Vol. 53 • No. 4

April 2010

Microwave Journal

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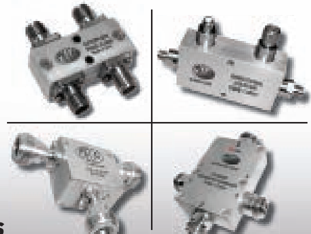

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APRIL 2010 VOL. 53 • NO. 4

2010 IEEE MTT-S International Microwave Symposium & Exhibition

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

POSTMASTER: Send address corrections to *Microwave Journal*, PO Box 3256, Northbrook, IL 60065-3256 or e-mail mwj@omeda.com. Subscription information: (847) 291-5216. This journal is issued without charge upon written request to qualified persons working in that part of the electronics industry, including governmental and university installation, that deal with VHF through light frequencies. Other subscriptions are: domestic, $120.00 per year, two-year subscriptions, $185.00; foreign, $200.00 per year, two-year subscriptions, $370.00; back issues (if available) and single copies, $10.00 domestic and $20.00 foreign. Claims for missing issues must be filed within 90 days of date of issue for complimentary replacement.

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Solutions for Characterizing Complex and Multi-stage Circuits—Using Arbitrary Load Impedance X-parameters to Optimize Non-50-ohm Measurements

White Paper, Agilent Technologies Inc.

High Power Amplifier Measurements Using Agilent's NVNA

White Paper, Agilent Technologies Inc.

RF Amplifier Output Voltage, Current Power and Impedance Relationship

Jason Smith, Applications Engineering Manager, and Pat Malloy, Sr., Applications Engineer, AR Worldwide

VSS and TestWave Software Integrate Measurement Data into the Design Process

Joel Kirshman, AWR Corp.

Executive Interview

John Ocampo, new owner of **M/A-COM Technology Solutions**, discusses the company's goals, strategy, target markets and future direction as they are once again an independent company and celebrating their 60th year in business.

Expert Advice

Alain Michel of **Ansoft France**, a division of **ANSYS Inc.**, discusses how to get more out of HFSS when designing antenna arrays through circuit co-simulation featuring "push" excitation capability and complete electromagnetic system simulation with HFSS HPC.

TestBench

This month we take a look at Anritsu's new scalable 12-port, 70 GHz measurement system introduced at DesignCon. The broadband vector network analyzer (VNA) based on its VectorStar® product can conduct highly accurate signal integrity measurements.

EDAFocus

Mentor Graphics provides a short application note on "Real-Time Tuning of Interconnects Using Electromagnetic Simulation Data" from recently acquired Zeland Software. This paper describes an interpolation scheme to quickly generate useful data using numerical electromagnetic (EM) simulation.

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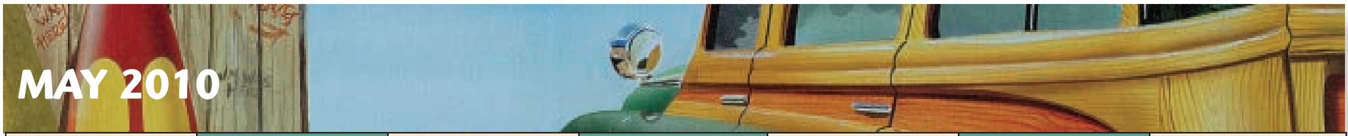

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
25	26	27	28	29	30	1 **MTT-SCV Short Course RF and Microwave Design Challenges for Future Technologies** Santa Clara, CA
2	3 **Antennas: Principles, Design and Measurements** Annapolis, MD	4	5	6	7	8
9 **MIE 2010 and ICMMT 2010** Chengdu, China	10	11 **MWJ Webinar: Impedance Matching in HF Circuits** Sponsored by: AWR ROHDE & SCHWARZ	12 **Radar 2010 IEEE International Radar Conference** Washington, DC	13	14	15
16	17 CST **PARTICLE STUDIO® Workshop at IVEC 2010** Monterey, CA	18	19 **Ansoft Product Training HFSS for SI** San Jose, CA ANSOFT	20	21	22
23 **IEEE Radio Frequency Integrated Circuits Symposium**	24	25 2010 INTERNATIONAL MICROWAVE SYMPOSIUM IEEE MTT-S • MAY 23-28, 2010 • ANAHEIM, CALIFORNIA THE GOLDEN STATE OF MICROWAVES **MicroApps**	26	27	28 **ARFTG**	29
30	31	1	2	3	4	5

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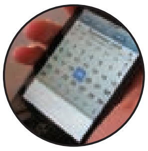

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MILCOM 2010
Deadline: August 6, 2010

Microwave Update (MUD)
Deadline: August 31, 2010

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

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

ANSYS Ansoft UK
Signal Integrity 'Info Day'
April 14, 2010 • Basingstoke, UK
www.ansys.com/uksiday

ARMMS RF and Microwave Society Conference
April 19–20, 2010 • Oxfordshire, UK
www.armms.org

MAY

IEEE MTT-SCV Short Course
May 1, 2010 • Mountain View, CA
www.mtt-scv.org

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

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

Radar 2010
IEEE International Radar Conference
May 10–14, 2010 • Washington, DC
www.radar2010.com

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

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

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

JULY

IEEE International Symposium on Antennas and Propagation
July 11–17, 2010 • Toronto, Ontario, Canada
www.apsursi2010.org

EMC 2010
IEEE International Symposium on Electromagnetic Compatibility
July 25–30, 2010 • Fort Lauderdale, FL
www.emc2010.org

SEPTEMBER

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

OCTOBER

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

IEEE International Symposium on Phased Array Systems & Technology
October 12–15, 2010 • Waltham, MA
www.array2010.org

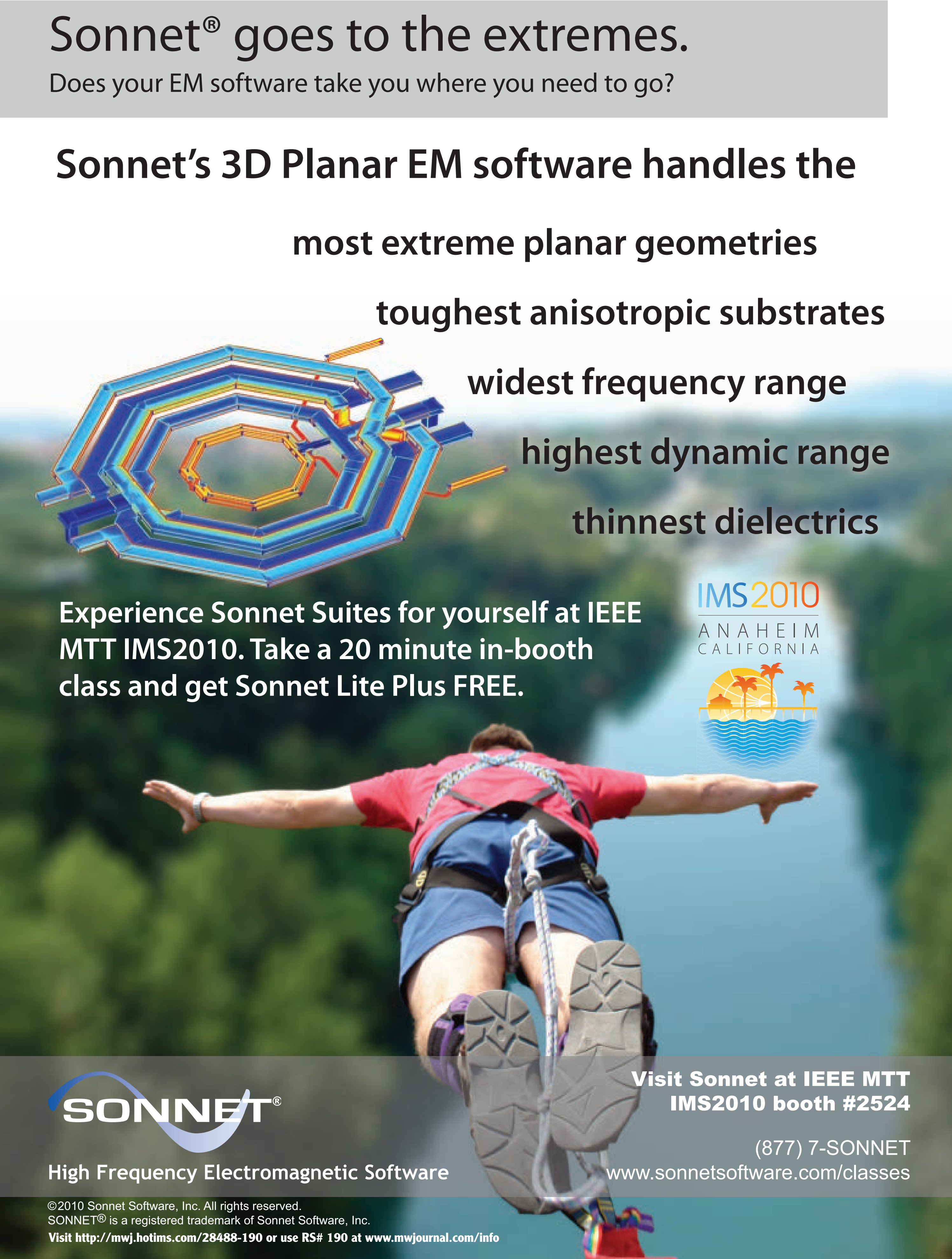
4G World
October 18–21, 2010 • Chicago, IL
https://4gworld.com

Microwave Update (MUD)
October 21–24, 2010 • Cerritos, CA
www.microwaveupdate.org

MILCOM 2010
October 31–November 3, 2010 • San Jose, CA
www.milcom.org

DECEMBER

Asia-Pacific Microwave Conference
December 7–10, 2010 • Yokohama, Japan
www.apmc2010.org



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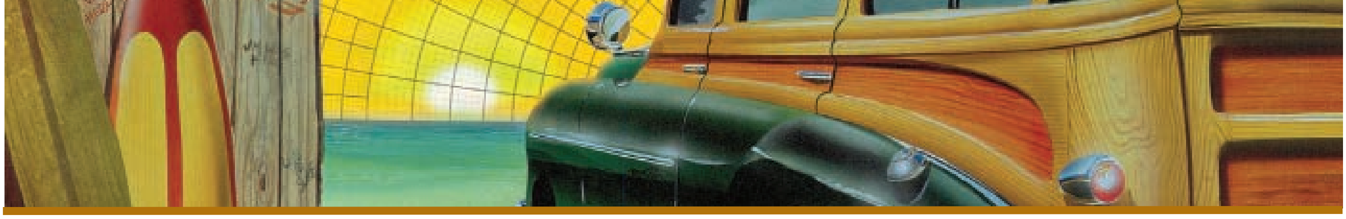


California Dreamin'

Here in the Northeast, we are seeing all the signs of an early spring. Outside temperatures are creeping up, the snow has melted away and the ground is starting to thaw. Another early rite of spring this year is our annual IEEE MTT-S IMS show issue, published this month to accommodate the conference in Anaheim, CA, May 23-28. Considering the earlier-than-usual arrival of spring, the conference and this month's special preview, I'll venture out on a limb and suggest that these are positive omens for the industry's fortunes in the second half of the year.

In last year's IMS show issue, I referred to the precarious economy as the "elephant in the room" and wondered how it would impact the event. Predictably, the mood was subdued, fitting for the rainy weather that shrouded Boston the entire week and continued through the early summer. And yet the event was by all measures a success, albeit a somewhat somber (and wet) one. This year, look for another strong showing, this time with more optimism about the future and plenty of sunshine.

Heading into Anaheim, there are encouraging tales of an industry ready to rebound with the economy. Companies are once again making multi-year forecasts and ordering inventory accordingly. In turn, production is ramping up and more money is being channeled into R&D. The activity at recent industry related shows including Mobile World Congress, Satellite 2010 and CTIA Wireless, indicates that communication networks and their supporting infrastructure will continue to demand more capacity and bandwidth.

What do we anticipate from the world's largest conference and exhibition for the microwave industry? Certainly a flood of new products as engineering teams race to have hardware and software available for that week. Marketing departments are undoubtedly busy preparing press releases, hoping to create the ultimate show buzz and praying that engineering delivers on time. This is the news you will be reading about on our web site and in our show newsletters leading up to, during and after the symposium. While Microwave Week provides a focal point for many companies to announce their new products, only a portion of individuals from the industry are able to attend. Don't worry, we have it covered.

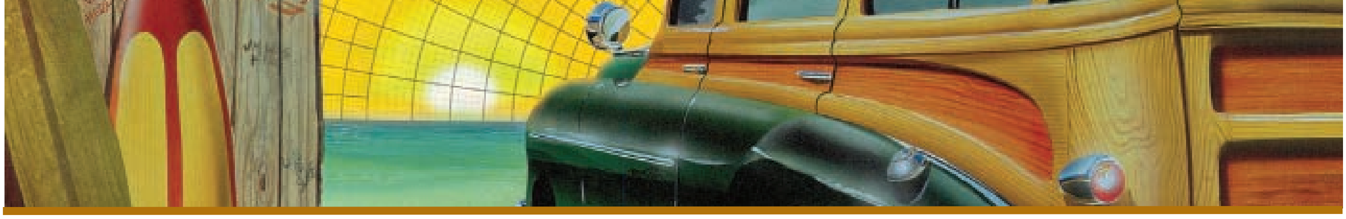
With one month left until the event, our editorial goals relating to pre-show coverage are twofold. We want to give our readers a glimpse of what to expect from the microwave component ecosystem for IMS 2010 and we strive to put this information in the context of larger trends occurring in technology. Hopefully, this will help attendees decide where they should focus their attention while at the show and serve as a head's up for people monitoring news items from their home or office.

To achieve these goals, we have a number of special reports that I hope our readers will enjoy and find useful. This year, we introduce Radar Rik, Peak-to-Average-Power Pat and Dual-band Dave. Each has compiled a list of items they intend to investigate while at the exhibition. Representing the radar, infrastructure and mobile device markets, Rik, Pat and Dave have been tasked by their colleagues to get the latest information on test equipment, software, components and sub-assemblies for their respective engineering needs. This feature presents an overview of these needs and a look at their shopping lists.

For the second year, we present "Exhibitor Profiles". This summary of who is showing what, by participating exhibitors, is your one-stop guide to the products that will be featured at the show. If you need help scheduling your time at IMS, the exhibitor profile section will help you prioritize who to visit. For those deciding which workshops and sessions to attend, we are also pleased to feature special messages from the chairs of the IMS, RFIC and ARFTG conferences as well as a note from the organizer of this year's MicroApps.

Lastly, this month's cover story features a history of the microwave industry in Northern and Southern California by Chuck Swift and Les Besser. These two well-known veterans of the west coast microwave scene have written the story of the individuals, companies, institutions and events that shaped our industry in the Golden State. With the IMS and microwave week as a backdrop, this historical perspective is a fitting cover story for our show issue. All together, our special features this month look at where we have come from, where we are today, and where we are headed. Venimus, vidimus, vicimus, baby.

David Vye
Editor, Microwave Journal



Microwaves in the Land of Sun and Honey

The three original US microwave geographic areas were established during WWII in locations with embedded engineering educational centers. MIT and its famous Rad Lab made Boston an incubator for a number of companies. In the Bay Area, Stanford and its nearby industrial park made the Peninsula home to a few systems companies (Sylvania, Dalmo-Victor) and a multitude of component and instrument companies. The third developed in Southern California where Cal Tech and JPL were the seeds from which a host of systems companies and, eventually, a group of component companies supporting them developed. This article reviews the microwave history of Southern and Northern California as told through two well-known participants.

Gilfillan Brothers

In 1941, Gilfillan Brothers, a Los Angeles manufacturer of radios with an excellent reputation for efficiency, was challenged to produce the Ground Approach Radar developed by MIT.

Gilfillan was contracted in the early days of the program to build ten of these pre-production units, operating under the supervision of Dr. Luis Alvarez of MIT. Alvarez, a pilot, got the idea that if you could use radar to track an airplane to shoot it down, you could track it for landing. The resulting AN/MPN-1 Radar (see ***Figure 1***) with its Airport Surveillance Radar (ASR) at S-band and Precision Approach Radar (PAR) at X-band set the military air traffic control standards. The system was simple, direct, and it worked well, even with previously untrained pilots. It was so successful that the military continued to use it for many years after the war, and it is in use in some countries even today.[1] While a great contributor to the winning of WWII, the GCA became famous for its ability to guide planes to a successful landing during the Russian Blockade of Berlin.

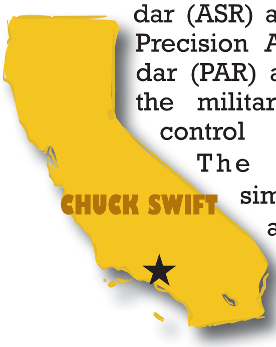


Fig. 1 The AN/MPN-1, the world's first GCA, was Gilfillan's entry into radar.

The first working system was called the Mark I. As soon as engineers in Boston got it working and demonstrated, bugs were identified and fixed and the information was passed along to Gilfillan in California. Some Gilfillan people were in Boston for the construction of the Mark I GCA. Among them was Homer Tasker, the chief engineer of Gilfillan, who brought two or three of the regular Gilfillan engineers to work hand-in-glove with the MIT crew.

The pre-production demonstrations held in Washington in February of 1943 were successful. The Army Air Corps then placed an order for 100 production units. Later on the Navy went to Bendix for their production and the Air Corps decided that they needed more than Gilfillan could produce so they also contracted with ITT

Chuck Swift and Les Besser

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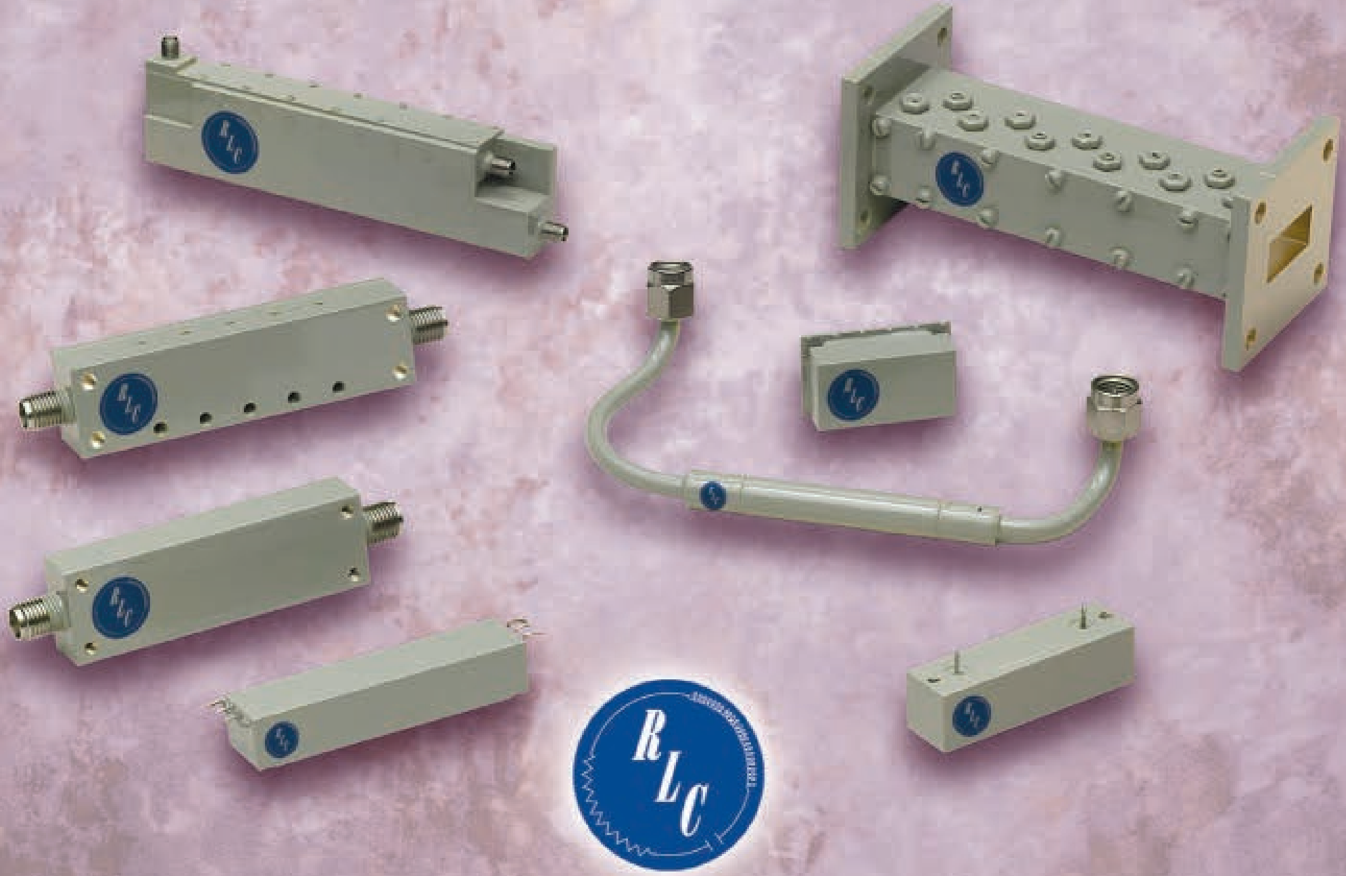

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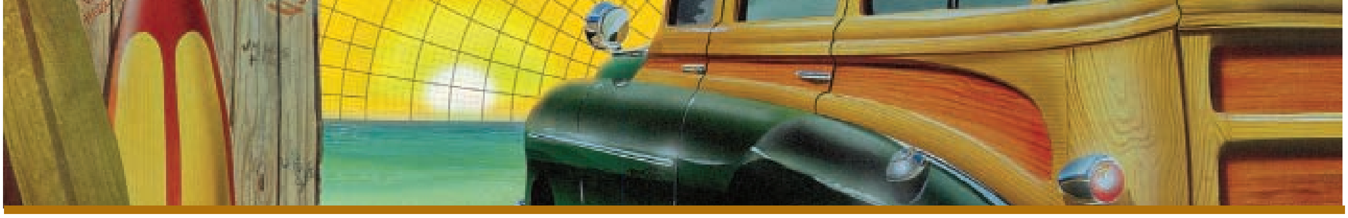

in New Jersey. In 1962, Gilfillan Brothers Inc.'s name was changed to Gilfillan Corp. On January 30, 1964, all of the assets were transferred to ITT Gilfillan, a wholly owned subsidiary of ITT Corp.[2] From this auspicious beginning, Gilfillan refined and developed other GCAs and Radar Approach Control (RAPCON) systems over the next 20 years.

During the 1960s, Gilfillan entered the air defense arena by expanding its microwave engineering expertise and its products. The company also developed long-range, three-dimensional radar produced ship-borne and land-based planar array radars (one of the first), both at S-band. Gilfillan also adapted planar arrays for air traffic control (ATC). In the 1980s, Gilfillan further expanded its product line with the development and production of the AN/TLQ-32 Anti-radiation Missile Decoy (ARM-D). Today, ITT-Gilfillan continues to develop microwave components such as low-loss combiners, high power RF amplifier modules and solid-state transmitters for a variety of customers, preserving its legacy as an important Los Angeles company.[3]

Some of the other early companies like Hoffman Radio (1949-1970) and Packard Bell (1948-1974) were radio companies and were asked to just "up the frequency." Of course, it was natural for these companies to be in the Los Angeles area to serve the broadcast and movie industry, both of which had interests in improving sound and transmission; for example, Gilfillan's Homer Tasker had been Associate Head of Sound at Paramount Pictures.

HUGHES AIRCRAFT

Was Howard Hughes (see ***Figure 2***) the catalyst for the microwave industry in Southern California? He gave it one hell of a push, but during WWII he was building the world's largest flying object, the Spruce Goose, which had very little microwave content. It was only after the war that Hughes was awarded a contract to build the M1 fire control system for the F86, which led to Hughes's prominence as a bastion of microwave technology.

▲ *Fig. 2 Aviation pioneer, inventor turned eccentric billionaire and founder of Hughes Aircraft, Howard Hughes.*

Hughes Aircraft was involved in the initial development of a guided air-to-air missile, which began in 1946. The company was awarded a contract for a subsonic missile under the project designation MX-798, which soon gave way to the supersonic MX-904 in 1947. The original purpose of the weapon was as a self-defense weapon for bomber aircraft, but after 1950 it was decided that it should arm fighter aircraft instead, particularly in the intercept role. The missile, known as the Falcon, entered service in 1956 with semi-active radar horning (SARH) and a range of about five miles.

Hughes had a facility in the swamps of Culver City, which had a runway at which the Air Force could test its flight systems and it became Hughes Radar. Eventually, there were a number of organizations with Hughes in their names: Ground Systems in Fullerton, Space and Communication in El Segundo and Electrodynamics in Torrance. At one time, Hughes Aircraft was the largest employer in Los Angeles County. When asked how many people worked at Hughes Aircraft, a known eccentric reportedly replied, "About half of them."

The Hughes Divisions generally worked for individual branches of the military with Radar Handling Air Force work, Ground Systems, Navy jobs and Space and Communications, Comsat and NASA projects.

HUGHES, SPACE & COMMUNICATIONS

In October, 1957, Russia successfully launched Sputnik, the first man-made object in Earth orbit. In April 1961, Hughes was awarded its first space contract. Programs with familiar names followed: Surveyor, the lunar soft lander, which provided data for the moon landing; Syncom, the world's first synchronous satellite, which brought live TV from the 1964 Tokyo Olympics; Early Bird, a commercial satellite for the international consortium Intelsat; and ATS-1, which provided a satellite view of Earth's weather, a boon to the TV weatherman. Later programs led to blanketing the Earth's surface with satellite reception. In 2000, GM sold S & C to Boeing.

BENDIX

The Bendix radio division was born in 1937 to make radio transmitter/receivers for aircraft and other types of avionics (aviation electronics). During the war, Bendix manufactured about three quarters of all avionics in American aircraft. During and after the war, Bendix made radar equipment of all kinds. Radar developments at Bendix Pacific between 1951 and 1959 included the APS-42A X-band search radar, the APS-55 tail warning radar, the Sparrow II missile, K-band active seeker; The Talos Terminal Guidance Module; and the Position Indicating Beacon Antenna (Ku-band) that was mounted high on the aircraft's vertical tail fin.

By 1955, the major system companies in Southern California included Hughes, Gilfillan, Bendix in North Hollywood, Hoffman in Los Angeles, General Dynamics/Pomona and RCA in West Los Angeles. Rockwell's Autonetics in Anaheim and Ford's Aeronutronic were established next followed in size by Ryan Aeronautical in San Diego (building Ku-band gear) and the General Dynamics Kearny

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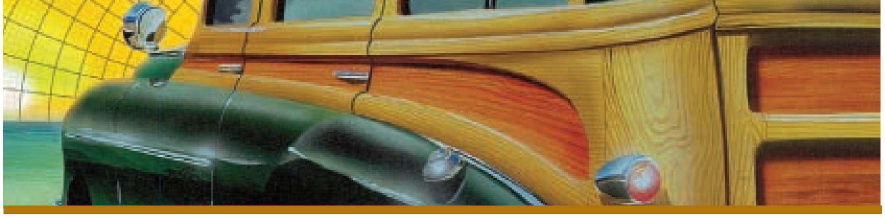


Mesa facility (building the Atlas missile); General Dynamics Convair next to Lindbergh Field was also in the microwave business.

ROCKWELL AUTONETICS

On 27 June 1966, Rockwell Autonetics won the contract for the Mark II Avionics system, which consisted of an attack radar, a navigation-attack system, and a lead computing optical sight to be installed on the F-111's A, C and E models. A fixed-price incentive contract with a target price of $145 M was signed with the prime contractor, General Dynamics. Aggressive competition had led bidders to be unduly optimistic. Autonetics delivered the first Mark IIs to General Dynamics on 21 November 1967. Flight testing by an F-111A began on 31 March 1968. Then the "unanticipated unknowns" appeared. During the first full system test, in June, components started interfering with each other. By late 1969, the Mark IIs' snowballing cost reduced the F-111D program from 315 to 96 and component costs swelled as mass production slumped. By June 1972 only 24 F-111Ds were available—two years beyond the time when a 72-plane wing should have been operationally ready. Autonetics' strategy of buying in, accomplished with the complicity of its backers in the Air Force and OSD, resulted in technical problems, remedial cures, and left the F-111D with a complex, highly integrated, one-of-a-kind avionics system.[6]

FORD AERONUTRONIC

Aeronutronic was a defense and space related division of Ford Motor Co. set up in 1956 in Newport Beach. In 1961 Ford purchased Philco and merged the two companies in 1963. Philco Aeronutronics became NASA's primary communications equipment vendor during the 1960s. Many portions of the Philco side of the company were sold off in the 1970s, until in 1975 all that was left was the original Aeronutronic divisions. These were renamed Ford Aerospace and Communications Corp. in December 1976 and then again to Ford Aerospace Corp. in January 1988. In October 1990 what remained was sold to Loral to become Loral Aeronutronic, before eventually disappearing when Loral was purchased by Lockheed Martin in 1997.

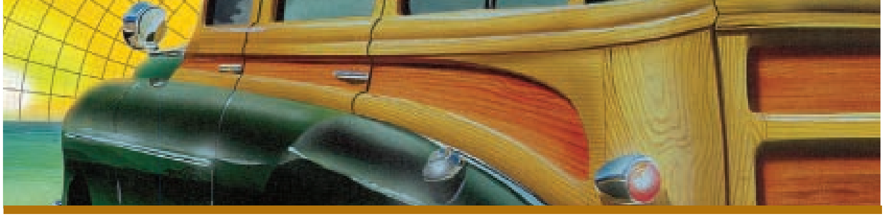
RYAN AERONAUTICAL CO.

The Ryan Aeronautical Co. was founded by T. Claude Ryan in 1934 and became part of Teledyne after 1969. Northrop Grumman purchased Teledyne Ryan in 1999. Ryan built several historically and technically significant aircraft, including two famous V/STOL designs, but its most successful production aircraft would be the Ryan Firebee line of unmanned drones used as targets and unmanned air vehicles.

TRW

The Ramo-Woolridge Corp. was founded by executives who split from Hughes. It was located in nearby Redondo Beach and many Hughes engineers moved to the new enterprise. In 1958, the company merged with Thompson Products, originally called the Cleveland Cap Screw Co., founded in 1901. The new company, Thompson Ramo Wooldridge Inc., shortened its name to TRW Inc. in 1965. TRW Inc. was active in the early development of missile systems and spacecraft, most notably the NASA deep space satellites Pioneer 10 and 11, which sent information back to Earth. TRW was also active in high frequency MMIC devices including GaAs device fabrication. In February 2002 Northrop Grumman launched a $5.9 B hostile bid for TRW. A bidding war between Northrop Grumman, BAE Systems and General Dynamics ended on July 1, 2002, when Northrop's increased bid of $7.8 B (£5.1 B) was accepted.[5]

During the MIMIC Program, TRW ended up being the sole developer of an epitaxial GaAs MMIC, a HBT grown by production quality Molecular Beam Epitaxy



(MBE). RF Micro Devices was one of the first to recognize the commercial potential of TRW's GaAs HBTs resulting from the MIMIC program. Early on in the epi game, TRW and RFMD teamed together (RFMD doing the design, test and marketing; TRW doing foundry and fab). In 1993, RFMD figured out not only how to design for manufacture to the TRW process, they also figured out how to sell the component for under $4.[7]

In 1992, the TRW space and electronics MMIC products office merged with Northrup Grumman Space Technology (NGST). In May 2001, a separate operating unit, Velocium, was launched. Today, NGST of Redondo Beach licenses its Velocium MMIC product line and related intellectual property through Hittite Microwave Corp. NGST continues to offer foundry services for a wide array of GaAs and InP technologies, and markets off-the-shelf and custom products above 86 GHz addressing new emerging markets including millimeter-wave imaging, sensor and communication applications.

ROCKWELL

Rockwell International developed a desktop calculator based on a MOSFET chip for use by its engineers. In 1967 Rockwell set up its own manufacturing plant to produce them, starting what would become Rockwell Semiconductor. Rockwell Semiconductor was then later spun-off from Rockwell in January 1999 and then became known as Conexant (which combined with Alpha Industries to become Skyworks), which spun-off the foundry as Jazz Semiconductor in 2002 (since acquired by Tower Semiconductor). Tower/Jazz is now a pure-play foundry in Newport Beach. The company does not process GaAs chips, offering signal processing ICs for broadband communication systems instead.

The systems companies spawned a number of Southern California component companies, including Micromega, CableAml and GammaF. Other component companies in the area that were established to support the system monsters include Connecting Devices, Daico (established in 1965, producing advanced IF/RF and microwave control products and amplifiers for the defense electronics, aerospace, commercial aircraft and wireless industries), Datcom and Rantec (specializing in waveguide slot arrays and reflector-feed antennas for land, air, sea and space applications, founded in 1957).

AMPLICA

Founded in 1972 by Chuck Abronson and Jim Cole, with funding from personal savings, family and friends, Amplica grew rapidly and profitably, with initial sales coming from the defense electronics market. The commercial availability of GaAs FETs a few years after the company started enabled an entirely new class of ultra low noise amplifiers (LNA), which very quickly rendered the only competing LNA technologies, tunnel diode and parametric amplifiers, obsolete. During 1974, Abronson modified a GaAs FET LNA that was originally designed for a military radar application to work over the commercial 3.7 to 4.2 GHz TVRO (television receive only) satellite downlink band.

This amplifier outperformed a cooled parametric amplifier in an early TVRO system, which was

Working at Hughes Aircraft

Jeff Stitt

I worked as a microwave engineer at Hughes Aircraft from March 1962 until the early '80s when I made a bit of a career change to Program Management. As a Program Manager, I worked mostly communications and radar programs and some classified programs, including satellite communications systems for Hughes Fullerton. Most of this work was in the area of solid-state microwave amplifiers. Read more about my experiences at www.mwjournal.com/working_at_Hughes.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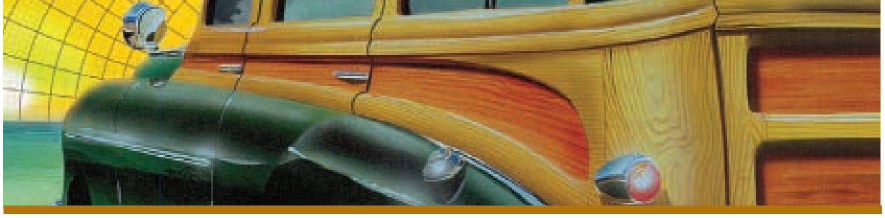


the first demonstrable commercial GaAs FET LNA for this application. The result was Amplica's entry into the highly profitable, rapidly growing commercial 3.7 to 4.2 GHz TVRO LNA market. Initially the sole producer of such amplifiers, Amplica dominated the LNA market for about the next eight years and went on to become a leading manufacturer of complete TVRO systems for commercial and consumer applications. After a highly successful IPO in 1981, the company merged with COMSAT in 1982.

TEST INSTRUMENTS

Maury Microwave

Mario A. Maury, Sr. founded Maury and Associates in Montclair in 1957. With the help of sons, Mario A. Maury, Jr., and Marc A. Maury, the company focused on the microwave test and calibration industry, developing a comprehensive line of precision instruments, coaxial and waveguide components, and support products.

Simulation Software

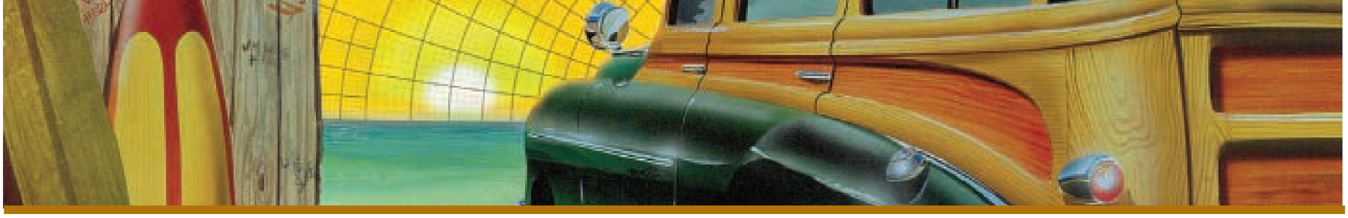
According to Jeff Stitt, Hughes engineers in the early '60s used slide rules for most calculations. If the program could afford it, they submitted stacks of cards to IBM computers for processing FORTRAN programs that typically ran over night. This was typically reserved for the computation of the performance of various phased array configurations and the design of microwave filters. It was expensive and slow.[11]

This changed rapidly in the late '60s and early '70s. Hughes signed up for GE time sharing services and started running BASIC programs from punched paper tape to compute the performance of what became the next big thing: Bipolar RF low noise amplifiers. They developed amplifier circuits using home-brewed CAD based on optimization routines, circuit models and transistor data. Hughes's home-brewed CAD eventually gave way to the hot new (at the time) commercial microwave computer-aided-design software from COMPACT and, later on, from EEsof.

EESOF

In 1983, Intel announced a math coprocessor for its IBM-compatible PCs that made fast floating-point calculations practical; this became the first computing platform for EEsof products. EEsof was co-founded by Bill Childs and Chuck Abronson in September 1983 and EEsof introduced its first product, Touchstone, at the 1984 MTT-S in San Francisco. A year later at the MTT-S, EEsof introduced a Touchstone interface to the HP Vector Network Analyzer, which was the first VNA computer interface capable of controlling the instrument to interactively extract and de-embed S-parameters (Touchstone remained the program of choice for such applications for many years).

In the late 1980s Hewlett Packard Co., after first licensing and distributing EEsof's products for sale on their proprietary desktop computers, introduced a product line that directly competed with EEsof. In 1992, Abronson approached HP with a proposal to merge their software operation into EEsof as an independent, standalone company. HP countered with an offer to acquire EEsof and the company was acquired by HP in 1993. Spun out of HP as part of Agilent Technologies Inc. IPO in 1999, EEsof continues today as a successful part of Agilent. In 1997 Abronson started CAP Wireless with Paul Daughenbaugh, the fourth employee to join Amplica. Today, Abronson is Managing General Partner of Accordance Ventures, LP, which holds investments in venture capital partnerships, real estate and a number of private technology companies including Southern California software provider, Applied Wave Research (AWR).



MICROWAVES IN NORTHERN CALIFORNIA

LES BESSER

Many noteworthy chapters of microwave history are set in Northern California. Early Bay Area electronics companies are characterized by local venture capitalists; close ties between industry and research universities; a product mix of electronic components, production equipment, advanced communications, instrumentation, and military electronics; inter-firm cooperation; and a tolerance for spin-offs.

The semiconductor and computer industries of Silicon Valley also made this region a hotbed for the development of microwave active components, test equipment, and simulation software. While many associate the beginning of Silicon Valley with the founding of the Shockley Transistor Corp. in 1955, the history of technology in the Bay Area actually goes back to the early days of radio development.

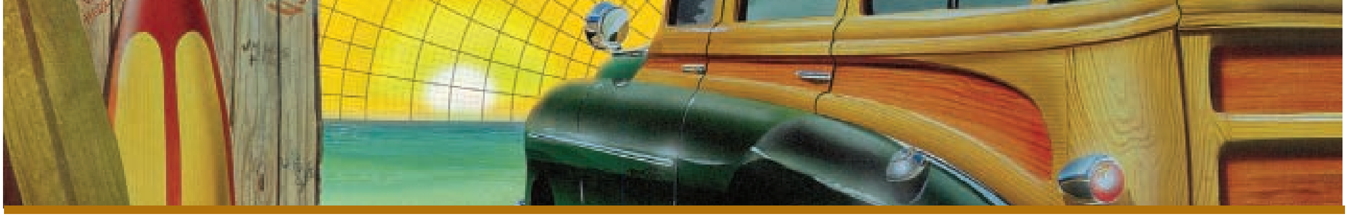
THE FEDERAL TELEGRAPH CO.

In 1908, Stanford graduate Cyril Elwell was having trouble getting a spark-based radio telegraph system to work using either a spark transmitter or an alternator. Contacting Dr. Vladimir Poulsen in Copenhagen, Elwell sought the US patent rights for his arc transmitter invention, which could transmit speech messages ten miles, and telegraph signals 180 miles. Elwell then approached Stanford president David Starr Jordan and C.D. Marx, the head of Stanford's civil engineering department, about financing a new company to provide wireless telephone and telegraph services on the Pacific Coast using this technology. Jordan invested $500, establishing a tradition of investing in new technologies by the university.

The company built a small system and invited the public to demonstrations of wireless voice and telegraph communication between Stockton and Sacramento. One year later, with Elwell as the technical leader, the company was renamed the Federal Telegraph Co.

In 1912, Elwell travelled to Washington, D.C. to generate interest in the Poulsen arc at the Navy. The system maintained contact with outbound Navy ships in the Florida Keys long after the transmissions from the competitor's unit faded to nothing. The Navy immediately ordered ten 30 kw arc transmitters for shipboard use.[8]

The Navy's demand for more powerful arc transmitters soon



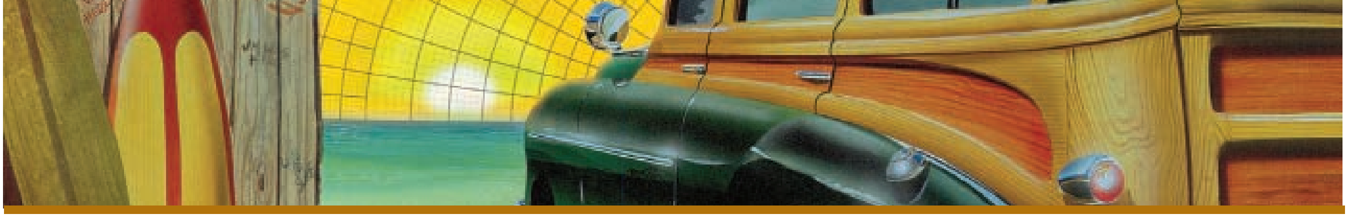
exceeded FTC's technical capabilities. In 1913, a 100 kW unit was requested for the first station in a "high-powered chain" that was to extend southward from Arlington to the Panama Canal Zone and westward to the Philippines. When the United States entered World War I, the entire radio industry was nationalized. FTC received orders for 300 two kW shipboard transmitters, 30 kW battleship transmitters, a 20 kW set for a cruiser and a 5 kW set for a Navy collier. The war work at FTC culminated in the installation of a pair of 1000 kW transmitters at the Lafayette Radio Station, 14 miles southwest of Bordeaux, France. Upon completion in January, 1920, the station was by far the most powerful in the world and had cost $3.5 M to build.[9]

However, the high-powered arcs emitted strong harmonic radio frequencies that interfered with smaller stations. During the war vacuum tubes had been developed that could generate high-power, "short-wave" radio signals that overcame many of the static problems that plagued the long-wave systems. By the war's end, vacuum tubes had been improved to the point where they could be successfully applied to all aspects of radio communications: transmission, reception and signal amplification. It was only a matter of time before they came to dominate the radio industry.

DEFOREST DEVELOPS THE TUBE AMPLIFIER

In 1910 Lee DeForest came to San Francisco to supervise the installation of wireless telegraph sets on two Army transport ships. The receivers used a vacuum tube, the "audion," invented by DeForest in 1906 and patented in 1907. While DeForest was in San Francisco, he met local radio enthusiasts, including Elwell, who was able to provide him with a laboratory, two assistants and free rein to develop his ideas.[8] At FTC, DeForest tackled the problem of amplifying incoming telegraph signals to the level at which they could be better received by FTC's "rotary ticker," which sent audible signals to the operator's headset. Within a few months, DeForest and his assistants had invented a three-element vacuum tube that was capable of amplifying the faint electrical signals from long distance telephone and radio transmissions. A few months later, the DeForest team found that the tube could also function as an oscillator.[9]

The vacuum tubes that could be applied to all three stages of wireless radio communication: signal generation (the oscillator), signal reception (the audion) and signal amplification (the amplifier). Because the amplifier could boost



weak signals, high-power transmission eventually became less crucial and the cost of long distance wireless systems was radically lowered. That same year, DeForest would hand over the patent rights to AT&T for a mere $50,000.[10]

An elaborate patent sharing arrangement between RCA, Westinghouse and GE, along with AT&T and United Fruit, created a virtual patent monopoly that locked out many home-grown electronic companies around the US. The early electronics industry in the Bay Area labored under constant threat of RCA litigation. If the cooperative nature of Bay Area electronics companies during the 1920s, 1930s and 1940s had any one source, it was in opposing the domination of the field by RCA. It also steered Bay Area companies away from consumer electronics and towards specialization in electronic instruments, military electronics, advanced communications technologies, electronic components and production equipment.[8]

The vacuum tube industry in the San Francisco Bay Area, while smaller than the captive operations of the large East Coast firms, was nevertheless an important one. The activities of Elwell, Fuller, DeForest, Farnsworth, Litton, Heintz and Kaufman (H&K), and Eitel and McCullough (Eimac, which was acquired by Varian in 1964), reveal an unbroken lineage in leading-edge electronic component design and production in the San Francisco Bay Area that preceded the region's semiconductor industry by nearly four decades.

Federal's transition from arcs to tubes spanned the years 1927 to 1934. A key figure in that era was engineer Charles V. Litton, a Stanford graduate who became fascinated by tube-blowing as a teenager. In 1931 Federal Telegraph's manufacturing operations were moved to New Jersey after company officials decided Palo Alto was too far away from sources of supplies, skilled labor and key markets. ITT eventually swallowed the company. Among the Federal employees who decided not to go east was Charlie Litton.[11]

LITTON INDUSTRIES

In 1928 Charles Litton, with degrees in electrical and mechanical engineering from Stanford University, was hired to manage FTC's in-house vacuum tube manufacturing department. Litton built his first ham radio set at the age of 10 and soon made his own vacuum tubes, which he sold to other hams. He even established voice communications with stations as far away as Australia and New Zealand.

When FTC moved to New Jersey in 1932, Litton formed Litton Engineering Laboratories to design

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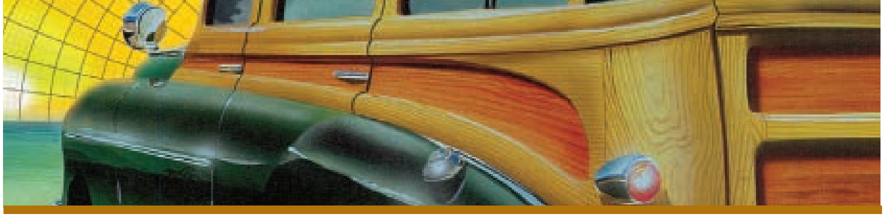


and manufacture vacuum tube production equipment. Litton's glass-blowing lathe was able to mass produce glass tube blanks at uniform quality, a huge improvement over the hand-blown blanks of the day. These machines were unique and were used for mass production by virtually all major vacuum tube makers, including GE, Westinghouse and RCA.

In 1940 Litton was the sole source manufacturer of large, high-powered "magnetron" vacuum tubes for ground-based radar systems. Although these tubes, some of which stood four feet high, were highly sought after by the US military, Litton began by fabricating them from scratch in his backyard. During World War II, tube production expanded and, as Litton said, "I woke up one day, and out of the clear blue sky... found myself the sole owner of a million-and-a-half-dollar concern." In 1946, Litton separated the tube business from his research laboratory and machinery business.

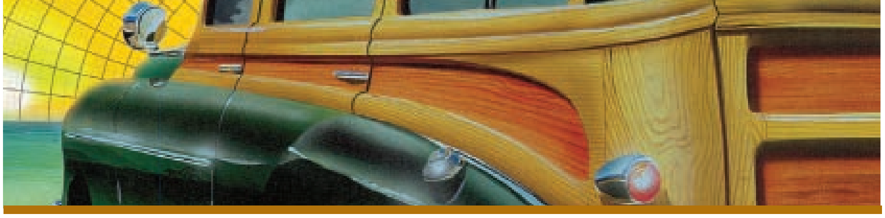
In 1953 Litton sold his tube business to former Hughes Aircraft executive Charles "Tex" Thornton and moved his laboratory to Grass Valley, east of the Sierra Nevada Mountains.[12] Thornton's plan was to grow the company, initially dubbed the Electro Dynamics Corp., into a diversified giant through the acquisition of small, innovative electronics companies. The company's first acquisition was Litton Industries, which reached $3 M in sales from Litton's state-of-the-art magnetron tubes in the first year. When he found that the name of Charles Litton carried a great deal of weight with the Navy, Thornton changed the company's name to Litton Industries. By 1959, Litton Industries reached $120 M in sales manufacturing inertial guidance systems for aircraft, duplexers, klystrons and other electronic products. During this period, almost 50 percent of Litton's business was with the US government. By 1961, Litton was the fastest growing company on the New York Stock Exchange. By 1980 Litton Industries had grown to $4.2 B in annual sales.[8]

THE BROTHERS VARIAN

Russell and Sigurd Varian moved with their family to Halcyon, CA, in 1914. Russell attended Stanford University, switching from the social studies program to physics due to his poor reading skills. Also somewhat weak in math, he took six years to graduate. He returned to Stanford later that year to begin graduate work, receiving his master's degree in 1927. Varian had a succession of jobs, including working on early television systems for Philo T. Farnsworth and Co. In 1935, Stanford University rejected his application for its PhD program because of his poor math and reading skills, and so he began working with his brother instead.

Meanwhile, Sigurd had become a flying enthusiast and barnstorming pilot. The interest spread to Russell and soon both men began to work on ideas to improve the primitive navigation equipment then available. Attempting to develop a radio compass, Russell got the idea for an "electron tube" capable of directing a beam of electrons, which could be used in a number of different applications, including the detection of airplanes by high-frequency radio signal. Approaching Stanford with Russell's concepts, Sigurd was able to obtain use of lab space in the basement of the old physics building, some equipment, and $100 in materials.[13]

William W. Hansen entered Stanford at the age of 16. Receiving his doctorate in 1933, Hansen invented the cavity resonator and began investigating the use of high-frequency waves to accelerate particles to high energy. The Varian brothers, who were in the physics department's basement generating very-high frequency short wavelength signals for radar and direction finding, began working with Hansen. By the summer of 1937 the first klystron tube, as it was called, had been constructed, and it was formally introduced in



the *Journal of Physics* in 1939.[14] The British lost no time in adapting klystron technology for use in radar stations, which helped defeat the Luftwaffe's air raids on London in the summer of 1940.

The klystron represents one of Stanford's best investments: $100 in seed money and use of a small laboratory room were turned into $2.56 M in licensing fees before the patents expired in the 1970s, three major campus buildings and hundreds of thousands of dollars in research funding.

THE STANFORD IMPACT

Hansen pioneered much of the development of microwave theory and techniques for testing microwave systems, giving courses on microwave theory at Stanford (and MIT RAD Lab) during World War II to physicists who had been recruited for research on the subject. After the war, Hansen founded Stanford's Microwave Laboratory to develop powerful klystrons and linear accelerators, which has since been named after him. After the war, the close relationship that existed between local industry and the university was extended through the efforts of Frederick Terman (see ***Figure 3***).

Since its inception, Stanford had contributed to Northern California's emergence as a center of technology with high-caliber engineering graduates, research support and financial aid. Stanford's first president David Starr Jordan set this precedence with his support of Elwell and FTC. But it was former FTC employee, Terman who would practically institutionalize this practice.

Along with Hansen, Terman had also been recruited to help with war-related research, directing a staff of more than 850 at the Radio Research Laboratory at Harvard University. This organization was the source of Allied jammers to block enemy radar, tunable receivers to detect radar signals, and aluminum strips ("chaff") to produce spurious reflections on enemy radar receivers. An avid inventor, Terman filed 36 patents

▲ *Fig. 3 Frederick Terman, Stanford Dean of Engineering and leading advocate for Stanford Industrial Park (Silicon Valley).*

between 1930 and 1947 and was elected president of the Institute of Radio Engineers in 1940—the first person west of Pittsburgh to achieve the honor.

From 1925 to 1941 Terman designed a course of study and research in electronics at Stanford that focused on work with vacuum tubes, circuits and instrumentation. During his tenure, Terman greatly expanded the science, statistics and engineering departments in order to win more research grants from the Department of Defense. His students included Oswald Garrison Villard, Jr., William Hewlett and David Packard, whom he encouraged to form their own companies and personally invested in many of them, resulting in firms such as Litton Industries and Hewlett-Packard.

In 1951 he spearheaded the creation of Stanford Industrial Park (now Stanford Research Park), whereby the university leased portions of its land to high-tech firms. First aboard was Varian Associates, which obtained a park lease in 1951. Terman then convinced Hewlett-Packard to head out to Page Mill Road. Soon, a flood of other corporations such as Eastman Kodak, General Electric and Lockheed Corp. moved into what would eventually become known as Silicon Valley.

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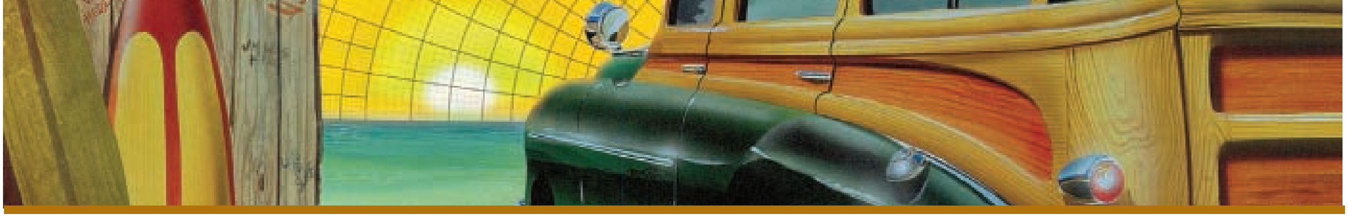


HEWLETT-PACKARD

Bill Hewlett and Dave Packard first met at Stanford and later decided to form a company in 1938. Even though they were not microwave engineers originally, their story is important because of their contribution to the field of microwave instrumentation. Very few people realize that Hewlett and Packard were not commercially successful with some of their earlier inventions, such as a foul line indicator for bowling alleys, a weight-reducing machine that provided electrical shocks while the user was eating, and a urine flusher system.

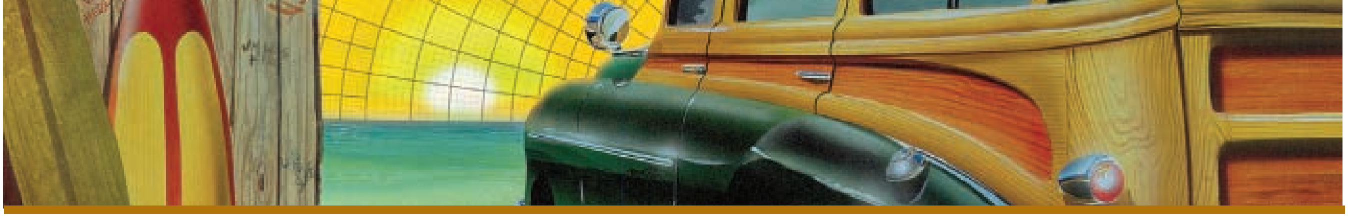
Their first successful product, an audio generator using a light bulb to improve oscillator stability, was created from Bill Hewlett's graduate project at Stanford. Terman, who was their electrical engineering professor, recognized the significance of the innovation and suggested that they produce the generator commercially. Bill and Dave's friend, Norman Neely, persuaded a fellow engineer to use the audio generator to produce the special sound effects in Walt Disney's Fantasia. Disney went along with the idea and purchased eight of the generators.

Hewlett and Packard grew rapidly during World War II with about a hundred people on the payroll in 1946. While both founders were skilled engineers, Hewlett concentrated on engineering problems while Packard focused more on the business aspects. After World War II, when Bill Hewlett returned from active duty in the Army Signal Corps, the decision was made to enter into microwave instrumentation. Hewlett and Packard brought in two extremely capable microwave engineers: Bruce Wholey, who had graduated from Stanford with a microwave background from Radio Research Labs at Harvard; and Art Fong, a University of California (Berkeley) graduate with a microwave background from MIT RAD Labs. With the assistance of these two men, the company quickly formed a team that soon rivaled General Radio's. This team developed a line of signal generators from 50 kHz to 21 GHz as well as such components as slotted lines. In the mid-1960s, the first-generation Spectrum Analyzer, followed by the Vector Voltmeter and the Network Analyzer, introduced new measurement capabilities to microwave engineers.

DALMO-VICTOR DEVELOPS AN AIRBORNE RADAR ANTENNA

In 1921, when he was nineteen, Tomlinson Moseley established his own machine shop in San Francisco, the Dalmo Manufacturing Co. In 1934 Moseley hired an immigrant PhD Russian research engineer named Alexander Poniatoff to help with the development work. In 1944, the two began work on a prototype airborne radar antenna for the Navy. According to Poniatoff, Moseley said to him, "Do you know anything about radar?" Poniatoff replied, "I don't, not a damn thing." "Neither do I," Moseley said, "but the contract says the unit must be completed in 100 days, so you can't waste time." In the Dalmo shop in San Carlos, they worked for 100 days without a break, often sleeping in the shop. Surprisingly, they won the contract.

Westinghouse offered to manage the contract, arguing that high-volume production would be too difficult for a small company like Dalmo Manufacturing. Moseley agreed, and the company, now Dalmo-Victor, moved to a larger facility in Belmont to produce the units. By the end of World War II, Dalmo-Victor had emerged as the leading manufacturer of airborne radar antennas. Dalmo-Victor was eventually acquired by the General Instrument Defense Systems Group, which in turn was acquired in 1991 by Litton Industries Applied Technologies Group, headquartered in San Jose.



DEFENSE FUNDING CREATES A MICROWAVE ECO-SYSTEM

With World War II and the Cold War came technological breakthroughs and military programs, first enabled by the reflex klystron and later by traveling wave tubes and eventually microwave semiconductor devices. This second, "Microwave" era lasted from the late '30s to the mid-'80s and spawned companies such as Varian, Applied Technology, Watkins-Johnson and Avantek.

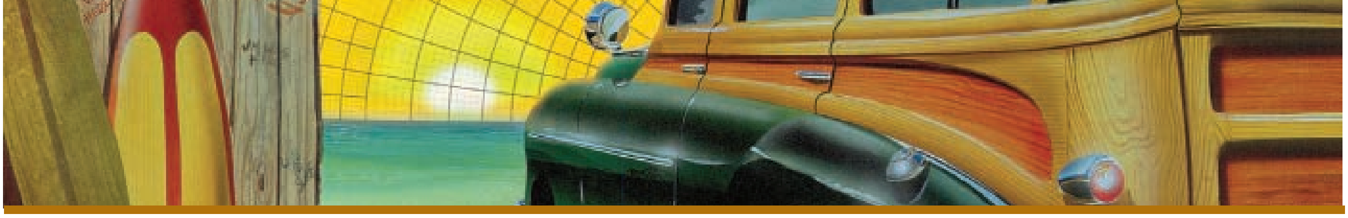
The number of companies working with the three branches of the armed services, DARPA, NASA and the intelligence agencies would expand throughout the Cold War. Funding included basic research and microwave component development efforts. Perhaps the most well-known R&D program was the filter technology development at Stanford Research Institute (SRI), which resulted in the classic publication by Matthaei, Young and Jones sponsored by the US Army Electronic Research Laboratory.

Competition for funding was intense, particularly for larger programs associated with major military systems. For example, each new aircraft would typically require a specialized avionics suite that resulted in large development and manufacturing programs. Many of the Bay Area companies had core expertise in certain technologies that resulted in niche products that were sold to larger companies who specialized in turn-key systems.[12] This specialization helped support an eco-system of component manufacturers (i.e. Varian Associates, Watkins-Johnson Co. and Avantek), system integrators (i.e. Lockheed, Ford Aerospace, Applied Technology, ESL) and supporting test equipment providers who were diversified by commercial markets (i.e. HP, Wiltron). The emergence of solid-state technology in the Bay Area would contribute to defense funding and, in turn, would benefit from it.

WATKINS-JOHNSON

Dean Watkins was working as a professor of electrical engineering at Stanford University. Richard Johnson was head of Hughes Aircraft Co. microwave laboratory (Southern California) where the two men met while working on TWTs. They both wanted to own their business, but they did not have any money. Once again, Stanford's Terman intervened by arranging financing through a local company that put up the $900,000 capital investment to launch the company in Palo Alto.

The two founders decided in 1957 to develop and manufacture microwave tubes and microwave solid-state devices, then use those products as a foundation from which to diversify into related electronic systems and equipment devices areas. During its first year the company showed a profit, primarily making TWTs, parametric amplifiers and backward wave



oscillators. The company's unique contribution was to combine tubes with power supplies, relieving the design engineer of having to address bias details. Watkins-Johnson made many wise acquisitions that allowed extremely rapid growth, purchasing Stewart Engineering for its backward-oscillator business, Communications Electronics for its receiver business and RELCOM for their mixers and the antenna lines of Granger.

TWTs were the multi-octave preamplifier of choice in the '50s thru mid-'70s. An example of a particularly sophisticated application was the SHRIKE anti-radiation missile preamplifier assembly that included three phase and amplitude matched TWTs (manufactured in significant quantity by WJ). While WJ was noted for low noise TWTs, others including Varian and MEC (Teledyne) led in high power TWT technology widely applied in jammer systems. In 2008, WJ was acquired by TriQuint Semiconductor.

SOLID-STATE MICROWAVE DEVICES

The Fairchild Semiconductor spin-off from Shockley Transistor and the "Fairchildren" that followed are widely believed to be the stimuli that set the Silicon Valley juggernaut in motion. Fairchild started developing Si RF transistors in the late 1950s, delivering "microwave sources" using transistor oscillators and varactor multipliers in 1965. The first GaAs MESFET was demonstrated at Fairchild in late 1960s; the newly formed Microwave and Optoelectronics Division began delivering GaAs devices in 1970, along with MIC components and microwave power transistors. Key employees of this new group, among others, included John Moll of the "Ebers-Moll Transistor Model," and Jim Early, developer of the "Early Effect." Fairchild's management, however, had not fully appreciated the importance of their product line and decided not to fully support the Microwave Division's pioneer work. As a result, most of the key people left to pursue other opportunities.

Hewlett-Packard also started work on GaAs MESFETs in 1969. By 1970, IBM and Fairchild research in this new compound semiconductor had produced reasonably good gain at microwave frequencies, but could not reduce the channel noise in these devices. Around this time Charles Liechti of Hewlett-Packard Laboratories recognized the impact that GaAs transistors might have on microwave systems and in 1971 led his research team to produce very impressive FET performance with low noise and high gain, and was subsequently awarded two Outstanding Paper Awards. Later, he also received the Microwave Prize with his coauthor, Bob Tillman.

A succession of Bay Area spin-offs from Fairchild and Hewlett Packard ended up serving the commercial microwave systems market with products rang-

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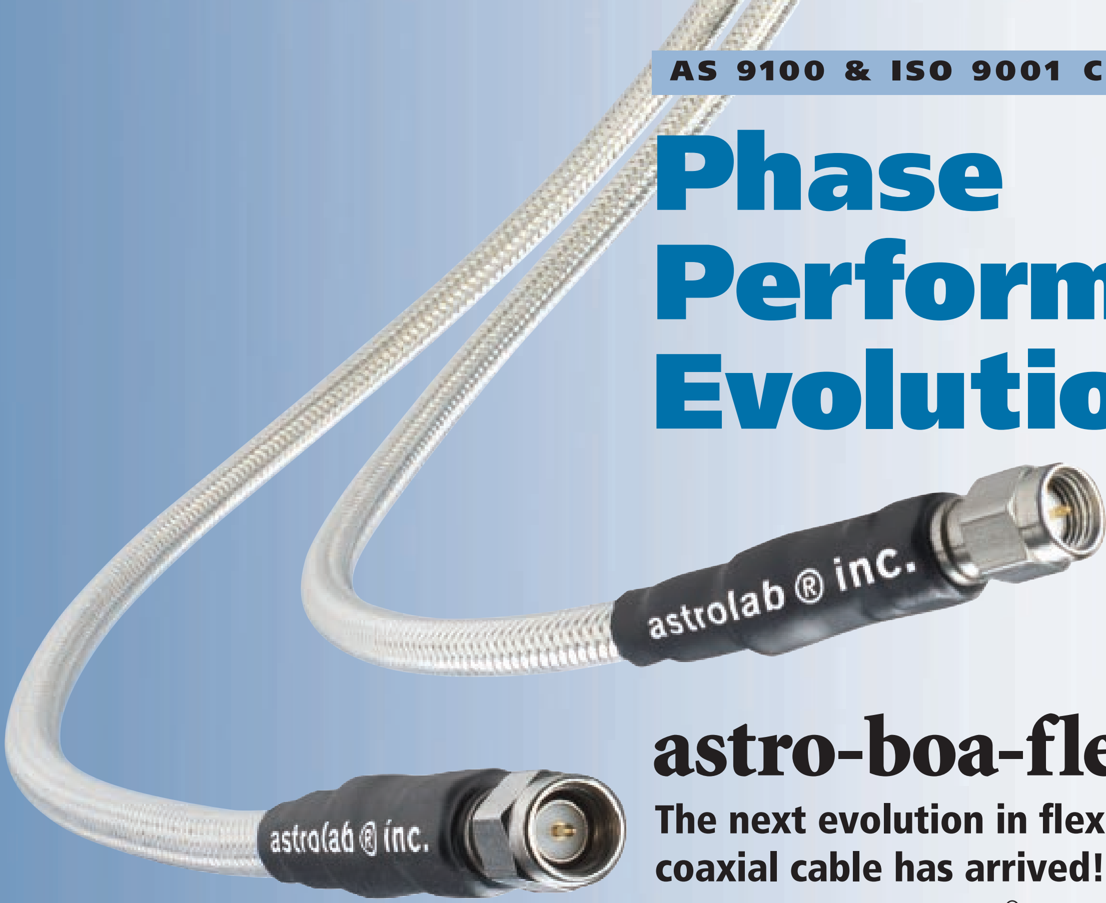

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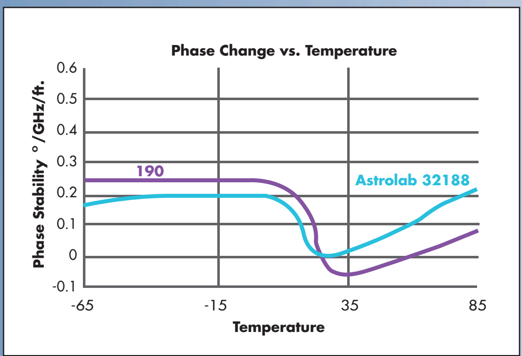

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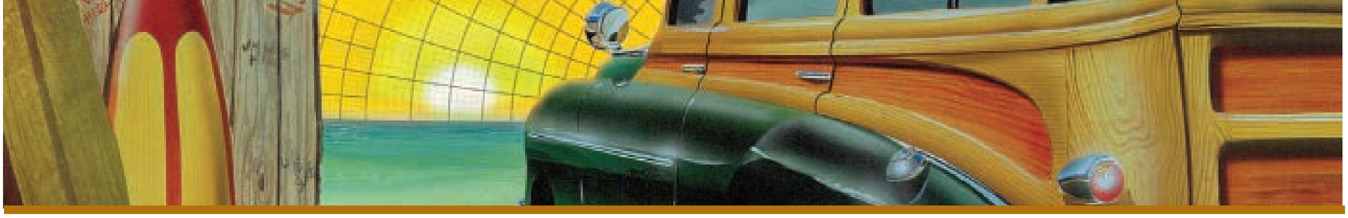


ing from discrete devices to hybrid microwave integrated circuits (MIC) to monolithic MICs (MMIC). A large number of intermediate-sized local spinoffs and start-ups emerged from both companies during the 1970s and 1980s, but most are no longer in business.

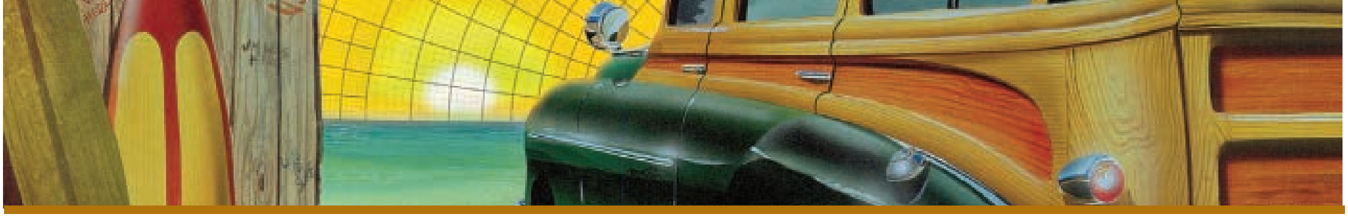
AVANTEK

In the mid-'60s, Applied Technology INC (ATI), out of Palo Alto, had been working on countermeasures. ATI generally worked on secret "black" programs and built specialized equipment in small lots. James Sterrett, a Senior Engineer at ATI, had developed a proprietary wideband UHF transistor amplifier line. ATI's Director of Marketing, 38 year-old Larry Thielen, quickly noticed that the devices were easy to sell to a wide customer base, simple to manufacture and had a large profit margin. Thielen had wanted to start his own company ever since he was Western Sales Manager at Ampex in Redwood City and now he saw his opportunity. Thielen, along with Sterrett, McVay and Seader (both ATI Engineering supervisors), announced they were leaving to form a startup called Avantek.

The company launched in 1965 with a line of solid-state RF components, quickly expanded into the microwave range, started in-house manufacture of Si transistors and GaAs FETs, and in 1972 introduced a 2 GHz digital radio product line using these devices until 1988 when this product line was sold to Telesciences (later sold to California Microwave in 1993). The company started with five people, used office furniture, their own money and no known orders. After 19 profitable years, they had 2500 people, total capitalization of approximately 380 million (19 million shares × \$20/share) and have produced over 25 millionaires. They shipped \$160 M in products 1984 and finished 1984 with a backlog of \$100 M. By 1991, Avantek's RF devices division was acquired by Hewlett-Packard, which became part of Agilent. As of December 2005, the Avantek division of HP that spun off to Agilent Technologies was sold and morphed into Avago.

CALIFORNIA MICROWAVE

ATI also spawned California Microwave, which was founded by David Leeson in 1968. The company started with a product line in competition with microwave sources that originated in 1963 at the Fairchild Microwave Division, but was subsequently acquired by Frequency Sources. The main users were Bell System companies retrofitting its 4, 6 and 11 GHz electron tube systems with solid-state subassemblies, and upgrading to higher capacities. California Microwave later expanded into a variety of microwave system product lines for a variety of customers, mainly through acquisitions. After a change of management in 1997 the com-



pany started selling off business entities, changed its name to Adaptive Broadband in 1999, sold its remaining microwave systems product line in 2000 and was acquired by Moseley Associates in 2001.

FARINON

In 1958, Bill Farinon began his firm in a one-room building located in San Carlos. Farinon Electric Co. would become well established in the microwave transmission, digital switching and auxiliary telephone equipment industry.

Beginning in 1970, Farinon introduced Gunn diode local oscillators and 1 W transmitter oscillators and amplifiers into analog and digital radios for the 6, 7 and 11 GHz bands. Farinon started building and using low-noise GaAs FET amplifiers in 1975 in the 2 GHz band, and power amplifiers in 1977. An in-house MIC facility was built in 1972. Farinon spin-off DMC also built an in-house MIC facility. In 1981, Harris Corp. purchased Farinon Electric and created the Harris Farinon Division.

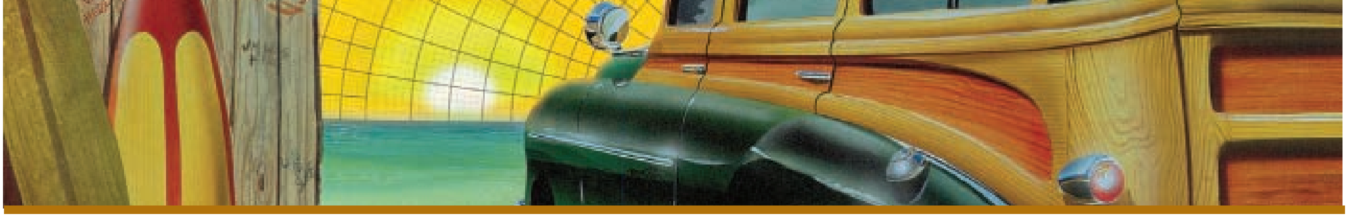
TELEDYNE

In 1960, Dr. Henry E. Singleton formed a company called Teledyne with Dr. George Kozmetsky, a colleague from Litton Industries. They each invested $225,000, money they earned from their Litton stock options. Loosely translated, Teledyne means Power through Communication. Despite an already crowded market, Singleton believed that producing semiconductors, the "basic building block of electronics," would lead to other high-technology and high-growth inventions. Their backgrounds in high technology and innovative ideas quickly paid off. The company achieved first year sales of $4.5 M and employed nearly 450 people. Second year sales of $10.5 M confirmed their success. The company's products included vacuum devices and integrated solid state microwave subassemblies for electronic warfare, satellite communication and radar applications; microelectronic modules for secure communications; high voltage connectors and cable assemblies; and contract manufacturing of military electronic assemblies.

MEASUREMENT SYSTEMS

The start of World War II turned a trickle of US government orders for electronic instruments into a stream and then a flood for HP. In 1943, HP entered the microwave field with signal generators developed for the Naval Research Laboratory and a radar-jamming device.

In 1951, HP invented the high-speed frequency counter (HP 524A), greatly reducing the time required to measure high frequencies. Radio stations used it to accurately set frequencies to comply with FCC regulations for frequency stability. Over the years,



frequency counters and related products accounted for billions of dollars in revenue. By 1956, HP produced its first oscilloscopes, models 130A/150A.

The S-parameter measuring technique was introduced by Hewlett Packard, and in 1968 the first Automated Network Analyzer (ANA) was brought to market also by HP using "small" minicomputers (see ***Figure 4***). It became an indispensable tool for the design and manufacture of microwave systems by simplified calibration and paved the way to computer-aided measurements. Cost of the system was approximately $250,000 and it required two men to move it around. Thanks to improved tech-

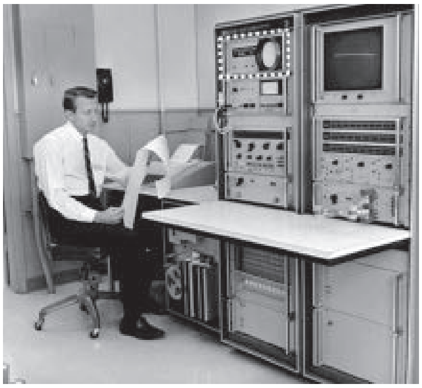


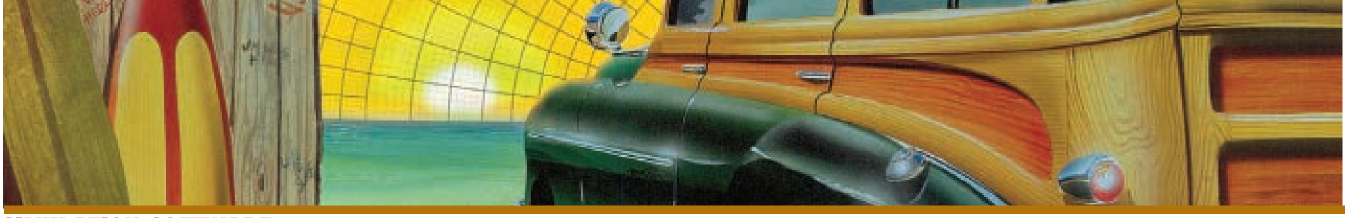
Fig. 4 The first HP Automatic Network Analyzer (ANA) developed in 1968.

nology and circuit integration, a far more capable ANA is now available in a size equivalent to the polar display unit located in the upper left corner of the Figure.

The technology developed for advanced weapons systems, EW and countermeasures would produce advanced instrumentation and require advanced measurement systems. Helped by the invention of the transistor and the analog and digital circuitry that came about with the introduction of minicomputers, Northern California was home to a number of microwave measurement system milestones. Test and measurement equipment also allowed companies to apply their technology to commercial markets any time military spending waned.

Wiltron had started out in the 1960s in Morgan Hill, CA as an electronics outfit operating primarily in the defense sector. With the reduction of defense spending following the collapse of communism in the late 1980s, Wiltron had begun repositioning itself around a core of commercial wireless and wireless test systems. The company was especially strong in the mid-range-frequency sector.

Like the system/component manufacturer eco-system that evolved around the military market, specialized microwave and millimeter-wave test and control instruments operating in the Bay Area include: Giga-tronics, Phase Matrix, Advantest, DCM Industries, Krytar and XL Microwave Inc.



SIMULATION SOFTWARE

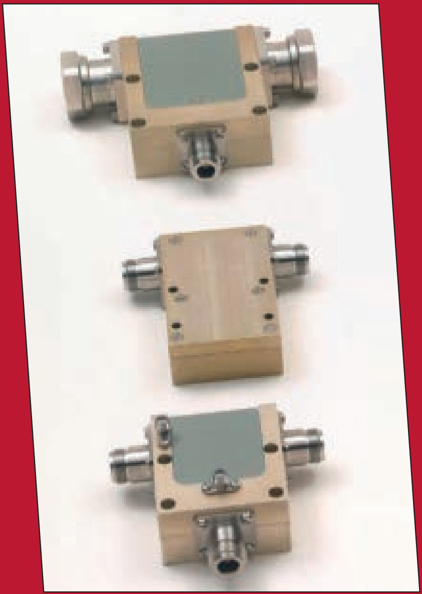
Computerization of microwave design was relatively slow compared to the other EE design disciplines. Traditionally, microwave circuit design was more of an art than science. Designers often achieved results by tweaking, tuning and shielding circuits on the bench, instead of using a systematic analytical approach.[15] In the 1960s, introductions of Hewlett-Packard's S-parameter test instruments revolutionized microwave component testing and characterization. Soon after, related S-parameter design techniques became available, using measured data directly. By the late 1960s, the newly formed timeshare industry introduced more convenient computer operating systems and programming languages for engineers. Soon after, several software packages were also developed, and became commercially available to microwave designers.

During the early 1970s, COMPACT (Computerized Optimization of Microwave Passive and Active CircuiTs)[16] had gradually become the industry standard due to its speed, nodal circuit description, large transistor S-parameter database and extensive application examples. The program had been available through six international time sharing systems as well as in-house installations. However, it was not until hardware manufacturers introduced powerful minicomputers and companies began to purchase them for dedicated scientific usage in the early 1980s that computer-aided design became widely accepted among microwave circuit designers.

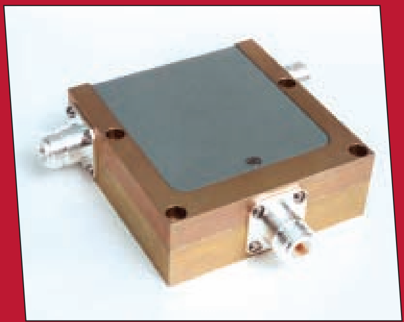
Compact Software merged with COMSAT in 1980 to form Comsat General Integrated Systems in Palo Alto to focus on engineering office automation.[17] In addition to the second-generation version circuit optimization program, SuperCOMPACT, the company also introduced the first automated microwave circuit layout routine, AutoArt.

WIRELESS SYSTEMS

By the late '80s, with dramatic advances in silicon analog and digital devices, and the post-Cold War decline in defense R&D spending, the microwave industry in Northern California began to focus on the "Wireless Revolution." This era reflected an increased focus on commercial microwave applications such as cellular, satellite or wireless local-area communications. The boundaries between microwave and high-speed electronics began to blur, as clock rates of mainstream semiconductors reached the GHz realm and microwave systems began to incorporate more and more digital signal processing. Companies such as ArrayComm, Proxim, Atheros and Airgo are examples of this era. Particularly noteworthy



Communications



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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

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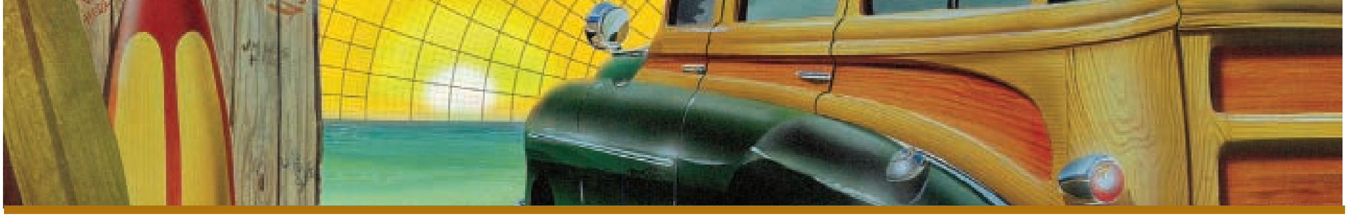


is the high degree of interconnection among the companies in the Bay Area. In a 2006 MTT-S presentation, over 90 percent of 100+ Bay Area companies examined traced their roots to one of the others, and over 50 percent spawned at least one significant spinoff.

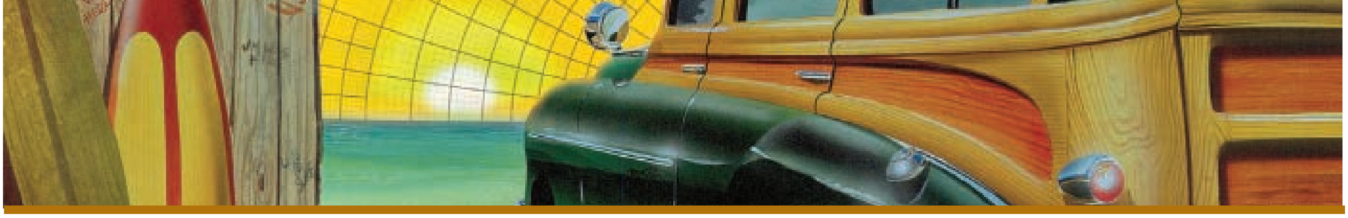
Wireless systems suppliers headquartered in the Bay Area or with local engineering and/or manufacturing activities included: Arraycom (1992), Alvarion (1992), Gigabit Wireless (1998, changed name to Iospan in 2000, and acquired by Intel in 2002), Aperto Networks (1999), TeleCIS (2000), Tropos Networks (2000), Airespace (2001, acquired by Cisco in 2005), Aruba Networks (2002), Meru Networks (2002), Trapeze Networks (2002), Beceem Communications (2003), Firetide (2003) and PacketHop (2003).

There were a number of additional manufacturers of point-to-point microwave systems that participated in this market. Among these are (years indicate actual system deliveries): Kebby Microwave (1964-1968), which became Farinon Microwave; Granger Associates (1970-1992) and Granger/Telettra (1986-1991); Culbertson Industries (1971-1974); and Aydin Microwave (1990-1999). While not a manufacturer of complete communications systems, Endwave, founded in 1992, evolved as a supplier of microwave and millimeter-wave subsystems to systems manufacturers in different bands ranging from about 3 to 65 GHz.

BESSER ASSOCIATES

After phasing out of the design software business, I felt that the universities had not adequately prepared engineering students to face practical real-life problems and founded a continuing education group in 1985. The company, Besser Associates (see ***Figure 5***), has trained over 50,000 RF, microwave and wireless engineering professionals and managers worldwide during the past 25 years. The company's instructors are highly experienced and accomplished microwave engineers, most of whom have published extensively in their areas of expertise. Courses are available at various experience levels, ranging from novice to experts, covering circuit and system design as well as RF/microwave measurements.

Fig. 5 Author and founder of Besser Associates, Les Besser.



CONCLUSION

While most people think of Silicon Valley as the home of the integrated circuit and computer, its history goes back much further to the early days of radio and is inextricably linked to the microwave industry that thrived here. A plaque at 367 Addison Ave. in Palo Alto summarizes the unique combination of entrepreneurs, innovators, venture capitalists, academia and government sponsors that made it all possible: "This garage is the birthplace of the world's first high-technology region, 'Silicon Valley.' The idea for such a region originated with Dr. Frederick Terman, a Stanford university professor who encouraged his students to start up their own electronics companies in the area instead of joining established firms in the East. The first two students to follow his advice were William R. Hewlett and David Packard, who in 1938 began developing their first product, an audio oscillator, in this garage." ■

Chuck Swift, *who refers to himself as "The Old Peddler", entered sales in 1955 and established his rep/distributor firm, C.W. Swift & Associates, in July, 1958. His product lines were RF and microwave connectors and components, and an occasional pistachio. Chuck attended his first IMS in 1961, and was Chairman of the 1989 Symposium in Long Beach. Awarded the N. Walter Cox Award in 1994, Chuck will be honored with a Luncheon (Chuck Roast) on Tuesday, May 25th. Look for him and his motorcycle in Anaheim.*

Les Besser *has worked in engineering and management capacities at the microwave divisions of HP and Fairchild, and also at Farinon Electric. He authored COMPACT and founded Compact Software, a pioneer CAD software company. Later, he formed Besser Associates, dedicated to continuing education through instructor-led short courses. He has published numerous technical articles, contributed to and co-authored several textbooks, and is a Life Fellow of the IEEE, receiving numerous awards for his many contributions to the field.*

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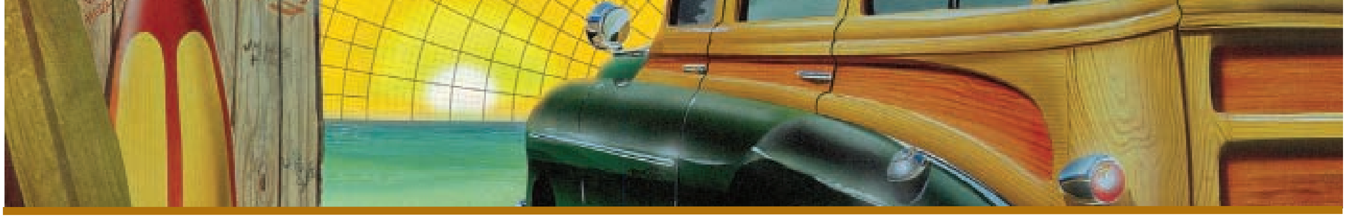


Welcome to the 2010 IEEE MTT-S International Microwave Symposium

Welcome and greetings from the entire IEEE IMS2010 Steering Committee. We look forward to seeing you in Anaheim, CA, during Microwave Week, May 23-28.

As you make your plans to attend, there are several things that one should consider about IMS2010. Microwave Week provides multiple opportunities to learn, meet new friends, and enjoy Anaheim and southern California. We hope that you get to experience them all.

The option to learn includes attending the Radio Frequency Integrated Circuit Symposium (www.rfic2010.org), the International Microwave Symposium (www.ims2010.org) and the 75th Automatic Radio Frequency Test Group Conference (www.arftg.org). Combined there are 32 Workshops, three Short Courses, 98 Oral Sessions, six Interactive Forums, nine Panel Sessions, and 13 Focused and Special Sessions to attend.

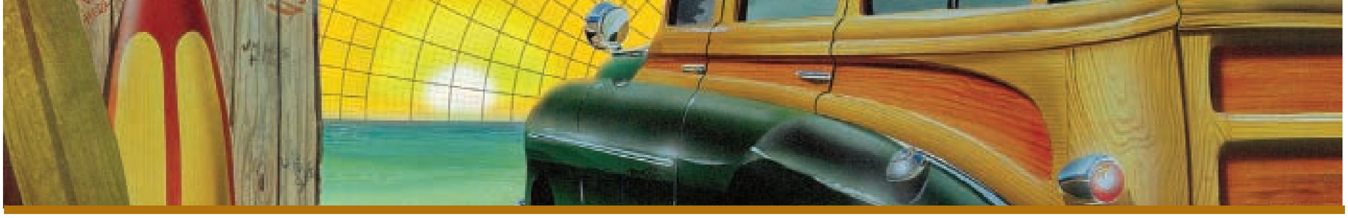
Madhu Gupta and Chuck Krumm.

We are delighted that the Honorable Zachary Lemnios, Director of Defense Research and Engineering, will make the keynote address. His talk is entitled, "A Strategic View of Defense Research and Engineering." All registered attendees and suitably registered guests are encouraged to attend. The Plenary Session will be Tuesday morning, May 25th, at 10:00 AM in the main ballroom of the Anaheim Convention Center.

This year, Dr. Madhu Gupta, the Technical Program Committee Chairman, and the entire IMS Technical Program Committee made a strong push to get papers submitted from emerging technologies and new areas of interest. As a result of their efforts, papers in new technical interest fields were received. Two new review committees were established to review the papers submitted. The two new areas include: High-power Microwaves for Industrial and Material Processing; and RFID and Power Scavenging Technologies. These fields are new to IMS and represented by three oral sessions and two interactive forum sessions in the technical program.

Taking time to attend the largest RF and microwave exhibition is an easy way to keep up with the latest product developments and trends. As of the latest count, there are over 850 booths from over 500 different exhibitors. Exhibit hours are Tuesday, May 25th, 9:00 AM to 5:00 PM, Wednesday, May 26th, 9:00 AM to 6:00 PM, and Thursday, May 27th, 9:00 AM to 3:00 PM. There are two things one should note for Wednesday, May 26th: Exhibit Only admission will be free for advanced registration and the exhibits are open for an additional hour in the evening. The Free Wednesday Exhibition

J.K. McKinney
IMS2010 General Chairman



will allow extra time for those who live in the southern California area the opportunity to drive in and enjoy the exhibition. The Industry Hosted Cocktail Reception will be held on Wednesday afternoon on the show floor between 5:00 and 6:00 PM.

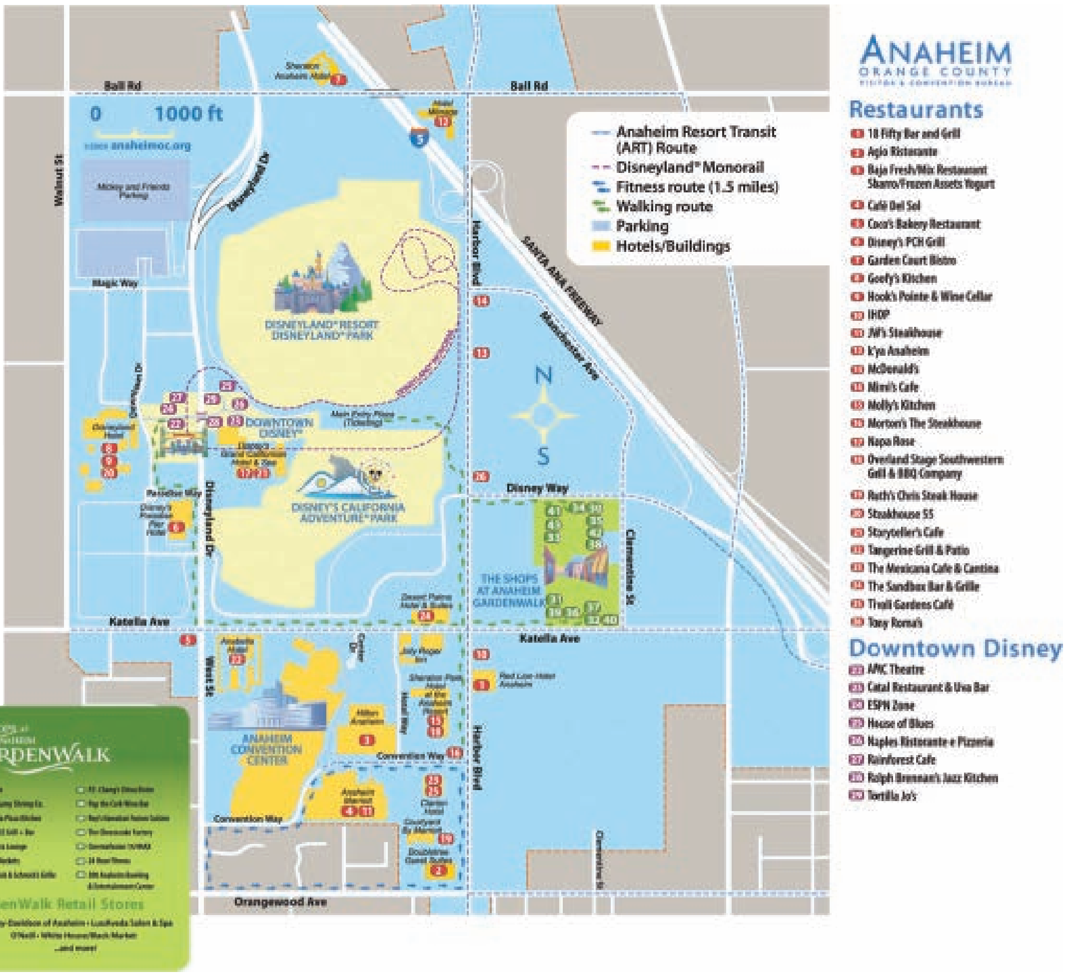
There are the informative MicroApps sessions to visit and enjoy. Here you will discover the latest advances in products and solutions by some of the exhibiting vendors. Presentations are held continuously during show hours in the MicroApps Theater on the exhibit floor starting at 9:10 AM daily.

