080p video, the highest specification HDTV and AV standard commonly available today (note: The "1080" stands for 1,080 horizontal scan lines, which with the common widescreen aspect ratio of 16:9 implies

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a horizontal resolution of 1920 pixels, and thus a frame resolution of 1,920 \times 1,080 or 2 million pixels. The "p" stands for progressive scan, meaning all the horizontal lines are drawn in sequence. Another standard mentioned in this paper is 1080i, which employs the same number of pixels, but interlaced, meaning only each second line is refreshed each scan. This allows the system data rate to be halved, but at the expense of some picture quality degradation). More than 500 million devices are forecast to be shipped with HDMI interfaces by 2010.1

Several wireless technologies in the 5 to 60 GHz frequency bands are under development to provide HDMI interconnectivity in living-room environments for linking together HDTV and other multi-media sources without wires. Major CE companies are starting to rollout models, with prototypes being displayed at recent CE trade shows. This paper reviews these technologies, providing an insight into the main contenders, standards, industry groups and commercial players that make up the wireless high definition landscape.

THE WIRELESS HD TECHNOLOGY LANDSCAPE

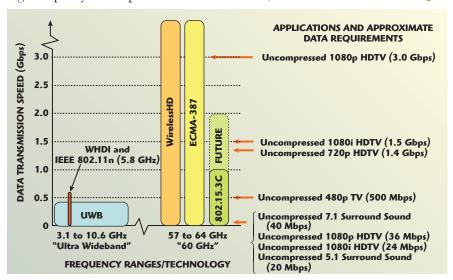
A summary of the wireless technologies vying for acceptance as short distance high data rate HD distribution technologies is shown in *Figure* 2, along with the data rate requirements for various multimedia AV applications, from surround sound to the highest quality uncompressed HDTV.

LOWER MICROWAVE BANDS FOR COMPRESSED WIRELESS HD CONNECTIVITY

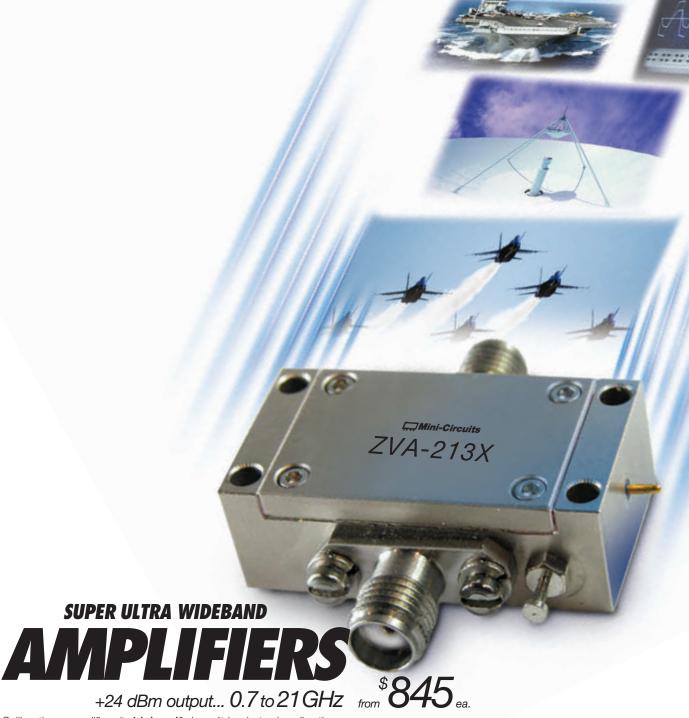
Within the lower microwave bands, there are three technologies able to support high definition multimedia transport. Two similar technologies, Wireless Home Digital Interface™ and IEEE 802.11n, operate within the 5.8 GHz band that is unlicensed in the US. Here channel sizes are limited to 20 MHz, restricting the amount of data that can be transferred. This means that only compressed, or some form of limited capability, HD can be transmitted. However, with proper design, such compression can have minimal perceived effect on viewed picture quality. The other, Ultra-wideband (UWB), operates with much wider channels, but has power limitations that restrict its distance capabilities. Each of these three technologies is explored further below.

IEEE 802.11n

IEEE 802.11n is one of the more recent iterations of the IEEE 802.11 wireless Local Area Network (LAN) standard, more commonly known as WiFi. IEEE 802.11n extends the previous theoretical maximum limit beyond 54 Mbps by use of multiple in, multiple out (MIMO) antenna technology, complex beamforming and channel aggregation to achieve theoretical data rates up to 600 Mbps. Although not yet formally released as a standard, "Draft N" products compliant with the current draft standard are widely available. Intel, for example,



▲ Fig. 2 Short distance wireless HD technologies and data rate requirements for various HD multimedia applications.



Calling these amplifiers "wideband" doesn't begin to describe them. Consider that both the ZVA-183X and ZVA-213X amplifiers are unconditionally stable and deliver typical +24 dBm output power at 1dB compression, 26 dB gain with +/- 1 dB flatness, noise figure of 3 dB and IP3 +33 dBm. What's more, they are so rugged they can even withstand full reflective output power when the output load is open or short. In addition to broadband military and commercial applications, these super wideband amplifiers are ideal as workhorses for a wide number of narrow band applications in your lab or in a production environment.

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	MODEL	FREQ. (GHz)	GAIN (dB)	Pout (dBm)	NOISE FIG (dB)	. PRICE (1-9)	
				@ 1 dB Com	ρ.		
200	ZVA-183X+	0.7-18	26	+24	3.0	845.00	
000	ZVA-213X+	0.8-21	26	+24	3.0	945.00	
- cellar	Note: Alternative	heat-sink mu	ust be provid	ed to limit maxim	um base plate	temperature.	
-							
	ZVA-183+	0.7-18	26	+24	3.0	895.00	
44.	ZVA-213+	0.8-21	26	+24	3.0	995.00	
200	All models	IN STO	C	O RoHS complian			











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produces the Ultimate N WiFi chipset that is 802.11a/b/g/Draft-N compliant and offers data rates up to a maximum of 450 Mbps.² The 802.11n standard is due for formal ratification in January 2010.

The ubiquitous availability and low cost of WiFi chipsets makes the use of this standard a rational choice for consumer-oriented multimedia applications. As such, vendors such as Celeno Wireless Communications and Quantenna Communications are employing 802.11n-based solutions for wireless HDMI-like applications. Quantenna's solution employs 4×4 MIMO, transmitter beamforming and dual-band operation (the unlicensed 2.4 GHz as well as the 5.8 GHz) to yield very high data rates in a small chip footprint.

One big advantage of 802.11n is that range is typically beyond 100 feet (30 m), with signals easily able to penetrate walls. Thus, this 5.8 GHz solution has potential for a "whole home" distribution solution rather than for a single room. However, with the explosion of other WiFi-enabled devices, the risk of interference grows over time.

Wireless Home Digital Interface (WHDI™)

WHDI is physically very similar to IEEE 802.11n, operating in the same 5.8 GHz unlicensed band and employing MIMO antenna technology to achieve similar data throughputs. However, WHDI differs from IEEE 802.11n in that it was specifically developed for video, audio and AV control, making it a more robust technology for HDTV delivery.

WHDI was developed by Amimon in Israel, with Motorola as an early backer and investor. In 2008, a WHDI special interest group was formed, which now includes Hitachi, Samsung, Sharp, Sony and LG Electronics as members. Amimon sold over 100,000 WHDI chipsets in 2008. Pricing for production quantities of Amimon's WHDI transmitter chipset is \$20 and \$25 for the receiver. The first WHDI products are expected to be available around the end of 2009.

Although WHDI claims uncompressed video data rates up to 1.5 Gbps in the 20 MHz channels available at 5.8 GHz (and 3.0 Gbps in paired 40 MHz channels), closer investigation of the technology and mar-

keting fine print shows that these are actually "equivalent" data rates and data compression is clearly employed to achieve them. Amimon uses a technique called Joint Source Channel Coding (JSCC) to provide "lossless compression", whereby the 1.5 Gbps 1080i HD video rate is reduced to between 250 and 800 Mbps.³ JSCC works by breaking down the uncompressed HD video stream into elements of importance, each of which is then mapped onto the wireless channel in a way that allocates priority and robustness to the most important data elements, transmitting them with the highest amounts of error correction. Less significant data is allocated less preference and lower error correction protection. When transmitted, so long as the higher priority data bits are not degraded, the user can tolerate the degradation of the less important data bits, and visual and audio quality close to the original uncompressed signal is maintained.

Neither Amimon nor WHDI publishes the actual data throughout of their technology. However, given WHDI's physical similarity to IEEE 802.11n, comparable data rates of around 400 to 600 Mbps are expected.

Ultra-wideband

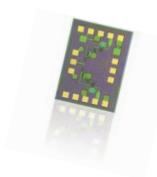
UWB is a technology that employs very low radio energy signals, spread over a wide frequency range, for short-range high-bandwidth communications. The FCC has approved the frequency band of 3.1 to 10.6 GHz for such transmissions. Global differences exist in how the bands are regulated around the world.

The UWB landscape is rather confusing with a number of industry organizations and special interest groups with much overlap and duplication. One leading group was the WiMedia Alliance, who was working to promote the adoption, regulation, standardization and multi-vendor interoperability of their Orthogonal Frequency Division Multiplexing (OFDM) UWB technology that delivered data rates of up to 480 Mbps at 10 ft (3 m) distances and 110 Mbps at 30 ft (10 m) distances. In March 2009, the WiMedia Alliance announced it was ceasing, and would be transferring all its current and future UWB specifications to the Bluetooth Special Interest Group, the USB Implementers Forum and



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SPECIFICATIONS

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FMS2024	SPDT	-1.6	-1.1	-	dB	-	-37	-34	dB	22	24	-	dBm
FMS2027	SPDT	-1.5	-1.3	-	dB	-	-42	-40	dB	21	22.5	-	dBm
FMS2029	SPST	-1.65	-1.4	-	dB	-	-60	-45	dB	23.5	25.2	-	dBm

FEATURES

- Low insertion loss
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the Wireless USB Promoter Group. This latter group champions its own Wireless USB standard, plus manages the "Certified Wireless USB™" distinction. Although different, Wireless USB is based upon the WiMedia Alliance's common UWB radio platform. An upcoming 1.1 Wireless USB specification will increase speeds to 1 Gbps.

In addition to these groups, many individual companies are championing wireless high definition connectivity via proprietary implementations of the WiMedia UWB framework. Given the short distance and data rate limitations of UWB, few UWB proponents are targeting HD multimedia applications. Three that are doing so successfully are TZero Technologies with its ZeroWire™ chipset and HDMI reference design kit, Sigma Designs with its Wireless HDAV™ products and Pulse~LINK with its CWave® UWB chipset.

MM-WAVE BANDS FOR UNCOMPRESSED WIRELESS HD CONNECTIVITY

The mm-wave frequency bands offer a big advantage for high data rate wireless transmission spectrum.⁴ Of interest here is the 7 GHz of bandwidth available from 57 to 64 GHz for unlicensed use in the US. Closely related frequency bands are available in Canada, Japan, Australia and under consideration in Europe. With 7 GHz of bandwidth available, multi-gigabit data rates can easily be achieved with conventional radio architectures without the system complexities needed to compress high data rates into the narrow channels available at lower frequencies (such as the much smaller 20 MHz channels available at 5.8 GHz). High atmospheric absorption of oxygen molecules at 60 GHz does limit propagation distances, making 60 GHz systems better suited for inroom, short-range use, rather than across a whole house. However, these distance limitations do help to control intersystem interference and abate "off site" reception concern of multimedia copyright owners.

Within the 60 GHz mm-wave band, there are three technologies being developed to support uncompressed HD multimedia transport. Being able to support uncompressed HD is espe-

cially advantageous in providing not only the ultimate in picture quality, but also for minimizing latency; a key requirement for gaming applications. Each of these three 60 GHz mm-wave technologies is explored further here.

Wireless HD™

WirelessHD is a standard specifically designed for wireless high definition multimedia connectivity. The WirelessHD consortium was formed in 2005 to promote the technology developed by SiBEAM. The group now includes Broadcom, Intel, LG, Panasonic, NEC, Samsung, Sony and Toshiba as members. The goals of the group were to develop a standard that met the following minimum set of requirements:

- Stream uncompressed high-definition video, in addition to audio and data
- High reliability
- Low cost
- Low power solutions for portable devices
- In-room connectivity (equating to a range of around 10 m)

The first WirelessHD specification was finalized in early 2008. In its first generation implementation, data rates as high as 4 Gbps were achieved. The core technology promotes theoretical data rates as high as 25 Gbps, permitting it to scale to significantly higher resolutions, color depth and range than available today. LG, Panasonic and Toshiba have all announced that they plan to ship commercial WirelessHD products in 2009.

WirelessHD employs beamforming technology to steer line-of-sight beams around a room. Adaptive beam steering and phased-array antennas move the high data rate content stream around the room, bouncing off walls, ceilings and floors without interruption. If a direct path becomes obstructed, the system quickly adapts and finds an alternative path for continuous streaming without any breaks (for example, around people walking across a room and blocking the main signal between HD transmitters and receivers).

Historically, millimeter-wave electronic components have only been feasible in relatively expensive and bulky semiconductors such as Gallium Arsenide (GaAs) and Indium Phosphide (InP). Using techniques developed by the University of Berkeley, Si-

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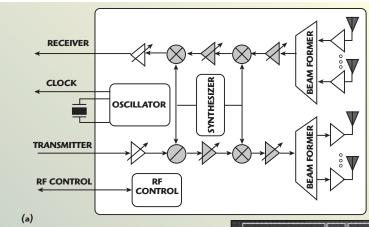
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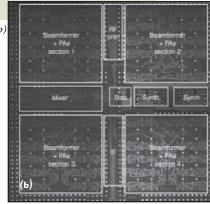






▲ Fig. 3 Radio architecture (a) and die photo (b) of SiBEAM's integrated 60 GHz chip.⁶

BEAM has developed 130 nm CMOS chips that operate to 60 GHz.⁵ These low cost silicon chips form the heart of its OmniLink 60 WirelessHD product. A block diagram and photo of the chips are shown in *Figure 3*. Having a silicon solution rather than GaAs or InP helps towards the all-important goal of reducing system cost to a price point competitive with HDMI cables. Also, system designs are being simplified; for example, initial designs that employed 36 patch antennas are being redesigned to operate with half that number of devices.



ECMA-387

Similar to WirelessHD, ECMA-387 is a 60 GHz standard that provides support for Gbps streaming video applications. However, unlike

CHAMAA	OV OF THE COM	TABLE I	CU DEFINITION TE	UNOLOGIES
HD Wireless Technology	Standard	Strengths	Weaknesses	Technology Drivers/Major Players
5.8 GHz	IEEE 802.11n Wide coverage (100 m) WHDI Transmission through walls Reasonably mature standards Available chipsets		Limited data rate (compressed HD transmission only) Possible interference with other 5.8 GHz devices	Celeno Quantenna Amimon
UWB	WiMedia Alliance Wireless USB	Available chipsets Mature technology	Short distance (few meters) Confusion and upheaval in standards and marketplace	Tzero Sigma Pulselink
60 GHz	Wireless HD ECMA-387 IEEE 802.15.3c	Good coverage (10 m) Very high data rates (uncompressed HDTV transmission) Solid traction with CE vendors	Line of sight (implementation difficulties) Cost of chipsets	SiBeam Philips



Wireless HD, ECMA-387 was developed to support more than uncompressed HD multimedia connections. The standard has provisions for fast file download support, wireless docking and even short distance point-tomultipoint "sync and go" for handheld devices. Developed by Ecma International with support from Phillips, Intel, Samsung, Panasonic and others, EMCA-387 has the potential to become the European standard for

short-range wireless ultra-high data rate networking. Ecma has already submitted the standard, published in December 2008, for fast-track consideration as an ISO/IEC standard.

The ECMA-387 standard supports data rates to 6.4 Gbps, which with channel bonding of up to four channels can extend data rates to beyond 25 Gbps. The Georgia Electronic Design Center have just recently demonstrated an ECMA-compliant chip sup-

porting multi-gigabit per second file transfers and 1080i uncompressed HD video streaming. The single-chip 60 GHz CMOS radio consumes less than 100 mW and incorporates an embedded antenna array, a 60 GHz front-end and multi-gigabit baseband signal processing into a standard QFN package.⁷

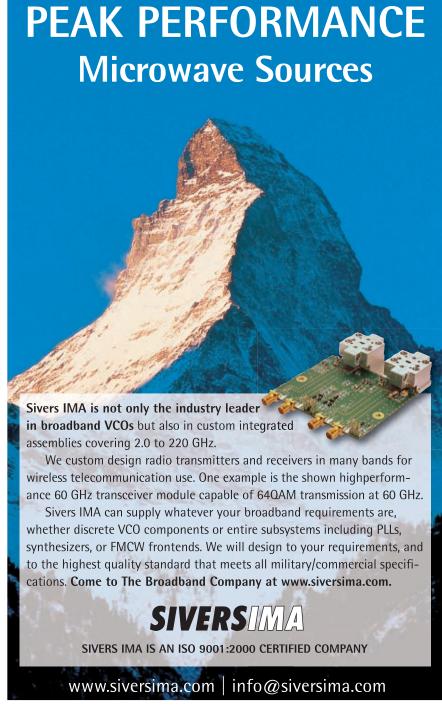
IEEE 802.15.3c

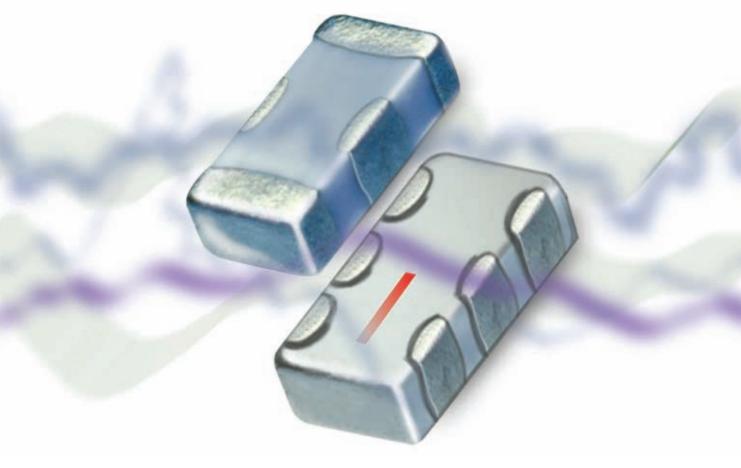
The IEEE 802.15.3 Task Group 3c was formed in March 2005 to develop a 60 GHz physical layer (PHY) for the existing Wireless Personal Area Network (PAN) Standard 802.15.3-2003. Although still under development and slated for publication in late 2009, this IEEE standard is designed to ensure compliance and coexistence with all other microwave systems in the 802.15 family of wireless PANs. In addition, the standard will support high data rates to at least 1 Gbps, with an option to support rates in excess of 2 Gbps in future options. Support of the uncompressed HDTV multimedia standards is a clear objective of the group.

CONCLUSION

There is a clear consumer desire to remove the mess of HDMI cables and interconnection headaches associated with modern HD multimedia systems. Several different wireless technologies are available that offer the promise of such cable-free high definition connectivity, providing users with seamless networking capabilities and visually-pleasing HD home theatre setups. However, there is a complex mix of standards, innovation, technologies and costs that companies have to balance before any clear winner gains dominance in the home. The current technical competitive situation is detailed in Table 1.

Three classes of system are in various stages of advancement. Systems based on the IEEE 802.11n standard (including the closely related WHDI) offer the advantages of householdwide coverage and the ability to support the higher quality HDTV formats. However, due to the limited channel sizes available in the 5.8 GHz operational band, some form of data compression is required, with a resulting latency penalty and some level of picture degradation. Nevertheless, the use of the relatively low and widely available 5.8 GHz frequency band opens up the possibilities of relatively





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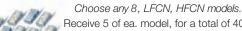
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low cost chipsets that are becoming widely available through the association with the standard WiFi protocol.

UWB is another technology that offers short distance, high capacity connectivity. However, the restricted power levels limit high capacity transmission distances to just a few feet, making the technology of limited use for living room applications. In addition, the unclear standard's roadmap and varied worldwide regulatory climate will ham-

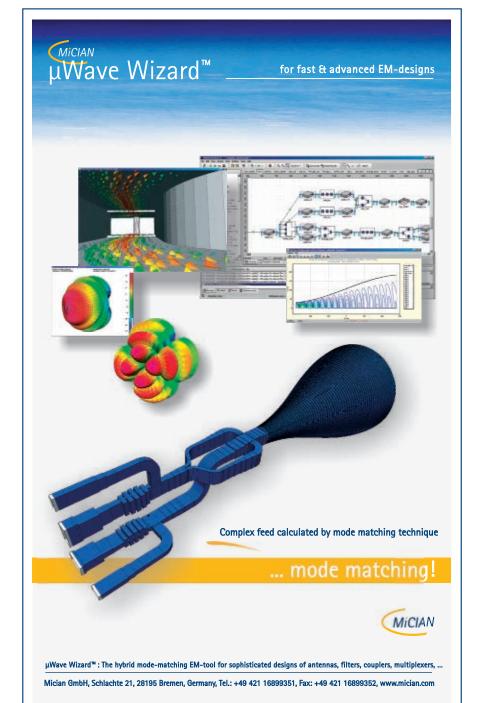
per UWB's adoption as a widely used HDTV transmission protocol.

One class of technology offering great promise is those operating within the millimeter-wave band around 60 GHz. Here, high bandwidths, favorable propagation characteristics and almost global regulatory recognition make such systems ideal for the connection of HD devices without the need for latency-inducing compression algorithms. WirelessHD has

the head start amongst the applicable 60 GHz short-range standards, with several systems in demonstration and commercial availability announced for this year. However, the ECMA-387 standard is close behind, which like the emerging IEEE 802.15.3c standard, has the potential to move beyond wireless high definition and multi-media support to a wide range of high data rate applications and global backing via the ISO and IEEE standards organizations.

So which technology will win the battle for the living room? Amimon's WHDI and SiBEAM's WirelessHD are leading the charge. Both have reasonably mature standards and various technology strengths. WHDI can provide wide-area coverage with low cost chipsets, but limits future scalability by being constrained to data rate liming channels. WirelessHD can support vastly larger data rates, but is shorter distance, more complex and potentially more costly to implement. At the end of the day, the dominance by CE vendors to "pull" one technology in front of the other will win in the marketplace. Both WHDI and WirelessHD boast strong traction with big-name CE vendors.

In the not too distant future, we will likely see microwave or millimeter-wave systems in our living rooms, seamlessly connecting our HD devices and wirelessly streaming digital content, removing the need for a mass of interconnecting cables and switches. Now if only we could develop a technology to remove those pesky power cords.

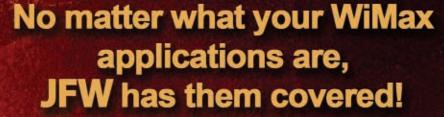


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ULTRACMOS RFICS EASE THE COMPLEXITY OF SATELLITE DESIGNS

ommercial and military satellites require cost-effective ICs that meet stringent high-reliability standards. In addition, they need to provide distinct advantages that allow designers to advance satellite technology in order to meet changing needs, especially in terms of cost (weight, power), reliability (number of transmission lines, radiation tolerance, redundancy) and performance (including the ability to enhance opportunities for flexible payload designs using phasedarray antennas or a switch matrix). Silicon on sapphire (SOS) is inherently a great match for these business and technical constraints, and is currently available in high-volume, high-yield commercial production.

A form of SOS technology that uses ultrathin films, UltraCMOS™ technology is an extension of RF complementary metal-oxidesemiconductor (CMOS) technology that enables the manufacture of high-performance RF devices. Particularly important for satellites, this technology has low gate capacitance and fully depleted devices, which enables high speeds at low power. These devices also greatly improve linearity as compared to typical silicon on insulator (SOI) and GaAs technologies, and they offer 2 kV typical Human Body Model (HBM) electrostatic discharge (ESD) protection. Presently in high-volume production for commercial applications, UltraCMOS technology meets high-reliability and environmental requirements for operating in space and yields

tend to be comparable to other CMOS processes.

PROCESS ADVANTAGES FOR SATELLITES

CMOS technology's advantages of low power and ease of integration are well known. UltraCMOS technology is a CMOS technology where a 50 to 100 nm silicon film is formed directly on a sapphire substrate. When properly processed, this provides for fully depleted devices with little or no body charge under the gate (see *Figure 1*). As compared to traditional CMOS processing, UltraCMOS offers the advantage of faster devices with reduced power loss, excellent linearity, high isolation and no kink effect. For satellite applications, this proves to be particularly valuable in the avoidance of single-event effects.

The insulating, single-crystal alumina properties of sapphire allow the manufacture of dielectrically-isolated transistors. This improves power handling as compared to other process technologies, such as GaAs. Also, since it is still a CMOS technology, it offers high yields, on-chip logic and low defect density. UltraCMOS processing can be classified as SOI technology. However, in most SOI technologies, a thin layer of insulating dielectric material is required between the MOSFET device and the silicon layer. While

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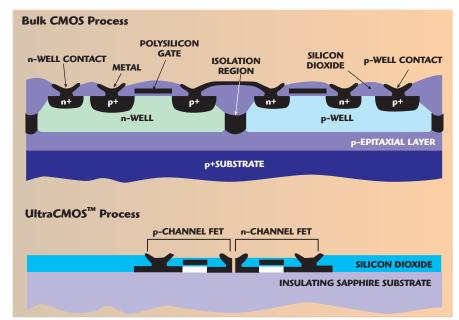
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▲ Fig. 1 Bulk Si process devices (top) have higher parasitics because of the thick layer of Si while UltraCMOS process devices utilize a thin 1000 Å Si layer.

this approach reduces the effects of the parasitic capacitances and leakage currents, it significantly limits device performance. UltraCMOS technology does not suffer the effects of a semiconducting silicon (Si) substrate.

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(although some deep-space satellites use nuclear energy). When a satellite's power needs to grow, it requires more solar cells and power supplies. In addition, power generates heat, which is very difficult to counter in a vacuum in space. This translates to more weight, which immediately means more cost. Estimates are that every additional kilogram of weight adds \$30,000 to the launch costs (see *Figure 2*). A current estimate of launching a very small satellite puts the cost at \$21 to \$28 M.²

The most effective way to address weight is with monolithic integration. Due to the insulating nature of the sapphire substrate, this technology has the ability to integrate RF, mixed signal analog, passive and digital functionality on the same device. *Figure* 3 shows the functional blocks of an UltraCMOS 3.5 GHz delta-sigma modulated fractional-N PLL frequency synthesizer IC (Peregrine Semiconductor). This type of single-chip implementation of a phase-locked loop (PLL) allows for easier control thanks to short lead lines, less weight, a smaller footprint and higher reliability. The PLL device pictured in Figure 3 features a 10/11 dual modulus prescaler, counters, a delta-sigma modulator and a phase comparator. Counter values are programmable through either a serial interface or directly hard-wired. UltraCMOS shows great promise for increased integration, especially of digital functionality, and higher integration directly addresses weight concerns as well as improved reliability.

After considering launch costs, the design focus often shifts to minimizing power usage in space (in order to reduce the number of solar panels and power supplies). To put power consumption in context, a typical planetary satellite uses 500 W to 10 kW of power, while a typical commercial LEO/GEO satellite uses 2 to 20 kW. It is important for satellite designers to select the most efficient devices for their designs in order to keep these numbers as low as possible. As an example, an UltraCMOS prescaler, for instance, uses 1/14th the power of a comparable GaAs part due to its lowpower CMOS design (see *Table 1*).

