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SPST								1247
0.2 – 2	SW1-002020RN1NF	1.7	70	1.6:1	10/10	20	35	35/70
2 – 8	SW1-020080RN1NF	2	80	1.7:1	10/10	20	35	35/70
4 – 12	SW1-040120RN1NF	2.2	80	1.7:1	10/10	20	35	35/70
2 – 18	SW1-020180RN1NF	3	80	2:1	10/10	20	35	35/70
1 – 18	SW1-010180RN1NF	3	70	2:1	10/10	20	35	35/70
SP2T								
0.2 – 2	SW2-002020RN1NF	1.5	70	1.6:1	10/10	20	35	60/60
2 – 8	SW2-020080RN1NF	1.8	80	1.7:1	10/10	20	35	60/60
4 – 12	SW2-040120RN1NF	2.2	80	1.7:1	10/10	20	35	60/60
2 – 18	SW2-020180RN1NF	2.8	80	2:1	10/10	20	35	60/60
1 – 18	SW2-010180RN1NF	3	70	2:1	10/10	20	35	60/60
SP3T								
0.2 – 2	SW3-002020RN1NF	1.6	70	1.6:1	20/20	150	180	85/85
2 – 8	SW3-020080RN1NF	1.9	80	1.7:1	20/20	150	180	85/85
4 – 12	SW3-040120RN1NF	2.4	90	1.7:1	20/20	150	180	85/85
2 – 18	SW3-020180RN1NF	3	80	2:1	20/20	150	180	85/85
1 – 18	SW3-010180RN1NF	3.1	70	2:1	20/20	150	180	85/85

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APRIL 2010 VOL. 53 • NO. 4

2010 IEEE MTT-S International Microwave Symposium & Exhibition

26 California Dreamin'

David Vye, Editor, Microwave Journal

Overview of Microwave Journal's coverage of the 2010 IEEE MTT-S International Microwave Symposium and Exhibition

28 Microwaves in the Land of Sun and Honey

Chuck Swift and Les Besser

Two industry stalwarts explore the history of microwaves in Southern and Northern California

66 Welcome to the 2010 IEEE MTT-S International Microwave Symposium

J.K. McKinney, IMS2010 General Chairman

Introduction by the symposium general chairman to Microwave Week 2010 events scheduled in Anaheim

70 2010 RFIC Symposium: RF Design for New Horizons

Yann Deval, 2010 RFIC General Chair

Introduction to the 2010 IEEE Radio Frequency Integrated Circuits Symposium, to be held in Anaheim, Sunday, May $23^{\rm rd}$ to Tuesday, May $25^{\rm th}$

74 75th ARFTG Conference Highlights

Ken Wong, Conference Chair

Preview of the 75^{th} Automatic Radio Frequency Techniques Group (ARFTG) Conference, to be held in Anaheim, Friday, May 28^{th}

76 IMS 2010 MicroApps: Diversity in Microwaves

Sherry Hess, AWR Corp.

Introduction to a forum designed for participating exhibitors to present the technology and capabilities behind their products

80 Assignment: Anaheim

Pat Hindle, Richard Mumford and David Vye, Microwave Journal Editors

Three engineers are assigned to explore the products and technologies on display at this year's Microwave Week exhibition

94 The Anaheim Connector

Use Microwave Journal's twitter feed to determine what to see and where to eat while in Anaheim

98 2010 IMS Exhibitors

Alphabetical listing of companies participating in the Microwave Week exhibition and their respective booth numbers

106 Exhibitor Profiles

Profiles from advertising IMS exhibitors



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FEATURES

TECHNICAL FEATURES

184 Comparison of Two GaN Transistor Technologies in Broadband Power Amplifiers

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

Comparison of the performance of two GaN technology transistors utilized in broadband power amplifiers at 0.7 to $1.8~\mathrm{GHz}$

194 Two-arm Archimedean Spiral Helical Antenna with Wraparound Absorber

Sandeep Palreddy and Rudolf Cheung, Microwave Engineering Corp.

Presentation of a method to miniaturize a spiral antenna without sacrificing performance at lower frequencies

206 Notch Implemented Dual Behavior Resonator Filter and Diplexer at Ku-band

K. Singh and K. Ngachenchaiah, Semi-Conductor Laboratory; D. Bhatnagar, University of Rajasthan; S. Pal, ISRO Satellite Center

Presentation of a dual behavior resonator-based microstrip filter for realization of a diplexer at Ku-band $\,$

218 Narrowband Microwave Bandpass Filter Design by Coupling Matrix Synthesis

 ${\it M. Hagensen, Guided Wave Technology ApS}$

Demonstration of practical filter design using coupling matrix synthesis and three-dimensional electromagnetic simulation techniques

SPECIAL REPORT

228 M/A-COM is Reborn on Its 60th Birthday

Pat Hindle, Microwave Journal Technical Editor

A brief history of M/A-COM as the company prepares to celebrate six decades as the "first name in microwave"

PRODUCT FEATURE

234 MicroSynthTM Integrated Hermetic Synthesizer Module

Hittite Microwave Corp.

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PRODUCT FEATURES

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

Avago Technologies

Introduction to a single-ended or balanced first-stage low noise amplifier for various cellular base station applications

242 1 W GaAs MMIC Amplifier for 18 GHz Cellular Backhaul Applications

 $TriQuint\ Semiconductor$

Development of a power amplifier designed to meet the requirements in the 17.7 to 19.7 GHz band allocated for wireless backhaul

246 37 to 43 GHz Power Amplifier Family

OMMIC

Introduction to a family of power amplifiers covering 37 to 43 GHz and providing 500 mW and 1 W output power

DEPARTMENTS

21 ... Mark Your Calendar

22 ... Coming Events

165 ... Defense News

169 ... International Report

173 ... Commercial Market

176 ... Around the Circuit

252 ... New Products

276 ... The Book End

278 ... Ad Index

280 ... Sales Reps

282 ... MWJ Puzzler



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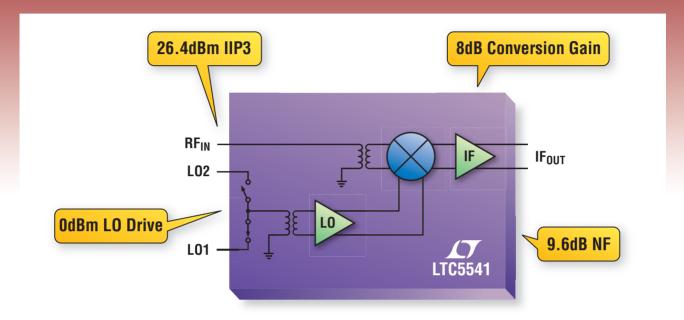
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White Paper, Agilent Technologies Inc.

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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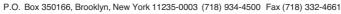
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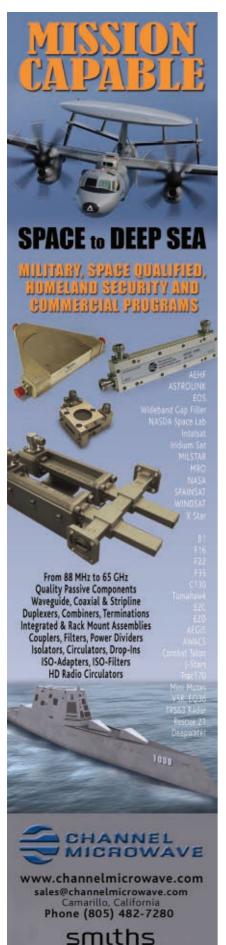














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October 21-24, 2010 • Cerritos, CA www.microwaveupdate.org

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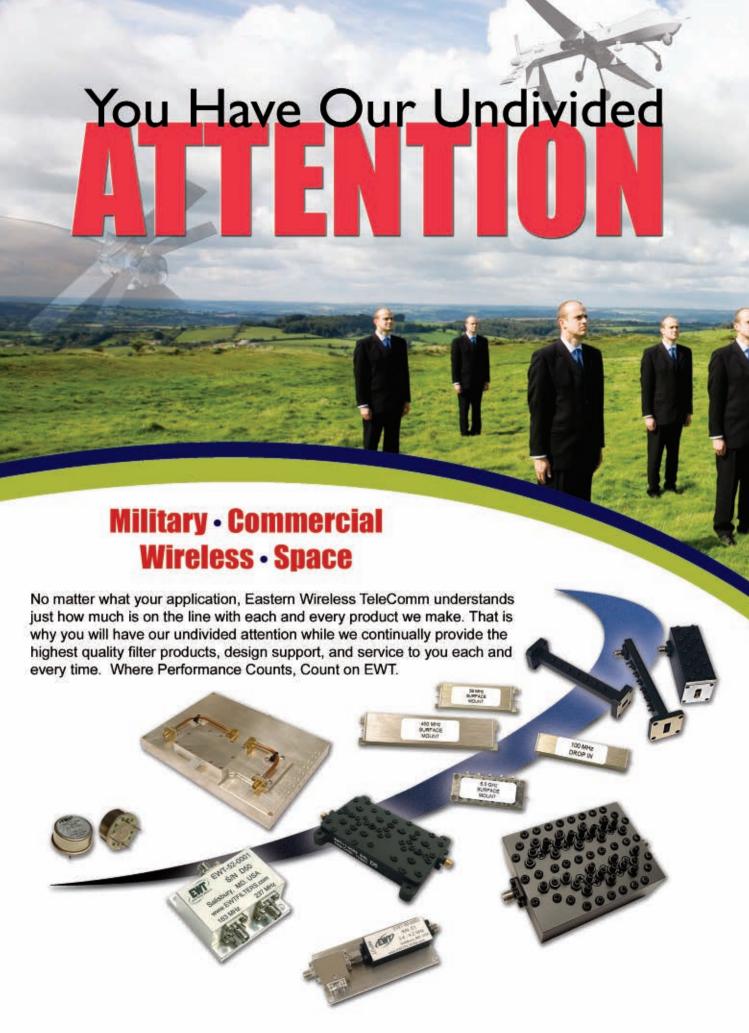
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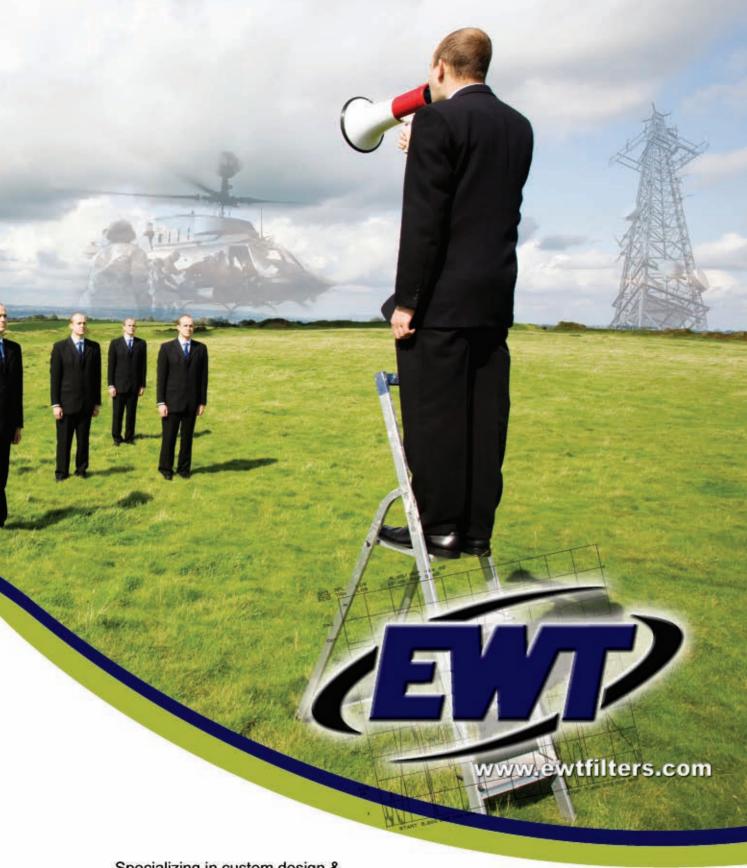
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CALIFORNIA DREAMIN9

ere 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 two-fold. 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.

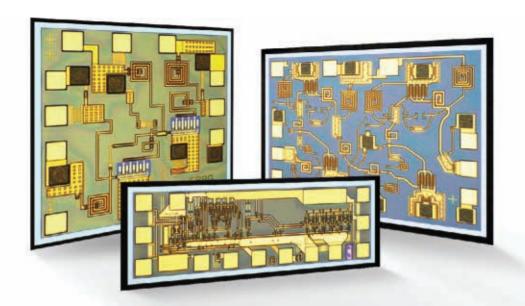
For the second year, we present "Exhibitor Profiles". This summary of who is showing what, by participating exhibitors, is your one-stop guide to the products that will be featured at the show. If you need help scheduling your time at IMS, the exhibitor profile section will help you prioritize who to 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

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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 Ra-

dar (ASR) at S-band and Precision Approach Radar (PAR) at X-band set the military air traffic standards. control The system was HUCK SWIFT 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. While a great contributor to the winning of WWII, the GCA became famous into radar. for its ability to

guide planes to a successful landing during the Russian Blockade of Berlin.

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



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

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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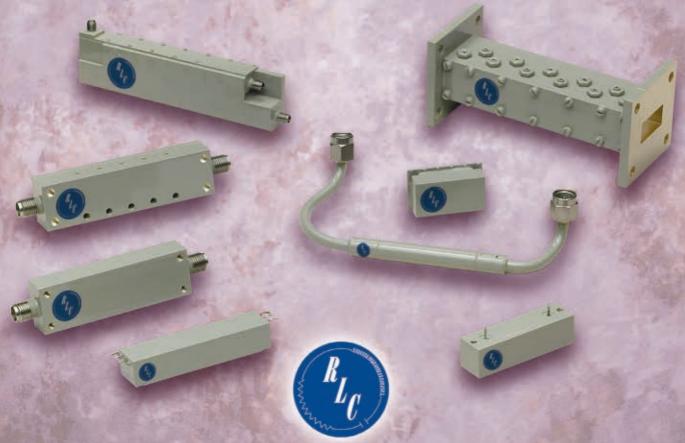
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in New Jersey. In 1962, Gilfillan Brothers Inc.'s name was changed to Gilfillan Corp. On January 30, 1964, all of the assets were transferred to ITT Gilfillan, a wholly owned subsidiary of ITT Corp.² From this auspicious beginning, Gilfillan refined 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 longrange, three-dimensional radar produced ship-borne and landbased 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/ TLO-32 Anti-radiation Missile Decov (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 con-



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

trol system for the F86, which led to Hughes's prominence as a bastion of microwave technology.

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, Kband 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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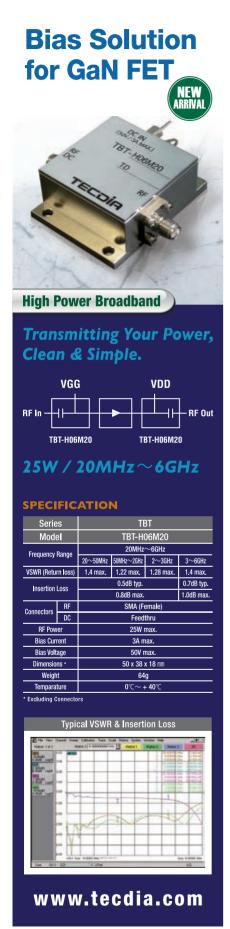
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CHANGING THE STANDARDS

TECDIA





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 Aero-

space 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

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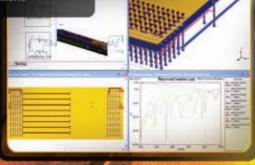
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(MBE). RF Micro Devices was one of the first to recognize the commercial potential of TRW's GaAs HBTs resulting from the MIMIC program. Early on in the epi game, TRW and RFMD teamed together (RFMD doing the design, test and marketing; TRW doing foundry 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

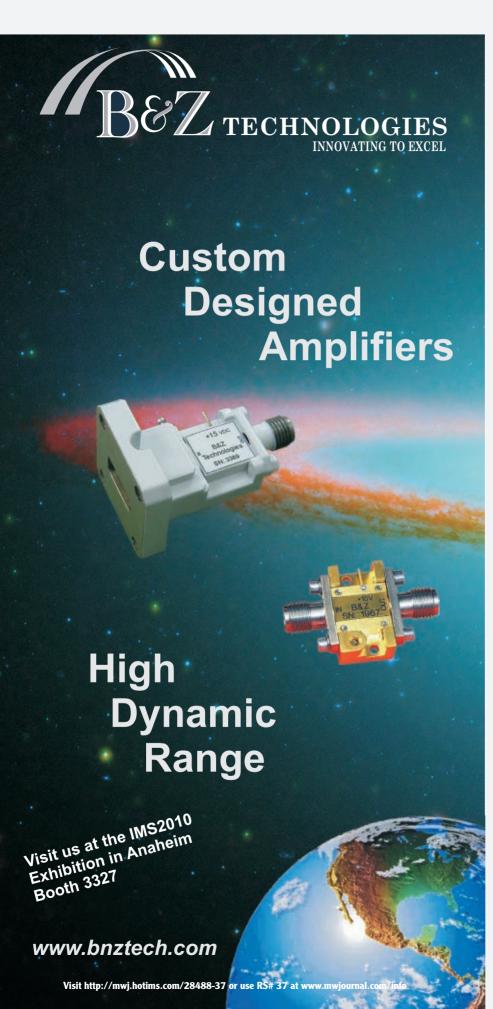
Founded in 1972 by Chuck Abronson and Jim Cole, with funding from personal savings, family and friends, Amplica grew rapidly and profitably, with initial sales coming from the defense electronics market. The commercial availability of GaAs FETs a few years after the company started enabled an entirely 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 homebrewed 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 IBMcompatible 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).

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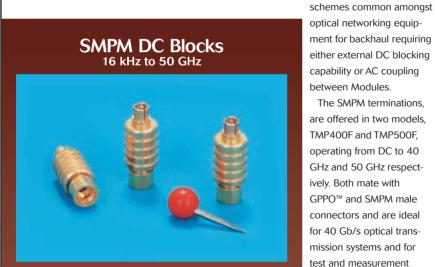
Manv noteworthy chapters of microwave history are set in Northern California. Early Bay Area electronics companies are characterized by local venture capitalists; close ties between industry and research universities; a product mix of electronic components, production equipment, advanced communications, instru-

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mentation, 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.

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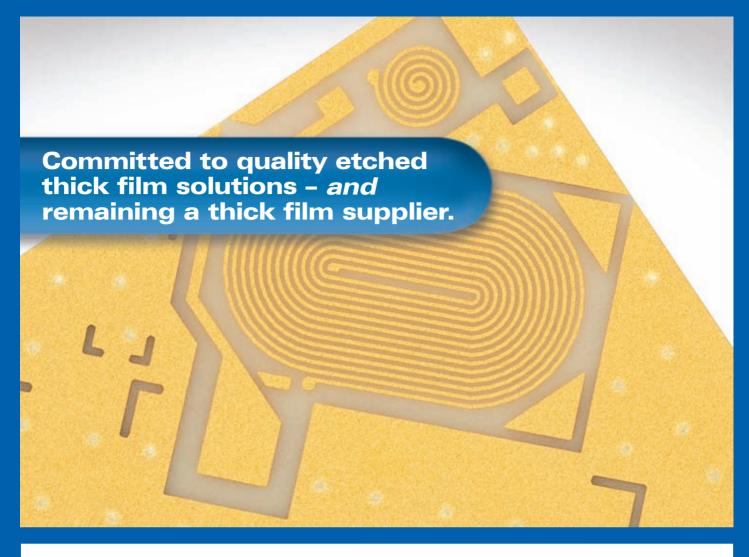
THE FEDERAL TELEGRAPH CO.

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

The Navy's demand for more powerful arc transmitters soon



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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 plaqued 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



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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

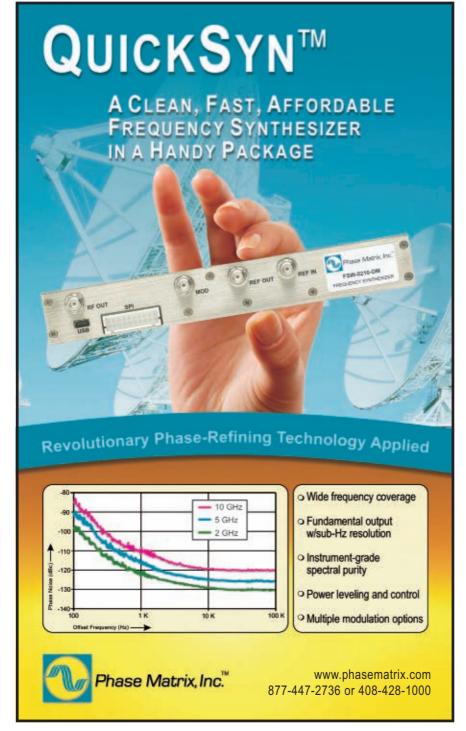
The vacuum tube industry in the San Francisco Bay Area, while smaller than the captive operations of the large East Coast firms, was nevertheless an important one. The activities of Elwell. Fuller, DeForest, Farnsworth, Litton, Heintz and Kaufman (H&K), and Eitel and McCullough (Eimac, which was acquired 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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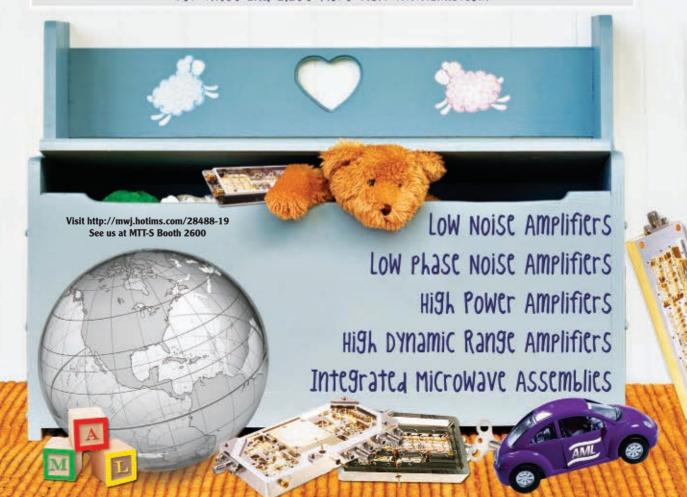


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and manufacture vacuum tube production equipment. Litton's glass-blowing lathe was able to mass produce glass tube blanks at uniform quality, a huge improvement over the hand-blown blanks of the day. These machines were unique and were used for mass 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-ofthe-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

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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 hightech 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.

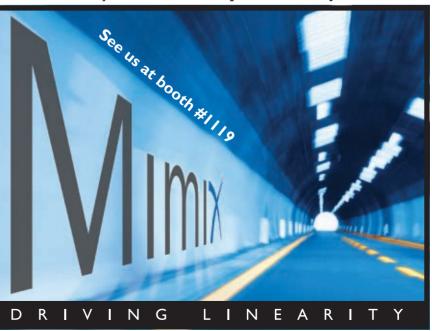
Westinghouse offered to manage the contract, arguing that high-volume production would be too difficult for a small company like Dalmo Manufacturing. Moseley agreed, and the company, now Dalmo-Victor, moved to a larger facility in Belmont to produce the units. By the end of World War II, Dalmo-Victor 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.

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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.

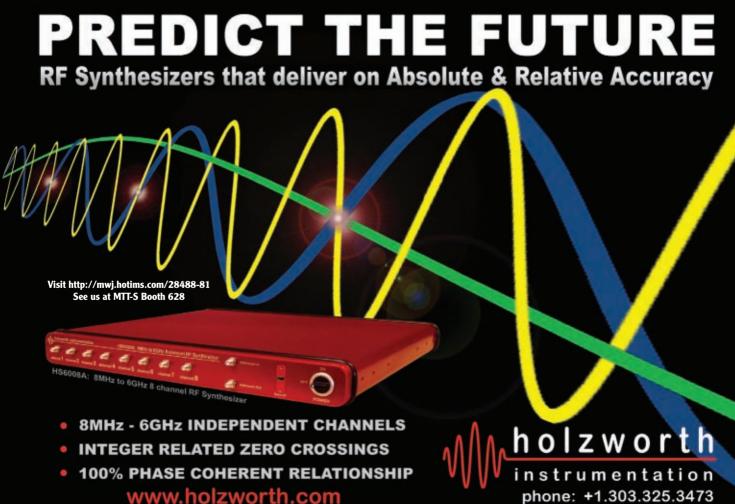
Competition for funding was intense, particularly for larger programs associated with major military systems. For example, each new aircraft would typically require a specialized avionics suite that resulted in large development and manufacturing programs. Many of the Bay Area companies had core expertise 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



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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.

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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 MES-

FET 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 MES-FETs 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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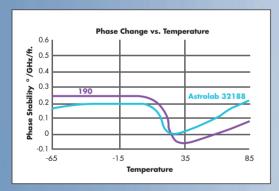




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ing from discrete devices to hybrid microwave integrated circuits (MIC) to monolithic MICs (MMIC). A large number of intermediate-sized local spinoffs and start-ups emerged from both companies during the 1970s and 1980s, but most are no longer in business.

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-

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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 am-

plifiers 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 highspeed 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,

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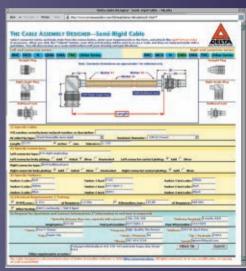
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frequency counters and related products accounted for billions of dollars in revenue. By 1956, HP produced its first oscilloscopes, models 130A/150A.

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-



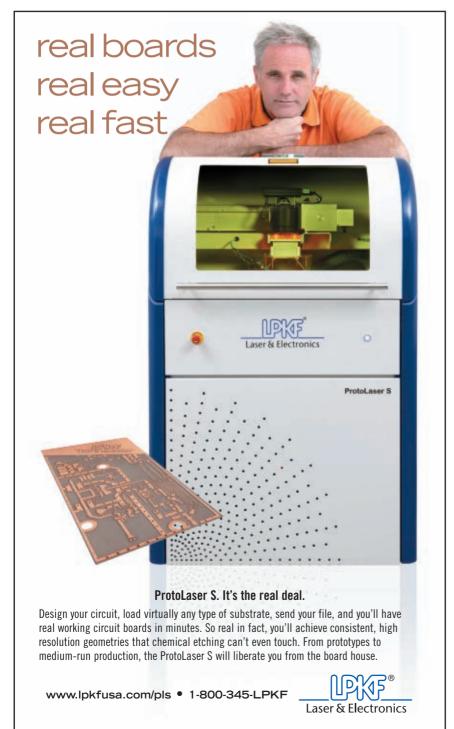
Fig. 4 The first HP Automatic Network
Analyzer (ANA) developed in 1968.

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.

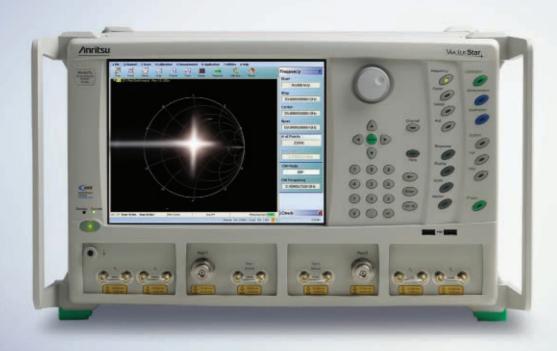
The technology developed for advanced weapons systems, EW and countermeasures would produce advanced instrumentation and require advanced measurement systems. Helped by the invention of the transistor and the analog and digital circuitry that came about with the introduction of minicomputers, Northern 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.



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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

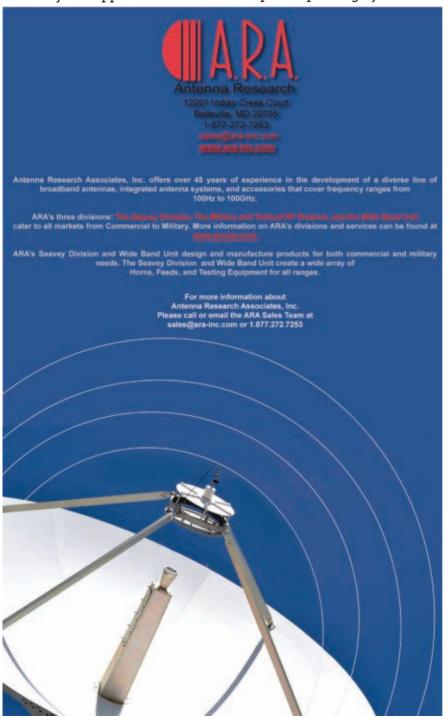
programming languages for engineers. Soon after, several software packages were also developed, and became commercially available to microwave designers.

During the early 1970s, COM-PACT (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, SuperCOM-PACT, 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 localarea 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





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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
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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-topoint 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



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







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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 devel-

oping 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 Angheim.



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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elcome 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



Madhu Gupta and Chuck Krumm.

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.

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

I.K. McKinney

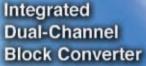
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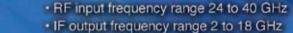
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will allow extra time for those who live in the southern California area the opportunity to drive in and enjoy the exhibition. The Industry Hosted Cocktail Reception will be held on Wednesday afternoon on the show floor between 5:00 and 6:00 PM.

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 exhibit-

ing vendors. Presentations are held continuously during show hours in the Micro-Apps 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 quest program to experience. IMS2010 has teamed with PRA Tours to provide an outstanding offering of tours allowing one to visit many of the famous California southern attractions. For information about the 11 different tours avail-

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Onsite information about the tours will be available daily in the hospitality

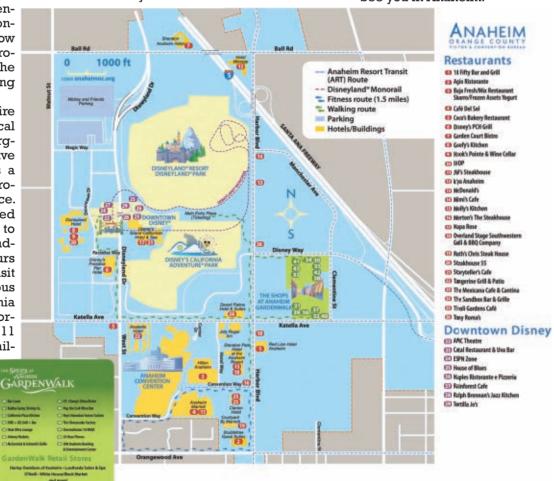
suite. The child-friendly hospitality suite will be located in the Sheraton Park Hotel next to the Anaheim Hilton. The hospitality suite provides both indoor and outdoor amenities. Please stop by and say hello to the helpful volunteers who will be there to ensure that your stay in Anaheim is enjoyable.

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 Dis-(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 iust 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.



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Technological highlights: signal generation

- I Frequency range up to 43.5 GHz
- Excellent spectral purity, e.g. typ. −120 dBc (1 Hz) at 10 GHz, 10 kHz offset
- I High output power, e.g. typ. +25 dBm at 20 GHz
- Flexible pulse generation for radar applications
- Easy replacement of legacy instruments



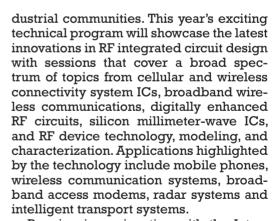


2010 RFIC Symposium: RF Design for New Horizons

elcome 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 vear its impact and reputation excellence. By bringing focus to the technical accomplishments in RF circuits, systems devices. the RFIC Symposium has become essential to both the academic and in-



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



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- Digital Noise Generation
- Satellite Communications (BER, Eb/No)
- Wireless (WiMAX & LTE)
- >60 GHz Noise Figure
- Serial Data Compliance (Jitter, Rj)
- Wireless HD Testing
- Receiver & Antenna Calibration











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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 multimode 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 So-

lutions 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 lunch-time 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-

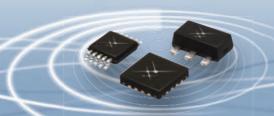
speed I/O: Electrical, Optical or Wireless?," is posed to stimulate interactive discussions with the audience. There will be a total of 21 oral paper sessions on Monday and Tuesday. The technical program will conclude with an Interactive Forum session on Tuesday afternoon, which will feature 26 poster 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			Breakfast 7am-9am				Breakfast 7am-9am				Breakfast 7am-9am			
8AM												RFIC Technical		
9AM		E E								REGISTRATION 7am-5pm		8am- 10:10am		
10AM		REGISTRATION 7am-6pm				mdc								
11AM		NOIL		Workshops		REGISTRATION 7am-5pm		RFIC	Panel					
NOON		STRA		Workshops & Tutorials 8am-5pm				Technical Session	Session 11:50pm-	RATIO			Panel Session 11:50pm- 1:20pm	
1PM		REGI		oum op	ISTRA		8am-5:10pm	1:20pm	GIST		RFIC	1.200111		
2PM	_					REG				~		Technical 1:20pm-3pm	Interactive Forum	
3РМ	Registration												2pm-4pm	
4PM	2pm-6pm													
5PM					Plenary									
6РМ					5:30pm- 6:40pm									
7PM					RFIC Reception									
8PM					7pm-9pm									
		RI	EGISTRATION	BREAKFAST	т тесні	NICA	L SOC	IAL	PANEL	1	INTERACTIVE FORUM			

Fig. 1 IEEE RFIC Symposium schedule.



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.



Wireless Energy Management

Unique front-end solutions for automated metering infrastructure (AMI), security, medical, and home/industrial automation. Products address all major ISM bands and ZigBee® / IEEE 802.15.4 standards.



Wireless Data Communications (WLAN, WiMAX)

High-performance RF switching and amplification solutions that enable design flexibility for all 802.11a,b,g,n WLAN applications, as well as fixed and mobile WiMAX applications targeting the licensed WiMAX bands: 2.5 GHz and 3.5 GHz.



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RF and microwave technical ceramics, switching, diode and amplification solutions for defense and homeland security systems, including radio communications, radars, electronic surveillance, electronic countermeasures and more. Screenings equivalent to JANS level of MIL-PRF-19500, and Class K of MIL-PRF-38534 available.

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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

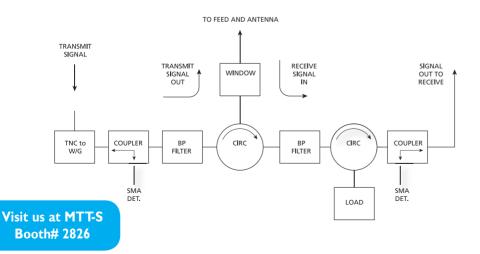
Conference Chair

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IMS 2010 MICROAPPS: DIVERSITY IN MICROWAVES

he 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



IMS 2009 MicroApps booth.

76

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

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 Micro-Apps 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 25^{th} .

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- Remote Control via RS422

RS485

Ethernet

- Automatic/Manual Control Modes
- · Remote Status
- Amplifier Current Fault Detection
- · Weather Resistant LNA/Switch Assembly
- · Time-Stamped Alarm History
- · Front Panel LNA Bias Control & Monitoring

FREQUENCY CONVERTERS for SATCOM and MILITARY APPLICATIONS

FEATURES

- · HF thru Ka Bands offered
- · Module and Chassis versions offered
- · External or Internal References
- · Low Intermodulation Distortion
- · No Spectral Inversion
- · Low Phase Noise
- · High Frequency Stability
- Temperature Compensation Available
- · Compact Size
- · Hermetic Units Available



PMI & AmpliTech together offering the worlds best:

Amplifier Products:

Industries Lowest Noise Figures

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



Gain Equalizers and Gain Equalized Amplifiers:

Positive or Negative Gain Slope Designs up to 40GHz Space / Military Qualified Excellent Gain Linearity SMA Coaxial Packages Phase Matching / Tracking



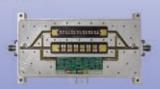
Cryogenic Amplifiers:

Unconditional Stability
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 Best Noise Figures Without Isolator Lightweight, Compact Design Weatherproof / Rugged Design High Gain Options



ASSISIMENT Since vendors keep new product information "confidential" Since vendors keep new producting what will create a stir at what will create a stir at a stir at years and the stir at a sti

Since vendors keep new product information "confidential to the product information" confidential will create a stir at a stir at the producting what will create a stir at until Microwave Week, predicting what will creat press releases and in a bit of a guessing game. Using recent press our editions is a bit of a guessing game. Using recent press from the related trade shows, our editions in a bit of a guessing game. White is a bit of a guessing game and structure and the following preview, written the radar, and new complied the following preview, written the radar, perspective of three (fictitious) attendees from the radar, perspective of three (fictitious) attendees, who discuss their infrastructure and mobile device markets, who discuss the related trade 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 an-

nouncements 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.

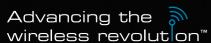
Finally, Dave expects to spend a lot of time with the RF power amplifier, switch, filter module guys. His company has dealt with the major vendors, so he knows them pretty well. His company has a good size product portfolio of mobile devices, so no one solution fits all their needs. Cost. added engineering effort, linearity and battery life-time are big concerns. Dave's company is keeping an eye on mode-specific versus converged multimode cellular frontend 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.





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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/DSA'70000), 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 NX252OSA TCXO), Valpey Fisher, Vectron International (TX-500 TCXO/BAW/SAW filters), Synergy Microwave, Crystel (CVT2O)

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: RF780x - 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 SKY7'760Xmultimode/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 multimode/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)" inclades
power amp and RF power management, switching and
signal conditioning in ref. design

features a GSM/GPRS PA and an integrated PHEMT switch

SK 477601/4 improved performance under mismatch and lower current consumption

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

TQM7M5013

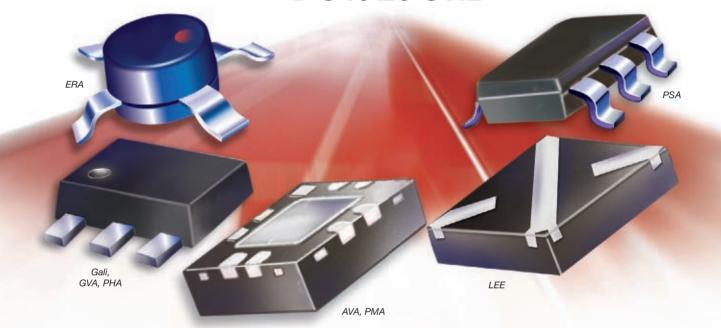
Includes Hadron PA, and SP6T switch (Quad-band) or SP4T (Dual-band) to support 3G WPGRS and WEDGE

Silicon on Insulator (Sol)

Various low cost single pole four and eight throw switches SK 414152/3/5

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DC to 20 GHz



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NF from 0.5 dB, IP3 to +48 dBm, Gain 10 to 30 dB, Pout to +30 dBm

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Tight process controls produce consistent performance across multiple production runs, ensuring repeatability and confidence with every unit. In fact, cascading multiple amplifiers often produce less than 1dB total gain variation at any given frequency. Operating from supply voltages as low as 2.8V, current consumption down to 20 mA and packages as small as our SOT-363, these MMIC amplifiers can meet critical size and power consumption system requirements.

Visit our website to locate the amplifier that meets your specific needs. Each model includes full electrical, mechanical and environmental specifications and a full set of characterization data including S-Parameters. Also - look for our application notes that provide characterization of our MMICs for complex modulation such as WCDMA, LTE, QAM and other digital standards. All models are in stock for immediate shipment.

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Assignment:

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 commercial applications and 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 tar-

gets 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.

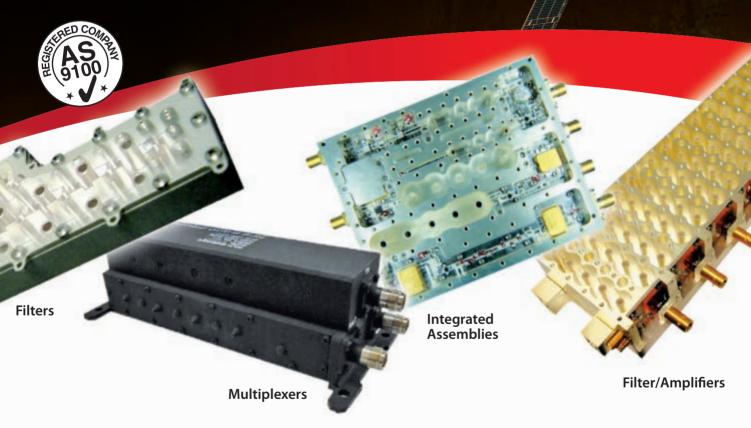
Footnote: Radar Rik and his company are fictitious and any resemblance to any existing past or present person or company is purely coincidental.