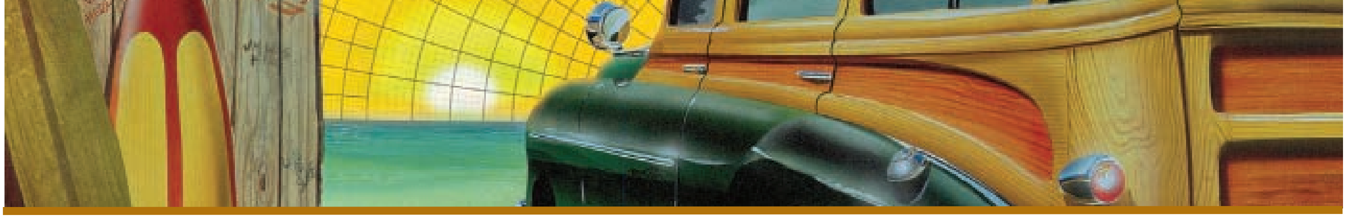
Should one desire more than Technical Sessions and the largest RF and microwave exhibition, there is a wonderful guest program to experience. IMS2010 has teamed with PRA Tours to provide an outstanding offering of tours allowing one to visit many of the famous southern California attractions. For information about the 11 different tours available visit www.pra-tours.com/IEEE for complete details. Onsite information about the tours will be available daily in the hospitality suite. The child-friendly hospitality suite will be located in the Sheraton Park Hotel next to the Anaheim Hilton. The hospitality suite provides both indoor and outdoor amenities. Please stop by and say hello to the helpful volunteers who will be there to ensure that your stay in Anaheim is enjoyable.

Should you still be looking for something more to do there are many famous restaurants and places to go after the daily sessions and exhibits have come to a close. There is the newly opened Garden Walk (www.anaheimgardenwalk.com), Downtown Disney (http://disneyparks.disney.go.com), and several popular restaurants. All are within easy walking distance of the Anaheim Convention Center. The concierge desk at the Convention Center will be glad to assist with reservations or any questions. Do not forget the wonders of Disneyland and California Adventure Park, which are just across the street.

As you can see, Microwave Week provides you with numerous opportunities to learn, meet new friends, and enjoy the sights and sounds of Anaheim and Southern California. The entire Steering Committee looks forward to your attendance. We know you will have an excellent time while here.

See you in Anaheim.





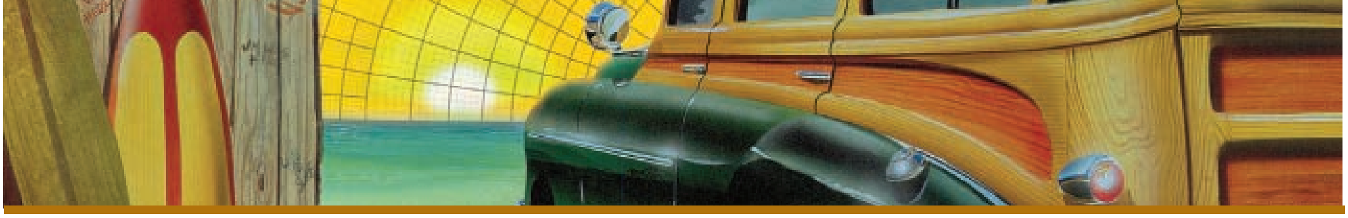
2010 RFIC Symposium: RF Design for New Horizons

Welcome to the IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, which will take place in Anaheim, CA, May 23-25, 2010 (www.RFIC2010.org). Our Symposium, held in conjunction with the IEEE MTT-S International Microwave Symposium (IMS), opens Microwave Week 2010, the largest worldwide RF/microwave meeting of the year.

The RFIC Symposium continues to build upon its heritage as one of the foremost IEEE technical conferences, increasing each year its impact and reputation of excellence. By bringing focus to the technical accomplishments in RF circuits, systems and devices, the RFIC Symposium has become essential to both the academic and industrial communities. This year's exciting technical program will showcase the latest innovations in RF integrated circuit design with sessions that cover a broad spectrum of topics from cellular and wireless connectivity system ICs, broadband wireless communications, digitally enhanced RF circuits, silicon millimeter-wave ICs, and RF device technology, modeling, and characterization. Applications highlighted by the technology include mobile phones, wireless communication systems, broadband access modems, radar systems and intelligent transport systems.

Running in conjunction with the International Microwave Symposium and Exhibition, the RFIC Symposium adds to the excitement of Microwave Week with three days focused exclusively on RFIC technology and innovation (see ***Figure 1***). The RFIC Symposium will start on Sunday with half-day and full-day workshops, covering a large breadth of topics. Some of the topics include: SiGe HBTs towards THz operation;

Yann Deval
2010 RFIC General Chair



interference and coupling effects in modern System on Chip (SoC) and System in Package (SiP); power management for integrated RF circuits; advances in filtering and sampling for integrated transceivers; MOSFET modeling for RFIC design; re-configurable multi-radios at the nanoscale; challenges and techniques for 3G/4G multi-mode front-end designs; and silicon-based technologies and design techniques for millimeter-wave applications.

The conference also includes a Plenary Session, which is held on Sunday evening. Keynote addresses will be given by two renowned leaders, one from academia and the other from industry. Both of them will share their views and insights on the direction and challenges that the RFIC industry is facing. The first speaker is Professor David James Allstot from the University of Washington, who will present his vision of one of the last great challenges of RF CMOS integration in his talk, "Power Amplification: Can CMOS Deliver?" The second speaker is Gregory L. Waters, Executive Vice President and General Manager, Skyworks Solutions Inc., Woburn, MA. He will discuss "The Universal Connector: RF Application Trends Over the Next Decade." In addition to the keynote addresses, the conference holds a student paper competition to encourage the publication of innovative research from university students. Consequently, best student paper awards are presented in the Plenary Session to acknowledge these contributions. The highly anticipated RFIC Reception will follow immediately after the Plenary Session, providing a relaxing time for all to mingle with old friends and catch up on the latest news.

On Monday and Tuesday, the conference will feature lunchtime panel sessions that traditionally draw strong debate between panel members as well as stimulating interaction between attendees and panelists. Monday's lunch panel session entitled, "The Challenges, Competitions and Future Prospect of 60 GHz," includes panelists from both industry and academia debating the future of high data rate wireless networks. Tuesday's lunch panel session, "Future of High-speed I/O: Electrical, Optical or Wireless?," is posed to stimulate interactive discussions with the audience. There will be a total of 21 oral paper sessions on Monday and Tuesday. The technical program will conclude with an Interactive Forum session on Tuesday afternoon, which will feature 26 poster session papers and the chance to speak directly with authors regarding their work.

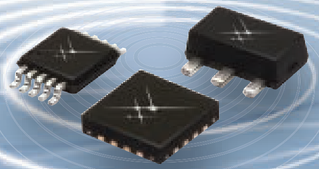
This year's location is the Anaheim Convention Center, in beautiful Southern California, a location made famous by cutting-edge high-tech industry, top universities, perfect weather, beautiful beaches and entertainment parks such as Disneyland, Universal Studios and Sea World, to name a few. Our Anaheim conference presents an opportunity for engineers to see the latest advances in RFIC design, while providing numerous options for entertaining the entire family. We hope that you take full advantage of these opportunities on your visit.

On behalf of the RFIC Steering Committee, we look forward to seeing you at the 2010 RFIC Symposium in Anaheim.

TIME	SATURDAY-MAY 22	SUNDAY-MAY 23				MONDAY-MAY 24				TUESDAY-MAY 25			
7AM		REGISTRATION 7am-6pm	Breakfast 7am-9am			REGISTRATION 7am-5pm	Breakfast 7am-9am			REGISTRATION 7am-5pm	Breakfast 7am-9am		
8AM				Workshops & Tutorials 8am-5pm				RFIC Technical Session 8am-5:10pm				RFIC Technical 8am-10:10am	
9AM													
10AM													
11AM									Panel Session 11:50pm-1:20pm				Panel Session 11:50pm-1:20pm
NOON													
1PM												RFIC Technical 1:20pm-3pm	
2PM	Registration 2pm-6pm												Interactive Forum 2pm-4pm
3PM													
4PM													
5PM					Plenary 5:30pm-6:40pm								
6PM													
7PM					RFIC Reception 7pm-9pm								
8PM													

REGISTRATION | BREAKFAST | TECHNICAL | SOCIAL | PANEL | INTERACTIVE FORUM

▲ *Fig. 1 IEEE RFIC Symposium schedule.*



SKYWORKS®

Discrete and Integrated RF Solutions

Skyworks broad product portfolio supports a wide variety of markets, including:

Cellular and Broadband Communications

Solutions for wireless communications infrastructure systems, including cellular base stations, WiMAX access points, land-mobile radio systems, point-to-point radio links and more. Also, highly integrated PA and FEM solutions with embedded mobile connectivity for GSM, GPRS, EDGE and WCDMA, CDMA, and LTE air interfaces.

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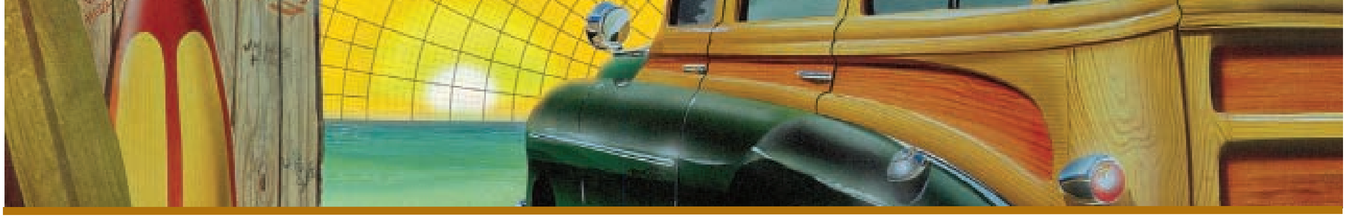


75th ARFTG Conference Highlights

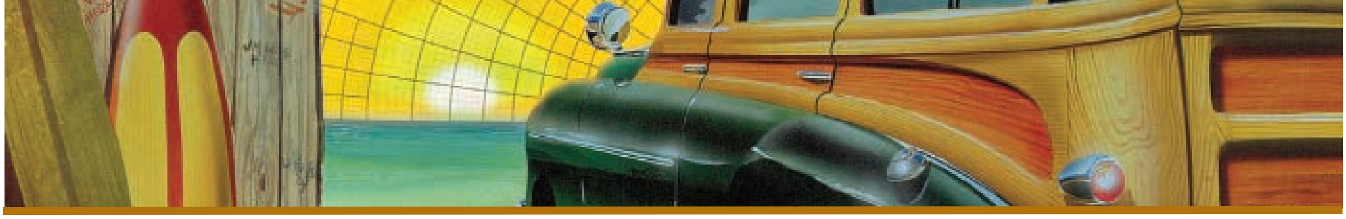
Since its inception in 1972, the Automatic RF Techniques Group (ARFTG) has worked to create a constructive forum and voice for the community of RF and microwave test engineers—both test instrumentation end users and vendors alike. Through its various conferences, workshops and training courses, the organization endeavors to keep its 600+ members worldwide up to date on the latest developments in test and measurement techniques.

Nowhere is this educational mission more evident than at the upcoming 75th ARFTG Microwave Measurement Conference, which is scheduled to take place in Anaheim, CA, on May 28, 2010. Here, colleagues, experts and vendors in the RF and microwave test and measurement community will have the opportunity to meet face-to-face to discuss ongoing developments and the similar challenges they each face.

This year, the conference will explore a critical theme—measurement of modulated signals for communication. Kicking off the discussion will be an invited talk on modern cellular wireless signals from Dr. McCune, RF Communication Consulting. The rest of the event will highlight an array of papers covering everything from vector signal measurements and complex waveform analysis to nonlinear measurement techniques in the time and envelope domains. The application of digital signal processing to communications signal measurements is another topic that will be discussed.

The 75th ARFTG conference is being held in conjunction with the 2010 IEEE MTT-S International Microwave Symposium. For additional information on this event, please visit: www.arftg.org or www.ims2010.org.

Ken Wong
Conference Chair



IMS 2010 MicroApps: Diversity in Microwaves

The Microwave Application Seminars (MicroApps)—scheduled for the Anaheim Convention Center, May 25-27, 2010, as part of IEEE-IMS/MTT-S—are a series of concise technical presentations given by exhibitors that are distinct and separate yet complementary to the IEEE technical sessions.

MicroApps are engineering topics of interest to the microwave community and cover new products, noteworthy state-of-the-art components, emerging technologies, and novel manufacturing and design techniques that incorporate the exhibitor's products and technologies in an application-centric setting.

This year's program is the most successful yet, offering more than 57 presentations on a diverse range of topics that include hardware, software and components, and come from more than 30 different firms from Germany and Switzerland to Japan and Australia as well as the United States. The papers have been categorized into seven areas of interest this year to allow for both breadth and depth of coverage in and around any one topic:

- high power
- software and signal processing (signal integrity, electromagnetics and amplifier)
- component modeling
- materials
- phase noise
- wide bandwidth
- test equipment and measurements

IMS 2009 MicroApps booth.

This year, Wednesday admission to the exhibit floor and also to the MicroApps Symposium is free. This means even more can take advantage of the special talks that day, which include a keynote presentation, "X-parameters: The Emerging Paradigm for Interoperable Characterization, Modeling and Design of Nonlinear Microwave and RF Components and Systems" by Dr. David Root of Agilent Technologies Inc. Attendees can also grab a glass of wine Wednesday evening at the industry-hosted reception and enjoy the talk by well-known industry expert Dr. James Rautio titled, "A Tutorial on Silicon Spiral Inductor Ground Return Effects on RFIC Design."

MicroApps sessions are open to everyone, thanks to sponsorship by Agilent Technologies. The MicroApps theatre is conveniently located in the midst of the exhibits at Booth 524. The complete and up-to-date MicroApps symposium schedule can be found in the IMS Program Book or online at the IMS2010.org website. A MicroApps CD of all the presentations will be available for free to all, and those who are unable to attend in person will be able to view the virtual presentations online at the IEEE website.

Come to MicroApps, learn and enjoy. We look forward to seeing you at Booth 524 during the week of May 25th.

Sherry Hess
AWR Corp.

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Amplifier Products:
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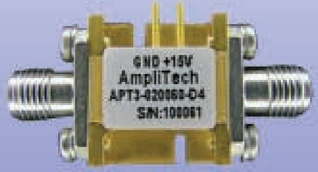
- Designs up to 40GHz
- Space / Military Qualified
- SATCOM Waveguide Interfaces
- High IP3 Models
- Phase Matching / Tracking
- Small Packages
- Coaxial Packages



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- SMA Coaxial Packages
- Phase Matching / Tracking

Cryogenic Amplifiers:
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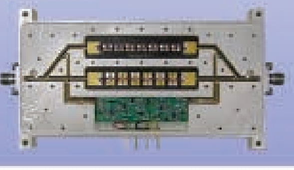
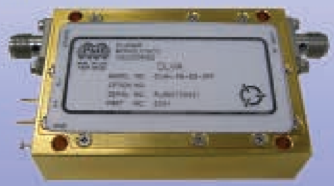
- Operation down to 16 Deg.K
- Space / Military Qualified
- Ultra-Low Current Draw
- Compact Packages
- +3 to +8VDC Operation

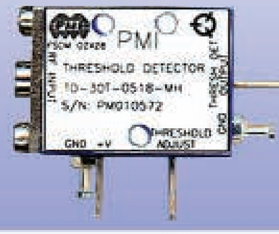
Filter Products:
- Designs up to 40GHz
- Lumped Element and Cavity
- Suspended Substrate
- Low/High and Band Pass Filters
- Band Reject Filters
- Switch Filter Bank Assemblies
- Industries Best Performance
- Coaxial In-Line



SDLVA Products:
- Designs up to 40GHz
- Excellent Frequency Response
- Excellent Log Linearity
- Limited IF Outputs Available
- CW Immunity Available
- Ultra Fast Pulse Response
- Low Power Consumption



Detector Products:
- Designs up to 40GHz
- Directional & Threshold
- High Dynamic Range
- Fixed or Adjustable
- High Speed
- Small Packages



Phase Shifter & Modulator Products:
- Analog & Digital
- High Speed
- Low Loss
- High Accuracy
- Small Size

Limiter Products:
- DC to 40GHz
- SMT & Connectorized
- Low Loss
- Hard Limiting
- Fast Recovery

Frequency Discriminators:
- Designs up to 40GHz
- High Speed
- High Accuracy
- Military or Space Screening
- Small Size

Integrated Assemblies:
Functions Include:
- Amplification
- Attenuation
- Filtering
- Switching
- Phase Shifting
- Power Detection
- Modulation
- Coupling
- Limiting
- Digital Control

Other Products Offered:
- Up/Down Converters
- Frequency Discriminators
- I/Q Vector Modulators
- RF Solid-State Switching Products
- RF Solid State Attenuation Products
- Power Dividers
- Switch Matrices
- Test Bench Amplifiers
- Comb Generators
- DTO's and VCO's up to 20GHz

Customized components and modules

SATCOM LNA's
- Extended Operating Temperature
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- Weatherproof / Rugged Design
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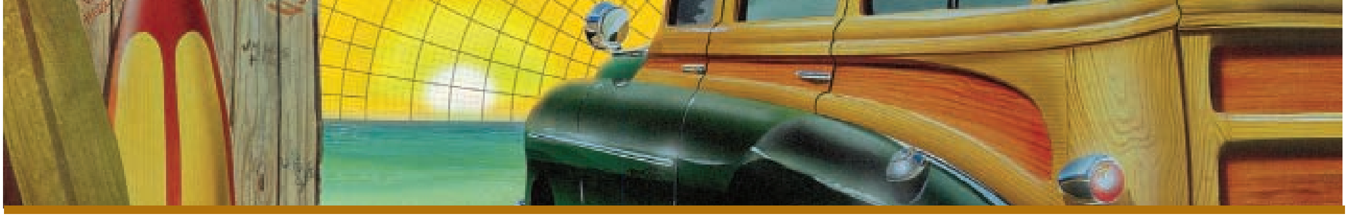


Assignment: ANAHEIM

Since vendors keep new product information "confidential" until Microwave Week, predicting what will create a stir at IMS is a bit of a guessing game. Using recent press releases and news items from other related trade shows, our editors have complied the following preview, written from the perspective of three (fictitious) attendees from the radar, infrastructure and mobile device markets, who discuss their needs and what they will be looking for.

Mobile Devices

Dual-band Dave

"Dual-band" Dave works for a large consumer electronics device manufacturer (think Handsets, Smartphones, PDAs, Cellular PC Datacards, Mobile Internet Devices (MID) and cellular modems). He is part of the RF design group. The company buys RF front-end components from various manufacturers (to keep their options open). Most of the group's design work focuses on system integration, RF board and antenna design. The company does design the occasional custom RFIC and multi-chip module (MCM). Since Dave's paper was accepted for the technical program, he will be among the few people from his company attending the conference. Upon hearing this, his envious co-workers began sending him e-mails and forwarding press releases on new products they would like more information on.

Dual-band Dave's colleagues have asked him to stop by a few of the software vendors for updates on simulation tools. The RFIC designers are particularly interested in IBIS-AMI support, the latest on circuit capacity comparisons between major circuit simulation vendors, libraries for system-level design (and links to Matlab), channel emulation/MIMO simulation and testing. The group also needs planar and 3D EM software for modeling on and off chip passive components, antenna design and packaging. There is also interest in nonlinear measurement models (X-parameters or equivalent).

The test lab has a budget for specific dedicated high-performance analyzers, including a spectrum/signal analyzer and a nonlinear VNA. Spectrum analyzer sensitivity and dynamic range are important. The NVNA is needed for characterizing components that are designed in-house or from suppliers. These components are to be tested under various load conditions, so a load-pull system will be required. The NVNA is also required to support RFIC designers who are validating foundry transistor models for their design work.

The test engineers would like to compare price vs. performance between various classes of spectrum/signal analyzers and digital oscilloscopes (real-time and sampling).

The test engineers want to know about upgrading existing instruments with top of the line equipment as well as what is available for mid-class high speed production testing. The group also needs quite a few test accessories (cables, connectors and RF boards for test fixtures, bench-top passive and control components). There have been several recent announcements on test equipment for user equipment (UE) that they would like Dave to follow-up with. The specific absorption rate (SAR) and interaction of the mobile device with the user/environment also needs to be investigated. Dave has been asked to collect information on a test-based vs. simulation solution. Currently, his company outsources this task, but they are evaluating cost/time savings of folding this activity into the earlier design process.

Finally, Dave expects to spend a lot of time with the RF power amplifier, switch, filter module guys. His company has dealt with the major vendors, so he knows them pretty well. His company has a good size product portfolio of mobile devices, so no one solution fits all their needs. Cost, added engineering effort, linearity and battery life-time are big concerns. Dave's company is keeping an eye on mode-specific versus converged multimode cellular front-end solutions and which architectures are most cost effective for the company's various platforms. The company is particularly interested in recent switch, power amp and transmit module developments for next-generation smart phones and data cards. Needless to say, Dual-band Dave is anticipating a very, very busy Microwave Week.

The List: Mobile Devices

Simulation Software
RFIC design: Agilent's Golden Gate, ADS, AWR's Analog Office (new multi-rate HB engine), status on Synopsys RFIC solution (Custom Designer)
System: Agilent SystemVue (and W1715 MIMO channel builder), AWR VSS, Mathworks RF blockset updates for Simulink?
EM simulation: Updates on 3D - Ansoft HFSS, CST MW Studio, Remcom, Agilent EM pro (integrated with ADS) , AWR Axiem (MWO) and Sonnet (3D planar)
PCB and test fixture design: ADS, Genesys, MWO, Designer note ask about device libraries, X-parameters. High speed design soln., links to test equipment, links to board layout tool. Intercept technologies.

Test Equipment
Signal Generators: Agilent (ESG sig. Gen w/ modulation capabilities 2G-4G, PSG CW and analog mod., PXB baseband generator/channel emulator); Rohde & Schwarz: (R&S SMU200A/SMJ100A, AWG support with WinIQSim, EUTRA/LTE avail.); Anritsu (MG3690B series, CW)
Arbitrary Waveform Generator: new 81180A from Agilent (4/12/10); Tektronix: AWG5000/7000 (Arb. Waveform Gen.)
Signal/Spectrum Analyzers: Rohde & Schwarz (FSV/FSQ/FSU), R&S FSUP (phase noise), FSMR (receiver test); Anristu (MS269XA series & new MS2830A - 2/12/10); Agilent (PXA/MXA/EXA/CXA); Tektronix (RSA3000 Series). Each vendor has tiered price/performance features
Digital Oscilloscopes: Tektronix (DPO/DSA70000), Agilent (Infiniium DSO/DSA 90000 series)
Nonlinear VNAs: Agilent, Anritsu, Rohde & Schwarz
Communications: get data on R&S CMW500 (network emulation, VSA/VSG); Anritsu's MD8480C Signaling Tester with Dual-Carrier HSPA Evolution; Agilent's N9073A W-CDMA/HSPA/HSPA+ for one-button RF transmitter conformance measurements

Materials & Passive Components
Rogers Corp. new RO4360 laminate (6.15 Dk), may be effective cost-down replacement, for LTCC, ARC Technologies Heat-X EMI suppression/magnetic absorbers/structural composites, Coilcraft (inductors), Tecdia (chip caps), Murata (SMT caps)

Active Components/RFICs/MMICs
Aeroflex Metelics (diodes, switches), Peregrine (SOS switches), Analog Devices (converters/gain blocks), Avago (FBAR high isolation and high rejection duplexers)

Timing Solutions
NDK (micro-miniature NX2520SA TCXO), Valpey Fisher, Vectron International (TX-500 TCXO/BAW/SAW filters), Synergy Microwave, Crystel (CVT20)

RF Front-ends
PA & Transmit Modules:
RFMD: PowerSmart architecture, supports four GSM/GPRS or EDGE bands; up to five bands of TD-SCDMA, W-CDMA/HSPA+, LTE, WiMAX or CDMA. New products: RF720x - 3G multimode PA with mode/band - specific front-end architectures for all major WCDMA/HSPA+ bands; RF71XX - dual & quad-band GSM/GPRS transmit modules; RF323X, and RF3171 - 3G transmit modules, for entry-level feature phones supporting one-to-two bands of W-CDMA and two-to-four bands of GSM/GPRS
Skyworks: new SKY7760Xmultimode/multiband PA modules for HSPA 3G, quad band GPRS and EDGE operations, supports bands 1,2,5 and 8 for W-CDMA and HSUPA modulation
TriQuint: TRITIUM PA-Duplexer Module and TRITON PAs - discrete components can be configured for global coverage of WCDMA/ HSPA+ in the 3GPP bands 1, 2, 4, 5 and 8; Tritium PA-Duplexer 4G LTE duplexer, Tx filter and PA for upper 700 MHz spectrum in band 13 and filters/duplexers for CDMA450. HADRON II PA Module for GSM/GPRS/EDGE. Quantum Transmit module and TRIUMF multi-mode/multi-band "convergence" architecture - protocols up to 4G

Switch Modules:
RFMD (new RF1603/4, SP3T/SP4T); Skyworks (antenna switch modules for 2/3/4G devices using GaAs and SOI; SKY13362 - single-pole ten-throw switch with integrated CMOS decoder and dual low pass harmonic filters), Peregrine UltraCMOS - PE4269X series

Notes:

(works in Cadence environment, new capacity, yield analysis, wireless test benches)

(integrated into ADS);

notes: antenna guys want 3D also need SAR analysis and model entire phone interaction with environment (i.e car, buildings, etc.), passive comp. guys want planar, parameterization for spiral designs

look into Agilent's MXG and PXB for real-time LTE eNB receiver testing and MIMO receiver implementation and PXA, signal analyzer, for RF transmitter testing. standards such as LTE FDD, LTE TDD, HSPA

compare samples/sec and bit resolution

wideband FFT analysis, CCDF, Freq. vs. Time, spectrum, power vs. time analysis. Compare dynamic range, phase noise, level accuracy and res. BW

125 MHz analysis BW

Compare edge trigger speeds, deep memory, sample rates

uses an RF configurable "Power Core (tm)" includes power amp and RF power management, switching and signal conditioning in ref. design

features a GSM/GPRS PA and an integrated PHEMT switch

SKY77601/4 improved performance under mismatch and lower current consumption

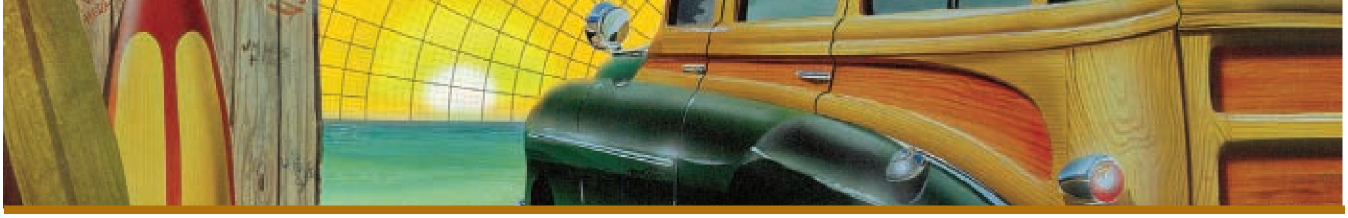
BiHEMT (PHEMT and HBT on same GaAs wafer), CuFlip: copper pillar die attach

TQM7M5013

Includes Hadron PA, and SP6T switch (Quad-band) or SP4T (Dual-band) to support 3G WPGRS and WEDGE

Silicon on Insulator (SoI)

Various low cost single pole four and eight throw switches SKY14152/3/5



Assignment: ANAHEIM

Radar

Radar Rik

For me, Radar Rik, attending the MTT-S in Anaheim in May is important on both a personal and professional level. The show offers networking opportunities, the chance to see the latest products on the exhibition floor and to connect and do business with suppliers and customers on a one-to-one basis in prearranged meetings. The sensitivity of my business, allied to a self-centered, melodramatic personality, prohibits me from divulging too much information. Suffice to say that my company designs, develops, builds and supports advanced ground, naval and airborne surveillance and tracking radar for both defense and commercial applications across the globe.

As well as involvement with individual contracts, we are also the main contractor or a subcontractor on a number of significant national/international projects and I shall be meeting up with fellow project managers to consider the technology that could be employed for imminent/ongoing collaborations.

Through an integrated business approach, which includes contract, project and supply chain management, design, software, hardware, systems engineering and manufacture, my company can offer a complete or part solution. Design software and components through to complete systems are all targets for me at the MTT-S and my simple task is to identify the technology and products that we can utilize to produce cost-effective, efficient and reliable solutions for our customers and feed that back to the relevant departments.

For instance, the design and development engineers are interested in the latest design software and simulation equipment and have told me to also be on the lookout for test and measurement equipment that could streamline and speed up test procedures.

In recent years the design emphasis has moved from hardware to software development mainly due to the continuous increase of both data and signal processing capacity that has made it possible to use cheap, generic processors, mostly COTS. Indeed, the use of commercial products has meant that companies such as ours have to look beyond traditional suppliers, and as a large percentage of device technology, especially power components and low noise front-ends, are being driven by the communications and broadcast industries, I shall be talking to companies active in these sectors too.

There has also been a significant reduction in the cost of microwave and hybrid integrated circuits for receivers and transmit/receive subsystems, which has led to the development and implementation of modular architectures such as multichannel receivers and phased arrays. With regards to integrated systems, the trend is for them to be designed for multiple functions, such as to improve surveillance (both active and passive), navigation and communication. Developments in all of these areas warrant investigation.

Current trends and hot topics include a shift towards fully electronically scanned arrays, multispectral apertures, frequency selective surfaces, solid-state devices, direct digital synthesis and adaptive systems with regards to the RF side, while the development of the 'back-end' concerns software beamforming, waveform design and encoding, element level digitisation, multi-aperture management, etc. What activity in these areas will be evident on the exhibition floor or in the conference sessions is unclear, but it will be interesting to find out.

From my preliminary contacts and the meetings that I have set up with potential clients and customers, I have expectations that I believe will be fulfilled. I also hope to find that unexpected nugget of information/idea/product.

Footnote: Radar Rik and his company are fictitious and any resemblance to any existing past or present person or company is purely coincidental.

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At Delta Microwave, we are committed to:
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Our commitment to these principles has made us one of the fastest growing RF and Microwave component companies in the world. When it comes to choosing a company to meet your rigorous requirements, there is a difference.
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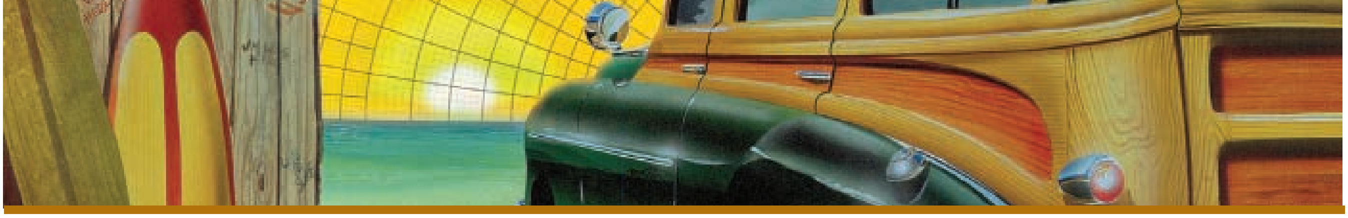
The List: Radar

Company	Product(s)	Notes
Test & Measurement:		
Agilent, Anritsu, Rohde & Schwarz	Network analyzers	*Check out new nonlinear capabilities - PNA-X; Vectorstar and ZVA, also Option H08 for pulsed RF from Agilent*
Agilent, Anritsu, Rohde & Schwarz, Tektronix	Signal/spectrum analyzers & digital oscilloscopes	
Focus Microwaves, Maury Microwave	Load-pull systems	*Waveform engineering and active harmonic tuning*
Aeroflex, Anritsu, Tektronix, Trilithic	Signal generators	*Consider Anritsu's MG37020A fast switching microwave signal generator and Aeroflex (2200 OEM Mod. Freq. Synth.)*
AR Worldwide, Empower RF Systems, MITEQ,	High power amp test systems, EMC test	
Boonton, Mini-Circuits, Micronetics, Noisecom	Power meters/sensors, noise sources	
Simulation Software:		
CST, Ansoft, Remcom	3D EM simulation	*Antenna design, radar cross section for electrically large structures*
Agilent, AWR, Sonnet	EEsof, Microwave Office	*RF circuit board design with planar EM and system simulation capabilities*
Systems:		
Cernex Inc., Cobham, Communications & Power Industries (CPI)	Antenna, transmitter, tracking systems, etc.	*Discuss Cobham's UWB time domain radar system that is used as the basis for single channel or multi-channel radars*
Subsystems:		
AML Communications, Cobham, Ducommun, Sage Laboratories, Teledyne Cougar	Transmit/receive subsystems and fully integrated subsystems	*Look at latest standard products and discuss custom design for upcoming project*
Assemblies, Front-ends, Receiver, Transceiver Modules:		
CPI, Ducommun, Networks International Corporation (NIC), Narda, MITEQ, Teledyne Cougar	Integrated microwave assemblies	*Consider Ducommun WiseWave millimeter-wave band sub-assemblies; NIC's duplexer LNA assemblies [L & S Band], and SYS9.0N01R three-channel X-band monopulse radar receiver and Model 127077 transmit/receive switch/amplifier from MITEQ*
Amplifiers:		
AML Communications, CTT Inc., Empower RF Systems, Quinstar Technology, Teledyne Cougar	Limiting, low noise and power amplifiers	*Find out how manufacturers are addressing the demand for more power*
Cables, Connectors and Waveguides:		
Astrolab, Carlisle Interconnect Technologies, Crystek Interconnects, EZ Form Cable, Huber + Suhner, MDL, Rosenberger, San-tron Inc, Spectrum Elektrotechnik, Spinner, Teledyne Storm, Tru Corp.	Cables, cable assemblies, connectors and interconnects	*Need products that are stable, reliable and rugged enough for harsh environments - look into Huber + Suhner's One-Stop Solution and investigate Spectrum's Components Group regarding design and manufacture of custom designs*
MDL, Spinner, Waveline, Cobham, Channel MW, RLC, Logus, Microtech	Waveguide systems	*Review advanced waveguide and coaxial components*
Rotary Joints:		
Cobham Sensor Systems	Rotary joints for ground based radar	*Investigate Kevlin Corp. offering*
Spinner	Rotary joints and slip rings for military and civilian radar systems.	*Look into waveguide/coaxial/slip ring combinations*
Semiconductors/RFICs/MMICs:		
Endwave, Hittite, Mimix Broadband, RFMD, Skyworks, RFHIC Corp.	Semiconductor, integrated circuit and materials development for radar applications	*Products: Hittite's HMC-C072 GaAs HBT ultra low phase noise amplifier module; Mimix Broadband's P1072-BD 34.0–37.0 GHz GaAs MMIC PA; RFHIC's wideband amplifiers (RRP models)*
Foundries:		
OMMIC, TriQuint Semiconductor, UMS, WIN Semiconductor	GaAs foundry services, PHEMTs and HBTs	
Actives - Power Transistors:		
Freescale, Integra Technologies, Microsemi, TriQuint Semiconductors	Power transistors and transmit/receivers. SiC, GaN, LDMOS and HV HBT (TriQuint)	*Products: Integra's S-band silicon bipolar power transistors; TriQuint Semiconductors' PowerBand(tm) RF transistors*
Passives - Isolators/Circulators/Attenuators/Filters, etc.:		
JQL, MECA Electronics, MESL Microwave, UTE Microwave	Isolators and circulators	*Products: MESL X-Band differential 4-port circulators or air-borne, ground and naval radars*
Anaren, American Microwave Corporation, Coilcraft, JQL, Logus Microwave, Micro Lambda, MECA Electronics, Reactel, UTE Microwave, Weinschel Associates, Werlatone	Surface mount couplers, attenuators, inductors, resistors, etc.	*The basic components - Products: Coilcraft's military grade RF Chip inductors*
K&L Microwave, Micro Lambda, NIC, Reactel	Filters - bandpass, high-pass etc. , diplexers, multiplexers	*Products: K&L's IB Series bandpass filter for ground base radar and the SH Series for general radar applications*



Assignment: ANAHEIM

Infrastructure

Peak-to-Average Power Pat

Peak-to-Average Power Pat works for a large cellular base station and infrastructure manufacturer in the purchasing department evaluating components for existing systems and new systems in development. He has an engineering background but works closely with the purchasing department to evaluate and select parts for procurement including new designs in R&D. He is one of a small group of engineers/managers attending MTT-S this year so several people have asked him to check out software, test equipment and components for various portions of their base station transmit and receive chains for both their 3G and future 4G systems. The company typically purchases components based on an overall cost/performance basis and sometimes finds it appropriate to buy integrated assemblies for portions of the systems as they can be more cost effective in some instances. This involves working closely with the supplier to design and test the subassembly properly so it can be dropped right into the system without problems.

The company often has needs for RF software for system simulation and component modeling so Peak-to-Average Power Pat needs to check out the major suppliers of software. His co-workers have scanned many of the MTT-S exhibitor's web sites and forwarded possible components and equipment to check out at the show. The test lab is looking for base station test equipment and conformance/verification test systems for newer standards like WiMAX and LTE. The test lab will also need supporting components such as test cables, standards, splitters, terminations, etc.

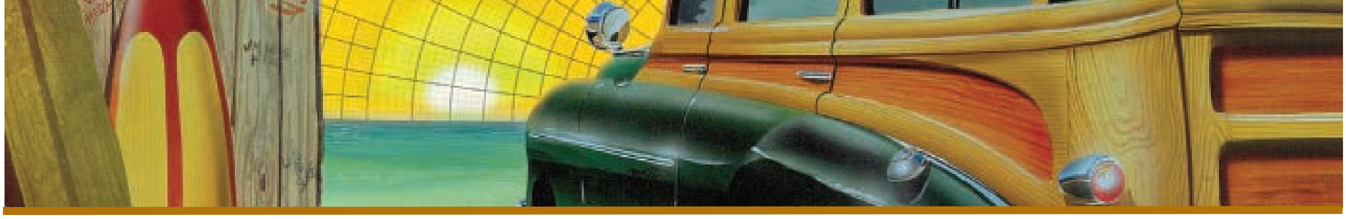
The system designers have forwarded a long list of various components for Peak-to-Average Power Pat to check out some newly released devices that might improve performance and/or reduce costs. The amplifier chains are a key area where they are looking for higher efficiency and more linear devices that will perform better in the new more demanding systems like LTE and WiMAX (OFDM applications). They also want to evaluate new technologies and device types such as GaN, next generation LDMOS and waveform engineered amplifiers that might help achieve these cost and performance goals without sacrificing reliability. That will help improve the transmit chain cost and performance. They are also looking to improve performance of the receive chain with better low noise amplifiers as some newly released devices appear to be below the 0.5 dB NF range, which would be an improvement over the current devices being used.

There is also a host of other devices in the transmit and receive chain that need to be reviewed such as VCOs, mixers, attenuators, switches, splitters, filters, etc. Lastly, Peak-to-Average Power Pat will evaluate suppliers who have the capability to integrate several components into subassemblies that could again reduce costs and improve performance by having suppliers provide portions of the base station as completed, fully tested sub-assemblies. This would help reduce the assembly constraints the company is currently experiencing by reducing the labor needed for each system. He will look for lower phase noise PLL solutions to achieve lower EVM for the system. He will need to look closely at how they can partner with these companies to ensure properly tested devices are shipped and that their reliability meets the system needs.

There is definitely a lot of ground to cover in one week so Peak-to-Average Power Pat will not be spending much time at Disneyland. He will sneak over to downtown Disney for dinner on most nights, probably with potential suppliers for extended discussions (and a little socializing).

The List: Infrastructure

Company	Product(s)	Notes
Test & Measurement:		
Aeroflex	TM500 DC-HSDPA Multi-UE Test Mobile	3G load testing
Agilent Technologies	SystemVue platform	LTE verification
	W1716 Digital Pre-Distortion builder	3G to 4G transition (high priority)
	N9030A PXA signal analyzer	BTS testing - priority
Anritsu	MT8820C Radio Communication Analyzer	LTE conformance
	MS2830A Spectrum Analyzer	BTS Testing - priority
Rohde & Schwarz	CMW500 wideband radio communication tester	Handoff testing
Tektronix, Trilithic, etc.		Scopes, etc.
Testing Support:		
Aeroflex	Splitter, attenuators, terminations, etc.	Need flexible configurations
AR	Amplifier systems	
See MWJ Cables & Connectors Supplement, March 2010	Cables/Connectors	Need stable, rugged test cables - worn cables are becoming a problem!
Simulation Software:		
Agilent Technologies	SystemVue Software	System design and evaluation
Ansoft	HFSS version 12.1 software	EM simulation of antennas and systems
AWR	Microwave Office and Visual System Simulator Software	EM simulation of antennas and systems
CST	CST Microwave Studio	EM simulation of antennas and systems
Others: Remcom, Sonnet, etc.		
Power Amps: Show me the Power!		
Nujira/TriQuint	TriPower w/ Coolteq.h	Very high efficiency - 2.1 GHz LTE 52%, GaAs (new technology to check out!)
RFMD	RF3931	30 W, GaN -
Freescale	Simplified Doherty designs	50 V LDMOS- check out HV8
Skyworks, M/A-COM, Hittite, RFHIC, Narda, Mimix, MicroSemi, Ciao, Mini-Circuits, ADI, Ommic		Check out any other options - perhaps custom sub-assembly
LNAs:		
Avago	MGA-633P8	NF as low as 0.37 dB - How low can you go!
Skyworks	SKY65037&40-360LF	NF 0.7 dB, dual stage
Mini-Circuits	PMA-5451+, TAMP-960LN+	NF 0.55 dB SMT
RFMD, Hittite, TriQuint, ADI, etc.		Check out any other options
Passives - Splitters/Combiners/Circulators/Coupler/Transformers:		
M/A-COM, Narda, Miteq, Trilithic, Weinschel, etc.	Circulator/combiner or power amplifier sub-assemblies?	Custom integrated assemblies? Can we work closely with these suppliers??
Anaren, Mini-Circuits, Synergy, Meca, Coilcraft, EMC, JQL, Tecdia, UTE, Filtel	Couplers, circulators, transformers, etc.	Standard products, SMT
		Check out new Zinger (Anaren)
		WiMAX splitters-Meca
VCOs:		
Crystek	CVCO55CC-1700-1700	-120 dB @ 10 kHz
Synergy	DCRO168172-8	-116 dB @ 10 kHz (new minatures)
Mini-Circuits	ROS-1960-219+	-121 dB @ 10 kHz
Z-Comm	ZRO1920A1LF	-117 dB @ 10 kHz
Valpey Fisher, ADI, Vectron, etc.		
Mixers:		
Hittite	HMC915LP4E	double-balanced GaAs MMIC
Mini-Circuits	SYM-63LH+	Wide band mixer
Synergy	SFM-5	
Anaren, ET, ADI, Skyworks, Mimix, M/A-COM, RFMD, TriQuint		
Switches/Attenuators:		
Mini-Circuits	HSWA2-30DR+	Check out low cost switches
M/A-COM	MASW-000825-12770T	Check out HMIC switches
Skyworks	SKY13286-359LF	High isolation
Hittite	HMC792LP4E	6-bit digital
RFMD	RF3021	High isolation, 58 dB?
JFW, Lorch, MECA, ET, RLC, EMC, ADI, TriQuint, Anaren		
Filters:		
Reactel, RLC, Filtel, K&L, Lorch	Custom designs?	1900 MHz Diplexers/Filters, etc.



The Anaheim Connector

Free time is hard to account for during Microwave Week. The IMS, RFIC, ARFTG conferences, the microwave exhibition and the various social events keep most attendees quite busy. This year's show in Anaheim probably won't be any different. In order to be more efficient with your time, the staff here at *Microwave Journal* has compiled a brief guide to help you find your way around town.

Visitors to the city may want to start by getting a quick lay of the land. Both **www.anaheimoc.org** and **www.comevisitanaheim.com** provide plenty of information regarding local restaurants, hotels, events and transportation. No trip to Anaheim would be complete without a trip to Disneyland, of course, and **http://disneyland.disney.go.com** has got you covered with prices, discounts and special events.

There are a couple of good sites that can help you decide where to eat. Both **www.anaheim.diningguide.com** and **www.letseatoc.com/anaheim.htm** break down a variety of Anaheim restaurants by location and cuisine. In addition, the new Shops at Anaheim GardenWalk (**www.anaheimgardenwalk.com**) offers 46 different stores and restaurants for you to choose from.

Photo courtesy of AOCVCB.

All Anaheim Tours (**www.allanaheimtours.com**) provides a great way to see Anaheim and the surrounding area. The company offers bus tours to theme parks like Universal Studios, Sea World and Six Flags Magic Mountain, the cities of Hollywood and Los Angeles, and longer trips to Las Vegas and even the Grand Canyon.

Good news for baseball fans: The Los Angeles Angels of Anaheim are at home during Microwave Week for games vs. the Toronto Blue Jays and the Seattle Mariners. Incidentally, the Angels will be hosting the 2010 Major League Baseball All-Star game. Visit **http://losangeles.angels.mlb.com** for more information.

Together on Twitter

Join in the fun and social media scene by using the Hashtag (or keyword) #MTTS2010 in your Tweets so everyone can follow the action. The "#" indicates the word is a Hashtag (developed by Hastags.org) and the text following it is the keyword. At last year's symposium we had a handful of companies Twittering about the latest product releases, news, social events and happenings on the show floor. We encouraged everyone to use a Hashtag and had a search feed displaying all the Tweets on our Online Show Daily web site. We will be doing the same this year.

If you do not yet have a Twitter account, go to **Twitter.com** and click "Sign up now." Pick a username and password and you are good to go. It's also helpful to upload a picture and complete any other desired profile information.

The Twitter network works even if the user is not at a computer or browsing the Web. Once you are registered, you can connect your mobile phone and instant messenger (IM) account. Go to Settings/Mobile to set up text messaging. There are many free applications for your mobile device that will allow you to send Tweets easily with your mobile device without dialing 40404 to send messages.

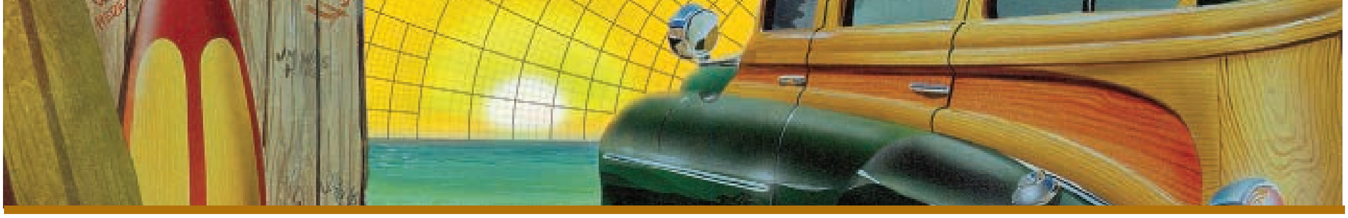
Use Twitter to note interesting sessions, new products, social events, good giveaways, interesting demos on the show floor, good restaurants and bars, etc. If everyone does a couple of Tweets a day about favorite (and not so favorite) things that have been found around town, everyone will know where the good restaurants and watering holes are in the area. It will also allow everyone to know in real time the exciting activities that are going on at the show or after hours.

Visit the *Microwave Journal* web site for the Twitter feed at **www.mwjournal.com**. Remember to use the Hashtag #MTTS2010 and trace the MWJ staff on Twitter by following David Vye @mwjournal, Pat Hindle @pathindle and Kristen Andersen @KAatMWJ.

MWJ Staff


2010 IEEE MTT-S INTERNATIONAL MICROWAVE SYMPOSIUM
MAY 23-28, 2010 • ANAHEIM, CALIFORNIA
THE GOLDEN STATE OF MICROWAVES
2010 IMS Conference Hotel Locations
A Anaheim Convention Center
1 Hilton Anaheim Hotel – Headquarters Hotel
2 Anabella Hotel
3 Best Western Stovall's Inn
4 Clarion Hotel Anaheim Resort
5 Crowne Plaza Anaheim Resort
6 Hyatt Regency Orange County
7 Portofino Inn & Suites
8 Red Lion Anaheim Maingate Hotel
9 Sheraton Park Hotel at the Anaheim Resort
10 Desert Palms Hotel & Suites
Ball Road
Walnut Street
Disneyland Drive
Disneyland®
Disneyland Park
Disney's California Adventure Park
SANTA ANA
FREEWAY
Disney Way
GARDENWALK
Katella Avenue
Haster Street
Manchester Avenue
Orangewood Avenue
West Street
Harbor Boulvard
Chapman Avenue
N
approx. 1/2 mile
map not to scale
State Collage Boulevard
ORANGE FREEWAY
Honda Center
Katella Avenue
GROVE OF ANAHEIM
Angel Stadium of Anaheim
Orangewood Avenue
5
57

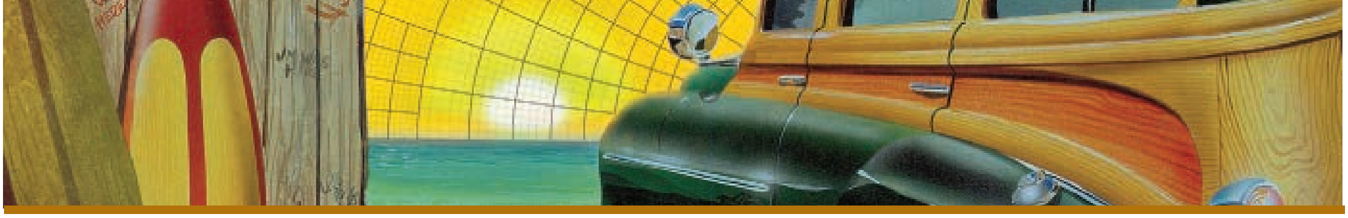
Map of Anaheim area provided courtesy of CTT, Inc. Stop by CTT's Booth 1806



2010 IMS Exhibitors

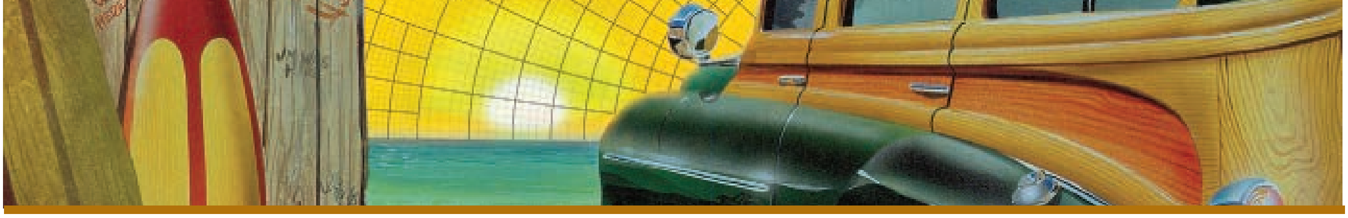
The following list is complete as of March 19, 2010. Exhibitors in bold have an ad in this issue.

2COMU	617
A-Alpha Waveguide Co.	2714
A.J. Tuck Co.	3524
A.T. Wall Co.	2018
Actipass R&M Co. Ltd	2842
AdTech Ceramics	1735
Advanced Control Components Inc.	2900
Advanced Test Equipment Rentals	2019
Aegis Technology Inc.	3226
AEM Inc.	2515
Aeroflex Inc.	1310
Aethercomm Inc.	2713
AFM Microelectronics Inc.	2403
Agilent Technologies	924
AI Technoloy Inc.	2502
Airpoint Co. Ltd.	3610
AKON Inc.	1613
Aldetec Inc.	2630
Allrizon-TG Communications Equipment	1020
Allstron Corp.	3414
AMCAD Engineering	1729
American Microwave Corp.	1833
American Standard Circuits Inc.	638
American Technical Ceramics	1706
Ametek HCC Industries	1813
AML Communications Inc.	2600
Amplifier Solutions Corp.	1331
AmpliTech Inc.	3030
Analog Devices Inc.	3330
AnaPico AG	1640
Anaren Inc.	327
Anatech Electronics Inc.	1344
Anoison Electronics	2938
Anritsu Co.	2910
ANSYS Inc. (Ansoft Products)	2700
Antenna Research Associates-ARA Inc.	500
Antenna Systems/Webcom Communications	2512
APA Wireless Technologies	1816
Applied Thin-Film Products	2406
AR RF/Microwave Instrumentation	3400
ARC Technologies Inc.	802
Arlon Tech. Enabling Innovation	2804
Artech House	3302
ASB Inc.	2836
Assemblies Inc.	1702
Astrolab Inc.	713
ATK	1637
Auriga Measurement Systems LLC	1028
Aurora Software & Testing SL	2541
Avago Technologies	1506
Aviel Electronics	2742
AWR Corp.	1318
AWT	519
Axiom Test Equipment Inc.	3710
B&Z Technologies	3327
Barry Industries Inc.	2421
BEEcube Inc.	3201
Beijing Corelogic Communication Co. Ltd.	942
Besser Associates Inc.	1005
Bliley Technologies Inc.	2828
Bowei Integrated Circuits Co. Ltd.	3227
Brush Ceramic Products	1638
C.W. Swift & Associates Inc.	1513
C-Tech	3137
C.E. Precision Assemblies Inc.	2426
CAD Design Software	700
Cadence Design Systems Inc.	3203
Cambridge University Press	604
Camponil Electronics Inc.	3030
CAP Wireless Inc.	2306
CapeSym Inc.	2405
Carlisle Interconnect Technologies	833
Cascade Microtech Inc.	1128
Centellax Inc.	2119
Cernex Inc.	2943
Channel Microwave Corp.	1018
Charter Engineering Inc.	1512
Chin Nan Precision Electronics Co. Ltd.	503
Ciao Wireless Inc.	2503
Cirexx International Inc.	2601
Coastline Metal Finishing Corp.	328
Cobham	1303
Coilcraft Inc.	1900
Coining Inc.	2614
Coleman Cable Inc.	1104
Coleman Microwave Co.	1604
Colorado Microcircuits	1836
COM DEV Ltd.	928
Communications & Power Industries	820
Compex Corp.	2829
Component Distributors Inc.	2505
COMSOL Inc.	2001
Connecticut Microwave Corp.	819
Connectronics Inc.	3128
Constant Wave Inc.	2937
Corning Gilbert Inc.	1006
Corry Micronics Inc	31
CORWIL Technology Corp.	1918
Crane Aerospace & Electronics	717
Crane Polyflon	719
Cree Inc.	836
Cristek Interconnects Inc.	2401
Crystek Corp.	3231
CST of America Inc.	2924
CTT Inc.	1806
Cuming Microwave Corp.	2945
Custom Cable Assemblies Inc.	2633
Custom Interconnects	1904
Custom Microwave Components Inc.	1437
Custom MMIC Design Services Inc.	1730
Daa-Sheen Technology Co. Ltd.	3502
dBm	2617
Defense Tech Briefs & RF & Microwave Tech	1044
Delta Electronics Mfg. Corp.	2706
Delta Microwave	2941
Design Workshop Technologies Inc.	737
DeWeyl Tool Co. Inc.	2629
Diablo Industries Thin Film	3202
Diamond Antenna & Microwave Corp.	741
Dielectric Laboratories Inc.	1619
Diemat Inc.	1142
DiTom Microwave Inc.	1100
Doo Sung Industrial Co. Ltd.	2017
Dorado International Corp.	1004
Dow Key Microwave Corp.	1715
Ducommun Technologies Inc.	706
Dyconex AG	2404
Dynawave Inc.	1828
e2v	329
EADS North America	613
Eagle Comtronics, Inc.	629
Eastern-Optx/NoiseXT	1818
Eclipse Microwave Inc.	1101
EE-Evaluation Engineering	3604
Electro Rent Corp.	1031
ElectroMagneticWorks Inc.	3600
Elisra Electronic Systems Ltd.	1834
EM Research Inc.	1810
EM Software & Systems-FEKO	2400
EMAG Technologies Inc.	701
EMCO Elektronik GmbH	3230
Emerson & Cuming Microwave Products	2615
Emerson Connectivity Solutions	3306
Empower RF Systems	1631
Endwave Corp.	2724
Epoch Microelectronics Inc.	3234
Epoxy Technology Inc.	3037
ET Industries	3133
ETL Systems	1628
ETS-Lindgren	1030
EuMW2010	3304
Euvis Inc.	2834
Excelics Semiconductor Inc.	1336
EZ Form Cable Corp.	3314
F&K Delvotec Inc.	510
Ferraz Shawmut Inc.	3221
Ferrite Co., The	521
Ferro-Ceramic Grinding	1934
Filtel Microwave Inc.	2504
Flann Microwave	1038
Flexco Microwave Inc.	2940
Florida RF Labs/EMC Technology	920
Focus Microwaves Inc.	2821
Fotofab	2000
Freescale Semiconductor	3106
Frontlynk Technologies Inc.	2934
FTG Corp.	3521
FujiFilm Dimatix Inc.	2300
FutureComm Co. Ltd.	1537
General Dynamics Satcom Technology	3620
Gerotron Communication GmbH	3230
GGB Industries Inc.	1144
GigaLane Co. Ltd.	1733
Gigatronics Inc.	1113
Global Communication Semiconductors	2841
GNI Microwave Co. Ltd.	3519
Gowanda Electronics	1538
Greenray Industries Inc.	1736
GuangShun Electronic Tech. Research Inst.	3131
Hantechnic Inc.	505
Harbour Industries Inc.	1703
Herley Industries	2101
Herotek Inc.	2831
Hesse & Knipps Inc.	3317
High Frequency Electronics	2510
Historical Booth	3530
Hittite Microwave Corp.	2105
Holzworth Instrumentation Inc.	628
Huada Intl. Electronics & Technology	1740
Hunter Technology	3518
HXI LLC	3706
IBM Corp.	3526
IEEE Microwave Magazine	400
IHP GmbH	1728
IMST GmbH	3511
In-Phase Technologies	829
INGUN Pruefmittelbau GmbH	514
Innertron Inc.	2734
Innovative Micro Technology	502
Instek America Corp.	1801
Instruments For Industry (IFI)	3500
Integra Technologies Inc.	2425
Integrand Software Inc.	3427
International Manufacturing Services	3003
Ion Beam Milling Inc.	816
Ironwood Electronics	632
Isola	1610
ISOTEC Corp.	1819
ITF Co. Ltd.	1536
ITT Microwave Systems Corp.	3032



IW Inc. (Insulated Wire) 2006
J MicroTechnology Inc. 1713
Jersey Microwave LLC 2202
JFW Industries Inc. 700
Johanson Manufacturing Corp. 607
Johanson Technology Inc. 2612
JQL Electronics Inc. 1040
Junper Interconnection Inc. 2002
Jye Bao Co. Ltd. 1815
K&L Microwave Inc. 1718
Kemac Technology Inc. 3120
Keragis Corp. 1103
Krytar Inc. 1338
KVG Quartz Crystal Technology GmbH 3513
Kyocera America Inc. 2818
L-3 Communications 3002, 3102
LA Techniques Ltd. 1817
LadyBug Technologies LLC 1037
Lake Shore Cryotronics Inc. 301
Lanjian Electronics 1541
Lansdale Semiconductor Inc. 2604
Lark Engineering Co. 611
Laser Process Mfg. Inc. 1936
Laser Processing Technology Inc. 619
Laser Services Inc. 2304
Lehrstuhl für Technische Elektronik 3230
Linearizer Technology Inc. 1804
Lintek Pty Ltd. 2631
Litron Inc. 1812
LNX Corp. 2200
Logus Microwave Corp. 1519
Lorch Microwave 1016
LPKF Laser & Electronics 600
M/A-COM Technology Solutions 2905
M2 Global Technology Ltd. 2929
Marcel Electronics International 3506
MathWorks 605
Maury Microwave Corp. 726
McGraw-Hill Professional 2501
MECA Electronics Inc. 2204
Mega Circuit Inc. 3038
MegaPhase 631
Meggitt Safety Systems Inc. 2917
Merrimac Industries Inc. 3320
MESL Microwave Ltd. 517
Metropole Products Inc. 1002
MIcable Inc. 1036
Mician GmbH 1710
Micreo Ltd. 2731
Micro Communications Inc. 3135
Micro Lambda Wireless Inc. 1300
Micro-Coax Inc. 734
Micro-Mode Products Inc. 1938
MicroApps 524
MicroFab Inc. 738
Micronetics Inc. 1140, 1340
Microphase Corp. 511
Microsemi Corp. 1905
Microtech Inc. 2417
Microwave Applications Group 3517
Microwave Circuits 1102
Microwave Communications Labs Inc. 1013
Microwave Development Labs Inc. 2826
Microwave Dynamics 1003
Microwave Engineering Corp. 407
Microwave Engineering Europe 2738
Microwave Filter Co. Inc. 818
Microwave Journal 3300
Microwave Marketing.com Ltd. 1811
Microwave Packaging Technology 3412
Microwave Product Digest 2930
Microwave Technology Inc. 2420
Microwavefilters S.R.L 2301
MIG-Microwave Innovation Group 2832
Millitech Inc. 916
Mimix Broadband 1119
Mini-Circuits 531
Mini-Systems Inc. 1118
MITEQ Inc. 3117
Mitsubishi Electric & Electronics 1315
Modelithics Inc. 1131
Modular Components National Inc. 3224
Molex 1517
Momentive Performance Materials 736
Mosis 2727
MPDevice Co. Ltd. 2931
MtronPTI 2500
Murata Electronics 906
Naeco 2732
Namics Technologies Inc. 1142
Nanjing Jiexi Technologies Co. Ltd. 602
National Instruments 322
National Reconnaissance Office 321
NAVICP 315
NDK 711
Nearfield Systems Inc. 931
Netcom Inc. 1805
Networks International Corp. (NIC) 940
Nitronex Corp. 2317
NoiseWave Corp. 3312
Norden Millimeter Inc. 817
Northrop Grumman 302
NTK Technologies Inc. 3233
NTT Advanced Technology 3034
Nuhertz Technologies LLC 733


GaN HEMT
High Volume Production
Over 400,000 devices shipped
Now SUMITOMO ELECTRIC
Formerly Eudyna
High Efficiency,
High Power, Wide Band



Nujira Ltd. 411
Nuvotronics 1829
NuWaves Engineering 3413
NXP Semiconductors 324
OEwaves Inc. 2517
OMMIC 2837
OPHIR RF Inc. 2736
Orient Microwave Corp. 2704
P1dB Inc. 1331
PA&E 3621
Partron Co. Ltd. 3235
Pascall Electronics Ltd. 1738
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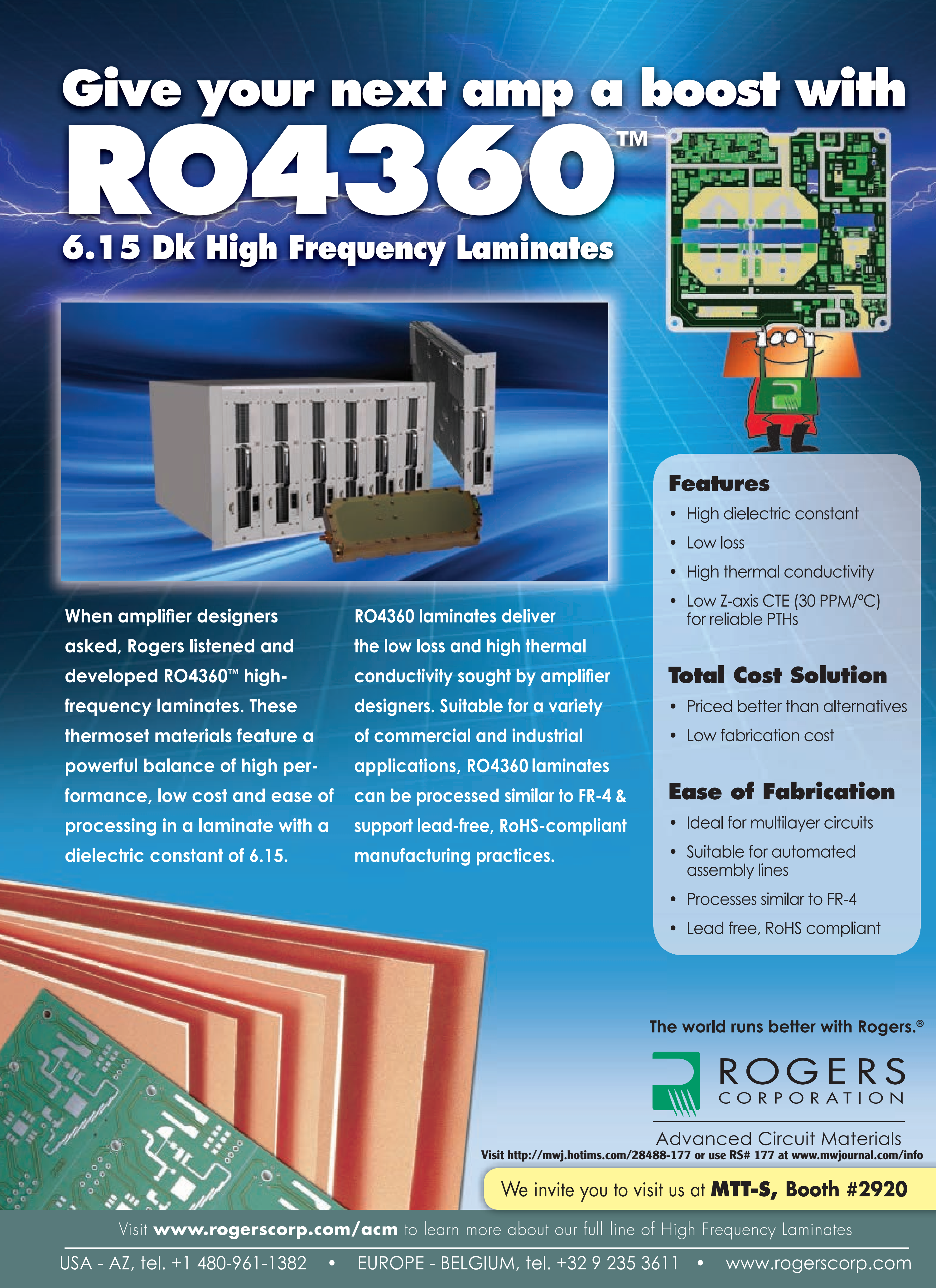

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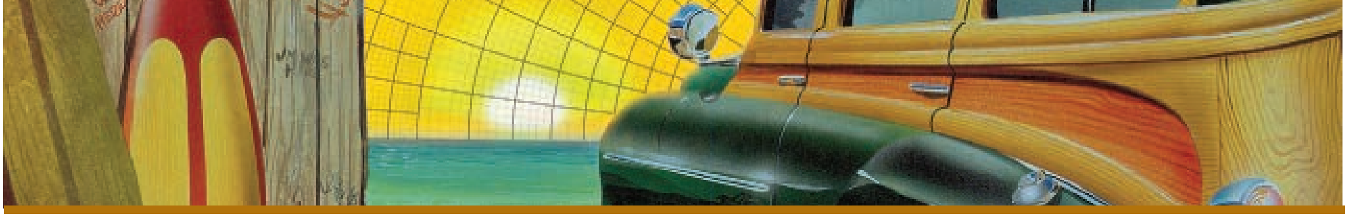

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Part Number	*F Low (MHz)*	*F High (mHz)*	*Output Power (dBm)*	*10 kHz Phase Noise (dBc/Hz)*	*100 kHz Phase Noise (dBc/Hz)*	*Pushing (MHz/V)*	*Pulling (MHz p-p at 2:1 VSWR)*	*Power Supply*
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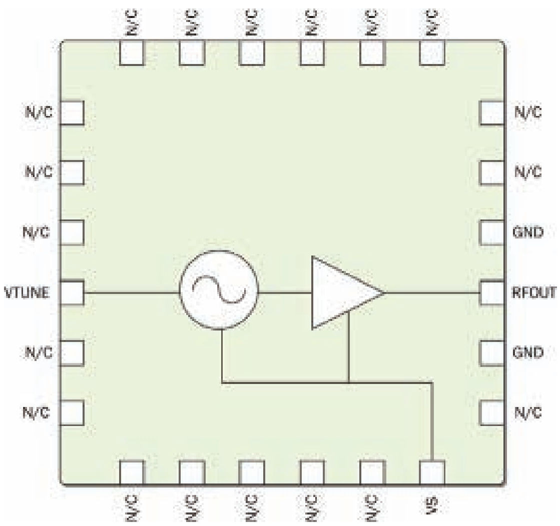

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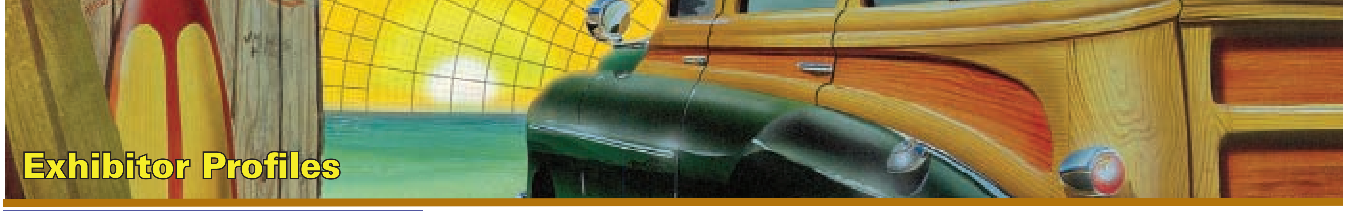

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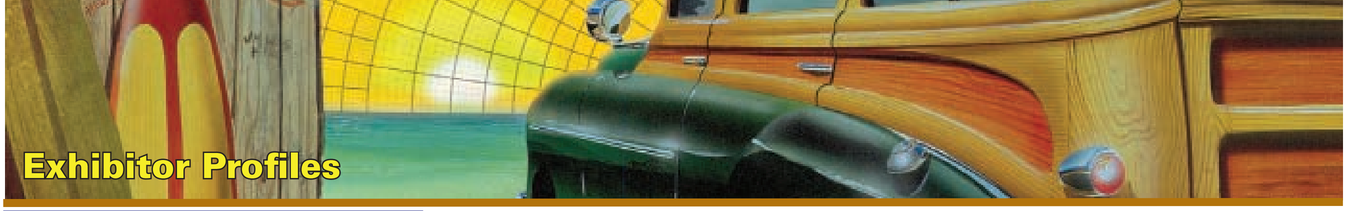

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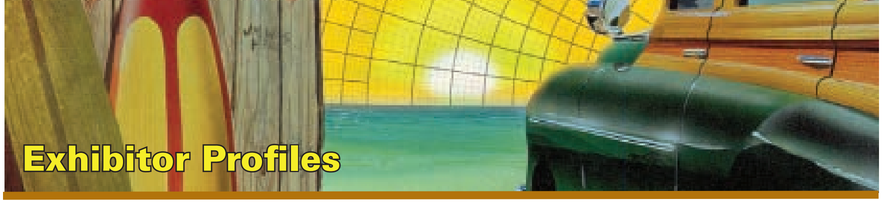

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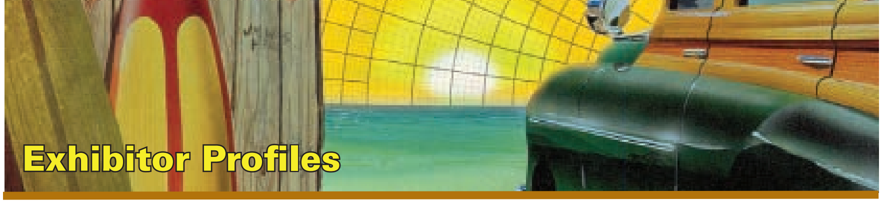

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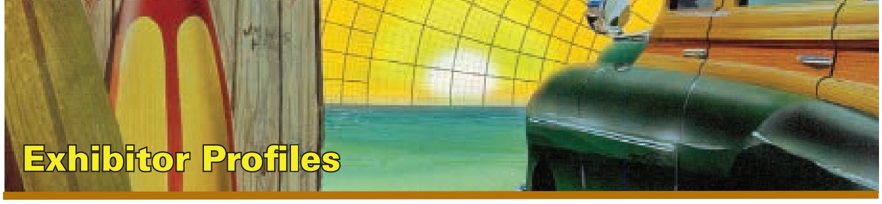

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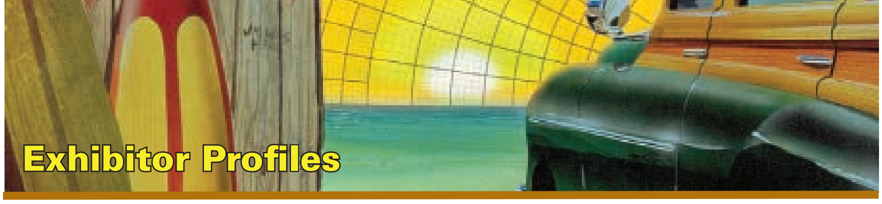

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CPI BMD designs and manufactures a broad range of microwave products for radar, communications and industrial heating applications. CPI BMD is the world's largest manufacturer of receiver protectors and related products. Other product lines include Integrated Microwave Assemblies, Control Components, Magnetrons, TWTs, CFAs, Transmitter Assemblies, Industrial Heating Systems, High-Power Solid State Switches and Switch Assemblies, Pressure Windows and a wide variety of multifunction super components and subassemblies.

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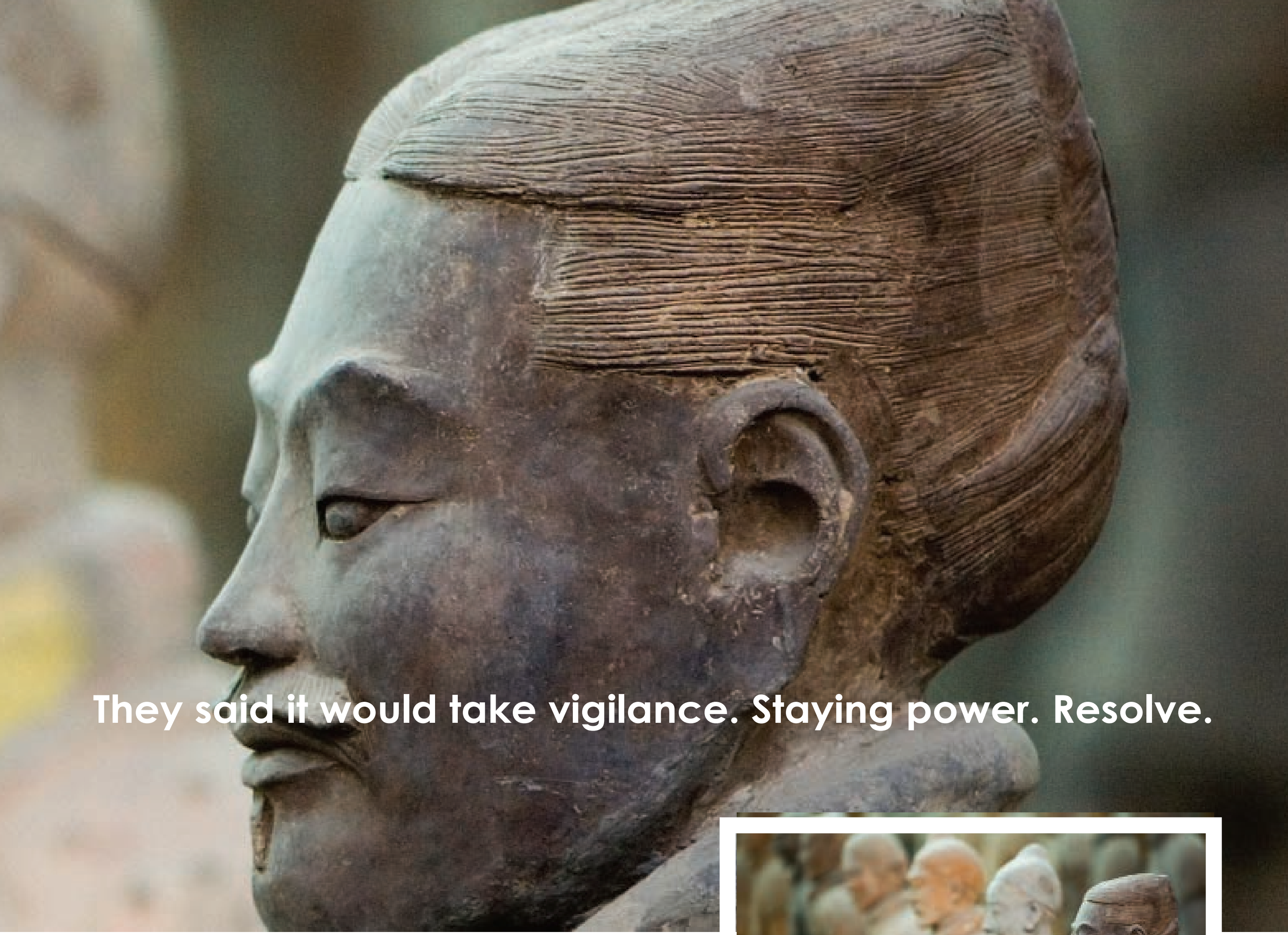
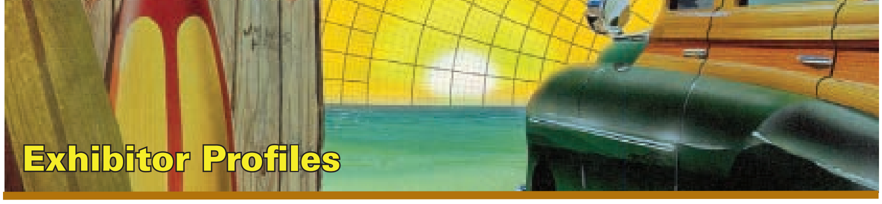

They said it would take vigilance. Staying power. Resolve.



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At IMS 2010, CTT is pleased to introduce three new products, including: A low-noise amplifier offering < 3 dB noise figure (2.5 dB typical), 1 GHz thru 18 GHz. Performing over more than four octaves, the amplifier finds a myriad of applications in instrumentation thru spread-spectrum. A 20 W power amplifier for tactical common data links (TCDL),14.4 to 15.35 GHz in both UAV and manned applications. A production version of CTT's Ka band (30.0 to 31.0 GHz) upconverter for SATCOM applications that require four, eight, or 12 W options.

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Delta Electronics Manufacturing Corp. is a leading manufacturer of over 80 different series of high quality, competitively priced RF/Microwave Connectors, Flexible and Semi-rigid cable assemblies, Transmission Line and Antenna assemblies as well as RF related subassemblies. Delta also offers the added service of Barrel and Rack Electroplating from our ISO9001:2008 certified Beverly, MA, facility (NADCAP Certification in process). Delta is a global manufacturer with facilities in the US, China and Taiwan.

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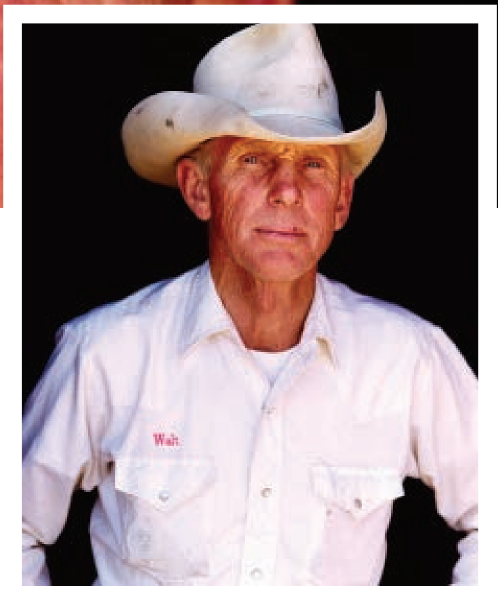
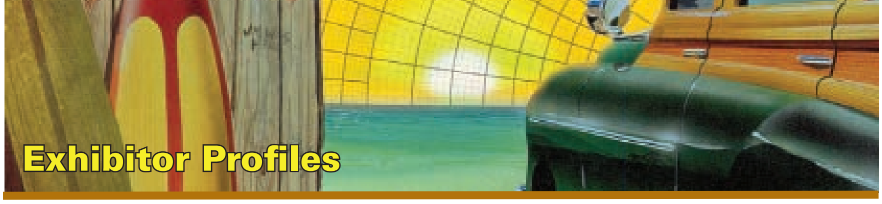
Founded in 1973, Delta Microwave is a top manufacturer of custom and standard microwave components. Our product lines include Filters, Filter/Amplifiers, Multiplexers, Passive Components, and Integrated Microwave Assemblies covering frequencies from 1 MHz to 40 GHz. Applications for our products include Space Flight, Military, and High Reliability Commercial. Delta Microwave's new 36,000 square foot facility with full design, manufacturing, and environmental test capabilities on-site provide the means to manufacture custom components affordably and quickly.

Booth No. 2941


They said only the strongest and most determined would be able to tame the new frontier.





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E-mail: sales@dilabs.com

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Fax: +972 3 6175299
E-mail: trm1@elisra.com

www.mw-elisra.com

Elisra Microwave Division has over 40 years of proven experience in supplying subassemblies for a wide variety of RF and microwave applications covering the frequency range of 1 MHz to 50 GHz. Our product list contains many kinds of customized microwave modules based on RF Multi-Layer technology. Among of our products: Super Heterodyne Receivers, Digital Instantaneous Frequency Measurement Modules (DIFM), Millimeter-Waves input Down Converters Modules, Solid-State High Power Amplifiers, LNAs, High Power PIN Diode switches, etc.

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EMC Technology/Florida RF Labs is a global leader in RF & microwave resistive components, including high frequency and high power attenuators and terminations. EMC Technology is the world's number 1 supplier of temperature variable and fixed attenuators, featuring our patented Thermopad® line of products. Florida RF Labs is a leading supplier of high-reliability Microwave cable assemblies and signal distribution components featuring the Hybrix® line of hybrid and directional couplers, power dividers and crossovers.

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Fax: (310) 412-9232

www.EmpowerRF.com

Empower RF Systems, headquartered in Los Angeles, CA, designs and builds solid state high power amplifiers and amplifier-based integrated assemblies. Products are offered as building block modules or rack mount amplifier solutions for deployment in defense and commercial applications. The company is featuring an array of amplifier products that utilize the latest device technologies, including high efficiency Gallium Nitride (GaN). Visit us at Booth 1631 to view a selection of our best amplifier products.

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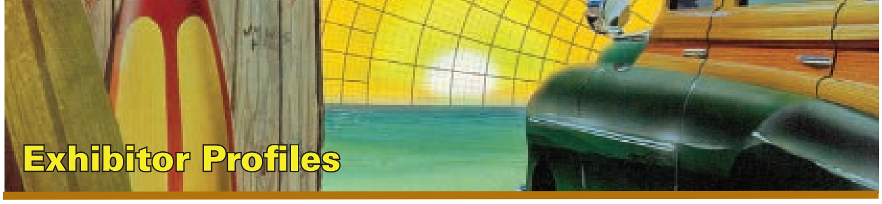

Exhibitor Profiles

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130 Baytech Drive
San Jose, CA 95134
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E-mail: info@endwave.com

www.endwave.com

Endwave Corp. designs, manufactures and markets RF MMICs and modules that enable the transmission, reception and processing of high-frequency signals. In addition to a broad line of high performance commercial and military caliber MMICs, Endwave is a leading provider of integrated transmit and receive modules that function in the microwave through millimeter-wave frequency range and serve the point-to-point radio market. Endwave has 42 issued patents covering its core technologies including semiconductor and proprietary circuit designs. Corporate headquarters are located in San Jose, CA, with other operations in Salem, NH, and Chiang Mai, Thailand.

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European Microwave Week is the largest event dedicated to RF, Microwave, Radar and Wireless Technologies in Europe. Capitalising on the success of the previous shows, the event promises growth in the number of visitors and delegates. EuMW 2010 will provide: 7,000 sqm of gross exhibition space; 5,000 key visitors from around the globe; 1,700 - 2,000 conference delegates; In excess of 250 exhibitors. Running alongside the exhibition are 4 separate, but complementary conferences: EuMIC; EuMC; EuWiT; EuRAD Plus Workshops and Short Courses. Interested in exhibiting? Book online now.

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www.ezform.com

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Fax: (450) 424-5819
E-mail: filtel@filtel.com

www.filtel.com

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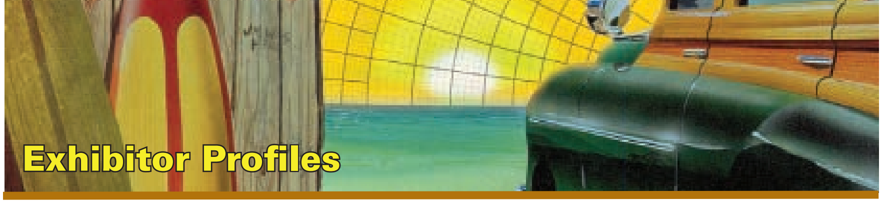

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With a 'can-do' attitude, Frontlynk management and staff alike treat each business opportunity with the type of open mind and flexibility that ever increasing customized requirements deserve. Furthermore, we realize that repeat business can only be achieved by getting it right every time, in an atmosphere of trust and honesty. Please surf our website www.frontlynk.com for details.

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Holzworth Instrumentation provides high performance RF Synthesizers, Multi-tone Signal Generators and Phase Noise Analyzers. Holzworth RF Synthesizers are well known for industry leading phase noise performance and unparalleled frequency stability. The proprietary non-PLL based synthesis architectures create phase coherent, phase continuous signals that provide both absolute and relative frequency accuracy. Industry leading performance, coupled with compact form factors have made Holzworth products a preference for embedded OEM and test system applications since 2004.

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ITT Microwave Systems designs and develops leading edge RF and Digital subsystems in support of the US Armed Services and Government Agencies.

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JQL Electronics Inc. is a technology company, designing and manufacturing microwave passive components and subsystems, such as ferrite isolator/circulators, directional couplers, power divider, combiners, ceramic filters waveguide components and solid state power amplifiers. With cutting edge design capabilities, JQL delivers innovative design, precise manufacturing, fast delivery and dedicated customer service to the customers. "No design is too challenge, no job is too big or small, and no customer is too little."

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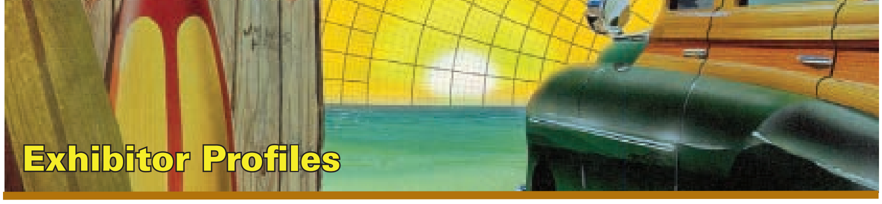

K&L Microwave
2250 Northwood Drive
Salisbury, MD 21801
Tel: (410) 749-2424
Fax: (443) 260-2268
E-mail: sales@klmicrowave.com

www.klmicrowave.com

K&L Microwave offers a full line of RF and microwave filters, duplexers, and subassemblies for military and commercial applications, including ceramic, lumped element, cavity, waveguide and tunable filters, as well as switch filter banks, high-performance receive and transmit filters, delay line filters, combiners, receive multi-couplers and base station wireless system assemblies.

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KRYTAR specializes in the design and manufacture of ultra broadband RF, microwave, and millimeter-wave components and test equipment covering the DC to 67.0 GHz frequency range. The KRYTAR product line includes directional couplers, 3 dB hybrids, MLDD power dividers/combiners, detectors, dual-directional couplers, directional detectors, terminations, coaxial adapters and a power meter.

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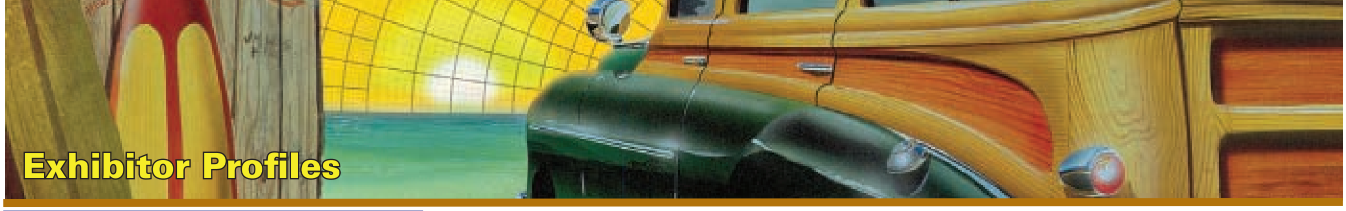

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A leading manufacturer of metrology-grade precision calibration standards and device characterization solutions operating from DC to 110 GHz. Products include Automated Tuner-based RF Device Characterization Systems, Precision Calibration Standards, Cryogenic and Thermal Noise Calibration Systems and Components, RF Adapters, and VNA Calibration Kits in most transmission line sizes and connector types, including rectangular waveguide devices in sizes rated up to 110 GHz. Maury's newest offering, the Tacti-Cal™ line of Instrument-Grade calibration standards, is now available.

