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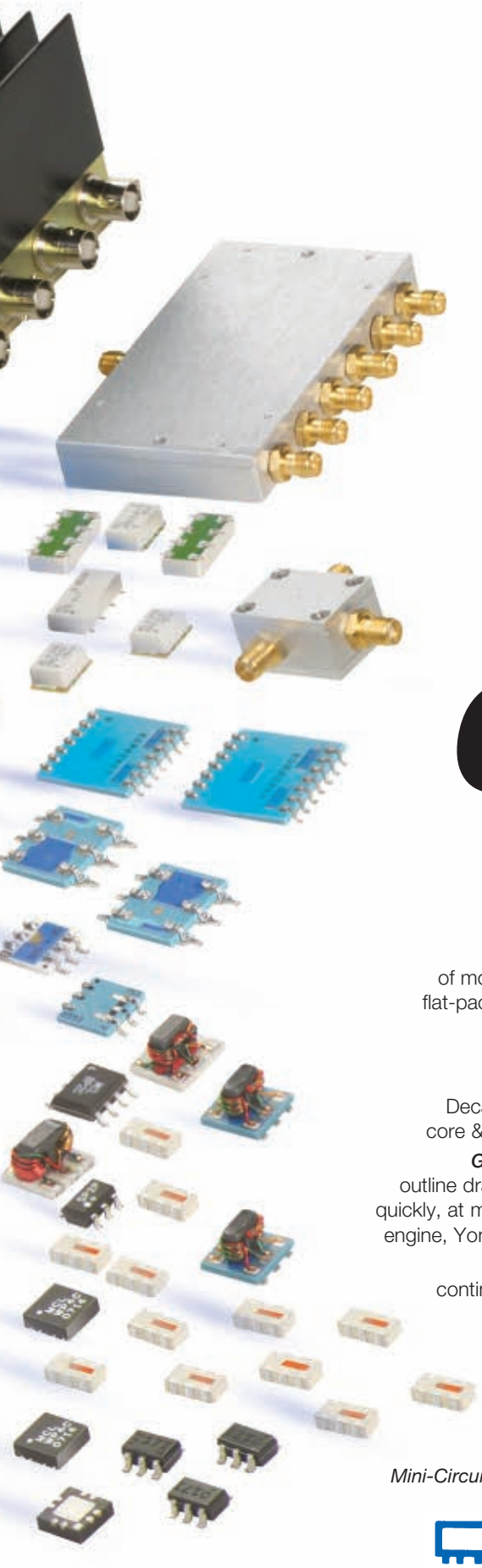
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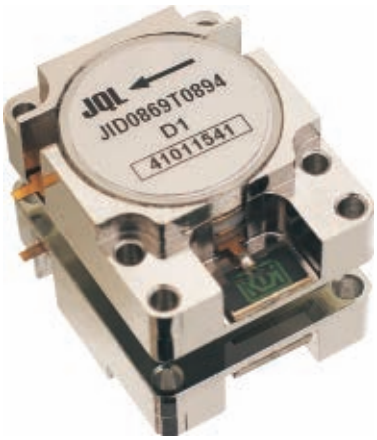
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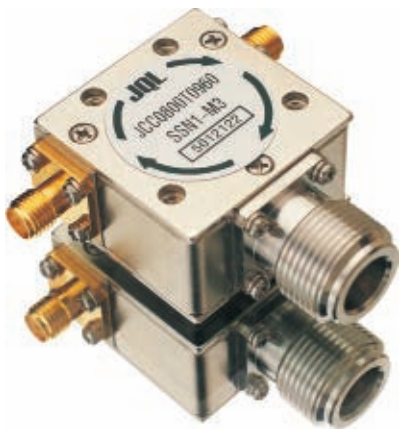
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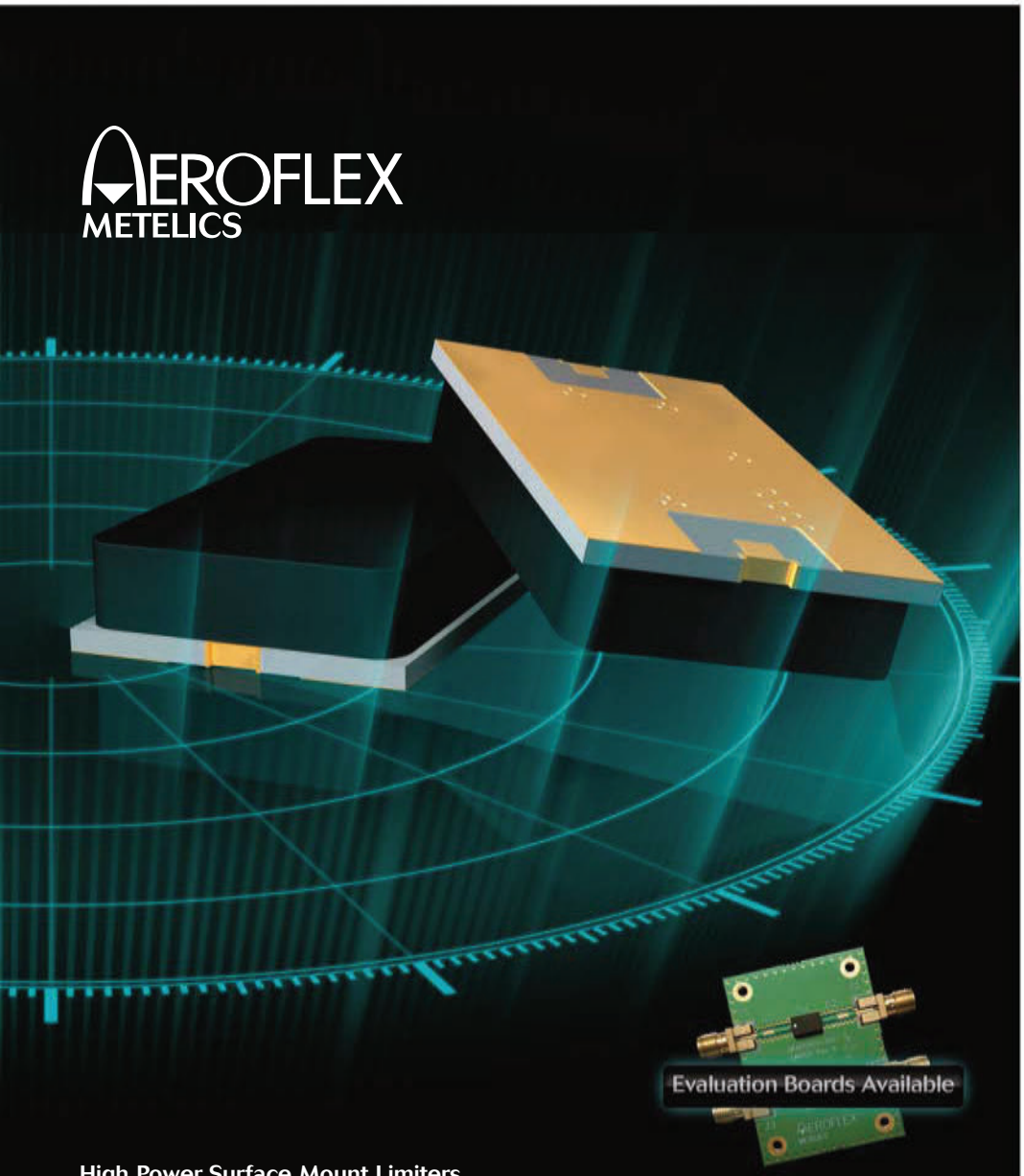


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LM501202-M-C-300	Octave Band, Medium Power	500-2000	0.4	30
LM202602-H-A-300	High Power	2000-6000	0.85	4
LM202602-H-C-300				
LM202802-L-C-300	Octave Band, Low Power	2000-8000	1.0	5
LM202802-M-C-300	Octave Band, Medium Power	2000-8000	1.2	30
LM401102-Q-B-301	Octave Band, High Power "Quasi-Active"	400-1000	0.3	125
LM401102-Q-C-301				
LM102202-H-C-301	Octave Band, High Power "Quasi-Active"	1000-2000	0.35	125
LM102202-Q-C-301				
LM202402-Q-C-301	Octave Band, High Power "Quasi-Active"	2000-4000	0.5	100
LM202402-Q-E-301	Octave Band, High Power "Quasi-Active"	2000-4000	0.5	125
LM202402-Q-F-301	Octave Band, High Power "Quasi-Active"	2000-4000	0.5	100
LM202802-Q-C-301	Octave Band, High Power "Quasi-Active"	2000-8000	1.1	125
LM2933-Q-B-301	High Power, Passive Two-stage Power Limiter	2900-3300	0.6	100

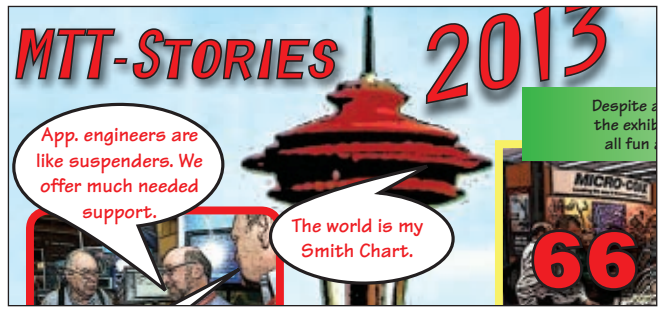
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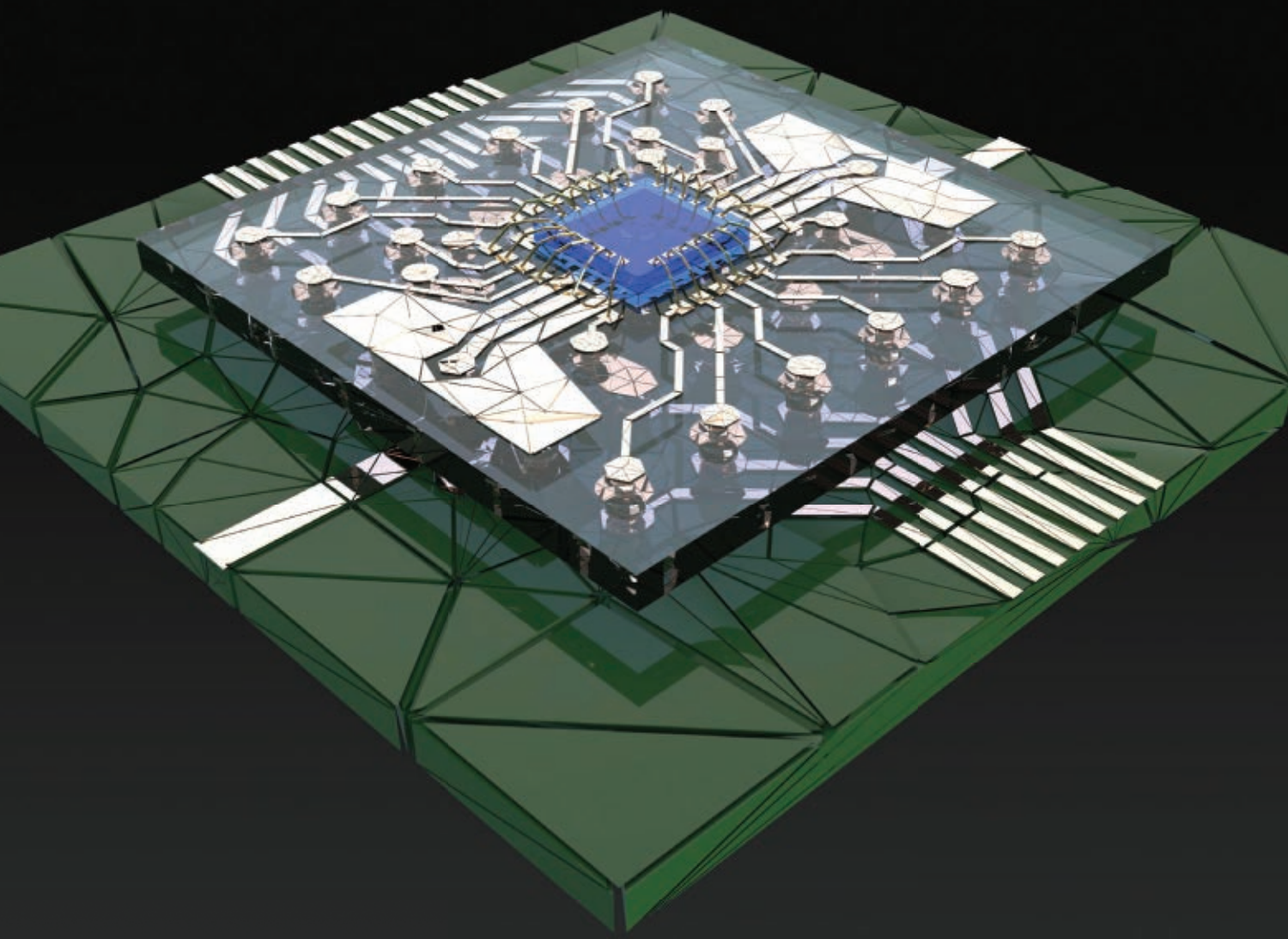
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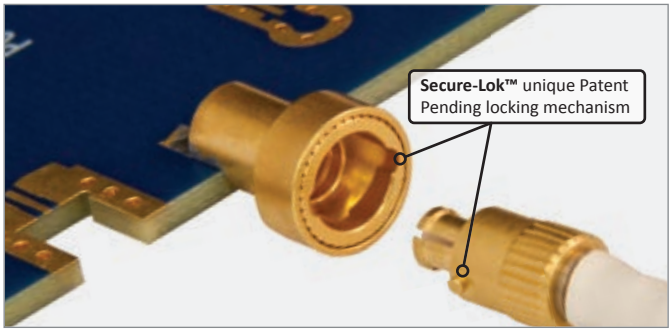


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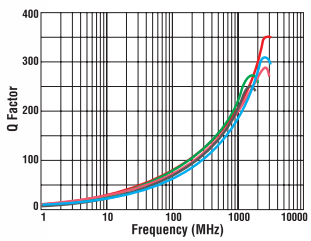
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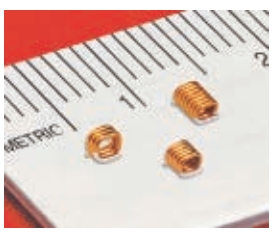
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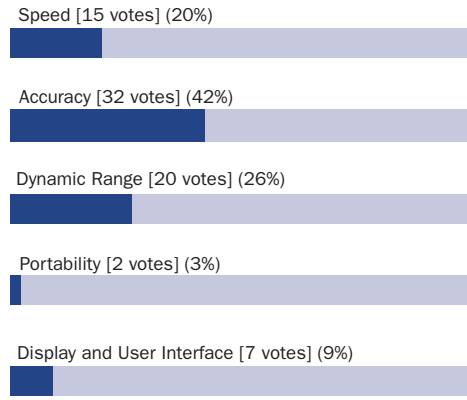
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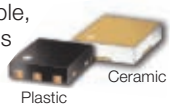


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2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	1	2	3	4	5	6

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May 21–23, 2013 • Las Vegas, NV
www.ctia2013.com

NCMMW 2013
National Conference on Microwave and Millimeter Wave

MWIE 2013
Microwave Industry Exhibition
May 21–24, 2013 • Chongqing, China
www.cnmw.org

JUNE

RFIC 2013
IEEE Radio Frequency Integrated Circuits Symposium
June 2–4, 2013 • Seattle, WA
www.rfic2013.org

IMS 2013
IEEE MTT-S International Microwave Symposium
June 2–7, 2013 • Seattle, WA
www.ims2013.org

81st ARFTG Microwave Measurement Conference
June 7, 2013 • Seattle, WA
www.arftg.org

AUGUST

EMC 2013
IEEE International Symposium on Electromagnetic Compatibility
August 5–9, 2013 • Denver, CO
www.emc2013.org

AUVSI's Unmanned Systems 2013
August 12–15, 2013 • Washington, D.C.
www.auvsishow.org

SEPTEMBER

IRMMW-THz 2013
38th International Conference on Infrared, Millimeter and Terahertz Waves
September 1–6, 2013 • Mainz, Germany
www.theconference2013.com

MMS 2013
13th Mediterranean Microwave Symposium
September 2–5, 2013 • Saida, Lebanon
www.iutsaida.ul.edu.lb/mms2013

ICUWB 2013
IEEE International Conference on Ultra-Wideband
September 15–18, 2013 • Sydney, Australia
www.icuwb2013.org

ION GNSS+ 2013
September 16–20, 2013 • Nashville, TN
www.ion.org

OCTOBER

AMTA 2013
35th Annual Symposium of the Antenna Measurement Techniques Association
October 6–11, 2013 • Columbus, OH
www.amta2013.org

EuMW 2013
European Microwave Week
October 6–11, 2013 • Nuremberg, Germany
www.eumweek.com

Phased Array 2013
IEEE International Symposium on Phased Array Systems & Technology
October 15–18, 2013 • Boston, MA
www.array2013.org

Microwave Update 2013
October 18–19, 2013 • Morehead, KY
www.microwaveupdate.org

IEEE COMCAS 2013
International Conference on Microwaves, Communications, Antennas and Electronic Systems
October 21–23, 2013 • Tel Aviv, Israel
www.comcas.org

IME/China 2013
8th International Conference and Exhibition on Microwave and Antenna
October 23–25, 2013 • Shanghai, China
www.imwexpo.com

4G World 2013
October 28–30, 2013 • Dallas, TX
www.4gworld.com

NOVEMBER

APMC 2013
Asia-Pacific Microwave Conference
November 5–8, 2013 • Seoul, Korea
www.apmc2013.org

2013 Loughborough Antennas & Propagation Conference
November 11–12, 2013 • Loughborough, UK
www.lapconf.co.uk

MILCOM 2013
Military Communications Conference
November 17–20, 2013 • San Diego, CA
www.milcom.org

DECEMBER

AEMC
4th Applied Electromagnetics Conference
December 18–20, 2013 • Bhubaneswar, India
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JANUARY

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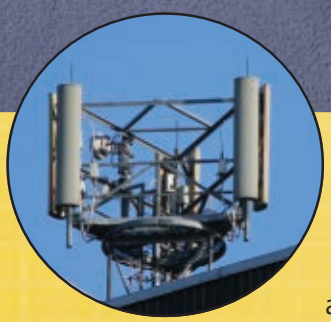
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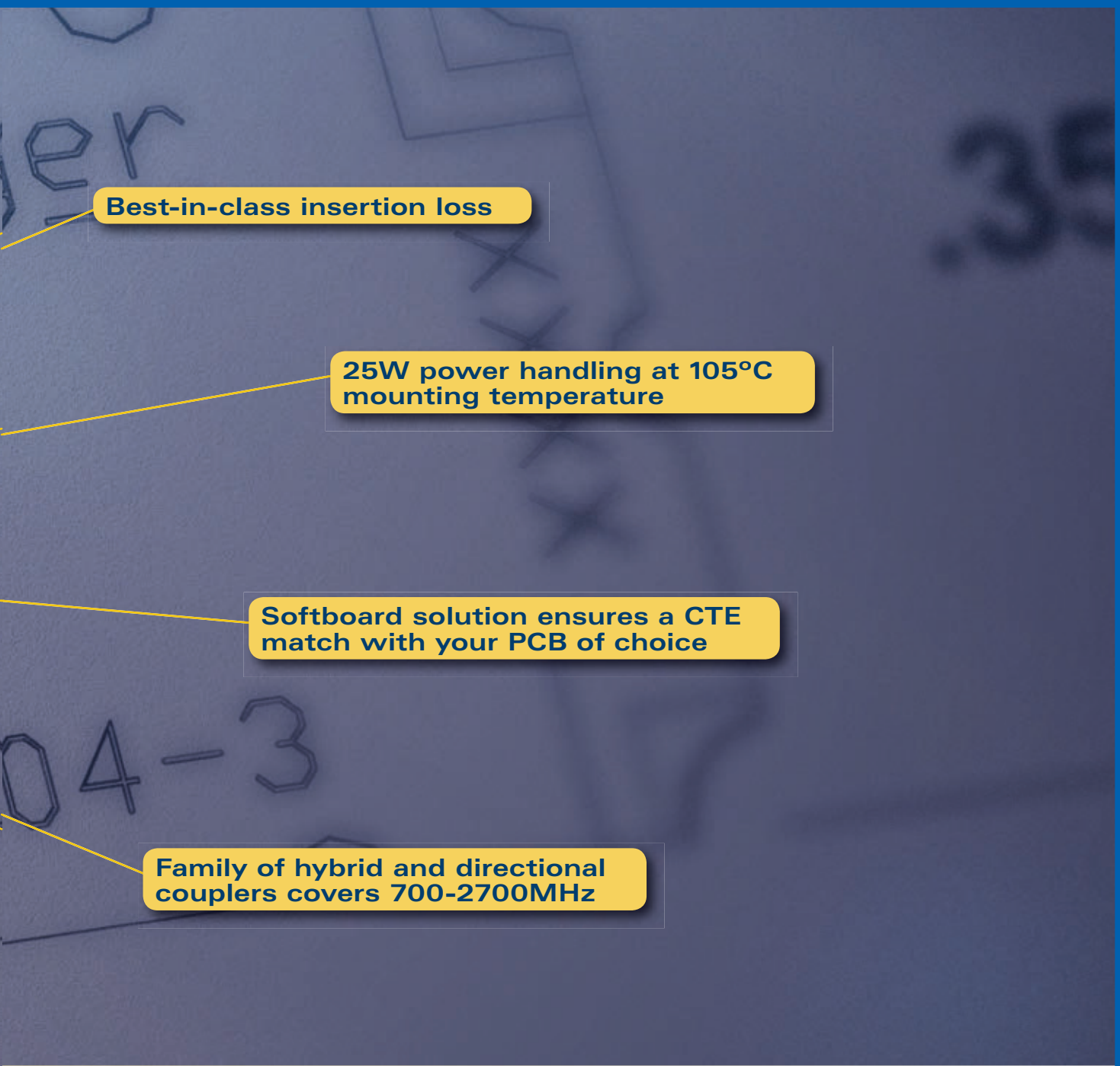
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Back in Seattle Again

Hello, Привет, 你好, willkommen, 인사, bom dia, whaddup dudes! and welcome to our "Microwaves International" special edition MTT-S IMS Show issue, celebrating the emerging communities of the global high-frequency electronics industry. From Barcelona to Beijing, Seattle to Saint Petersburg, the microwave technology footprint continues to grow as communication systems proliferate and aerospace/defense markets worldwide expand to meet regional requirements. With sequestration and economic uncertainty at home, companies are wise to pursue each and every reasonable opportunity, including those offshore. And so, as the industry prepares to converge next month at IMS, we are pleased to present a global perspective in addition to our annual preview of North America's largest microwave symposium and exhibition.

Since new markets in Asia, South America, Eastern Europe and Russia have opened up, many of the companies have been expanding their international presence. In 2012, we joined the globalization movement with the launch of *Microwave Journal China* and announced the launch of the Electronic Design Innovation Conference (EDI CON), an industry-driven event which took place this past March in Beijing. Both have been very well received by a growing audience of microwave technologists in China, allowing the Journal to expand its media reach on behalf of multi-national companies pursuing business there and establishing a beachhead for more companies to follow.

Engineering resources are essential to the health of our industry. Such resources, represented by a thriving technical community, combined with financial resources and a demand for systems requiring high-frequency components create microwave business opportunities. Through a native-language media outlet and world-class, industry-driven conference/exhibition, *MWJ China* and EDI CON allow the industry to support a growing Chinese RF community with technical information and products.

In this issue, we look at this emerging community and its unique technology needs in our recap of EDI CON 2013. This EDI CON special report reveals that the world's largest mobile device market is about to transition to mobile broadband and microwave backhaul technology on a massive scale, the country is in the conceptual planning stage for government sponsored smart cities and next generation satellite navigation systems and has substantial demand for the communication ICs that will support these initiatives.

From Beijing we travel to Russia where Dr. Alexander Chenakin, vice president at Phase Matrix introduces our readers to Russian companies at the forefront of design and manufacture of oscillators, synthesizers and test equipment in this market. At the Journal, we have witnessed an increasing level of activity among Russian microwave companies in Europe at EuMW and China at EDI CON.

As an internationally recognized expert in the field of microwave frequency synthesis with a PhD degree from Kiev Polytechnic Institute, Chenakin provides unique insight into the Russian microwave community. Chenakin shares his intimate knowledge of the country's microwave history, its technical strengths and some of the individuals and companies to watch for.

Closer to home, we turn our attention to the gathering of IMS delegates and exhibitors next month with coverage of this year's activities including a special report on two new events – Wireless Industry Day, hosted by the local IEEE Seattle Chapter, and the "Death of GaAs?" panel, hosted by Strategy Analytics. Guest editorial from the IMS, RFIC and ARFTG symposia chairs preview the technical program.