One way to minimize power consumption is to select devices with the best power handling efficiency. In the case of RFICs, that also means finding parts that offer high linearity. Input

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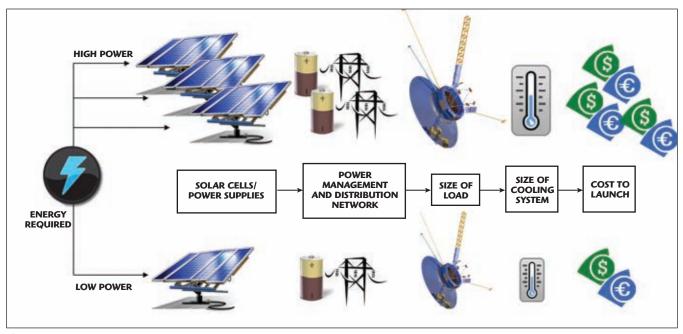


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📤 Fig. 2 Weight is critical in satellite design—every Kg of load costs approximately \$30,000 to launch.

third-order intercept point (IIP3) is a key specification that measures linearity. Because UltraCMOS features fully depleted operation, the devices tend to have high linearity and attenuation accuracy. Generally speaking, digital step attenuators (DSA) manufactured using this technology demonstrate linearity that is about 8% better than comparable GaAs parts. For example, one UltraCMOS DSA features +34 dBm peak output power

at 1 dB compression (P1dB) typical, +52 dBm IIP3 typical and flat performance from 1 MHz to 3 GHz. This device is used in many communications payloads and in phased-array applications. It is a simple monolithic design that replaces design types using PIN diodes or discrete GaAs switches.

In another example, an Ultra-CMOS single-pole double-throw (SPDT) switch is often selected for use in phased-array applications in satellites because of its linearity and lower power. This switch demonstrates an 18 percent improvement in linearity over typical GaAs products with an IIP3 of +60 dBm at 6 GHz (see *Figure 4*).

Broadband operation offers another cost-saving opportunity for satellite designers. The cost to qualify a component for use in space can range from 100s of thousands to a million dollars, so a component that operates across a wide bandwidth offers the advantage of being 'future proof' when design changes occur. An UltraCMOS prescaler that operates from 3 to 13.5 GHz is well suited for a range of applications. And, since this IC is made in a highvolume commercial process, its quality control and production lifetime can be better than devices that are manufactured in non-commercial flows.

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CBL-2FT-SMNM+ CBL-3FT-SMNM+ CBL-4FT-SMNM+ CBL-6FT-SMNM+ CBL-15FT-SMNM+	SMA to N-Type SMA to N-Type SMA to N-Type SMA to N-Type SMA to N-Type	2 3 4 6 15	1.1 1.5 1.6 3.0 7.3	27 27 27 27 27 27	99.95 104.95 112.95 114.95 156.95
CBL-2FT-NMNM+ CBL-3FT-NMNM+ CBL-6FT-NMNM+ CBL-10FT-NMNM+ CBL-15FT-NMNM+ CBL-20FT-NMNM+ CBL-25FT-NMNM+	N-Type N-Type N-Type N-Type N-Type N-Type N-Type	2 3 6 10 15 20 25	1.1 1.5 3.0 4.7 7.3 9.4 11.7	27 27 27 27 27 27 27 27	102.95 105.95 112.95 156.95 164.95 178.95 199.95
CBL-3FT-SFSM+	SMA-F to SMA-M	3	1.5	27	93.95
CBL-2FT-SFNM+ CBL-3FT-SFNM+	SMA-F to N-M SMA-F to N-M	2	1.1 1.5	27 27	119.95 124.95
CBL-6FT-SFNM+	SMA-F to N-M	6	3.0	27	146.95
ARMORED CABLES			le to Male	07	101.05
APC-6FT-NM-NM+ APC-10FT-NM-NM+ APC-15FT-NM-NM+	N-Type	6 10 15	3.0 4.8 7.3	27 27 27	181.95 208.95 243.95

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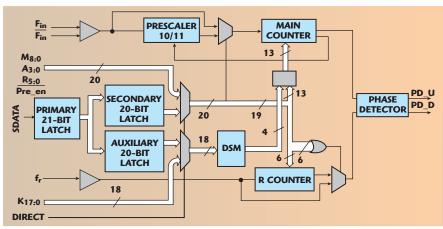


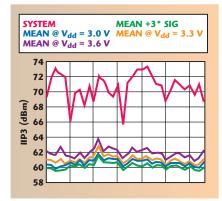
Fig. 3 An UltraCMOS device can integrate this discrete device PLL in a single 68-lead CQFJ package.

lent design and tight manufacturing tolerances, some ways to improve reliability are to reduce the number of control lines, minimize the number of components through integration and maintain the necessary radiation tolerances. Because it can include digital control logic, UltraCMOS is fast becoming a process technology of choice for space applications, especially those that use phased-array antennas (which require high levels of control).

Eliminating wires and lines inside a satellite reduces weight and removes potential points of failure, which improves reliability. Unlike GaAs, Ultra-CMOS can easily incorporate serial addressability, so that only two to three lines are required to control the device. Without this feature, it is necessary to directly wire each line on any device. Without serial addressability, designers have to run multiple lines with line drivers across sections of the satellite (recognize that a satellite can be the size of a truck). For example, in one UltraCMOS DSA, this feature allows designers to address up to eight separate DSAs (using addresses 000 - 111).

Radiation tolerance is a basic necessity for the reliable devices that must be used in space applications.

UltraCMOS does not use bulk CMOS (which is subject to parasitics), so it has a natural resistance to 'single event effects.' Commercial submicron Ultra-CMOS also handles total dose radiation well enough that no special design or



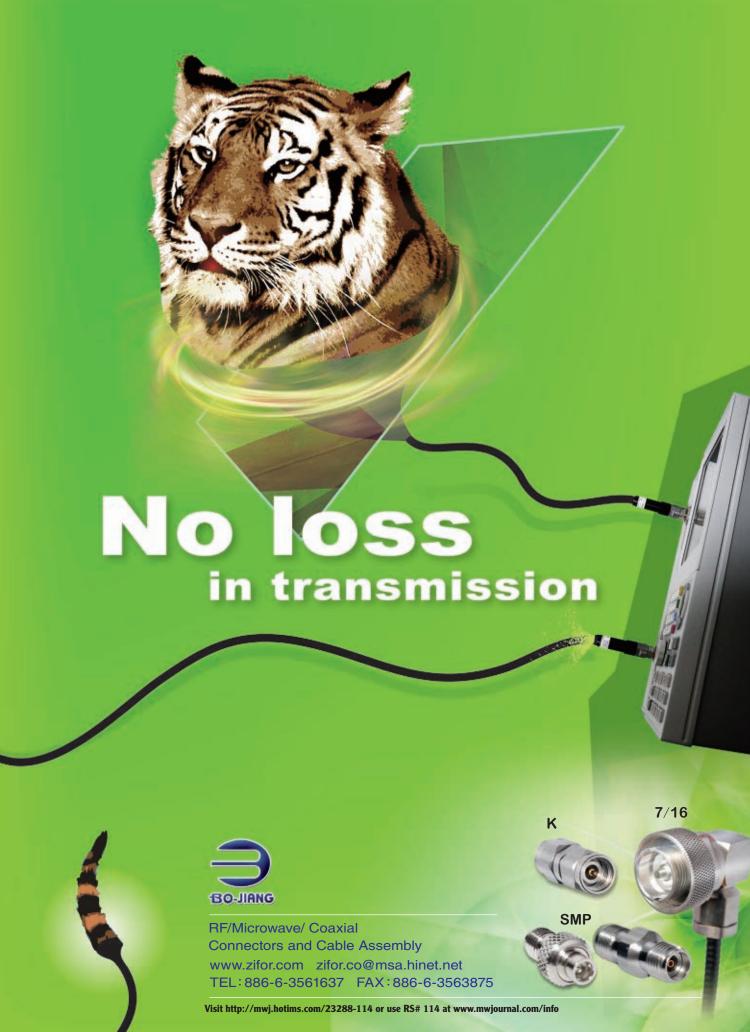
▲ Fig. 4 By selecting RFICs with higher linearity, satellite designers can reduce power consumption and launch costs.

process modifications are needed for the vast majority of radiation-hardened products used in space.

Radiation environments require RFICs to be immune to the single event effects that occur when a particle from a cosmic ray or a high-energy proton travels through the die and impacts performance. Because UltraCMOS has only a very thin layer of silicon, it is much more resistant to these issues than traditional CMOS. There are two types of single event effects: Single-event upsets of a logic

TABLE I ULTRACMOS DEVICES CAN OFFER LARGE POWER SAVINGS TO COMPARABLE GaAs DEVICES (COMPARISONS BASED ON PUBLISHED DATASHEETS)

Product Type	Power Consumption UltraCMOS	Power Consumption GaAs	Power Savings		
PLL	148 mW	1.55 W	90%		
Prescaler	42 mW	600 mW	93%		
DSA	300 uW	30 mW	90%		



gate (non-destructive errors that can be corrected by rewriting to the logic gate) and single-event latchups (hard errors that can be destructive to the device). Primarily an issue for bulk CMOS designs, single event latchups can cause a short circuit, requiring at minimum a power down to recover. (Keep in mind that resetting can take days in space applications.) Products manufactured using UltraCMOS do not contain the bulk parasitics found in regular CMOS devices, making latchup impossible. As a result, products come with guaranteed immunity to single-event latchup, and they demonstrate an exceptional natural tolerance to single-event upsets.

PERFORMANCE

In satellite designs, increased performance leads to faster data handling. This is beneficial for commercial applications, yielding more revenuegenerating opportunities, and military applications, because delivering more data can allow scanning in more areas and/or reduce the need for satellites or equipment. Some of the key per-

formance metrics for improving performance in satellite RFICs include ESD performance, phase noise and high voltage handling.

Most satellites use state-of-the-art ESD controls, but they can still benefit from components with good ESD protection. UltraCMOS offers this kind of additional protection, with up to 4 kV HBM ESD protection with low parasitics.

Phase noise is perhaps one of the most critical performance parameters for satellite RFICs. Simply put: Every 3 dB improvement of phase noise can double the data handling capability of the satellite. UltraCMOS PLLs were designed to compete in tough commercial base station markets and therefore have excellent phase noise. i.e. one UltraCMOS PLL design features phase noise of -216 dBc/Hz. The potential for even better phase noise performance exists. For instance, the current generation of this product realized a 4 to 10 dB improvement over the previous generation. In addition, this part boasts low power consumption of 45 mA at $3.3 \, \text{V}$.

Dramatic improvements such as these in phase noise performance have been applied to flexible payload systems. This trend in satellite design is moving towards in-orbit payload flexibility, which extends a satellite's revenue-earning potential. In the past, a signal was transmitted to the satellite and then broadcast to a fixed location back on Earth. In this model, companies would buy access. but they were not really transmitting large amounts of data. With a flexible payload, the satellite can handle data on the fly, transmitting to various locations on Earth on-demand by using electrically reconfigurable (phased array) antennas rather than fixed ones. The advantage of this approach is that each independent channel beam is programmable, and it can be repeatedly assigned to new addresses. In the commercial realm, providers are able to sell more data access and be more flexible where it is sent. On the military side, more data can be processed and delivered. It also increases reliability in missioncritical applications, allowing one sat-

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S4W2 S5W2	S4W5 S5W5	N4W5 N5W5	4 5	±0.40 ±0.40
S6W2	S6W5	N6W5	6	±0.40
\$7W2 \$8W2 \$9W2	\$7W5 \$8W5 \$9W5	N7W5 N8W5 N9W5	7 8 9	-0.4, +0.9 ±0.60 -0.4, +0.8
S10W2	S10W5	N10W5	10	±0.60
S12W2 S15W2	S12W5 S15W5	N12W5 N15W5	12 15	±0.60 ±0.60



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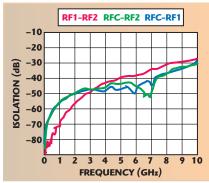


Fig. 5 UltraCMOS SPDT switches can achieve 82 dB isolation at 100 MHz.

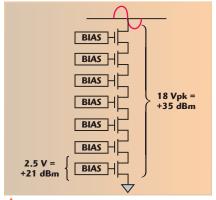


Fig. 6 Stacking FETs in series can enable high voltage handling.

ellite to back up another in a fleet if necessary.

Another popular design trend in satellites is the use of a switch matrix. This type of design is made possible by high-performance solid state switches. However, these multiple radio signals also require high isolation. In the case of a SPDT switch a good target would be 70 dB isolation. With Ultra-CMOS, devices are being manufactured with high levels of isolation (see Figure 5). This is made possible because sapphire is a perfect insulator,³ allowing the transistors to be dielectrically isolated, which provides both latch-up immunity and high isolation. One UltraCMOS SPDT broadband switch design that is frequently used in switch matrix applications typically runs at a low IF and features 82 dB isolation at 100 MHz (see Figure 5).

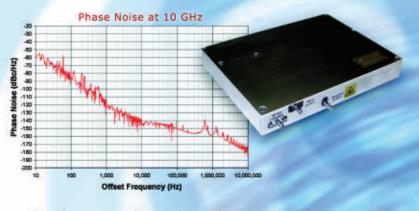
Because of the lack of parasitics in the UltraCMOS process, RFIC designers can stack field effect transistors (FET) in a series, which allows for high voltage handling (see *Figure 6*). In contrast, bulk CMOS processes cannot support stacking to the same degree.

Voltage handling has been an important feature in commercial terrestrial designs, but now interest is growing in using this feature for satellite designs as well. For instance, a Ultra-CMOS SPDT that is used as a highpower switch in public safety radios and many other commercial applications is now being explored for use in satellite phased-array applications to replace circulators. This switch achieves 50 W P1dB, with unmatched performance by GaAs MMIC options. As an additional advantage, eliminating a circulator and replacing it with a high-power switch would allow satellite designers to save up to 2 kg per satellite.

TECHNOLOGY FUTURE

Future development is expected to include further improvements in performance, such as phase noise, higher frequencies and higher integration. The use of UltraCMOS in satellite applications is growing rapidly. For many years, SOS was the technology of choice, but the purely military usage caused the technology to lose mo-

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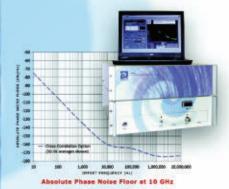
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AMPLIFIERS										
Model Number	Frequency (GHz)	Gain (dB, Min.)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	In/Out VSWR (Max.)	Output Power at 1dB Comp. (dBm, Typ.)				
JSW4-18002600-20-5A	18-26	34	1.5	2.0	2.0:1/2.0:1	5				
JSW4-26004000-28-5A	26-40	25	2.5	2.8	2.2:1/2.0:1	5				
JSW4-18004000-35-5A	18-40	21	2.5	3.5	2.5:1/2.5:1	5				
JSW4-33005000-45-5A	33-50	21	2.5	4.5	2.5:1/2.5:1	5				
JSW5-40006000-55-0A	40-60	18	2.5	5.5	2.75:1/2.75:1	0				

Higher output power options available.



	MIXER/CONVERTER PRODUCTS												
	F	requency (GI	łz)	Conversion Gain/Loss	Noise Figure	Image Rejection	LO-RF Isolation						
Model Number	RF	LO	IF	(dB, Typ.)	(dB, Typ.)	(dB, Typ.)	(dB, Typ.)						
LNB-1826-30	18-26	Internal	2-10	42	2.5	25	45						
LNB-2640-40	26-40	Internal	2-16	42	3.5	25	45						
IR1826N17*	18-26	18-26	DC-0.5	11	9.5	25	25						
IR2640N17*	26-40	26-40	DC-0.5	11	9.5	25	25						
SBW3337LG2	33-37	33-37	DC-4	-7.5	8	N/A	25						
TB0440LW1	4-40	4-42	.5-20	-10	10.5	N/A	20						
DB0440LW1	4-40	4-40	DC-2	-9	9.5	N/A	25						
SBE0440LW1	4-40	2-20	DC-1.5	-10	10.5	N/A	20						

* For IF frequency options, please contact MITEQ.



	MULTIPLIERS											
	Frequency (GHz)		Input Level	Output Power	Fundamental Feed Through Level	DC current @+15VDC						
Model Number	Input	Output	(dBm, Min.)	(dBm, Min.)	(dBc, Min.)	(mA, Nom.)						
MAX2M260400	13-20	26-40	10	10	18	160						
MAX2M200380	10-19	20-38	10	10	18	200						
MAX2M300500	15-25	30-50	10	10	18	160						
MAX4M400480	10-12	40-48	10	10	18	250						
MAX3M300300	10	30	10	10	60	160						
MAX2M360500	18-25	36-50	10	10	18	160						
MAX2M200400	10-20	20-40	10	10	18	160						
TD0040LA2	2-20	4-40	10	-3	30	N/A						
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mentum. By applying a commercial technology to satellite and other high reliability markets (99.997 percent of all UltraCMOS devices have shipped to purely commercial applications), worldwide satellite systems are improved. As satellite designers work with more phased-array and communication payload designs, they can take advantage of the inherent characteristics that are made possible by the extremely thin layer of silicon and the subsequent elimination of bulk parasitics. As satellite manufacturers increase the number of transmit and receive elements and arrays (up to 10s of 1000s in one antenna), they are likely to utilize the technology's advantages in power consumption, digital control and integration.

When RFIC designers work out the challenges before them, they will be deciding what level of integration is possible and needed, perhaps bringing RF, digital and analog all together on the same UltraCMOS chip, including input/output switches, digital/analog converters, attenuator, phase shifter and digital control. The good news is that UltraCMOS offers the cost, reliability and performance characteristics that make it future-proof for satellite design and these devices are already shipping in high volume.

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UltraCMOS Development History

SOS technology was invented in 1963 at North American Aviation (now Rockwell/Conexant), Autonetics Division in Anaheim, CA. The first published report is by Harold Manasevit and William Simpson.

In the mid-1960s, researchers at the RCA Laboratories in Princeton, NJ worked on making SOS a manufacturable technology. The primary application was for high-speed digital systems. RCA led the development of SOS technology into the mid-1970s.

The first attempt at commercializing SOS was by a company named Inselek, a spin-off of RCA. Inselek, however, did not survive into the 1980s. Hewlett-Packard developed a number of products based on SOS technology in the 1970s and 1980s. HP's RF and high-performance SOS digital products found their way into many applications, most notably signal processors for medical equipment and the Hewlett-Packard 41-Series calculators.

The major technological barrier to SOS becoming commercially successful in the 1970s was the high number of defects in the film. The defects caused leakage current when the transistor was off and reduced carrier mobility. SOS was successfully used in thicker films where the defect density is reduced, but in order to achieve really high performance, an ultra-thin film was required. (An ultra-thin film is generally considered to be less than 100 nm, or only about 100 atoms, thick.) Ultra-thin films enable the use of shorter gate lengths, which leads to higher speed electronics.

During the 1970s and 1980s, the US Navy expended approximately \$10 M in SOS process improvements and proof of manufacturability. Many of the processes developed during this time are still used in SOS and thin-film UltraCMOS processing today. UltraCMOS circuits were first commercialized by Peregrine Semiconductor.





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applications such as ISM, GPS, GSM, CDMA, W-CDMA, TD-SCDMA, LTE, WiMAX and WLAN receivers.

These parts feature noise figures as low as 0.6 dB including all external components, adjustable gain and high linearity. Moreover, the shared pin-out and application board layout allows for easy implementation in various frequency bands. The noise figure performance of all three devices is illustrated in *Figure 1*.

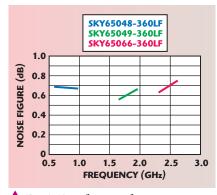


Fig. 1 Noise figure performance vs. frequency.

DESIGN

This LNA family was designed using Skyworks' proprietary low noise 0.5 µm PHEMT depletion mode process achieving both very low noise amplification and low loss passive elements. The design topology consists of two cascaded common source amplification stages with an internal interstage matching network. This topology simultaneously produces low noise and high linearity performance in addition to providing flexibility. The flexibility of the design is a key feature as its performance can be optimized through selection of external components to meet a wide range of specifications. All three amplifiers share the same FR4 application board layout, but unique bills of material for circuits optimized for specific performance requirements are provided in the product datasheets. All reference circuits meet or exceed common performance requirements including unconditional stability up to 18 GHz. Similar RF performance can be ob-

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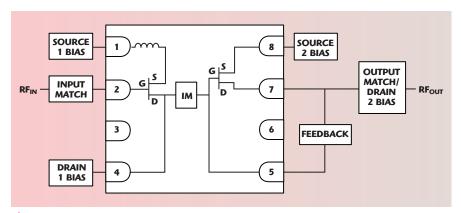
tained anywhere within the 0.7 to 2.7 GHz frequency band. Figure 2 illustrates the different sections of the external reference circuit. Pins 1, 4, and 7, 8 are used to set the bias of the first and second stage, respectively. Pins 4 and 7 supply the bias voltage through a bias circuit that typically consists of a voltage drop resistor, bias inductors and RF decoupling capacitors. The bias inductors are also parts of the input and output impedance matching circuits. The supply current through each stage is set by the value of the resistors connected to Pins 1 and 8, thus eliminating the need for a negative bias at the gate of each stage. A capacitor is used to provide RF grounding. Pin 1 also has an internal source degenerating inductor for added stability, improved noise figure and better than 18 dB input return loss.

Pin 5 gives access to the gate of the second stage FET to enable optional feedback of a portion of the RF signal from Pin 7 (RF Out), thus reducing the gain without degrading the noise figure or output linearity. The feedback circuitry generally consists of an RC network.

Finally, Pins 2 (RF $_{\rm IN}$) and 7 (RF $_{\rm OUT}$) are externally matched through the use of simple matching networks, thus providing maximum flexibility to optimize performance over various bands. This also allows for tradeoffs in bias and output return loss for improved linearity performance.

BIAS

Optimum noise and linearity performance of a transistor impose conflicting bias requirements. A two-stage design allows both noise and linearity performance requirements to be addressed simultaneously by optimizing each stage to a specific performance characteristic. Optimal noise figure is



📤 Fig. 2 LNA functional block diagram.

typically achieved by biasing the first stage to approximately 20 percent IDSS, which allows excellent noise performance while avoiding early saturation. The second stage transistor is biased to achieve optimal linearity with more current or supply voltage, thereby producing higher third order intercept (IP3) or 1 dB compression level (P_{1dB}) performance. The optimal drain voltage of each stage is also determined through the use of external voltage dropping resistors in the bias circuits.

MATCHING COMPONENTS

Component selection for the input impedance match is critical for achieving good noise figure performance as any loss at the input will add directly to the intrinsic noise of the device. It is recommended to use high-Q components on the RF input (Pin 2) for the best noise figure results. Output impedance match and bias do not require the use of high-Q components. Output match can also be tuned to optimize output return loss and linearity performance ($\rm P_{1dB}$ and IP3).

STABILITY AND GOOD LAYOUT PRACTICE

As can be seen in Figure 3, a

TABLE I LNA PERFORMANCE										
Part Number	Operating Frequency (MHz)	Test Frequency (MHz)	Gain (dB)	S ₁₁ (dB)	NF (dB)¹	OIP3 (dBm)	OP _{1dB} (dBm)	VDD (V)	Quiescent Current (mA)	
SKY65048- 360LF	700-1000	900	15-25	18	0.7	35.5	18	5	85	
SKY65049- 360LF	1500-2400	1950	15-25	18	0.7	34.5	18	5	75	
SKY65066- 360LF	2300-2700	2500	15-25	18	0.7	35.5	18	5	75	
Note 1: Inp	Note 1: Input connector loss removed from measurement.									

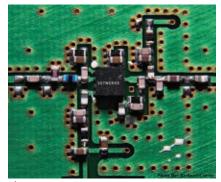
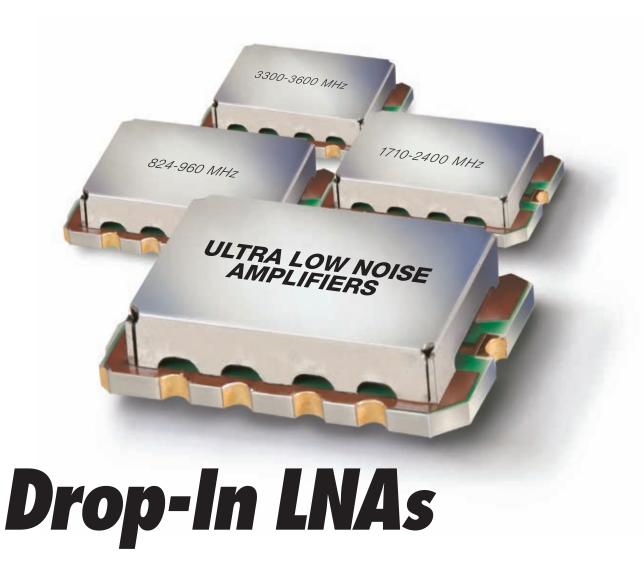


Fig. 3 LNA evaluation board.

grounded coplanar waveguide transmission line (CPWG) is preferred over the microstrip line as it offers more tuning flexibility for shunt components and provides inherent signal isolation due to the presence of the grounded top metal layer.

The test board was realized on FR4. This material was selected due to its low loss, low cost and relatively low dielectric constant. The line width and spacing to the ground plane were selected to accommodate shunt 0402 size surface-mount components while maintaining a uniform 50 ohm line even when optional shunt components are not populated. Both topside ground planes of the CPWG line are referenced to the bottom ground plane through the use of vias on each side, to insure only the CPWG propagation mode exists.

As frequency increases, vias become increasingly inductive and the performance of lumped components may change in nature when used near or beyond their self-resonant frequency. At some frequencies, these changes may allow a positive RF feedback path, which may lead to unstable performance, including oscillation.



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The TAMP series of LNAs not only eliminates the need for designers to optimize low noise transistor bias and matching circuitry, but they're also optimized to give superior performance of *ultra low noise* and high dynamic range in a self contained, drop-in, compact metal-shielded case. The case PCB area is smaller than most LNA transistor designs with external circuitry.

The TAMPs do not require any external elements, are unconditionally stable, and are matched to 50Ω input/output. They're the ideal mix of flexibility, efficiency, and price and come in a single, integrated component ready to drop-in to your assembly board.

TAMP Typical Specifications

MODEL	Frequency, GHz	NF dB	Gain dB	Max Output dBm	Price \$ (5-49)
TAMP-960LN+	.8296	0.55	18.0	16.5	9.95
TAMP-242LN+	1.7-2.4	0.65	13.0	17.0	9.95
TAMP-242GLN-	+ 1.7-2.4	0.85	30.0	20.0	13.95
TAMP-272LN+	2.3-2.7	0.90	14.0	18.0	9.95
TAMP-362LN+	3.3-3.6	0.90	12.0	11.0	10.95
TAMP-362GLN-	+ 3.3-3.6	0.90	20.0	16.0	14.95

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The bias circuits of both stages are physically and electrically separated as much as possible and sharing of ground vias is avoided. The top ground plane is also intentionally broken in various sections to open any potential positive RF current feedback loops. The resulting metal "islands" are then brought to the common ground reference through the use of multiple vias in order to prevent unwanted resonances.

Vias should also be placed as close as possible to board components in order to minimize the electrical length to the ground reference, which includes the vias' length. The most sensitive regions are the input match and the RF decoupling regions of drain and source terminals of each stage. Careful attention must be paid to the layout of these regions to achieve good gain and noise figure performance. These sensitive regions are carefully addressed on the evaluation board by the addition of multiple vias to minimize parasitic inductance in these paths.

PERFORMANCE

The application circuits were tuned to operate with 5 V DC drain bias and 75 to 85 mA drain current. Each stage of the amplifier is biased separately from a single DC supply to achieve the targeted noise and linearity performance. The first stage transistor is biased at 20 percent of IDSS, about 20 mA in this case. Performance specifications are summarized in *Table 1*. These circuits can be changed to operate at lower or higher power.

All performance parameters are achieved with an external reference circuit. High Q, low loss Coilcraft-HP inductors and Murata-GJM capacitors are used for the input matching network to optimize noise figure. All three LNAs are able to attain less than 0.7 dB noise figure with return loss of 18 dB in their respective frequency ranges, including matching network losses. Output third order intercept (OIP3) performance is better than 34.5 dBm for all devices with output 1 dB compression (OP1dB) of 18 dBm.