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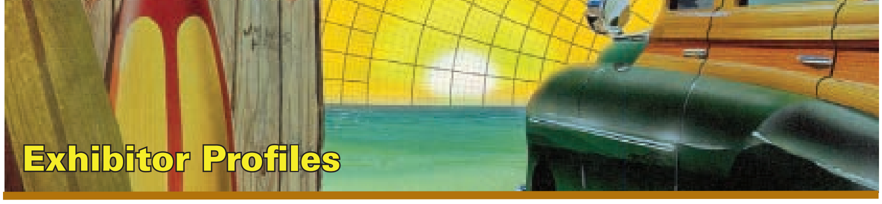

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Tel: +86 591 87382856
Fax: +86 591 87382857
E-mail: sales@micable.cn

www.micable.cn

MIcable Inc. is a high-tech enterprise formed by SSI Cable Corp. of the USA and Mitron Inc. of China, which manufactures and sells microwave coaxial cable assemblies. MIcable's manufacturing process and techniques are completely introduced by SSI Cable Corp. It has the advanced manufacturing and testing equipments related to cable assembly production and the production line is set up according to strict quality control standard (ISO9001:2008 certified).

Booth No. 1036

MiCIAN

Mician GmbH
Schlachte 21
28195 Bremen,
Germany
Tel: +49 421 168 993 51
Fax: +49 421 168 993 52

www.mician.com

Mician develops and markets software products for fast and advanced EM-designs. Mician's major product is the full wave 3D simulation software µWave Wizard™. The software tool includes features such as 64 bit capability (including multiprocessor capabilities) and fast frequency sweep based on adaptive rational function interpolation. Typical applications for µWave Wizard™ are complex passive waveguide components and structures like waveguide and comb line filters; couplers, tapers, multiplexers and horn antennas.

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For over 40 years, MICRO-COAX has been serving the defense, telecommunications, airframe, spaceflight and test/measurement marketplaces. With a reputation for excellent customer service and unmatched reliability in our high-performance transmission line products, MICRO-COAX offers innovative and practical solutions for your RF/microwave needs. Our products are designed and manufactured in our Pottstown, PA facility, which is how we offer a price/performance ratio unequaled in the industry. No matter what the transmission line problem – MICRO-COAX has the solution.

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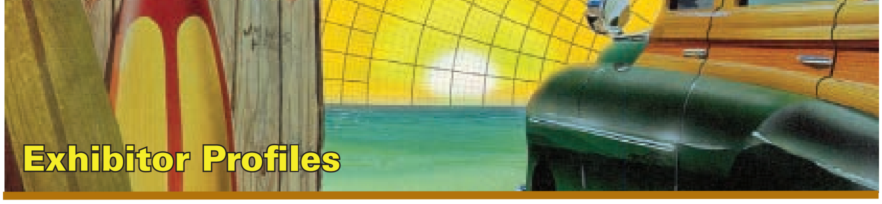

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Fax: (203) 271-0352
E-mail: sales@microtech-inc.com

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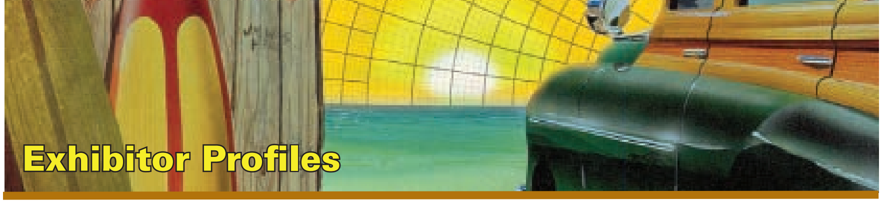

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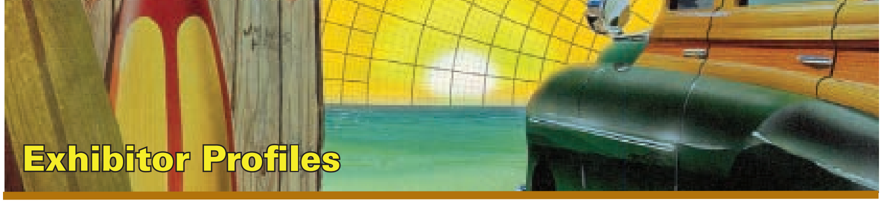

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Booth No. 3002, 3102

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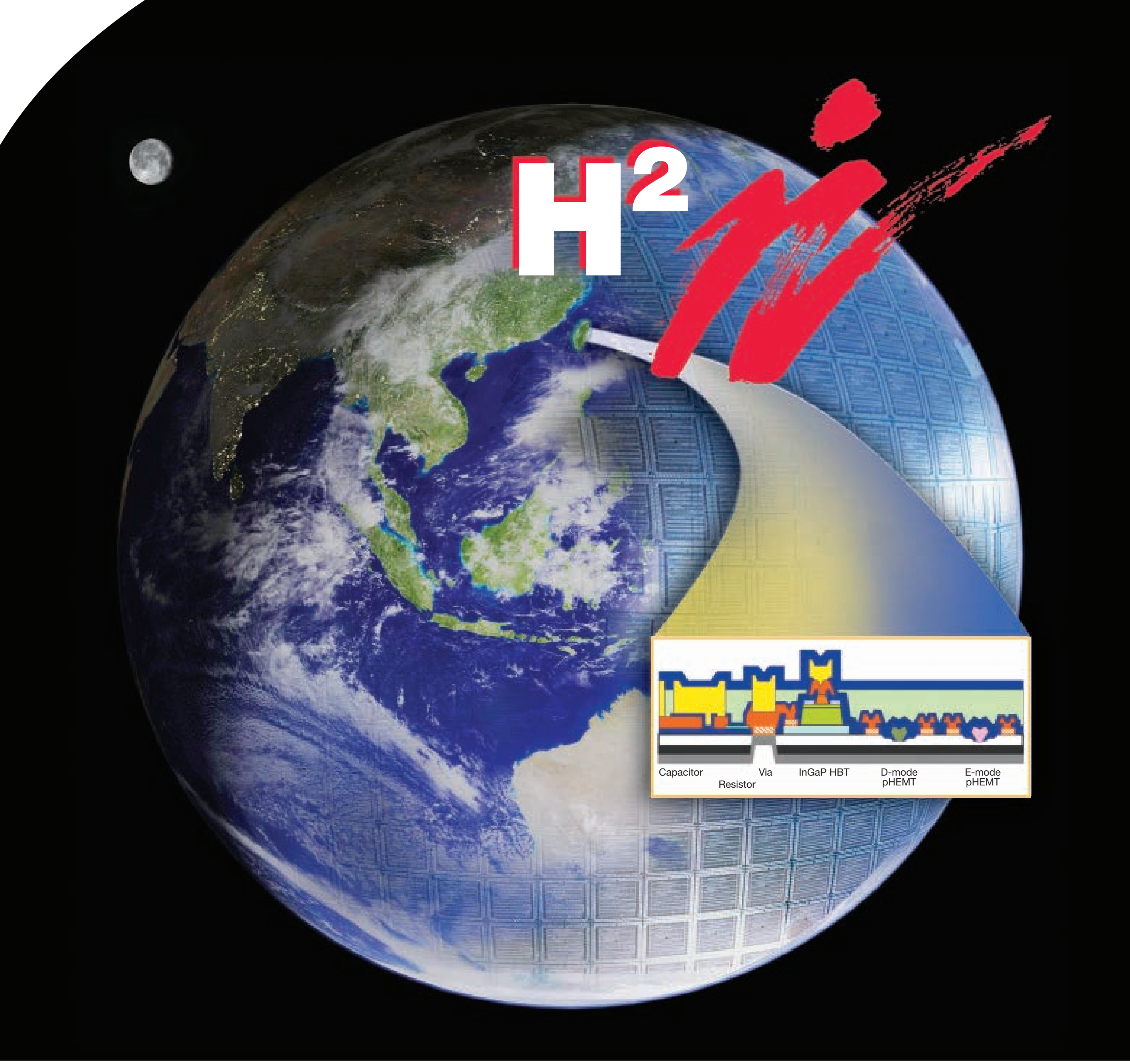
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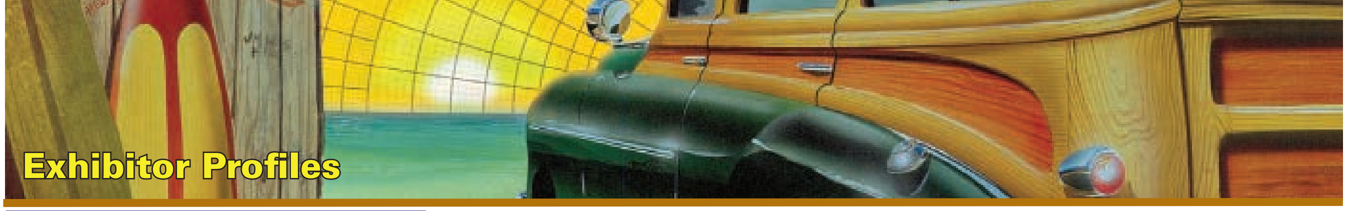

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Tel: (301) 662-5019
Fax: (301) 662-1731
E-mail: sales@pmi-rf.com

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www.quinstar.com

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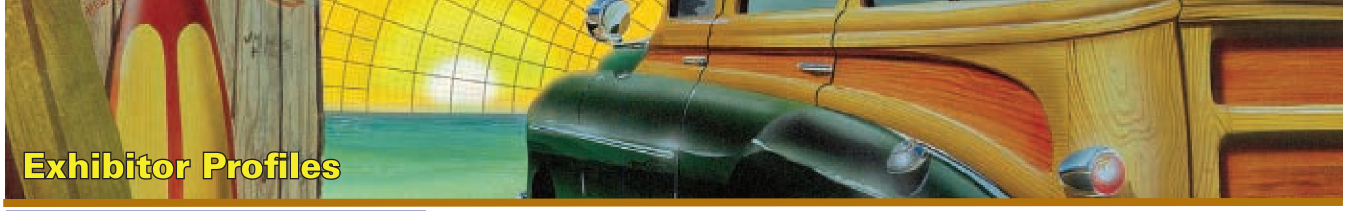

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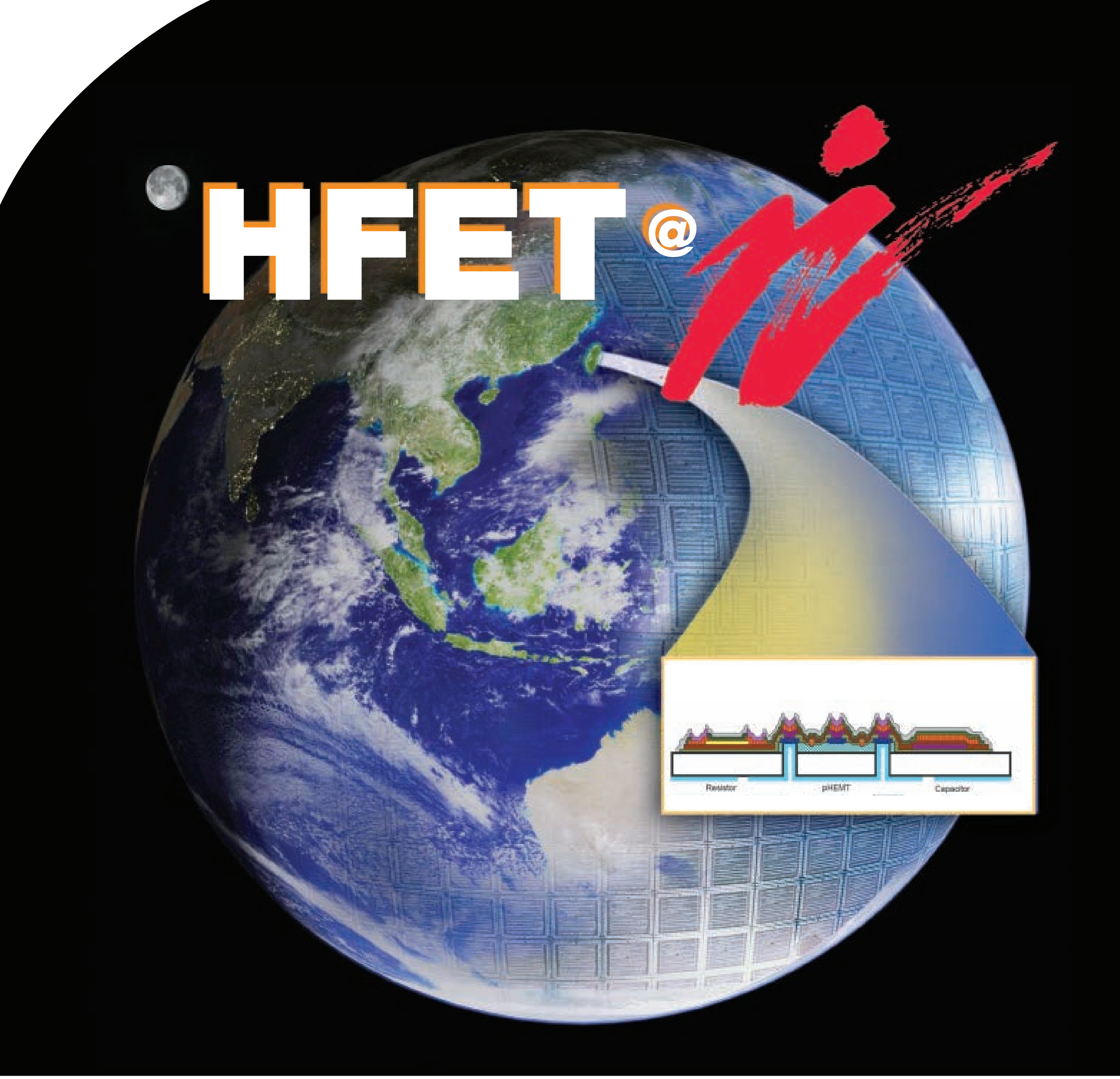

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BVDGO @ VGS=-3.0 V	33 V
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Idmax @VDS=4V, VGS=+0.5V	250 mA/mm
VPO @VDS=4 V	-1.1 V
MIM Capacitance	500 pF/mm^2
CGS	1900 pF/mm^2
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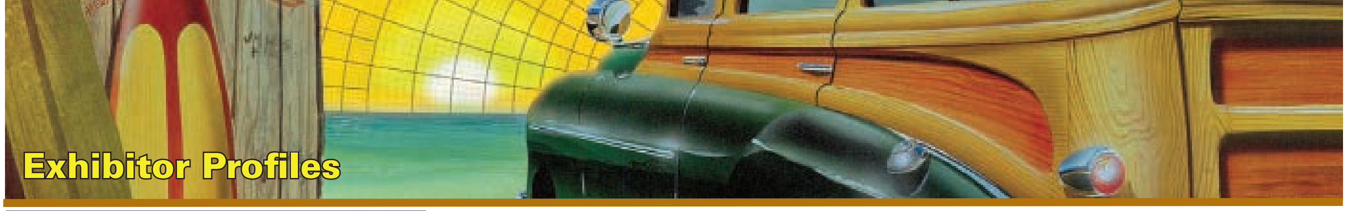

Richardson Electronics

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Fax: (630) 208-2200, (630) 208-2550
E-mail: rfpd@rell.com

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Richardson Electronics Ltd. is a global provider of engineered solutions and a global distributor of electronic components to the RF and wireless communications market and the industrial power conversion market. Richardson Electronics designs, manufactures, and distributes discrete devices, components, and assemblies used in RF and wireless infrastructure communications networks, digital broadcasting, defense and power conversion. More information is available on our new website, www.rell.com, featuring Engineer-Focused Navigation™.

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E-mail: Sales@RLCElectronics.com

www.rlcelectronics.com

RLC Electronics has for almost 50 years provided innovative RF and microwave products to this industry. Currently offering switches up to 65 GHz, programmable attenuators, connectorized and surface-mount filters, power dividers, couplers and detectors. Waveguide switches, filters, couplers and adapters have recently been added to the product range.

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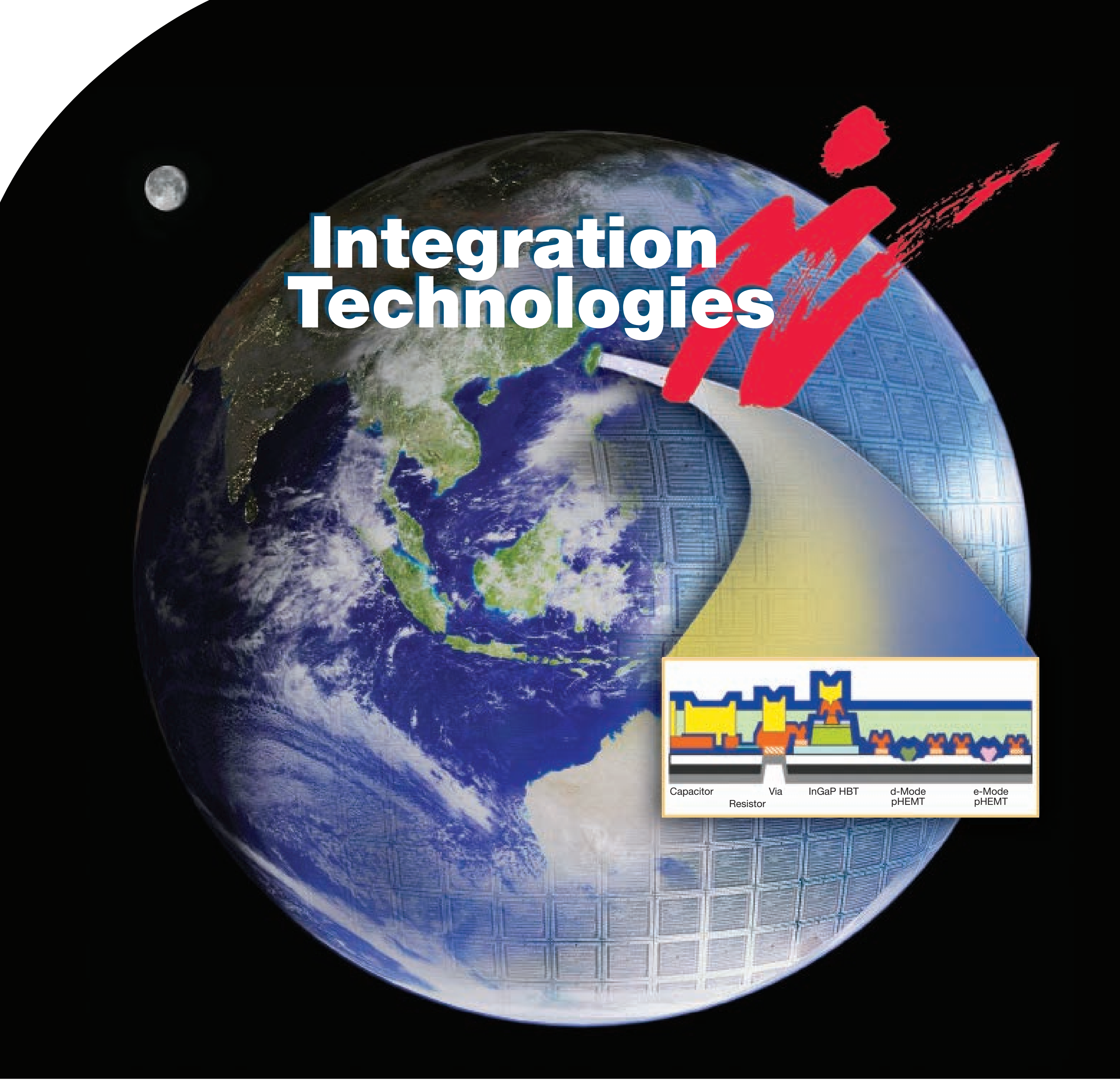
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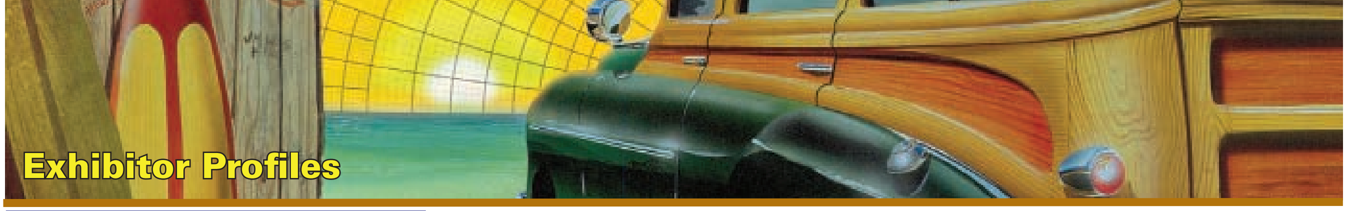

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Booth No. 2519

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Fax: (717) 399-9885
E-mail: info@rosenbergerna.com

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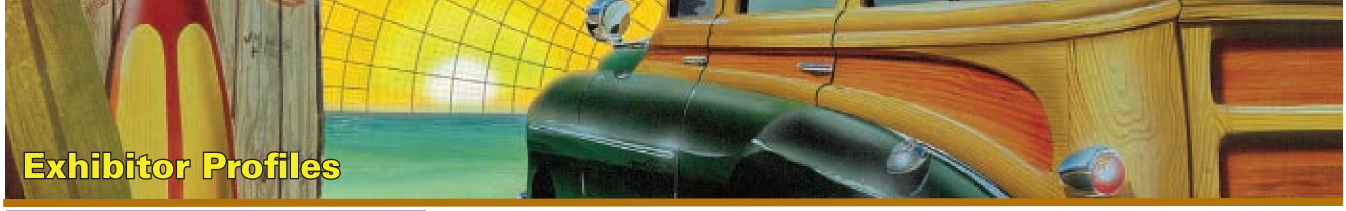

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SGMC Microwave is a registered ISO 9001:2000 manufacturer of precision coaxial connectors. SGMC Microwave was founded to provide the Defense, Test & Measurement, Telecommunications, Satellite and Aerospace industries with high performance microwave and millimeter-wave connectors. SGMC Microwave has built a reputation for quality, reliability and performance for nearly 10 years by supplying our customers with precision cable connectors, receptacles and adapters for various applications through 65 GHz. The latest simulation software and test equipment are a part of our design and development validation process.

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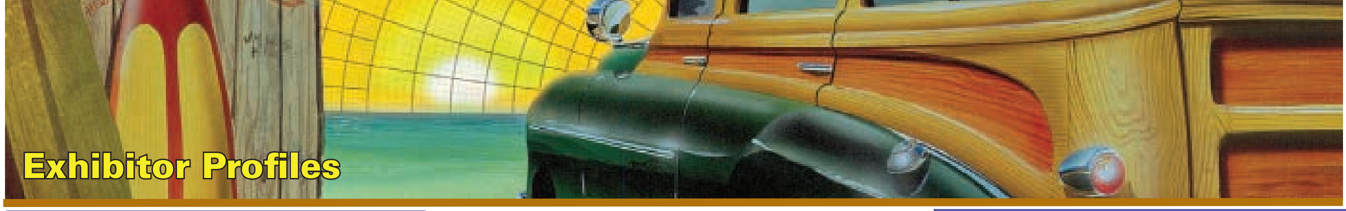

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9055 S. McKemy St.
Tempe, AZ 85284
Tel: (480) 783-0201
Fax: (480) 783-0360

www.southwestmicrowave.com

Southwest Microwave, owned and operated by engineers, including the founders of Omni-Spectra, is the recognized leader in supplying microwave and millimeter connectors and adapters. Southwest incorporates proven microwave transmission line principals in all connector designs. These structural features minimize transmission losses and reflections and provides the industry's lowest typical VSWR and RF leakage. Our SMA, N, TNC, SSMA, 2.92 mm, 2.4 mm, and PCB End Launch connectors are the best performing connectors on the market. Accessories and installation tools are available. Space/Hi-Rel, Lot-Control, Materials Traceability, ISO9001:2008, DFARS, RoHS and REACH compliant.

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www.spectrum-et.com

For 29 years Spectrum Elektrotechnik GmbH has been a world leader in the design and manufacture of high quality products for microwave applications up to 65 GHz. The company created and trademarked the SBX and SBY connectors, designed the Push-Pull Connectors and Adapters, which can slide onto any standard Series SMA, N, TNC and 7/16 connector and introduced the SQ, TQ, IQ, BQ, CQ and RQ Series Multipin Connectors that feature up to 80 coaxial quick connections up to 40 GHz.

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SPINNER GmbH
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SPINNER is a global leader in developing and manufacturing state-of-the-art RF components. Since 1946, the industry's leading companies have trusted SPINNER to provide them with innovative products and outstanding customised solutions. Headquartered in Munich, and with production facilities in Germany, Hungary, USA and China, the SPINNER Group now has over 1,400 employees worldwide.

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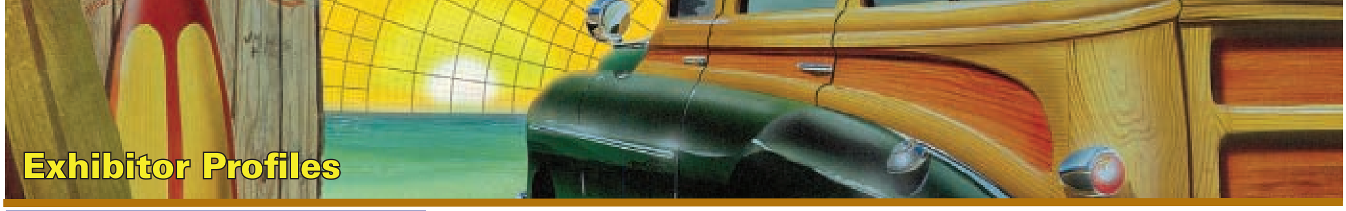

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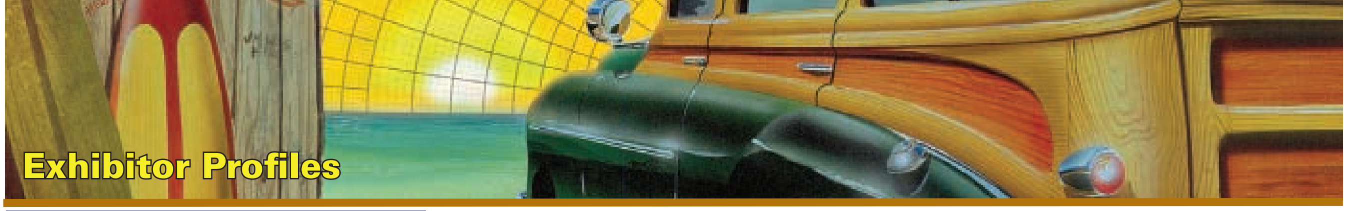

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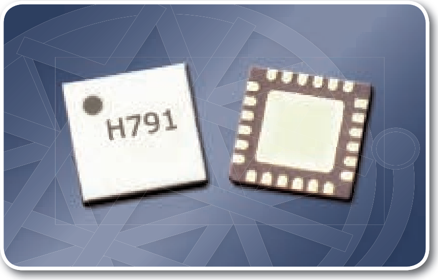

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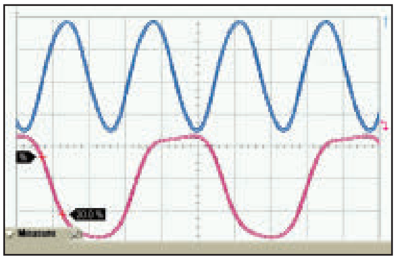
Output Signal



	Current	Minimum	Maximum	Total Count
Rise Time (/2)	12.00 ps	12.00 ps	12.67 ps	50
Fall Time (/2)	12.67 ps	12.67 ps	13.33 ps	51
Rise Time (/4)	16.67 ps	16.00 ps	16.67 ps	51
Fall Time (/4)	16.67 ps	16.67 ps	16.67 ps	51

Vertical Scale (/2)	65 mV/div
Vertical Scale (/4)	80 mV/div
Horizontal Scale	30.0.ps/div

Test Conditions:
CK/2 and CK/4 outputs are presented on an Infinium 86100C
Input Clock Frequency = 28 GHz
Vin = -6 dBm

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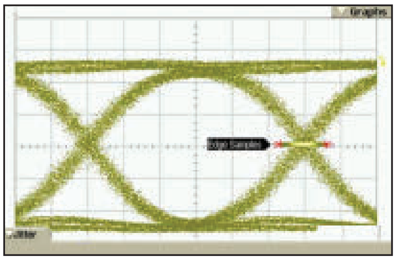
Eye Diagram @ 25 Gbps



Parameter	Conditions
Bit Rate	24.9900 Gbps
Pattern Length	127 Bits
DJ (d-d)	2.0 ps
Vertical Scale	100 mV / div
Time Scale	6.7 ps / div

Test Conditions:
Pattern generated with a 2^7-1 PN generator at 25 GHz. Measured using an Agilent 86100C 33 GHz DCA. Single ended 550 mV data and 400 mV clock inputs.

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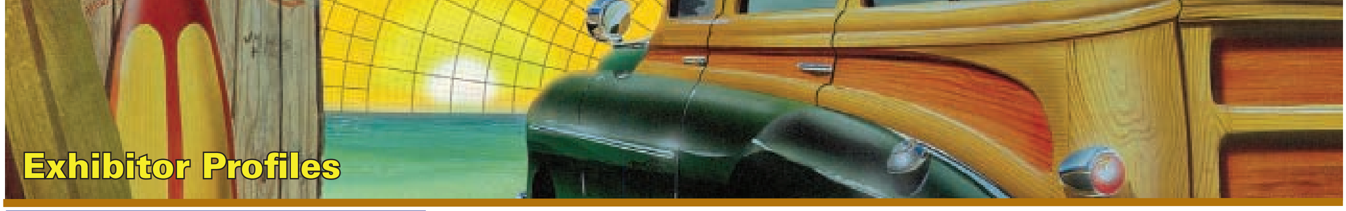

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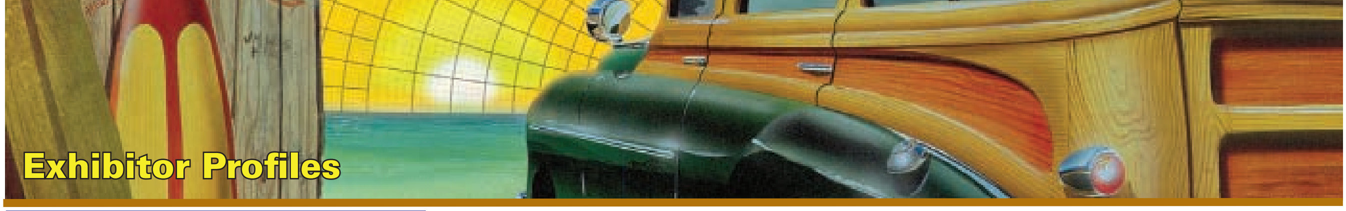

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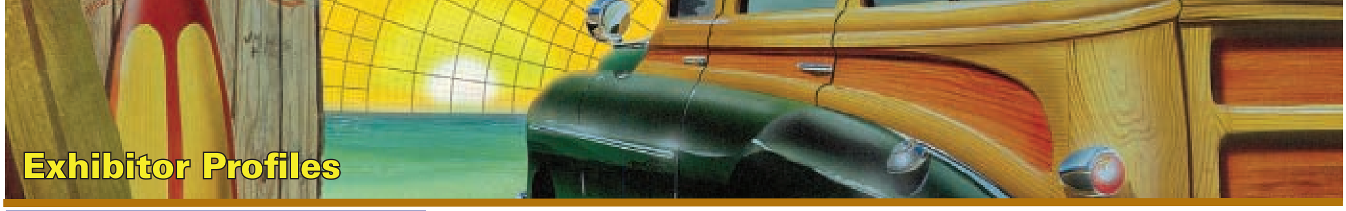

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Dan Massé, Associate Technical Editor

Airborne Early Warning and Control Capabilities Expanding Via Electronics

The combination of radar, sensor, onboard processing and communications electronics provides critical "see all", "know all" capabilities in Airborne Early Warning and Control (AEW&C) platforms that offers a fundamental building block of a national defense or combat strategy. The Strategy Analytics Advanced Defense Systems (ADS) service predicts that improving AEW&C capabilities creates new opportunities for advanced electronic components with the annual market for electronics growing by over 50 percent through 2020. Details may be found in the report, "Future Trends in Airborne Early Warning & Control Systems."

While the Boeing Wedgetail and Saab Erieye represent AESA (active electronically scanned arrays)-based future generation platforms, the Boeing E-3D Sentry AWACS and Northrop Grumman E-2C Hawkeye represent the operational state of the art. The development time, longevity and expense of the airframe platform makes the AEW&C market uniquely suited to the upgrade market. While the number of new platforms is relatively small, the potential market for upgrades to electronics in existing platforms has the potential to reach $22 B through 2020.

"With the long lifespan of the airframe, the electronics technology has gone through several iterations," observed Asif Anwar, Director of the Advanced Defense Systems (ADS) service at Strategy Analytics. "New platforms and upgrades are increasingly based on AESA, using solid-state T/R (transmit-receive) modules, as well as using broadband EW systems, coupled with fiber-optic signal transmission, sensors and more powerful processors. While these trends will provide increasing opportunities for GaAs, SiGe and other advanced semiconductor technologies, mainstream technologies such as TWT will continue to underpin many platforms."

...the potential market for upgrades to electronics in existing platforms has the potential to reach $22 B...

SRC Secures $8.1 M for Foliage Penetration Radar

SRC, formerly Syracuse Research Corp., announced that it has secured $8.1 M in funding for its Foliage Penetration Reconnaissance, Surveillance, Tracking and Engagement Radar, also known as FORESTER. The revolutionary airborne radar system penetrates through foliage to track people and vehicles on the ground.

The funding for the FORESTER program is a combination of two awards to the corporation. The first award of $5.3 M was awarded to SRC as a result of a solicitation by the US Army for an additional FORESTER system to be delivered by June 2011. An additional $2.8 M was secured through the 2009 Consolidated Security, Disaster Assistance and Continuing Appropriations Act for FORESTER technology improvements.

"The FORESTER technology redefines modern warfare," said Bob Roberts, SRC's President and CEO. "This additional funding highlights the commitment of the US Government to safeguarding Americans at home and abroad." SRC is currently completing a five-year contract from the Defense Advanced Research Projects Agency and the US Army's Communications-Electronics Research, Development and Engineering Center to develop and test two prototypes of the FORESTER system mounted on Boeing A160 Hummingbirds (YMQ-18A), which are unmanned helicopters. The additional funding will help SRC to transition the FORESTER system from a prototype to an operationally fielded system.

Raytheon Wins Contract to Develop Next-generation GPS Control Segment

The US Air Force has selected Raytheon Co. for an initial contract of $886 M to develop a new element of the Global Positioning System to improve the accuracy of information from GPS satellites. The contract represents the first two development blocks of the advanced control segment (OCX), which will have a significant impact on GPS capabilities. The OCX system will include anti-jam capabilities and improved security, accuracy and reliability, and will be based on a modern service-oriented architecture to integrate government and industry open-system standards.

"We are excited to partner with the Air Force to provide the best-value GPS control system for the future," said Lynn Dugle, President of Raytheon's Intelligence and Information Systems business. "Raytheon's broad experience in delivering satellite-to-ground command and control systems will ensure that our nation's military and civil GPS users worldwide are provided new capabilities." The OCX will dramatically affect GPS command, control and mission capabilities, and make it easier for the operations team to run the current GPS block II and all future GPS satellites.

The OCX will dramatically affect GPS command, control and mission capabilities...

"Raytheon is proud to deliver innovative technologies to help the Air Force meet its mission of protecting GPS operational services," said Bob Canty, GPS OCX Vice President and Program Manager for Raytheon. "The advanced control segment is a critical program for our nation's combat forces, coalition partners, as well as domestic and international civil

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users. By selecting Raytheon, the Air Force recognizes our experience and commitment to take GPS to the next level."

Raytheon brings more than four decades of experience in command and control systems for satellites to the OCX program. Teammates include The Boeing Co., ITT, Braxton Technologies, Infinity Systems Engineering and the Jet Propulsion Laboratory. The contract was awarded by the Air Force Space and Missile Systems Center at Los Angeles Air Force Base.

Harris Awarded Contract for Communications Backbone of Army Battle Command System

High band networking radios from Harris Corp. will form the communications backbone of the US Army's new Integrated Air and Missile Defense Battle Command System (IBCS). As a member of Northrop Grumman's IBCS team, Harris will supply its radios to carry critical battle-command information, and will provide system and network engineering services over the five-year life of the program.

IBCS will integrate the fire-control networks of current and future air and missile defense systems. This command system will enable warfighters to use any combination of sensors and weapons to achieve mission objectives in a true open-architecture environment. The unique design of the Harris Highband Networking Radio™ (HNR) ensures all information from the battle command center will arrive at the right location to defend troops against a missile attack. This radio includes the first-ever use of directive beam technology to achieve higher throughput over longer distances in a robust, self-forming and self-healing directional mesh network. The Harris HNR system is a part of the US Army's WIN-T Increment 2 program.

This radio includes the first-ever use of directive beam technology...

Systems that will be integrated via IBCS include:

- Patriot, Surface-Launched Advanced Medium Range Air-to-Air Missile (SLAMRAAM).
- Joint Land Attack Cruise Missile Defense Elevated Netted Sensor (JLENS).
- Improved Sentinel Radar.
- And—if the US Department of Defense directs the inclusion—Terminal High Altitude Area Defense (THAAD) and Medium Extended Air Defense System (MEADS).

Harris Defense Programs develops, supplies and integrates communications and information processing products, systems and networks for a diverse base of aerospace, terrestrial and maritime applications supporting US Department of Defense missions. Harris is committed to delivering leading-edge technologies that support the military's ongoing transformation to network-centric communications.

European Carriers Face Capacity Crunch Challenges

The scale of the take-up of smartphones has increased traffic and put unprecedented pressure on networks. Consequently, European carriers, in particular, are facing significant capacity crunch and spectral efficiency challenges. Explaining that limited spectrum and spectral congestion were key issues, Alan Solheim, VP of Product Management at DragonWave, told *Microwave Journal*, "For a long time European regulators have recognised that the spectrum is a non-renewable resource, so licensing regimes have been geared towards preserving that spectrum. Because of the pricing regime and the usage patterns of microwaves, European operators are looking at either new spectrum or ways to use their existing spectrum more efficiently."

He elaborated, "One of the problems that carriers are facing is that as they increase the capacity on the microwave backhaul they can only do so much—going to higher modulation, or adaptive modulation to get higher throughputs over the existing infrastructure but eventually you hit a wall. A lot of the last mile links have been connected with 7 or 14 MHz channels, which can typically deliver a few tens of Mbits over conventional systems.

"What DragonWave has done is to address the fact that in order to deliver the capacities that are needed in those channel sizes, you need to get a factor of two improvement in the spectral efficiency of the product. We have done many things—higher modulation rates, cross-pole interference cancellation to allow true polarisation multiplexing, adaptive modulation—and then we have added a suite of baseband optimisation techniques that take a look at the lossless compression, etc. So, using conventional microwave techniques we can get up to about 100 Mbits out of a 7 MHz channel and using baseband techniques we can get almost 200 Mbits out of that baseband channel."

"...European operators are looking at either new spectrum or ways to use their existing spectrum more efficiently."

Explaining how European carriers in particular can benefit, he commented, "A whole new realm of possibilities is opened up. Instead of operators having to redesign their networks, go back to their regulators and try to re-engineer their spectrum allocation in the backhaul segment they can simply deploy new equipment and upgrade the technology to LTE-style capacity without having to re-engineer and deal with all of the churn."

Read more at www.mwjournal.com/europe_capacity_crunch.

Finnish Network to Test High-speed TEDS

State Security Networks Ltd., operator of the Finnish VIRVE network, and EADS Defence & Security (DS) have joined forces to start testing the TETRA Enhanced Data Service (TEDS) as of May 2010. The work will be conducted on a test network with the same characteristics as the live VIRVE authority network, apart from the TEDS-capable software.

Finland pioneered the adoption of TETRA technology in everyday use in the late 1990s and TEDS is the high-speed data evolution of the TETRA radio communication standard. A TEDS-capable TETRA network will provide significantly faster data services than today's TETRA networks without compromising any of the technology's high security or coverage capabilities. TEDS is claimed to be the most cost-effective way to introduce wide area high-speed capability for TETRA users.

Finnish Police are looking forward to enhancing their efficiency with increased use of secure data.

EADS Defence & Security was the first vendor to demonstrate TEDS in June 2007 and has continued to develop the software in order to run the system on existing EADS TETRA hardware as well as developing TEDS-capable TETRA radios. System elements and trial terminals for the VIRVE test network will be delivered in April/May this year.

"Public authorities need high-speed data capabilities in their radio communication networks to enhance their field operations," said Dirk Borchardt, Head of Security and Communication Solutions at EADS DS. "They also need high speed data to be reliable, secure and available over a wide area. TEDS can meet these strict requirements."

Beecham Research Undertakes Satellite M2M Study

Leading M2M analyst and consulting firm Beecham Research Ltd. has been awarded a €200,000 contract by the European Space Agency to conduct an intensive study of the worldwide market for Satellite M2M. The company will act as prime contractor for the study and will be aided by its subcontract partner Astrium, part of the EADS Group and based in Toulouse, France. This first-of-a-kind study will assess both the current market for Satellite M2M services and the opportunities for market development through new technology initiatives.

"Satellite M2M has enormous potential as part of the M2M World of Connected Services," said Robin Duke-Woolley, CEO of Beecham Research. "We will be working

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to ensure this substantial and timely study demonstrates the tremendous prospects for the global Satellite M2M market in the future and examines in depth what needs to be done to achieve it."

"Satellite M2M has enormous potential as part of the M2M World of Connected Services"

Beecham's partner Astrium Services will provide detailed input on satellite technology trends and on commercial application opportunities. Commenting on the award, Jean-Marc Villevieille, head of technologies and business alliances at the company, said, "Satellite M2M is just at the beginning of what promises to be a huge growth market. We are delighted to be working with Beecham Research to provide our technical experience in this field and help with recommendations for evolution of future satellite M2M systems."

NGMN Alliance Achieves Milestone to ORI Interface

The Board of the NGMN Alliance has endorsed the proposal to seek establishment of an ETSI Industry Specification Group (ISG)—Open Radio Equipment Interface (ORI)—to further develop and maintain the specifications for open interfaces between Remote Equipment Control (REC) and Radio Equipment (RE).

The objective of the open interface specifications for radio equipment will be to ensure more economical and efficient deployment of base stations and will also consider ecological aspects when renewing a system in the next generation mobile network. An open interface between REC-RE will enable the possibility to connect and operate equipment from different vendor origin.

"The agreement to establish the ETSI ISG is a major step towards the successful interface specification..."

An NGMN project team of leading operators and vendors has worked towards the successful development of the open interface implementation recommendations. A scope document for the ISG is being developed by the NGMN project team with the objective to develop an interface specification.

Dr. Peter Meissner, Operating Officer of the NGMN Alliance, said, "We do expect from the open interface implementation significant improvements in terms of efficiency and cost savings that will benefit the whole industry. The agreement to establish the ETSI ISG is a major step towards the successful interface specification, and demonstrates the alignment of key industry players."

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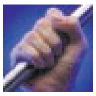

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Dan Massé, Associate Technical Editor

Automotive Bluetooth Strategy Key to Infotainment Success

Strategy Analytics forecasts global automotive Bluetooth to grow from 7.6 M units in 2008 to 54.7 M units in 2016, representing a CAGR of 28 percent over the forecast period.

The Strategy Analytics Automotive Multimedia and Communications Service (AMCS) report, "Automotive Bluetooth: Profile Strategy Key to Infotainment Success," details market developments, Bluetooth connectivity and Bluetooth profile adoption in the automotive market.

Critical elements for automotive infotainment planning include:

- Selecting the most appropriate Bluetooth profiles;
- Timing the introduction of Bluetooth profiles; and
- Designing solutions that are capable of Bluetooth profile upgrades.

"Bluetooth is not just for hands-free calling," remarked Mark Fitzgerald, Senior Analyst in the Strategy Analytics Global Automotive Practice. "It is essential for in-vehicle infotainment systems to incorporate appropriate Bluetooth solutions in order to leverage the features and applications of these devices as consumers use more sophisticated portable devices, such as smartphones that integrate audio and video media, text messaging, internet browsing and location-based technologies."

Wireless Infrastructure: 2009 Not as Bad as Feared

There is no doubt that 2009 was a bad financial year, and there were fears at its beginning that the wireless infrastructure market would see a severe downturn. Estimates for contraction ranged as high as 10 to 12 percent.

However, in a just-released study, ABI Research finds that the final picture is a good deal brighter than that. "There was a contraction in the wireless infrastructure market to be sure," says Practice Director Aditya Kaul. "But our analysis shows overall CAPEX down only about 5 percent compared to 2008. Even net base station spending was down only 5 percent."

The report, which presents a high-level overview of the global wireless infrastructure market, shows that operators resumed spending in the second half of 2009. North America's market saw continued spending by the likes of Verizon with its LTE network and Clearwire with its WiMAX deployments.

According to Kaul, "The biggest positive impact was from China with 243,000 new wireless base stations added in 2009, which really kept the momentum going. In what turned out to be a case of good timing, 3G spectrum became available at the beginning of the year, which led to deployments continuing through the year."

In India, 3G spectrum issues slowed down the market to some extent in 2009. Africa saw continued momentum in base station spending, with Huawei providing vendor financing to operators in the region.

With the mobile capacity crunch starting to affect operators, 2009 was also a year in which backhaul and core network upgrades became high-priority areas.

There was some vendor consolidation, with Nortel announcing bankruptcy while Cisco acquired Starent on the core network side. 2009 was also a year that saw managed services gaining increasing importance for wireless OEMs, becoming a market estimated at $7 B.

Mobile Networks Snapshot: LTE and WiMAX Deployments Go Head to Head

December 2009 saw the first commercial launch of LTE networks, with TeliaSonera the first service provider in the world to offer the service in Stockholm and Oslo. 2010 promises to see the commercial launch of several LTE networks, including large operators such as Verizon Wireless in the United States and NTT DoCoMo in Japan. With voice standards still in development and a lack of compatible handsets, however, one can expect these networks to carry only data traffic for some time to come.

As LTE deployments begin to pick up pace, WiMAX continues its steady progress. ABI Research Analyst Bhavya Khanna says, "While LTE does promise data speeds greater than 50 Mbps, they have yet to be achieved by live or trial networks, whereas mobile WiMAX is now a tried and tested standard." Several operators, including Sprint in the United States, have chosen to go with WiMAX as their 4G network of choice. ABI Research reports 164 mobile WiMAX networks in trial or commercial operation at the end of 2009, compared to just over 100 LTE trials.

In addition, the total number of network contract announcements for mobile WiMAX tracked by ABI Research was 242, compared to only 38 for LTE. With the planned launch of several WiMAX devices in 2010, including handsets from smartphone maker HTC, it looks likely that this technology will co-exist with LTE for some time to come.

Wireless Broadband and Emerging Markets Change Baseband Rules

Qualcomm, MediaTek, Infineon and Broadcom increased their share in cellular basebands in 2009 despite an overall decline in the market, as described in "Rapid Changes in the Baseband Market Lead to Rising Fortunes for a Chosen Few," from the Strategy Analytics RF & Wireless Component market research service. This comprehensive report explores market and technology trends, as well as competitive positioning and prospects for future success in cellular basebands.

According to Christopher Taylor, author of this report, "Qualcomm, MediaTek, ST-Ericsson, Infineon and Broadcom will dominate in basebands over the next five years, a market that will grow to more than $15 B by 2014. These

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companies will continue to offer the most highly-integrated, power-efficient baseband processors capable of supporting high-rate wireless, new applications and cloud computing, either through integrated applications processing or partnerships with suppliers of external applications processors."

RAYSPAN Announces Breakthrough Antenna Solutions for LTE Devices

RAYSPAN® Corp., the world's only provider of metamaterial and advanced RF air interface solutions for wireless communications, announced the availability of RAYSPAN MTM-E™ solutions for long-term evolution (LTE).

MTM-E is the only antenna solution that can support six or more bands operating from 698 to 960 MHz in the low band and 1710 to 2170 MHz as well as 2.6 GHz in the high band without requiring any switching elements or matching circuits. MTM-E is the smallest LTE antenna platform available, meeting the requirements for portable LTE devices such as mobile phones, laptops, USB dongles, wireless routers and wireless modems. The RAYSPAN MTM-E solution is the only antenna technology that offers integrated LTE, 3G, Bluetooth and GPS all from a single-feed antenna solution. "RAYSPAN MTM-E is uniquely suited to the requirements of wireless and mobile standards, and especially LTE," stated Gregory Poilasne, VP of Business Development at RAYSPAN. "We are pleased to be able to offer an LTE antenna solution that not only leads the industry in performance, integration, low power consumption and time to market, but is ready for manufacturers today." Unlike competing 3D antennas designed for LTE, the MTM-E antenna is a simple 2D design in which copper artwork is printed directly on a device's printed circuit board (PCB) using standard PCB manufacturing techniques. This enables MTM structures to be built using the finest line widths and spacing available for antennas. These MTM structures, along with eliminating the need for switching elements and matching circuits, simplify system integration, lower power consumption, accelerate time to market and allow for smaller handset designs.

MTM-E is the smallest LTE antenna platform available...

The RAYSPAN MTM-E solution complies with the current LTE standard which calls for multiple input, multiple output (MIMO) technology requiring two separate antenna structures that operate over the same frequency band, at the same time, and from the same location. The MTM-E MIMO antenna solution exhibits excellent MIMO gain performance with > 50 percent efficiency values in free-space for handset applications, better than -10 dB in near field isolation, and better than 0.3 far-field envelop correlation coefficient. The secondary LTE MIMO antenna also supports 3G diversity and GPS applications.

Jennifer DiMarco, Staff Editor

INDUSTRY NEWS

Crane Co., a diversified manufacturer of highly engineered industrial products, announced the successful completion of its tender offer for **Merrimac Industries Inc.** Crane has accepted 2,796,642 validly tendered Merrimac shares, including 23,162 shares tendered under the tender offer's guaranteed delivery procedures. The tendered shares, excluding those tendered through the guaranteed delivery process, constitute approximately 92.5 percent of the total Merrimac shares of common stock outstanding. Crane expects to promptly complete the acquisition of Merrimac through a short-form merger.

Harris Corp., an international communications and information technology company, has acquired the technology assets of **OSI Geospatial Inc.**'s land-based, situational awareness business. These technologies will enhance the company's capabilities in delivering assured communications systems and applications for defense and public safety customers. With this acquisition, Harris gains advanced software for capturing, viewing and disseminating critical strategic and tactical information to domestic and international defense and public safety customers. The situational awareness software provides commanders and team members in the field with real-time information, such as the location of deployed personnel. These applications are capable of being embedded into both tactical and public safety radios.

Electro Technik Industries Inc. (ETI), an electronics manufacturing company based out of Largo, FL, has acquired **Arizona Capacitors** and its subsidiaries: West Cap of Arizona, SFE Technologies and Component Research Co. Arizona Capacitors and West Cap manufacture film capacitors for both the industrial and military markets. Arizona Capacitors builds to MIL-STD-790 and is ISO 9001:2000 approved. The company also designs and manufactures a family of electronic filters.

SELEX Galileo, a Finmeccanica company and a defence electronics manufacturer, and **RFMD Inc.**, a leader in the design and manufacture of high performance radio frequency components and compound semiconductor technologies, announced the extension of its collaboration to develop high frequency GaAs MMIC solutions focused on SELEX Galileo's next generation of electronically-scanned (E-SCAN) phased array radar systems. SELEX Galileo and RFMD have collaborated in GaAs MMICs since signing a strategic cooperation agreement in May 2008. In a related announcement, RFMD has commenced production shipments to SELEX Galileo of GaAs MMIC chipsets for insertion into SELEX Galileo's surveillance and fire control radar systems. RFMD manufactures its GaAs MMIC process for SELEX Galileo on six-inch substrates at RFMD's GaAs wafer fab in Durham, UK.

Valpey Fisher Corp., a leader in low noise timing solutions, announced the creation of its Microwaves Products Group. The group will focus on the design, manufacture and marketing of high performance RF/microwave components and integrated modules for a broad range of end markets, including microwave point to point, wireless infrastructure and military communications.

VI Technology MMTS™ for production testing of new and existing components was used in the development of the second-generation of Ford's SYNC system. VI Technology MMTS is an automated test system designed to improve productivity for design and test engineers needing analog and digital measurements for audio/video devices. Ford has continued to innovate and add features to SYNC, including adding traffic, directions and information capabilities starting with the 2010 model year.

Organizers announced the formation of **Crystal RFI Solutions LLC** (CRFIS), a new company dedicated to providing global solutions for preventing and identifying the source of Radio Frequency Interference (RFI). RFI Sentry provides satellite operators and users the ability to prevent costly RFI to satellite transponders and to quickly identify sources of transponder RFI from anywhere around the world.

AWR Corp., a leader in high frequency EDA, announced that it has expanded its global presence by establishing a direct sales, support and marketing office in Korea. To better serve the region's growing customer base, Kyung Hwa Kim has been appointed AWR Korea's Country Manager. For more information, visit AWR Korea's new content rich, local language website: www.awr.co.kr. To contact AWR Korea directly: AWR Korea Co. Ltd., B-1412, Intellige-II, 24 Jeongja-dong, Bundang-gu, Seongnam-si, Gyeonggi-do, South Korea, 463-811; +82 31 603 7772; +82 31 603 7773; info.kr@awrcorp.com.

Delta Microwave announced the company's relocation into a new and expanded 36,000 square foot facility. With full engineering, drafting, machine shop, assembly, electrical and environmental testing on-site, Delta Microwave can manufacture components with tough mechanical, electrical, and environmental specifications quickly and affordably. The new facility includes 20,000 square feet of ESD assembly and test to accommodate increased demand and includes a 5,000 square foot Class 100,000 clean room for space flight hardware.

ARC Technologies has expanded its manufacturing capacity by acquiring a 50,000 sq. ft. facility adjacent to its existing operation in Amesbury, MA. The new manufacturing facility, which includes new equipment for thermoplastic extrusion and injection molding manufacturing operations, will also house a renovated sales office.

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MINIATURE FOOTPRINT VCO'S

Model	Frequency Range (MHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Typ.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.]	Size (Inch)
DCO Series					
DCO50100-5	**500 - 1000**	**0.3 - 15**	**+5 @ 26 mA**	**-100**	[illegible]
DCO7075-3	**700 - 750**	**0.5 - 3**	**+3 @ 10 mA**	**-108**	[illegible]
DCO80100-5	**800 - 1000**	**0.5 - 8**	**+5 @ 21 mA**	**-111**	**0.3 x 0.3 x** [illegible]
DCO100200-5	**1000 - 2000**	**0.5 - 24**	**+5 @ 30 mA**	**-95**	**0.3 x 0.3 x 0.1**
DCO1198-8	**1195 - 1205**	**0.5 - 8**	**+8 @ 24 mA**	**-115**	**0.3 x 0.3 x 0.1**
DCO170340-5	**1700 - 3400**	**0.5 - 24**	**+5 @ 24 mA**	**-90**	**0.3 x 0.3 x 0.1**
DCO200400-5 DCO200400-3	2000 - 4000	0.5 - 18	+5 @ 35 mA +3 @ 35 mA	-90 -89	0.3 x 0.3 x 0.1
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 x 0.3 x 0.1
DCO490517-5 DCO490517-3	4900 - 5175	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-88 -86	0.3 x 0.3 x 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

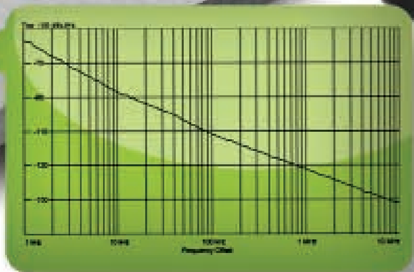
New! Wideband Models

Model	Frequency Range (GHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Typ.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.]	Size (Inch)
DXO Series					
DXO810900-5 **DXO810900-3**	8.1 - 8.925	0.5 - 15	+5 @ 26 mA +3 @ 26 mA	-82 -80	0.3 x 0.3 x 0.1
DXO900965-5 **DXO900965-3**	9.0 - 9.65	0.5 - 12	+5 @ 22 mA +3 @ 22 mA	-80 -78	0.3 x [illegible] 0.1
DXO10701095-5	10.70 - 10.95	0.5 - 15	+5 @ 21 mA	-82	0.3 x [illegible]
DXO11441200-5	11.44 - 12.0	0.5 - 15	+5 @ 23 mA	-82	0.3 x [illegible]
DXO11751220-5	11.75 - 12.2	0.5 - 15	+5 @ 24 mA	-80	0.3 x 0.3 x 0.1

New! Models

Features

- Exceptional Phase Noise
- Dimensions: 0.3" x 0.3" x 0.1"
- Excellent Tuning Linearity
- Models Available from 4 to 12 GHz
- High Immunity To Phase Hits
- Lead Free RoHS Compliant
- Patented Technology



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Auriga Measurement Systems LLC announced it will be doing business as **Auriga Microwave**. The new name better signifies the company's strength and direction. Building upon its strong "Auriga" brand, Auriga Microwave expands its products and services to include design and manufacture of RF modules, particularly power amplifiers. Leveraging the team's depth of experience, the company's goal is to be the leading provider of high-performance microwave modules to system integrators, principally for the Department of Defense.

Mimix Broadband Inc., a supplier of high performance gallium arsenide (GaAs) semiconductors from DC to 50 GHz for RF, microwave and millimeter-wave applications, commemorates its 10th year of business in 2010. The company will celebrate the occasion throughout the year, including at the 2010 IEEE MTT-S International Microwave Symposium, to be held next month in Anaheim, CA.

Raytheon Co. has developed a mobile Civil Communications solutions demonstration that allows first responders to experience seamless communications capabilities that could help save lives when crises strike. The mobile demonstration is a high-tech experience where public safety professionals can fully immerse themselves in rescue scenarios and realize the benefits that interoperable communications provide.

Sapphicon Semiconductor, a designer and manufacturer of high performance integrated circuits based on silicon-on-sapphire (SoS) process technology, and **AWR Corp.**, a leader in high frequency EDA, introduced process design kits (PDK) for AWR software that support Sapphicon's advanced SoS processes.

As wireless operators upgrade their microwave backhaul networks to keep up with increasing demands for capacity, **Comsearch**, a CommScope company, has launched a new suite of support services aimed at reducing operators' capital and operating expenditures and speeding network deployment. Comsearch's iQ.link® Services suite includes four offerings that provide network engineering analysis as well as software database and system maintenance to enable network planners to roll out high capacity backhaul networks quickly and efficiently. These services allow network planners to focus on their core expertise by off-loading other time-consuming tasks.

VTI Instruments Corp. announced that it has received the **Lockheed Martin** STAR Supplier Award. VTI has been selected as a top performing supplier by Lockheed Martin Simulation, Training & Support (STS). The STAR Supplier Award was implemented as a way to develop stronger supply chain relationships and recognize outstanding performance by top performing suppliers. Selection is based on a number of performance criteria including high product quality, on time delivery and cost competitiveness.

Laser Services Inc., a precision laser cutting, drilling, scribing, etching and welding job shop, has announced its recent recertification of ISO 9001:2008. The certification verifies the company's Quality Management System as "applicable to laser scribing, drilling, cutting, marking, welding, and other processing for materials to include ceramics, metals, plastic, and adhesives used in the microelectronics, medical, aerospace, and commercial industries." The qualification was assessed and approved by National Quality Assurance, USA, an accredited organization under the Aerospace Registrar Management Program.

Technology Marketing Corp. (TMC) has recognized **Aeroflex**'s contributions to 4G wireless technology with a 4GWE Product of the Year award for the 7100 Digital Radio Test Set. Award recipients represent the most innovative new products brought to market during 2009.

WiSpry Inc., a leader in tunable RF semiconductor products for the wireless industry, announced that the company's patent application for Micro-Electro-Mechanical System (MEMS) Variable Capacitors and Actuation Components, and Related Methods has been granted by the US Patent and Trademark Office (Patent number 7,545,622).

CONTRACTS

Cobham has been awarded a contract from **Sikorsky Aircraft Corp.** to manufacture advanced composite components and assemblies for the main rotor blades of the United States Marine Corps' CH-53K Heavy Lift Replacement Helicopter under development by Sikorsky Aircraft Corp., a subsidiary of United Technologies Corp. Depending on how many CH-53K helicopters are eventually built by Sikorsky for the US Marine Corps, the contract could be worth up to US$25 M.

Herley Industries Inc. announced that its Herley New England division in Woburn, MA, has been awarded a contract valued at approximately $11.7 M from a major US Prime contractor. Herley New England will manufacture a number of multi-function IMAs for a US Navy Electronic Attack Aircraft. In related news, Herley announced that its Herley Lancaster division has received a follow-on contract valued at more than $1 M from a major US prime contractor to manufacture multi-function integrated microwave assemblies (IMA) for a US Navy electronic attack aircraft.

RF Micro Devices (RFMD) announced that it has been awarded $3.2 M in R&D contracts by the United States Department of Defense related to GaN microelectronics, including materials, device fabrication and high power circuits. The $3.2 M in R&D contracts extends RFMD's contract backlog for calendar 2010 to approximately $5 M. Since calendar 2004, RFMD has been awarded approximately $13 M in R&D contracts by the US Government.

Micronetics Inc. announced that it has been awarded a contract valued at approximately $2 M from a defense contractor for high performance microwave isolators that will be used in a radar system. Deliveries on this contract will commence in Q1 FY2011 and continue for 18 months.


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RF & Wireless Semiconductors
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BIG MERGER. SMALL CHANGES.
Same Great Products. Same Great Service.
We congratulate our long-standing partner, NEC Electronics, on the completion of its merger with Renesas Technology Corporation. Other than our partner's new name, Renesas Electronics Corporation, little has changed for CEL. We'll continue to supply our customers with the same great products, from RF to optical semiconductors. And all from the same best-in-class production facilities that are world-renowned for manufacturing quality and reliability. Here's to another 50 years of smooth sailing.
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Carlisle Interconnect Technologies recently signed two long-term supply agreements with Airbus in Toulouse, France. Under the first agreement, Carlisle Interconnect Technologies will supply (DR) style airframe wire and cable to Airbus. This culminates a multi-year qualification effort by Carlisle Interconnect Technologies to gain approval for all Airbus production aircraft. Production is expected to start immediately with first deliveries beginning in March of 2010. Carlisle will manufacture the Airbus airframe wire in its St. Augustine, FL facility. Under the second agreement, ECS, recently acquired by Carlisle Interconnect Technologies, will supply ARINC 600 trays for all Airbus aircraft. The trays are designed and manufactured in its Franklin, WI facility.

Agilent Technologies Inc. announced that its Advanced Design System (ADS) software has been selected by **Paratek Microwave** for use in development of tunable antenna modules for the mobile handset market. The accuracy, capacity and performance offered by ADS will aid Paratek in the design of optimized modules as well as in the creation of models for its customers.

Cambridge Consultants, a technology product design and development firm, announced the inclusion of its holographic radar technology in a US Department of Defense (DoD) demonstration program geared at improving the projectile scoring capabilities of the US Navy and Army. This demonstration project, funded by the Department for Operational Test & Evaluation (DOT&E) for both services, will align holographic radar technology and target scoring technology applications for the first time.

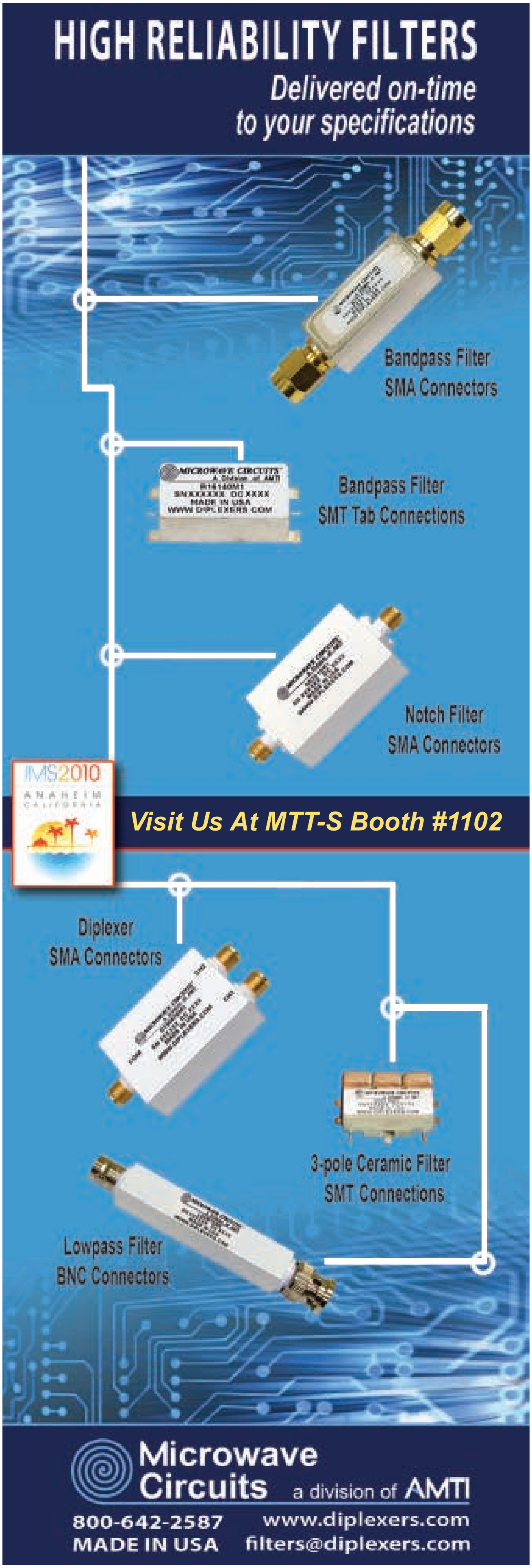
NEW MARKET ENTRY

CogniTech Sales LLC provides consultative technical sales for leading manufacturers of RF, microwave, millimeter-wave, lightwave components, integrated circuits, cable assemblies, subsystems and systems. In addition to the company's synergistic line-up of component and communication systems, it offers test and measurement equipment, high frequency simulation tools, high precision simulation models, electronic manufacturing services (EMS) and high technology printed circuitry. Alen Fejzuli, Director, Advanced Products Sales and Founder of CogniTech Sales LLC, has extensive technical sales, management, and high frequency design experience in the commercial, military RF/microwave and fiber optic industries. For more information, visit www.cognitechsales.com.

PERSONNEL


▲ Andy Humen

Andy Humen has been promoted to the position of Vice President of Cobham Sensor Systems. He is responsible for the sensor and microwave electronics and microwave components business units in San Diego, CA, Richardson, TX, San Jose, CA, Lowell, MA, Roanoke,



VA, Milton Keynes, UK and Lansdale, PA. Previously, Humen was the Vice President for the Sensor Electronics operations in Lansdale, PA, Baltimore, MD, Bolton, MA, and Largo, FL. Previous to that he was the Director of Advanced Technology for Cobham Sensor Systems, responsible for the coordination of technology development across the SBU and Cobham.

▲ *Timothy J. Rainear*

AR RF/Microwave Instrumentation has announced the appointment of **Timothy J. Rainear** to the post of Regional Manager, North America. Rainear comes to AR with over 20 years of experience in the sales and marketing of technology solutions. Most recently Rainear was consulting as the VP of Business Development at an early stage start-up company based in Cambridge, MA. His extensive technical background enabled him to investigate and penetrate several key commercial markets for this DARPA-backed, analog signal processing company.

Phase Matrix Inc. announced the recent appointment of **Alexander Chenakin** to Vice President of the Signal Sources group. In this new role, Chenakin will be responsible for overseeing the development and marketing of a new generation of microwave signal sources.

REP APPOINTMENTS

Richardson Electronics Ltd. announced it has teamed with **Scintera Inc.** to bring Scintera's recently announced SC1887 to the worldwide market. The SC1887 delivers critically needed power amplifier linearity improvements without requiring access to the I/Q baseband signals. This digitally controlled analog technology works at the RF signal level, can be brought to market quickly, and requires only the addition of a few standard RF components to implement. Scintera's SC1887 Adaptive RF Power Amplifier Linearizer is a practical, cost-effective solution that satisfies today's needs for reduced amplifier distortion, increased power efficiency and higher output power.

Modelithics Inc. announced its new agreement with **CogniTech Sales LLC**, for sales and service representation for the Southeastern United States. Larry Dunleavy, Modelithics' CEO, and the Advanced Products Sales Director, Alen Fejzuli, have signed a comprehensive agreement designed to fully support Modelithics in the Florida, Alabama and Georgia markets for RF and microwave simulation models as well as characterization services. CogniTech will also be assisting with establishing new relationships for Modelithics Vendor Partner Program (MVP).

Technical Communities Inc. announced an exclusive government services partnership agreement with **Casella USA**, the North American subsidiary of UK-based Casella Measurement Inc. The agreement authorizes Technical Communities to distribute more than 300 Casella products.

Comparison of Two GaN Transistor Technologies in Broadband Power Amplifiers

This article compares the performance of two different GaN transistor technologies, GaN HEMT on silicon substrate (PA1) and GaN on SiC (PA2), utilized in two broadband power amplifiers operating at 0.7 to 1.8 GHz. The study explores the broadband power amplifier potential of both GaN HEMT technologies for phased-array radar (PAR) and electronic warfare (EW) systems. The measured maximum output power for PA1 is 42.5 dBm (18 W) with a maximum PAE of 66 percent and a gain of 19.5 dB. The measured maximum output power for PA2 is 40 dBm with a PAE of 37 percent and a power gain slightly above 10 dB. The high power gain, PAE, wider bandwidth and unconditional stability was obtained without feedback for the amplifier based on GaN HEMT technology, fabricated on Si substrate.

Phased-array radars, wireless communication transmitters, including public safety radio networks, medical instrumentation and other various traditional civil and military applications, require demanding performance of microwave power transistors. The broadband operating capability is always demanding in various RF circuits and subsystems. Wireless systems deliver high data rate signals to provide multimedia and broadband connectivity. This demanding performance of power amplifiers in a system should cover wide bandwidth and at the same time have a high linearity to amplify the signals without distortion. In combination with these properties, the high efficiency is also important, especially with the mobile systems, where cooling is additional and of relatively higher cost on the system. The next generation cell phones also require wider bandwidth and improved efficiency. These high power and high frequency applications require transistors with a large breakdown voltage, high electron velocity and high thermal conductivity. Therefore, a wide bandgap (WBG) semiconductor such as GaN is a favorable choice.[1]

The high output power density of GaN transistors allows the fabrication of much smaller devices compared to Si and GaAs. A higher impedance, due to the smaller size, allows for easier and lower loss matching networks in amplifiers. The wider bandgap also enables the electronics to operate at elevated temperatures. These features in amplifiers, enabled by the superior semiconductor properties, make GaN a promising candidate in microwave power applications.

S. Azam, C. Svensson and Q. Wahab
Linköping University, Linköping, Sweden
R. Jonsson
Swedish Defense Research Agency Linköping, Sweden

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- Exceptional Phase Noise
- Excellent Spectral Purity
- Phase Lock Option Available
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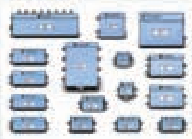
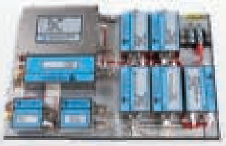
Standard Frequency Options		Output Frequency	Typical Output Level	Typical Phase Noise (dBc/Hz) (Free-Running)				Harmonics	Sub-Harmonics	Spurious
Part Number	Package Size			100 Hz	1 kHz	10 kHz	100 kHz			
MXO-200-J1	2.25 x 4 x 1"	**200 MHz**	+13 ±2 dBm	-123	-149	-167	-168	≤ -25 dBc	≤ -60 dBc	≤ -80 dBc
MXO-500-J1	2.25 x 4 x 1"	**500 MHz**	+13 ±2 dBm	-115	-142	-160	-161	≤ -25 dBc	≤ -60 dBc	≤ -80 dBc
MXO-1000-J1	2.25 x 4 x 1"	**1 GHz**	+13 ±2 dBm	-109	-133	-151	-152	≤ -25 dBc	≤ -60 dBc	≤ -80 dBc
MXO-1280-J2	3.205 x 4 x 1"	**1.28 GHz**	+13 ±2 dBm	-107	-129	-147	-148	≤ -25 dBc	≤ -80 dBc	≤ -80 dBc
MXO-2560-J3	4.16 x 4 x 1"	**2.56 GHz**	+13 ±2 dBm	-101	-122	-140	-141	≤ -25 dBc	≤ -80 dBc	≤ -80 dBc
MXO-5120-J3	4.16 x 4 x 1"	**5.12 GHz**	+13 ±2 dBm	-95	-115	-133	-134	≤ -25 dBc	≤ -80 dBc	≤ -80 dBc
MXO-10000-J3	4.16 x 4 x 1"	**10 GHz**	+13 ±2 dBm	-89	-111	-129	-130	≤ -25 dBc	≤ -80 dBc	≤ -80 dBc
MXO-12000-J3	4.16 x 4 x 1"	**12 GHz**	+13 ±2 dBm	-87	-108	-126	-127	≤ -25 dBc	≤ -80 dBc	≤ -80 dBc

NOTE: Contact factory to discuss external reference frequencies, loop bandwidth options, and custom / specific output frequencies.

RF Systems & Synthesizers



Blue Tops RF Modules



Sub-Assemblies

Ultra Low Noise Crystal Oscillators

Integrated Microwave Assemblies (IMA)

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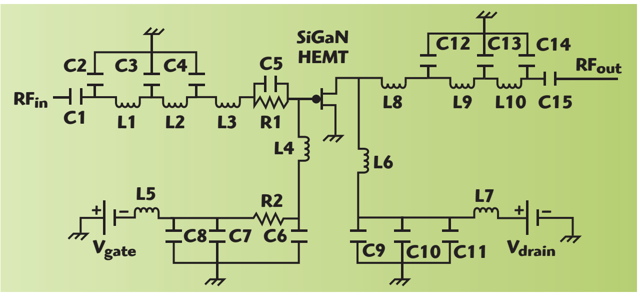


Fig. 1 Schematic of the fabricated PA1 amplifier.

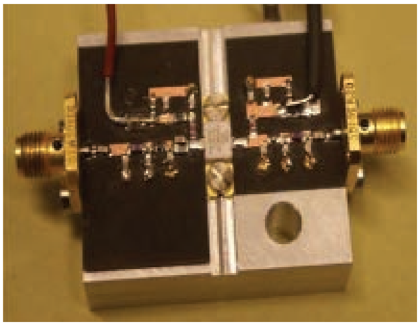


Fig. 2 Photograph of the PA1 amplifier.

Due to these superior electronic properties of GaN semiconductor and the possibility to utilize SiC substrate, which has a high thermal conductivity (3.5 to 4.9 W/cm K), a power density as high as 30 W/mm at 4 GHz[2] as well as an output power of 500 W at 1.5 GHz[3] have already been demonstrated. An output power of 75 W for a packaged single-ended GaN-FET has been reported under pulsed conditions for L/S band applications.[4] The introduction of GaN HEMTs on silicon substrates is considered to be a great development for reducing the cost of these transistors. Therefore, these transistors are also expected to replace some Si LDMOS designs in the telecommunications sector. GaN technology has already been used in power amplifiers for mobile base station applications, and a number of manufacturers and researchers have reported high efficiencies, output powers and power densities.[5-10]

In this article, the results of two fabricated power amplifiers in two different GaN HEMT technologies are presented. The purpose of this work is to explore the broadband performance and capabilities of these transistors for PAR and EW systems.

POWER AMPLIFIER DESIGNS

Power Amplifier Using GaN HEMT on Silicon (PA1)

A hybrid amplifier operating in the 0.2 to 1.8 GHz band for phased-array transmitters has been designed and fabricated. The design is based on a large-signal model of packaged 25 W (wideband 15 W) GaN HEMT on Si from Nitronex. The actual designed bandwidth is wider than the amplifier described in the next section. It has lumped matching networks (without feedback) built on Rogers Duroid 5880 substrates. The amplifier is first designed using ideal components, which were later replaced by their models and S-parameter blocks. An unconditional stability is obtained by adding a parallel combination of resistor R1 and capacitor C5 in series to the input matching network. The schematic diagram and picture of the fabricated amplifier are shown in ***Figures 1*** and **2**, respectively.

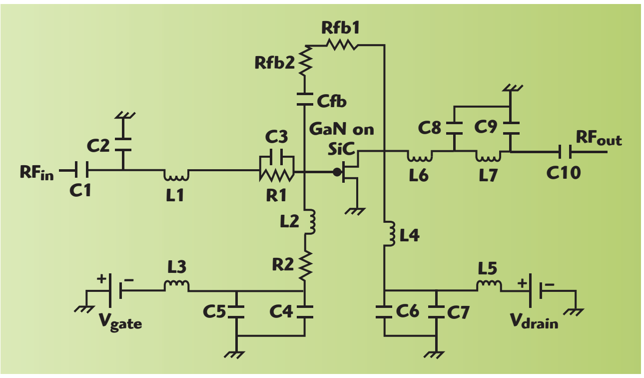
Hybrid Power Amplifier Using GaN HEMT on SiC (PA2)

A 0.7 to 1.8 GHz hybrid amplifier for high power phased-array transmitter applications have been designed and fabricated. This amplifier is based on a packaged 10 W GaN HEMT from Eudyna. It has lumped matching networks (with feedback) built on the same Rogers Duroid 5880 substrate. A parallel combination of resistor R1 and capacitor C3 in series to the input matching network is added in combination with feedback to enhance stability, increase the bandwidth and reduce distortion. The feedback network consists of a capacitor Cfb and total resistor of 80 V. The resistor is divided between two 1206 SMT resistors Rfb1 and Rfb2 to enhance power tolerance. It was very difficult to obtain unconditional stability without feedback for this amplifier. A schematic diagram and picture of the fabricated amplifier are shown in ***Figures 3*** and **4**, respectively.

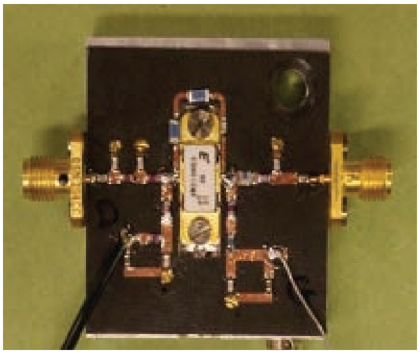
RESULTS AND DISCUSSION

Simulation and Measured Results for the Fabricated PA1

The simulated and measured small-signal gain S_{21} and



▲ *Fig. 3 Schematic of the fabricated PA2 amplifier.*

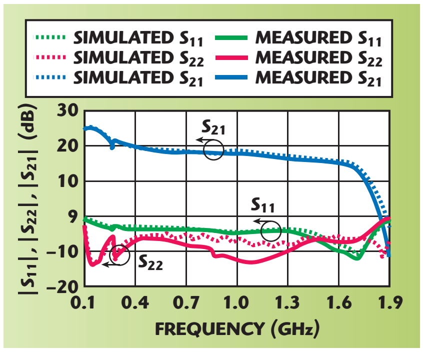


▲ *Fig. 4 Photograph of the PA2 amplifier.*

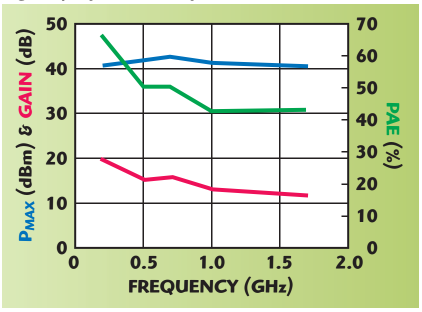
input reflection coefficient S_{11} showed good agreement over the entire frequency band. A gain greater than 15 dB is achieved for the entire frequency band. The design shows matching below -4 dB for S_{11} and below -7 dB for $S_{22,}$ as shown in ***Figure 5***. The output reflection coefficient S_{22} shows good agreement up to 500 MHz and, at higher frequencies, measured results are better than the simulation. There is also frequency shift at the upper band, which could be because of some minor error in the output matching network for higher frequencies or due to some minor error in the large-signal model. The design shows unconditional stability at all simulated frequencies. The class AB bias point used was V_g = -1.5 V and V_d = 28 V with a quiescent drain current of 230 mA.

Power measurements were performed at five different frequencies from 0.2 to 1.8 GHz and the results are shown in ***Figure 6***. A maximum output power of > 40.6 dBm (11.5 W) with a power gain of ≥ 11 dB is obtained at all measured frequencies. A maximum output power is obtained at 700 MHz, which is 42.52 dBm (~18 W) and a maximum PAE of 66 percent with a maximum gain of 19.5 dB is obtained at 200 MHz. The measured output power is almost constant at all measured frequencies as shown in the figure.

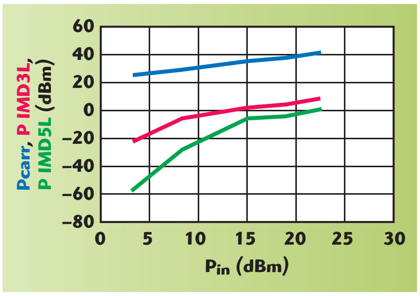
A two-tone inter-modulation distortion measurement was carried out at 1 GHz. The separation between the two carrier tones was 4 MHz. The IMD3 at 10 dB back off the P1dB was -31 dBc and the output IP3 was 48 dBm. The results are shown in ***Figure 7***.



▲ *Fig. 5 Simulated and measured small-signal performance of PA1.*



▲ *Fig. 6 Power mesurements at V_d = 28 V for the PA1 amplifier.*



▲ *Fig. 7 Two-tone test results for PA1 at 1 GHz with a tone spacing of 4 MHz.*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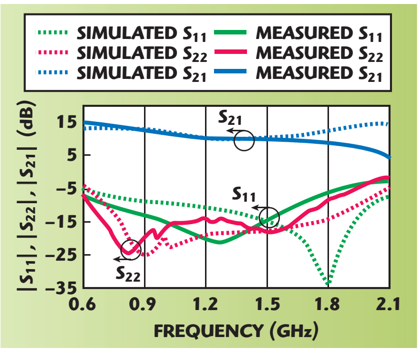
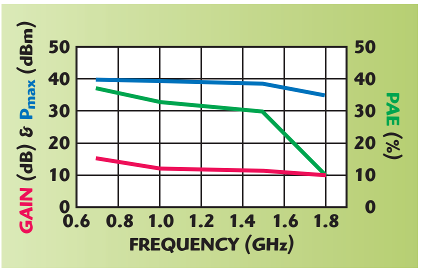
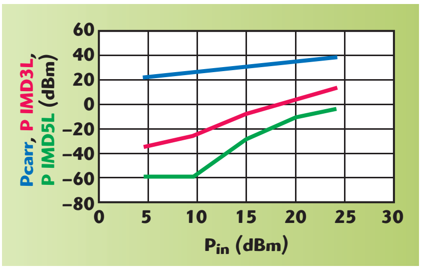


▲ *Fig. 8 Simulated and measured small-signal performance of PA2.*



▲ *Fig. 9 Power measurement results of PA2 at V_d = 48 V.*



▲ *Fig. 10 Two-tone test results for PA2 at 1 GHz with a tone spacing of 4 MHz.*

Simulation and Measured Results for the Fabricated PA2

Simulated and measured S-parameters showed good agreement up to approximately 1.4 GHz. Above this frequency the measured small-signal gain starts to decrease compared to the simulation. The gain achieved is greater than 10 dB up to 1.4 GHz and is above 9 dB across the remainder of the band. The design showed an input matching below -4 dB (for S_{11}) and below -10 dB at the output (for S_{22}), as shown in ***Figure 8***. The design shows unconditional stability at all simulated frequencies. The class AB bias point used was V_g = -0.4 V and V_d = 48 V with a quiescent drain current of 270 mA.

Power measurements were performed at four different frequencies from 0.7 to 1.8 GHz and the results are shown in ***Figure 9***. The maximum output power, measured at 700 MHz at 2.5 dB gain compression, was 39.9 dBm (~10 W) with a PAE of 37 percent and a gain greater than 15 dB. As can be seen, the output power and efficiency are almost constant at all measured frequencies.

A two tone inter-modulation distortion measurement was carried out at 1 GHz. The separation between the two carrier tones was the same as before, 4 MHz. The IMD3 at 10 dB back off the P1dB was -32 dBc and the output IP3 was 50 dBm. The results are shown in ***Figure 10***.

COMPARISON OF BOTH POWER AMPLIFIERS

The measured results indicate that PA2 is more stable than PA1, because there is less variation in the results obtained for PA2 (except at 1.8 GHz), while major differences are seen in the results at different frequencies for gain and PAE for PA1. This could possibly be because the design for PA1 was without feedback and was totally dependent on its bias and input matching network for stability. The second reason could be the thermal conductivity of the SiC substrate (PA2), which is higher than Si (PA1). At V_d = 28 V, P_{max} at 700 MHz for PA1 is 18 W, which is 10 W for PA2 at V_d = 48 V. The average maximum output power obtained from PA2 is almost equal to the power out designated by the manufacturer of the transistor, while a higher power than the designated one was obtained for broadband at almost one third of the bandwidth in the case of Si-based GaN HEMT (PA1). The PAE for PA1 is above 40 percent at all measured frequencies (and 66 percent at 200 MHz) comparing to PA2, for which it varies between 10 and 37 percent. The PA2 had the advantage of operating at a higher drain bias of V_d = 48 V. A wider frequency band, high power gain, PAE and unconditional stability was achieved without feedback using a Si-based transistor (PA1) compared to SiC-based GaN HEMT (PA2). The linearity of both amplifiers is also comparable.

CONCLUSION

Two single-stage broadband power amplifiers, using two different GaN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HEMT technologies, have been designed and fabricated. Both amplifiers showed good performance in output power, PAE, gain and linearity for the frequency band of 0.7 to 1.8 GHz. It is interesting that a wider bandwidth, higher power, gain and PAE were achieved for a GaN transistor grown on a Si substrate (PA1). Since GaN on Si is a cost-effective solution, together with high quality performance, it is the future technology of choice, due to the cost advantage of large diameter silicon wafers. In PAR and the communication sector, the major hindrance for adoption of GaN technology compared to its rival LDMOS is its cost, which is gradually decreasing by introducing GaN on Si. The results of the Si-based GaN technology indicate that these devices have strong potential to replace the same present Si LDMOS designs in the telecommunications sector. This technology can become the first choice in many other RF and microwave applications. ■

ACKNOWLEDGMENT

The authors acknowledge the subsystem group (previously the microwave group) at the Swedish Defense Research Agency (FOI-Linköping) for providing the laboratory facilities and participating in technical discussions.

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TWO-ARM ARCHIMEDEAN SPIRAL HELICAL ANTENNA WITH WRAPAROUND ABSORBER

Two-arm spiral antennas usually have wideband characteristics (these antennas usually have constant beam width and circular polarization over a broad range of frequencies),[1,2] and thus are suitable for communicating (transmitting and receiving) over bands of frequencies (multiple channels). At lower frequencies, for a given size, these antennas tend to have poor performance (high S_{11}, low gain and high axial ratio).[1,2] This can be improved by increasing the diameter of the spirals. The real question, however, is can the poor performance at low frequencies be improved without sacrificing the compactness of the antenna? This article shows an innovative approach that can improve the performance of an antenna without increasing its size.

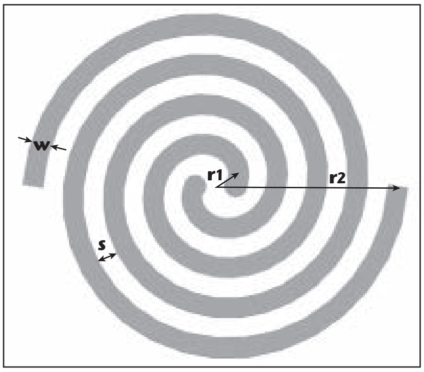

Fig. 1 An Archimedean two-arm spiral antenna.

METHODOLOGY

The two-arm spiral used in this study is an Archimedean spiral, as shown in ***Figure 1***. The benchmark for this study is a two-arm Archimedean spiral whose diameter is 6 inches. The goal is to build a two-arm spiral antenna, with reduced size, whose diameter is 4.4 inches, but has gain and return loss across the desired band (0.5 to 2 GHz) of at least that of the benchmark antenna. The 6-inch diameter two-arm Archimedean spiral antenna with a ground plane placed 2.6 inches below is shown in ***Figure 2***, where r_1 = 0.05" and r_2 = 3.0" are the initial and final radius, respectively. W = 0.04" is the width of the spiral arm and S = 0.06" is the gap between turns. The antenna has 17.75 turns. Its performance is simulated (solved using MoM) in FEKO and its S_{11} and gain are shown in ***Figure 3***.

The 4.4-inch final diameter two-arm Archimedean spiral antenna with a ground plane placed 2.6 inches below is shown in ***Figure 4***. Its dimensions are r_1 = 0.05", r_2 = 2.2", W = 0.04", S = 0.06" and 13 turns. Its gain and S_{11} are simulated (solved using MoM) in FEKO and are shown ***Figure 5***.

Comparing the two simulated performances, it is obvious that reducing the diameter resulted in lower gain and higher S_{11} at low frequencies (the gain decreased by 5.5 and 4 dB and S_{11} increased by 0.4 and 15 dB at 500 and 750 MHz, respectively). To improve the gain at the low frequencies, two helices are

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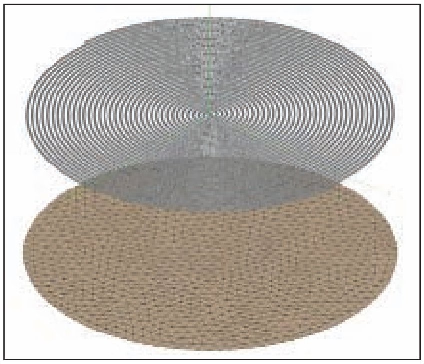
added such that they connect the two spiral arms to the ground plane. The two-arm spiral antenna with helices is shown in ***Figure 6***; its simulated (in FEKO using MoM) results are shown in ***Figure 7***.

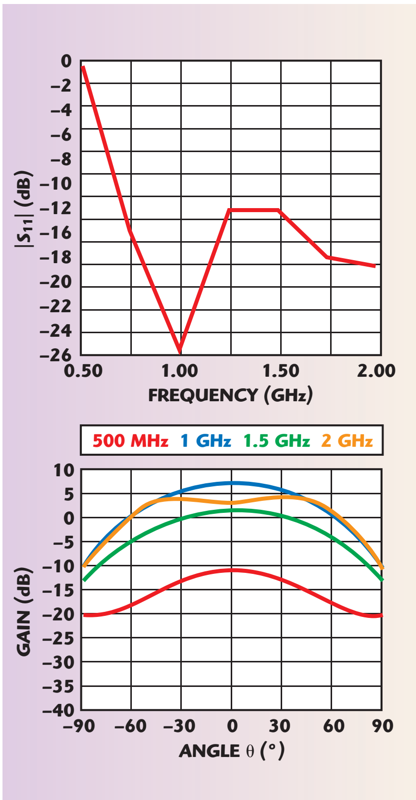
Comparing the simulated results for the reduced size antennas with and without helices, it is obvious that adding helices has slightly improved the gain at low frequencies (especially at 500 MHz), but still not comparable to the gain of the 6-inch diameter spiral antenna. The S_{11} of the antenna with helices, which remains high at 500 MHz, indicates that improving the S_{11} can improve the gain. To improve the S_{11} at the low frequencies, a dielectric absorber is added around the antenna (see ***Figure 8***).