From year to year, depending on the location and economy, IMS attracts approximately 2000 delegates, 1500 exhibitor attendees, and 4000 exhibitor staff. This yearly get-together gives attendees the chance to connect with friends and former colleagues in the exhibition hall, social events, hotel lobbies and airport lounges. To acknowledge this social component of Microwave Week, we offer our third installment of "MTT-Stories," a graphic novel depicting the event's lighter side.

Many exhibitors will time their new product launches to coincide with Microwave Week to capitalize on this concentration of microwave technologists. The Journal is grateful to those companies with the foresight and resources to provide a preview of these new products in this month's new product section and the advertisements throughout this issue. Doing so helps IMS attendees get a sense of hot products, which companies to visit and what to look for. Those not attending IMS are sure to appreciate the information as well.

We conclude the May issue with this month's Puzzler – Mr. Smith's (aka Smitty) Super Seattle Scavenger Hunt, our tip of the hat to the famous icons that define this great city of the Pacific Northwest. Seattle offers great sights, excellent dining and fun entertainment. Hopefully, you will be among those of us enjoying all the city has to offer as we gather for the North American leg of the international microwave community's world tour. Happy reading and safe travels.

David Vye
Microwave Journal *Editor*

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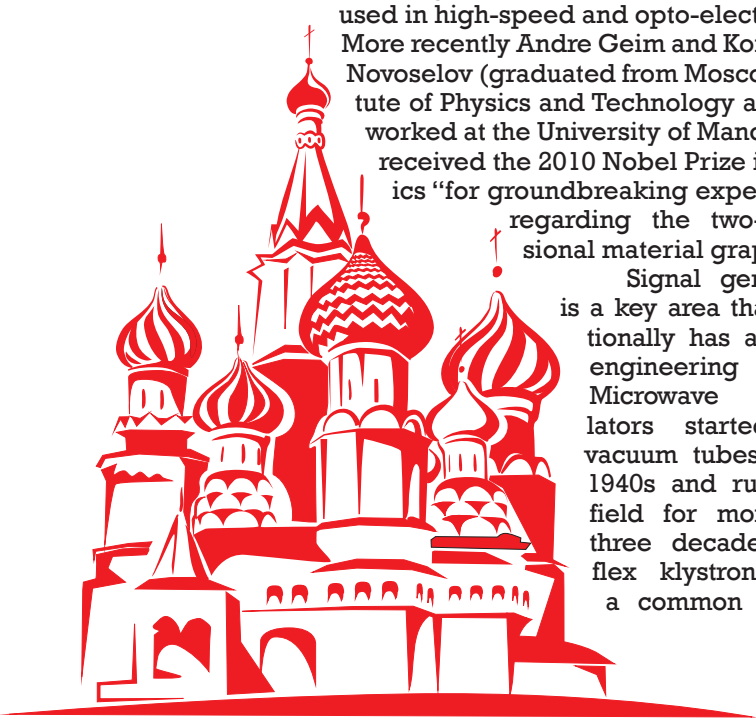
Agilent Technologies

From a Russian Source

Oscillator and Synthesizer Developments in Russia

There have been many recent developments in the Russian RF/microwave signal generation and test & measurement industry spurred by investments from the government. In keeping with this month's 'Microwaves International' theme, Alexander Chenakin examines some of these recent developments in the Russian market. He highlights various new technology developments and introduces some of the leading Russian companies involved in the industry.

Russia has traditionally been a large center for microwave activities.[1,2] This can be traced back to 1894 when Alexander Popov built a device, called the "coherer," that detected electromagnetic waves. Essentially, Popov's device proved that radio communication was feasible by receiving radio waves. Since those days, Russian engineers and scientists have made major contributions to the microwave industry as recently recognized by the 2000 Nobel Prize in physics received by Zhores Alferov "for developing semiconductor heterostructures used in high-speed and opto-electronics." More recently Andre Geim and Konstantin Novoselov (graduated from Moscow Institute of Physics and Technology and then worked at the University of Manchester) received the 2010 Nobel Prize in physics "for groundbreaking experiments regarding the two-dimensional material graphene."



Signal generation is a key area that traditionally has attracted engineering talents. Microwave oscillators started with vacuum tubes in the 1940s and ruled the field for more than three decades.[3] Reflex klystrons were a common way to generate low to moderate power levels in those days. A typical klystron capable of generating tens of milliwatts of microwave power with its DC supply used to be the size of some test equipment today. Nevertheless, it provided a relatively clean signal due to the inherent high-Q cavity utilized. Higher output power levels were achieved with magnetrons using the interaction of a stream of electrons with magnetic field. Solid-state devices started playing a role in signal generation around 1970. Gunn and IMPATT diodes were early devices that were widely used to construct microwave oscillators up to 100 GHz. A Gunn oscillator utilizes a negative resistance effect created in a solid-state diode structure when a DC bias is applied. Gunn oscillators have the advantage of lower phase noise compared to IMPATT oscillators. On the other hand, IMPATT diode oscillators exhibit a higher output power and higher efficiency compared to the Gunn. Further improvements were associated with a progress in transistor devices. The extension of the bipolar transistors to microwave frequencies and the development of GaAs FET devices in the 1970s have made compact, cost-effective and low-noise sources for use in the microwave and millimeter-wave frequency ranges possible.

ALEXANDER CHENAKIN
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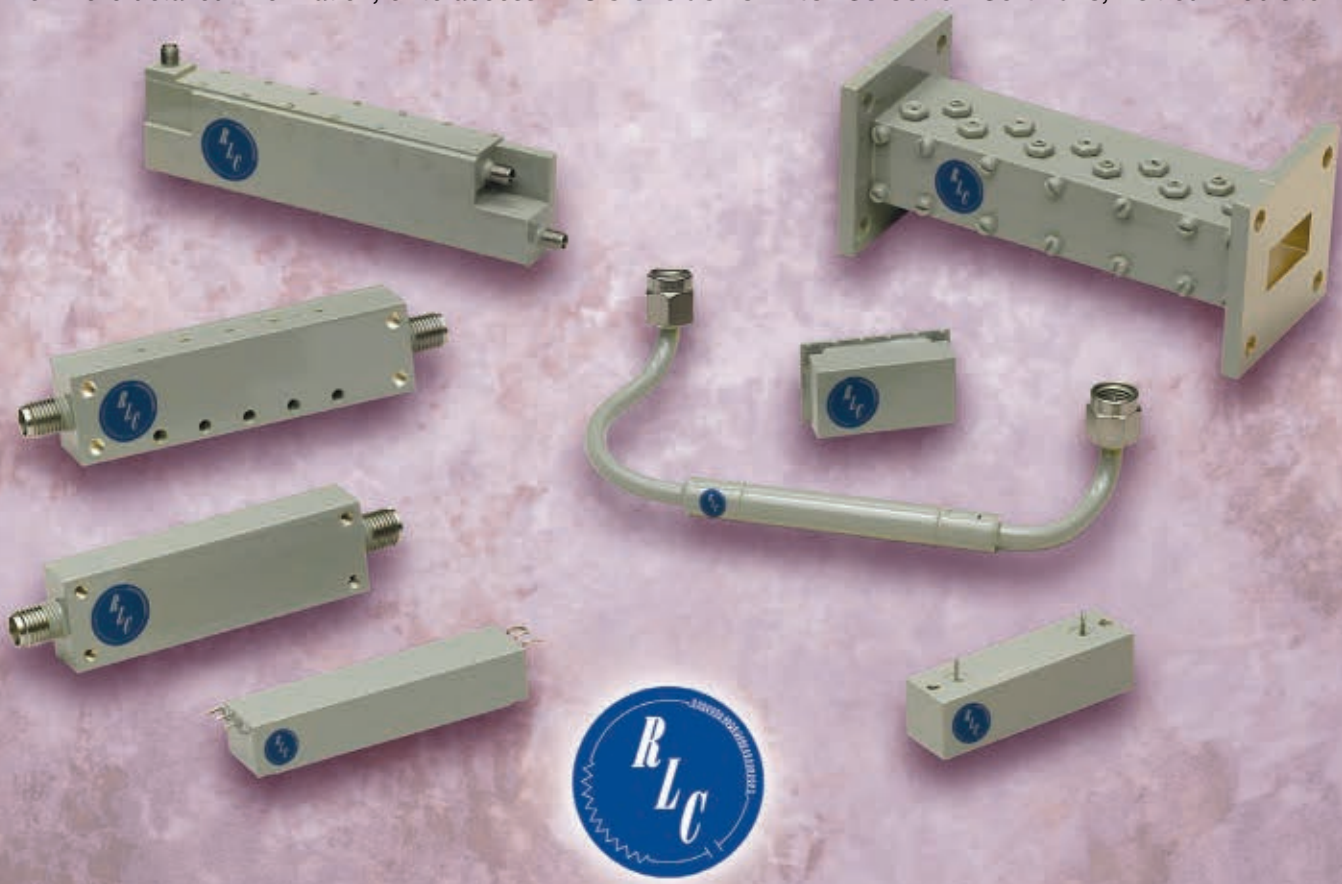
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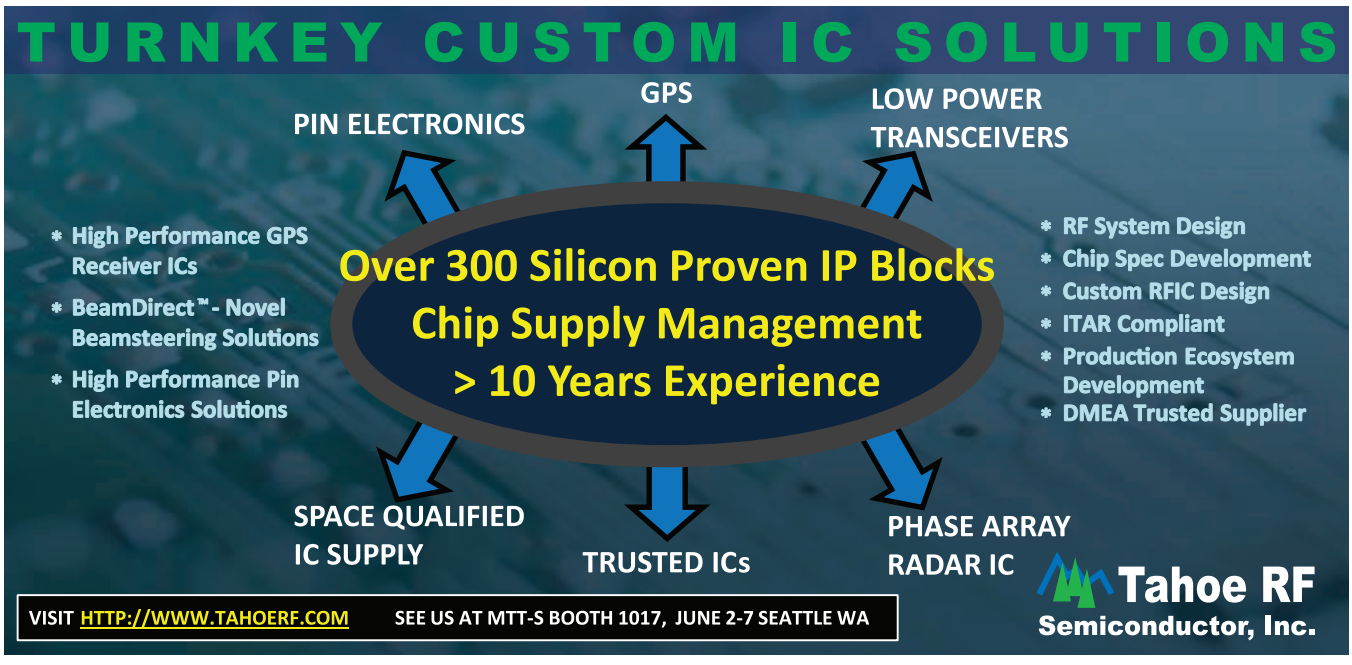
The integration trend continued absorbing discrete devices into more complex and sophisticated solutions. Eventually, frequency synthesizer technologies gained in popularity. A frequency synthesizer is essentially a device that translates one (or more) input reference frequency (typically created with a crystal oscillator) to a number of output frequencies with desired characteristics. Today, the frequency synthesizer is a key component of virtually any test and measurement, communication and monitoring system. It generates a stimulus signal and is used as a local oscillator (LO) source in a variety of up- and down-conversion schemes.

Synthesizer designs utilize various techniques and are almost as diverse as the number of their applications.[4,5] Although all synthesizers exhibit significant differences as a result of specific applications, they share basic fundamental design objectives. The ideal synthesizer should be broadband with fine frequency resolution that allows addressing a larger number of potential applications. Aside from frequency coverage and resolution, phase noise and spurs are critical parameters that impose the ultimate limit in the system's ability to resolve signals of small amplitude. Another key parameter of the synthesizer that impacts overall system performance is frequency switching speed. The time spent by the synthesizer transitioning between frequencies becomes increasingly valuable since it cannot be used for data processing. Modern synthesizers tend to be faster due to the ongoing increase of the data rates of RF/microwave systems. Another challenge is cost reduction. These requirements — wide frequency coverage, small step size, fast switching speed, adequate spectral purity and low cost — are the key drivers in the development of modern frequency synthesizers.[6]

The Russian government recently issued several programs for research, development and innovation in science, education and technologies. Not surprisingly, there are many new developments in the RF/microwave frequency generation area.[7-17] This article provides an overview of microwave oscillator and frequency synthesizer developments in Russia. It starts with crystal oscillators traditionally used as references and then progresses to chip-level and connectorized module developments. The review concludes with some more sophisticated instrument-level solutions.

CRYSTAL OSCILLATORS

Crystal oscillators have been the industry's workhorse for the embeddable, precise timing base used in frequency synthesizers. **Morion Inc.** (www.morion.com.ru) is a leading Russian supplier of quartz frequency control products such as crystal oscillators, filters and crystals themselves. They originated from a Siemens & Halske telegraph workshop established around 1855 and started the production of quartz devices in the early 1930s. Since 1971, the company has been named Morion (which is a name of the natural dark colored quartz) and is a dedicated quartz devices manufacturer. With over 75 years of experience, Morion has become a premier producer of high-end quartz products. The company is located in Saint Petersburg employing about 500 people. It is currently lead by Dr. Yakov Vorokhovsky who received a prestigious IEEE award in the quartz industry — C. B. Sawyer Memorial Award — "for outstanding entrepreneurship in leading Morion Inc. to become a world class company" (see ***Figure 1***). Under his leadership, Morion became not only the main quartz manufacturer in Russia (over 70 percent of the market of precision devices) but also a well-known name worldwide.

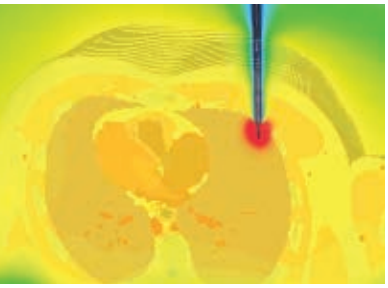




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Fig. 1 In 2001, Dr. Vorokhovsky received an IEEE C. B. Sawyer Memorial Award.

Morion supports and continuously improves quality control based on Russian space and military standards as well as international standards. Since 1999, Morion has been ISO9001 certified. An advantage is that Morion controls the entire production process from a quartz blank to finished quartz oscillators at one facility. This is one key advantage that has enabled Morion to become a reliable supplier for many programs such as COSPAS/SARSAT international space search and rescue system, spacecraft "Buran," international space station "Alfa," international space project "Sea Launch," NASA's project "Mars Odyssey 2001" and others.

TABLE I

MORION'S OCXOS OFFER GOOD PHASE NOISE AND AGING CHARACTERISTICS

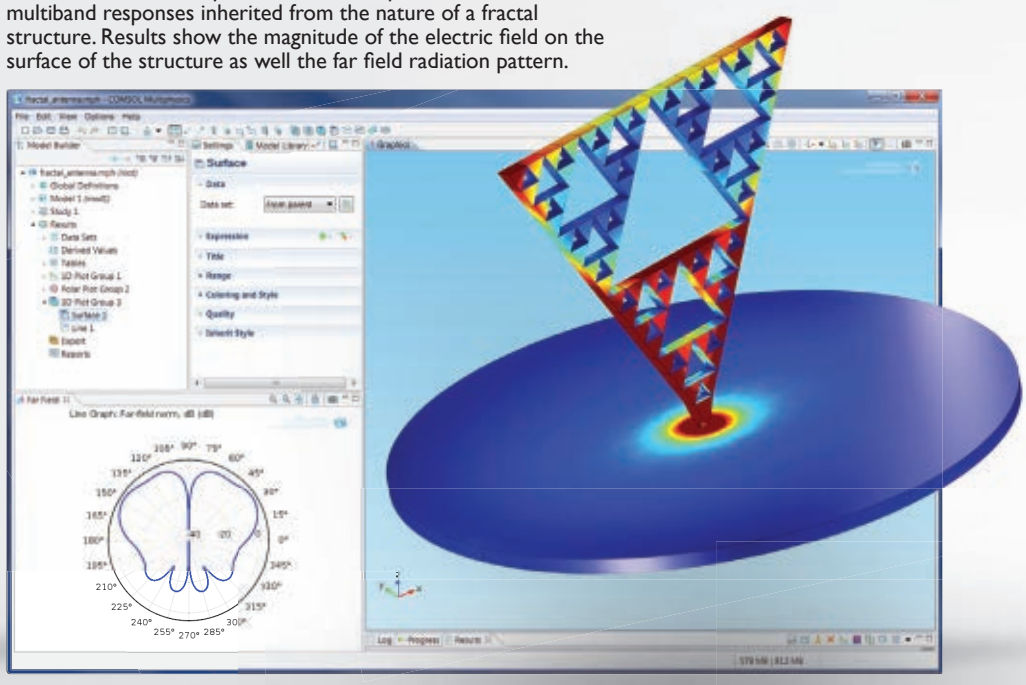
Model	MV317	MV318
Frequency Range	48 to 125 MHz	48 to 125 MHz
Package Size	1"×1"×0.5"	2"×2"×0.5"
Temperature Stability	$\pm5\times10^{-8}$	$\pm5\times10^{-8}$
Aging, per year	$\pm1\times10^{-7}$	$\pm1\times10^{-7}$
Phase Noise at 100 MHz	dBc/Hz	dBc/Hz
10 Hz	-97	-97
100 Hz	-128	-128
1 kHz	-156	-156
10 kHz	-174	-175
100 kHz	-177	-178

One of Morion's core competencies is in the field of oven-controlled crystal oscillators (OCXO). Morion's oscillators are certified for use in the Russian Federal Space Agency programs. For designers of frequency synthesizers, Morion has recently developed a new family of low phase noise OCXOs (MV317 and MV318) offering a noise floor down to –178 dBc/Hz and excellent aging characteristics (see ***Table 1***). These parameters are achieved using in-house proprietary technologies for the design and production of precision blanks in combination with advanced filtering methods incorporated into the OCXO design. In contrast, the MV200 and MV220 models (see ***Table 2***) bring temperature stability of $\pm2\times10^{-10}$ between -40° and +85°C at a 10 MHz output. These oscillators are being used in various time keeping applications. With more than 15 percent of revenues invested annually into R&D, Morion continuously stays on top of precision crystal oscillator developments.

Magic Xtal Ltd. (www.magicxtal.com) was founded in 2001 as a research and production enterprise entirely dedicated to development of advanced oven controlled crystal oscillators for both domestic and international markets. The company currently employs about 80 people and is located in Omsk, a large industrial center in western Siberia. Magic Xtal develops and manufactures OCXOs utilizing the unique internally heated resonator (IHR) technology. The IHR design incorporates the whole oven-controlled system integrated with the crystal plate inside a miniature TO-8 vacuum holder. This ensures extreme-



ANTENNAS: The Sierpinski fractal monopole antenna shows multiband responses inherited from the nature of a fractal structure. Results show the magnitude of the electric field on the surface of the structure as well the far field radiation pattern.



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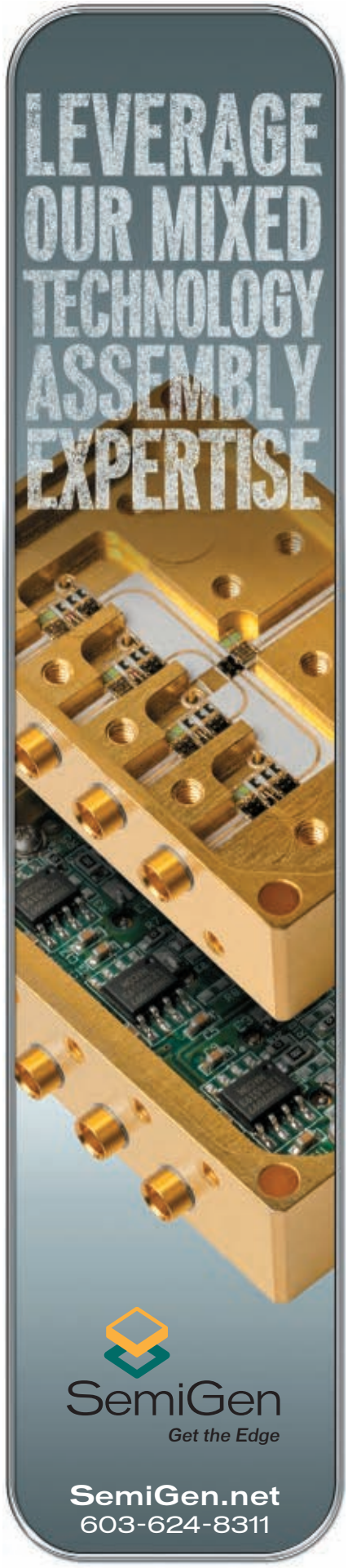
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ly low power consumption, very small size and short warm-up time. Permanent improvements of the IHR design have yielded a family of OCXOs exhibiting high performance characteristics. ***Table 3*** shows the MXO37/8 and MXO37/14 models' performance featuring the DIP8 and DIP14 compatible sizes with less than 150 mW power consumption and 15 to 45 seconds warm-up time. Despite the small sizes and low power consumption, these OCXOs have ±5 ppb frequency stability (between –40° and +85°C), less than 0.2 ppb/day aging and a phase noise floor of –173 dBc/Hz.

Besides the miniature low-power OCXOs, the IHR technology is successfully employed in new double-oven oscillators. The MXODR model provides excellent temperature and long-term frequency stability of a double-oven design in a compact 20 × 20 × 13 mm package (see ***Table 4***). The MXODR oscillators are available at operating frequencies between 8 and 100 MHz and can be used as a Rubidium reference replacement.