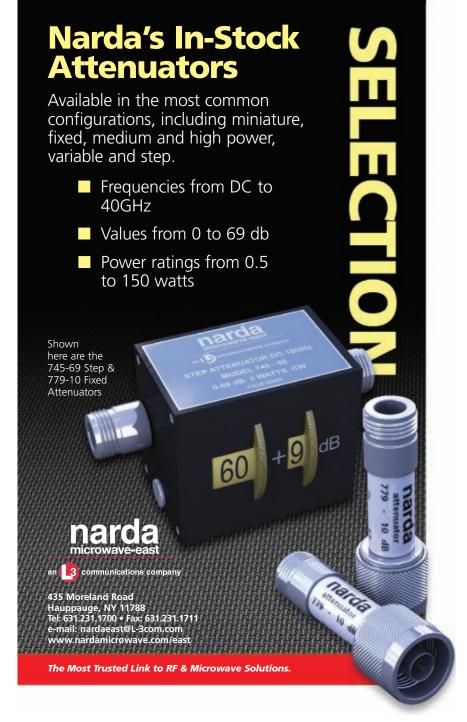
APPLICATIONS

These LNAs are typically used in receiver applications that demand low noise and high sensitivity while maintaining compact size and low cost. Typical examples are ISM, GPS, GSM, ČDMA, W-CDMA, TD-SCD-MA, LTE, WiMAX and WLAN receivers. Through the use of external components to achieve acceptable input impedance match, the LNAs can be tuned to operate over a wide frequency range and under various bias conditions, while meeting demanding performance requirements.

S-parameters, populated evaluation boards and suggested PCB layouts are available. Additional applications support is also available upon request.

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RS No. 302



















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ROTARY JOINTS FOR SATCOM APPLICATIONS

EXECUTIVE INTERVIEW SERIES

MWJ SPEAKS WITH KLAUS-DIETER BECK, HEAD OF SALES AND MARKETING, RADAR AND SATELLITE DIVISION, SPINNER GMBH.

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odern mobile satellite communication systems provide bidirectional broadband network access for moving ground, maritime and airborne terminals. Applications enabled by mobile SatCom systems include broadband Internet access, video conferencing and data transmission. Currently such systems—commonly called SatCom on-themove—are being introduced on a large scale all over the world for commercial as well as for governmental (civilian and military) use. For mobile SatCom equipment the commercial Kuband is often chosen since this frequency range offers a trade-off between reduction of antenna size on the one hand, and reasonable resistance to adverse weather conditions on the other.

A moving satellite terminal requires a highly sophisticated beam steering system in order to continuously track the satellite during opera-

tion. There are two basic technologies that can be employed for pointing an antenna beam: The electronically phased-array antenna and the mechanically steered pencil beam antenna.

When the latter system is used, the strong space restrictions imposed by a mobile SatCom terminal require the adoption of a small aperture antenna together with a low-profile pedestal. Likewise the rotary joints employed for signal transmission along the mechanical steering axes need to be small and often shaped specifically for the application.

Therefore, in order to provide equipment manufacturers with rotary joints tailored to the specific requirements of fixed and mobile Sat-Com systems, Spinner has developed two new rotary joint product families—single channel waveguide rotary joints for Ku-band, and dual channel coaxial rotary joints, which are suitable for Ku-band and intermediate frequency applications.

Both product lines follow a common design philosophy that is characterized by well-thought-out modularity that allows a large variety of solutions with a minimum number of different piece parts and excellent electrical and mechanical performance, allied to a simple and highly reliable design.

SINGLE CHANNEL ROTARY JOINTS

Figure 1 shows the U-shaped and L-shaped

SPINNER GMBH Munich, Germany



Fig. 1 U- and L-shaped variants of the new Ku-band rotary joint family.

300 kHz to 14 GHz

AMPLIFIERS



Mini-Circuits ZX60 family of compact coaxial amplifiers serve a broad range of applications from 300 kHz to 14 GHz. ZX60 models offer many combinations of gain (as high as 38 dB), noise figure, output power, and linearity (IP3 performance) over wide bandwidths, allowing designers, for example, to optimize system dynamic range through a wide choice of noise-figure performance levels (as low as 0.4 dB at 1.4 GHz) and high IP3 performance (as high as +45 dBm at 2.4 GHz). ZX60 amplifiers are small in size and low in cost, and still deliver excellent active directivity (isolation-gain) and outstanding unit-to-unit performance repeatability. All models feature Mini-Circuits exclusive Unibody housing (protected by US Patent No. 6,790,049) for reliability. And when these ready-to-ship standard models won't do, Mini-Circuits technical team is ready to quickly meet your most demanding requirements with effective custom solutions.

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Model	Freq. (GHz)	Gain (dB) Typ.	NF (dB) Typ.	IP3 (dBm) Typ.	P _{out} @ 1dB Comp. (dBm) Typ.	DC Volts (V)	Current (mA) Max.	Price \$ ea. (1-9)
Lengtl	h: 0.74" x (W) 1				71	()		(- /
ZX60-2510M	0.5-2.5	12.9	5.4	+28.8	17.1	5.0	95	59.95
ZX60-2514M	0.5-2.5	16.4	4.8	+30.3	16.5	5.0	90	59.95
ZX60-2522M	0.5-2.5	23.5	3.0	+30.6	18.0	5.0	95	59.95
ZX60-3011	0.4-3.0	12.5	1.7	+31.0	21.0	12.0	120	139.95
ZX60-3018G	0.02-3.0	20.0	2.7	+25.0	11.8	12.0	45	49.95
ZX60-4016E	0.02-4.0	18.0	3.9	+30.0	16.5	12.0	75	49.95
ZX60-5916M	1.5-5.9	17.0	6.4	+28.3	14.4	5.0	96	59.95
ZX60-6013E	0.02-6.0	14.0	3.3	+28.7	10.3	12.0	50	49.95
ZX60-8008E	0.02-8.0	9.0	4.1	+24.0	9.3	12.0	50	49.95
ZX60-14012L	0.0003-14.0	12.0	5.5	+20.0	11.0	12.0	68	172.95
ZX60-33LN	0.05-3.0	17.6	1.1	+30.0	17.5	5.0	80	79.95
-								
Leng	gth: 1.20" x (W) 1.18" x	(H) 0.	46"				
ZX60-1215LN	0.8-1.4	15.5	0.4	+27.5	12.5	12.0	50	149.95
ZX60-1614LN	1.217-1.620	14.0	0.5	+30.0	13.5	12.0	50	149.95
ZX60-2411BM	0.8-2.4	11.5	3.5	45.0	24.0	5.0	360	119.95
ZX60-2531M	0.5-2.5	35.0	3.5	+26.1	16.1	5.0	130	64.95
ZX60-2534M	0.5-2.5	38.0	3.1	+30.0	17.2	5.0	185	64.95
ZX60-3800LN	3.3-3.8	23.0	0.9	+36.0	18.0	5.0	110	119.95
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members of the product family, while the main characteristics of the Kuband waveguide rotary joints are summarized in *Table 1*. Although realized in a non-contacting design, the Ku-band family is characterized by wide frequency coverage (relative bandwidth of 30 percent and above). An advanced electromagnetic design employing two stepped impedance transformers makes it possible to cover the full satellite band portion of the Ku-band with a high return loss and low insertion loss (see *Figure 2*).

These rotary joints are suitable for downlink frequencies (10.70 to 12.75 GHz) and uplink frequencies (13.75 to 14.50 GHz) as well as for the guard band in between. This last feature is being demanded by more and more customers. Figure 2 shows that any parasitic resonances are placed clearly outside the specified transmission band.

Another significant feature of the single channel rotary joints is that they are able to handle high average power levels safely. This feature is a result of

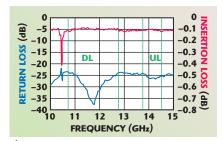


Fig. 2 Typical frequency response of the new Ku-band rotary joint family.

TABLE I			
KU-BAND SINGLE CHANNEL WAVEGUIDE ROTARY JOINTS			
Model	BN 635710	BN 635709	BN 635707
Case style	I	L	U
Interface center distance(s)	74 mm	65 mm / 22 mm	52 mm / 22 mm
Frequency range	10.7 to 14.5 GHz		
Return loss, min./typ.	20 dB / 23 dB (see Figure 2)		
Insertion loss, max./typ.	0.2 dB / 0.1 dB (see Figure 2)		
Insertion loss variation, max./typ.	0.1 dB / 0.02 dB		
Peak power, max.	5 kW		
Average power, max.	$600\mathrm{W}$		
Interfaces	PBR120 and/or UBR120 mod.		

the low insertion loss and the method of construction, with large cross-section metallic parts that allow for efficient axial heat removal towards both ends of the joint.

Besides good RF performance the Ku-band rotary joints are characterized by a dust-tight design that is protected against water jets (protection level to IP65) by the inclusion of a dy-



Fig. 3 I- and L-shaped variants of the new dual channel rotary joint family.

namic seal. In order to accommodate this seal the torque is increased and the housing slightly lengthened, but both are kept to a minimum.

DUAL CHANNEL ROTARY JOINTS

The newly introduced dual channel rotary joints belong to a universal product family that covers different preferential frequency ranges, different case styles and flanges. The predecessor to this family is the multipurpose rotary joint BN153118 that is shown on the left of *Figure 3*.

Its main characteristics are summarized in *Table 2*. This dual band rotary joint and its derivatives are realized with galvanic contacts at the center and outer conductors. As a result of this design each channel enables combined RF and DC transmission. This DC



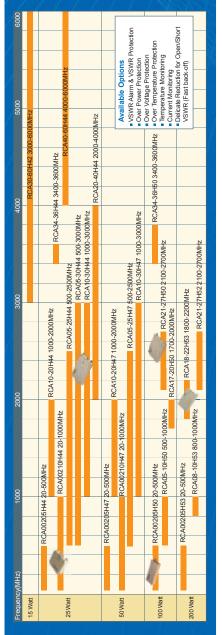


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BN 153118 M	JLTI-PURPOSE DUAL-CHANNE	L ROTARY JOINT, I-STYLE
Channel	CH1	CH2
Frequency range	DC to 18 GHz	DC to 18 GHz
VSWR, max.	1.35 @ DC to 8 GHz 1.5 @ 8 to 18 GHz	2.0 @ DC to 4 GHz 2.5 @ 4 to 8 GHz 3.5 @ 8 to 12 GHz 4.5 @ 12 to 18 GHz
VSWR variation, max.	0.1	0.1 @ DC to 4 GHz 0.4 @ 4 to 8 GHz 0.8 @ 8 to 12 GHz 2.0 @ 12 to 18 GHz
Insertion loss, max.	0.4 dB @ DC to 8 GHz 1.0 dB @ 8 to 18 GHz	0.5 dB @ DC to 4 GHz 1.0 dB @ 4 to 8 GHz 1.5 dB @ 8 to 12 GHz 3.5 dB @ 12 to 18 GHz
Insertion loss variation, max.	0.06 dB	0.1 dB @ DC to 4 GHz 0.35 dB @ 4 to 8 GHz 0.7 dB @ 8 to 12 GHz 1.5 dB @ 12 to 18 GHz
Isolation, min.	5	50 dB
Interfaces	1.5-3.5 female, fu	lly compatible to SMA

transmission makes it possible to supply active components on the rotating part of a platform (e.g. an LNA).

Besides the I-shaped models like the one shown on the left in Figure 3, the new product family also includes rotary joints with L-shaped (shown on the right in Figure 3) and U-shaped housings that allow for a space-saving antenna pedestal design. These L-shaped and U-shaped variants significantly simplify the integration of the rotary joint. In order to cover a large variety of customer needs, the different basic case styles are available with standard and custom specific mounting flanges.

The different housing variants described above are just one advantage. Moreover, specialized versions are available that incorporate application specific tuning of the second channel in order to fulfill more stringent performance requirements within a dedicated frequency range. The L-shaped rotary joint BN 153146 shown on the right side of Figure 3 is an example of a variant optimized for SatCom use.

As a result of this optimization channel, CH2 of BN 153146 clearly outperforms channel CH2 of BN 153118 with respect to all RF parameters. At the expense of a narrower usable frequency range, channel CH2 of BN 153146 does now comply with a VSWR below 2.0 (compared to 3.5), a VSWR variation during rotation less than 0.5 (compared to 0.8), an insertion loss below 1.0 dB (compared to 1.5 dB) and a



▲ Fig. 4 Custom specific combination of a dual channel rotary joint with a slip ring assembly.

maximum insertion loss variation of 0.4 dB (compared to 0.8 dB).

For applications that require a contacting transmission of supply power (DC, AC) or low frequency signals (analog, data), the dual channel rotary joints are also available in combination with standard and customer specific slip ring assemblies. *Figure 4* shows a typical combination of an I-style rotary joint mounted within such an assembly.

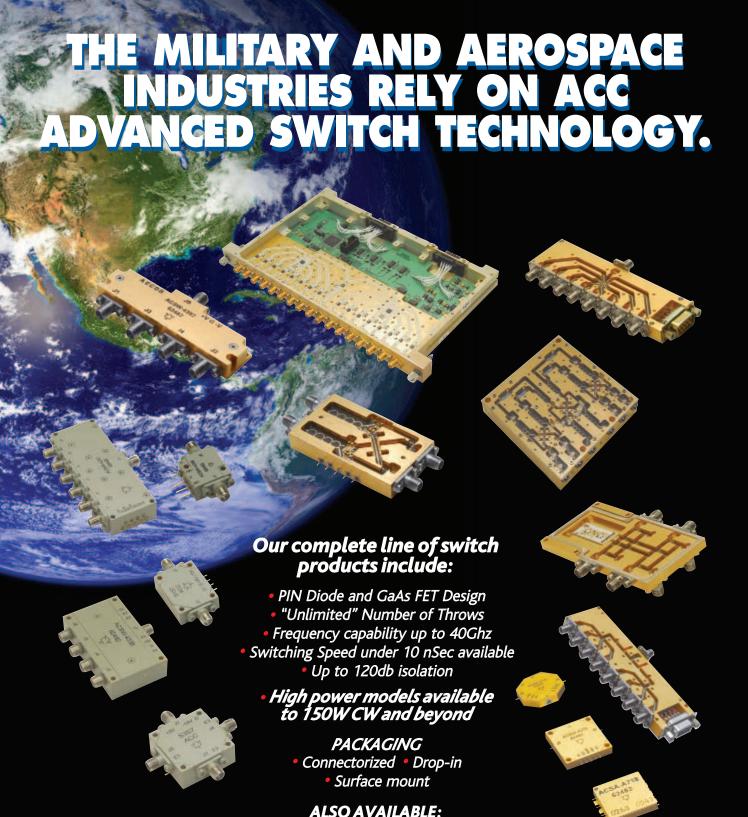
CONCLUSION

45 mm flange dia. x 32 mm OD x 56 mm length

These two new SatCom rotary joints that have been introduced by Spinner define a reference standard in electrical and mechanical performance. The Ku-band single channel waveguide rotary joints stand out due to their extremely wide transmission band. The dual channel rotary joint family features a unique variety of shapes in conjunction with its excellent RF data.

Spinner GmbH, Munich, Germany +49 89 12601 1160, info@spinner.de.

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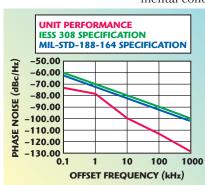
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X-BAND 100 W BLOCK Upconverter

n the world of tactical military communications, small size, light weight and versatility are essential for all components required for each deployable system. Locus Microwave, now part of the Codan family, has added the UB61000-050 X-band 100 W Block Upconverter (BUC) in accordance with this effort. The UB61000-050 features an L-band input interface with an X-band (7.9 to 8.4 GHz) output at 100 W PldB (typical). This is the latest addition to the Locus line of X-band BUC products that now extend from 5 to 100 W in a variety of packaging sizes and configurations. The Locus Microwave UB61000-050 provides a solution for outdoor military communication applications where a compact package is required for performance in a variety of environmental conditions.



▲ Fig. 1 Phase noise performance of UB61000-050.

PACKAGE FEATURES

The Locus Microwave UB61000-050 X-band Block Upconverter features a robust package in a compact size and weight. The UB61000-050 weighs in at slightly less than 25 pounds at the approximate size of a large shoebox. The exact dimensions are 14.5 inches long, 7.5 inches wide and 7.5 inches high.

The UB61000-050 package is ruggedized for a variety of

environmental and tactical combat conditions. Operating temperatures are rated for -40 $^{\circ}$ to +60 $^{\circ}$ C. With environmental temperature concerns solved, the UB61000-050 is also rated to 100 percent humidity resistance taking care of moisture considerations. This rating allows for condensation buildup as well.

An additional feature of the Locus UB61000-050 package is the thermal cooling system. The package is self-cooled by forced air flowing over custom thermal heat sinks allowing for cool operating temperatures throughout the interior operating electronics. The advantage of this system is realized by the mounting flexibility it provides from being completely self-contained. Outside cooling is simply not necessary. All of the UB61000-050 package features provide a compact solution with the versatility and ruggedness required for current military communication.

TECHNICAL PARAMETERS

The Locus Microwave UB61000-050 converts a L-band (950 to 1450 MHz) input frequency to a X-band (7.9 to 8.4 GHz) output frequency using a phase locked 6.95 GHz local oscillator and mixer. Amplification is provided at both the L-band IF range and the 8 GHz output range.

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Phase noise performance the Locus UB61000-050 exceeds both MIL-STD-188-164 and IESS 308 specifications, as illustrated in *Figure 1*. The specification for phase noise (SSB) at 1 kHz offset is -76 dBc/ Hz (typical), at 10 kHz offset is -86 dBc/Hz (typical) and at 100 kHz offset is -108 dBc/ Hz (typical).

Typical gain for the UB61000-050 is 64 dB with a minimum of 60 dB. Other gain levels are available frequency. with factory con-

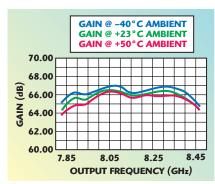


Fig. 2 Gain vs. frequency performance.

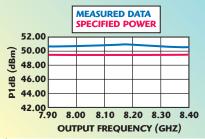


Fig. 3 1 dB compression point vs.

sultation. Gain versus frequency performance data at -40°, $+23^{\circ}$ and $+50^{\circ}$ C is illustrated in **Figure 2**. Gain flatness is measured at ± 1.25 dB maximum per full band with a slope of ± 0.4 dB per 40 MHz. **Figure 3** is representative of data illustrating 1 dB compression point versus frequency from the Locus UB61000-050, which is an example of how performance can exceed what is listed on the spec sheet.

Another feature of this 100 W X-band BUC is that it locks to an external 10 MHz reference frequency at a level of 0 dBm ±5 dB. Standard connectors for the UB61000-050 include Type N female IF input/External Reference, CPR112G Waveguide RF output and PT02E-14-12-P DC Power/M&C. Additional connector options are available after consultation with the Locus factory.

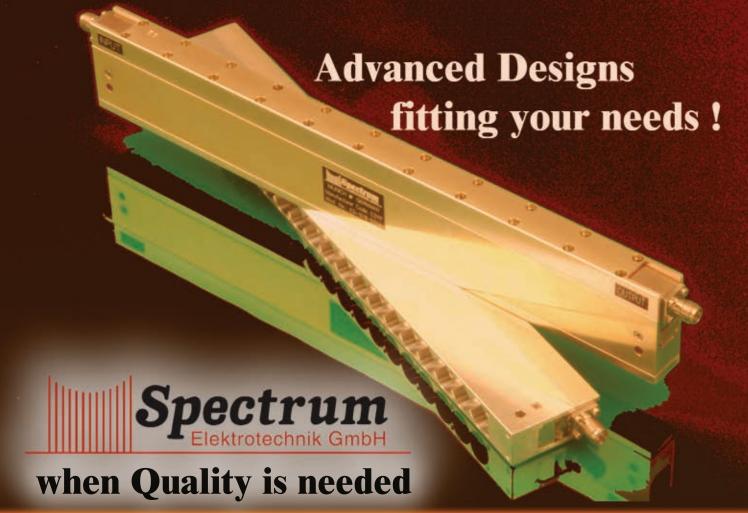
The Locus UB61000-050 features an attractively low power consumption of only 500 W, which sets it apart in terms of efficiency. The standard input power requirement for this block upconverter is 48 V DC. An AC power solution can be provided.

APPLICATIONS

The X-band frequency range is considered the "military band". As illustrated in Figure 1, the UB61000-050 outperforms the MIL-STD-188-164 and IESS-308 specifications for phase noise performance. The compact size and light weight of this unit allow for a host of flexible mounting options on a variety of military communication systems. The rugged durability of this unit allows for a variety of deployment environments, which is essential for modern military communication.

Locus Microwave, Boalsburg, PA (814) 466-6275, info@locusmicrowave.com, www.locusmicrowave.com.

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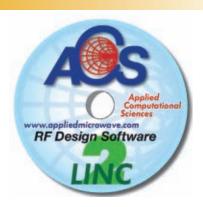
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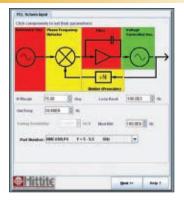
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DESIGN AND SIMULATION SOFTWARE

A new version of the LINC2 Pro RF and microwave design and simulation software suite has been released by ACS. LINC2 V2.72 includes many new enhancements and upgrades, including new circuit models and simulation methods. Included among the many new enhancements are variable parameter sweeps, user defined equations, and special output functions for post processing simulation data. Special intrinsic functions provide new ways of processing and viewing simulation results, such as finding and tracking the frequency point at which the maximum value of a circuit response occurs or tracking the frequency of oscillation for an oscillator relative to the value of a variable parameter or circuit component value.

Applied Computational Sciences (ACS), Escondido, CA (760) 612-6988, www.appliedmicrowave.com. RS No. 310



PLL PHASE NOISE SOFTWARE VENDORVIEW

The widely popular PLL Phase Noise Calculator tool on Hittite's website was specifically designed to help synthesizer designers select the best Hittite divider, phase frequency detector and VCO for their PLL circuit needs. The interrelation of these building blocks is critical to achieving optimal PLL phase noise, and each component in the PLL circuit will impact overall performance. A graphical interface guides the user through the component selection process, and the calculator uploads the key performance attributes for each Hittite component selected. The PLL Phase Noise Calculator quickly provides the phase noise contribution of each PLL element, as well as the total for the entire loop.

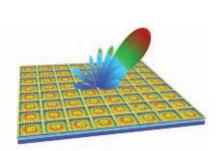
Hittite Microwave Corp., Chelmsford, MA (978) 250-3343, www.hittite.com. RS No. 312



ANTENNA DESIGN TOOL VENDORVIEW

Antenna Magus is an expert system for antenna design with a large database of antennas that makes it suitable for a broad range of applications. Its feature set is targeted at aiding engineers to get to the customization phase of an antenna design quickly and reliably. Validated, parametric models of the initial design are exported seamlessly into CST MICRO-WAVE STUDIO or FEKO, where customization can be done in tried-and-trusted analysis tools. Antenna Magus will expand both the number of antennas it can design and export, as well as in the number of analysis tools it interfaces with. It will aid antenna design engineers, EMC engineers requiring antenna models and system integrators who require antenna models for antenna placement studies.

Computer Simulation Technology (CST) AG, Darmstadt, Germany +49 6151 7303 0, www.cst.com. RS No. 311



EM FIELD SOLVER UPDATE

The new version 5.20 of the EMPIRE XCcelTM 3D EM field solver for the design and analysis of RF and microwave components and antennas features the Perfect Geometry Approximation (PGA) algorithm to yield highly accurate results for curved and off-axis structures without loss of simulation speed. The on-the-fly code generation for each model and processor produces up to 1,600 million FDTD cells per second on a conventional multi-core PC supporting up to 256 GB RAM. Other features include an Object Library with 3D, 2D, wire and SMD objects, a Port Library supporting circular waveguides, internal waveguide ports with higher order modes, object snap on edges, corners and midpoint, fast plane wave excitations, superposition of near and far fields, and an Update Manager.

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Components

14 to 18 GHz Bandpass Filter



Model A65-MH004 is a 14 to 18 GHz bandpass filter. This filter has a 1 dB maximum insertion loss, 2:1 maximum VSWR, 10 W maximum operating power, and a stop band of -70 dB minimum from 0 to 11,900 MHz and 21 to 25 GHz.

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

RS No. 235

Power Dividers



ET Industries announced its newest product line, power dividers to 65 GHz. The model D-1865-2 is a two-way power divider and model D-1865-4 is a four-way power di-

vider that spans the frequency range from 18 to 65 GHz. Amplitude and phase imbalance are ±1.0 dB and ±12° maximum. Isolation is 20 dB minimum. VSWR is less than 2.0:1. The maximum insertion loss is 3.5 dB for the two-way and 6.0 dB for the four-way. Connectors are "V" 1.85 mm females. Eight-way and sixteen-way power dividers to 65 GHz are also available.

Electromagnetic Technologies Industries Inc., Boonton, NJ (973) 394-1719, www.etiworld.com.

RS No. 236

Pseudo Elliptic Bandpass Filter



KR Electronics introduces part number 2910, a surface-mount 875 MHz pseudo elliptic bandpass filter. The filter has a typical insertion loss of 3.5 dB and minimum 3 dB bandwidth of 42 MHz. The filter attains over 50 dB rejection by 831 and 920 MHz. The use of elliptic bandpass at bandwidths as low as 5 percent allows superior performance to all-pole designs in a smaller package. The filter is supplied in a surface-mount package measuring $2.0^{\rm w} \times 0.5^{\rm w} \times 0.3^{\rm w}$ and can also be supplied connectorized. The filter can be customized for other center frequencies and bandwidths.

KR Electronics Inc., Avenel, NJ (732) 636-1900, www.krfilters.com.

77 GHz Economic Sensor



Model SRF-77120910-01 is a low cost 77 GHz sensor designed for Doppler speed measurement. It is constructed with a

high performance circular horn antenna, a linear to circular polarizer and T/R diplexer. It also incorporates a balanced mixer and a high performance Gunn oscillator. The sensor features a 12 degree 3 dB beam width, 10 dBm output power and 9 dB conversion loss. The sensor can readily be modified to offer different beam widths, dual channel (I-Q) output or FMCW versions.

Ducommun Technologies, Carson, CA (310) 847-2859, www.ducommun.com.

RS No. 216

Quick-release Waveguide Couplings



Manufactured from Alochromed aluminum with stainlesssteel threaded inserts and screws, the QRF series of couplings attach to the rear of waveguide flanges. The self-aligning couplings are equipped with dowels to ensure precise posi-

tioning, while the use of spring-loaded screws prevents parts from being lost. The screws are designed to be finger tightened and also incorporate hex bolts to allow the use of a torque wrench. Available in different versions to suit all popular waveguide sizes, the QRF series is designed for rapid installation and is suitable for maintenance personnel in the defense, broadcast and telecommunications sectors.

Link Microtek Ltd., Basingstoke, Hampshire, UK +44 (0) 1256 355771, www.linkmicrotekeng.com.

RS No. 217

Miniature Lumped Element Low Pass Filter



Model 3LP8-100-S is a miniature lumped element low pass filter. The unit exhibits a 3 dB cut-off frequency of 100 MHz with an insertion loss of 0.6 dB from 500 kHz to 90 MHz. VSWR is 1.5:1 typical and is 1.25" \times 5" \times 0.4".

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

RS No. 218

Feed-thru Terminations

VENDORVIEW



These feed-thru terminations are designed to provide high impedance devices such as an oscilloscope with a characteristic 50 Ohm impedance. MECA's family of

RoHS compliant feed-thru terminations operate between 300 to 1000 MHz and are available off-the-shelf in N, SMA, BNC and TNC connector configurations. Units are rated at 2 W average (500 W peak). These feed-thru terminations are made in the USA and offer a 36-month warranty. **MECA Electronics Inc.**.