FEKO optimization is used to determine the loss tangent (tan δ) and the thickness of the absorber. An optimization routine is set up with the goal of reaching the gain (better than -10 dB) and maximizing the return loss (minimizing S_{11}) at 500 MHz. The optimized values found for tan δ and absorber thickness are 0.4 and 0.2 inches, respectively. This design is validated by fabricating a prototype and comparing the measured and simulated data. Finally, both the MoM (FEKO) and FEM (HFSS) design results are compared with the measured data. ***Figure 9*** shows the antenna that was built with the FEKO optimization results and was later used to obtain the measured data.

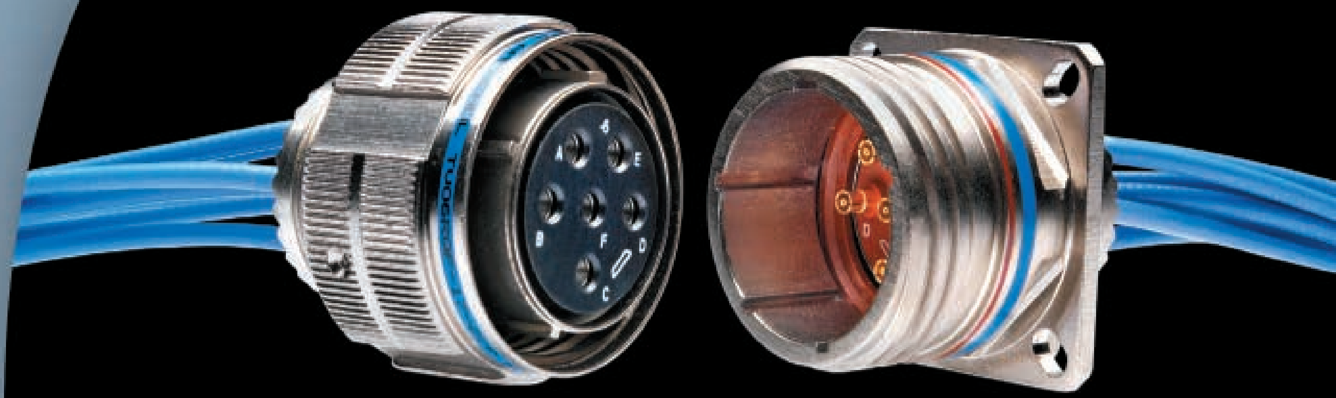
The simulated S_{11} for the prototype model from FEM and MoM are



▲ *Fig. 2 Meshed FEKO model of benchmark antenna.*



▲ *Fig. 3 Simulated S_{11} and gain of the benchmark antenna.*



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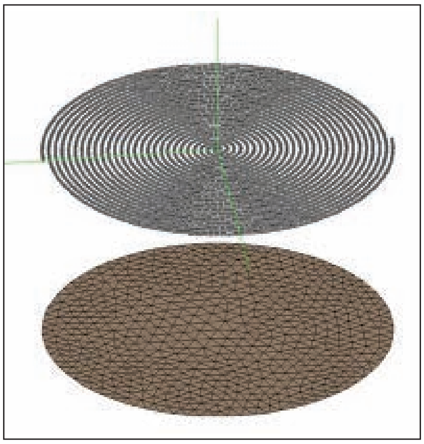
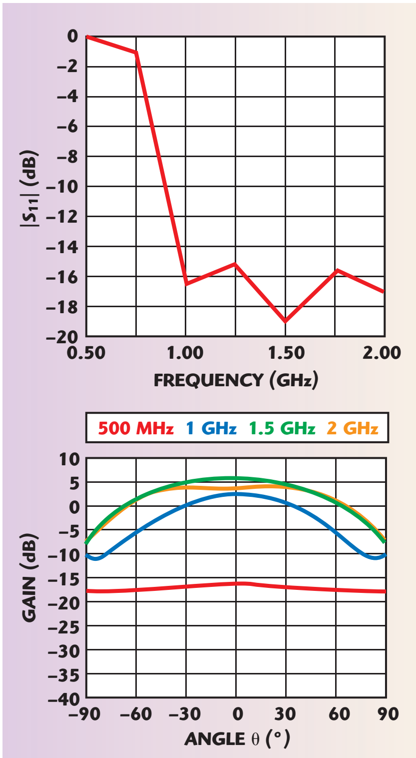
shown in ***Figure 10***. It can be seen that both the simulations agree closely, and the S_{11} is improved compared to the case of the 6-inch diameter spiral antenna. ***Figures 11*** through ***17*** compare the gain of FEKO, HFSS and measured data at 500 MHz, 750 MHz, 1 GHz, 1.25 GHz, 1.5 GHz, 1.75 GHz and 2 GHz, respectively. The measured data and FEM data is imported into the FEKO's post processing interface and compared with the MoM results. The axial ratios of the four antenna models are also compared in ***Figure 18***.

Looking at Figures 10 through 16, it can be seen that the MoM simulated gain and measured gain agree quite well, but the FEM simulated gain shows a slight disagreement with the measured gain for frequencies less than 1 GHz. This is because, in the FEM simulation setup, the radiation boundary was placed at a quarter-wavelength away from the antenna at 1 GHz, due to the memory constraints. At 0.5 GHz, the radiation boundary at a quarter-wavelength away from the antenna needed more than 32 GB of RAM for a convergence result, which was not available on the host computer and thus, as expected, for frequencies greater than 1 GHz, the MoM simulated gain, the FEM simulated gain and the measured gain agree quite well.

In Figure 18, it can be seen that the optimized model has the lowest axial ratio (less than 2 dB) compared to the other three models. The opti-



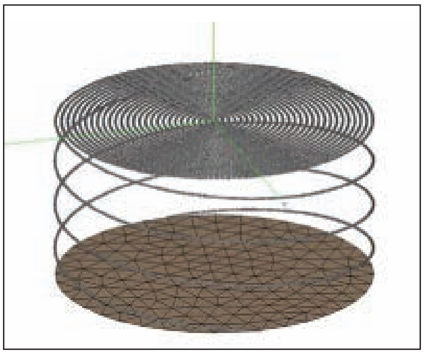
▲ *Fig. 4 Meshed FEKO model of the reduced size antenna.*



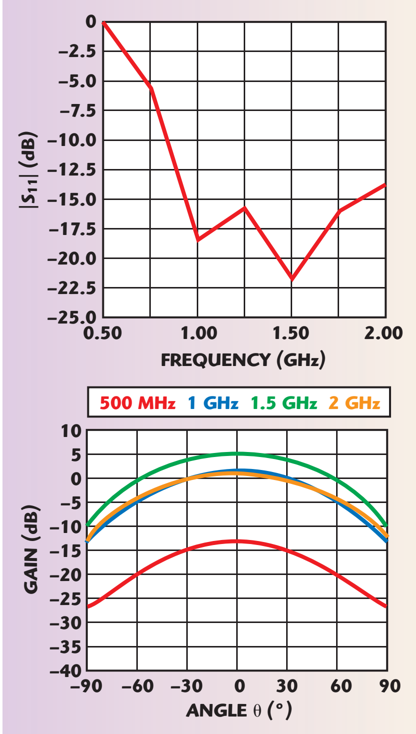
▲ *Fig. 5 Simulated S_{11} and gain of the reduced size antenna.*

mized model has better performance (higher gain, lower S_{11} and lower axial ratio) and is compact compared to the bench mark antenna.

In Figure 9, it can be seen that the two spiral arm circuits are printed on a thin dielectric substrate, which is not taken into account in the MoM and FEM simulations, thus causing some small difference between the measured gain and simulated gain (FEKO and HFSS). The computation time and resource usage of MoM and

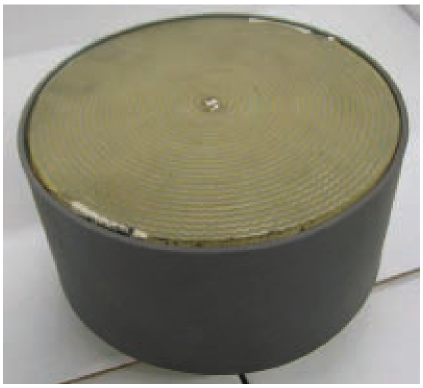


▲ *Fig. 6 Spiral antenna with helices connecting the spiral to the ground plane.*

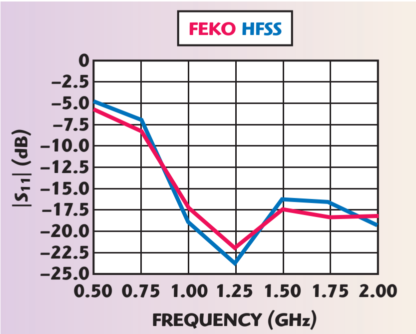


▲ *Fig. 7 Simulated S_{11} and gain of the spiral antenna with helices.*

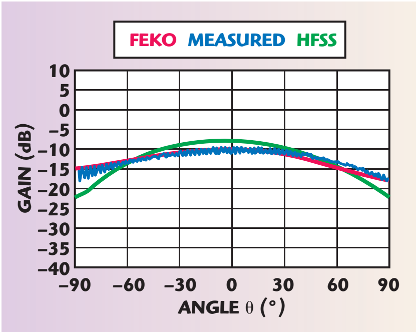
▲ *Fig. 8 Antenna with spirals, helices and wraparound absorber.*



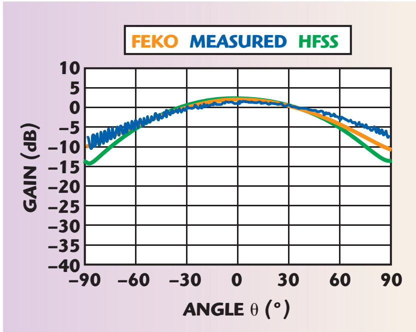
▲ *Fig. 9 Two-arm spiral antenna prototype with helices and wraparound absorber.*



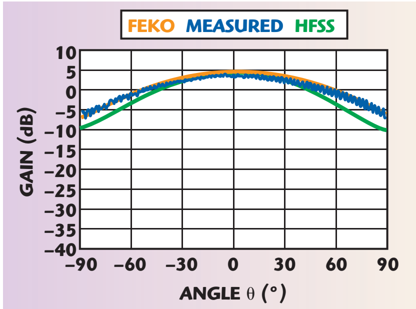
▲ *Fig. 10 Comparison of the S_{11} of the prototype antenna simulated with FEKO and HFSS.*



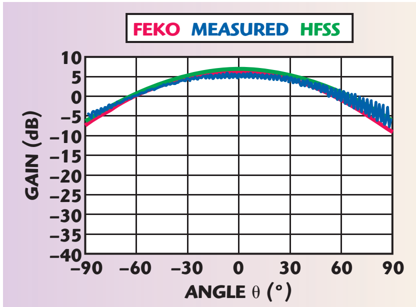
▲ *Fig. 11 Comparison of gains at 500 MHz.*



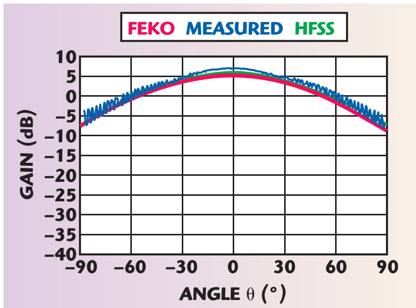
▲ *Fig. 12 Comparison of gains at 750 MHz.*



▲ *Fig. 13 Comparison of gains at 1 GHz.*



▲ *Fig. 14 Comparison of gains at 1.25 GHz.*

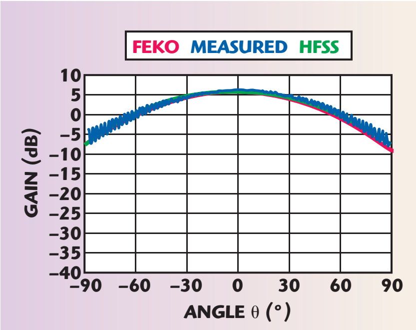


▲ *Fig. 15 Comparison of gains at 1.5 GHz.*

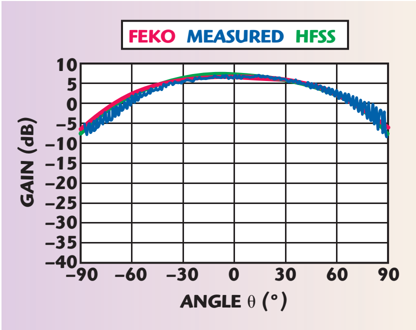
FEM, for the model in Figure 8, is compared in ***Table 1.***

CONCLUSION

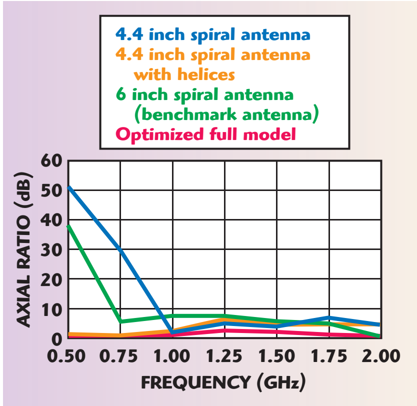
A method was presented to miniaturize a spiral antenna, without sacrificing performance at lower frequencies. FEKO's optimization routine (using MoM) is used effectively to accomplish the design and is verified using measured data and comparison with FEM (HFSS) simulated results. FEM (HFSS), being a field solver (volume



▲ *Fig. 16 Comparison of gains at 1.75 GHz.*



▲ *Fig. 17 Comparison of gains at 2.0 GHz.*



▲ *Fig. 18 Comparison of the axial ratios of the four models.*

TABLE I

COMPARISON OF MoM (FEKO) AND FEM (HFSS) COMPUTATION TIME AND RESOURCE USAGE

	Computation Time (Hrs)	Memory Usage (GBytes)
MoM (FEKO)	1.468	2.616
FEM (HFSS)	26.48	28.78

meshing), needed far more computation time and memory than MoM (FEKO). ■

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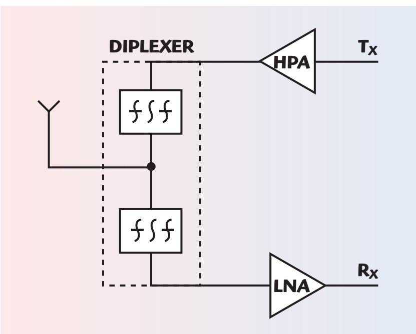
NOTCH IMPLEMENTED DUAL BEHAVIOR RESONATOR FILTER AND DIPLEXER AT KU-BAND

This article presents a dual behavior resonator (DBR)-based microstrip filter for the realization of a diplexer at Ku-band. The transmit – receive (Tx – Rx) filter topologies are designed at the required frequency and are cascaded using an optimized T-junction. A notch in the transmission line is introduced to improve rejection at the receiving/transmitting bands and a detailed comparison study has been carried out. The diplexer is realized both on alumina and high resistivity silicon substrates. The measured result of the realized diplexer and the fabrication steps are detailed in this article.

Modern communication systems need new filters, diplexers and multiplexers to meet electrical performance, size and manufacturing cost requirements, which are difficult to achieve using classical topologies. Diplexers are widely used in communication systems for reducing mass and volume of the required hardware. They separate different bands of a signal into different ports and enable the use of the same antenna for different frequency bands, resulting in more compact systems. Alternatively, a diplexer combines two different signals with different spectral components into one common port. A typical architecture of a transceiver RF front-end is shown in ***Figure 1***.



▲ *Fig. 1 Basic components of a transceiver front end.*

The diplexer is one of the key components in the overall system, as shown in the figure within the dotted line. The transmitter and receiver operate in different frequency bands and are duplexed to the antenna by the transmit-receive diplexer. The diplexer consists of a power divider and two channel filters that can have very stringent specifications. The transmit filter must reject out-of-band noise generated in the power amplifier, so it must have a high level of stop band attenuation, particularly in the receive band. It should have a low pass band insertion loss in order to maximize the DC to RF efficiency of the power amplifier. On the other hand, the receive filter should have high attenuation in the transmit band in order to protect the front-end

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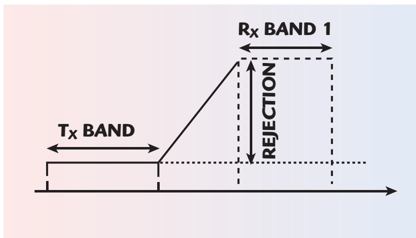
low noise amplifier (LNA) from the large transmit signals, which would otherwise saturate the receiver or produce high levels of distortion. The most important parameter in the diplexer design is the isolation between the receive and transmit channels.

Waveguide filters are an alternative solution and have been used until now, because of their good characteristics in terms of insertion loss at the expense of weight, volume and cost. In the near future, waveguides in satellite equipment will be replaced by planar structures. Therefore, a planar solution would be a better approach to achieve the desired specifications of insertion loss, return loss and rejection. Parallel coupled line (PCL) transmission lines can be used to construct many types of filters. A PCL approach, using the standard classical techniques, is unsuitable for the diplexer application as it does not achieve the desired narrow bandwidth. Alternatively, a multi-section bandpass coupled line filter, having a narrow bandwidth, can be employed, as required for the diplexer applications. However, limitations of this approach yield large size and uncontrollable transmission zeros resulting in poor selectivity.[1] Hairpin topology is considered to be another approach for placing the transmission zeros (TZ), but the desired rejection is still not achieved. A modified hairpin topology has recently been proposed[2] using the cross-coupling effect, but it increases the circuit complexity and needs tight fabrication tolerances.

This article presents the design and development of a microstrip diplexer using the dual behavior resonator (DBR) approach. To achieve the desired specifications, two filters at the Rx and Tx frequency bands are optimized. A notch effect on the filter performance is carried out and further implemented in the receive filter. To achieve the desired specifications, the notch, along with the concept of an oversized stub, has been implemented to have better rejection characteristics in both receive-transmit bands. Further, a suitable T-combiner has been designed to integrate the Rx and Tx filters for the diplexer arrangement.

KU-BAND DIPLEXER SPECIFICATIONS

The main objective of this work is to demonstrate a compact diplexer design for onboard communication satellites. The precise specification for the receive band, as described in ***Figure 2***, shows a high rejection for the transmit frequencies while preserving the receive frequencies. The same is true for the transmit frequencies, to be passed with low loss, eliminating the receive frequencies. In the present article, the transmit frequency is 12.5 GHz and the receive frequency is 14.5 GHz, suitable for the onboard Ku-band transponder. The specified criteria of inser-



▲ *Fig. 2 Receive band specification.*

tion loss and flatness are better than 3 and 1 dB, respectively. The isolation requirements between the two bands are greater than 20 dB. The main challenge here is to get a better rejection while restricting the number of resonators to be used so as to reduce both the level of insertion loss and the structure size. This specification can be met with the DBR approach, using an oversized stub, which allows increasing the rejection level without altering the TZ frequency.[3]

DBR APPROACH

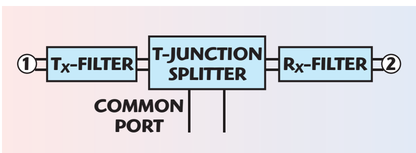
The dual behavior resonator (DBR) is a basic resonator that presents a dual frequency behavior in the pass band and stop band regions. It allows independent control of the rejected bands, through the addition of the transmission zeros and a centered bandpass. Dual behavior resonators are achieved by associating two different parallel open-ended stubs. Each stub brings its own TZ with respect to the fundamental resonant condition and a bandpass is created between them.[4] It allows an independent control of each frequency band of interest, that is the center frequency bandpass and the attenuated bands.[5] The resonator, in the case of a DBR, is composed of two stubs (low and high frequency stubs), in which only one of them can be modified, which consequently improves the rejection either near the low frequency transmission zero or the high frequency transmission zero. With the number of available parameters and its initial behavior, a dual behavior resonator allows independent control of the following:[6]

- one pole in the operating bandwidth
- one transmission zero in the lower attenuated band
- one transmission zero in the upper attenuated band

The concept of the oversized stub improves the rejection either at the lower frequency end or at the higher frequency end as both cannot be modified simultaneously.

DESIGN METHODOLOGY

The diplexer design starts with the design of the channel filters (bandpass filters), which must achieve the required pass band performances before they are connected to the power divider. Usually, two methods are followed to obtain the final device. In the first one, the bandpass filters are reoptimized within the diplexer environment, which includes the effect of the power divider discontinuities as well as the interaction between the filters. In the second method, the original filter designs are maintained and an optimum matching circuit is incorporated into the power divider junction to obtain the required matching in the pass bands. In the present communication, the second approach is adopted, reducing the minimum number of variables for the circuit optimization. The design of the diplexer can be divided into three parts: Tx filter, Rx filter and T-junction. The overall basic building blocks are shown in ***Figure 3***.



▲ *Fig. 3 Basic building blocks of a diplexer.*

Transmitter Filter Design

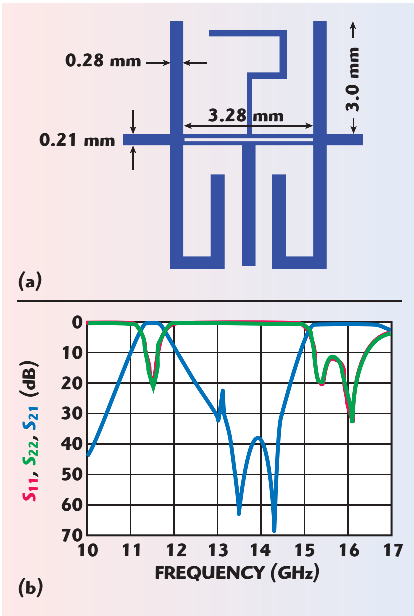
The channel filter for the transmitter has been designed for 12.2 to 12.8 GHz. The circuit layout is shown in ***Figure 4*** with its electromagnetic (EM) simulated response. The EM simulation has been carried out using Linmic and ADS tools.[8] The simulated response shows a rejection level greater than 50 dB at the receiver frequency with an insertion loss less than 1 dB. The minimum strip width and gap is kept to approximately 0.1 mm. The notch in the filter is introduced in the transmission line as shown in Figure 4. The effect of the notch has been studied using the EM circuit simulator. The notch implemented filter called Mod in ***Figure 5*** shows a rejection improvement of more than 15 dB at the receive band. There is no change in the other major characteristics like insertion loss and return loss of the filter. This is attributed to the field's interaction in the notch, leading to coupled line behavior by introducing two nearby poles at the receive band.

Receiver Filter Design

The receiver filter is designed and optimized at 14.5 GHz. The layout and the current plot of the EM simulated structure are shown in ***Figure 6***. The effect of the notch has also been studied in this configuration. Introducing a smaller notch in the transmission line has no significant effect on RF performance. Extending the notch length changes the RF performance considerably, as shown in ***Figure 7***. The notch width in the present study is kept constant (0.12 mm) and the simulation study is carried out by taking two different notch lengths. The study shows that the notch introduces poles at the transmit frequency bands, which clearly shows an improvement of approximately 20 dB. This rejection enhancement overall improves the diplexer performance, compared to the standard topology suggested by Quendo, et al.[7] Since the notch considerably affects the center frequency, the notch in the receive filter is not implemented as it affects the layout dimensions, which need re-simulation and layout reorientation. This concept is not implemented in the present Rx filter development.

Power Divider

The power divider is an essential



▲ *Fig. 4 The transmitter channel filter: (a) layout and (b) simulated performance.*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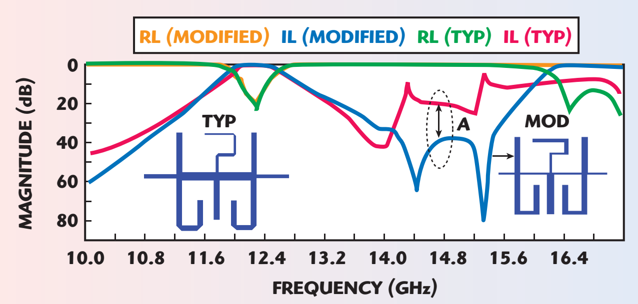
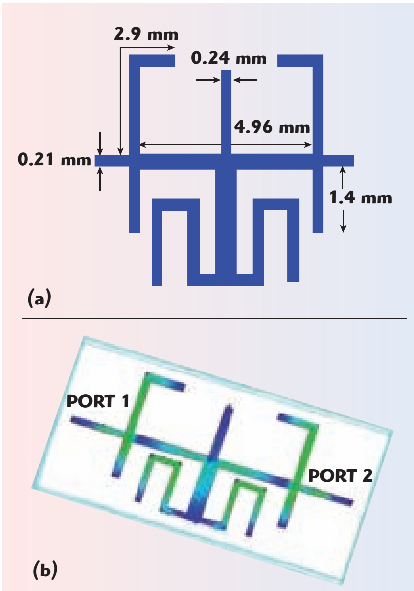


▲ *Fig. 5 Comparison of the proposed (mod) technology with the standard (typ) topology.*

part of the diplexer and a T-combiner is chosen to join both the transmitter and receiver filters. The lossless T-divider shown in ***Figure 8***, is constructed using 100 Ω lines at the output, but the discontinuity due to the lower width of the 100 Ω leads to considerable losses at the output. Therefore, to achieve improved isolation characteristics between the output ports, the line width has been maintained to have impedances of 70.7 ohms and phases are adjusted accordingly to get the desired response. Transmitter and receiver filters are joined together using the T-combiner and further optimization has been carried out as the second approach discussed earlier in the Design Methodology section. The layout of the overall circuit is shown in ***Figure 9***.

FABRICATION ASPECTS

The proposed filter was implemented on a 10 mil thick alumina substrate having a dielectric constant $\varepsilon_r = 9.9$. The filter is realized on the microstrip substrate and attached using conductive epoxy. Further connectors are attached using ribbon bonds. The overall size of the diplexer is 1 × 1 inch. The line lengths at the input and output ports are extended by 2 mm to facilitate connector placement. The measured results show a pass band insertion loss of less than 3 dB and an attenuation of more than 10 dB in the transmit band. The results show a slight frequency drift with higher insertion loss at the receive frequency band. This is attributed to the fabrication tolerances along with permittivity dispersion. The drift in the permittivity affects the T-combiner matching, which degrades the overall circuit performance. The comparison



▲ *Fig. 6 Layout (a) and current conduction behavior (b) of the receive filter.*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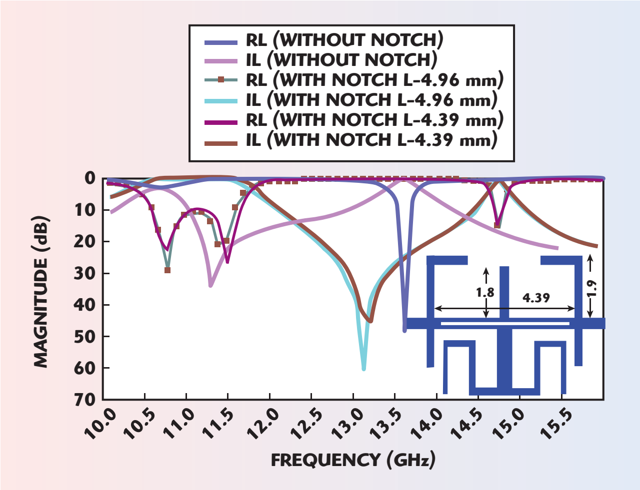

Fig. 7 *Study of the notch on receive filter performance.*

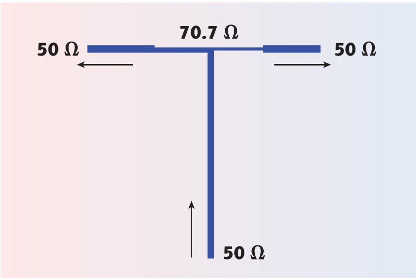

Fig. 8 *T-combiner topology.*

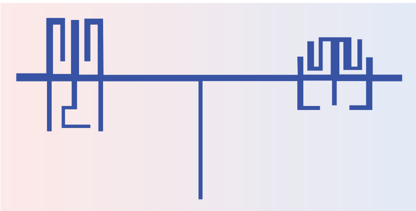

Fig. 9 *Final layout of the diplexer.*

of the simulated and measured performance is shown in ***Figure 10***.

The diplexer was also fabricated on a high resistivity silicon substrate (> 8 k Ω-cm). After being subjected to standard thin film substrate cleaning cycles, the high resistivity silicon substrates (25.4 × 25.4 × 0.6 mm) were sputtered with a thin layer of TiW (200 to 300 Å) followed by a 8000 Å gold film on both sides of the substrates. This combination of under layers was electroplated with gold to the required thickness of 4.5 µm ± 3 percent and the circuits were patterned using standard optical lithography and a subtractive etching process. The patterned substrate was attached to a gold metalized kovar carrier plate, using a silver-based conductive epoxy. The carrier plate was mounted in the test jig and RF connectors were connected by gold ribbon 20 mils wide and 1 mil thick, using parallel gap welding. The fabricated silicon diplexer has been measured with a PNA vector network analyzer (8261A), showing isolation characteristics better than 24 dB, as shown in ***Figure 11***.

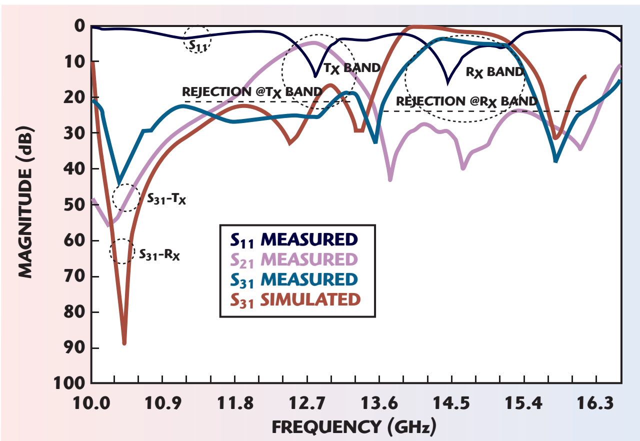

Fig. 10 *Comparison of simulated and measured performance of the diplexer fabricated on an alumina substrate.*

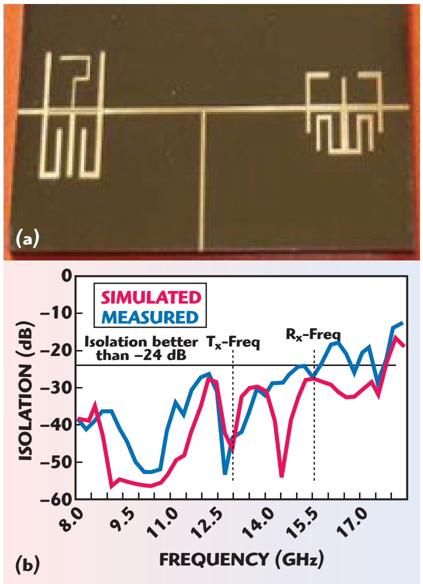

Fig. 11 *Fabricated diplexer on a silicon substrate (a) and its simulated and measured isolation characteristics (b).*

CONCLUSION

The planar realization of a diplexer is shown on alumina and silicon substrates using microstrip technology. The effect of a notch has been studied and implemented for high rejection, along with the concept of the oversized stub. Fabrication of the diplexer on the silicon substrate has been detailed. This planar diplexer shows a minimal effect of the cover height and can be easily implemented in the payload of telecommunication satellites, where size and cost are at a premium. Furthermore, a micro-machined patch antenna, integrated with the proposed diplexer on silicon, will enhance the overall system performance. ■

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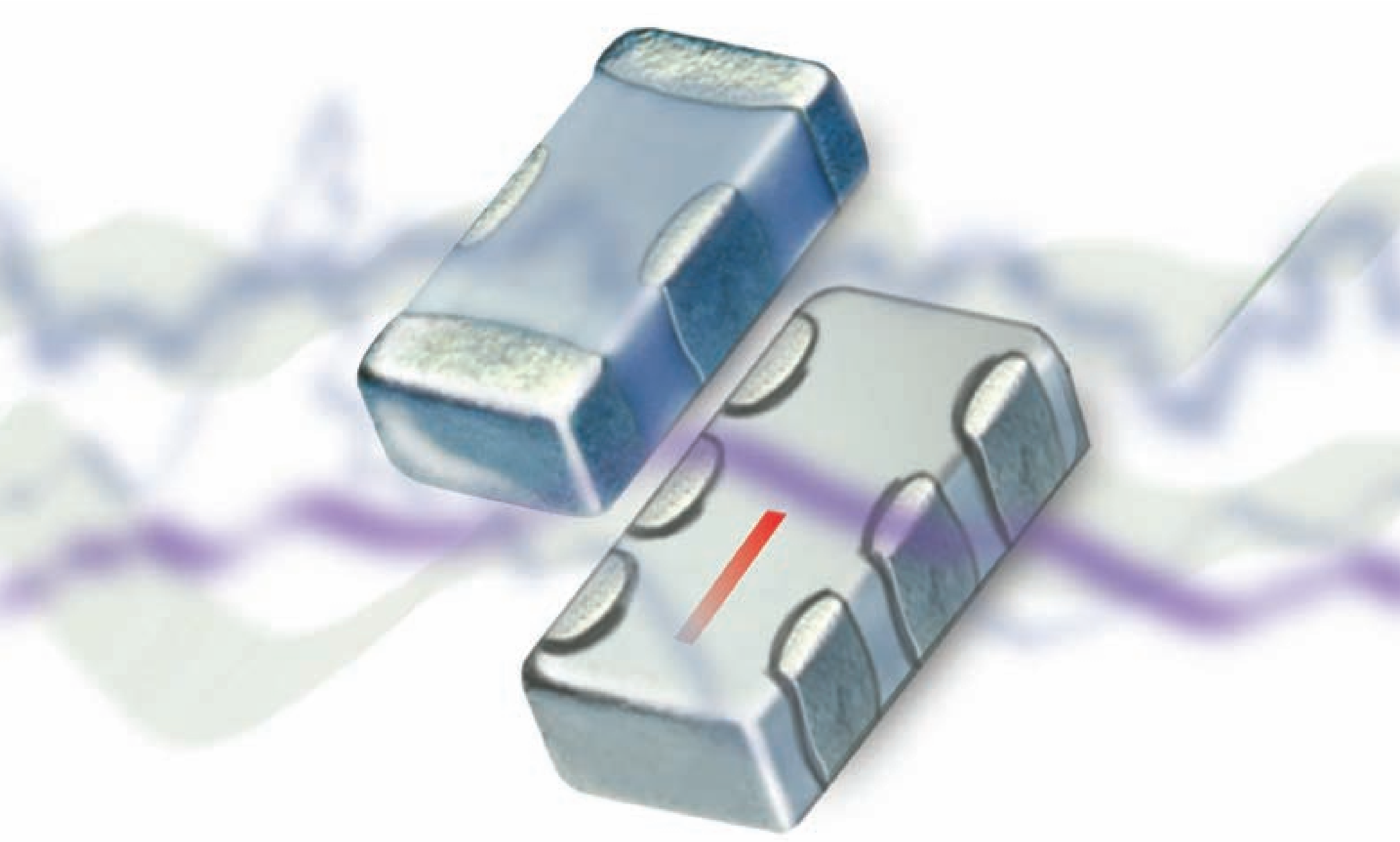

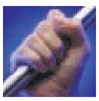

NARROWBAND MICROWAVE BANDPASS FILTER DESIGN BY COUPLING MATRIX SYNTHESIS

In recent years, advances within two fields have had a major impact on how filters are designed today. One is the advent of powerful electromagnetic (EM) software, which provides results that are close to measurements. However, analysis and optimization of complete filters is often too resource and time consuming to be useable in practice. Therefore, methods that separate the entire structure into discrete components for individual EM analysis are often employed.[1]

The other field that has had a major impact on filter design methods is advances within the coupling matrix representation of microwave filter circuits. The coupling matrix concept was introduced in the 1970s, but general methods have recently been introduced for its synthesis.[2] The coupling matrix concept has also been reformulated to accommodate couplings directly from the source and the load to internal resonators.[3]

The coupling matrix representation of bandpass filters is convenient since, with matrix operations, it is possible to transform between topologies whereby the best suited topology for a given problem may be found. The recent coupling matrix formulation leads to more accurate determination of practical filter characteristics; highly complex filters with multiple non-adjacent couplings are now easily synthesized.

Even though a large number of articles dealing with coupling matrix synthesis have recently been published, almost none of them go into details about how to convert the synthesized matrices into physical filters. In this article, practical filter design using the coupling matrix synthesis and simple 3-D EM simulation techniques is demonstrated. Even though EM solvers in this article are used for the designs, the adopted methods may be applied even without EM solvers available. In that case a couple of test circuits must be manufactured. Emphasis is made on practical approaches and it is demonstrated that even fairly complex x-coupled filters can be made in just one iteration. The methods are validated through measurements on manufactured coaxial cavity filters. It is also demonstrated how coupling matrix synthesis may be used to better understand and explain differences between calculated and measured filter responses.

COUPLING

To design microwave filters a basic understanding of coupling and coupling mechanisms is necessary. In this section the coupling mech-

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anisms in bandpass filters are investigated. It is shown how coupling coefficients can be measured.

INTER RESONATOR COUPLING

To demonstrate the concept of coupling between adjacent resonators, the two-pole circuit in ***Figure 1*** is used. Two metallic resonators are enclosed in a metallic housing and loosely coupled to the in and output ports. The corresponding measured transmission characteristic (S_{21}) is also shown. The two resonators are identical and are both resonating at frequency f_0. The coupling between the resonators results in a displacement Δf of the resonance frequencies. In this case, the coupling is Δf MHz and is referred to as the coupling bandwidth. If the coupling bandwidth is divided by the ripple bandwidth BW of the filter, the normalized coupling coefficient is obtained. Therefore, the normalized coupling coefficient is given by

$$M_{12} = \Delta f / BW \qquad (1)$$

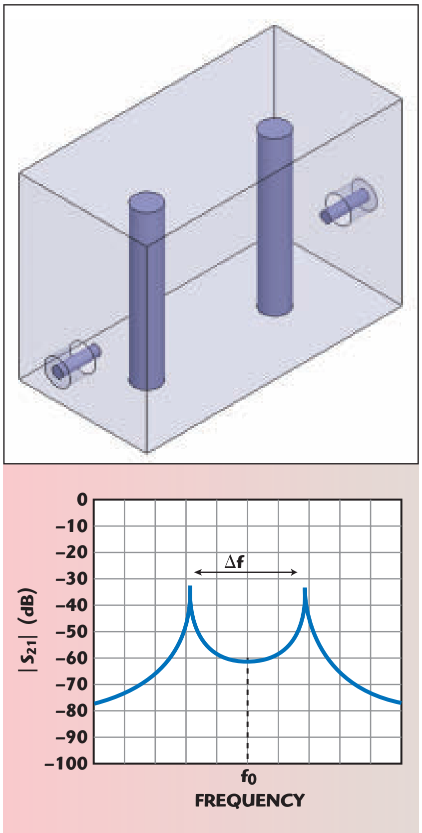
where Δf is the coupling bandwidth, which expressed in Hz, and M_{12} is the normalized coupling coefficient between resonator 1 and 2.

To minimize the influence of input and output connections on the coupling measurement, the resonators must be loosely connected to the input and output ports. If the top-point of the two peaks—or alternatively the "valley" between them—is kept below approximately -30 dB, the influence of the I/O ports can be neglected.

EXTERNAL COUPLING

The couplings, which connect the filter to the outside world, are called external couplings and are often expressed as Q values, that is external Q's. The external Q concept can be explained by the single resonator circuit shown in ***Figure 2***. The resonator is here coupled to the I/O port by a rod (tapped input), but could also be coupled by a non-touching capacitive disc, a loop or similar arrangement.

Also in the figure is shown a loosely coupled "sniffer" port, which allows one to do the transmission measurement shown to the right in the figure. The influence of the sniffer port can



▲ *Fig. 1 Two-pole box and associated transmission characteristic.*

be neglected if the peak of the resonance characteristic is kept below 25 to 30 dB.

The external coupling bandwidth is found by measuring the 3 dB bandwidth of the resonance curve, denoted Δf_{3dB}. The external Q is then found by

$$Q_{ext} = Q_{loaded} = f_0 / \Delta f_{3dB} \qquad (2)$$

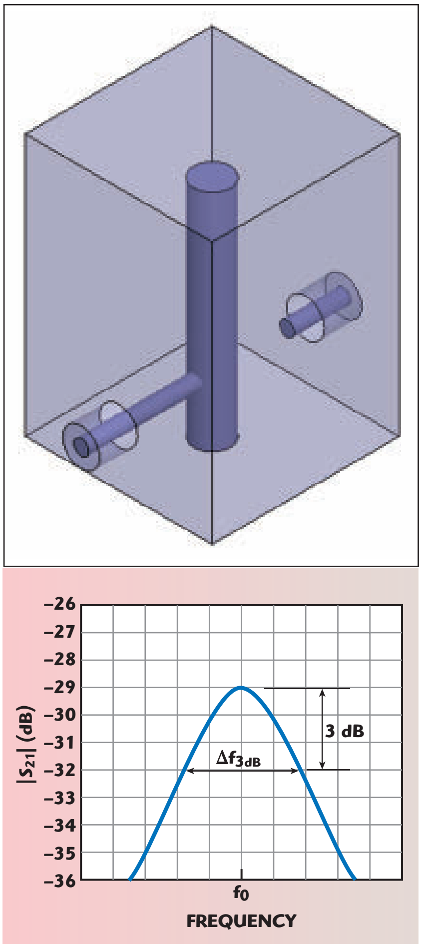
where it is assumed that the unloaded Q is much bigger than loaded Q so that $Q_{ext} = Q_{loaded}$ applies.

The external Q can also be expressed by the normalized coupling coefficient M_{01}

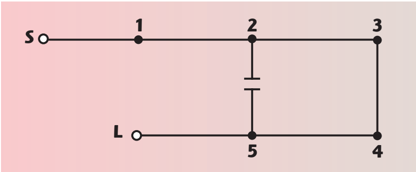
$$Q_{ext} = f_0 / (BW \cdot M_{01}^{\,2}) \qquad (3)$$

where BW is the ripple bandwidth of the filter.

It is seen that a low external Q value corresponds to a wide 3 dB bandwidth and hence a strong coupling. For the tapped resonator in Figure 2, the coupling increases by moving the tap-point closer to the top of the resonator. It is also possible to determine the external Q by measuring the group delay of S_{11}.[4]



▲ *Fig. 2 One-pole box with tapped input and associated characteristic.*



▲ *Fig. 3 A five-pole filter topology with positive main couplings and a negative x-coupling.*

CROSS-COUPLING

It is well known that couplings between non-adjacent resonators—x-couplings—may be used either to:

- introduce transmission zeroes in the stopband for increased skirt selectivity or
- equalize group delay in the passband

Couplings may either be inductive or capacitive and are often schematically represented, as shown in ***Figure 3***. In the schematic circuit diagram, the numbered black dots represent resonators; the white circles represent source/load terminals (that is "connectors"). Inductive

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Part Number	Configuration	F (MHz)*	Loss (dB)	VSWR	Isolation (dB)	C.W. Incident Power (dBm)
MSW2000–200	SP2T T-R Switch	50–1000	0.15	1.15:1	50	+ 51
MSW2001–200	SP2T T-R Switch	400–4000	0.2	1.2:1	45	+ 51
MSW2050–205	SP2T T-R Switch	50–1000	0.2	1.2:1	47	+ 52
MSW2051–205	SP2T T-R Switch	400–4000	0.25	1.3:1	40	+ 52
MSW2030–203	Symmetrical SP2T	50–1000	0.3	1.2:1	50	+ 51
MSW2031–203	Symmetrical SP2T	400–4000	0.35	1.3:1	45	+ 51
MSW2040–204	Symmetrical SP2T	50–1000	0.2	1.2:1	47	+ 52
MSW2041–204	Symmetrical SP2T	400–4000	0.3	1.2:1	45	+ 52
MSW3000–310	Symmetrical SP3T	50–1000	0.4	1.2:1	50	+ 51
MSW3001–310	Symmetrical SP3T	400–4000	0.5	1.4:1	43	+ 51

* 50–1000 MHz specs at 500 MHz, 400–4000 MHz specs at 2000 MHz

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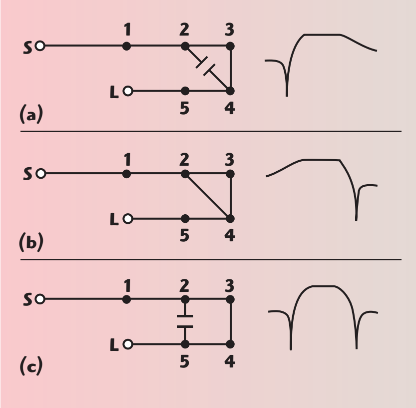


▲ *Fig. 4 Three commonly used x-coupling configurations and their characteristics.*

couplings are indicated by unbroken lines and capacitive couplings by a capacitor symbol. By convention inductive couplings are positive and capacitive couplings negative. A single x-coupling—bypassing one resonator (also called a triplet)—may, under certain conditions, give rejection corresponding to approximately two extra filter poles. The use of x-couplings could in such case reduce the required filter order by two, leading to a more compact filter, which at the same time may also have lower insertion loss. The penalty is that the increased selectivity gained at one side of the passband is sacrificed by reduced selectivity on the other side of the passband. Three commonly used x-coupling configurations are shown in ***Figure 4*** for a triplet with negative (capacitive) x-coupling, a triplet with positive (inductive) x-coupling and a quadruplet with negative (capacitive) coupling. These are x-couplings bypassing either one or two resonators. The theory of cross-couplings is explained in the literature[6,7] by equivalent lumped circuits and phase relationships.

TABLE I

DIFFERENT RESONATOR TYPES AND CORRESPONDING UNLOADED Q

Technology	Unloaded Q
Microstrip, stripline & coplanar	100-600
Coaxial cavity & combline	1000-6000
Waveguide	4000-15,000
Dielectric resonator	5000-50,000

UNLOADED Q

The unloaded Q is not directly related to couplings but is included here because it is measured in a very similar way to the external Q. The unloaded Q is an important parameter since it is directly related to the losses of the resonator/filter and is a function of geometry as well as the materials used. If the tapped input shown previously is replaced by yet another loosely coupled "sniffer" port, the unloaded Q would be found instead of the external Q.

To estimate the unloaded Q for a circular coaxial resonator, the following expression may be used:

$$Qu = \frac{0.75n\lambda\,\mathrm{sqrt}(\pi f_0 4\pi \times 10^{-7}\sigma)}{[4 + n(\lambda/D2)(1 + D2/D1)/\ln(D2/D1)]} \quad (4)$$

where

f_0 = resonance frequency

σ = conductivity of metal forming cavity and resonator (silver: 6e7 Siemens/m)

D2 = cavity diameter. For rectangular cavities D2 is diameter in a circle, which has the same area as the rectangular cavity base area.

D1 = resonator diameter

h = resonator height

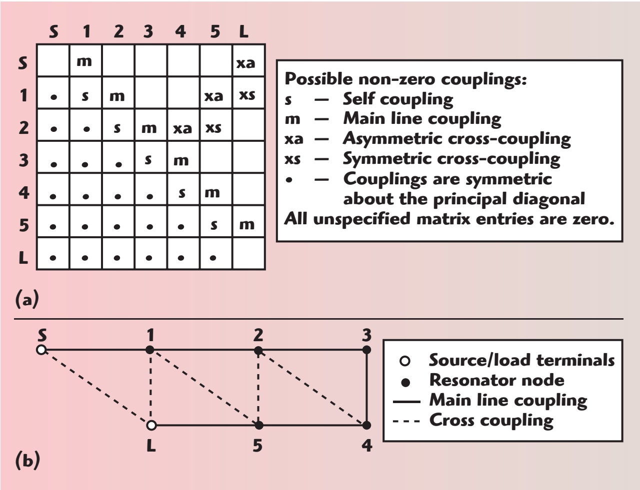
λ = wavelength at f_0

n = h/(λ/4) resonator length expressed in quarter wavelengths.

The factor of 0.75 is an estimate for imperfections like the slightly poorer conductivity that will be found in the 'real world', surface roughness, influence of tuning screws, etc.

Equation 4 is a modified version of an expression given by Montgomery[8] for optimal unloaded Q of coaxial resonators. The original expression assumes resonator lengths, which are an integer number of a quarter wavelength ("n" is an integer). The formula, however, is also found to be useable for other resonator lengths. In Equation 4 "n" is a real number (such as 0.5 for a λ/8 resonator).

Microwave filters may be implemented in many different ways. Very often it is the loss requirement that dictates the filter technology that must be used. ***Table 1*** gives some indications of typical unloaded Q's for different resonator types.



▲ *Fig. 5 Folded network coupling form, fifth degree example. (Reprinted from Ref. 2).*

COUPLING MATRIX SYNTHESIS

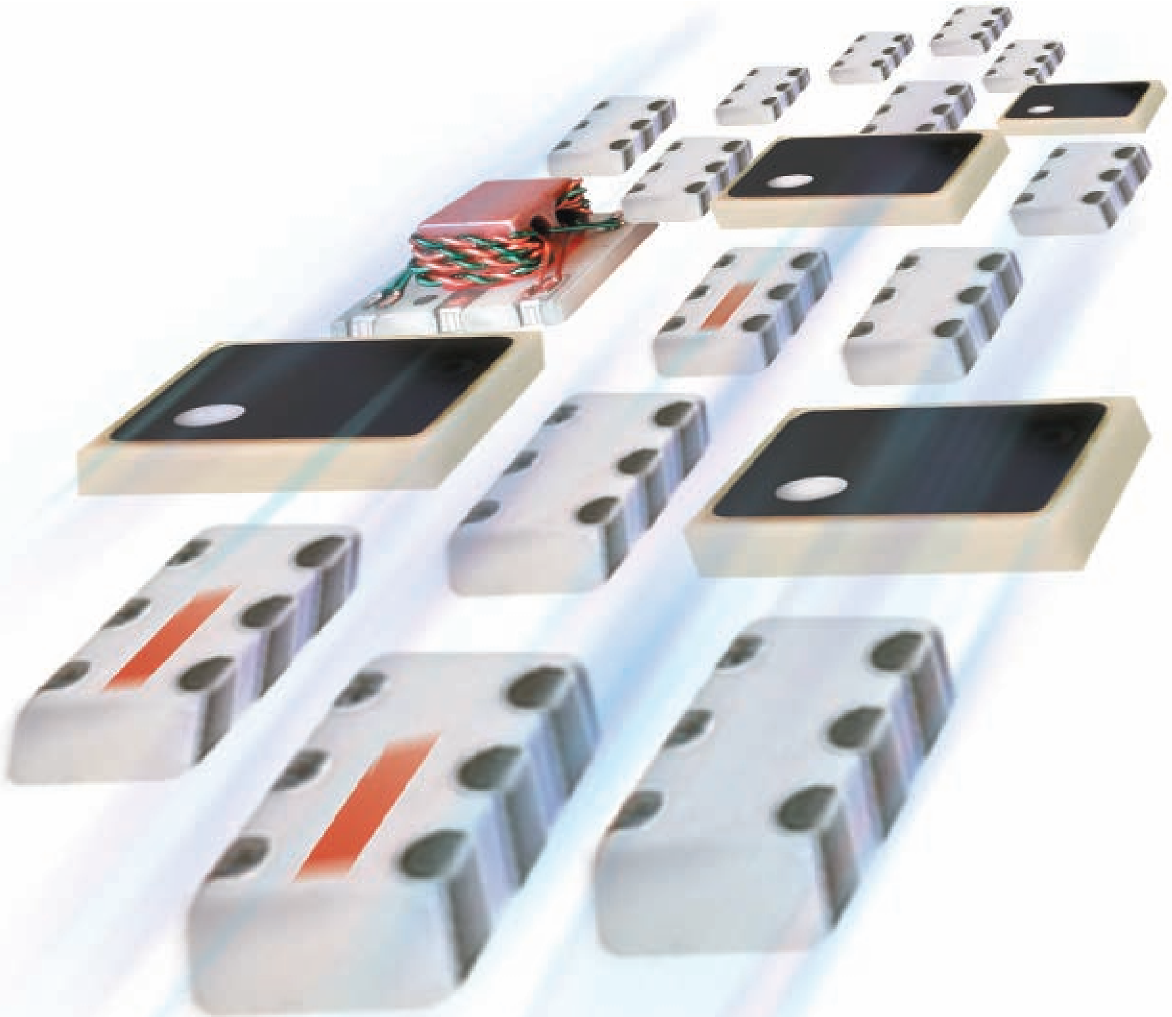
A low pass prototype filter can be described by a normalized coupling matrix M of order N+2, where N is the filter order.[5] The term "low pass prototype" refers to that it is centered around 0 (zero) rad/s and has upper and lower corner frequencies of ± 1 rad/s. Once a prototype network has been synthesized, a frequency transformation is applied, which transforms the low pass prototype to a bandpass filter with the right center frequency and bandwidth.

The synthesis of low pass prototype networks—and hence filter characteristics and coupling matrices—is well described in the literature[2,3,5] and will not be dealt with here. In the following, the Guided Wave Technology's Filter and Coupling Matrix Synthesis tool (CMS)[9] is used for this purpose.

THE N+2 COUPLING MATRIX

The N+2 normalized coupling matrix M is a full description of all coupling paths in a filter. The order of M is N+2, where N is the filter order. M is a symmetric matrix with real elements M_{ij}. The "+2" term refers to the fact that the N+2 coupling matrix is extended to include the input and output connections. ***Figure 5*** explains the N+2 coupling matrix in more detail for the folded topology: (A) is the folded matrix form, "s" and "xa" coupling are zero for symmetric characteristics; (B) is the coupling and routing schematic. The N+2 coupling matrix includes the input/output couplings in the synthesis. Couplings may therefore be made directly from the source/load nodes to internal resonators or directly between the source and load.

Fully canonical filtering functions (that is Nth-degree characteristics with N finite-position transmission zeroes) may also be synthesized. The self couplings "s" in the main diagonal in the figure represent the resonance frequencies of the individual resonators. In an x-coupled filter the bypassed resonators will have frequencies which deviate from the center frequency - f_0 - of the filter. In a filter without x-couplings the main diagonal elements will all be 0 (meaning that all resonators are tuned to f_0). Outside the main diagonal, the normalized couplings—M_{ij}—may be transformed to coupling bandwidths by multiplying by the ripple bandwidth.



Coupling matrix synthesis gives results that are fully equivalent to filters realized by lumped element (that is RLC) theory. Filters synthesized and analyzed in this way do not therefore account for effects related to the use of transmission lines as resonating elements or couplings. Couplings are assumed frequency invariant and the results obtained by coupling matrix synthesis are therefore most accurate for narrow band filters (relative BW < 10 percent) in—and close around—the passband.

CONCLUSION

This article addresses the practical aspects of making physical microwave bandpass filters based on coupling matrix synthesis. With the coupling matrix synthesis approach, a set of filter S-parameters are first created by proper choice of filter order, return loss, unloaded Q and position plus number of transmission zeros. A suitable filter topology is then defined and finally the corresponding matrix is synthesized.

This coupling matrix fully defines the filter. With this at hand, the corresponding physical filter can be designed and manufactured. To close the gap between the coupling matrix representation of a filter and the physical filter, practical directions about how to measure and calculate coupling bandwidth and external Q are given. These parameters can be determined either by use of 3D simulators or by measurements; procedures have been given for both by use of the two-pole box method.

To demonstrate the design process, two six-order coaxial cavity filters for WiMAX applications at 3.44 GHz have been designed and manufactured. Details of the design procedure and measurements on the fabricated filters can be found on the *Microwave Journal* web site at www.mwjournal.com/GWTfilter. The conclusion of this work is that, with coupling matrix synthesis, it is possible to design and manufacture advanced x-coupled bandpass filters in just one iteration. The results obtained are in excellent agreement with the predicted characteristics. ■

The complete article is available online at www.mwjournal.com/GWTfilter.

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M/A-COM IS REBORN ON ITS 60TH BIRTHDAY

It has been a tumultuous couple of years for M/A-COM. The company has been split up and sold off to several different companies by Tyco Electronics and Cobham plc. This iconic company, dubbed "The First Name in Microwave," has been reborn as M/A-COM Technology Solutions (M/A-COM Tech) under its new owner and industry entrepreneur, John Ocampo.

M/A-COM was independent for about 45 years until it was purchased in 1995 by connector giant AMP, a company that wanted to diversify into other markets. In 1999 AMP was acquired by the even larger Tyco International. In 2007, Tyco International split up into three companies, one of which was Tyco Electronics (the medical companies formed a new company called Covidien; the security companies stayed with the Tyco International name). Tyco Electronics contained the former AMP and M/A-COM companies along with many other brands. Shortly after that time, Tyco Electronics decided most of the M/A-COM product portfolio was not part of its future strategy and put the defense and commercial components businesses up for sale.

Cobham plc purchased the commercial and defense components businesses in 2008 with the intent to re-sell the commercial business as soon as a buyer was found. At about the same time, the automotive sensor products were sold to Autoliv, a Swedish auto parts supplier. Cobham recently found a buyer as GaAs Labs purchased the commercial components business, which retains its name developed under Cobham as M/A-COM Technology Solutions (John Ocampo is the owner of the GaAs Labs group, which is also a large investor in Mimix Broadband). In between all of this, Micronetics purchased the RFID product lines from the commercial business in a separate transaction, which should complement the company's existing product lines.

Last year, the private radio group of M/A-COM (Wireless Systems) was purchased from Tyco Electronics by Harris Corp. This should bring strength to both groups as Harris has a strong foothold in the military mobile radio market and M/A-COM Wireless Systems has been growing primarily in the public safety market. Therefore, pieces of the original M/A-COM now reside with Cobham, Autoliv, Micronetics, Harris and M/A-COM Technology Solutions, which is the entity that will carry on the brand name that started 60 years ago in Boston, MA.

M/A-COM began life in the summer of 1950 as Microwave Associates. Four ex-Sylvania engineers—Vessarios Chigas, Louis Roberts, Hugh Wainright and Richard Walker—started as a consulting and research company for millimeter-wave technology for an expanding

PAT HINDLE
Microwave Journal *Technical Editor*

microwave industry (see ***Figure 1***). The US Signal Corps was one of their first customers and they soon started producing magnetrons. United Paramount Theaters (now ABC) and Western Union were some of the original investors that helped the company grow, and in 1957 the company moved from Boston to Burlington, MA (see ***Figure 2***) and went public. In its first year the stock went from $7 to $30 per share. *Microwave Journal* was the first to profile Microwave Associates in its January 1959 issue.

Microwave Associates grew quickly and expanded into the communications and television broadcast industries in the 1960s. During the summer of 1968, the company's equipment broadcast the Mexico Summer Olympics and Democratic Convention. They started expanding geographically by purchasing Microwave and Semiconductor Devices in the UK, and International Microwave Corp. and Huggins Labs in Sunnyvale, CA. In 1969, they acquired Ferrotec, which expanded the company's ferrite line and was the start of its subsystems operation that is now owned by Cobham plc.

During the 1970s, the company leveraged its semiconductor technology and was one of the first companies to start replacing tubes with solid state devices. The company's annual report for 1974 stated, "Almost all major microwave systems produced domestically and abroad (exclusive of the Communist Block) to some degree or other utilize Microwave Associates components." They had a strong hand in helping to develop capabilities that resulted in the proliferation of remote broadcast because much of the mobile broadcast TV equipment was born from the company's technology. They also purchased a long list of companies, including Digital Communications Corp. (expanding its data, voice communications and satellite capabilities), the GaAs products division of Monsanto (they were the only domestic supplier of GaAs for many years until the business was closed a few years ago),

▲ *Fig. 1 Microwave Associates started with $10,000 and rented 2,800 sq. ft. in Boston.*

various transistor lines from Harvard Industries and KMC Semiconductor Corp., and diodes from Varian. In 1978 Microwave Associates changed its name to M/A-COM Inc. to reflect the growing part that microwave communications would play in its future.

M/A-COM continued to acquire even more companies in the 1980s as it tried to find the right mix of products in the marketplace. Some of these companies would be spun off and develop into major global companies. Among these were PHI (transistors), OmniSpectra (connectors) and Adams-Russell (which included Anzac, RHG, SDI and Eurotec). Others that were acquired and divested included Linkabit (now part of L-3), Laser Diode, Lawrence Labs, Prodelin, MPD and others. Two of the founders from Linkabit (Irwin Jacobs and Andrew Viterbi) went on to found Qualcomm. One of the significant accomplishments during the '80s was the development of the scrambling technology that set the standard for future scrambling of cable satellite transmissions for cable providers.

▲ *Fig. 2 Microwave Associates relocated to a 50,000 sq. ft. facility in Burlington, MA in 1957.*

M/A-COM's Telecommunications division was a major acquisition for Hughes Networks. In 1984, M/A-COM established the Advanced Semiconductor Operation in Lowell, MA, to focus on GaAs ICs and today is M/A-COM Tech's headquarters (see ***Figure 3***).

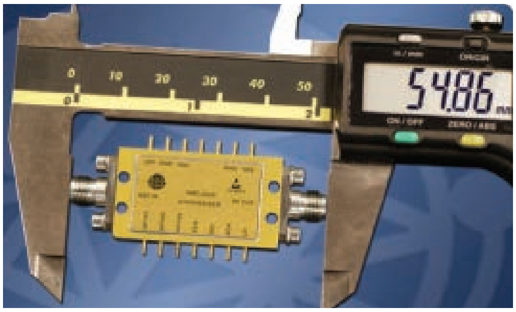
▲ *Fig. 3 M/A-COM Tech's headquarters in Lowell, MA.*

After expanding and acquiring so many companies in the '70s and '80s, M/A-COM spent the first part of the 1990s divesting and consolidating businesses. With the defense markets shrinking, M/A-COM, like many companies in the microwave industry, shifted from about 80 percent defense to 80 percent commercial to take advantage of the growing commercial wireless industries. The first big commercial business came from Lucent Technologies and then AT&T for components for base stations as M/A-COM became a major player in the cell phone market. This later launched into components for handsets. In 1993, M/A-COM had combined several divisions into a new 300,000 square foot manufacturing operation in Lowell, MA (formerly a Wang Laboratories facility) establishing itself as one of the largest employers in the city. In the mid-1990s, M/A-COM used its communications technology to develop a proprietary voice and data network that was adopted by FedEx to track its packages. This launched the company into the private radio business and M/A-COM's IP radio technology has been adopted by several states for their public safety radio networks and systems. M/A-COM won the largest radio contract ever from New York State for $2 B (which has since been cancelled due to disagreements).

In 2000, M/A-COM acquired GaAsTEK labs from ITT to expand its GaAs MMIC product lines, and in 2001 acquired Stellex Microwave Systems. In 2001, the company acquired Com-Net Ericsson and supported the 9/11 rescue effort by supplying EDACS radio systems out of its Lynchburg, VA operation. Two of its key customers, the New York-New Jersey Port Authority and the New York State Police, were operating M/A-COM's EDACS radio systems that were in serious trouble when the towers collapsed. Within a 20-hour window after receiving the call for help, the M/A-COM team produced and shipped via rental truck 300 portable radios for the Port Authority and 200 portable radios for the New York State Police to assist the emergency responder teams in their recovery efforts. They also worked with a local firm (supplying the amplifier unit) that had designed a listening system to help locate them by using triangulation of the cell phone's pilot tone signal to locate cell phones within the mountain of debris from the World Trade Center collapse to help find victims.

In 2005, the Aerospace and Defense group produced some of the first mobile IED jammers (Warlock Blue) in record time to deliver them to Iraq to help save the lives of coalition forces. They produced and shipped the first units in 33 days from the time of order by the military and the whole order would be complete in less than 60 days. In the late 2000s M/A-COM ramped up its automotive sensor and antenna products including a patented GPS module for Ford's SYNC system and radar sensors for Mercedes and Audi.

M/A-COM is now reborn from the commercial products businesses sold by Cobham plc to John Ocampo as it comes full circle as an independent company. The company is reorganizing its product portfolio and focusing on its core technologies to bring new products to market. They have had their first profitable quarter and are looking to continue their long and storied history. "The First Name in Microwave" lives on. ■



MICROSYNTH™ INTEGRATED HERMETIC SYNTHESIZER MODULE

Frequency synthesis is the cornerstone of all RF and microwave systems. Often dictated by specifications that push technological, spatial and economic envelopes, the design and implementation of frequency sources can often run into hurdles that force performance, schedule, or cost compromises. Hittite Microwave has one of the most comprehensive product portfolios and knowledge base that serves this critical function. The new MicroSynth™ integrated hermetic synthesizer product platform extends that portfolio by integrating many functions into one compact module. By leveraging its industry leading library of catalog and custom integrated circuits, Hittite is in a unique position to offer "best-in-class" integrated synthesizer solutions. Integrating a phase lock loop (PLL), broadband voltage-controlled oscillator (VCO), microwave amplifier and active loop filter, the HMC-C070 MicroSynth combines high performance SiGe, GaAs PHEMT and InGaP HBT technologies (see ***Figure 1***), rugged construction, and an incredibly small form factor of 3.7 cm^3 (0.226 in^3). In addition, the modular nature of the design allows Hittite to provide customized designs to optimize performance for a given application and frequency range.

The HMC-C070 integrated hermetic synthesizer operates from 5.5 to 10.5 GHz and provides 22 dBm of output power across that band. ***Table 1*** details the electrical performance of the HMC-C070. The HMC-C070 also features fully integrated low noise regulators and an output buffer amplifier that results in superior ripple rejection, and pushing and

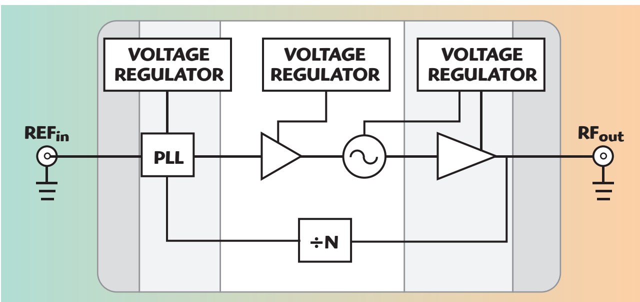


Fig. 1 HMC-C070 block diagram.

HITTITE MICROWAVE CORP.
Chelmsford, MA

MILLIMETER WAVE RECTANGULAR TE_{10} WAVEGUIDE INFORMATION

WG Band	Waveguide Frequency Range (GHz)	Wavelength Range λo (mil)	Wavelength Range λo (mm)	Guide Wavelength Range (λg/λo)	Waveguide Impedance Range (Ω)	TE_{10} Cutoff Freq (GHz)	TE_{10} Cutoff λc (mil)	TE_{10} Cutoff λc (mm)	Internal Dimensions (mils)	Internal Dimensions (mm)
WR-28	26.5 - 40.0	445.4 - 295.1	11.313 - 7.495	1.650 - 1.177	621.9 - 443.6	21.1	560.0	14.22	280.0 x 140.0	7.112 x 3.556
WR-22	33.0 - 50.0	357.7 - 236.1	9.085 - 5.996	1.661 - 1.177	626.0 - 443.6	26.3	448.0	11.38	224.0 x 112.0	5.690 x 2.845
WR-19	40.0 - 60.0	295.1 - 196.7	7.495 - 4.997	1.613 - 1.173	608.3 - 442.4	31.4	376.0	9.55	188.0 x 94.0	4.775 x 2.388
WR-15	50.0 - 75.0	236.1 - 157.4	5.996 - 3.997	1.657 - 1.181	624.8 - 445.1	39.9	296.0	7.52	148.0 x 74.0	3.759 x 1.880
WR-12	60.0 - 90.0	196.7 - 131.1	4.997 - 3.331	1.690 - 1.186	637.2 - 447.1	48.4	244.0	6.20	122.0 x 61.0	3.099 x 1.549
WR-10	75.0 - 110.0	157.4 - 107.3	3.997 - 2.725	1.620 - 1.185	610.9 - 446.7	59.0	200.0	5.08	100.0 x 50.0	2.50 x 1.270
WR-08	90.0 - 140.0	131.1 - 84.3	3.331 - 2.141	1.746 - 1.177	658.1 - 443.6	73.8	160.0	4.06	80.0 x 40.0	2.032 x 1.016
WR-06	110.0 - 170.0	107.3 - 69.4	2.725 - 1.763	1.771 - 1.183	667.7 - 445.9	90.8	130.0	3.30	65.0 x 32.5	1.651 x 0.826
WR-05	140.0 - 220.0	84.3 - 53.6	2.141 - 1.363	1.777 - 1.176	669.7 - 443.3	115.7	102.0	2.59	51.0 x 25.5	1.295 x 0.648
WR-04	170.0 - 260.0	69.4 - 45.4	1.763 - 1.153	1.695 - 1.177	638.8 - 443.9	137.2	86.0	2.18	43.0 x 21.5	1.092 x 0.546
WR-03	220.0 - 325.0	53.6 - 36.3	1.363 - 0.922	1.627 - 1.183	613.5 - 445.9	173.6	68.0	1.73	34.0 x 17.0	0.864 x 0.432
WR-02.8	260.0 - 400.0	45.4 - 29.5	1.153 - 0.749	1.708 - 1.177	643.8 - 443.6	210.8	56.0	1.42	28.0 x 14.0	0.711 x 0.356
WR-02.2	325.0 - 500.0	36.3 - 23.6	0.922 - 0.600	1.771 - 1.185	667.7 - 446.7	268.2	44.0	1.12	22.0 x 11.0	0.559 x 0.279
WR-01.9	400.0 - 600.0	29.5 - 19.7	0.749 - 0.500	1.587 - 1.169	598.3 - 440.6	310.6	38.0	0.97	19.0 x 9.5	0.483 x 0.241
WR-01.5	500.0 - 750.0	23.6 - 15.7	0.600 - 0.400	1.620 - 1.175	610.9 - 442.8	393.4	30.0	0.76	15.0 x 7.5	0.381 x 0.191
WR-01.2	600.0 - 900.0	19.7 - 13.1	0.500 - 0.333	1.746 - 1.194	658.1 - 450.1	491.8	24.0	0.61	12.0 x 6.0	0.305 x 0.152
WR-01.0	750.0 - 1100.0	15.7 - 10.7	0.400 - 0.273	1.620 - 1.185	610.9 - 446.7	590.1	20.0	0.51	10.0 x 5.0	0.254 x 0.127

TABLE I

HMC-C070 INTEGRATED HERMETIC SYNTHESIZER SPECIFICATIONS

Specification	Performance	Units
Frequency Range	5.5 to 10.5	GHz
Step Size (min)	1.2	Hz
Output Power	+22	dBm
Loop Bandwidth (nominal)	100	kHz
Reference Spur	-60	dBc
SSB Phase Noise		
@ 100 Hz Offset	-80	dBc/Hz
@ 1 kHz Offset	-88	dBc/Hz
@ 10 kHz Offset	-88	dBc/Hz
@ 100 kHz Offset	-92	dBc/Hz
@ 1 MHz Offset	-117	dBc/Hz
Reference Frequency Input	10	MHz
Bias Supply	Vcc = +20 V @ 30 mA, +6 V@ 250 mA +3.6 V @ 100 mA	

pulling insensitivity. The HMC-C070 has been fully characterized over temperature; ***Figures 2*** and ***3*** illustrate the power and phase noise performance over temperature, respectively. At 22 dBm of output power, the HMC-C070 can drive multiple high linearity mixers or provide enough additional power to overcome filter losses that may be required by some stringent system specifications.

At the core of the HMC-C070 design is a Hittite SiGe Fractional-N PLL chip that provides features such as frequency sweeping with programmable ramp and dwell times, frequency hopping, charge pump optimization, temperature monitoring, lock detection, hardware/software triggering, and three general-purpose I/O pins that can be programmed to drive subsequent serially-controlled devices.

The MicroSynth product has been designed to accept a 10 MHz reference signal. This value was chosen due to the common availability of this frequency at the rear panel of most current test equipment. However, this reference frequency can range from 250 kHz to 75 MHz by modifying the loop filter design to optimize for the non-standard requirement. Higher reference frequencies are possible by use of internal prescalers or by using the higher reliability integer mode PLL ICs.

At 54.86 × 19.05 × 6.22 mm (2.16" × 0.75" × 0.245"), the HMC-C070 is a very compact module that is an order of magnitude smaller than competitive solutions. Without SMA connectors, the module length decreases to 31.24 mm (1.23") and can also be used with SMP connectors if a quick release option is desired. The plot in Figure 3 shows the additive phase noise of the HMC-C070 at 5.5 GHz at temperatures of -40°, +25° and +85°C. The typical performance is shown to be -88 dBc/Hz and -92 dBc/Hz at 10 and 100 kHz offsets, respectively.

Each MicroSynth module is an integrated single loop synthesizer, as shown in Figure 1. This synthesizer consists of core building blocks (PLL, microwave amplifier, wideband VCO) that can be swapped out to address a given application. Since these building blocks are all Hittite components, configuring a custom solution is more straightforward than having to secure die level solutions from multiple vendors. Naturally, custom solutions vary in development time and cost based on the complexity of the requirements and expected volumes. Hittite's depth and breadth of RF and microwave solutions provide multiple options to match custom requirements. Optional microwave processing functions (attenuators, switches, filters, frequency dividers and multipliers) may be added to a MicroSynth product to achieve a custom solution to fit a customer's requirements. Examples of the core and optional signal processing function options are as follows:

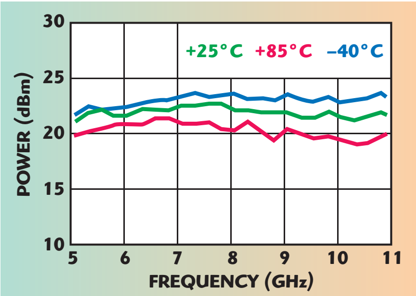


Fig. 2 HMC-C070 MicroSynth output power vs. frequency.

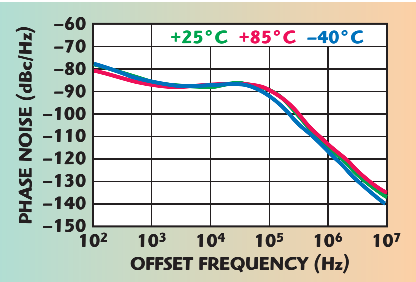


Fig. 3 HMC-C070 MicroSynth phase noise vs. temperature at 5.5 GHz.

PLLs: The PLL IC can be either a high performance, feature rich, fractional-N based synthesizer that can provide step sizes down to sub-1 Hz resolution, frequency sweeping, frequency hopping, temperature sensing, serial control, etc., or can be a robust, parallel control, integer mode synthesizer that is more suited to harsher environments (e.g. space).

VCOs: Hittite currently has more than 45 catalog VCOs that range from 2 to 27 GHz with various bandwidths. The standard MicroSynth products incorporate broadband VCOs, but if an application requires a higher performing, narrowband VCO, the unit can be modified easily to incorporate this requirement. The frequency range can be expanded further by the use of active multipliers and dividers to realize output frequencies as high as 64 GHz.

Amplifiers: Hittite has an extensive range of microwave amplifiers that can be used to boost the signal at nearly any frequency up to 80 GHz. The standard HMC-C070 MicroSynth model provides 22 dBm of output power, which is enough to drive multiple mixer circuits.

Frequency Dividers & Multipliers: Low phase noise single and multi-modulus frequency dividers (divide by 1 to 32) as well as passive and active frequency multipliers (multiply by 2 to 16) can be used to provide single to multiple LO and reference frequency outputs.

Control Products: Phase shifters, attenuators, switches and power detectors significantly expand on the MicroSynth base of products to include phase variation, amplitude variation, multi-port capability and signal detection.

Tunable Filters: Hittite now offers a complete line of tunable MMIC low and bandpass filters operating from DC to 7.6 GHz that can be easily implemented within the MicroSynth platform.

Class H or Class K: The MicroSynth products are provided in hermetically sealed modules that can be up-screened per military or space specifications. The standard RF interfaces are field-replaceable SMA connectors with provisions for optional SMP style connectors or no connectors for microstrip mounting. This integrated ruggedness, flexibility and off-the-shelf availability provides a quick solution for system designers that could otherwise take several months of integrating and adjusting the right components to meet the desired electronic, environmental and form factor goals. For custom developments, screening requirements can be tailored toward higher standards or lower costs.

The integration of Hittite's SiGe, GaAs PHEMT and InGaP HBT semiconductor technologies and decades of frequency generation expertise has yielded a very high functioning, high performance synthesizer module platform. The HMC-C070 is the first product that has been released for this new product line and demonstrates an aggressive balance of performance, functionality and size. Any custom requirements can be met by leveraging Hittite's extensive library of catalog and custom integrated circuit solutions into a similar form factor. All connectorized module products, including the HMC-C070, are available from stock and can be ordered via the company's e-commerce site or via direct purchase order.

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Chelmsford, MA
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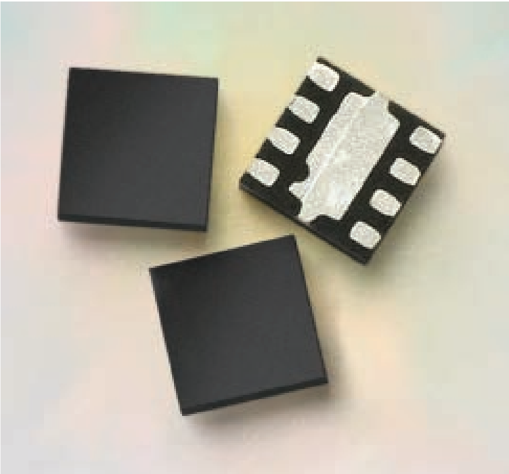

Ultra Low NF Active Bias LNA Addresses BTS RF Front-end Design Challenges

Base station (BTS) RF front-end design has in the past put more emphasis on performance compared to cost and size. However, to meet the evolving needs of the wireless infrastructure industry, BTS designers today are facing more challenges. Achieving the desired RF performance is only part of the equation for today's BTS RF front-end design. At the same time, cost is also a critical consideration to maintain competitiveness in handling escalating pricing pressure. More channels are now required to fit into a transmit/receive (Tx/Rx) card, which leads to PCB real estate becoming another key factor for BTS designers. In addition, the time to market has condensed, so design cycle time is a critical consideration for BTS RF front-end design.

A critical design consideration for BTS receiver RF front-end design is selecting an appropriate low noise amplifier (LNA) to address all the new design challenges mentioned above. With the release of the MGA-633P8 ultra low noise, high linearity active bias low noise amplifier, Avago Technologies has provided an optimal solution. The MGA-633P8 has superior RF performance achieved through the use of the company's proprietary 0.25 μm GaAs enhancement-mode PHEMT process, with an optimum operating frequency range of 450 to 2000 MHz. Similar to Avago's former MGA-631P8 and MGA-632P8 active bias LNA series, the MGA-633P8 is housed in the same industrial standard miniature 2.0 × 2.0 × 0.75 mm surface-mount 8-lead QFN package. The MGA-633P8 is targeted as the single-ended or balanced first-stage LNA for various cellular base station applications, such as transceiver radio cards, tower mounted amplifiers (TMA), combiners, repeaters and remote/digital radio heads.

Receiver sensitivity is one of the most critical requirements for BTS receive path design. This is especially important with the recent development of the wireless infrastructure industry, where providing optimum coverage with the best signal quality is highly desirable. A proper selection of the LNA, in particular the first-stage LNA that greatly affects the BTS receiver sensitivity performance, is required. At

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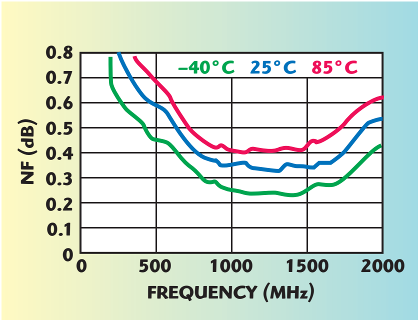
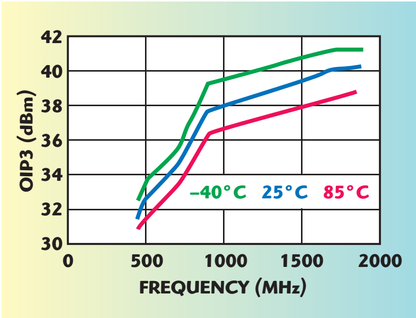
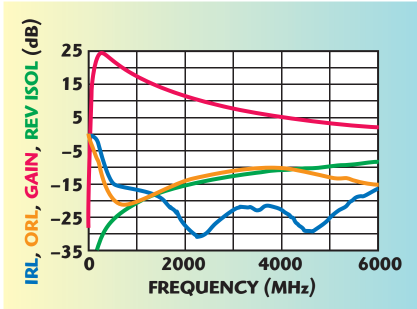
San Jose, CA



▲ *Fig. 1 NF vs. frequency at various temperatures.*



▲ *Fig. 2 OIP3 vs. frequency at various temperatures.*



▲ *Fig. 3 Input return loss, output return loss, gain and reversion isolation vs. frequency.*

900 MHz, the superior noise figure of 0.37 dB and gain of 18 dB, the MGA-633P8 is one of the best candidates to offer superior receiver sensitivity performance for today's BTS design (see ***Figure 1***). The MGA-633P8 is best suited to both single-ended and balanced configuration applications.

Another key element for the BTS receiver path design is the linearity requirement, which affects the ability of the receiver to distinguish between the closely spaced wanted and spurious signals. At 900 MHz, typical operating condition of 5 V/54 mA, the MGA-633P8 offers 37 dBm OIP3. With the optimum NF and OIP3, the MGA-633P8 offers enough design margins for the BTS receiver path, especially the first-stage LNA application. ***Figure 2*** shows OIP3 performance versus frequency.

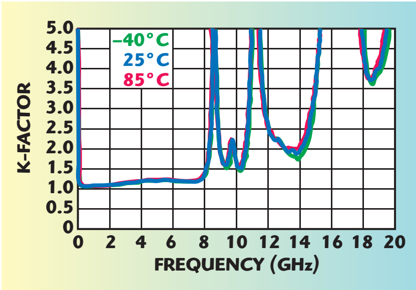
With built-in active bias circuitry, the MGA-633P8 also comes with a current adjustable feature. The I_{dd} current is adjustable by changing the R_{bias} value. This allows designers to choose between I_{dd} versus OIP3, while maintaining optimum NF. This feature offers BTS designers the flexibility to meet various design requirements and needs with the same product.

Besides offering the optimized NF and OIP3 performance, the MGA-633P8 also offers input return loss of 15 dB and output return loss of 21 dB at 900 MHz (see ***Figure 3***). Therefore, the MGA-633P8 is easy to use in the BTS design where either an RF filter or attenuator are typically used in the preceding or later stage of a LNA. S-parameters and noise parameters are available to designers who wish to further simulate and optimize the performance based on their specific requirement (see ***Figure 4***).

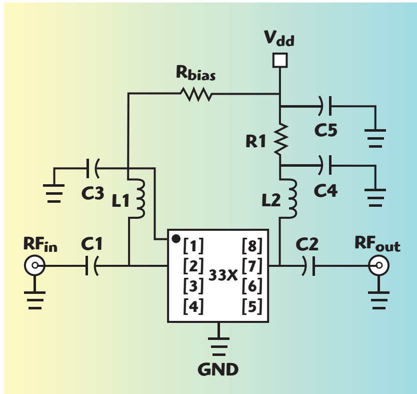
In addition to optimized RF performance, the MGA-633P8 is equipped with a high P_{in} absolute maximum rating of +20 dBm. This prevents MGA-633P8 from being damaged by the high input power leaking into the receiver path, particularly a TDD application.

As far as application circuitry is concerned, the MGA-633P8 is designed with built-in active bias circuitry, thus eliminating the needs of designing an external active bias network, which is complex and time consuming. The MGA-633P8 is designed with input and output close to 50 ohms. It requires one inductor and one capacitor for both the input and output match. Including DC blocking capacitors, RF bypass capacitors and $R_{bias,}$ the MGA-633P8 requires nine external components for typical operating conditions (see ***Figure 5***). With a minimum amount of external components count, coupled with a built-in active bias feature, the MGA-633P8 greatly simplifies the design efforts, occupies a minimal amount of PCB space and improves manufacturing yield at the same time.

There are three products in total for this new active bias LNA series, and the upcoming MGA-634P8 and MGA-635P8 (aiming to be released in June of 2010) will be covering 1500 to 2500 MHz and 2300 to 4000 MHz, respectively, thus supporting all major cellular bands for GSM, CDMA, UMTS, WiMAX and next generation LTE bands. Most importantly, all these products will be sharing the same package footprint, $P_{in/out}$ and external matching network; thus, a common PCB design can be used for BTS designed to operate at different frequency bands. This further adds value to the BTS designs by reducing the PCB layout iterations and is essential for the BTS application with common platform designs.



▲ *Fig. 4 K-factor vs. frequency at various temperatures.*



▲ *Fig. 5 MGA-633P8 application schematic.*

The key objective of Avago Technologies' Wireless Semiconductor Division is to distinguish customer product with differentiated RF semiconductor technology. With all the key features stated above, the new MGA-633P8 from Avago Technologies has created a distinct value proposition for customer products, and assisting BTS designers to overcome today's BTS design challenges.

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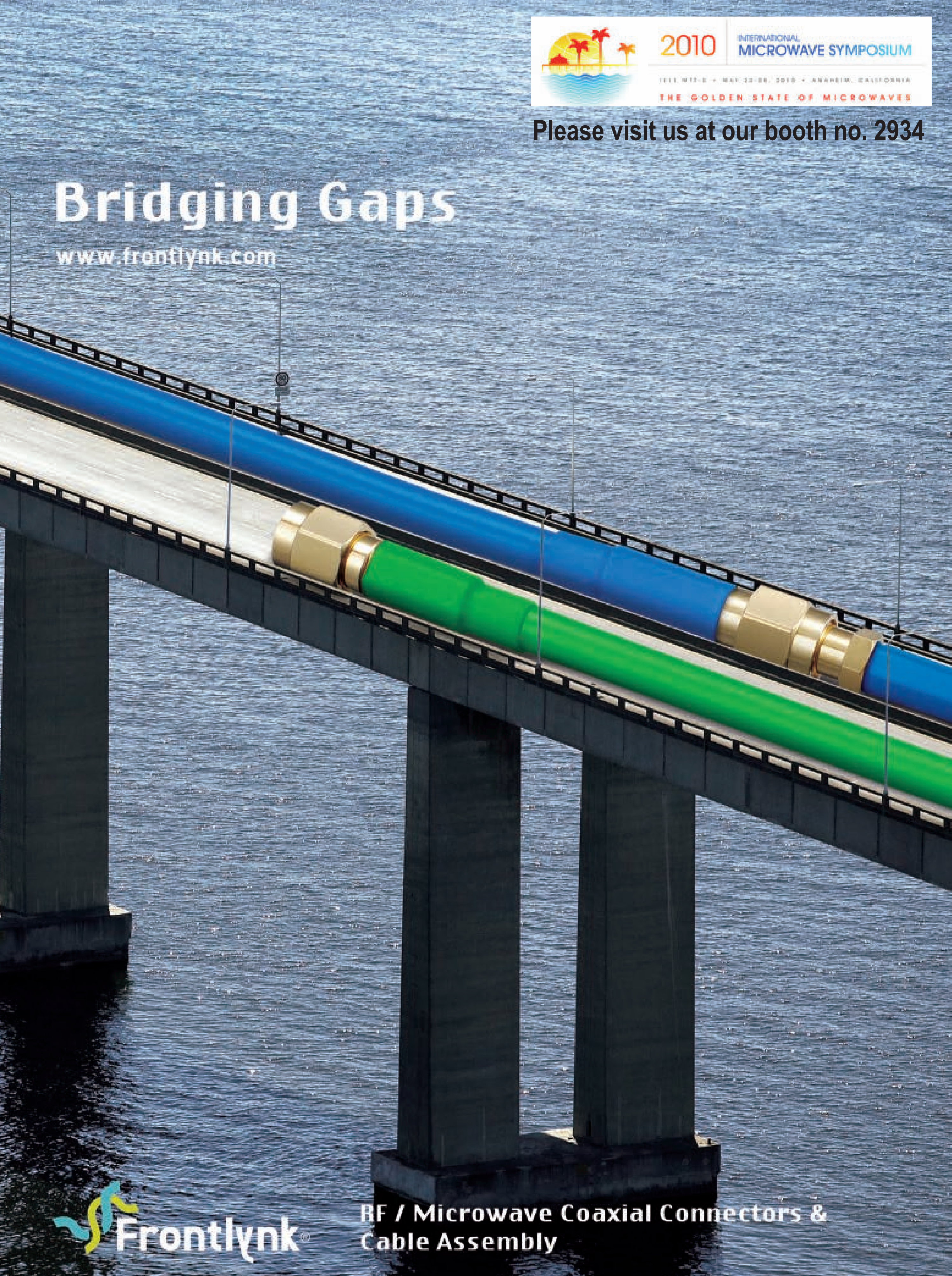
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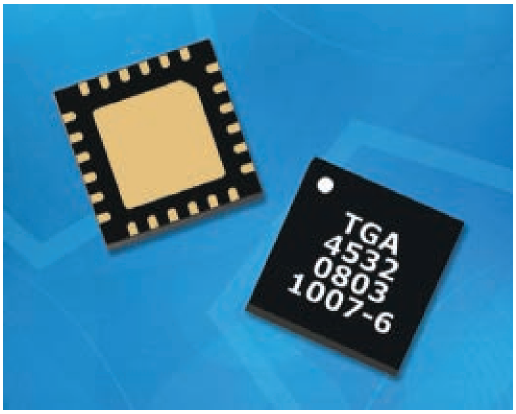

1 W GaAs MMIC Amplifier for 18 GHz Cellular Backhaul Applications

The US wireless industry has chosen Long Term Evolution (LTE) as one of the major pathways for delivering fourth-generation data services. LTE will make data-intensive applications such as high-quality video streaming and fast file transfers possible. However, migrating beyond 3G to LTE (as well as WiMAX) presents two formidable challenges for wireless carriers: The need to handle the massive amounts of traffic in the uplink and downlink paths that these services will generate; and the task of upgrading their ability to "backhaul" this data from cell sites to the network hub.

The answer to the backhaul challenge lies in fiber, microwave and millimeter-wave links, either singly or together. The radios employed by the latter solutions require RF power devices and amplifiers with extremely high performance. The TGA4532-SM 1 W GaAs MMIC power amplifier from TriQuint Semiconductor has been designed to meet these requirements in the 17.7 to 19.7 GHz band allocated for wireless backhaul.

BACKHAUL IN FOCUS

The wireless industry has continuously demanded greater spectrum allocations especially since the emergence of third-generation access technologies such as HSPA and CDMA 2000 Rev. A; they received it in the 700 MHz FCC spectrum auction. LTE will be deployed there by Verizon Wireless and AT&T, which garnered most of the licenses in the US. Nevertheless, it is still possible that the massive amount of data traffic that LTE users will generate may saturate the capacity of current spectrum. Thus, the demands for more spectrum may likely continue.

Backhaul, although it accounts for 20 to 30 percent of carrier operating costs, hasn't received much attention until lately. This is because leased T1 lines used almost exclusively for backhaul by US carriers have been adequate for voice traffic, which until 2008 accounted for most network volume. This situation changed dramatically in 2009, when data traffic exceeded voice traffic by 400 terabytes. This shift, along with the transition from Plesiochronous Digital Hierarchy (PDH)-based backhaul to IP-based solutions and the high cost of T1 leases, will soon make T1-based backhaul solutions inadequate.