TABLE II

MV200 AND MV220 MODELS EXHIBIT ±2X10^{-10} STABILITY (*AT A 10 MHz OUTPUT)

Model	MV200	MV220
Frequency Range	10 to 40 MHz	10 to 40 MHz
Package Size	2"×2"×0.5"	2"×2"×0.5"
Temperature Stability*	±2×10^{-10}	±2×10^{-10}
Aging, per year*	±2×10^{-8}	±2×10^{-8}
Phase Noise*	dBc/Hz	dBc/Hz
10 Hz	-137	-133
100 Hz	-157	-158
1 kHz	-161	-163
10 kHz	-162	-168
100 kHz	-162	-168

TABLE III

MXO37 OVEN CONTROLLED CRYSTAL OSCILLATORS FEATURE SMALL SIZE AND LOW POWER CONSUMPTION

Model	MXO37
Frequency Range	8 to 150 MHz
Temperature Stability (-40° to +85°C)	5 ppb
Aging (10 MHz), per day	0.2 ppb
Phase Noise at 100 kHz offset	-173 dBc/Hz
Power Consumption (at 25°C)	<150 mW
Warm-Up Time (to 0.1 ppm accuracy)	15 to 45 s

TABLE IV

THE MXODR OSCILLATOR INCORPORATES A DOUBLE-OVEN STRUCTURE FOR BETTER THERMAL STABILITY

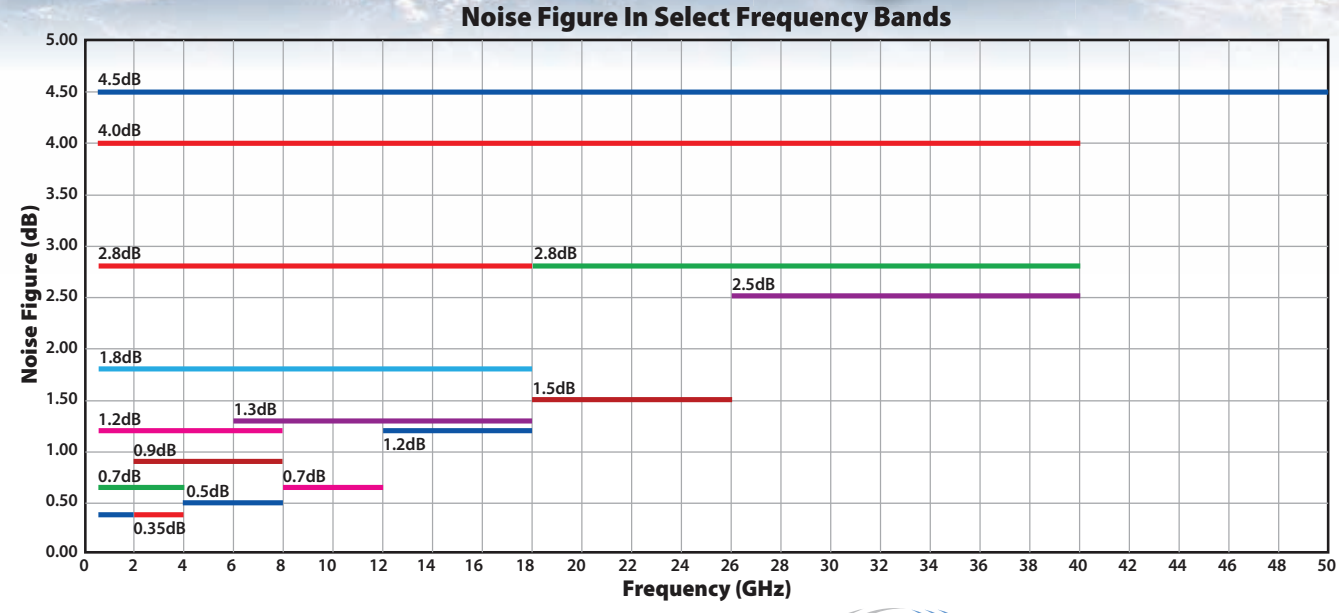
Model	MXODR
Frequency Range	8 to 100 MHz
Temperature Stability (-10° to +60°C)	0.2 ppb
Aging (10 MHz), per day	0.2 ppb
Allan Variance, 1 s	3×10^{-12}
Package Size (mm)	20×20×13

SYSTEM-ON-A-CHIP

Frequency synthesizers come in a variety of forms ranging from tiny chips and moderate-size modules to bench-top signal generator instruments. The R&D Center **ELVEES** (www.elvees.ru) is situated in Zelenograd, Moscow region and focuses on system-on-a-chip (SoC) technology. A good example is the 1508PL8T direct digital synthesizer (DDS) featuring two 1 GSPS 10-bit DACs. This IC allows generating digitally programmable sinusoidal waveforms up to 400 MHz with fast frequency hopping and a fine tuning resolution of 48 bits. The frequency tuning control words are loaded into the device via a serial or parallel interface. A high-speed 16-bit parallel interface enables high data rates for advanced modulation schemes and fast reprogramming. The two available channels can operate either independently or synchronously providing quadrature output signals for IQ modulators. A unique feature of the 1508PL8T is built-in correc-

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tion of phase, amplitude and DC offset. Being properly applied, this correction allows suppressing the LO leakage and unwanted sideband in IQ modulators. It also supports a user defined linear sweep, linear FM, up/down ramp at different rates, optional phase reset and mute. The IC is specified to operate between –60° and +85°C. Applications include agile frequency synthesizers, programmable clock generators, FM chirp sources for radars and test and measurement equipment.

TABLE V

A FAST-SWITCHING SYNTHESIZER MODULE DEVELOPED BY SPECTRAN

Frequency Range	9 kHz to 20 GHz
Frequency Resolution	0.01 Hz
Switching Time	3 µs
Output Power	-10 to +10 dBm
Phase Noise at 10 kHz Offset	-98 dBc/Hz at 20 GHz
Spurs	-64 dBc
Dimensions	110×75×20 mm
Weight	250 g

MODULES

Synthesizer modules are developed by many Russian companies. **Spectran** (www.spectran.org) was founded in 2004 in Saratov. The company collaborates with the Central Research Institute of Measurement Equipment developing various frequency synthesizer products. One of the new designs is a low-cost 20 GHz synthesizer module presented in ***Table 5***. This is a phase-lock-loop (PLL) design that integrates a DDS for fine frequency resolution. The module provides 9 kHz to 20 GHz frequency coverage with fast switching speed and a resolution of 0.01 Hz. Phase noise performance is shown in ***Figure 2***. The spur level is managed by simultaneously changing the DDS clock frequency and PLL division ratio. Optimal DDS clock frequencies and division ratios are stored in an internal memory and then fetched by an FPGA that controls synthesizer components. The synthesizer is programmed via a parallel interface; USB, SPI and LAN options are available as well. The design is implemented in a compact metal housing that is 110 × 75 × 20 mm in size.

The research and production company **Micran** (www.micran.ru) was founded in 1991 in Tomsk (western Siberia). Today Micran is a large enterprise employing more than 1100 people that develop and manufacture complex RF/microwave equipment for the test and measurement and related markets. Micran's products include vector and scalar network analyzers, spectrum analyzers, noise figure analyzers and signal sources up to 60 GHz. New developments and research activities are carried out in close cooperation with Tomsk State University of Control Systems and Radioelectronics. Recent develop-

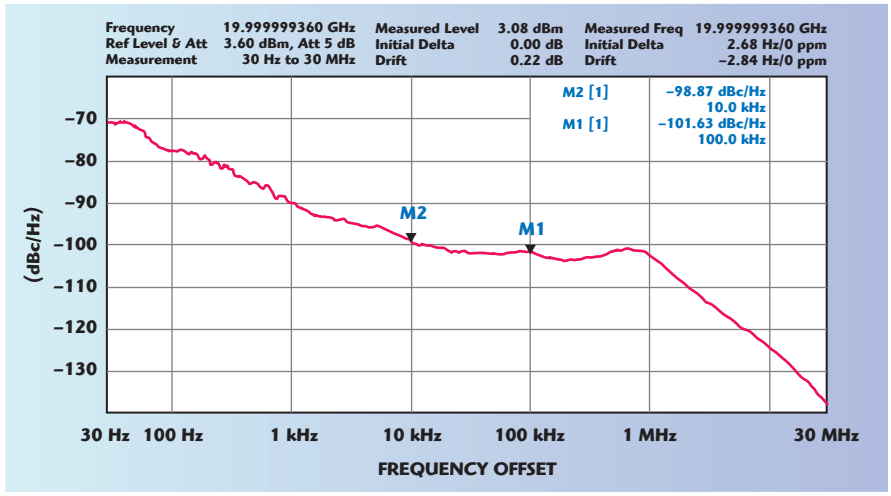
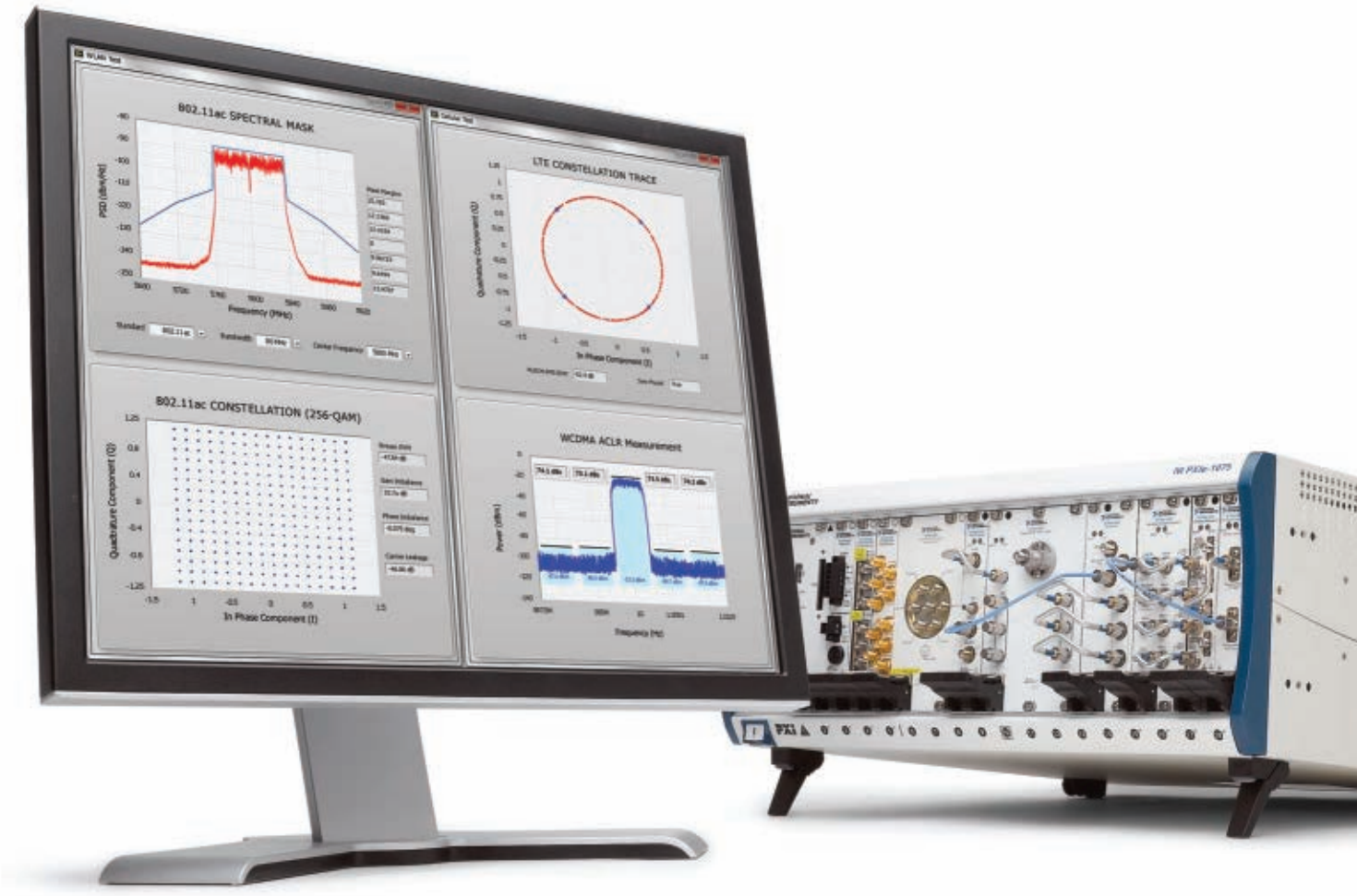


Fig. 2 Spectran's synthesizer phase noise performance at 20 GHz.

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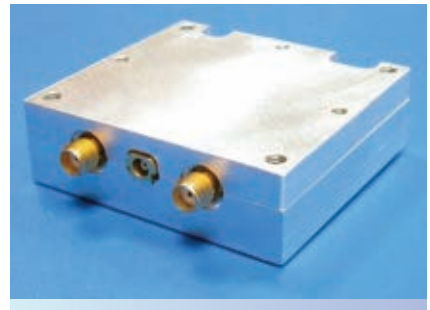
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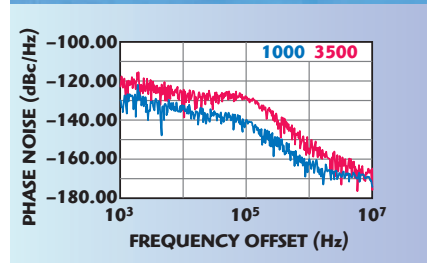
ments include a 3 to 8 GHz YIG-based synthesizer for embedded applications (see ***Table 6***). The synthesizer utilizes a high-frequency sampler that provides frequency conversion within a PLL feedback to ensure low phase noise and low spurious characteristics. A DDS is used as a PLL reference for small frequency steps. The synthesizer provides less than 1 Hz frequency resolution, phase noise of –130 dBc/Hz at 10 kHz from the 4 GHz carrier and fast frequency settling of 500 µs. These high performance characteristics are in a compact 250 × 112 × 45 mm module that includes multiple interfaces. The module also incorporates a built-in YIG preselector driver that can be conveniently used in spectrum analyzer instruments.

TABLE VI

A 3 TO 8 GHz YIG-BASED SYNTHESIZER MODULE DEVELOPED BY MICRAN

Frequency Range	3 to 8 GHz
Frequency Resolution	1 Hz
Switching Time	500 µs
Phase Noise at 10 kHz/4 GHz	-130 dBc/Hz
Spurious	-70 dBc
Dimensions	250×112×45 mm
Weight	1200 g





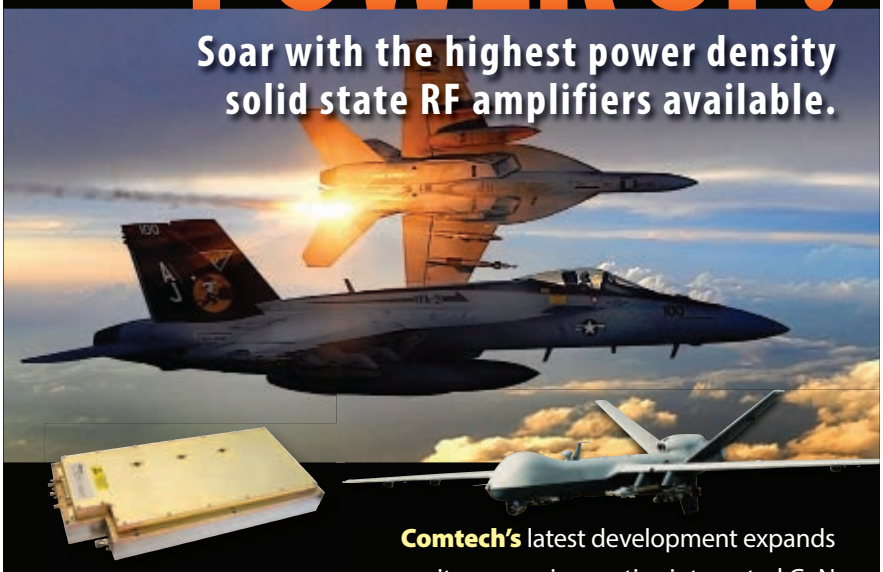
▲ *Fig. 3 Micran's low noise CRO synthesizer provides two signal outputs.*

Another interesting Micran design is its compact, dual-output microwave synthesizer, shown in ***Figure 3***. It consists of two independent channels that utilize ceramic coaxial resonator oscillators (CRO) running at 1 and 3.5 GHz, respectively. Both CROs are locked to an external reference supplied via an MCX connector. A frequency offset PLL architecture is utilized in both synthesizers to minimize noise. The phase noise at 100 kHz offset is about –140 and –128 dBc/Hz at 1 and 3.5 GHz, respectively. This module can be used in various double-conversion receiver schemes where two independent low-noise LO signals are required.

Micran also develops various oscillator products based on LC, quartz, SAW, YIG and sapphire resonators.[17] They manufacture a

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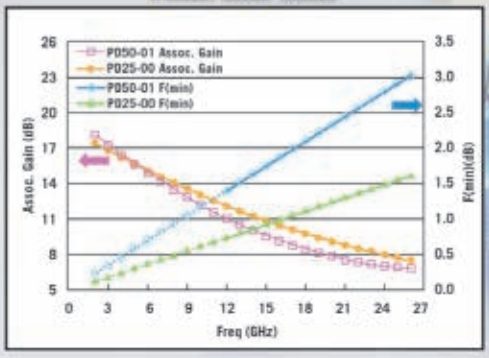
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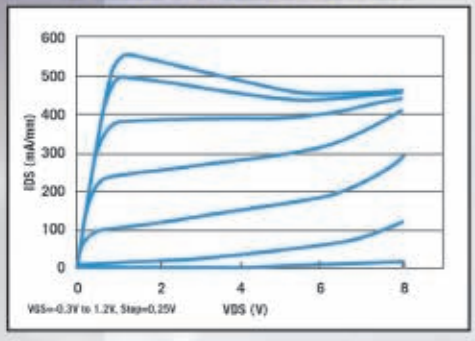
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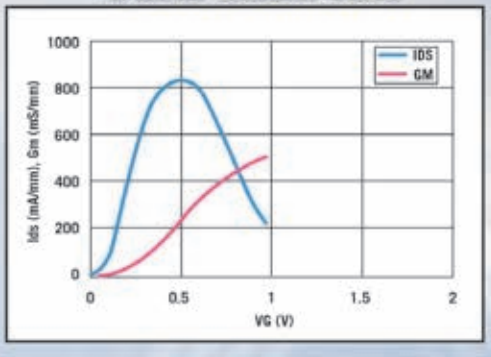
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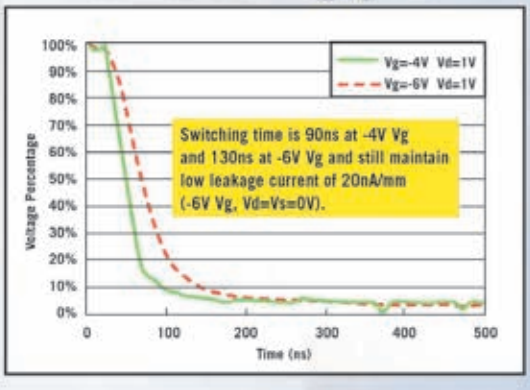
E-mode I-V Characteristics



E-mode Transfer Curve



D-mode Switching Speed



D-mode Device Performance

	PD50-01		PD25-00	
	Single	Triple	Single	Triple
Ron (ohm.mm)	1.9	3.7	1.3	2.2
Coff (fF/mm)	168	83	163	92
RonxCoff(ohm.fF)	316	310	209	198

DUT: NOF x UGW= 5 x 12μm

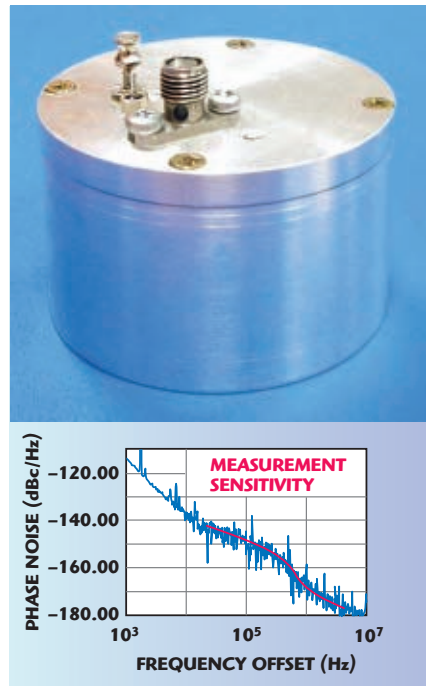
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4 GHz ultra low-noise dielectric resonator oscillator (DRO) shown in ***Figure 4***. The design utilizes a high-Q dielectric resonator (Q < 8000) as well as a silicon bipolar transistor with low flicker noise. The resonator is placed into a relatively large metal chamber (the distance from the chamber walls is 3 to 5 times greater than the dielectric puck radius). This allows achieving remarkable phase noise performance that is close to –140 dBc/Hz at 10 kHz offset from 4 GHz carrier.

Radiocomp LLC (www.radiocomp.ru) was started in 1995 in collaboration with Moscow Technical University of Communication and Informatics (MTUCI). The company is located in Moscow and is led by Dr. Kochemasov, a well-known Russian expert in the frequency synthesis field. The company's staff includes 25 full-time employees and also collaborates with R&D teams from MTUCI and Moscow Power Engineering Institute (MPEI). An interesting recent development is the company's 6 GHz frequency synthesizer, SLFM-RC-2500, that is capable of generating precise linear FM signals with up to 600 MHz frequency deviation. The modulation is realized by utilizing a two-channel DDS and IQ-modulator. The synthesizer is available as a compact module measuring 112 × 57 × 21 mm in dimensions.



▲ *Fig. 4 A 4 GHz low noise DRO exhibits about –140 dBc/Hz at 10 kHz offset.*

Special Technological Center (STC) in Saint Petersburg (www.stc-spb.ru) was founded in 2001 as a design, development and manufacturing company specializing in test and measurement equipment for radio-monitoring and frequency management. The company's product lines include multi-channel measuring receivers, RF/microwave direction finders, various types of antennas and other monitoring systems from 10 kHz to 40 GHz. The company uses frequency synthesizers widely in their

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internal developments and also offers them as stand-alone modules such as presented in Figure 5. The 24 GHz fast-switching synthesizer provides a 200 MHz step size with –105 dBc/Hz phase noise and incorporates an integer-N PLL with high phase detector comparison frequency for fast switching (see Figure 5a). A 1.4 to 2.8 GHz synthesizer incorporates a DDS for fine resolution (see Figure 5b).

INSTRUMENTS

Broadband operation, fine frequency resolution, low spurious and low phase noise are the key specifications for test and measurement signal generator instruments. As a dedicated test and measurement equipment manufacturer, **ELVIRA Production Co. Ltd.** (www.elvira.ru) offers spectrum analyzers and synthesized signal generators up to 40 GHz. Elvira is a private company founded in 1993 and is located in Zheleznodorozhny, Moscow region. Since its founding, the company has committed to designing the most advanced instruments for communications, scientific and aerospace applications. A good example is SK4-BELAN, a 40 GHz spectrum analyzer (shown in ***Figure 6***) that displays the highest level of performance offered by the Russian industry today. The model offers analysis bandwidths of 30 MHz and optionally 160 MHz, phase noise of –125 dBc/Hz at 10 kHz offset from 10 GHz carrier, TOI of +20 dBm and –150 dBm/Hz DANL across the entire frequency range. An optional preamplifier further improves DANL down to -165 dBm/Hz at 40 GHz.

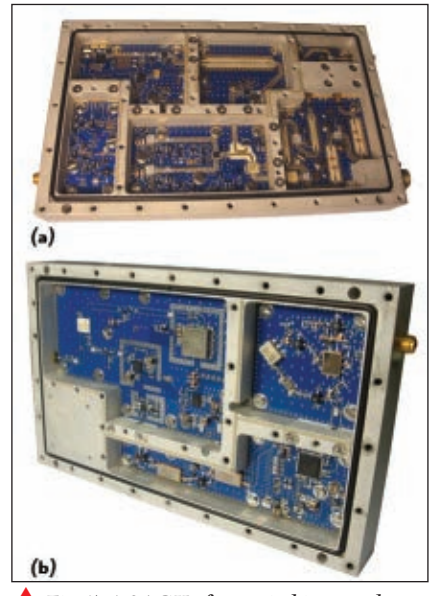


Fig. 5 A 24 GHz fast-switching synthesizer (a) and 1.4 to 2.8 GHz synthesizer (b).



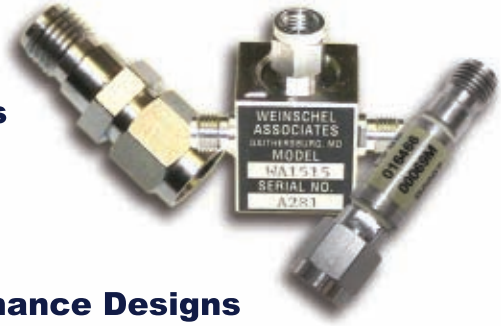
Fig. 6 SK4-BELAN is a 40 GHz spectrum analyzer.

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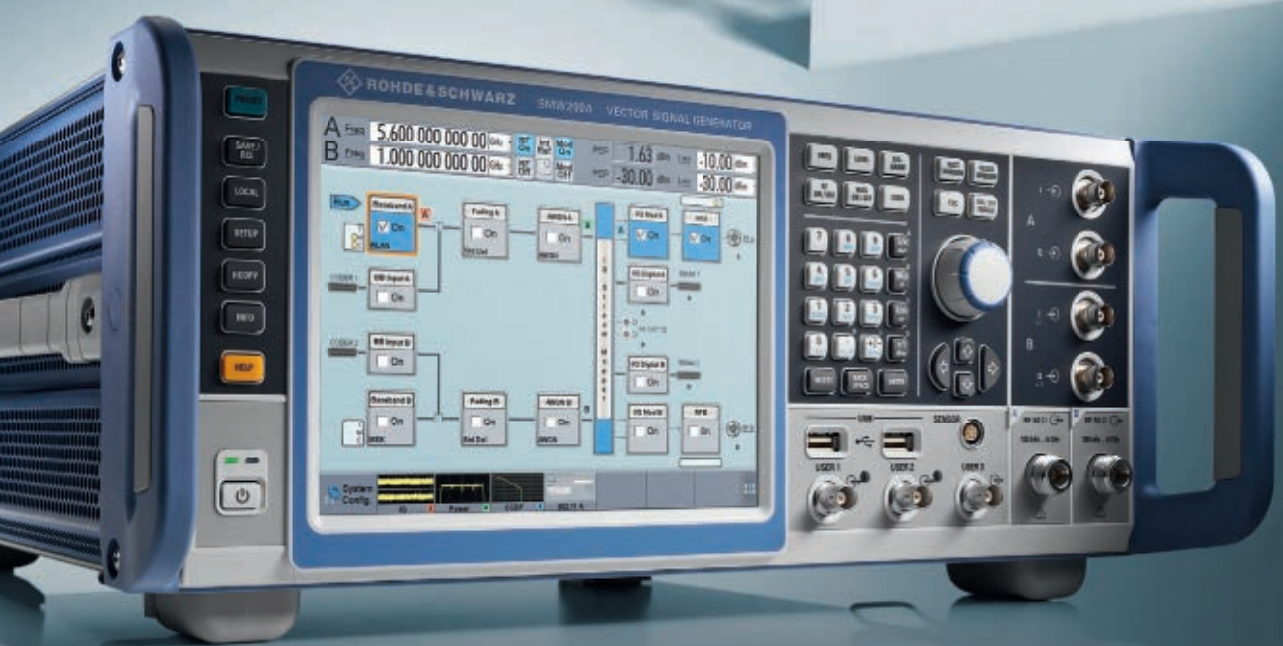
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ELVIRA also has two lines of signal generator instruments. The BELSYNTH bench-top generator (see ***Figure 7***) utilizes two Phase Matrix QuickSyn synthesizer modules featuring excellent spectral purity and fast tuning speeds inherent to the QuickSyn technology. The BELSYNTH also adds low-frequency extension, step attenuator, high output power of +28 dBm, additional harmonic rejection, built-in modulation sources and other important functions. The two channels can be synchronized or tuned independently, essentially offering two independent generators in one box.