Denville, NJ (866) 444-6322, www.e-meca.com.

RS No. 219

Frequency Doubler VENDORVIEW



MITEQ introduces its new frequency doubler, model MAX2M0714N01U, which produces an output of +23 dBm from 13,500 to

14,500 MHz with an input harmonic rejection of –20 dBc typical. This doubler requires an input power of 10 dBm typical, +15 V DC at 350 mA and –15 V DC at 10 mA. It is supplied with type "K" female connectors. The MAX2M-0714N01U measures 0.90" \times 0.69" \times 0.23" without connectors.

MITEQ, Hauppauge, NY (631) 436-7400, www.miteq.com.

RS No. 220

High Frequency Miniature Cavity Filters



NIC introduces its miniature size cavity filters designed for use in airborne, ship or ground applications. These filters can be custom designed for any center frequencies varying from 3 to 18 GHz, and 3 dB bandwidths from 5 to 30 percent. Features include: hermetically-sealed package; low insertion loss, high selectivity and wide bandwidth; Gull wing surface-mount RF pins or field replaceable SMA connectors; up to 80 percent reduction in weight and volume compared to standard combline filters; and good ultimate rejection.

Networks International Corp., Overland Park, KS (913) 685-3400, www.nickc.com.

RS No. 238

112

RS No. 237

MICROVAVE SWITCHES NOW 100 MILLION CYCLES

DC-18 GHz





\$13995 from 139 IN STOCK

Tired of the high cost and lost time that come with constantly having to replace your current mechanical switches? Then why not change over to Mini-Circuits ultra reliable DC to 18 GHz switches, (three versions available; SPDT reflective, SPDT absorptive and Transfer switches) – you could start saving up to 90% right away.

How? Our RF/microwave mechanical switches use breakthrough, advanced technology to eliminate springs and other life shortening moving parts. The result? Switches that are so reliable they're backed by our 1-year, 10 million cycle warranty, extendable to a 10-year, 100 million cycle warranty. In fact, they're so robust we've even tested them in sleep mode for up to four years without a single start up failure. Plus, they still deliver the superior performance, good impedance matching, low insertion loss, and high isolation (up to18 GHz), you've come to expect from any of Mini-Circuits high quality components. For details, please see our website.

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The Design Engineers Search Engine Provides ACTUAL Data Instantly From MINI-CIRCUITS At: www.minicircuits.com

E-GSM Diplexer VENDORVIEW



Reactel part number 2DP-EGSM-900 is a diplexer for the E-GSM Band. This unit features passbands of 880 to 915 and 925 to 960

MHz with an in-band insertion loss of less than 1.2 dB. With 40 dB of isolation and minimum handling capability of 20 W, this unit is a great fit for your application.

Reactel Inc., Gaithersburg, MD (301) 519-3660, www.reactel.com.

RS No. 221

Switch Filter Box Assembly



RLC Electronics offers a custom design capability that integrates discrete components into a specific common platform for multi-function ability, tailored to meet your specifications. Integrated products include coaxial-based filters, multiplexers, switches (both pin diode and me-

R&K/Power/Amplifier
NEW/Lineup!!

- High Performance
- Panel Meter (Color Display)
- External Memory Function

Model	Frequency	@P1dB
A080M102-5252R	80-1000MHz	150W
A080M102-5757R	80-1000MHz	500W
A080M102-6060R	80-1000MHz	1kW
DBA080M102-5252R	80-1000MHz	150W
DBA080M102-5757R	80-1000MHz	500W
DBA080M102-6060R	80-1000MHz	1kW
GA801M302-4444R	800-3000MHz	20W
GA801M302-4747R	800-3000MHz	40W
GA801M302-4949R	800-3000MHz	60W
GA801M302-5151R	800-3000MHz	100W
GA801M302-5353R	800-3000MHz	150W
GA801M302-5656R	800-3000MHz	300W
GA801M302-5858R	800-3000MHz	500W
GA252M602-4040R	2500-6000MHz	10W
GA252M602-4343R	2500-6000MHz	20W
GA252M602-4747R	2500-6000MHz	40W
GA252M602-5050R	2500-6000MHz	70W

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120

chanical), couplers, hybrids, power dividers, attenuators, detectors and terminations. Typical configurations are 19" rack assemblies in various sizes. Range of performance exceeds 40 GHz. Typical applications for military and commercial end use includes calibration services, ATE, assembly miniaturization and consolidation.

RLC Electronics Inc., Mount Kisco, NY (914) 241-1334, www.rlcelectronics.com.

RS No. 222

RF Compact LC Diplexer



This small footprint diplexer is designed for the DC to 2000 MHz band. This diplexer features lowpass rejections of 60 dB minimum from 1200 to 2000 MHz and highpass rejections of 60 dB minimum from DC to 800 MHz. This compact mechanical package is rated at 10 W input power, features SMA connectors on all ports, high broadband isolation and wide frequency ranges. High power models are also available. Standard delivery: five to six weeks.

Trilithic Inc., Indianapolis, IN (317) 895-3600, www.trilithic.com.

RS No. 223

Amplifiers

High Power, Broadband GaN Amplifier



Model SSPA 0.225-2.000-50 is a high power, broadband GaN amplifier that operates from 225 to 2000 MHz minimum. It is designed for harsh environments such as munitions and high performance fighter aircraft. Power added efficiency in saturation is typically 40 percent across the band. Input VSWR is 2.0:1 maximum. Output VSWR is 2.0:1 typical. This unit is equipped with Aethercomm's proprietary DC switching circuitry that enables and disables the DC-DC circuitry in

1200 nSec typical for turn on and 2900 nSec for turn off time. Standard features include reverse polarity protection, output short and open circuit protection, and reverse polarity protection.

Aethercomm Inc., Carlsbad, CA (760) 208-6002, www.aethercomm.com.

RS No. 224

LNA and Driver Amplifier SMTs VENDORVIEW



The HMC504LC4B is a GaAs MMIC low noise wideband amplifier housed in a leadless 4×4 mm ceramic surface-mount package. The amplifier operates between 14 and 27 GHz, providing up to 19 dB of small-signal gain, 2.2 dB noise figure, and output IP3 of +26 dBm, while requiring only 90 mA from a +4 V supply. The HMC635LC4 is a GaAs PHEMT MMIC driver amplifier die that operates between 18 and 40 GHz. The amplifier provides 18.5 dB of gain, +27 dBm output IP3, and +22 dBm of output power at 1 dB gain compression, while requiring only 280 mA from a +5 V supply.

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

RS No. 225

High Power Bias Amplifier VENDORVIEW



This GaAs MMIC high power amplifier (HPA) offers +37 dBm saturated output power and 27 dB small-signal gain. This HPA, identified as XP1058-BD, uses a dual-sided bias architecture, covers

14.5 to 16 GHz, and achieves +44 dBm OIP3. The device is well suited for millimeter-wave military, radar, satellite and weather applications.

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

RS No. 226

Ultra Low Noise MMIC Amplifier VENDORVIEW



Mini-Circuits PMA-545+ is a E-PHEMT-based ultra-low noise MMIC amplifier that operates from 100 MHz to 6 GHz with a unique combi-

The unique MILMEGA 5 Year Warranty



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- 48 Hour Factory Turnaround
- No Shipment costs
- No Labour costs
- No Parts costs
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Setting a New Standard for Customer Service

No hidden costs, no additional service contracts to purchase, no pressure to buy a replacement - just 5 years peace of mind and a simple promise to deliver the type of service you deserve.

Add to this the benefits of our unrivalled upgradeable topology, class leading power density and an enviable reputation for going the extra mile for our customers and it becomes clear why MILMEGA is the preferred choice for solid state power amplifiers.

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Designers and Manufacturers of High Power Microwave and RF Amplifiers





Asia-Pacific Microwave Conference

December 7-10, 2009, Singapore

http://www.apmc2009.org

2009 Asia-Pacific Microwave Conference and Technical Exhibition in Singapore

2009 Asia-Pacific Microwave Conference (APMC 2009) will be held in Singapore from Monday, December 7 to Thursday, December 10, 2009.

APMC dates back to 1986 in New Delhi, and it is now recognized as one of the premier international conferences of microwave community. Singapore is proud to organize the 2009 APMC. This event will continue the spirit of APMC, address important issues in the microwave community, and network the region to the world.

APMC 2009 will offer a rich scientific program of the highest quality with invited speakers from all over the world and provide a broad forum of exchange for both academia and industry alike. The conference will cover the entire scope of microwave engineering, including RF/microwave, antennas & propagation and EMC/EMI. Short courses and workshops will be scheduled on Dec. 7, 2009. Technical parallel sessions will be held from Dec. 8-10, 2009.

All accepted papers will be included in IEEE Xplore and indexed by EI.

Authors of presented papers at APMC 2009 are invited to submit an extended version of their manuscripts to the APMC Special Issue of IEEE Trans. on Microwave Theory and Techniques scheduled for Sept. 2010.

Technical Topics

- Antenna and array designs
- Computational electromagnetics and CAD packages
- Passive and active microwave components, devices and modules
- MMIC, hybrid IC, and other packaging techniques
- Microwave and millimeter-wave systems and networks
- Electromagnetic field theory
- Wave propagation and scattering
- Microwave photonics and optoelectronics
- RFID components, standards, and applications
- Instrumentation and measurements
- EMC management, modeling and simulation
- Biological effects and medical applications
- MEMS and NEMS, nanotechnology

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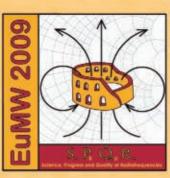
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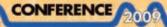
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The 2nd European Wireless Technology Conference



The 6th European Radar Conference



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EUROPEAN MICROWAVE WEEK 2009

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The historical, cultural and stylish city of Rome will be the backdrop for the 12th European Microwave Week when it plays host to Europe's premier Microwave, RF, Wireless Technology and Radar event for the very first time. The vibrant Italian capital complements the focussed and challenging Week, which covers FIVE days, encompassing FOUR cutting edge conferences and ONE dynamic trade and technology exhibition featuring leading players from across the globe.

THE MUST GO SHOW

Concentrating on the needs of engineers the event showcases the latest trends and developments that are widening the field of application of microwaves. Pivotal to the week is the European Microwave Exhibition, which offers YOU the opportunity to see, first hand, the latest technological developments from global leaders in microwave technology, complemented by demonstrations and industrial workshops. Registration to the Exhibition is FREE!

- · International Companies meet the industry's biggest names and network on a global scale
- Cutting-edge Technology exhibitors showcase the latest product innovations, offer hands-on demonstrations and provide the opportunity to talk technical with the experts
- . Technical Workshops get first hand technical advice and guidance from some of the industry's leading innovators
- Four Conferences European Microwave Integrated Circuits Conference (EuMIC), European Microwave Conference (EuMC), European Wireless Technology Conference (EuWiT), European Radar Conference (EuRAD)

BE THERE

Exhibition Dates Opening Times
Tuesday 29th September 09.30 - 17.30
Wednesday 30th September 09.30 - 17.30
Thursday 1st October 09.30 - 16.30

EUROPEAN MICROWAVE EXHIBITION REGISTRATION FORM

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Don't miss Europe's premier microwave conference event. The 2009 week consists of four conferences and associated workshops:

- The European Microwave Integrated Circuits Conference (EuMIC)
- The European Wireless Technology Conference (EuWiT)
- The European Microwave Conference (EuMC)
- The European Radar Conference (EuRAD)

- Monday & Tuesday
- Monday & Tuesday
- Tuesday, Wednesday, Thursday
- Wednesday, Thursday, Friday

The four conferences specifically target ground breaking innovation in microwave research through a call for papers explicitly inviting the submission of presentations on the latest trends in the field, driven by industry roadmaps. The result is four superb conferences created from the very best papers, carefully selected from over 1,250 submissions from all over the world.

Special rates are available for EuMW delegates. For a detailed description of the conferences, workshops and short courses please visit www.eumweek.com. The full conference programme can be downloaded from there.

REGISTRATION

- ADVANCE REGISTRATION at reduced rates via the web at www.eumweek.com or by fax or mail see form overleaf for details.
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- After these dates you must register ON-SITE at the conference at the higher rates listed below.

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Advance registration is up to 30% lower. See reverse for details.

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EuMIC	€410	€120	€540	€160	
EuWiT	€410	€120	€540	€160	
EuRAD	€290	€110	€380	€150	
2 Conferences (10% discount for Stand	ard)				
EuMC and EuMIC	€840	€250	€1,090	€330	
EuMC and EuWiT	€840	€250	€1,090	€330	
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EuMIC and EuWiT	€740	€240	€960	€320	
EuMIC and EuRAD	€630	€230	€820	€310	
EuWiT and EuRAD	€630	€230	€820	€310	
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EuMC & EuMIC & EuWiT	€1,080	€370	€1,400	€490	
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EuMC & EuWiT & EuRAD	€980	€360	€1,270	€480	
EuMIC & EuWiT & EuRAD	€890	€350	€1,160	€470	
4 Conferences (30% discount for Stand	ard)	**************************************	0.0000000000000000000000000000000000000		
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1/2 Day WITH conference registration	€80	€60	€110	€80			
1/2 Day WITHOUT conference registration	€110	€80	€150	€110			
Full Day WITH conference registration	€120	€90	€160	€110			
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Advance Conference Registration European Microwave Week 2009 28 September – 2 October 2009, Rome, Italy



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EUWIT EURAD	□ €10 □ €220	⊒ €90 □ €80	□ €410 □ €290	□ €120	
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EuMC & EuMIC	□ €640	⊒ €190	⊒ €840	□ €250	☐ WHMO4 (EuMC/EuMIC) 1/2 day €_
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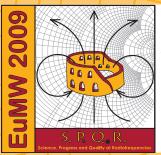
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NEW PRODUCTS

nation of low noise and high IP3 making this amplifier ideal for sensitive receiver applications. This design operates on a single 3 V supply and is internally matched to 50 Ohms. Size: 3×3 mm MCLP Pkg. Price: \$1.49 (Qty. 10-49). Mini-Circuits,

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

RS No. 227

200 to 800 MHz SDLVA



The model SDLVA-0120-70 with options DB and 0208 is a successive detection log video amplifier (SDLVA) that operates from 200 to 800 MHz with a limited IF output of -16 dBm and a logging range of -75 to -5 dBm. The input VSWR at -23 dBm is 2.5 and the TSS is -80 dBm typical. The rise and fall times are < 30 ns and the power supply is +15 VDC at 100 mA maximum and -15 VDC at 190 mA maximum. Size: $3.75" \times 1.50" \times 0.50"$.

Planar Monolithics Industries Inc., Frederick, MD (301) 631-1579, www.planarmonolithics.com.

RS No. 239

High Power Pallet Amplifier



The PP470-860-600 is a Linear Class AB pallet amplifier featuring the latest generation LD-MOS transistors, covering the entire UHF TV band. The PP470-860-600 can be used as an output power amplifier at 600 W Pk-Sync at 5 IRE Sync Compression typical or an output power amplifier at 150 W of DVBT Average Digital Output Power, shoulder = < -33 dBc.

Power Module Technology Inc., Carson City, NV (775) 883-1122, www.pmtrf.com.

RS No. 228

High Gain MMICs

The AE314 and AE312 are GaAs E-PHEMT MMICs with superior distortion characteristics aimed at the FTTx, CATV and broadcasting markets. The AE314 is a cascade amplifier with a typical gain of 22 dB. DC to 1 GHz, or DC to 2 GHz matching application is provided for FTTx, satellite applications driver amplifier or a final amplifier. The AE312 has a current mirror circuit within the MMIC and is stable even in harsh environments. Its typical noise figure of 1.0 dB makes it suitable for low noise amplifier applications for CATV and optical ONU applications. Both use a 5 V supply voltage, and



are 75 Ω impedance matched with strong in/out

RFHIC Corp., Suwon, Korea +82-31-250-5011, www.rfhic.com.

RS No. 230

Digital Pre-distortion MCPAs



This line of single and multi-carrier DPD power amplifiers is designed for WiMAX, WCDMA and LTE in a variety of operating frequencies and power levels. A 50 Ω RF input is standard and CPRI/OBSAI interfaces are planned for TMA models. The DPD technology employed is modulation-agnostic and can automatically adapt to any mix of carrier types within its operating bandwidth. Having baseband flexibility in an RF power amplifier allows for higher levels of integration with other signal processing functions, such as digital interfacing, digital up-conversion, crest factor reduction, envelope tracking and linear effects compensation.

Low Noise Frequency Synthesizer

Fraguency Offset

Stealth Microwave, Ewing, NI (609) 538-8586, www.steal thmicrowave.com.

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RS No. 229

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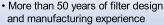
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Anatech Electronics Inc 70 Outwater Lane, Garfield NJ 07026

973 772 4242 sales@anatechelectronics.com



The THOR-14280 frequency synthesizer is designed to operate at 14.28 GHz in a military airborne application. The THOR units can be designed to operate with an external or optionally integrated reference from 10 to

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

MTS2500-110250-10

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

MTS2500-200400-10

Output Frequency 2000 - 4000 MHz						
Bandwidth	2000	MHz				
External Reference	101	AHz.				
Step Size	Programma	ible to 1 Hz				
Bias Voltage	+5/+	3.3 V				
Output Power	+5.5 dBm (Min.)					
Spurious Suppression	60 dB (Typ.)					
Harmonic Suppression	10 dB (Typ.)					
	Offset	dBc/Hz.				
Typical Phase Noise	1 kHz	-88				
Typical Phase Noise	10 kHz	-87				
	100 kHz	-100				
Independent	Within 1 kHz	<10 mSec				
Settling Time	Within 10 Hz	<20 mSec				
Operating Temperature Range	-20 to	+70 °C				

MTS2500-300600-10

Output Frequency	3000 - 60	000 MHz						
Bandwidth	3000	MHz						
External Reference	10 N	MHz						
Step Size	Programma	ble to 1 Hz						
Bias Voltage	*5/*	3.3 V						
Output Power	+2 dBn	n (Min.)						
Spurious Suppression	60 dB (Typ.)							
Harmonic Suppression	20 dB (Typ.)							
	Offset	dBc/Hz.						
Typical Phase Noise	1 kHz	-87						
Typical Friase Noise	10 kHz	-83						
	100 kHz	-108						
Para Taran	Within 1 kHz	<6 mSec						
Settling Time	Within 10 Hz	<12 mSec						
Operating Temperature Range	-20 to +70 °C							

Patented Technology

Programming Interface:

- -- 3.3V SPI (Standard)
- -- RS232

Also available in connectorized package with the following options.

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New Products

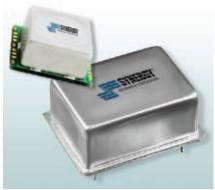
250 MHz. The THOR units feature low phase noise (<-90 dBc/Hz at 10 kHz) and low current draw (+5 V at 265 mA). THOR units are capable of maintaining excellent performance over vibration, shock and temperature featuring a rugged, connectorized package (1.50" \times 1.50" \times 0.6"), which can be optionally hermetically-sealed.

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

RS No. 240

Oven-controlled Crystal Oscillators VFNDORVIEW

This OXO series of ultra-low phase noise oven-controlled crystal oscillators offer excellent frequency and long-term stability. These high performance crystal oscillators include electronic tuning port and reference voltage output. Models are currently available in 10, 100 and 120 MHz output frequency in small C-08 package. Also available is a 10 MHz surface-mount version. These high performance products complement well their line of high resolution synthesizers for applications in test equipment, base stations, portable transceivers and RA-DAR. SMA connectorized versions with single



or multiple isolated outputs are also available. Synergy Microwave Corp., Paterson, NJ (973) 881-8800, www.synergymwave.com.

RS No. 231

Fixed Frequency Synthesizer



Z-Comm announces a new RoHS compliant fixed frequency synthesizer model SFS1920A-LF in L-band. The SFS1920A-LF is a single frequency synthesizer that operates at 1920 MHz. This synthesizer features a typical phase noise of -98 dBc/Hz at 10 kHz offset and a typical sideband spurs of -75 dBc. The SFS1920A-LF is designed to deliver a typical output power of 0 dBm with a VCO voltage supply of 5 V DC while drawing 24 mA (typical) and a phase-locked loop voltage of 3 V DC while drawing 9 mA (typical) over the temperature range of -40° to 85°C. This fixed frequency synthesizer features typical second harmonic suppression of -20 dBc and comes in Z-Comm's industry standard PLL-V12N package with low shield measuring $0.60" \times 0.60" \times 0.13"$.

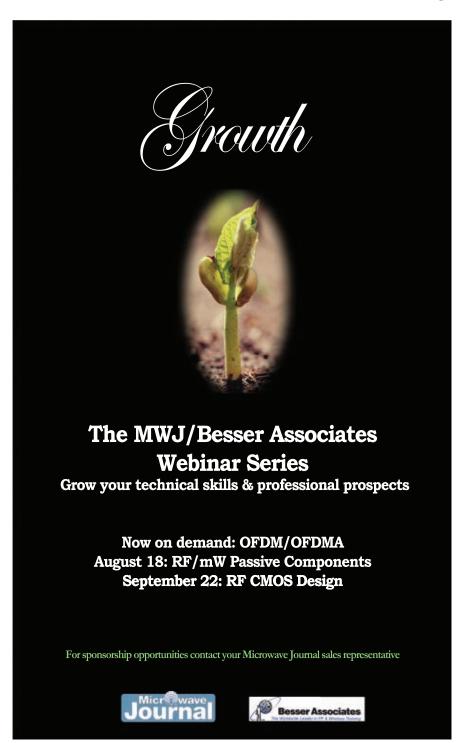
Z-Communications Inc., San Diego, CA (858) 621-2700, www.zcomm.com.

RS No. 232

Processing Equipment

Laser Depaneling and Routing System

The ProtoLaser U can cut, drill and structure almost any kind of material. It can depanel individual PCBs from a large printed circuit board. The system can cut LTCC and prepregs, drill holes and microvias, structure TCO/ITO layers, and open up solder masks. The high pulse energy of the UV laser causes ablation without leaving any residues and the



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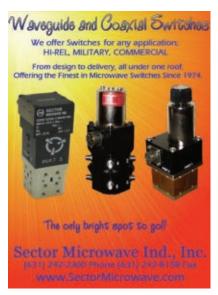




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RS 99



RS 46

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Modco MD Series VCOs offer very low Phase Noise in a half inch package. Models are low cost and available for a variety of Frequency Bands. No NRE for custom designs

Model MD108MST

902 - 928 MHzVcc: 5 V Vt: 0.5 to 4.5 V Current: 16 ma Power: +4 dBm

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Modco, Inc.

Sparks, NV (775) 331-2442 www.modcoinc.com

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These Voltage Controlled Oscillators offer exceptionally low Phase Noise in the industry

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Tuning Voltage of 0.5V to 4.5V and a Frequency Range of 1270-1290MHz is rated -122dBc @ 10khz offset. Many other catalog models are available and custom designs can be supplied with no NRE

www.modcoinc.com

RS 78







integrated vacuum table holds flexible and thin substrates safely and firmly in place. The laser process is controlled by the integrated Circuit-ČAM software. The ProtoLaser U is compact, optimized for the laboratory and suitable for the prototyping

and production of small-series. LPKF Laser & Electronics, Tualatin, OR (800) 345-5753, www.lpkfusa.com.

RS No. 234

Subsystems

Manpack Communication **Platform**



Cobham Sensor Systems (Bolton) announces the SAT1711 (Man Pack) communication platform. Key features include: lightweight, low volume; rugged

construction; rapid one man deployment; interchangeable petal design and NATO SHF Tx/Rx capable. Designed for use and transport by one person, the SAT1711 provides an extremely lightweight, low transport volume NATO communication platform for voice and data. Proven suitable for use in extreme environments, that can be assembled without tools by one person in less than two minutes.

Cobham Sensor Systems, Bolton, MA (979) 779-6963, www.cobham.com.

RS No. 233

Installation Kit



The RFA-4511 series is a comprehensive installation kit series for crimping N-type connectors onto LMR-400® or equivalent cables. The kit combines a cable cutter, one-step cable stripper, the Cable Devil® preparation tool, professional grade crimp tool and die, and 25 N male connectors. All are housed in a rugged, foam lined case with installation instructions.

RF Industries. San Diego, CA (858) 549-6340, www.rfindustries.com.

RS No. 241

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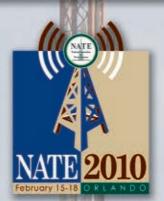
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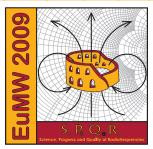


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Detecting and Classifying Low Probability of Intercept Radar; Second Edition

Phillip E. Pace

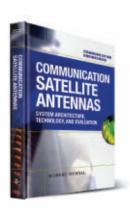
This comprehensive book presents Low Probability of Intercept (LPI) radar design essentials, including ambiguity analysis of LPI waveforms, FMCW radar, and phase-shift and frequency-shift keying techniques. Moreover, it details new OTHR modulation schemes, noise radar and spatial multiple-input multiple-output (MIMO) systems. The book explores autonomous nonlinear classification signal processing algorithms for identifying LPI modulations. It also demonstrates four intercept receiver signal processing techniques for LPI radar detection that help to determine which time-frequency, bi-frequency technique best suits any LPI modulation of interest. A CD-ROM is included.