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Compar Test &	ny : Measurement:	Product(s)	Notes
	, Anritsu, Rohde & Schwarz	Network analyzers	Check out new nonlinear capabilities - PNA-X; Vectorstar and ZVA
			asso Option H08 for pulsed RF from Agilent
Agilent	, Anritsu, Rohde & Schwarz,	Signal/spectrum analyzers & digital oscilloscopes	<i></i>
	Aicrowaves, Maury Microwave	Load-pull systems	Waveform engineering and active harmonic tuning
Aerofle	x, Anritsu, Tektronix, Trilithic	Signal generators	Consider Anritsa's MG37020A fast switching microwave signal generator and
			Aeroflex (2200 DEM Mod. Freq. Synth.)
AR Wor	Pldwide, Empower RF Systems,	High power amp test systems, EMC test	
Boonton	n, Mini-Circuits, Micronetics,	Power meters/sensors, noise sources	
	ation Software:		
	asoft, Remcom	3D EM simulation	Antenna design, radar cross section for electrically large structure
Agilent Syster	, AWR, Sonnet ns:	EEsof, Microwave Office	RF circuit board design with planar EM and system simulation capabi
Cernex		Antenna, transmitter, tracking systems, etc.	Discuss Cobham's UWB time domain radar system that is used as the
Subsy	stems:		basis for single channel or multi-channel radars
AML Co	ommunications, Cobham, Ducom- age Laboratories, Teledyne Cougar	Transmit/receive subsystems and fully integrated subsystems	Look at latest standard products and discuss castom design for upcoming project
Assem	nblies, Front-ends, Receiver,	Transceiver Modules:	projecti
	ation (NIC), Narda, MITEQ, Tele-	Integrated microwave assemblies	Consider Ducommun WiseWave millimeter—wave band sab-assemblies; NIC's daplexer LNA assemblies [L& SBand], and SYS9.0N01
			three-channel X-band monopulse radar receiver and Model 127077
0			transmit/receive switch/amplifier from MITEQ
power I	mers: ommunications, CTT Inc., Em- RF Systems, Quinstar Technology, ne Cougar	Limiting, low noise and power amplifiers	Find out how manufacturers are addressing the demand for more power
	s, Connectors and Waveguide	S: Cables, cable assemblies, connectors and intercon-	W
gies, Cr ble, Hul San-tro	ystek Interconnects, EZ Form Ca- ber + Suhner, MDL, Rosenberger, in Inc, Spectrum Elektrotechnik, r, Teledyne Storm, Tru Corp.		Need products that are stable, reliable and ragged enough for harsh environments—look into Haber + Sakner's One-Stop Solation and in tigate Spectrum's Components Group regarding design and manafactu
MDL, S	pinner, Waveline, Cobham, Chan-	Waveguide systems	of custom designs Review advanced waveguide and coaxial components
nel MW	, RLC, Logus, Microtech		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,
	y Joints: n Sensor Systems	Rotary joints for ground based radar	1 + + + + + + + + + + + + + + + + + + +
Spinner	The state of the s	Rotary joints and slip rings for military and civilian	Investigate Kevlin Corp. offering Look into waveguide/coaxial/slip ring combinations
	onductors/RFICs/MMICs:	radar systems.	The system, severally sup i my community
Endway	ve, Hittite, Mimix Broadband, Skyworks, RFHIC Corp.	Semiconductor, integrated circuit and materials development for radar applications	Products: Hittite's HMC-C072 GoAs HBT altra low phase noise amplifier module; Mimia Broadband's P1072-BD 34.0-37.0 GHz G
			MMIC PA; RFHIC's wideband amplifiers (RRP models)
Found	ries:		
OMMIC WIN Se	, TriQuint Semiconductor, UMS, miconductor	GaAs foundry services, PHEMTs and HBTs	1 2 5
Active	es - Power Transistors:		0 0
	ale, Integra Technologies, emi, TriQuint Semiconductors	Power transistors and transmit/receivers. SiC, GaN, LDMOS and HV HBT (TriQuint)	Products: Integra's S-band silicon bipolar power transistors; TriQui Semiconductors PowerBand(tm) RF transistors
	ves - Isolators/Circulators/At ECA Electronics, MESL Micro-	ttenuators/Filters, etc.: Isolators and circulators	DIAMERIKA INI SIR SIR SI
	TE Microwave	TOO WOLD WITH OIL ORIGINAL D	Products, MESLX-Band differential 4-port circulators or airborn ground and naval radars
tion, Co Micro I Reacte	n, American Microwave Corpora- pilcraft, JQL, Logus Microwave, Lambda, MECA Electronics, I, UTE Microwave, Weinschel ates, Werlatone	Surface mount couplers, attenuators, inductors, resistors, etc.	The basic components-Products; Coilcraft's military grade RF Ch inductors
	ficrowave, Micro Lambda, NIC,	Filters - bandpass, high-pass etc. , diplexers, multiplexers	Products: K&L's IB Series bandpass filter for ground base radar i



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Assignment:

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 ex-

hibitor'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).

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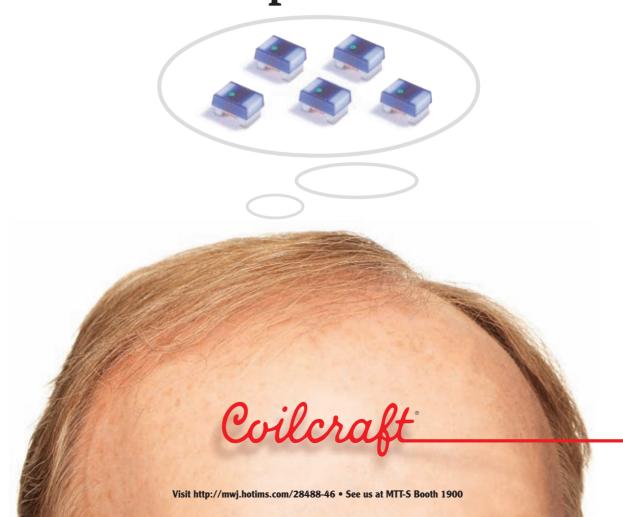
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The List: Infrastructure

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	
Rohde & Schwarz	CMW500 wideband radio communication tester	BTS Testing-priority
Tektronix, Trilithic, etc.		Handoff testing Scopes, etc.
		oupes, eu.
Testing Support: Aeroflex	Splitter, attenuators, terminations, etc.	Need flexible configurations
AR	Amplifier systems	The earlier configurations
See MWJ Cables & Connectors	Cables/Connectors	Need stable, rugged test cables - warn cables are becoming a problem!
Supplement, March 2010		, reconstant, ragger continues and recomming up assum,
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.		v v
Power Amps: Show me the Power!	Mari December of Goodh	
Nujira/TriQuint	TriPower w/ Coolteq.h	Very high efficiency-2.1 GHzLTE 52%, GoAs (new technology to chec
		out!)
RFMD	RF3931	30 W, GaN-
Freescale	Simplified Doherty designs	50 VLDMOS-check out HV8
Skyworks, M/A-COM, Hittite, RFHIC, Narda, Mimix, MicroSemi, Ciao, Mini- Circuits, ADI, Ommic		Check oat 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/Cir	culators/Coupler/Transformers:	
M/A-COM, Narda, Miteq, Trilithic, Wein-	Circulator/combiner or power amplifier	Custom integrated assemblies? Can we work closely with these suppliers;
schel, etc. Anaren, Mini-Circuits, Synergy, Meca,	sub-assemblies? Couplers, circulators, transformers, etc.	Standard products, SMT
Coilcraft, EMC, JQL, Tecdia, UTE, Filtel	<u>.</u>	
		Check out new Zinger (Anaren)
VCOs:		WiMAX splitters-Meca
Crystek	CVC055CC-1700-1700	and P. O an III
		-120 dB @ 10 kHz
Synergy	DCR0168172-8	-116 dB @ 10 kHz (new minatures)
Mini-Circuits	ROS-1960-219+	-121 dB @ 10 kHz
Z-Comm	ZR01920A1LF	-117 B @ 10 kHz
Valpey Fisher, ADI, Vectron, etc.		-111 W W 10 KAIZ
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:		
	HSWA2-30DR+	Check out low cost switches
Mini-Circuits	MASW-000825-12770T	Check out HMIC switches
Mini-Circuits M/A-COM		
	SKY13286-359LF	High icalation
M/A-COM		High isolation 6-bit diatal
M/A-COM Skyworks	SKY13286-359LF	6-bit digital
M/A-COM Skyworks Hittite RFMD JFW, Lorch, MECA, ET, RLC, EMC, ADI,	SKY13286-359LF HMC792LP4E	
M/A-COM Skyworks Hittite RFMD JFW, Lorch, MECA, ET, RLC, EMC, ADI, TriQuint, Anaren	SKY13286-359LF HMC792LP4E	6-bit digital
M/A-COM Skyworks Hittite RFMD JFW, Lorch, MECA, ET, RLC, EMC, ADI,	SKY13286-359LF HMC792LP4E	6-bit digital



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Octave Band Amplifiers

AMPLITECH MODEL NUMBER	FRED. RANGE (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (dB, Max.)	NOISE FIGURE (dB, Max.)	VSWR INPUT (Max.)	VSWR OUTPUT (Max.)	POWER @1dB C.P. (dBm, Min.)	NOM, DC POWER (+15 V, mA)	AmpliTech OUTLINE DRAWING
APT3-01000200-0510-D4	1-2	38	± 1.00	0.50	2.0:1	2.0:1	10	150	D4
APT3-08001200-1010-D4	8-12	29	± 1.00	1.00	2.0:1	2.0:1	10	125	D4

Multi-Octave Wideband Amplifiers									
AMPLITECH MODEL NUMBER	FREQ RANGE (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (dB, Mex.)	NOISE FIGURE (dB, Max.)	VSWR INPUT (Max.)	VSWR OUTPUT (Max.)	POWER @1dB C.P. (dBm, Min.)	NOM. DC POWER (+15 V, mA)	AmpliTech OUTLINE DRAWING
APT3-00500600-1010-D4	.5-6	28	± 1.25	1.00	2.0:1	2.0:1	10	125	D4
APT4-00501800-2410-D6	.5-18	26	± 2.50	2.40	2.5:1	2.5:1	10	225	D6
APT2-02002000-4510-D2	2-20	12	±1.00	4.50	2.0:1	2.0:1	10	100	D2
APT2-18002650-2208-D2	18-26.5	22	± 2.50	2.20	2.5 :1	2.5:1	8	150	D2

Ultra-Wide Band Amplifiers										
									AmpliTech OUTLINE DRAWING	
APT3-00100200-1015-D4	.1-2	38	±1.00	1.00	2.0:1	2.0:1	15	175	D4	
APT4-00102650-4008-D4	.1-26.5	18	± 2.50	4.00	2.5:1	2.5:1	8	175	D4	

		Mediu	m Power	Amplifie	rs				
AMPLITECH MODEL NUMBER	FREQ. RANGE (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (dB, Max.)	NOISE FIGURE (dB, Max.)	VSWR INPUT (Max.)	VSWR OUTPUT (Max.)	POWER @1dB C.P. (dBm, Min.)	NOM. DC POWER (+15 V, mA)	AmpliTech OUTLINE DRAWING
APTMP1-00010100-1821-D4	.01-1	15	± 1.50	1.80*	2.5:1	2.5:1	21	150	D4
APTMP3-00502000-5018-D4	.5-20	16	± 2.75	5.00	2.5:1	2.5:1	18	350	D4









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SATCOM LNA's

AMPLITECH MODEL NUMBER	FREQ. RANGE (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (dB, Max.)	TEMP ("K, Max.)	RETURN LOSS - IN (dB Min.)	RETURN LOSS-OUT (dB Min.)	POWER @1dB C.P. (dBm, Min.)	NOM. DC POWER (+15 V, mA)	AmpliTech OUTLINE DRAWING
APTW5-07100840-55K10-112	7.1-8.4	50	± 1.0	55	14	14	10	200	112+D4
APTW4-18002650-214K10-42	18.0-26.5	40	± 2.0	214	7	10	10	275	42+D4

	Cryoge	nic/Low P	ower Co	nsumptio	on Ampli	fiers			
AMPLITECH MODEL NUMBER	FREQ. RANGE (GHz)	GAIN (dB, Min.)	GAIN FLATNESS (dB, Max.)	MOIBE FIGURE (dB)	VSWR INPUT (Max.)	VSWR OUTPUT (Max.)	POWER @1dB C.P. (dBm, Min.)	NOM. DC POWER (V, mA)	AmpliTech OUTLINE DRAWING
APTC2-04000800-0700-D4-V	4-8	23	± 1.75	0.10	2.0:1	2.0:1	0	+3, 40	D4
APTC3-01000200-0500-D4-V	1-2	36	± 1.00	0.05	2.0 :1	2.0:1	0	+3, 40	D4

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LM - 0518 - 10 - 1W - SHS - 1

QC - 2040 QC - 4080 QC - 6012

QC - 8018 APD - 2 - 0518

SLVAC - 06135

SDLVA - 2020 - 70 - 0518 ILF - 1227 - 12 - BP ILF - 1575 - 15 - PB

27310820 DLVA - 7M - 80 - SFF PUB - 14 - 30M20G - 14 - LCA PUB - 14 - 500M20G - 14 - LCA POB - 16 - 48 - 22 - LCA

27305840 PE230 - 24 - 1R6 - 10 - 12 27300320 - B PE210R258R515SFFLM Rev.B 0.25 TO 8.5 GHz LNA, OP1dB 16 dBm

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2.0 - 4.0GHZ QUADRATURE COUPLER

4.0 - 8.0GHZ QUADRATURE COUPLER 6.0 - 12.0GHZ QUADRATURE COUPLER

8.0 - 18.0GHZ QUADRATURE COUPLER 0.5 - 18.0GHZ 2 - WAY POWER DIVIDER

0.6 - 1.35GHZ SDLVA (SURFACE MOUNT) 0.5 - 18.0GHZ SDLVA (CONNECTORIZED)

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0.5 - 20 GHz, 14dB Gain, OP1dB 14dBm, Ultra - Broadband Amp

4 - 8GHz Amp, 16dB Gain, OP1dB 22dBm

2-4 GHz LNA, 1.6 dB N.F.







THE ANAHEIM CONNECTOR

ree 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



Photo courtesy of AOCVCB.

Anaheim GardenWalk (www. anaheimgardenwalk.com) offers 46 different stores and restaurants for you to choose from.

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.

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A.J. Tuck Co.	
A.T. Wall Co.	
Actipass R&M Co. Ltd	2842
AdTech Ceramics	1735
Advanced Control Components Inc	
Advanced Test Equipment Rentals	
Aegis Technology Inc	3226
AEM Inc	2515
Aeroflex Inc.	1310
Aethercomm Inc.	
AFM Microelectronics Inc	
Agilent Technologies	
AI Technoloy Inc	2502
Airpoint Co. Ltd.	3610
AKON Inc.	
Aldetec Inc	
Allrizon-TG Communications Equipment	
Allstron Corp	3414
AMCAD Engineering	
American Microwave Corp.	
American Standard Circuits Inc	
American Technical Ceramics	1706
Ametek HCC Industries	1813
AML Communications Inc.	
* 1'C C.1 C. C.	2000
Amplifier Solutions Corp	
AmpliTech Inc.	
Analog Devices Inc	3330
AnaPico AG	
Anaren Inc.	
Anatech Electronics Inc.	
Anoison Electronics	2938
Anritsu Co	2910
ANSYS Inc. (Ansoft Products)	2700
AND ID INC. (Alison Floudets)	
X-4 D	
Antenna Research Associates-ARA Inc	500
Antenna Systems/Webcom Communications	500 2512
	500 2512
Antenna Systems/Webcom Communications APA Wireless Technologies	500 2512 1816
Antenna Systems/Webcom Communications APA Wireless Technologies	500 2512 1816 2406
Antenna Systems/Webcom Communications APA Wireless Technologies	500 2512 1816 2406 3400
Antenna Systems/Webcom Communications APA Wireless Technologies	500 2512 1816 2406 3400
Antenna Systems/Webcom Communications APA Wireless Technologies	500 2512 1816 2406 3400
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation.	500 2512 1816 2406 3400 802
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House	500 2512 1816 2406 3400 802 2804
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc.	500 2512 1816 2406 3400 802 2804 3302 2836
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc.	500 2512 1816 3400 802 2804 3302 2836
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc.	500 2512 1816 3400 802 2804 3302 2836 1702
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc.	500 2512 1816 3400 802 2804 3302 2836 1702
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK	500 2512 1816 3400 802 2804 3302 2836 1702 713
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC.	500251218162406340080228043302283617027131637
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL.	5002512181624063400802280433022836170271316371028
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation AR Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc Assemblies Inc Astrolab Inc ARK AMIGA Measurement Systems LLC Aurora Software & Testing SL Avago Technologies	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Aurora Software & Testing SL. Avago Technologies Aviel Electronics	5002512181624063400802280433022836170216371028254115062742
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation AR Technologies Inc Arlon Tech. Enabling Innovation. Artech House ASB Inc Assemblies Inc Astrolab Inc ARK AMIGA Measurement Systems LLC Aurora Software & Testing SL Avago Technologies	5002512181624063400802280433022836170216371028254115062742
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. Atrk Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC Aurora Software & Testing SL Avago Technologies Aviel Electronics AWR Corp. AWT AXION Test Equipment Inc.	500 2512 2818 2818 2406 3400 802 2804 3302 2836 1702 713 1637 1028 2541 1506 2742 1318 519
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT AXIOM Test Equipment Inc. B&Z Technologies	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC Aurora Software & Testing SL Avago Technologies Aviel Electronics AWR Corp. AWT AXION Test Equipment Inc.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT AXIOM Test Equipment Inc. B&Z Technologies	500 2512 2612 2816 2406 3400 802 2804 3302 2131 1637 1028 2541 1506 2742 1318 519 3710 3327 2421
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Avaiel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BECcube Inc.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. BEEcube Inc. Beijing Corelogic Communication Co. Ltd	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. BEEcube Inc. Besser Associates Inc.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. BEEcube Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Bliley Technologies Inc.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. BEEcube Inc. Besser Associates Inc.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. BEEcube Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Bliley Technologies Inc.	500 2512 2612 2816 2406 3400 802 2804 3302 2713 1637 1028 2742 1318 519 3710 3720 3227 2421 3201 1008 2828 3227
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Billey Technologies Inc. Bowei Integrated Circuits Co. Ltd. Brush Ceramic Products.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Avago Technologies AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Bowei Integrated Circuits Co. Ltd. Brush Ceramic Products. C. W. Swift & Associates Inc.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Billey Technologies Inc. Bowei Integrated Circuits Co. Ltd. Brush Ceramic Products. C.W. Swift & Associates Inc. C-Tech.	
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT. Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. BEEcube Inc. BEEcube Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Bliley Technologies Inc. Bowei Integrated Circuits Co. Ltd. Brush Ceramic Products C. W. Swift & Associates Inc. C-Tech. C.E. Precision Assemblies Inc.	500 2512 2812 2816 2406 3400 802 2804 3702 2836 1702 2836 2742 1506 2742 1318 3127 2421 1005 2828 3227 1638 1638
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Billey Technologies Inc. Bowei Integrated Circuits Co. Ltd. Brush Ceramic Products. C.W. Swift & Associates Inc. C-Tech.	500 2512 2812 2816 2406 3400 802 2804 3702 2836 1702 2836 2742 1506 2742 1318 3127 2421 1005 2828 3227 1638 1638
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Billey Technologies Inc. Bowei Integrated Circuits Co. Ltd. Brush Ceramic Products. C. W. Swift & Associates Inc. C-Tech. C Precision Assemblies Inc. CAD Design Software	500 2512 2512 2612 2712 3400 802 2804 3302 2836 1702 2713 1637 1038 2541 1506 2742 1318 2541 1506 2742 1318 3210 3211 3201 1005 2628 3227 1638 1513 3137 2426
Antenna Systems/Webcom Communications APA Wireless Technologies Applied Thin-Film Products AR RF/Microwave Instrumentation ARC Technologies Inc. Arlon Tech. Enabling Innovation. Artech House ASB Inc. Assemblies Inc. Astrolab Inc. ATK Auriga Measurement Systems LLC. Aurora Software & Testing SL. Avago Technologies Aviel Electronics AWR Corp. AWT. Axiom Test Equipment Inc. B&Z Technologies Barry Industries Inc. BEEcube Inc. BEEcube Inc. BEEcube Inc. Beijing Corelogic Communication Co. Ltd. Besser Associates Inc. Bliley Technologies Inc. Bowei Integrated Circuits Co. Ltd. Brush Ceramic Products C. W. Swift & Associates Inc. C-Tech. C.E. Precision Assemblies Inc.	

Camponil Electronics Inc.	3030
CAP Wireless Inc	
CapeSym Inc Carlisle Interconnect Technologies	
Cascade Microtech Inc	
Centellax Inc.	
Cernex Inc.	
Channel Microwave Corp	
Charter Engineering Inc.	1512
Chin Nan Precision Electronics Co. Ltd	
Ciao Wireless Inc.	
Cirexx International Inc	
Coastline Metal Finishing Corp	
Colleraft Inc.	
Coining Inc	
Coleman Cable Inc.	
Coleman Microwave Co	
Colorado Microcircuits	
COM DEV Ltd	
Communications & Power Industries	
Compex Corp.	2829
Component Distributors Inc	
COMSOL IncConnecticut Microwave Corp	
Connectronics Inc.	
Constant Wave Inc	
Corning Gilbert Inc	
Corry Micronics Inc	
CORWIL Technology Corp	
Crane Aerospace & Electronics	
Crane Polyflon	
Cree Inc. Cristek Interconnects Inc.	
Crystek Corp.	
CST of America Inc.	2924
CTT Inc.	
Cuming Microwave Corp	
Custom Cable Assemblies Inc	
Custom Interconnects	
Custom Microwave Components Inc.	
Custom MMIC Design Services Inc Daa-Sheen Technology Co. Ltd	
dBm	
Defense Tech Briefs & RF & Microwave Tech	1044
Delta Electronics Mfg. Corp	2706
Delta Microwave	
Design Workshop Technologies Inc	
DeWeyl Tool Co. Inc.	
Diablo Industries Thin Film	3202
Diamond Antenna & Microwave Corp Dielectric Laboratories Inc.	
Diemat Inc	
DiTom Microwave Inc.	1100
Doo Sung Industrial Co. Ltd.	2017
Dorado International Corp	
Dow Key Microwave Corp	
Ducommun Technologies Inc.	706
Dyconex AG	
Dynawave Inc	
e2v	
EADS North America Eagle Comtronics, Inc.	
Eagle Comtronics, Inc. Eastern-Optx/NoiseXT	
Eclipse Microwave Inc	
EE-Evaluation Engineering	
Electro Rent Corp	
ElectroMagneticWorks Inc	3600
Elisra Electronic Systems Ltd	1834
EM Research IncEM Software & Systems-FEKO	1810

EMAG Technologies Inc.	. 70
EMCO Elektronik GmbH	
Emerson & Cuming Microwave Products	
Emerson Connectivity Solutions	
Empower RF Systems	
Endwave Corp	
Epoch Microelectronics Inc	
Epoxy Technology Inc	
ET Industries	
ETL Systems	
ETS-Lindgren	
Euvis Inc	
Excelics Semiconductor Inc.	
EZ Form Cable Corp.	
F&K Delvotec Inc	
Ferraz Shawmut Inc.	
Ferrite Co., The	. 52
Ferro-Ceramic Grinding	
Filtel Microwave Inc	
Flann Microwave	
Flexco Microwave Inc	
Florida RF Labs/EMC Technology	
Focus Microwaves Inc	
Freescale Semiconductor	
Frontlynk Technologies Inc.	
FTG Corp.	
FujiFilm Dimatix Inc.	
FutureComm Co. Ltd	
General Dynamics Satcom Technology	3620
Gerotron Communication GmbH	
GGB Industries Inc.	
GigaLane Co. Ltd	
Gigatronics Inc	
Global Communication Semiconductors	
GNI Microwave Co. Ltd	
Gowanda Electronics	
GuangShun Electronic Tech. Research Inst	
Hantechnic Inc.	
Harbour Industries Inc.	
Herley Industries	
Herotek Inc	
Hesse & Knipps Inc	331
High Frequency Electronics	
Historical Booth	
Hittite Microwave Corp.	210
Holzworth Instrumentation Inc	
Hunter Technology	
HXI LLC	
IBM Corp	
IEEE Microwave Magazine	
IHP GmbH	
IMST GmbH	
In-Phase Technologies	. 829
NGUN Pruefmittelbau GmbH	
Innertron Inc.	
Innovative Micro Technology	
Instek America Corp.	
Instruments For Industry (IFI)	
Integra Technologies Inc.	
Integrand Software IncInternational Manufacturing Services	
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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.	
Lintek Pty Ltd	
Litron Inc.	
LNX Corp.	2200
Logus Microwave Corp	1519
Lorch Microwave	
LPKF Laser & Electronics	
M/A-COM Technology Solutions	
M2 Global Technology Ltd.	
Marcel Electronics International	
MathWorks	605
Maury Microwave Corp. McGraw-Hill Professional	126
MECA Electronics Inc.	
Mega Circuit Inc	
MegaPhase	. 631
Meggitt Safety Systems Inc	2917
Merrimac Industries Inc.	3320
MESL Microwave Ltd	
Metropole Products Inc.	1002
MIcable Inc.	
Mician GmbH	
Micreo Ltd	
Micro Communications Inc	
Micro-Coax Inc.	
Micro-Mode Products Inc.	
MicroApps	
MicroFab Inc.	
Micronetics Inc	
Microphase Corp.	
Microsemi Corp	
Microtech Inc.	
Microwave Applications Group	3517
Microwave Circuits	
Microwave Communications Labs Inc	
Microwave Development Labs Inc.	
Microwave Dynamics	
Microwave Engineering Corp. Microwave Engineering Europe	
Microwave Filter Co. Inc.	
Microwave Journal	
Microwave Marketing.com Ltd.	1811
Microwave Packaging Technology	
Microwave Product Digest	2930
Microwave Technology Inc	
Microwavefilters S.R.L	
MIG-Microwave Innovation Group	2832
Millitech Inc.	
Mimix Broadband	
Mini-Circuits	
MITEO Inc.	
Mitsubishi Electric & Electronics	
Modelithics Inc	
Modular Components National Inc.	
Molex	
Momentive Performance Materials	736
Mosis	
MPDevice Co. Ltd.	
MtronPTI	
Murata Electronics	
Namics Technologies Inc	
Nanjing Jiexi Technologies Co. Ltd.	602
National Instruments	
National Reconnaissance Office	
NAVICP	
NDK	
Nearfield Systems Inc	
Netcom Inc.	
Networks International Corp. (NIC)	
Nitronex Corp.	
NoiseWave Corp Norden Millimeter Inc.	
Norden Willimeter Inc. Northrop Grumman.	
NTK Technologies Inc	
NTT Advanced Technology	
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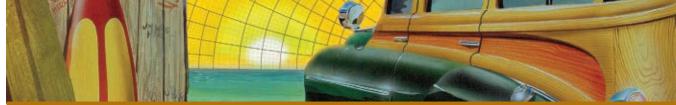
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Nujira Ltd. Nuvotronics	
NuWaves Engineering	
NXP Semiconductors	
OEwaves Inc	2517
OMMIC	2837
OPHIR RF Inc	2736
Orient Microwave Corp	2704
PldB Inc.	1331
PA&E	3621
Partron Co. Ltd	
Pascall Electronics Ltd.	1738
Passive Microwave Technology Inc	1919

Passive Plus Inc. PedaSoft LLC. Penn Engineering Components Inc Penton Media/Microwaves & RF. Peregrine Semiconductor Corp. Phase Matrix Inc. Phoenix Company of Chicago, The. Photofabrication eng. Inc Piconics Inc. Pivotone Communication Tech. Inc Planar Monolithics Industries Inc Plextek Ltd.	633 . 2402 . 1802 . 2914 . 1533 . 1712 434 . 1727 . 2431 . 3031
Pole/Zero Corp	. 1717

Polyfet RF Devices	
Power Module Technology	415
Precision Connector Inc	831
Precision Ferrites & Ceramic Inc.	
Precision Photo-Fab Inc.	
Presidio Components Inc.	
Prewell Corp.	
Protocast/John List Corp	
Pulsar Microwave Corp	3230
Q Microwave Inc	
Q3 Laboratory	
Quest Microwave Inc.	1010
Questech Services Corp	
Quik-Pak/Gel-Pak	405
QuinStar Technology Inc.	2711
R&D Microwaves LLC	300
R&K Co. Ltd.	
Radant MEMS Inc	
Rayspan Corp	
Reactel Inc.	
Reinhardt MicrotechAG	3310
RelComm Technologies Inc	3313
Remcom Inc.	
Remtec Inc.	
Refilled Inc.	301
Renaissance Electronics Corp.	
Research Electronics International	536
Resin Systems Corp	1436
RF Connections LLC	
RF Depot Inc	
RF Industries RF Connectors Div.	27/12
RF Logic	
RF Morecom	
RFcore Co. Ltd.	1444
RFHIC Corp.	1440
RFMD	
RFMW Ltd	
RFS/Ferrocom Ferrite Division	
RH Laboratories Inc	
RHe Microsystems GmbH	3310
Richardson Electronics	
RIV Inc	
RIV Inc	1935
RIV Inc	1935 3017
RIV Inc	1935 3017 2628
RIV Inc	1935 3017 2628 2427
RIV Inc	1935 3017 2628 2427
RIV Inc	1935 3017 2628 2427 2920
RIV Inc RJR Polymers Inc RLC Electronics Inc Rockwell Collins Rogers Corp. Rohde & Schwarz Inc	1935 3017 2628 2427 2920 2519
RIV Inc RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC	1935 3017 2628 2427 2920 2519
RIV Inc RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc	1935 3017 2628 2427 2920 2519 621 1917
RIV Inc RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc Rsoft Design Group	1935 3017 2628 2427 2920 2519 621 1917 3018
RIV Inc RJR Polymers Inc. RLC Electronics Inc Rockwell Collins. Rogers Corp. Rohde & Schwarz Inc Rosenberger North America LLC. Roswin Inc Rsoft Design Group RUPPTRONIK	1935 3017 2628 2427 2920 2519 621 1917 3018 3230
RIV Inc RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc Rsoft Design Group	1935 3017 2628 2427 2920 2519 621 1917 3018 3230
RIV Inc RJR Polymers Inc. RLC Electronics Inc Rockwell Collins. Rogers Corp. Rohde & Schwarz Inc Rosenberger North America LLC. Roswin Inc Rsoft Design Group RUPPTRONIK	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505
RIV Inc RJR Polymers Inc. RLC Electronics Inc Rockwell Collins Rogers Corp. Rohde & Schwarz Inc Rosenberger North America LLC Roswin Inc Rsoft Design Group RUPPTRONIK Sage Laboratories Inc Sainty-Tech Communications Ltd	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430
RIV Inc RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602
RIV Inc RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc.	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 2430 1602 1820
RIV Inc. RJR Polymers Inc RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samec Inc. San-tron Inc. Sangshin Elecom Co. Ltd.	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602 1820
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc.	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602 1820 1331 2634
RIV Inc RJR Polymers Inc. RLC Electronics Inc Rockwell Collins Rogers Corp. Rohde & Schwarz Inc Rosenberger North America LLC Roswin Inc Rsoft Design Group RUPPTRONIK Sage Laboratories Inc Sainty-Tech Communications Ltd Santeon Inc San-tron Inc Sangshin Elecom Co. Ltd Sawnics Inc Schmid & Partner Engineering AG	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602 1331 2634 533
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp.	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 2430 1602 1331 2634 533 1532
RIV Inc RJR Polymers Inc. RLC Electronics Inc Rockwell Collins Rogers Corp. Rohde & Schwarz Inc Rosenberger North America LLC Roswin Inc Rsoft Design Group RUPPTRONIK Sage Laboratories Inc Sainty-Tech Communications Ltd Santeon Inc San-tron Inc Sangshin Elecom Co. Ltd Sawnics Inc Schmid & Partner Engineering AG	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 2430 1602 1331 2634 533 1532
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sansphin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp.	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602 1820 1331 2634 533 1532 3528
RIV Inc. RJR Polymers Inc RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosfi Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera. SEI.	1938 3017 2628 2427 2920 2519 3018 3230 3505 2430 1602 1331 2634 533 3528 1600
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc.	1938 3017 2628 2427 2920 2519 3018 3230 3505 2430 1602 1331 2634 533 1532 3528 1600 3334
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sanshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor	1935 3017 2628 2427 2920 2519 1917 3018 3230 3505 2430 1602 1331 2634 1532 3528 1600 3334 3230 3334 3528
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor. SETTECH	1935 3017 2628 2427 2920 2519 1917 3018 3230 3505 2430 1602 1331 2634 1532 3528 1600 3334 3230 3334 3528 1600 3334 3330 3330 3330 3330 3330 3330 3
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc Sainty-Tech Communications Ltd. Samtec Inc. San-ton Inc. Sangshin Elecom Co. Ltd. Sampins Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor Serter BGMC Microwave	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602 1331 1632 3528 1600 3344 3230 3342 3352 3352 3352 3352 3352 3352 3352
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor. SETTECH	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602 1331 1632 3528 1600 3344 3230 3342 3352 3352 3352 3352 3352 3352 3352
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc Sainty-Tech Communications Ltd. Samtec Inc. San-ton Inc. Sangshin Elecom Co. Ltd. Sampins Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor Serter BGMC Microwave	1935 3017 2628 2427 2920 2519 621 1917 3018 3230 3505 2430 1602 1331 1632 3528 1600 334 3230 33528 1600 331 3528 3528 3528 3528 3528 3528 3528 3528
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. Sangshin Elecom Co. Ltd. Savnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. SEI. Semi Dice Inc. Senseor. SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd.	1935 3017 2628 2427 2920 2519 621 1917 3038 2430 1602 1820 1820 1831 1532 3528 1600 3334 3230 3334 3230 334 3528 1600 1100 1100 1100 1100 1100 1100 110
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor. SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd.	1935 3017 2628 2427 2920 2518 3018 3230 3509 2430 1602 1820 1820 1832 1634 3230 3334 3230 3334 3230 3334 3230 3334 3230 3334 3230 3334 3230 3334 3230 3334 3230 3334 3230 3334 3230 3334 3334
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co.	1935 3017 2628 2427 2920 2519 2930 1917 3018 3230 3505 2430 1602 1820 1831 1532 3528 1600 3334 3230 3334 3230 3230 3230 3230 32
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co.	1935 3017 2628 2427 2920 2518 3018 3230 3505 2430 2634 3153 2634 3153 32634 327 327 328 328 328 329 329 329 329 329 329 329 329 329 329
RIV Inc. RJR Polymers Inc RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosenberger Rorth America LLC Roswin Inc. Rosel Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. Santy-Tech Communications Ltd. Samtec Inc. Sandy-Tech Communications Ltd. Samtec Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. SIPAT Co. Skyworks Solutions Inc.	1935 3017 2628 2427 2920 2518 2518 2618 323 3505 2430 1182 2634 3153 3230 334 3230 334 3230 334 3230 324 3230 324 3230 324 3230 324 324 324 324 324 324 324 324 324 324
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosenberger North America LLC Roswin Inc. Rosenberger Roup. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH Semseor SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. SIPAT Co. Skyworks Solutions Inc.	1935 3017 2628 2427 3018 3230 2519 1602 1331 2634 1602 1331 1532 3528 1600 3334 3230 3230 3230 3230 3231 3231 3231 3231
RIV Inc. RJR Polymers Inc RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosenberger Rorth America LLC Roswin Inc. Rosel Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. Santy-Tech Communications Ltd. Samtec Inc. Sandy-Tech Communications Ltd. Samtec Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. SIPAT Co. Skyworks Solutions Inc.	1935 3017 2628 2427 3018 3230 2519 1602 1331 2634 1602 1331 1532 3528 1600 3334 3230 3230 3230 3230 3231 3231 3231 3231
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosenberger North America LLC Roswin Inc. Rosenberger Roup. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH Semseor SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. SIPAT Co. Skyworks Solutions Inc.	1935 3017 2628 3017 2628 2519 621 1917 323 3508 2430 1602 11331 2634 533 1532 3528 3528 3634 2230 3101 2827 2100 3121 28427 2100 3121 2420 504
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sanshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEL Semi Dice Inc. Semi Dice Inc. Senseor SETTECH. SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. Styworks Solutions Inc. Solid Sealing Technology Sonnet Software Inc.	1935 3017 2628 2628 2519 1917 3018 2430 3505 2430 3505 2430 3505 2430 3505 2430 3505 2430 3505 2430 3505 2430 3505 2430 3505 3505 3505 3505 3505 3505 3505 3
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. Skyworks Solutions Inc. Solid Sealing Technology Sonnet Software Inc. Soshin Electric Co. Ltd. Southwest Microwave Inc.	1935 3017 2628 2427 3018 3018 303505 2430 1602 1820 1830 1602 1331 1532 3528 1602 1331 1202 1212 1222 1311 1242 13110 1504 1311 1311 1311 1311 1311 1311 1311 13
RIV Inc. RJR Polymers Inc RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosenberger North America LLC Roswin Inc. Rosel Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. Santy-Tech Communications Ltd. Samtec Inc. Santy-Tech Communications Ltd. Samtec Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH. SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. SIPAT Co. Skyworks Solutions Inc. Solid Sealing Technology Sonnet Software Inc. Soshin Electric Co. Ltd. Southwest Microwave Inc. Spectracom	1935 3017 2628 3017 2628 1621 1917 3018 3230 3509 2433 1600 3334 3230 3334 3334
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rosenberger North America LLC Roswin Inc. Rosenberger Roup. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor SETTECH Semsor Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. SIPAT Co. SlPAT Co. Soshin Electric Co. Ltd. Soshin Electric Co. Ltd. Southwest Microwave Inc. Soetrum Elektrotechnik GmbH	1935 3017 2628 3017 2628 2621 2920 2519 2621 1917 3018 303505 2430 3505 2430 1600 21321 2634 2533 15322 3120 3334 3230 3334 3230 3121 2622 2100 3121 2827 2827 2827 2827 2827 2827 2827 2
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor. SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sirlat Co. SliPAT Co. Shyworks Solutions Inc. Soshin Electric Co. Ltd. Southwest Microwave Inc. Spectrum Elektrotechnik GmbH Spectrum Elektrotechnik GmbH Spectrum Elektrotechnik GmbH Spectrum Elektrotechnik GmbH	1935 3017 2628 3017 2628 2519 2519 2519 2519 2519 2519 2519 2519
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. San-tron Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEL Semi Dice Inc. Senseor SETTECH. SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sinclair Manufacturing Co. SiPAT Co. Skyworks Solutions Inc. Soshin Electric Co. Ltd. Southwest Microwave Inc. Spectrum Elektrotechnik GmbH Spectrum Elektrotechnik GmbH Spectrum Microwave Inc. Spinner Ktlanta	1935 3017 2628 3017 2628 2519 2519 2519 2519 2519 2519 2519 2519
RIV Inc. RJR Polymers Inc. RLC Electronics Inc. Rockwell Collins Rogers Corp. Rohde & Schwarz Inc. Rosenberger North America LLC Roswin Inc. Rsoft Design Group. RUPPTRONIK Sage Laboratories Inc. Sainty-Tech Communications Ltd. Samtec Inc. Sangshin Elecom Co. Ltd. Sawnics Inc. Schmid & Partner Engineering AG Scientific Microwave Corp. Scintera SEI. Semi Dice Inc. Senseor. SETTECH SGMC Microwave Shanghai Huaxiang Computer Comm. Eng. Shenzhen Yulongtong Electron Co. Ltd. Signatone (Lucas/Signatone) Sirlat Co. SliPAT Co. Shyworks Solutions Inc. Soshin Electric Co. Ltd. Southwest Microwave Inc. Spectrum Elektrotechnik GmbH Spectrum Elektrotechnik GmbH Spectrum Elektrotechnik GmbH Spectrum Elektrotechnik GmbH	1935 3017 2628 3017 2628 2519 2519 2519 2519 2519 2519 2519 2519





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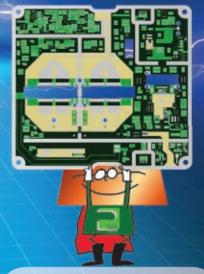
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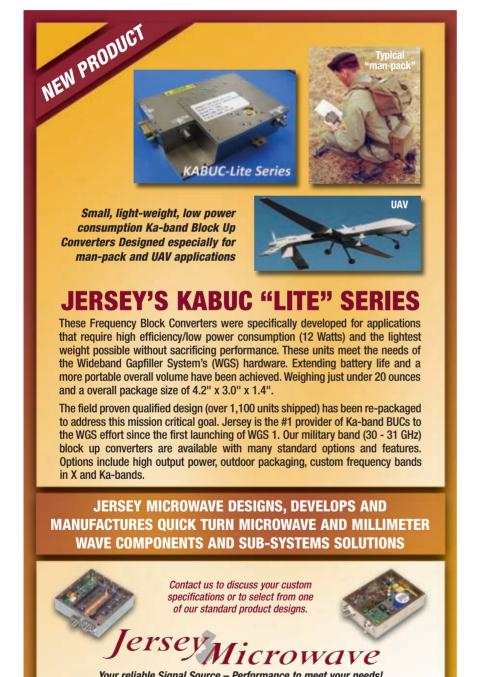
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SRI Hermetics	32
SSI Cable Corp. 103	36
State Of The Art Inc 90	00
Statek Corp	37
Stellar Industries Corp	33
Stellar Microelectronics	10
StratEdge Corp	21
Sumitomo Devices Innovations U.S.A. Inc 133	33
Summitek Instruments Inc 102	21
Sunwave Communication Co. Ltd	36
Superior Technical Ceramics Corp)2

SUSS Microtec Inc	3200
SV Microwave Inc	2902
Synergy Microwave Corp	1400, 1500
Synopsys Inc	2806
SynQor Inc	3606
T-Tech Inc	828
Taconic	2419
Tactron Elektronik oHG	3230
Tahoe RF Semiconductor Inc	3700
TDI International Inc	3238
TDK-Lambda Americas	2302