Future developments include a new synthesizer, SAPSYNTH, which is only available as a prototype at this point. This can be considered as a new breed of frequency synthesizers in terms of spectrum quality. Rather than being built around a traditional 100 MHz OCXO, it uses an ultra-low noise sapphire loaded cavity oscillator. This synthesizer is intended to provide a significant improvement in terms of phase noise performance. The prototypes demonstrate phase noise of –140 dBc/Hz at 10 kHz offset from 18 GHz carrier (see ***Figure 8***) with a potential for further improvements. This new synthesizer core can also be used in novel phase noise measurement systems to boost the raw sensitivity of phase noise measurements.

Founded in 2004, **Advantex LLC** (www.advantexrf.com) is located in Moscow and develops various RF/microwave modules such as frequency synthesizers, up/downconverters, modulators, demodulators and transceivers for digital communications, radar and other applications. Since 2010, Advantex also develops test and measurement instruments such as the SG8 bench-top signal generator shown in ***Figure 9***. The generator provides 10 MHz to 8 GHz frequency coverage with 0.001 Hz resolution, –65 dBc spurs and output power up to +28 dBm. This high output level enables various



Fig. 7 BELSYNTH signal generator provides two independent signal outputs from 10 MHz to 20 GHz.

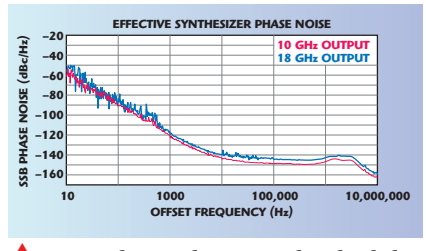


Fig. 8 Elvira utilizes a sapphire loaded cavity oscillator for further phase noise improvements.



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measurements without additional power amplifiers. Phase noise performance is depicted in ***Figure 10***. A distinctive advantage of this instrument is its attractive price-to-performance ratio in its instrument class.

Planar LLC (www.planar.chel.ru) is a privately owned company based in Chelyabinsk, a big industrial city located on the east side of the Ural Mountain range in central Russia. The company was founded in 1992 and currently manufactures various products for telecommunications and the test and measurement market. Some of Planar's products are frequency synthesizers developed as a key part of **Copper Mountain Technologies'** (www.coppermountaintech.com) line of vector network analyzers. These VNAs are designed for operation with an external computer (such as the 804/1 model shown in ***Figure 11***). Fast-switching synthesizers are integrated to provide the required frequency coverage with minimal acquisition time. These analyzers are an excellent value solution for performing the full range of magnitude and phase measurements over the frequency range of 20 kHz to 8 GHz.



Fig. 9 Advantex' SG8 signal generator.

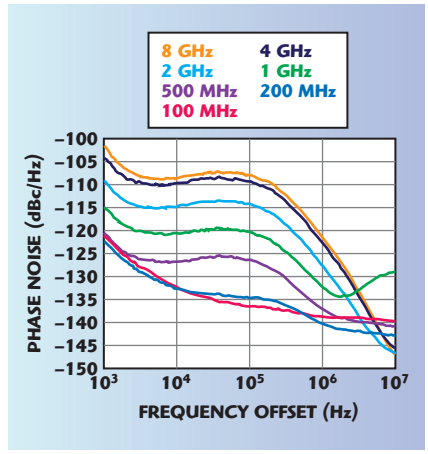


Fig. 10 Phase noise perfomance of Advantex' SG8 generator.



Fig. 11 The 804/1 VNA is based on Planar's fast-switching synthesizers.

ACKNOWLEDGMENTS

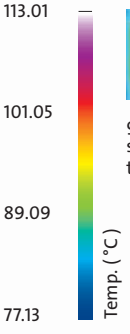
This article presents a brief overview of some selected developments in the area of frequency generation and synthesis that have recently occurred in Russia. Further details can be found in the references. The author would like to thank Y. Vorokhovsky, V. Kochemasov, L. Be-

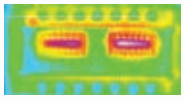
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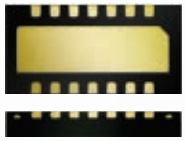
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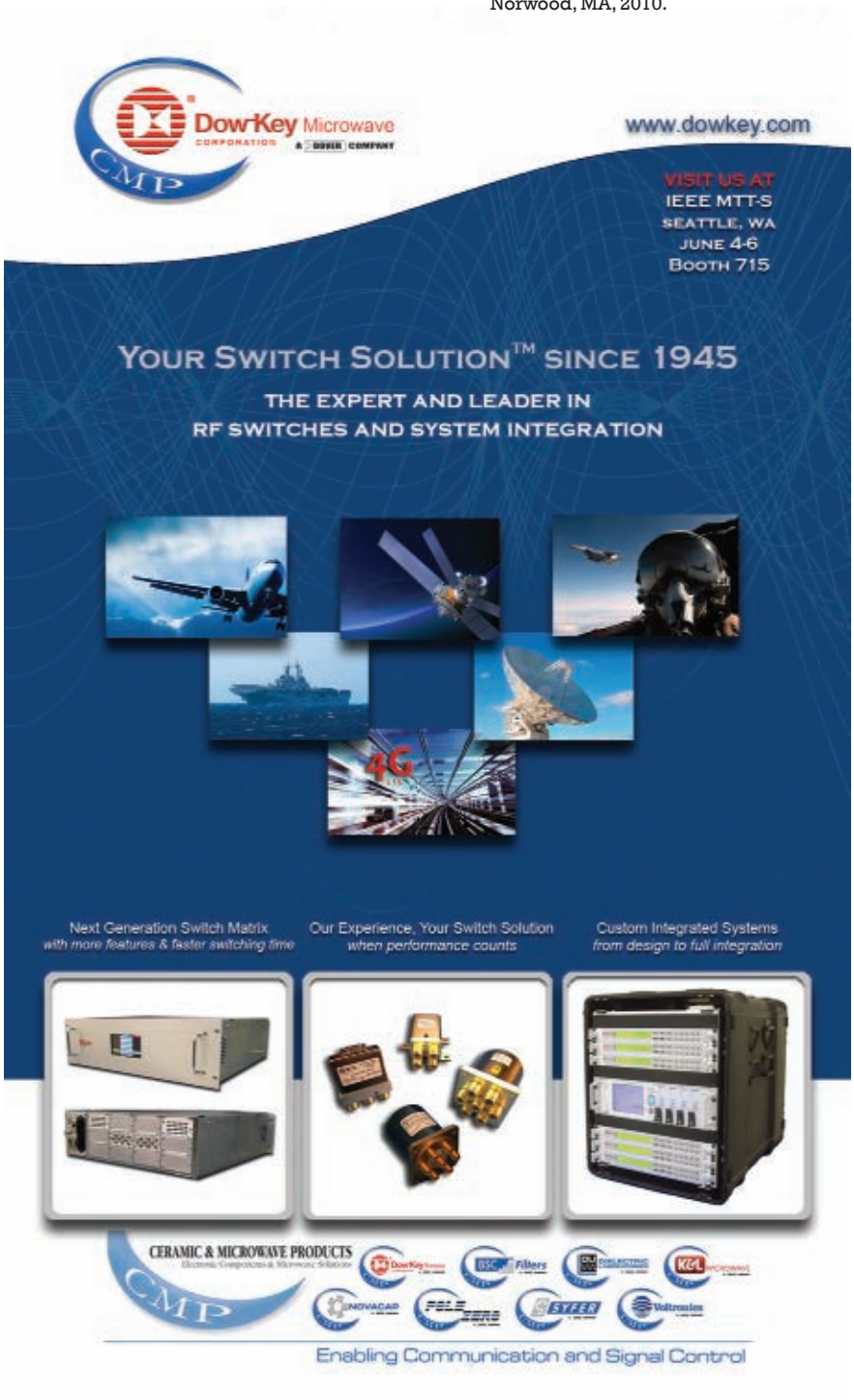
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lov, S. Beltchicov, Y. Petrichkovich, V. Romashov, A. Gorevoy, A. Polyakov, S. Zaostrovnykh, A. Goloschokin, A. Anufriev, I. Abramzon, A. Pivak, Y. Matveev and many other colleagues who have provided the material for this article.

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Dr. Alexander Chenakin *is the vice president of signal sources at Phase Matrix, a National Instruments company, where he oversees the development of advanced signal generator products for test and measurement applications. His professional interests also include various microwave components and subsystems including low phase noise oscillators and frequency synthesizers. His professional achievements have been widely presented in trade publications and international conferences. Chenakin has also authored a book on frequency synthesizers. He is a senior IEEE member and has been an invited speaker for several IEEE-sponsored events.*

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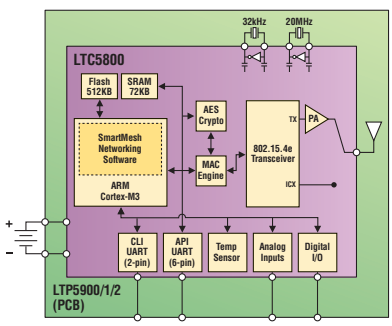
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Welcome to IMS 2013



On behalf of the IMS 2013 Steering Committee, it is my privilege to welcome you to Seattle and invite you to attend the International Microwave Symposium to be held the week of 2 June 2013.

It has been eleven years since IMS was held in Seattle and so much has changed. The city of Seattle has grown and its character continues to evolve. You will find it even more active, vibrant and fun than it was in 2002. The Northwest microwave community has evolved as well, with major industry contributors in RFID, avionics, semiconductors, and test and measurement.

In addition, our local companies have had a great part in expanding the scope and capability of our global wireless imprint. We can now create and communicate almost anywhere in the world as a result of the collective work of IMS attendees, presenters and exhibitors. The Pacific Northwest has participated in the most recent wireless revolution in a very significant way. Local companies based in Seattle, Portland and Vancouver, BC, have been at the forefront of key advancements such as the implementation of LTE and the development of semiconductors that have enabled new technology. You will witness significant participation by the Northwest community in the plenary and closing sessions, in the historical exhibit and on the exhibition floor.

Microwave Week has countless opportunities to present, learn and connect with other members of our growing industry. No other event in the RF and microwave world offers as much technical information, has as many exhibitors or provides as good a forum to exchange ideas and meet key personnel who truly move our industry forward. Co-located with IMS as part of Microwave Week are the Radio Frequency Integrated Circuit (RFIC) Symposium (www.rfic2013.org), and the Automatic Radio Frequency Techniques Group (ARFTG) Microwave Measurement Conference (www.arftg.org).

The plenary session will be held in the early evening on Monday, June 3. Our plenary address is being given by Patrick Ennis, the global head of technology for Intellectual Ventures. The Technical Program Committee has crafted an excellent program and topics include circuit theory, passive components, active components, systems and applications, and emerging technologies. Our closing session address will feature two speakers: Dr. David Tennenhouse, corporate vice president, technology policy, Microsoft Corp.; and Michael Thorburn, division head, National Radio Astronomy Observatory.

IMS 2013 hosts the world's largest exhibition dedicated to RF and microwave technology. You will find components, semiconductors, subsystems, materials, design software and instrumentation. Everything from oscillators to antennas will be there! IMS 2013 will have over 500 exhibitors in 800+ booths. We would like to extend a special thank you to our sponsors for IMS 2013. Platinum: Agilent Technologies and AWR Corp./National Instruments. Gold: NXP Semiconductors and RFMD. Silver: CST of America Inc., Sonnet Software Inc. and TriQuint Semiconductor.

Seattle has so much to offer visitors. The city has a rapidly increasing downtown population, resulting in an area surrounding the hotels and convention center that is very vibrant. Seattle offers entertainment for all tastes, as well as a great variety of restaurants and activities. My favorite picks are: for oysters on the half shell, the Brooklyn Restaurant; for beef, the Metropolitan Grill (table 43 gives one a good view of the interesting crowd – there's always something going on – plus they have a great happy hour); for Thai food, the Wild Ginger; for seafood, the Palisade Restaurant (a taxi ride – get the king crab legs). The Washington State Convention Center is located in the heart of the downtown area, close to all the action. Hotels are all within easy walking distance.

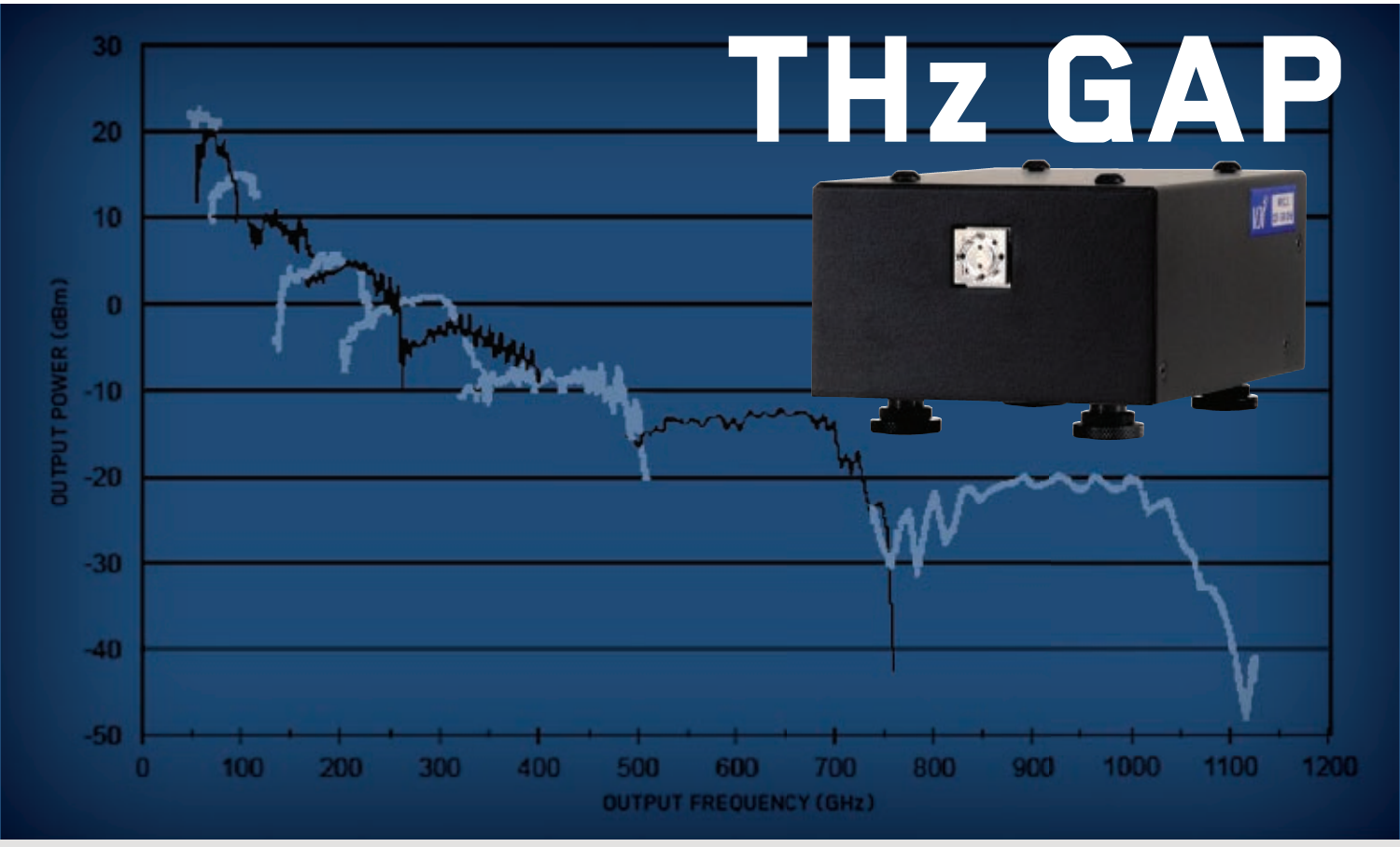
Our social program has a wide variety of interesting activities to choose from and it's never too early to start making your plans. Visit our website (www.ims2013.org) often; it is evolving and will provide topical information as we approach June 2, 2013.

We look forward to seeing you in Seattle!

TOM RASCHKO
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Multiplication Factors	4	6	12	12	12	18	36	54	81
Input Frequencies (GHz)	12.5 - 18.8	12.5 - 18.3	7.5 - 11.7	9.2 - 14.2	11.7 - 18.3	12.2 - 18.3	9.0 - 13.9	9.3 - 13.9	9.3 - 13.6
Alternate Multiplication Factors	2	3	6	8 or 4	6	9	24 or 12	36 or 18	54 or 27
Typical Output Power (dBm)	20	14	9	8	4	-2	-10	-21	-25/-35
Minimum Output Power (dBm)	17	10	3	2	0	-8	-18	-30	-33/-40

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RFIC 2013 General Chair's Message

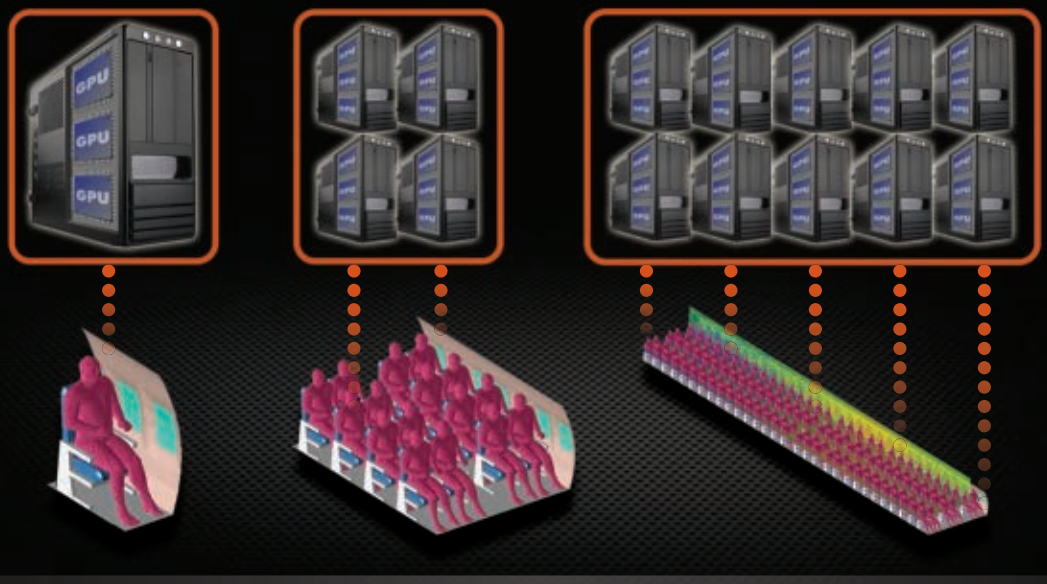


Welcome to the 2013 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium, which will take place in Seattle, WA, on June 2-4 2013. Our Symposium is held in conjunction with the IEEE Microwave Theory and Technology Society's (MTT-S) International Microwave Symposium (IMS) and opens Microwave Week 2013, the largest worldwide RF/microwave meeting of the year, with three days focused exclusively on RFIC technology and innovation.

As in past years, the focus of the 2013 RFIC Symposium will be on emerging technologies and applications of Radio Frequency Integrated Circuits. This year, several forums will feature multiband reconfigurable, software-defined and cognitive radios and the use of system-on-chips (SoC) to realize high-data rate RF solutions for smartphone, notepad and notebook applications. The continued exploitation of frequencies above 60 Hz in the realization of silicon millimeter wave circuits and systems will be presented throughout the conference. Lastly, the emergence of RF for bio-medical applications and the reintroduction of wireline transceivers for high-speed I/O to our conference reflect some of the exciting developments in the radio IC community. As in previous years, the latest advances in RF IC design from the device to the system level will be covered in various forums including workshops, panel sessions and two exciting days of technical paper presentations.

The 2013 RFIC Symposium will open in grand style on Sunday, June 2 with a full lineup of 13 half-day and full-day workshops covering a wide array of topics with presentations from experts in their respective fields. This year's workshops will have a combination of tutorial and advanced presentations on some of the hottest topics in our community, including high-efficiency supply modulated PAs and signal generation at THz frequencies. A special full-day interactive Doherty tutorial workshop includes lab exercises where attendees will get hands-on experience by simulating (using ADS) designs using concepts covered in lecture, culminating

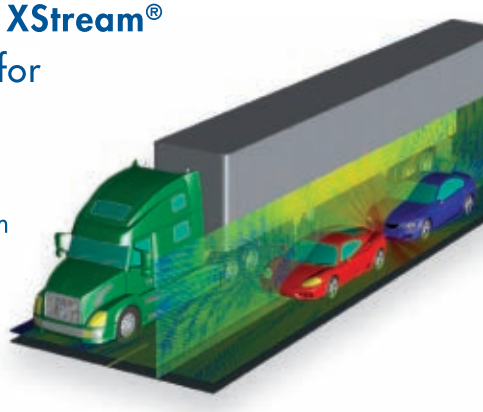
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RFIC 2013 General Chairman



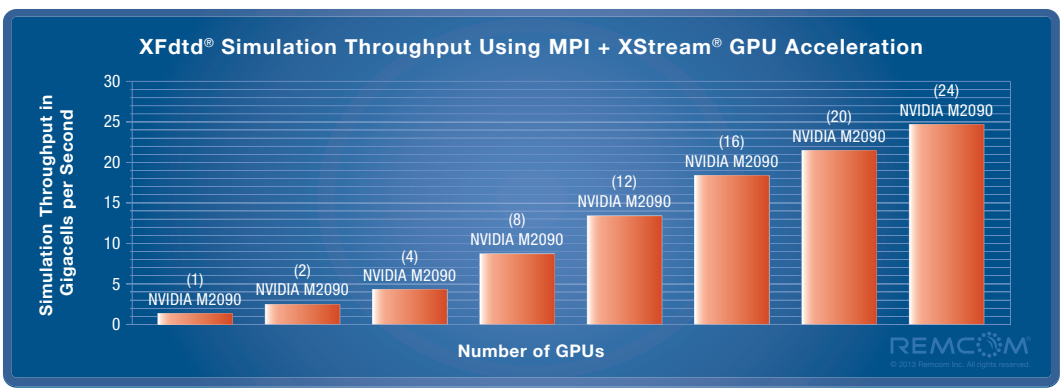
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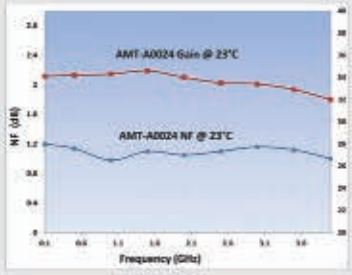


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AMT-A0026	0.8-2	30	1.4	22	34

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in a complete high power Doherty amplifier design. One of the workshops, "Interference Robust Radio Receiver Techniques," focuses on the performance needs of modern integrated radios in an increasingly crowded spectrum. More advanced topics include SDR transmitters, the influence of MEMs on RF architectures, RF assisted medicine, self-healing circuits and compensation, near field communication and VCO design in modern silicon processes. Other workshops will focus on the design of inductorless front ends and how to push the RF performance limits in modern CMOS technologies.

The plenary session will be held on Sunday evening with keynote addresses given by two renowned industry leaders from the Pacific Northwest. They will share their insight on the direction of, and challenges faced by, the RF IC design community. The first speaker is Neville Ray, CTO of T-Mobile, who will explore some of the exciting system developments from the cellular carrier perspective in his talk, "Wireless Spectrum Challenges & Opportunities: Maximizing Assets for Growth." The second speaker is Barrie Gilbert, who will share his insight on the history of RF and wireless transceivers and present his vision of the future of RF IC design. The title of his talk will be "Microwave Technology: The First Century." During the plenary session, students with outstanding contributions to the conference will be recognized with the three best paper awards. Immediately following the plenary session, conference attendees can gather at the RFIC Reception, which provides a relaxing environment for all to mingle with old friends and catch up on the latest news.