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Hillsboro, OR

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Actual size

2-18 GHz

Model Number	Frequency (GHz)	Gain (dB)	Power (dBm)	OIP3 (dBm)	NF (dB)	Supply/Current V/mA
PA020180-3922	2.0 - 18	38	Psat > 39	48	-	+28 / 1200
PA020180-3025	2.0 - 18	30	P1dB> 30	40	9	+12 / 2000
PA002005-21	0.2 - 0.5	20	P1dB> 21	35	1.1	+5 / 100
PA001002-22	0.1 – 0.2	19	P1dB> 23	37	1.5	+5 / 100
PA001040-27	0.1 – 4.0	25	P1dB> 27	40	5	+10 / 290
PA001060-4440	0.1 – 6.0	40	Psat> 44	50	-	+50 / 1000

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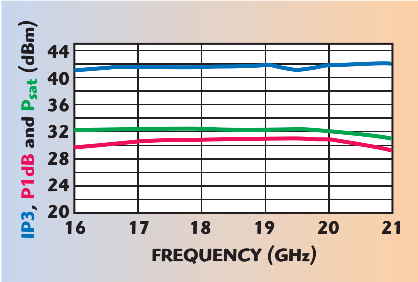
Lightwave (fiber) systems, as well as microwave and millimeter-wave (radio) links, represent the two technologies with the bandwidth to accommodate the impending backhaul onslaught—each with strengths and limits. If fiber nodes were available at every cell site, that would be the obvious choice, as they eliminate interference and have massive bandwidth. However, only about 20 percent of the more than 250,000 US cell sites are served by fiber connections, and fiber deployment cost rivals that of copper, which is very high, particularly after the recent devastating earthquake in Chile, where approximately 30 percent of the world's copper originates.

Microwave links typically deliver throughput ranging from 155 to 500 Mb/s, are less expensive to deploy and operate than copper lines (based on cost per transferred bit), and are extremely reliable. The high millimeter-wave FCC allocations for backhaul from 71 to 76 and 81 to 86 GHz can provide data rates in excess of 1 Gb/s (as they have greater channel bandwidths than lower-frequency allocations), but their cost is higher than microwave and low-millimeter-wave systems and have much shorter range, so they will likely be used only when the lower-frequency allocations have been saturated.

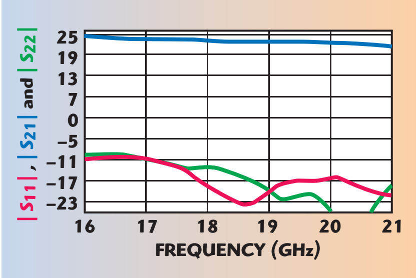
In Europe, microwave links currently handle 70 percent of wireless backhaul traffic because leasing costs for E1 (comparable to T1) lines are even higher than in the US. Globally, wireless backhaul accounts for about 50 percent of backhaul traffic. The consensus today is that fiber will be the choice where it is available, while microwave and millimeter-wave links will be used both where fiber is not located and to bring traffic to the nearest fiber node.

TGA4532-SM PERFORMANCE

The TGA4532-SM is the latest in a family of TriQuint GaAs MMIC power amplifiers designed exclusively for use in point-to-point microwave applications. It is based on one of the company's GaAs PHEMT processes and operates from 6 VDC with quiescent current consumption of 816 mA. The TGA4532-SM is housed in a 4×4 mm leadless QFN package enabling easier assembly compared to leaded SMT packages.



▲ *Fig. 1 IP3 (TOI at 22 dBm/tone), P1dB and P_{sat} vs. frequency for TGA4532-SM at 6 V, 816 mA.*



▲ *Fig. 2 Gain and input/output losses vs. frequency for TGA4532-SM at 6 V, 816 mA.*

TGA4532-SM represents best in class performance for a 1 W packaged power amplifier for the 17.7 to 19.7 GHz communication band. For example, the third-order intercept point is nominally 41 dBm at 22 dBm output power per tone. P1dB output power is 31 dBm; saturated output power is greater than 32 dBm (see ***Figure 1***). The TG4532-SM delivers 23 dB of gain with an extremely flat response over the frequency band; the input and output return losses are well below 12 dB over most of the frequency range of interest (see ***Figure 2***). Combining these RF performance characteristics with a DC power dissipation of less than 5 W, the TGA4532-SM offers an excellent solution for 18 GHz point-to-point applications (see ***Table 1***).

Other devices in the family include the TGA2522-SM, which covers the same frequency range as the TGA4532-SM, provides P1dB output power of at least 27 dBm and P_{sat} output of 28.5 dBm, third-order intercept of at least 36 dBm, gain of 21 dB, and is also housed in a 4×4 mm QFN package. It draws 712 mA from a 5 VDC supply. The TGA2706-SM, which delivers P1dB RF output power of 2 W over the 5.5 to 8.5 GHz point-to-point microwave band, is housed in a 5×5 mm QFN surface-mount package. It produces 32 dBm at P1dB with 42 dBm third-order intercept, small-signal gain of 31 dB, and a noise figure of 7 dB. Performance is extremely flat over its 3 GHz bandwidth.

TABLE I

KEY TGA4532-SM SPECIFICATIONS (NOMINAL 25°C)

Frequency range (GHz)	17.7 to 19.7
Third-order intercept (dBm)	41
Gain (dB)	23
P1dB RF output (dBm)	31 (1 W)
Return loss (dB)	>12
Power supply (V at mA)	6 at 816
Package	4×4mm QFN

In the bands above 23 GHz allocated for point-to-point microwave operation, bare die are commonly used to deliver the highest performance. TriQuint's recently-introduced TGA4538 GaAs MMIC die offers excellent performance from 37 to 40 GHz. The device's P1dB RF output power is at least 28 dBm (29.5 dBm P_{sat}), third-order intercept performance is 38 dBm and gain is 24 dB. It draws 600 mA from a 5 VDC supply.

CONCLUSION

For manufacturers of point-to-point microwave and millimeter-wave radios and their components, the cellular backhaul market promises to grow dramatically in the next few years. The reason for that growth is simple: Along with lightwave systems, which are not available in a sizeable number of cell site locations, only point-to-point microwave offers the bandwidth to handle the massive volumes of data that LTE and WiMAX deployments will produce. Radio-based backhaul is also cost-effective both to deploy and operate, and has demonstrated its reliability in this as well as many other applications throughout the world. TriQuint will continue to introduce MMICs to serve this application for all allocated bands from 6 to 38 GHz, providing the linearity and other characteristics required to satisfy the demands of higher-order modulation schemes that point-to-point systems employ.

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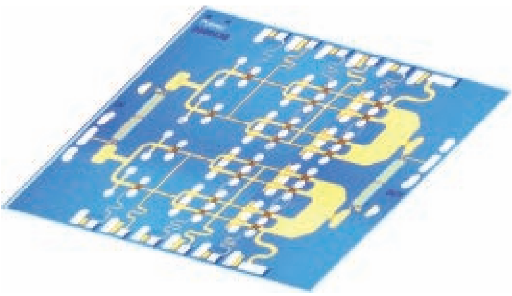


37 TO 43 GHZ POWER AMPLIFIER FAMILY

The requirements for higher and higher data rates and the saturation of existing frequencies and networks are pushing applications higher and higher in frequency. This is true for both the 'traditional' frequency bands around 38 GHz, but also at frequencies higher than 40 GHz. This movement has been consolidated by the authorization of the 40.5 to 43.5 GHz band in Europe and elsewhere for telecommunications. Today, this spectrum is under-used and several companies are introducing systems to provide 100+ Mb/s transmission rates. Even higher frequencies are also being considered, including the 71 to 76 GHz and 81 to 86 GHz bands. As well as terrestrial links there are similar requirements for satellite links.

OMMIC has been very active in providing standard products at lower frequencies while enabling its customers access to the technologies under a 'Foundry Service' for the higher frequencies. The company is now actively developing power amplifier MMICs to cover applications from 20 to 86 GHz. In particular, a family of four new products—the CGY2130UH, CGY2131UH, CGY2132UH and CGY2133UH power amplifiers—has been developed that between them cover 37 to 43 GHz and provide 500 mW and 1 W output power.

TECHNOLOGY

To have a good power amplifier at these higher frequencies requires a different trade-off of parameters than for the traditional lower frequency MMIC technologies. While high current (IDS_{max}) and breakdown voltages (VBGD, VDS_{max}) are required, it is also essential to have high cut-off frequencies (F_t, F_{max}). OMMIC has developed a short gate length, high F_t process called the D01PH.

Developed originally for the fiber optic driver market, this technology has an excellent trade-off between its breakdown voltage (11 V) and its very high F_t (105 GHz) and F_{max}. This allows high gain, high output power and good power added efficiency (PAE) from power amplifiers even at 43 GHz. On-wafer load pull measurements at 40 GHz have demonstrated 500 mW (at 1 dB compression point) per mm of gate width, which is compatible with the fabrication of MMICs with output powers up to 4 W.

The PHEMT process has a 0.13 µm T-gate, a double recess and offset drain-source spacing. The MMIC process includes all normal passive components such as epitaxial and NiCr

OMMIC
Paris, France

TABLE I

MEASURED ELECTRICAL CHARACTERISTICS FOR CGY2130UH MMIC

Feature	Symbol	Min	Typ	Max
Frequency Range (GHz)	F_{range}	37		41
Gain (dB)	Gain		23	
1dB Compression Point (dBm)	P_{1dB}		27	
Saturated Power (dBm)	P_{sat}		28	
Power Added Efficiency (%)	PAE		18	
DC Power Consumption (W)	P_{DC}		3.3	
Drain Voltage (V)	V_{DD}		4.5	

TABLE II

MEASURED ELECTRICAL CHARACTERISTICS FOR CGY2131UH MMIC

Feature	Symbol	Min	Typ	Max
Frequency Range (GHz)	F_{range}	39		44
Gain (dB)	Gain		22	
1dB Compression Point (dBm)	P_{1dB}		27	
Saturated Power (dBm)	P_{sat}		28	
Power Added Efficiency (%)	PAE		17	
DC Power Consumption (W)	P_{DC}		3.3	
Drain Voltage (V)	V_{DD}		4.5	

resistors, spiral inductors, airbridges and via holes. The substrate height is 100 μm to maximize overall production yield.

The process has been available for more than 10 years and has been successfully evaluated by the European Space Agency and is on the European Preferred Parts List. Ongoing developments with this process include the design and fabrication of space qualified 20 GHz, 2 W devices specifically for the European space industry.

500 MW MMICS

The CGY2130UH and the CGY2131UH are the two new 500 mW MMICs. The first power amplifier covers the band 37 to 41 GHz, while the second from 39 to 44 GHz. Both devices operate from a relatively low drain voltage of 4.5 V, but exhibit excellent PAE of over 15 percent. The performances of the two devices are shown in ***Tables 1*** and ***2***, respectively. The design is based around classic power combining networks with an optimal choice of transistor size per section for the linearity and power added efficiency. A total of three stages of amplification are used to achieve 22 dB of gain and an output power of over 500 mW.

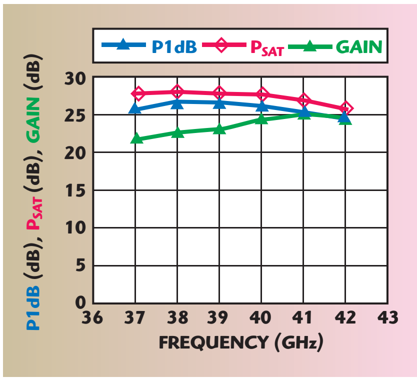
Figure 1 shows the measured 1 dB compression point, saturated output power and small-signal gain versus frequency for the CGY2130UH at 4.5 V. The performance presented here is for nominal biasing, measured in CW mode and are on-wafer measurements, which are not optimal for thermal dissipation. ***Figure 2*** represents the measured power added efficiency for the CGY2130UH versus input power for a range of frequencies.

It can be seen that a high gain (22 dB) with good PAE (17 percent) is achieved and over a wide bandwidth too. The performance of the CGY2130UH and CGY2131UH is such that they are very suitable for applications in the 37 to 44 GHz frequency bands and cover many different applications over these bands. For both the CGY2130UH and the CGY2131UH the measured output IP3 is 34.5 dBm, measured under nominal biasing conditions.

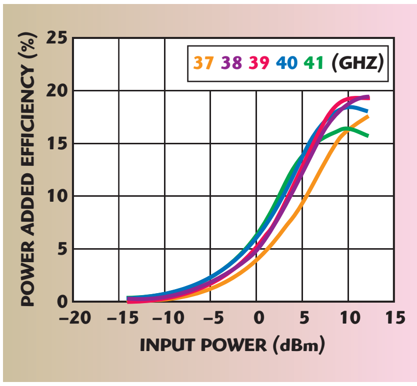
1 W MMICS

Two 1 W MMICs have been launched for the same frequency bands: The CGY2132UH, which operates from 36 to 41 GHz, and the CGY2133UH from 39 to 44 GHz. Similar building blocks have been used as for the 500 mW MMIC with the addition of Lange couplers at the input and output as power splitters and combiners. This results in an excellent and wideband input and output match and the possibility to match the impedance of the last stage for maximum power and PAE. A total of three stages of amplification are used to achieve 20 dB of gain and a saturated output power of 1 W.

The specification of each device is presented in ***Tables 3*** and ***4***; both devices have saturated output powers of 30 dBm with 20 dB of small-signal gain when biased from a 4.5 V supply. ***Figure 3*** shows the measured on-wafer 1 dB compression point, saturated output power and small-signal gain versus frequency for the CGY2132UH at 4.5 V.

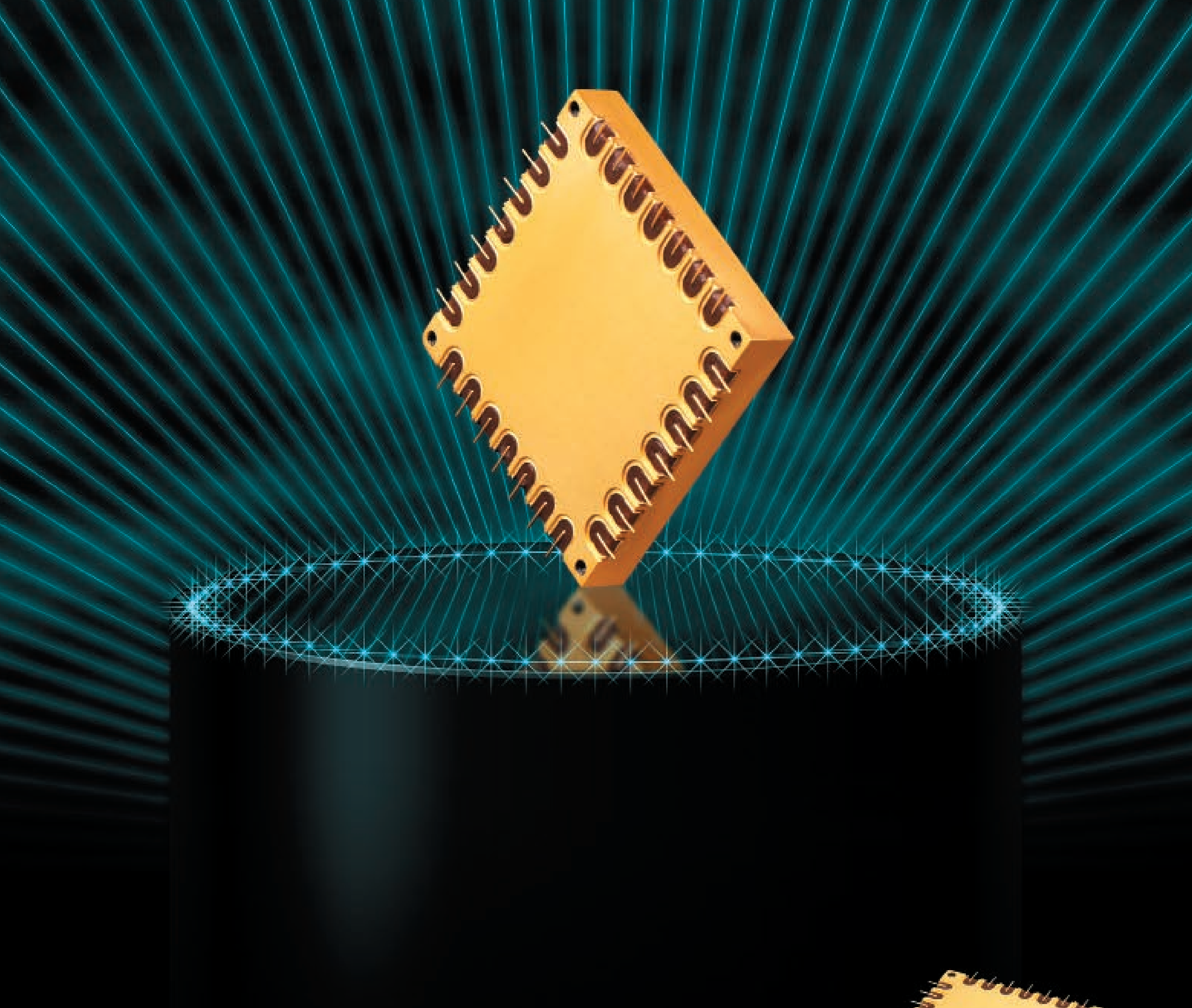


▲ *Fig. 1 Measured electrical characteristics for CGY2130UH at 4.5 V.*



▲ *Fig. 2 Measured PAE vs. input power and frequency for CGY2130UH.*

Again it should be noted that the results presented are for the worst-case on-wafer non-pulsed CW measurement conditions; the same MMICs mounted with good thermal conditions have been shown to have typically 1 dBm higher output compression point. ***Figure 4*** shows the overall power added efficiency of the CGY2132UH. The measured output IP3 for the 1 W device is typically found to be the P1dB plus 8 dB (37 dBm).

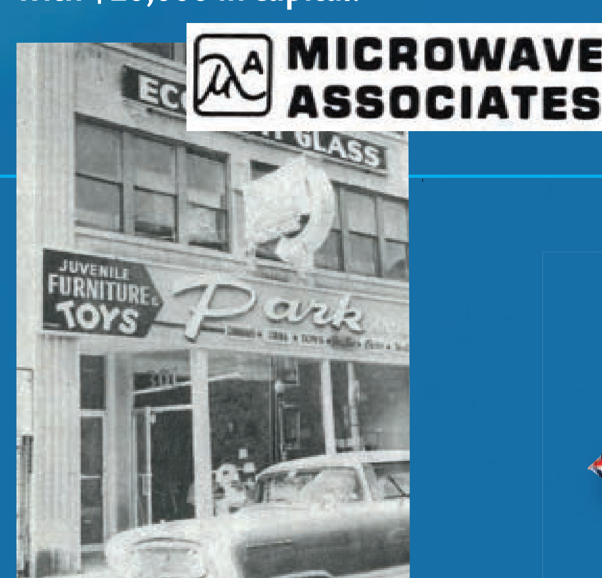


M/A-COM Techn
The First Name
60 Years of Histo

INNOVATIVE PRODUCTS INNOVATIVE PEOPLE 60

1950

August 1950
Microwave Associates is founded in a loft in Boston, Massachusetts with $10,000 in capital.



One of Microwave Associates' first products is a magnetron, a key component for microwave radar. Its development is an important factor in the evolution of the microwave industry in the U.S.

Throughou
Microwave
componen
radar, miss
equipment
B-52 bomb
the Telstar

1960

1962
Microwave Associates goes international, opening Microwave Associates, Ltd. in Dunstable, England, to meet the needs of the emerging microwave market in Europe.

1970

1970
Microwave Associates positions itself for growth by replacing vacuum tubes with semiconductors in microwave applications.

1976
Microwave Associates develops and patents the first high power S-band phase shifter which is used in the Nike X phased array missile site radar.

1980

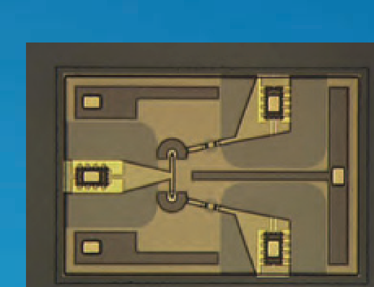
1981
M/A-COM , Inc. acquires Power Hybrids Incorporated, a technical leader in the RF power semiconductor industry for applications such as commercial air traffic control systems and cellular radar markets, avionics, and navigational measuring equipment.

phi Power Hybrids Inc.
1742 CRENSHAW BLVD., TORRANCE, CA 90501

1984
M/A-C
Advan
in Lowe
Employ
The Wa
key tec
Richard

1990

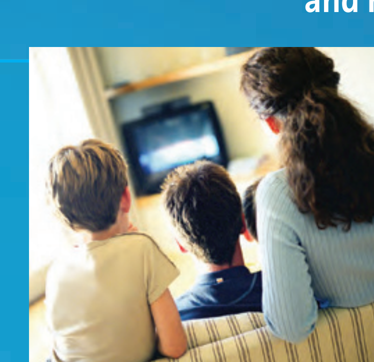
1991
M/A-COM , Inc. develops the first GaAs RFIC for handset applications. This T/R SPDT switch is the genesis of a long standing history of revolutionary switch products still being developed today.



1994
The company introduces Heterolithic Microw
a revolutionary MW and mmW IC topology
structures based upon a marriage of silicon
This state-of-the-art process has and contin
to produce high performance MMICs, rangin
mixers to multi-hundred watt monolithic sw
and military communications markets.

2000

2001
M/A-COM supplies 500 working radios within a 20-hour window after receiving the call for help from first responders supporting recovery efforts following the 9/11 terrorist attacks on The World Trade Center.



2005
M/A-COM is first with a patented new filter technology for high performance CATV infrastructure systems that set the tone for this booming business.

2010: Visit macomtech.com for Inno

nology Solutions
e in Microwave

orical Milestones

M/A-COM Technology Solutions
CELEBRATING 60 YEARS

ut the 60s (and the 50s as well), e Associates produces microwave ts used as building blocks for sile and communications t on the Polaris submarine, per, Mariner II Venus Probe, and satellite.

1957
Successful IPO – Microwave Associates goes public with first stock offering, with the stock price increasing in 1.5 years from $7/share to $30/share.

March 6, 1959
Pioneer IV, the first U.S. spacecraft placed in solar orbit, carries a parametric amplifier employing a Microwave Associates varactor with a noise figure of 1 dB.

1968
Microwave Associates expands its product offering to communications and broadcast industries. Microwave Associates equipment brings the Mexico City Summer Olympic games, as well as political conventions, to households across the U.S.

Microwave Associates develops the first high power PIN diodes that are fundamental to the success of high power phase shifters and control components used throughout the military industry. Microwave Associates becomes a leading supplier of high quality PIN diodes.

1978
Following several acquisitions, Microwave Associates changes its name to M/A-COM, Inc. to reflect the growing part RF and microwave communications would play in its future.

1979
M/A-COM, Inc. becomes the first domestic supplier of semi-insulating GaAs and among the top five world suppliers for nearly 20 years.

4
OM , Inc. establishes the ced Semiconductor Operation ell, Massachusetts. yees refer to this building as alker Building in honor of hnologist and co-founder d M. Walker.

1985
M/A-COM, Inc. becomes a Fortune 500 company.

1988
M/A-COM , Inc. establishes outsourced manufacturing presence in China.

Adams Russell

1989
M/A-COM, Inc. bolsters its product portfolio by acquiring Adams-Russell Electronics, a leading manufacturer of components, subassemblies and systems.

wave Integrated Circuit (HMIC)— that creates three-dimensional and glass at a waferscale level. ues to demonstrate the ability ng from HMIC double balanced witches—for cellular, basestation,

1995
M/A-COM , Inc. is acquired by AMP Incorporated. AMP retains M/A-COM brand.

1995
All M/A-COM, Inc. facilities are certified to ISO9000:2008.

1999
Tyco International Ltd. acquires AMP Incorporated.

2008
Cobham plc acquires M/A-COM's RF components and microwave subsystems business from Tyco Electronics, and consolidates the components business assets in newly-formed M/A-COM Technology Solutions Inc.

2008
M/A-COM Tech goes back to its roots, using the essence of the first innovations and building on those, with aerospace and defense, CATV/broadcast, test and instrumentation, and point-to-point.

2008
M/A-COM Tech starts production on a patented GPS module that includes an antenna, GPS engine, microprocessor and a CAN transceiver along with three levels of software. This device is used in Ford's SYNC® system.

2009
John Ocampo, industry veteran and entrepreneur, acquires M/A-COM Tech from Cobham plc and sets a course for industry leadership.

vative Products by Innovative People

TABLE III

MEASURED ELECTRICAL CHARACTERISTICS FOR GY2132UH MMIC

Feature	Symbol	Min	Typ	Max
Frequency Range (GHz)	F_{range}	36		41
Gain (dB)	Gain		20	
1dB Compression Point (dBm)	P_{1dB}		28.5	
Saturated Power (dBm)	P_{sat}		30	
Power Added Efficiency (%)	PAE		15	
DC Power Consumption (W)	P_{DC}		4.5	
Drain Voltage (V)	V_{DD}		4.5	

TABLE IV

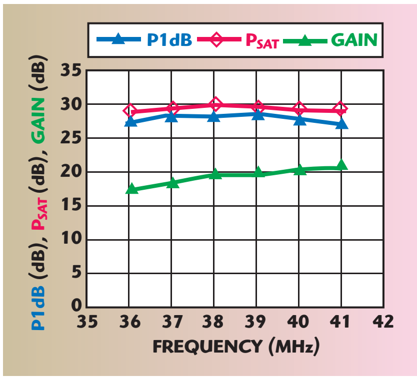
MEASURED ELECTRICAL CHARACTERISTICS FOR CGY2133UH MMIC

Feature	Symbol	Min	Typ	Max
Frequency Range (GHz)	F_{range}	39		44
Gain (dB)	Gain		20	
1dB Compression Point (dBm)	P_{1dB}		28.5	
Saturated Power (dBm)	P_{sat}		30	
Power Added Efficiency (%)	PAE		15	
DC Power Consumption (W)	P_{DC}		4.5	
Drain Voltage (V)	V_{DD}		4.5	

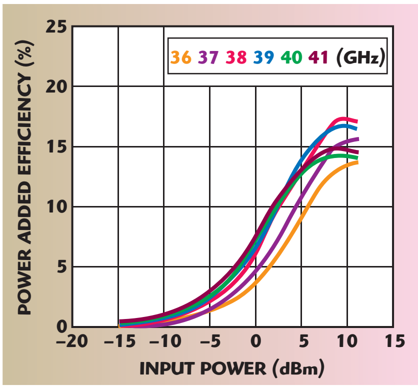
To simplify the use of the devices over multiple platforms, the CGY2132UH and CGY2133UH have common dimensions and pad positioning, again positioning the two amplifiers for many different terrestrial and satellite applications in the 36 to 44 GHz bands.

CONCLUSION

Four new MMICs provide 500 mW and 1 W of output power up to 44 GHz and provide a very versatile power amplifier line up over the 36 to 44 GHz frequency bands. Excellent power added efficiency and high gain are obtained for the four MMICs and all use a qualified and proven process from OMMIC's own foundry. Ongoing product development includes completing the product range with new 2 and 4 W devices in the 36 to 44 GHz frequency range, as well as extending the company's power amplifier product range to the new 71 to 76 GHz and 81 to 86 GHz bands.



▲ *Fig. 3 Measured on-wafer electrical characteristics for CGY2132UH at 4.5 V.*



▲ *Fig. 4 Overall PAE vs. input power and frequency for CGY2132UH.*

OMMIC,
Paris, France,
Tel: +33 (0)1 4510 6731,
Fax: +33 (0)1 4510 6953,
E-mail: information@ommic.com,
www.ommic.com.

RS No. 302

The following booth numbers are complete as of March 18, 2010.

Waveguide Bends

A-Alpha Waveguide Co., a manufacturer of cold drawn waveguide tube, has expanded its manufacturing capabilities. The company has purchased state-of-the-art equipment to manufacture formed waveguide bends with consistent repeatability. A-Alpha will be soliciting requisitions for formed waveguide bends to customer specifications. These precision dimensioned bends will add to the company's other waveguide products that are in stock at its El Segundo, CA facilities. A-Alpha offers same-day shipping of aluminum, copper, bronze, stainless steel, and coin silver waveguide tube, aluminum and bronze cast bends, and extruded aluminum flange stock.

A-Alpha Waveguide Co., El Segundo, CA (310) 322-3487, www.a-alphawaveguide.com.
Booth 2714 **RS 216**

50 GHz DC Blocks

These new high frequency SMPM DC blocks are ideal for use in a variety of modulation schemes common amongst optical networking equipment providers who require either external DC blocking capability or AC coupling between modules. These DC blocks offer both a low cost of ownership and a high quality of design. This model, 8535MP, operates from 16 kHz to 50 GHz and combines excellent RF characteristics and a proven mechanical design. The SMPM push-on connectors mate with GPPO connectors and provide reliable high performance in a compact package.

Aeroflex/Inmet, Ann Arbor, MI (734) 426-5553, www.aeroflex.com/inmet.
Booth 1310 **RS 217**

PIN Diode Attenuators

Aeroflex-KDI announced the addition of two new digitally-controlled voltage variable PIN diode attenuators to its "Flatliner" family of products. These attenuators cover bandwidth from 0.5 to 2 GHz (part number GT-R502-32/64), and 2 to 18 GHz (part number GT-0218-32/64). Using new linearization techniques and state-of-the-art manufacturing practices, this attenuator family has unsurpassed attenuation linearity over temperature. Linearization over temperature is achieved using the latest microcontroller architecture. These are ideally suited for ESM/ECM/EW, communication, simulation and instrumentation applications.

Aeroflex/KDI-Integrated Products, Whippany, NJ (973) 887-5700, www.aeroflex.com/kdi-integrated.
Booth 1310 **RS 218**

25 W Power Amplifier

The model SWPA002030-4440 is a hot switching 25 W power amplifier that operates in a frequency range from 250 to 3000 MHz. This amplifier features hot switching of < 50 ns switching speed, 25 W typical output power PSAT at 500 MHz, > 40 dB gain, > 30 dB isolation, unconditionally stable, compact size and extremely low control current. Applications include: transmitters, smart antennas, T/R modules and impulse radios.

Aeroflex Plainview–AMS, Plainview, NY (800) 843-1553, www.aeroflex.com/bband.
Booth 1310 **RS 219**

40 GHz Programmable Attenuators

VendorView

Aeroflex/Weinschel's new 153 Series of programmable attenuators operate in the DC to 40 GHz frequency range and are available in 0 to 70 dB in 10 dB steps and 0 to 110 dB in 10 dB steps. Other features include low insertion loss and excellent repeatability; life of 5 million operations and compact rugged construction and light weight.

Aeroflex/Weinschel Inc., Frederick, MD (301) 846-9222, www.aeroflex.com/weinschel.
Booth 1310 **RS 220**

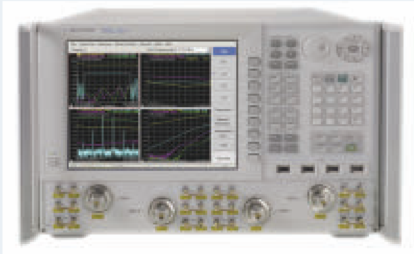
GaN Broadband Power Amplifier

Model number SSPA 2.0-4.0-100 is a high power, Gallium Nitride (GaN) amplifier that operates from 2000 to 4000 MHz minimum and is packaged in a rugged enclosure. This amplifier is designed for operation in harsh environments. Typical output power is 100 W across the band at P3dB. Small-signal gain is 54 dB ± 3.0 dB across the band typically. Input and output VSWR is 2.0:1 maximum. This unit is equipped with DC switching circuitry that enables and disables the RF devices inside the amplifier in 540 nSec typical for turn on and 230 nSec typical for turn off time.

Aethercomm Inc., Carlsbad, CA (760) 208-6002, www.aethercomm.com.
Booth 2713 **RS 221**

Microwave Network Analyzers

VendorView

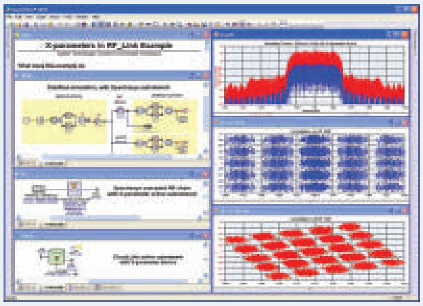


Agilent's PNA-X Series of microwave network analyzers now offer high-accuracy, source-corrected noise-figure measurements of frequency converters and mixers, as well as amplifiers. For measurements up to 26.5 GHz, an internal low-noise receiver is available that eliminates the need for an external preamplifier, making set up and calibration as easy as that required for measuring S-parameters. A new option is also available for measuring noise-figure using the network analyzer's S-parameter receivers, extending source-corrected measurement capability to 50 GHz.

Agilent Technologies Inc., Test and Measurement Division, Santa Clara, CA (800) 829-4444, www.agilent.com.
Booth 924 **RS 222**

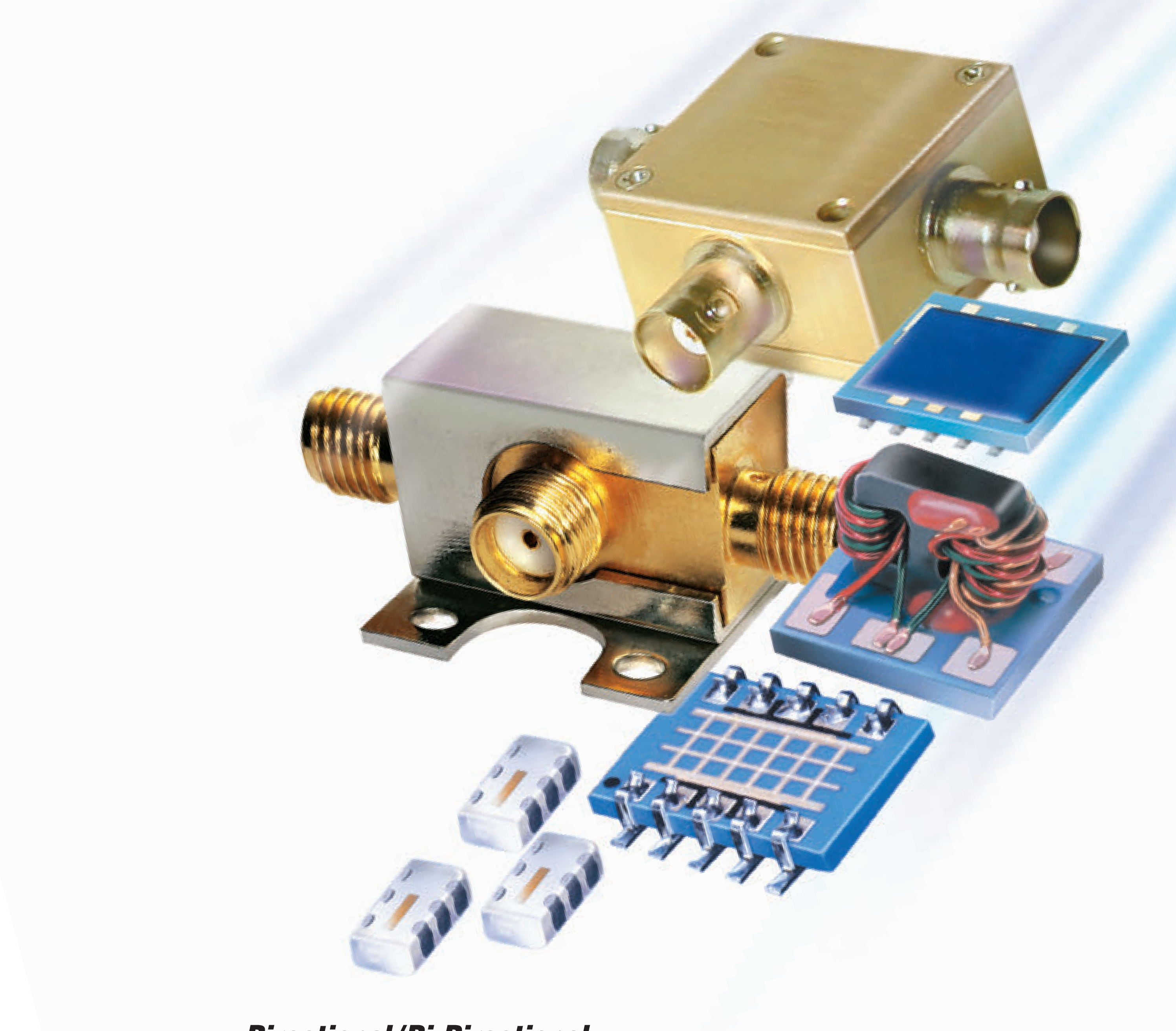
System-level X-parameters

VendorView



Until now, nonlinear analog X-parameter models have focused narrowly on RF circuit designers. Now with system-level implementations in Agilent's SystemVue 2010.01 and Genesys 2010.05 platforms, X-parameters move beyond RF into system-level design. The nonlinear model support provides convenient and reliable design flow closure between wireless circuit designers, RF system architects, and non-analog colleagues doing communications PHY algorithms and baseband signal processing. Come to MTT Booth 924 to see how Agilent is expanding the convenience and accuracy of X-parameters from RF to baseband.

Agilent Technologies Inc., EEsof Division, Santa Clara, CA (800) 829-4444, www.agilent.com.
Booth 924 **RS 223**



NEW WAVES

Miniature RF Switches

VENDORVIEW

AKON offers a line of high performance, high speed and high isolation miniature RF switches. These switches are available in standard configurations such as SPST through SP8T and higher. Switching speeds are typically in the order of 100 nanoseconds, but units under 10 ns are also available. Switch off state isolation can be 60 dB or greater. Both reflective and absorptive configurations are available. Frequency band coverage is model dependent, but ranges from 500 MHz to 40 GHz. Connector options include SMA, GPO, TNC, type N or an extended pin for drop-in. Standard control logic is single ended TTL. The reflective SP5T switch shown here covers 2 to 18 GHz, with 50 nS switching speed (typical), 60 dB isolation, 3 dB maximum insertion loss, maximum VSWR of 2.0:1 and +24 dBm power handling.

AKON Inc.,
San Jose, CA (408) 432-8039,
www.akoninc.com.
Booth 1613 **RS 224**

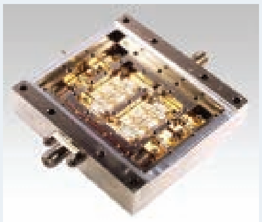
Ultra-broadband Capacitor

ATC's new 550L ultra-broadband capacitor (UBC) has been designed and manufactured with the highest quality materials to provide reliable and repeatable ultra-broadband performance from 16 kHz through 40+ GHz. Now available with gold terminations, this unique component provides ultra-low insertion loss, flat frequency response and an excellent match over multiple octaves of frequency spectrum. The 550L has been engineered in a one piece orientation-insensitive 0402 SMT package, making it fully compatible with high speed automated pick-and-place manufacturing operations.

American Technical Ceramics,
Huntington Station, NY (631) 622-4700,
www.atceramics.com.
Booth 1706 **RS 225**

Low Phase Noise Amplifier

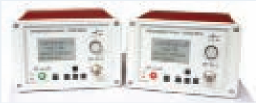
AML specializes in the design and supply of ultra low phase noise amplifiers. This low phase noise X-band high power amplifier, model AML812PND1501, operates in the frequency range of 8 to 12 GHz and provides output P1dB of +34 dBm minimum (2.5 W). This amplifier delivers 1/f phase noise -155 dBc/Hz at 1 kHz and -165 dBc/Hz at 100 kHz offset. Dimensions are 2.24"L × 2.45"W × 0.58"H.



AML Communications Inc.,
Camarillo, CA (805) 388-1345,
www.amlj.com.
Booth 2600 **RS 226**

RF Signal Generator

The new APGEN3000 fast-sweeping RF signal generator complements the company's family of fast-sweeping, low noise signal generators in the range from 9 kHz to 20 GHz. Especially designed to offer fast switching speed, high power, and dedicated analogue modulation capabilities, the signal generator can be used in virtually any application where a high-quality, reliable RF signal is required. These small and portable instruments are also available in customized versions for OEMs.



Anapico Ltd.,
Zurich, Switzerland
+41 44 440 00 51, www.anapico.com.
Booth 1640 **RS 227**

EM Field Simulation Software

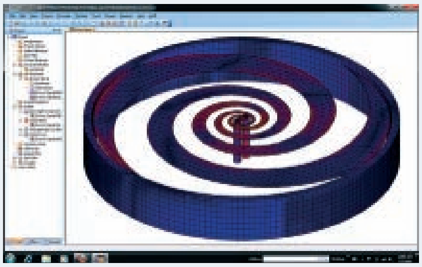
VENDORVIEW

ANSYS Inc. will demonstrate new advancements in Ansoft HFSS 12.1, the industry leading 3D full-wave electromagnetic field simulation software. These features include: Domain Decomposition, a breakthrough technology in HFSS enabling inter and intra machine parallel processing. HFSS-IE, a powerful, open integral equation solution technique for modeling large, open radiating problems; ECAD interface for HFSS for easy setup of electronic package and PCB designs; Integrated multiphysics and optimization capabilities through links with ANSYS® Workbench™.

ANSYS Inc.,
Canonsburg, PA (724) 746-3304,
www.ansys.com.
Booth 2700 **RS 228**

High Frequency EDA

VENDORVIEW



Visit AWR in Booth 1318 during IMS 2010 for a preview of the company's 2010 software release(s). New feature highlights include: Microwave Office's lumped and distributed filter synthesis module, connectivity tracker/tracer, linear stability analysis, and non-linear behavioral modeling (including X-parameter support); Microwave Office/Visual System Simulator (VSS) PA memory effect modeling and VSS's turbo decoders, as well as AXIEM's antenna analysis and post-processing. Learn more at www.awrcorp.com and www.awr.tv.

AWR Corp.,
El Segundo, CA (310) 726-3000,
www.awrcorp.com.
Booth 1318 **RS 229**

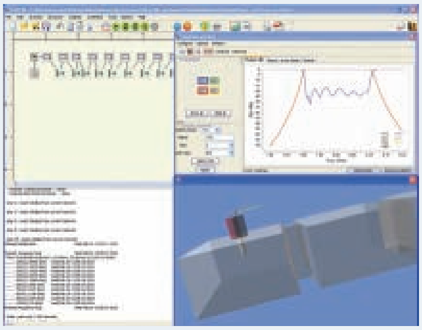
Three-channel Power Meter

VENDORVIEW

AR's model PM2003 is a three-channel power meter with exceptional high-speed measurement capability and a wide dynamic range. Model PM2003 delivers 200 readings per second with one channel; and 100 readings per second when two channels are used. Two channels at a time can be simultaneously displayed and recorded; the third channel can be easily switched in to be displayed or recorded.

AR RF/Microwave Instrumentation,
Souderton, PA (215) 723-8181,
www.ar-worldwide.com.
Booth 3400 **RS 230**

EM Software Tool



FEST3D version 6.6 shall be launched during the IMS 2010 to be held in Anaheim, CA. FEST3D is a software tool capable of analyzing complex passive microwave components based on waveguide technology in extremely short computational times with a high accuracy. Version 6.6 features 64-bit, multi-threading, new analysis capabilities and advanced synthesis tools for low pass, bandpass and dual-mode filters. For a full DEMO version freely downloadable, visit: www.fest3d.com/download.php.

Aurora Software and Testing S.L.,
Universidad Politécnica de Valencia,
Valencia, Spain +34 963 714 257,
www.aurorasat.com.
Booth 2541 **RS 231**

Power Components

These flange-mounted power resistors and terminations range in power from 400 to 1500 W and are specifically designed for the industrial equipment market, i.e., amplifiers, MRIs, etc. These devices have been developed on copper flanges, and are highly reliable for dissipating large amounts of power while maintaining excellent RF characteristics. Barry has tested these parts under the most stringent conditions and found their durability and performance unsurpassed. Barry also offers a full line

NEW WAVES

of low and high power custom resistors, terminations and attenuators in a variety of substrate and metallization options.
Barry Industries Inc.,
Attleboro, MA (508) 226-3350,
www.barryind.com.
Booth 2421 **RS 232**

High Density RF Interconnect

VENDORVIEW

Carlisle Interconnect Technologies offers the ultimate in density and high frequency performance with its patented HDRFI™ product line. Up to 34 coaxial lines can be accommodated in a standard 38999 shell providing broadband performance to 40 GHz. Other connector options include D-sub, ARINC and custom blocks. This revolutionary technology uses a z-axis elastomeric connector to transfer very high data rates with minimal interference at the connector interface.
Carlisle Interconnect Technologies,
Long Beach, CA (866) 282-4708,
www.carlisleit.com.
Booth 833 **RS 306**

RF Coaxial Connector

Chin Nan offers a wide selection of SMA and 2.92 MM with EMI/RFI gaskets for panel mount receptacle type, which provides both waterproof protection and EMI shielding. All EMI/RFI gasket material meets standard of MIL-G-83528 TYPE F.
Chin Nan Precision Electronics Co. Ltd.,
Tainan, Taiwan 886-6-2678303,
www.chinnan.com.tw.
Booth 503 **RS 233**

Low Noise Amplifiers

Ciao Wireless features high linearity low noise amplifiers (LNA) covering different bands between 0.5 to 8 GHz. This line of amplifiers features ultra-high linearity performance with exceptional "headroom" between the P1dB PT and output IP3 of +16 dBm minimum (ICP3 at +42 dBm typical), going above and beyond the standard 10 dB separation as is normally seen. Designs cover 0.5 to 2 GHz, 2 to 4 GHz and 4 to 8 GHz with gain levels at 35 to 40 dB minimum and noise figures typically below 2.0 dB. Delivery is one to two weeks ARO with competitive pricing.
Ciao Wireless,
Camarillo, CA (805) 389-3224,
www.ciaowireless.com.
Booth 2503 **RS 234**

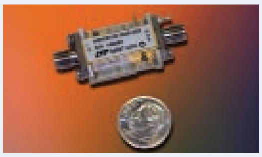
Bicone Antenna

The model A6473 is a bicone antenna that operates at high frequency, provides omni-directional azimuth coverage, and can handle 5 W CW. This antenna features rugged aluminum and composite construction and includes an integral protective radome. It is available with optional vertical linear or circular polarization. The A6473 operates from 18 to 40 GHz, is approximately 2.5 inches tall by 4 inches diameter, and provides nominal gain of +3 dBiL. Other models are also available for other frequency ranges and gain; contact Cobham Sensor Systems to discuss your specific requirements. This antenna is suitable for a range of uses including broadband communications systems and electronic warfare (EW) applications.
Cobham Sensor Systems –
Sensor Electronics,
Baltimore, MD (410) 542-1700,
www.cobham.com.
Booth 1303 **RS 235**

RF Coaxial Cable Assemblies

These low-loss RF coaxial cable assemblies feature rugged stainless-steel solder-clamp construction and attenuation of 0.36 dB/ft. at 18 GHz. The LL142 Series cable offers shielding effectiveness of greater than -110 dB with an operating temperature range of -55° to +85°C (extended range of -55° to +125°C available through special order). The LL142 Series cable offers a minimum bend radius of 0.8 in. and is available in-stock with SMA Male to SMA Male connectors, as well as Type N and TNC connectors. Crystek's stocking distributors also support a large variety of RG174 and RG316DS cables in a variety of configurations.
Crystek Corp.,
Fort Myers, FL (239) 561-3311,
www.crystek.com.
Booth 3231 **RS 236**

Low Noise Amplifier



This compact, low noise amplifier (LNA) operates in the 1 to 18 GHz frequency range for a wide variety of RF and microwave applications. Conceived with two goals in mind, CTT's latest compact LNA offers noise figures of less than 2.5 dB (typical) over an instantaneous bandwidth of more than four octaves (1 through 18 GHz). This new LNA will find use in a wide range of applications including radar imaging, spread-spectrum, and a myriad of ultra-wide bandwidth applications including the related instrumentation for each. CTT model AMX/0118-3026 is based on GaAs PHEMT technology with input and output impedance matching. The compact LNA is available as a drop-in package or with SMA connectors.
CTT Inc.,
Sunnyvale, CA (408) 541-0596,
www.cttinc.com.
Booth 1806 **RS 308**

High Frequency Connectors

Delta is announcing the additions of SMP and SMPM connectors and cable assembly services as a full product catalog offering. The SMP and SMPM's plugs/receptacles are offered for termination to 0.047 and 0.085 semi-rigid cable. The board mount receptacles are offered in the three detent configurations including smooth, limited and full bore. For board stacking/interconnecting Delta offers a variety of "bullet" sizes to accommodate a variety of board spacing needs. The company's fully vertically integrated facility including plating allows Delta the ability to customize your application as well. A series of SMP/SMPM adapters rounds out the line. The connectors are designed to perform through 40 GHz (SMP) and 60 GHz (SMPM).
Delta Electronics Manufacturing Corp.,
Beverly, MA (978) 927-1060,
www.deltarf.com.
Booth 2706 **RS 237**

Fast-switching Frequency Synthesizer

The SLX-4000 is a broadband, fast switching frequency synthesizer for battery powered military systems and devices. The unit operates from 3000 to 4000 MHz (30 percent bandwidth) locked to a 10 MHz external reference and features 5 MHz step size with 34 µSec step and 50 µSec full band switch speeds. The unit also features +4 dBm output power, low spurs (≤60 dBc), low noise, extremely low current draw (+5 V at 75 mA, typical) and extended operating temperature range (-40° to +85°C). The SLX Series is housed in an ultra-miniature 0.5" square package. The SLX-4000 is ideal for use in battery powered military systems and devices, including microwave radios, satellite communications and telemetry systems.
EM Research Inc.,
Reno, NV (775) 345-2411,
www.emresearch.com.
Booth 1810 **RS 238**

Interference Control Solutions

Emerson & Cuming offers injection moldable grades of both its ECCOSTOCK® low-loss dielectrics, and its ECCOSORB® microwave absorbers. Supplied as net shape or near-net shape 3D parts, Emerson & Cuming's injection moldable materials offer low cost solutions to your high-volume requirements for 1 GHz through mm wave applications. Contact one of the company's Application Engineers today to discuss your project.
Emerson & Cuming Microwave
Products Inc.,
Randolph, MA (781) 961-9600,
www.eccosorb.com.
Booth 2615 **RS 239**

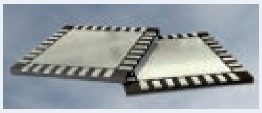
Harsh Environment Packaging

Many of Empower's standard modules and systems can be adapted to be installed into

an "All environment" rated enclosure. Many Empower COTS modules can also be hardened for the most severe operating conditions. In addition to the company's normal design processes for ruggedized environments, manufacturing and packaging enhancements can be implemented to insure maximum reliability and survivability in extreme, high altitude applications.

Empower RF Systems Inc., Inglewood, CA (310) 412-8100, www.empowerrf.com.
Booth 1631 **RS 240**

MMIC VCOs



Endwave's array of over 20 released VCOs have industry pacing phase noise performance as low as -117 dBc/Hz at 100 kHz offset, as well as some of the best frequency pushing data found at just 5 MHz/V at any tuning voltage. The highly reliable VCOs endure extensive qualification testing on over 100 devices, making them attractive for multiple industries and applications. Endwave's VCOs are available as either a raw die or packaged device, and provide for a true pin for pin compatible, low cost, second source alternative to other industry offerings.

Endwave Inc., San Jose, CA (408) 522-3100, www.endwave.com.
Booth 2724 **RS 241**

EM Simulation Solution

FEKO is a comprehensive EM simulation solution, based on the accurate full-wave MoM with various state-of-the-art extensions. The leading MLFMM and hybridisation with asymptotic high frequency techniques allow users to move beyond the computational resource limits of conventional full-wave solvers, to solve problems with extremely large electrical size. Several techniques, including the FEM, are available for the modelling of complex dielectric regions. Applications include the analysis of antennas, antenna placement, EMC, bio-EM, microwave components, EM circuits, radomes and scattering (RCS).

FEKO, distributed in North America by EMSS-USA, (866) 419-3356, www.feko.info.
Booth 2400 **RS 242**

NEW WAVES

Quick End Launch Connector

The new Quick End Launch (QEL) SMA is designed for quick connection at the edge of PCB boards up to 18 GHz. The specially designed leg automatically adjusts and firmly attaches to the PCB. It is an ideal solution for all active and speedy tests required in R&D. When compared with conventional end launch connectors, it reduces soldering and assembly time when deployed in mass production.

GigaLane Co. Ltd.,
Gyeonggi-do, Korea +82-31-233-7325,
www.gigalane.com.
Booth 1733 **RS 244**

THz Diode Foundry Process

Global Communication Semiconductors Inc. (GCS) announced the showcase of its new THz Diode foundry process. The planar Schottky diode process features cut-off frequency (fco) > 1 THz with an ideality factor of 1.1. The low diode turn-on voltage (< 500 mv) allows mixer operation with a LO power below 10 dBm and a conversion loss of 6.5 dB at W-band. GCS's process can be integrated with other passive components, such as MIM caps, spiral inductors, thin film resistors and transmission lines to realize diplexers and filters monolithically. The monolithic integration eliminates unwanted parasitic elements from wire bond, which is highly undesirable at mm Wave frequencies. For microwave frequency transceiver components, this THz diode is ideal for low conversion loss mixers, with options to be monolithically integrated with HBT and HEMT circuits.

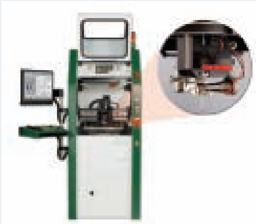
Global Communication Semiconductors Inc.,
Torrance, CA (310) 530-7274,
www.gcsincorp.com.
Booth 2841 **RS 245**

Temperature-compensated Crystal Oscillator

The T1215 series temperature-compensated crystal oscillator (TCXO) measures 9 × 7 × 2.8 mm and features a hermetic, ceramic package with ruggedized construction. It has been designed to deliver consistent, reliable frequency control performance in high shock and vibration environments. Reduced acceleration sensitivity down to 5×10^{-10}/g is available for improved phase noise performance during vibration and acceleration. The T1215 offers a wide range of available frequencies, from 750 kHz to 800 MHz, and a choice of CMOS, LVPECL or LVDS outputs.

Greenray Industries Inc.,
Mechanicsburg, PA (717) 766-0223,
www.greenrayindustries.com.
Booth 1736 **RS 246**

Thin Wire Wedge Bonder



Hesse & Knipps' thin wire wedge bonder, the Bondjet BJ820, handles all wire bonding challenges on a single platform including RF and microwave devices, COB, MCM and hybrids, fiber optics and automotive using aluminum wire, gold wire or ribbon. The BJ820 demonstrate loop height consistency down to 10 microns and features PiQC™ Process-integrated Quality Control system, which utilizes real production data to alert users in real time of questionable bonds due to deteriorating wedges, bad sections of wire, or possibly contaminated devices.

Hesse & Knipps,
Paderborn, Germany
+49 (0) 5251 1560-0,
www.hesse-knipps.com.
Booth 3317 **RS 247**

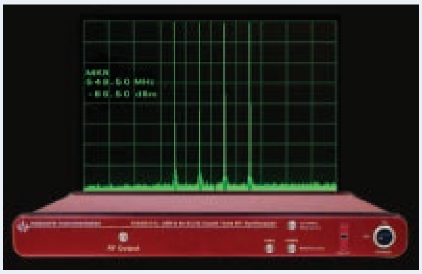
Tunable Filters

VENDORVIEW

Hittite's 25^{th} product line, tunable filters are ideal for pre-selection in multi-band communication systems, wideband radar, and test and measurement equipment. The HMC881LP5E and HMC882LP5E are seventh-order, low pass filters with adjustable cut-off frequencies and 35 dB stop-band rejection out beyond 30 GHz. A voltage control signal provides continuous adjustment of passband cut-off. The HMC890LP5E and HMC891LP5E are third-order, bandpass filters with independent voltage-controlled adjustment of passband frequency and bandwidth. The BPFs maintain 30 dB of stop-band rejection out to 9 GHz, and both filter types exhibit 10 dB of return loss.

Hittite Microwave Corp.,
Chelmsford, MA (978) 250-3343,
www.hittite.com.
Booth 2105 **RS 248**

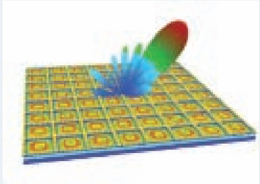
Quad-Tone Analog Synthesizer



Holzworth Instrumentation introduced the Quad-Tone series of RF synthesizers to address the critical requirements of IMD test signal generation. These broadband synthesizers (8 MHz to 6 GHz) combine independent, phase coherent tones via a single output. These Quad-Tone RF synthesizers maintain the absolute and relative frequency/phase stability relationship between the generated tones. Integration of Holzworth's unique non-PLL synthesis architecture provides unsurpassed signal performance with independent control over the amplitude, frequency, and phase offset of each tone.

Holzworth Instrumentation,
Boulder, CO (303) 325-3473,
www.holzworth.com.
Booth 628 **RS 249**

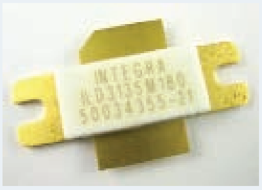
EM Simulation Tool



EMPIRE XCcel is a 3D full-wave EM simulation tool for antennas, microwave circuits, EM chip design, etc., and is based on the powerful Finite Difference Time Domain (FDTD) method. Its adaptive on-the-fly code generation exhibits a fast simulation engine and with this highly accelerated kernel full-wave EM-simulation, problems can be solved in minutes. For structure definition, a powerful Graphical User Interface is included in the package and several structure import and export formats are supported. The new 5.40 release is further optimized to solve large simulation domains, hundreds of wavelength in size.

IMST GmbH,
Kamp-Lintfort, Germany
+49 2842 981 0, www.empire.de.
Booth 3511 **RS 250**

S-band Radar Transistor



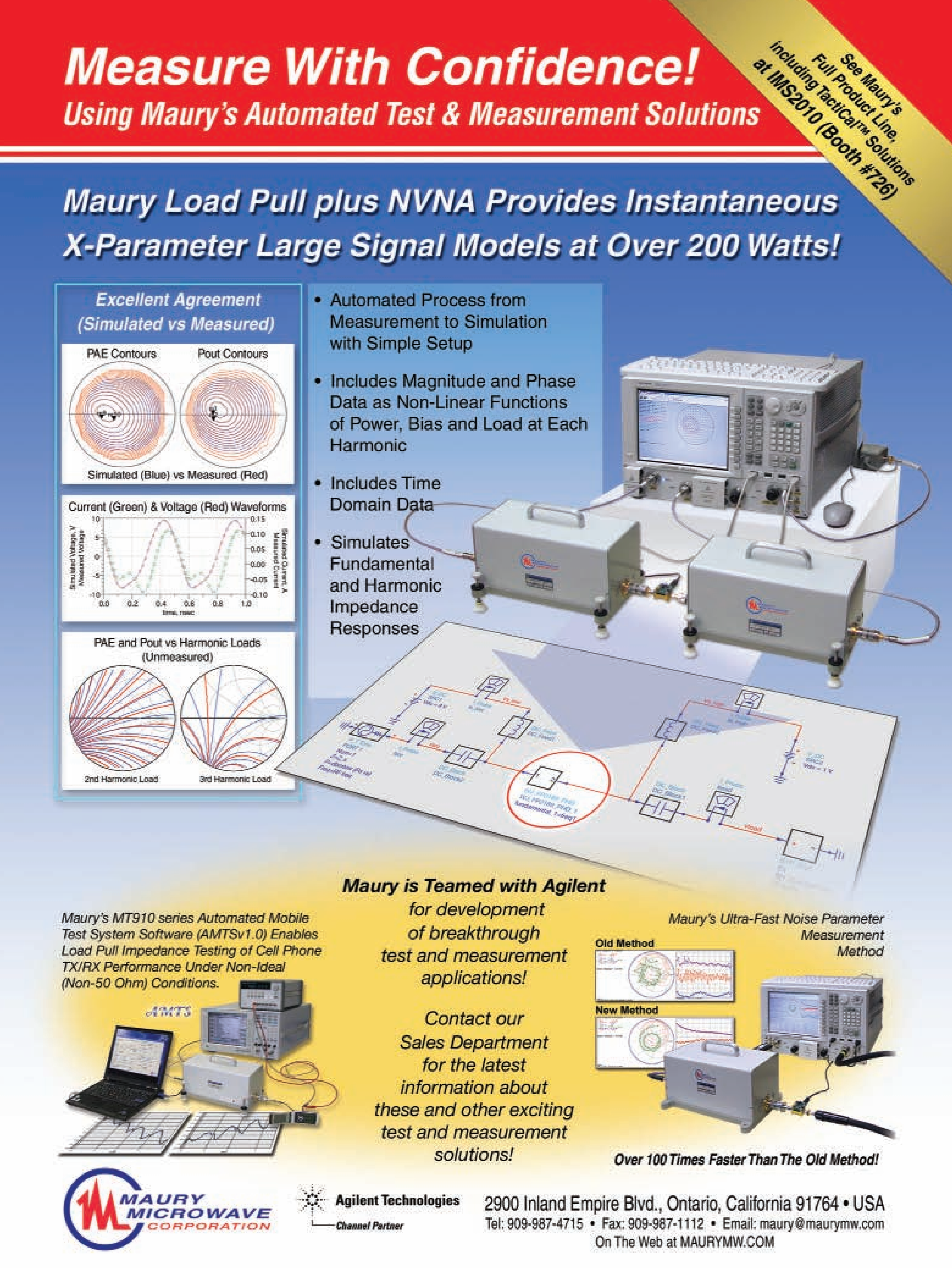
The ILD3135M180 is designed for S-band radar applications operating over the 3.1 to 3.5 GHz instantaneous frequency band. Under 300 µs pulse width and 10 percent duty cycle pulsing conditions, it typically supplies a minimum of 180 W of peak output power with 10 dB gain. Specified operation is with Class AB bias. All devices are 100 percent screened for large-signal RF parameters in a fixed tuned broadband matching circuit. The broadband test fixture includes a temperature compensated bias network. Available for sampling.

Integra Technologies Inc.,
El Segundo, CA (310) 606-0855,
www.integratech.com.
Booth 2425 **RS 251**

Wideband Attenuator

VENDORVIEW

The new 50P-1857 programmable attenuator offers solid-state reliability and superior broadband performance. With an operating frequency range of 200 to 6000 MHz, it is ideal for today's wideband variable attenuator requirements including VHF/UHF, LTE and WiMAX testing applications. This 50 Ohm device has a dynamic range of 0 to 95 dB in 1 dB steps and is guaranteed monotonic across its entire bandwidth. SMA female connectors are



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PAE Contours
Pout Contours
Simulated (Blue) vs Measured (Red)
Current (Green) & Voltage (Red) Waveforms
PAE and Pout vs Harmonic Loads (Unmeasured)
2nd Harmonic Load
3rd Harmonic Load
• Automated Process from Measurement to Simulation with Simple Setup
• Includes Magnitude and Phase Data as Non-Linear Functions of Power, Bias and Load at Each Harmonic
• Includes Time Domain Data
• Simulates Fundamental and Harmonic Impedance Responses
Maury is Teamed with Agilent for development of breakthrough test and measurement applications!
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Over 100 Times Faster Than The Old Method!
MAURY MICROWAVE CORPORATION
Agilent Technologies
Channel Partner
2900 Inland Empire Blvd., Ontario, California 91764 • USA
Tel: 909-987-4715 • Fax: 909-987-1112 • Email: maury@maurymw.com
On The Web at MAURYMW.COM

standard on the input and output, but other connector configurations may also be available upon request.

JFW Industries Inc.,
Indianapolis, IN (317) 887-1340,
www.jfwindustries.com.
Booth 1700 **RS 252**

Directional Coupler

The model 110067016 is a directional coupler that operates in a frequency range from 10 to 67 GHz. This model offers coupling (with respect to output) of 16 ± 1.1 dB and frequency sensitivity of ± 2.0 dB. The coupler provides directivity of 7.25 dB, maximum VSWR (any port) of 2.0, insertion loss of < 1.95 dB maximum, and power rating (input) of 20 W average, 3 KW Peak. Standard connectors are 1.85 mm female. This model provides an operating temperature of -54° to +85°C. Delivery: stock to 30 days.

Krytar,
Sunnyvale, CA (408) 734-5999,
www.krytar.com.
Booth 1338 **RS 253**

Two-channel Switch Bank

The 3IFAX-1100/2250-ML is a two-channel switch bank with a bypass channel. Path A is the by-pass and Path B is the two-channel switch option. The switch bank has a low band from 20 to 1100 MHz and a high channel of 1300 to 2250 MHz. The bypass covers 1300 to 2250 MHz. The unit features a 3.2 × 1.9 × 0.35 inch package with surface-mount pins. The power supply is a single +5 V with LVTTL for control logic. The bank features 50 and 60 dB stopbands and 1.5:1 VSWR. The operating temperature is -40° to +85°C.

Lorch Microwave,
Salisbury, MD (410) 860-5100,
www.lorch.com.
Booth 1016 **RS 254**

Fully Enclosed Laser System

The ProtoLaser S is a fully enclosed laser system for PCB prototyping and production on-demand. This standalone laser-based system works directly off of CAD data to produce circuits on a variety of materials; including ceramic, PTFE, as well as thin and flexible substrates, making it an ideal component for RF and microwave PCBs. The revolutionary tool-less laser processing method can be used to produce lines, spaces and corner radii. The protective cabinet allows for a Class 1 laser safety rating.

LPKF Laser & Electronics,
Tualatin, OR
(503) 454-4200,
www.lpkfusa.com.
Booth 600 **RS 255**

Nanosecond PHEMT Switches

VENDORVIEW

M/A-COM Technology Solutions switches are used extensively in RF and microwave commercial, industrial and military applications. These IC-based switches span from DC to 20 GHz and are ideal for voice and data applications. The switches range from single pole single throw to multi-throw devices and are available in industry standard and new ultra miniature packages. M/A-COM Tech also recently introduced a new family of reduced gate lag devices with exceptionally fast switch settling time. These new PHEMT switches give designers a critical advantage when multiple series switches or high data rates are key functions in test and communications equipment.

M/A-COM Technology Solutions Inc.,
Lowell, MA
(978) 656-2546,
www.macomtech.com.
Booth 2905 **RS 256**

NEW WAVES

Precision Components and Calibration Standards

This new line of instrument-grade precision components is designed to provide users with the right level of performance at the right price. This new product line, Tacti-CalTM, includes calibration standards manufactured to the same high quality and exacting requirements that have made Maury's metrology-grade products the Gold Standard of the Test & Measurement industry for over 50 years. TactiCal precision components and calibration standards include 50 ohm coaxial VNA calibration kits, opens, fixed loads, and shorts in 1.85 mm, 2.4 mm, 3.5 mm and type N. This new product line also includes between-series and in-series coaxial adapters in these same connector types.

Maury Microwave Corp.,
Ontario, CA (909) 987-4715,
www.maurymw.com.
Booth 726 **RS 257**

Power Divider/Combiners

VENDORVIEW

The V-Line power divider/combiners feature increased power rating and extended frequency range. These two-way through 16-way, 40 W power divider/combiners are optimized for excellent performance across all wireless bands from 700 MHz to 2.7 GHz. The divider/combiners rugged construction makes them ideal for both base stations and in-building wireless systems. These products are available from stock to two weeks ARO in N, SMA, BNC, or TNC connector configurations for your 3G or 4G/LTE–WiMAX applications. One hundred percent made in the USA with a 36-month warranty.

MECA Electronics Inc.,
Denville, NJ (973) 625-0661,
www.e-meca.com.
Booth 2204 **RS 258**

Coaxial Circulators and Isolators

MESL Microwave introduces a new range of low cost co-axial circulators and isolators covering the range 1 to 18 GHz. Using a modular design approach that enables short lead-times, these parts offer improved microwave performance with insertion loss of 0.3 dB and isolation of 23 dB for a 15 percent bandwidth device. These parts are available in narrow band and broadband designs and are suitable for use in a wide variety of commercial, military, industrial and test bench applications.

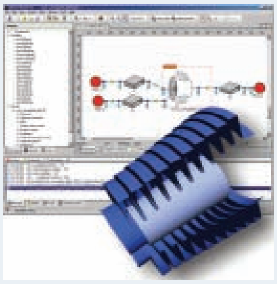
MESL Microwave,
Edinburgh, UK +44 131 333 2000,
www.meslmicrowave.com.
Booth 517 **RS 259**

Low Loss Flexible Cable Assemblies

The C02 Series are the cable assemblies with good phase stability vs. flexure of ±0.9° at 18 GHz, the typical insertion loss of one meter cable asembly is at 2.0 dB at 18 GHz, and the typical return loss is at 22 dB at 18 GHz. These cable assemblies are especially a good fit for the applications of RF and microwave test systems, and mobile communications.

MIcable Inc.,
Fuzhou, Fujian, China +86 591 87382856,
www.micable.cn.
Booth 1036 **RS 260**

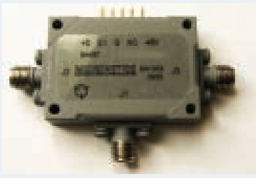
EM CAD Tool



The µWave WizardTM EM CAD tool is a fast and accurate electromagnetic solver that utilizes the well-known Mode-matching technique and its derivatives as well as the flexible 2D FE- and 3D FE-Method. Improvements with this release include several new features for existing elements as well as new elements that offer advanced designs, e.g. more kinds of low pass filters or corrugated coax horn antennas. µWave Wizard offers numerous features such as fast frequency sweep based on adaptive rational function interpolation and 64 bit capability (including multi-processor capabilities).

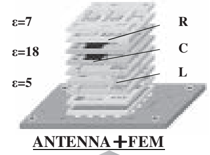
Mician GmbH,
Bremen, Germany
+49 421 168 993 56,
www.mician.com.
Booth 1710 **RS 261**

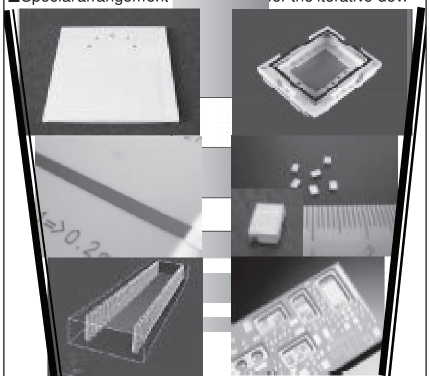
300 W SPDT Switches



Micronetics unveils a line of high power 300 W SPDT switches that can support switching repetition rates of 2 MHz. These switches are ideal for field radar and instrumentation radar applications where rapid switching between transmit and receive is a necessity. All Micronetics high power switches are 100 percent high power tested for maximum field reliability.

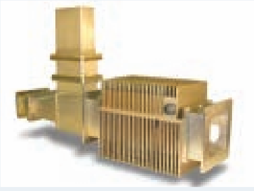
Micronetics Inc.,
Hudson, NH
(603) 883-2900,
www.micronetics.com.
Booth 1140, 1340 **RS 262**





NEW WAVES

L-band Polarizer



This L-band polarizer sets a new standard for air-cooled ferrite control devices required to operate at high average power levels. Capable of switching between vertical linear and right-hand circular polarization, the L-band polarizer handles 65 kW peak and 6.5 kW average power. Maximum insertion loss is 0.4 dB, with 500 microseconds switching between states. The L-band polarizer allows the FAA LRR to switch between polarization modes dependent on weather conditions, providing feedback indicating the proper moment for switching.

Microwave Applications Group,
Santa Maria, CA (805) 928-5711,
www.magsmx.com.
Booth 3517 **RS 263**

QFN Packaged Up-converter

VENDORVIEW

This 5.6 to 10.5 GHz GaAs MMIC up-converter integrates a double-balanced image reject mixer, LO buffer amplifier, RF buffer amplifier and variable attenuator, all within a fully molded 4×4 mm QFN package. This RoHS-compliant, packaged up-converter has an output third-order intercept point (OIP3) of +25 dBm, a conversion gain of 8 dB and a typical image rejection of 15 dBc. Variable gain regulation can be achieved by adjusting the bias, with turn-down trajectories optimized to maintain linearity and minimal 2xLO leakage over the gain control range. The XU1012-QH is well suited for point-to-point (PTP) radio, LMDS, SATCOM and VSAT applications. The XU1012-QH is one hundred percent RF and DC tested.

Mimix Broadband Inc.,
Houston, TX (281) 988-4600,
www.mimixbroadband.com.
Booth 1119 **RS 264**

5 to 20 GHz Wideband Microwave Amplifier

VENDORVIEW

The Mini-Circuits AVA-24+ is a surface-mount, microwave amplifier and fully integrated gain block up to 20 GHz. It is packaged in Mini-Circuits' industry standard 3×3 mm MCLP (QFN) package, which provides excellent RF and thermal performance. The AVA-24+ integrates the entire matching network with the majority of the bias circuit inside the package, reducing the need for complicated external circuits. This approach makes the AVA-24+ extremely flexible and enables simple, straightforward use.

Mini-Circuits,
Brooklyn, NY (718) 934-4500,
www.minicircuits.com.
Booth 531 **RS 265**

COMPLETE Library

Modelithics Inc. announces a significant update to its linear and nonlinear device and system level component model library. The Modelithics COMPLETE Library v7.0 encompasses all passive and active Modelithics models available for designers using Agilent Technologies' ADS. Modelithics COMPLETE Library versions for AWR Microwave Office and Agilent Genesys are scheduled for release by June. Increased flexibility is also available with the company's multi-simulator option for customers using multiple EDA tools. Get more information or a free trial at sales@modelithics.com.

Modelithics Inc.,
Tampa, FL (813) 866-6335,
www.modelithics.com.
Booth 1131 **RS 266**

Versatile Materials

Momentive Performance Materials' is a leader in thermal management products. Momentive's thermally annealed pyrolytic graphite (TPG) has thermal conductivity over four times that of copper, yet is only 1/4th the weight of copper. The ever increasing power consumption of microelectronics demands more advanced technologies and materials. TPG provides new solutions to thermal problems in many aerospace and military applications, including radars, satellites and fighter jets. Ongoing programs are designed to translate this success to broader commercial markets.

Momentive Performance Materials,
Strongsville, OH (440) 878-5700,
www.momentive.com.
Booth 736 **RS 267**

Ku-band Block Up Converter

VENDORVIEW

Narda is capitalizing on its Ultimate SMTSM Technology to produce low cost BUC/BDC modules for X-, Ku- and Ka-band SATCOM applications. These complex integrated microwave assemblies (IMA) are constructed using a single multilayer board with the microwave circuitry on the top side and the control circuitry on the bottom. Connections from top to bottom are made with via holes as appropriate. These vias combined with a novel sub cover approach meet required high isolation levels.

Narda Microwave-East,
Hauppauge, NY (631) 231-1700,
www.nardamicrowave.com.
Booth 3002, 3102 **RS 268**

Broadband High Power Amplifier

Ophir RF 5213 is a 1000 W amplifier system that covers the 200 to 1000 MHz frequency range. This small and lightweight amplifier system utilizes Class A/AB linear power devices that provide excellent third-order intercept point, high gain and a wide dynamic range. RF input signal formats of CW/AM/FM/PM and pulse. The amplifier can be fully controlled by the front panel key-pads or remotely by RS232/Ethernet or IEEE488. System protected against VSWR, thermal overload, over current and voltage. Operating voltage is 186 to 264 VAC, three phases. Fifty ohms input and output impedance with Type-N input and 7/16-DIN output connectors.

Ophir RF,
Los Angeles, CA (310) 306-5556,
www.ophirrf.com.
Booth 2736 **RS 269**

Quad Ridge Horn Antenna

Orient Microwave Corp. introduces a specially designed quad ridge horn antenna. This antenna shows superior characteristics for a wide frequency range. The antenna operates in a frequency range from 2 to 18 GHz; offers VSWR of 3.0:1 maximum; gain of 8 to 18 dBi; power of 10 W maximum; isolation of 25 dB maximum; and input connector of SMA (jack) × 2. Size: 126 × 126 × 195 mm. Weight: 550g maximum.

Orient Microwave Corp.,
Shiga, Japan +81-749-45-8121,
www.orient-microwave.com.
Booth 2704 **RS 270**

RF Coaxial Cables

YouForm™ high quality, low cost jacketed hand formable cables that feature stainless steel SMA plugs on each end are now available in straight and right angle configurations. One hundred percent VSWR tested 1.35:1 at 18 GHz for SMA straight connectors and 1.35:1 at 12.4 GHz for SMA right angle. YouForm cables are available in two diameters 0.085 (0.102(OD) and 0.141 (0.161(OD). Lengths from 2 inch to 18 inch in stock for one low price $9.95 each for straight SMAs; $13.95 for straight to right angle SMAs and $14.95 for SMA right angle to right angle. Longer lengths available at a slightly higher price. Applications include RF and microwave rack mounted systems, radar, base stations, module to module links, communications systems and military COTS.

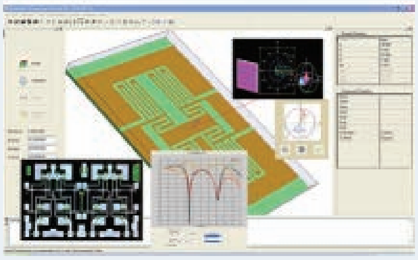
P1dB Inc.,
distributed by RFMW Ltd.,
San Jose, CA (408) 414-1450,
www.rfmw.com.
Booth 1331 **RS 271**

Hi Q/Low ESR Capacitors

Passive Plus Inc. now offers an Extended Working Voltage capability for its core Hi Q/low ESR Capacitor line. Available in six case sizes: 0.055" × 0.055" extended up to 300 W VDC; 0.110" × 0.110" extended up to 1,000 W VDC; 0.225" × 0.225" extended up to 5,000 W VDC; 0.390" × 0.390" extended up to 7,200 W VDC; 0.614" × 0.433" extended up to 9,000 W VDC; and 0.760" × 0.760" extended up to 10,000 W VDC. All product lines are available in P90 or NPO dielectrics with a variety of terminations and lead styles. All products are also available in non-magnetic termination styles. Delivery: stock to two weeks.

Passive Plus Inc.,
Huntington Station, NY (631) 425-0938,
www.passiveplus.com.
Booth 1902 **RS 272**

EM Supreme Version 2010



PedaSoft LLC announced EM-Supreme Version 2010. EM-Supreme is a time-domain Field-Device-Circuit Co-simulator that can be used to model passive structures, active components, and complete RF and millimeter-wave modules. EM-Supreme is an accurate alternative to what RF designers are using today "i.e. modeling the active and passive parts of the chip using separate field and circuit simulators, followed by combining the results employing simple approximations, without taking the effect of electromagnetic coupling, radiation, and interference into consideration," which leads to inaccurate models especially at high power and/or high frequency RF chips. With EM-Supreme, RF designers can model CMOS as well as GaAs and GaN FETs. The tool enables RF designers achieving first-pass design success, eliminating ad-hoc design, and reducing time-to-market and development cost.

PedaSoft LLC,
Chandler, AZ (480) 821-9201, www.pedasoft.com.
Booth 633 **RS 273**

Microwave Frequency Synthesizers

The QuickSyn® series of microwave synthesizers delivers instrument-grade performance, increased functionality, and efficient power consumption at a reduced size and low cost. The synthesizers employ a revolutionary phase-refining technology that provides a unique combination of fast-switching speed and low phase noise characteristics. In addition to synthesizers, Phase Matrix designs and manufactures other custom components and subassemblies for commercial and military applications. Circuit designs include amplifiers, VCOs, DTOs, up/down-converters, frequency multipliers, SPMT switches, filters, diplexers, variable attenuators, and phase-locked oscillators up to 50 GHz.

Phase Matrix Inc.,
San Jose, CA (408) 428-1000, www.phasematrix.com.
Booth 1533 **RS 274**

Cavity Triplexer

VENDORVIEW

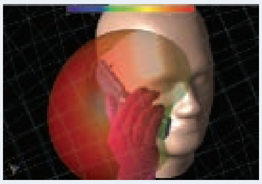
Reactel model 3TP-1176.45/1575.42-S11 is a cavity triplexer designed for all three GPS frequencies: L1 (New Civilian) L2 (Civilian) and L5 (Safety of Life). The passbands for this particular unit are L1: 1560.42 to 1590.42 MHz; L2: 1212.6 to 1242.6 MHz; and L5: 1164.45 to 1188.45 MHz. This unit has insertion loss of less than 1 dB mid-band, and a high degree of band to band isolation. It is outfitted with SMA connectors and is sized at 1.625" × 2.5" × 4.75" excluding connectors. Reactel manufactures a wide variety of GPS filters and multiplexers and dual filters; please contact the factory with your requirement.

Reactel Inc.,
Gaithersburg, MD (301) 519-3660,
www.reactel.com.
Booth 3507 **RS 275**

New Waves

3D EM Simulation Software

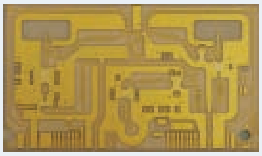
XFdtd 7 (XF7) is the market's most modern 3D electromagnetic (EM) simulation software for FDTD-based modeling and simulation. XF7 simplifies workflow with a streamlined user interface, cross-platform functionality, and several unique time-saving features.



XF7 includes XStream, Remcom's GPU acceleration technology, for free. Using the power and flexibility of NVIDIA's CUDA architecture, XStream improves EM simulation performance with ultra-fast FDTD numerical computations -- from 30 to 300 times faster than a modern 64-bit CPU.

Remcom Inc.,
State College, PA (814) 861-1299,
www.remcom.com.
Booth 3410 **RS 276**

Leadless SMT Ceramic Packages

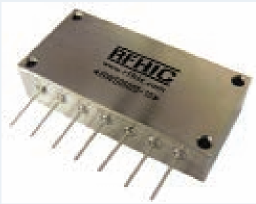


Remtec extended its line of cost-effective, low upfront tooling, ceramic leadless substrates and packages to mm-wave. Etchable, high definition conductors (± 50 μ), low RF loss thermal hermetic vias and copper heat spreaders eliminate the need for an external metal housing, providing shorter low-inductance interconnects. Miniature size packages (hermetic if needed) are fabricated using PCTF technology, with integrated resistors, transmission lines, and multilayers and improved electrical and thermal performance. Remtec offers microwave modeling, design, test and assembly of MW packages.

Remtec Inc.,
Norwood, MA (781) 762-9191,
www.remtec.com.
Booth 307 **RS 277**

GaN Power Amplifier

VENDORVIEW



RFHIC introduced a molded styled power amplifier (GaN on SiC) generating 20 W and covering 20 to 1000 MHz. RWS05020-10 is based on GaN on SiC transistor, promising a solid reliability at high temperature; it provides a 36 dB of gain and a typical 43 dBm at P3dB with 50 percent efficiency. Moreover, the physical size of RWS05020-10 is only 2.1" × 1" × 0.5", which is much smaller than a typical business card.

RFHIC Corp.,
Suwon, South Korea +82-31-250-5079,
www.rfhic.com.
Booth 1440 **RS 278**

GaN Wideband Power Amplifier

VENDORVIEW

RFMD's RF3826 is a wideband power amplifier designed for CW and pulsed applications such as wireless infrastructure, radar, two-way radios and general-purpose amplification. Using an advanced high power density RFMD fabricated Gallium Nitride (GaN) semiconductor process, these high performance amplifiers achieve high efficiency, flat gain and large instantaneous bandwidth in a single amplifier design. The RF3826 is an input matched GaN transistor packaged in an air cavity ceramic package.

RFMD,
Greensboro, NC (336) 664-1233,
www.rfmd.com.
Booth 810 **RS 279**

Test Cables

Test grade cables are desired in applications where multiple connector attachment and continuous flexing demands are a priority. RF Industries now offers 18 GHz precision test cables in standard or custom lengths, suitable for production or lab environments. Featuring high-grade, passivated, stainless steel SMA males with PTFE in-

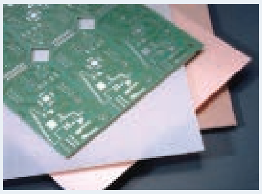
New Waves

sulators, this unique cable is configured for low loss and low VSWR. With triple shielding for optimum EMI protection, they are very phase-stable during mechanical and environmental stresses. Manufactured to MIL-DTL-17, type IX specification.
RF Precision Products,
a Division of RF Industries, San Diego, CA
(858) 549-6340,
www.rfp2.com.
Booth 2742 **RS 280**

Band Reject Filters

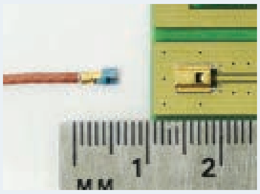
RLC Electronics now provides band stop and cavity filters that can be re-adjusted by the customer to new center frequencies. These filters are tunable over a ±7.5 percent center frequency range with minimal change in bandwidth.
RLC Electronics Inc.,
Mount Kisco, NY
(914) 241-1334,
www.rlcelectronics.com.
Booth 2628 **RS 281**

High Frequency Laminates



Rogers recently launched the groundbreaking RO4360 high frequency laminates, the latest addition to the RO4000® product family. RO4360 thermoset laminate materials are specially formulated to meet a Dk of 6.15 and exhibit a low dissipation factor of 0.0038 at 10 GHz. RO4360 laminates possess a Z-axis coefficient of thermal expansion of 30 ppm/°C (CTE) for dependable plated-through-hole (PTH) quality in multilayer circuit and package designs and are lead free process capable. Look for Rogers bonding layer with a matching 6.15 dielectric constant coming soon.
Rogers Corp.,
Chandler, AZ
(480) 961-1382,
www.rogerscorporation.com.
Booth 2920 **RS 282**

RF Cable Clamp



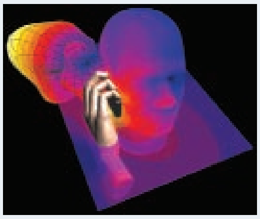
Rosenberger introduces a Micro RF Cable Clamp whose ultra small size and excellent performance from DC to 8 GHz makes it the designers' choice for high density applications. The mating cable connector is spring loaded; just push in place, wait for the click and the connector is locked in the correctly aligned position. The Micro RF Cable Clamp fits on pc board space of 5.0 × 3.6 mm and is < 2 mm in height, a perfect connector for premium space applications. The mating cable connector comes in a variety of configurations, including Cable Clamp to SMA, Cable Clamp to SMP and Cable Clamp to Cable Clamp.
Rosenberger of North America LLC,
Lancaster, PA
(717) 290-8000,
www.rosenbergerna.com.
Booth 621 **RS 283**

S292 Connectors

San-tron has announced the release of a new series of 2.92 mm connectors. S292™ connectors have been standardized to Thunderline-Z's TL-150 glass bead resulting in a transitional RF geometry that greatly reduces the tolerance sensitivity of the final product deployment. By matching the dielectric properties of Corning glass #7070 within the 50 ohm structure of a 0.012 diameter pin, the company achieves VSWR of < 1.04 through 12 GHz and < 1.18 through 40 GHz.
San-tron Inc.,
Ipswich, MA
(978) 356-1585,
www.santron.com.
Booth 1820 **RS 307**

NEW WAVES

FDTD Simulation Platform



Named after one of the most impressive mountains in Switzerland, the FDTD simulation platform SEMCAD-X offers extended usability (novel window management approach), functionality (handling, visualization) and features (network distributed optimization, multiport analysis, multi-threaded postprocessing). SEMCAD-X is defining new standards to solve real RF and MW engineering problems.

Schmid & Partner Engineering AG, Zurich, Switzerland +41 44 245 9700, www.semcad.com.
Booth 533 **RS 285**

Power Amplifiers

VENDORVIEW

Skyworks Solutions Inc. introduced two new high performance wireless local area network (WLAN) power amplifiers (PA) that complement the company's current solutions for

access points, routers and gateways. Targeting the growing multiple-in-multiple-out (MIMO) configurations on 802.11n customer premise equipment (CPE), the SKY65165 (for 2.4 GHz) and the SKY65168 (for 5 GHz) are small form factor, high efficiency, mid-power PAs that are optimized for multiple-transmit-channel applications.

Skyworks Solutions Inc., Woburn, MA (781) 376-3000, www.skyworksinc.com.
Booth 3110 **RS 287**

Microwave Coax Contacts

Southwest Microwave's SSBP microwave coax contacts are now offered in sizes 8, 12, 16 and 20. SSBP contacts fit in standard non-coax contact cavities in off-the-shelf circular MIL-DTL-38999 series I, II and IV, D-Sub under MIL-PRF-24308, and slightly customized Micro-D under MIL-DTL-83513. Different SSBP contact sizes and non-coax contacts can now all be placed in the same connector. This allows the engineer to take advantage of RF/microwave performance, packaging miniaturization/flexibility, systemic cost savings and improved reliability by just doing one connection.

Southwest Microwave Inc., Tempe, AZ (480) 783-0201, www.southwestmicrowave.com.
Booth 1136 **RS 288**

VNA Calibration Kits

The portfolio of SPINNER covers two product lines of calibration kits for the calibration of network analyzers with one or more ports. Standard calibration kits feature an extreme high precision and are available for connector sizes 1.85 mm to 7-16. Compact calibration kits combines all standards needed in one handy unit, characterized by excellent handling due to ergonomic arrangement of the components, as well as small size and low weight. Available versions: 3-in-1 / 4-in-1 – 3.5mm, N, 7-16.

SPINNER GmbH, Munich, Germany +49 89 12601-0, www.spinner-group.com.
Booth 512 **RS 289**

RF Heating Sensors

This line of microwave heater sensor chips utilize platinum on alumina and oxidized silicon. These new heater/sensors can be utilized in a host of applications in areas from microelectronics to biomedical engineering. Potential applications include determination of thermal resistance of IC chips, variable optical attenuation of arrayed waveguide gratings, and thermal management in miniature chambers (mini-cell arrays). Avail-

able with two design options, the TM365 with two thermal sensors in close proximity to the heater for extremely stringent temperature control, and the TM364 single sensor design with moderate temperature control. Both designs with operating temperatures up to 250°C. The self-heating of the sensors is below 4 mW/°C.

State of the Art Inc.,
State College, PA
(800) 458-3401,
www.resistor.com.
Booth 900 ***RS 309***

Solid-state Power Amplifier

The SM002052-50LD is a 100 W, 20 to 520 MHz solid-state power amplifier (SSPA) designed for various wideband and UHF radio applications. The unit operates from 20 to 520 MHz with a P1dB of +50 dBm. Small-signal gain is 50 dB with a flatness of ±1.0 dB across the band. Standard features include VSWR, thermal, and RF input protection and voltage variable attenuator gain control. This unit is designed to meet most MIL-STD-810G test methods. In module form, the unit measures 6.0" × 2.5" × 1.5".

Stealth Microwave,
Ewing, NJ
(609) 538-8586,
www.stealthmicrowave.com.
Booth 1340 ***RS 290***

Voltage-controlled Oscillators

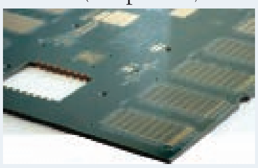
VENDORVIEW

The DXO400800-3 and the DXO400800-5 are tiny 0.3" × 0.3" × 0.08" packaged octave tuning voltage-controlled oscillators. These VCOs are designed for +3 and +5 V supplies and cover the frequency band of 4 to 8 GHz, with ultra-low power consumption of less than 100 mW and fast tuning for agile synthesizer applications. These VCOs are based on Synergy's proprietary patented technology and patents pending, which enhances bandwidth, reduces phase noise and improves immunity to vibration. These value packed VCOs are ideal replacements for YIG oscillators, improving on agility, and huge reduction in size and power consumption. Similarly, other tiny DCO and DXO series models will be presented with frequency generation capabilities of up to 13 GHz.