Tecdia Inc.	1511
Tech-X Corp	. 705
Tektronix Inc.	
Teledyne Coax Switches	1224
Teledyne Cougar	1324
Teledyne Defence Ltd	1324
Teledyne MEC	
Teledyne Microelectronics	1324
Teledyne Microwave	1324
Teledyne Relays	
Teledyne Scientific Co	1224
Teledyne Storm Products	0010
Teledyne Technologies Inc	1324
Telegartner Inc	2811
Telnova Technology Co. Ltd	3035
Telogy LLC	3602
Temp-Flex Cable Inc	618
Temwell Corp.	
TestEquity LLC	401
TestEquity buo	1000
Thales Components Corp	1636
THINFILMS Inc	
Thunderline-Z	3306
Times Microwave Systems	2717
TLC Precision Wafer Technology Inc	2728
TMD Technologies Ltd	2741
Torrey Hills Technologies LLC	2120
Torrey milis reciniologies inc	0100
Toshiba America Electronic Cmpts.	
TowerJazz	
TRAK Microwave Corp.	. 918
Trak Microwave Ltd./Farran Tech	1019
Transcom Inc	1838
Transline Technology Inc.	
Trilithic Inc.	
TriQuint Semiconductor	
TRM Microwave	
Tronser Inc	
TRU Corp. Inc.	
TTE Inc.	1800
Tyco Electronics Relay Products Group	
	801
UltraSource Inc	3124
UltraSource Inc	3124 1632
UltraSource Inc	3124 1632 3140
UltraSource Inc	3124 1632 3140 704
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth UTE Microwave Inc. VACCO Industries	3124 1632 3140 704 641
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth UTE Microwave Inc. VACCO Industries	3124 1632 3140 704 641
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp.	3124 1632 3140 704 641 3415
UltraSource Inc UMS (United Monolithic Semiconductors) University Booth UTE Microwave Inc VACCO Industries Valpey Fisher Corp. Vectron International	3124 1632 3140 704 641 3415 1615
UltraSource Inc UMS (United Monolithic Semiconductors) University Booth UTE Microwave Inc VACCO Industries Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote	3124 1632 3140 704 641 3415 1615 3130
UltraSource Inc UMS (United Monolithic Semiconductors) University Booth UTE Microwave Inc VACCO Industries Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote VIDA Products Inc	3124 1632 3140 704 641 3415 1615 3130 2319
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote. VIDA Products Inc. VidaRF.	3124 1632 3140 704 641 3415 1615 3130 2319 2004
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp. Vectron International Verspecht-Teyssier-Degroote VIDA Products Inc. VidaRF. Virginia Diodes Inc.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp. Vectron International Verspecht-Teyssier-Degroote VIDA Products Inc. VidaRF. Virginia Diodes Inc.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130
UltraSource Inc. UMS (United Monolithic Semiconductors). University Booth. UTE Microwave Inc. VACCO Industries. Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote. VIDA Products Inc. VidaRF. Virginia Diodes Inc. Vishay Intertechnology. Voltronics Corp.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130 2513 1618
UltraSource Inc. UMS (United Monolithic Semiconductors). University Booth. UTE Microwave Inc. VACCO Industries. Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote. VIDA Products Inc. VidaRF. Virginia Diodes Inc. Vishay Intertechnology. Voltronics Corp.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130 2513 1618
UltraSource Inc. UMS (United Monolithic Semiconductors). University Booth. UTE Microwave Inc. VACCO Industries. Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote. VIDA Products Inc. VidaRF. Virginia Diodes Inc. Vishay Intertechnology. Voltronics Corp. VTI Instruments Corp.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130 2513 1618 930
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp. Vectron International Verspecht-Teyssier-Degroote. VIDA Products Inc. VidaRF Virginia Diodes Inc. Vishay Intertechnology Voltronics Corp. VIT Instruments Corp. Vubiq Inc.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130 2513 1618 930 1042
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote VIDA Products Inc. VidaRF. Virginia Diodes Inc. Vishay Intertechnology. Voltronics Corp. VIT Instruments Corp. Vubiq Inc. W.L. Gore & Associates.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130 2513 1618 930 1042 731
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp. Vectron International Verspecht-Teyssier-Degroote VIDA Products Inc. VidaRF. Virginia Diodes Inc. Vishay Intertechnology. Voltronics Corp. VTI Instruments Corp. Vubiq Inc. WL. Gore & Associates. Wavenics Inc.	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130 2513 1618 930 1042 731 2020
UltraSource Inc. UMS (United Monolithic Semiconductors) University Booth. UTE Microwave Inc. VACCO Industries Valpey Fisher Corp. Vectron International. Verspecht-Teyssier-Degroote VIDA Products Inc. VidaRF. Virginia Diodes Inc. Vishay Intertechnology. Voltronics Corp. VTI Instruments Corp. Vubiq Inc. W.L. Gore & Associates Wavenics Inc. Weinschel Associates	3124 1632 3140 704 641 3415 1615 3130 2319 2004 1130 2513 1618 930 1042 731 2020 3315
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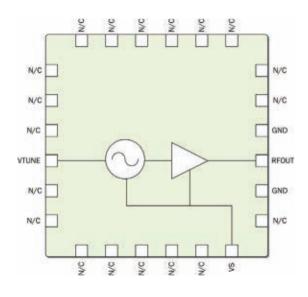
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SPECIFICATIONS

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			Output	10 kHz	100 kHz		Pulling	
Part	F Low	F High	Power	Phase Noise	Phase Noise	Pushing	(MHz p-p	
Number	(MHz)	(mHz)	(dBm)	(dBc/Hz)	(dBc/Hz)	(MHz/V)	at 2:1 VSWR)	Power Supply
RFVC-1800	8000	12000	4.0	66.0	93.0	75	7	5 V at 55 mA
RFVC-1801	5000	10000	3.0	72.0	96.0	18	6	5 V at 55 mA
RFVC-1802	4000	8000	3.5	74.0	99.0	16	4	5 V at 55 mA
RFVC-1803	6000	9000	3.5	73.0	97.0	22	_	5 V at 52 mA



FEATURES

- Wideband performance
- Pout +3 to +4 dBm typical
- No external resonator required
- Integrated buffer amplifier
- Compact, low-profile package: 4.0 x 4.0 mm QFN

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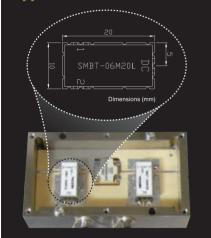
TECDIA





20MHz \sim 6GHz Typical Installation

Surfacemount type



SPECIFICATION

Model		SMBT-06	M20 L/R		
5 D			SMBT-06M20 L/R		
	20MHz∼6GHz				
Frequency Range	20~50MHz	50MHz \sim 2GHz	2∼3GHz	3∼6GHz	
VSWR (Return loss)	1.5 max.	1.22 max.	1.28 max.	1.4 max.	
Insertion Loss	0.8dB max. 1.0dB m		1.0dB max.		
RF Power	5W max.				
Bias Current	2A max.				
Bias Voltage	50V max.				
Dimensions	20 x 10 x 5 mm				
Weight	2 g				
Temparature	-40°C∼ + 90°C				

Typical VSWR & Insertion Loss



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Exhibitor Profiles



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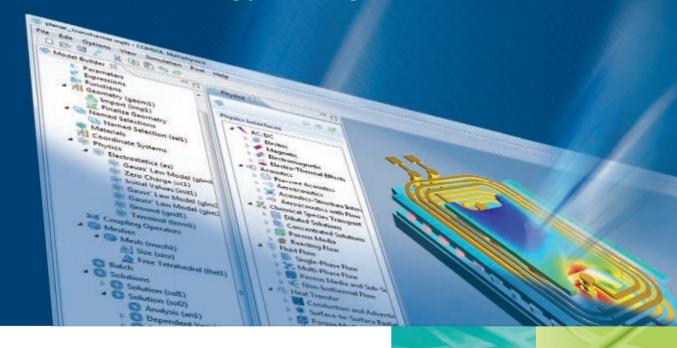
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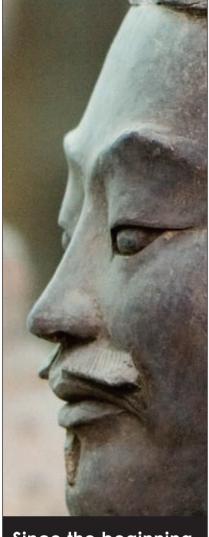
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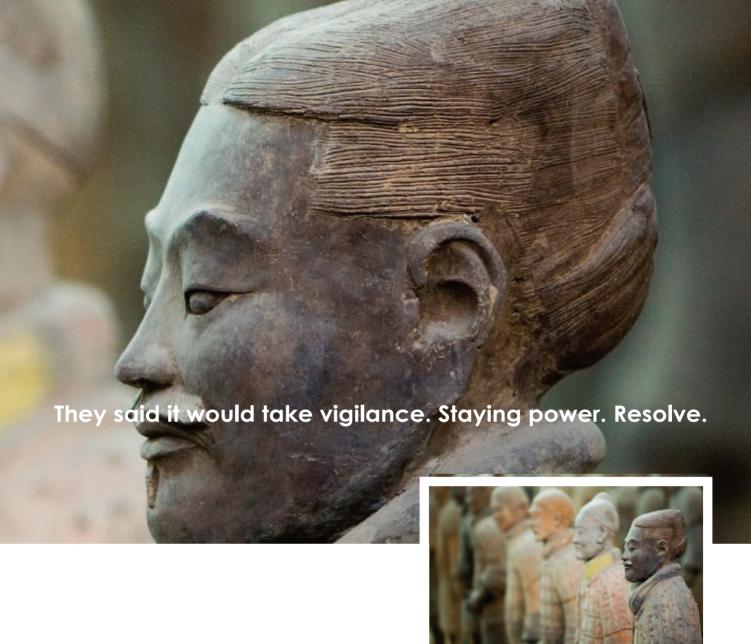




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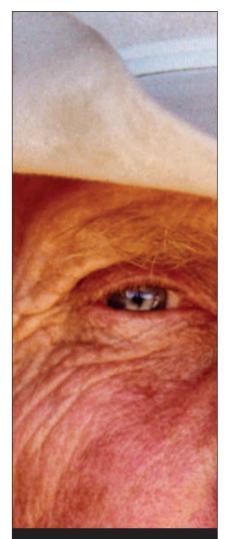
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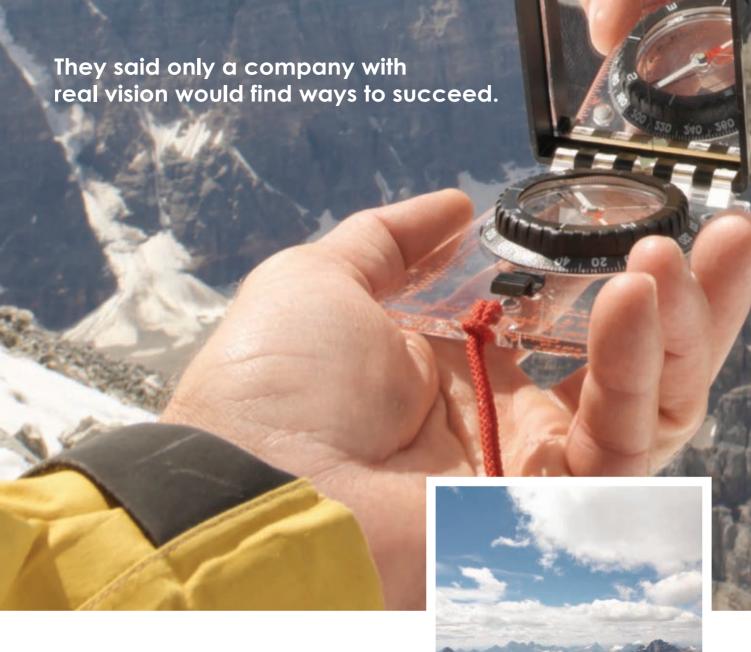
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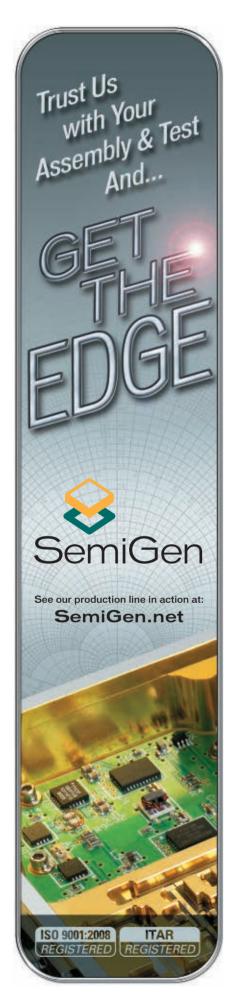
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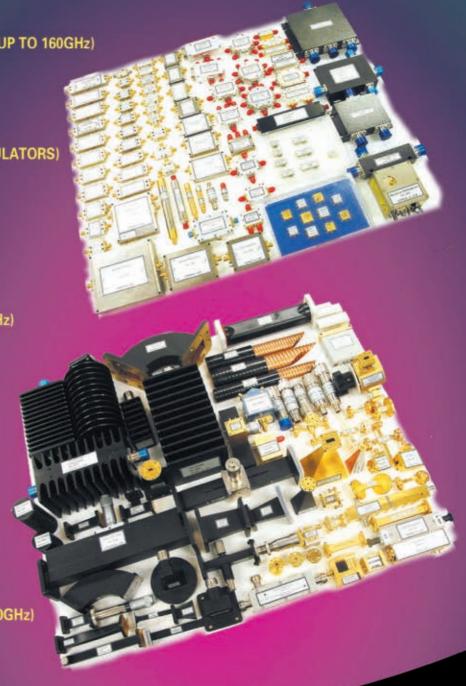
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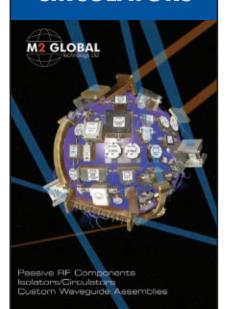
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RFW2500H10-28	20~2500	36
RWP05020-10	20~1000	43
RWP05040-10	20~1000	45
RWP06040-10	450~880	45
RWP15020-10	1000~2000	43
RUP15020-11	500~2500	40
RUP15030-10	500~2500	44
RUP15050-10	500~2500	46
RWP15020-G1	1000~2000	43
RWP25020-G1	2000~3000	43
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RWS05020-10	20~1000	43
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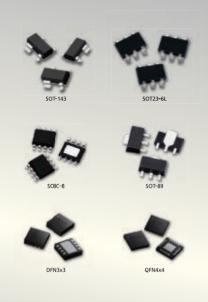
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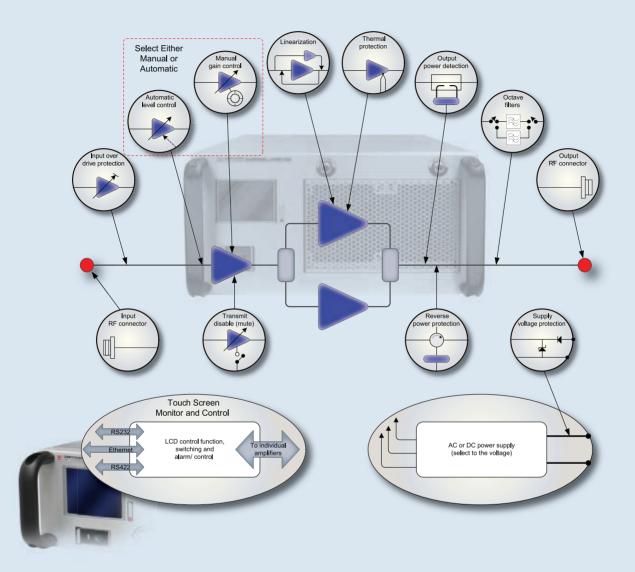
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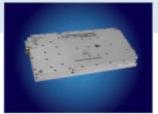
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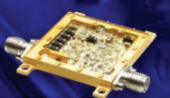
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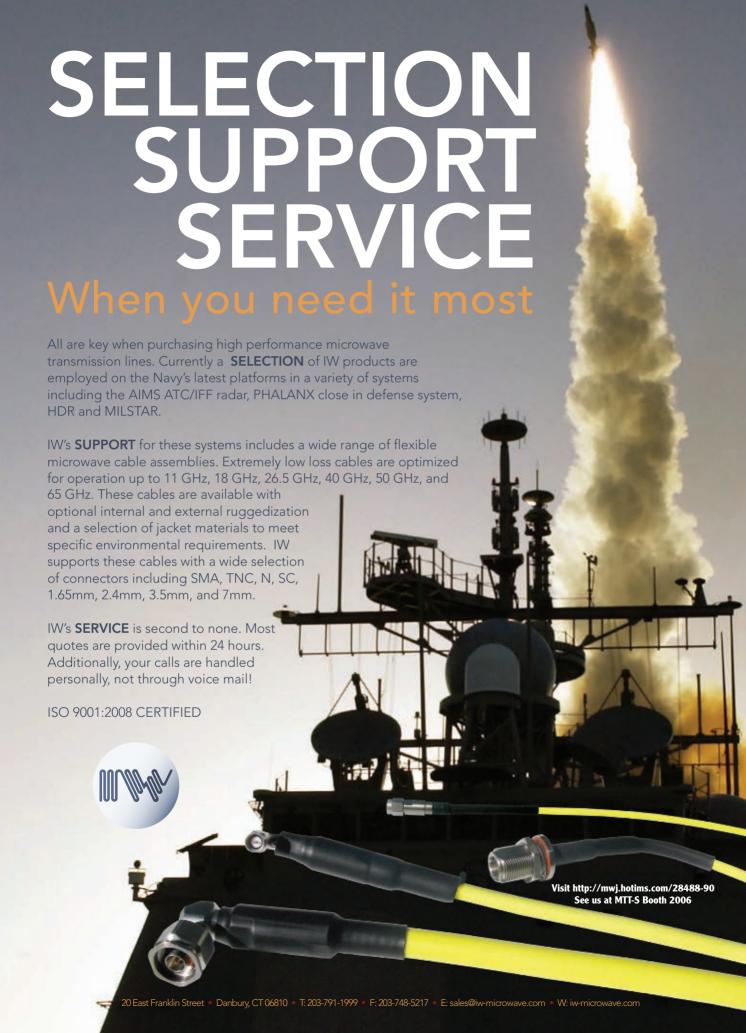
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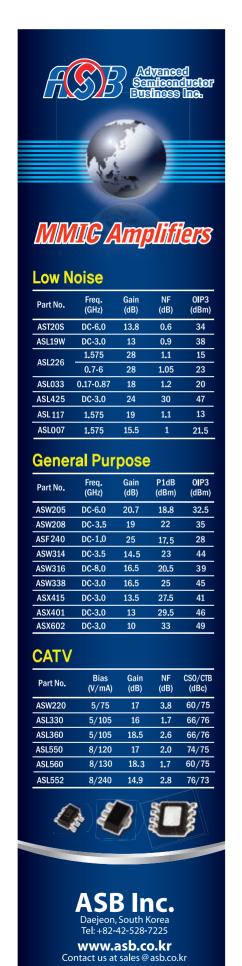


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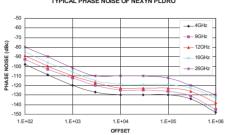
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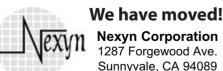


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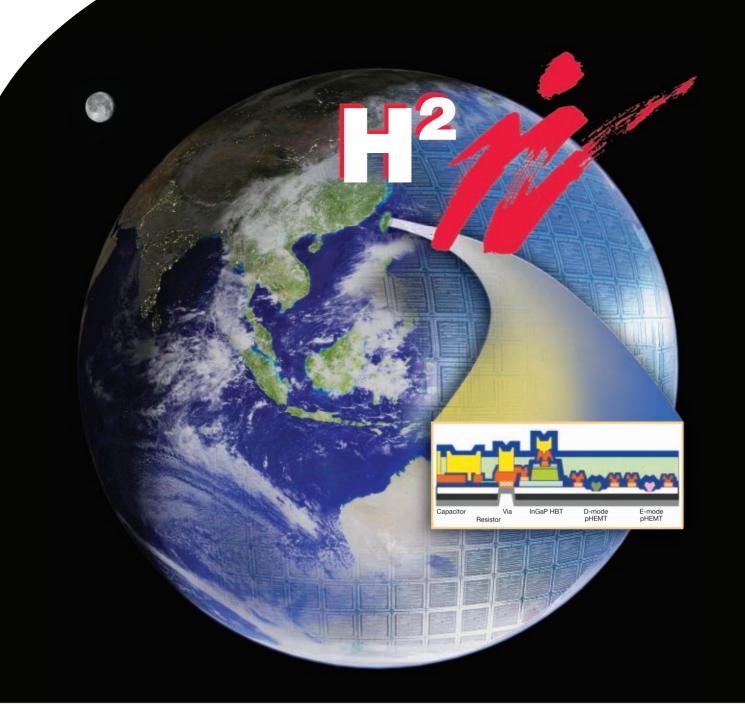
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Ε	Idss	0.01 uA/mm
e-pHEMT	BVdg	21 V
	Vth	0.35 V
Ιď	Fmin	0.44 dB
ė	Ft	30 GHz
	Fmax	90 GHz
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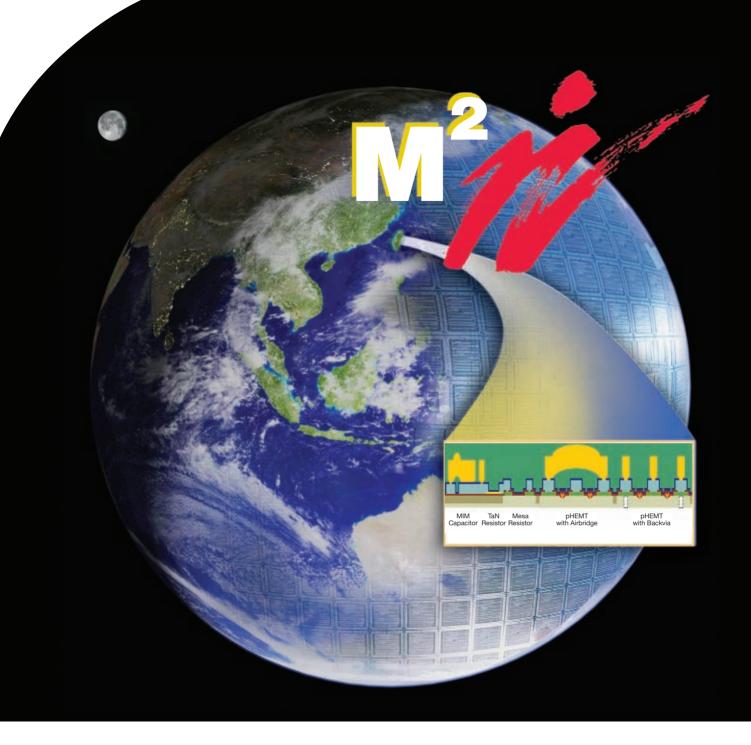


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Vb	14 V
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P1dB*	600 mW/mm
Ron	1 Ohm-mm
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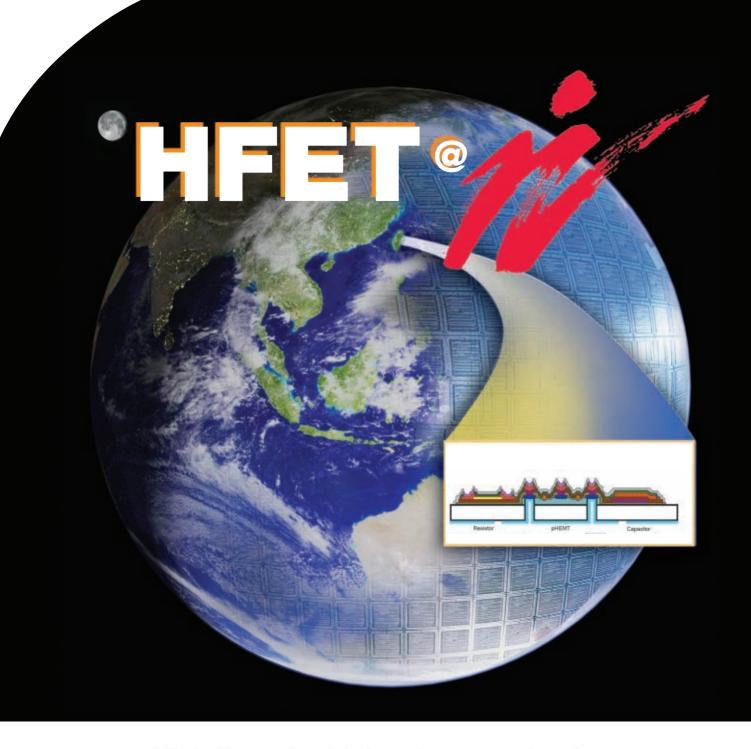
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VPO @VDS=4 V	-1.1 V
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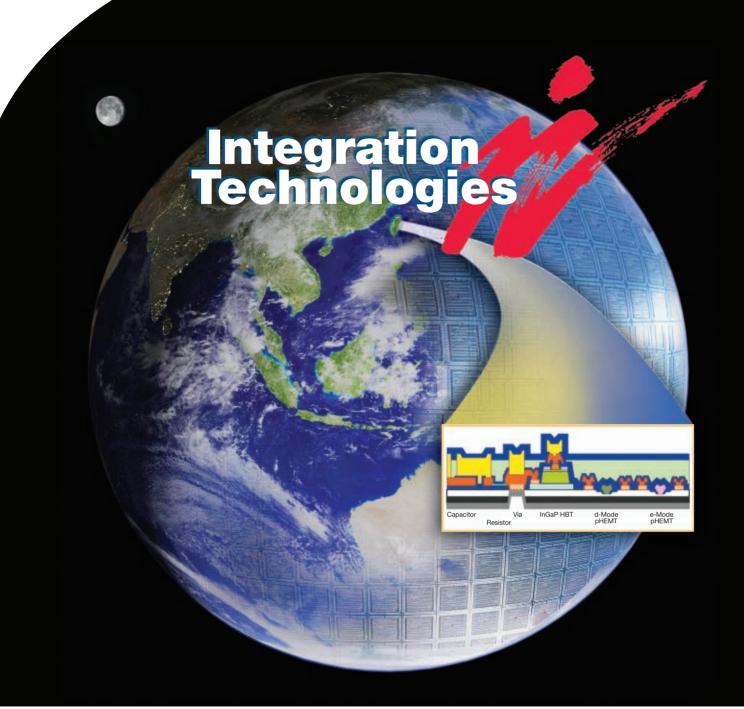


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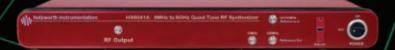
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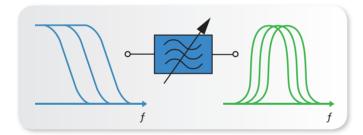
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LOW PASS

Freq. Range (GHz)	Return Loss (dB)	Cutoff Frequency Range (GHz)	Stopband Frequency (Rej. >20 dB)	Tuning Response (ns)	Package	Part Number
DC - 4.0	10	2.2 - 4.0	1.25 x Fcutoff	150	LP5	HMC881LP5E
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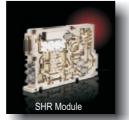
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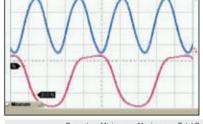


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Output Signal



	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
Horizontal Scale	30.0.ps/div

CK/2 and CK/4 outputs are presented on an Infinium 86100C

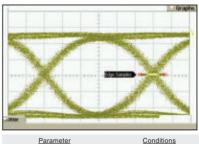
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Eye Diagram @ 25 Gbps



<u>Parameter</u>	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

Pattern generated with a 27-1 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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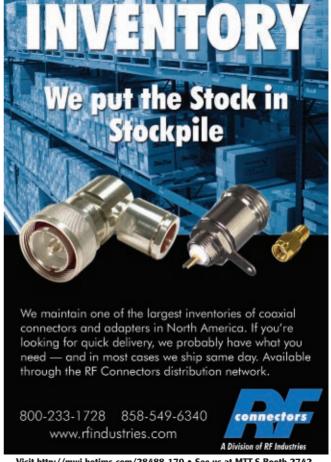


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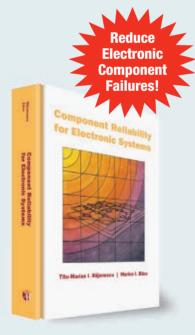


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OCTAVE BA	ND LOW N	OISE AMP	LIFIERS			
Model No. CA01-2110 CA12-2110 CA24-2111 CA48-2111 CA012-3111 CA1218-4111 CA1826-2110	Freq (GHz) 0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0 8.0-12.0 12.0-18.0 18.0-26.5	Gain (dB) MIN 28 30 29 29 27 25 32	Noise Figure (db) 1.0 MAX, 0.7 TYP 1.0 MAX, 0.7 TYP 1.1 MAX, 0.95 TYP 1.3 MAX, 1.0 TYP 1.6 MAX, 1.4 TYP 1.9 MAX, 1.7 TYP 3.0 MAX, 2.5 TYP	Power-out @ P1-d8 +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN	+20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm	VSWR 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1
			D MEDIUM POV			2.0.1
CA1315-3110 CA12-3114 CA34-6116 CA56-5114 CA812-6115 CA812-6116 CA1213-7110 CA1722-4110	0.4 - 0.5 0.8 - 1.0 1.2 - 1.6 2.2 - 2.4 2.7 - 2.9 3.7 - 4.2 5.4 - 5.9 7.25 - 7.75 9.0 - 10.6 13.75 - 15.4 1.35 - 1.85 3.1 - 3.5 5.9 - 6.4 8.0 - 12.0 12.2 - 13.25 14.0 - 15.0 17.0 - 22.0	30 40 30 30 30 28 30 25	0.6 MAX, 0.4 TYP 0.6 MAX, 0.4 TYP 0.6 MAX, 0.4 TYP 0.6 MAX, 0.5 TYP 1.0 MAX, 0.5 TYP 1.0 MAX, 0.5 TYP 1.2 MAX, 1.0 TYP 1.4 MAX, 1.2 TYP 1.6 MAX, 1.4 TYP 4.0 MAX, 3.0 TYP 4.5 MAX, 3.5 TYP 5.0 MAX, 4.0 TYP 4.5 MAX, 3.5 TYP 5.0 MAX, 4.0 TYP 5.0 MAX, 4.0 TYP 5.0 MAX, 4.0 TYP 3.5 MAX, 3.5 TYP 5.0 MAX, 4.0 TYP 3.5 MAX, 3.5 TYP	+10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +10 MIN +33 MIN +31 MIN +33 MIN +33 MIN +33 MIN +34 MIN +34 MIN +35 MIN +36 MIN +37 MIN +38 MI	+20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +20 dBm +21 dBm +41 dBm	2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1
Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power -out @ P1-dB		VSWR
CA0102-3111 CA0106-3111 CA0108-3110 CA0108-4112 CA02-3112 CA26-3110 CA26-4114 CA618-6114 CA218-4116 CA218-4112 LIMITING A	0.1-2.0 0.1-6.0 0.1-8.0 0.1-8.0 0.5-2.0 2.0-6.0 6.0-18.0 2.0-18.0 2.0-18.0	28 26 32 36 26 22 25 35 30 30 29	1.6 Max, 1.2 TYP 1.9 Max, 1.8 TYP 2.2 Max, 1.8 TYP 3.0 MAX, 1.8 TYP 4.5 MAX, 2.5 TYP 2.0 MAX, 3.5 TYP 5.0 MAX, 3.5 TYP 5.0 MAX, 3.5 TYP 3.5 MAX, 2.8 TYP 5.0 MAX, 3.5 TYP 5.0 MAX, 3.5 TYP 5.0 MAX, 3.5 TYP	+10 MIN +10 MIN +10 MIN +22 MIN +30 MIN +30 MIN +30 MIN +30 MIN +20 MIN +24 MIN	+20 dBm +20 dBm +20 dBm +32 dBm +40 dBm +20 dBm +40 dBm +33 dBm +40 dBm +30 dBm +30 dBm +34 dBm	2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1
Model No.		nput Dynamic F	Range Output Power I	Range Psat Pow	ver Flatness dB	VSWR
CLA24-4001 CLA26-8001 CLA712-5001 CLA618-1201	2.0 - 4.0 2.0 - 6.0 7.0 - 12.4 6.0 - 18.0	-28 to +10 d -50 to +20 d -21 to +10 d -50 to +20 d	Bm +7 to +11 Bm +14 to +1 Bm +14 to +1	l dBm + 8 dBm + 9 dBm +	-/- 1.5 MAX -/- 1.5 MAX -/- 1.5 MAX -/- 1.5 MAX	2.0:1 2.0:1 2.0:1 2.0:1
Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB) Pow			
CAOO1-2511A CAO5-3110A CA56-3110A CA612-4110A CA1315-4110A CA1518-4110A	0.025-0.150 0.5-5.5 5.85-6.425 6.0-12.0 13.75-15.4 15.0-18.0	23 28 24 25 30	5.0 MAX, 3.5 TYP 2.5 MAX, 1.5 TYP 2.5 MAX, 1.5 TYP 2.5 MAX, 1.5 TYP 2.2 MAX, 1.6 TYP	+12 MIN +18 MIN +16 MIN	30 dB MIN 20 dB MIN 22 dB MIN 15 dB MIN 20 dB MIN 20 dB MIN	2.0:1 2.0:1 1.8:1 1.9:1 1.8:1 1.85:1
Model No.		ERS Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110 CA001-2211 CA001-2215 CA001-3113 CA002-3114 CA003-3116 CA004-3112	0.01-0.10 0.04-0.15 0.04-0.15 0.01-1.0 0.01-2.0 0.01-3.0 0.01-4.0	18 24 23 28 27 18 32	4.0 MAX, 2.2 TYP 3.5 MAX, 2.2 TYP 4.0 MAX, 2.2 TYP 4.0 MAX, 2.8 TYP 4.0 MAX, 2.8 TYP 4.0 MAX, 2.8 TYP	+10 MIN +13 MIN +23 MIN +17 MIN +20 MIN +25 MIN +15 MIN	+20 dBm +23 dBm +33 dBm +27 dBm +30 dBm +35 dBm +25 dBm	2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1 2.0:1
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Defense News

Dan Massé, Associate Technical Editor

Airborne Early Warning and Control Capabilities Expanding Via Electronics

he 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

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

SRC Secures \$8.1 M for Foliage Penetration Radar

RC, 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

he 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 opensystem 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

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

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.

"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

s -

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

igh 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 RadioTM (HNR) ensures all information from the battle command center will arrive at the right location to defend troops against a

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

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.

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).

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INTERNATIONAL REPORT

Richard Mumford, International Editor

European Carriers Face Capacity Crunch Challenges

he 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 improve-

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

ment 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."

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

tate 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-



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

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.

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

eading 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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INTERNATIONAL REPORT

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

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

Beecham's partner Astrium Services will provide detailed input

be done to achieve it."

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

he 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 speci-

fications 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.

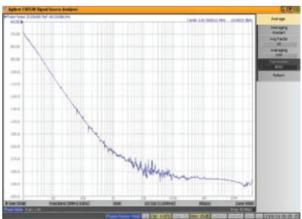
An NGMN project team of leading operators and vendors has worked towards the successful development of the open interface implementa"The agreement to establish the ETSI ISG is a major step towards the successful interface specification..."

tion 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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US patent 6,943,629 *Low frequency determined by coupling cap.

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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

here 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 fi-

COMMERCIAL MARKET

Dan Massé, Associate Technical Editor

nancing 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

ecember 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

ualcomm, 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

ms -

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Commercial Market

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

AYSPAN® Corp., the world's only provider of metamaterial and advanced RF air interface solutions for wireless communications, announced the availability of RAYSPAN MTM-ETM 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 fin-

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

est 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.

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 freespace 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.

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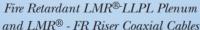
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INDUSTRY NEWS

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.

AROUND THE CIRCUIT

Jennifer DiMarco, Staff Editor

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 MMTSTM 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.

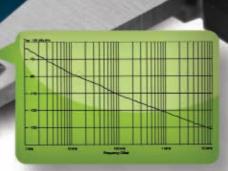




Model	Frequency Range (MHz)	Tuning Voltage (VDC)	DC Bias VDC @ I [Typ.]	Phase Noise @ 10 kHz (dBc/Hz) [Typ.	Size (Inch)
DCO Series	VIII				Non
DC050100-5	500 - 1000	0.3 - 15	+5 @ 26 mA	-100	Wideband
DC07075-3	700 - 750	0.5 - 3	+3 @ 10 mA	-108	Models
DC080100-5	800 - 1000	0.5 - 8	+5 @ 21 mA	-111	0.3 x 0.3 x
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
DC0170340-5	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
CO432493-5 CO432493-3	4325 - 4950	0.5 - 11	+5 @ 17 mA +3 @ 17 mA	-88 -86	0.3 x 0.3 x 0.1
0CO473542-5 0CO473542-3	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 × 0.3 × 0.1
CO608634-5 CO608634-3	6080 - 6340	0.5 - 5	+5 @ 22 mA +3 @ 22 mA	-86 -84	0.3 x 0.3 x 0.1
0C0615712-5 0C0615712-3	6150 - 7120	0.5 - 18	+5 @ 22 mA +3 @ 22 mA	-85 -83	0.3 x 0.3 x 0.1
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 0.1
XO10701095-5	10.70 - 10.95	0.5 - 15	+5 @ 21 mA	-82	0.3 x
XO11441200-5	11.44 - 12.0	0.5 - 15	+5 @ 23 mA	-82	0.3 x 0. Meday
OXO11751220-5	11.75 - 12.2	0.5 - 15	+5 @ 24 mA	-80	0.3 x 0.3 x 0.1

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AROUND THE CIRCUIT

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 siliconon-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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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 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,

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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.

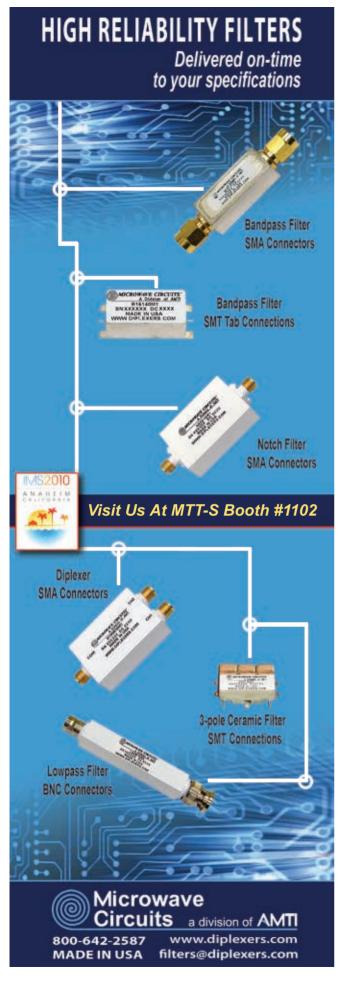
Phase Matrix Inc. announced the recent appointment of **Alexander Chenakin** to Vice President of the Signal Sources group. In this new role, Chenakin will be responsible for overseeing the development and marketing of a new generation of microwave signal sources.

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.



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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.

hased-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.

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Part Number	Package Size	J. Companies		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

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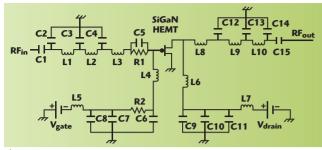


Fig. 1 Schematic of the fabricated PA1 amplifier.

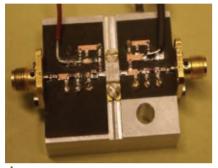


Fig. 2 Photograph of the PA1 amplifier.

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 GHz² as well as

an output power of 500 W at 1.5 GHz³ 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 broad-

band 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 \boldsymbol{S}_{21} and

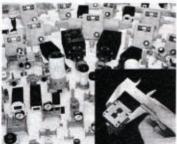
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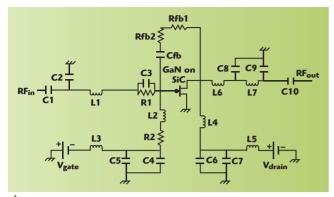
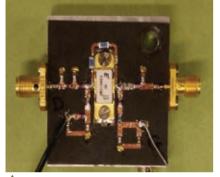


Fig. 3 Schematic of the fabricated PA2 amplifier.



▲ Fig. 4 Photograph of the PA2 amplifier.

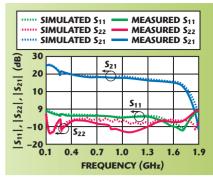
input reflection coefficient S_{11} showed good agreement over the entire frequency band. A gain greater than 15 dB is achieved for the entire frequency band. The design shows matching below -4 dB for S_{11} and below -7 dB for S_{22} as shown in **Figure 5**. The output reflection coefficient S_{22} 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_{σ} =

-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 (\sim 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 smallsignal performance of PA1.

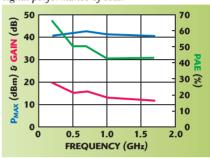


Fig. 6 Power mesurements at $V_d = 28 \text{ V}$ for the PA1 amplifier.

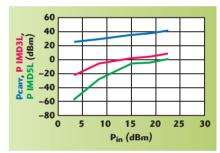


Fig. 7 Two-tone test results for PA1 at 1 GHz with a tone spacing of 4 MHz.

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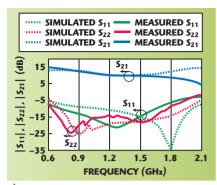
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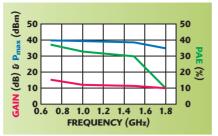


▲ Fig. 8 Simulated and measured small-signal performance of PA2.

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 dBat 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_{σ} = -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 per-



ightharpoonup Fig. 9 Power measurement results of PA2 at $V_d = 48 \text{ V}$.

cent 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),

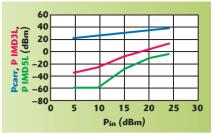


Fig. 10 Two-tone test results for PA2 at 1 GHz with a tone spacing of 4 MHz.

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 $V_d = 48 \text{ V}$. 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 $V_d = 48 \text{ V. A wider frequency band,}$ 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 di-

ameter 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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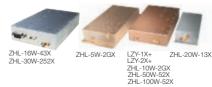
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TWO-ARM ARCHIMEDEAN SPIRAL HELICAL ANTENNA WITH WRAPAROUND ABSORBER

wo-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 S₁₁, 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.