The RFIC technical sub-committees were further re-organized this year to align with the dynamic trends in industry and academia. Technical papers will be presented during oral sessions throughout Monday and Tuesday morning, followed by an interactive poster forum in the afternoon. This session features papers presented in poster format, giving the attendee a chance to speak directly with authors regarding their work.

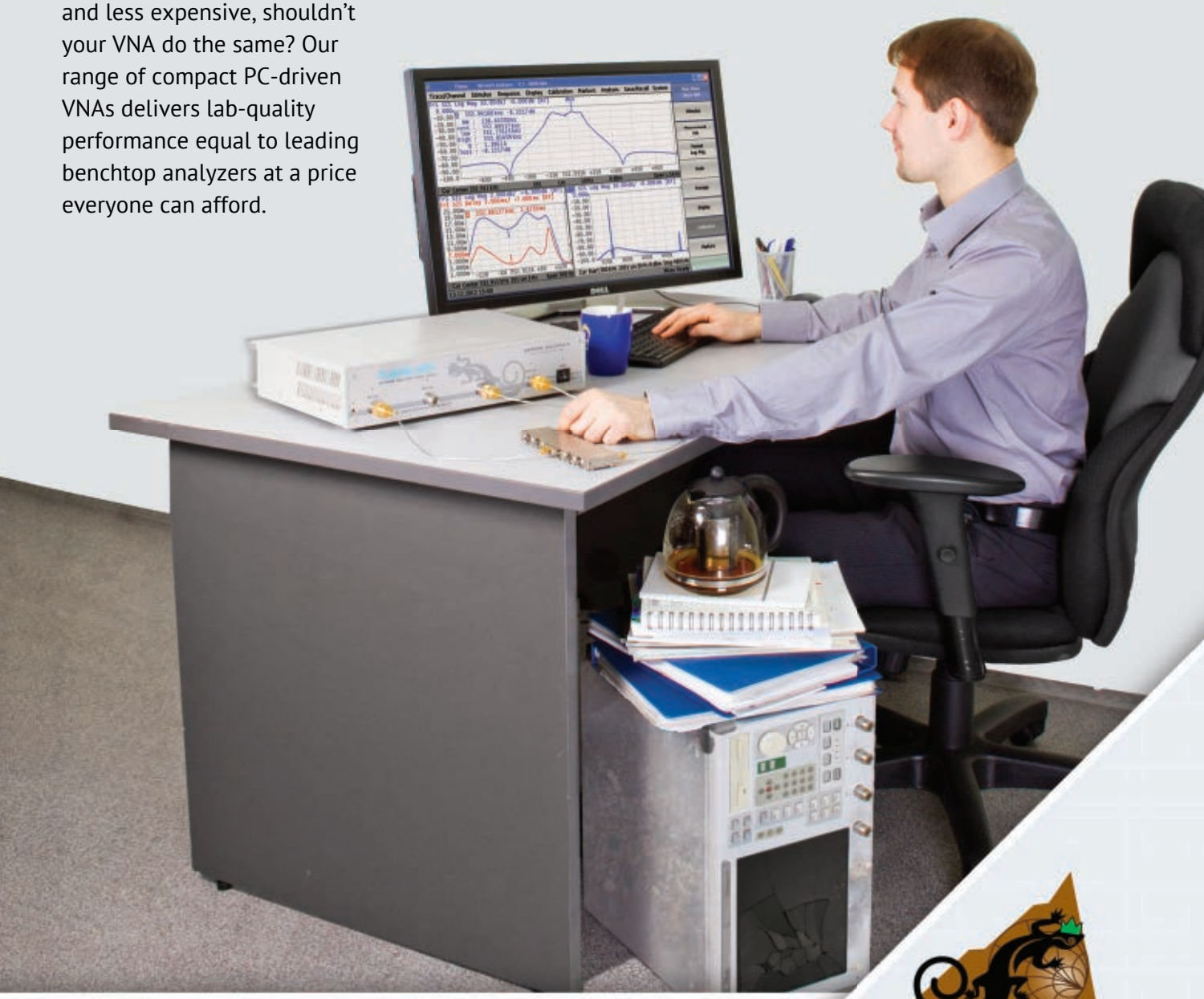
On both Monday and Tuesday, the conference will feature lunchtime panel sessions that traditionally draw lively debate among the panelists and stimulating interaction with the attendees. The Monday panel session is titled "WiFi vs. Cellular, Future Convergence or Utter Divergence" and will debate how much future high-speed data will be shared between WiFi and cellular networks and the implication on IC design. The Tuesday panel session, titled "Universities are from Venus, Industries are from Mars," explores the diverging aspects of university including industry research, resource, and educational needs. A panel of leading academics and industrialists will explore the shared needs and differences between the university and corporate world, as well as discuss improved interactive models to better serve both industry and academics.

Seattle is one of the most beautiful cities in North America with countless activities both within the city and the immediate surrounding area. The conference will be held at the Washington State Convention Center in downtown Seattle, just a few minutes' walk from several local attractions. Conference attendees can enjoy a cup of coffee at the original Starbucks, watch flying fish at the world-renowned Pike Place Market, or take a ride to the top of the city's iconic Space Needle. For the outdoor enthusiasts, several spectacular hiking trails can be found within an hour's drive of the downtown area.

On behalf of the RFIC Steering Committee, I would like to extend to all of you a warm welcome to this year's 2013 RFIC Symposium. We look forward to an exciting program and ask all of you to "come as you are," this June in Seattle! ■

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Welcome to the 81st Automatic RF Techniques Group (ARFTG) Microwave Measurement Conference being held at the Grand Hyatt Seattle on Friday, June 7, 2013.

The Friday schedule includes four sessions with 15 oral presentations and an interactive forum with 25 posters. Fueled by breakfast, lunch and coffee breaks, exhibitors with table-top displays interact in ways impossible to find in larger halls.

The contributed conference papers range from practical methods and techniques to cutting edge research on measurement technology and over such topics as nonlinear measurement systems, calibration issues, on-wafer measurement, uncertainty, broadband and millimeter-wave, and other areas of RF and microwave measurement.

Your ARFTG conference registration also includes access to joint IMS/ARFTG measurement sessions on Thursday, the Nonlinear Vector Network Analyzer (NVNA) Users' forum Thursday night, and a one year membership in ARFTG.

Thursday's joint sessions are "Measurements Supporting Active Device Modeling" and "Innovative Measurements Across the Spectrum (RF to THz)." The NVNA Users' forum is an informal discussion group

81ST ARFTG HIGHLIGHTS

Monday

ARFTG Sponsored Workshops (not included in ARFTG registration)

WMC - The Importance of Low-Frequency Measurements on High-Frequency Characterization

WME - High Speed Signal Integrity

Thursday

ARFTG/IMS Joint Technical Sessions

TH2D - Measurements Supporting Active Device Modeling
TH3D - Innovative Measurements Across the Spectrum (RF to THz)

Nonlinear Vector Network Analyzer Users' Group

Friday

Four Oral Presentation Sessions and Interactive Forum

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Breakfast, Lunch and Coffee Breaks (AM and PM)

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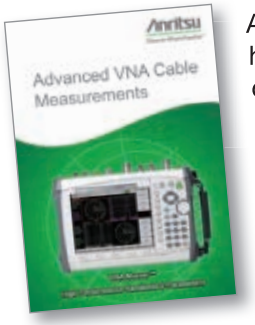


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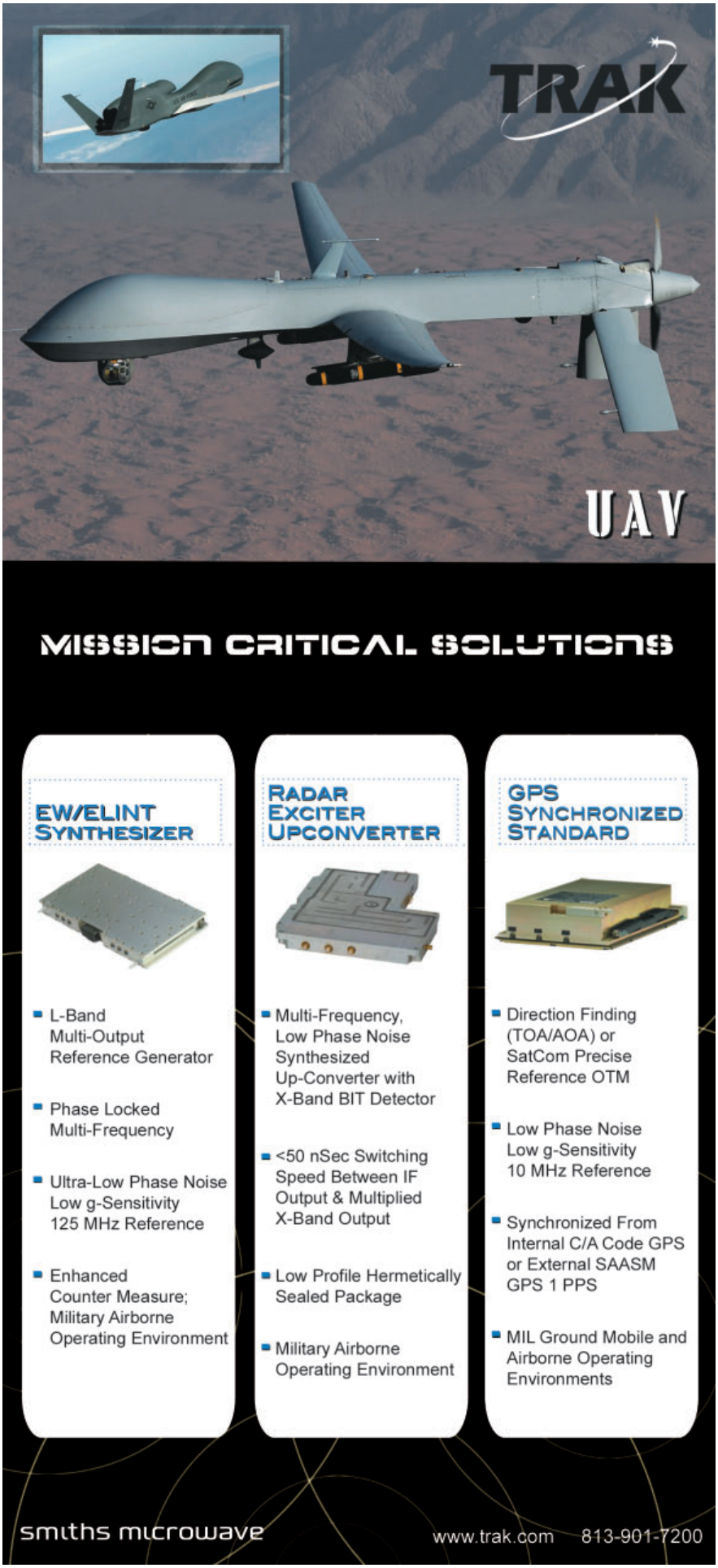
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devoted to sharing information and issues related to instrumentation utilized in vector large-signal analysis of microwave circuits and systems that contain nonlinear elements. This event is open to all ARFTG, IMS and RFIC attendees.

Consider also registering for one of the ARFTG sponsored workshops: "The Importance of Low-Frequency Measurements on High-Frequency Characterization" and "High Speed Signal Integrity." These all-day workshops are scheduled for the Monday of Microwave Week and provide focused analyses of these interesting topics.

No better opportunity is available to interact with vendors, experts and colleagues in the RF and microwave test and measurement community. Ask questions, propose collaboration or simply learn vicariously from their hard-won experience. ARFTG's two annual conferences are well known for this unique opportunity and welcoming environment. Starting with breakfast and continuing through the exhibition, interactive forum and luncheon, there will be ample opportunity for discussion with others facing similar challenges. Attendees find that these interactions are often the best source of ideas and information for their current projects.

Full details of the technical program and conference are available at www.arftg.org. ARFTG Conference registration is available through the IMS website at www.ims2013.org. ■

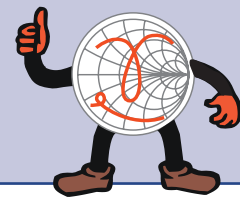


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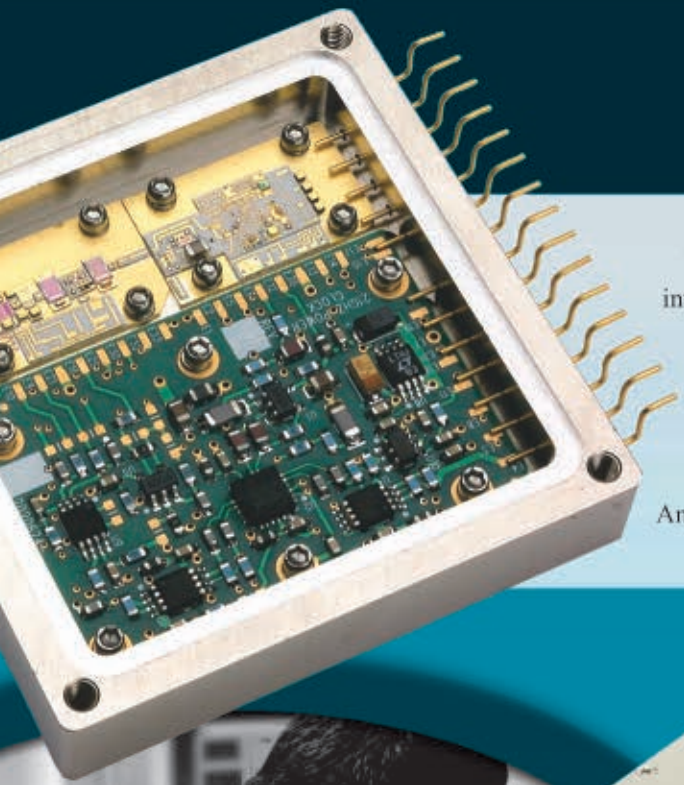
Smitty says...
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High-Frequency Designers

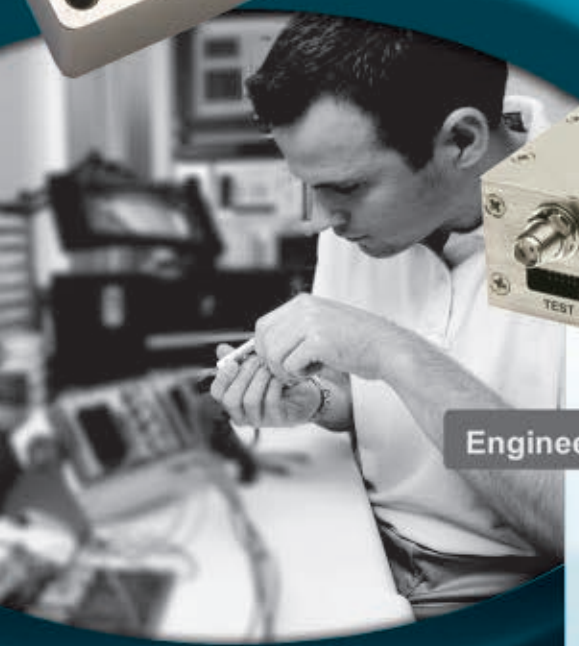
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Introducing Wireless Industry Day

The IEEE Seattle section has created a full day seminar on emerging wireless technologies from the Pacific Northwest. Wireless Industry Day, developed under the direction of Takao Inoue from National Instruments and Janet O'Neil of ETS-Lindgren will be a special event offering practical, application-oriented information from local technologists discussing trends in wireless technology across multiple industries including aerospace, wireless medical and communications. The event will be held on Wednesday, June 5, 2013, during IMS 2013.

As a meeting coordinator for AMTA with extensive experience organizing technical events, O'Neil has applied her talents and connections to create a program with top notch technical experts. While most of the speakers are from the region, O'Neil has tapped into her AMTA connections for the event's opening and closing presentations. The first talk, "From Maxwell's Equations to Modern Electromagnetics and Antenna Engineering Marvels" will be given by Professor Yahya Rahmat-Samii, a past vice president of AMTA and IEEE Fellow from the University of California, Los Angeles. Rahmat-Samii looks at how meta-materials, modern electromagnetic numerical and evolutionary optimization techniques in antenna system designs is supporting advances in the personal communications antennas that address human interactions and reconfigurable designs. This presentation also examines current medical applications including wearable, RFID, implantable and ingestible systems. Rahmat-Samii touches upon the wireless medical industry that will be further presented by Bill Saltzstein, president of connectBlue Inc., a Redmond, WA company that specializes in integrating Bluetooth based communication solutions in products for industrial or commercial use.

Saltzstein's talk, "Bluetooth: The Future of Wireless Medical Technology," will address the challenges of power consumption among portable medical devices, taking a look at how power needs for the wireless connections of these devices may constrain architecture and limit applications. This situation may change with the introduction of Bluetooth low energy technology specified in Bluetooth v4.0.

Dr. Julio Navarro, senior technical fellow with Boeing, will discuss how this company and many others are adapting to the ongoing technological advances that include a wide diversity of devices, device content, varying standards and methods of delivery. Navarro will discuss how various technology choices and the company's decision making process drives its relationship with suppliers and ultimately impacts Boeing competitiveness and the bottom line.

Representing the perspective of a wireless chip manufacturer, Dr. Debabani Choudhury, IEEE Fellow, senior technologist and Harry Skinner, senior principal engineer, both of Intel Labs, Hillsboro, OR, will consider the proliferation of diverse wireless communication services in their talk, "Prospects and Challenges for GHz to THz Technologies/Architectures for Future Wireless Communications." This talk will take a look at the worldwide research of various architectures including different variations of MIMO, MU-MIMO as well as mm-wave and THz research for ultra-high data rate applications.

Representing the communications industry from the operator's perspective will be Scott Prather, lead product development engineer, AT&T of Redmond, WA discussing "Radiated Performance Assessment of Wireless Communications Devices - An Operator's Perspective." This presentation looks at how the assessment of radiated performance, which often requires special testing considerations and techniques, has become a major concern for network operators.

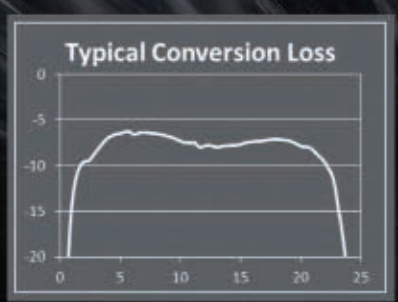
The final talk of the day, "Evaluating Over-The-Air Performance of MIMO Wireless Devices," is by Dr. Michael Foegelle, director of technology development, ETS-Lindgren. Dr. Foegelle, an expert in the area of MIMO OTA testing, will discuss the pros and cons of different techniques that are vying to become the standardized approach for industry certification of MIMO devices. This presentation will demonstrate the differences in a number of these concepts and provide a range of measured results showing the variation between good and bad wireless devices.

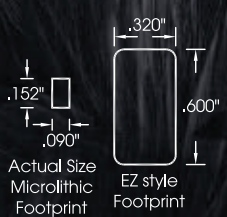
David Vye
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Panel Session: The Death of GaAs?

Thursday, June 6, 2013, 12:00-13:20

The GaAs device market closed 2012 with revenues of slightly more than $5.3 billion. This extends a trend of growth in GaAs device revenue that began in 2004, coinciding with the dawn of the commercial wireless communications era. The GaAs device industry has benefited from rapid growth in mobile handset adoption as power amplifiers and switches have formed the basis for increasingly sophisticated smartphones. As wireless standards evolve to LTE and HSPA+ and new frequency bands are designated to meet the seemingly insatiable desire for data consumption, the RF content in the front end of a handset is increasing. This increasing RF content coupled with nearly 1.6 billion phones shipped in 2012 has been very good for the GaAs industry. Strategy Analytics estimates that handset applications accounted for more than 50 percent of total GaAs device revenue in 2012.

With further handset shipment increases in 2013 and smartphones continuing to capture market share, it would seem GaAs device revenues are poised for continued long-term growth. Despite this rosy outlook, there are storm clouds forming on the horizon, however. At the recently concluded Mobile World Congress, Qualcomm released information about their RF360 family of CMOS-based front-end products, consisting of multi-mode, multi-band PAs, envelope tracking (ET) power management ICs and antenna tuners. For some time, the RF front-end architecture has been trending away from GaAs, as many of the largest handset switch manufacturers now use silicon-on-insulator (SOI) technology and the bias, control, tuning and filtering functions are realized using other materials.

While it is not surprising that the switching functions in the handset front end are transitioning to silicon, the announcement of a CMOS multi-mode, multi-band PA targeting LTE applications raises the threat level for the GaAs industry. While the Qualcomm announcement garnered the most attention, no fewer than 10 companies released new details at Mobile World Congress about how they will support LTE devices with CMOS multi-mode, multi-band PAs and envelope tracking. By our estimation, these announcements have shortened the time to volume for CMOS-based power amplifiers by approximately 18 months, leaving the long-term growth prospects for GaAs device revenue much more vulnerable.

To explore this potential game changing development, Strategy Analytics will lead a panel discussion titled, "The Death of GaAs?" at IMS 2013 in Seattle, WA. Please join analysts from Strategy Analytics, along with experts from the CMOS, SOI, SiGe, GaN and GaAs device industry as they discuss the advantages and disadvantages of these technologies and future trends in the GaAs device market.

ERIC HIGHAM
Strategy Analytics

Social Media Grows Up

In early April, the Securities and Exchange Commission ruled that publically traded companies can announce corporate news to investors via social media sites like Twitter and Facebook. Until then it was not allowed because it might provide an unfair advantage to those who see it there before others who are not involved in social media. When a U.S. government agency officially rules on something like this, it is a clear sign that social media has become mainstream.

Each year, we take a look at the state of social media as related to the microwave industry as the MTT-S IMS show approaches since that is a popular time for the exchange of ideas and product promotion via social media. For the last couple of years, we have been talking about how social media is continuously growing, but it is clear today that it is an integral part of our lives.

LinkedIn has seen very strong growth in its use among engineers as evidenced by the size of our RF and Microwave Community, now more than 17,000 members. Some aerospace and defense groups and large event groups like Mobile World Congress and CTIA have tens of thousands of members. LinkedIn is still widely used for job searching and networking along with exchanging ideas and sharing technical information. A key strength of the site is the large variety of focused groups that allow users to choose specific areas of interest and get involved in the conversation about their work expertise or personal interests. Another advantage of LinkedIn is that it is accessible in China where Facebook and Twitter are blocked.

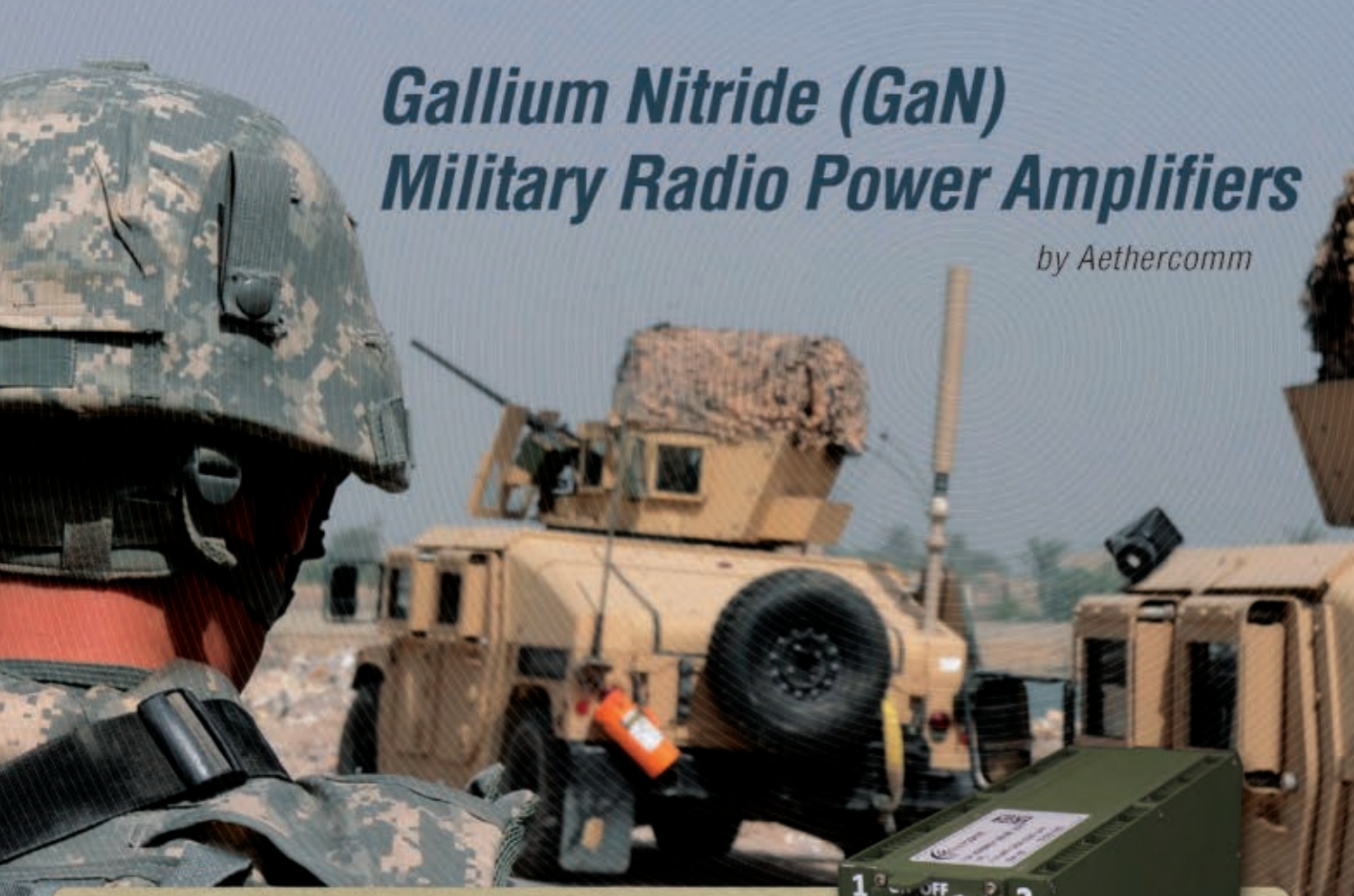
Although many companies in our industry have Facebook pages and Twitter accounts, it seems the trend for individuals is to gravitate toward LinkedIn for work-related purposes. LinkedIn clearly seems to serve more as a professional forum whereas Facebook and Twitter seem to be personal and lighthearted in nature. Google+ has grown rapidly of late and is trying to compete with Facebook but it has a long way to go. Of course, there are other social media sites like Instagram and Pinterest.