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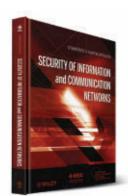
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Robert Dybdal

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60,61,62,63,					7
64,65,66,67,					
68,69,70,71,					
72,73,74					
75,76,77	MITEQ Inc		631-436-7400	631-436-7430	http://mwj.hotims.com/23288-75
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81,82	Narda Microwave-East,	,			T
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83	National Association of	,			1 3
	Tower Erectors	129	605-882-5865	605-886-5184	http://mwj.hotims.com/23288-83
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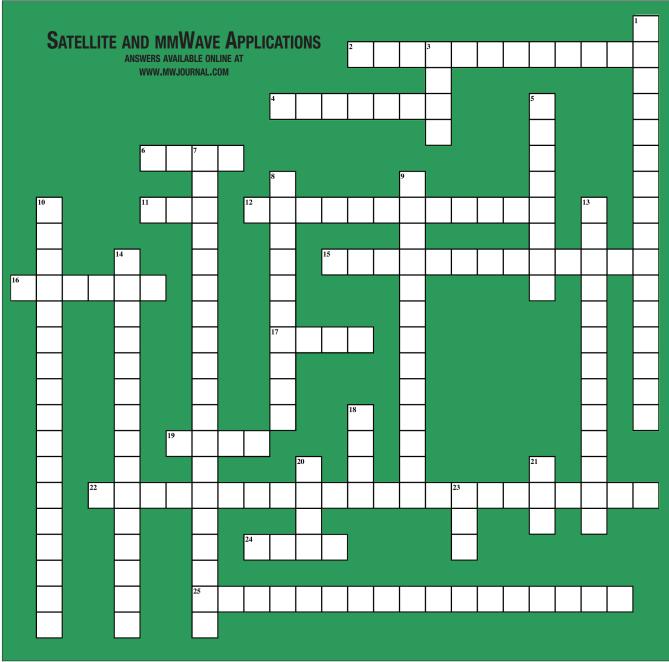
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Across

- 2 The process of recovering intelligence from a signal, some parameter of which was modified to carry the intelligence
- **4** The frequency interval from 12.4 to 18 GHz (hyphenated)
- 6 Joint Tactical Radio System
- 11 Block Upconverter
- **12** The ratio of the number of bits in a data transmission that are incorrectly received to the number of bits received (3 words)
- **15** A reactive circuit that rejects signals whose frequencies are above the 3 dB point frequency and propagates signals whose frequencies are below the 3 dB point frequency (3 words)

- 16 Satellite Communications
- 17 Solid State Power Amplifier
- 19 Very Small Aperture Terminal
- 22 The surreptitious gathering of information from an opponent or enemy through the use of electronic systems (2 words)
- 24 Mobile User Objective System
- 25 TWT (3 words)

Down

- 1 A technique for improving power efficiency of an amplifier where the voltage to the output transistor is adjusted dynamically, in synchronism with the envelope of the modulated RF signal (2 words)
- 3 Orthogonal frequency division multiplexing
- 5 Permanently sealed to the extent that transmission of

gases and liquids is reduced or eliminated

- **7** The minimum received signal power level for which a receiver can produce a discernible output signal (2 words)
- **8** Standard specifically designed for wireless high definition multimedia connectivity
- **9** The apparent shift in frequency of an incident wave that is the result of relative velocity between the emitter of the wave and the receiver of the wave (2 words)
- **10** RCS (3 words)
- **13** UWB (2 words)
- **14** A reference signal generating circuit that is contained within a receiver or transmitter (2 words)
- 18 Wireless Home Digital Interface
- 20 Multiple in, multiple output antenna technology
- 21 Wideband Global SatCom program



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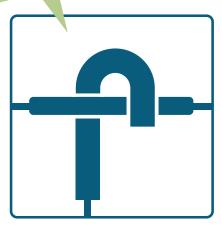
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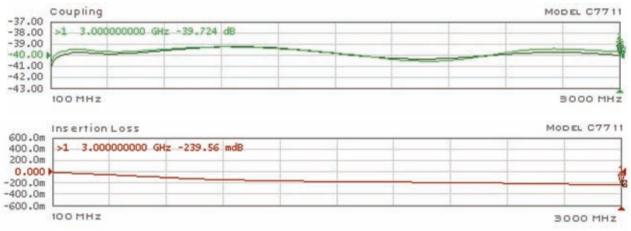
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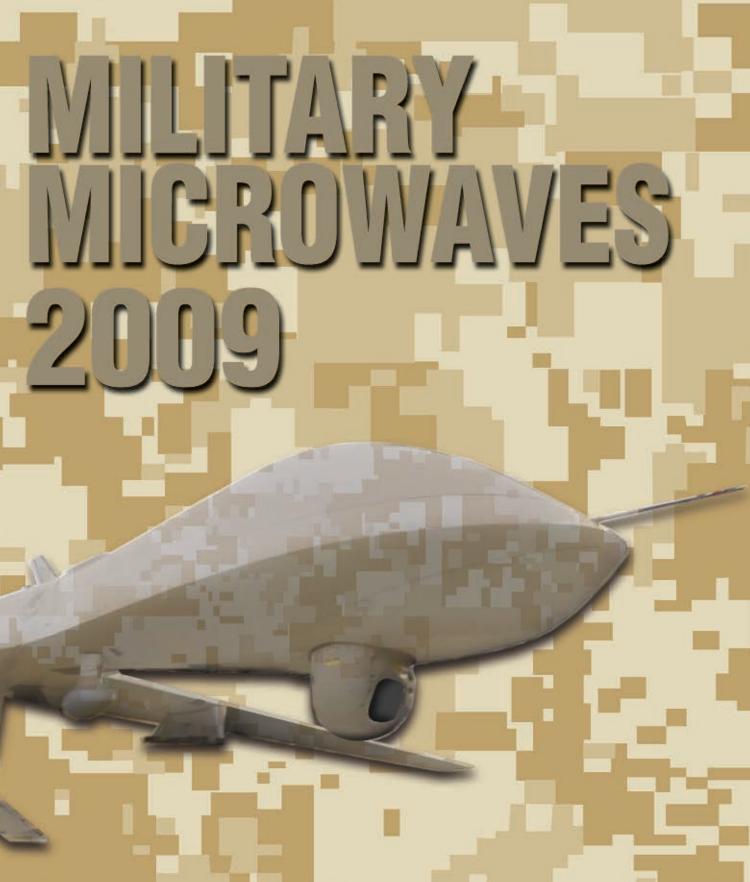


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	C7734	Dual Directional	30-2500	100	43	±1.5	0.35	1.25:1	18	3.5 x 2.6 x 0.7
	C7148	Bi Directional	60-600	200	10	±1.0	0.35	1.20:1	20	6.0 x 4.0 x 0.75
ı	C7711	Dual Directional	100-3000	100	40	±1.0	0.35	1.25:1	18	3.0 x 2.2 x 0.7
	C7783	Bi Directional	200-1000	200	20	±0.75	0.2	1.20:1	20	3.0 x 1.5 x 0.53
١	C6600	Bi Directional	200-2000	200	20	±1.2	0.25	1.25:1	18	4.0 x 2.0 x 0.72
١	C7152	Bi Directional	300-3000	100	20	±1.0	0.35	1.20:1	15	3.7 x 2.0 x 0.75
ı	C7811	Dual Directional	500-2500	100	40	±0.5	0.2	1.25:1	20	3.0 x 2.0 x 0.6
	C7753	Bi Directional	700-4200	100	20	±1.0	0.35	1.25:1	18	1.8 x 1.0 x 0.6



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MILITARY MICROWAVES SUPPLEMENT TABLE OF CONTENTS

FEATURES

TECHNICAL FEATURES

6 Radar Cross-section Reduction of Antennas Using a Stop-band Frequency Selective Surface

Bao Lu, Xi Gong, Jin Ling and Hong Wei Yuan, Xidian University
Use of a stop-band frequency selective surface in achieving good stability
of resonant frequency and a narrow stop bandwidth

20 Single-supply, TTL-level Gate Switching and Radiation Hardening by Design Using E-PHEMTs

Christopher T. Rodenbeck and Richard T. Knudson, Sandia National Laboratories

Demonstration of a GaAs E-PHEMT radio frequency pulse modulator operating off a single supply voltage

30 Addressing the Battlefield Communications Power Gap

Shaun Cummins, Nujira Limited

Examination of the latest developments in military communications technology

40 A Unidirectional Horn-shaped Bowtie Antenna for Ultra High Resolution Radar

Young-Kil Kwag, Korea Aerospace University

Design and fabrication of a horn-shaped bowtie antenna fed by a tapered planar stripline $\,$

PRODUCT FEATURES

48 Ultra Low Phase Noise—Phase Coherent Synthesizers

Holzworth Instrumentation

Development of a radio frequency synthesizer capable of tuning frequencies from 8 MHz to 3 GHz in 0.001 Hz steps

54 PhaseTrack II: Thermally Stable Coaxial Cables

Times Microwave Systems

Introduction to a newly engineered dielectric material for use in cable assemblies designed for phase stability

LITERATURE SHOWCASE

58 Detailed descriptions of over 20 company catalogs and brochures

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Radar Cross-section Reduction of Antennas Using a Stop-band Frequency Selective Surface

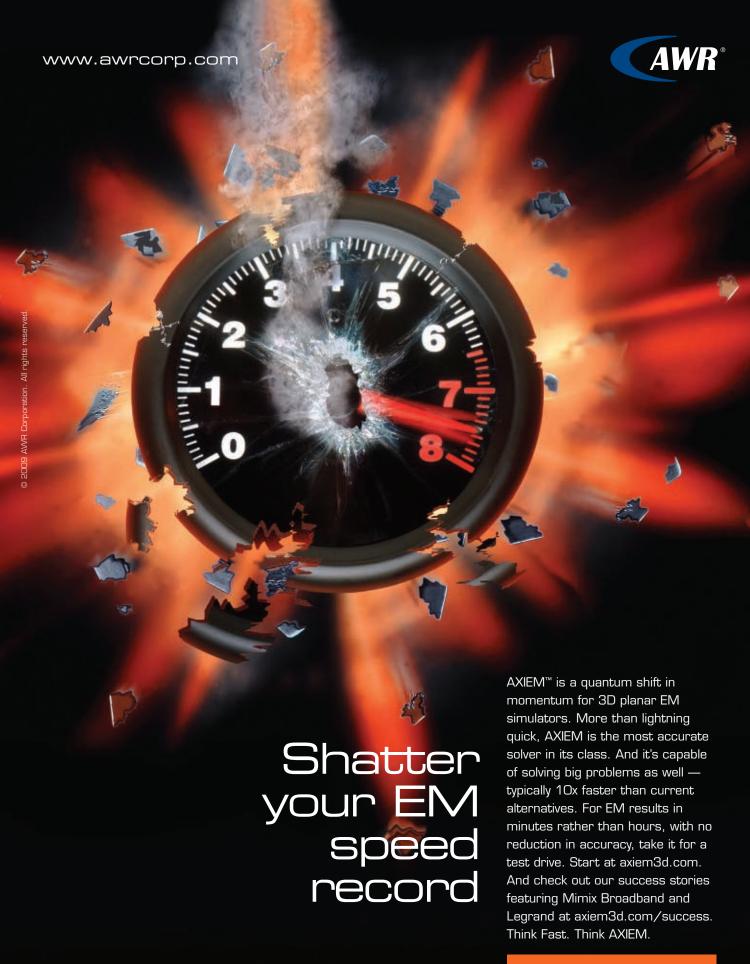
novel stop-band frequency selective surface (FSS) is presented. By adding four narrow branches to conventional square-loop FSS, the proposed FSS can achieve a good frequency stability for different oblique angles and a high frequency selective ability. An equivalent circuit model is used to analyze its transmission property. Due to the band stop characteristic of the FSS, it was used as the ground plane of a microstrip dipole antenna. In the stop-band, the FSS acts as a conventional metallic ground plane that enhances the radiation gain, but within the passband the incident waves penetrate the antenna more effectively, thus reducing the structural radar cross-section (RCS) of the antenna. The measurements of the RCS were carried out in an anechoic chamber at the National Key Laboratory of UAV Specialty Technique. Experimental and simulated results show that the crosssection of the antenna with this FSS ground plane is reduced effectively.

Recently, a growing interest has been devoted to the application of frequency selective surfaces¹ in many fields such as radar systems, telecommunication, military and wireless security.²⁻⁴ According to their different transmission properties, there are two kinds of FSS. One is the passband FSS, the other is the stopband FSS. For the application of RCS reduction, there are many reports on the utilization of passband FSS as radomes for antennas.⁵⁻⁸

The integration of a frequency selective surface with a protective radome can considerably reduce the RCS of the enclosed antenna outside its operating band. In contrast, there are little reports on the RCS reduction using the stop-band FSS.

Most antennas, such as dipoles, microstrip patches, etc., need a metallic ground that acts as a reflector to enhance the radiation gain. However, the metallic ground plane, which largely reflects the energy of incident waves, is one of the most important scattering components of an antenna. In order to reduce this scattering component, the conventional metallic ground is replaced by the proposed FSS. Due to the reflection property of the FSS in stop-band, it can be utilized as a ground plane to enhance the radiation gain of the antenna in place of conventional metallic ground planes. In the stop-band, the FSS operates as a conventional metallic ground plane to enhance the radiation gain. However, in the passband, most of the electromagnetic waves penetrate the antenna so that the structural RCS of the antenna can be greatly reduced. For RCS reduction of the antenna, the FSS that is used as a ground plane must possess two important bandstop properties. One is the stability of the resonant

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frequency the angles of incident waves. If the resonant frequency shifts too much, the stop-band of the FSS will move outside the operfrequency band, thus decreasing the radiation gain. The other is the stop-band bandwidth of the FSS. If the bandwidth is too wide, the FSS plane will excessively reflect the incident energy beyond the operation frequency, thus increasing the RCS of antenna.

Based on the above reasons, a novel stop-band FSS is proposed and applied to the ground plane of an antenna. By introducing four narrow

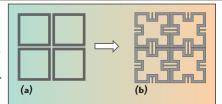


Fig. 1 Conventional (a) and proposed (b) FSS configurations.

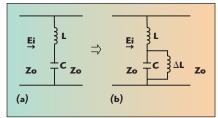


Fig. 2 Equivalent circuits of conventional (a) and proposed (b) FSS.

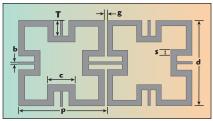


Fig. 3 Detailed configuration of the proposed FSS structure.

branches to a conventional square loop FSS, the proposed FSS has good resonant frequency stability for different incident angles. Meanwhile, its stop-band width is so narrow that more incident waves, beyond the operating frequency, can penetrate the antenna. In order to validate the method, the proposed FSS is applied to a microstrip dipole antenna for RCS reduction. Simulated and measured results show that antennas using the new FSS ground plane can simultaneously have a much lower monostatic RCS with various incident angles and little disturbances to the radiation property.

FSS DESIGN AND RESULTS

Configuration and Formulas

The configuration of both conventional square-loop FSS and the proposed FSS are shown in **Figure 1**. It can be found that the proposed FSS is a transformation form of the conventional square-loop FSS. Besides, four narrow branches are added to each element and connected to neighboring elements. Being different from conventional designs, the narrow branches introduce an additional inductance. In **Figure 2**, the array of FSS unit cells is represented by a single series LC circuit shunted across a transmission line of the impedance Z_0 , where Z_0 is the characteristic impedance in free space. L and C denote the inductance and capacitance, respectively. ΔL is the additional inductance that is introduced by the narrow branches. The values of L and C are determined as follows: 9,10

$$\frac{X_L}{Z_0} = \omega L = \frac{d}{p} F(p, 2s, \lambda, \theta) \tag{1}$$

$$\frac{B_{c}}{Z_{o}} = \omega C = 4 \frac{d}{p} F(p, g, \lambda, \theta) \epsilon_{eff}$$
 (2)

where

$$F(p, w, \lambda, \theta) = \frac{p}{\lambda} \cos \theta \left[\ln \left(\cos \operatorname{ec} \frac{\pi w}{2p} \right) + G(p, w, \lambda, \theta) \right] \tag{3}$$

 $G(p,w,\lambda,\theta) =$

$$\frac{0.5(1-\beta^2)\biggl[(1-\frac{\beta^2}{4})(A_+ + A_-) + 4\beta^2 A_+ A_-\biggr]}{(1-\frac{\beta^2}{4}) + \beta^2 \biggl(1+\frac{\beta^2}{2} - \frac{\beta^4}{8}\biggr](A_+ A_-) + 2\beta^6 A_+ A_-} \tag{4}$$

with

$$\mathbf{A}_{\pm} = \frac{1}{\sqrt{1 \pm \left(\frac{2p\sin\theta}{\lambda} - \frac{p\cos\theta}{\lambda}\right)^2}} - 1 \tag{5}$$

$$\beta = \sin(\frac{\pi w}{2p}) \tag{6}$$

 $\epsilon_{\rm eff}$ is the effective dielectric permittivity of the substrate of FSS. According to Sung, et al. 10 if one side of the FSS is backed by a dielectric substrate whose thickness is greater than 0.05 dielectric wavelength, the dielectric slab will behave with an effective permittivity $\epsilon_{\rm eff} = (1+\epsilon r)/2$, which affects the capacitive impedance value of the equivalent circuit in Equation 2. Each element of the proposed FSS lattice consists of four connecting branches, as shown in $\it Figure~3$. These narrow branches, together with insets at the connections, introduce an additional inductance ΔL . According to the equivalent circuit shown previously, the resonant frequency of the conventional square-loop FSS can be determined as follows:

$$f_{c} = \frac{1}{2\pi\sqrt{LC}} \tag{7}$$

Similarly, the resonant frequency of the proposed FSS is determined as follows:

$$f_{p} = \frac{1}{2\pi\sqrt{LC}} \tag{8}$$

$$L' = L \cdot \frac{1}{1 + (L / \Delta L)} \tag{9}$$



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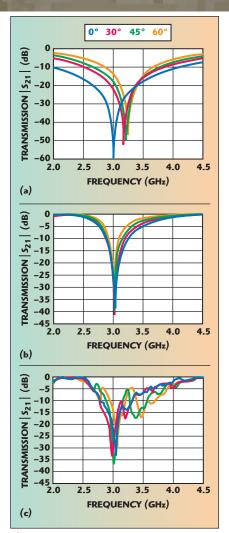
The bandwidth of a FSS is related to $\sqrt{L/C}$. From Equation 9, it can be found that the inductance L is smaller than that of the conventional one. Therefore, the proposed FSS has a narrower bandwidth compared to conventional one. This prediction will later be validated by curves shown in **Figure 4**.

Theoretical and Experimental Results

An S-band FSS with the proposed structure was designed. The parameters of the proposed FSS, whose resonant frequency is 3 GHz, are p = 18 mm, d = 17.5 mm, c = 5 mm, s = 1 mm, g = 0.5 mm, b = 0.5 mm, t = 3.5 mm, and the thickness and dielectric permittivity of the dielectric substrate are h = 1.5 mm, $\epsilon r = 6$, respectively.

A FDTD method is used to simulate the proposed FSS and the conventional square-loop FSS, respectively. In Figures 4 (a) and (b), the simulated results of oblique incident angles are presented for vertical perpendicular polarization (TE). As shown, for 0°, 30°, 45° and 60° angles, the resonant frequencies of the proposed FSS are 3.04, 3.02, 3.01 and 3.0 GHz, respectively. The -10 dB stop-band bandwidths for 0°, 30°, 45° and 60° angles are 370, 320, 240 and 180 MHz, respectively. However, for 0°, 30°, 45° and 60° angles, the resonant frequencies of the conventional square-loop FSS are 3.01, 3.17, 3.21 and 3.25 GHz, respectively. The -10 dB stop-band bandwidths for 0° , 30° , 45° and 60° angles are 2.13, 1.36, 1.15 and 0.83 GHz, respectively. With the incident angle of 60°, the maximum resonant frequency shift of the proposed FSS is 1.3 percent whereas the resonance shift is 8 percent for the conventional FSS. Hence, compared with conventional FSS, the proposed FSS has a better stability of resonant frequency with different incident angles. Similarly, with the incident angle of 60°, the -10 dB stop-band bandwidth of the proposed FSS is 6 percent but is 27 percent for the conventional FSS. As Equation 9 predicts, the proposed FSS has a narrower bandwidth than the conventional FSS.

A photograph of the fabricated proposed FSS with 10×10 unit cells is illustrated in *Figure 5 (a)*. The measurement of the proposed FSS was carried out in an anechoic chamber.

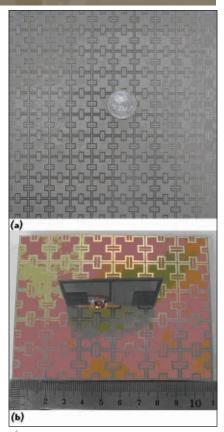


ightharpoonup Fig. 4 Transmission coefficients for different incident angles: (a) Theoretical coefficient for conventional FSS with infinite unit cells (b) theoretical coefficient of the proposed FSS with infinite unit cells; and (c) measured coefficients of the proposed FSS with 10×10 unit cells.

The measured transmission coefficients for different incident angles are shown in Figure 4 (c). For 0° , 30° , 45° and 60° angles, the measured resonant frequencies are 3.04, 2.98, 3.0 and 3.06 GHz, respectively. Due to the finite elements of the fabricated FSS, the measured results are a little different from theoretical results of an infinite FSS. However, it can be seen that the measured and simulated results are in good agreement.

APPLICATION TO RCS REDUCTION

There are many methods available to reduce the RCS of antennas. Radar absorbing materials (RAM), lumped loads¹¹ and distributed loads¹² have been used for controlling the RCS of



▲ Fig. 5 Photograph of the fabricated 10 × 10 cells FSS (a) and a microstrip dipole with the proposed FSS ground plane (b).

antennas. In addition, the scattering response of antenna can be tuned to minimize the RCS at threatened frequencies by control of a varactor.¹³ However, these methods for RCS reduction always lead to complicated antenna structures or high cost.

Unlike the methods discussed above, the stop-band FSS is used as the ground plane of the antenna in order to reduce its RCS. If the operating frequencies of the antenna are within the stop-band of the FSS, the FSS will reflect the incident waves so that the FSS operates as a conventional metallic ground plane. Beyond the operating band of the antenna, due to the spatial filtering property of the FSS, the incident waves penetrate the antenna, which can effectively reduce the structural RCS of the antenna. In order to show validation of this method, a microstrip dipole antenna operating in the stop-band of the proposed FSS ground plane is presented.

Radiation of Antenna with FSS Ground Plane

The microstrip dipole antenna with the proposed FSS is shown in

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Figure 5 (b). The FSS ground plane consists of 5×6 units. In order to research the effect of the FSS ground plane on the radiation of the antenna, the radiation gain pattern is simulated and measured in an anechoic chamber. *Figure 6* shows the simulated and measured results of the same antenna with different ground planes at the central operating frequency of 3 GHz.

As shown, the radiation pattern

of the antenna with the FSS ground plane varies little as compared to the antenna with a metallic ground plane. Due to unperfected reflection of FSS, the gains of antenna with FSS ground plane decrease approximately 1 dB in both E and H plane as compared to an antenna with metallic ground plane. By now, the validation of the proposed FSS ground plane for antenna application has been proven.

RCS Research of Antenna with FSS Ground Plane

Once the validation of the proposed FSS for the application on an antenna is proven, the next step is to see what effect the proposed FSS will bring to the RCS reduction of an antenna. The monostatic RCS of the antenna with different ground planes is simulated with Ansoft HFSS and measured in an anechoic chamber at the National Key Laboratory of Spe-



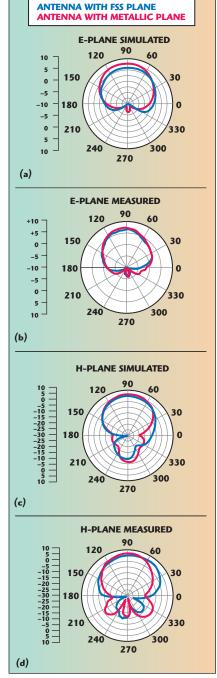


Fig. 6 Simulated and measured radiation patterns with different ground planes.



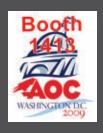
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cialty Technology. The measurement was carried out in a frequency range of 1 to 10 GHz. A metallic sphere whose diameter is 150 mm is used as a calibration object. Figure 7 shows the photograph of the measurement of the same antenna with FSS and metallic ground plane, respectively.

Figure 8 shows the simulated and measured monostatic RCS of an antenna with different ground planes at normal incident angle, respectively.

According to Figure 8 (a), outside the operation band of the antenna, the RCS of the antenna with proposed FSS ground plane is reduced considerably at some wide bands of 1 to 3 and 4 to 8 GHz. The maximum reduction of RCS is 22 dBsm at 2.2 GHz. In contrast, inside the operation band of the antenna, due to the stop-band property of FSS, the RCS has not been reduced instead of increasing about 0.9 dBsm at 3.1 GHz. Similarly,

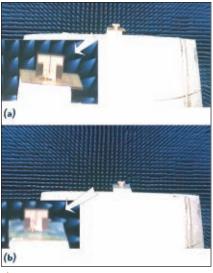


Fig. 7 Photo of RCS measurement of antenna with proposed FSS plane with 5×6 unit cells (a) and antenna with metallic plane (b) in two planes in anechoic chamber.

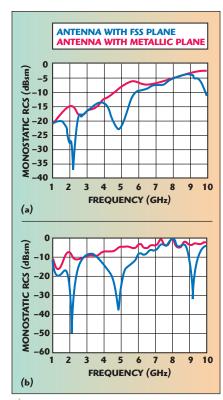
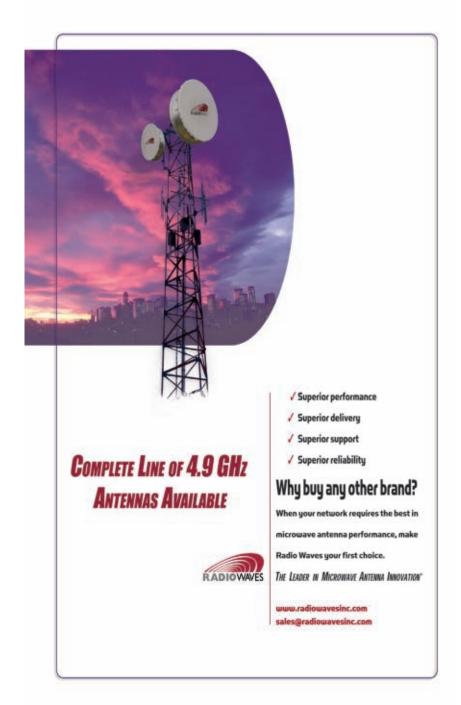


Fig. 8 Simulated (a) and measured (b) monostatic RCS of antenna for normal incident angle.

in Figure 8 (b), outside the operation band of the antenna, for three bands of 1 to 3, 4 to 8 and 8.5 to 10 GHz, the RCS of the antenna is reduced effectively by the proposed FSS ground plane. The maximum reduction of RCS is 40 dBsm at 2.1 GHz.

Figure 9 shows the simulated RCS of the antenna with different ground





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plane at incident angle of $\theta=30^\circ$ and $\phi=45^\circ$. Although the RCS of the antenna with FSS ground plane increases at 5 to 7 GHz, the FSS ground plane reduces the RCS of the antenna considerably in two wide bands of 1 to 5 and 7 to 10 GHz. The maximum reduction of RCS is 15 dBsm.

When the incident angle is $\theta = 60^{\circ}$ and $\phi = 45^{\circ}$, as **Figure 10** shows, the FSS ground plane reduces the RCS of the antenna almost for the full band of

1 to 10 GHz. The maximum reduction of RCS is 12 dBsm at 5.1 GHz. But in two narrow bands of 6.8 to 7.1 and 9 to 10 GHz, the RCS of the antenna increase 2 and 3 dBsm, respectively.

DICUSSION

For normal incident angle, the measured RCS is approximately 10 dBsm smaller than theoretical RCS for low frequencies. Because for low frequencies, the background environ-

ment of the anechoic chamber becomes worse, leading to some error for the measured results. When the frequency becomes higher, the effect of this error becomes smaller, as Figure 10 shows, the simulated and measured results are in good agreement.

CONCLUSION

By adding four narrow branches to a conventional square-loop FSS, the proposed FSS can achieve good stability of resonant frequency and a narrow stop bandwidth. This has been demonstrated through both simulation and experiments. For the proposed FSS, the maximum shift of resonant frequency occurs at the incident angle of 60° and the maximum shift is 1.3 percent whereas the resonance shift is 8 percent for conventional FSS. The -10 dBsm bandwidth with incident angle of 60° is 6 percent for the proposed FSS and 27 percent for the conventional FSS.

Good frequency stability of the design ensures that the FSS will be used as a ground plane of antennas in

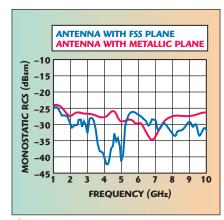
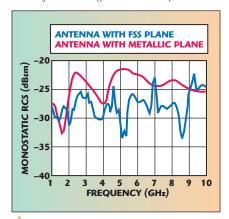
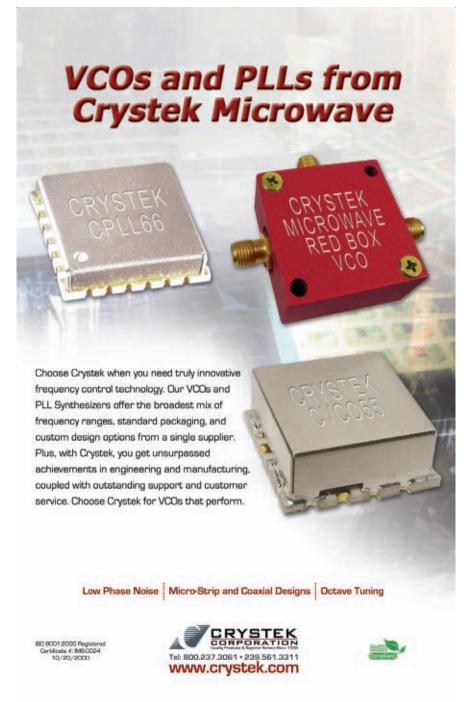


Fig. 9 Simulated monostatic RCS of antenna of incident angle $\theta = 30^{\circ}$ and $\varphi = 45^{\circ}$.