Synergy Microwave Corp.,
Paterson, NJ
(973) 881-8800,
www.synergymwave.com.
Booth 1400, 1500 ***RS 291***

Low Loss Core

The TSM-DS is a dimensionally stable low loss laminate that offers low Df of 0.0010 at 10 GHz while providing better dimensional stability than epoxy. TSM-DS is a ceramic-filled reinforced material with low fiberglass content (~5 percent) that assures consistency and predictability in



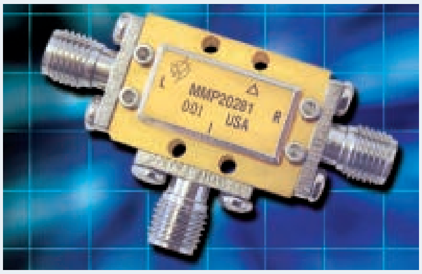
fabricating large format, high layer count PWBs. For microwave applications, the low x, y and z CTE values assure that critical spacing between traces in filters and couplers have low movement with temperature. TSM-DS can be used with low profile copper foils yielding a clear copper edge between coupled lines. TSM-DS has a temperature stable Dk ± 0.35 percent (-30° to 120°C) and is compatible with resistor foils.

Taconic Advanced Dielectric Division,
Petersburgh, NY
(518) 658-3202,
www.taconic-add.com.
Booth 2419 ***RS 292***

NEW WAVES

2 to 20 GHz Triple-balanced Mixer

Teledyne Cougar's triple balanced mixer model MMP20281 covers 2 to 20 GHz, with an IF frequency range of 5 MHz to 6 GHz. Nominal LO drive is +13.0 dBm producing +18 dBm third-order intercept. Typical SSB conversion loss is 7.0 dB. LO to RF isolation is 25 dB typical and LO to IF isolation is 20 dB typical. The MMP20281 operates from -55° to +85°C and is available in the Cougar MixerPak. Cougar offers a complete line of RF and microwave components, including amplifiers, gain control



and limiting amplifiers, VCOs, frequency mixers, doublers and IQ modulators, detectors, and integrated assemblies.

Teledyne Cougar,
Sunnyvale, CA (408) 522-3838,
www.cougarcorp.com.
Booth 1324 ***RS 310***

Highly Flexible Assemblies

Applications requiring low resistance to flexure, low weight, continual movement or having tight space constraints will benefit from design-in of Teledyne Storm's new FlexFit™ cable assemblies. With its stranded center conductor, FlexFit cables offer ultra flexibility (> 500,000 flexures) while maintaining electrical and physical stability. This offers the advantages of no movement-related performance degradation, low resistance to movement and increased performance life. In addition, the cable's small size (0.052"/1.32 mm OD) satisfies weight and space constraints that can impact ease of installation.

Teledyne Storm Products,
Woodridge, IL (630) 754-3300,
www.teledynestorm.com.
Booth 2813 ***RS 294***

USB Controlled RF Switch

Telemakus LLC introduces the TES6000-30, laboratory-quality, RF SPDT switch with 30 dB isolation and < 2 dB insertion loss. The switch is fully terminated at all ports with a return loss better than 20 dB at 4 GHz. The RF connectors are SMA, with the common port male and ports 1 and 2 female allowing for easy interconnection. The DC/control connector is USB type A allowing direct connection to a PC or via a USB extender cable. The device also has 0.5 GB of flash memory containing all the installation files, data sheet and test results. The windows-based user interface allows simple control of the switch configuration including both ports isolated. The unit can also be used with common ATE software. Multiple switches can be used allowing complex switch matrices to be built.

RFMW Ltd.,
San Jose, CA
(877) 367-7369,
www.rfmw.com/telemakus.
Booth 1331 ***RS 295***

Tube-based Broadband MPM

With the new MPM operating over 18 to 40 GHz frequency band, Thales is now able to propose the full band, 6 to 40 GHz, for ECM ap-

NEW WAVES

plication. Thales offers complete power transmitter subsystems to meet the needs of today's armed forces and defense system manufacturers. The company's equipment is primarily used in radars, electronic countermeasures and data links. The products cover a wide range of frequencies from C-band to EHF band and meets military environment standards.

Thales Electron Devices,
Velizy-Villacoublay, France
+33 (0) 1 30 70 36 40,
www.thalesgroup.com.
Booth 1636 **RS 296**

RF Lightning Protection

Times Microwave has introduced Times-Protect™ line of innovative RF lightning protection products. These unique surge protection devices address applications throughout the entire useful RF frequency range from DC with capability up to and including 6 GHz. Among the most noteworthy features available in the new Times-Protect™ line of RF lightning protection products: new DC blocking technology; unmatched passive intermodulation (PIM) performance; exceptional longevity; excellent multi-strike performance; outstanding S-parameters over the operating frequency band; superior surge performance; weatherization to IP67 standard; available bi-directional designs; and available DC Pass capability.

Times Microwave Systems,
Wallingford, CT
(203) 949-8400,
www.timesmicrowave.com.
Booth 2717 **RS 297**

YIG-based Frequency Synthesizer

The V10WTS YIG-based frequency synthesizer, with the V10 oscillator, meet the demanding requirements of portable test equipment, high data-rate digital radios, satellite communications systems, fast switching radar and sensor systems. Supplied in VIDA's proven Hammerhead package, these synthesizers are tunable over 8 to 21 GHz with total power consumption of under 5 W from the 5 V supply and phase noise performance of -150 dBc/Hz at 1 MHz offset. Software defined features enable 10 microsecond tuning and a choice of USB, I2C, parallel and serial interfaces. Available with operation on internal or external frequency references sources and multiple signal outputs.

VIDA Products,
Santa Rosa, CA
(707) 541-7000,
www.vidaproducts.com.
Booth 2319 **RS 298**

Single-octave Band Power Divider

XMA Corp. announced its first power divider created with Omni Spectra® technology. The OS2091-6201-00 is a 1 to 2 GHz, 5 W, single-octave band power divider. This circuit features a ceramic substrate using Microstrip Thin Film design and includes 5 W of input power, low insertion loss and VSWR as well as high isolation between output ports. The –CYRO version is capable of use down to cryogenic temperatures approaching 0 Kelvin. XMA provides both standard and custom built power dividers for military and aerospace applications.

XMA Corp.,
Manchester, NH
(603) 222-2256,
www.xmacorp.com.
Booth 2642 **RS 299**

Fixed Frequency Synthesizer

The SFS13500Z-LF is a single frequency signal source that is pre-programmed to operate at 13.5 GHz. This fixed frequency PLL has a typical phase noise of -80 dBc/Hz at 10 kHz offset with a reference spur suppression of -65 dBc. It is designed to operate over the temperature range of -40° to +85°C while delivering 0 dBm of output power into a 50 ohm load and is available in a package measuring 1" × 1" × 0.22".

Z-Communications Inc.,
San Diego, CA
(858) 621-2700,
www.zcomm.com.
Booth 2812 **RS 305**

MICRO-ADS

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PHASED ARRAY ANTENNAS, SECOND EDITION

R. C. HANSEN

This new edition contains new chapters on connected arrays, reflectarrays and retrodirective arrays, and array fed reflector antennas, both focal plane with coma correction and near-field Cassegrain and Gregorian. An explanation, with equations, on commonly misunderstood measurement of Scan Element Pattern, along with correct procedure is given. Artificial Magnetic Conductors and limitations are discussed. Also Bode and Fano matching limitations are covered. Detailed coverage of aperture distributions, pattern synthesis, feeding systems, spatial and spectral Scan Impedance calculations, multiple beam and conformal arrays, time delay, and finite array models carries over from the first edition.

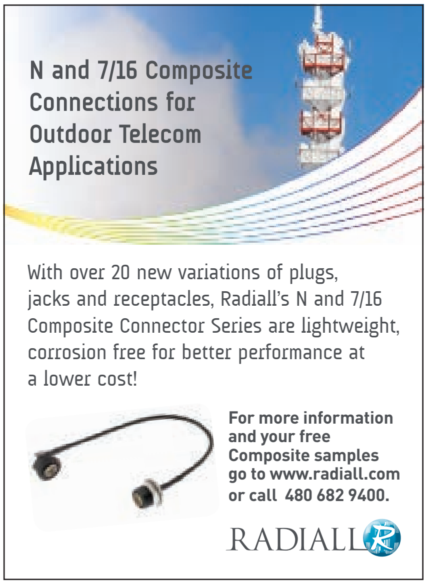
John Wiley & Sons 877-762-2974 2009
ISBN 978-0-470-40102-6

RS 164

RS 95

RS 184

RS 171



RS 165

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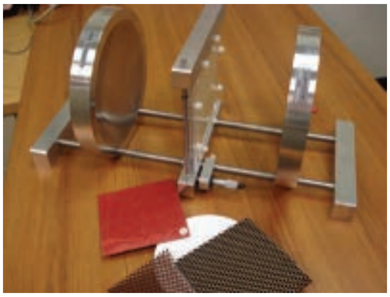

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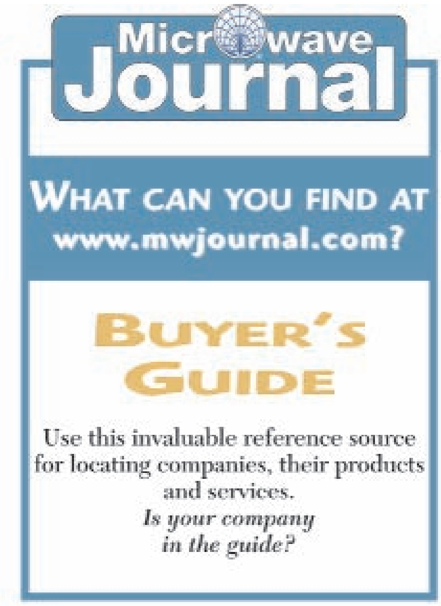
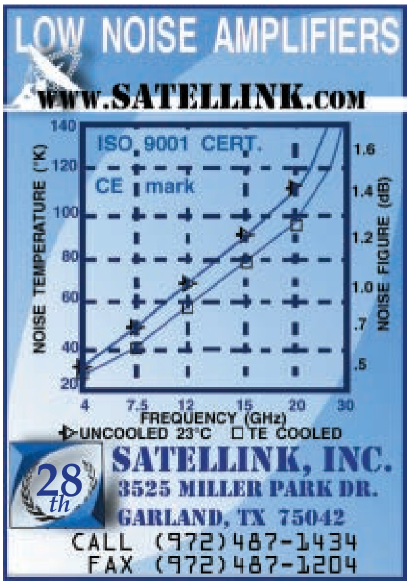
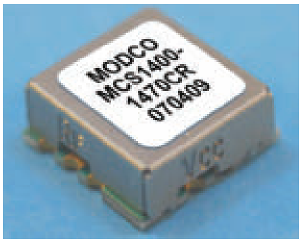




RS 183

Miniature 0.3 inch square CRO



Modco announces its MCS Series CRO's. Low Vcc of 3.3V and current consumption of 13ma and makes it ideal for battery powered applications. Model Number MCS1400-1470CR tunes 1400-1470MHz with a Vt of 0.3-2.7V It provides 0dBm output power. Phase Noise is -110dBc @ 10kHz Pushing is 0.2MHz per volt and Pulling is 0.9MHz. Many models are available.

www.modcoinc.com

RS 144

Microwave Radio Transmission Design Guide, Second Edition

Trevor Manning

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

The author notes that the backhaul bottleneck is a major strategic issue for operators. Yet, despite 70 to 80 percent of the backhaul in the access network being carried over microwave, little attention is given to the solutions available with this technology. It is his view that this is a result of a mix of viewpoints: Some think the technology is mature and therefore the design is trivial; others view it as digital microwave systems and forget that the RF carrier is analog so it is affected by varying atmospheric conditions. He believes that we need to go back to the basics to master our understanding and use the latest technologies to design more capable systems to address the capacity issues.

This book is written in an easy-to-understand style and the author provides practical guidelines based on hands-on experience. It covers link planning, reliability standards, transport technologies, radio equipment, microwave propagation, antenna considerations, frequency planning and link design as the main chapter subjects. It also addresses designing and planning SDH/SONET broadband networks, wireless local loop networks and backhaul for mobile radio networks plus frequency planning for radio networks, digital radio equipment characteristics, and fading in radio systems.

Microwave Radio Transmission Design utilizes materials from many different industry companies and organizations to update the second edition, which makes it a practical guide. Using practical case studies, the book provides proven advice that helps save time and money when developing new networks, and reduces the risk of encountering problems during design and planning.

To order this book, contact:

Artech House
685 Canton St., Norwood, MA 02062
(781) 769-9750 ext. 4030;
or
16 Sussex St., London SW1V 4RW, UK
+44 (0) 20 7596-8750

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2010 Asia-Pacific Microwave Conference

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http://www.apmc2010.org

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Final Call for Papers

The 2010 Asia-Pacific Microwave Conference (APMC 2010) will be held at the Pacifico Yokohama, Yokohama, Japan, on December 7-10, 2010. This conference is organized and sponsored by the Institute of Electronics, Information and Communication Engineers (IEICE), and is cooperatively sponsored by IEEE MTT-S, EuMA, IEEE AP-S, URSI, IEEE MTT-S Japan Chapter and IEEE MTT-S Kansai Chapter.
Regular papers accepted by APMC 2010 will appear in IEEE Xplore and extended version can be published in a Special issue of IEICE Transactions on Electronics.

CONFERENCE TOPICS

A Active Devices and Circuits

Low-Noise Devices and Circuits, High-Power Devices and Circuits, Microwave Tubes, Control Circuits (MIX, OSC., SW, etc.), MMICs, RFICs and HMICs (Receivers, Transmitters, etc.), Active and Adaptive Antennas, Others

B Passive Components

Filters and Resonators, Ferrite and Acoustic Wave Components, Packaging, Waveguides and Striplines, Optical Components, Metamaterial, RF MEMS, LTCC Devices, Directional Couplers and Hybrids, Others

C Systems

Wireless and Cellular Communication Systems, Signal Processing Circuits and Systems, Microwave Medical and Biological Applications, EMC, Radars and Sensors, Satellite Systems, Digital Broadcasting, MIMO Systems, Optical Fiber Systems, Others

D Basic Theory and Techniques

Scattering and Propagation, Electromagnetic Field Theory and CAD, Antenna Theory, Microwave Antennas, Microwave Photonics, Microwave Superconductivity, Measurement Techniques, Others

Time Table

Paper Submission Deadline: May 31, 2010
Notification of Acceptance: August 10, 2010
Final PDF file with Camera-Ready Manuscript Deadline: September 15, 2010

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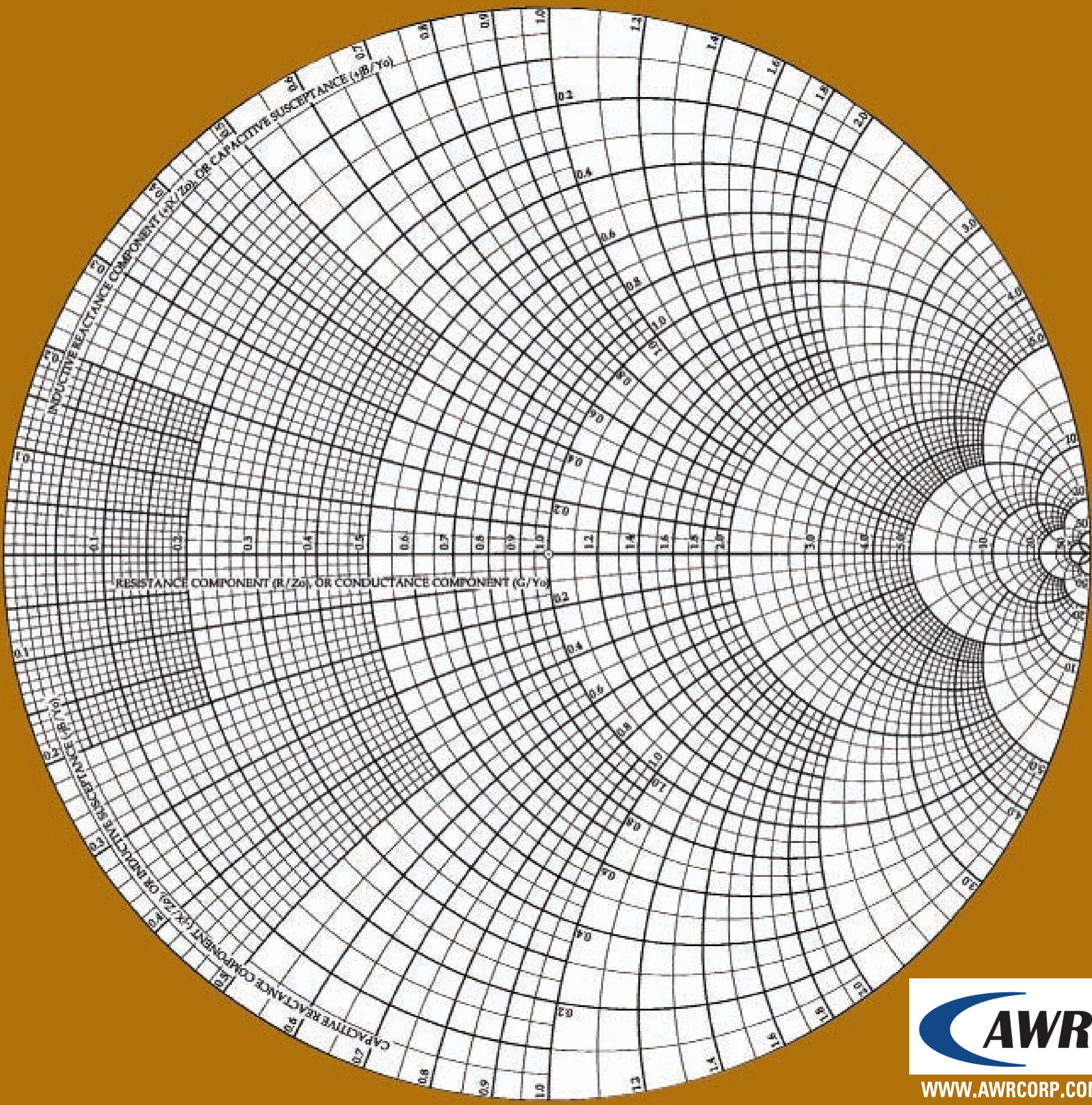
THIS MONTH'S PUZZLER IS A QUICKIE, PLOT THESE IMPEDANCES AND YOU'LL SEE _ _ _ _ _ _.

ANSWER AVAILABLE ONLINE AT WWW.MWJOURNAL.COM



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3. 0.55 + j 0.60
4. 0.40 + j 0.58
5. 0.30 + j 0.50
6. 0.24 + j 0.40
7. 0.22 + j 0.32
8. 0.22 + j 0.26

9. 0.23 + j 0.18
10. 0.25 + j 0.13
11. 0.29 + j 0.07
12. 0.33 + j 0.05
13. 0.50 + j 0.02
14. 0.48 - j 0.10
15. 0.46 - j 0.23
16. 0.47 - j 0.42

17. 0.50 - j 0.60
18. 0.60 - j 0.80
19. 0.72 - j 1.00
20. 0.90 - j 1.15
21. 1.20 - j 1.30
22. 1.50 - j 1.35
23. 1.90 - j 1.35
24. 2.40 - j 1.00

25. 2.60 - j 0.60
26. 2.50 - j 0.05
27. 3.00 + j 0.00
28. 3.80 + j 0.50
29. 4.00 + j 1.90
30. 2.60 + j 2.90
31. 1.60 + j 2.65
32. 0.90 + j 2.25

33. 0.90 + j 1.80
34. 0.85 + j 1.40
35. 0.95 + j 1.10
36. 1.00 + j 0.90
37. 1.25 + j 0.75
38. 1.10 + j 0.65
39. 0.90 + j 0.57
40. 0.80 + j 0.48


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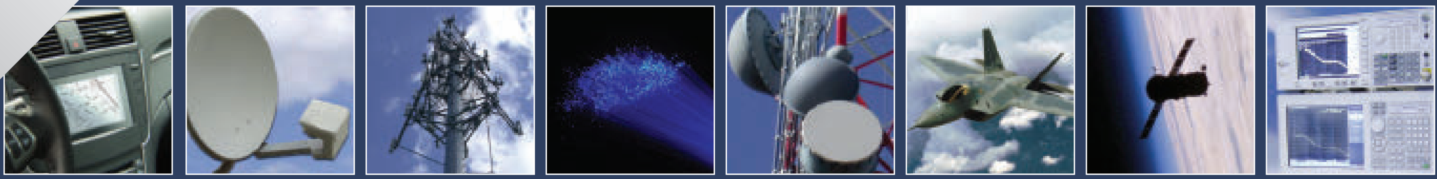
SERVICE • INNOVATION • QUALITY
Celebrating 25 Years

Product Selection Guide

Analog & Mixed-Signal ICs, Modules, Subsystems & Instrumentation, DC - 110 GHz



Automotive
Telematics & Sensors

Broadband
Cable Modem, CATV, DBS & VoIP
WiMAX, WiBro, WLAN & UWB

Cellular Infrastructure
GSM, GPRS, CDMA, TD-SCDMA,
WCDMA, UMTS & 4G /LTE

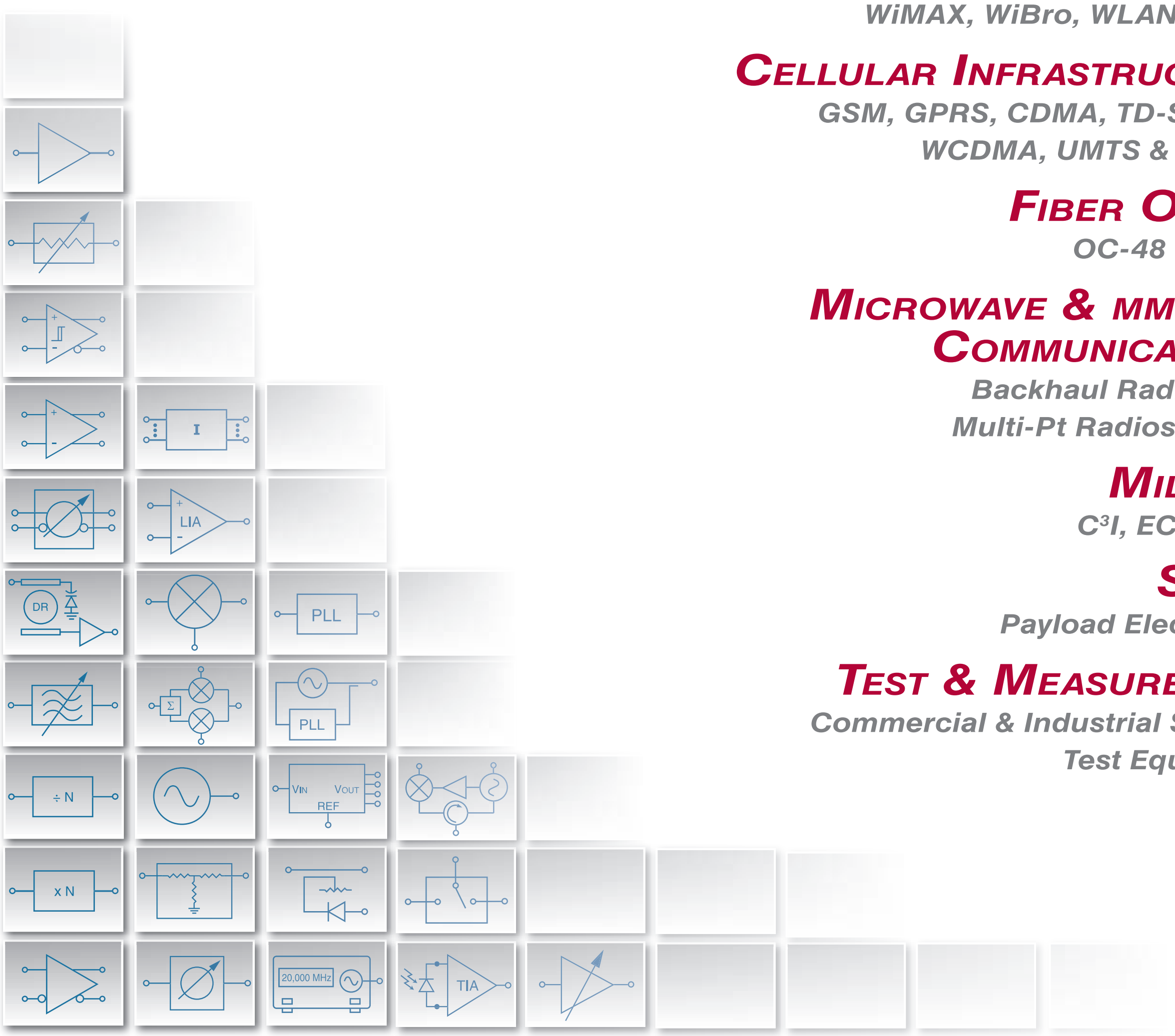
Fiber Optics
OC-48 to 100G

Microwave & mmWave Communications
Backhaul Radio Links
Multi-Pt Radios & VSAT

Military
C^3I, ECM & EW

Space
Payload Electronics

Test & Measurement
Commercial & Industrial Sensors
Test Equipment



Hittite
MICROWAVE CORPORATION

April 2010

INTRODUCING THE APRIL 2010 SELECTION GUIDE!

Hittite Microwave Corporation is pleased to introduce our April 2010 Product Selection Guide summarizing over 825 products including 35 new products and 2 new product lines; Broadband Time Delays and Tunable Filters. This selection guide organizes Hittite's portfolio by product line as well as by market applications. Full specifications for each product are available at www.hittite.com. Click on "*My Subscription*" to receive the latest product releases.

SERVICE • INNOVATION • QUALITY
Celebrating 25 Years

HOW TO BUY:

Hittite Microwave Corporation offers many convenient ways to order products and/or receive pricing and delivery information. Our order entry/MRP system assures customer sample requests and orders will be entered quickly, tracked easily, and completed accurately on-time.

Direct Sales

- **HMC Field Sales Offices:**
  You may contact our corporate or field sales offices listed on the back cover for assistance in purchasing Hittite products.

- **Purchase On-line: www.hittite.com**
  With Hittite Microwave's E-Commerce capability customers can enjoy the convenience of on-line ordering via a secure shopping cart interface. Products can be purchased using either a MasterCard, Visa, American Express or JCB card. Orders are confirmed within one business day with delivery information. Orders ship within 2 business days of confirmation, based on availability.

- **Purchase Orders via HMC Corporate Sales:**
  You may contact Hittite Microwave directly at (978) 250-3343. Purchase orders can be faxed to (978) 250-3373 or sent via email to sales@hittite.com. There is a minimum purchase order value of $500.00 (U.S. Dollars).

Worldwide Network of Sales Representatives

You may purchase our products through our network of manufacturer representatives.

- ***European customers may also purchase products in Euros (€) directly from Hittite Microwave Deutschland GmbH.***

NEW!
- ***Japanese customers may also purchase products in Yen (¥) directly from Hittite KK - Japan.***

OUR QUALITY POLICY:

Hittite Microwave Corporation is Committed to:

- *Being a supplier of products of the highest quality.*
- *Advancing state-of-the-art technology to support our products.*
- *Enhancing our competitive position with superior products.*

Hittite's Quality Policy Recognizes Responsibilities for Every Individual to:

- *Take the initiative to promote quality.*
- *Create an environment where the highest quality standards are maintained.*
- *Participate in continuous improvement practices.*

QUALITY & PRODUCT SUPPORT:

The Quality & Product Support Section of Our Web Site Includes:

- *Quality Assurance - Product manufacturing, qualification & screening flows.*
- *Product Reliability*
- *Qualification Test Reports*

Product Application Support

- *Application Engineering Support*
- *Application Notes*
- *Mixer Spur Chart Calculator & PLL Phase Noise Calculator*
- *Package & Layout Drawings - Product outline, PCB land pattern and tape & reel drawings.*
- *Product Cross Reference - Thousands of ICs cross-referenced to HMC products.*
- *Published Papers*
- *S-Parameter Files*

Data Sheets

- *Complete product data sheets can be found on our web site.*

WHAT WE DO

Hittite Microwave is an innovative designer and manufacturer of analog and mixed-signal ICs, modules, subsystems and instrumentation for digital, RF, microwave and millimeterwave applications covering DC to 110 GHz. Our RFIC/MMIC products are developed using state-of-the-art GaAs, GaN, InGaP/GaAs, InP, SOI, SiGe, CMOS and BiCMOS semiconductor processes utilizing MESFET, HEMT, pHEMT, mHEMT, HBT and PIN devices. We offer over 825 products across 26 product lines

Amplifiers	*Mod / Demodulators*
Attenuators	*Passives*
Broadband Time Delays	*Phase Shifters*
Comparators	*PLLs*
Data Converters	*PLLs w/ Integrated VCOs*
DROs	*Power Conditioning*
Filters - Tunable	*Power Detectors*
Freq. Dividers & Detectors	*Sensors*
Freq. Multipliers	*Signal Generators*
High Speed Digital Logic	*Switches*
Limiting Amplifiers	*Transimpedance Amplifiers*
Interface	*VGAs*
Mixers	*VCOs & PLOs*

We design and supply custom ICs, modules, subsystems and instrumentation, combining multiple functions for specific requirements. We select the most appropriate semiconductor and package technologies, uniquely balancing digital and analog integration techniques.

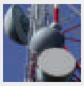
Our custom and standard products support a wide range of wireless / wired communications & radar applications for the following markets:

Automotive
Telematics & Sensors

Broadband
CATV, DBS, WiBro,WiMAX, WLAN, Fixed Wireless & UWB

Cellular Infrastructure
GSM, GPRS, CDMA, WCDMA, UMTS, TD-SCDMA & 4G/LTE

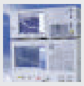
Fiber Optic
OC-48 to 100G



Microwave & mmWave Communications
Backhaul Radio Links
Multi-Pt Radios & VSAT

Military
C^3I, ECM & EW

Space
Payload Electronics



Test & Measurement
Commercial / Industrial
Sensors & Test Equipment

HMC is ISO 9001:2000 and AS9100 B certified. Every component is backed by every Hittite employee and subcontractor's commitment to total quality, thus providing our customers with products that meet or exceed all requirements, are delivered on-time and function reliably throughout their useful life.

AMPLIFIERS - Differential Gain Block & Connectorized Low Phase Noise Amp & PA Modules

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
5 - 10	Low Noise	20	28	1.7	16	+3.5V @ 80mA	Chip	EAR99	HMC902
5 - 10	Low Noise	19	28	1.8	16	+3.5V @ 80mA	LP3	EAR99	HMC902LP3E
5.6 - 17	Low Noise	19	26	1.6	15	+3.5V @ 80mA	Chip	EAR99	HMC903
5.6 - 17	Low Noise	18	25	1.7	14	+3.5V @ 80mA	LP3	EAR99	HMC903LP3E
DC - 1.0	50 / 75 Ohm Differential Gain Block	16	40	3.5	24	+8V @ 350mA	LP4B	EAR99	HMC771LP4BE
DC - 10	pHEMT Gain Block	15	26	5	18	+5V @ 65mA	LP2	EAR99	HMC788LP2E
DC - 22	Power Amplifier, 1 Watt	14	40	2.5	28	+11V @ 400mA	Chip	3A001.b.2.c	HMC797
0.2 - 25	Power Amplifier, 1/2 Watt	13	38	3	27	+11V @ 365mA	Chip	3A001.b.2.c	HMC907

AMPLIFIERS - Low Phase Noise Modules

Frequency (GHz)	Function	Gain / NF (dB)	OIP3 (dBm)	Phase Noise (dBc/Hz)	P1dB / Psat (dBm)	Bias Supply	Package / Connector	ECCN Code	Part Number
4 - 8	Low Phase Noise	9 / 6	33	-180	22 / 25	+7V @ 300mA	C-16 / SMA	EAR99	HMC-C079

ATTENUATORS - Digital

Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
DC - 10	1-Bit Digital	2	10	54	0 / +3 to +5V	LP3	EAR99	HMC800LP3E
DC - 10	1-Bit Digital	1.5	15	53	0 / +3 to +5V	LP3	EAR99	HMC801LP3E
DC - 10	1-Bit Digital	2.5	20	53	0 / +3 to +5V	LP3	EAR99	HMC802LP3E

BROADBAND TIME DELAYS - New Product Line!

Data / Clock Rate (Gbps/GHz)	Function	Rise / Fall (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vp-p)	DC Power Consumption (mW)	Vee Power Supply (Vdc)	Package	ECCN Code	Part Number
28	Time Delay	14 / 16	11	0.1 - 0.8	1450	+3.3	LC4B	3A001.a.11.b	HMC910LC4B

COMPARATORS - Window

Analog Input B/W (GHz) / Clock Rate (Gbps)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power Consumption (mW)	Vcco / V_{term} * Power Supply (Vdc)	Package	ECCN Code	Part Number
10	Window Comparator	2	88	0.4	240	+2 / 0	LC3C	3A001.a.11.b	HMC974LC3C

** Note that Vee = -3.0V & Vcci = +3.3V*

FILTERS - Tunable (Band Pass & Low Pass) - New Product Line!

Band Pass

Freq. Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth (%)	Low Side Rejection Frequency (Rej. >20 dB)	High Side Rejection Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
1 - 2	Band Pass	10	11	0.8 x Fcenter	1.2 x Fcenter	200	LP5	EAR99	HMC890LP5E
2 - 3.9	Band Pass	10	9	0.9 x Fcenter	1.15 x Fcenter	200	LP5	EAR99	HMC891LP5E

Low Pass

Freq. Range (GHz)	Function	Return Loss (dB)	Cutoff Frequency Range (GHz)	Stopband Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
DC - 4.0	Low Pass	10	2.2 - 4.0	1.25 x Fcutoff	150	LP5	EAR99	HMC881LP5E
DC - 7.6	Low Pass	10	4.5 - 7.6	1.23 x Fcutoff	150	LP5	EAR99	HMC882LP5E

FREQUENCY DIVIDERS

Input Frequency (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
0.4 - 6	Programmable Divider (N = 1 to 6)	0 to +9	+5	-156	+3.3V @ 100mA	LP3	3A001.a.11.b	HMC905LP3E

HIGH SPEED DIGITAL LOGIC

Data / Clock Rate (Gbps/GHz)	Function	Rise / Fall (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vp-p)	DC Power Consumption (mW)	Vee Power Supply (Vdc)	Package	ECCN Code	Part Number
13 / 13	Fast Rise Time 1:2 Fanout Buffer*	19 / 18	2	0.6 - 1.1	300	-3.3	LP3	3A001.a.11.b	HMC720LP3E
50	1:2 Fanout Buffer*	11 / 11	3	0.4 - 1.2	465	-3.3	LC4B	3A001.a.11.b	HMC842LC4B
13 / 13	Fast Rise Time AND / NAND / OR / NOR*	19 / 18	2	0.6 - 1.1	230	-3.3	LP3	3A001.a.11.b	HMC722LP3E
45	AND / NAND / OR / NOR*	10 / 10	2	0.2 - 0.85	500	-3.3	LC4B	3A001.a.11.b	HMC843LC4B
13 / 13	Fast Rise Time D-Type Flip-Flop*	19 / 17	2	0.7 - 1.3	260	-3.3	LP3	3A001.a.11.b	HMC723LP3E
43	D-Type Flip-Flop*	12 / 12	2	0.2 - 0.85	630	-3.3	LC4B	3A001.a.11.b	HMC841LC4B
13 / 13	Fast Rise Time XOR / XNOR*	19 / 18	2	0.6 - 1.1	230	-3.3	LP3	3A001.a.11.b	HMC721LP3E

** With Programmable Output Voltage*

APRIL 2010 - 35 NEW PRODUCTS

Hittite MICROWAVE CORPORATION

I/Q DOWNCONVERTER / RECEIVERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Noise Figure (dB)	Image Rejection (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
9 - 12	I/Q Downconverter / Receiver	DC - 3.5	11	2.2	25	2	LC5	EAR99	HMC908LC5
17 - 21	I/Q Downconverter / Receiver	DC - 3.3	11	2.2	21	2	LC5	EAR99	HMC904LC5

MIXERS - *Double Balanced & Sub-Harmonic Mixers*

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
3 - 10	+17 LO, DBL-BAL Mixer	DC - 4	-9	55	23	LC3B	EAR99	HMC787LC3B
17.7 - 23.6	Sub-Harmonic, Upconverter	DC - 3.5	15	40	13	LC5	EAR99	HMC711LC5

MODULATORS - *Direct Quadrature Modulator with VGA*

Input Freq. (GHz)	Function	OIP3 (dBm) / Carrier Suppression (dBc)	Modulation Bandwidth (MHz)	Output Noise Floor (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
0.05 - 2.7	Direct Quadrature with VGA	25 / 50	DC - 440	-159	+5V @ 120mA	LP5	3A001.a.11.b	HMC795LP5E

POWER DETECTORS - *SDLVA*

Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package	ECCN Code	Part Number
0.6 - 20	SDLVA*	59	14	-54	+3.3V @ 80mA	Chip	EAR99	HMC913
2 - 20	SDLVA* w/ Limited RF Output	50	45	-45	+12V @ 370mA -5V @ 20mA	C-21 / SMA	EAR99	HMC-C078

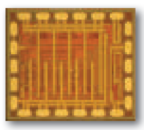
** Successive Detection Log Video Amplifier*

SIGNAL GENERATORS - *Precise RF Signal Generation for ATE & Lab Environments*

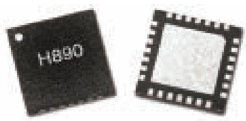
Frequency (GHz)	Function	Frequency Resolution (MHz)	Maximum Power Output (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Spurious @ 1 GHz (dBc)	Switching Speed @ 100 MHz Steps (µs)	Package	ECCN Code	Part Number
0.01 - 20	Portable Signal Generator	0.01	+27 @ 2 GHz +25 @ 10 GHz	-113 @ 1 GHz -93 @ 10 GHz	-80	300	Portable / Benchtop	EAR99	HMC-T2100B

SWITCHES - *SP4T*

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
DC - 20	SP4T	2.1	42	23	0 / -5V	LC4	EAR99	HMC641LC4



HMC913



HMC890LP5E

HMC-C078

HMC-T2100B

NEW PRODUCTS

New Comparator Line Delivers 20 Gbps with 50% Less Power Consumption!

Hittite Microwave offers high speed analog, digital and mixed-signal die & SMT components for medical imaging / diagnostics, test and industrial applications. Hittite specializes in Comparator solutions that offer a unique combination of low propagation delay for low input overdrive while minimizing propagation dispersion and power dissipation.

Features

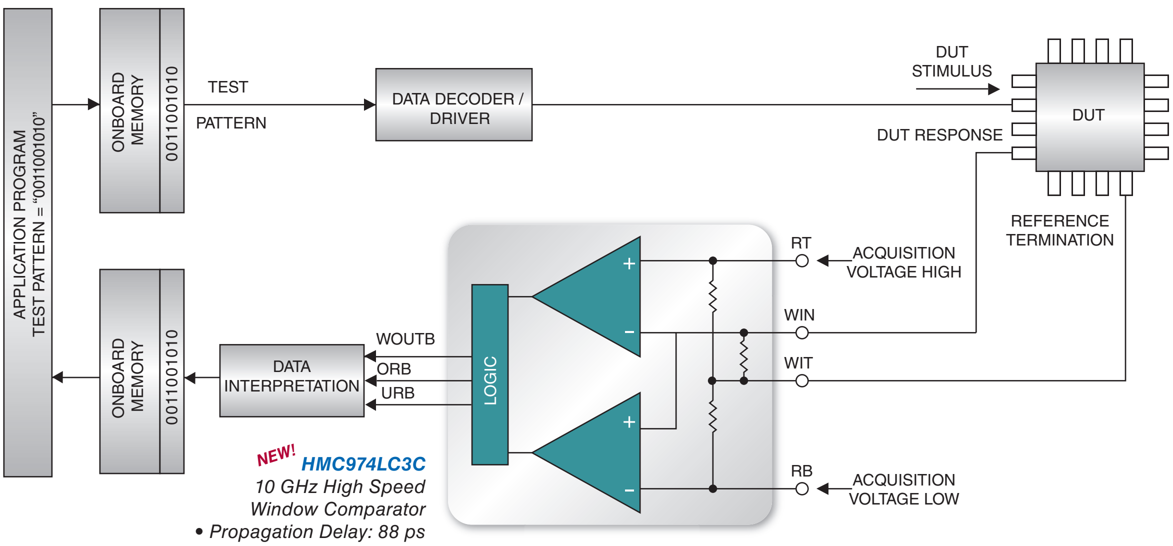
- *RSPECL, RSCML & RSECL Versions Available*
- *10 GHz Input Bandwidth*
- *Low Propagation Delay Clock to Output: 120 ps*
- *Low Overdrive & Slew Rate Dispersion: 10 ps*
- *Minimum Pulse Width: 60 ps*
- *Low Power Dissipation: 130 mW*

4 NEW IN-STOCK HIGH SPEED COMPARATORS

	Analog Input B/W (GHz) / Clock Rate (Gpbs)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power Consumption (mW)	Vcco / Vterm [2] Power Supply (Vdc)	Package	Part Number
NEW!	10 / 20	Clocked Comparator - RSPECL	<3	120	0.4	150	+3.3 / +1.3	LC3C	**HMC874LC3C**
NEW!	10 / 20	Clocked Comparator - RSCML	<3	120	0.4	130	0 / 0	LC3C	**HMC875LC3C**
NEW!	10 / 20	Clocked Comparator - RSECL	<3	120	0.4	150	0 / -2.0	LC3C	**HMC876LC3C**
	10 / [1]	Latched Comparator - RSPECL	2	85	0.4	140	+3.3 / +1.3	LC3C	**HMC674LC3C**
	10 / [1]	Latched Comparator - RSCML	2	100	0.4	100	0 / 0	LC3C	**HMC675LC3C**
	10 / [1]	Latched Comparator - RSECL	2	100	0.35	120	0 / -2.0	LC3C	**HMC676LC3C**
NEW!	10 / -	Window Comparator	2	88	0.4	240	+2 / 0	LC3C	**HMC974LC3C**

[1] Note that HMC674/675/676LC3C is a family of Level Latched Comparators
[2] Vee = -3.0V & Vcci = +3.3V

Automatic Test Equipment (ATE)

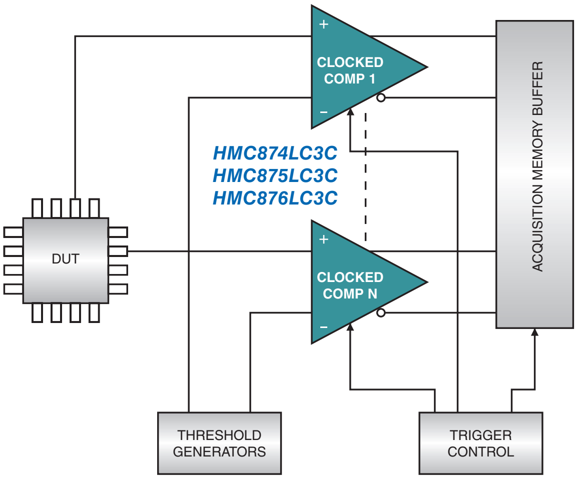


NEW! *HMC974LC3C*
10 GHz High Speed Window Comparator
- *Propagation Delay: 88 ps*
- *Overdrive & Slewrate Dispersion: 20 ps*
- *Power Dissipation: 240 mW*

Hittite's 20 Gbps / 150 mW Clocked Comparators Reduce Total ATE System Power!

High Speed Clocked Comparators

LOGIC ANALYZERS AND OSCILLOSCOPES



HMC874LC3C *NEW!*
20 Gbps Clocked Comparator - RSPECL
- *0.2 ps RMS Random Jitter*
- *Overdrive & Slew Rate Dispersion: 10 ps*

HMC875LC3C *NEW!*
20 Gbps Clocked Comparator - RSCML
- *0.2 ps RMS Random Jitter*
- *Overdrive & Slew Rate Dispersion: 10 ps*

HMC876LC3C *NEW!*
20 Gbps Clocked Comparator - RSECL
- *0.2 ps RMS Random Jitter*
- *Overdrive & Slew Rate Dispersion: 10 ps*

Hittite Comparators Deliver Superior Channel-to-Channel Jitter Matching!

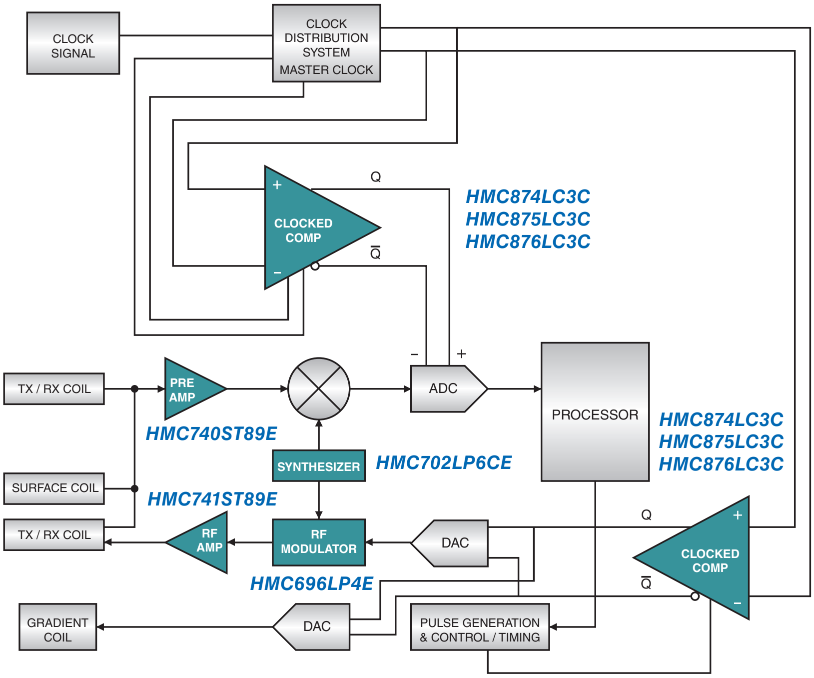
MAGNETIC RESONANCE IMAGING (MRI)

HMC740ST89E
InGaP HBT Gain Block
- *0.05 - 3 GHz*
- *15 dB Gain*

HMC741ST89E
InGaP HBT Gain Block
- *0.05 - 3 GHz*
- *20 dB Gain*

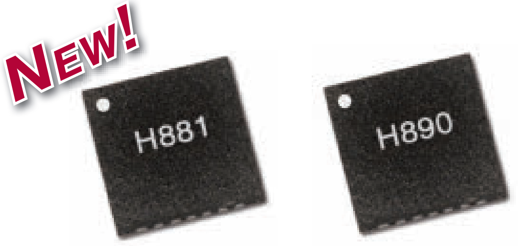
HMC702LP6CE
Fractional-N w/ Int. Sweeper
- *10 kHz to 14 GHz*
- *Low Phase Noise:*
- *-227 FOM Integer Mode*

HMC696LP4E
Direct Quad. Modulator
- *20 - 2700 MHz*
- *> 42 dBc Sideband Suppression*
- *-163 dBc/Hz Broadband Noise Floor*



Hittite's Low Jitter Comparators Drive ADC Clocks & Maintain High SINAD!

TUNABLE FILTER MMICs, DC TO 7.6 GHz!



Low Pass   Band Pass

Features

- Fast Tuning Speed Response; 150 ns
- Excellent Wideband Rejection; 30 dB
- Single Chip Replacement for Mechanically Tuned Designs
- Single Analog Tuning Voltage Between 0 and 14V
- 32 Lead 5x5 mm SMT Package

BAND PASS

Freq. Range (GHz)	Return Loss (dB)	3 dB Bandwidth (%)	Low Side Rejection Frequency (Rej. >20 dB)	High Side Rejection Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
1 - 2	10	11	0.8 x Fcenter	1.2 x Fcenter	200	LP5	EAR99	HMC890LP5E
2 - 3.9	10	9	0.9 x Fcenter	1.15 x Fcenter	200	LP5	EAR99	HMC891LP5E

LOW PASS

Freq. Range (GHz)	Return Loss (dB)	Cutoff Frequency Range (GHz)	Stopband Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
DC - 4.0	10	2.2 - 4.0	1.25 x Fcutoff	150	LP5	EAR99	HMC881LP5E
DC - 7.6	10	4.5 - 7.6	1.23 x Fcutoff	150	LP5	EAR99	HMC882LP5E

Ideal for Frequency Selection in Multi-Band Synthesizer Systems, Wideband Radar, and Test & Measurement

QUAD OUTPUT LOW NOISE, HIGH PSRR, LINEAR VOLTAGE REGULATOR!

Features

- Low Noise Spectral Density:
  3nV/√Hz at 10 kHz
  7nV/√Hz at 1 kHz
- High Power Supply Rejection Ratio:
  80 dB at 1 kHz
  60 dB at 1 MHz
- Four Voltage Outputs:
  VR1 at 3V / 75 mA
  VR2, VR3 at 3V / 15 mA
  VR4 at 4.5V / 100 mA
- All Outputs Are Adjustable From 2.5V to 5.2V

HIGH PSRR - QUAD LINEAR VOLTAGE REGULATOR

Input Voltage (V)	Function	Output Voltage (V)	Output Current (mA)	Power Supply Rejection Ratio (PSRR) (dB) 1 kHz	Power Supply Rejection Ratio (PSRR) (dB) 1 MHz	Output Noise Spectral Density (nV/√Hz) 1 kHz	Output Noise Spectral Density (nV/√Hz) 10 kHz	Regulated Outputs	Package	Part Number
3.35 - 5.6	Quad High PSRR	2.5 - 5.2	15 - 100	80	60	7	3	4	LP3	**HMC860LP3E**

Ideal for Powering Hittite's Broad Line of Frequency Generation Products Including Our Low Noise PLL with Integrated VCOs!

New & Expanded Product Lines

Frequency Generation Expanded to Include New PLLs with Integrated VCOs

PLLs with Integrated VCOs Cover 665 MHz to 13.4 GHz!

New!

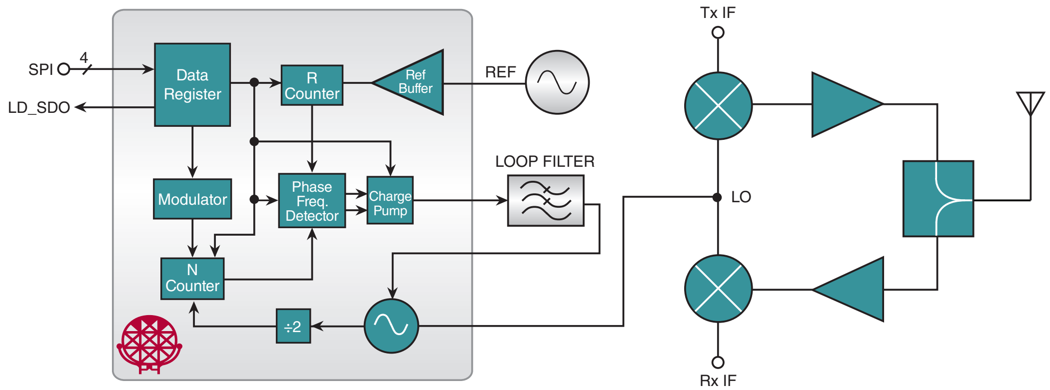
PLL w/ Integrated
RF VCO

PLL w/ Integrated
Microwave VCO

Features

- *10 kHz Closed Loop SSB Phase Noise:*
  -120 dBc/Hz - HMC824LP6CE @ 870 MHz
  -102 dBc/Hz - HMC764LP6CE @ 7.8 GHz
- *Fully Integrated LO Solution*
  Just Add Crystal Reference & Loop Filter
- *6x6 mm QFN Package*

Miniature LO Solutions for Demanding Transceiver Applications



12 NEW IN-STOCK LOW PHASE NOISE PLLs w/ INTEGRATED VCOs

Frequency (GHz)	Closed Loop SSB Phase Noise @10kHz Offset	Open Loop VCO Phase Noise @1MHz Offset	Pout (dBm)	RMS Jitter Fractional Mode (fs)	Integrated PN Fractional Mode (deg rms)	Package	Part Number
0.665 - 0.825 1.33 - 1.56 2.66 - 3.30	-115 dBc/Hz	-142 dBc/Hz	+10	190	0.10	LP6C	**HMC822LP6CE**
0.78 - 0.87	-120 dBc/Hz	-147 dBc/Hz	+12	190	0.05	LP6C	**HMC824LP6CE**
0.86 - 1.04 1.72 - 2.08 3.44 - 4.16	-113 dBc/Hz	-140 dBc/Hz	+10	190	0.12	LP6C	**HMC821LP6CE**
0.99 - 1.105	-118 dBc/Hz	-145 dBc/Hz	+10	190	0.07	LP6C	**HMC826LP6CE**
1.095 - 1.275 2.19 - 2.55 4.38 - 5.10	-110 dBc/Hz	-139 dBc/Hz	+10	190	0.17	LP6C	**HMC820LP6CE**
1.285 - 1.415	-116 dBc/Hz	-142 dBc/Hz	+10	190	0.10	LP6C	**HMC828LP6CE**
1.815 - 2.01	-112 dBc/Hz	-141 dBc/Hz	+9	190	0.13	LP6C	**HMC831LP6CE**
3.365 - 3.705	-107 dBc/Hz	-135 dBc/Hz	0	190	0.25	LP6C	**HMC836LP6CE**
7.3 - 8.2	-102 dBc/Hz	-140 dBc/Hz	+15	196	0.55	LP6C	**HMC764LP6CE**
7.8 - 8.5	-102 dBc/Hz	-139 dBc/Hz	+13	193	0.58	LP6C	**HMC765LP6CE**
11.5 -12.5	-100 dBc/Hz	-134 dBc/Hz	+11	181	0.78	LP6C	**HMC783LP6CE**
12.4 - 13.4	-98 dBc/Hz	-134 dBc/Hz	+8	175	0.81	LP6C	**HMC807LP6CE**

Ideal for Cellular/4G, Microwave Radio, Industrial / Medical Test Equipment, Military Communications & Sensors

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
Low Noise Amplifiers									
0.175 - 0.66	Low Noise	24	37	0.5	19	+5V @ 90mA	LP3	EAR99	HMC616LP3E
0.2 - 4.0	Low Noise, High IP3	13	38	2.3	22	+5V @ 110mA	ST89	EAR99	HMC639ST89E
0.2 - 4.0	Low Noise, High IP3	13	40	2.2	22	+5V @ 155mA	ST89	EAR99	HMC636ST89E
0.23 - 0.66	Low Noise, Dual Channel	22	37	0.5	19	+5V @ 97mA	LP4	EAR99	HMC816LP4E
0.3 - 3.0	Low Noise, High IP3	15	37	1.5	22	+5V @ 90mA	SOT26	EAR99	HMC374E
0.55 - 1.2	Low Noise	16	37	0.5	21	+5V @ 88mA	LP5	EAR99	HMC617LP3E
0.55 - 1.2	Low Noise, Dual Channel	16	37	0.5	20.5	+5V @ 95mA	LP4	EAR99	HMC817LP4E
0.6 - 1.4	Low Noise	32	40	0.9	21.5	+5V @ 254mA	LP4	EAR99	HMC718LP4E
0.7 - 1.2	Low Noise w/ Failsafe Bypass	16	33	0.9	13	+5V @ 57mA	LP3	EAR99	HMC668LP3E
0.7 - 2.2	Low Noise	22	36	1.7	24	+5V @ 227mA	LP3	EAR99	HMC758LP3E
1 - 11	Low Noise	17	30	1.5	18	+5V @ 55mA	LP4	EAR99	HMC753LP4E
1 - 12	Low Noise	17	28	1.5	19	+5V @ 55mA	Chip	EAR99	HMC-ALH444
1.2 - 3.0	Low Noise	26	21	1.3	11.5	+5V @ 21mA	LP3	EAR99	HMC548LP3E
1.3 - 2.9	Low Noise	34	39	1	21.5	+5V @ 272mA	LP4	EAR99	HMC719LP4E
1.7 - 2.2	Low Noise	19	36	0.75	20	+5V @ 117mA	LP3	EAR99	HMC618LP3E
1.7 - 2.2	Low Noise w/ Failsafe Bypass	17	29	1.4	12	+5V @ 86mA	LP3	EAR99	HMC669LP3E
1.7 - 2.2	Low Noise, Dual Channel	20.5	35	0.85	21	+5V @ 112mA	LP4	EAR99	HMC818LP4E
2 - 4	Low Noise	10	36	2.6	21	+6V @ 100mA	Chip	EAR99	HMC594
2 - 4	Low Noise	10	36	3	21	+6V @ 100mA	LC3B	EAR99	HMC594LC3B
2 - 4	Low Noise	20.5	36	3	21	+6V @ 170mA	Chip	EAR99	HMC609
2 - 4	Low Noise	20	36.5	3.5	21.5	+6V @ 170mA	LC4	EAR99	HMC609LC4
2.1 - 2.9	Low Noise	19	33	0.9	19	+5V @ 95mA	LP3	EAR99	HMC715LP3E
2.2 - 12	Low Noise	15	25	1.8	13	+4V @ 45mA	LC4	EAR99	HMC772LC4
2.3 - 2.5	Low Noise	19	12	1.7	6	+3V @ 8.5mA	SOT26	EAR99	HMC286E
2.3 - 2.7	Low Noise	19	29.5	0.75	16.5	+5V @ 59mA	LP2	EAR99	HMC667LP2E
2.3 - 2.7	Low Noise w/ Bypass	20	31	1.1	17	+5V @ 74mA	LP3	EAR99	HMC605LP3E
2.4 - 2.5	Transceiver, Front End	13	10	3	5	+3V @ 24mA	MS8G	EAR99	HMC310MS8GE
3.1 - 3.9	Low Noise	18	33	1	19	+5V @ 65mA	LP3	EAR99	HMC716LP3E
3.3 - 3.8	Low Noise w/ Bypass	19	29	1.2	16	+5V @ 40mA	LP3	EAR99	HMC593LP3E
3.4 - 3.8	Low Noise w/ Bypass	16	18	2	7	+3V @ 9mA	LP3	EAR99	HMC491LP3E
3.5 - 7.0	Low Noise	15.5	28	2.4	16	+5V @ 50mA	Chip	EAR99	HMC392
3.5 - 7.0	Low Noise	16	30	2.5	16	+5V @ 55mA	LC4	EAR99	HMC392LC4
3.5 - 7.0	Low Noise	15	28	3	16	+5V @ 65mA	LH5	EAR99	HMC392LH5
4.8 - 6.0	Low Noise w/ Bypass	15	26	1.5	14	+5V @ 42mA	LP3	EAR99	HMC604LP3E
4.8 - 6.0	Low Noise	16.5	31.5	1.1	18.5	+5V @ 73mA	LP3	EAR99	HMC717LP3E
5 - 6	Low Noise	9	13	2.5	2	+3V @ 6mA	MS8G	EAR99	HMC318MS8GE
5 - 6	Low Noise	12	10	2.5	9	+3V @ 25mA	MS8G	EAR99	HMC320MS8GE
NEW! 5 - 10	Low Noise	20	28	1.7	16	+3.5V @ 80mA	Chip	EAR99	HMC902
NEW! 5 - 10	Low Noise	19	28	1.8	16	+3.5V @ 80mA	LP3	EAR99	HMC902LP3E
5 - 20	Low Noise	13	26	2.2	16	+5V @ 30mA	Chip	EAR99	HMC-ALH435
NEW! 5.6 - 17	Low Noise	19	26	1.6	15	+3.5V @ 80mA	Chip	EAR99	HMC903
NEW! 5.6 - 17	Low Noise	18	25	1.7	14	+3.5V @ 80mA	LP3	EAR99	HMC903LP3E
6 - 20	Low Noise	22	20	2.3	10	+3V @ 53mA	Chip	EAR99	HMC565
6 - 20	Low Noise	21	20	2.5	10	+3V @ 53mA	LC5	EAR99	HMC565LC5
7 - 13.5	Low Noise	17	24	1.8	12	+3V @ 51mA	Chip	EAR99	HMC564
7 - 14	Low Noise	17	25	1.8	13	+3V @ 51mA	LC4	EAR99	HMC564LC4
7 - 17	Low Noise	21	20	1.8	15	+3V @ 65mA	Chip	EAR99	HMC516
9 - 18	Low Noise	20	25	2	14	+3V @ 65mA	LC5	EAR99	HMC516LC5
12 - 16	Medium Power LNA	23	34	2.5	25	+5V @ 200mA	LP5	EAR99	HMC490LP5E
12 - 17	Medium Power LNA	27	35	2	26	+5V @ 200mA	Chip	EAR99	HMC490
13 - 25	Low Noise	21	13	3.5	5	+3V @ 41mA	Chip	EAR99	HMC342
13 - 25	Low Noise	22	20	3.5	9	+3V @ 43mA	LC4	EAR99	HMC342LC4
14 - 27	Low Noise	19.5	-	2.2	17	+4V @ 90mA	LC4B	5A991.h	HMC504LC4B
14 - 27	Low Noise	18	-	2.5	14	+4V @ 90mA	Chip	5A991.h	HMC-ALH216
14 - 27	Low Noise	20	-	2	14	+4V @ 90mA	Chip	5A991.h	HMC-ALH476
17 - 26	Low Noise	19	23	2.2	11	+3V @ 65mA	Chip	EAR99	HMC517
17 - 26	Low Noise	19	23	2.5	13	+3V @ 67mA	LC4	EAR99	HMC517LC4
17 - 27	Low Noise	25	25	2.2	13	+4V @ 73mA	LC4	EAR99	HMC751LC4
18 - 32	Low Noise	15	23	2.8	12	+3V @ 65mA	Chip	3A001.b.2.d	HMC519
18 - 31	Low Noise	15	23	3.5	11	+3V @ 75mA	LC4	EAR99	HMC519LC4
18 - 40	Low Noise	10	-	3.9	12	+5V @ 45mA	Chip	3A001.b.2.d	HMC-ALH445
20 - 32	Low Noise	15	23	3	12	+3V @ 65mA	Chip	3A001.b.2.d	HMC518
20 - 36	Low Noise	20	18	2.2	8	+3V @ 58mA	LP4	3A001.b.2.d	HMC263LP4E
21 - 29	Low Noise	13	19	2.5	8	+3V @ 35mA	LC3B	EAR99	HMC341LC3B

Hittite MICROWAVE CORPORATION

SMT & Chip (Die) Products

AMPLIFIERS

	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
	22 - 26.5	Low Noise	25	-	3	12	+2.5V @ 52mA	Chip	5A991.h	HMC-ALH311
	24 - 28	Low Noise	25	26	2.5	13	+3V @ 70mA	LC4	EAR99	HMC752LC4
	24 - 30	Low Noise	13	16	2.5	6	+3V @ 30mA	Chip	EAR99	HMC341
	24 - 32	Low Noise	21	-	2	7	+5V @ 68mA	Chip	3A001.b.2.d	HMC-ALH364
	24 - 36	Low Noise	23	17	2	8	+3V @ 58mA	Chip	3A001.b.2.d	HMC263
	24 - 40	Low Noise	12	-	3.5	13	+4V @ 45mA	Chip	3A001.b.2.d	HMC-ALH244
	24 - 40	Low Noise	22	-	2	11	+5V @ 66mA	Chip	3A001.b.2.d	HMC-ALH369
	24 - 40	Low Noise	11.5	-	4	15	+4V @ 60mA	Chip	3A001.b.2.d	HMC-ALH140
	27 - 33	Low Noise	20	-	3	12	+2.5V @ 52mA	Chip	3A001.b.2.d	HMC-ALH313
	29 - 36	Low Noise	20	23.5	2.8	12	+3V @ 80mA	Chip	3A001.b.2.d	HMC566
	28 - 36	Low Noise	21	24	2.8	12	+3V @ 82mA	LP4	3A001.b.2.d	HMC566LP4E
	35 - 45	Low Noise	16	-	2	6	+4V @ 87mA	Chip	3A001.b.2.d	HMC-ALH376
	37 - 42	Low Noise	22	-	3.5	12	+2.5V @ 52mA	Chip	3A001.b.2.d	HMC-ALH310
	57 - 65	Low Noise	21	-	4	12	+2.5V @ 64mA	Chip	3A001.b.2.f	HMC-ALH382
	71 - 86	Low Noise	13	-	5	7	+2.4V @ 30mA	Chip	3A001.b.2.f	HMC-ALH508
	71 - 86	Low Noise	14	-	5	7	+2V @ 50mA	Chip	3A001.b.2.f	HMC-ALH509
	***Broadband Gain Blocks** (Listed by P1dB Output Power)*									
	DC - 6	SiGe Gain Block	15.5	22	3	8	+5V @ 25mA	MP86	EAR99	HMC474MP86E
	DC - 6	SiGe Gain Block	15	20	3	8	+3V @ 25mA	SC70	EAR99	HMC474SC70E
	DC - 6	SiGe Gain Block	20	25	2.5	12	+5V @ 35mA	MP86	EAR99	HMC476MP86E
	DC - 6	SiGe Gain Block	19	24	2.5	12	+5V @ 35mA	SC70	EAR99	HMC476SC70E
	DC - 10	HBT Gain Block	15	24	4.5	13	+5V @ 56mA	Chip	EAR99	HMC397
	DC - 10	HBT Gain Block	15	25	4	13	+5V @ 50mA	Chip	EAR99	HMC405
	DC - 6	HBT Gain Block	17	27	6.5	14	+5V @ 50mA	SOT26	EAR99	HMC313E
	DC - 8	HBT Gain Block	12	30	6	14	+5V @ 56mA	Chip	EAR99	HMC396
	DC - 4	HBT Gain Block	15	28	4.5	15	+5V @ 54mA	Chip	EAR99	HMC395
	DC - 6	HBT Gain Block	14.5	32	4.5	15	+5V @ 56mA	LP3	EAR99	HMC311LP3E
	DC - 8	HBT Gain Block	15	30	5	15	+5V @ 54mA	SC70	EAR99	HMC311SC70E
	DC - 6	HBT Gain Block	16	31.5	4.5	15.5	+5V @ 54mA	ST89	EAR99	HMC311ST89E
	DC - 4	SiGe Gain Block	24	31	2.5	16	+5V @ 62mA	SC70	EAR99	HMC478SC70E
	DC - 4	SiGe Gain Block	22	32	2	18	+5V @ 62mA	MP86	EAR99	HMC478MP86E
	DC - 4	SiGe Gain Block	22	33	3	18	+5V @ 62mA	ST89	EAR99	HMC478ST89E
	DC - 5	SiGe Gain Block	15	34	4	18	+8V @ 72mA	MP86	EAR99	HMC479MP86E
	DC - 5	SiGe Gain Block	15	34	4	18	+8V @ 75mA	ST89	EAR99	HMC479ST89E
NEW!	DC - 10	pHEMT Gain Block	15	26	5	18	+5V @ 65mA	LP2	EAR99	HMC788LP2E
	DC - 5	SiGe Gain Block	20	33	3.5	19	+8V @ 79mA	ST89	EAR99	HMC481ST89E
	DC - 5	SiGe Gain Block	19	34	2.9	20	+8V @ 82mA	ST89	EAR99	HMC480ST89E
	DC - 5	SiGe Gain Block	20	33	3.5	20	+8V @ 74mA	MP86	EAR99	HMC481MP86E
	DC - 4	HBT Gain Block	21	33	4	21	+5V @ 82mA	ST89	EAR99	HMC589ST89E
	DC - 1	HBT Gain Block	22	37	2.8	22	+5V @ 88mA	ST89	EAR99	HMC580ST89E
	DC - 4.5	HBT Gain Block	21	35	3.5	22	+8V @ 110mA	ST89	EAR99	HMC475ST89E
	DC - 5	SiGe Gain Block	19	36	4	22.5	+8V @ 110mA	ST89	EAR99	HMC482ST89E
	DC - 5	Dual SiGe Gain Block	15	34	4	18	+8V @ 75mA	MS8G	EAR99	HMC469MS8GE
	DC - 5	Dual SiGe Gain Block	20	34	3.2	20	+8V @ 80mA	MS8G	EAR99	HMC471MS8GE
	CATV Amplifiers									
	0.04 - 0.96	Low Noise, Dual Output	5	27	3.5	12	+5V @ 120mA	MS8G	EAR99	HMC549MS8GE
	0.05 - 0.96	Low Noise, 75 Ohm	14	39	2.2	19	+5V @ 120mA	ST89	EAR99	HMC599ST89E
NEW!	DC - 1.0	50 / 75 Ohm Differential Gain Block	16	40	3.5	24	+8V @ 350mA	LP4B	EAR99	HMC771LP4BE
	0.04 - 1.0	50 / 75 Ohm Differential Gain Block	16	40	2.5	23.5	+5V @ 270mA	LP4B	EAR99	HMC770LP4BE
	0.05 - 3.0	HBT Gain Block	15	40	3.5	18	+5V @ 88mA	ST89	EAR99	HMC740ST89E
	0.05 - 3.0	HBT Gain Block	20	42	2.5	18	+5V @ 96mA	ST89	EAR99	HMC741ST89E
	DC - 1	HBT Gain Block, 75 Ohm	14	38	5.5	21	+5V @ 160mA	S8G	EAR99	HMC754S8GE
	Driver Amplifiers									
	0.7 - 2.8	HBT Driver Amplifier	18	42	3.8	25	+5V @ 125mA	ST89	EAR99	HMC789ST89E
	0.8 - 3.8	Driver Amplifier	18	30	7.5	17	+5V @ 53mA	SOT26	EAR99	HMC308E
	3.0 - 4.5	HBT Driver Amplifier	21	36	5	23.5	+5V @ 130mA	MS8G	EAR99	HMC326MS8GE
	17.5 - 41	Driver Amplifier	21	27	-	20	+5V @ 295mA	Chip	3A001.b.2.d	HMC-AUH256
	Linear & Power Amplifiers									
	0.4 - 2.5	High IP3 Amp, 1/2 Watt	12.5	42	6	27	+5V @ 150mA	ST89	EAR99	HMC454ST89E
	1.6 - 2.2	Medium Power Amplifier	22	40	5.5	27	+3.6V @ 270mA	QS16G	EAR99	HMC413QS16GE
	5 - 6	Medium Power Amplifier	18	38	6	26	+5V @ 300mA	MS8G	EAR99	HMC406MS8GE
	5 - 7	Medium Power Amplifier	15	40	5.5	25	+5V @ 230mA	MS8G	EAR99	HMC407MS8GE
	5 - 18	Medium Power Amplifier	18	28	7	19.5	+5V @ 120mA	LP3	EAR99	HMC451LP3E
	5 - 20	Medium Power Amplifier	22	30	6.5	20	+5V @ 127mA	Chip	EAR99	HMC451
	5 - 20	Medium Power Amplifier	19	30	7	19	+5V @ 114mA	LC3	EAR99	HMC451LC3

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
6 - 18	Medium Power Amplifier	15.5	32	4.5	20	+5V @ 95mA	Chip	EAR99	HMC441
6 - 18	Medium Power Amplifier	17	32	4.5	20	+5V @ 95mA	LC3B	EAR99	HMC441LC3B
6.5 - 13.5	Medium Power Amplifier	14	29	4.5	18	+5V @ 95mA	LP3	EAR99	HMC441LP3E
7 - 15.5	Medium Power Amplifier	15	32	4.8	20	+5V @ 95mA	LH5 Hermetic	EAR99	HMC441LH5
7 - 15.5	Medium Power Amplifier	15	30	4.5	19	+5V @ 90mA	LM1	EAR99	HMC441LM1
9.5 - 11.5	Medium Power Amplifier	29.5	33	6	27	+5V @ 310mA	LC4	EAR99	HMC608LC4
12 - 30	Medium Power Amplifier	16	25	7	16	+5V @ 101mA	Chip	EAR99	HMC383
12 - 30	Medium Power Amplifier	15	25	7.5	16.5	+5V @ 100mA	LC4	EAR99	HMC383LC4
16 - 33	Medium Power Amplifier	17	33	-	24	+5V @ 400mA	Chip	5A991.h	HMC-APH596
17 - 24	Medium Power Amplifier	24	34	4	25	+5V @ 250mA	Chip	EAR99	HMC498
17 - 24	Medium Power Amplifier	22	36	4	25	+5V @ 250mA	LC4	EAR99	HMC498LC4
17 - 30	Medium Power Amplifier	20	31	-	22	+4.5V @ 400mA	Chip	EAR99	HMC-APH196
17.5 - 24	Medium Power Amplifier	14	28	6.5	21.5	+5V @ 85mA	LM1	EAR99	HMC442LM1
17.5 - 25.5	Medium Power Amplifier	13	27	8	22	+5V @ 84mA	LC3B	EAR99	HMC442LC3B
17.5 - 25.5	Medium Power Amplifier	15	28	5.5	22	+5V @ 85mA	Chip	EAR99	HMC442
21 - 32	Medium Power Amplifier	16	33	5	24	+5V @ 200mA	Chip	3A001.b.2.b	HMC499
21 - 32	Medium Power Amplifier	17	34	5	23	+5V @ 200mA	LC4	3A001.b.2.b	HMC499LC4
34 - 42	Medium Power Amplifier	18.5	29	6.5	18	+5V @ 120mA	Chip	3A001.b.2.d	HMC-ABH264
37 - 40	Medium Power Amplifier	20	35	-	26	+5V @ 640mA	Chip	3A001.b.2.d	HMC-APH510
37 - 45	Medium Power Amplifier	21	32	-	23	+5V @ 475mA	Chip	3A001.b.2.d	HMC-APH403
50 - 66	Medium Power Amplifier	24	25	-	17	+5V @ 220mA	Chip	3A001.b.2.f	HMC-ABH241
55 - 65	Medium Power Amplifier	13	25	-	16	+5V @ 80mA	Chip	3A001.b.2.f	HMC-ABH209
71 - 76	Medium Power Amplifier	24	-	-	17.5	+4V @ 130mA	Chip	3A001.b.2.f	HMC-AUH318
71 - 76	Medium Power Amplifier	13	-	-	20	+4V @ 240mA	Chip	3A001.b.2.f	HMC-APH633
71 - 86	Medium Power Amplifier	15	-	-	15	+4V @ 130mA	Chip	3A001.b.2.f	HMC-AUH320
81 - 86	Medium Power Amplifier	22	-	-	17.5	+4V @ 160mA	Chip	3A001.b.2.f	HMC-AUH317
81 - 86	Medium Power Amplifier	12	-	-	19	+4V @ 240mA	Chip	3A001.b.2.f	HMC-APH634
NEW! DC - 22	Power Amplifier, 1 Watt	14	40	2.5	28	+11V @ 400mA	Chip	3A001.b.2.c	HMC797
0.4 - 2.2	Power Amplifier, 1 Watt	21	49	6.5	30	+5V @ 510mA	ST89	EAR99	HMC452ST89E
0.4 - 2.2	Power Amplifier, 1.6 Watt	20.5	49	6.5	32	+5V @ 725mA	ST89	EAR99	HMC453ST89E
0.45 - 2.2	Power Amplifier, 1 Watt	22.5	48	7	30	+5V @ 485mA	QS16G	EAR99	HMC452QS16GE
0.45 - 2.2	Power Amplifier, 1.6 Watt	21.5	51	6.5	33	+5V @ 725mA	QS16G	EAR99	HMC453QS16GE
NEW! 0.2 - 25	Power Amplifier, 1/2 Watt	13	38	3	27	+11V @ 365mA	Chip	3A001.b.2.c	HMC907
1.7 - 2.2	Power Amplifier, 1 Watt	27	46	5	30.5	+5V @ 500mA	QS16G	EAR99	HMC457QS16GE
2.3 - 2.8	Power Amplifier, 2 Watt	31	45	5	32.5	+5V @ 430mA	LP4	EAR99	HMC755LP4E
3 - 4	Power Amplifier, 1/2 Watt	21	40	5	27	+5V @ 250mA	MS8G	EAR99	HMC327MS8GE
3.3 - 3.8	Power Amplifier, 1 Watt	31	45.5	5.8	30.5	+5V @ 615mA	LP4	EAR99	HMC409LP4E
5.1 - 5.9	Power Amplifier, 1 Watt	20	43	6	30	+5V @ 750mA	LP3	EAR99	HMC408LP3E
6 - 9.5	Power Amplifier, 1 Watt	21	40	-	30.5	+7V @ 820mA	LP5	3A001.b.2.d	HMC590LP5E
6 - 9.5	Power Amplifier, 2 Watt	18	41	-	33	+7V @ 1340mA	LP5	3A001.b.2.d	HMC591LP5E
6 - 10	Power Amplifier, 1 Watt	25	41	-	31.5	+7V @ 820mA	Chip	3A001.b.2.d	HMC590
6 - 10	Power Amplifier, 2 Watt	23	43	-	33.5	+7V @ 1340mA	Chip	3A001.b.2.d	HMC591
7 - 9	Power Amplifier, 2 Watt	26	40	6.5	33.5	+7V @ 1.3A	Chip	3A001.b.2.b	HMC486
7 - 9	Power Amplifier, 2 Watt	22	40	7	32	+7V @ 1.3A	LP5	3A001.b.2.b	HMC486LP5E
9 - 12	Power Amplifier, 2 Watt	20	36	8	32	+7V @ 1.3A	LP5	3A001.b.2.b	HMC487LP5E
10 - 13	Power Amplifier, 1 Watt	19	38	-	31	+7V @ 750mA	Chip	3A001.b.2.b	HMC592
12 - 16	Power Amplifier, 1 Watt	13	34	9	31	+7V @ 1.3A	LP5	3A001.b.2.b	HMC489LP5E
15 - 27	Power Amplifier, 1 Watt	17	37	-	29	+5V @ 1.44A	Chip	3A001.b.2.c	HMC-APH462
16 - 24	Power Amplifier, 1 Watt	23	41	-	31	+7V @ 790mA	Chip	3A001.b.2.c	HMC756
16 - 24	Power Amplifier, 1/2 Watt	22	37	-	29	+7V @ 395mA	Chip	3A001.b.2.c	HMC757
18 - 20	Power Amplifier, 1 Watt	17.5	38.5	-	30	+5V @ 900mA	Chip	3A001.b.2.c	HMC-APH478
21 - 24	Power Amplifier, 1 Watt	17	39	-	30.5	+5V @ 950mA	Chip	3A001.b.2.c	HMC-APH518
22.5 - 26.5	Power Amplifier, 1 Watt	17	40	-	30	+5V @ 950mA	Chip	3A001.b.2.c	HMC-APH608
24 - 29.5	Power Amplifier, 1/2 Watt	22	-	-	26.5	+6V @ 360mA	Chip	EAR99	HMC863
24 - 29.5	Power Amplifier, 1 Watt	27	40	-	29	+6V @ 750mA	Chip	3A001.b.2.c	HMC864
27 - 31.5	Power Amplifier, 1 Watt	14	37	-	28	+5V @ 900mA	Chip	3A001.b.2.c	HMC-APH460
27 - 34	Power Amplifier, 1 Watt	17.5	37	-	29	+5V @ 800mA	Chip	3A001.b.2.d	HMC693
37 - 40	Power Amplifier, 1 Watt	15	37	-	28	+5V @ 1.08A	Chip	3A001.b.2.d	HMC-APH473
Wideband (Distributed) Amplifiers									
DC - 20	Wideband LNA	14	28	2.5	16	+8V @ 60mA	Chip	EAR99	HMC460
DC - 20	Wideband LNA	14	29.5	2.5	17	+8V @ 75mA	LC5	EAR99	HMC460LC5
2 - 20	Wideband LNA	15.5	26.5	2.5	15	+5V @ 63mA	Chip	EAR99	HMC462
2 - 20	Wideband LNA	13	25	2.5	14	+5V @ 66mA	LP5	EAR99	HMC462LP5E
2 - 20	Wideband LNA w/AGC	14	28	2.5	19	+5V @ 60mA	Chip	EAR99	HMC463
2 - 20	Wideband LNA w/AGC	13	26	3	18	+5V @ 60mA	LP5	EAR99	HMC463LP5E

SMT & Chip (Die) Products

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
2 - 20	Wideband LNA w/AGC	14	28	2.5	18	+5V @ 60mA	LH250	EAR99	HMC463LH250
2 - 20	Wideband LNA	10	-	3.5	10	+2V @ 55mA	Chip	EAR99	HMC-ALH102
2 - 22	Wideband LNA	16	-	1.7	14	+4V @ 45mA	Chip	EAR99	HMC-ALH482
2 - 18	Wideband, Low Phase Noise	14	27	4.5	15	+5V @ 64mA	Chip	EAR99	HMC606
2 - 18	Wideband, Low Phase Noise	13.5	27	7	15	+5V @ 64mA	LC5	EAR99	HMC606LC5
DC - 20	Wideband Driver	17	30	2.5	22	+8V @ 160mA	Chip	EAR99	HMC465
DC - 20	Wideband Driver	15	28	3	23	+8V @ 160mA	LP5	EAR99	HMC465LP5E
DC - 35	Wideband Driver	15	-	-	21	+5V @ 200mA	Chip	3A001.b.2.d	HMC-AUH249
DC - 43	Wideband Driver	14	-	5.4	16.5	+5V @ 180mA	Chip	3A001.b.2.d	HMC-AUH232
0.5 - 65	Wideband Driver	10	-	-	-	+8V @ 60mA	Chip	3A001.b.2.d	HMC-AUH312
2 - 35	Wideband Driver	12.5	27	3	18	+8V @ 80mA	Chip	3A001.b.2.d	HMC562
5 - 17	Wideband Driver	31	30	8	23	+5V @ 180mA	Chip	EAR99	HMC633
5.5 - 17	Wideband Driver	30	30	8	23	+5V @ 180mA	LC4	EAR99	HMC633LC4
5 - 20	Wideband Driver	22	31	7.5	23	+5V @ 180mA	Chip	EAR99	HMC634
5 - 20	Wideband Driver	21	29	7.5	22	+5V @ 180mA	LC4	EAR99	HMC634LC4
18 - 40	Wideband Driver	19.5	29	8	23	+5V @ 280mA	Chip	3A001.b.2.e	HMC635
18 - 40	Wideband Driver	18.5	27	7	22	+5V @ 280mA	LC4	3A001.b.2.d	HMC635LC4
DC - 6	Wideband Power Amplifier	14	45	5	29	+12V @ 400mA	Chip	EAR99	HMC637
DC - 6	Wideband Power Amplifier	13	40	5	29	+12V @ 400mA	LP5	EAR99	HMC637LP5E
DC - 10	Wideband Power Amplifier	12	41	6	28.5	+12V @ 300mA	Chip	EAR99	HMC619
DC - 10	Wideband Power Amplifier	12	41	6	28	+12V @ 300mA	LP5	EAR99	HMC619LP5E
DC - 15	Wideband Power Amplifier	19	35	2	26.5	+8V @ 300mA	Chip	EAR99	HMC659
DC - 15	Wideband Power Amplifier	19	35	2.5	27.5	+8V @ 300mA	LC5	EAR99	HMC659LC5
DC - 18	Wideband Power Amplifier	17	32	3	25	+8V @ 290mA	Chip	EAR99	HMC459
DC - 20	Wideband Power Amplifier	14	36	4	28	+10V @ 400mA	Chip	3A001.b.2.c	HMC559
2 - 20	Wideband Power Amplifier	16	30	4	26	+8V @ 290mA	Chip	EAR99	HMC464
2 - 20	Wideband Power Amplifier	14	30	4	26	+8V @ 290mA	LP5	EAR99	HMC464LP5E

AMPLIFIERS - Microwave & Optical Drivers

Frequency (GHz)	Function	Gain (dB)	Group Variation Delay (ps)	Additive Jitter (ps)	P1dB (dBm)	Output Voltage Level (Vp-p)	Package	ECCN Code	Part Number
DC - 20	10 Gbps Modulator Driver	18	±15	0.3	22	2.5 - 8	LC5	EAR99	HMC870LC5
DC - 20	12.5 Gbps EML Modulator Driver	15	±16	0.3	16.5	2.5 - 4	LC5	EAR99	HMC871LC5

AMPLIFIERS - Limiting (LIA)

Data Rate (Gbps)	Function	Small Signal Bandwidth (GHz)	Differential Gain (dB)	Deterministic Jitter (ps p-p)	Additive Random Jitter (ps rms)	Supply Current	Package	ECCN Code	Part Number
12.5	Limiting Amplifier	11	44	5	0.2	+5V @ 106mA	LP4	EAR99	HMC750LP4E
32	Limiting w/ DC Offset	25	30	5	0.3	+3.3V @ 90mA	LC3C	EAR99	HMC865LC3C
32	Limiting w/o DC Offset	25	29	7	0.3	+3.3V @ 85mA	LC3C	EAR99	HMC866LC3C

AMPLIFIERS - Transimpedance (TIA)

Data Rate (Gbps)	Function	Transimpedance (kΩ)	Input Overload (mApp)	Small Signal Bandwidth (GHz)	Deterministic Jitter (ps)	Noise (pA/√Hz)	Package	ECCN Code	Part Number
0.1 - 1.0	10 kΩ Low Noise TIA	10	20	0.7	<100	4.6	LP3	EAR99	HMC799LP3E
1 - 10	10 Gbps Transimpedance	1.25	3	7.5	<10	11	Chip	EAR99	HMC690

ATTENUATORS

Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
Attenuators - Analog								
0.45 - 2.2	Analog VVA	1.9	0 to 48	20	0 to +3V	MS8	EAR99	HMC473MS8E
DC - 8	Analog VVA	1.5	0 to 32	10	0 to -3V	MS8G	EAR99	HMC346MS8GE
DC - 8	Analog VVA	2	0 to 30	10	0 to -3V	C8	EAR99	HMC346C8
DC - 8	Analog VVA	2	0 to 30	10	0 to -3V	G8 Hermetic	EAR99	HMC346G8
DC - 14	Analog VVA	2	0 to 30	10	0 to -3V	LP3	EAR99	HMC346LP3E
DC - 18	Analog VVA	1.5	0 to 30	10	0 to -3V	LC3B	EAR99	HMC346LC3B
DC - 20	Analog VVA	2.2	0 to 25	10	0 to -3V	Chip	EAR99	HMC346
5 - 26.5	Analog VVA	3.5	0 to 28	32	0 to -3V	LP3C	EAR99	HMC712LP3CE
5 - 30	Analog VVA	2.5	0 to 30	32	0 to -3V	Chip	EAR99	HMC712
5 - 30	Analog VVA	2	0 to 28	28	0 to -3V	LC4	EAR99	HMC812LC4
17 - 27	Analog VVA	1.5	0 to 22	17	-4 to +4V	Chip	5A991.h	HMC-VVD102
36 - 50	Analog VVA	1.5	0 to 22	17	0 to +4V	Chip	5A991.h	HMC-VVD106
70 - 86	Analog VVA	2	0 to 14	-	-5 to +5V	Chip	5A991.h	HMC-VVD104

ATTENUATORS

	Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
	Attenuators - Digital								
	DC - 5	1-Bit Digital	1	10	50	TTL/CMOS	LP3	EAR99	HMC541LP3E
NEW!	DC - 10	1-Bit Digital	2	10	54	0 / +3 to +5V	LP3	EAR99	HMC800LP3E
NEW!	DC - 10	1-Bit Digital	1.5	15	53	0 / +3 to +5V	LP3	EAR99	HMC801LP3E
NEW!	DC - 10	1-Bit Digital	2.5	20	53	0 / +3 to +5V	LP3	EAR99	HMC802LP3E
	0.7 - 4.0	2-Bit Digital	0.5	2 to 6	52	0 / +3V	SOT26	EAR99	HMC290E
	0.7 - 4.0	2-Bit Digital	0.9	4 to 12	54	0 / +3V	SOT26	EAR99	HMC291E
	DC - 6	2-Bit Digital	0.5	2 to 6	50	TTL/CMOS	LP3	EAR99	HMC467LP3E
	0.75 - 2.0	3-Bit Digital	1.8	4 to 28	45	0 / +3V	MS8	EAR99	HMC230MS8E
	0.7 - 3.7	3-Bit Digital	1.3	2 to 14	51	0 / +3V	MS8	EAR99	HMC288MS8E
	DC - 6	3-Bit Digital	0.7	1 to 7	50	TTL/CMOS	LP3	EAR99	HMC468LP3E
	DC - 5.5	4-Bit Digital	0.8	1 to 15	50	TTL/CMOS	LP3	EAR99	HMC540LP3E
	DC - 6	4-Bit Digital, Serial & Parallel Control	2.5	3 to 45	50	0 / +5V	LP4	EAR99	HMC629LP4E
	0.7 - 2.7	5-Bit Digital	2.3	1 to 31	54	0 / +3V	QS16	EAR99	HMC274QS16E
	0.7 - 3.0	5-Bit Digital	1.3	0.5 to 15.5	48	0 / +3V	MS10	EAR99	HMC603MS10E
	0.7 - 3.0	5-Bit Digital	1.3	0.5 to 15.5	48	0 / +3V	QS16	EAR99	HMC603QS16E
	0.7 - 3.7	5-Bit Digital, Serial Control	2.1	1 to 31	48	Serial TTL/CMOS	LP4	EAR99	HMC271LP4AE
	0.7 - 3.8	5-Bit Digital	2.1	1 to 31	48	0 / +3V	MS10G	EAR99	HMC273MS10GE
	0.7 - 3.8	5-Bit Digital, Serial Control	1.5	0.5 to 15.5	52	Serial TTL/CMOS	LP4	EAR99	HMC305LP4AE
	0.7 - 3.8	5-Bit Digital	1.5	0.5 to 15.5	52	0 / +3V	MS10	EAR99	HMC306MS10E
	DC - 3	5-Bit Digital	2.0	1 to 31	44	0 / -5V	G16 Hermetic	EAR99	HMC335G16
	DC - 3	5-Bit Digital	1.3	1 to 31	45	TTL/CMOS	LP3	EAR99	HMC470LP3E
	DC - 4	5-Bit Digital	1.9	1 to 31	44	0 / -5V	QS16G	EAR99	HMC307QS16GE
	DC - 4	5-Bit Digital	0.7	0.25 to 7.75	50	TTL/CMOS	LP3	EAR99	HMC539LP3E
	DC - 3.8	6-Bit Digital	1.5	0.5 to 31.5	45	TTL/CMOS	LP4	EAR99	HMC472LP4E
	DC - 3	6-Bit Digital	3.0	0.5 to 31.5	32	0 / -5V	G16 Hermetic	EAR99	HMC424G16
	DC - 3	6-Bit Digital, Serial Control	1.2	0.5 to 31.5	45	Serial TTL/CMOS	LP4	EAR99	HMC542LP4E
	DC - 3	6-Bit Digital, Serial Control	1.2	0.5 to 31.5	45	Serial TTL/CMOS	LP4	EAR99	HMC542LP4AE
	DC - 6	6-Bit Digital, Serial & Parallel Control	1.8	31.5	55	0 / +5V	LP4	EAR99	HMC624LP4E
	DC - 6	6-Bit Digital, Serial & Parallel Control	1.8	15.75	55	TTL/CMOS	LP4	EAR99	HMC792LP4E
	DC - 13	6-Bit Digital	4.0	0.5 to 31.5	32	0 / -5V	Chip	EAR99	HMC424
	DC - 13	6-Bit Digital	3.2	0.5 to 31.5	32	0 / -5V	LH5 Hermetic	EAR99	HMC424LH5
	DC - 13	6-Bit Digital	4.0	0.5 to 31.5	32	0 / -5V	LP3	EAR99	HMC424LP3E
	2.4 - 8.0	6-Bit Digital	3.5	0.5 to 31.5	40	0 / +5V	Chip	EAR99	HMC425
	2.2 - 8.0	6-Bit Digital	3.2	0.5 to 31.5	40	0 / +5V	LP3	EAR99	HMC425LP3E
	0.01 - 0.3	7-Bit Digital	3.3	31.75	40	TTL/CMOS	LP3	EAR99	HMC759LP3E

BROADBAND TIME DELAYS - *New Product Line!*

	Data / Clock Rate (Gbps/GHz)	Function	Rise / Fall (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vp-p)	DC Power Consumption (mW)	Vee Power Supply (Vdc)	Package	ECCN Code	Part Number
NEW!	28	Time Delay	14 / 16	11	0.1 - 0.8	1450	+3.3	LC4B	3A001.a.11.b	HMC910LC4B

COMPARATORS - *High Speed Clocked, Latched and Window Comparators*

	Analog Input B/W (GHz) /Clock Rate (Gbps)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power (mW)	Vcc / Vterm [1] Power Supply (Vdc)	Package	ECCN Code	Part Number
	Clocked Comparators									
	10 / 20	Clocked Comparator-RSPECL	<3	120	0.4	150	+3.3 / +1.3	LC3C	3A001.a.11.b	HMC874LC3C
	10 / 20	Clocked Comparator-RSCML	<3	120	0.4	130	0 / 0	LC3C	3A001.a.11.b	HMC875LC3C
	10 / 20	Clocked Comparator-RSECL	<3	120	0.4	150	0 / -2.0	LC3C	3A001.a.11.b	HMC876LC3C
	Latched Comparators									
	10 / [2]	Latched Comparator-RSPECL	2	85	0.4	140	+3.3 / 3.0	LC3C	3A001.a.11.b	HMC674LC3C
	10 / [2]	Latched Comparator-RSCML	2	100	0.4	100	0 / 0	LC3C	3A001.a.11.b	HMC675LC3C
	10 / [2]	Latched Comparator-RSECL	2	100	0.35	120	0 / -2.0	LC3C	3A001.a.11.b	HMC676LC3C
	Window Comparators									
NEW!	10 / -	Window Comparator	2	88	0.4	240	+2 / 0	LC3C	3A001.a.11.b	HMC974LC3C

[1] Vee = -3.0V & Vcci = +3.3V
[2] Note that HMC674/675/676LC3C is a family of Level Latched Comparators

DATA CONVERTERS - *Track-and-Hold*

Input Freq. (GHz)	Function	Single Tone THD/SFDR (dB)	Maximum Clock Rate (GS/s)	Output Noise (mV RMS)	Hold Mode Feed-through Rejection (dB)	Package	ECCN Code	Part Number
DC - 4.5	Track-and-Hold	-66 / 67	3.0	0.95	>60	LC4B	3A001.a.11.b	HMC660LC4B

IC Products

SMT & Chip (Die) Products

FILTERS - Tunable (Band Pass & Low Pass) - New Product Line!