We first wrote about Pinterest, a virtual bulletin board site where people can put together boards of their favorite photos that link back to the pages where they appear, last year as a virtual part of our new products section. Businesses are still finding uses for Pinterest, kind of in the state where Twitter was a few years ago. Consumers first jump in and as the user base grows, businesses start to

PATRICK HINDLE
Microwave Journal *Technical Editor*

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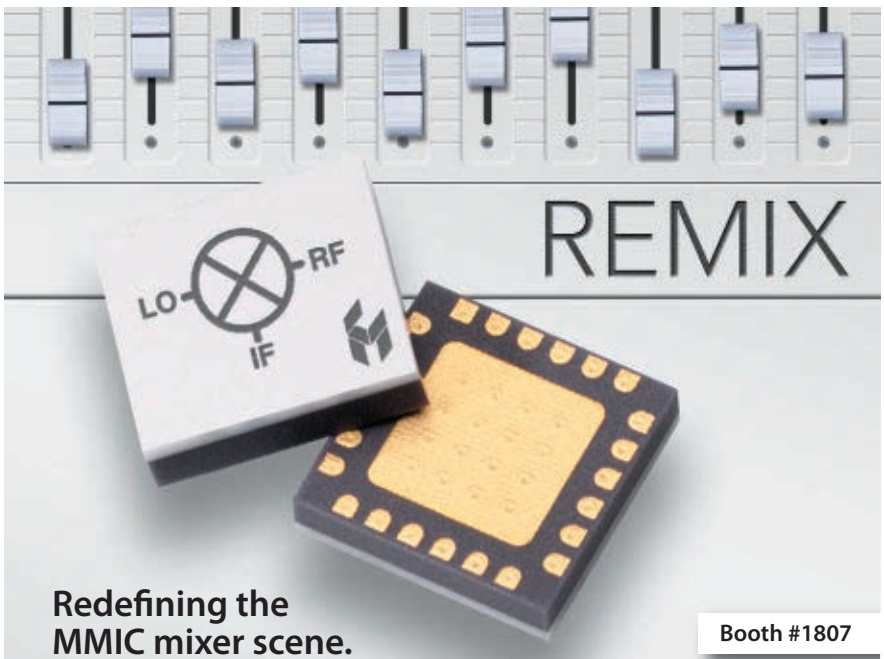
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find ways in which they can generate traffic to their content.

Microwave Journal is again using Pinterest to create new product boards using entries from our IMS 2013 Product Showcase (boards can be viewed at www.pinterest.com/pathindle). We have developed Pinterest boards by product category using pictures of products that will be featured at the exhibition. The pictures link to descriptions of what the company is featuring at the show including the specific product "pinned" on the board. These are available on our Online Show Daily page along with show news, a Twitter feed, conference messages from the chairs, special session information, and more.

Last year in Montréal, about a dozen companies were very creative in using social media to highlight their presence in the exhibition. The Passport to IMS 2012 Montréal program, spearheaded by Jamie Leger of SLN and Judy Warner of Transline, gave participants a passport book with 12 exhibitors listed in it and they had to visit a number of the booths to get their passport stamped. This year they are doing the "Road to IMS Seattle" in which attendees will be provided with a map to take around the exhibition to get a stamp from sponsoring companies. When completed, they can turn it in for daily prize drawings.

Trade shows are a perfect time to use Twitter to highlight interesting sessions, great booth giveaways, new product releases and great places to visit in the area. If you plan to use Twitter at MTT-S IMS this year, use the hashtag #IMS2013 so that people can easily follow your Tweets. Our Online Show Daily page (www.mwjournal.com/IMS2013) will have a real-time Twitter feed displaying them.

At this time last year, some companies were pouring most of their efforts into social media but most have learned now that it is just one part of an integrated marketing effort to promote the company and its products and services. While much of it may be free, without some planning, hard work and a strategy, it is of limited value. ■

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The IMS 2013 welcomes its international guests



Rushing to appointments, MTT-S 2012 Pres. Nick Kolias barely has time to think

For all the meetings I've attended, they could have played "Hail to the Chief" at least once.



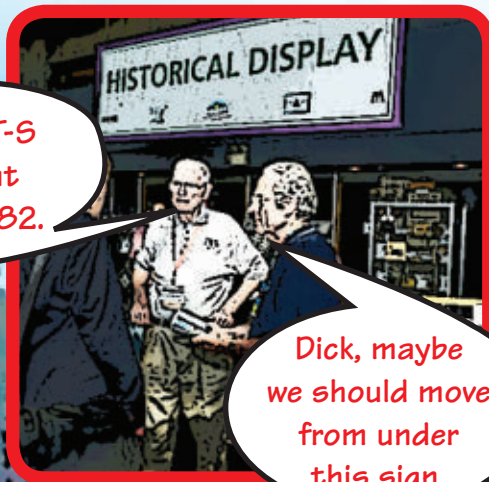
Getting to the symposium on time is serious business



Race you to the top!!



I was MTT-S president back in 1982.



Dick, maybe we should move from under this sign.

Loyalty runs bone deep among MTT-S members

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This Qualcomm panelist could be trouble.



Game changing technology is discussed at Strategy Analytics' "Death of GaAs?" Panel

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Despite appearances, the exhibition is NOT all fun and games



The hockey theme made more sense in Montréal.



Hey, it was a hit with the students from U of BC, Vancouver.

Say hello to Chuck's Angels.



IMS guests enjoy the sights and tastes of Seattle



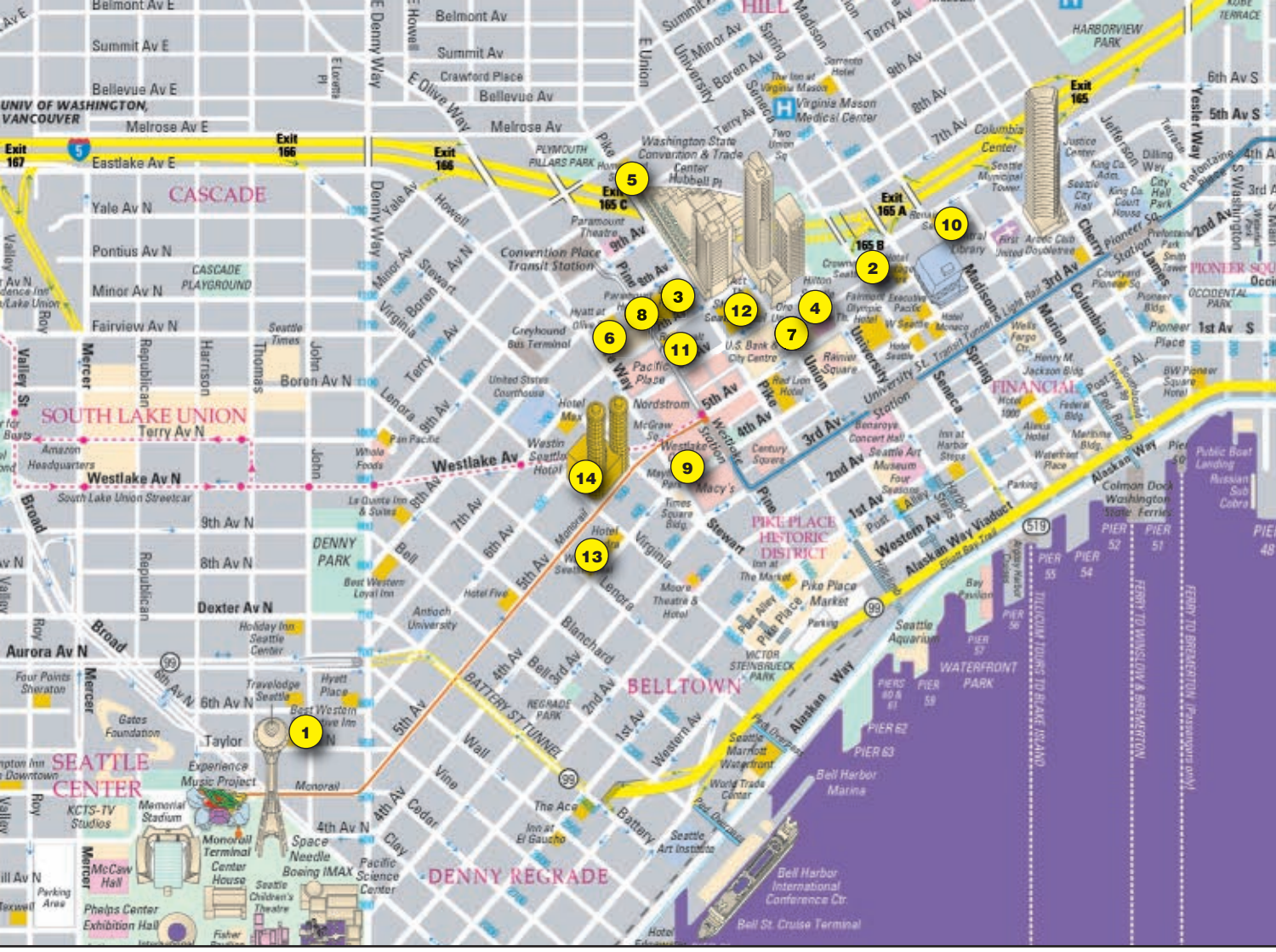
We all got the memo to wear something salmon-colored.

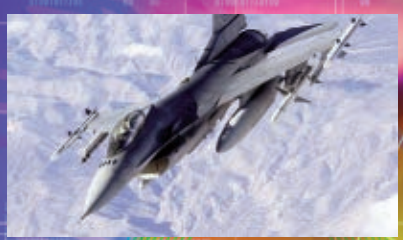


Uncle Jr. sayz....

I may have over done it with the salmon last night.





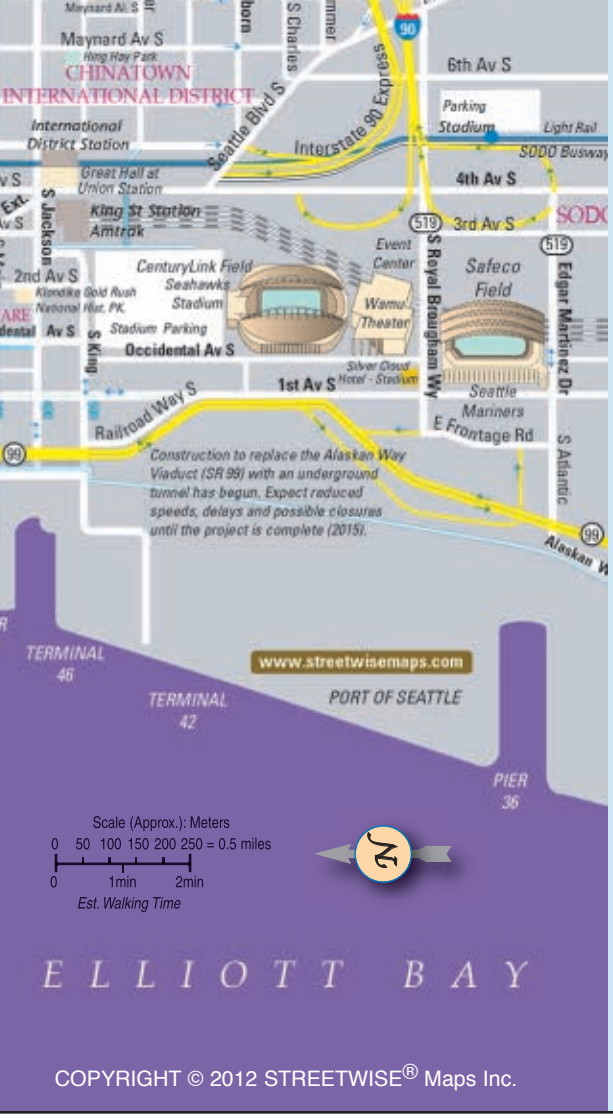




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7. Inn at Washington Athletic Club
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9. Mayflower Park Hotel
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- EW

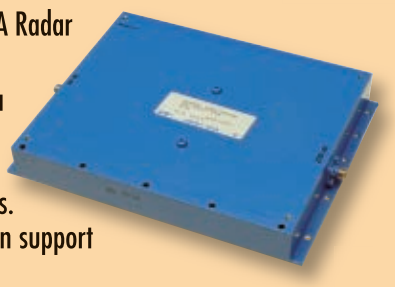
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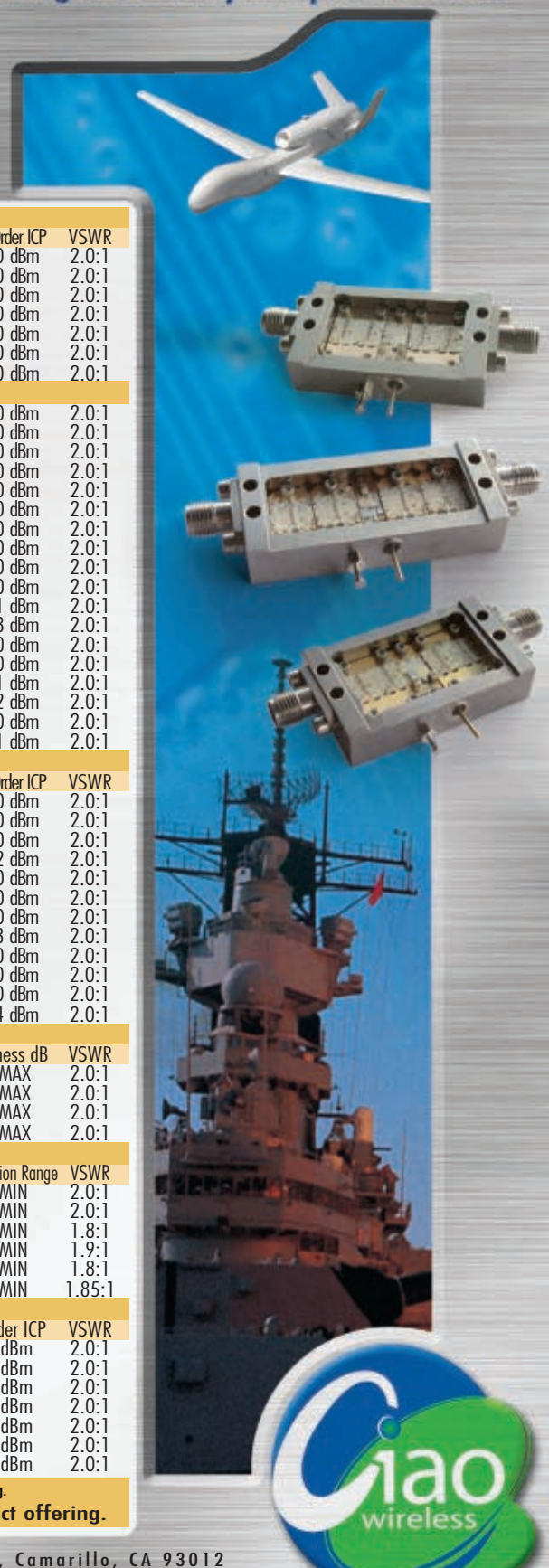
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CA01-2110	0.5-1.0	28	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA12-2110	1.0-2.0	30	1.0 MAX, 0.7 TYP	+10 MIN	+20 dBm	2.0:1
CA24-2111	2.0-4.0	29	1.1 MAX, 0.95 TYP	+10 MIN	+20 dBm	2.0:1
CA48-2111	4.0-8.0	29	1.3 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA812-3111	8.0-12.0	27	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA1218-4111	12.0-18.0	25	1.9 MAX, 1.7 TYP	+10 MIN	+20 dBm	2.0:1
CA1826-2110	18.0-26.5	32	3.0 MAX, 2.5 TYP	+10 MIN	+20 dBm	2.0:1

NARROW BAND LOW NOISE AND MEDIUM POWER AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA01-2111	0.4 - 0.5	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA01-2113	0.8 - 1.0	28	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3117	1.2 - 1.6	25	0.6 MAX, 0.4 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3111	2.2 - 2.4	30	0.6 MAX, 0.45 TYP	+10 MIN	+20 dBm	2.0:1
CA23-3116	2.7 - 2.9	29	0.7 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA34-2110	3.7 - 4.2	28	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA56-3110	5.4 - 5.9	40	1.0 MAX, 0.5 TYP	+10 MIN	+20 dBm	2.0:1
CA78-4110	7.25 - 7.75	32	1.2 MAX, 1.0 TYP	+10 MIN	+20 dBm	2.0:1
CA910-3110	9.0 - 10.6	25	1.4 MAX, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA1315-3110	13.75 - 15.4	25	1.6 MAX, 1.4 TYP	+10 MIN	+20 dBm	2.0:1
CA12-3114	1.35 - 1.85	30	4.0 MAX, 3.0 TYP	+33 MIN	+41 dBm	2.0:1
CA34-6116	3.1 - 3.5	40	4.5 MAX, 3.5 TYP	+35 MIN	+43 dBm	2.0:1
CA56-5114	5.9 - 6.4	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6115	8.0 - 12.0	30	4.5 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA812-6116	8.0 - 12.0	30	5.0 MAX, 4.0 TYP	+33 MIN	+41 dBm	2.0:1
CA1213-7110	12.2 - 13.25	28	6.0 MAX, 5.5 TYP	+33 MIN	+42 dBm	2.0:1
CA1415-7110	14.0 - 15.0	30	5.0 MAX, 4.0 TYP	+30 MIN	+40 dBm	2.0:1
CA1722-4110	17.0 - 22.0	25	3.5 MAX, 2.8 TYP	+21 MIN	+31 dBm	2.0:1

ULTRA-BROADBAND & MULTI-OCTAVE BAND AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
CA0102-3111	0.1-2.0	28	1.6 Max, 1.2 TYP	+10 MIN	+20 dBm	2.0:1
CA0106-3111	0.1-6.0	28	1.9 Max, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-3110	0.1-8.0	26	2.2 Max, 1.8 TYP	+10 MIN	+20 dBm	2.0:1
CA0108-4112	0.1-8.0	32	3.0 MAX, 1.8 TYP	+22 MIN	+32 dBm	2.0:1
CA02-3112	0.5-2.0	36	4.5 MAX, 2.5 TYP	+30 MIN	+40 dBm	2.0:1
CA26-3110	2.0-6.0	26	2.0 MAX, 1.5 TYP	+10 MIN	+20 dBm	2.0:1
CA26-4114	2.0-6.0	22	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA618-4112	6.0-18.0	25	5.0 MAX, 3.5 TYP	+23 MIN	+33 dBm	2.0:1
CA618-6114	6.0-18.0	35	5.0 MAX, 3.5 TYP	+30 MIN	+40 dBm	2.0:1
CA218-4116	2.0-18.0	30	3.5 MAX, 2.8 TYP	+10 MIN	+20 dBm	2.0:1
CA218-4110	2.0-18.0	30	5.0 MAX, 3.5 TYP	+20 MIN	+30 dBm	2.0:1
CA218-4112	2.0-18.0	29	5.0 MAX, 3.5 TYP	+24 MIN	+34 dBm	2.0:1

LIMITING AMPLIFIERS

Model No.	Freq (GHz)	Input Dynamic Range	Output Power Range Psat	Power Flatness dB	VSWR
CLA24-4001	2.0 - 4.0	-28 to +10 dBm	+7 to +11 dBm	+/- 1.5 MAX	2.0:1
CLA26-8001	2.0 - 6.0	-50 to +20 dBm	+14 to +18 dBm	+/- 1.5 MAX	2.0:1
CLA712-5001	7.0 - 12.4	-21 to +10 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1
CLA618-1201	6.0 - 18.0	-50 to +20 dBm	+14 to +19 dBm	+/- 1.5 MAX	2.0:1

AMPLIFIERS WITH INTEGRATED GAIN ATTENUATION

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	Gain Attenuation Range	VSWR
CA001-2511A	0.025-0.150	21	5.0 MAX, 3.5 TYP	+12 MIN	30 dB MIN	2.0:1
CA05-3110A	0.5-5.5	23	2.5 MAX, 1.5 TYP	+18 MIN	20 dB MIN	2.0:1
CA56-3110A	5.85-6.425	28	2.5 MAX, 1.5 TYP	+16 MIN	22 dB MIN	1.8:1
CA612-4110A	6.0-12.0	24	2.5 MAX, 1.5 TYP	+12 MIN	15 dB MIN	1.9:1
CA1315-4110A	13.75-15.4	25	2.2 MAX, 1.6 TYP	+16 MIN	20 dB MIN	1.8:1
CA1518-4110A	15.0-18.0	30	3.0 MAX, 2.0 TYP	+18 MIN	20 dB MIN	1.85:1

LOW FREQUENCY AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure dB	Power-out @ P1-dB	3rd Order ICP	VSWR
CA001-2110	0.01-0.10	18	4.0 MAX, 2.2 TYP	+10 MIN	+20 dBm	2.0:1
CA001-2211	0.04-0.15	24	3.5 MAX, 2.2 TYP	+13 MIN	+23 dBm	2.0:1
CA001-2215	0.04-0.15	23	4.0 MAX, 2.2 TYP	+23 MIN	+33 dBm	2.0:1
CA001-3113	0.01-1.0	28	4.0 MAX, 2.8 TYP	+17 MIN	+27 dBm	2.0:1
CA002-3114	0.01-2.0	27	4.0 MAX, 2.8 TYP	+20 MIN	+30 dBm	2.0:1
CA003-3116	0.01-3.0	18	4.0 MAX, 2.8 TYP	+25 MIN	+35 dBm	2.0:1
CA004-3112	0.01-4.0	32	4.0 MAX, 2.8 TYP	+15 MIN	+25 dBm	2.0:1

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QinetiQ Develops New Radar to Detect Low Trajectory Rockets

QinetiQ has developed a new radar, Alarm™, specifically designed to provide sufficient warning against short range, low trajectory rocket attacks, enabling personnel to take evasive action and significantly reduce casualties.

The availability of mortars and rockets to a wide variety of groups makes indirect fire a continuing threat to military bases. Conventional mortar locating radar systems detect high trajectory rounds and can predict the point of origin and the point of impact, giving troops valuable seconds warning to take cover. However, short range, low trajectory rocket attacks are difficult to detect and their high velocity reduces the amount of potential warning time available.

The Alarm radar is fully automatic, requires no manning and can be set up in 2 to 3 hours. It has proven to be effective in a series of trials against several hundred short range rockets, and the capability has been extended to cover other direct fire weapons. The training burden is small and the system exhibits a very low false alarm rate (essential for an automated system) and a very high probability of detection. Alarm is now in high rate production.

QinetiQ has now been awarded a second contract for a quantity of radars and software development and has plans to develop the capability further to address other key threats, therefore maintaining a leading edge and local expertise in this specialist area.

Dr. Jeremy Ward at QinetiQ in Malvern said, "I am delighted that our talented radar scientists and engineers have once again demonstrated that we have outstanding capability to solve difficult problems. Alarm is a world first for this type of solution, building on our 70 year heritage of developing radar and shows great future promise in being able to address challenging threats of the future to NATO forces."