W- (r) r2

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

 $2~\mathrm{GHz})$ 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 $\it Figure~2$, 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 $\it Figure~3$.

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*).

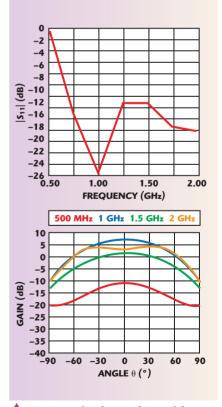
FEKO optimization is used to determine the loss tangent $(\tan \delta)$ and the thickness of the absorber. An optimization routine is set up with

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



 \blacktriangle Fig. 3 Simulated S_{II} 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 S₁₁ 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-

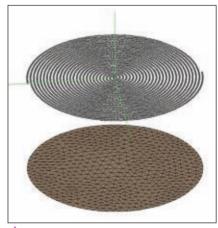
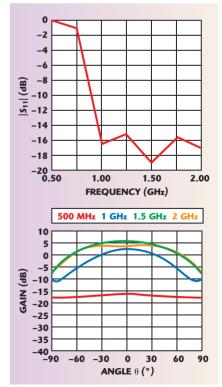


Fig. 4 Meshed FEKO model of the reduced size antenna.



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

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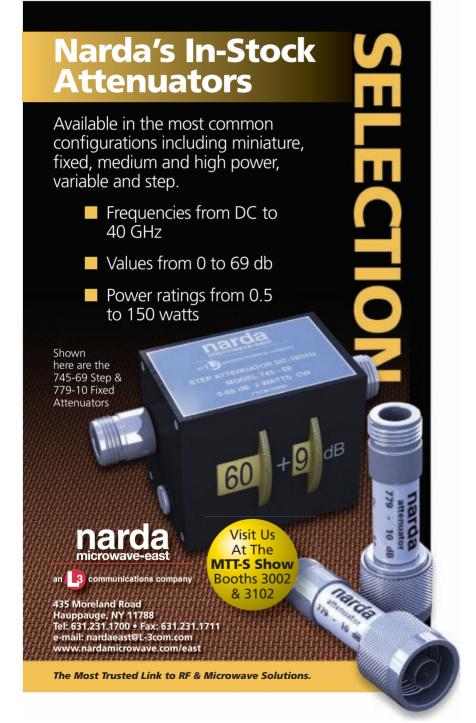


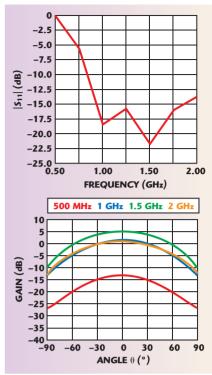
mized model has better performance (higher gain, lower S_{11} and lower axial ratio) and is compact compared to the bench mark antenna.

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.





ightharpoonup 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.

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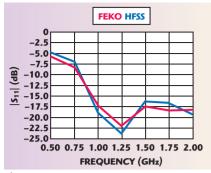
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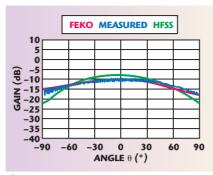


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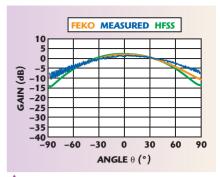
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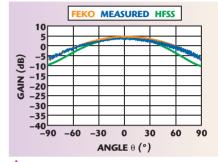
 \blacktriangle Fig. 10 Comparison of the S_{11} of the prototype antenna simulated with FEKO and HFSS.



▲ Fig. 11 Comparison of gains at 500 MHz.



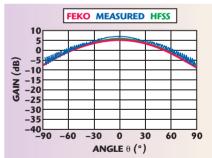
▲ Fig. 12 Comparison of gains at 750 MHz.



▲ 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



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▲ Fig. 17 Comparison of gains at 2.0 GHz.

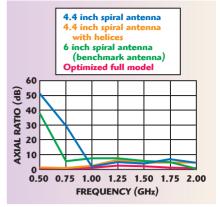


Fig. 18 Comparison of the axial ratios of the four models.

TABLE I **COMPARISON OF MoM (FEKO) AND** FEM (HFSS) COMPUTATION TIME AND **RESOURCE USAGE** Computation Memory Time Usage (Hrs) (GBytes) MoM (FEKO 2.616 1.468 FEM (HFSS) 26.48 28.78

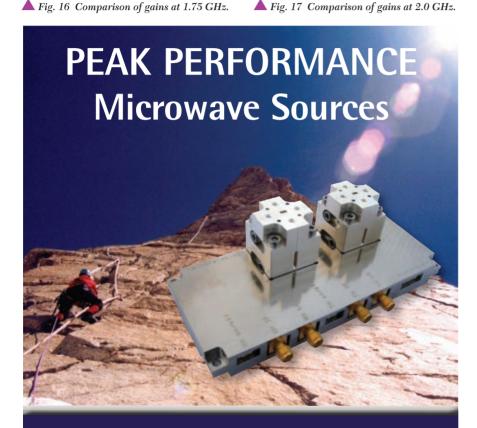
meshing), needed far more computation time and memory than MoM (FEKO). ■

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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.

odern 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*.

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

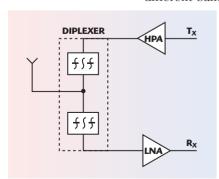


Fig. 1 Basic components of a transceiver front end.

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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. 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 proposed² 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-

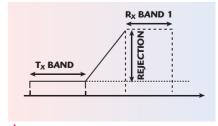
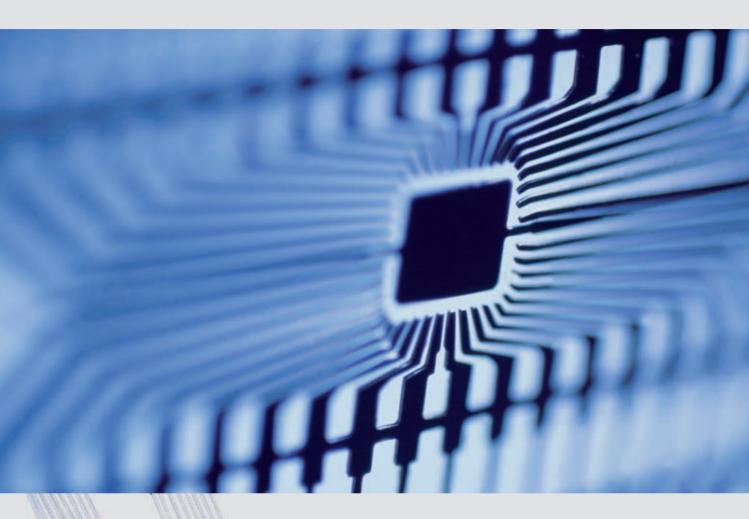


Fig. 2 Receive band specification.









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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

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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

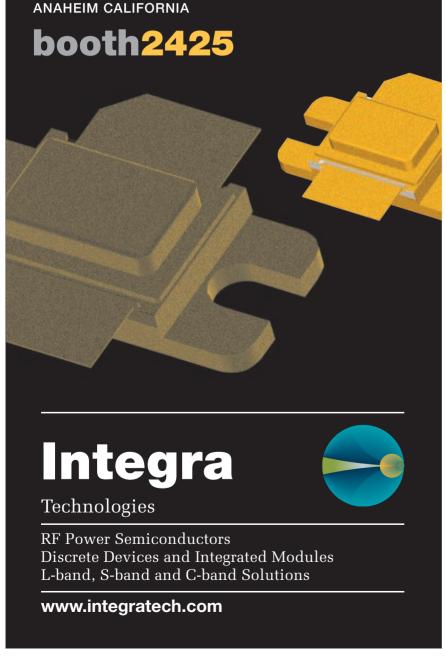
and a bandpass is created between them.⁴ It allows an independent control of each frequency band of interest, that is the center frequency bandpass and the attenuated bands.⁵ The resonator, in the case of a DBR, is composed of two stubs (low and high frequency stubs), in which only one of them can be 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*.



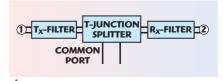


Fig. 3 Basic building blocks of a diplexer.

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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

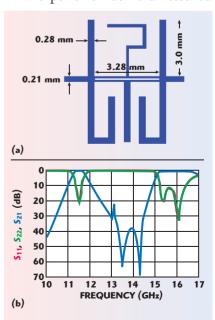
field's interaction in the notch, leading to coupled line behavior by introducing two nearby poles at the receive band.

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

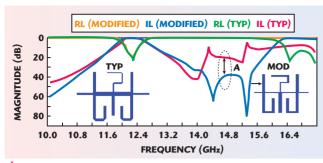
The power divider is an essential



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







▲ 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 100Ω lines at the output, but the discontinuity due to the lower width of the 100Ω 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

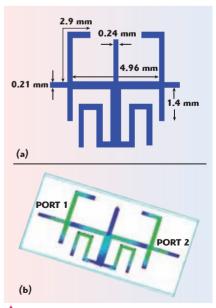
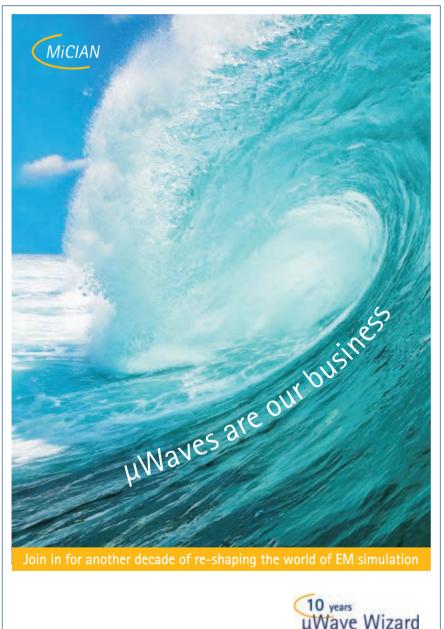


Fig. 6 Layout (a) and current conduction behavior (b) of the receive filter.



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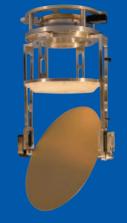


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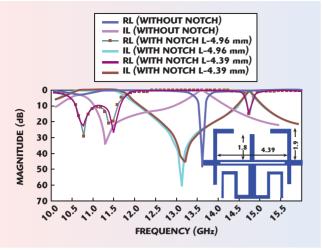


Fig. 7 Study of the notch on receive filter performance.

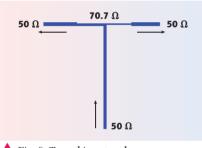


Fig. 8 T-combiner topology.

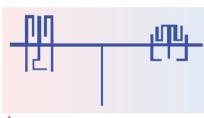
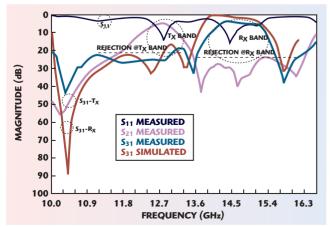


Fig. 9 Final layout of the diplexer.

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

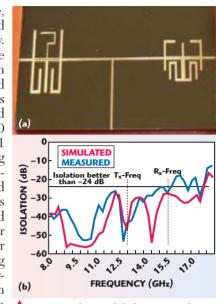
The diplexer was also fabricated on a high resistivity silicon substrate (> 8 k Ω -cm). After being subjected to standard thin film substrate cleaning cycles, the high resistivity silicon substrates (25.4) $\times 25.4 \times 0.6 \text{ mm}$ sputtered with a thin layer of TiW (200 to 300 Å) followed 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 μ m \pm 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



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

kovar carrier plate, using a silver-based conductive epoxy. The carrier plate mounted in the test jig and RF connectors were connected by gold ribbon 20 mils wide and 1 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.



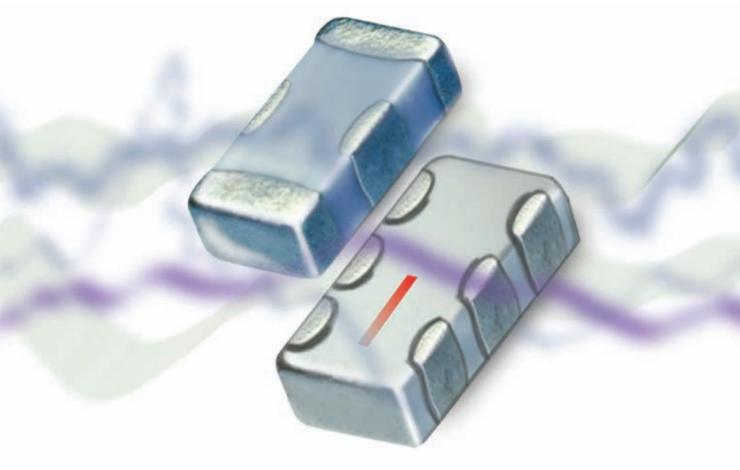
▲ Fig. 11 Fabricated diplexer on a silicon substrate (a) and its simulated and measured isolation characteristics (b).

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. The coupling matrix concept has also been reformulated to accommodate couplings directly from the source and the load to internal resonators. The coupling matrix concept has also been reformulated to accommodate couplings directly from the source and the load to internal resonators.

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.

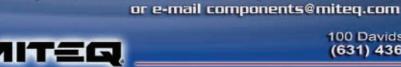
COUPLING

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 $\bar{\Delta}f$ 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

$$\mathbf{M}_{12} = \Delta \mathbf{f} / \mathbf{BW} \tag{1}$$

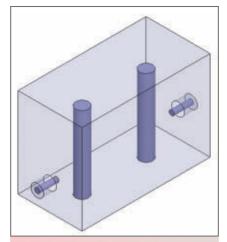
where Δf is the coupling bandwidth, which expressed in Hz, and M_{12} is the normalized coupling coefficient between resonator 1 and 2.

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



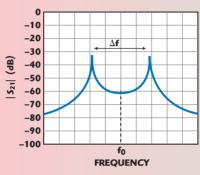


Fig. 1 Two-pole box and associated transmission characteristic.

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

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

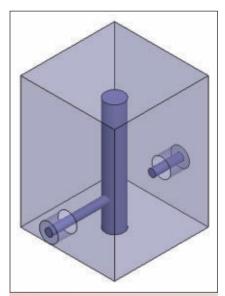
where it is assumed that the unloaded Q is much bigger than loaded Q so that $Q_{\text{ext}} = Q_{\text{loaded}}$ applies.

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

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



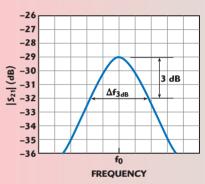
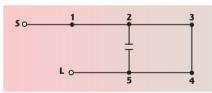


Fig. 2 One-pole box with tapped input and associated characteristic.



▲ 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—xcouplings—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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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
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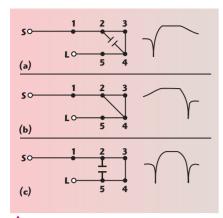


Fig. 4 Three commonly used x-coupling configurations and their characteristics.

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

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			

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.



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 O.

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

Ou-

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

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

 $n = h/(\lambda/4)$ 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 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 $\lambda/8$ 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.





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SCCX500	.01-220	500	57
M404	.01-220	500	57
M406	.01-220	1000	60
TCCX2000	.01-220	2000	63
TCCX2200	.01-220	2200	63
TCCX2500	.01-220	2500	64
CMX/	SMX Series	s • .01-1000 I	ИНz
SMX301	.01-1000	300/100	55/50
SMX302	.01-1000	300/200	55/53
SMX303	.01-1000	300/300	55/55
SMX501	.01-1000	500/100	57/50
SMX502	.01-1000	500/200	57/53
SMX503	.01-1000	500/300	57/55
CMX10001	.01-1000	1000/100	60/50
CMX100010	.01-1000	1000/1000	60/60



Microwave Solid State and TWT Amplifiers

	Freq	Min Pwr	Min Sat
Model	Range	Out	Gain
Number	(GHz)	(Watts)	(dB)
T-200 Serie	es • 200-300 l	Natts CW 1-	21.5 GHz
T251-250	1-2.5	250	54
T82-250	2-8	250	54
T188-250	7.5-18	250	54
T2118-250	18.0-21.7	250	54
T-500 Se	eries <i>• 500 W</i>	atts CW 1-1	8 GHz
T251-500	1-2.5	500	57
T7525-500	2.5-7.5	500	57
T188-500	7.5-18	500	57
MMT Sei	ries • <i>5-150</i>	Watts, 18-4	10 GHz
T2618-40	18-26.5	40	46
T4026-40	26.5-40	40	46
S/T-50 Se	ries • 40-60	Watts CW 1	-18 GHz
S21-50	1-2	50	47
T82-50	2-8	50	47
T188-50	8-18	50	47



Solid State Amplifiers

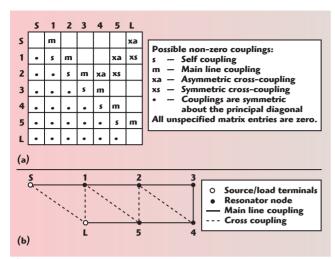
Model Number	Freq Range (MHz)	Min Pwr Out (Watts)	Min Sat Gain (dB)
SMO	CC Series • 2	200-1000 M	Hz
SMCC350	200-1000	350	55
SMCC600	200-1000	600	58
SMCC1000	200-1000	1000	60
SMCC2000	200-1000	2000	63
SM	C Series •	80-1000 MF	Hz
SMC250	80-1000	250	54
SMC500	80-1000	500	57
SMC1000	80-1000	1000	60
SMX-0	CMX Series	· .01-1000	MHz
SMX100	.01-1000	100	50
SMX200	.01-1000	200	53
SMX500	.01-1000	500	57
SVC-S	MV Series	100-1000	MHz
SVC500	100-500	500	57
SMV500	500-1000	500	57

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▲ 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. The term "low pass prototype" refers to that it is centered around 0 (zero) rad/s and has upper and lower corner frequencies of \pm 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

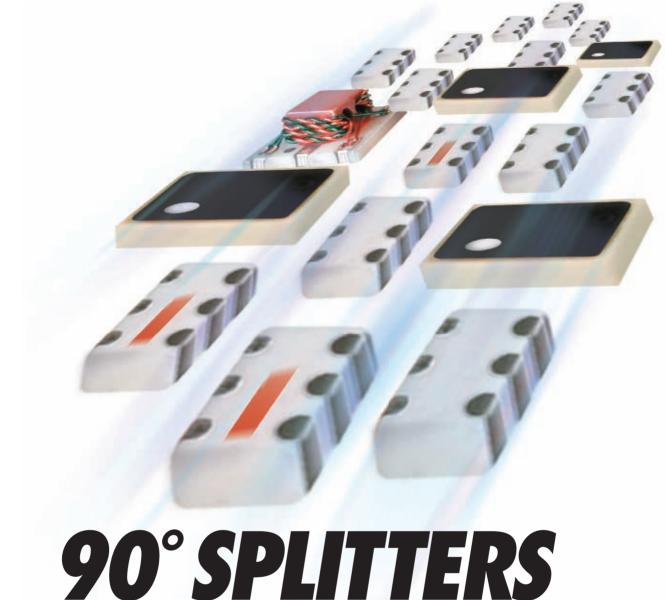
filter characteristics and coupling matrices—is well described in the literature^{2,3,5} and will not be dealt with here. In the following, the Guided Wave Technology's Filter and Coupling Matrix Synthesis tool (CMS)⁹ is used for this purpose.

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.





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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

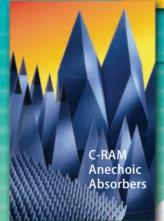
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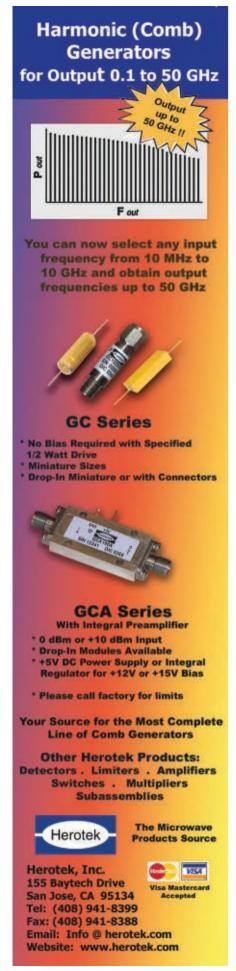


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microwave industry (see *Figure 1*). The US Signal Corps was one of their first customers and they soon started producing magnetrons. United Paramount Theaters (now ABC) and Western Union were some of the original investors that helped the company 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 Com-

munications 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 busiwas 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 Iacobs 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.

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FM IF Helical Band Pass Filter 7H3 (Triple Tunning) RL>16				
TW-P/N-FO FO / B.W / IL MHz/MHz/dB TW-P/N-FO MHz/MHz/d				
60 / 4.0 / 4.0	TT67693B-101M	101 / 8.0 / 3.5		
70 / 9.0 / 3.0	TT67181B1-128M	128 / 23.0 / 1.5		
71 / 15.0 / 2.5	TT6756B-140M	140 / 3.0 / 7.5		
90 / 2.0 / 6.0	TT6755D1-140M	140 / 5.0 / 3.5		
90 / 6.0 / 3.0	TT67676B-140M	140 / 8.0 / 3.0		
98 / 22.0 / 2.0	TT67205B-140M	140 / 10.0 / 3.0		
	Fo / B.W / IL MHz/MHz/dB 60/4.0/4.0 70/9.0/3.0 71/15.0/2.5 90/2.0/6.0 90/6.0/3.0	Fo / B.W / IL MHz/MHz/db TW-P/N-Fo 60 / 4.0 / 4.0 TT67693B-101M 70 / 9.0 / 3.0 TT67789B-128M 71 / 15.0 / 2.5 TT6758B-140M 90 / 2.0 / 6.0 TT6755D-140M 90 / 6.0 / 3.0 TT67676B-140M		

Lo (OSC) O

Conversion

Down: IF= ±f_{Lo -/+}f_{RF}

UP: RF= file ± file

Temwell Type VHF 138-260MHz Band Pass Filter 7H2/7H3 RL>16				
TW-P/N-Fo	Fo / B.W / IL MHz/MHz/dB	TW-P/N-Fo	Fo / B.W / IL MHz/MHz/dB	
TD67194B-140M	140 / 9.0 / 3.0	TT67677B1-140M	140 / 13.0 / 3.0	
TD67281B-160M	160 / 8.0 / 2.5	TT67711B-160M	160 / 10.0 / 3.0	
TD6730B-180M	180 / 6.0 / 2.5	TT67183B1-180M	180 / 12.0 / 2.5	
TD6732B-200M	200 / 8.0 / 3.0	TT6761B-200M	200 / 11.0 / 3.5	
TD6732B-220M	220 / 8.0 / 3.0	TT6761B-220M	220 / 11.0 / 3.5	
TD6734B-240M	240 / 8.0 / 2.5	TT6763B-240M	240 / 12.0 / 3.0	
TD6737B-260M	260 / 10.0 / 2.5	TT6764B-260M	260 / 12.0 / 3.0	
Temwell Toko Tyne (7H2/7H3) (Double/Triple Tunning) RI>16				

reminent tour type (1115/ 1119) (pounte) trible triuming) urs to					
TW-P/N-Fo-BW	TW-P/N-Fo-BW	TW-P/N-Fo-BW	TW-P/N-Fo-BW		
K2B1-360M-10M	K2B1-505M-13M	K3BT-435M-20M	K3CT1-833M-21M		
K2B1-370M-10M	K2B1-525M-13M	K3BT-455M-20M	K3BT-835M-20M		
K2B1-380M-10M	K3BT-370M-10M	K3BT-465M-15M	K3CT1-860.5M-23M		
K2B1-390M-10M	K3BT-370M-16M	K3B-485M-20M	K3BT-880M-25M		
K2B1-410M-10M	K3BT-390M-10M	K3BT-510M-15M	K3CT1-904M-12M		
K2B1-420M-11M	K3BT-390M-16M	K3BT-500M-16M	K3CT1-915M-12M		
K2B1-435M-11M	K3BT-410M-11M	K3CT2-600M-20M	K3CT1-938M-15M		
KOD4 4EOM 44M	1/2DT 440M 46M	LODE CTOM TOW	MOCTA DATA ADM		

Temwell Toko Type (5R2/5R3) (Double/Triple Tunning) RL>16

K2B1-460M-11M K3BT-415M-16M K3CT2-651M-10M K3CT1-960M-12M

K3BT-680M-13M

K3BT-415M-20M

TW-P/N-Fo-BW	TW-P/N-Fo-BW	TW-P/N-Fo-BW	TW-P/N-Fo-BW	
K2RB-320M-10M	K2RB-820M-20M	K3RFT-390M-20M	K3RBT-590M-18M	
K2RB-340M-10M	K2RB-862M-21M	K3RFT-400M-15M	K3RBT-635M-18M	
K2RB-365M-10M	K2RB-880M-20M	K3RFT-410M-15M	K3RBT-655M-16M	
K2RB-380M-10M	K2RB-914M-25M	K3RFT-410.7M-10M	K3RBT-705M-20M	
K2RB-415M-10M	K2RB-959M-25M	K3RFT-420M-16M	K3RBT-735M-20M	
K2RB-425M-10M	K2RB-1010M-26M	K3RFT-430M-18M	K3RBT-800M-20M	
K2RB-430M-10M	K2RB-1130M-26M	K3RFT-435M-10M	K3RBT-830M-20M	
K2RB-450M-11M	K2RC-1195M-35M	K3RFT-440M-18M	K3RBT-862M-20M	
K2RB-475M-11M	K2RC-1225M-35M	K3RFT-450M-18M	K3RBT-880M-20M	
K2RB-474M-11M	K2RC-1305M-35M	K3RFT-460M-18M	K3RBT-945M-20M	
K2RB-505M-14M	K3RFT-320M-20M	K3RFT-470M-18M	K3RBT-980M-20M	
K2RB-530M-14M	K3RFT-340M-20M	K3RFT-480M-18M	K3RBT-1010M-20M	
K2RB-545M-14M	K3RFT-350M-20M	K3RFT-495M-20M	K3RBT-1055M-20M	
K2RB-625M-14M	K3RFT-360M-20M	K3RFT-515M-20M	K3RBT-1090M-20M	
K2RB-670M-20M	K3RFT-370M-20M	K3RFT-518M-20M	K3RCT3-1125M-20M	
K2RB-700M-20M	K3RFT-380M-20M	K3RBT-520M-14M	K3RCT3-1230M-20M	
K2RB-735M-20M	- See 3000	Perf on"www.ter	nwell.com"	
IJHE Halical Rand Dace Either 5W3 (Trinle Tunning) DI >16				

OUL HEIICH DAIM LASS LIKEL SMS (TUBIE IMIIIIIIS) KT\10					
TW-P/N-Fo-BW	TW-P/N-Fo-BW	TW-P/N-Fo-BW			
TTW3489B-713M-14M	TTW3537F-1441M-34M	TTW3608B-2400M-100M			
TTW3489B-743M-17M	TTW3538B-1489M-43M	TTW3536B-2450M-95M			
TTW3512B-815M-35M	TTW3539E-1489M-34M	TTW3859B-2450M-100M			
TTW3513B-850M-33M	TTW3588B-1575M-40M	TTW3840B-2450M-175M			
TTW3739B-1275M-50M	TTW3527F-1747.5M-69M	TTW3841B-2500M-190M			
TTW3810B-1375M-72M	TTW3529E-1842.5M-70M	TTW3875B-2583M-140M			

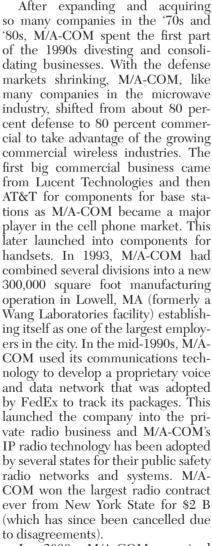
VHF UHF Band of Band Pass Filter 7H3 (Triple Tunning) RL>16

TW-P/I	I-Fo-BW	TW-P/N-Fo-BW	TW-P/N-Fo-BW	TW-P/N-Fo-BW
TT63228B	-288M-80M	TT6393F-530M-120M	TT63337F-725M-120M	TT67868B-933M-140M
TT63348B	-375M-100M	TT67155F-575M-120M	TT63348F-805M-140M	TT67862B-975M-120M
TT6395F-4	50M-120M	TT67618F-625M-130M	TT63353E-900M-165M	TT67864B-1075M-120M
TT63355F	-480M-120M	TT63333F-666M-135M	TT67861B-925M-120M	TT63362F-1300M-200M
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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



quarters (see Fig. 3 M/A-COM Tech's headquarters in Lowell, MA.

Iersev 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.

Thank You



For forty years, we at Mini-Circuits have held firm to a single goal:

demonstrate total commitment to our customers by creating high-quality products, quickly and efficiently, at exceptionally competitive prices and with uncompromising technical support and service. And, for forty years, you have rewarded our commitment to you with your confidence and your business. We thank you and we pledge to work even harder to keep earning your confidence and bringing value to your business.

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MICROSYNTHTM INTEGRATED HERMETIC SYNTHESIZER MODULE

requency 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

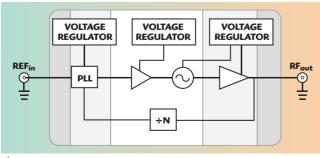


Fig. 1 HMC-C070 block diagram.

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 Micro-Synth combines high performance SiGe, GaAs PHEMT and InGaP HBT technologies (see *Figure 1*), rugged construction, and an incredibly small form factor of 3.7 cm³ (0.226 in³). 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

HITTITE MICROWAVE CORP. Chelmsford, MA

MILLIMETER WAVE RECTANGULAR TE₁₀ WAVEGUIDE INFORMATION

WG Band	Waveguide Frequency Range (GHz)	Wavelength Rangeλο (mil)	Wavelength Rangeλο (mm)	Guide Wavelength Range (λg/λο)	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	260.0	14.22	280.0 × 140.0	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	5.690×2.845
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	4.775×2.388
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	0.06 - 0.09	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	29.0	200.0	2.08	100.0 × 50.0	2.50×1.270
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	2.032×1.016
WR-06	110.0- 170.0	107.3 - 69.4	2.725 - 1.763	1.771-1.183	667.7 - 445.9	8.06	130.0	3.30	65.0 x 32.5	1.651×0.826
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	1.295×0.648
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	1.092×0.546
WR-03	220.0- 325.0	53.6 - 36.3	1.363 - 0.922	1.627-1.183	613.5- 445.9	173.6	0.89	1.73	34.0 x 17.0	0.864×0.432
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	26.0	1.42	28.0 x 14.0	0.711×0.356
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	0.559×0.279
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	26.0	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	92.0	15.0 x 7.5	0.381×0.191
WR-01.2	0.006 -0.009	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	0.305×0.152
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 × 5.0	0.254×0.127



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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	dBe					
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 seriallycontrolled 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

At $54.86 \times 19.05 \times 6.22$ mm (2.16" \times 0.75" \times 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:

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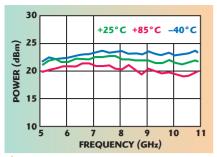


Fig. 2 HMC-C070 MicroSynth output power vs. frequency.

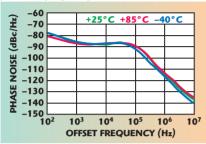


Fig. 3 HMC-C070 MicroSynth phase noise vs. temperature at 5.5 GHz.

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 multimodulus 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 Micro-Synth base of products to include phase variation, amplitude variation, multiport 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.

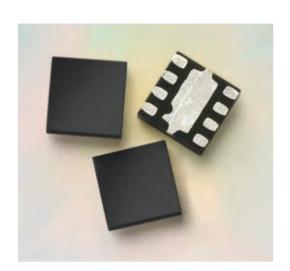
Class H or Class K: The Micro-Synth products are provided in hermetically sealed modules that can be up-screened per military or space specifications. The standard RF interfaces are field-replaceable SMA connectors with provisions for optional SMP style connectors or no connectors for microstrip mounting. 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.

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

RS No. 303





ULTRA LOW NF ACTIVE BIAS LNA ADDRESSES BTS RF FRONT-END DESIGN CHALLENGES

ase 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 \times 2.0 \times 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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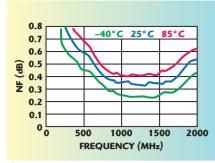


Fig. 1 NF vs. frequency at various temperatures.

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 $I_{\rm dd}$ current is adjustable by changing the $R_{\rm bias}$ value. This allows designers to choose between $I_{\rm dd}$ 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

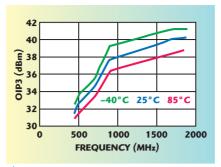


Fig. 2 OIP3 vs. frequency at various temperatures.

with a high $P_{\rm in}$ 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 vield 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.

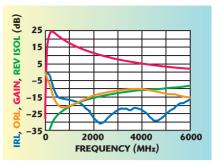


Fig. 3 Input return loss, output return loss, gain and reversion isolation vs. frequency.

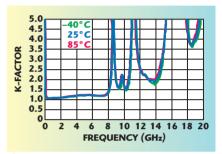


Fig. 4 K-factor vs. frequency at various temperatures.

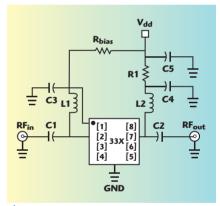


Fig. 5 MGA-633P8 application schematic.

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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RS No. 300



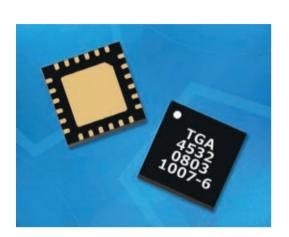
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1 W GAAS MMIC Amplifier for 18 GHz Cellular Backhaul Applications

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 espe-

cially 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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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	K	+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	N	+50 / 1000



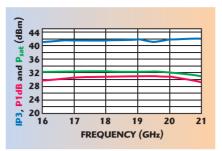
Lightwave (fiber) systems, as well as microwave and millimeter-wave (radio) links, represent the two technologies with the bandwidth to accommodate the impending backhaul onslaught-each with strengths and limits. If fiber nodes were available at every cell site, that would be the obvious choice, as they 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 millimeterwave 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.

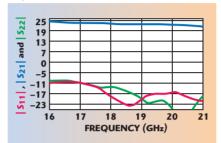


Fig. 2 Gain and input/output losses vs. frequency for TGA4532-SM at 6 V, 816 mA.

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. PldB 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-topoint 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 pointto-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, smallsignal gain of 31 dB, and a noise figure

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				

of 7 dB. Performance is extremely flat over its 3 GHz bandwidth.

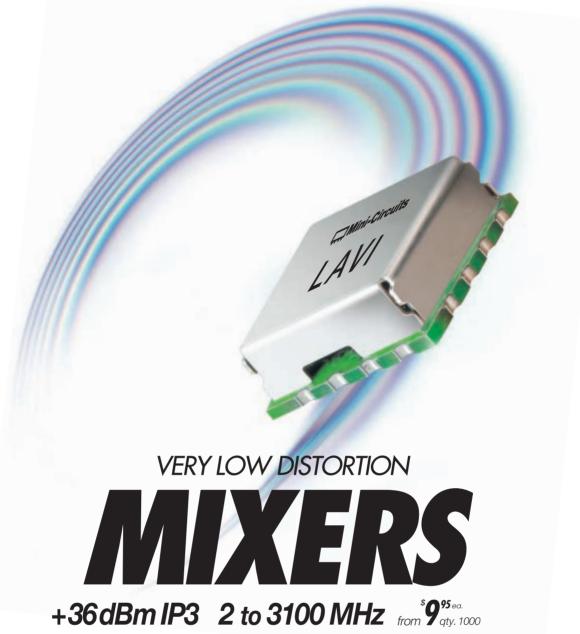
In the bands above 23 GHz allocated for point-to-point microwave operation, bare die are commonly used to deliver the highest performance. Tri-Quint's recently-introduced TGA4538 GaAs MMIC die offers excellent performance from 37 to 40 GHz. The device's P1dB RF output power is at least 28 dBm (29.5 dBm $P_{\rm sat}$), 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-topoint 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.

TriQuint Semiconductor, Hillsboro, OR, info-networks@tqs.com, www.triquint.com.

RS No. 301



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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.

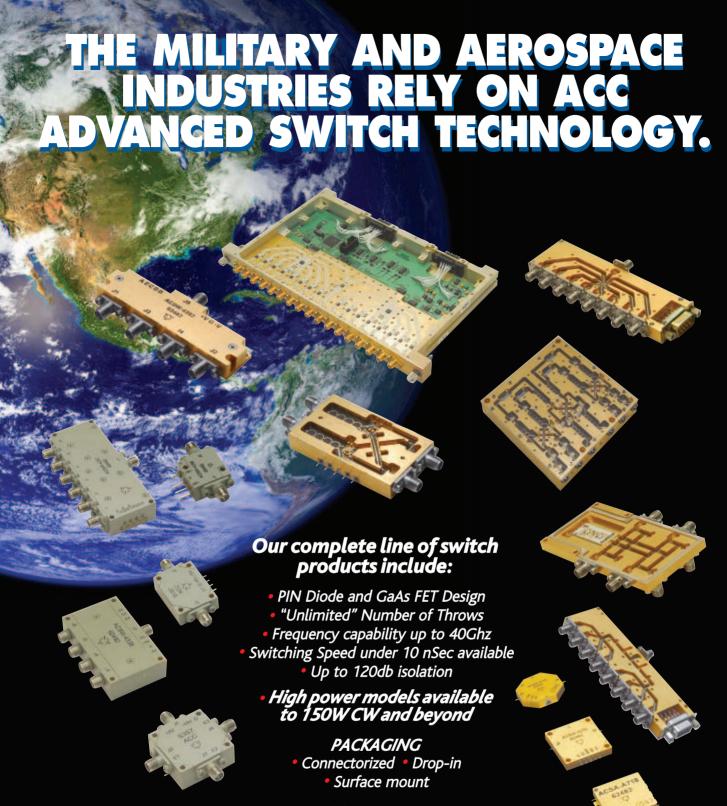
TECHNOLOGY

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 $_{\rm max}$) and breakdown voltages (VBGD, VDS $_{\rm max}$) are required, it is also essential to have high cut-off frequencies (F $_{\rm t},$ F $_{\rm max}$). OMMIC has developed a short gate length, high F $_{\rm t}$ 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 $F_{\rm t}$ (105 GHz) and $F_{\rm max}$. 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



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TABLE I							
MEASURED ELECTRICAL CHARACTERISTICS FOR CGY2130UH MMIC							
Feature	Symbol	Min	Тур	Мах			
Frequency Range (GHz)	$\mathbf{F}_{\mathrm{range}}$	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)	$V_{_{ m DD}}$		4.5				

TABLE II MEASURED ELECTRICAL CHARACTERISTICS FOR CGY2131UH MMIC							
Feature	Symbol	Min	Тур	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)	$V_{_{ m DD}}$		4.5				

resistors, spiral inductors, airbridges and via holes. The substrate height is $100~\mu m$ 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

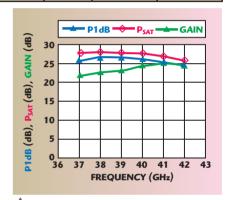
for the CGY2130UH versus input power for a range of frequencies.

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.

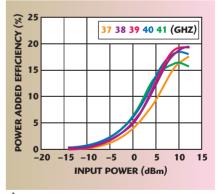
1 W MMICS

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.

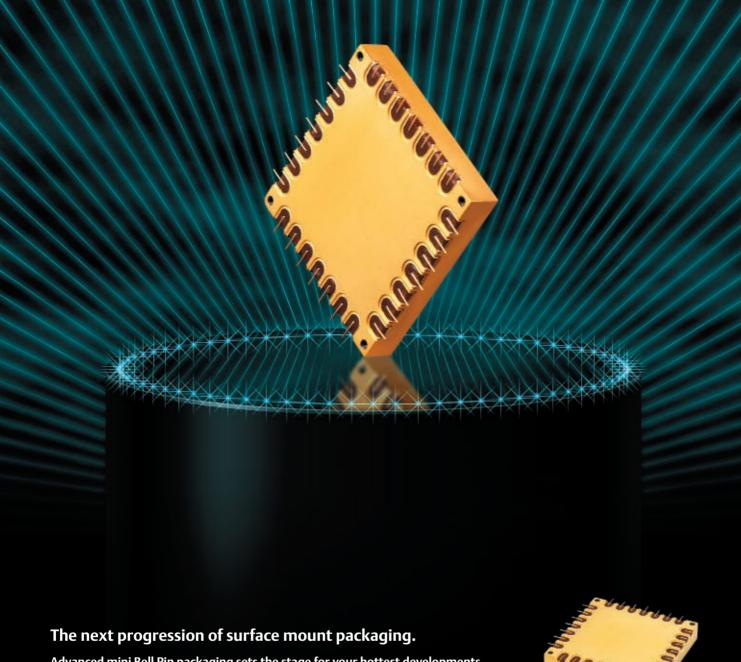


▲ Fig. 1 Measured electrical characteristics for CGY2130UH at 4.5 V.



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

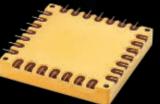
Again it should be noted that the results presented are for the worst-case on-wafer non-pulsed CW measurement conditions; the same MMICs mounted with good thermal conditions have been shown to have typically 1 dBm higher output compression point. Figure 4 shows the overall power added efficiency of the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



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

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.



1960

1962

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

Throughou Microwave component radar, miss equipmen B-52 bomb the Telstar

1984

M/A-C

in Low

Employ

The Wa

key ted Richard

1970

1970

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



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.

1991





1994

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

1990

2001

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.

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.

2000



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



1968

across the U.S.

1957

Microwave Associates expands its product offering

to communications and broadcast industries. Microwave

Olympic games, as well as political conventions, to households

Associates equipment brings the Mexico City Summer

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.