 \blacktriangle Fig. 10 Simulated monostatic RCS of antenna of incident angle $\theta = 60^{\circ}$ and $\phi = 45^{\circ}$.



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order to reduce the RCS of antennas. Simulated and measured results show that, in contrast to conventional metallic ground plane, the proposed FSS ground plane considerably reduce the monostatic RCS of a microstrip dipole antenna for a wide frequency band in 1 to 10 GHz. ■

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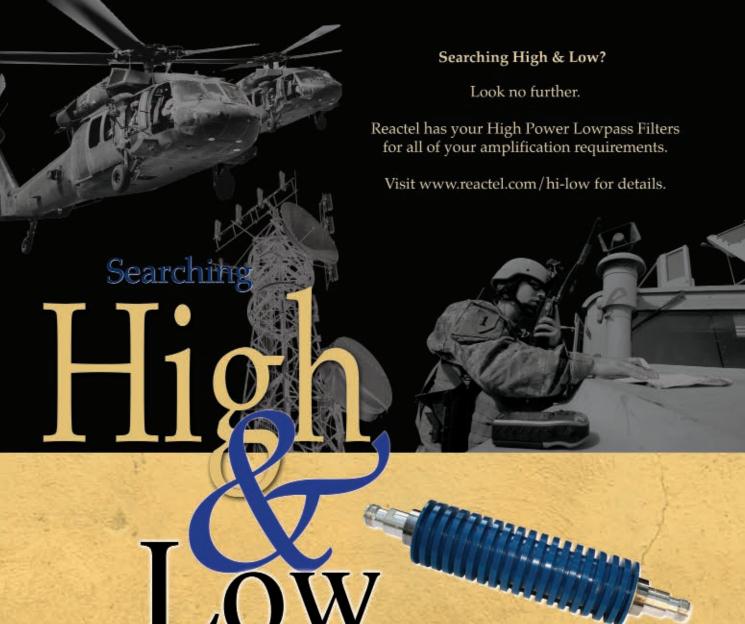
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20 - 115 MHz, minimum	≥ 40 dB @ 150 MHz & ≥ 50 dB @ 250 - 600 MHz
20 - 150 MHz, minimum	≥ 40 dB @ 200 MHz & ≥ 50 dB @ 300 - 600 MHz
20 - 220 MHz, minimum	> 40 dB @ 300 MHz & > 50 dB @ 450 - 900 MHz
20 - 335 MHz, minimum	≥ 40 dB @ 440 MHz & ≥ 50 dB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

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Single-supply, TTL-level Gate Switching and Radiation Hardening by Design Using E-PHEMTs

nhancement-mode PHEMTs significantly extend the usefulness of GaAs RFIĆs for general-purpose RF component designs. To demonstrate the technology's benefits, this article demonstrates a 2 to 3 GHz GaAs PHEMT RF pulse modulator operating off a single, positive supply voltage, switched by a TTL-level logic signal. Active gate bias networks, designed using feedback techniques, provide exceptional stability of performance over a wide range of supply voltages and harden the RFIC against severe levels of radiation. Although greater levels of integration are easily achieved using RFICs, this design highlights the flexibility and robustness of the RFIC approach for "drop-in" component designs.

The modernization of legacy hardware is an important activity for RF/microwave designers in the aerospace industry. The task of upgrading a legacy system can include replacing a single RF component, a chain of components, or an entire RF transmitter/receiver. Signal processing, digital control and available power supplies may or may not be "off-limits" for the redesign. Depending on tradeoffs and limitations involved, the design approach generally can take one of two different courses: Commercial-off-the-shelf (COTS)-based design or custom radio frequency IC (RFIC) design. Combinations of the two approaches are also possible.

COTS devices range from RF discretes

to multifunction ICs. They typically come in plastic encapsulated packages (PEMS) and ceramic packages with pedigrees ranging from commercial grade though military/space qualified. The COTS approach can be extremely cost effective if design requirements conform to the functionality of commercially available products. But if customization is unavoidable, the total number of required components can rapidly proliferate with associated penalties in size, weight, power, qualification time, reliability and cost.

An alternative approach is to replace legacy components/systems with application-specific RFICs. There are advantages to this. RFIC designs can easily meet custom requirements; for example, a receiver output signal specifically conditioned for an existing signal processor. Greater margins of operation can be achieved using foundry-validated device models and controlled on-chip parasitics; for example, broader bandwidth, temperature compensation, or reduced sensitivity to supply variation. Such performance advantages can even allow RFICs to be "over-designed" for a particular application in order to permit reuse on multi-

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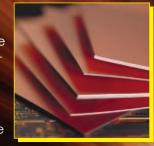
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ple projects, thus reducing long-term development costs. Proprietary RFIC chipsets can also protect against component obsolescence, which currently costs the US Department of Defense \$10 B per year.¹

Perhaps the most important advantage to RFIC-based design are the manufacturing improvements: Minimized part count, enhanced reliability, reduced qualification time, less vendors and a production process compatible with industry best practices.

Today's RFICs come in various flavors of gallium arsenide (GaAs) and silicon. Each technology has its benefits. In the case of silicon, the advantages are p-type devices, analog/digital integration, lower power consumption, smaller circuit size and improved cost/yield in high volume applications. The benefits of GaAs, on the other hand, are higher breakdown voltage, improved output power and power handling, higher-Q on-chip passives, inherent radiation hardness, longer sunsets for old processes, far less expensive software design flows, and—depending on the type of process chosen—surprisingly low cost for small and medium volumes.

Recently, the usefulness of GaAs RFICs for insertion in legacy systems has increased due to advances in the RF performance and producibility of enhancement-mode PHEMTs (E-PHEMT). Unlike conventional depletion-mode GaAs devices, E-PHEMTs have positive threshold voltages that allow much greater flexibility in biasing and control—a feature particularly relevant for designs targeting the replacement of existing components.

This article demonstrates the advantages of E-PHEMT RFICs for a basic "drop-in" component design—an RF pulse modulator. The pulse modulator is designed as a gateswitched two-stage amplifier running off a single, positive power supply. A TTL-level logic signal provides the control. Measured results show greater than 26 dB gain in the on-state and greater than 79 dB on/off isolation over the entire 2 to 3 GHz band. The detected rise/fall times are less than 13 nsec. Active bias circuits and feedback allow the circuit to maintain good performance and output power over a wide range of voltages and under severe radiation conditions. These

results are expected to offer many practical advantages for RF component design in a variety of aerospace applications.

DESIGN

The design shown in this article uses TriQuint Semiconductor's TQPED process (0.5 µm enhancement and depletion mode PHEMTs). Competing technologies are also available from other vendors. The f_t and f_{max} of the E-PHEMT devices are 33 and 100 GHz, respectively; the minimum guaranteed breakdown voltage is 15 V. Figure 1 il-

lustrates the transfer curve of a TQPED E-PHEMT for a V_{ds} of 7.2 V. The threshold voltage is +0.35 V; 0 V on the gate can easily turn off the device. An Imax of 320 mA/mm occurs at approximately $V_{gs} = \bar{1} \bar{V}$.

The E-PHEMT's positive threshold voltage makes it possible to design a single-supply acsonable immunity device Q1. to thermal drift or supply voltage vari-

ation. Figure 2 illustrates a network for biasing a common-source connected GaAs FET; similar topologies are described in the literature.²⁻⁴ The objective is to control the bias point for the RF transistor Q1. Q2 acts as a current mirror. R4 sets the value of the current in Q2. Depending on the options available, this resistor should be selected to have a low variation with temperature at the expense of resistor size. Transistor Q3 provides an additional, strong feedback; the diodes and Q4 are used simply to provide a known voltage drop. Note that, unlike MOS devices, there is a gate current that varies with temperature. Because of this, the RF stability resistor R1 should be kept to as low a value as practical, in order to reduce the bias point's sensitivity to temperature drift and process variations that would affect the gate current (that is, variations in threshold voltage). Furthermore, it is important to scale R1 and R2 according to the gate currents in Q1 and Q2 in order to have identical

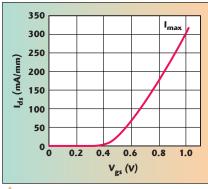
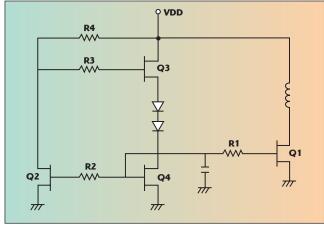


Fig. 1 Transfer curve of a 0.5 μm E-PHEMT biased at $V_{ds} = 7.2 \text{ V}$.



tive bias with rea- A Fig. 2 GaAs FET active bias circuit for a common-source connected

gate-source voltages for both devices. The appropriate scaling relationships

$$\frac{W_{Q1}}{W_{Q2}} = \frac{I_{D,Q1}}{I_{D,Q2}} = \frac{I_{G,Q1}}{I_{G,Q2}} = \frac{R2}{R1} \quad (1)$$

where W_{O1} and W_{O2} are the total channel widths of transistors Q1 and Q2, respectively. $I_{D,Q1}$ and $I_{D,Q2}$ are the drain currents, and $I_{G,Q1}$ and $I_{G,Q2}$ are the gate currents.

Figure 3 illustrates the schematic of the complete pulse modulator. The design is a two-stage amplifier with gate switching and independent active biasing for each stage. The nominal drain voltage is 7.2 V and the operating bandwidth is 2 to 3 GHz. The active bias networks are optimized to provide a stable class-A operating point for each commonsource amplifier stages over a ±15 percent variation in supply voltage and a -55° to +80°C variation in temperature. Both common-source amplifier stages are $8 \times 50 \mu m$ devices.



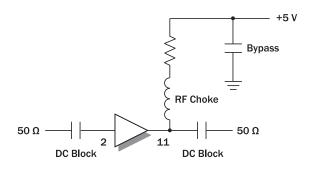
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SPECIFICATIONS

Part	Freq Range	OP1dB	OIP3dB	Gain	NF	Package Size
Number	(GHz)	(dBm)	(dBm)	(dB)	(dB)	(mm)
SUF-1033	DC to 18.0	13.7	24.3	9.5	4.8	QFN-16, 3 x 3
SUF-5033	0.1 to 4.0	21.5	27.6	18.5	3.6	QFN-16, 3 x 3
SUF-8533	DC to 12.0	16.8	25.2	14.5	4.2	QFN-16, 3 x 3



FEATURES

- Broadband performance
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The first stage is reactively matched at the input. The second stage uses a negative feedback in order to make the output power level/match insensitive to process variations or model errors. The shunt switch FETs at the gates of both common-source stages can switch the amplifier on and off. Referring to the transfer curve, when the control signal is 0 V, the shunt switches are open and the amplifier is on. For a +3 V control signal, the shunt switches are closed and the amplifier is off. Note that the resistive tees at the gates of both switch FETs serve multiple purposes: (i) to divide down the +3 V control voltage so that the switch FETs cannot exceed I_{max}; (ii) to provide broadband attenuation to prevent loop oscillations between the first and second amplifier stages; and (iii) to RC filter the control signal. The shunt capacitance in parallel with each resistive tee is 20 pF, which is a tradeoff between switching speed and the level of RC filtering.

Figure 4 shows the chip layout as

it appears in Agilent ADS.⁵ The chip size is constrained to 1.75×3.5 mm by the size of other chips on a multiproject run. Because this chip area is far greater than required for the design, over 325 pF of on-chip bypassing is added to the lay-

out. The RF input and output pads are asymmetric for compatibility with an existing module design. Note that the first and second stage VDD and control pads are separate on the chip for testing purposes, but combined at the module level. Also, the "L"shaped pads placed at the upper left and lower right corners serve as autorecognition fiducials for roboticallycontrolled wire bonding in the production environment. Figure 5 shows the fabricated RFIC integrated into a previously existing multilayer LTCC module. As mentioned, the module had already been manufactured for an earlier pulse modulator design.

PERFORMANCE

The RFIC is tested at the die level

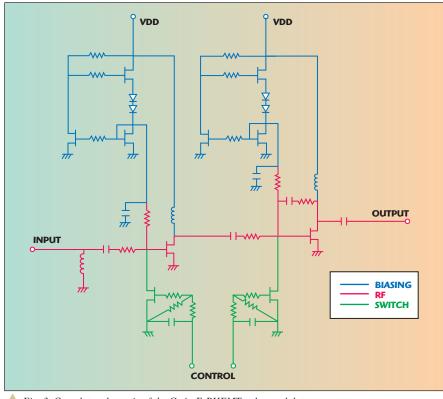
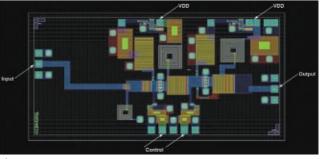


Fig. 3 Complete schematic of the GaAs E-PHEMT pulse modulator.



on-chip bypassing A Fig. 4 Chip layout in Agilent ADS.



Fig. 5 The fabricated RFIC integrated into an existing multilayer LTCC module.

on a manual wafer probe station. All the instrument grounds are tied directly to the RFIC backside ground on the

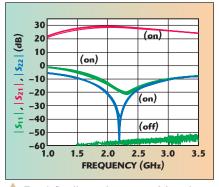


Fig. 6 Small-signal response of the pulse modulator in the on- and off-states.

wafer prober. The force/sense lines, connecting the power supply outputs to the DC probes, reference all measured voltages and currents to the DC probes. The power meter and S-parameter measurements are referenced to the RF probe tips, using off-chip SOLT calibration standards. Figure 6 shows the small-signal frequency response of the pulse modulator for the on- and off-states. The results for five randomly selected RFICs are shown. Across the 2 to 3 GHz band, the maximum return losses are better than 10 dB. The gain decreases from 28 dB at 2 GHz to 26 dB at 3 GHz; the minimum on/off isolation decreases from 85 dB at 2 GHz to 79 dB at 3 GHz.

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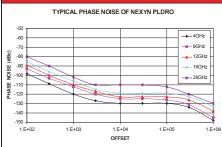
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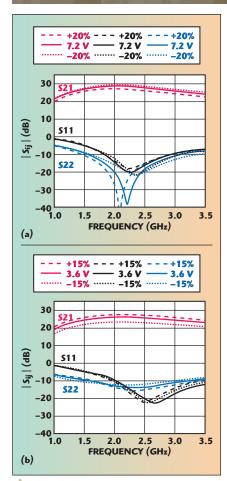


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Arr Fig. 7 Variations in the on-state small-signal response for 7.2 V $\pm 20\%$ (a) and 3.6 V $\pm 15\%$ (b).

As shown in **Figure 7**, when the supply voltage drifts by ±20 percent from the nominal 7.2 V, the amplifier is still matched across the 2 to 3 GHz band, and the gain remains above 25 dB. In fact, the figure also shows that the design maintains good performance over the same band, even when using a 3.6 V supply varying ± 15 percent. For both cases, the off-state \$21 remains unchanged from its value at the nominal power supply voltage. The relative insensitivity of the design to supply variations is further illustrated by the power measurements shown in Figure 8. At 7.2 V, the P_{1dB} is 21 dBm with a current draw of 59 mA. At 3.6 V, the P_{1dB} is 17 dBm with a current draw of 18 mA. This stability of performance across a wide range of supply voltages testifies to the robustness of the feedback designed into the active bias network and to the effectiveness of the negative feedback used for the output match.

For dynamic testing, the pulse mod-

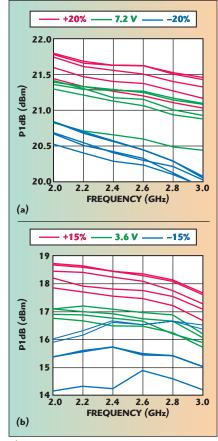


Fig. 8 Variations in the on-state output power for 7.2 V $\pm 20\%$ (a) and 3.6 V $\pm 15\%$ (a).

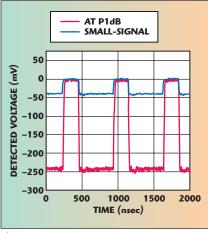


Fig. 9 Output time domain waveforms.

ulator is switched on and off with a low-level TTL signal (0 V, +3 V) generated by an Agilent 81111A signal generator. The envelope of the detected RF waveform is shown in $Figure\ 9$ under small-signal drive conditions as well as at P_{1dB} . For a CW input frequency of 2.5 GHz, the slowest rise/fall times observed are for the small-signal case: 12.6 nsec rise (10 to 90 percent) and 7.8 nsec fall (90 to 10 percent).

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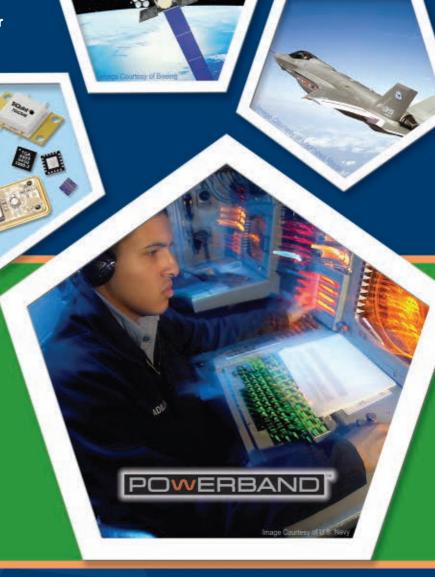


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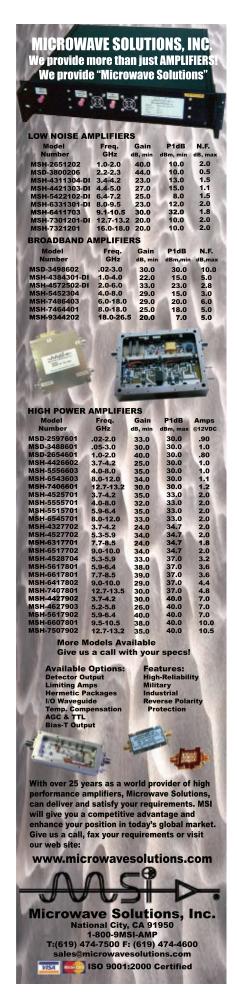


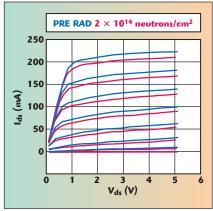
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ightharpoonup Fig. 10 Characteristic I-V curves for 6 × 50 μm device before and after exposure to a 2 × 10¹⁴ neutrons/cm² radiation.

The active bias networks that make this design robust against wide variations in supply voltage also serve to harden the design against severe radiation exposure. GaAs is electrically insulating and therefore inherently hard against several forms of radiation. In **Figures 10** and **11**, an individual $6 \times$ 50 µm PHEMT and the overall pulse modulator RFIC are subjected to a fluence of 2 \times 10¹⁴ neutrons/cm².⁶ The individual device shows some degradation after exposure to this high level of neutron radiation, but the effect on the gain of the on-state pulse modulator is negligible for all practical purposes.

CONCLUSION

The RF pulse modulator described in this article demonstrates some of the benefits and techniques possible using E-PHEMTs technology: Single-supply operation, TTL-level logic control and active bias networks. The RFIC shows good gain and output power over the entire 2 to 3 GHz bandwidth. Worst-case switching times are less than 13 nsec. The performance remains stable over a wide range of supply voltages and under severe radiation conditions. Although much greater levels of integration are possible, these results illustrate the flexibility and robustness of GaAs RF-ICs for the replacement of existing RF component/subsystem hardware.

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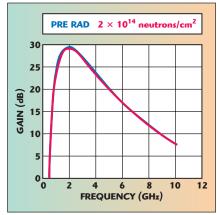


Fig. 11 Small-signal gain of the pulse modulator RFIC before and after radiation exposure

facturing and Technologies as well as P. Litzenberg and K. Mays of TriQuint Semiconductor for helpful technical discussions.

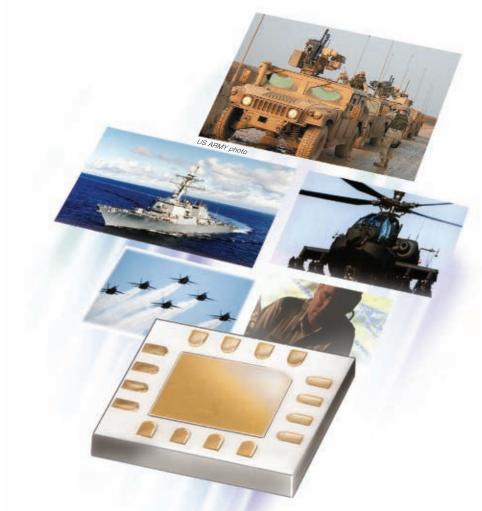
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Addressing the Battlefield Communications Power Gap

ower density of the new communications systems supporting the networked battlefield can be four times lower than that of the AM/FM radios they replace due to the use of advanced modulation techniques to improve data throughput of Net-Centric communications systems. These software-defined radios must operate over wide transmit bandwidths, which combined with the newer waveforms compound the already challenging task of making these radios lighter and last longer on fewer batteries. A power management technique described by Bell Labs in 1937, but only recently successfully implemented in commercial cellular and broadcast communication systems, is attracting interest. This article examines the latest developments in military communications technology.

UPGRADING MILITARY COMMUNICATIONS

To put the current situation into context, it is believed that military communications systems will go through a dramatic upgrade cycle over the next five to ten years. The upgrade, which has already started, will create a Net-Centric communication system where voice, data and video information can flow securely and rapidly throughout all theatre elements in the battlefield.

The USA's Joint Tactical Radio System (JTRS) program is the vanguard of this change

in how the military communicates in the battlefield. New Handheld, Manpack and Small Form Factor (HMS) radios under the JTRS program offer tactical vehicles and dismounted units with reliable, good quality connectivity over a wide bandwidth even in rugged and urban environments.

Such secure, reliable high bandwidth voice, data and video communications technology is essential to deliver the required speed of command in today's conflict environment. It is the two-way backbone that connects the whole chain of command from the top down to the lowest level, giving critical and immediate situational awareness and maximizing combat effectiveness.

These new standards derive their higher throughput by using more complex modulation schemes, but these reduce the efficiency of the RF power transmitters. The 2 MHz to 2 GHz bandwidth specification for JTRS radios imposes further challenges to the designer of the RF transmission circuits. Power density of the new radios can be worse than the established frequency hopping AM/FM technology by a factor of four, with a negative impact on the Size, Weight and Power (SWaP) envelope of the communications systems a vehicle-borne or dismounted unit needs to carry.

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These considerations are driving a major push to improve the efficiency of battlefield communications technologies. A major area of focus is the RF amplifier, which can end up consuming as much as half the power in a high speed modem. Power amplifier designers are faced with a difficult optimization challenge that must balance size and efficiency yet work over the demanded transmit bandwidth.

Advances in power transistor technologies have allowed designers to meet their size goals by addressing the wide transmit bandwidth in only one or two power amps; however, the efficiency has suffered accordingly. It is time to take a fresh look at the design of the RF transmission amplifier chain.

RF POWER AMPLIFIER EFFICIENCY

The waveforms used in the new networked battlefield communications protocols are usually OFDM- or QAM-based and support frequency hopping and adaptive signal to noise encoding schemes. For example, the Wideband Networking Waveform (WNW) specified by JTRS for ground to ground and ground to air communications and the Tactical Targeting Network Technology (TTNT) used for airborne sensor, shooter and ord-

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Fig. 1 Conventional Class AB power amplifier configuration.

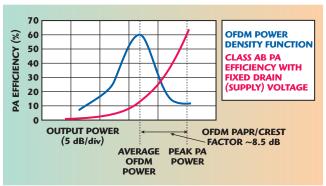


Fig. 2 Drain efficiency vs. power output and probability distribution of the instantaneous output power value.

nance communication is based on the OFDM modulation scheme.

The Soldier Radio Waveform (SRW) for soldier to soldier communications is based on OAM modulation. The Mobile User Objective System (MUOS) for satellite to ground, sea or air communication uses both OFDM and OAM, and leverages the technology developed W-CDMA commercially for existing mobile phone networks.

Channel coding and modulation techniques like QAM and OFDM require faithful reproduction of the amplitude of the transmitted RF signal. RF PAs are classic Class AB amplifiers (see **Figure 1**), which offer the most efficient operation when the RF envelope waveform is closest to peak

Efficiency is a function of the RF signal crest factor (peak-to-average power ratio or PAPR) where the higher the peak power with respect to the mean power, the lower the efficiency. This in turn is determined by the type of modulation and coding scheme. There is no single formula that defines that relationship, but a good rule of thumb is that every dB of crest factor reduction provides a 2 to 2.5 percent efficiency change.

In a W-CDMA transmitter, the PA peak power is usually 4 to 6.5 dB above the mean power. OFDM signals are

RF

FINAL POWER AMPLIFIER STAGE OUTPUT composed of a large number of individual components, the power of each varying with time. The resultant amplitude of the composite signal over time is therefore not constant, but 'peaky' in nature and results in even higher crest factors—up to 9.5 dB—and even lower PA efficiencies.

In general, the higher the data rates, the higher the PAPR and the more difficult the amplification design process becomes. This non constant amplitude modulation means that a typical amplifier rarely runs up to its saturated output power capability resulting in lower efficiency.

High PAPR signals make the design of PAs difficult for two reasons: Firstly, the amplifier must be linear over a wide dynamic range to preserve modulation accuracy and spurious performance. It is possible to use a technique called Crest Factor Reduction (CFR) to allow the PA to operate closer to peak power for most of the time by limiting the peaks of the signal using DSP techniques. However, this needs to be done with care to minimize distortion and maintain adequate signal Error Vector Magnitude (EVM). Typical CFR will reduce the PAPR to around 8.0 to 8.5 dB.

Secondly, the variation with time of the PA output power results in poor overall power efficiency. The reason for this is shown in **Figure 2**. A Class AB (linear) PA is at its most efficient at peak power, but the drain (power conversion) efficiency, as shown by the solid line, drops off rapidly as the output power decreases. The probability distribution of instantaneous output power for a typical OFDM signal (dashed curve [not to a specific scale]) shows that for much of the time the signal power lies well below the peak power and hence the device is operating at low (average) efficiency. Note that the PAPR value shown in this diagram assumes that CFR has been used to reduce the PAPR of the transmitted signal; without this, overall efficiency would be even lower.

IMPROVING PA EFFICIENCY

A number of techniques are now being used to improve PA efficiency. The majority of these have found their first use in the cellular industry, where the problems of high network power consumption and environmental impact have already caused many network operators to force the pace of change and demand significantly improved equipment efficiency from their suppliers.

The three major techniques are:

- Digital Pre-Distortion (DPD) and Linearization
- Doherty
- Envelope Tracking

DPD AND LINEARIZATION

As already noted, CFR can make a

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useful contribution to improving PA efficiency by allowing controlled compression of peak signals, effectively allowing the PA to operate nearer peak power and hence at a higher efficiency. DPD and Linearization techniques build on this by compensating for nonlinearities in the final RF output stage. In the process they also improve adjacent channel and EVM performance, and by allowing some compensation for the distortion caused by nonlinearities near compression, the PA can be driven harder, resulting in an improvement in power efficiency.

The best improvements result when DPD and Linearization are used as part of a system architecture incorporating active sampling of the output signal as part of a feedback loop. Only then can the system fully compensate for changes in amplifier characteristics with time, temperature and signal characteristics.

DOHERTY

The Doherty PA configuration uses two amplifying devices driven in parallel, with their outputs combined. One amplifier (the 'carrier', typically a Class AB amplifier) provides all the output power (with the second device turned off) until the power required causes it to enter its nonlinear region, at which point the second ('peaking') amplifier (typically operating in Class C) is switched on and provides additional power. While several academic papers have quoted impressively high

efficiency capabilities for Doherty amplifiers, in practice the typical efficiency being achieved with these designs is around 25 to 30 percent. However, this improved efficiency comes with a number of drawbacks, including the difficulty in maintaining matching and linearity over time and

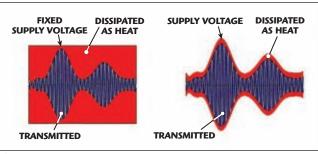
earity over time and with temperature and device variations.