Boeing Delivers FAB-T Test Units to U.S. Air Force

The Boeing Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) wideband communications program has entered a new phase by delivering the first two engineering development models to the U.S. Air Force.

Able to perform nearly all FAB-T production terminal mission functions, the models will be tested through June under realistic operational conditions aboard aircraft and at Hanscom Air Force Base in Bedford, MA.

"These models will allow the Air Force to test how actual terminals will perform in their deployed configurations," said Paul Geery, Boeing vice president and FAB-T program manager. "With tests conducted in 2012, Boeing has demonstrated that FAB-T can perform effectively even in the extreme vibration and harsh temperatures found on airborne platforms."

"Boeing has demonstrated that FAB-T can perform effectively even in the extreme vibration and harsh temperatures found on airborne platforms."

FAB-T will carry protected communications for the command and control of U.S. nuclear forces via Advanced Extremely High Frequency and Milstar satellites. The terminals will be used aboard B-2 and B-52 bombers, RC-135 reconnaissance aircraft and E-4 and E-6 Special Air Mission aircraft, as well as in fixed and transportable configurations on the ground.

"These milestones validate that Boeing has a mature design that meets operating requirements for all mission environments," Geery said. "Our solution offers the quickest and lowest-risk path to putting all the FAB-T functions into warfighters' hands."

Cobra Judy Replacement Radars Perform Exceptionally During First Live-Launch Test

The Raytheon Co.-led Cobra Judy Replacement (CJR) program surpassed expectations during its first tests against a live rocket launch on March 19. From approximately 100 miles off the Florida coast, the powerful X- and S-Band radars integrated onboard the USNS Howard O. Lorenzen (T-AGM 25) successfully acquired and tracked both stages of an Atlas V rocket launched from Cape Canaveral and collected all associated data.

The exceptional demonstration of CJR's performance validates its mission capability, advancing the program on schedule toward Initial Operational Capability (IOC) in January 2014. To be deployed as a strategic, global asset for ballistic missile monitoring, data collection and treaty verification, the large-scale, complex dual-band radar suite of CJR consists of X- and S-Band phased-array sensors, a common radar suite controller and other related mission equipment.

"CJR continues to excel at each stage of development and testing – no small feat for a new program with its level of scale and complexity," said U.S. Navy Captain Rod Wester, CJR program manager, Program Executive Office – Integrated Warfare Systems (PEO IWS 2I). "The performance of the radars – and the platform as a whole – has been outstanding and it is a testament to the skill, experience and dedication of the government-industry team of experts, working together to bring this critical capability closer to deployment."

Raytheon is the prime contractor for the CJR mission equipment and principal on an industry team that includes Northrop Grumman Electronic Systems. The team has been a model of collaboration, focused on the delivery of a high-performing shipboard radar capability that the U.S.

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Navy, the U.S. Air Force and the nation can rely upon as a critical global asset.

This live-launch exercise follows a series of achievements for this true dual-band, active phased-array radar suite. Since at-sea testing began in July 2012, the program team has been incrementally testing and fine-tuning the radars against targets of increasing complexity. In late 2012, two critical firsts were achieved: the demonstration of full-power radiation capability of the high-sensitivity shipboard X- and S-Band radars; and the successful dual-band acquisition and tracking of satellites under the control of the CJR common radar suite controller.

U.S. Navy Awards Lockheed Martin $57 M to Upgrade EW Ship Defense System

The U.S. Navy awarded Lockheed Martin a $57 M contract to upgrade the fleet's electronic warfare defenses against anti-ship missile threats.

Under this low-rate production contract for Block 2 of the Navy's Surface Electronic Warfare Improvement Program (SEWIP), Lockheed Martin will upgrade the AN/SLQ-32(V)2 system found on all U.S. aircraft carriers, cruisers, destroyers and other warships with key capabilities to determine if the electronic sensors of potential foes are stalking the ship.

"The SEWIP Block 2 upgrade will ensure the AN/SLQ-32 system continues to outpace the threat and establishes a framework to easily install future upgrades," said Joe Ottaviano, SEWIP program director for Lockheed Martin Mission Systems and Training. "The system is the first sensor to be fully compliant with the Navy's Product Line Architecture strategy, which facilitates the rapid introduction of new technology into the fleet. By using commercial-off-the-shelf components, we provide additional cost savings and ease of maintenance for sailors."

Block 2 is the latest in an evolutionary succession of improvement "blocks" the Navy is pursuing for its shipboard electronic warfare system, which will incrementally add new defensive technologies and functional capabilities. The Navy competitively awarded Lockheed Martin a contract in 2009 to develop SEWIP Block 2 and the company recently completed successful integration and test activities for two engineering development models.

Work on the SEWIP program will be performed at the company's Syracuse, NY facility.

In January 2012, Lockheed Martin teamed with Raytheon Co., the original developer of the AN/SLQ-32, to pursue the Navy's competitive SEWIP Block 3 program, which will upgrade the system's electronic attack electronic warfare capabilities. A formal Navy request for Block 3 proposals is anticipated later this year.



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NXP and Cohda Wireless Sign MoU

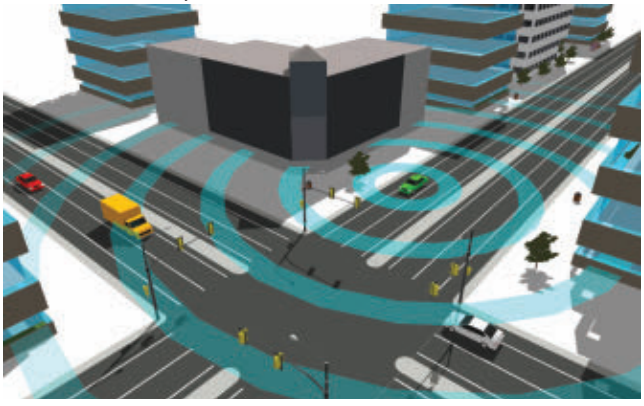
NXP Semiconductors and Cohda Wireless have signed the CAR 2 CAR Communication Consortium Memorandum of Understanding (MoU). The memorandum aims at implementing and deploying harmonized technology for the wireless communication between cars, or between cars and traffic infrastructure, in Europe.

In addition, NXP and Cohda have announced the introduction of Roadlink™ as their new technology brand for marketing a total Car-to-X (C2X) communication and security solution for on-board units and road-side units in Intelligent Transport Systems (ITS). Automotive-ready modules based on Roadlink are currently being developed by companies including lesswire AG in Germany. lesswire has announced a C2X module which supports the introduction of automotive applications from 2015 onwards, as planned by the CAR 2 CAR Communication Consortium.

The overall objective of the CAR 2 CAR Communication Consortium is to implement and deploy cooperative Intelligent Transport Systems. This will be the basis for achieving new levels of traffic safety and improving traffic efficiency on European roads. The consortium is therefore pushing for global harmonization of Car-to-Car (C2C) and Car-to-Infrastructure (C2I) communication standards, recognizing the need to adapt software to the regional characteristics of the U.S., European and Japanese markets.

"We are pleased to have NXP sign the memorandum," said Søren Hess, general manager, CAR 2 CAR Communication Consortium. "The fact that NXP, as a major driver of secure connected mobility solutions, has designed first automotive-ready products for C2X is a major step in the consortium's plans of making car-to-car communication on European roads a reality from 2015 onwards."

Torsten Lehmann, senior vice president and general manager car entertainment solutions at NXP Semiconductors, explained, "Signing the memorandum of understanding underscores our commitment to make the connected car a reality, reducing road accidents, saving lives, reducing CO_2 emissions and improving traffic flow. The IEEE802.11p modules that lesswire is designing based on RoadLink technology will set new benchmarks in the automotive industry.



Roke Awarded UK Sensor Research Programme Contract

Roke Manor Research Ltd. has been awarded a three-year, £5 million research contract by the UK government's Defence Science and Technology Laboratory (Dstl). Under the Dismounted Close Combat Sensors (DCCS) Research Programme, Roke will lead a team of specialists, drawn from across industry and academia, to assess, mature and integrate innovative sensor technology for the dismounted close combat infantry soldier.

An important goal of the programme is to develop an open system architecture, in line with the developing Generic Soldier Architecture (GSA), to allow for the integration of multiple sensor-based subsystems, such as acoustic, thermal imaging and RF subsystems. The system would enhance situational awareness, facilitate collaborative targeting and increase operational tempo, while minimising the size, weight and power burden on the soldier.

The DCCS Research Programme Team comprises Roke as prime, SEA and QinetiQ, performing a comprehensive system integration, architecture and experimentation role. The team will work with a wide range of technology and exploitation partners, in an open framework, to assess and integrate sensor technologies. Roke will also work closely with Dstl to ensure the objectives of the programme are met.

"The intent is to develop the UK's dismounted soldier as an integrated sensor capability within the wider ISTAR enterprise …"

Dr. David Massey, programme lead for Dstl's C4ISR Domain, stated, "The DCCS research to be delivered by Roke is an important programme for the Ministry of Defence. The intent is to develop the UK's dismounted soldier as an integrated sensor capability within the wider ISTAR enterprise, thus providing him with greater local and shared situational awareness whilst increasing his overall combat effectiveness. Over the next three years, Roke, along with its partners, will be developing the key low-power, low-weight sensor and processing technologies that will realise the benefits envisaged."

James Fisher, business sector manager at Roke, added, "The team will be casting the net wide to identify novel sensor technologies, developing them into workable solutions that improve military capability and therefore maximise the return on this programme's investment."

TSB to Maintain UK's Leading Place in Aerospace

The Technology Strategy Board (TSB) has welcomed the UK government's new industrial strategy for aerospace and the establishment of the Aerospace Tech-

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"Within 20 years, the global aerospace market could be worth $4.5 trillion …"

nologies Institute (ATI), pledging that the UK's innovation agency will play a full part in ensuring the UK stays at the forefront of this rapidly changing sector.

The ATI will build on work already being carried out by the TSB. The board will partner with the ATI to deliver new, large-scale projects by bringing together leading industrial and academic interests. A number of specialist programmes will also use the resources of the High Value Manufacturing Catapult, a technology and innovation centre established and overseen by the TSB.

The TSB's chief executive, Iain Gray, said, "Aerospace is among the most technologically-demanding of sectors. It is one where innovation in processes, materials or technologies can give the developer a global competitive advantage. The creation of an Aerospace Technologies Institute will help the UK retain its leading role in this area."

"Within 20 years, the global aerospace market could be worth $4.5 trillion," he added. "The new Aerospace Technologies Institute can help ensure that the UK gets a large share of that business. The Technology Strategy Board, with its experience of leveraging the wealth of innovative ideas in the UK's business community, will play a full part in realising that potential."

415 Operators in 124 Countries Investing in LTE

The latest update of the Global mobile Suppliers Association's (GSA) Evolution to LTE Report confirms 361 firm LTE network deployments are planned or in progress in 114 countries, including 163 networks which are commercially launched in 67 countries. MVNOs are excluded and multi-band networks are counted as one network.

A further 54 operators in 10 additional countries are engaged in pre-commercial LTE technology pilot trials, tests or studies. Taken together, it means that 415 operators in 124 countries are now investing in LTE, and the GSA forecasts there will be 248 commercial LTE networks in 87 countries by the end of 2013.

LTE is the fastest developing mobile system technology and is now mainstream. The total number of LTE subscriptions reached 68.33 million in Q4 2012. Seventy-four operators have launched commercial LTE1800 (band 3) systems in 43 countries either as a single band system, or as part of a multi-band deployment. 1800 MHz is the most widely used band for LTE deployments globally. LTE1800 serves millions of subscribers (Q4 2012 = 14.27 million) on over 45 percent of commercially launched LTE networks today.

The next most widely used band for LTE deployments is 2.6 GHz (50 networks, i.e., over 30 percent of networks in service). Fifteen LTE TDD systems are commercially launched (within the total of 163 commercial networks) including six that are deployed in combined LTE FDD and TDD operations.

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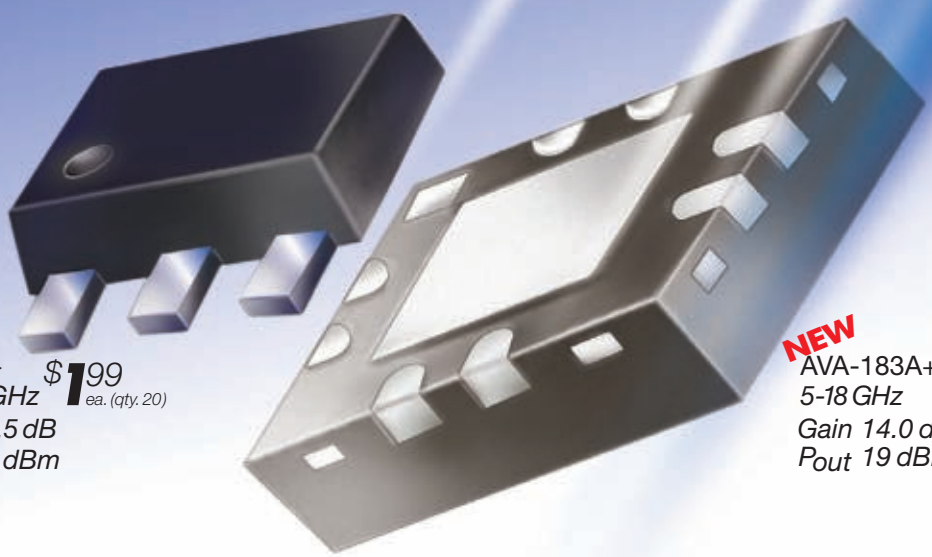
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Integrated Platforms Increasingly Important; Rising to 46% of Handsets in 2018

Mobile device design is increasingly reliant on integrated platforms, which are chipsets based on combinations of application processor, baseband processor and wireless connectivity technologies. In 2012, 19 percent of handsets shipped were based on an integrated platform; set to more than double to 46 percent in 2018.

"Integrated solutions are used in many handsets from mass-market smartphones to flagship smartphones and will eventually find their way into feature phones," noted research director Philip Solis. "One industry dynamic mitigating the need for integrated platforms are device reference designs and related services offered by semiconductor vendors."

Qualcomm certainly benefits from its integrated platform products as it offers a large number of them with different features. Currently, only Qualcomm integrates wireless connectivity into its products, and is the only vendor offering integrated solutions including application processors, baseband processors and wireless connectivity. ABI Research expects other suppliers to eventually catch up, with Intel and Broadcom looking to be the most significant competitors.

In 2012, 80 percent of handsets shipped were based on a single-core processor. This will flip by 2018 with 92 percent of handsets using a dual-core or higher application processor. This includes quad-core processors consisting of 4 cores or 4.4 (big.LITTLE, sometimes referred to as "octacore") cores. In 2018, over one billion smartphones will ship with quad-core processors.

Also, in 2012, 12 percent of handsets included LTE. This will increase to 35 percent of all handsets, with a small percentage of these being singlemode LTE.

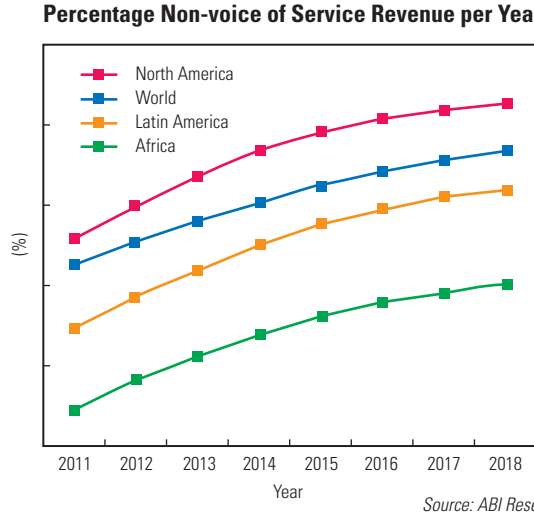
GaAs Device Revenue Grows in 2012

Growth in the last quarter of 2012 pulled GaAs device revenue to a slight gain for 2012. The Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) Insight, "GaAs Device Industry Closes up in 2012", explores GaAs device revenue growth and trends. It also presents the revenue performance of leading GaAs device manufacturers and foundries like RFMD, Skyworks, TriQuint Semiconductor, Avago Technologies and WIN Semiconductors.

The Insight concludes that handset growth, particularly smartphones, is responsible for most of the revenue growth in the GaAs device market. As data consumption continues to soar, handsets will remain the primary driver for GaAs device growth. In the short-term, revenue in the GaAs device market is expected to exceed the historical average. In the longer term, the Insight points out that recent developments in CMOS multi-mode, multi-band handset PAs from Qualcomm and others will pose a significant threat to the GaAs device market.

"Smartphones continue to grow faster than the overall handset market. This growth, coupled with more bands and increased GaAs device content remains the single biggest driver for revenue growth in the GaAs device market," noted Eric Higham, director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs). "In the short-term, we anticipate this combination of factors will drive GaAs device revenue growth above historical averages."

Global Mobile Data Will Exceed 40% of Total Service Revenue by 2014



Source: ABI Research

Global mobile data service revenue, made up of mobile internet and messaging revenue, will rise by 21.4 percent between 2012 and 2014 to represent 40.4 percent of the US$1 trillion mobile customers will be spending on their mobile phone services. Thanks to strong commitments to LTE network deployment in Latin America and Africa, not just the developed markets, growth rates in the regions will be substantially faster as the increase in usage outstrips mobile data pricing decline. This represents a significant opportunity for regional mobile content and application developers, which will stimulate a very nascent mobile apps and content marketplace.

North America will be the first region to see mobile data service revenue eclipse voice revenue in 2016. "By offering unlimited voice calls and texts, while making data the only component in a bundled plan with positive marginal costs to consumers, wireless operators as AT&T and Verizon help to prop up voice and messaging, making positive revenue contributions in the short to medium-term. Rich communication services (RCS) and voice and messaging APIs are a key part of their strategy of making carrier-based calls and messaging relevant to their customers," according to Ying Kang Tan, research associate at ABI Research.

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"While global messaging service revenue is in gradual decline, mobile internet service revenue is very much the main driver of revenue growth (2012: US$244.2 B, 21 percent year-on-year)," added Jake Saunders, VP and practice director, core forecasting. "As smartphones have become the entertainment hub in our lives, music, video and TV streaming's contribution of mobile internet service revenue has jumped to 26 percent in 2012."

Small Cell Market to Hit $2.7 B by 2017

Infonetics Research released excerpts from its latest Small Cell Equipment market size and forecast report, which tracks 3G microcells, picocells, and public access femtocells and 4G LTE mini eNodeBs and public access femtocells.

"2013 is shaping up as a kick-off year for small cells, driven by 4G small cells deployed for capacity upgrades," expects Stéphane Téral, principal analyst for mobile infrastructure and carrier economics at Infonetics Research. "AT&T, Sprint, and Verizon Wireless in the U.S., Vodafone in Europe, LG U+ in South Korea, and NTT DOCOMO in Japan have all announced major small cell plans, driven by the need to enhance the capacity of saturated macrocellular networks as they seek to deliver denser, higher-capacity coverage to tech-savvy populations in urban areas."

Co-author of the report, Richard Webb, directing analyst for microwave and carrier WiFi at Infonetics, adds, "As operators formulate their plans for small cell rollouts, one of the key decisions will be how tightly to integrate Wi-Fi. Last year, we saw clear indications that picocells would have integrated Wi-Fi, and this has indeed materialized. Both technologies have similar range and power requirements, which may provide an advantage for picocells over microcells, as the dense cell option could have its own in-built offload option."

Small Cell Market Highlights

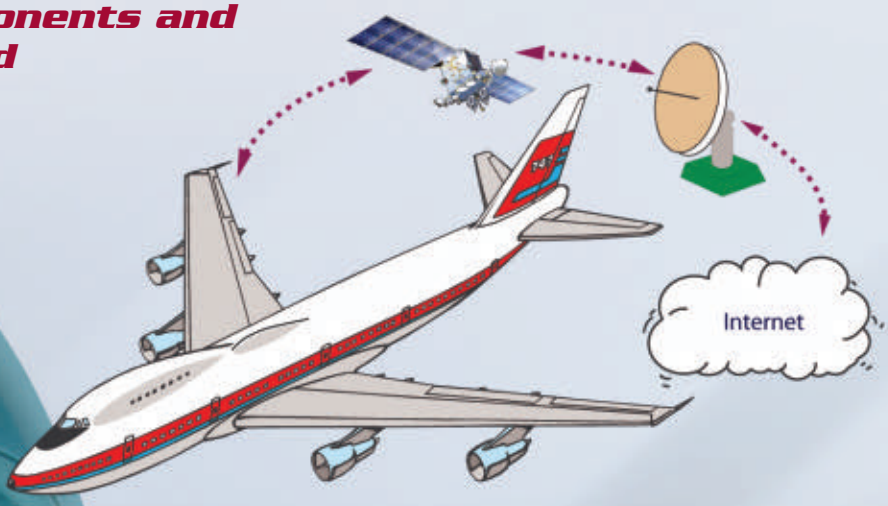
- Infonetics forecasts the global small cell market to grow from a very small base now to $2.7 billion by 2017
- Given the current pace of LTE rollouts worldwide, 4G small cell shipments are anticipated to overtake 3G shipments by the end of 2013
- South Korea's SK Telecom has deployed close to 40,000 small cells and is the leading adopter of 4G public access femtocells to date
- Backhaul is no longer an inhibitor to small cell growth, but could remain an issue depending on factors such as location or mobile operator
- Geographically, Infonetics expects Asia Pacific to lead the small cell market in 2013 with 50 percent of all units shipped, followed by EMEA with 34 percent, and North America with 14 percent



Ka-Band Inflight Communication Solutions

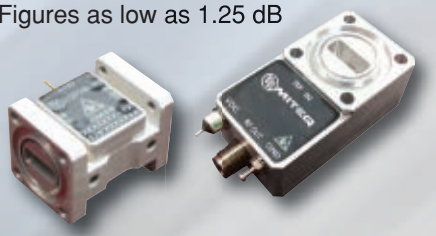
MITEQ offers a wide range of flight proven [RTCA DO-160 E/F] components and subsystems at Ka-Band

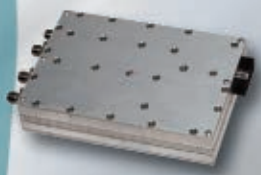




Low Noise Amplifiers

- 17.7-21.2 GHz with Noise Figures as low as 1.25 dB
- Lightweight/Hermetic
- Waveguide or Coaxial
- Low Voltage [+5 VDC]



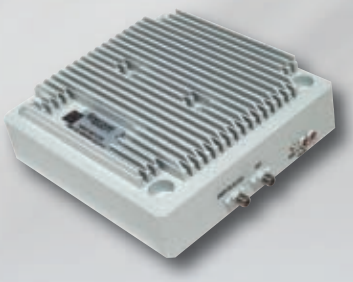


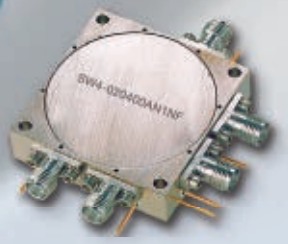
Modular Frequency Converters

- Small Efficient Up/Downconverters
- Wideband IF coverage
- High Linearity

Power Amplifiers

- 29.5-31 GHz
- Power levels to 10 watts
- Adjustable Gain



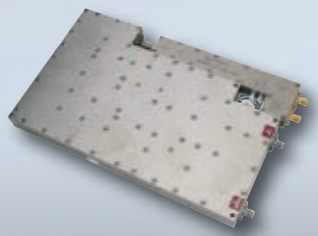


PIN Diode Switches

- SP2T-SP4T Coaxial Absorptive type
- High Isolation

Frequency Sources

- Ultra-low Phase Noise vibration insensitive
- Step sizes down to 1 kHz (synthesizer)



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Around the Circuit

Laura Glazer, Staff Editor

COLLABORATIONS

Ericsson and **STMicroelectronics** announced an agreement on the way forward for the joint venture ST-Ericsson. After months of intensive joint work, the parent companies have selected the strategic option which maximizes their respective future prospects and growth plans. The main steps agreed upon to split up the joint venture are: Ericsson will take on the design, development and sales of the LTE multimode thin modem products, including 2G, 3G and 4G multimode; ST will take on the existing ST-Ericsson products, other than LTE multimode thin modems, and related business as well as certain assembly and test facilities; the remaining parts of ST-Ericsson will be closed down.

Modelithics Inc. has announced new collaborations with three companies. **Mini-Circuits** and Modelithics Inc. will work together on the development of high-accuracy EDA simulation models of Mini-Circuits' surface-mount microwave precision fixed attenuators YAT and RCAT series. The models are currently in development and will be available later this quarter. Modelithics has added **Passive Plus Inc.** (PPI) to its Vendor Partner Program, collaborating with PPI to develop Global Models for four series of PPI's ultra-low ESR capacitors. These models are currently available and included in the 2013 Modelithics Library releases. **Piconics Inc.** and Modelithics have collaborated to upgrade the previous Piconics conical inductor S-parameter models to full equivalent circuit models. The models are currently available as pre-release models and will be added to the next version of the Modelithics Library of advanced high frequency simulation models in 2013.