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.



the military industry. Microwave

Associates becomes a leading supplier

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

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.

OM, Inc. establishes the red Semiconductor Operation ell, Massachusetts. ees refer to this building as

alker Building in honor of

hnologist and co-founder

d M. Walker.

of high quality PIN diodes.

1985

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

1995

brand.

M/A-COM, Inc.

is acquired by AMP

Incorporated. AMP

retains M/A-COM



1989

Adams Russell

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

1988

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



vave Integrated Circuit (HMIC) that creates three-dimensional and glass at a waferscale level. ues to demonstrate the ability ng from HMIC double balanced vitches—for cellular, basestation, 1995

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



1999

Tyco International Ltd. acquires AMP Incorporated.



2009

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

Technology Solutions

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.

TABLE III								
MEASURED ELECTRICAL CHARACTERISTICS FOR GY2132UH MMIC								
Feature	Symbol	Min	Тур	Мах				
Frequency Range (GHz)	$\mathbf{F}_{\mathrm{range}}$	36		41				
Gain (dB)	Gain		20					
1dB Compression Point (dBm)	P_{1dB}		28.5					
Saturated Power (dBm)	P _{sat}		30					
Power Added Efficiency (%)								
DC Power Consumption (W)	P_{DC}		4.5					
Drain Voltage (V)	V_{pp}		4.5					

TABLE IV						
MEASUREI		CAL CHAI 133UH M	RACTERISTICS MIC	FOR		
Feature	Symbol	Min	Тур	Мах		
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)	$V_{_{ m DD}}$		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

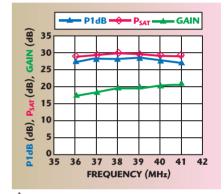
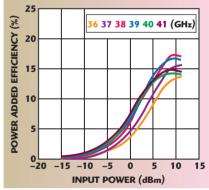


Fig. 3 Measured on-wafer electrical characteristics for CGY2132UH at 4.5 V.



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

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.

OMMIC,

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RS No. 302



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If you haven't been to the **IMS2010 website** please take a moment to log on and view updates for the upcoming IMS2010 symposium. The IMS2010 website is a great place to start if you are not familiar with the symposium or local area. Here you can gather **general information** and also learn about **travel** and **lodging** near the Anaheim convention center. We also recommend that you view the **technical** program schedule along with learning more about who is **exhibiting** and how your company can become an **exhibitor**.

Don't forget to mark your **calendars** for two fun-filled hours of networking with "Microwave & RF" female colleagues during IMS2010. There is a **Women in Microwave**Engineering (WIM) reception happy hour to be held Tuesday evening at the **Uva Bar** located in Downtown Disney. Check the IMS program for more details.

For those **family** and **guest** of attendees, please be sure to visit the IMS2010 **hospitality suite** which will be located at the Sheraton Hotel. Only a short distance from the Anaheim convention center, we have created a **comfortable setting** where you can meet with friends, grab a snack, **check email** and learn what the local area has to offer. There will also be special activities for the **children**.

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for IMS2010











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FEATURING VENDORVIEW STOREFRONTS

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 sameday 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 network-

ing 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 digitallycontrolled voltage variable PIN diode attenuators to its "Flatliner" fam-

ily 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 tures hot switch-

ing 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 operates

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. Smallsignal 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



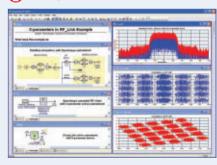


Agilent's PNA-X Series of microwave network analyzers now offer high-accuracy, source-corrected noise-figure measurements of frequency converters and mixers, as well as amplifiers. For measurements up to 26.5 GHz, an internal lownoise receiver is available that eliminates the need for an external preamplifier, 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



Directional/Bi-Directional

LTCC COUPLER FAMILY

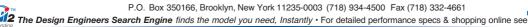


Mini-Circuits LTCC coupler family offers versatile, low cost solutions for your **5** *kHz* to **4600** *MHz* needs with rugged connectorized models from .74"x.50" to surface mount couplers from .12"x.06", the smallest in the world! Choose from our 50 & 75 Ω directional and bi-directional couplers with coupling ranging from 6-22 dB and with capability to pass DC. Mini-Circuits offers the world's most highly evolved LTCC

technology delivering both minimal insertion loss and high directivity with models handling up to 65 W. All of our couplers are ESD compliant and available as RoHS compliant. For full product details and specifications for all our couplers, go to Mini-Circuits web site and select the best couplers for your commercial, industrial and military requirements.

Mini-Circuits... Your partners for success since 1969







Miniature RF Switches





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



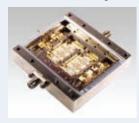
ATC's new 550L ultra-broadband capacitor (UBC) has been designed and manufactured with the highest quality materials to provide

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 opera-

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 offer

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 full-wave electromagnetic field simulation software. These features in-

clude: 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® WorkbenchTM.

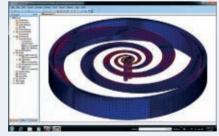
ANSYS Inc.,

Canonsburg, PA (724) 746-3304, www.ansys.com.

Booth 2700

DC 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**



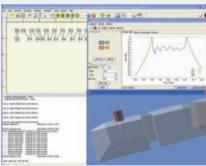
model PM2003 is a three-channel power with exceptional high-speed

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. RS 230

Booth 3400

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 flangemounted power resistors 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 Adapters, Attenuators, Blind Mate Connectors, Cable Assemblies, Connectors, Delay Lines, Duplexers Equalizers, Fine Grain Equalizers, Gain Amplitude Equalizers, Line Stretchers, Machines, Phase Adjusters, Push - On Connectors & Adapters, Quick Connections, Terminations (Coax-), Tools, Waveguide to Coax - Adapters & Transmissions, and.......

WG/Coax Adapters

Rectangular WG & Double Ridge WG, End Launched & Top Launched Aluminum, Copper, Brass, all Standard Flanges available

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P.O. Box 450533

Facsimile: +49-89-3548-0490

Email: sales@spectrum-et.com

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 HDRFITM prod-

uct 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

cle type, which provides both waterproof protection and EMI shielding. All EMI/RFI gasket material meets standard of MIL-G-83528

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 $\hat{18}$ 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

Low Noise Amplifier



This compact, low noise amplifier (LNA) operates in the 1 to 18 GHz frequency range for a wide vari-

RS 236

RS 308

ety 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

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 (\leq 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 ultraminiature 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

Harsh Environment Packaging

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

RS 239



an "All environment" rated enclosure. Many Empower COTS modules can also be hardened for the most severe op-

erating 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



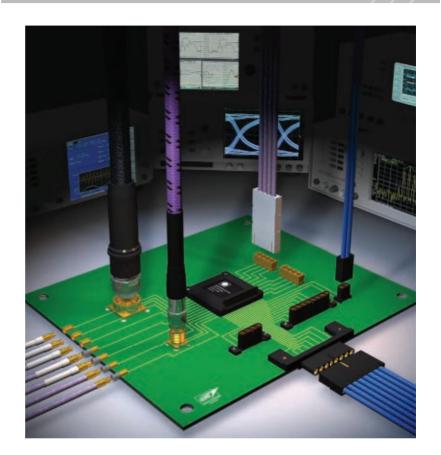
FEKO is a comprehensive EM simulation solution, based on the accurate full-wave MoM with various state-of-the-art extensions. The leading MLFMM and hybridisation with asymp-

totic 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

Repeatable Signal Integrity.





GORETM Microwave/RF Cable Assemblies

Gore develops a wide of range of reliable, innovative, high-performance products to meet your most challenging system requirements. With over 50 years of experience in maximizing repeatable signal integrity and vigorous fitness-for-use testing, Gore insures that our products do what we say they'll do each time, every time. Gore delivers.

gore.com/mwj





GORE™ VNA Microwave / RF Test Assemblies



GORE™ Ultra High Density Interconnects



Quick End Launch Connector



The new Ouick End Launch (OEL) SMA is designed quick connection at the edge of PCB boards up to 18 GHz. specially The

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

Temperature-compensated Crystal Oscillator



The T1215 series temperature-compensated oscillator (TĆXO) measures 9 × 7 \times 2.8 mm and features a her-

RS 245

metic, 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 \times 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.greenrauindustries.com. RS 246 **Booth 1736**

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 de-

vices, 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 PiQCTM 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



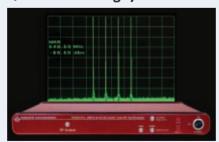
Hittite's 25th product line. tunable filters are ideal for pre-selection in multi-band communication systems, wide-

RS 248

band 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

Quad-Tone Analog Synthesizer



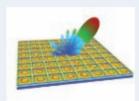
Holzworth Instrumentation introduced the Quad-Tone series of RF synthesizers to address the critical requirements of IMD test signal generation. These broadband synthesizers (8 MHz to 6 GHz) combine independent, phase coherent tones via a single output. These Quad-Tone RF synthesizers maintain the absolute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

tecture provides unsurpassed signal performance with independent control over the amplitude, frequency, and phase offset of each

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. EMchip design, etc., and is based on the powerful Fi-

nite 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, Germanu +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



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 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

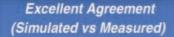
steps and is guaranteed monotonic across its entire bandwidth. SMA female connectors are

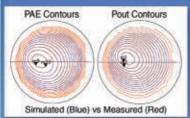
Measure With Confidence!

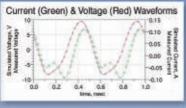
Using Maury's Automated Test & Measurement Solutions

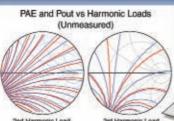
A IMSO TO GO BOOM \$7.00

Maury Load Pull plus NVNA Provides Instantaneous X-Parameter Large Signal Models at Over 200 Watts!

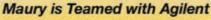








- · Automated Process from Measurement to Simulation with Simple Setup
- Includes Magnitude and Phase Data as Non-Linear Functions of Power, Bias and Load at Each Harmonic
- Includes Time Domain Data
- Simulates **Fundamental** and Harmonic Impedance Responses



for development of breakthrough test and measurement applications!

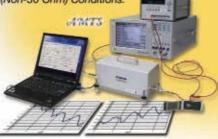
Contact our Sales Department for the latest information about these and other exciting test and measurement solutions!

Maury's Ultra-Fast Noise Parameter Measurement



Over 100 Times Faster Than The Old Method!

Maury's MT910 series Automated Mobile Test System Software (AMTSv1.0) Enables Load Pull Impedance Testing of Cell Phone TX/RX Performance Under Non-Ideal (Non-50 Ohm) Conditions.







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

IFW 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 re-



spect to output) of 16 + 1.1 dB and frequency sensitivity ± 2.0 dB. The coupler vides directivity of 7.25 dB, max-

imum 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

DC 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 bank has a low band from 20 to 1100 MHz and

RS 254

a high channel of 1300 to 2250 MHz. The bypass covers 1300 to 2250 MHz. The unit features a $3.2 \times 1.9 \times 0.35$ 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

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

Booth 1016

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 including materials; 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



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 equip-

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

RS 256

Microwave Solid State Power Amplifiers from Herley General Microwave

Your time-trusted source

"NEW" X & Ku **Band SSPAs**

Herley General Microwave announces its new family of Solid-State Power Amplifiers whose key features include:

- Up to 400 Watts Output Power
- Graceful Power Output Degradation
- Up to 1000 MHz Bandwidth
- Ultra Quiet Switching Power Supply
- Low Standby Current, Fast On/Off Response
- Built-in Test Capability

This new family of SSPAs offer a high performance, cost-effective alternative, to electron tube devices. Their robust design, high reliability and small size make them ideally suited to replace TWTs used in today's demanding Airborne Radar, Missile and Communication Systems.

To learn more or receive a free SSPA brochure, please contact us.



Proven Microwave Performance

www.herley.com

Herley New York • 227A Michael Drive, Syosset, NY 11791 **Telephone**: 516-802-0900 • **FAX**: 516-802-0897 • **E-mail**: sales@herleyny.com

Precision Components and Calibration Standards



This new line of instrumentgrade precision components is designed to provide users with the right level of performance at the right price. This new prod-uct 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 formance across all wireless bands from 700 MHz to 2.7 GHz. The divider/combiners rugged struction 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 per-

cent 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 $\pm 0.9^{\circ}$ 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 $22\ \mathrm{dB}$ at $18\ \mathrm{GHz}$. These cable assemblies are especially a good fit for the applications of RF and microwave test systems, and mobile communications.

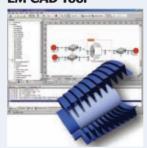
MIcable Inc..

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. μŴave 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 support can switching repletion 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

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

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

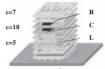
R&K Company Limited

Tel: +81-545-31-2600 http://rk-microwave.com Fax: +81-545-31-1600 E-mail: info@rkco.jp

Visit http://mwj.hotims.com/28488-163 See us at MTT-S Booth 2726

"Reasonable device-LTCC

HIRAI's featured LTCC process, in-house plating, forming and mm-wave technologies enable you to design SiP with high Q and lower cost.

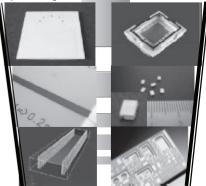


LTCC

ANTENNA + FEM

- ■One week shipment
- ■Design kit download
- ■Design support
- ■DC&RF tests are ■Special arrangement







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-converterVENDOR**VIEW**

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 turndown trajectories optimized to maintain lin-

earity and minimal 2xLO leakage over the gain control range. The XU1012-QH is well suited for point-to-point (PTP) radio, LMDS, SAT-COM 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





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

mal 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-,

RS 268

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

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

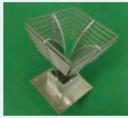
utilizes Class A/AB linear power devices that provide excellent third-order intercept point, high gain and a wide dynamic range. RF input signal formats of CW/AM/FM/PM and pulse. The amplifier can be fully controlled by the front panel key-pads or remotely by RS232/Ethernet or IEEE488. System protected 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) \times 2. Size: 126 \times 126 \times 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 TM 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. You-

Form 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.

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

RS 271

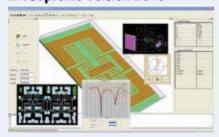
Hi Q/Low ESR Capacitors

Passive Plus Inc. now offers an Extended Working Voltage capability for its core Hi Q/low ESR Capacitor line. Available in six case sizes: $0.055^{\circ}\times0.055^{\circ}$ extended up to 300 W VDC; $0.110^{\circ}\times0.110^{\circ}$ extended up to 1,000 W VDC; $0.225^{\circ}\times0.225^{\circ}$ extended up to 5,000 W VDC; $0.390^{\circ}\times0.390^{\circ}$ extended up to 7,200 W VDC; $0.614^{\circ}\times0.433^{\circ}$ extended up to 9,000 W VDC; and 0.760 $^{\circ}\times0.760^{\circ}$ 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

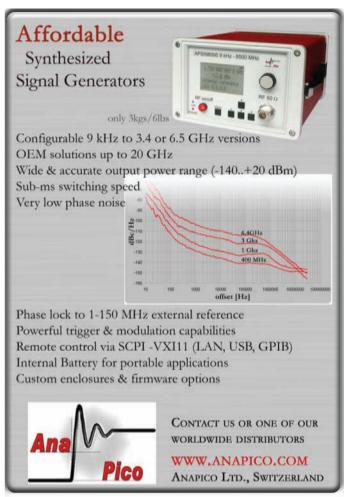


Reactel model 3TP-1176.45/1575.42-S11 is a cavity triplexer designed for all three GPS frequencies: L1 (New Civilian) L2 (Civilian) and L5 (Safety of Life). The passbands for this particular unit are L1: 1560.42 to 1590.42 MHz; L2: 1212.6 to 1242.6 MHz; and L5: 1164.45 to 1188.45 MHz. This unit has insertion loss of less than 1 dB mid-band, and a high degree of

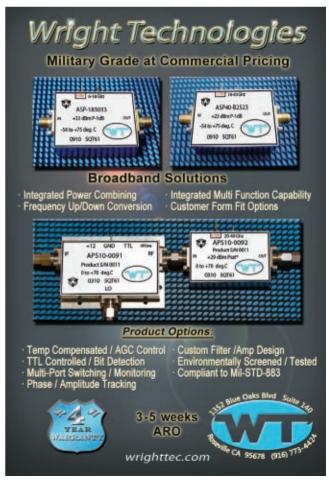
band to band isolation. It is outfitted with SMA connectors and is sized at $1.625" \times 2.5" \times 4.75"$ excluding connectors. Reactel manufactures a wide variety of GPS filters and multiplexers and dual filters; please contact the factory with your requirement.

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

RS 275

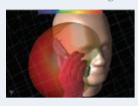


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3D EM Simulation Software

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 timesaving 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 ultrafast 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 (\pm 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

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

RS 277

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 $2.1"\times1"\times0.5"$, 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 generalpurpose 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.

REMD

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 flex-

ing 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-



2010 IEEE International Symposium on Phased Array Systems & Technology



Revolutionary Developments in Phased Arrays 12 – 15 October 2010 Westin Waltham Hotel, Greater Boston, Massachusetts, USA

About the Conference:

During recent decades, phased array systems have made major steps forward with the development of many major radar and communications systems. Due to many recent advances, including MMIC, photonics, and digital beamforming, phased array systems and technology continue to progress rapidly. Current and future developments of ground-based, sea-based, airborne, and space-based phased array radar, communications, and other electronic systems will be discussed at this international symposium.

Plenarary Speakers:

Prof. David McLaughlin, UMASS Amherst Fred McKeen, MDA Dr. Tim Clark, DARPA Dr. A. Farina, Selex, Italy

Tutorials:

Phased Array Basics and Recent Breakthroughs Dr. Eli Brookner, Raytheon
Digital Beam Forming
Dr. Hans Steyskal, Consultant (AFRL)
Adaptive Processing Using a Single Snapshot of Data
Prof. Tapan Sarkar, Syracuse Univ.
Phased Array Antenna Modeling using Matlab
Prof. Sergey Markarov, WPI Dr. Kenji Itoh, Mitsubishi Electric, Japan Prof. William Chappell, Purdue Univ. Dr. Jean-Luc Melin

Dr. Eli Brookner, Raytheon

Electronic Scanned Array (ESA) Design
Dr. John Williams, Aerospace Corporation
Phased Array Radar Trade-Offs, Specs and Performance Estimation
Dr. Thomas W. Jeffry, Raytheon
Solid State T/R Modules
Mike Borkowski and Nick Kolias, Raytheon
Phased Array Antenna Measurements
Katie Hauck, Applied Radar and Dr. Alan Fenn, MIT/LL

Technical Sessions:

(1) Plenary; (2) Array Design I; (3) Radar I; (4) Adaptive Arrays; (5) Beamforming and Calibration; (6) Radar II; (7) Array Design II; (8) Wideband and Multifunction; (9) Direction Finding; (10) Array Design III; (11) Special Session on Widefield Radio Astronomy Arrays; (12) Special Session on T/R Modules; (13) Special Session on Overlapped Subarrays and Non-Regular Arrays

Women in Engineering (WIE) Reception:

Tuesday October 12, 2010 (6:30 – 8:30 pm)
*Reception not limited to conference attendees, all welcome

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Output Frequency	1100 - 25	500 MHz				
Bandwidth	1400 MHz					
External Reference	10 A	MHz				
Step Size	Programma	ble to 1 Hz				
Bias Voltage	+5/+	3.3 V				
Output Power	+9 dBm (Min.)					
Spurious Suppression	60 dB (Typ.)					
Harmonic Suppression	15 dB (Typ.)					
	Offset	dBc/Hz.				
Typical Phase Noise	1 kHz	-93				
Typical Phase Noise	10 kHz	-95				
	100 kHz	-110				
Outlies Time	Within 1 kHz	<22 mSec				
Settling Time	Within 10 Hz	<36 mSec				
Operating Temperature Range	-20 to +70 °C					

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

Output Frequency	3000 - 60	3000 - 6000 MHz					
Bandwidth	3000 MHz						
External Reference	10 8	MHz					
Step Size	Programma	able to 1 Hz					
Bias Voltage	+5/+	3.3 V					
Output Power	+2 dBm (Min.)						
Spurious Suppression	60 dB (Typ.)						
Harmonic Suppression	20 dB (Typ.)						
	Offset	dBc/Hz.					
Typical Phase Noise	1 kHz	-87					
Typical Phase Noise	10 kHz	-83					
	100 kHz	-108					
William Co.	Within 1 kHz	<6 mSec					
Settling Time	Within 10 Hz <12 n						
Operating Temperature Range	-20 to +70 °C						

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Programming Interface:

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Also available in connectorized package with the following options.

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- Low priase noise option





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sulators, this unique cable is configured for low loss and low VSWR. With triple shielding for optimum EMI protection, they are very phasestable 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



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

Band Reject Filters



VENDORVIEW

High Frequency Laminates

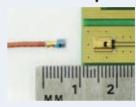
Rogers recently launched groundbreaking RO4360 high frequency laminates, the latest addition the RO4000® product family.

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 VENDORVIEW



San-tron has announced the release of a new series of 2.92 mm connectors. S292TM 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, iririr.santron.com. **Booth 1820**

RS 307









































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Are you looking for high ROI for your test investment? Do you need low life-cycle cost for your test applications? Aeroflex's SMART^E[™] 5000 (Synthetic Multifunction Adaptable Reconfigurable Test Environment) offers parametric and functional, DC to 40 GHz, configurable high throughput testing at the lowest possible cost. By combining the best-in-class throughput and measurement components available on the market today (i.e. PXI, cPCI, LXI, object-oriented open software architecture), SMART[™] gives you obsolescence resistance and highly competitive cost-of-test for all your needs. When combined with Aeroflex's worldwide fast response global support, SMART^E[™] is the only fully supported and customizable system-level synthetic test solution!

Let the Synthetic Test experts at Aeroflex show you how to solve your RF/microwave and mixed-signal test needs.

For a demonstration, data sheets or more information, call us today.

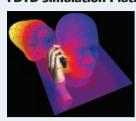
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FDTD Simulation Platform



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

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 multiplein-multiple-out (MIMO) config-

urations 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 heat-

er/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-



Phase Locked And Crystal Oscillators

Features:

- Band Coverage from,
 VHF through Ka-Band
 - Proven Performance in Various Applications
 - Single and Dual Loop Models available with Internal and External Reference
 - Small Modular Assemblies from 2.25" x 2.25" x 0.6"
 - High Power and Low Harmonic Options available







	E		Typical Phase Noise			Output	Output			
Model	Frequency Range	Туре	10	100	1K	10K	100K	1M	Output Frequency	Power (dBm, Min.)
XTO-05	5-130 MHz	Ovenized Crystal	-95	-120	-140	-155	-160	1	100 MHz	II
PLD	30-130 MHz	P.L. Crystal	-95	-115	-140	-155	-155	1 - 1 -	100 MHz	13
PLD-1C	130-1000 MHz	P.L. Mult. Crystal	-80	-100	-120	-130	-135	170	560 MHz	13
BCO	.100-16.5 GHz	P.L. Single Loop	-65	-75	-80	-90	-115		16.35 GHz	13
VFS	1-14 GHz	Multiple Freq. Dual Loop	-60	-75	-110	-115	-115	113	12.5 GHz	13
DLCRO	.8-26 GHz	P.L. CRO Dual Loop	-60	-85	-110	-115	-115	-138	10 GHz	13
PLDRO	2-40 GHz	P.L. DRO Single/Dual	-60	-80	-110	-115	-120	-145	10 GHz	13
CP	.8-3.2 GHz	P.L. CRO Single Loop	-80	-110	-120	-130	-130	-140	2 GHz	13
CPM	4-15 GHz	P.L. Mult. Single Loop	-60	-90	-105	-110	-115	-130	12 GHz	13
ETCO	.1-24 GHz	Voltage Tuned CRO	Mary Control	35	-70	-100	-120	-130	2-4 GHz*	13
* Octave h	and	THE REAL PROPERTY OF THE PARTY	1 3	137	-	77.07			- 13/10/2	

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White Paper, Agilent Technologies

High Power Amplifier Measurements using Agilent's NVNA

White Paper, Agilent Technologies



RF Amplifier Output Voltage, Current Power and Impedance Relationship

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



270

VSS and TestWave Software Integrate Measurement Data into the Design Process

Joel Kirshman, AWR Corporation

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Library (www.mwjournal.com/resources)



NEW WAVES

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 \pm 50 dBm. Small-signal gain is 50 dB with a flatness of \pm 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 $6.0"\times2.5"\times1.5".$

Stealth Microwave, Ewing, NJ (609) 538-8586, www.stealthmicrowave.com. Booth 1340

RS 290

Voltage-controlled Oscillators





The DXO400800-3 and the DXO400800-5 are tiny $0.3" \times 0.3" \times 0.08"$ 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 pro-

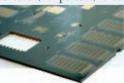
prietary patented technology and patents pending, which enhances bandwidth, reduces phase noise and improves immunity to vibration. These value packed VCOs are ideal replacements for YIG oscillators, improving on agility, and huge reduction in size and power consumption. Similarly, other tiny DCO and 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 (\sim 5 percent) that assures consistency and predictability in



Possible States and predictability in a 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 \pm 0.35 percent (-30° to 120°C) and is compatible with resistor foils.

Taconic Advanced Dielectric Division, Petersburgh, NY

(518) 658-3202,

Booth 2419

RS 292

Network with the RF/Microwave Industry

CTIA Pavilion

Join the leading suppliers of high frequency electronics solutions in The RF/Microwave Zone at CTIA. MWJ organizes a complementary array of RF and microwave companies in this technology pavilion to provide onestop-shopping for potential buyers at this global event.

The Magazine

Your ad in Microwave Journal reaches 50,000 qualified design engineers and engineering managers in the publication that RF and microwave professionals rate as the number one magazine in its field. More companies advertise in MWJ than in any competing publication because they know that MWJ delivers.

The Website

Reach more than 60,000 registered users with your message on the "Home Page of the RF/Microwave Industry". The website combines the editorial content from the magazine with unique engineering tools and resources and provides an array of lead generating advertising/sponsorship opportunities.

European Microwave Week

Exhibit at the largest RF/Microwave trade show in Europe and showcase your company's products to this global audience. The Symposium boasts four conferences and various workshops and courses by leading experts to attract highly qualified delegates.

Expert Advice

Industry experts share their insights and knowledge in this regular feature to the MWJ website. Interaction with members of the community creates a blog environment providing perspectives on different market segments.

Webinars

Are you interested in receiving over 1,000 quality leads from a single webinar sponsorship? Our webinar series with partners Besser Associates and Strategy Analytics do just that, while also presenting your company's message to this global audience.

Executive Interviews

MWJ editors speak with industry executives to gain insight to their company's current activities and long-term objectives. This monthly feature is archived in the Resources section of the MWJ website.

Show Coverage

Online Show Dailies and Newsletters provide in-depth coverage of the EuMW and IMS events and excellent opportunities for exhibitors to deliver their message to attendees of the industry's two biggest industry trade shows.

Vendor View Storefronts

These featured storefronts in the Buyer's Guide section of the MWJ website provide a portal for your company's news, products, MWJ articles, white papers and downloads. Vendor View companies get their products featured in the Microwave ADVISOR and the RFIQ tool generates instant leads to your marketing group.

China Website

MWJ is pleased to announce the debut of our China website, designed to meet the needs of the rapidly growing Asian RF and microwave market. This website provides the opportunity for your company to target this important market through banner ads and sponsorships.

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Leading suppliers of cables, connectors and related components love this supplement for its targeted content and bonus distribution at CTIA and IMS. Your ad reaches engineers looking for the latest developments in transmission-line technology.

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If your company sells into the defense sector, you won't want to miss this annual publication. Always our most popular print supplement with advertisers, this piece features the latest developments in component and sub-system architecture and delivers bonus distribution to the EuMW and MILCOM events.

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This annual publication focuses on the rapidly evolving wireless communications market with cuttingedge content from industry experts. Bonus distribution at the Mobile World Congress provides exposure to this enormous audience of potential buyers.

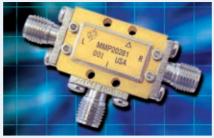
www.mwjournal.com

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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 FlexFitTM 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 $(0.052^{\circ}/1.32~\text{mm}~\text{OD})$ 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

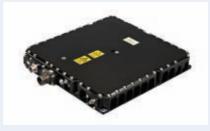


Telemakus LLC introduces the TES6000-30, laboratory-quality, RF SPDT switch with 30 dB isolation and < 2 dB insertion loss. The switch is fully terminated at all ports with a return loss better than 20 dB at 4 GHz. The RF connectors are SMA, with the common port male and ports 1 and 2 female allowing 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-







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RS 4



RS 49

New Modco MCR Series Ceramic Resonator VCO

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

Standard one half inch square package. Model MCR1270-1290MC with an Input Voltage of +5.0V,



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

www.modcoinc.com

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-ProtectTM 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-ProtectTM 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 $1^{\rm w} \times 1^{\rm w} \times 0.22^{\rm w}$.

Z-Communications Inc., San Diego, CA (858) 621-2700, www.zcomm.com. Booth 2812

RS 305

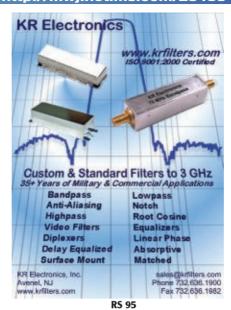
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R. C. HANSEN

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John Wiley & Sons 877-762-2974 2009 ISBN 978-0-470-40102-6



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RS 184

RS 164



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RS 165



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RS 56

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

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RS 144







Microwave Radio Transmission Design Guide, Second Edition

Trevor Manning

his 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 millimeterwave 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;

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Randall W. Rhea

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- How to create unique designs that elegantly match your specification needs.

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CONFERENCE TOPICS



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

В

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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Advanced Surfact Expansion	2,3		45.047	h				
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10 AcerollaryMethics, Inc. 21 Hagy/mwy, bottoms compressed 1 Hagy/mwy, bottoms compressed 2 Hagy/mwy, bottoms compressed 3 Hagy/mwy, bottoms compressed	3	•	102	http://mwi.hotims.com/28/88_9		•		
1. Acerdies/Meinschee 1.	10			1				
12 Auroliux Plainwiew 243 Auroliux Plainwiew 244 Auroliux Plainwiew 244 Auroliux Plainwiew 245 Auroliux Plain							201	nttp://mwj.notims.com/28488-77
13 Aerbercom 1.5 Aerbe					70,79,00		151 150 155	http://mwi.hatima.com/20400.70
14					01 02			
17 Ann. An					03			11ttp://11wj.11oti111s.com/20400-03
A marican Microwave 10							1 011	
Part	18	American Microwave					26/	www.array2010.org
Manumentanismans March Marchange M		Corporation	110	http://mwj.hotims.com/28488-18			204	**************************************
28	19	AML Communications Inc.	43				251	www.ims2010.org
Analico Devices 113	20	AmpliTech Inc. 78	-79,92-93		84			
22		Analog Devices	113	www.analog.com		•		
22 Anatech Enteronics, Inc. 291 http://mwj.hotms.com/2848-24 Anatech Enteronics, Inc. 291 http://mwj.hotms.com/2848-25 3 Anatech Enteronics, Inc. 3 http://mwj.hotms.com/2848-26 3 Anatech Enteronics, Inc. 3 http://mwj.hotms.com/2848-26 3 Anatech Enteronics, Inc. 3 http://mwj.hotms.com/2848-26 3 Anatech Enteronics 3 http://mwj.hotms.com/2848-27 3 Marken Microwave Systems 6 http://mwj.hotms.com/2848-28 3 Anatech House 10,276 http://mwj.hotms.com/2848-29 3 Marken House 10,276 http://mwj.hotms.com/2848-29 Marken House 10,276 http://mwj.hotms.com/2848-39 Marken House 10,276 http://mwj.hotms.com/2848-30 Marken House 10,276 http://mwj.hot	21	AnaPico AG	263	http://mwj.hotims.com/28488-21		9	210	11ttp://111vj.110time.50til/20100 00
A Anristo Company 59	22	Anaren Microwave	39	http://mwj.hotims.com/28488-22	00	•	201	http://mwi.hotims.com/28488-86
A Arsitus Company	23	Anatech Electronics, Inc.	250	http://mwj.hotims.com/28488-23	87			1 11 2
	24	Anritsu Company	59	http://mwj.hotims.com/28488-24				р.,, јошого, 20 100 07
APMIC 2017 Applied Computational Sciences 130 http://mwy.jhotims.com/28488-27 391 Jarsay Microwave 104 http://mwy.jhotims.com/28488-27 391 Jarsay Microwave 104 http://mwy.jhotims.com/28488-27 393 Jarsay Microwave 104 http://mwy.jhotims.com/28488-28 393 Jol. Electronics.in. 6 http://mwy.jhotims.com/28488-29 Jarsay Microwave Jarsa	25	Ansoft Corporation	33	http://mwj.hotims.com/28488-25	00		34	http://mwi.hotims.com/28488-88
APMC 2010	26	Antenna Research Associates	60	http://mwj.hotims.com/28488-26	89			
27 Applied Computational Sciences 130 http://mwij.hotims.com/28488-12 13 Jaresy Microwave 194 http://mwij.hotims.com/28488-13 13 Jaresy Microwave 194 http://mwij.hotims.com/28488-13 13 Arch House 160,776 http://mwij.hotims.com/28488-24 14 Arch House 160,776 http://mwij.hotims.com/28488-24 14 Arch House 160,776 http://mwij.hotims.com/28488-24 14 Arch House 150,776 http://mwij.hotims.com/28488-24 15 Arriga Massurement 15 http://mwij.hotims.com/28488-25 15 http://mwij.hotims.com/28488-36 15 http://mwij.hotims.com/28488-40 15 http://m		APMC 2010	277	www.apmc2010.org		•		
28 ARF-Microwave	27	Applied Computational Sciences	130	http://mwj.hotims.com/28488-27				
Instrumentation 65	28	AR RF/Microwave						
AgR To fachhologies, Inc. 159 http://mwij.hotims.com/28488-29 58 KR Blectronics, Inc. 275 http://mwij.hotims.com/28488-30 101 Mz Global Technology Corporation 101 Int. 101 Int. 101 Int. 101 Int. 101 Int. Int		Instrumentation		http://mwj.hotims.com/28488-28				
30,31 Affach House	29	ARC Technologies, Inc.	159	http://mwj.hotims.com/28488-29				
23,23 A. Stg. Inc. 134,136 http://mwij.hotims.com/28488-32 A. dartolab. Inc. 53 http://mwij.hotims.com/28488-35 A. duriga Measurement Systems, I.C 162-163 http://mwij.hotims.com/28488-35 NavR 81 http://mwij.hotims.com/28488-35 http://mwij.hotims.com/28488-36 NavR 81 http://mwij.hotims.com/28488-36 NavR 152-163 http://mwij.hotims.com/2848-36 NavR 152-163 http://mwij.hotims.com/2848-37 NavR 162-163 NavR 162-					95		275	
Astrolab, Inc. 53 http://mwij.hotims.com/28488-34 97 Linear Technology Corporation 167 http://mwij.hotims.com/28488-35 ltp://mwij.hotims.com/28488-36 ltp://mwij.hotims.com/28488-37 ltp://mwij.hotims.com/28488-14 ltp://mwij.hotims.com/28488-15 ltp://mwij.hotims.com/28488-15 ltp://mwij.hotims.com/28488-15 ltp://mwij.hotims.com/28488-16 ltp://mwij.hotims.com/28488-16	32,33	ASB, Inc.	134,136				62	
Sample S	34	Astrolab, Inc.	53	http://mwj.hotims.com/28488-34	97	•	n 17	
AWR	35	•				• .		
BaZ Technologies LLC 35					99	LPKF Laser & Electronics	58	http://mwj.hotims.com/28488-99
CW. SWIFT & Associates, Inc. 161					100	Luff Research, Inc.	132	http://mwj.hotims.com/28488-100
California Eastern Labs 179					101	M2 Global Technology, Ltd.	124	http://mwj.hotims.com/28488-101
Camponil Electronics 92-93 www.CamponilElectronics.com 166,107 120,121 http://mwj.hotims.com/28488-102 Technologies, Inc. 107 http://mwj.hotims.com/28488-142 Technologies, Inc. 107 http://mwj.hotims.com/28488-143 Technologies, Inc. 108,110 Maury Microwave Corporation 32.59 http://mwj.hotims.com/28488-144 111 MECA Electronics, Inc. COV 2 http://mwj.hotims.com/28488-143 112 MESL Microwave Corporation 32.59 http://mwj.hotims.com/28488-144 113 MECA Electronics, Inc. COV 2 http://mwj.hotims.com/28488-145 114 MECA Electronics, Inc. COV 2 http://mwj.hotims.com/28488-145 115 MECA Electronics, Inc. COV 2 http://mwj.hotims.com/28488-145 116 Micro-Caax Components 207 http://mwj.hotims.com/28488-145 116 Micro-Caax Components 214 http://mwj.hotims.com/28488-145 116 Micro-Caax Components 227 http://mwj.hotims.com/28488-145 116 Micro-Caax Components 227 http://mwj.hotims.com/28488-145 117 Micro-Gaax Components 227 http://mwj.hotims.com/28488-145 118 Microsemi 99 http://mwj.hotims.com/28488-145 118 Microsemi 99 http://mwj.hotims.com/28488-145 118 Microsemi 99 http://mwj.hotims.com/28488-151 128 Microwave Circuits 182 http://mwj.hotims.com/28488-151 129 Microwave Circuits 182 http://mwj.hotims.com/28488-151 129 Microwave Circuits 182 http://mwj.hotims.com/28488-152 129 Microwave Circuits 182 http://mwj.hotims.com/28488-152 120 Microwave Corporation 182 http://mwj.hotims.com/28488-152 120 Microwave Corporation 182 http://mwj.hotims.com/28488-152 120					102,103	, M/A-COM Technology	116,117,	
Carlisle Interconnect					104,105	Solutions	118,119,	
Technologies			92-93	www.CamponilElectronics.com	106,107		120,121	http://mwj.hotims.com/28488-102
Cernex, Inc. 123	40				108	Massachusetts Bay		
At the common the co						Technologies, Inc.	107	http://mwj.hotims.com/28488-108
Charter Engineering, Inc. 52 http://mwj.hotims.com/28488-43 112 MESL Microwave 150 http://mwj.hotims.com/28488-112 Micable Inc. 207 http://mwj.hotims.com/28488-113 Micable Inc. 207 http://mwj.hotims.com/28488-113 Micable Inc. 207 http://mwj.hotims.com/28488-114 Micable Inc. 208 http://mwj.hotims.com/28488-114 Micable Inc. 208 http://mwj.hotims.com/28488-114 Micable Inc. 208 http://mwj.hotims.com/28488-124 Micable Inc. 208 http://mwj.hotims.com/28					109,110	Maury Microwave Corporatio	n 9,259	http://mwj.hotims.com/28488-109
Ciao Wireless, Inc. 164					111	MECA Electronics, Inc.	COV 2	http://mwj.hotims.com/28488-111
Cobam Defense					112	MESL Microwave	150	http://mwj.hotims.com/28488-112
Electronic Systems			164	http://mwj.hotims.com/28488-44	113	MIcable Inc.	207	http://mwj.hotims.com/28488-113
Colleraft Section College Co	45				114	MiCIAN GmbH	214	http://mwj.hotims.com/28488-114
Coleman Microwave Company 144		•			115	Micro Lambda Wireless, Inc.	111	http://mwj.hotims.com/28488-115
COMSOL, Inc. 115					116	Micro-Coax Components	227	http://mwj.hotims.com/28488-116
CPE Italia 274					117		95	http://mwj.hotims.com/28488-117
CPI Beverly Microwave Division 41					118	Microsemi	99	
Crane Aerospace & Electronics 180						•		1 ** 2
Crystek Corporation 202		•					195	1 ** 2
CST of America, Inc. 31 http://mwj.hotims.com/28488-53					121		182	http://mwj.hotims.com/28488-121
CTT Inc. 96-97					122			
Cuming Microwave								http://mwj.hotims.com/28488-122
Corporation 229			96-97	http://mwj.hotims.com/28488-54		Microwave Journal		
Damaskos Inc. 275	55	•	000	h				
State Stat	F0	•						
Delta Electronics Mfg. Corp. 57								http://mwj.hotims.com/28488-124
59 Delta Microwave 85 http://mwj.hotims.com/28488-59 130,131, 172,183, 60 Dielectric Laboratories Inc. 127 http://mwj.hotims.com/28488-60 132,133, 193,217, 61 Eastern Wireless								
Dielectric Laboratories Inc. 127								
Eastern Wireless 134,135, 225,233, 2								
TeleComm, Inc. 24-25 http://mwj.hotims.com/28488-61 136,137, 245,253,			121	nttp://iliwj.flotillis.com/28488-80				
62 Elektrobit Ltd. 224 http://mwj.hotims.com/28488-62 138 279 http://mwj.hotims.com/28488-126 63 Elisra Electronic Systems Ltd. 139,140, MITEQ Inc. 10,67, (Microwave Division) 152 http://mwj.hotims.com/28488-63 141,142 219,269 http://mwj.hotims.com/28488-139 64 EMC Technology Inc. 192 http://mwj.hotims.com/28488-64 143,144 Modelar Components http://mwj.hotims.com/28488-143 65 Empower RF Systems, Inc. 129 http://mwj.hotims.com/28488-65 145 Modular Components National, Inc. 231 http://mwj.hotims.com/28488-145 67 ES Microwave, LLC 156 http://mwj.hotims.com/28488-67 146 Molex RF/Microwave http://mwj.hotims.com/28488-145	01		24-25	http://mwi.hotima.com/20400.61				
Elisra Electronic Systems Ltd.	eo.							
(Microwave Division) 152 http://mwj.hotims.com/28488-63 141,142 219,269 http://mwj.hotims.com/28488-139 64 EMC Technology Inc. 192 http://mwj.hotims.com/28488-64 143,144 Modular Components 274,275 http://mwj.hotims.com/28488-143 65 Empower RF Systems, Inc. 129 http://mwj.hotims.com/28488-65 145 Modular Components National, Inc. 231 http://mwj.hotims.com/28488-145 67 ES Microwave, LLC 156 http://mwj.hotims.com/28488-67 146 Molex RF/Microwave 31 http://mwj.hotims.com/28488-145			224	ոււթ.//шwj.поишѕ.сош/2ŏ4ŏŏ-о2		MITTO		http://mwj.hotims.com/28488-126
64 EMC Technology Inc. 192 http://mwj.hotims.com/28488-64 143,144 Modco, Inc. 274,275 http://mwj.hotims.com/28488-143 65 Empower RF Systems, Inc. 129 http://mwj.hotims.com/28488-65 145 Modular Components 66 Endwave 87 http://mwj.hotims.com/28488-66 National, Inc. 231 http://mwj.hotims.com/28488-145 67 ES Microwave, LLC 156 http://mwj.hotims.com/28488-67 146 Molex RF/Microwave	03	•	152	http://mwi.hotima.com/20400.02				
65 Empower RF Systems, Inc. 129 http://mwj.hotims.com/28488-65 145 Modular Components 66 Endwave 87 http://mwj.hotims.com/28488-66 National, Inc. 231 http://mwj.hotims.com/28488-145 67 ES Microwave, LLC 156 http://mwj.hotims.com/28488-67 146 Molex RF/Microwave	64							
66 Endwave 87 http://mwj.hotims.com/28488-66 National, Inc. 231 http://mwj.hotims.com/28488-145 67 ES Microwave, LLC 156 http://mwj.hotims.com/28488-67 146 Molex RF/Microwave							2/4,275	http://mwj.hotims.com/28488-143
67 ES Microwave, LLC 156 http://mwj.hotims.com/28488-67 146 Molex RF/Microwave	66 00				145	·		1.0. 11. 21. 22. 22. 22. 22. 22. 22. 22. 22
00 FOMO 11 0 40 14 14 14 14 17 19000 00					4.0		231	http://mwj.hotims.com/28488-145
Connector Division 239 http://mwj.hotims.com/28488-146					146		900	http://www.i-h-stimes/00400-440
	00	Lom ouble outporation	100	110p.,, 1110vj.110u1113.00111/20700-00		Connector DIVISION	239	nup.//mwj.noums.com/28488-146