Band Pass

	Frequency Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth (%)	Low Side Rejection Frequency (Rej. >20 dB)	High Side Rejection Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
NEW!	1 - 2	Band Pass	10	11	0.8 x Fcenter	1.2 x Fcenter	200	LP5	EAR99	HMC890LP5E
NEW!	2 - 3.9	Band Pass	10	9	0.9 x Fcenter	1.15 x Fcenter	200	LP5	EAR99	HMC891LP5E

Low Pass

	Frequency Range (GHz)	Function	Return Loss (dB)	Cutoff Frequency Range (GHz)	Stopband Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	ECCN Code	Part Number
NEW!	DC - 4.0	Low Pass	10	2.2 - 4.0	1.25 x Fcutoff	150	LP5	EAR99	HMC881LP5E
NEW!	DC - 7.6	Low Pass	10	4.5 - 7.6	1.23 x Fcutoff	150	LP5	EAR99	HMC882LP5E

FREQUENCY DIVIDERS (PRESCALERS) & DETECTORS

	Input Frequency (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
	DC - 8	Divide-by-2	-12 to +12	-6	-148	+3V @ 42mA	SOT26	3A001.a.11.b	HMC432E
	DC - 10	Divide-by-2	-15 to +10	3	-148	+5V @ 83mA	S8G	3A001.a.11.b	HMC361S8GE
	DC - 11	Divide-by-2	-15 to +10	3	-148	+5V @ 105mA	Chip	3A001.a.11.b	HMC361
	DC - 12.5	Divide-by-2	-15 to +10	2	-145	+5V @ 105mA	S8G	3A001.a.11.b	HMC364S8GE
	DC - 13	Divide-by-2	-15 to +10	1	-145	+5V @ 105mA	Chip	3A001.a.11.b	HMC364
	DC - 13	Divide-by-2	-15 to +10	5	-145	+5V @ 110mA	G8 Hermetic	3A001.a.11.b	HMC364G8
	DC - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 77mA	LP3	3A001.a.11.b	HMC492LP3E
	DC - 8	Divide-by-3	-12 to +12	-2	-153	+5V @ 69mA	MS8G	3A001.a.11.b	HMC437MS8GE
	DC - 4	Divide-by-4	-15 to +10	3.5	-146	+3V @ 13mA	MS8	3A001.a.11.b	HMC426MS8E
	DC - 8	Divide-by-4	-12 to +12	-3	-150	+3V @ 53mA	SOT26	3A001.a.11.b	HMC433E
	DC - 11	Divide-by-4	-15 to +10	-6	-149	+5V @ 68mA	Chip	3A001.a.11.b	HMC362
	DC - 12	Divide-by-4	-15 to +10	-6	-149	+5V @ 68mA	S8G	3A001.a.11.b	HMC362S8GE
	DC - 13	Divide-by-4	-15 to +10	2	-151	+5V @ 110mA	Chip	3A001.a.11.b	HMC365
	DC - 13	Divide-by-4	-15 to +10	7	-151	+5V @ 120mA	G8 Hermetic	3A001.a.11.b	HMC365G8
	DC - 13	Divide-by-4	-15 to +10	2	-151	+5V @ 110mA	S8G	3A001.a.11.b	HMC365S8GE
	DC - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 96mA	LP3	3A001.a.11.b	HMC493LP3E
	10 - 26	Divide-by-4	-15 to +10	-4	-150	+5V @ 96mA	LC3	3A001.a.11.b	HMC447LC3
	DC - 7	Divide-by-5	-12 to +12	-1	-153	+5V @ 80mA	MS8G	3A001.a.11.b	HMC438MS8GE
	DC - 8	Divide-by-8	-5 to +12	-2	-150	+3V @ 62mA	SOT26	3A001.a.11.b	HMC434E
	DC - 12	Divide-by-8	-15 to +10	-9	-153	+5V @ 70mA	Chip	3A001.a.11.b	HMC363
	DC - 12	Divide-by-8	-15 to +10	4	-153	+5V @ 90mA	G8 Hermetic	3A001.a.11.b	HMC363G8
	DC - 12	Divide-by-8	-15 to +10	-9	-153	+5V @ 70mA	S8G	3A001.a.11.b	HMC363S8GE
	DC - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 105mA	LP3	3A001.a.11.b	HMC494LP4E
	0.01 - 6.5	Programmable Divider (N = 1 to 17)	-15 to +10	0	-153	+5V @ 200mA	LP4	3A001.a.11.b	HMC705LP4E
	0.2 - 2.0	Programmable Divider (N = 1 to 4)	-2 to +10	10	-160	+5V @ 135mA	LP3	3A001.a.11.b	HMC794LP3E
NEW!	0.4 - 6	Programmable Divider (N = 1 to 6)	0 to +9	5	-156	+3.3V @ 100mA	LP3	3A001.a.11.b	HMC905LP3E
	DC - 2.2	5-bit Counter, ÷2 to 32	-15 to +10	4	-153	+5V @ 194mA	LP4	3A001.a.11.b	HMC394LP4E
	Phase / Frequency Detectors								
	0.01 - 1.3	Phase Frequency Detector	-10 to +10	2 Vpk-pk	-153	+5V @ 96mA	QS16G	3A001.a.11.b	HMC439QS16GE

FREQUENCY MULTIPLIERS - Active

Input Frequency (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package	ECCN Code	Part Number
3 - 4	x2 Active	6 - 9	0	17	-140	LP4	EAR99	HMC575LP4E
4.0 - 10.5	x2 Active	8 - 21	5	17	-139	Chip	EAR99	HMC561
4.0 - 10.5	x2 Active	8 - 21	5	14	-139	LP3	EAR99	HMC561LP3E
4 - 11	x2 Active	8 - 22	5	12	-134	LC3B	EAR99	HMC573LC3B
4.5 - 8.0	x2 Active	9 - 16	2	15	-140	LP4	EAR99	HMC368LP4E
4.95 - 6.35	x2 Active	9.9 - 12.7	0	4	-142	LP3	EAR99	HMC369LP3E
6.5 - 12.3	x2 Active	13.0 - 24.6	4	17	-136	Chip	EAR99	HMC814
6.5 - 12.3	x2 Active	13.0 - 24.6	4	17	-136	LC3B	EAR99	HMC814LC3B
9.0 - 14.5	x2 Active	18 - 29	3	17	-132	Chip	EAR99	HMC576
9.0 - 14.5	x2 Active	18 - 29	3	15	-132	LC3B	EAR99	HMC576LC3B
9.5 - 12.5	x2 Active	19 - 25	0	11	-135	Chip	EAR99	HMC448
10.0 - 12.5	x2 Active	20 - 25	0	11	-135	LC3B	EAR99	HMC448LC3B
11 - 23	x2 Active	22 - 46	5	15	-	Chip	EAR99	HMC598
12.0 - 16.5	x2 Active	24 - 33	3	17	-132	Chip	EAR99	HMC578
12.0 - 16.5	x2 Active	24 - 33	3	15	-132	LC3B	EAR99	HMC578LC3B
13.5 - 15.5	x2 Active	27 - 31	0	9	-132	LC3B	EAR99	HMC449LC3B
13.5 - 15.5	x2 Active	27 - 31	5	20	-128	LC4B	EAR99	HMC577LC4B
13.5 - 16.5	x2 Active	27 - 33	0	10	-132	Chip	EAR99	HMC449

FREQUENCY MULTIPLIERS - Active

Input Frequency (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package	ECCN Code	Part Number
16 - 23	x2 Active	32 - 46	3	13	-127	Chip	EAR99	HMC579
2.45 - 2.8	x4 Active	9.8 - 11.2	-15	3	-142	LP4	EAR99	HMC443LP4E
2.85 - 3.3	x4 Active	11.4 - 13.2	-15 to +5	7	-140	LP4	EAR99	HMC695LP4E
3.6 - 4.1	x4 Active	14.4 - 16.4	-15	0	-140	LP4	EAR99	HMC370LP4E
14 - 16	x4 Active	56 - 64	2	-6	-	Chip	3A001.b.2.f	HMC-XDH158
1.2375 - 1.4	x8 Active	9.9 - 11.2	-15	6	-136	LP4	EAR99	HMC444LP4E
0.61875 - 0.6875	x16 Active	9.9 - 11	-15	7	-130	LP4	EAR99	HMC445LP4E

FREQUENCY MULTIPLIERS - Passive

Input Frequency (GHz)	Function	Output Frequency (GHz)	Conversion Loss (dB)	1Fo / 4Fo Isolation (dBm)	Input Drive (dBm)	Package	ECCN Code	Part Number
0.7 - 2.4	x2 Passive	1.4 - 4.8	15	47 / 38	10 to 20	Chip	EAR99	HMC156
0.7 - 2.4	x2 Passive	1.4 - 4.8	15	47 / 38	10 to 20	C8	EAR99	HMC156C8
0.85 - 2.0	x2 Passive	1.7 - 4.0	15	45 / 40	10 to 20	MS8	EAR99	HMC187AMS8E
1.25 - 3.0	x2 Passive	2.5 - 6.0	15	45 / 45	10 to 20	MS8	EAR99	HMC188MS8E
1.3 - 4.0	x2 Passive	2.6 - 8.0	15	45 / 40	10 to 20	Chip	EAR99	HMC158
1.3 - 4.0	x2 Passive	2.6 - 8.0	15	45 / 40	10 to 20	C8	EAR99	HMC158C8
2 - 4	x2 Passive	4 - 8	13	34 / 40	10 to 15	MS8	EAR99	HMC189AMS8E
4 - 8	x2 Passive	8 - 16	20	45 / 38	10 to 15	Chip	EAR99	HMC204
4 - 8	x2 Passive	8 - 16	17	41 / 40	10 to 15	C8	EAR99	HMC204C8
4 - 8	x2 Passive	8 - 16	17	42 / 50	10 to 15	MS8G	EAR99	HMC204MS8GE
6 - 12	x2 Passive	12 - 24	17	32 / 32	10 to 15	Chip	EAR99	HMC205
10 - 15	x2 Passive	20 - 30	13	30	+13	Chip	5A991.h	HMC-XDB112
12 - 18	x2 Passive	24 - 36	14	50 / 60	11 to 15	Chip	EAR99	HMC331
24 - 30	x3 Passive	72 - 90	19	-	+13	Chip	5A991.h	HMC-XTB110

HIGH SPEED DIGITAL LOGIC

	Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vp-p)	DC Power (mW)	DC Power Supply (Vdc)	Package	ECCN Code	Part Number
	1:2 Fanout Buffer									
	13 / 13	1:2 Fanout Buffer*	22 / 20	<1	0.4 - 1.1	240	-3.3	LC3C	3A001.a.11.b	HMC670LC3C
	13 / 13	Fast Rise Time 1:2 Fanout Buffer*	19 / 18	2	0.6 - 1.1	300	-3.3	LC3C	3A001.a.11.b	HMC720LC3C
NEW!	13 / 13	Fast Rise Time 1:2 Fanout Buffer*	19 / 18	2	0.6 - 1.1	300	-3.3	LP3	3A001.a.11.b	HMC720LP3E
	13 / 13	Fast Rise Time 1:2 Fanout Buffer	19 / 18	2	1.1	300	-3.3	LC3C	3A001.a.11.b	HMC724LC3C
	13 / 13	Fast Rise Time 1:2 Fanout Buffer*	22 / 20	2	0.6 - 1.2	290	+3.3	LC3C	3A001.a.11.b	HMC744LC3C
NEW!	50	1:2 Fanout Buffer*	11 / 11	3	0.4 - 1.2	465	-3.3	LC4B	3A001.a.11.b	HMC842LC4B
	2:1 Selector									
	13 / 13	2:1 Selector*	17 / 15	2	0.6 - 1.2	250	-3.3	LC3C	3A001.a.11.b	HMC678LC3C
	13 / 13	2:1 Selector	17 / 15	2	1.1	250	-3.3	LC3C	3A001.a.11.b	HMC728LC3C
	13 / 13	2:1 Selector*	22 / 22	2	0.6 - 1.2	250	+3.3	LC3C	3A001.a.11.b	HMC748LC3C
	AND / NAND / OR / NOR									
	13 / 13	AND / NAND / OR / NOR*	22 / 20	<1	0.4 - 1.1	180	-3.3	LC3C	3A001.a.11.b	HMC672LC3C
	13 / 13	Fast Rise Time AND / NAND / OR / NOR*	19 / 18	2	0.6 - 1.1	230	-3.3	LC3C	3A001.a.11.b	HMC722LC3C
NEW!	13 / 13	Fast Rise Time AND / NAND / OR / NOR*	19 / 18	2	0.6 - 1.1	230	-3.3	LP3	3A001.a.11.b	HMC722LP3E
	13 / 13	Fast Rise Time AND / NAND / OR / NOR	19 / 18	2	1.1	230	-3.3	LC3C	3A001.a.11.b	HMC726LC3C
	13 / 13	Fast Rise Time AND / NAND / OR / NOR*	22 / 21	2	0.6 - 1.2	230	+3.3	LC3C	3A001.a.11.b	HMC746LC3C
NEW!	45	AND / NAND / OR / NOR*	10 / 10	2	0.2 - 0.85	500	-3.3	LC4B	3A001.a.11.b	HMC843LC4B
	Clock Divider									
	28 / 28	Clock Divide-by-2/4	12 / 14	-	0.6	660	-3.3	LC4B	3A001.a.11.b	HMC791LC4B
	D-Type Flip-Flop									
	13 / 13	D-Type Flip-Flop*	22 / 20	<1	0.4 - 1.1	210	-3.3	LC3C	3A001.a.11.b	HMC673LC3C
	13 / 13	Fast Rise Time D-Type Flip-Flop*	19 / 17	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC723LC3C
NEW!	13 / 13	Fast Rise Time D-Type Flip-Flop*	19 / 17	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC723LP3E
	13 / 13	Fast Rise Time D-Type Flip-Flop	19 / 17	2	1.1	260	-3.3	LC3C	3A001.a.11.b	HMC727LC3C
	13 / 13	Fast Rise Time D-Type Flip-Flop*	22 / 20	2	0.7 - 1.2	264	+3.3	LC3C	3A001.a.11.b	HMC747LC3C
	28 / 28	D-Type Flip-Flop*	15 / 14	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC853LC3C
NEW!	43	D-Type Flip-Flop*	12 / 12	2	0.2 - 0.85	630	-3.3	LC4B	3A001.a.11.b	HMC841LC4B
	NRZ-to-RZ Converter									
	13 / 13	NRZ-to-RZ Converter	15 / 13	2	0.3 - 1.2	594	+3.3	LC3C	3A001.a.11.b	HMC706LC3C
	T Flip-Flop									
	26 / 26	T Flip-Flop w/ Reset*	18 / 17	2	0.4 - 1.1	270	-3.3	LC3C	3A001.a.11.b	HMC679LC3C
	26 / 26	T Flip-Flop w/Reset	18 / 17	2	1.1	270	-3.3	LC3C	3A001.a.11.b	HMC729LC3C
	26 / 26	T Flip-Flop w/ Reset*	18 / 17	2	0.6 - 1.2	270	+3.3	LC3C	3A001.a.11.b	HMC749LC3C

Hittite MICROWAVE CORPORATION

SMT & Chip (Die) Products

HIGH SPEED DIGITAL LOGIC

	Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vp-p)	DC Power (mW)	DC Power Supply (Vdc)	Package	ECCN Code	Part Number
	XOR / XNOR									
	13 / 13	XOR / XNOR*	22 / 20	<1	0.4 - 1.1	180	-3.3	LC3C	3A001.a.11.b	HMC671LC3C
	13 / 13	Fast Rise Time XOR / XNOR*	19 / 18	2	0.6 - 1.2	230	-3.3	LC3C	3A001.a.11.b	HMC721LC3C
NEW!	13 / 13	Fast Rise Time XOR / XNOR*	19 / 18	2	0.6 - 1.2	230	-3.3	LP3	3A001.a.11.b	HMC721LP3E
	13 / 13	Fast Rise Time XOR / XNOR	19 / 18	2	1.1	230	-3.3	LC3C	3A001.a.11.b	HMC725LC3C
	13 / 13	Fast Rise Time XOR / XNOR*	21 / 19	2	0.6 - 1.2	240	+3.3	LC3C	3A001.a.11.b	HMC745LC3C

** These products feature programmable output voltage swing.*

INTERFACE - RF Switch, Attenuator & Phase Shifter Digital Drivers

Bit Rate (mbps)	Function	Input	Output Voltage (V)	Output Current (mA)	Bias Supply	Package	ECCN Code	Part Number
10	6-Bit Driver / Controller	TTL/CMOS	-5 / +2.2	1	+5V @ 1.5mA	LP5	EAR99	HMC677LP5E

I/Q MIXERS / IRMs

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
I/Q Mixers / IRMs								
3 - 7	I/Q Mixer / IRM	DC - 3.5	-7.5	33	23	Chip	EAR99	HMC620
3 - 7	I/Q Mixer / IRM	DC - 3.5	-7.5	32	22	LC4	EAR99	HMC620LC4
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	23	Chip	EAR99	HMC525
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	23	LC4	EAR99	HMC525LC4
5.9 - 12.0	I/Q Mixer / IRM	DC - 1.5	-8	30	18	Chip	EAR99	HMC256
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7	40	22	Chip	EAR99	HMC520
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7	40	23	LC4	EAR99	HMC520LC4
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	40	28	Chip	EAR99	HMC526
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	40	28	LC4	EAR99	HMC526LC4
8.5 - 13.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	24	Chip	EAR99	HMC521
8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-7.5	35	28	Chip	EAR99	HMC527
8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-7.5	34	28	LC4	EAR99	HMC527LC4
8.5 - 13.6	I/Q Mixer / IRM	DC - 3.5	-7.5	38	24	LC4	EAR99	HMC521LC4
10 - 16	I/Q Mixer / IRM, 0 LO	DC - 3.5	-8	25	25	LC5	EAR99	HMC775LC5
11 - 16	I/Q Mixer / IRM	DC - 3.5	-7.5	35	24	Chip	EAR99	HMC522
11 - 16	I/Q Mixer / IRM	DC - 3.5	-7.5	35	24	LC4	EAR99	HMC522LC4
11 - 16	I/Q Mixer / IRM	DC - 3.5	-8	35	27	Chip	EAR99	HMC528
11 - 16	I/Q Mixer / IRM	DC - 3.5	-8	35	26	LC4	EAR99	HMC528LC4
15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	25	25	LC4	EAR99	HMC523LC4
15 - 23.6	I/Q Mixer / IRM	DC - 3.5	-8	27	25	Chip	EAR99	HMC523
19 - 33	I/Q Mixer / IRM	DC - 5	-8	25	17	Chip	5A001.h	HMC-MDB172
22 - 32	I/Q Mixer / IRM	DC - 3.5	-10	23	20	Chip	EAR99	HMC524
22 - 32	I/Q Mixer / IRM	DC - 4.5	-10	20	20	LC3B	EAR99	HMC524LC3B
31 - 38	I/Q Mixer / IRM	DC - 3.5	-10.5	17	21	Chip	EAR99	HMC555
35 - 45	I/Q Mixer / IRM	DC - 5	-8	25	17	Chip	5A991.h	HMC-MDB171
36 - 41	I/Q Mixer / IRM	DC - 3.5	-11	18	23	Chip	EAR99	HMC556
55 - 64	I/Q Mixer / IRM	DC - 3	-9	30	16	Chip	5A991.h	HMC-MDB207
26 - 33 RF	Sub-Harmonic, I/Q Mixer / IRM	DC - 3	-11	22	16	Chip	EAR99	HMC404
54 - 64 RF	Sub-Harmonic, I/Q Mixer / IRM	DC - 3	-12.5	30	7	Chip	5A991.h	HMC-MDB218

I/Q DOWNCONVERTER / RECEIVERS

	RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Noise Figure (dB)	Image Rejection (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
	7 - 9	I/Q Downconverter / Receiver	DC - 3.5	10	2.5	35	1.5	LC5	EAR99	HMC567LC5
	9 - 12	I/Q Downconverter / Receiver	DC - 3.5	14	2	33	-1	LC5	EAR99	HMC568LC5
NEW!	9 - 12	I/Q Downconverter / Receiver	DC - 3.5	11	2.2	25	2	LC5	EAR99	HMC908LC5
	12 - 16	I/Q Downconverter / Receiver	DC - 3.5	14	2.8	32	-1	LC5	EAR99	HMC869LC5
NEW!	17 - 21	I/Q Downconverter / Receiver	DC - 3.3	11	2.2	21	2	LC5	EAR99	HMC904LC5
	17 - 21	I/Q Downconverter / Receiver	DC - 3.5	10	3	17	3	Chip	EAR99	HMC570
	17 - 21	I/Q Downconverter / Receiver	DC - 3.5	10	3	18	2	LC5	EAR99	HMC570LC5
	21 - 25	I/Q Downconverter / Receiver	DC - 3.5	11	3	24	5	Chip	EAR99	HMC571
	21 - 25	I/Q Downconverter / Receiver	DC - 3.5	10	2	20	5	LC5	EAR99	HMC571LC5
	24 - 28	I/Q Downconverter / Receiver	DC - 3.5	8	3.5	20	5	Chip	EAR99	HMC572
	24 - 28	I/Q Downconverter / Receiver	DC - 3.5	8	3.5	18	5	LC5	EAR99	HMC572LC5

I/Q UPCONVERTER / TRANSMITTERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Sideband Rejection (dBc)	OIP3 (dBm)	Package	ECCN Code	Part Number
11 - 17	I/Q Upconverter / Transmitter	DC - 2	13	-20	26	LC5	EAR99	HMC709LC5
16 - 21	I/Q Upconverter / Transmitter	DC - 3.5	12	-20	30	LC5	EAR99	HMC710LC5

I/Q UPCONVERTER / TRANSMITTERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Sideband Rejection (dBc)	OIP3 (dBm)	Package	ECCN Code	Part Number
17.7 - 23.6	I/Q Upconverter / Transmitter	DC - 3.5	15	-35	35	LC5	EAR99	HMC819LC5
21 - 27	I/Q Upconverter / Transmitter	DC - 3.75	12	-20	27	LC5	EAR99	HMC815LC5

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
High IP3 Mixers								
0.45 - 0.5	High IP3, SGL-END	DC - 0.15	-9.5	20	32	MS8	EAR99	HMC387MS8E
0.4 - 0.65	High IP3, 0 LO	DC - 0.25	-9	7	33	MS8G	EAR99	HMC585MS8GE
0.5 - 2.7	High IP3, DBL-BAL, +2 LO	DC - 1	-8	28	28	LP4	EAR99	HMC915LP4E
0.6 - 1.2	High IP3, SGL-BAL	DC - 0.3	-7.5	22	27	MS8	EAR99	HMC350MS8E
0.7 - 1.0	High IP3, SGL-END	DC - 0.25	-8.5	24	35	MS8	EAR99	HMC399MS8E
0.7 - 1.0	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7	23	32	LP4	EAR99	HMC684LP4E
0.7 - 1.1	High IP3, DBL-BAL, 0 LO	0.05 - 0.25	-7.5	24	40	LP4	EAR99	HMC786LP4
0.7 - 1.2	High IP3, DBL-BAL	DC - 0.3	-9	42	25	S8	EAR99	HMC351S8E
0.7 - 1.4	High IP3, 0 LO	DC - 0.35	-9	20	33	MS8G	EAR99	HMC483MS8GE
0.7 - 1.5	High IP3, DBL-BAL, 0 LO	DC - 0.5	-7.5	24	34	LP4	EAR99	HMC686LP4E
0.8 - 1.2	High IP3, DBL-BAL, 0 LO	DC - 0.3	-8	27	27	LP4	EAR99	HMC551LP4E
1.5 - 3.5	High IP3, DBL-BAL	DC - 1	-8	38	25	MS8	EAR99	HMC316MS8E
1.6 - 3.0	High IP3, DBL-BAL, 0 LO	DC - 1	-8	30	25	LP4	EAR99	HMC552LP4E
1.7 - 2.2	High IP3, SGL-END	DC - 0.3	-8.8	30	36	MS8	EAR99	HMC400MS8E
1.7 - 2.2	High IP3, 0 LO	0.05 - 0.3	-9.2	9	35	MS8G	EAR99	HMC485MS8GE
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	30	35	LP4	EAR99	HMC685LP4E
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	31	34	LP4	EAR99	HMC687LP4E
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	0.05 - 0.30	-8	30	38	LP4	EAR99	HMC785LP4E
1.7 - 3.0	High IP3, SGL-BAL	DC - 0.8	-9	30	30	MS8	EAR99	HMC304MS8E
1.7 - 4.0	High IP3, DBL-BAL, +4 LO	DC - 1.0	-8	32	25	LP4	EAR99	HMC215LP4E
1.8 - 2.2	High IP3, SGL-END	DC - 0.5	-8.5	25	31	MS8	EAR99	HMC402MS8E
2.2 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	25	31	LP4	EAR99	HMC688LP4E
2.2 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	26	31	LP4	EAR99	HMC689LP4E
2.3 - 4.0	High IP3, +4 LO	DC - 1	-10	15	35	LP4	EAR99	HMC615LP4E
2.4 - 4.0	High IP3, SGL-END	DC - 1	-10	30	34	MS8	EAR99	HMC214MS8E
3.3 - 3.9	High IP3, DBL-BAL, 0 LO	DC - 0.6	-8.5	28	30	LP4	EAR99	HMC666LP4E
6 - 12	High IP3, DBL-BAL	DC - 4	-8	40	30	LC3	EAR99	HMC663LC3
9 - 15	High IP3, DBL-BAL	DC - 2.5	-7.5	40	24	MS8G	EAR99	HMC410AMS8GE
Downconverter RFICs								
0.7 - 1.0	Downconverter	0.05 - 0.25	12.5	25	15	QS16	EAR99	HMC420QS16E
0.7 - 1.0	High IP3, Dual Downconverter	0.06 - 0.5	7.5	16	23	LP6C	EAR99	HMC683LP6CE
0.9 - 1.6	Hi-IP3 Downconverter w/RF Amplifier	0.05 - 0.5	30	45	6	LP4	EAR99	HMC621LP4E
0.8 - 0.96	Hi-IP3 Dual Downconverter	0.05 - 0.3	9	4	26	LP6	EAR99	HMC581LP6E
0.8 - 1.0	Hi-IP3 Downconverter	0.05 - 0.25	13.8	28	15	QS16G	EAR99	HMC377QS16GE
0.8 - 2.7	Hi-IP3 Wideband Downconverter	0.001 - 0.6	-1	48	26	LP4	EAR99	HMC334LP4E
1.4 - 2.3	Hi-IP3 Downconverter	0.05 - 0.3	9	33	19	QS16G	EAR99	HMC421QS16E
1.7 - 2.2	Hi-IP3 Downconverter	0.05 - 0.3	11	25	19	QS16G	EAR99	HMC380QS16GE
1.7 - 2.2	Hi-IP3 Dual Downconverter	50 - 300	9	10	27	LP6	EAR99	HMC381LP6E
1.7 - 2.2	Hi-IP3, Dual Downconverter	0.06 - 0.4	6	25	25	LP6C	EAR99	HMC682LP6CE
1.8 - 2.7	Hi-IP3 Downconverter w/RF Amplifier	0.05 - 0.65	33	45	11	LP4	EAR99	HMC623LP4E
0 to +7 dBm LO Double & Single Balanced Mixers								
0.6 - 1.3	Low LO, DBL-BAL	DC - 0.4	-8	35	15	MS8	EAR99	HMC423MS8E
0.7 - 1.2	0 LO, DBL-BAL	0.25 - 0.45	10	36	23	LP4	EAR99	HMC665LP4E
1.8 - 3.9	+3 LO, DBL-BAL	0.2 - 0.55	9	33	23	LP4	EAR99	HMC622LP4E
1.2 - 2.5	Low LO, DBL-BAL	DC - 1	-8	30	15	MS8	EAR99	HMC422MS8E
3 - 3.8	Low LO, SGL-BAL	DC - 1	-8.5	15	10	SOT26	EAR99	HMC333E
4 - 7	0 LO, DBL-BAL	DC - 2.5	-7	32	15	MS8G	EAR99	HMC488MS8GE
4.5 - 6.0	+7 LO, DBL-BAL	DC - 1.6	-7	30	18	MS8	EAR99	HMC218MS8E
+10 dBm LO Double & Single Balanced Mixers								
0.7 - 2.0	+10 LO, DBL-BAL	DC - 0.3	-9	45	17	S8	EAR99	HMC207S8E
0.7 - 2.0	+10 LO, DBL-BAL	DC - 0.5	-9	24	17	MS8	EAR99	HMC208MS8E
1.5 - 4.5	+10 LO, DBL-BAL	DC - 1.5	-8.5	40	19	MS8	EAR99	HMC213AMS8E
1.7 - 3.0	+10 LO, SGL-BAL	DC - 0.8	-9	30	21	MS8	EAR99	HMC272MS8E
1.7 - 3.5	+10 LO, SGL-BAL	DC - 0.9	-9	30	21	SOT26	EAR99	HMC285E
4.5 - 8.0	+10 LO, DBL-BAL	DC - 2	-8.2	35	16	C8	EAR99	HMC168C8
5 - 12	+10 LO, DBL-BAL	DC - 4	-7.5	25	17	MS8	EAR99	HMC220MS8E
7 - 10	+10 LO, DBL-BAL	DC - 2	-9	32	16	C8	EAR99	HMC171C8

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
+13 dBm LO Double & Single Balanced Mixers								
0.7 - 1.2	+13 LO, SGL-BAL	DC - 0.3	-9	26	21	MS8	EAR99	HMC277MS8E
1.7 - 4.5	+13 LO, DBL-BAL	DC - 1	-8	30	20	MS8	EAR99	HMC175MS8E
1.7 - 4.5	+13 LO, Dual Channel	DC - 1.5	-8	-	23	LP5	EAR99	HMC340ALP5E
2.5 - 4.0	+13 LO, DBL-BAL	DC - 2	-9	45	18	C8	EAR99	HMC170C8
4.5 - 9.0	+13 LO, DBL-BAL	DC - 2.5	-8.5	25	21	MS8	EAR99	HMC219MS8E
6 - 26	+13 LO, DBL-BAL	DC - 10	-9	32	20	Chip	EAR99	HMC773
6 - 26	+13 LO, DBL-BAL	DC - 8	-9	38	22	LC3B	EAR99	HMC773LC3B
7 - 14	+13 LO, DBL-BAL	DC - 5	-7	48	22	Chip	EAR99	HMC553
7 - 14	+13 LO, DBL-BAL	DC - 5	-7	50	22	LC3B	EAR99	HMC553LC3B
7 - 34	+13 LO, DBL-BAL	DC - 8	-11	35	22	LC3B	EAR99	HMC774LC3B
7 - 43	+13 LO, DBL-BAL	DC - 10	-9	35	22	Chip	EAR99	HMC774
9 - 15	+13 LO, DBL-BAL	DC - 2.5	-7.5	40 - 50	17	MS8G	EAR99	HMC412MS8GE
10 - 15	+13 LO, SGL-BAL	DC - 3	-9	27	16	MS8G	EAR99	HMC411MS8GE
11 - 20	+13 LO, DBL-BAL	DC - 6	-7	46	18	Chip	EAR99	HMC554
11 - 20	+13 LO, DBL-BAL	DC - 6	-7	46	18	LC3B	EAR99	HMC554LC3B
14 - 26	+13 LO, DBL-BAL	DC - 8	-7.5	39	20	Chip	EAR99	HMC260
14 - 26	+13 LO, DBL-BAL	DC - 8	-7.5	38	20	LC3B	EAR99	HMC260LC3B
16 - 30	+13 LO, DBL-BAL	DC - 8	-8	40	21	LC3B	EAR99	HMC292LC3B
17 - 31	+13 LO, DBL-BAL	DC - 6	-8	32	19	LM3C	EAR99	HMC292LM3C
18 - 32	+13 LO, DBL-BAL	DC - 8	-7.5	38	19	Chip	EAR99	HMC292
24 - 32	+13 LO, DBL-BAL	DC - 8	-10	38	19	LC3B	EAR99	HMC329LC3B
24 - 40	+13 LO, DBL-BAL	DC - 18	-8	35	21	Chip	EAR99	HMC560
24 - 40	+13 LO, DBL-BAL	DC - 17	-10	35	21	LM3	EAR99	HMC560LM3
25 - 40	+13 LO, DBL-BAL	DC - 8	-9.5	42	19	Chip	EAR99	HMC329
26 - 40	+13 LO, DBL-BAL	DC - 8	-8	37	19	LM3	EAR99	HMC329LM3
54 - 64	+13 LO, DBL-BAL	DC - 5	-8	30	13	Chip	5A991.h	HMC-MDB169
+15 to +20 dBm LO Double & Single Balanced Mixers								
70 - 90	+14 LO, DBL-BAL	DC - 18	-12	-	-	Chip	5A991.h	HMC-MDB277
1.8 - 5.0	+15 LO, DBL-BAL	DC - 3	-7	42	18	Chip	EAR99	HMC128
1.8 - 5.0	+15 LO, DBL-BAL	DC - 2	-10	40	18	G8 Hermetic	EAR99	HMC128G8
2.5 - 7	+15 LO, DBL-BAL	DC - 3	-7	48	22	Chip	EAR99	HMC557
2.5 - 7	+15 LO, DBL-BAL	DC - 3	-7	48	22	LC4	EAR99	HMC557LC4
4 - 8	+15 LO, DBL-BAL	DC - 3	-7	40	17	Chip	EAR99	HMC129
4 - 8	+15 LO, DBL-BAL	DC - 3	-8	30	18	G8 Hermetic	EAR99	HMC129G8
4 - 8	+15 LO, DBL-BAL	DC - 3	-7	40	17	LC4	EAR99	HMC129LC4
5.5 - 14	+15 LO, DBL-BAL	DC - 6	-7	45	24	Chip	EAR99	HMC558
5.5 - 14	+15 LO, DBL-BAL	DC - 6	-7	45	24	LC3B	EAR99	HMC558LC3B
6 - 11	+15 LO, DBL-BAL	DC - 2	-7	40	17	Chip	EAR99	HMC130
6 - 15	+15 LO, DBL-BAL	DC - 2	-8.5	35	20	C8	EAR99	HMC141C8 / 142C8
6 - 18	+15 LO, DBL-BAL	DC - 6	-10	25	21	Chip	EAR99	HMC141 / 142
7 - 14	+15 LO, DBL-BAL	DC - 2	-10	35	20	LH5 Hermetic	EAR99	HMC141LH5
14 - 23	+15 LO, DBL-BAL	DC - 2	-10.5	38	18	Chip	EAR99	HMC203
NEW! 3 - 10	+17 LO, DBL-BAL	DC - 4	-9	55	23	LC3B	EAR99	HMC787LC3B
5 - 20	+20 LO, DBL-BAL	DC - 3	-10	30	25	Chip	EAR99	HMC143 / 144
6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	23	LC4	EAR99	HMC144LC4
6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	24	LH5 Hermetic	EAR99	HMC144LH5
Sub-Harmonic Mixers								
14 - 20	Sub-Harmonic	DC - 3	-10	40	7	LM3	EAR99	HMC258LM3
14 - 21	Sub-Harmonic	DC - 3	-10	40	7	Chip	EAR99	HMC258
14.5 - 19.5	Sub-Harmonic	DC - 3.5	-10	45	5	LC3B	EAR99	HMC258LC3B
17 - 25	Sub-Harmonic	DC - 3	-9	27	10	Chip	EAR99	HMC337
NEW! 17.7 - 23.6	Sub-Harmonic, Upconverter	DC - 3.5	15	40	13	LC5	EAR99	HMC711LC5
20 - 30	Sub-Harmonic	DC - 6	-10	40	13	Chip	EAR99	HMC264
21 - 31	Sub-Harmonic	DC - 6	-9	40	13	LC3B	EAR99	HMC264LC3B
20 - 30	Sub-Harmonic	DC - 4	-9	30	10	LM3	EAR99	HMC264LM3
20 - 31	Sub-Harmonic, Downconverter	0.7 - 3.0	3	28	8	LM3	EAR99	HMC265LM3
20 - 32	Sub-Harmonic, Downconverter	0.7 - 3.0	3	30	10	Chip	EAR99	HMC265
20 - 40	Sub-Harmonic	1 - 3	-12	24	13	Chip	EAR99	HMC266
24 - 34	Sub-Harmonic	DC - 3	-11	33	13	LC3B	5A991.b	HMC338LC3B
24 - 34	Sub-Harmonic	DC - 4	-10	30	22	LC4	EAR99	HMC798LC4
26 - 33	Sub-Harmonic	DC - 2.5	-9	33	11	Chip	5A991.b	HMC338
33 - 42	Sub-Harmonic	DC - 3	-10	37	10	Chip	EAR99	HMC339

IC PRODUCTS

DEMODULATORS - *I/Q Demodulator*

Input Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Noise Figure (dB)	IIP3 / IIP2 (dBm)	Package	ECCN Code	Part Number
0.1 - 4.0	I/Q Demodulator	DC - 0.6	-3.5	15	+25 / +60	LP4	EAR99	HMC597LP4E

MODULATORS - *Bi-Phase Modulator*

Input Frequency (GHz)	Function	Loss (dB)	Amp / Phase Balance (dB/Deg)	Carrier Suppression (dBc)	Bias Control (mA)	Package	ECCN Code	Part Number
1.8 - 5.2	Bi-Phase	8	0.2 / 2.5	30	+/- 5	Chip	EAR99	HMC135
4 - 8	Bi-Phase	8	0.1 / 4.0	30	+/- 5	Chip	EAR99	HMC136
6 - 11	Bi-Phase	9	0.25 / 10.0	20	+/- 5	Chip	EAR99	HMC137

MODULATORS - *Direct Quadrature Modulator*

	Input Freq. (GHz)	Function	OIP3 (dBm) / Carrier Suppression (dBc)	Modulation Bandwidth (MHz)	Output Noise Floor (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
	0.02 - 2.7	Direct Quadrature	23 / 42	DC - 700	-162	+5V @ 160mA	LP4	EAR99	HMC696LP4E
	0.1 - 4	Direct Quadrature	23 / 42	DC - 700	-159	+5V @ 170mA	LP4	EAR99	HMC497LP4E
	0.25 - 3.8	Direct Quadrature	14 / 38	DC - 250	-158	+3.3V @ 108mA	LP3	EAR99	HMC495LP3E
	0.45 - 4.0	Direct Quadrature	22 / 43	DC - 700	-165	+5V @ 168mA	LP4	EAR99	HMC697LP4E
NEW!	0.05 - 2.7	Direct Quadrature with VGA	25 / 50	DC - 440	-159	+5V @ 120mA	LP5	3A001.a.11.b	HMC795LP5E
	4 - 7	Direct Quadrature	17 / 34	DC - 250	-157	+3V @ 93mA	LP3	EAR99	HMC496LP3E

MODULATORS - *Vector Modulators*

Frequency (GHz)	Function	Gain Range (dB)	Continuous Phase Control (deg)	IP3 / Noise Floor (Ratio)	IIP3 @ Max. Gain (dBm)	Package	ECCN Code	Part Number
0.7 - 1.0	Vector	-50 to -10	360	186.5	34	LP3	EAR99	HMC630LP3E
1.8 - 2.7	Vector	-50 to -10	360	186	35	LP3	EAR99	HMC631LP3E
1.8 - 2.2	Vector	-50 to -10	360	185	33	LP3	EAR99	HMC500LP3E

PASSIVES - *Fixed Attenuators*

Frequency (GHz)	Function	Attenuation Accuracy (dB)	Nominal Attenuation (dB)	Maximum Input Power (dBm)	Chip Size	Package	ECCN Code	Part Number
DC - 50	Thru Line	±0.2	0.15	-	17 x 18	Chip	EAR99	HMC650
DC - 50	Thru Line	±0.3	0.15	-	23 x 18	Chip	EAR99	HMC651
DC - 50	Passive	±0.2	2	27	17 x 18	Chip	EAR99	HMC652
DC - 50	Passive	±0.2	3	26	17 x 18	Chip	EAR99	HMC653
DC - 50	Passive	±0.2	4	25	17 x 18	Chip	EAR99	HMC654
DC - 50	Passive	±0.2	6	26	17 x 18	Chip	EAR99	HMC655
DC - 50	Passive	±0.1	10	25	17 x 18	Chip	EAR99	HMC656
DC - 25	Passive	±1.5	10	25	N/A	LP2	EAR99	HMC656LP2E
DC - 50	Passive	±0.4	15	25	17 x 18	Chip	EAR99	HMC657
DC - 25	Passive	±2	15	25	N/A	LP2	EAR99	HMC657LP2E
DC - 50	Passive	±0.5	20	25	23 x 18	Chip	EAR99	HMC658
DC - 25	Passive	±2	20	25	N/A	LP2	EAR99	HMC658LP2E

PHASE SHIFTERS - *Analog*

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd harmonic Pin = 10 dBm (dBc)	Control Voltage Range (Vdc)	Package	ECCN Code	Part Number
5 - 18	Analog	4	500° @ 5 GHz 100° @ 18 GHz	80	0V to +10V	Chip	EAR99	HMC247
6 - 15	Analog	7	750° @ 6 GHz 500° @ 15 GHz	40	0V to +5V	LP4	EAR99	HMC538LP4E

PHASE SHIFTERS - *Digital*

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
8 - 12	4-Bit Digital	5	22.5 to 360	40	0 / -3V	Chip	EAR99	HMC543
8 - 12	4-Bit Digital	6.5	22.5 to 360	37	0 / -3V	LC4B	EAR99	HMC543LC4B
15 - 18.5	5-Bit Digital	7	11.25 to 360	40	0 / -3	Chip	EAR99	HMC644
15 - 18.5	5-Bit Digital	7	11.25 to 360	40	0 / -3	LC5	EAR99	HMC644LC5
2.5 - 3.1	6-Bit Digital	4	5.625 to 360	54	0 / +5	Chip	EAR99	HMC647
2.5 - 3.1	6-Bit Digital	4	5.625 to 360	54	0 / +5	LP6	EAR99	HMC647LP6E
2.9 - 3.9	6-Bit Digital	4	5.625 to 360	45	0 / +5	Chip	EAR99	HMC648
2.9 - 3.9	6-Bit Digital	5	5.625 to 360	45	0 / +5	LP6	EAR99	HMC648LP6E
3 - 6	6-Bit Digital	6.5	5.625 to 360	44	0 / +5	Chip	EAR99	HMC649
3 - 6	6-Bit Digital	8	5.625 to 360	44	0 / +5	LP6	EAR99	HMC649LP6E
9 - 12	6-Bit Digital	6.5	5.625 to 360	38	0 / -3	Chip	EAR99	HMC643
9 - 12	6-Bit Digital	7	5.625 to 360	38	0 / -3	LC5	EAR99	HMC643LC5

Hittite MICROWAVE CORPORATION

SMT & Chip (Die) Products

PHASE SHIFTERS - Digital

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
9 - 12.5	6-Bit Digital	6.5	5.625 to 360	41	0 / +5	Chip	EAR99	HMC642
9 - 12.5	6-Bit Digital	7	5.625 to 360	41	0 / +5	LC5	EAR99	HMC642LC5

PHASE LOCKED LOOP - Synthesizer ICs

Frequency (GHz)	Function	Max. PFD Freq. (MHz)	Max. Reference Freq. (MHz)	Figure of Merit (Frac/Int) (dBc/Hz)	Frequency Resolution w/ 50 MHz Ref.	Bias Supply	Package	ECCN Code	Part Number
10 kHz - 8 GHz	Fractional-N w/ Int. Sweeper	75	200	-221 / -227	3 Hz	+5V @ 37mA +3.3V @ 90mA	LP6C	3A001.a.11.b	HMC701LP6CE
10 kHz - 14 GHz	Fractional-N w/ Int. Sweeper	75	200	-221 / -227	6 Hz	+5V @ 37mA +3.3V @ 136mA	LP6C	3A001.a.11.b	HMC702LP6CE
10 MHz - 8 GHz	Fractional-N	70	200	-221 / -226	3 Hz	+5V @ 7mA +3.3V @ 95mA	LP4	3A001.a.11.b	HMC700LP4E
80 MHz - 7 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 310mA	LP5	3A001.a.11.b	HMC698LP5E
160 MHz - 7 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 310mA	LP5	3A001.a.11.b	HMC699LP5E
10 MHz - 2.8 GHz	Integer-N	1300	1300	-233	50 MHz	+5V @ 250mA	QS16G	3A001.a.11.b	HMC440QS16GE

PLLs with INTEGRATED VCOs

Frequency (GHz)	Function	Closed Loop SSB Phase Noise @ 10 kHz Offset	Open Loop VCO Phase Noise @ 1 MHz Offset	Pout (dBm)	RMS Jitter Fractional Mode (fs)	Integrated PN Fractional Mode (deg rms)	Package	ECCN Code	Part Number
0.66 - 3.3	Tri-Band RF VCO	-115 dBc/Hz	-142 dBc/Hz	+10	190	0.10	LP6C	3A001.a.11.b	HMC822LP6CE
0.78 - 0.87	RF VCO	-120 dBc/Hz	-147 dBc/Hz	+12	190	0.05	LP6C	3A001.a.11.b	HMC824LP6CE
0.86 - 4.16	Tri-Band RF VCO	-113 dBc/Hz	-140 dBc/Hz	+10	190	0.12	LP6C	3A001.a.11.b	HMC821LP6CE
0.99 - 1.105	RF VCO	-118 dBc/Hz	-145 dBc/Hz	+10	190	0.07	LP6C	3A001.a.11.b	HMC826LP6CE
1.095 - 5.10	Tri-Band RF VCO	-110 dBc/Hz	-139 dBc/Hz	+10	190	0.17	LP6C	3A001.a.11.b	HMC820LP6CE
1.285 - 1.415	RF VCO	-116 dBc/Hz	-142 dBc/Hz	+10	190	0.10	LP6C	3A001.a.11.b	HMC828LP6CE
1.815 - 2.01	RF VCO	-112 dBc/Hz	-141 dBc/Hz	+9	190	0.13	LP6C	3A001.a.11.b	HMC831LP6CE
3.365 - 3.705	RF VCO	-107 dBc/Hz	-135 dBc/Hz	0	190	0.25	LP6C	3A001.a.11.b	HMC836LP6CE
7.3 - 8.2	Microwave VCO	-102 dBc/Hz	-140 dBc/Hz	+15	196	0.55	LP6C	3A001.a.11.b	HMC764LP6CE
7.8 - 8.8	Microwave VCO	-102 dBc/Hz	-139 dBc/Hz	+13	193	0.58	LP6C	3A001.a.11.b	HMC765LP6CE
11.5 -12.5	Microwave VCO	-100 dBc/Hz	-134 dBc/Hz	+11	181	0.78	LP6C	3A001.a.11.b	HMC783LP6CE
12.4 - 13.4	Microwave VCO	-98 dBc/Hz	-134 dBc/Hz	+8	175	0.81	LP6C	3A001.a.11.b	HMC807LP6CE

** Figure of merit (FOM) of synthesizer is -225/-226 dBc/Hz (fractional/integer).*

POWER CONDITIONING – High PSRR Quad Linear Voltage Regulators

Input Voltage (V)	Function	Output Voltage (V)	Output Current (mA)	Power Supply Rejection Ratio (PSRR) (dB)		Output Noise Spectral Density (nV/√Hz)		Regulated Outputs	Package	ECCN Code	Part Number
				1 kHz	1 MHz	1 kHz	10 kHz				
3.35 - 5.6	Quad High PSRR	2.5 - 5.2	15 - 100	80	60	7	3	4	LP3	EAR99	HMC860LP3E

POWER DETECTORS

Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV/dB)	RF Threshold Level (dBm)	Bias Supply	Package	ECCN Code	Part Number
Log Detector/Controller								
50 Hz - 3.0	Log Detector / Controller	74 ±3	19	-66	+3.3V @ 29mA	LP4	EAR99	HMC612LP4E
0.001 - 8.0	Log Detector / Controller	70 ±3	-25	-61	+5V @ 113mA	LP4	EAR99	HMC602LP4E
0.001 - 10.0	Log Detector / Controller	73 ±3	-25	-65	+5V @ 103mA	Chip	EAR99	HMC611
0.001 - 10.0	Log Detector / Controller	70 ±3	-25	-65	+5V @ 106mA	LP4	EAR99	HMC611LP4E
0.01 - 4.0	Log Detector / Controller	70 ±3	19	-68	+3.3V @ 30mA	LP4	EAR99	HMC601LP4E
0.05 - 4.0	Log Detector / Controller	70 ±3	19	-69	+3.3V @ 29mA	LP4	EAR99	HMC600LP4E
0.05 - 8.0	Log Detector / Controller	54 ±1	17.5	-55	+5V @ 17mA	LP3	EAR99	HMC713LP3E
0.1 - 2.7	Log Detector / Controller	54 ±1	17.5	-52	+5V @ 17mA	MS8	EAR99	HMC713MS8E
8 - 30	Log Detector	54 ±3	13.3	-55	+3.3V @ 88mA	LP3	EAR99	HMC662LP3E
RMS Power Detectors								
DC - 3.9	True RMS Power Detector	69 ±1	37	-60	+5V @ 65 mA	LP4	EAR99	HMC610ALP4E
Successive Detection Log Video Amplifier								
0.1 - 20	SDLVA	59	14	-54	+3.3V @ 83mA	LC4B	EAR99	HMC613LC4B
NEW! 0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80mA	Chip	EAR99	HMC913
0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80mA	LC4B	EAR99	HMC913LC4B

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
SPST & SPDT Switches								
DC - 6	SPST, Failsafe	0.7	25	27	0 / +2.2 to +5V	SOT26	EAR99	HMC550E

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
DC - 6	SPST, Hi Isolation	1.4	52	27	0 / -5V	G7 Hermetic	EAR99	HMC231G7
DC - 2.5	SPDT, Reflective	0.4	36	29	0 / -5V	S8	EAR99	HMC239S8E
DC - 3	SPDT, Reflective	0.4	27	30	0 / +3V	MS8	EAR99	HMC190AMS8E
DC - 3	SPDT, Hi Isolation	0.7	50	23	0 / +5V	MS8	EAR99	HMC194MS8E
DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	EAR99	HMC197AE
DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	EAR99	HMC221AE
DC - 3	SPDT, Reflective	0.3	31	34	0 / +3 to +8V	SOT26	EAR99	HMC545E
DC - 3.5	SPDT, Hi Isolation	0.5	45	25	0 / +5V	MS8G	EAR99	HMC284MS8GE
DC - 4	SPDT, Reflective	0.5	28	29	0 / -5V or +5V / 0	Chip	EAR99	HMC240
DC - 4	SPDT, Hi Isolation	0.9	65	31	0 / +5V	LP4C	EAR99	HMC349LP4CE
DC - 4	SPDT, Hi Isolation	0.9	57	31	0 / +5V	MS8G	EAR99	HMC349MS8GE
DC - 4	SPDT, Hi Isolation	1.1	47	31	0 / +5V	MS8G	EAR99	HMC435MS8GE
DC - 6	SPDT, Hi Isolation	1.4	50	26	0 / -5V	G7 Hermetic	EAR99	HMC232G7
DC - 6	SPDT, Hi Isolation	1.4	43	26	0 / -5V	G8 Hermetic	EAR99	HMC232G8
DC - 6	SPDT, Hi Isolation	1.4	43	26	0 / -5V	G8 Hermetic	EAR99	HMC233G8
DC - 6	SPDT, Hi Isolation	1.6	42	25	0 / +5V	MS8G	EAR99	HMC336MS8GE
DC - 6	SPDT, Hi Isolation	1.4	46	27	0 / -5V	G7	EAR99	HMC607G7
DC - 6	SPDT, Hi Isolation	0.8	60	35	0 / +3 to +5V	LP4C	EAR99	HMC849LP4CE
DC - 8	SPDT, Hi Isolation	1.4	50	26	0 / -5V	C8	EAR99	HMC232C8
DC - 8	SPDT, Hi Isolation	1.5	45	26	0 / -5V	C8	EAR99	HMC234C8
DC - 8	SPDT, Hi Isolation	1.2	48	23	0 / -5V	MS8G	EAR99	HMC270MS8GE
DC - 8	SPDT, Hi Isolation	2.0	44	23	0 / -5V	C8	EAR99	HMC347C8
DC - 8	SPDT, Hi Isolation	2.2	35	23	0 / -5V	G8 Hermetic	EAR99	HMC347G8
DC - 12	SPDT, Hi Isolation	1.5	55	27	0 / -5V	LP4	EAR99	HMC232LP4E
DC - 15	SPDT, Hi Isolation	1.4	50	26	0 / -5V	Chip	EAR99	HMC232
DC - 15	SPDT, Hi Isolation	1.6	44	23	0 / -5V	LP3	EAR99	HMC347LP3E
DC - 15	SPDT, Hi Isolation	1.7	60	26	0 / -5V	Chip	EAR99	HMC607
DC - 20	SPDT, Hi Isolation	1.7	45	23	0 / -5V	Chip	EAR99	HMC347
DC - 20	SPDT, Hi Isolation	1.8	47	23	0 / -5V	LP3	EAR99	HMC547LP3E
55 - 86	SPDT, Reflective	2	30	-	-5 / +5	Chip	5A991.h	HMC-SDD112
0.1 - 2.1	SPDT, 40W, Failsafe	0.4	22	46	0 / +3V to +8V	LP2	EAR99	HMC646LP2E
0.2 - 2.2	SPDT, 10W, Failsafe	0.4	40	> 40	0 / +3 to +8V	MS8G	EAR99	HMC546MS8GE
0.2 - 2.7	SPDT, 10W, Failsafe	0.4	35	43	0 / +3 to +8V	LP2	EAR99	HMC546LP2E
0.824 - 0.894	SPDT, 10W, T/R	0.6	22	> 40	0 / +5V	SOT26	EAR99	HMC446E
DC - 2.5	SPDT, CATV	0.6	58	28	0 / +5V	LP3	EAR99	HMC348LP3E
DC - 3	SPDT T/R	0.5	25	39	TTL/CMOS	MS8	EAR99	HMC174MS8E
DC - 3	SPDT, 5W, T/R	0.3	30	39	0 / +3 to +10V	MS8	EAR99	HMC574MS8E
DC - 3	SPDT, 3W, T/R	0.3	30	37	0 / +3 to +10V	SOT26	EAR99	HMC595E
DC - 4	SPDT T/R	0.25	23	39	0 / +3 to +5V	SOT26	EAR99	HMC544E
DC - 4	SPDT, 10W, T/R	0.4	30	40	0 / +3 to +8V	MS8G	EAR99	HMC784MS8GE
DC - 6	SPDT T/R	0.5	27	37	0 / +3 to +5V	MS8G	EAR99	HMC536MS8GE
DC - 6	SPDT T/R	0.6	27	37	0 / +3 to +5V	LP2	EAR99	HMC536LP2E
5 - 6	SPDT T/R	1.2	31	33	TTL/CMOS	MS8	EAR99	HMC224MS8E
Multi-Throw Switches								
DC - 3.5	SP3T	0.5	44	26	TTL/CMOS	QS16	EAR99	HMC245QS16E
DC - 2	SP4T	0.8	32	24	0 / -5V	S14	EAR99	HMC182S14E
DC - 3.5	SP4T	0.5	45	25	TTL/CMOS	QS16	EAR99	HMC241QS16E
DC - 4	SP4T	0.6	47	26	TTL/CMOS	LP3	EAR99	HMC241LP3E
DC - 4	SP4T	0.7	40	25	TTL/CMOS	G16 Hermetic	EAR99	HMC244G16
DC - 8	SP4T	1.8	42	21	0 / -5V	Chip	EAR99	HMC344
DC - 8	SP4T	2.0	45	26	0 / -5V	LC3	EAR99	HMC344LC3
DC - 8	SP4T	1.8	40	21	0 / -5V	LP3	EAR99	HMC344LP3E
DC - 8	SP4T	2.2	32	21	0 / 5V	LP3	EAR99	HMC345LP3E
DC - 12	SP4T	1.8	42	27	0 / -5V	LH5 Hermetic	EAR99	HMC344LH5
DC - 18	SP4T	2.1	42	24	0 / -5V	Chip	EAR99	HMC641
NEW! DC - 20	SP4T	2.1	42	23	0 / -5V	LC4	EAR99	HMC641LC4
DC - 3	SP6T	0.8	41	24	TTL/CMOS	QS24	EAR99	HMC252QS24E
DC - 2	SP8T	1.3	30	20	0 / -5V	QS24	EAR99	HMC183QS24E
DC - 2.5	SP8T	1.1	36	23	TTL/CMOS	QS24	EAR99	HMC253QS24E
DC - 3.5	SP8T	1.2	36	24	TTL/CMOS	LC4	EAR99	HMC253LC4
DC - 8	SP8T	2.3	40	23	0 / 5V	LP4	EAR99	HMC321LP4E
DC - 10	SP8T	2	38	23	0 / -5V	Chip	EAR99	HMC322
DC - 8	SP8T	2.5	25	23	0 / -5V	LP4	EAR99	HMC322LP4E
Bypass, Diversity, Matrix & Transfer Switches								
DC - 2.5	Bypass DPDT	0.3	25	23	0 / +5V	MS8	EAR99	HMC199MS8E

SMT & Chip (Die) Products

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
4.9 - 5.9	DPDT or SP3T	1	23	30	0 / +3V	MS8G	EAR99	HMC436MS8GE
5 - 6	Diversity DPDT	1.2	20	30	0 / +5V	MS8G	EAR99	HMC393MS8GE
0.2 - 3.0	4x2 Matrix	6	44	26	0 / +5V	LP4	EAR99	HMC276LP4E
0.2 - 3.0	4x2 Matrix	6.5	43	22	0 / +3 to +5V	LP4	EAR99	HMC596LP4E
0.7 - 3.0	4x2 Matrix	5.8	33	26	0 / +5V	QS24	EAR99	HMC276QS24E
DC - 8.0	Transfer	1.2	42	26	0 / +5V	LP3	EAR99	HMC427LP3E

VARIABLE GAIN AMPLIFIERS

Frequency (GHz)	Function	Gain Control Range (dB)	NF * (dB)	OIP3 * (dBm)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
2.3 - 2.5	Analog	-8 to 22	2.5	7	3	+3V @ 9mA	MS8	EAR99	HMC287MS8E
6 - 17	Analog	23	5	30	22	+5V @ 170mA	Chip	EAR99	HMC694
6 - 17	Analog	23	6	30	22	+5V @ 175mA	LP4	EAR99	HMC694LP4E
0.03 - 0.4	5-Bit digital, Differential Outputs	-4 to +19	5	40	25	+5V @ 240mA	LP4	EAR99	HMC680LP4E
0.05 - 0.8	5-Bit Digital	-8 to 15	5	35	18	+5V @ 65mA	LP4	EAR99	HMC628LP4E
0.07 - 4.0	6-Bit Digital, Serial & Parallel Control	-19.5 to 12	4	39	23	+5V @ 150mA	LP5	EAR99	HMC742LP5E
0.7 - 1.2	6-Bit Digital, Serial & Parallel Control	-2.5 to +29	0.8	38.5	21	+5V @ 236mA	LP5	EAR99	HMC707LP5E
1.7 - 2.2	6-Bit Digital, Serial & Parallel Control	-2.5 to +29	1.0	37.5	21.5	+5V @ 252mA	LP5	EAR99	HMC708LP5E
DC - 1	6-Bit Digital, Serial & Parallel Control	-11.5 to 20	4.3	36	20	+5V @ 90mA	LP5	EAR99	HMC627LP5E
DC - 1	6-Bit Digital, Parallel Control	8.5 to 40	2.8	36	20	+5V @ 176mA	LP5	EAR99	HMC626LP5E
DC - 1	6-Bit Digital, Serial Control	13.5 to 45	2.7	36	20	+5V @ 176mA	LP5	EAR99	HMC681LP5E
DC - 6	6-Bit Digital, Serial & Parallel Control	-13.5 to 18	6	33	19	+5V @ 88mA	LP5	EAR99	HMC625LP5E
DC - 4	12-Bit Digital, Serial Control	-45 to +18	6	33	18	+5V @ 82mA	LP6C	EAR99	HMC743LP6CE

** Maximum Gain State*

VOLTAGE CONTROLLED OSCILLATORS*

Fo Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
VCOs with Buffer Amplifier								
2.05 - 2.25	VCO with Buffer	3.5	-89	-112	+3V @ 35mA	LP4	EAR99	HMC384LP4E
2.25 - 2.5	VCO with Buffer	4.5	-89	-115	+3V @ 35mA	LP4	EAR99	HMC385LP4E
2.6 - 2.8	VCO with Buffer	5	-88	-115	+3V @ 35mA	LP4	EAR99	HMC386LP4E
2.75 - 3.0	VCO with Buffer	4.5	-89	-114	+3V @ 37mA	LP4	EAR99	HMC416LP4E
3.15 - 3.4	VCO with Buffer	4.9	-88	-113	+3V @ 39mA	LP4	EAR99	HMC388LP4E
3.35 - 3.55	VCO with Buffer	4.7	-89	-112	+3V @ 41mA	LP4	EAR99	HMC389LP4E
3.55 - 3.9	VCO with Buffer	4.7	-87	-112	+3V @ 42mA	LP4	EAR99	HMC390LP4E
3.9 - 4.45	VCO with Buffer	5	-81	-106	+3V @ 30mA	LP4	EAR99	HMC391LP4E
4.45 - 5.0	VCO with Buffer	4	-79	-105	+3V @ 30mA	LP4	EAR99	HMC429LP4E
5.0 - 5.5	VCO with Buffer	2	-80	-103	+3V @ 27mA	LP4	EAR99	HMC430LP4E
5.5 - 6.1	VCO with Buffer	2	-80	-102	+3V @ 27mA	LP4	EAR99	HMC431LP4E
5.8 - 6.8	VCO with Buffer	10	-82	-105	+3V @ 100mA	MS8G	EAR99	HMC358MS8GE
6.1 - 6.72	VCO with Buffer	4.5	-73	-101	+3V @ 31mA	LP4	EAR99	HMC466LP4E
6.8 - 7.4	VCO with Buffer	11	-80	-106	+3V @ 80mA	LP4	EAR99	HMC505LP4E
7.1 - 7.9	VCO with Buffer	14	-80	-101	+3V @ 85mA	LP4	EAR99	HMC532LP4E
7.8 - 8.7	VCO with Buffer	14	-80	-103	+3V @ 77mA	LP4	EAR99	HMC506LP4E
8.6 - 10.2	VCO with ÷4	18	-70	-100	+5V @ 220mA	LP5	3A001.a.11.b	HMC734LP5E
10.5 - 12.2	VCO with ÷4	17	-75	-100	+5V @ 220mA	LP5	3A001.a.11.b	HMC735LP5E
13.2 -13.5	VCO with ÷8	-8	-83	-110	+5V @ 230mA	QS16G	3A001.a.11.b	HMC401QS16GE
14.0 - 15.0	VCO with ÷8	6	-75	-110	+5V @ 260mA	QS16G	3A001.a.11.b	HMC398QS16GE
23.8 - 24.8	VCO with ÷16	12	-70	-95	+5V @ 220mA	LP4	3A001.a.11.b	HMC533LP4E
Wideband VCOs								
4 - 8	Wideband VCO	5	-75	-100	+5V @ 55mA	LC4B	EAR99	HMC586LC4B
5 - 10	Wideband VCO	5	-65	-95	+5V @ 55mA	LC4B	EAR99	HMC587LC4B
8 - 12.5	Wideband VCO	5	-65	-93	+5V @ 55mA	LC4B	EAR99	HMC588LC4B

** HMC VCOs integrate resonator, negative resistance generator and tuning varactor circuits on-chip. No external components are required.*

VOLTAGE CONTROLLED OSCILLATORS WITH Fo/2 OUTPUT

Fo Frequency (GHz)	Fo/2 Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
VCOs with Fo/2									
6.65 - 7.65	3.325 - 3.825	VCO with Fo/2	13	-90	-115	+5V @ 230mA	LP5	EAR99	HMC507LP5E
7.3 - 8.2	3.65 - 4.1	VCO with Fo/2	15	-90	-116	+5V @ 240mA	LP5	EAR99	HMC508LP5E
7.8 - 8.8	3.9 - 4.4	VCO with Fo/2	13	-90	-115	+5V @ 250mA	LP5	EAR99	HMC509LP5E

VOLTAGE CONTROLLED OSCILLATORS WITH Fo/2 OUTPUT

Fo Frequency (GHz)	Fo/2 Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
9.05 - 10.15	4.525 - 5.075	VCO with Fo/2	13	-88	-115	+5V @ 265mA	LP5	EAR99	HMC511LP5E
14.5 - 15.0	7.25 - 7.5	VCO with Fo/2	9	-80	-105	+4.2V @ 150mA	LP4	EAR99	HMC736LP4E
14.9 - 15.5	7.45 - 7.75	VCO with Fo/2	9	-80	-105	+4.2V @ 150mA	LP4	EAR99	HMC737LP4E
VCOs with Fo/2 & ÷4									
8.45 - 9.55	4.225 - 4.775	VCO with Fo/2 & ÷4	13	-92	-116	+5V @ 315mA	LP5	3A001.a.11.b	HMC510LP5E
9.5 - 10.8	4.75 - 5.4	VCO with Fo/2 & ÷4	11	-85	-110	+5V @ 350mA	LP5	3A001.a.11.b	HMC530LP5E
9.6 - 10.8	4.8 - 5.4	VCO with Fo/2 & ÷4	9	-85	-111	+5V @ 330mA	LP5	3A001.a.11.b	HMC512LP5E
10.43 - 11.46	5.215 - 5.73	VCO with Fo/2 & ÷4	7	-85	-110	+3V @ 275mA	LP5	3A001.a.11.b	HMC513LP5E
10.6 - 11.8	5.3 - 5.9	VCO with Fo/2 & ÷4	11	-82	-110	+5V @ 350mA	LP5	3A001.a.11.b	HMC534LP5E
11.1 - 12.4	5.55 - 6.2	VCO with Fo/2 & ÷4	9	-83	-110	+5V @ 350mA	LP5	3A001.a.11.b	HMC582LP5E
11.17 - 12.02	5.585 - 6.01	VCO with Fo/2 & ÷4	7	-87	-110	+3V @ 275mA	LP5	3A001.a.11.b	HMC514LP5E
11.5 - 12.5	5.75 - 6.25	VCO with Fo/2 & ÷4	10	-83	-110	+5V @ 200mA	LP5	3A001.a.11.b	HMC515LP5E
11.5 - 12.8	5.75 - 6.4	VCO with Fo/2 & ÷4	11	-80	-110	+5V @ 350mA	LP5	3A001.a.11.b	HMC583LP5E
12.4 - 13.4	6.2 - 6.7	VCO with Fo/2 & ÷4	8	-83	-110	+5V @ 260mA	LP5	3A001.a.11.b	HMC529LP5E
12.5 - 13.9	6.25 - 6.95	VCO with Fo/2 & ÷4	10	-81	-110	+5V @ 330mA	LP5	3A001.a.11.b	HMC584LP5E
13.6 - 14.9	6.8 - 7.45	VCO with Fo/2 & ÷4	7	-82	-110	+5V @ 260mA	LP5	3A001.a.11.b	HMC531LP5E
14.25 - 15.65	7.125 - 7.825	VCO with Fo/2 & ÷4	9	-80	-107	+5V @ 350mA	LP5	3A001.a.11.b	HMC632LP5E
VCOs with Fo/2 & ÷16									
20.9 - 23.9	10.45 - 11.95	VCO with Fo/2 & ÷16	9	-65	-95	+5V @ 200mA	LP4	3A001.a.11.b	HMC738LP4E
23.8 - 26.8	11.9 - 13.4	VCO with Fo/2 & ÷16	8	-64	-93	+5V @ 200mA	LP4	3A001.a.11.b	HMC739LP4E

PHASE LOCKED OSCILLATOR

Fo Frequency (GHz)	Function	Fo Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	ECCN Code	Part Number
14.7 - 15.4	Phase Locked Oscillator	9	-80	-110	+5V @ 340mA +12V @ 28mA	LP4	3A001.a.11.b	HMC535LP4E

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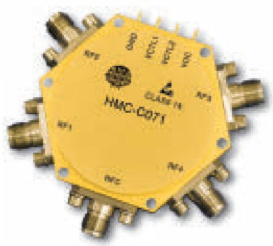

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AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package / Connector	ECCN Code	Part Number
1 - 12	Low Noise	16	30	1.8	16	+6V @ 60mA	C-10B / SMA	EAR99	HMC-C059
1.8 - 4.2	Low Noise	26	26	0.7	15.5	+8V @ 112mA	C-10 / SMA	EAR99	HMC-C045
5 - 9	Low Noise	24	25	1.4	15	+12V @ 105mA	C-10 / SMA	EAR99	HMC-C048
29 - 36	Low Noise	20	22	2.9	11	+3V @ 80mA	C-10 / 2.92mm	3A001.b.4.c	HMC-C027
2 - 20	Wideband LNA	15	25	2.5	14	+12V @ 65mA	C-1 / SMA	EAR99	HMC-C001
2 - 20	Wideband LNA	14	26	2	18	+12V @ 60mA	C-2 / SMA	EAR99	HMC-C002
2 - 20	Wideband LNA	14	27	2	16	+8V @ 75mA	C-2B / SMA	EAR99	HMC-C022
7 - 17	Wideband LNA	22	25	2	14	+8V @ 93mA	C-1 / SMA	EAR99	HMC-C016
17 - 27	Wideband LNA	18	25	3	14	+8V @ 96mA	C-1B / 2.92mm	EAR99	HMC-C017
0.01 - 15	Wideband Driver	16	33	3	23	+12V @ 195mA	C-3 / SMA	3A001.b.4.f	HMC-C004
0.01 - 15	Wideband Driver	15	30	3	23	+12V @ 225mA	C-3B / SMA	3A001.b.4.f	HMC-C024
2 - 35	Wideband Driver	12	29	3	18	+11V @ 92mA	C-10 / 2.92mm	3A001.b.4.c	HMC-C038
0.01 - 6.0	Power Amplifier, 1 Watt	13	40	5	29.5	-5V @ 5mA +15V @ 450mA	C-17 / SMA	EAR99	HMC-C074
0.01 - 6.0	Power Amplifier, 1 Watt	24	42	5	29.5	-5V @ 5mA +15V @ 740mA	C-17 / SMA	EAR99	HMC-C075
0.05 - 15	Wideband Power Amplifier, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-10B / SMA	3A001.b.4.f	HMC-C036
0.05 - 15	Wideband Power Amplifier, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-12 / SMA	3A001.b.4.f	HMC-C037
2 - 20	Wideband Power Amplifier	15	34	4	26	+12V @ 310mA	C-2 / SMA	3A001.b.4.f	HMC-C003
2 - 20	Wideband Power Amplifier	15	34	4	26	+12V @ 310mA	C-2B / SMA	3A001.b.4.f	HMC-C023
2 - 20	Wideband Power Amplifier	31	33	3	26	+12V @ 400mA	C-3B / SMA	3A001.b.4.f	HMC-C026
17 - 24	Wideband Power Amplifier	22	33	3.5	24	+8V @ 250mA	C-10 / 2.92mm	3A001.b.4.f	HMC-C020
21 - 31	Wideband Power Amplifier	15	32	5	24	+8V @ 215mA	C-10 / 2.92mm	3A001.b.4.c	HMC-C021
0.4 - 1.0	10 Watt Power Amplifier	40	54	12	40	+12V @ 6.5A	C-7 / SMA	EAR99	HMC-C012
0.8 - 2.0	10 Watt Power Amplifier	43	56	12	40	+12V @ 6.5A	C-7 / SMA	EAR99	HMC-C013
1.8 - 2.2	15 Watt Power Amplifier	42	53	6	42	+14V @ 6.5A	C-7 / SMA	EAR99	HMC-C008

AMPLIFIERS - Low Phase Noise

	Frequency (GHz)	Function	Gain / NF (dB)	OIP3 (dBm)	Phase Noise (dBc/Hz)	P1dB / Psat (dBm)	Bias Supply	Package / Connector	ECCN Code	Part Number
	1.5 - 5.0	Low Phase Noise	14 / 4.5	26.5	-157	17 / 22	+7V @ 170mA	C-16 / SMA	EAR99	HMC-C077
	2 - 18	Low Phase Noise	13.5 / 5	22.5	-150	15 / 18.5	+5V @ 80mA	C-1 / SMA	EAR99	HMC-C050
NEW!	4 - 8	Low Phase Noise	9 / 6	33	-180	22 / 25	+7V @ 300mA	C-16 / SMA	EAR99	HMC-C079
	6 - 12	Low Phase Noise	11 / 4.5	34	-174	20 / 22	+7V @ 170mA	C-16 / SMA	EAR99	HMC-C072
	7 - 11	Low Phase Noise	9 / 6	33	-180	22 / 25	+7V @ 300mA	C-16 / SMA	EAR99	HMC-C076

ATTENUATORS - Analog & Digital

Frequency (GHz)	Function	Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package / Connector	ECCN Code	Part Number
DC - 20	Analog VVA	5.5	35	10	-5	C-10 / SMA	EAR99	HMC-C053
DC - 13	6-Bit Digital, Serial Control	3.6	0.5 to 31.5	32	Serial TTL/CMOS	C-6 / SMA	EAR99	HMC-C018
DC - 13	6-Bit Digital	3.2	0.5 to 31.5	38	0 / +5V	C-6 / SMA	EAR99	HMC-C025

DIELECTRIC RESONATOR OSCILLATORS (DRO)

Frequency (GHz)	Function	Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Frequency Drift (ppm/°C)	Bias Supply	Package	ECCN Code	Part Number
8.0 - 8.3	Dielectric Resonator Oscillator	14.5	-122	-140	2	+6 to +15V @ 125mA	C-18 / SMA	EAR99	HMC-C200

FREQUENCY DIVIDERS (PRESCALERS)

Input Freq. (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package / Connector	ECCN Code	Part Number
DC - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 75mA	C-1 / SMA	3A001.a.11.b	HMC-C005
DC - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 93mA	C-1 / SMA	3A001.a.11.b	HMC-C006
0.5 - 8	Divide-by-5	-15 to +10	-1	-155	+5V @ 80mA	C-1 / SMA	3A001.a.11.b	HMC-C039
DC - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 98mA	C-1 / SMA	3A001.a.11.b	HMC-C007
0.5 - 17	Divide-by-10	-15 to +10	-1	-155	+5V @ 152mA	C-1 / SMA	3A001.a.11.b	HMC-C040

FREQUENCY MULTIPLIERS - Active

Input Freq. (GHz)	Function	Output Freq. (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package / Connector	ECCN Code	Part Number
3 - 5	x2 Active	6 - 10	3	17	-140	C-10 / SMA	EAR99	HMC-C031
9.0 - 14.5	x2 Active	18 - 29	3	16	-132	C-10 / 2.92mm	EAR99	HMC-C032
12.0 - 16.5	x2 Active	24 - 33	3	17	-132	C-10 / 2.92mm	EAR99	HMC-C033
16 - 23	x2 Active	32 - 46	3	13	-130	C-10 / 2.92mm	EAR99	HMC-C034
4.0 - 10.5	x2 Active	8 - 21	6	14	-142	C-10 / SMA	EAR99	HMC-C056

HIGH SPEED DIGITAL LOGIC

Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vpp)	DC Power (mW)	Vee Power Supply (Vdc)	Package / Connector	ECCN Code	Part Number
50 / 25	AND / NAND / OR / NOR	9 / 10	2	0.5	560	-3.3	C-13 / 1.85mm	3A001.a.11.b	HMC-C065
50 / 30	1:2 Fanout Buffer	9.5 / 11	2	0.5	455	-3.3	C-13 / 1.85mm	3A001.a.11.b	HMC-C062
43 / 43	D-Type Flip-Flop	9 / 10	1.5	0.5	580	-3.3	C-13 / 1.85mm	3A001.a.11.b	HMC-C060
50 / 25	D-Type Flip-Flop Double Edge Triggered	8.5 / 10	1.5	0.5	690	-3.3	C-13 / 1.85mm	3A001.a.11.b	HMC-C061
50 / 25	XOR / XNOR	6.5 / 10	2	0.5	550	-3.3	C-13 / 1.85mm	3A001.a.11.b	HMC-C064

I/Q MIXERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	IIP3 (dBm)	Package / Connector	ECCN Code	Part Number
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	35	23	C-4 / SMA	EAR99	HMC-C009
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	35	25	C-4 / SMA	EAR99	HMC-C041
8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-8	28	25	C-4 / SMA	EAR99	HMC-C042
11 - 16	I/Q Mixer / IRM	DC - 3.5	-9	30	28	C-4 / SMA	EAR99	HMC-C043
15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	30	25	C-4 / 2.92mm & SMA	EAR99	HMC-C044
20 - 31	I/Q Mixer / IRM	DC - 4.5	-10	24	22.5	C-4B / 2.92mm & SMA	EAR99	HMC-C046
30 - 38	I/Q Mixer / IRM	DC - 3.5	-10.5	15	19	C-4 / 2.92mm & SMA	EAR99	HMC-C047

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO/RF Isolation (dB)	IIP3 (dBm)	Package / Connector	ECCN Code	Part Number
7 - 14	+13 LO, DBL-BAL	DC - 5	-7	48	20	C-11 / SMA	EAR99	HMC-C049
11 - 20	+13 LO, DBL-BAL	DC - 6	-7	43	18	C-11 / SMA	EAR99	HMC-C051
16 - 32	+13 LO, DBL-BAL	DC - 8	-8	35	19	C-11 / 2.92mm & SMA	EAR99	HMC-C014
23 - 37	+13 LO, DBL-BAL	DC - 13	-9	35	19	C-11 / 2.92mm & SMA	EAR99	HMC-C035
24 - 38	+13 LO, DBL-BAL	DC - 8	-8.5	35	20	C-11 / 2.92mm & SMA	EAR99	HMC-C015

CONNECTORIZED MODULES

Hittite MICROWAVE CORPORATION

Robust, High Performance RF to Light Solutions

PHASE SHIFTERS - Analog

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd harmonic Pin = 10 dBm (dBc)	Control Voltage Range (Vdc)	Package / Connector	ECCN Code	Part Number
6 - 15	Analog	7	750° @ 6 GHz 450° @ 15 GHz	40	0V to +5V	C-1 / SMA	EAR99	HMC-C010

PHASE SHIFTERS - Digital

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Voltage Range (Vdc)	Package / Connector	ECCN Code	Part Number
8 - 12	4-Bit Digital	7	22.5 to 360	38	0V to +5V	C-6 / SMA	EAR99	HMC-C055

POWER DETECTORS

	Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package / Connector	ECCN Code	Part Number
	1 - 20	SDLVA *	59	14	-67	+12V @ 86mA	C-10 / 2.92mm	EAR99	HMC-C052
NEW!	2 - 20	SDLVA * w/ Limited RF Output	50	45	-45	+12V @ 370mA -5V @ 20mA	C-21 / SMA	EAR99	HMC-C078

** Successive Detection Log Video Amplifier*

SWITCHES - SPST, SPDT & SP4T

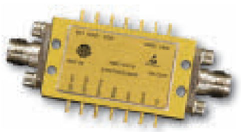
Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package / Connector	ECCN Code	Part Number
DC - 20	SPST, Hi Isolation	3	100	23	0 / +5V	C-9 / SMA	EAR99	HMC-C019
DC - 18	SPDT, Hi Isolation	2	55	27	0 / +5V	C-14 / SMA	EAR99	HMC-C058
DC - 20	SPDT, Hi Isolation	2	40	23	0 / -5V	C-5 / SMA	EAR99	HMC-C011
DC - 20	SP4T, Hi Isolation	3	40	24	0 / +5V	C-15 / SMA	EAR99	HMC-C071

SYNTHESIZER MODULE - MicroSynth™

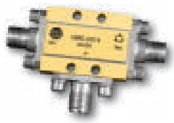
Frequency (GHz)	Function	Min. Step Size Resolution (Hz)	Reference Frequency (MHz)	Phase Noise @ 100 kHz Offset (dBc/Hz)	Output Power (dBm)	Bias Supply	Package	ECCN Code	Part Number
5.5 - 10.5	MicroSynth™ Synthesizer	1.2	10	-92	21	+20V @ 20mA +6V @ 300mA +3.6V @ 100mA	C-20 / SMA	3A001.a.11.b	HMC-C070

VOLTAGE CONTROLLED OSCILLATORS*

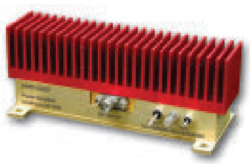
Frequency (GHz)	Function	Output Power (dBm)	10k Hz SSB Phase Noise (dBc/Hz)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package / Connector	ECCN Code	Part Number
4 - 8	Wideband VCO	20	-75	-95	+12V @ 185mA	C-1 / SMA	EAR99	HMC-C028
5 - 10	Wideband VCO	20	-64	-93	+12V @ 195mA	C-1 / SMA	EAR99	HMC-C029
8 - 12.5	Wideband VCO	21	-59	-83	+12V @ 195mA	C-1 / SMA	EAR99	HMC-C030
38.4 - 43.2	Wideband VCO	13	-74	-98	+5V @ 350mA	C-19 / SMA	EAR99	HMC-C073



C-20



C-11



C-12

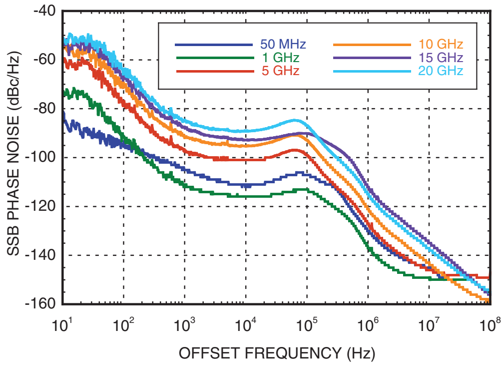
CONNECTORIZED MODULES

HMC-T2100B

HIGHLY PORTABLE!

Battery Powered Signal Generator Outputs +27 dBm From 10 MHz to 20 GHz!

SSB Phase Noise vs. Frequency



Performance

- ♦ Wide Frequency Range: 10 MHz to 20 GHz
- ♦ High Output Power: +27 dBm
- ♦ Power Resolution: 0.1 dB
- ♦ Frequency Resolution: 10 kHz
- ♦ Excellent SSB Phase Noise: -113 dBc/Hz @ 1 GHz @ 100 kHz Offset
- ♦ Spurious @ 1 GHz: -80 dBc
- ♦ USB, GPIB & Ethernet Control
- ♦ Battery Operation: 4 Hours

SIGNAL GENERATORS - Precise RF Signal Generation for ATE & Lab Environments

	Frequency (GHz)	Function	Frequency Resolution (MHz)	Maximum Power Output (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Spurious @ 1 GHz (dBc)	Switching Speed @ 100 MHz Steps (µs)	Package	ECCN Code	Part Number
	0.01 - 20	Synthesized Signal Generator	0.01	+27 @ 2 GHz +25 @ 10 GHz	-113 @ 1 GHz -93 @ 10 GHz	-80	<300	Rack Mountable / Benchtop	EAR99	HMC-T2100
NEW!	0.01 - 20	Portable Synthesized Signal Generator	0.01	+27 @ 2 GHz +25 @ 10 GHz	-113 @ 1 GHz -93 @ 10 GHz	-80	300	Portable / Benchtop	EAR99	HMC-T2100B
	0.7 - 8.0	Synthesized Signal Generator	1	+17 @ 2 GHz +15 @ 4 GHz	-78 @ 1 GHz -87 @ 4 GHz	-57	<200	Rack Mountable / Benchtop	EAR99	HMC-T2000

Applications

- ♦ ATE
- ♦ Test & Measurement
- ♦ R&D Laboratories

Advantages

- ♦ Versatile: Higher Drive Simplifies Test Set-Ups
- ♦ Efficient: 300 µs Frequency Switching
- ♦ Reliable: Incorporates Hittite MMICs
- ♦ Flexible: Manual or Software Control

HMC-T2000 & HMC-T2100 Rack Mount Kit Available!

Dual Rack Mounting Plate 19” 2u Chassis

See www.hittite.com For Ordering Information

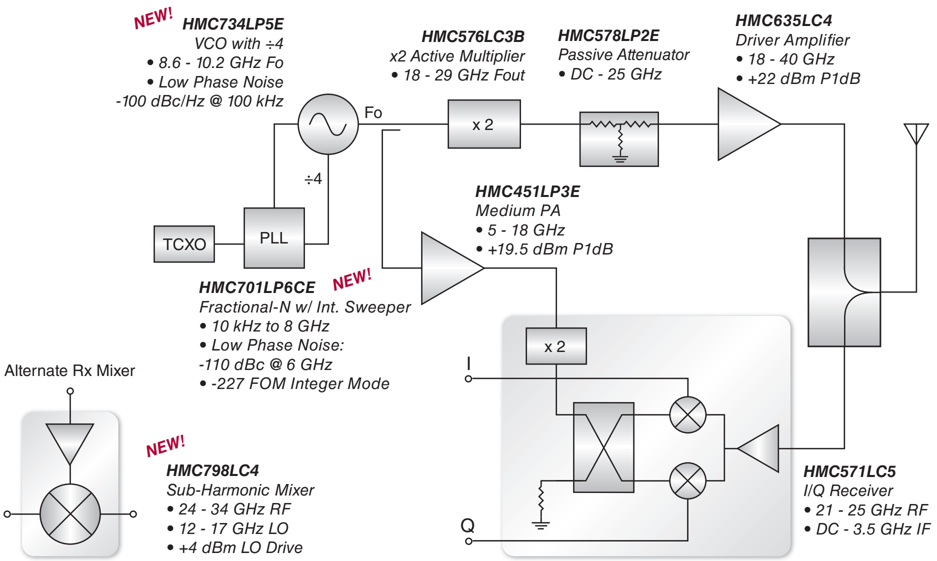
Contact Us Today with Your Custom Test Instrumentation Requirements at TE@hittite.com

A selection of components, see the full product listing starting on page 10.