The most important limitation, however, is the limited PA bandwidth due to the complicated and essentially narrow-band matching required between the two amplifiers. Whilst the bandwidth available is adequate for cellular systems, it does not address all battlefield communications requirements.

ENVELOPE TRACKING

Envelope Tracking, as a technique for improving power efficiency of RF power amplifiers, was first described by Bell Labs in 1937. Instead of optimizing a final RF stage power transistor supplied by constant voltage, the supply voltage to the power amplifier output transistor is adjusted dynamically, in synchronism with the envelope of the modulated RF signal passing through the device.

This ensures that the output device



including the difficulty in maintaining and the energy dissipated as heat.

Fig. 3 Envelope tracking (right) reduces the voltage difference between the supply voltage and the signal envelope significantly reducing the energy dissipated as heat.

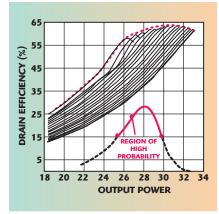


Fig. 4 Efficiency of a power amplifier driven by variable voltage.

remains in its most efficient operating region (i.e. in saturation), dramatically reducing the energy dissipated. *Figure 3* shows envelope tracking in operation. Without envelope tracking, the difference between the constant power into the RF amplifier and the RF output waveform is dissipated in



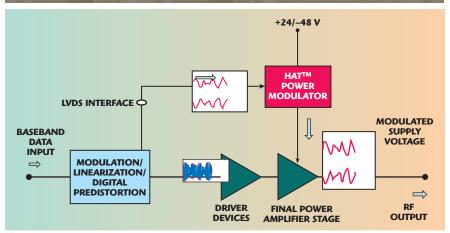


Fig. 5 Application of a HAT power modulator to a standard power amplifier.

the RF power transistor as heat. With envelope tracking, the supply voltage tracks the signal envelope, dramatically reducing the energy dissipated.

Figure 4 demonstrates the high efficiency of an envelope tracking amplifier throughout the high-probability region of continuous output power. It is essentially a superposition of Figure 2, showing a series of drain efficiency versus RF power output curves as the supply voltage is varied. The locus of these curves represents the efficiency of a power amplifier driven by variable voltage.

IMPLEMENTATION OF ENVELOPE TRACKING

Although the principles of envelope tracking have been known for some time, the practical difficulties of implementing a working system have prevented the concept from being employed until recently. The challenge is to make a power supply modulator capable of achieving the accuracy, bandwidth and noise specifications necessary at a level of conversion efficiency that delivers significant energy saving for the system as a whole. Critical performance issues include tracking accuracy, modulator efficiency, stability, compliance with spurious-signal and noise specifications, and bandwidth for multi-carrier support.

However, an evolution of this principle, High Accuracy Tracking (HATTM), is showing an improvement in efficiency, going from typically 30 percent for a standard Class AB amplifier to beyond 60 percent with HAT. Japanese cellular infrastructure vendor Sumitomo has recently launched a product based on the HAT

principle, and multiple other base station and Digital TV transmitter manufacturers are at an advanced stage of adopting this new technology in their products. A solution for handsets is in development.

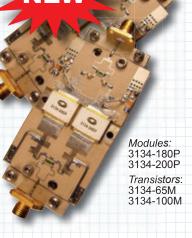
HAT technology has been demonstrated on a GaN PA. With QAMbased waveforms similar to SRW, they have shown a potential for 30 per cent less power consumption and 42 percent more battery life for a manpack radio based on SRW. This was achieved over a wide frequency range and across multiple modulation modes. The power dissipation of the PA transistor itself is reduced by twothirds, leading to a significant reduction in device thermal management requirements. Significant reduction in device temperature also leads to increased PA device reliability. Also, for handset applications, demonstrations have shown an improvement in linearity with HAT, eliminating the requirement for DPD altogether.

HAT implementation is relatively straightforward (see *Figure 5*), involving the addition of a HAT modulator module. The only addition required to the standard PA architecture is an



Fig. 6 Nujira HAT power modulator integrated with a typical PA.





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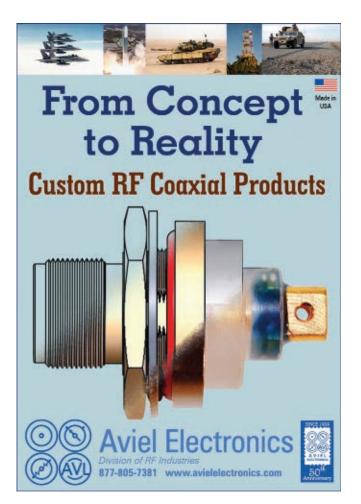
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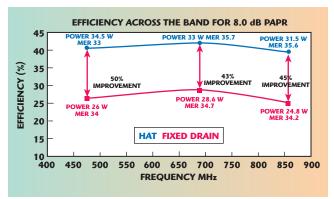
output from the DPD/Linearization function to drive the HAT Power Modulator with a digital representation of the modulation envelope. The module can be a small box (70 mm \times 70 mm \times 18 mm for the commercial units supporting 40 W cellular base station transmitters, as shown in *Figure 6*), or can be a silicon chip for lower power handheld transmitters. In the future, the HAT algorithm may be integrated into power management chips already used in a radio transmitter. In addition, some minor redesign of the PA layout is needed to ensure optimal matching and hence efficiency.

To retain compliance with demanding noise and spurious specification, the power modulator tracks the RF signal envelope with utmost accuracy in both timing and amplitude. It does so by calculating the amplitude from the digital signal ($\sqrt{(I^2+Q^2)}$) and applying a simple function to arrive at the optimum instantaneous drain voltage. In parallel, a delay is calculated and applied to the RF signal before it is input to the amplifier, cancelling out the delay in the modulator.

EFFICIENCY IMPROVEMENT ACROSS UHF BAND

Figure 7 shows the level of energy efficiency improvement that can be obtained when using an envelope tracking HAT power modulator in a wideband UHF system. It can be seen that the efficiency improvement exactly tracks the normal Class AB 'fixed drain' solution across the whole band, whilst maintaining strong linearity and providing





▲ Fig. 7 Level of energy efficiency improvement obtainable when using an envelope tracking HAT power modulator in a wideband UHF system.

some additional benefit in the form of increased power output from the transistor (due to thermal management improvement).

Note that the efficiency enhancement is maintained across a very wide band—a characteristic of envelope tracking. This need to provide adequate linearity with enhanced efficiency over a wide band with high peak to average signals is the type of challenge now facing designers for the next generation of networked battlefield communications systems. It has been shown that with envelope tracking, linearity is intrinsically improved compared to Class AB designs and the result can be achieved without the use of DPD and the added system complexity that this would bring.

CONCLUSION

To put the above discussion into context, the 40 percent of the 50 to 55 kg kit carried by the $21^{\rm st}$ century infantryman can be power related, and 30 percent of the load carried by a platoon can now be related to powering the communications and other electronics it carries. There is high level realization that the benefits of new communications standards need to be realized while reducing, rather than adding to this burden.

In consequence, western armed forces are giving focus to the power density of their systems, defined as watt hours per kilogram. The vision is to drive power density upwards from today's 200 Wh/kg through 400 Wh/kg to a goal of 600 Wh/kg by 2011. Though DPD, linearization and Doherty can all make a contribution towards this target, HAT has demonstrated that it is capable of fully compensating for the inherent inefficiencies of transmitting OFDM, QAM and similar signals, and reversing the trend of rising RF transmitter energy use.



Shaun Cummins graduated from Nottingham Trent University in 1994 with a degree in Electrical and Electronic Engineering. He is presently the advanced technology director at Nujira looking at new architectures and systems where envelope tracking technology can be applied. Cummins is one of the earliest members of Nujira and has been active in a broad range of envelope tracking technology development. He has also been very active in the area of linearization technology, particularly Digital Pre-Distortion, as it applies to ET systems.

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	ZHL-5W-2G+	800-2000	45	+37	+38	8.0	+44	24	2.0	995	945
	ZHL-10W-2G+	800-2000	43	+40	+41	7.0	+50	24	5.0	1295	1220
	ZHL-16W-43+	1800-4000	45	+41	+42	6.0	+47	28	4.3	1595	1545
•	ZHL-20W-13	20-1000	50	+41	+43	3.5	+50	24	2.8	1395	1320
	ZHL-30W-252+	700-2500	50	+44	+46	5.5	+52	28	6.3	2995	2920
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Price

A Unidirectional Horn-shaped Bowtie Antenna for Ultra High Resolution Radar

This article presents a high-performance unidirectional bowtie antenna backed by a corner reflector, which has a high-directive radiation covering over 100 percent bandwidth of the whole ultra-wideband (UWB) frequency band. This design implements a horn-shaped bowtie radiating element with a tapered coplanar stripline (CPS) feeder on a single-sided dielectric substrate, which shows a measured return loss of less than -10 dB over the whole UWB frequency band of 3 to 11.7 GHz. The measured radiation pattern is unidirectional with consistent gain over the frequency band. These results show enhanced performance with a compact size, which is useful for ultra high resolution radar medical imaging and directional communications applications.

n ultra high resolution radar is one of many promising areas of UWB applications because of its inherent nature of ultra wide bandwidth.1 In theory, UWB radar could achieve the ultra high range resolution of up to 2 cm if a single antenna could cover the whole UWB frequency bandwidth of 7.5 GHz from 3.1 to 10.6 GHz. Thus, a compact UWB antenna design with an ultra wide bandwidth and high-directive radiation has been a challenging problem in radar applications. The bowtie antenna is known to be one of the most common UWB antennas since it has many advantages in its small size, light weight, wide bandwidth and omni-directional radiation pat $tern.^{1-6}$

To achieve the ultra wide bandwidth performance, several types of bowtie antennas have been reported for UWB communications and radar applications such as patch-type,² slot-type,³⁻⁴ coplanar waveguide (CPW) and coplanar stripline types.³⁻⁶ However, the bandwidth

of a typical bowtie antenna with a compact size is still not sufficient to cover the whole UWB frequency band within an acceptable level of return loss.

More importantly for high resolution radar applications, an omni-directional antenna's performance can be degraded by multi-target, multi-path reflections from the unwanted objects in or around the radiation direction. However, most existing UWB bowtie antennas still exhibit a bi-directional or omni-directional radiation pattern. Excently, the patch-type bowtie antenna has been reported for unidirectional radiation, but the antenna size is large and its bandwidth is still narrow in covering the whole ultra-wideband frequency. Thus, the design of a new unidirectional UWB bowtie an-

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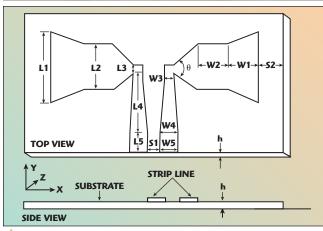


Fig. 1 Base model structure of the proposed UWB bowtie antenna.

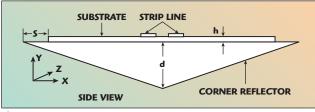


Fig. 2 Pyramidal reflector of the proposed bowtie antenna.

tenna is highly desirable for ultra high resolution radar and communication applications.

A novel bowtie antenna with and without a pyramidal corner reflector is proposed and the performances are compared for UWB radar applications by satisfying two critical requirements: much lower return loss less than -10 dB over the 100 percent UWB frequency band and unidirectional radiation pattern with a high front-to-back ratio.

SHAPED BOWTIE RADAR ANTENNA DESIGN

A high-performance bowtie radar antenna with unidirectional radiation has been designed for covering the whole UWB frequency band using a new method of a shaped tapered antenna design approach. The geometry of the base model of the proposed horn-shaped bowtie antenna is shown in Figure 1. From the wave dispersion characteristic point of view, the shaped bowtie radiating element can give wider gain bandwidth than ridged square and triangular-shaped conventional types of bowtie elements.⁶ A pair of horn-shaped bowtie radiating elements on a dielectric substrate is symmetrically arranged on a singlesided copper clad laminate. A CPS is then placed with a tapered strip width and narrow gap between shaped bow-

tie radiating elements, since this structure is less dependent of the characteristic impedance matching.⁵ For the unidirectional design requirement, a horn-shaped pyramidal reflector (see Figure 2) is separately designed and compactly attached to the back of the bowtie plate for reducing the back radiation and giving more unidirectional gain to the target direction. To implement the shaped tapered bowtie antenna design approach, most of the step discontinuities from conventional type of triangular

bowtie radiating element were removed, and the discrete shape of the stripline feed was smoothly tapered in order to enhance the impedancebandwidth of the antenna. Through a parametric simulation and search (using MicroStripes by Flomerics Ltd., UK), it was found that the bandwidth increases with the increase of L1, L2 and W1, W2 within a certain limited compact size. It was also observed that the impedance bandwidth is changing depending on the width and gap of the tapered stripline with the different lengths of L4 and L5. The overall dimensions of the horn-shaped bowtie element were obtained as follows: L1=15.8 mm, L2=11.8 mm, L3=1.0 mm, W1=6.6 mm, and W2=9.6 mm, θ =104 degrees. The dimensions of the stripline extended to the bowtie element are selected as: L4=14.1 mm, L5=3.2 mm, W3=1.4 mm, W4=2.8mm and W5=2.8 mm, respectively. The stripline gap between a pair of bowtie elements is selected as S1=2 mm. The overall size of the bowtie antenna plate is 48 mm (x direction) \times 32 mm (y direction) \times 1.6 mm (-z direction), which is very compact.

For the unidirectional radiation requirement, the dimensional depth and stripline distance of the pyramidal corner reflector is found to affect the return loss, bandwidth, resonant frequency and radiation characteristics. The depth of reflector, d, and stripline distance, S2, were finally selected as S2=4 mm and d=20 mm, respectively. The overall size of the antenna with a reflector is 60 mm (x direction) \times 44 mm (y direction) \times 20 mm (-z direction), which is compact in size, light weight and easy to fabricate for any UWB radar applications; thus, this size can possibly be integrated within the size of the ultra-wideband device.

FABRICATION AND EXPERIMENT

experimental horn-shaped bowtie antenna with and without the pyramidal reflector was fabricated, as shown in Figure 3. To implement the bowtie radiating element, the single-sided 35 micron copper-clad substrate (FR4 board) was chosen with a thickness of 1.6 mm and dielectric constant of 4.55. For achieving unidirectional radiation with a high frontback ratio, a horn-shaped pyramidal corner reflector element was made of thin copper sheet with the thickness of 0.1 mm, and a 4 mm-slot was spaced between the bowtie plate and a pyramidal corner reflector. The return loss, S_{11} , of the antenna was measured using a vector network analyzer (HP 8722ES). The radiation pattern and gain-transfer function, S₂₁, were measured in an anechoic chamber using two identical bowtie

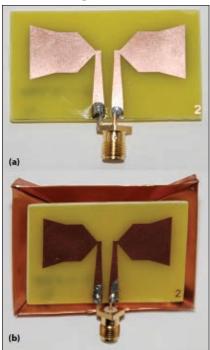


Fig. 3 Fabricated bowtie antenna without reflector (a) and with reflector (b).



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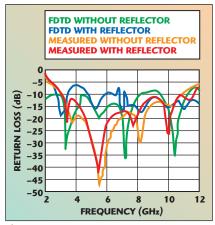


Fig. 4 Return loss comparison with and without reflector.

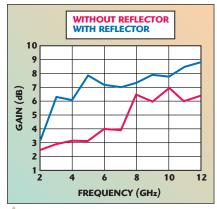


Fig. 5 Antenna gain comparison with and without reflector.

antennas separated by a distance well into the far-field range for all frequencies under consideration. For the radiation measurement, the transmitting bowtie antenna was situated on a turn table and rotated 360 degrees in steps of 1 degree while simultaneously sweeping the whole UWB frequency bands of 2 to 12 GHz, recording 1601 frequency points. A set of measured S_{21} data for each frequency was then selected in order to produce the full radiation pattern at selected frequencies in the UWB band.

RESULT AND DISCUSSION

The return loss of the fabricated bowtie antenna with and without a reflector was compared with the predicted and measured results, as shown in *Figure 4*. As can be seen, the simulated return loss of the antenna without a reflector shows less than -10 dB over the very wide frequency range of 2 to 11.3 GHz, except for the frequency band of 8.2 to 9.4 GHz, which allows a bit higher than -10 dB. However, the measured return loss for the

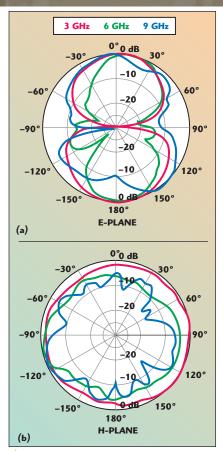


Fig. 6 Radiation pattern of the antenna without reflector.

tapered bowtie antenna is less than -10 dB over the complete UWB frequency band of 3 to 10.8 GHz, and even less than -12 dB over 3.2 to 10.5 GHz, showing a better gain-bandwidth performance. There is a slight difference between the simulated and the measured return loss, but the degree of the return loss is still within the requirements in both cases and their trends are similar to each other. For unidirectional radiation performance, the same optimized design of the antenna with the reflector shows a much wider bandwidth from 3.06 to 11.7 GHz at the same threshold level of return loss of -10 dB. It is observed that a smoothly tapered bowtie antenna without a discrete step in the stripline can give more wide gain bandwidth and lower return loss, compared to the simply ridged shape of bowtie antennas with a discrete step as in the case of conventional triangular or rectangular-type antennas. The overall performance of the predicted return loss with and without a reflector shows a good agreement with the measured results that satisfies the crit-

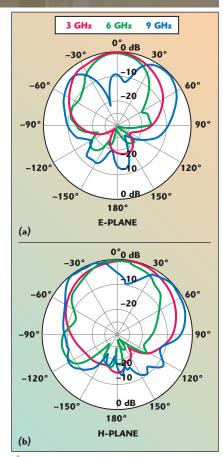


Fig. 7 Radiation pattern of the antenna with reflector.

ical design requirements for covering the whole UWB frequency bandwidth from 3.1 to 10.6 GHz defined by the FCC. The antenna gain was obtained by the simulation in both cases, as shown in **Figure 5**. The gain of the bowtie antenna without a reflector ranges from 2.5 dBi at 3 GHz to 6.9 dBi at 10 GHz, which consistently increases with the increase in frequency over the whole UWB frequency band. The gain of the antenna with a reflector, however, increases from 6.5 to 8.5 dBi, almost double the case without a reflector, which gives more highly directional gain to the target direction.

The radiation pattern for a bowtie antenna with and without a pyramidal reflector was measured in the E-plane and H-plane at the selected frequencies of 3, 6 and 9 GHz from the whole UWB frequency ranges, as shown in *Figures* 6 and 7, respectively. The trend of the broadband radiation of the antenna without a reflector is changing from bi-directional (forward and backward lobes) to quasi omni-directional as the frequency, while the bowtie antenna with a reflector shows a good unidirec-

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tional radiation performance compared to the case without a reflector. The measured radiation pattern of the reflector backed antenna shows a high front-to-back radiation ratio of 30 dB at the lower frequency band. However, as the operating frequency increases, the main beam tends to squint slightly in the off-broadside direction. This is an inherent limitation of the UWB antenna due to the finite physical size of the bowtie element in accommodating the whole ultra-wideband frequency. The overall antenna pattern shows the unidirectional radiation to the desired target direction, which is useful for high-directive radar imaging applications.

CONCLUSION

A new horn-shaped bowtie antenna with a corner reflector that is fed by a tapered planar stripline is designed and fabricated with a compact size for lower return loss, wider gain bandwidth, and unidirectional radiation for UWB radar and medical imaging applications. The measured bandwidth covers over 100 percent of the whole UWB frequency band over 3 to 11.7 GHz at a return loss of less than -10 dB, and the radiation pattern is unidirectional with stable high front-to-back ratio over the frequency band. These high performance and compact geometry features can be attractive for UWB radar imaging and directional communication systems applications.

ACKNOWLEDGMENT

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SIZE MATTERS PERFORMANCE RULES

SIZE

- MULTI-CHANNEL: 1U High Rack Mountable
- SINGLE CHANNEL: 1 x 4 x 6 inches

PERFORMANCE (NON-PLL SYNTHESIS)

- PHASE NOISE: -151 dBc/Hz (100MHz, 10kHz OS)
- BROADBAND: 8MHz to 6GHz (0.001Hz resolution)
- SWITCHING SPEED : < 5μS
- PHASE DRIFT : < 0.5 deg (channel channel)</p>
- PHASE COHERENT INDEPENDENT CHANNELS

RF Synthesizer Channel Options

FREQ. RANGE	MODEL	CH's	Phase Noise ¹	Spurious	
8MHz to	HS1001C	1	7,111		
100000000000000000000000000000000000000	HS1004A	4	-131	-65	
1GHz	HS1008A	8		060	
8MHz to	HS2001A	1			
2GHz	HS2004A	4	-125	-65	
2GHZ	HS2008A	8			
	HS3001A	1		-65	
8MHz to	HS3002A	2	101		
3GHz	HS3004A	4	-121		
	HS3008A	8			
	HS6001A	1			
8MHz to	HS6002A	2	446		
6GHz	HS6004A	4	-115	-65	
	HS6008A	8			

¹ Typical performance at maximum output frequency, 10kHz offset

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Ultra Low Phase Noise— Phase Coherent Synthesizers

olzworth has released a product line of ultra low phase noise, multi-channel CW sources that incorporate up to eight independently tunable channels inside a single 1U high housing. One example is the HS3008A, 3 GHz RF synthesizer, which is capable of tuning frequencies from 8 MHz to 3 GHz in 0.001 Hz steps. Like all Holzworth synthesizers, the HS3008A demonstrates industry leading phase noise with excellent channel-tochannel phase stability. The non-PLL-based synthesis architecture is currently available with bandwidths up to 6 GHz while enabling tight stability, phase coherency and extremely fast tuning speeds. Holzworth's versatile multichannel synthesizer products can be controlled directly by the proprietary application software, a shared library file (LinixTM) or any standard control program/language capable of communicating with a DLL file. These USB instruments also offer an optional SPI interface.

DESIGN

Holzworth RF synthesizers are stand alone units with an integrated precision 100 MHz OCXO. An external 10 or 100 MHz precision reference may also be used with the standard auto-detection reference input/output ports. Holzworth synthesizers are unique in that they do not utilize a PLL-based architecture to achieve broadband, low phase noise frequency generation. The proprietary design approach enables industry leading phase noise, spectral

purity and ultra fast switching speeds inside highly compact form factors. Multi-channel synthesizers benefit greatly from the elimination of phase-locked loops because the phase response is continuous and therefore the relationship between every reference locked channel is precisely coherent by design. In the multi-channel models, each synthesized channel operates independently, yet on the exact same reference clock cycle (instead of locking to a free running oscillator), thereby improving channel-to-channel phase stability. Up to 64 channels can be reference linked within a system to maintain a fully phase coherent relationship across all independently tunable channels. The non-PLL designs also offer valuable channel-to-channel phase drift performance, being less than 0.5 degrees between any two channels.

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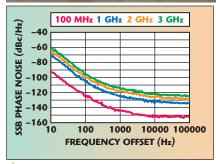


Fig. 1 SSB phase noise at 100 MHz, 1 GHz, $\stackrel{\circ}{2}$ GHz and $\stackrel{\circ}{3}$ GHz (P_{out} = +12 dBm).

PERFORMANCE

As an example, the HS3008A has typical phase noise of -151 dBc/Hz at 100 MHz (10 kHz offset). Figure 1 shows the SSB phase noise performance versus frequency offset at 100 MHz, 1, 2 and 3 GHz with an output power of +12 dBm. The output power range is adjustable in 0.1 dB steps from -110 to +15 dBm (absolute limits are frequency dependent). Figure 2 demonstrates the output power flatness performance from -19 to +15 dBm in 1 dB increments over the frequency range of 8 MHz to 3 GHz. The tuning speeds are extremely fast,

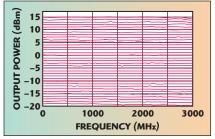


Fig. 2 Output power flatness vs. frequency.

being as low as 5 µs with settling times of approximately 100 ns (narrowband list mode). Custom options are available for external controlled SPI tuning speeds of <200 µs for frequency changes that span the full bandwidth of the instrument.

Spectral purity compliments the ultra low phase noise performance. Figure 3 shows the spurious/harmonic performance of the synthesizer at 100 MHz, 1, 2 and 2.9 GHz at an output power of +10 dBm. Figure 4 demonstrates the absolute performance of the second and third harmonics as they vary with the output power and the second and third harmonic levels relative to the fundamental. Holzworth synthesizers offer frequency

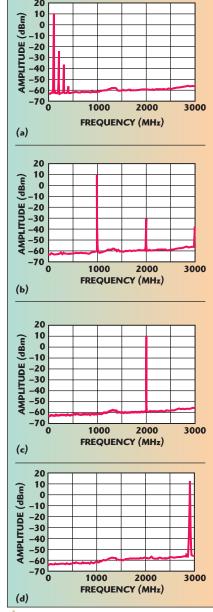


Fig. 3 Spectral data at 100 MHz (a), 1 GHz (\widecheck{b}), 2 \widecheck{G} Hz (c) and 2.9 GHz (d) (P_{out} = +10 dBm).

tuning resolution of 0.001 Hz, amplitude tuning resolution of 0.1 dBm and phase offset tuning resolution of 0.1 degree (frequency dependent). Figure 5 displays the channel-to-channel phase drift performance at 3 GHz, over a period of one hour at 20 ± 2 °C.

OPTIONS

Holzworth multi-channel synthesizer units are available with both standard and custom options.

- OPT-FIX10 Fixed 10 MHz (+5 dBm) reference output port
- OPT-FIX100 Fixed 100 MHz (+5 dBm) reference output port
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SYNTHESIZER CONTROL

Holzworth synthesizers offer both USB and SPI control interfaces as Virtual Instruments that have been designed to be highly versatile for integration into existing systems. All models can be controlled by the proprietary GUI application, LabVIEW™, MATLAB™, a shared library file (Linix), or any application capable of sending/receiving commands through a DLL file. Under the USB interface, the synthesizers utilize the HID (Human Interface Device) transfer protocol. The HID protocol requires no installation of hardware drivers while providing the highest level of stability.

The provided GUI application is Java[™]-based, making for a robust platform that is accepted as an industry standard. Operating on a minimal amount of memory (<2 MB), users can run the application directly from a USB memory stick. Full DLL access is provided to the user for absolute control over the instrument, allowing for ease of integration with proprietary programs.

CONCLUSION

The attractive performance-toprice ratio, with models operating to 6 GHz, makes Holzworth RF synthesizers optimal solutions for precision measurement and phased-array systems where maintaining the phase relationship across multiple channels is imperative. These designs have been optimized to maintain best in class channel-to-channel phase drift over both temperature and time.

Holzworth synthesizers have been integrated into the most demanding and precise applications by world renowned companies and laboratories since its inception in 2004. Originally

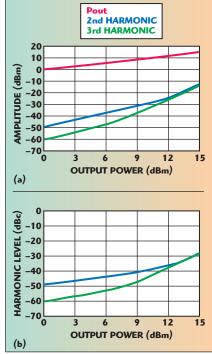


Fig. 4 Absolute (a) and relative (b) harmonic data ($F_0 = 1 \text{ GHz}$).

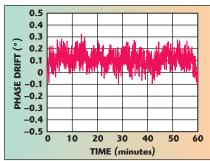


Fig. 5 Channel to channel phase drift performance (3 GHz, 20 ± 2°C)

recognized for broadband performance inside compact form factors, the evolution of the multi-channel synthesizer products has gained recognition for exceptional phase coherency and phase stability. The relative channel density of these multi-channel synthesizers is remarkable when considering an example where a 64 channel array of fully phase coherent, independently tunable synthesizers will now integrate to within 16 inches of vertical rack space. Holzworth also designs application specific synthesis and phase noise measurement products.