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	TID TENTIOLII	AGE 110.	TTLD FILDRICO			I AUE INU.	
147,148	Narda Microwave-East,			185	SemiGen	122	http://mwj.hotims.com/28488-185
	an L3 Communications Co.	40,200	http://mwj.hotims.com/28488-147	186	SGMC Microwave	37	http://mwj.hotims.com/28488-186
149	Networks International			187	Sivers IMA	204	http://mwj.hotims.com/28488-187
	Corporation	109	http://mwj.hotims.com/28488-149	188	Skyworks Solutions, Inc.	73	http://mwj.hotims.com/28488-188
150	Nexyn Corporation	138	http://mwj.hotims.com/28488-150	189	SLN Advertising	266	http://mwj.hotims.com/28488-189
151	Noisecom	71	http://mwj.hotims.com/28488-151	190	Sonnet Software, Inc.	23	http://mwj.hotims.com/28488-190
152	NoiseWave Corp.	8	http://mwj.hotims.com/28488-152	191	Southwest Microwave Inc.	211	http://mwj.hotims.com/28488-191
153	Norden Millimeter Inc.	44	http://mwj.hotims.com/28488-153	192	Spacek Labs Inc.	213	http://mwj.hotims.com/28488-192
154	Nuhertz Technologies	158	http://mwj.hotims.com/28488-154	193	Special Hermetic Products, Inc	c. 140	http://mwj.hotims.com/28488-193
155	OML Inc.	235	http://mwj.hotims.com/28488-155	194	Spectrum Elektrotechnik Gmbł	H 255	http://mwj.hotims.com/28488-194
156	OMMIC	196	http://mwj.hotims.com/28488-156	195	Spinnaker Microwave, Inc.	188	http://mwj.hotims.com/28488-195
157	Pascall Electronics Limited	170	http://mwj.hotims.com/28488-157	196	Spinner GmbH	154	http://mwj.hotims.com/28488-196
158	Peregrine Semiconductor Corp	. 55	http://mwj.hotims.com/28488-158	197	State of the Art, Inc.	102	http://mwj.hotims.com/28488-197
159	Phase Matrix, Inc.	42	http://mwj.hotims.com/28488-159	198	Strand Marketing, Inc.	272	http://mwj.hotims.com/28488-198
160	Planar Monolithic			199	Sumitomo Electric USA Inc.	101	http://mwj.hotims.com/28488-199
	Industries, Inc.	8-79,92-93	http://mwj.hotims.com/28488-160	200	SV Microwave, Inc.	197	http://mwj.hotims.com/28488-200
161	Pulsar Microwave Corporation	208	http://mwj.hotims.com/28488-161	201,202	Synergy Microwave		
162	Quest Microwave Inc.	36	http://mwj.hotims.com/28488-162		Corporation	177,265	http://mwj.hotims.com/28488-201
	QuinStar Technology, Inc.	215	www.quinstar.com	203,204	Tecdia, Inc.	32,112	http://mwj.hotims.com/28488-203
163	R&K Company Limited	261	http://mwj.hotims.com/28488-163	205	Tecom Industries, Inc.	212	http://mwj.hotims.com/28488-205
164	R.C. Hansen Inc.	275	http://mwj.hotims.com/28488-164	206	Teledyne Coax Switches	199	http://mwj.hotims.com/28488-206
165	Radiall	275	http://mwj.hotims.com/28488-165	207	Teledyne Cougar	100	http://mwj.hotims.com/28488-207
166	Radio Waves, Inc.	64	http://mwj.hotims.com/28488-166	206	Teledyne Relays	199	http://mwj.hotims.com/28488-206
167	Reactel, Incorporated	168	http://mwj.hotims.com/28488-167	208	Teledyne Storm Products	51	http://mwj.hotims.com/28488-208
168	Remcom	147	http://mwj.hotims.com/28488-168	209	Temwell Corporation	232	http://mwj.hotims.com/28488-209
169	Renaissance Electronics		. ,	210	Thunderline-Z	249	http://mwj.hotims.com/28488-210
	Corporation	47	http://mwj.hotims.com/28488-169	211	Times Microwave Systems	175	http://mwj.hotims.com/28488-211
170	RF Connectors,		. ,	212	TRAK Microwave Corporation	205	http://mwj.hotims.com/28488-212
	Division of RF Industries	158	http://mwj.hotims.com/28488-170	213	Universal Microwave		
171	RF TEC Mfg., Inc.	275	http://mwj.hotims.com/28488-171		Components Corporation	114	http://mwj.hotims.com/28488-213
172,173	RFHIC	126,128	http://mwj.hotims.com/28488-172	214	UTE Microwave Inc.	61	http://mwj.hotims.com/28488-214
174	RFMD	105	http://mwj.hotims.com/28488-174	215	Valpey Fisher Corporation	91	http://mwj.hotims.com/28488-215
175	Richardson Electronics, Ltd.	149	http://mwj.hotims.com/28488-175	325	Vectron International	125	http://mwj.hotims.com/28488-325
176	RLC Electronics, Inc.	29	http://mwj.hotims.com/28488-176	326	W.L. Gore & Associates, Inc.	257	http://mwj.hotims.com/28488-326
177	Rogers Corporation	103	http://mwj.hotims.com/28488-177	327	Waveline Inc.	186	http://mwj.hotims.com/28488-327
178	Rohde & Schwarz GmbH	69	http://mwj.hotims.com/28488-178	328	Weinschel Associates	222	http://mwj.hotims.com/28488-328
179	Rohde & Schwarz, Inc.	236-237	http://mwj.hotims.com/28488-179	329	Wenzel Associates, Inc.	185	http://mwj.hotims.com/28488-329
180	Rosenberger	187	http://mwj.hotims.com/28488-180	330	Werlatone, Inc.	COV 4	http://mwj.hotims.com/28488-330
181	RT Logic	181	http://mwj.hotims.com/28488-181	331	West Bond Inc.	148	http://mwj.hotims.com/28488-331
182	Santron Inc.	49	http://mwj.hotims.com/28488-182	332.333	, Win Semiconductors Corp.	139,141,	, , , , , , , , , , , , , , , , , , , ,
183	Satellink, Inc.	275	http://mwj.hotims.com/28488-183	334,335		143,145	http://mwj.hotims.com/28488-332
184	Sector Microwave	-	, ,	336	Wright Technologies	263	http://mwj.hotims.com/28488-336
	Industries, Inc.	275	http://mwj.hotims.com/28488-184	337	Z~Communications, Inc.	137	http://mwj.hotims.com/28488-337

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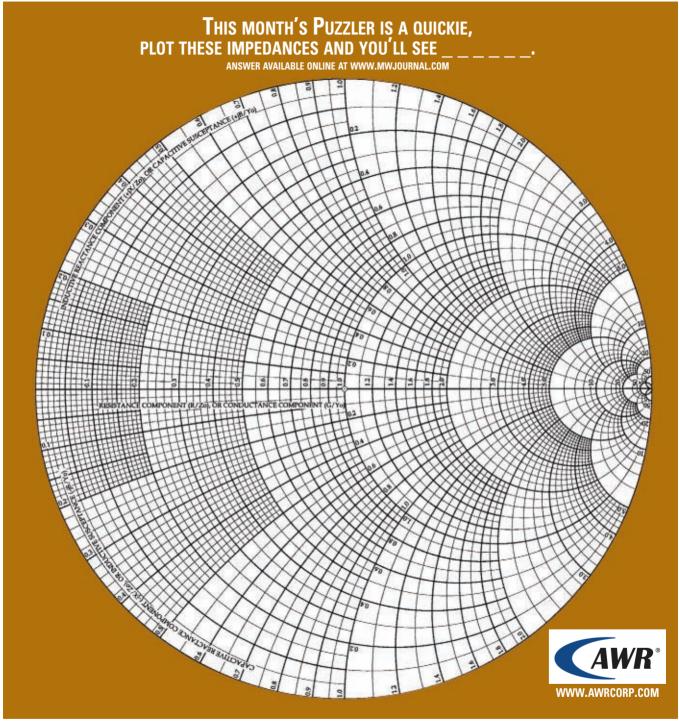
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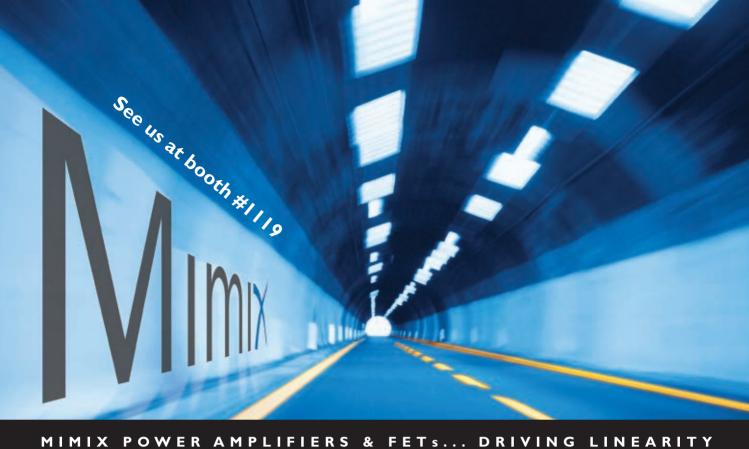
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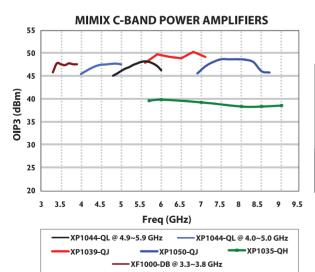


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5 . 0.30 + j 0.50	13. 0.50 + j 0.02	21. 1.20 - j 1.30	29. 4.00 + j 1.90	
6 . 0.24 + j 0.40	14. 0.48 - j 0.10	22. 1.50 - j 1.35	30. 2.60 + j 2.90	38. 1.10 + j 0.65
7 . 0.22 + j 0.32	15 . 0.46 - j 0.23	23. 1.90 - j 1.35	31. 1.60 + j 2.65	39. 0.90 + j 0.57
8 . 0.22 + j 0.26	16. 0.47 - j 0.42	24. 2.40 - j 1.00	32. 0.90 + j 2.25	40. 0.80 + j 0.48



In today's world, the challenge is moving an ever-increasing amount of information through the same narrow bandwidths. Here at Mimix Broadband, our power amplifiers and FETs drive linearity and minimize distortion, maximizing innovation.

Like our XP1050-QJ Power Amplifier. This PA delivers 15 dB of gain, 34.5 dBm of P1dB and 48 dBm of OIP3 in a standard QFN package, making it an ideal choice for point-to-point radios operating in the ETSI 7 GHz radio band, with modern high-order modulation schemes. The XP1050-QJ is the light at the end of the tunnel!



MIMIX BROADBAND IS DRIVING LINEARITY

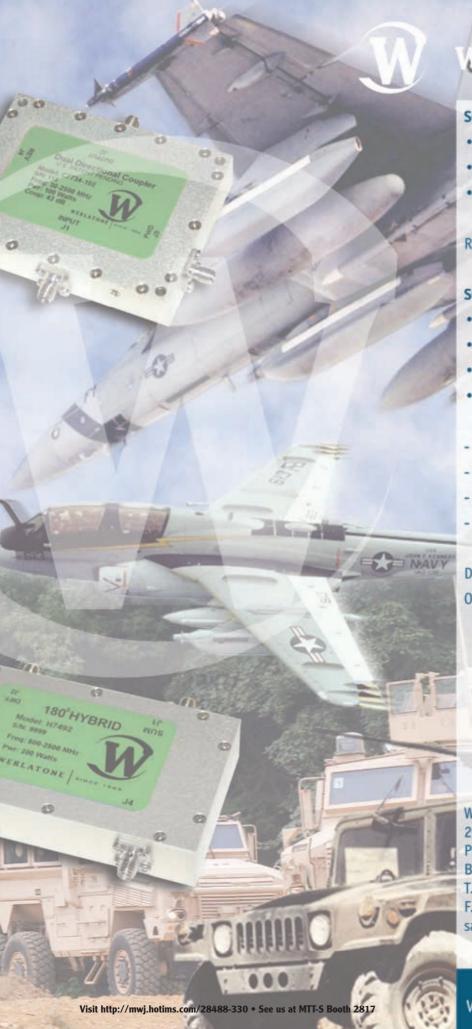
	Device	Frequency (GHz)	Gain (dB)	PIdB (dBm)	OIP3 (dBm)	Current (mA)	Voltage (V)	Package (mm)
iers	XPI044-QL	3.5-6.0	19.5**	34.0	46.0	850	8.0	7x7
mplif	XPI039-QJ	5.6 - 7. I	16.6	35.5	49.0	I400	8.0	6x6
Power Amplifiers	XPI050-QJ	7.0-9.0	15.0	34.5	48.0	I 400	8.0	6x6
Po	XPI035-QH	5.9-9.5	26.0	29.0	39.0	500	6.0	4x4
*s_	XFI000-DB	DC - 6.0	10.0***	34.0	47.0	550	8.0	3×6
Ħ	XFI00I-SC	DC - 6.0	10.0**	30.0	45.0	350	8.0	SOT-89

*FETs Coming Soon | **@ 6.0 GHz | ***@ 4.9 GHz

Explore our wide range of high linearity products and download complete datasheets at www.mimixbroadband.com.



providing optimal semiconductor solutions worldwide



WERLATONE

SOPHISTICATED APPLICATIONS

- JAMMING
- COMMUNICATIONS
- CO-SITE MANAGEMENT

REQUIRE,

SOPHISTICATED SOLUTIONS

- MORE POWER
- GREATER BANDWIDTH
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- SMALLER PACKAGES
- POWER COMBINERS/DIVIDERS
- 90° HYBRID COUPLERS
- 0°/180° HYBRID JUNCTIONS
- DIRECTIONAL COUPLERS

DESIGNED TO MEET THE MOST STRINGENT OPERATING CONDITIONS.

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



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 **I**NFRASTRUCTURE

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

C3I, ECM & EW

SPACE

Payload Electronics

TEST & MEASUREMENT

Commercial & Industrial Sensors Test Equipment

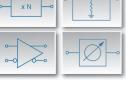














TABLE OF CONTENTS

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.



General Information	Page #
Customer Support	
New Products	4
New & Expanded Product Lines	8
High Speed Clocked Comparators Filters - Tunable Power Conditioning PLLs with Integrated VCOs	8 8

IC Products Selection Guide

)	election Guide
	Amplifiers10
	Amplifiers - Limiting
	Amplifiers - Transimpedance
	Attenuators
	Broadband Time Delays
	Comparators
	Data Converters
	Filters - Tunable15
	Frequency Dividers & Detectors
	Frequency Multipliers15
	High Speed Digital Logic
	Interface
	Mixers17
	Modulators/Demodulators20
	Passives
	Phase Shifters
	Phase Locked Loop
	PLL with Integrated VCOs 21
	Power Conditioning 21
	Power Detectors 21
	Switches
	Variable Gain Amplifiers
	VCOs & PLOs

Connectorized Modules Selection Guide	Page
Amplifiers	25
Attenuators	26
Dielectric Resonator Oscillators (DROs)	26
Frequency Dividers & Detectors	
Frequency Multipliers	26
High Speed Digital Logic	26
Mixers	26
Phase Shifters	27
Synthesizer Module, MicroSynth™	27
Power Detectors	27
Switches	27
VCOs	27
Instrumentation Selection Guide Market & Application Solutions	
Automotive	
Broadband	
Cellular Infrastructure	
Fiber Optics	37
Test & Measurement & Sensors	40
rest & weasurement & sensors	40
Military & Space	45
Designer's Kits	46
Package Information	47
Competitor Cross-Reference	48
Part Number Index	50

Hittite Microwave Corporation has carefully reviewed the product specification information herein and it is believed to be accurate and reliable. However, no responsibility is assumed for inaccuracies or errors. Use of this information and/or any of our products does not convey to the user any patent rights or licenses. Hittite products are designed to be used only within the electrical and environmental limits published in their respective data sheets or custom quoted specifications. Hittite does not authorize the use of any of its products beyond the current published data sheet limits. Such use beyond the currently published electrical and/or environmental data sheet limits voids all Hittite warranties. Hittite reserves the right to change component circuitry, specifications or other information at any time without prior notice. Hittite products are not authorized for use as critical components in life support devices or systems without the express written approval of Hittite Microwave Corporation. Life support devices or systems are devices or systems which (A) are intended for surgical implant into the body or (B) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided on the labeling, can be reasonably expected to result in a significant injury to the user.

CUSTOMER SUPPORT



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 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

Passives Attenuators

Broadband Time Delays Phase Shifters Comparators PIIs

PLLs w/ Integrated VCOs Data Converters DROS Power Conditioning Filters - Tunable Power Detectors

Freq. Dividers & Detectors Sensors

Freq. Multipliers Signal Generators High Speed Digital Logic Switches

Transimpedance Amplifiers Limiting Amplifiers

VGAs Interface 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

C3I, 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.



APRIL 2010 - 35 NEW PRODUCTS

AMPLIFIERS -	Differential Gain	Block & Connectorized	Low Phase Noise	Amp & PA Modules
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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			Phase Noise (dBc/Hz)			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 = -3.0)V & 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 Cutoff Frequency (dB) 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)		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

I/Q DOWNCONVERTER / RECEIVERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)			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)		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



High Speed Clocked Comparators

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

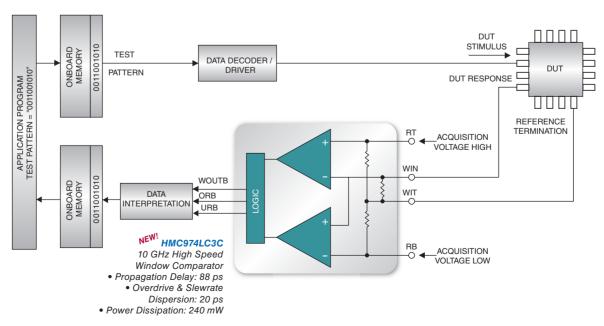
- ♦ RSPECL, RSCML & RSECL Versions Available
- ♦ 10 GHz Input Bandwidth
- ♦ Low Propagation Delay Clock to Output: 120 ps
- ♦ Low Overdrive & Slew Rate Dispersion: 10 ps
- ♦ Minimum Pulse Width: 60 ps
- ♦ Low Power Dissipation: 130 mW

4 NEW IN-STOCK HIGH SPEED COMPARATORS

В	Analog Input /W (GHz) / Clock Rate (Gpbs)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power Consumption (mW)	Vcco / V _{term} ^[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

AUTOMATIC TEST EQUIPMENT (ATE)



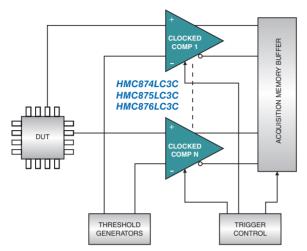
Hittite's 20 Gbps / 150 mW Clocked Comparators Reduce Total ATE System Power!

^[2] Vee = -3.0V & Vcci = +3.3V



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

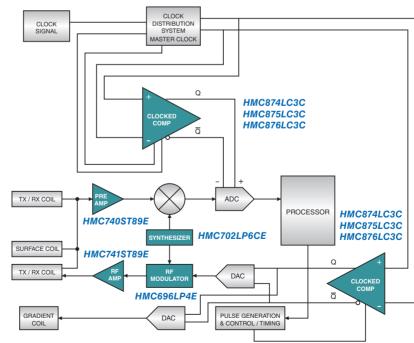
HMC876LC3C NEW!

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 & Power Conditioning

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: ♦ Four Voltage Outputs: 3nV/JHz at 10 kHz 7nV/JHz at 1 kHz
- ♦ High Power Supply Rejection Ratio: 80 dB at 1 kHz 60 dB at 1 MHz
- 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)		ly Rejection SRR) (dB)		se Spectral (nV/√Hz)	Regulated Outputs	Package	Part Number
(V)		voitage (v)	Current (IIIA)	1 kHz	1 MHz	1 kHz	10 kHz	Outputs		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!



Frequency Generation Expanded to Include New PLLs with Integrated VCOs

PLLs with Integrated VCOs Cover 665 MHz to 13.4 GHz!







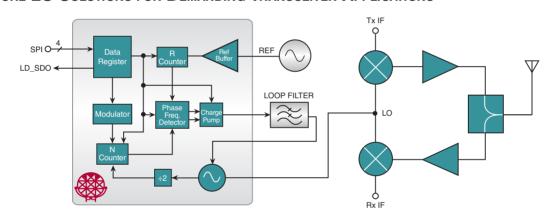
PLL w/ Integrated Microwave VCO

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



SMT & Chip (Die) Products

requency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
w Noise Am	plifiers	(ab)	(4.511)	(412)	(wbiii)	— Guppiy			
.175 - 0.66	Low Noise	24	37	0.5	19	+5V @ 90mA	LP3	EAR99	HMC616LP3
0.2 - 4.0	Low Noise, High IP3	13	38	2.3	22	+5V @ 110mA	ST89	EAR99	HMC639ST89
0.2 - 4.0	Low Noise, High IP3	13	40	2.2	22	+5V @ 155mA	ST89	EAR99	HMC636ST89
0.23 - 0.66	Low Noise, Dual Channel	22	37	0.5	19	+5V @ 97mA	LP4	EAR99	HMC816LP4
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	HMC617LP3
0.55 - 1.2	Low Noise, Dual Channel	16	37	0.5	20.5	+5V @ 95mA	LP4	EAR99	HMC817LP4
0.6 - 1.4	Low Noise	32	40	0.9	21.5	+5V @ 254mA	LP4	EAR99	HMC718LP4
0.7 - 1.2	Low Noise w/ Failsafe Bypass	16	33	0.9	13	+5V @ 57mA	LP3	EAR99	HMC668LP3
0.7 - 2.2 1 - 11	Low Noise	22 17	36 30	1.7	24 18	+5V @ 227mA	LP3 LP4	EAR99	HMC758LP3
1 - 12	Low Noise Low Noise	17	28	1.5	19	+5V @ 55mA +5V @ 55mA	Chip	EAR99 EAR99	HMC753LP4
1.2 - 3.0	Low Noise	26	21	1.3	11.5	+5V @ 21mA	LP3	EAR99	HMC548LP3
1.3 - 2.9	Low Noise	34	39	1	21.5	+5V @ 272mA	LP4	EAR99	HMC719LP4
1.7 - 2.2	Low Noise	19	36	0.75	20	+5V @ 117mA	LP3	EAR99	HMC618LP3
1.7 - 2.2	Low Noise w/ Failsafe Bypass	17	29	1.4	12	+5V @ 86mA	LP3	EAR99	HMC669LP3
1.7 - 2.2	Low Noise, Dual Channel	20.5	35	0.85	21	+5V @ 112mA	LP4	EAR99	HMC818LP4
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	HMC594LC
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	HMC609LC
2.1 - 2.9	Low Noise	19	33	0.9	19	+5V @ 95mA	LP3	EAR99	HMC715LP
2.2 - 12	Low Noise	15	25	1.8	13	+4V @ 45mA	LC4	EAR99	HMC772LC
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	HMC667LP
2.3 - 2.7	Low Noise w/ Bypass	20	31	1.1	17	+5V @ 74mA	LP3	EAR99	HMC605LP
2.4 - 2.5	Transceiver, Front End	13	10	3	5	+3V @ 24mA	MS8G	EAR99	HMC310MS8
3.1 - 3.9	Low Noise	18	33	1	19	+5V @ 65mA	LP3	EAR99	HMC716LP
3.3 - 3.8	Low Noise w/ Bypass	19	29	1.2	16 7	+5V @ 40mA	LP3 LP3	EAR99	HMC593LP
3.4 - 3.8 3.5 - 7.0	Low Noise w/ Bypass Low Noise	16 15.5	18 28	2.4	16	+3V @ 9mA +5V @ 50mA	Chip	EAR99 EAR99	HMC491LP:
3.5 - 7.0	Low Noise	16	30	2.5	16	+5V @ 55mA	LC4	EAR99	HMC392LC
3.5 - 7.0	Low Noise	15	28	3	16	+5V @ 65mA	LH5	EAR99	HMC392LF
4.8 - 6.0	Low Noise w/ Bypass	15	26	1.5	14	+5V @ 42mA	LP3	EAR99	HMC604LP
4.8 - 6.0	Low Noise	16.5	31.5	1.1	18.5	+5V @ 73mA	LP3	EAR99	HMC717LP
5 - 6	Low Noise	9	13	2.5	2	+3V @ 6mA	MS8G	EAR99	HMC318MS8
5 - 6	Low Noise	12	10	2.5	9	+3V @ 25mA	MS8G	EAR99	HMC320MS8
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	HMC902LP
5 - 20	Low Noise	13	26	2.2	16	+5V @ 30mA	Chip	EAR99	HMC-ALH4
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	HMC903LP
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	HMC565LC
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 Chin	EAR99	HMC564LC
7 - 17	Low Noise	21	20	1.8	15	+3V @ 65mA	Chip	EAR99	HMC516
9 - 18 12 - 16	Low Noise Medium Power LNA	20	25 34	2.5	14 25	+3V @ 65mA +5V @ 200mA	LC5 LP5	EAR99 EAR99	HMC516LC
12 - 16	Medium Power LNA	27	35	2.5	26	+5V @ 200mA	Chip	EAR99	HMC490LP
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	HMC342LC
14 - 27	Low Noise	19.5	-	2.2	17	+4V @ 90mA	LC4B	5A991.h	HMC504LC
14 - 27	Low Noise	18	-	2.5	14	+4V @ 90mA	Chip	5A991.h	HMC-ALH2
14 - 27	Low Noise	20	-	2	14	+4V @ 90mA	Chip	5A991.h	HMC-ALH4
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	HMC517LC
	Low Noise	25	25	2.2	13	+4V @ 73mA	LC4	EAR99	HMC751LC
17 - 27	Laur Maine	15	23	2.8	12	+3V @ 65mA	Chip	3A001.b.2.d	HMC519
17 - 27 18 - 32	Low Noise								
	Low Noise	15	23	3.5	11	+3V @ 75mA	LC4	EAR99	HMC519LC
18 - 32		15 10	23	3.5 3.9	11 12	+3V @ 75mA +5V @ 45mA	LC4 Chip	EAR99 3A001.b.2.d	
18 - 32 18 - 31	Low Noise								HMC519LC HMC-ALH44 HMC518



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 C	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
EW! 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 DC - 5	HBT Gain Block	21	35	3.5	22	+8V @ 110mA	ST89	EAR99	HMC475ST89E
DC - 5	SiGe Gain Block Dual SiGe Gain Block	19 15	36 34	4	22.5 18	+8V @ 110mA	ST89 MS8G	EAR99 EAR99	HMC482ST89E HMC469MS8GE
DC - 5	Dual SiGe Gain Block Dual SiGe Gain Block	20	34	3.2	20	+8V @ 75mA +8V @ 80mA	MS8G	EAR99	HMC471MS8GE
		20	34	3.2	20	+6V @ 6UIIIA	WISOG	EARSS	HIVIC47 TIVISAGE
CATV Amplif			07	0.5	40	FV @ 400 A	14000	EAROO	LIMO5 40M0005
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
EW! DC - 1.0 0.04 - 1.0	50 / 75 Ohm Differential Gain Block 50 / 75 Ohm Differential Gain Block	16 16	40	3.5 2.5	24	+8V @ 350mA +5V @ 270mA	LP4B LP4B	EAR99 EAR99	HMC771LP4BE HMC770LP4BE
0.05 - 3.0		15		3.5		+5V @ 27011A +5V @ 88mA	ST89	EAR99	
	HBT Gain Block HBT Gain Block	20	40		18			EAR99	HMC740ST89E HMC741ST89E
0.05 - 3.0 DC - 1	HBT Gain Block, 75 Ohm	14	42 38	2.5 5.5	18 21	+5V @ 96mA +5V @ 160mA	ST89 S8G	EAR99	HMC754S8GE
Driver Ampli		14	30	5.5	21	+5V @ 160111A	360	EARSS	HIVIO/3436GE
		10	40	0.0	05	. F.V. @ 105 A	CTOO	FAROO	LIMOZOOCTOOF
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 +5V @ 295mA	MS8G Chin	EAR99	HMC326MS8GE HMC-AUH256
17.5 - 41	Driver Amplifier	21	27	-	20	+5V @ 295IIIA	Chip	3A001.b.2.d	DIVIO-AUDZ36
	ver Amplifiers	10.5	40		07	. EV @ 450 A	CTOO	EADOO	LIMO 45 40 TOCS
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



SMT & Chip (Die) Products

AMPLIFIERS

(GHz) 6 - 18 6 - 18 6.5 - 13.5 7 - 15.5 7 - 15.5	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	ECCN Code	Part Number
6 - 18 6.5 - 13.5 7 - 15.5 7 - 15.5	Medium Power Amplifier	15.5	32	4.5	20	+5V @ 95mA	Chip	EAR99	HMC441
6.5 - 13.5 7 - 15.5 7 - 15.5	Medium Power Amplifier	17	32	4.5	20	+5V @ 95mA	LC3B	EAR99	HMC441LC3B
7 - 15.5 7 - 15.5	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
	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	HMC442LC3E
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-APH400
50 - 66	Medium Power Amplifier	24	25	-	17	+5V @ 220mA	Chip	3A001.b.2.f	HMC-ABH24
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-APH63
71 - 86	Medium Power Amplifier	15	-	-	15	+4V @ 130mA	Chip	3A001.b.2.f	HMC-AUH32
81 - 86	Medium Power Amplifier	22	-	-	17.5	+4V @ 160mA	Chip	3A001.b.2.f	HMC-AUH31
81 - 86	Medium Power Amplifier	12	-	-	19	+4V @ 240mA	Chip	3A001.b.2.f	HMC-APH63
V! 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	HMC452ST89
0.4 - 2.2	Power Amplifier, 1.6 Watt	20.5	49	6.5	32	+5V @ 725mA	ST89	EAR99	HMC453ST89
0.45 - 2.2	Power Amplifier, 1 Watt	22.5	48	7	30	+5V @ 485mA	QS16G	EAR99	HMC452QS160
0.45 - 2.2	Power Amplifier, 1.6 Watt	21.5	51	6.5	33	+5V @ 725mA	QS16G	EAR99	HMC453QS160
W! 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	HMC457QS160
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	HMC327MS8G
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	HMC486LP5I
9 - 12	Power Amplifier, 2 Watt	20	36	8	32	+7V @ 1.3A	LP5	3A001.b.2.b	HMC487LP58
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	HMC489LP5I
15 - 27	Power Amplifier, 1 Watt	17	37	-	29	+5V @ 1.44A	Chip	3A001.b.2.c	HMC-APH46
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 Power Amplifier, 1 Watt	17.5 17	38.5	-	30 5	+5V @ 900mA	Chip	3A001.b.2.c	HMC-APH478
21 - 24			39		30.5	+5V @ 950mA +5V @ 950mA	Chip	3A001.b.2.c	HMC-APH60
21 - 24	Power Amplifier, 1 Watt	17 22	40		30		Chip	3A001.b.2.c	HMC-APH60
22.5 - 26.5	Power Amplifier, 1/2 Watt				26.5	+6V @ 360mA +6V @ 750mA	Chip	34001 b 2 c	HMC863
22.5 - 26.5 24 - 29.5	Power Amplifier, 1 Watt	27	40	-	29		Chip	3A001.b.2.c	HMC864 HMC-APH46
22.5 - 26.5 24 - 29.5 24 - 29.5	Power Amplifier, 1 Watt	14	37 37		28	+5V @ 900mA	Chip	3A001.b.2.c	HMC-APH46
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5	Power Amplifier 1 Met		.37	-	29	+5V @ 800mA	Chip	3A001.b.2.d	mivico93
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5 27 - 34	Power Amplifier, 1 Watt	17.5			00	. EV/ @ 4 00 A	Chin	24001 5 0 4	
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5 27 - 34 37 - 40	Power Amplifier, 1 Watt	17.5	37	-	28	+5V @ 1.08A	Chip	3A001.b.2.d	
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5 27 - 34 37 - 40 Wideband (Dist.)	Power Amplifier, 1 Watt ributed) Amplifiers	15	37						HMC-APH47
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5 27 - 34 37 - 40 <i>Wideband (Dist.</i>	Power Amplifier, 1 Watt ributed) Amplifiers Wideband LNA	15 14	37 28	2.5	16	+8V @ 60mA	Chip	EAR99	HMC-APH47
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5 27 - 34 37 - 40 <i>Wideband (Dist.</i> DC - 20 DC - 20	Power Amplifier, 1 Watt ributed) Amplifiers Wideband LNA Wideband LNA	15 14 14	28 29.5	2.5 2.5	16 17	+8V @ 60mA +8V @ 75mA	Chip LC5	EAR99 EAR99	HMC-APH47 HMC460 HMC460LC5
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5 27 - 34 37 - 40 Wideband (Distributed DC - 20 DC - 20 2 - 20	Power Amplifier, 1 Watt ributed) Amplifiers Wideband LNA Wideband LNA Wideband LNA	15 14 14 15.5	28 29.5 26.5	2.5 2.5 2.5	16 17 15	+8V @ 60mA +8V @ 75mA +5V @ 63mA	Chip LC5 Chip	EAR99 EAR99 EAR99	HMC460 HMC460LC5 HMC462
22.5 - 26.5 24 - 29.5 24 - 29.5 27 - 31.5 27 - 34 37 - 40 Wideband (Dist) DC - 20 DC - 20	Power Amplifier, 1 Watt ributed) Amplifiers Wideband LNA Wideband LNA	15 14 14	28 29.5	2.5 2.5	16 17	+8V @ 60mA +8V @ 75mA	Chip LC5	EAR99 EAR99	HMC-APH47 HMC460 HMC460LC5



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 $(k\Omega)$	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 - Ana	log							
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



SMT & Chip (Die) Products

ATTENUATORS

	Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
Α	ttenuators -	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 / V _{term} ^[1] Power Supply (Vdc)	Package	ECCN Code	Part Number
Clocked Compar	ators								
10 / 20	Clocked Comparator-RSPECL	<3	120	0.4	150	+3.3 / +1.3	LC3C	3A001.a.11.b	HMC874LC30
10 / 20	Clocked Comparator-RSCML	<3	120	0.4	130	0/0	LC3C	3A001.a.11.b	HMC875LC30
10 / 20	Clocked Comparator-RSECL	<3	120	0.4	150	0 / -2.0	LC3C	3A001.a.11.b	HMC876LC30
Latched Compar	ators								
10 / [2]	Latched Comparator-RSPECL	2	85	0.4	140	+3.3 / 3.0	LC3C	3A001.a.11.b	HMC674LC30
10 / [2]	Latched Comparator-RSCML	2	100	0.4	100	0/0	LC3C	3A001.a.11.b	HMC675LC30
10 / [2]	Latched Comparator-RSECL	2	100	0.35	120	0 / -2.0	LC3C	3A001.a.11.b	HMC676LC30
Window Compara	ators								
<u>"</u> 10 / -	Window Comparator	2	88	0.4	240	+2 / 0	LC3C	3A001.a.11.b	HMC974LC30

[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

F	Input Freq. (GHz)	Function	Single Tone I THD/SFDR (dB)		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



SMT & Chip (Die) Products

FILTERS - Tunable (Band Pass & Low Pass) - New Product Line!

Ran	A	Pass
Dall		Pass

	Frequency Range (GHz)	Function	Return Loss (dB)	3 dB Bandwidth (%)	Frequency (Rej. >20 dB)	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	HMC437MS8GI
	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	HMC438MS8G
	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
!	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
Ph	ase / Frequ	uency Detectors							
	0.01 - 1.3	Phase Frequency Detector	-10 to +10	2 Vpk-pk	-153	+5V @ 96mA	QS16G	3A001.a.11.b	HMC439QS16G
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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



SMT & Chip (Die) Products

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

	ta / Clock Rate pps / 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 F	anout Bu	ıffer								
	13 / 13	1:2 Fanout Buffer*	22 / 20	<1	0.4 - 1.1	240	-3.3	LC3C	3A001.a.11.b	HMC670LC3
	13 / 13	Fast Rise Time 1:2 Fanout Buffer*	19 / 18	2	0.6 - 1.1	300	-3.3	LC3C	3A001.a.11.b	HMC720LC3
W!	13 / 13	Fast Rise Time 1:2 Fanout Buffer*	19 / 18	2	0.6 - 1.1	300	-3.3	LP3	3A001.a.11.b	HMC720LP3
	13 / 13	Fast Rise Time 1:2 Fanout Buffer	19 / 18	2	1.1	300	-3.3	LC3C	3A001.a.11.b	HMC724LC3
	13 / 13	Fast Rise Time 1:2 Fanout Buffer*	22 / 20	2	0.6 - 1.2	290	+3.3	LC3C	3A001.a.11.b	HMC744LC3
W!	50	1:2 Fanout Buffer*	11 / 11	3	0.4 - 1.2	465	-3.3	LC4B	3A001.a.11.b	HMC842LC4
2:1 S	Selector									
	13 / 13	2:1 Selector*	17 / 15	2	0.6 - 1.2	250	-3.3	LC3C	3A001.a.11.b	HMC678LC3
	13 / 13	2:1 Selector	17 / 15	2	1.1	250	-3.3	LC3C	3A001.a.11.b	HMC728LC3
	13 / 13	2:1 Selector*	22 / 22	2	0.6 - 1.2	250	+3.3	LC3C	3A001.a.11.b	HMC748LC3
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	HMC672LC
	13 / 13	Fast Rise Time AND / NAND / OR / NOR*	19 / 18	2	0.6 - 1.1	230	-3.3	LC3C	3A001.a.11.b	HMC722LC
W!	13 / 13	Fast Rise Time AND / NAND / OR / NOR*	19 / 18	2	0.6 - 1.1	230	-3.3	LP3	3A001.a.11.b	HMC722LP3
	13 / 13	Fast Rise Time AND / NAND / OR / NOR	19 / 18	2	1.1	230	-3.3	LC3C	3A001.a.11.b	HMC726LC
	13 / 13	Fast Rise Time AND / NAND / OR / NOR*	22 / 21	2	0.6 - 1.2	230	+3.3	LC3C	3A001.a.11.b	HMC746LC
W!	45	AND / NAND / OR / NOR*	10 / 10	2	0.2 - 0.85	500	-3.3	LC4B	3A001.a.11.b	HMC843LC
Cloc	k Divider	•								
2	28 / 28	Clock Divide-by-2/4	12 / 14	-	0.6	660	-3.3	LC4B	3A001.a.11.b	HMC791LC
D-Ty	pe Flip-Fl	lop								
	13 / 13	D-Type Flip-Flop*	22 / 20	<1	0.4 - 1.1	210	-3.3	LC3C	3A001.a.11.b	HMC673LC
	13 / 13	Fast Rise Time D-Type Flip-Flop*	19 / 17	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC723LC
W!	13 / 13	Fast Rise Time D-Type Flip-Flop*	19 / 17	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC723LP
	13 / 13	Fast Rise Time D-Type Flip-Flop	19 / 17	2	1.1	260	-3.3	LC3C	3A001.a.11.b	HMC727LC
	13 / 13	Fast Rise Time D-Type Flip-Flop*	22 / 20	2	0.7 - 1.2	264	+3.3	LC3C	3A001.a.11.b	HMC747LC
2	28 / 28	D-Type Flip-Flop*	15 / 14	2	0.7 - 1.3	260	-3.3	LC3C	3A001.a.11.b	HMC853LC
W!	43	D-Type Flip-Flop*	12 / 12	2	0.2 - 0.85	630	-3.3	LC4B	3A001.a.11.b	HMC841LC
NRZ	-to-RZ Co	onverter								
-	13 / 13	NRZ-to-RZ Converter	15 / 13	2	0.3 - 1.2	594	+3.3	LC3C	3A001.a.11.b	HMC706LC
	p-Flop	· · · · · · · · · · · · · · · · · · ·								
	26 / 26	T Flip-Flop w/ Reset*	18 / 17	2	0.4 - 1.1	270	-3.3	LC3C	3A001.a.11.b	HMC679LC
	26 / 26	T Flip-Flop w/Reset	18 / 17	2	1.1	270	-3.3	LC3C	3A001.a.11.b	HMC729LC
	26 / 26	T Flip-Flop w/ Reset*	18 / 17	2	0.6 - 1.2	270	+3.3	LC3C	3A001.a.11.b	HMC749LC



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
)	(OR / 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 vol	tage 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



SMT & Chip (Die) Products

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

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 - 0.0	-8	40	30	LC3	EAR99	HMC663LC3
9 - 15	High IP3, DBL-BAL	DC - 4	-7.5	40	24	MS8G	EAR99	HMC410AMS8G
Downconverter I		DC - 2.5	-7.5	40	24	MS6G	EARSS	HIVIC4TUAIVIS6GI
0.7 - 1.0	Downconverter	0.05 - 0.25	12.5	25	15	QS16	EAR99	HMC420QS16E
						LP6C		
0.7 - 1.0	High IP3, Dual Downconverter	0.06 - 0.5	7.5	16	23		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	HMC377QS16GI
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	HMC380QS16G
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
) to +7 dBm LO L	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	HMC488MS8GI
4.5 - 6.0	+7 LO, DBL-BAL	DC - 1.6	-7	30	18	MS8	EAR99	HMC218MS8E
	ble & 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 - 1.5	-6.5	30	21	MS8	EAR99	HMC272MS8E
		_				SOT26		
1.7 - 3.5	+10 LO, SGL-BAL	DC - 0.9	-9	30	21		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



SMT & Chip (Die) Products

MIXERS

R	RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Package	ECCN Code	Part Number
+1:	3 dBm LO Doul	ble & 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		DC - 10	-9	35	22			
_		+13 LO, DBL-BAL					Chip	EAR99	HMC774
_	9 - 15	+13 LO, DBL-BAL	DC - 2.5	-7.5	40 - 50	17	MS8G	EAR99	HMC412MS8G
	10 - 15	+13 LO, SGL-BAL	DC - 3	-9	27	16	MS8G	EAR99	HMC411MS8G
	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	HMC554LC3E
	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	HMC260LC3E
	16 - 30	+13 LO, DBL-BAL	DC - 8	-8	40	21	LC3B	EAR99	HMC292LC3E
	17 - 31	+13 LO, DBL-BAL	DC - 6	-8	32	19	LM3C	EAR99	HMC292LM30
	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	HMC329LC3E
	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-MDB16
±1		O Double & Single Balanced Mix							
т,	70 - 90	+14 LO, DBL-BAL	DC - 18	-12	-		Chip	5A991.h	HMC-MDB27
_	1.8 - 5.0		DC - 18	-12	42	18		EAR99	
		+15 LO, DBL-BAL	DC - 3		42		Chip		HMC128
_	1.8 - 5.0	+15 LO, DBL-BAL		-10		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	HMC558LC3E
	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 / 142
	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
/!	3 - 10	+17 LO, DBL-BAL	DC - 4	-9	55	23	LC3B	EAR99	HMC787LC3E
	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
Su	b-Harmonic Mi	<u> </u>							
ou	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	HMC258LC3E
	17 - 25	Sub-Harmonic	DC - 3	-9	27	10	Chip	EAR99	HMC337
/!	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	HMC264LC3I
	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	HMC338LC3I
	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
				-			- · · · P		



SMT & Chip (Die) 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
IEW!	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)			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



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 (F	OM) of synthesizer is	s -225/-226 dBc/Hz (fi	ractional/integer).						