AUTOMOTIVE; DC - 6 GHz and 6 - 80 GHz

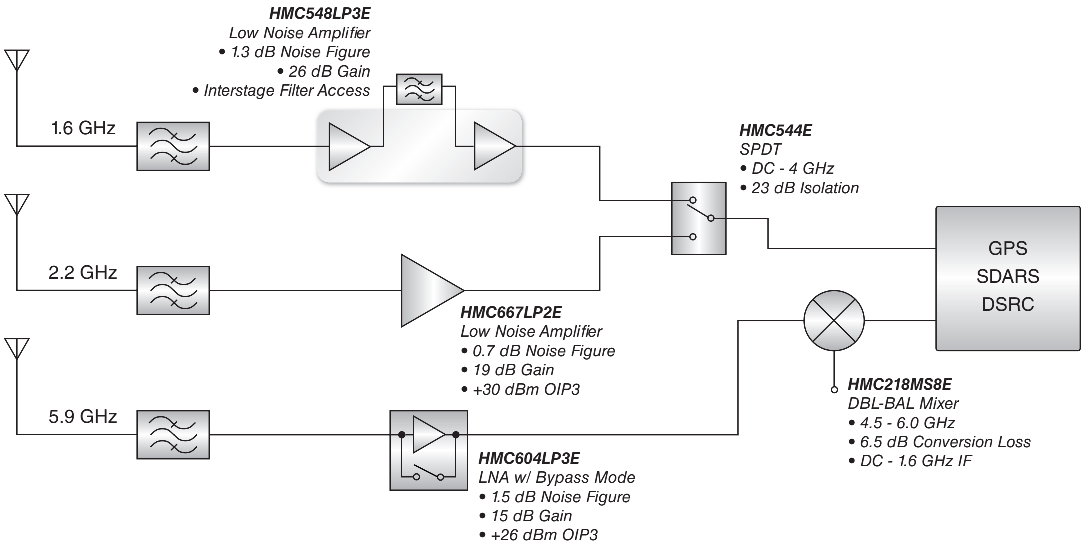
Function	DC - 6 GHz			6 - 80 GHz		
	Chip	SMT		Chip	SMT	
Amplifiers Gain Blocks & Drivers	HMC396 HMC405 HMC397	HMC311LP3E HMC311ST89E HMC313E HMC770LP4BE	HMC474MP86E HMC478MP86E HMC480ST89E	HMC562 HMC465 HMC606	HMC383LC4 HMC442LC3B HMC451LC3 HMC462LP5E HMC463LP5E	HMC464LP5E HMC465LP5E HMC489LP5E HMC490LP5E HMC635LC4
Low Noise Amplifier	HMC392 HMC609 HMC594	HMC374E HMC392LH5 HMC548LP3E HMC667LP2E HMC758LP3E	HMC594LC3B HMC604LP3E HMC605LP3E HMC617LP3E	HMC565 HMC518 HMC263 HMC566 HMC-ALH508 HMC-ALH509	HMC341LC3B HMC504LC4B HMC516LC5 HMC519LC4	HMC517LC4 HMC565LC5
Linear & Power Amplifier	HMC459 HMC559 HMC606	HMC318MS8GE HMC320MS8GE HMC327MS8GE	HMC407MS8GE HMC409LP4E HMC606LC5	HMC464 HMC562 HMC592 HMC693 HMC-ABH264	HMC383LC4 HMC464LP5E	HMC489LP5E HMC498LC4 HMC499LC4
Attenuator: Analog		HMC346C8		HMC712	HMC812LC4	HMC712LP3CE
Attenuator: Digital		HMC425LP3E HMC467LP3E HMC468LP3E HMC540LP3E HMC629LP4E	HMC759LP3E HMC792LP4E			
Frequency Divider & Detector	HMC361 HMC362	HMC432E HMC433E	HMC437MS8GE HMC438MS8GE HMC794LP3E	HMC363 HMC365	HMC447LC3 HMC492LP3E	HMC493LP3E HMC494LP4E
Frequency Multipliers: Active	HMC561	HMC369LP3E HMC370LP4E HMC443LP4E HMC695LP4E	HMC444LP4E HMC575LP4E HMC561LP3E HMC695LP4E	HMC449 HMC576 HMC579 HMC-XDH158	HMC370LP4E HMC449LC3B HMC573LC3B	HMC576LC3B HMC577LC4B HMC578LC3B
Frequency Multipliers: Passive	HMC156	HMC187AMS8E	HMC188MS8E	HMC205 HMC-XTB110	HMC204MS8GE	
Mixer Fundamental	HMC128 HMC129	HMC175MS8E HMC213AMS8E HMC218MS8E	HMC285E HMC488MS8GE HMC615LP4E	HMC292 HMC554 HMC560 HMC-MDB169 HMC-MDB277	HMC144LC4 HMC260LC3B HMC292LC3B	HMC329LC3B HMC554LC3B HMC560LM3
Mixers: I/Q, IRM, Sub-Harmonic & I/Q Upconverters/ Downconverters	HMC525 HMC620	HMC340ALP5E HMC525LC4	HMC620LC4	HMC339 HMC404 HMC556 HMC572 HMC-MDB171 HMC-MDB172 HMC-MDB207 HMC-MDB218	HMC258LM3 HMC264LC3B HMC265LM3 HMC338LC3B HMC709LC5 HMC815LC5 HMC869LC5	HMC522LC4 HMC523LC4 HMC528LC4 HMC572LC5 HMC710LC5 HMC798LC4
Modulator		HMC495LP3E HMC696LP4E HMC697LP4E	HMC497LP3E HMC696LP4E HMC697LP4E		HMC496LP3E	
PLLs: Synthesizer ICs		HMC698LP5E HMC699LP5E	HMC700LP4E HMC701LP6CE		HMC698LP5E HMC699LP5E	HMC700LP4E HMC701LP6CE
Power Detector		HMC601LP4E HMC713LP3E	HMC610ALP4E		HMC602LP4E HMC713MS8E HMC714LP5E	HMC611LP4E HMC662LP3E
Switch: SPST, SPNT, SPDT, SPDT T/R, Bypass, Diversity, Matrix & Transfer	HMC240 HMC322 HMC344 HMC641	HMC321LP4E HMC332E HMC336MS8GE HMC544E HMC436MS8GE	HMC536MS8GE HMC550E HMC784MS8GE HMC849LP4CE	HMC232 HMC347 HMC607 HMC-SDD112	HMC232LP4E HMC321LP4E HMC344LP3E	HMC347LP3E HMC427LP3E HMC547LP3E
VGAs: Digital		HMC625LP4E HMC743LP6CE	HMC742LP5E			
VCO * Requires x2 or x4		HMC388LP4E HMC389LP4E HMC390LP4E	HMC391LP4E HMC431LP4E HMC586LC4B		HMC515LP5E* HMC531LP5E* HMC534LP4E HMC736LP4E	HMC535LP5E HMC587LC4B HMC588LC4B HMC737LP4E

24 GHz FMCW Automotive Sensor



Typical Automotive application is illustrated.
See the full product listing for alternatives to the HMC products shown in each functional block.

GPS, SDARS & DSRC RF Front-End for Telematics



Typical Automotive application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

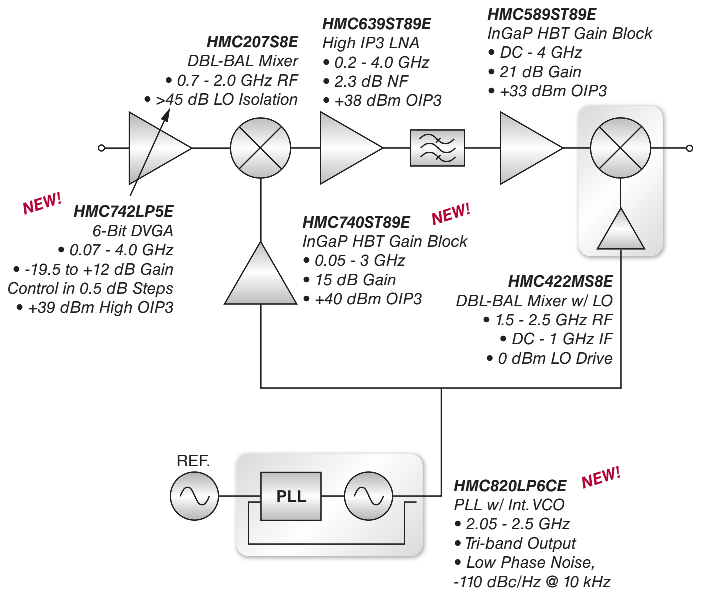
A selection of components, see the full product listing starting on page 10.

BROADBAND, DC - 11 GHz – CATV, DBS, VoIP, WiMAX, WiBro & WLAN

Function	0.005 - 2.15 GHz CATV & DBS	1.8 - 2.7 GHz WiMAX / WiBro	3.3 - 3.9 GHz WiMAX / WiBro	4.9 - 5.9 GHz WiMAX / Fixed
Low Noise Amplifier	HMC548LP3E HMC549MS8GE HMC599ST89E	HMC286E HMC287MS8GE HMC605LP3E HMC636ST89E HMC639ST89E HMC715LP3E	HMC476SC70E HMC491LP3E HMC593LP3E HMC636ST89E HMC639ST89E HMC716LP3E	HMC318MS8GE HMC320MS8GE HMC476SC70E HMC604LP3E HMC717LP3E
Driver Amplifier & Gain Block	HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E HMC770LP4BE	HMC308E HMC311SC70E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E HMC755LP4E	HMC311SC70E HMC326MS8GE HMC327MS8GE HMC474SC70E HMC475ST89E HMC476SC70E	HMC311SC70E HMC406MS8GE HMC407MS8GE HM415LP3E HMC474SC70E HMC476SC70E
Linear & Power Amplifier	HMC453QS16GE HMC636ST89E	HMC454ST89E HMC636ST89E	HMC409LP4E HMC636ST89E	HMC408LP3E
Attenuator: Analog	HMC473MS8E	HMC346MS8GE	HMC346MS8GE	HMC346MS8GE
Attenuator: Digital	HMC467LP3E HMC468LP3E HMC542LP4E HMC624LP4E HMC629LP4E HMC759LP3E	HMC305ALP4E HMC540LP3E HMC542LP4E HMC624LP4E HMC629LP4E HMC792LP4E	HMC424LP3E HMC467LP3E HMC539LP3E HMC624LP4E HMC629LP4E HMC792LP4E	HMC425LP3E HMC467LP3E HMC468LP3E HMC624LP4E HMC629LP4E HMC792LP4E
Mixer	HMC207S8E HMC208MS8E HMC400MS8E HMC483MS8GE	HMC215LP4E HMC285E HMC316MS8E HMC334LP4E HMC552LP4E HMC557 HMC557LC4 HMC622LP4E HMC688LP4E HMC689LP4E	HMC214MS8E HMC215LP4E HMC333E HMC340ALP5E HMC557 HMC557LC4 HMC615LP4E HMC622LP4E HMC666LP4E	HMC220MS8E HMC218MS8E HMC219MS8E HMC488MS8GE HMC525LC5 HMC557 HMC557LC4
Demodulator	HMC597LP4E	HMC597LP4E HMC631LP3E	HMC597LP4E	
Modulator	HMC495LP3E HMC497LP4E HMC696LP4E	HMC495LP3E HMC497LP4E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC697LP4E	HMC496LP3E
Phase Shifter: Digital		HMC647 HMC647LP6E	HMC648 HMC648LP6E HMC649 HMC649LP6E	HMC649 HMC649LP6E HMC638LP5E
PLL	HMC700LP4E	HMC700LP4E	HMC700LP4E	HMC700LP4E
Power Detector	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E HMC612LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E HMC612LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E
Switch: SPST & SPNT	HMC253QS24E HMC536MS8GE HMC536LP2E HMC544E HMC550E HMC646LP2E HMC784MS8GE HMC849LP4CE	HMC241LP3E HMC536MS8GE HMC546LP2E HMC550E HMC784MS8GE HMC849LP4CE	HMC241LP3E HMC349MS8GE HMC536MS8GE HMC544E HMC550E HMC784MS8GE HMC849LP4CE	HMC224MS8E HMC321LP4 HMC536LP2E HMC536MS8GE HMC550E
Switch: Bypass, Diversity, Matrix & Transfer	HMC276LP4E HMC427LP3E HMC596LP4E	HMC276LP4E HMC427LP3E HMC596LP4E	HMC427LP3E	HMC436MS8GE HMC427LP3E
VCO	HMC384LP4E	HMC384LP4E HMC385LP4E	HMC388LP4E HMC389LP4E	HMC430LP4E HMC431LP4E
VGA	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E	HMC625LP5E HMC680LP4E HMC681LP5E	HMC625LP5E HMC680LP4E HMC681LP5E	HMC625LP5E HMC680LP4E HMC681LP5E

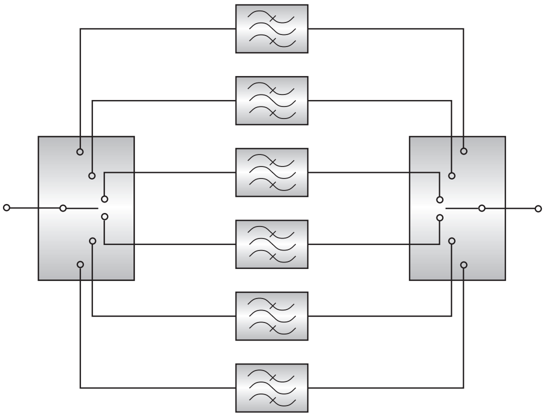
Cable Modem, CATV, DBS & VoIP Solutions, 5 - 2150 MHz

Cable Modem Termination System (CMTS)



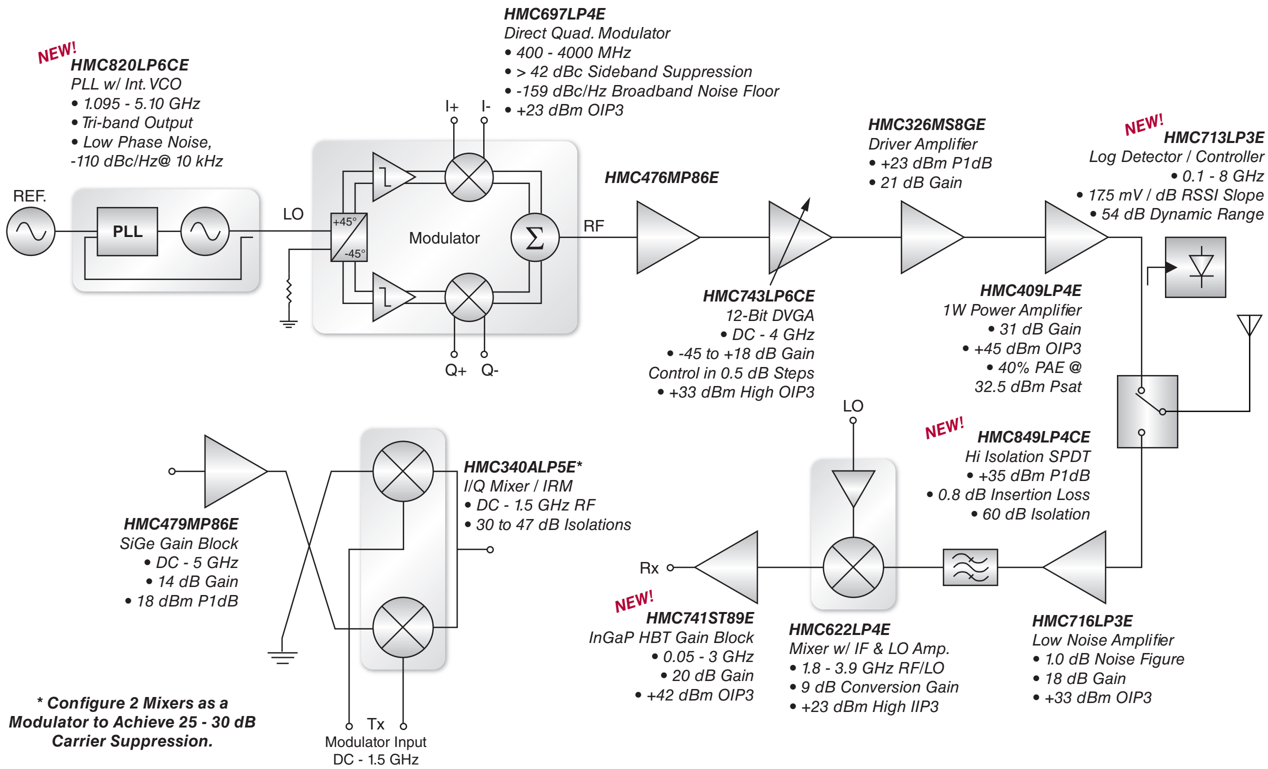
A Selection of SPNT Switches for CATV Filter & Signal Routing

Part Number	Frequency (GHz)	Function	1 GHz Loss / Isolation (dB)
HMC348LP3E	DC - 2.5	SPDT, 75 Ω	0.6 / 58
HMC349LP4CE	DC - 4	SPDT	0.9 / 65
HMC347LP3E	DC - 15	SPDT	1.4 / 65
HMC245QS16GE	DC - 3.5	SP3T	0.5 / 44
HMC345LP3E	DC - 8	SP4T	2.0 / >50
HMC252QS24E	DC - 3	SP6T	2.0 / >45
HMC321LP4E	DC - 8	SP8T	2.0 / >45



Typical Broadband applications are illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

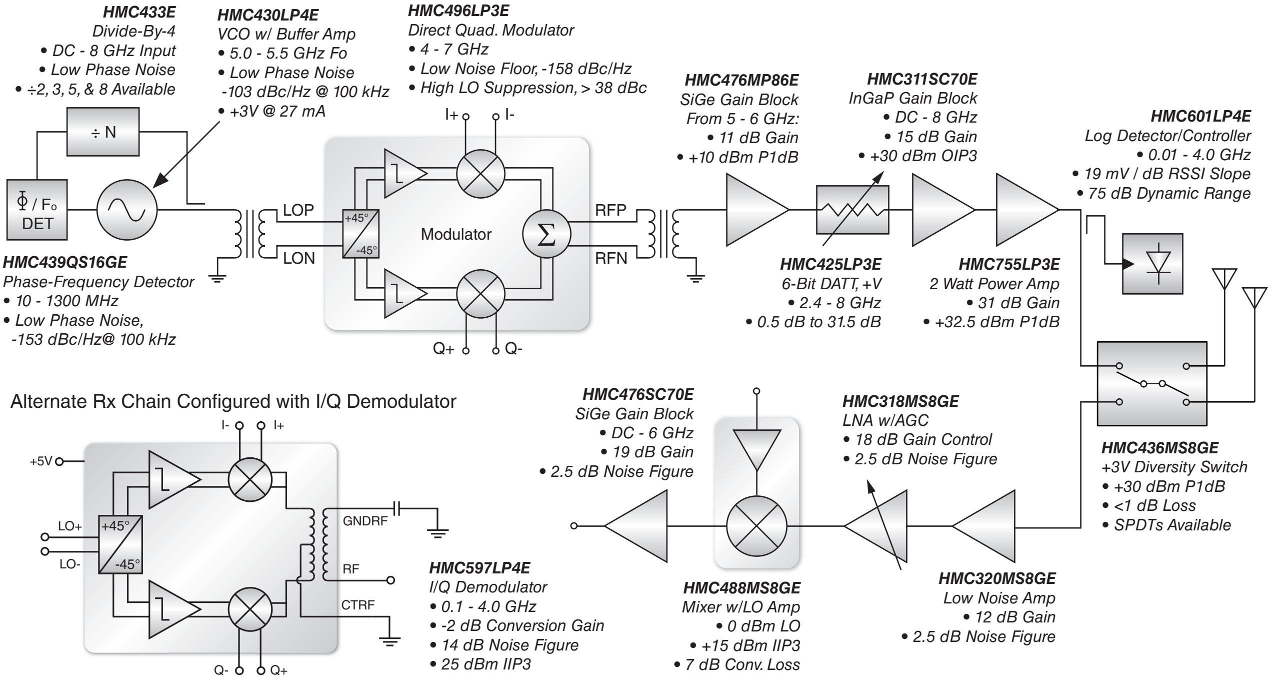
WiMAX & Fixed Wireless, 2 - 6 GHz



Alternate Modulator Circuit Configured with Two HMC340LP5 Mixers

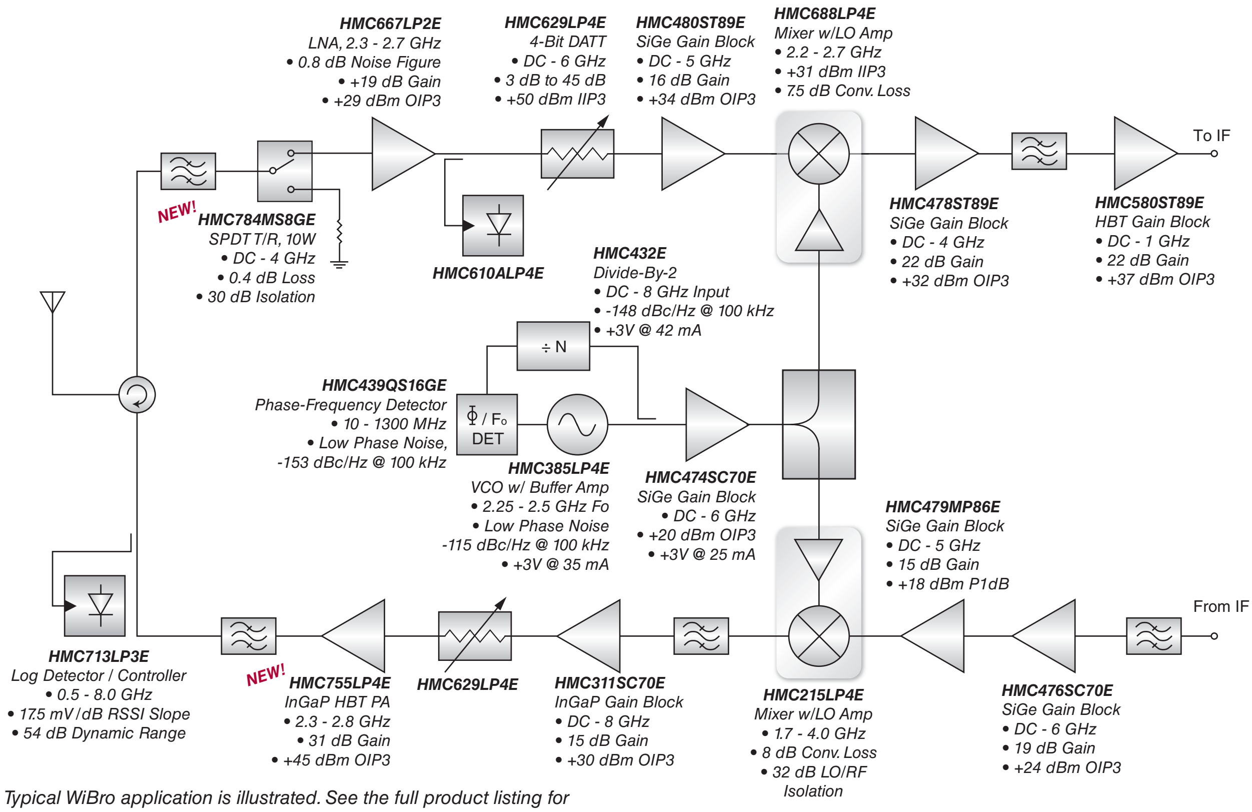
Typical WiMAX / FWA Transceiver is illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

WirelessLAN, UWB, UNII & ISM Solutions, 2.4, 4.9, 5.4, 5.8 & 3 - 11 GHz



Typical 4.9 - 5.9 GHz Wi-Fi Access Point application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

WiBro "Wireless Broadband", 1.82 - 1.87, 2.3 - 2.5 & 3.48 - 3.52 GHz

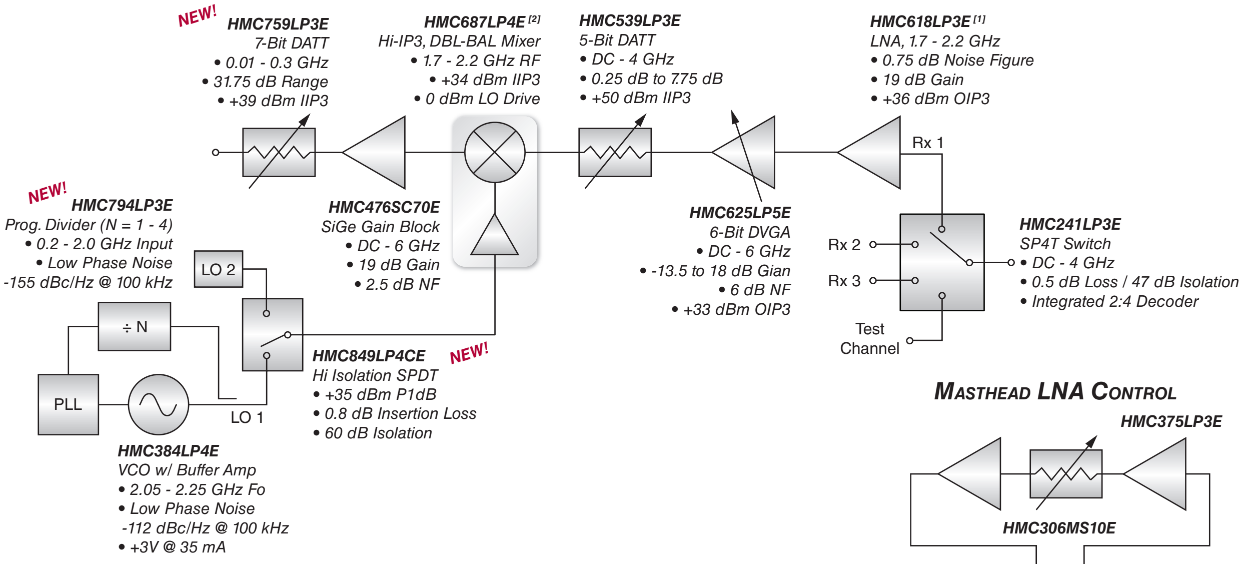


Typical WiBro application is illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

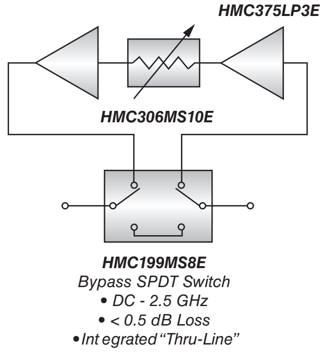
CELLULAR INFRASTRUCTURE,
380 - 2200 MHz – GSM, GPRS, CDMA, TD-SCDMA, WCDMA, UMTS & 4G/LTE

Function	400 MHz	700 / 800 / 900 MHz	1800 / 1900 MHz	2100 / 2200 MHz
Low Noise Amplifier	HMC374E HMC616LP3E HMC636ST89E	HMC617LP3E HMC636ST89E HMC718LP4E	HMC618LP3E HMC636ST89E HMC719LP4E	HMC618LP3E HMC636ST89E HMC667LP2E
Driver Amplifier & Gain Block	HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC478ST89E HMC580ST89E	HMC308E HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E	HMC308E HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E	HMC308E HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E
Linear & Power Amplifier	HMC452ST89E HMC453ST89E HMC454ST89E HMC636ST89E	HMC452ST89E HMC453ST89E HMC454ST89E HMC636ST89E	HMC452ST89E HMC453ST89E HMC454ST89E HMC457QS16GE HMC636ST89E	HMC452ST89E HMC453ST89E HMC454ST89E HMC636ST89E
Attenuator: Analog	HMC473MS8E	HMC473MS8E		
Attenuator: Digital	HMC540LP3E HMC541LP3E HMC472LP4E HMC542LP4E HMC624LP4E HMC629LP4E HMC759LP3E HMC792LP4E	HMC540LP3E HMC541LP3E HMC467LP3E HMC542LP4E HMC624LP4E HMC629LP4E HMC759LP3E HMC792LP4E	HMC539LP3E HMC541LP3E HMC468LP3E HMC542LP4 HMC624LP4E HMC629LP4E HMC759LP3E HMC792LP4E	HMC539LP3E HMC541LP3E HMC542LP4E HMC624LP4E HMC629LP4E HMC759LP3E HMC792LP4E
Frequency Divider & Detector	HMC394LP4E HMC434E HMC439QS16GE HMC705LP5E	HMC394LP4E HMC434E HMC439QS16GE HMC705LP5E	HMC394LP4E HMC434E HMC439QS16GE HMC705LP5E	HMC394LP4E HMC434E HMC439QS16GE HMC705LP5E
Mixer	HMC387MS8E HMC585MS8GE	HMC334LP4E HMC399MS8E HMC423MS8E HMC483MS8GE HMC551LP4E HMC581LP6E HMC621LP4E HMC665LP4E HMC683LP6E HMC684LP4E HMC686LP4E	HMC215LP4E HMC334LP4E HMC381LP6E HMC400MS8E HMC485MS8GE HMC552LP4E HMC622LP4E HMC623LP4E HMC682LP6E HMC685LP4E HMC687LP4E	HMC215LP4E HMC334LP4E HMC400MS8E HMC421QS16GE HMC422MS8E HMC615LP4 HMC622LP4E HMC688LP4E HMC689LP4E
Demodulator	HMC597LP4E	HMC597LP4E	HMC597LP4E	HMC597LP4E
Modulator: **Direct Quadrature & Vector**	HMC495LP3E HMC497LP4E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC630LP3E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC631LP3E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC631LP3E HMC696LP4E HMC697LP4E
PLL: Synthesizer ICs	HMC700LP4E	HMC700LP4E	HMC700LP4E	HMC700LP4E
Power Detector	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E HMC611LP4E HMC612LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E HMC611LP4E HMC612LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E HMC611LP4E HMC612LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610ALP4E HMC611LP4E HMC612LP4E
Switch: SPST & SPNT	HMC546MS8GE HMC550E HMC646LP2E HMC784MS8GE HMC849LP4CE	HMC550E HMC574MS8E HMC646LP2E HMC784MS8GE HMC849LP4CE	HMC545E HMC546MS8GE HMC646LP2E HMC784MS8GE HMC849LP4CE	HMC546LP2E HMC550E HMC646LP2E HMC784MS8GE HMC849LP4CE
Switch: Bypass, Diversity, **Matrix & Transfer**	HMC199MS8E HMC596LP4E	HMC199MS8E HMC596LP4E	HMC199MS8E HMC596LP4E	HMC199MS8E HMC596LP4E
VGA	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC680LP4E HMC681LP5E	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC680LP4E HMC681LP5E	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC680LP4E HMC681LP5E	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC680LP4E HMC681LP5E

BTS Receiver Solutions Featuring High IP3 Mixer



Masthead LNA Control



[1] For 700 - 1000 MHz Systems Use:

HMC686LP4E
Hi-IP3, DBL-BAL Mixer
• 0.7 - 1.1 GHz RF
• +34 dBm IIP3
• 0 dBm LO Drive

HMC617LP3E
LNA, 550 - 1200 MHz
• 0.5 dB Noise Figure
• 16 dB Gain
• +37 dBm OIP3

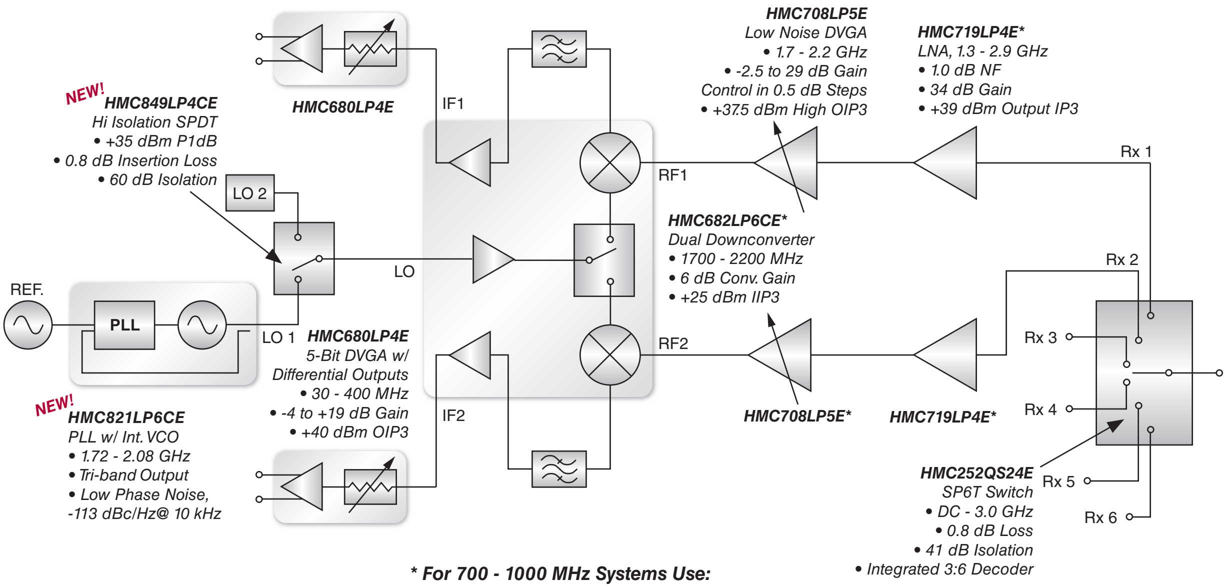
[2] For 380 - 500 MHz Systems Use:

HMC585MS8GE
Hi-IP3 Mixer w/ LO Amp
• 400 - 650 MHz RF
• +33 dBm IIP3
• 0 dBm LO Drive

HMC616LP3E
LNA, 175 - 660 MHz
• 0.5 dB Noise Figure
• 17 dB Gain
• +35 dBm OIP3

Ask About Our Custom VCO Capabilities!

BTS Receiver Solutions Featuring Dual RFIC Downconverter



*** For 700 - 1000 MHz Systems Use:**

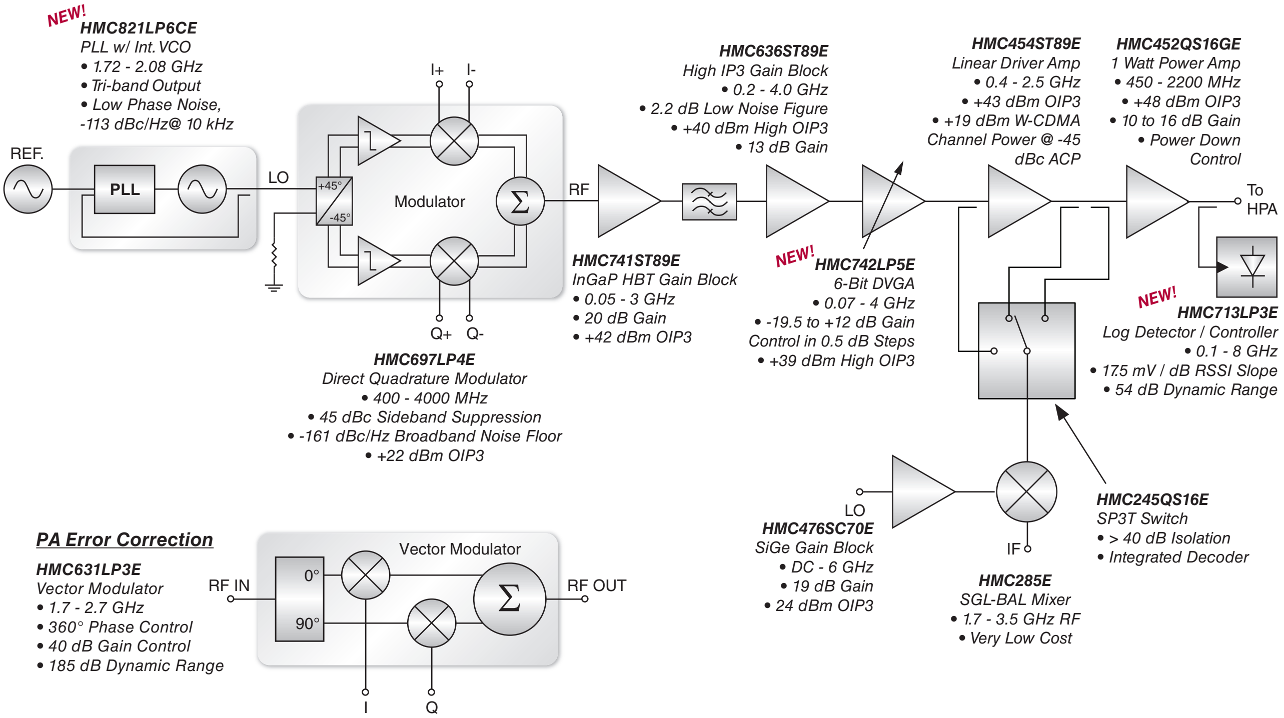
HMC718LP4E
Low Noise Amplifier
• 0.6 - 1.4 GHZ
• 0.9 DB NOISE FIGURE
• 32 DB GAIN
• +40 DBM OIP3

HMC707LP5E
Low Noise DVGA
• 0.7 - 1.2 GHz
• -2.5 to 29 dB Gain
Control in 0.5 dB Steps
• +38 dBm High OIP3

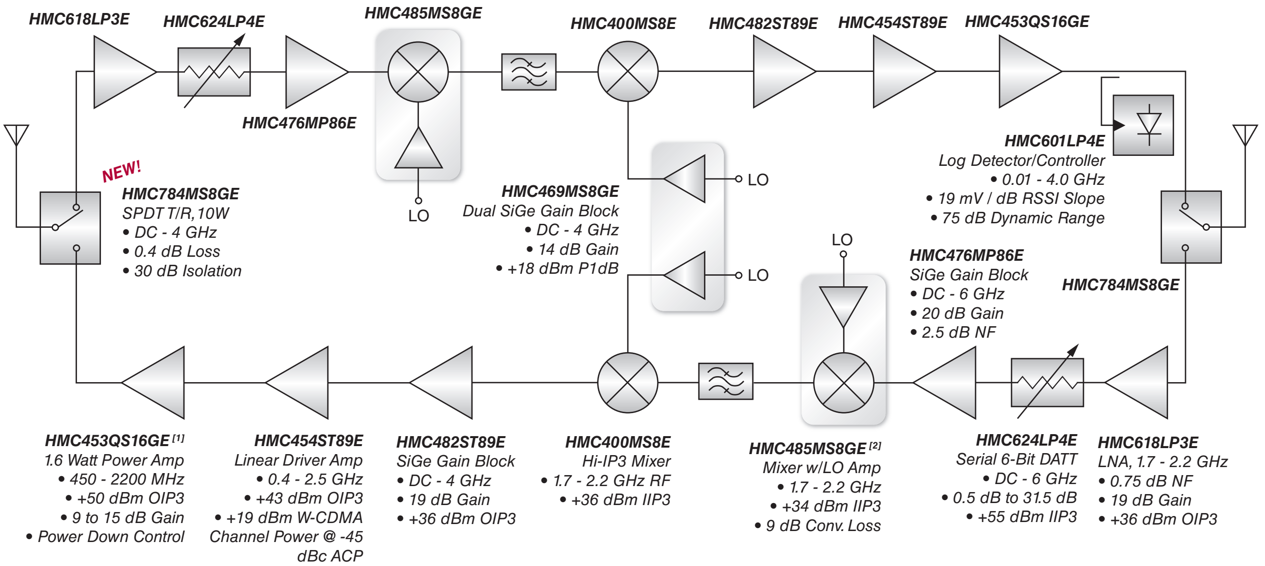
HMC683LP6CE
Dual Downconverter
• 700 - 1000 MHz
• 7.5 dB Conversion Gain
• +23 dBm IIP3

Typical Cellular/PCS/3G applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

BTS Transmitter Solutions



CDMA / GSM / TD-SCDMA Repeater Solutions



[1] High Gain Option:

HMC457QS16GE
1 Watt Power Amp
• 1.7 - 2.2 GHz
• +46 dBm OIP3
• 26 dB Gain

[2] For 700 - 1000 MHz Systems Use:

HMC483MS8GE
Mixer w/LO Amp
• 0.7 - 1.4 GHz
• +35 dBm IIP3

Typical Cellular/PCS/3G applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

A selection of components, see the full product listing starting on page 10.

FIBER OPTICS, OC-48 to 100G

Fiber Optic Custom Solutions Inquiries: FO@hittite.com

Function	OC-1	OC-3	OC-12	OC-48	OC-192	OC-768
Broadband Gain Blocks	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC405	
Limiting Amplifier	HMC750LP4E	HMC750LP4E	HMC750LP4E	HMC750LP4E	HMC750LP4E	
Transimpedance Amplifier					HMC690	
Wideband (Distributed) Amplifiers	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC637LP5E HMC-AUH312 HMC-AUH232 HMC-AUH249	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC637LP5E HMC-AUH312 HMC-AUH232 HMC-AUH249	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC637LP5E HMC-AUH312 HMC-AUH232 HMC-AUH249	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC637LP5E HMC-AUH312 HMC-AUH232 HMC-AUH249	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC-AUH312 HMC-AUH232 HMC-AUH249	HMC-AUH312
Connectorized Amplifier Modules	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037	
Attenuators: Analog	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346LP3	HMC-VVD104 HMC-VVD106
Attenuators: Digital	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E	
Attenuators: Passive	HMC650 - HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 - HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 - HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 - HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 - HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 - HMC655 HMC656 HMC657 HMC658
Connectorized Attenuator Modules	HMC-C018 HMC-C053	HMC-C018 HMC-C053	HMC-C018 HMC-C053	HMC-C018 HMC-C053	HMC-C025 HMC-C053	
Frequency Dividers & Detectors	HMC394LP4E HMC439QS16GE HMC440QS16GE HMC492LP3E HMC493LP3E HMC494LP4E	HMC394LP4E HMC439QS16GE HMC440QS16GE HMC492LP3E HMC493LP3E HMC494LP4E	HMC394LP4E HMC439QS16GE HMC440QS16GE HMC492LP3E HMC493LP3E HMC494LP4E	HMC440QS16GE HMC492LP3E HMC493LP3E		
Connectorized Freq. Divider Modules	HMC-C040	HMC-C006 HMC-C007 HMC-C039 HMC-C040	HMC-C005 HMC-C006 HMC-C007 HMC-C039 HMC-C040	HMC-C005 HMC-C006		
Frequency Multipliers: Active					HMC448LC3B HMC576 HMC576LC3B HMC561LP3E HMC598 HMC-XDB112 HMC-XDH158	HMC579 HMC598
Connectorized Freq. Multiplier Modules					HMC-C032 HMC-C033 HMC-C034	

FIBER OPTICS

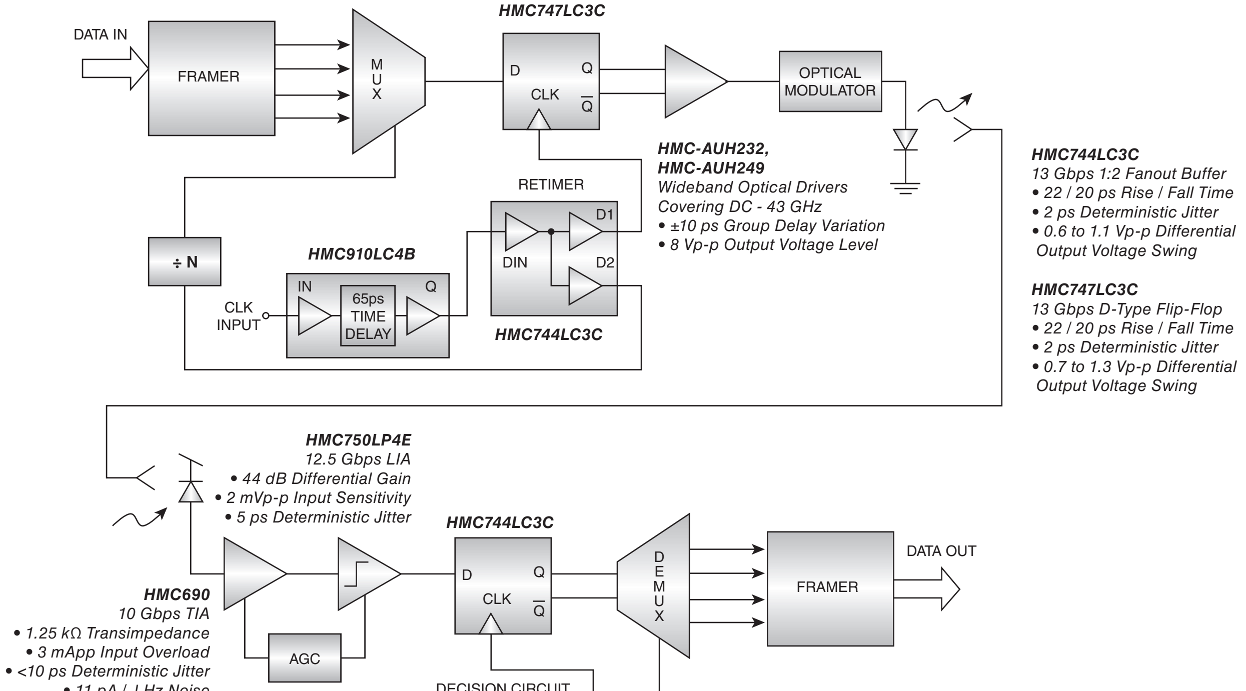
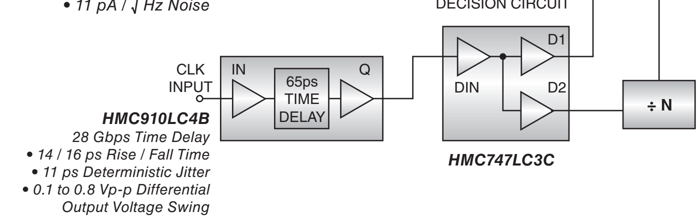
FIBER OPTICS, OC-48 to 100G

Fiber Optic Custom Solutions Inquiries: FO@hittite.com

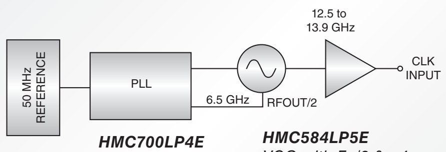
Function	OC-1	OC-3	OC-12	OC-48	OC-192	OC-768
High Speed Digital Logic:						
1:2 Fanout Buffer	HMC720LC3C	HMC720LC3C	HMC724LC3C	HMC724LC3C	HMC744LC3C	
2:1 Selector	HMC678LC3C	HMC678LC3C	HMC728LC3C	HMC728LC3C	HMC748LC3C	HMC748LC3C
XOR / XNOR	HMC721LC3C	HMC721LC3C	HMC725LC3C	HMC725LC3C	HMC745LC3C	
AND / NAND / OR / NOR	HMC722LC3C	HMC722LC3C	HMC726LC3C	HMC726LC3C	HMC746LC3C	
D-Type Flip-Flop	HMC723LC3C	HMC723LC3C	HMC727LC3C	HMC727LC3C	HMC747LC3C	HMC853LC3C
T Flip-Flop w/ Reset	HMC679LC3C	HMC679LC3C	HMC729LC3C	HMC729LC3C	HMC749LC3C	HMC749LC3C
NRZ-to-RZ Converter	HMC706LC3C	HMC706LC3C	HMC706LC3C	HMC706LC3C	HMC706LC3C	
Clock Divider	HMC791LC4B	HMC791LC4B	HMC791LC4B	HMC791LC4B	HMC791LC4B	HMC791LC4B
Connectorized High Speed Digital Logic Modules						HMC-C060 HMC-C061 HMC-C062 HMC-C064 HMC-C065
Connectorized Mixer Modules	HMC-C035	HMC-C035	HMC-C035	HMC-C035		
Phase Shifters: Analog				HMC247 HMC538LP4E	HMC247 HMC538LP4E	
Phase Shifters: Digital				HMC647 HMC647LP6E HMC648 HMC648LP6E	HMC642LC5 HMC643LC5 HMC644 HMC644LC5	
Connectorized Phase Shifter Modules					HMC-C010	
Switches: SPDT	HMC232LP4E HMC347 HMC347LP3E HMC547LP3E HMC646LP2E	HMC232LP4E HMC347 HMC347LP3E HMC547LP3E HMC646LP2E	HMC232LP4E HMC347 HMC347LP3E HMC547LP3E HMC646LP2E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC-SDD112
Switches: Multi-Throw	HMC253LC4 HMC344LC3 HMC641	HMC253LC4 HMC344LC3 HMC641	HMC253LC4 HMC344LC3 HMC641	HMC253LC4 HMC344LC3 HMC641	HMC641	
Switches: Transfer	HMC427LP3E	HMC427LP3E	HMC427LP3E	HMC427LP3E		
Connectorized Switch Modules	HMC-C011 HMC-C019 HMC-C058	HMC-C011 HMC-C019 HMC-C058	HMC-C011 HMC-C019 HMC-C058	HMC-C011 HMC-C019 HMC-C058	HMC-C011 HMC-C019 HMC-C058	
Connectorized VCO Modules						HMC-C073

Fiber Optics, OC-48 to 100G

Typical Serial Fiber Optic Data Transmission System

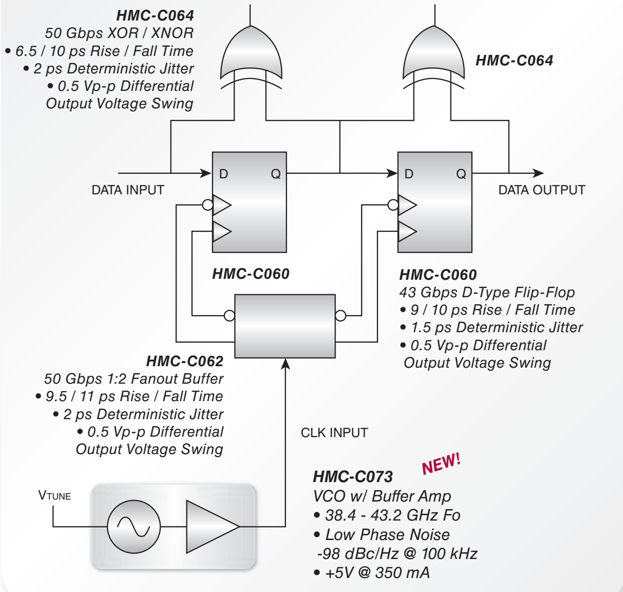
Clock Driver Circuit



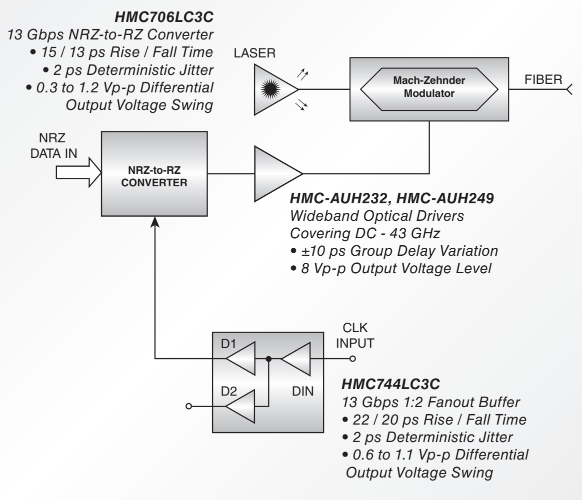
HMC700LP4E
Fractional-N Synthesizer
- 1 MHz to 8 GHz
- Low Phase Noise: -108 dBc @ 6 GHz
- -227 FOM Integer Mode

HMC584LP5E
VCO with Fo/2 & ÷4
- 12.5 - 13.9 GHz
- -110 dBc/Hz SSB Phase Noise @ 100 kHz

43 Gbps Hogge Phase Detector for Clock & Data Recovery



13 Gbps, NRZ-to-RZ Conversion



Typical Fiber Optic applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

MICROWAVE & MILLIMETERWAVE RADIO, 7 to 23 GHz

Function	7 / 8 GHz	11 GHz	13 GHz	15 GHz	18 GHz	23 GHz
Low Noise Amplifier	HMC392LC4 HMC392LH5 HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC565 HMC565LC5	HMC504LC4B HMC516LC5 HMC565 HMC565LC5	HMC517LC4 HMC519LC4 HMC565 HMC565LC5	HMC341LC3B HMC504LC4B HMC517LC4 HMC519 HMC519LC4
Driver Amplifier	HMC441LP3E HMC451LC3 HMC516LC5	HMC441LP3E HMC451LC3 HMC451LP3E HMC516LC5	HMC441LC3B HMC451LC3 HMC451LP3E HMC490LP5E	HMC441LC3B HMC451LC3 HMC451LP3E HMC490LP5E	HMC383LC4 HMC442LC3B HMC451LP3E HMC498LC4 HMC635LC4	HMC383LC4 HMC442LC3B HMC498LC4 HMC635 HMC635LC4
Power Amplifier	HMC486LP5E HMC590 HMC590LP5E HMC591 HMC591LP5E HMC637 HMC637LP5E	HMC487LP5E HMC592 HMC608LC4	HMC489LP5E HMC592	HMC489LP5E HMC-APH462	HMC498LC4 HMC-APH196 HMC-APH462 HMC-APH478 HMC-APH596	HMC498LC4 HMC-APH196 HMC-APH462 HMC-APH518 HMC-APH596
Wideband (Distributed) Amplifiers	HMC463LH250 HMC606 HMC606LC5 HMC619 HMC619LP5E HMC633 HMC633LC4 HMC634 HMC634LC4 HMC659 HMC-C050 HMC-ALH102 HMC-ALH435 HMC-ALH444 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC633 HMC633LC4 HMC634 HMC634LC4 HMC-C050 HMC-ALH102 HMC-ALH435 HMC-ALH444 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC633 HMC633LC4 HMC634 HMC634LC4 HMC-C050 HMC-ALH102 HMC-ALH435 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC633 HMC633LC4 HMC634 HMC634LC4 HMC-C050 HMC-ALH102 HMC-ALH216 HMC-ALH435 HMC-ALH476 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC634 HMC634LC4 HMC659 HMC-ALH102 HMC-C050 HMC-ALH216 HMC-ALH435 HMC-ALH445 HMC-ALH476 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMc-AUH256 HMC-AUH312	HMC635 HMC-ALH216 HMC-ALH311 HMC-ALH445 HMC-ALH476 HMC-AUH232 HMC-AUH249 HMC-AUH256 HMC-AUH312
Attenuator: Analog	HMC346LP3E HMC812LC4 HMC-C053	HMC346LP3E HMC812LC4 HMC-C053	HMC346LP3E HMC812LC4 HMC-C053	HMC346LC3B HMC812LC4 HMC-C053	HMC346LC3B HMC-C053 HMC-VVD102	HMC812LC4 HMC-VVD102
Divide-by-2	HMC361S8GE	HMC364S8GE	HMC492LP3E	HMC492LP3E	HMC492LP3E	
Divide-by-4	HMC362S8GE	HMC365S8GE	HMC493LP3E	HMC493LP3E	HMC447LC3	HMC447LC3
Divide-by-8	HMC363S8GE	HMC363S8GE	HMC494LP4E	HMC494LP4E		
Multiplier: Active X2	HMC368LP4E HMC575LP4E HMC561LP3E	HMC368LP4E HMC573LC3B HMC561LP3E HMC-XDB112	HMC368LP4E HMC573LC3B HMC561LP3E HMC-XDB112	HMC368LP4E HMC573LC3B HMC561LP3E HMC-XDB112	HMC448LC3B HMC576 HMC576LC3B	HMC448LC3B HMC576 HMC576LC3B
Multiplier: Active X4		HMC443LP4E	HMC370LP4E	HMC370LP4E HMC-XDH158		
Multiplier: Passive X2	HMC189AMS8E	HMC189AMS8E	HMC204MS8GE	HMC204MS8GE	HMC204MS8GE	HMC205
I/Q Downconverter / Rx I/Q Upconverter/Tx	HMC567LC5	HMC568LC5	HMC869LC5	HMC570 HMC570LC5 HMC709LC5	HMC571 HMC571LC5 HMC710LC5	HMC572 HMC572LC5 HMC815LC5
I/Q Mixer / IRM	HMC520LC4 HMC525LC4 HMC620 HMC620LC4	HMC521LC4 HMC527LC4	HMC521LC4 HMC527LC4	HMC522LC4 HMC528LC4	HMC523 HMC523LC4	HMC523 HMC523LC4 HMC524 HMC-MDB172
Mixer: Fundamental	HMC129LC4 HMC144LC4 HMC219MS8E HMC220MS8E HMC553 HMC553LC3B HMC558 HMC558LC3B HMC663LC3	HMC144LC4 HMC411MS8GE HMC412MS8GE HMC553 HMC553LC3B HMC558 HMC558LC3B HMC-C051 HMC663LC3	HMC144LC4 HMC411MS8GE HMC412MS8GE HMC553 HMC553LC3B HMC558 HMC558LC3B HMC-C051	HMC144LC4 HMC260LC3B HMC412MS8GE HMC554 HMC554LC3B HMC558 HMC558LC3B HMC-C051	HMC144LC4 HMC260LC3B HMC292LC3B HMC554 HMC554LC3B HMC-C051	HMC260LC3B HMC292LC3B

Market & Application Guide

A selection of components, see the full product listing starting on page 10.

MICROWAVE & MILLIMETERWAVE RADIO, 7 to 23 GHz

Function	7 / 8 GHz	11 GHz	13 GHz	15 GHz	18 GHz	23 GHz
Mixer: **Sub-Harmonic**				HMC258LM3	HMC258LC3B HMC258LM3 HMC337	HMC264LC3B HMC338LC3B
PLLs: **Synthesizer ICs**	HMC698LP5E HMC699LP5E HMC700LP4E HMC701LP6CE					
Switch	HMC547LP3E HMC641	HMC607 HMC641	HMC547LP3E HMC641	HMC607 HMC641	HMC547LP3E HMC641	
Signal Generator	HMC-T2000					
VCO & PLO: ****Requires X2 or X4**	HMC466LP4E HMC505LP4E HMC506LP4E HMC532LP4E HMC586LC4B HMC587LC4B	HMC513LP4E HMC515LP5E HMC534LP4E HMC582LP5E HMC588LC4B HMC735LP5E	HMC513LP4E HMC529LP4E HMC584LP5E	HMC529LP4E HMC531LP5E HMC535LP5E HMC632LP5E HMC736LP4E HMC737LP4E	HMC429LP4E**	HMC431LP4E** HMC738LP4E HMC739LP4E
VGA: Analog	HMC694 HMC694LP4E	HMC694 HMC694LP4E	HMC694 HMC694LP4E	HMC694 HMC694LP4E	HMC694 HMC694LP4E	

MICROWAVE & MILLIMETERWAVE RADIO, 26 to 86 GHz

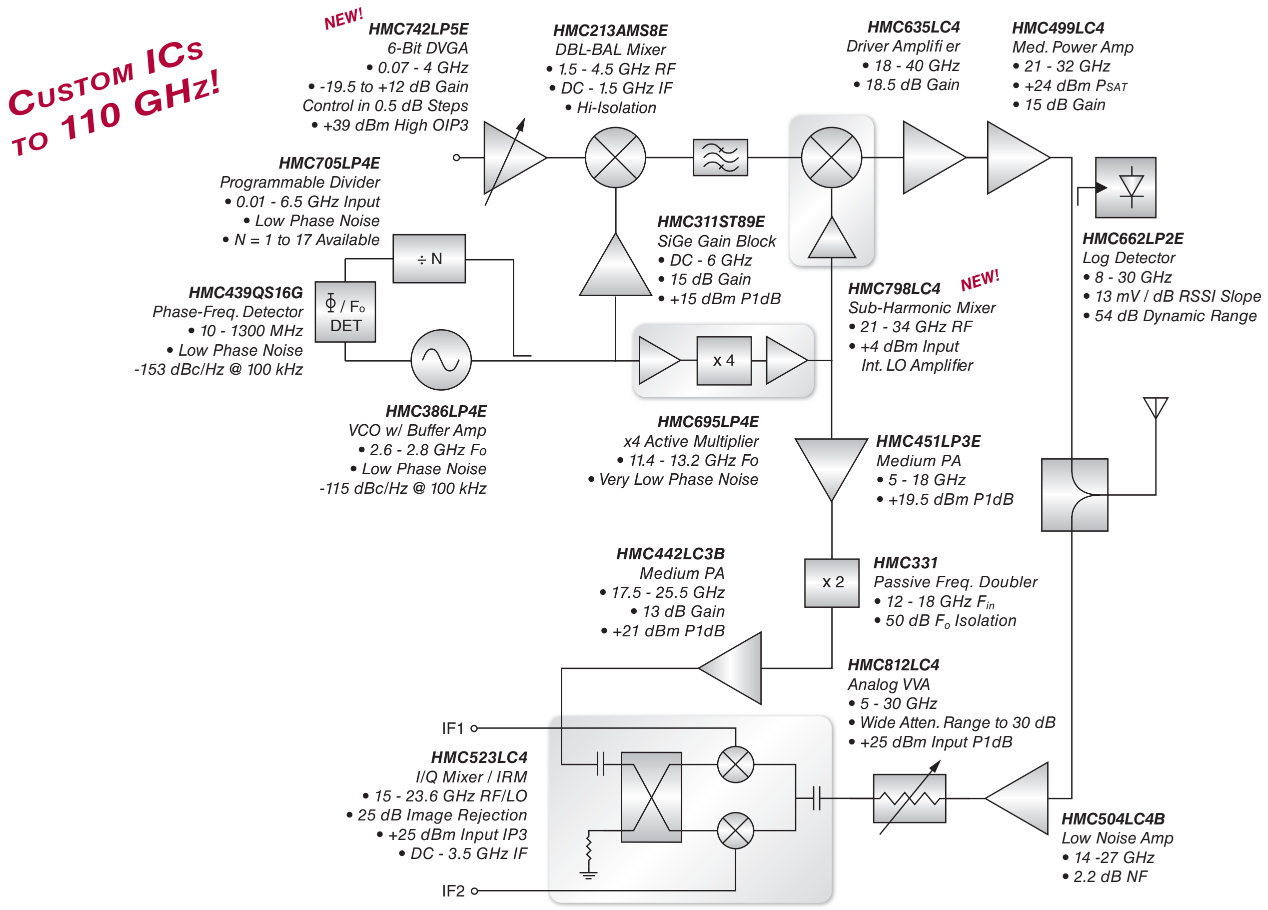
Function	26 / 28 GHz	32 / 38 GHz	32 - 43 GHz	44 - 66 GHz	71 - 86 GHz
Low Noise Amplifier	HMC341LC3B HMC517LC4 HMC519LC4 HMC635 HMC693	HMC263 HMC566 HMC635 HMC693	HMC-ALH376	HMC-ALH382	HMC-ALH459 HMC-ALH509
Driver Amplifier	HMC383LC4 HMC499LC4 HMC635LC4	HMC300LM1 HMC383LC4 HMC635LC4	HMC-APH403 HMC-APH473 HMC-APH510	HMC-ABH209 HMC-ABH241 HMC-ABH403	HMC-AUH317 HMC-AUH318 HMC-AUH320
Power Amplifier	HMC499LC4 HMC693 HMC-APH196 HMC-APH460 HMC-APH462 HMC-APH596 HMC-APH608	HMC693 HMC-ABH264 HMC-APH403 HMC-APH473 HMC-APH510 HMC-APH596	HMC693 HMC-ABH264 HMC-APH403 HMC-APH473 HMC-APH510 HMC-AUH256	HMC-ABH209 HMC-ABH241 HMC-ABH403	HMC-ALH508 HMC-AUH317 HMC-AUH318 HMC-AUH320
Wideband **(Distributed)** **Amplifiers**	HMC-ALH140 HMC-ALH216 HMC-ALH244 HMC-ALH311 HMC-ALH313 HMC-ALH364 HMC-ALH369 HMC-ALH445 HMC-ALH476 HMC-AUH232 HMC-AUH249 HMC-AUH256 HMC-AUH312	HMC635 HMC-ALH140 HMC-ALH244 HMC-ALH310 HMC-ALH313 HMC-ALH364 HMC-ALH369 HMC-ALH376 HMC-ALH445 HMC-AUH249 HMC-AUH256	HMC-ALH140 HMC-ALH244 HMC-ALH310 HMC-ALH313 HMC-ALH364 HMC-ALH369 HMC-ALH376 HMC-ALH445 HMC-AUH232 HMC-AUH249 HMC-AUH256 HMC-AUH312	HMC-ALH376 HMC-AUH312	
Attenuator: Analog	HMC712LP3CE HMC812LC4 HMC-VVD102	HMC-VVD106	HMC-VVD106	HMC-VVD106	HMC-VVD104
Divide-by-4	HMC447LC3				
Multiplier: Active x2	HMC448LC3B HMC577LC4B HMC578LC3B HMC598	HMC449LC3B HMC578LC3B HMC579 HMC598	HMC598	HMC598 HMC-XDH158	
Multiplier: Active x4					
Multiplier: Passive x2 / x3	HMC331	HMC331			

A selection of components, see the full product listing starting on page 10.

MICROWAVE & MILLIMETERWAVE RADIO, 26 to 86 GHz

Function	26 / 28 GHz	32 / 38 GHz	32 - 43 GHz	44 - 66 GHz	71 - 86 GHz
I/Q Receiver	HMC572 HMC572LC5				
I/Q Mixer / IRM	HMC524 HMC524LC3B HMC-MDB172	HMC404 HMC555 HMC556	HMC-MDB171 HMC-MDB172	HMC-MDB171 HMC-MDB207	
Mixer: Fundamental	HMC292LC3B HMC329LC3B HMC557 HMC557LC4 HMC560 HMC560LM3	HMC294 HMC329LM3 HMC560 HMC560LM3		HMC-MDB169	
Mixer: Sub-Harmonic	HMC264LC3B HMC265LM3 HMC338LC3B HMC798LC4	HMC338 HMC339 HMC798LC4		HMC-MDB218	
Power Detectors	HMC662LP3E				
Switch				HMC-SDD112	HMC-SDD112
VCO & PLO: **Requires X2 or X4	HMC515LP5E** HMC531LP5E** HMC639LP4E HMC739LP4E	HMC505LP4E HMC506LP4E			
Switch				HMC-SDD112	HMC-SDD112
VCO & PLO: **Requires X2 or X4	HMC515LP5E** HMC531LP5E**	HMC505LP4E HMC506LP4E			

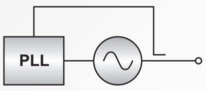
Double Upconversion & Direct Downconversion



Hittite's High Frequency LO Source Alternatives

PLL & VCO Chipset

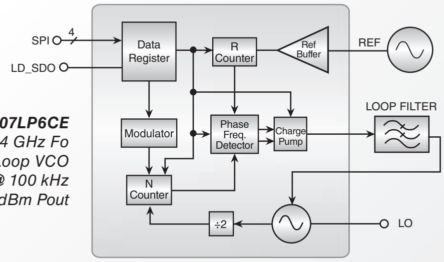
HMC702LP6CE
Fractional-N Synthesizer (PLL)
• 10 KHz to 14 GHz
• Low Phase Noise: -103 dBc
• -227 FOM Integer Mode



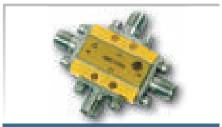
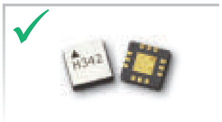
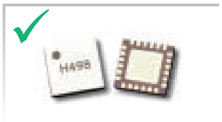
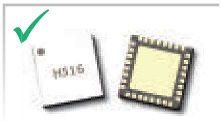
HMC584LP5E
VCO with Fo/2 & Fo/4 Output
• 12.5 - 13.9 GHz Fo
• Low Phase Noise
-110 dBc/Hz @ 100 kHz
• +10 dBm Pout

PLL with Integrated VCO IC (see pg. 9)

NEW!
HMC807LP6CE
• 12.4 - 13.4 GHz Fo
• -110 dBc/Hz Open Loop VCO Phase Noise @ 100 kHz
• +8 dBm Pout



Products Available in Die, SMT or Connectorized Package Form to 86 GHz!

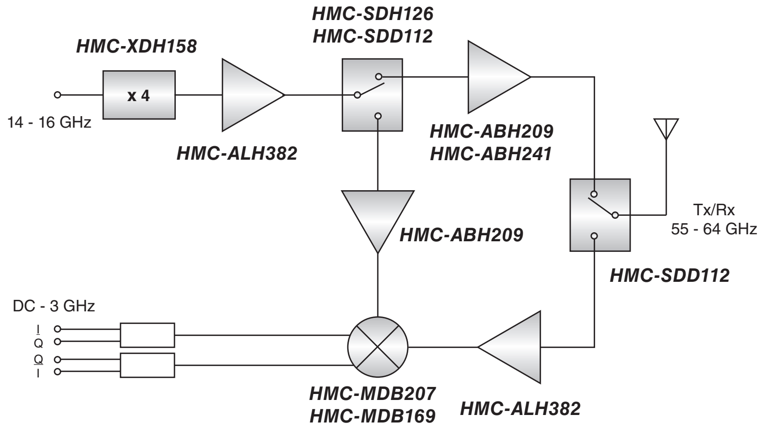
				
C-4	LC3 / LC3B	LC4 / LC4B	LC5	LM1 / LM3
41.66 x 36.32 x 8.50 mm	3.0 x 3.0 x 1.0 mm	4.0 x 4.0 x 1.0 / 1.2 mm	5.0 x 5.0 x 1.0 mm	5.1 x 5.1 x 1.1 mm

Typical Microwave / Millimeterwave application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

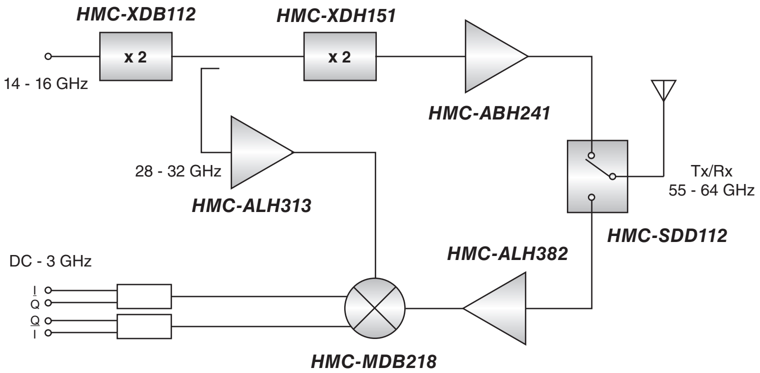
60 GHz Tx/Rx Chipset

Features:

- < 4 dB LNA Noise Figure
- +18 dBm Psat PA Output Power
- Sub-Harmonic Option Available
- I/Q or Double-Balanced Mixer Products Available



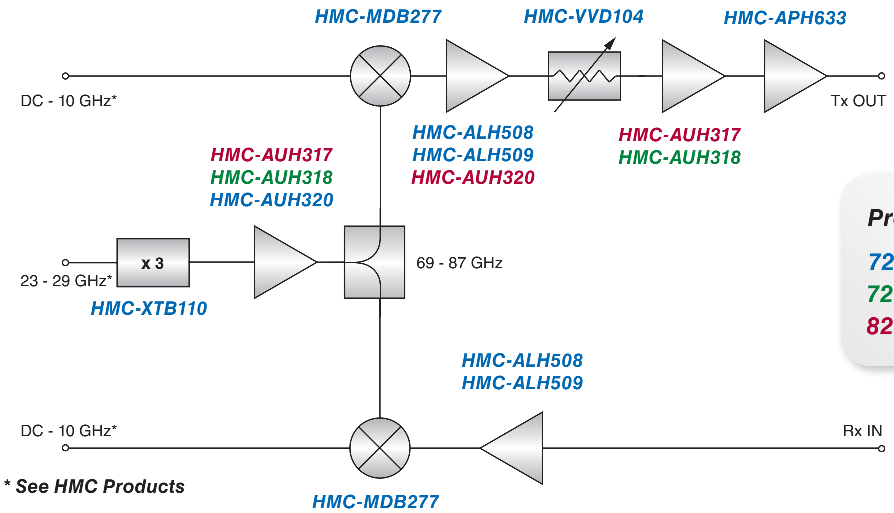
Sub-Harmonic Option for 60 GHz Chipset



Applications:

- Short Haul High Capacity Links
- Picocell Mobile Phone Links
- Network Backbone & Branch Links
- HDTV Wireless Component Links

72 & 82 GHz Tx/Rx Chipset for High Capacity Communication Links



Product Key

72 & 82 GHz

72 GHz Only

82 GHz Only

Typical Microwave / Millimeterwave application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

MILITARY & SPACE

High Reliability Solutions for Land, Sea, Air & Space

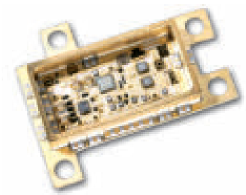
MILITARY LEVEL COMPONENTS, MODULES & SUBSYSTEMS

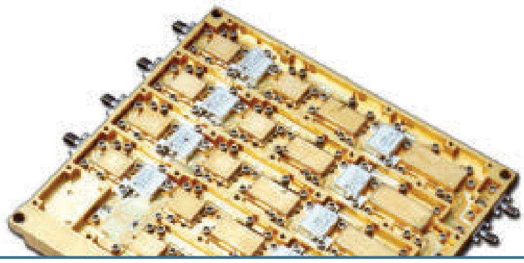
- Class B screening on standard & custom product die and SMT packaging.
- Design, production & screening of highly integrated MIC sub-assemblies for major defense OEMs.
- Military & Space Upscreening to Customer Specifications.

Military Solution Inquiries: MIL@hittite.com

Class B Screening & Qualification

- ***VI to Method 2010B & 2017H***
- ***Bond Pull & Die Shear Test***
- ***Solderability Test***
- ***High Temp Burn-In Test***
- ***Vibration Stress Test***
- ***Temp Cycle Stress Test***
- ***Constant Acceleration Stress Test***
- ***Fine & Gross Hermeticity Test***
- ***Serialized Test Data***
- ***ESD Characterization***





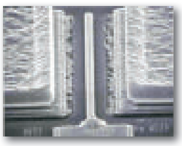
SPACE LEVEL COMPONENTS, MODULES & SUBSYSTEMS

Class S Screening & Qualification

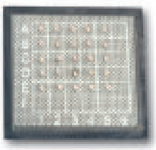
- ***VI to Methods***
  2010A & 2017K
- ***Temp Cycle Stress Test***
- ***High Temp Burn-In & Life Test***
- ***Wafer Lot Acceptance Test***
  Bond Pull & Die Shear Test
  SEM Inspection
  Metal & Glass Thicknesses
- ***Serialized Test Data***
- ***Qualification Report***

- Class S screening on standard & custom product die and SMT packaging.
- Military & Space Upscreening to Customer Specifications.
- Qualified by major spacecraft OEMs worldwide.
- Over 45,000 S-Level components currently operational on dozens of commercial, scientific & military spacecraft.

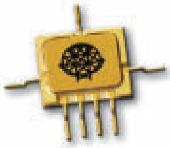
Space Solution Inquiries: SPACE@hittite.com



FET Channel SEM

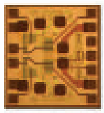


Serialized Die in GEL-PAK



Hermetic SMT Package

Hermetic Modules



Chip (Die)

Contact Us Today With Your High Reliability Mixed-Signal RF, Microwave & Millimeterwave Requirements!

7 DESIGNER'S KITS AVAILABLE TO CHOOSE FROM!

NEW!

- ***Gain Blocks DC - 6 GHz, HMC-DK001***
- ***Linear Driver Amplifiers 0.4 - 2.5 GHz, HMC-DK002***
- ***High IP3 Mixers 0.45 - 4.0 GHz, HMC-DK003***
- ***Digital Attenuators DC - 6 GHz, HMC-DK004***
- ***SPDT Switches DC - 12 GHz, HMC-DK005***
- ***Passive Attenuator Chips DC - 50 GHz, HMC-DK006***
- ***Serial/Parallel USB Interface Kit, HMC-DK008 NEW!***

Design engineers can order pre-packaged MMIC Designer's Kits which enable them to quickly assess which Hittite product is the best choice for their application. The end result is a design that goes to layout more quickly and with fewer subsequent changes.

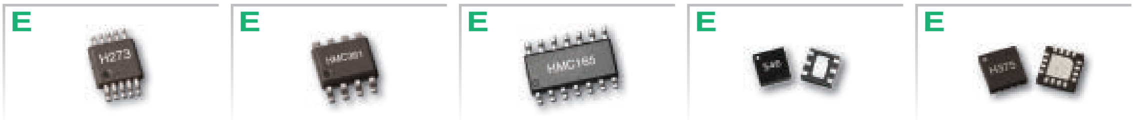
Each Hittite Designer's Kit contains an assembled & tested connectorized evaluation board, 5 to 10 ICs of each part and the latest Hittite CD-ROM catalog.

Designer's Kit	Kit Contents: ICs		Kit Contents: Eval Boards	
Gain Blocks DC - 6 GHz HMC-DK001	HMC474MP86E HMC476MP86E HMC313E HMC311ST89E HMC478MP86E HMC478ST89E	HMC479MP86E HMC479ST89E HMC481ST89E HMC480ST89E HMC481MP86E HMC482ST89E	104217 – HMC313E 110161 – HMC478ST89E 107490 – HMC481MP86E	
Linear Driver Amps 0.4 - 2.5 GHz HMC-DK002	HMC454ST89E HMC450QS16GE HMC413QS16GE	HMC452ST89E HMC453ST89E HMC457QS16GE	107749 – HMC454ST89E 108349 – HMC450QS16GE 105000 – HMC413QS16GE	108712 – HMC452ST89E 108718 – HMC453ST89E 106043 – HMC457QS16GE
Hi-IP3 Mixers 0.45 - 4.0 GHz HMC-DK003	HMC387MS8E HMC483MS8GE HMC399MS8E HMC316MS8E HMC400MS8E HMC485MS8GE	HMC402MS8E HMC214MS8E HMC478ST89E HMC481ST89E HMC480ST89E	110161 – HMC478ST89E 105188 – HMC485MS8GE	106334 – HMC399MS8E 101830 – HMC400MS8E
Digital Attenuators DC - 6 GHz HMC-DK004	HMC291E HMC468LP3E HMC274QS16E HMC271ALP4E HMC273MS10GE	HMC305ALP4E HMC306MS10E HMC470LP3E HMC472LP4E	103372 – HMC291E 107302 – HMC468LP3E 104976 – HMC274QS16E 108782 – HMC271ALP4E 103393 – HMC273MS10GE	108782 – HMC305AMS10E 103393 – HMC306MS10E 107006 – HMC470LP3E 107010 – HMC472LP4E
SPDT Switches DC - 12 GHz HMC-DK005 *UPDATED!*	HMC221AE HMC284MS8GE HMC349MS8GE HMC232LP4E HMC544E	HMC595E HMC574MS8E HMC784MS8GE HMC536MS8GE	101675 – HMC221AE 107662 – HMC349MS8GE 107723 – HMC232LP4E	104124 – HMC574MS8E 104124 – HMC784MS8GE 105143 – HMC536MS8GE
Passive Attenuators DC - 50 GHz HMC-DK006	HMC650 HMC651 HMC652 HMC653 HMC654	HMC655 HMC656 HMC657 HMC658		
Serial/Parallel USB Interface Kit HMC-DK008 *NEW!*	The HMC-DK008 Serial/Parallel Interface Designer's kit enables users to interface with Hittite's family of digital attenuators and variable gain amplifiers. Including: HMC743LP6CE and HMC792LP4E			

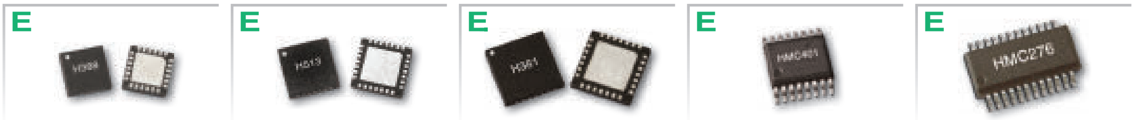
Package Information

Available Plastic, Ceramic, Hermetic SMT & Connectorized Module Packages

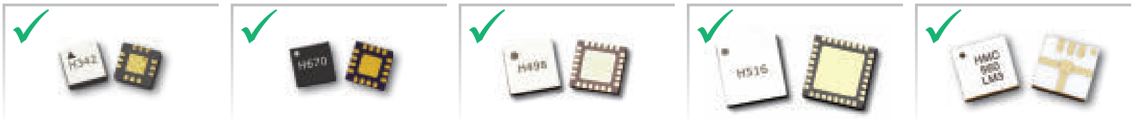
E	E	E	E	E
MP86 "Micro-P"	SC70	SOT26	ST89	MS8 / MS8G
5.21 x 5.08 x 1.57 mm	2.15 x 2.1 x 0.9 mm	2.8 x 2.9 x 1.2 mm	4.50 x 4.14 x 1.54 mm	4.9 x 3.0 x 1.0 mm



E	E	E	E	E
MS10 / MS10G	S8 / S8G	S14	LP2 "DFN"	LP3 "QFN"
4.9 x 3.0 x 1.0 mm	6.0 x 4.9 x 1.6 mm	6.0 x 8.7 x 1.6 mm	2.0 x 2.0 x 1.0 mm	3.0 x 3.0 x 1.0 mm



E	E	E	E	E
LP4 / LP4B / LP4C "QFN"	LP5 "QFN"	LP6 / LP6C "QFN"	QS16 / QS16G	QS24
4.0 x 4.0 x 1.0 mm	5.0 x 5.0 x 1.0 mm	6.0 x 6.0 x 1.0 mm	6.0 x 4.9 x 1.5 mm	6.0 x 8.7 x 1.6 mm



✓	✓	✓	✓	✓
LC3 / LC3B	LC3C	LC4 / LC4B	LC5	LM1 / LM3
3.0 x 3.0 x 1.0 mm	3.0 x 3.0 x 1.45 mm	4.0 x 4.0 x 1.0 / 1.2 mm	5.0 x 5.0 x 1.0 mm	5.1 x 5.1 x 1.1 mm

✓	✓	✓	✓	✓
C8	LH250 Hermetic	LH5 Hermetic	G8 Hermetic	G7 Hermetic
7.4 x 5.1 x 2.4 mm	6.35 x 6.35 x 1.27 mm	5.0 x 5.0 x 1.0 mm	10.2 x 4.6 x 1.8 mm	16.1 x 17.3 x 1.7 mm

✓	✓	✓	✓	✓
G16 Hermetic	C-1 / C-1B	C-2 / C-2B	C-3 / C-3B	C-4
10.4 x 10.4 x 1.7 mm	35.31 x 17.78 x 7.38 mm	38.1 x 17.78 x 7.38 mm	40.89 x 17.78 x 7.38 mm	41.66 x 36.32 x 8.50 mm

✓	✓	✓	✓	✓
C-5	C-6	C-7	C-9	C-10 / C-10B
41.66 x 26.8 x 8.79 mm	45.34 x 17.27 x 8.50 mm	192.3 x 106.7 x 35.0 mm	44.45 x 21.59 x 8.76 mm	46.63 x 21.59 x 8.50 mm

✓	✓	✓	✓	✓
C-11	C-12	C-13	C-14	C-15
41.66 x 26.8 x 8.64 mm	107.6 x 43.0 x 43.0 mm	39.43 x 47.12 x 11.42 mm	41.91 x 29.85 x 9.65 mm	59.69 mm DIA x 9.14 mm

✓	✓	✓	✓	✓
C-16	C-17	C-18	C-19	C-20
48.0 x 48.26 x 14.10 mm	68.5 x 66.0 x 14.2 mm	38.10 x 47.62 x 26.67 mm	27.31 x 25.15 x 5.84 mm	53.59 x 19.05 x 6.22 mm

E *or* ✓ *= RoHS Compliant.*

For more information on our "Green" component program, please contact earthfriendly@hittite.com for details on our RoHS Compliant products or see the RoHS Compliant Components link on our web site.

GAIN BLOCKS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Gain Blocks	Mini-Circuits	Gali-1, Gali-19, Gali-2, Gali-21, Gali-29	HMC311ST89E	
Gain Blocks	Mini-Circuits	VAM-3, VAM-6, VAM-7, VNA-21		HMC313E
Gain Blocks	Mini-Circuits	LEE-49, LEE-59		HMC396
Gain Blocks	Mini-Circuits	LEE-39		HMC397
Gain Blocks	Mini-Circuits	LEE-19, LEE-29		HMC405
Gain Blocks	Mini-Circuits	MAR-1SM, MAR-2SM, MAR-6SM, MAR-7SM	HMC474MP86E	
Gain Blocks	Mini-Circuits	ERA-1, ERA-1SM, ERA-2, ERA-21SM, ERA-2SM, ERA-3, ERA-3SM, ERA-8SM, MAR-3SM, RAM-1, RAM-2, RAM-3, RAM-4, RAM-6, RAM-7, RAM-8	HMC476MP86E	
Gain Blocks	Mini-Circuits	MNA-3, MNA-5, VNA-23 , VNA-28		HMC476MP86E
Gain Blocks	Mini-Circuits	Gali-S66	HMC476ST89E	
Gain Blocks	Mini-Circuits	ERA-33SM, MAR-4SM, MAR-8ASM, MAR-8SM	HMC478MP86E	
Gain Blocks	Mini-Circuits	MNA-7		HMC478MP86E
Gain Blocks	Mini-Circuits	Gali-3, Gali-33, Gali-39, Gali-4F, Gali-51F, Gali-52, Gali-55, Gali-5F, Gali-6F	HMC478ST89E	
Gain Blocks	Mini-Circuits	ERA-4SM, ERA-4XSM, ERA-5, ERA-6, ERA-6SM, MAV-11SM, MAV-11BSM, MAV-11A	HMC479MP86E	
Gain Blocks	Mini-Circuits	MNA-2 , MNA-4, VNA-22		HMC479MP86E
Gain Blocks	Mini-Circuits	Gali-4, Gali-49, Gali-6	HMC479ST89E	
Gain Blocks	Mini-Circuits	Gali-5, Gali-51, Gali-59	HMC480ST89E	
Gain Blocks	Mini-Circuits	ERA-4, ERA-50SM, ERA-51SM, ERA-5SM, ERA-5XSM	HMC481MP86E	
Gain Blocks	Mini-Circuits	MNA-6, VNA-25		HMC481MP86E
Gain Blocks	Mini-Circuits	Gali-74	HMC482ST89E	
Gain Blocks	RFMD	SGA-4163, SGA-4263		HMC311ST89E
Gain Blocks	RFMD	NGA-586, NGA-589, NGA-686, NGA-689		HMC313E
Gain Blocks	RFMD	SGA-0163, SGA-0363, SGA-1163, SGA-1263, SGA-2163, SGB-2233, SGA-2263, SGA-2363, SGA-2463, SGB-4333		HMC474MP86E
Gain Blocks	RFMD	SGA-2186, SGA-2286, SGA-2386, SGA-2486	HMC474MP86E	
Gain Blocks	RFMD	SGA-3263, SGA-3363, SGA-3463, SGA-3563, SGB-2433, SGB-4533		HMC476MP86E
Gain Blocks	RFMD	NGA-386 , SGA-3286, SGA-3386, SGA-3486, SGA-3586	HMC476MP86E	
Gain Blocks	RFMD	SGA-4186, SGA-4286, SGA-4386, SGA-4486, SGA-5386, SGA-5486, SGA-5586	HMC478MP86E	
Gain Blocks	RFMD	SGB-6433, SGB-6533		HMC478MP86E
Gain Blocks	RFMD	SGA-4363, SGA-4463, SGA-4563		HMC478ST89E
Gain Blocks	RFMD	SGA-4586, SGA-5389, SGA-5489, SGA-5589	HMC478ST89E	
Gain Blocks	RFMD	SGA-5263		HMC479ST89E
Gain Blocks	RFMD	SGA-5286	HMC479MP86E	
Gain Blocks	RFMD	SGA-5289	HMC479ST89E	
Gain Blocks	RFMD	NGA-489 , SGA-6289, SGA-6389, SGA-6489, SGA-6589, SGA-7489	HMC580ST89E	
Gain Blocks	RFMD	SGA-6386, SGA-6286, SGA-6486, SGA-6586	HMC481MP86E	
Gain Blocks	RFMD	NGA-186, NGA-286, NGA-486		HMC480ST89E
Gain Blocks	RFMD	SGA-7489	HMC482ST89E	
Gain Blocks	Triquint	AH1	HMC636ST89E	
Gain Blocks	Triquint	AM-1	HMC639ST89E	
Gain Blocks	Triquint	ECG004B, ECG006F	HMC311ST89E	HMC311LP3E
Gain Blocks	Triquint	AG102, AG103	HMC580ST89E	
Gain Blocks	Triquint	AG302-63, AG303-63, ECG004F		HMC313E
Gain Blocks	Triquint	AG201-63, AG202-63, AG203-63		HMC474MP86E
Gain Blocks	Triquint	AG201-86, AG202-86, AG203-86	HMC474MP86E	
Gain Blocks	Triquint	AG302-86, AG303-86, ECG001C, ECG004C	HMC476MP86E	
Gain Blocks	Triquint	ECG001F, ACG001B		HMC476MP86E
Gain Blocks	Triquint	AG503-86, ECG002C, ECG006C	HMC478MP86E	
Gain Blocks	Triquint	ECG002F		HMC478MP86E
Gain Blocks	Triquint	ECG006B, ECG002B, SCG002B, AG503-89	HMC478ST89E	
Gain Blocks	Triquint	AG402-86, ECG040C, AG602-86, EC1119C	HMC479MP86E	
Gain Blocks	Triquint	AG402-89, ECG040B, AG602-89, EC1119B	HMC479ST89E	
Gain Blocks	Triquint	AG603-89, AG604-89, ECG050B, EC1019B	HMC480ST89E	
Gain Blocks	Triquint	AG403-86, ECG005C, ECG055C, AG603-86, AG604-86, ECG050C, EC1019C, EC1078C	HMC481MP86E	
Gain Blocks	Triquint	AG403-89, ECG005B, ECG055B	HMC481ST89E	
Gain Blocks	Triquint	EC1078B, ECG003, ECG008	HMC482ST89E	

Competitor Cross-Reference

Hittite MICROWAVE CORPORATION

Hittite Microwave Offers Performance & Price Competitive Components

ATTENUATORS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Digital Attenuators	Skyworks	AA100-59LF	HMC230MS8E	
Digital Attenuators	Skyworks	AA101-80	HMC274QS16E	
Digital Attenuators	Skyworks	AA106-86	HMC603MS10E	
Digital Attenuators	Skyworks	SKY12322-86	HMC306MS10E	
Digital Attenuators	Skyworks	SKY12323-303	HMC273MS8GE	
Digital Attenuators	Skyworks	SKY12324-73	HMC291E	
Digital Attenuators	Skyworks	SKY12325-350LF	HMC468LP3E	
Digital Attenuators	M/A-COM	MAATSS0002	HMC274QS16E	
Digital Attenuators	M/A-COM	MAATSS0001, MAATSS0017	HMC603QS16E	
Digital Attenuators	M/A-COM	MAATSS0012	HMC306MS10E	

HIGH SPEED ICs

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
High Speed Logic	Inphi	13600DF	HMC727LC3C	
High Speed Logic	Inphi	13610XR	HMC725LC3C	
High Speed Logic	Inphi	13612OR	HMC726LC3C	
High Speed Logic	Inphi	13616CF	HMC724LC3C	
High Speed Logic	Inphi	20708SE	HMC728LC3C	
High Speed Logic	Inphi	13620TF	HMC729LC3C	
High Speed Logic	Inphi	25720TF		HMC729LC3C
High Speed Logic	Inphi	13707RZ	HMC706LC3C	

POWER DETECTORS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Log Detectors	Analog Devices	AD8313		HMC600LP4E HMC601LP4E
Log Detectors	Analog Devices	AD8317		HMC611 HMC611LP4E
Log Detectors	Analog Devices	AD8318		HMC602LP4E HMC611LP4E
RMS Detectors	Analog Devices	AD8362		HMC610ALP4E
Log Detectors	Maxim	MAX2014,		HMC612LP4E
Log Detectors	Maxim	MAX2015		HMC600LP4E HMC601LP4E
RMS Detectors	Maxim	MAX2203		HMC610ALP4E
Log Detectors	Linear Technology	LT5534, LT5538		HMC600LP4E HMC601LP4E
Log Detectors	Linear Technology	LT5570		HMC612LP4E
RMS Detectors	Linear Technology	LT5581		HMC610ALP4E

SWITCHES

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Switches	Skyworks	AS204-80	HMC241QS16E	
Switches	Skyworks	AS196-307	HMC349LP4CE	
Switches	Skyworks	AS193-73	HMC544E	
Switches	Skyworks	AS169-73	HMC545E	
Switches	Skyworks	AS186-302	HMC435MS8GE	
Switches	M/A-COM	SW-239	HMC239S8E	
Switches	M/A-COM	SW-395		HMC544E
Switches	RFMD	SSW-124	HMC234C8	

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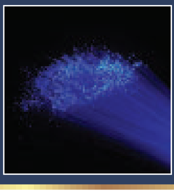
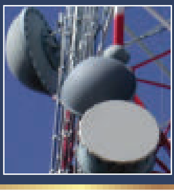
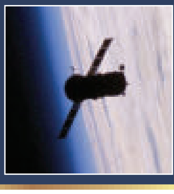
Connecting Our World Through Integrated Solutions

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