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hase stability with respect to temperature has a direct impact on system performance and is therefore an important characteristic for high frequency components and subassemblies. Enhanced phase tracking with temperature translates into lower residual noise and reduced system uncertainties. Cable assemblies interconnecting critical high frequency signal paths will also significantly contribute to the phase characteristics of the entire system. Many conventional cables utilizing polytetrofluorethelene (PTFE) dielectric materials demonstrate an acute phase gradient versus temperature. In turn, this will adversely impact system performance such as the minimum discernable signal level, jamming and clutter resistance, and ultimately system range. A newly engineered dielectric material called TF5[™] produced by Times Microwave Systems and used in its PhaseTrack II flexible coaxial cables offers greatly improved phase character-

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Fig. 1 Typical coaxial cable assembly construction.

istics over temperature, essentially eliminating the sharp phase gradient associated with cables using PTFE or other dielectric materials.

High performance cables are used as interconnects for phase sensitive microwave transmitters, receivers and antennas on airframes, missiles, ships and ground-based communication systems. Test and measurement applications also require cables with high phase stability in order to reduce temperature-related drift, which leads to measurement inaccuracies and the need for frequent re-calibration. This is especially true for field testing of aircraft, ground-based radar or cellular infrastructure where outdoor temperatures fluctuate. Given the importance of maintaining phase stability over temperature (as well as low loss, weight and cost), cable manufacturers are continually improving the quality of these seemingly simple structures through the use of new materials and innovative mechanical design.

A typical microwave coaxial cable is a composite structure that consists of metal conductors separated by a polymer dielectric. The entire assembly is encapsulated with a polymer jacket, as shown in *Figure 1*. The behaviour of these materials with temperature and their

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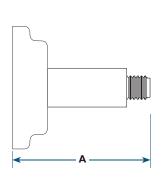
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26.5 - 40.0			1.00	2.9mm	
22.0 - 33.0			1.00	2.4mm	
22.0 - 33.0	34AEL86	1.35	1.00	2.9mm	
18.0 - 26.5	42AEL86	1.25	1.15	2.9mm	
15.0 - 22.0	51AEL86	1.25	1.50	SMA	
12.4 - 18.0	62AEL86	1.25	1.50	SMA	
12.4 - 18.0	62AEL106	1.35	1.75	TNC	
10.0 - 15.0	75AEL46	1.25	1.75	N	
10.0 - 15.0	10.0 - 15.0 75AEL86		1.50	SMA	
8.2 - 12.4	90AEL86	1.35	1.50	SMA	

Standard material is Aluminium with MIL-Spec Flange. Other waveguide sizes and specials available upon request.

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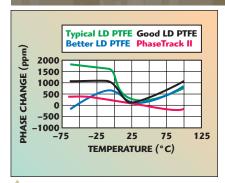


Fig. 2 Phase change vs. temperature for various cable assemblies.

interactions with one another will affect the overall phase versus temperature response of the assembly. At a constant frequency, the principle variables that will affect the electrical length (and thus the insertion phase) are the physical length and the net dielectric constant of the propagation material. Many high performance coaxial cables use PTFE or expanded PTFE as the dielectric insulator. This material undergoes dimensional changes, expanding (and becoming less dense) with increasing temperature. The result is a decrease in the effective dielectric constant that increases the velocity of propagation and results in a reduced electrical length. In addition, at approximately 19°C there is a dramatic change in the dielectric dimensions due to a change in the crystal structure. This abrupt change in the physical dimensions translates into a sharp gradient in the phase versus temperature response of PTFE cables.

While the dielectric constant decreases with temperature, thereby reducing the electrical length of the cable, the metal conductors in the coax cable are expanding and thus the physical length (and thereby the electrical length) is actually increasing. The inverse relationship between increased electrical length due to conductor expansion and decreased electrical length due to a lower dielectric constant is beneficial in reducing the overall change in phase over temperature. Many cable manufacturers have utilized this inverse relationship to minimize phase change versus temperature through their choice of materials and mechanical design. However, the abrupt change still impacts cable phase stability over this widely used temperature range. The

TABLE I CABLE ASSEMBLY SPECIFICATIONS								
Electrical and Physical Specifications								
CABLE TYPE	PHASETRACK II 200 AA-9525	PHASETRACK II 240 AA-9526	PHASETRACK II 400 AA-9528					
Tested frequency range	0.5 to 18 GHz	0.5 to 18 GHz	0.5 to 10 GHz					
Characteristic impedance	50 Ohms	50 Ohms	50 Ohms					
Velocity of propagation	82%	82%	84%					
Phase stability with bending Less than 1°/GHz per 360° wrap at minimum bend radius								
Shielding effectiveness Better than -90 dB per foot								
Insertion loss	Insertion loss Loss (dB/100'= $k1\sqrt{F(MHz)}$ + $k2 F(MHz)$							
K1	0.349221	0.263520	0.150138					
K2	0.000331	0.000331	0.000262					
dB100'@2 GHz	16.28	12.45	7.24					
dB100'@6 GHz	29.04	22.40	13.20					
dB100'@10 GHz	38.23	29.66	17.63					
dB100'@18 GHz	52.81	41.31	N/A					
Maximum operating vol	tage 2500 V (10	000 V with SMA connect	ors)					
Operating temperature	range -40°	to +85°C/-40° to +185°F						
Cable Mechanical Specifications								
Outside diameter (in)	0.200	0.240	0.400					
Minimum bend radius (in)	2.4	4.0						

TADIE

TF5 material from Times Microwave does not exhibit this change in dielectric constant and therefore maintains a relatively flat phase variation versus temperature.

0.036

Weight (lbs/foot)

The phase change (in ppm) versus temperature for the PhaseTrack II cables, shown in Figure 2, demonstrates the flat phase response relative to cables with various PTFE dielectric materials. Having the best absolute phase change characteristics in a cable allows system engineers to reduce frequent phase calibrations, simplify system error correction software, and increase system availability and accuracy. By utilizing the most phase stable dielectric material available, PhaseTrack II flexible coaxial cables can significantly improve performance in phase sensitive systems. Typical electrical and physical specifications for the PhaseTrack II cable assemblies are shown in Table 1. PhaseTrack II cable assemblies are designed to operate up to 18 GHz for applications requiring minimal change of electrical length over a dynamic temperature range combined with low insertion loss and weight. Such applications include AESA Radar, ICBM Tracking Radar, interferometry-based broadband ELINT Systems, Phased Array and Synthetic Aperture Radar.

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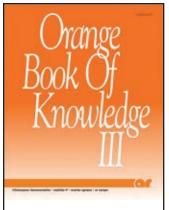
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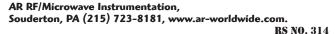
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AR's Orange Book of Knowledge

VENDORVIEW

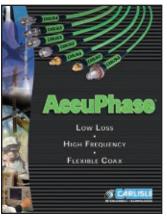
The third edition of AR's "Orange Book of Knowledge" is now available. The book contains articles and application notes on a wide range of topics and applications, including "Custom Pulses Made Easy" to a reference guide for coaxial connectors and cables. Contact your local AR sales associate for a copy.





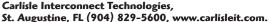
AWR, El Segundo, CA (310) 726-3000, www.awrcorp.com.

RS NO. 315



Product Catalog VENDORVIEW

AccuPhase® is a complete product family of low loss and phase stable flexible coaxial cable with frequencies up to 40 GHz. All cables within the AccuPhase family are engineered to terminate with Carlisle's high performance RF connectors for optimum performance. These new solutions are designed to meet the needs of any application where performance and stability at higher frequency ranges is critical.



RS NO. 316



Cobham Sensor Systems, Lowell, MA (978) 442-4636, www.cobham.com.

RS NO. 337

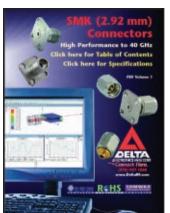


Product Catalog

This 36-page catalog features 175 all-new amplifier products, including lightweight and compact LNAs based on GaAs PHEMT active devices. CTT's extended product offering includes Gallium Nitride (GaN)-based power amplifiers for wideband jammers applications (25 W from 0.5 to 2 GHz), as well as narrowband radar applications (80 W from 8.5 to 9.6 GHz). In addition, several new subsystem offerings have been introduced including a VMEbus-compatible two-channel IF conditioner.

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

RS NO. 317



Product Brochure

your success.

Sensor Systems

Capabilities Brochure

Cobham Defense Systems is a

technology solutions provider for

aerospace and defense customers.

Cobham's Sensor Systems Division

is focused on RF, MW and MMW technologies. Its products are in

EW, Missile and Communication

Systems. In this new brochure, Cob-

ham outlines its market philosophy,

organization and technology port-

folio. Cobham can deliver advanced

devices, components, subsystems and antenna-based subsystems. Cobham is a trusted partner who stands with you, and is dedicated to

Delta Electronics Manufacturing Corp. has released a new line of SMK series microwave connectors that operate to 40 GHz mode-free. Delta SMK (2.92 mm) series connectors feature maximum VSWR for cable connectors of 1.15:1 from DC to 18 GHz, and 1.3:1 from 18 to 40 GHz. The maximum VSWR for receptacles and adapters is 1.15:1 from DC to 18 GHz, and 1.25:1 from 18 to 40 GHz. More information, including a downloadable brochure in Acrobat (.pdf) format, is available on the company's website at www.deltarf.com.

Delta Electronics Manufacturing, Beverly, MA (978) 927-1060, www.deltarf.com.

RS NO. 318

CROWD CONLIBOR

Is your RF equipment its own worst enemy?

The complex missions of the modern warfighter require a variety of critical communication links. Multiple transmitters and receivers in close proximity must operate simultaneously and without degradation from self-generated (cosite) interference. Pole/Zero can provide a comprehensive evaluation of your platform's cosite communication vulnerabilities, ensuring full range communications performance in the most crowded electromagnetic environments.

Optimize Your Equipment with a **Detailed Cosite Analysis**

Pole/Zero is an industry leader in high dynamic range RF communications solutions with over 20 years of experience. We will partner with your team to analyze the communications environment at any point over the entire life cycle of your platform, providing the information necessary to cost-effectively maximize the availability of your communication links/channels.









Use Pole/Zero Cosite Interference Analysis Results to Determine:

- Optimal communications hardware selection
- Minimum channel frequency separation determination
- Optimal platform antenna placement
- Minimum link budget margins



Put Pole/Zero's 20+ years of experience to work for you.





513.870.9060 • support@polezero.com www.polezero.com

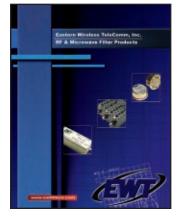
MILITARY MICROWAVES SUPPLEMENT LITERATURE SHOWCASE



Space and Missile Components Catalog

Delta Microwave is announcing a brand new space and missile components catalog highlighting its updated product capabilities and new facility. The brochure covers commercial, military and science space payload applications. Also included are products for Ballistic Missile, Ballistic Missile Defense and Targets applications. Product covered include: filters, multiplexers, filter/amplifiers and integrated assemblies.



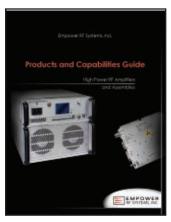


Filter Catalog

This new short form catalog features a sampling of the company's RF and microwave filter products to 40 GHz utilized in military, commercial and wireless applications. The catalog also highlights some of the company's diverse filter design and manufacturing capabilities.

Eastern Wireless TeleComm Inc., Salisbury, MD (410) 749-3800, www.ewtfilters.com.

RS NO. 319



RF Amplifiers Catalog

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

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

RS NO. 320

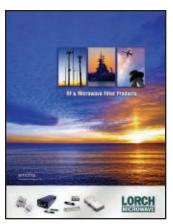


Product Catalog

K&L Microwave's 128-page catalog can be used as a desktop reference guide that offers details and specifications to help designers and engineers choose products quickly. Integrated assemblies and a wide assortment of lumped component, cavity, ceramic and suspended substrate filters are among the many types of products featured in this catalog.

K&L Microwave, Salisbury, MD (410) 749-2424, www.klmicrowave.com, www.klfilterwizard.com.

RS NO. 321

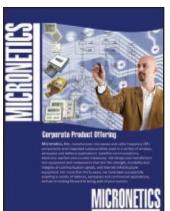


Short Form Product Guide

The Lorch Microwave short form product guide presents the complete product range in a clear and concise format. The products featured are used in a wide range of military and commercial applications. Also included are frequency range of operation, photographs and specific application information, charts and tables.

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

RS NO. 322

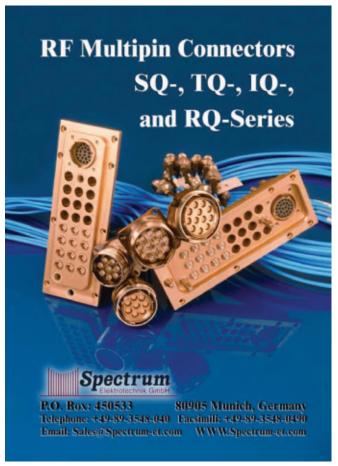


Corporate Line Card

This brochure provides a brief descriptive overview of Micronetics' family of microwave components, integrated subsystems, RFID solutions and test equipment used in a variety of wireless, aerospace and defense applications (satellite communications, electronic warfare and counter-measures). For more than 30 years, the company has been successfully enabling a variety of defense, aerospace and commercial applications.

Micronetics Inc., NH, NJ, CT, CA (603) 883-2900, www.micronetics.com.

RS NO. 323



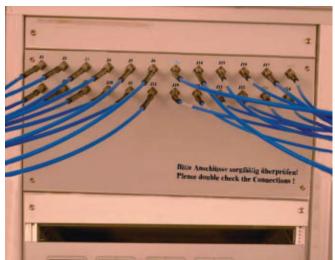
Catalogue RF Multipin Connectors 52 pages showing in detail 4 coaxial Multipin Connector Series, demonstrating how to connect and disconnect up to 23 coaxial lines in seconds and saving space.



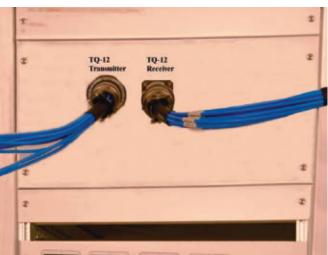








The Problem: In various applications many coaxial microwave links have to be connected and disconnected. This means threadening and unthreadening, torquing and untorquing. Very dense packaging is not possible, as there is still room needed for manual threadening and for the use of a torque wrench. In helicopters and aircrafts all connectors usually have to be safely secured, wiring the coupling nuts of the connectors, using wire holes, a time-consuming process.



The Solution: Spectrum's Multipin Connectors are available with four (4), seven (7), eight (8), twelve (12) and twenty three (23) coaxial inserts (terminating the coaxial cable assemblies) at the Multipin end, and connecting all the coaxial cable assemblies at once and in seconds with no need of a torque wrench, no need for safety wires and using minimum space.

Spectrum Elektrotechnik GmbH P.O.Box 450533 80905 Munich Tel. +49-89-3548-040 Email: Sales@Spectrum-et.com www.Spectrum-et.com

MILITARY MICROWAVES SUPPLEMENT ATTERATURE SHOWCASE



Product Selection Guide VENDORVIEW

Mimix Broadband Inc. announced the release of the May 2009 version of its product selection guide. This print catalog features the company's complete product line sorted by both product type and market, as well as new product highlights, application solutions, package outlines, RoHS program information, and distributor and sales contact information. This version of the selection guide provides quick reference to its newly introduced products along with comprehensive listings of products with matrix tables offering vital specifications.

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

RS NO. 324



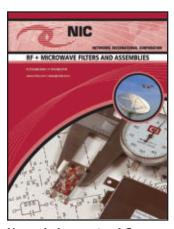
Bipolar Amplifiers Catalog

VENDORVIEW

This 30-page catalog features the company's complete bipolar amplifier line up to 3 GHz (C-22H). The catalog offers low noise, medium power, wideband, MRI, cellular/ PCM and INMARSAT bands. Typical amplifier performance curves are shown, including conversion tables, reflection measurements, outline drawings and explanation of options and specification definitions.

MITEQ Inc., Hauppauge, NY (631) 439-9220, www.miteq.com.

RS NO. 325

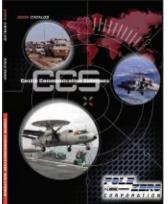


Capabilities Brochure

NIC introduces its new RF and microwave products and capabilities brochure. Products include: cavity, ceramic, crystal and LC filters, multiplexers and diplexers; RF assemblies - filter/amplifiers, switched filter banks, phase shifters; oscillators - TCXOs and VCTCXOs and Space Qualified products. Advanced Environmental Testing capabilities and Filter Design considerations are also included.

Networks International Corp., Overland Park, KS (913) 685-3400, www.nickc.com.

RS NO. 326



Tunable RF Filter Catalog

Are you looking for tunable RF bandpass and notch filters? Do you need pre/post-selectors, filter/amplifier cascades or LNAs? In the new 2009 catalog, Pole/Zero offers a complete line of tunable cosite filter products in the 1.5 MHz to 2 GHz range. Call or visit the website to get a copy and solve your tunable filter needs today.

Pole/Zero Corp., West Chester, OH (513) 870-9060, www.polezero.com.

RS NO. 327



RF and Microwave Filters

VENDORVIEW

This catalog features the company's full line of RF and microwave filter products. The catalog highlights high reliability filters, multiplexers and switched filter banks that cover DC to 50 GHz and are tailored to meet the military market. To request a complimentary copy, e-mail: catalog@reactel.com.

Reactel Inc., Gaithersburg, MD (301) 519-3660, www.reactel.com.

RS NO. 328



Product Selection Guides

VENDORVIEW

The RFMD® Multi-Market Product Selection Guide and Aerospace & Defense Product Selection Guide offer broad portfolios of RF components organized in convenient, easy-to-scan formats. You will find a listing of products with complete specs or customization information

for components that are designed to fit a wide variety of applications. Download a copy at www.rfmd.com/productguides or locate the sales representative nearest you at www.rfmd.com/globalsales for a complimentary copy.

RFMD, Greensboro, NC (336) 664-1233, www.rfmd.com.

RS NO. 329



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 $<250\eta s$. 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 $1\mu s$ 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.



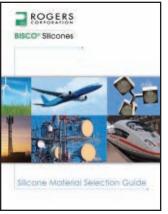


ISO 9001:2000 • AS9100 • MIL-PRF-38534 • Class H & Class K Certified

927 Thompson Place • Sunnyvale, CA 94085 408-522-3838 • Fax 408-522-3839 www.teledyne-cougar.com • email: cougar@teledyne.com



MILITARY MICROWAVES SUPPLEMENT LITERATURE SHOWCASE

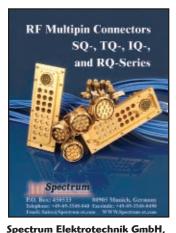


Selection Guide VENDORVIEW

This 16-page Material Selection Guide highlights Rogers' BISCO® Silicone materials, which are offered in cellular, solid and specialty grades. These materials are used in a wide range of markets, from transportation and communications to electronics and high intensity lighting. The new BISCO Selection Guide includes product samples and tips for materials selection based on market applications.

Rogers Corp., Rogers, CT (800) 935-2940, www.rogerscorp.com.

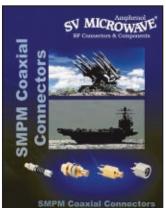
RS NO. 330



RF Multipin Connector Catalog

This 52-page catalog aims to illustrate that there is a solution to the problem of connecting and disconnecting many microwave assemblies, threading and unthreading, tightening and untightening connectors quickly and in a small area. It gives details of all of the company's multipin connectors that are available with 4, 7, 8, 12 and 23 coaxial inserts. Up to 23 microwave cable assemblies are packaged in one small connector, with connection and disconnection in seconds without any torque wrench and no safety wires.

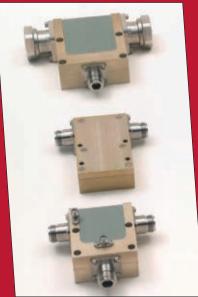
Munich, Germany +49 8935 48040, www.spectrum-et.com.
RS NO. 331



Product Catalog

SV Microwave released its new SMPM catalog. The new catalog features detailed information on SV's entire collection of SMPM coaxial connectors, including technical specifications, drawings and part numbers. SV Microwave SMPM connectors, a push-on design, provide microwave performance through 65 GHz.

SV Microwave Inc., West Palm Beach, FL (561) 840-1800, www.svmicrowave.com. RS NO. 332



Communications



Telecom



Scientific - Medical

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

Isolators Circulators For Military Applications.



100 MHz to 20 GHz

Military and Radar

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.

FEATURES:

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

The following models are examples of our High Power units

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

Visit http://mwj.hotims.com/23289-46 or use RS# 46 at www.mwjournal.com/info

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



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

MILITARY MICROWAVES SUPPLEMENT TERATURE SHOWCASE



Teledyne Storm Products,

Product Brochure

This brochure introduces the new 190E Series Phase Master® product: highly shielded, phase stable assemblies. An enhanced, multilayer shield construction yields significantly increased shielding effectiveness and increased product durability, especially with regard to torsion and connector retention, in addition to a high level of phase stability vs. temperature and flexure. Graphs, mechanical and electrical specs, and ordering information are also included.



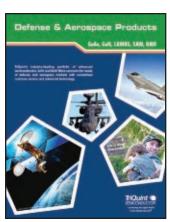


Product Brochure

The PhaseTrack™ II brochure describes in detail the characteristics that make PhaseTrack II an ultrathermally stable flexible coaxial cable that can significantly improve performance in phase sensitive systems. The brochure also explains how the cable has the most phase stable dielectric material available to provide superior phase tracking performance from cable to cable with the lowest phase change through its temperature range.

Times Microwave Systems, Wallingford, CT (203) 949-8400, www.timesmicrowave.com.

RS NO. 334



Defense and Aerospace Brochure

VENDORVIEW

TriQuint is a defense/aerospace leader, supplying high-reliability GaAs, GaN, SAW and BAW products. TriQuint's PowerBandTM discrete RF transistors offer instantaneous bandwidth across 2.5 GHz and high PAE (45 to 50 percent+), with GaN device samples now available. TriQuint's acclaimed GaAs foundry now also offers DoDaccredited Category 1A 'Trusted Foundry' services.

TriQuint Semiconductor Inc., Hillsboro, OR (503) 615-9000, www.triquint.com.

RS NO. 335



Precision Timing Solutions

With over 50 years of experience, Vectron is a leader in providing frequency control and hybrid solutions to its customers around the world. Vectron's innovative approach to design and manufacture has resulted in the most advanced product offering of any frequency control supplier in the world.

Vectron International. Hudson, NH (888) 328-7661, www.vectron.com.

RS NO. 336

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2	AR RF/Microwave Instrumentation	25	http://mwj.hotims.com/23289-2		a division of Micronetics	17	http://mwj.hotims.com/23289-23
3	Aviel Electronics,			24	Microwave Development Laboratories	55	http://mwj.hotims.com/23289-24
	a division of RF Industries	38	http://mwj.hotims.com/23289-3	25	Microwave Solutions, Inc.	28	http://mwj.hotims.com/23289-25
4	AWR	7	http://mwj.hotims.com/23289-4	26	Mimix Broadband, Inc.	COV 3	http://mwj.hotims.com/23289-26
5	Carlisle Interconnect Technologies	49	http://mwj.hotims.com/23289-5	27,28	Mini-Circuits	29,39	http://mwj.hotims.com/23289-27
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11	Delta Microwave	COV 4	http://mwj.hotims.com/23289-11	35	RFMD	23	http://mwj.hotims.com/23289-35
12	Eastern Wireless TeleComm, Inc.	47	http://mwj.hotims.com/23289-12	36	Rogers Corporation	21	http://mwj.hotims.com/23289-36
13	Emerson & Cuming		, , , , , , , , , , , , , , , , , , , ,	37	Rohde & Schwarz GmbH	9	http://mwj.hotims.com/23289-37
	Microwave Products	52	http://mwj.hotims.com/23289-13	38	Spectrum Elektrotechnik GmbH	61	http://mwj.hotims.com/23289-38
14	Empower RF Systems, Inc.	13	http://mwj.hotims.com/23289-14	39	Spinner GmbH	53	http://mwj.hotims.com/23289-39
15	ES Microwave, LLC	50	http://mwj.hotims.com/23289-15	40	State of the Art, Inc.	12	http://mwj.hotims.com/23289-40
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17	Evans Capacitor Company	18	http://mwj.hotims.com/23289-17	42	Teledyne Cougar	63	http://mwj.hotims.com/23289-42
18	Holzworth Instrumentation	46	http://mwj.hotims.com/23289-18	43	Teledyne Storm Products	31	http://mwj.hotims.com/23289-43
19	K&L Microwave, Inc.	15	http://mwj.hotims.com/23289-19	44	Times Microwave Systems	45	http://mwj.hotims.com/23289-44
20	Lorch Microwave	COV 2	http://mwj.hotims.com/23289-20	45	TriQuint Semiconductor, Inc.	27	http://mwj.hotims.com/23289-45
29	MCL Inc., a MITEQ Company	33	http://mwj.hotims.com/23289-29	46	UTE Microwave Inc.	65	http://mwj.hotims.com/23289-46
21	Microphase Corporation	51	http://mwj.hotims.com/23289-21	47	Vectron International	43	http://mwj.hotims.com/23289-47
22	Microsemi	37	http://mwj.hotims.com/23289-22				



CELEBRATING 2009: THE YEAR OF MMIX

Stress-tested, reliable and resistant to traffic, wind and seismic events, the Golden Gate Bridge has become an iconic testament to innovative design since its 1937 opening. Here at Mimix, we're building our own reputation for tested, reliable products for the Defense & Space market by combining our strong traditions of advanced technology and superior quality with more than 20 years of Defense & Space product development and space flight legacy.

Today we are bridging the market gap between our volume commercial products and Defense & Space applications like satellite, signal intelligence, defense communications systems, radar and aircraft platforms by providing high reliability and performance products at a practical cost.

HIGH FREQUENCY POWER AMPLIFIERS

Unparalleled Linearity & Efficiency★ 8W Linear Power at Ku-Band

- × 3W Linear Power at Ka-Band
- ★ 6W Pulsed Power at Ka-Band

SPACE-QUALIFIED FETs & MMICs

Legacy & Space Flight Heritage

- X Class K Die to 19500 or 38534 MIL Standards
- ★ Class K FET Die Bank Inventory!
- ▼ Packaged Products to JANS/JANTXV/JANTX

40 GHz SURFACE MOUNT DEVICES

Highest Levels of Integration

- ★ Receivers, Transmitters and Multipliers
- ★ Power Amplifiers with Integrated Detectors and Gain Control
- **★** ESD Protection

LOW THERMAL & PHASE NOISE GAIN BLOCKS Active Bias & ESD Protection

- ★ CGB7XXX and CGB8XXX Series
- x -154 dBc/Hz @ 10 kHz Offset Phase Noise
- ★ DC-6 GHz Flat Gain Response

Explore our wide range of Defense & Space products and download complete datasheets at www.mimixbroadband.com.

2009 translates in Roman numerals to "MMIX," so Mimix Broadband is celebrating by declaring 2009 the Year of MMIX. We're highlighting key advances in our product portfolio and paying tribute to other engineering feats – specifically the Seven Wonders of the Modern World as chosen by the American Society of Civil Engineers. Learn more at www.mimixbroadband.com/year-of-MMIX.



providing optimal semiconductor solutions worldwide





Today's RF environment is tougher than ever. With potential problems occurring across the entire spectrum. Now, more than ever you need RF front end protection and signal selectivity to meet increasing threats that can come from the enemy, or the numerous high power transmitters in today's military. Delta has the expertise to help you tackle your biggest challenges. For over 35 years Delta has been delivering quality RF components for the toughest applications. There is a difference, the Delta Difference



Switch filters