POWER CONDITIONING - High PSRR Quad Linear Voltage Regulators

Input Voltage (V)	Function	Output Voltage (V)	Output Current (mA)	Power Supply Rejection Output Noise Spectral Ratio (PSRR) (dB) Density (nV/\/Hz)			Regulated Package		ECCN Code	Part Number	
voitage (v)				1 kHz	1 MHz	1 kHz	10 kHz	Outputs		Code	Number
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
og Detector/Co	ntroller							
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
MS Power Dete	ectors							
DC - 3.9	True RMS Power Detector	69 ±1	37	-60	+5V @ 65 mA	LP4	EAR99	HMC610ALP4E
uccessive Dete	ction Log Video Amplifier							
0.1 - 20	SDLVA	59	14	-54	+3.3V @ 83mA	LC4B	EAR99	HMC613LC4B
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	HMC913LC4E

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	ECCN Code	Part Number
SPST & SPDT Swi	itches							
DC - 6	SPST, Failsafe	0.7	25	27	0 / +2.2 to +5V	SOT26	EAR99	HMC550E



SMT & Chip (Die) Products

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	HMC231G
DC - 2.5	SPDT, Reflective	0.4	36	29	0 / -5V	S8	EAR99	HMC239S8
DC - 3	SPDT, Reflective	0.4	27	30	0 / +3V	MS8	EAR99	HMC190AMS
DC - 3	SPDT, Hi Isolation	0.7	50	23	0 / +5V	MS8	EAR99	HMC194MS
DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	EAR99	HMC197A
DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	EAR99	HMC221AI
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	HMC284MS8
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	HMC349LP4
DC - 4	SPDT, Hi Isolation	0.9	57	31	0 / +5V	MS8G	EAR99	HMC349MS8
DC - 4	SPDT, Hi Isolation	1.1	47	31	0 / +5V	MS8G	EAR99	HMC435MS8
DC - 6	SPDT, Hi Isolation	1.4	50	26	0 / -5V	G7 Hermetic	EAR99	HMC232G
DC - 6	SPDT, Hi Isolation	1.4	43	26	0 / -5V	G8 Hermetic	EAR99	HMC232G
DC - 6	SPDT, Hi Isolation	1.4	43	26	0 / -5V	G8 Hermetic	EAR99	HMC233G
DC - 6	SPDT, Hi Isolation	1.6	42	25	0 / +5V	MS8G	EAR99	HMC336MS8
DC - 6	SPDT, Hi Isolation	1.4	46	27	0 / -5V	G7	EAR99	HMC607G
DC - 6	SPDT, Hi Isolation	0.8	60	35	0 / +3 to +5V	LP4C	EAR99	HMC849LP4
DC - 8	SPDT, Hi Isolation	1.4	50	26	0 / -5V	C8	EAR99	HMC232C
DC - 8	SPDT, Hi Isolation	1.5	45	26	0 / -5V	C8	EAR99	HMC234C
DC - 8	SPDT, Hi Isolation	1.2	48	23	0 / -5V	MS8G	EAR99	HMC270MS
DC - 8	SPDT, Hi Isolation	2.0	44	23	0 / -5V	C8	EAR99	HMC347C
DC - 8	SPDT, Hi Isolation	2.2	35	23	0 / -5V	G8 Hermetic	EAR99	HMC347G
DC - 12	SPDT, Hi Isolation	1.5	55	27	0 / -5V	LP4	EAR99	HMC232LP
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	HMC347LP
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	HMC547LP
55 - 86	SPDT, Reflective	2	30	-	-5 / +5	Chip	5A991.h	HMC-SDD1
0.1 - 2.1	SPDT, 40W, Failsafe	0.4	22	46	0 / +3V to +8V	LP2	EAR99	HMC646LP
0.2 - 2.2	SPDT, 10W, Failsafe	0.4	40	> 40	0 / +3 to +8V	MS8G	EAR99	HMC546MS
0.2 - 2.7	SPDT, 10W, Failsafe	0.4	35	43	0 / +3 to +8V	LP2	EAR99	HMC546LP
0.824 - 0.894	SPDT, 10W, T/R	0.6	22	> 40	0 / +5V	SOT26	EAR99	HMC446I
DC - 2.5	SPDT, CATV	0.6	58	28	0 / +5V	LP3	EAR99	HMC348LP
DC - 3	SPDT T/R	0.5	25	39	TTL/CMOS	MS8	EAR99	HMC174MS
DC - 3	SPDT, 5W, T/R	0.3	30	39	0 / +3 to +10V	MS8	EAR99	HMC574MS
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		0.23	30	40	0 / +3 to +8V	MS8G	EAR99	HMC784MS
	SPDT, 10W, T/R						EAR99	
DC - 6	SPDT T/R	0.5	27	37	0 / +3 to +5V	MS8G		HMC536MS
DC - 6	SPDT T/R	0.6	27	37	0 / +3 to +5V	LP2	EAR99	HMC536LP
5 - 6	SPDT T/R	1.2	31	33	TTL/CMOS	MS8	EAR99	HMC224MS
lulti-Throw S								
DC - 3.5	SP3T	0.5	44	26	TTL/CMOS	QS16	EAR99	HMC245QS
DC - 2	SP4T	0.8	32	24	0 / -5V	S14	EAR99	HMC182S1
DC - 3.5	SP4T	0.5	45	25	TTL/CMOS	QS16	EAR99	HMC241QS
DC - 4	SP4T	0.6	47	26	TTL/CMOS	LP3	EAR99	HMC241LP
DC - 4	SP4T	0.7	40	25	TTL/CMOS	G16 Hermetic	EAR99	HMC244G
DC - 8	SP4T	1.8	42	21	0 / -5V	Chip	EAR99	HMC344
DC - 8	SP4T	2.0	45	26	0 / -5V	LC3	EAR99	HMC344L0
DC - 8	SP4T	1.8	40	21	0 / -5V	LP3	EAR99	HMC344LP
DC - 8	SP4T	2.2	32	21	0 / 5V	LP3	EAR99	HMC345LP
DC - 12	SP4T	1.8	42	27	0 / -5V	LH5 Hermetic	EAR99	HMC344LI
DC - 18	SP4T	2.1	42	24	0 / -5V	Chip	EAR99	HMC641
DC - 20	SP4T	2.1	42	23	0 / -5V	LC4	EAR99	HMC641L0
DC - 3	SP6T	0.8	41	24	TTL/CMOS	QS24	EAR99	HMC252QS
DC - 2	SP8T	1.3	30	20	0 / -5V	QS24	EAR99	HMC183QS
DC - 2.5	SP8T	1.1	36	23	TTL/CMOS	QS24	EAR99	HMC253QS
DC - 3.5	SP8T	1.2	36	24	TTL/CMOS	LC4	EAR99	HMC253L0
DO - 0.0	SP8T	2.3	40	23	0 / 5V	LP4	EAR99	HMC321LP
DC . Q	01-01	2.3	+∪	23	0/30	LF 4		
DC - 8	CDQT	2	20	22	0 / -51/	Chin	EVDOO	LIMESON
DC - 10	SP8T	2	38	23	0 / -5V	Chip	EAR99	HMC322
DC - 10 DC - 8	SP8T SP8T rsity, Matrix & Transfer S	2.5	38 25	23 23	0 / -5V 0 / -5V	Chip LP4	EAR99 EAR99	HMC322LP



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 Bufi	fer 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 VCO	s							
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

	00.1022		. 0110 1111	0,2 00	0.				
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



SMT & Chip (Die) Products

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



CONNECTORIZED MODULES

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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

APRIL 2010



CONNECTORIZED MODULES

Robust, High Performance RF to Light Solutions

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

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	Function	Insertion	Phase	IIP3	Control Voltage	Package /	ECCN	Part
(GHz)		Loss (dB)	Range (deg)	(dBm)	Range (Vdc)	Connector	Code	Number
8 - 12	4-Bit Digital	7	22.5 to 360	38	0V to +5V	C-6 / SMA	EAR99	HMC-C055

POWER DETECTORS

F	requency (GHz)	Function	Function Dynamic RSSI S Range (dB) (mV /		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)		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



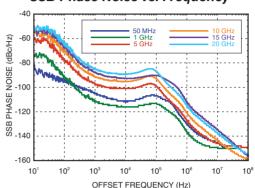
Synthesized Signal Generators

HMC-T2100B



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.

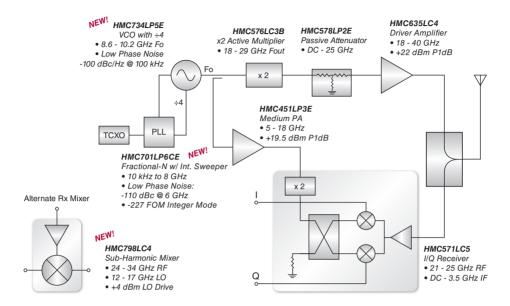
AUTOMOTIVE; DC - 6 GHz and 6 - 80 GHz

Function	DC - 6 GHz			6 - 80 GHz			
ranction	Chip	SI	МТ	Chip	SI	ИΤ	
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	
ow 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	
inear & 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: /Q, IRM, Sub-Harmonic & /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	
witch: PST, SPNT, SPDT, SPDT T/R, typass, Diversity, Matrix & ransfer	HMC240 HMC322 HMC344 HMC641	HMC321LP4E HMC332E HMC336MS8GE HMC544E HMC436MS8GE	HMC536MS8GE HMC550E HMC784MS8GE HMC849LP4CE	HMC232 HMC347 HMC607 HMC-SDD112	HMC232LP4E HMC321LP4E HMC344LP3E	HMC347LP3E HMC427LP3E HMC547LP3E	
/GAs: Digital		HMC625LP4E HMC743LP6CE	HMC742LP5E				
VCO * Requires x2 or x4		HMC388LP4E HMC389LP4E HMC390LP4E	HMC391LP4E HMC431LP4E HMC586LC4B		HMC515LP5E* HMC531LP5E* HMC534LP4E HMC736LP4E	HMC535LP5E HMC587LC4B HMC588LC4B HMC737LP4E	



Automotive: Telematics & Sensors, 2 - 110 GHz

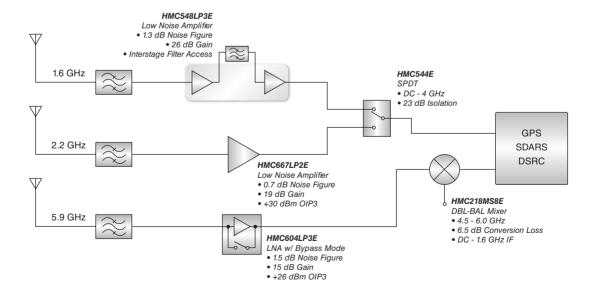
24 GHz FMCW AUTOMOTIVE SENSOR



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
ow Noise Amplifier	HMC548LP3E	HMC286E	HMC476SC70E	HMC318MS8GE
JW Noise Ampimer	HMC549MS8GE	HMC287MS8GE	HMC491LP3E	HMC320MS8GE
	HMC599ST89E	HMC605LP3E	HMC593LP3E	HMC476SC70E
	665561652	HMC636ST89E	HMC636ST89E	HMC604LP3E
		HMC639ST89E	HMC639ST89E	HMC717LP3E
		HMC715LP3E	HMC716LP3E	
river Amplifier & Gain Block	HMC311SC70E	HMC308E	HMC311SC70E	HMC311SC70E
	HMC454ST89E	HMC311SC70E	HMC326MS8GE	HMC406MS8GE
	HMC474SC70E	HMC474SC70E	HMC327MS8GE	HMC407MS8GE
	HMC475ST89E	HMC475ST89E	HMC474SC70E	HM415LP3E
	HMC476SC70E	HMC476SC70E	HMC475ST89E	HMC474SC70E
	HMC589ST89E	HMC589ST89E	HMC476SC70E	HMC476SC70E
	HMC770LP4BE	HMC755LP4E		
inear & Power Amplifier	HMC453QS16GE	HMC454ST89E	HMC409LP4E	HMC408LP3E
	HMC636ST89E	HMC636ST89E	HMC636ST89E	
ttenuator: Analog	HMC473MS8E	HMC346MS8GE	HMC346MS8GE	HMC346MS8GE
ttenuator: Digital	HMC467LP3E	HMC305ALP4E	HMC424LP3E	HMC425LP3E
	HMC468LP3E	HMC540LP3E	HMC467LP3E	HMC467LP3E
	HMC542LP4E	HMC542LP4E	HMC539LP3E	HMC468LP3E
	HMC624LP4E	HMC624LP4E	HMC624LP4E	HMC624LP4E
	HMC629LP4E HMC759LP3E	HMC629LP4E HMC792LP4E	HMC629LP4E HMC792LP4E	HMC629LP4E HMC792LP4E
livor	HMC207S8E			
/lixer		HMC215LP4E	HMC214MS8E	HMC220MS8E
	HMC208MS8E	HMC285E	HMC215LP4E	HMC218MS8E
	HMC493MS8E	HMC316MS8E	HMC333E	HMC219MS8E
	HMC483MS8GE	HMC334LP4E	HMC340ALP5E	HMC488MS8GE
		HMC552LP4E HMC557	HMC557 HMC557LC4	HMC525LC5 HMC557
		HMC557LC4	HMC615LP4E	
				HMC557LC4
		HMC622LP4E	HMC622LP4E	
		HMC688LP4E HMC689LP4E	HMC666LP4E	
emodulator	HMC597LP4E	HMC597LP4E HMC631LP3E	HMC597LP4E	
Indulator	LIMC40EL D2E		LIMC40EL D2E	HMC406I D2E
lodulator	HMC495LP3E HMC497LP4E	HMC495LP3E HMC497LP4E	HMC495LP3E HMC497LP4E	HMC496LP3E
	HMC696LP4E	HMC696LP4E	HMC697LP4E	
	HIMO090LF4E	HMC697LP4E	HIMO097EF4E	
hase Shifter: Digital		HMC647	HMC648	HMC649
nace chinter: Digital		HMC647LP6E	HMC648LP6E	HMC649LP6E
		1111100 17 21 02	HMC649	HMC638LP5E
			HMC649LP6E	11111000021 02
LL	HMC700LP4E	HMC700LP4E	HMC700LP4E	HMC700LP4E
ower Detector	HMC600LP4E	HMC600LP4E	HMC600LP4E	HMC600LP4E
	HMC601LP4E	HMC601LP4E	HMC601LP4E	HMC601LP4E
	HMC602LP4E	HMC602LP4E	HMC602LP4E	HMC602LP4E
	HMC610ALP4E	HMC610ALP4E	HMC610ALP4E	HMC610ALP4E
	HMC612LP4E	HMC612LP4E		
witch: SPST & SPNT	HMC253QS24E	HMC241LP3E	HMC241LP3E	HMC224MS8E
	HMC536MS8GE	HMC536MS8GE	HMC349MS8GE	HMC321LP4
	HMC536LP2E	HMC546LP2E	HMC536MS8GE	HMC536LP2E
	HMC544E	HMC550E	HMC544E	HMC536MS8GE
	HMC550E	HMC784MS8GE	HMC550E	HMC550E
	HMC646LP2E	HMC849LP4CE	HMC784MS8GE	
	HMC784MS8GE		HMC849LP4CE	
	HMC849LP4CE			
witch: Bypass, Diversity,	HMC276LP4E	HMC276LP4E	HMC427LP3E	HMC436MS8GE
latrix & Transfer	HMC427LP3E	HMC427LP3E		HMC427LP3E
100	HMC596LP4E	HMC596LP4E	10.00000	
CO	HMC384LP4E	HMC384LP4E HMC385LP4E	HMC388LP4E HMC389LP4E	HMC430LP4E HMC431LP4E
GA	HMC625LP5E	HMC625LP5E	HMC625LP5E	HMC625LP5E
		HMC680LP4E	HMC680LP4E	HMC680LP4E
	HIVIODZBLESE			
	HMC626LP5E HMC627LP5E	HMC681LP5E	HMC681LP5E	HMC681LP5E



Broadband, DC - 11 GHz

CABLE MODEM, CATV, DBS & VoIP Solutions, 5 - 2150 MHz

• 1.5 - 2.5 GHz RF • DC - 1 GHz IF • 0 dBm LO Drive

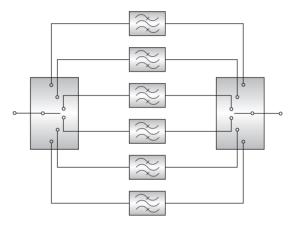
HMC820LP6CE NEW PLL w/ Int. VCO 2.05 - 2.5 GHz • Tri-band Output Low Phase Noise -110 dBc/Hz @ 10 kHz



HMC639ST89E InGaP HBT Gain Block HMC207S8E High IP3 LNA • DC - 4 GHz • 0.2 - 4.0 GHz DBL-BAL Mixer • 21 dB Gain • 0.7 - 2.0 GHz RF • 2.3 dB NF • +33 dBm OIP3 • +38 dBm OIP3 • >45 dB LO Isolation NEW! HMC742LP5E HMC740ST89E 6-Bit DVGA InGaP HBT Gain Block • 0 07 - 4 0 GHz • 0.05 - 3 GHz • -19.5 to +12 dB Gain • 15 dB Gain HMC422MS8E Control in 0.5 dB Steps +40 dRm OIP3 DBL-BAL Mixer w/ LO • +39 dBm High OIP3

A Selection of SPNT Switches for CATV Filter & Signal Routing

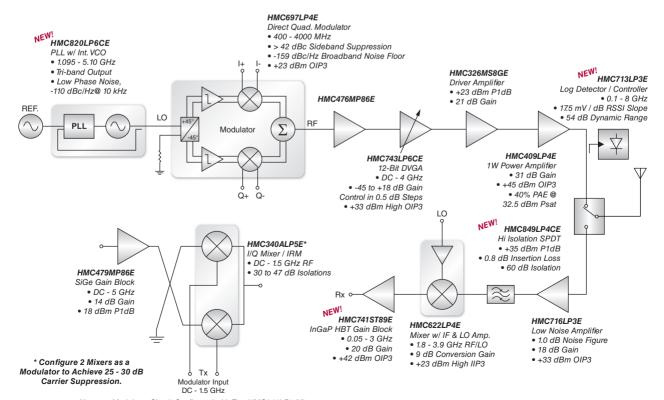
Part Number	Frequency (GHz)	Function	1 GHz Loss / Isolation (dB)
HMC348LP3E	DC - 2.5	SPDT, 75 Ω	0.6 / 58
HMC349LP4CE	DC - 4	SPDT	0.9 / 65
HMC347LP3E	DC - 15	SPDT	1.4 / 65
HMC245QS16GE	DC - 3.5	SP3T	0.5 / 44
HMC345LP3E	DC - 8	SP4T	2.0 / >50
HMC252QS24E	DC - 3	SP6T	2.0 / >45
HMC321LP4E	DC - 8	SP8T	2.0 / >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

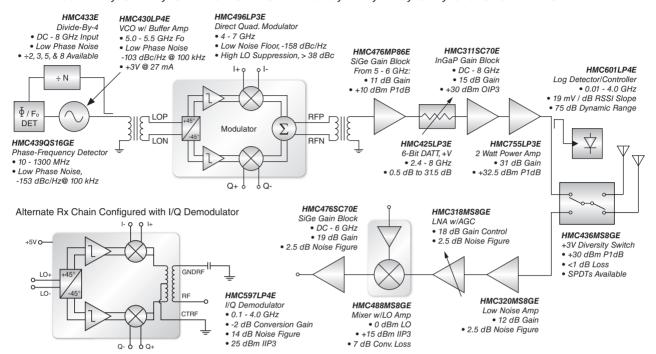
RFF



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.

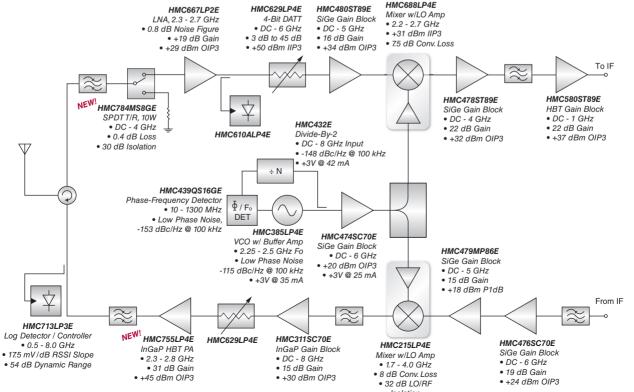
Broadband, DC - 11 GHz

Wireless LAN, 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.



A selection of components, see the full product listing starting on page 10.

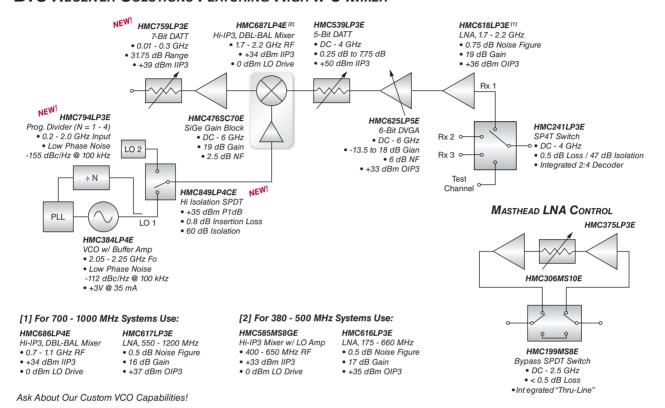
CELLULAR INFRASTRUCTURE, 380 - 2200 MHz – GSM, GPRS, CDMA, TD-SCDMA, WCDMA, UMTS & 4G/LTE

	400 MHz	700 / 800 / 900 MHz	1800 / 1900 MHz	2100 / 2200 MHz
ow Noise Amplifier	HMC374E	HMC617LP3E	HMC618LP3E	HMC618LP3E
	HMC616LP3E	HMC636ST89E	HMC636ST89E	HMC636ST89E
	HMC636ST89E	HMC718LP4E	HMC719LP4E	HMC667LP2E
river Amplifier & Gain Block	HMC311SC70E	HMC308E	HMC308E	HMC308E
	HMC454ST89E	HMC311SC70E	HMC311SC70E	HMC311SC70E
	HMC474SC70E	HMC454ST89E	HMC454ST89E	HMC454ST89E
	HMC475ST89E	HMC474SC70E	HMC474SC70E	HMC474SC70E
	HMC476SC70E	HMC475ST89E	HMC475ST89E	HMC475ST89E
	HMC478ST89E	HMC476SC70E	HMC476SC70E	HMC476SC70E
	HMC580ST89E	HMC589ST89E	HMC589ST89E	HMC589ST89E
inear & Power Amplifier	HMC452ST89E	HMC452ST89E	HMC452ST89E	HMC452ST89E
	HMC453ST89E	HMC453ST89E	HMC453ST89E	HMC453ST89E
	HMC454ST89E	HMC454ST89E	HMC454ST89E	HMC454ST89E
	HMC636ST89E	HMC636ST89E	HMC457QS16GE	HMC636ST89E
			HMC636ST89E	
ttenuator: Analog	HMC473MS8E	HMC473MS8E		
ttenuator: Digital	HMC540LP3E	HMC540LP3E	HMC539LP3E	HMC539LP3E
	HMC541LP3E	HMC541LP3E	HMC541LP3E	HMC541LP3E
	HMC472LP4E	HMC467LP3E	HMC468LP3E	HMC542LP4E
	HMC542LP4E	HMC542LP4E	HMC542LP4	HMC624LP4E
	HMC624LP4E	HMC624LP4E	HMC624LP4E	HMC629LP4E
	HMC629LP4E	HMC629LP4E	HMC629LP4E	HMC759LP3E
	HMC759LP3E	HMC759LP3E	HMC759LP3E	HMC792LP4E
	HMC792LP4E	HMC792LP4E	HMC792LP4E	
requency Divider & Detector	HMC394LP4E	HMC394LP4E	HMC394LP4E	HMC394LP4E
-	HMC434E	HMC434E	HMC434E	HMC434E
	HMC439QS16GE	HMC439QS16GE	HMC439QS16GE	HMC439QS16GE
	HMC705LP5E	HMC705LP5E	HMC705LP5E	HMC705LP5E
lixer	HMC387MS8E	HMC334LP4E	HMC215LP4E	HMC215LP4E
	HMC585MS8GE	HMC399MS8E	HMC334LP4E	HMC334LP4E
		HMC423MS8E	HMC381LP6E	HMC400MS8E
		HMC483MS8GE	HMC400MS8E	HMC421QS16GE
		HMC551LP4E	HMC485MS8GE	HMC422MS8E
		HMC581LP6E	HMC552LP4E	HMC615LP4
		HMC621LP4E	HMC622LP4E	HMC622LP4E
		HMC665LP4E	HMC623LP4E	HMC688LP4E
		HMC683LP6E	HMC682LP6E	HMC689LP4E
		HMC684LP4E	HMC685LP4E	
		HMC686LP4E	HMC687LP4E	
emodulator	HMC597LP4E	HMC597LP4E	HMC597LP4E	HMC597LP4E
lodulator:	HMC495LP3E	HMC495LP3E	HMC495LP3E	HMC495LP3E
Direct Quadrature & Vector	HMC497LP4E	HMC497LP4E	HMC497LP4E	HMC497LP4E
	HMC696LP4E	HMC630LP3E	HMC631LP3E	HMC631LP3E
	HMC697LP4E	HMC696LP4E	HMC696LP4E	HMC696LP4E
		HMC697LP4E	HMC697LP4E	HMC697LP4E
LL: Synthesizer ICs	HMC700LP4E	HMC700LP4E	HMC700LP4E	HMC700LP4E
ower Detector	HMC600LP4E	HMC600LP4E	HMC600LP4E	HMC600LP4E
	HMC601LP4E	HMC601LP4E	HMC601LP4E	HMC601LP4E
	HMC602LP4E	HMC602LP4E	HMC602LP4E	HMC602LP4E
	HMC610ALP4E	HMC610ALP4E	HMC610ALP4E	HMC610ALP4E
	HMC611LP4E	HMC611LP4E	HMC611LP4E	HMC611LP4E
	HMC612LP4E	HMC612LP4E	HMC612LP4E	HMC612LP4E
witch: SPST & SPNT	HMC546MS8GE	HMC550E	HMC545E	HMC546LP2E
	HMC550E	HMC574MS8E	HMC546MS8GE	HMC550E
	HMC646LP2E	HMC646LP2E	HMC646LP2E	HMC646LP2E
	HMC784MS8GE	HMC784MS8GE	HMC784MS8GE	HMC784MS8GE
	HMC849LP4CE	HMC849LP4CE	HMC849LP4CE	HMC849LP4CE
witch: Bypass, Diversity, latrix & Transfer	HMC199MS8E	HMC199MS8E	HMC199MS8E	HMC199MS8E
	HMC596LP4E	HMC596LP4E	HMC596LP4E	HMC596LP4E
/GA	HMC625LP5E	HMC625LP5E	HMC625LP5E	HMC625LP5E
	HMC626LP5E HMC627LP5E	HMC626LP5E HMC627LP5E	HMC626LP5E HMC627LP5E	HMC626LP5E
		DIVIDDZ/LF3E	I IIVIOUZ/LF3E	HMC627LP5E
			HMC6381 D4E	HMC6301 DAE
	HMC628LP4E HMC680LP4E	HMC628LP4E HMC680LP4E	HMC628LP4E HMC680LP4E	HMC628LP4E HMC680LP4E

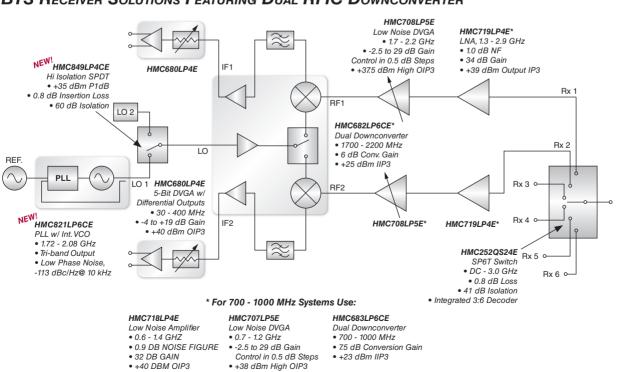


Cellular Infrastructure, 380 - 2200 MHz

BTS Receiver Solutions Featuring High IP3 Mixer



BTS Receiver Solutions Featuring Dual RFIC Downconverter



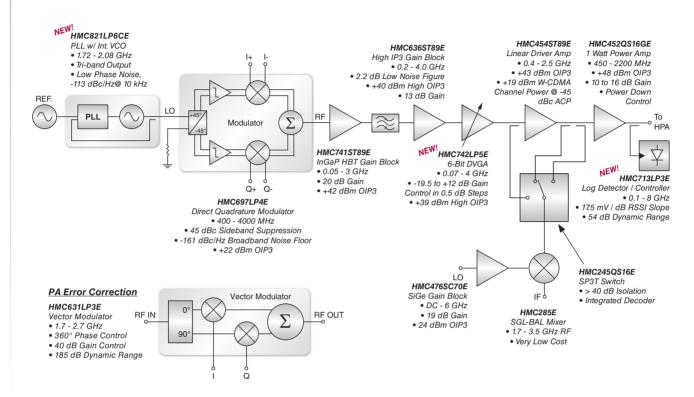
Typical Cellular/PCS/3G applications are illustrated.

See the full product listing for alternatives to the select HMC products shown in each functional block.

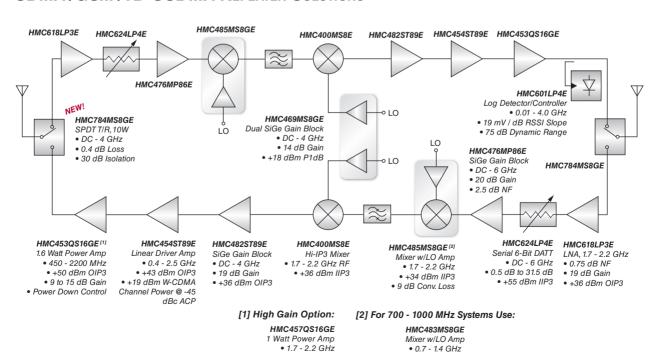


Cellular Infrastructure, 380 - 2200 MHz

BTS TRANSMITTER SOLUTIONS



CDMA/GSM/TD-SCDMA REPEATER SOLUTIONS



Typical Cellular/PCS/3G applications are illustrated.

See the full product listing for alternatives to the select HMC products shown in each functional block.

• +35 dBm IIP3

• +46 dBm OIP3

• 26 dB Gain



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

FIBER OF IICS, OC-48					ons inquiries: F	
Function	OC-1	OC-3	OC-12	OC-48	OC-192	OC-768
Broadband Gain Blocks	HMC311SC70E	HMC311SC70E	HMC311SC70E	HMC311SC70E	HMC405	
	HMC396	HMC396	HMC396	HMC396		
	HMC405	HMC405	HMC405	HMC405		
	HMC474MP86E	HMC474MP86E	HMC474MP86E	HMC474MP86E		
	HMC474SC70E	HMC474SC70E	HMC474SC70E	HMC474SC70E		
	HMC475ST89E	HMC475ST89E	HMC475ST89E	HMC475ST89E		
	HMC476SC70E	HMC476SC70E	HMC476SC70E	HMC476SC70E		
	HMC478SC70E	HMC478SC70E	HMC478SC70E	HMC478SC70E		
_imiting Amplifier	HMC750LP4E	HMC750LP4E	HMC750LP4E	HMC750LP4E	HMC750LP4E	
Fransimpedance Amplifier					HMC690	
	HMC459	HMC459	HMC459	HMC459	HMC459	HMC-AUH312
Distributed) Amplifiers	HMC460	HMC460	HMC460	HMC460	HMC460	
Distributed) Ampimers	HMC465	HMC465	HMC465	HMC465	HMC465	
	HMC465LP5E	HMC465LP5E	HMC465LP5E	HMC465LP5E	HMC465LP5E	
	HMC559	HMC559	HMC559	HMC559	HMC559	
	HMC637LP5E	HMC637LP5E	HMC637LP5E	HMC637LP5E	HMC-AUH312	
	HMC-AUH312	HMC-AUH312	HMC-AUH312	HMC-AUH312	HMC-AUH232	
	HMC-AUH232	HMC-AUH232	HMC-AUH232	HMC-AUH232	HMC-AUH249	
	HMC-AUH249	HMC-AUH249	HMC-AUH249	HMC-AUH249		
Connectorized	HMC-C004	HMC-C004	HMC-C004	HMC-C004	HMC-C004	
Amplifier Modules	HMC-C036	HMC-C036	HMC-C036	HMC-C036	HMC-C036	
	HMC-C037	HMC-C037	HMC-C037	HMC-C037	HMC-C037	
Attenuators: Analog	HMC346	HMC346	HMC346	HMC346	HMC346	HMC-VVD104
Attenuators. Analog						
	HMC346G8	HMC346G8	HMC346G8	HMC346G8	HMC346LP3	HMC-VVD106
	HMC346LP3E	HMC346LP3E	HMC346LP3E	HMC346LP3E		
	HMC346MS8GE	HMC346MS8GE	HMC346MS8GE	HMC346MS8GE		
Attenuators: Digital	HMC424	HMC424	HMC424	HMC424	HMC424	
	HMC424LH5	HMC424LH5	HMC424LH5	HMC424LH5	HMC424LH5	
	HMC424LP3E	HMC424LP3E	HMC424LP3E	HMC424LP3E	HMC424LP3E	
	HMC542LP4E	HMC542LP4E	HMC542LP4E	HMC542LP4E		
	HMC624LP4E	HMC624LP4E	HMC624LP4E	HMC624LP4E		
	HMC629LP4E	HMC629LP4E	HMC629LP4E	HMC629LP4E		
Attenuators: Passive	HMC650 - HMC655	HMC650 - HMC65				
	HMC656LP2E	HMC656LP2E	HMC656LP2E	HMC656LP2E	HMC656LP2E	HMC656
	HMC657LP2E	HMC657LP2E	HMC657LP2E	HMC657LP2E	HMC657LP2E	HMC657
	HMC658LP2E	HMC658LP2E	HMC658LP2E	HMC658LP2E	HMC658LP2E	HMC658
Connectorized	HMC-C018	HMC-C018	HMC-C018	HMC-C018	HMC-C025	
Attenuator Modules	HMC-C053	HMC-C053	HMC-C053	HMC-C053	HMC-C053	
Frequency	HMC394LP4E	HMC394LP4E	HMC394LP4E	HMC440QS16GE		
Dividers & Detectors	HMC439QS16GE	HMC439QS16GE	HMC439QS16GE	HMC492LP3E		
Sividers & Beleeters	HMC440QS16GE	HMC440QS16GE	HMC440QS16GE	HMC493LP3E		
				TIMO493EF3E		
	HMC492LP3E	HMC492LP3E	HMC492LP3E			
	HMC493LP3E	HMC493LP3E	HMC493LP3E			
	HMC494LP4E	HMC494LP4E	HMC494LP4E			
Connectorized	HMC-C040	HMC-C006	HMC-C005	HMC-C005		
Freq. Divider Modules		HMC-C007	HMC-C006	HMC-C006		
		HMC-C039	HMC-C007			
		HMC-C040	HMC-C039			
			HMC-C040			
Frequency					HMC448LC3B	HMC579
Aultipliers: Active					HMC576	HMC598
						HIMIC398
wallipliers. Active					HMC576LC3B	
wulliphers. Active						
nditipliers. Active					HMC561LP3E	
wantphers. Active					HMC561LP3E HMC598	
wullipliers. Active						
wullipliers. Active					HMC598	
Connectorized					HMC598 HMC-XDB112 HMC-XDH158	
,					HMC598 HMC-XDB112	



A selection of components, see the full product listing starting on page 10.

FIBER OPTICS, OC-48 to 100G

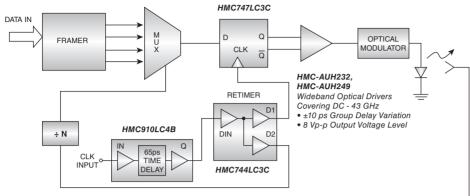
Fiber Optic Custom Solutions Inquiries: FO@hittite.com

FIBER OF IICS, OC-46	riber Optic Custom Solutions Inquiries: FO@nitite.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	HMC853LC30
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	HMC791LC4E
Connectorized High Speed Digital						HMC-C060
ogic Modules						HMC-C061
						HMC-C062
						HMC-C064
						HMC-C065
Connectorized Mixer Modules	HMC-C035	HMC-C035	HMC-C035	HMC-C035		
Phase Shifters: Analog				HMC247	HMC247	
				HMC538LP4E	HMC538LP4E	
Phase Shifters: Digital				HMC647	HMC642LC5	
-				HMC647LP6E	HMC643LC5	
				HMC648	HMC644	
				HMC648LP6E	HMC644LC5	
Connectorized					HMC-C010	
Phase Shifter Modules						
Switches: SPDT	HMC232LP4E	HMC232LP4E	HMC232LP4E	HMC232	HMC232	HMC-SDD112
	HMC347	HMC347	HMC347	HMC232LP4E	HMC232LP4E	
	HMC347LP3E	HMC347LP3E	HMC347LP3E	HMC347	HMC347	
	HMC547LP3E	HMC547LP3E	HMC547LP3E	HMC347LP3E	HMC347LP3E	
	HMC646LP2E	HMC646LP2E	HMC646LP2E	HMC547LP3E	HMC547LP3E	
Switches: Multi-Throw	HMC253LC4	HMC253LC4	HMC253LC4	HMC253LC4	HMC641	
	HMC344LC3	HMC344LC3	HMC344LC3	HMC344LC3		
	HMC641	HMC641	HMC641	HMC641		
Switches: Transfer	HMC427LP3E	HMC427LP3E	HMC427LP3E	HMC427LP3E		
Connectorized	HMC-C011	HMC-C011	HMC-C011	HMC-C011	HMC-C011	
Switch Modules	HMC-C019	HMC-C019	HMC-C019	HMC-C019	HMC-C019	
	HMC-C058	HMC-C058	HMC-C058	HMC-C058	HMC-C058	
Connectorized VCO Modules						HMC-C073



Fiber Optics, OC-48 to 100G

TYPICAL SERIAL FIBER OPTIC DATA TRANSMISSION SYSTEM

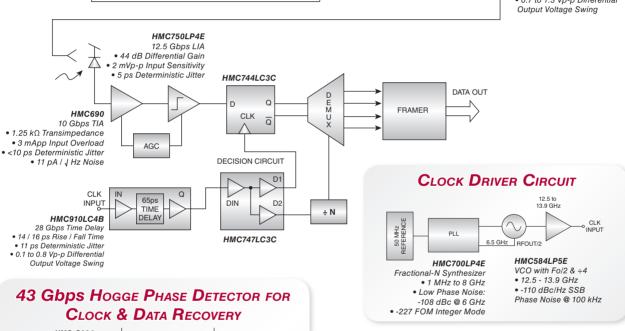


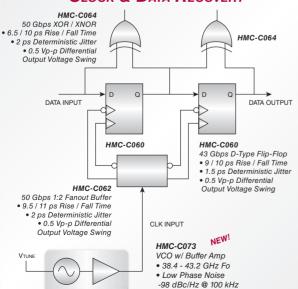
HMC744LC3C

- 13 Gbps 1:2 Fanout Buffer 22 / 20 ps Rise / Fall Time
- 2 ps Deterministic Jitter
- 0.6 to 1.1 Vp-p Differential Output Voltage Swing

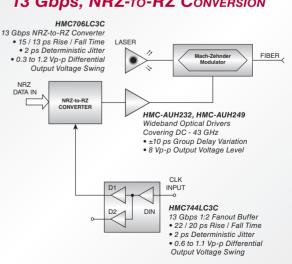
HMC7471 C3C

- 13 Gbps D-Tvpe Flip-Flop
- 22 / 20 ps Rise / Fall Time
- 2 ps Deterministic Jitter
- 0.7 to 1.3 Vp-p Differential





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.

+5V @ 350 mA

APRIL 2010



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
ow Noise Amplifier	HMC392LC4	HMC516LC5	HMC516LC5	HMC504LC4B	HMC517LC4	HMC341LC3B
	HMC392LH5	HMC564	HMC565	HMC516LC5	HMC519LC4	HMC504LC4B
	HMC564	HMC564LC4	HMC565LC5	HMC565	HMC565	HMC517LC4
	HMC564LC4	HMC565		HMC565LC5	HMC565LC5	HMC519
	HMC565 HMC565LC5	HMC565LC5				HMC519LC4
river Amplifier	HMC441LP3E	HMC441LP3E	HMC441LC3B	HMC441LC3B	HMC383LC4	HMC383LC4
Anton Ampinion	HMC451LC3	HMC451LC3	HMC451LC3	HMC451LC3	HMC442LC3B	HMC442LC3B
	HMC516LC5	HMC451LP3E	HMC451LP3E	HMC451LP3E	HMC451LP3E	HMC498LC4
		HMC516LC5	HMC490LP5E	HMC490LP5E	HMC498LC4	HMC635
					HMC635LC4	HMC635LC4
Power Amplifier	HMC486LP5E	HMC487LP5E	HMC489LP5E	HMC489LP5E	HMC498LC4	HMC498LC4
	HMC590	HMC592	HMC592	HMC-APH462	HMC-APH196	HMC-APH196
	HMC590LP5E	HMC608LC4			HMC-APH462	HMC-APH462
	HMC591				HMC-APH478	HMC-APH518
	HMC591LP5E				HMC-APH596	HMC-APH596
	HMC637 HMC637LP5E					
Videband	HMC463LH250	HMC463LH250	HMC463LH250	HMC463LH250	HMC463LH250	HMC635
Distributed)	HMC606	HMC606	HMC606	HMC606	HMC606	HMC-ALH216
Amplifiers	HMC606LC5	HMC606LC5	HMC606LC5	HMC606LC5	HMC606LC5	HMC-ALH311
	HMC619	HMC633	HMC633	HMC633	HMC634	HMC-ALH445
	HMC619LP5E	HMC633LC4	HMC633LC4	HMC633LC4	HMC634LC4	HMC-ALH476
	HMC633	HMC634	HMC634	HMC634	HMC659	HMC-AUH232
	HMC633LC4	HMC634LC4	HMC634LC4	HMC634LC4	HMC-ALH102	HMC-AUH249
	HMC634	HMC-C050	HMC-C050	HMC-C050	HMC-C050	HMC-AUH256
	HMC634LC4	HMC-ALH102	HMC-ALH102	HMC-ALH102	HMC-ALH216	HMC-AUH312
	HMC COEO	HMC-ALH435 HMC-ALH444	HMC-ALH435	HMC-ALH216	HMC-ALH435 HMC-ALH445	
	HMC-C050 HMC-ALH102	HMC-ALH482	HMC-ALH482 HMC-AUH232	HMC-ALH435 HMC-ALH476	HMC-ALH476	
	HMC-ALH435	HMC-AUH232	HMC-AUH249	HMC-ALH482	HMC-ALH482	
	HMC-ALH444	HMC-AUH249	HMC-AUH312	HMC-AUH232	HMC-AUH232	
	HMC-ALH482	HMC-AUH312		HMC-AUH249	HMC-AUH249	
	HMC-AUH232			HMC-AUH312	HMc-AUH256	
	HMC-AUH249				HMC-AUH312	
	HMC-AUH312					
Attenuator: Analog	HMC346LP3E	HMC346LP3E	HMC346LP3E	HMC346LC3B	HMC346LC3B	HMC812LC4
	HMC812LC4 HMC-C053	HMC812LC4 HMC-C053	HMC812LC4 HMC-C053	HMC812LC4	HMC-C053	HMC-VVD102
				HMC-C053	HMC-VVD102	
Divide-by-2	HMC361S8GE	HMC364S8GE	HMC492LP3E	HMC492LP3E	HMC492LP3E	11110117
Divide-by-4	HMC362S8GE	HMC365S8GE	HMC493LP3E	HMC493LP3E	HMC447LC3	HMC447LC3
Divide-by-8	HMC363S8GE	HMC363S8GE	HMC494LP4E	HMC494LP4E	LIMC440LC0D	LIMC440LCOD
Multiplier: Active X2	HMC368LP4E HMC575LP4E	HMC368LP4E HMC573LC3B	HMC368LP4E HMC573LC3B	HMC368LP4E HMC573LC3B	HMC448LC3B	HMC448LC3B
	HMC561LP3E	HMC561LP3E	HMC561LP3E	HMC561LP3E	HMC576 HMC576LC3B	HMC576 HMC576LC3B
	THEOGOTE OF	HMC-XDB112	HMC-XDB112	HMC-XDB112	1111100702000	111100702002
Multiplier: Active X4		HMC443LP4E	HMC370LP4E	HMC370LP4E		
				HMC-XDH158		
Multiplier: Passive X2	HMC189AMS8E	HMC189AMS8E	HMC204MS8GE	HMC204MS8GE	HMC204MS8GE	HMC205
/Q Downconverter / Rx	HMC567LC5	HMC568LC5	HMC869LC5	HMC570	HMC571	HMC572
/Q Upconverter/Tx				HMC570LC5	HMC571LC5	HMC572LC5
				HMC709LC5	HMC710LC5	HMC815LC5
/Q Mixer / IRM	HMC520LC4	HMC521LC4	HMC521LC4	HMC522LC4	HMC523	HMC523
	HMC525LC4	HMC527LC4	HMC527LC4	HMC528LC4	HMC523LC4	HMC523LC4
	HMC620					HMC524
	HMC620LC4			10.00.00.00		HMC-MDB172
Mixer:	HMC129LC4	HMC144LC4	HMC144LC4	HMC144LC4	HMC144LC4	HMC260LC3B
undamental	HMC144LC4	HMC411MS8GE	HMC411MS8GE	HMC260LC3B	HMC260LC3B	HMC292LC3B
	HMC219MS8E	HMC412MS8GE	HMC412MS8GE	HMC412MS8GE	HMC292LC3B	
	HMC220MS8E HMC553	HMC553 HMC553LC3B	HMC553 HMC553LC3B	HMC554 HMC554LC3B	HMC554 HMC554LC3B	
	HMC553LC3B	HMC558	HMC558	HMC558	HMC-C051	
	HMC558	HMC558LC3B	HMC558LC3B	HMC558LC3B		
	HMC558LC3B	HMC-C051	HMC-C051	HMC-C051		
	HMC663LC3	HMC663LC3				



A selection of components, see the full product listing starting on page 10.

MICROWAVE & MILLIMETERWAVE RADIO, 7 to 23 GHz

7 / 8 GHz	11 GHz	13 GHz	15 GHz	18 GHz	23 GHz
			HMC258LM3	HMC258LC3B	HMC264LC3B
				HMC258LM3	HMC338LC3B
				HMC337	
HMC698LP5E					
HMC699LP5E					
HMC700LP4E					
HMC701LP6CE					
HMC547LP3E	HMC607	HMC547LP3E	HMC607	HMC547LP3E	
HMC641	HMC641	HMC641	HMC641	HMC641	
HMC-T2000					
HMC466LP4E	HMC513LP4E	HMC513LP4E	HMC529LP4E	HMC429LP4E**	HMC431LP4E**
HMC505LP4E	HMC515LP5E	HMC529LP4E	HMC531LP5E		HMC738LP4E
HMC506LP4E	HMC534LP4E	HMC584LP5E	HMC535LP5E		HMC739LP4E
HMC532LP4E	HMC582LP5E		HMC632LP5E		
HMC586LC4B	HMC588LC4B				
HMC587LC4B	HMC735LP5E		HMC737LP4E		
HMC694	HMC694	HMC694	HMC694	HMC694	
HMC694LP4E	HMC694LP4E	HMC694LP4E	HMC694LP4E	HMC694LP4E	
	HMC698LP5E HMC699LP5E HMC700LP4E HMC701LP6CE HMC547LP3E HMC641 HMC-T2000 HMC466LP4E HMC505LP4E HMC508LP4E HMC586LC4B HMC587LC4B HMC694	HMC698LP5E HMC700LP4E HMC700LP4E HMC701LP6CE HMC547LP3E HMC641 HMC641 HMC-T2000 HMC466LP4E HMC505LP4E HMC505LP4E HMC532LP4E HMC532LP4E HMC532LP4E HMC586LC4B HMC587LC4B HMC587LC4B HMC735LP5E HMC694 HMC694	HMC698LP5E HMC700LP4E HMC700LP4E HMC701LP6CE HMC547LP3E HMC641 HMC641 HMC-T2000 HMC466LP4E HMC513LP4E HMC505LP4E HMC505LP4E HMC532LP4E HMC532LP4E HMC532LP4E HMC532LP4E HMC586LC4B HMC588LC4B HMC587LC4B HMC694 HMC694 HMC694 HMC694	HMC698LP5E HMC699LP5E HMC700LP4E HMC701LP6CE HMC547LP3E HMC641 HMC641 HMC641 HMC641 HMC641 HMC641 HMC72000 HMC466LP4E HMC513LP4E HMC505LP4E HMC505LP4E HMC505LP4E HMC534LP5E HMC532LP4E HMC532LP4E HMC532LP4E HMC532LP4E HMC586LC4B HMC588LC4B HMC735LP5E HMC736LP4E HMC735LP5E HMC694 HMC694 HMC694	HMC258LM3 HMC258LM3 HMC258LM3 HMC258LM3 HMC258LM3 HMC337 HMC699LP5E HMC700LP4E HMC700LP4E HMC701LP6CE HMC641 HMC513LP4E HMC505LP4E HMC505LP4E HMC505LP4E HMC534LP5E HMC534LP5E HMC536LP4E HMC534LP5E HMC536LP4E HMC536LP4E HMC536LP4E HMC586LC4B HMC588LC4B HMC735LP5E HMC694 HMC694 HMC694 HMC694 HMC694 HMC694 HMC694

MICROWAVE & MILLIMETERWAVE RADIO, 26 to 86 GHz

Function	26 / 28 GHz	32 / 38 GHz	32 - 43 GHz	44 - 66 GHz	71 - 86 GHz
ow Noise Amplifier	HMC341LC3B	HMC263	HMC-ALH376	HMC-ALH382	HMC-ALH459
	HMC517LC4	HMC566			HMC-ALH509
	HMC519LC4	HMC635			
	HMC635	HMC693			
	HMC693				
Driver Amplifier	HMC383LC4	HMC300LM1	HMC-APH403	HMC-ABH209	HMC-AUH317
	HMC499LC4	HMC383LC4	HMC-APH473	HMC-ABH241	HMC-AUH318
	HMC635LC4	HMC635LC4	HMC-APH510	HMC-ABH403	HMC-AUH320
Power Amplifier	HMC499LC4	HMC693	HMC693	HMC-ABH209	HMC-ALH508
	HMC693	HMC-ABH264	HMC-ABH264	HMC-ABH241	HMC-AUH317
	HMC-APH196	HMC-APH403	HMC-APH403	HMC-ABH403	HMC-AUH318
	HMC-APH460	HMC-APH473	HMC-APH473		HMC-AUH320
	HMC-APH462	HMC-APH510	HMC-APH510		
	HMC-APH596	HMC-APH596	HMC-AUH256		
	HMC-APH608				
Videband	HMC-ALH140	HMC635	HMC-ALH140	HMC-ALH376	
Distributed)	HMC-ALH216	HMC-ALH140	HMC-ALH244	HMC-AUH312	
mplifiers	HMC-ALH244	HMC-ALH244	HMC-ALH310		
	HMC-ALH311	HMC-ALH310	HMC-ALH313		
	HMC-ALH313	HMC-ALH313	HMC-ALH364		
	HMC-ALH364	HMC-ALH364	HMC-ALH369		
	HMC-ALH369	HMC-ALH369	HMC-ALH376		
	HMC-ALH445	HMC-ALH376	HMC-ALH445		
	HMC-ALH476	HMC-ALH445	HMC-AUH232		
	HMC-AUH232	HMC-AUH249	HMC-AUH249		
	HMC-AUH249	HMC-AUH256	HMC-AUH256		
	HMC-AUH256		HMC-AUH312		
	HMC-AUH312				
Attenuator: Analog	HMC712LP3CE	HMC-VVD106	HMC-VVD106	HMC-VVD106	HMC-VVD104
	HMC812LC4				
	HMC-VVD102				
Divide-by-4	HMC447LC3				
Multiplier: Active x2	HMC448LC3B	HMC449LC3B	HMC598	HMC598	
	HMC577LC4B	HMC578LC3B		HMC-XDH158	
	HMC578LC3B	HMC579			
	HMC598	HMC598			
Multiplier: Active x4					
Multiplier: Passive x2 / x3	HMC331	HMC331			



A selection of components, see the full product listing starting on page 10.

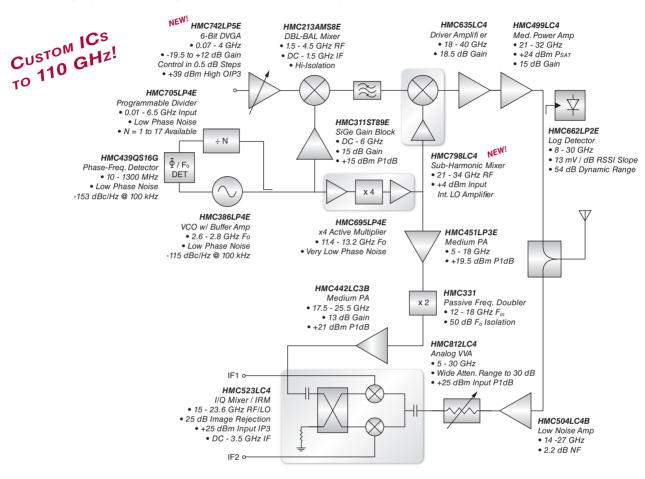
MICROWAVE & MILLIMETERWAVE RADIO, 26 to 86 GHz

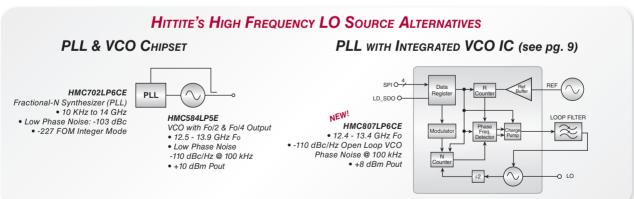
		-,			
Function	26 / 28 GHz	32 / 38 GHz	32 - 43 GHz	44 - 66 GHz	71 - 86 GHz
/Q Receiver	HMC572				
	HMC572LC5				
/Q Mixer / IRM	HMC524	HMC404	HMC-MDB171	HMC-MDB171	
	HMC524LC3B	HMC555	HMC-MDB172	HMC-MDB207	
	HMC-MDB172	HMC556			
Mixer:	HMC292LC3B	HMC294		HMC-MDB169	
undamental	HMC329LC3B	HMC329LM3			
	HMC557	HMC560			
	HMC557LC4	HMC560LM3			
	HMC560				
	HMC560LM3				
Mixer:	HMC264LC3B	HMC338		HMC-MDB218	
Sub-Harmonic	HMC265LM3	HMC339			
	HMC338LC3B	HMC798LC4			
	HMC798LC4				
Power Detectors	HMC662LP3E				
Switch				HMC-SDD112	HMC-SDD112
/CO & PLO:	HMC515LP5E**	HMC505LP4E			
*Requires X2 or X4	HMC531LP5E**	HMC506LP4E			
	HMC639LP4E				
	HMC739LP4E				
Switch				HMC-SDD112	HMC-SDD112
VCO & PLO:	HMC515LP5E**	HMC505LP4E			
Requires X2 or X4	HMC531LP5E	HMC506LP4E			



Microwave & mmWave Communications, Test & Measurement & Sensors, 2 - 86 GHz

DOUBLE UPCONVERSION & DIRECT DOWNCONVERSION





PRODUCTS AVAILABLE IN DIE, SMT OR CONNECTORIZED PACKAGE FORM TO 86 GHZ!



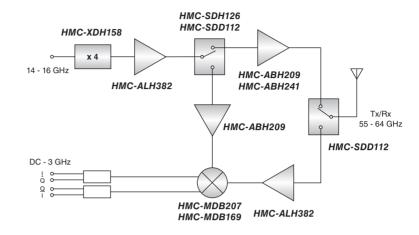


Microwave & mmWave Communications, Test & Measurement & Sensors, 2 - 86 GHz

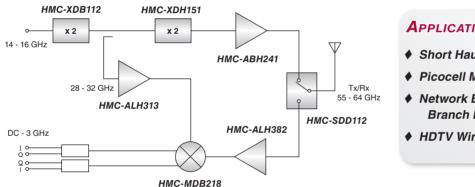
60 GHz Tx/Rx Chipset

FEATURES:

- ♦ < 4 dB LNA Noise Figure
- ♦ +18 dBm Psat PA Output Power
- ♦ Sub-Harmonic Option Available
- ♦ I/Q or Double-Balanced Mixer Products Available



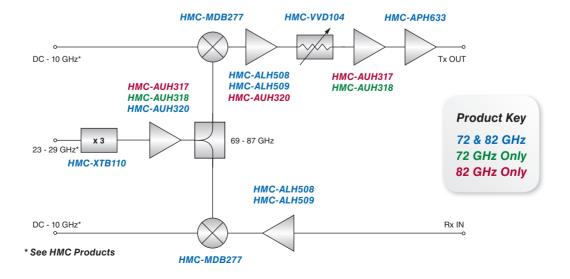
Sub-Harmonic Option for 60 GHz Chipset



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



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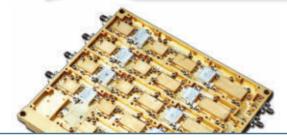




Class B Screening & Qualification

- 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

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- ♦ 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.

Decimonia Kit		Kit Contents				
Designer's Kit	IC	s	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	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 NEW! HMC-DK008			's kit enables users to interface v HMC743LP6CE and HMC792LP			





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COMPETITOR CROSS-REFERENCE

Hittite Microwave Offers Performance & Price Competitive Components

GAIN BLOCKS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performand	Hittite P/N e 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-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	THIIOGOOGTOOL	HMC313E
Gain Blocks	Triquint	AG201-63, AG202-63, AG203-63		HMC474MP86E
Gain Blocks	Triquint	AG201-86, AG202-86, AG203-86	HMC474MP86E	11104741011 001
Gain Blocks	Triquint	AG302-86, AG303-86, ECG001C, ECG004C	HMC476MP86E	
Gain Blocks	Triquint	ECG001F, ACG001B	TIMO470MF00L	HMC476MP86E
Gain Blocks	Triquint	AG503-86, ECG002C, ECG006C	HMC478MP86E	TIMO470IMF00I
	•		TIMO476IMF60L	LMC470MD06
Gain Blocks	Triquint	ECG002F	LIMC470CT00E	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 Gain Blocks	Triquint Triquint	AG603-89, AG604-89, ECG050B, EC1019B AG403-86, ECG005C, ECG055C, AG603-86, AG604-86, ECG050C, EC1019C,	HMC480ST89E HMC481MP86E	
Jani Diocks	riiquirit	EC1078C	I IIVIO40 IIVIPõõE	
Gain Blocks	Triquint	AG403-89, ECG005B, ECG055B	HMC481ST89E	
	Triquint	EC1078B, ECG003, ECG008	HMC482ST89E	



COMPETITOR CROSS-REFERENCE

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	



PART NUMBER INDEX

Part #	Page#	Part #	Page#	Part #	Page#	Part #	Page#	Part #	Page#
HMC128	19	HMC286E	10	HMC389LP4E	23	HMC468LP3E	14	HMC542ALP4E	14
HMC128G8	19	HMC287MS8E	23	HMC390LP4E	23	HMC469MS8GE	11	HMC543	20
HMC129	19	HMC288MS8E	14	HMC391LP4E	23	HMC470LP3E	14	HMC543LC4B	20
HMC129G8	19	HMC290E	14	HMC392	10	HMC471MS8GE	11	HMC544E	22
HMC129LC4	19 19	HMC291E	14	HMC392LC4	10	HMC472LP4E	14	HMC545E	22
HMC130 HMC135	20	HMC292 HMC292LC3B	19 19	HMC392LH5 HMC393MS8GE	10 23	HMC473MS8E HMC474MP86E	13 11	HMC546LP2E HMC546MS8GE	22 22
HMC136	20	HMC292LM3C	19	HMC394LP4E	23 15	HMC474SC70E	11	HMC547LP3E	22
HMC137	20	HMC304MS8E	18	HMC395	11	HMC475ST89E	11	HMC548LP3E	10
HMC141 / 142	19	HMC305ALP4E	14	HMC396	11	HMC476MP86E	11	HMC549MS8GE	11
HMC141C8 / 142C8	19	HMC306MS10E	14	HMC397	11	HMC476SC70E	11	HMC550E	21
HMC141LH5	19	HMC307QS16GE	14	HMC398QS16GE	23	HMC478MP86E	11	HMC551LP4E	18
HMC143 / 144	19	HMC308E	11	HMC399MS8E	18	HMC478SC70E	11	HMC552LP4E	18
HMC144LC4	19	HMC310MS8GE	10	HMC400MS8E	18	HMC478ST89E	11	HMC553	19
HMC144LH5 HMC156	19 16	HMC311LP3E HMC311SC70E	11 11	HMC401QS16GE HMC402MS8E	23 18	HMC479MP86E	11	HMC553LC3B	19
HMC156C8	16	HMC311ST89E	11	HMC404	17	HMC479ST89E HMC480ST89E	11 11	HMC554 HMC554LC3B	19 19
HMC158	16	HMC313E	11	HMC405	11	HMC481MP86E	11	HMC5555	17
HMC158C8	16	HMC316MS8E	18	HMC406MS8GE	11	HMC481ST89E	11	HMC556	17
HMC168C8	18	HMC318MS8GE	10	HMC407MS8GE	11	HMC482ST89E	11	HMC557	19
HMC170C8	19	HMC320MS8GE	10	HMC408LP3E	12	HMC483MS8GE	18	HMC557LC4	19
HMC171C8	18	HMC321LP4E	22	HMC409LP4E	12	HMC485MS8GE	18	HMC558	19
HMC174MS8E	22 19	HMC322	22 22	HMC410AMS8GE	18	HMC486	12	HMC558LC3B	19
HMC175MS8E HMC182S14E	22	HMC322LP4E HMC326MS8GE	11	HMC411MS8GE HMC412MS8GE	19 19	HMC486LP5E HMC487LP5E	12 12	HMC559 HMC560	13 19
HMC183QS24E	22	HMC327MS8GE	12	HMC413QS16GE	11	HMC488MS8GE	18	HMC560LM3	19
HMC187AMS8E	16	HMC329	19	HMC416LP4E	23	HMC489LP5E	12	HMC561	15
HMC188MS8E	16	HMC329LC3B	19	HMC420QS16E	18	HMC490	10	HMC561LP3E	15
HMC189AMS8E	16	HMC329LM3	19	HMC421QS16E	18	HMC490LP5E	10	HMC562	13
HMC190AMS8E	22	HMC331	16	HMC422MS8E	18	HMC491LP3E	10	HMC564	10
HMC194MS8E	22	HMC333E	18	HMC423MS8E	18	HMC492LP3E	15	HMC564LC4	10
HMC197AE HMC199MS8E	22 22	HMC334LP4E HMC335G16	18 14	HMC424	14 14	HMC493LP3E HMC494LP3E	15	HMC565 HMC565LC5	10 10
HMC203	19	HMC336MS8GE	22	HMC424G16 HMC424LH5	14	HMC494LP3E HMC495LP3E	15 20	HMC566	11
HMC204	16	HMC337	19	HMC424LP3E	14	HMC496LP3E	20	HMC566LP4E	11
HMC204C8	16	HMC338	19	HMC425	14	HMC497LP4E	20	HMC567LC5	17
HMC204MS8GE	16	HMC338LC3B	19	HMC425LP3E	14	HMC498	12	HMC568LC5	17
HMC205	16	HMC339	19	HMC426MS8E	15	HMC498LC4	12	HMC570	17
HMC207S8E	18	HMC340ALP5E	19	HMC427LP3E	23	HMC499	12	HMC570LC5	17
HMC208MS8E	18	HMC341	11	HMC429LP4E	23	HMC499LC4	12	HMC571	17
HMC213AMS8E	18 18	HMC341LC3B	10 10	HMC430LP4E	23	HMC500LP3E	20 10	HMC571LC5 HMC572	17 17
HMC214MS8E HMC215LP4E	18	HMC342 HMC342LC4	10	HMC431LP4E HMC432E	23 15	HMC504LC4B HMC505LP4E	23	HMC572LC5	17
HMC218MS8E	18	HMC344	22	HMC433E	15	HMC506LP4E	23	HMC573LC3B	15
HMC219MS8E	19	HMC344LC3	22	HMC434E	15	HMC507LP5E	23	HMC574MS8E	22
HMC220MS8E	18	HMC344LH5	22	HMC435MS8GE	22	HMC508LP5E	23	HMC575LP4E	15
HMC221AE	22	HMC344LP3E	22	HMC436MS8GE	23	HMC509LP5E	23	HMC576	15
HMC224MS8E	22	HMC345LP3E	22	HMC437MS8GE	15	HMC510LP5E	24	HMC576LC3B	15
HMC230MS8E	14	HMC346	13	HMC438MS8GE	15	HMC511LP5E	24	HMC577LC4B	15
HMC231G7	22 22	HMC346C8	13 13	HMC439QS16GE	15	HMC512LP5E	24	HMC578	15 15
HMC232 HMC232C8	22	HMC346G8 HMC346LC3B	13	HMC440QS16GE HMC441	21 12	HMC513LP5E HMC514LP5E	24 24	HMC578LC3B HMC579	16
HMC232G7	22	HMC346LP3E	13	HMC441LC3B	12	HMC515LP5E	24	HMC580ST89E	11
HMC232G8	22	HMC346MS8GE	13	HMC441LH5	12	HMC516	10	HMC581LP6E	18
HMC232LP4E	22	HMC347	22	HMC441LM1	12	HMC516LC5	10	HMC582LP5E	24
HMC233G8	22	HMC347C8	22	HMC441LP3E	12	HMC517	10	HMC583LP5E	24
HMC234C8	22	HMC347G8	22	HMC442	12	HMC517LC4	10	HMC584LP5E	24
HMC239S8E	22	HMC347LP3E	22	HMC442LC3B	12	HMC518	10	HMC585MS8GE	18
HMC240 HMC241LP3E	22 22	HMC348LP3E	22 22	HMC442LM1	12	HMC519	10	HMC586LC4B	23 23
HMC241QS16E	22	HMC349LP4CE HMC349MS8GE	22	HMC443LP4E HMC444LP4E	16 16	HMC519LC4 HMC520	10 17	HMC587LC4B HMC588LC4B	23
HMC244G16	22	HMC350MS8E	18	HMC445LP4E	16	HMC520LC4	17	HMC589ST89E	11
HMC245QS16E	22	HMC351S8E	18	HMC446E	22	HMC521	17	HMC590	12
HMC247	20	HMC358MS8GE	23	HMC447LC3	15	HMC521LC4	17	HMC590LP5E	12
HMC252QS24E	22	HMC361	15	HMC448	15	HMC522	17	HMC591	12
HMC253LC4	22	HMC361S8GE	15	HMC448LC3B	15	HMC522LC4	17	HMC591LP5E	12
HMC253QS24E	22	HMC362	15	HMC449	15	HMC523	17	HMC592	12
HMC256 HMC258	17 19	HMC362S8GE	15	HMC449LC3B	15	HMC523LC4	17	HMC593LP3E HMC594	10 10
HMC258LC3B	19	HMC363 HMC363G8	15 15	HMC451 HMC451LC3	11 12	HMC524 HMC524LC3B	17 17	HMC594LC3B	10
HMC258LM3	19	HMC363S8GE	15	HMC451LP3E	11	HMC525	17	HMC595E	22
HMC260	19	HMC364	15	HMC452QS16GE	12	HMC525LC4	17	HMC596LP4E	23
HMC260LC3B	19	HMC364G8	15	HMC452ST89E	12	HMC526	17	HMC597LP4E	20
HMC263	11	HMC364S8GE	15	HMC453QS16GE	12	HMC526LC4	17	HMC598	15
HMC263LP4E	10	HMC365	15	HMC453ST89E	12	HMC527	17	HMC599ST89E	11
HMC264	19	HMC365G8	15	HMC454ST89E	11	HMC527LC4	17	HMC600LP4E	21
HMC264LC3B	19 19	HMC365S8GE	15	HMC457QS16GE	12	HMC528	17	HMC601LP4E	21 21
HMC264LM3 HMC265	19	HMC368LP4E HMC369LP3E	15 15	HMC459 HMC460	13 12	HMC528LC4 HMC529LP5E	17 24	HMC602LP4E HMC603MS10E	14
HMC265LM3	19	HMC370LP4E	16	HMC460LC5	12	HMC530LP5E	24	HMC603WS10E	14
HMC266	19	HMC374E	10	HMC460LC3	12	HMC531LP5E	24	HMC604LP3E	10
HMC270MS8GE	22	HMC377QS16GE	18	HMC462LP5E	12	HMC532LP4E	23	HMC605LP3E	10
HMC271ALP4E	14	HMC380QS16GE	18	HMC463	12	HMC533LP4E	23	HMC606	13
HMC272MS8E	18	HMC381LP6E	18	HMC463LH250	13	HMC534LP5E	24	HMC606LC5	13
HMC273MS10GE	14	HMC383	12	HMC463LP5E	13	HMC535LP4E	24	HMC607	22
HMC274QS16E	14 23	HMC383LC4	12	HMC464	13	HMC536LP2E	22	HMC607G7	22 12
HMC276LP4E HMC276QS24E	23	HMC384LP4E HMC385LP4E	23 23	HMC464LP5E HMC465	13 13	HMC536MS8GE HMC538LP4E	22 20	HMC608LC4 HMC609	12 10
HMC277MS8E	19	HMC386LP4E	23	HMC465LP5E	13	HMC539LP3E	20 14	HMC609LC4	10
HMC284MS8GE	22	HMC387MS8E	18	HMC466LP4E	23	HMC540LP3E	14	HMC610ALP4E	21
HMC285E	18	HMC388LP4E	23	HMC467LP3E	14	HMC541LP3E	14	HMC611	21
ADDII 0040									



PART NUMBER INDEX

Part #		Page#	Part #	Page#	Part #	Page#	Part #	Page#	Part #	Page#
HMC611LI		21	HMC693	12	HMC800LP3E	4, 14	HMC-C001	25	HMC-ABH209	12
HMC612L		21 21	HMC694	23	HMC801LP3E	4, 14	HMC-C002	25	HMC-ABH241	12
HMC613L HMC615L		18	HMC694LP4E HMC695LP4E	23 16	HMC802LP3E HMC807LP6CE	4, 14 21	HMC-C003 HMC-C004	25 25	HMC-ABH264 HMC-ALH102	12 13
HMC616L		10	HMC696LP4E	5, 20	HMC812LC4	13	HMC-C005	26	HMC-ALH140	11
HMC617L		10	HMC697LP4E	20	HMC814	15	HMC-C006	26	HMC-ALH216	10
HMC618L HMC619	P3E	10 13	HMC698LP5E HMC699LP5E	21 21	HMC814LC3B HMC815LC5	15 18	HMC-C007 HMC-C008	26 25	HMC-ALH244 HMC-ALH310	11 11
HMC619L	P5E	13	HMC700LP4E	21	HMC816LP4E	10	HMC-C009	26	HMC-ALH311	11
HMC620	0.4	17	HMC701LP6CE	21	HMC817LP4E	10	HMC-C010	27	HMC-ALH313	11
HMC620L HMC621L		17 18	HMC702LP6CE HMC705LP4E	21 15	HMC818LP4E HMC819LC5	10 18	HMC-C011 HMC-C012	27 25	HMC-ALH364 HMC-ALH369	11 11
HMC622L		18	HMC706LC3C	16	HMC820LP6CE	21	HMC-C012	25	HMC-ALH376	11
HMC623L		18	HMC707LP5E	23	HMC821LP6CE	21	HMC-C014	26	HMC-ALH382	11
HMC624L HMC625L		14 23	HMC708LP5E HMC709LC5	23 17	HMC822LP6CE HMC824LP6CE	21 21	HMC-C015 HMC-C016	26 25	HMC-ALH435 HMC-ALH444	10 10
HMC626L		23	HMC710LC5	17	HMC826LP6CE	21	HMC-C017	25	HMC-ALH445	10
HMC627L		23	HMC711LC5	5, 19	HMC828LP6CE	21	HMC-C018	26	HMC-ALH476	10
HMC628L HMC629L		23 14	HMC712 HMC712LP3CE	13 13	HMC831LP6CE HMC836LP6CE	21 21	HMC-C019 HMC-C020	27 25	HMC-ALH482 HMC-ALH508	13 11
HMC630L		20	HMC713LP3E	21	HMC841LC4B	4, 16	HMC-C021	25	HMC-ALH509	11
HMC631L		20	HMC713MS8E	21	HMC842LC4B	4, 16	HMC-C022	25	HMC-APH196	12
HMC632L HMC633	.P5E	24 13	HMC715LP3E HMC716LP3E	10 10	HMC843LC4B HMC849LP4CE	4, 16 22	HMC-C023 HMC-C024	25 25	HMC-APH403 HMC-APH460	12 12
HMC633L	.C4	13	HMC717LP3E	10	HMC853LC3C	16	HMC-C024	26	HMC-APH462	12
HMC634		13	HMC718LP4E	10	HMC860LP3E	21	HMC-C026	25	HMC-APH473	12
HMC634L HMC635	.C4	13 13	HMC719LP4E HMC720LC3C	10 16	HMC863 HMC864	12 12	HMC-C027 HMC-C028	25 27	HMC-APH478	12
HMC635L	.C4	13	HMC720LP3E	4, 16	HMC865LC3C	13	HMC-C029	27 27	HMC-APH510 HMC-APH518	12 12
HMC636S		10	HMC721LC3C	17	HMC866LC3C	13	HMC-C030	27	HMC-APH596	12
HMC637 HMC637L	DEE	13 13	HMC721LP3E	4 16	HMC869LC5	17	HMC-C031	26	HMC-APH608	12
HMC639S		10	HMC722LC3C HMC722LP3E	4. 16	HMC870LC5 HMC871LC5	13 13	HMC-C032 HMC-C033	26 26	HMC-APH633 HMC-APH634	12 12
HMC641		22	HMC723LC3C	16	HMC874LC3C	14	HMC-C034	26	HMC-AUH232	13
HMC641L	C4	5, 22	HMC723LP3E	4, 16	HMC875LC3C	14	HMC-C035	26	HMC-AUH249	13
HMC642L	C5	21 21	HMC724LC3C HMC725LC3C	16 17	HMC876LC3C HMC881LP5E	14 4, 8, 15	HMC-C036 HMC-C037	25 25	HMC-AUH256 HMC-AUH312	11 13
HMC643		20	HMC726LC3C	16	HMC882LP5E	4, 8, 15	HMC-C038	25	HMC-AUH317	12
HMC643L	.C5	20	HMC727LC3C	16	HMC890LP5E	4, 8, 15	HMC-C039	26	HMC-AUH318	12
HMC644 HMC644L	C5	20 20	HMC728LC3C HMC729LC3C	16 16	HMC891LP5E HMC902	4, 8, 15 4, 10	HMC-C040 HMC-C041	26 26	HMC-AUH320 HMC-MDB169	12 19
HMC646L		22	HMC734LP5E	23	HMC902LP3E	4, 10	HMC-C042	26	HMC-MDB171	17
HMC647	DCE	20	HMC735LP5E	23	HMC903	4, 10	HMC-C043	26	HMC-MDB172	17
HMC647L HMC648	POE	20 20	HMC736LP4E HMC737LP4E	24 24	HMC903LP3E HMC904LC5	4, 10 5, 17	HMC-C044 HMC-C045	26 25	HMC-MDB207 HMC-MDB218	17 17
HMC648L	P6E	20	HMC738LP4E	24	HMC905LP3E	4, 15	HMC-C046	26	HMC-MDB277	19
HMC649	Do-F	20	HMC739LP4E	24	HMC907	4, 12	HMC-C047	26	HMC-SDD112	22
HMC649L HMC650	P6E	20 20	HMC740ST89E HMC741ST89E	11 11	HMC908LC5 HMC910LC4B	5, 17 4, 14	HMC-C048 HMC-C049	25 26	HMC-VVD102 HMC-VVD104	13 13
HMC651		20	HMC741CTGCE	23	HMC913	5, 21	HMC-C050	25	HMC-VVD104	13
HMC652		20	HMC743LP6CE	23	HMC913LC4B	21	HMC-C051	26	HMC-XDB112	16
HMC653 HMC654		20 20	HMC744LC3C HMC745LC3C	16 17	HMC915LP4E HMC974LC3C	18 4	HMC-C052 HMC-C053	27 26	HMC-XDH158 HMC-XTB110	16 16
HMC655		20	HMC746LC3C	16	11W0374E030	-	HMC-C055	27	TIMO-XTBTTO	10
HMC656	Do-F	20	HMC747LC3C	16			HMC-C056	26		
HMC656L HMC657	.P2E	20 20	HMC748LC3C HMC749LC3C	16 16			HMC-C058 HMC-C059	27 25		
HMC657L	P2E	20	HMC750LP4E	13			HMC-C060	26		
HMC658	DOE	20	HMC751LC4	10			HMC-C061	26		
HMC658L HMC659	.P2E	20 13	HMC752LC4 HMC753LP4E	11 10			HMC-C062 HMC-C064	26 26		
HMC659L	.C5	13	HMC754S8GE	11			HMC-C065	26		
HMC660L		14	HMC755LP4E	12			HMC-C070	27		
HMC662L HMC663L		21 18	HMC756 HMC757	12 12			HMC-C071 HMC-C072	27 25		
HMC665L	P4E	18	HMC758LP3E	10			HMC-C073	27		
HMC666L		18	HMC759LP3E	14			HMC-C074	25		
HMC667L HMC668L		10 10	HMC764LP6CE HMC765LP6CE	21 21			HMC-C075 HMC-C076	25 25		
HMC669L		10	HMC770LP4BE	11			HMC-C077	25		
HMC670L		16	HMC771LP4B	4			HMC-C078	5, 27		
HMC671L HMC672L		17 16	HMC771LP4BE HMC772LC4	11 10			HMC-C079 HMC-C200	4, 25 26		
HMC673L		16	HMC773	19			HMC-T2000	28		
HMC674L		14	HMC773LC3B	19			HMC-T2100	28		
HMC675L HMC676L		14 14	HMC774 HMC775LC5	19 17			HMC-T2100B	5, 28		
HMC677L		17	HMC783LP6CE	21						
HMC678L		16	HMC784MS8GE	22						
HMC679L HMC680L		16 23	HMC785LP4E HMC786LP4	18 18						
HMC681L		23	HMC787LC3B	5, 19						
HMC682L	P6CE	18	HMC788LP2E	11						
HMC683L		18	HMC789ST89E	11 16						
HMC684L HMC685L		18 18	HMC791LC4B HMC792LP4E	16 14						
HMC686L	P4E	18	HMC794LP3E	15						
HMC687L HMC688L		18 18	HMC795LP5E HMC797	5, 20 4, 12						
HMC689L		18	HMC797 HMC798LC4	4, 12 19						
HMC690		13	HMC799LP3E	13						

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