Lime Microsystems has signed a deal with **Interlligent RF & MW Solutions** to use the company's latest test and measurement technology in the development of its field programmable RF (FPRF) transceiver ICs. Lime will use Interlligent to further its development of software configurable transceivers.

Nigerian Communications Satellite (NigComSat) Ltd. has selected satellite specialist **Newtec** to provide a Ka-Band hub platform including terminals to offer B2B and B2C broadband services. The broadband platform will enable voice, data, video, Internet and application service solutions over Nigeria via the NigComSat-1R satellite. Newtec's VSAT Hub and terminals have been selected to be part of NigComSat's mission to provide cost-effective satellite broadband services to Nigerian consumers and SMEs, with planned services for West Africa. The installation of a first Newtec broadband hub is already complete and NigComSat plans to operate several thousands of satellite modems within the first year of operation.

Tensilica Inc. has strengthened its strategic relationship with **Huawei** with the announcement that HiSilicon, the semiconductor division of Huawei, is expanding its use of Tensilica's Dataplane Processor Units (DPU), including Tensilica's Xtensa customizable processor technology, HiFi Digital Signal Processors (DSP) for audio and voice processing in smartphones and set-top boxes, and ConnX Baseband Engines for LTE base stations, handsets, and other network infrastructure and customer premise equipment.

NEW STARTS

A versatile **NASA** airborne imaging radar system is showcasing its broad scientific prowess for studying Earth during a month-long expedition over the Americas. A NASA C-20A piloted aircraft carrying the Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) is wrapping up studies over the U.S. Gulf Coast, AZ, and Central and South America. NASA's Jet Propulsion Laboratory in Pasadena built and manages UAVSAR. The campaign is addressing a broad range of science questions, from the dynamics of Earth's crust and glaciers to the carbon cycle and the lives of ancient Peruvian civilizations.

Carlson Wireless announced the launch of the first TV white space (TVWS) trial in South Africa. Led by **Google**, the trial will test TVWS wireless broadband in ten schools across the Cape Town area. Carlson, the project's equipment vendor, Google and other project partners will attempt to show that broadband can be offered over white spaces without interfering with licensed spectrum holders. To prevent interference with other channels, the network utilizes Google's spectrum database to determine white space availability. Carlson's RuralConnect Broadband Solution, enabled by the Neul Horizon software, provides the communications backbone for the trial.

Anritsu Co. announces the **Toughest Site Competition 2013** that recognizes the challenges faced every day by field engineers and technicians responsible for deploying, installing, and maintaining wireless networks. The contest, which runs until June 30, 2013, highlights how field professionals overcome harsh weather conditions, extreme environments, and technical challenges to ensure the operation of private and commercial wireless networks. Twelve finalists will receive GoPro cameras and the grand prize winner will drive away with a Harley-Davidson motorcycle.

COMBILENT USA announces the opening of its U.S. facility in the Chicago area to support OEM customers and their channel partners. The facility is fully operational with distribution, testing and assembly capabilities.

ACHIEVEMENTS

Sierra Nevada Corp. (SNC) delivered the first low rate initial production (LRIP) Mobile Tower System (MOTS)

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HPXO series

High Performance

Crystal Oscillators

Model	Frequency (MHz)	Output Power dBm (typ.)	Harmonics dBc (Typ.)	Frequency Stability Over Temp. (Typ.)	Bias Voltage VDC (Typ.)	Phase Noise (dBc/Hz) [Typ.]		
						@100 Hz	@1 kHz	@10 kHz
HPXO100	100	+15	-35	±0.2 ppm	+12	-140	-162	-183
HPXO125	125	+15	-35	±0.2 ppm	+12	-140	-160	-183

RoHS



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- *Oven / Voltage Controlled*
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to the **United States Army** ahead of schedule. The LRIP contract was awarded in March 2012 for 10 MOTS. An early development MOTS has been deployed with the 3rd Infantry Division in Afghanistan since November 2012. The new AN/MSQ-135 MOTS will replace the Army's aging AN/TSW-7A air traffic control tower. The MOTS system will also provide a worldwide deployable ATC capability to U.S. Army Aviation.

Cassidian and **Astrium Services** have successfully completed the final validation tests for their remote solution for linking Tetrapol tactical cells using Astrium Services' satellite communication services. The aim is to provide operations centers and the departmental fire and rescue services in France with access to dedicated satellite communications that are available 24/7, in particular for crisis situations. The first operational use of this solution will take place in the spring of 2013.

AMETEK Programmable Power announces that its ReFlex Power (RFP) System is now qualified for use in standard Department of Defense Automated Test Systems (ATS) across all major military branches. It is the only power system on the market that satisfies all of the military services' test protocols, including the Navy's electronic Consolidated Automated Support System (eCASS), scheduled to be deployed in 2015 as well as the Marines' Reconfigurable Transportable CASS (RTCASS) program, the Army's Next Generation Automatic Test System (NGATS), and the Air Force's Versatile Depot Automatic Test Station (VDATS).

CONTRACTS

Harris Corp. has received a $500 M increase in the ceiling value of its 2011 Indefinite Delivery, Indefinite Quantity (IDIQ) contract with the **U.S. Army Communications Electronics Command**. The increased ceiling provides the U.S. government with greater flexibility in acquiring Harris radios, accessories, systems and services to assist international partners with their mission-critical communication needs. Under the contract, Harris provides military and land mobile radio systems to international partners of the U.S. State Department and U.S. Department of Defense.

Cassidian has won a €50 M programme to equip the airfields of the **Royal Canadian Airforce** with latest-technology airport surveillance radars. The Canadian contracting authority Public Works and Services Canada has selected Cassidian to deliver seven of its ASR NG airport surveillance radars to improve the flight safety on Canadian airbases and to enhance the integration of military aviation into civil air traffic. Cassidian is working together with Lockheed Martin Canada as a strong local partner in this project.

Defense and security company **Saab** has received an order worth SEK380 million from **Brazilian Embraer Defense and Security**. The contract is for the delivery of an upgrade of the existing Erieye Airborne Early Warning and Control (AEW&C) systems, as part of the modernization programme

NITRONEX

The Largest family of GaN RF Power Devices on Silicon Just got Bigger

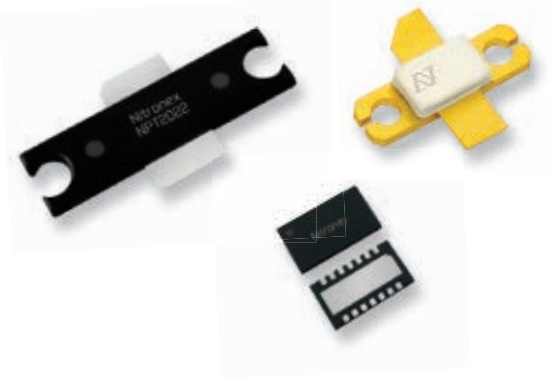
Introducing the Newest Family of 48V GaN RF Power Devices

See Nitronex and the 48V GaN product line at IMS 2013 - Booth 1522

Psat (W)	Plastic
12	NPT2018 (3X6 DFN)
25	NPT2019 (3X6 DFN)
50	NPT2021 (T0272)
100	NPT2022 (T0272)

Psat (W)	Ceramic
50	NPT2020 (AC360)
100	NPT2010 (AC360)

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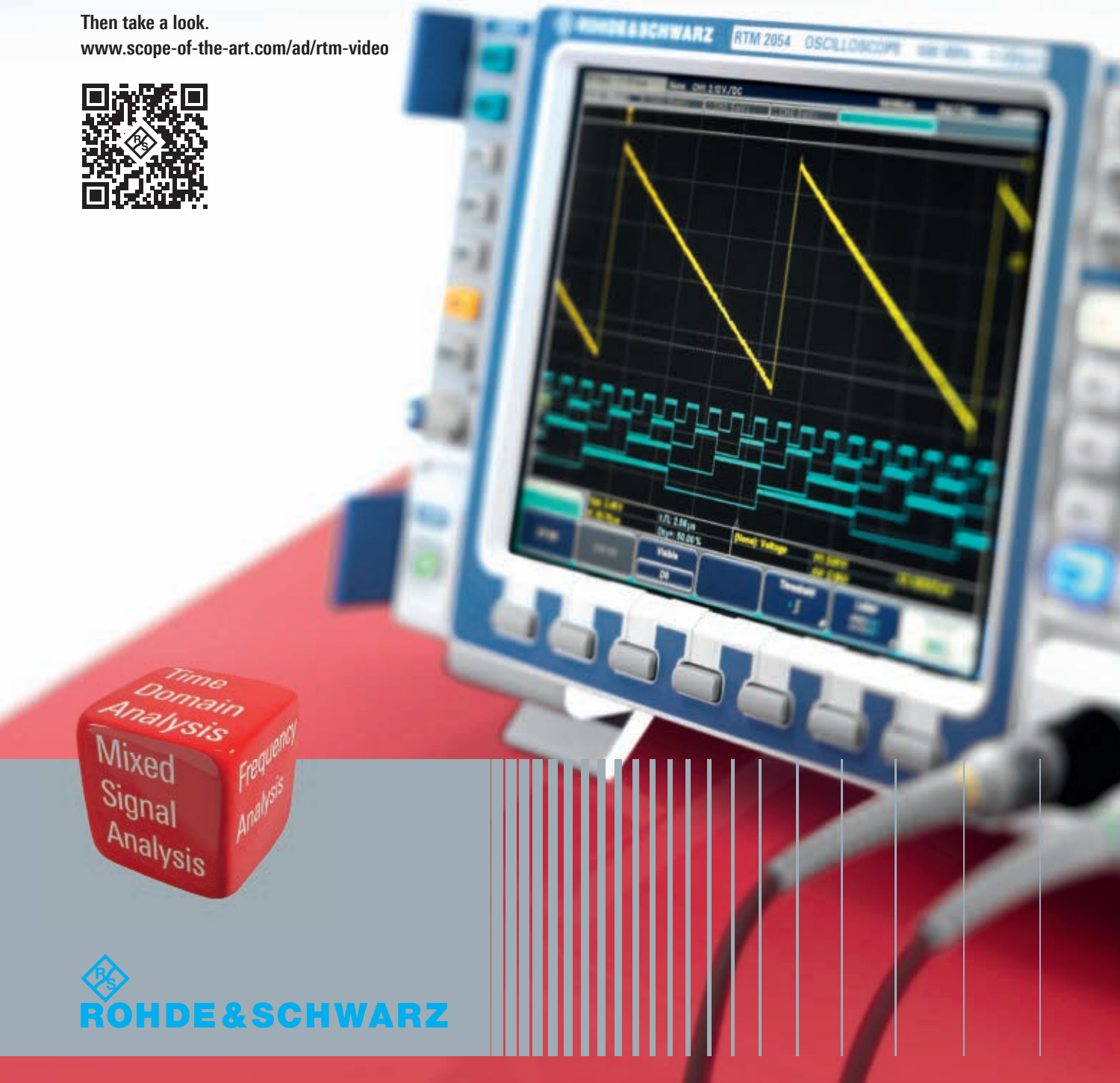
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for the Embraer 145 AEW&C, named E-99 in the Brazilian Air Force. The E-99 is important within the Brazilian Air Force for the control of airspace and border surveillance and the upgrade will bring a substantial increased operational capability. The upgrade will be delivered from 2014 until 2017.

The **U.S. Navy** awarded **Lockheed Martin** a $57 M contract to upgrade the fleet's electronic warfare defenses against anti-ship missile threats. Under this low-rate production contract for Block 2 of the Navy's Surface Electronic Warfare Improvement Program (SEWIP), Lockheed Martin will upgrade the AN/SLQ-32(V)2 system found on all U.S. aircraft carriers, cruisers, destroyers and other warships with key capabilities to determine if the electronic sensors of potential foes are stalking the ship.

Cobham has been awarded a £16 M order to supply **NATO** forces with leading-edge vehicle mounted Improvised Explosive Device (IED) detection equipment. These systems will be delivered in 2013 by Cobham Antenna Systems in the UK. Additionally, Cobham's Brazilian subsidiary has secured its first major contract in Brazil to equip State Police helicopters with HD video surveillance downlinks which will be used on helicopters in 12 cities during the 2013 Confederations Cup and the 2014 World Cup. The contract was developed with a local integration partner following the opening of the Cobham's Sao Paulo office in August 2012 and includes both airborne and ground based equipment.

Ceragon Networks Ltd. has received follow on orders from **Telefónica** for network upgrading in Mexico, which means that the company will now provide high-capacity wireless backhaul solutions to Telefónica in four markets throughout Latin America.

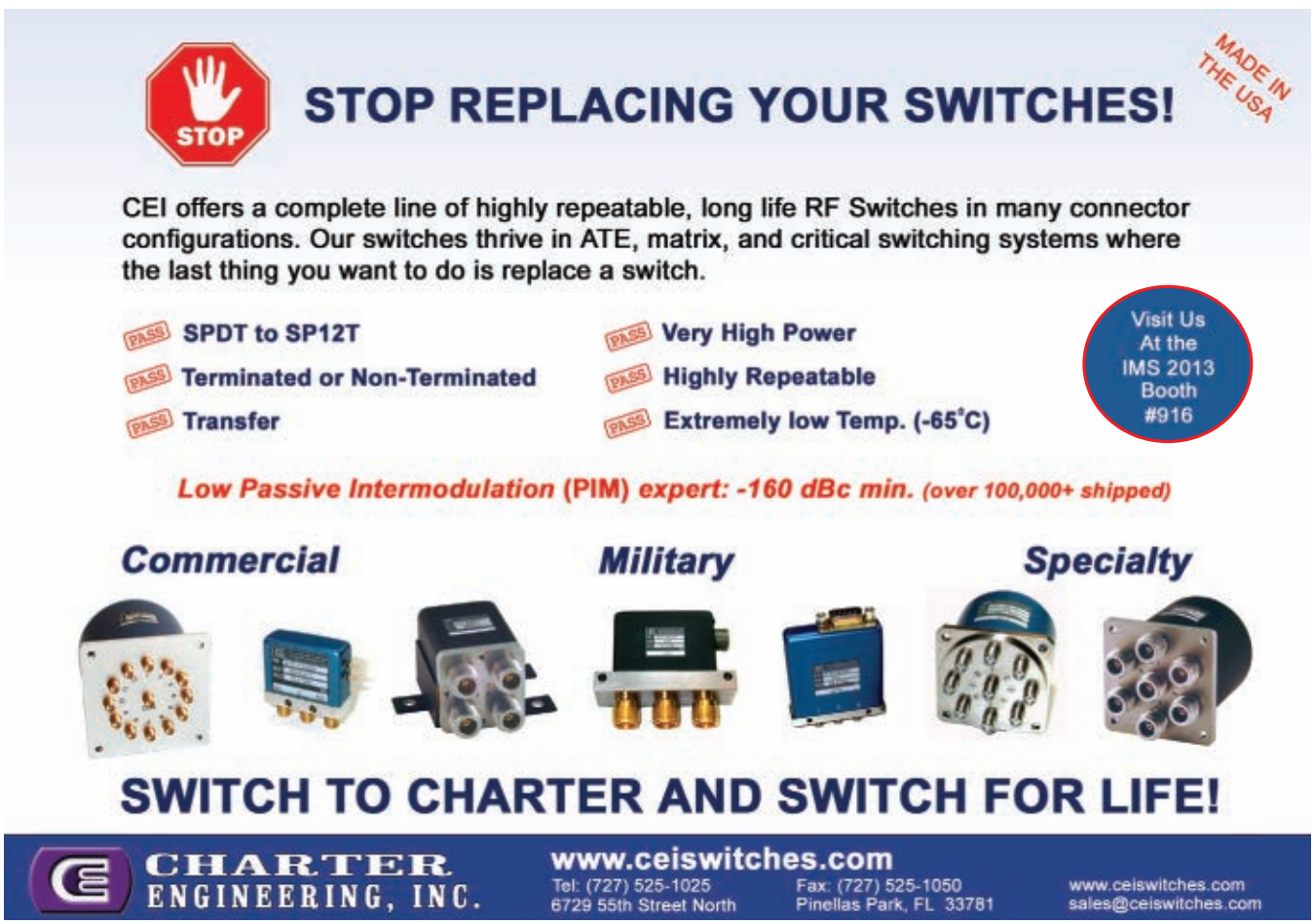
PEOPLE

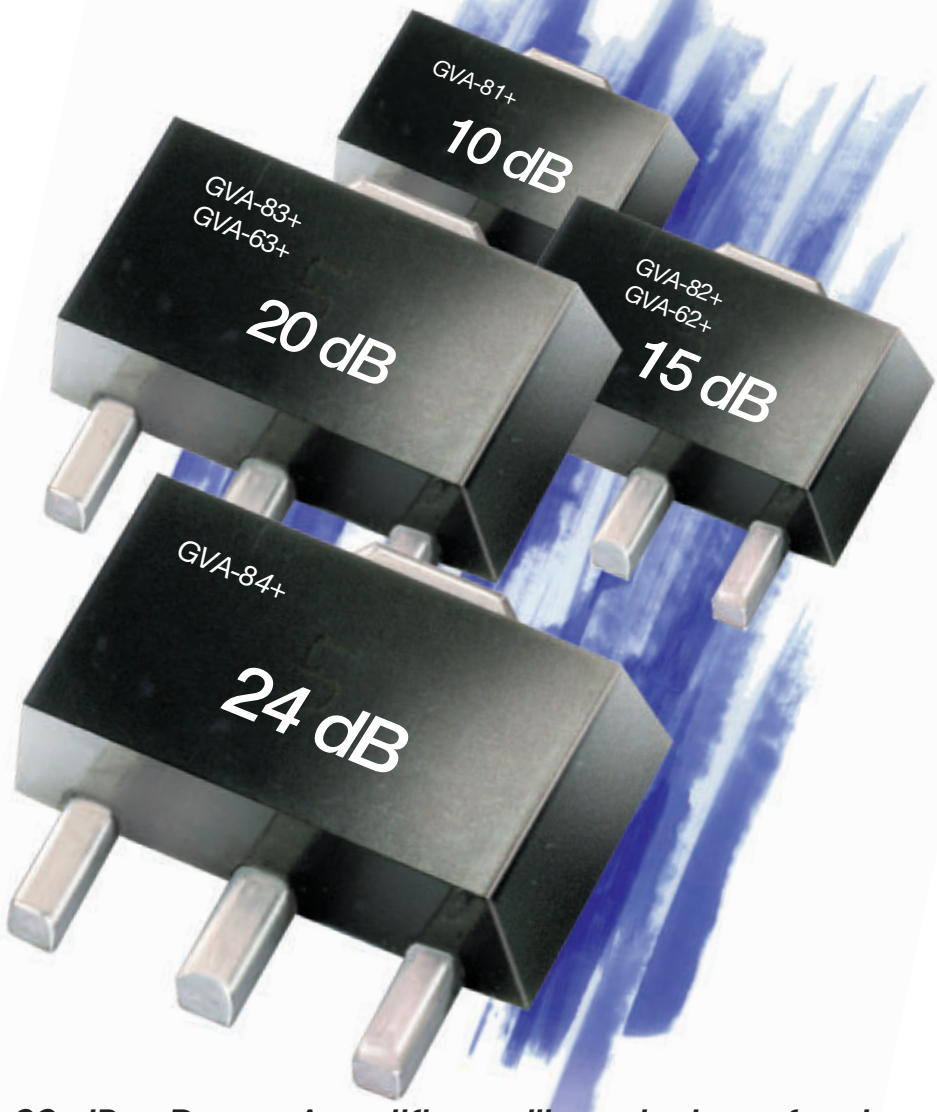


▲ *Rick D. Hess*

The board of directors of **Hittite Microwave Corp.** announced Stephen G. Daly stepped down as the company's chairman, president and chief executive officer. The board named **Rick D. Hess** as the company's next president and chief executive officer. The board also announced **Franklin Weigold** was named non-executive chairman of the board. Daly will support the transition in an advisory role to the new CEO as needed, and will remain a director until the 2013 annual shareholders meeting later this month.

RF Micro Devices Inc. announced the appointment of **James A. Clifford** as vice president, foundry services. Clifford is a recognized industry leader with wide-ranging experience in technology, procurement, supply chain, operations, quality, and program management. He previously served at QUALCOMM Corp. for 18 years, most recently as senior VP and general manager of operations. Prior to QUALCOMM, Clifford spent 21 years at Unisys Corp. In his newly created position at RFMD, Clifford will be responsibile for RFMD's relationships with external foundry





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DC* to 7 GHz from 94¢ ea. (qty. 1000)

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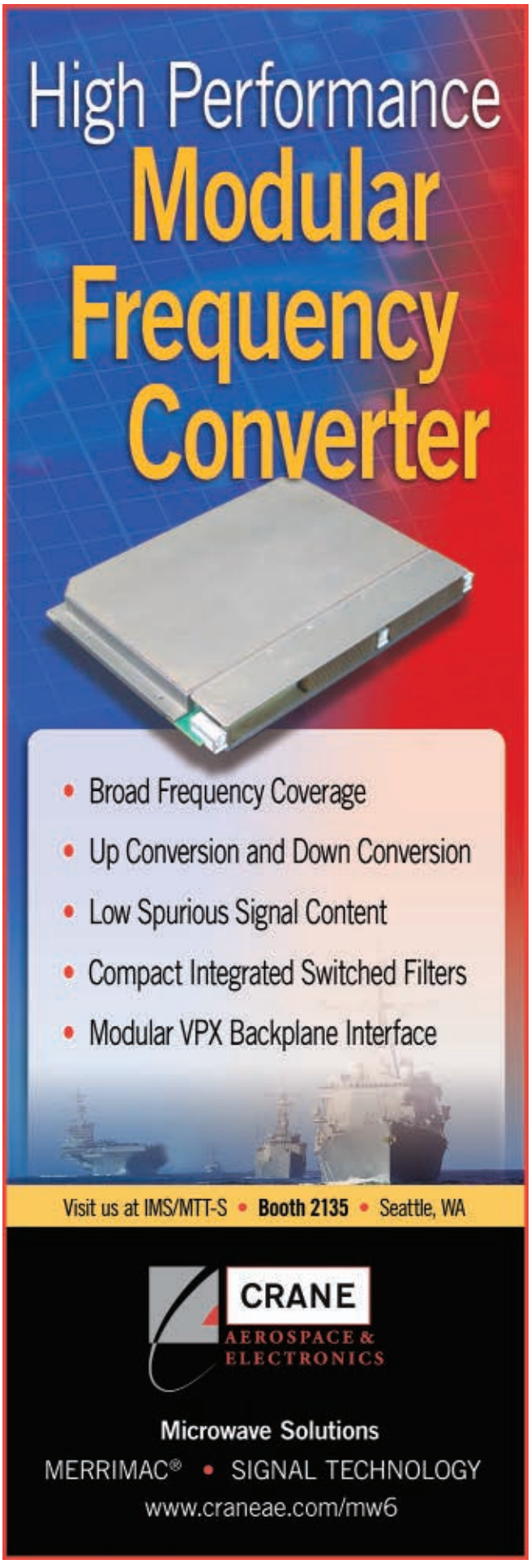
**Low frequency cut-off determined by coupling cap, except for GVA-62+ and GVA-63+ low cutoff at 10 MHz.*

US patent 6,943,629

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Around the Circuit

partners. Clifford will be based in RFMD's headquarters in Greensboro, NC.



▲ Robert Donahue



▲ Gaurav Menon



▲ Dave Corman

Anokiwave announced three new appointments. **Robert Donahue** joined the company as CEO in April 2013. He has 30 years of experience in both commercial and military RF-mmW semiconductor industries. Prior to joining Anokiwave Donahue was the CSO and COO of M/A-COM Tech. He received his BSEE from UMASS Lowell, MSEE from UMASS Amherst on a Raytheon Fellowship and an MS in the Management of Technology from the MIT Sloan School. **Gaurav Menon**, who joined Anokiwave in May 2008 as a senior design engineer and also served as director of engineering, has been promoted to VP of Si RFIC development. Over the past decade, he has designed and led the development of microwave and mm-wave GaAs MMICs, SiGe RFICs, discrete MICs, modules and packages. He holds seven U.S. patents. **Dave Corman** has joined Anokiwave as chief systems architect. His primary focus is the achievement of higher levels of functional integration by combining system engineering with enabling solid state integrated circuit technologies including GaN, GaAs, SiGe and CMOS. He holds over 40 patents worldwide.

Santier announced the hiring of **Kevin Cotner** as chief operating officer. Cotner will manage Santier's sales, manufacturing and procurement departments. He will report to Vim Dutt, Santier's president and CEO. A respected industry veteran, Cotner brings more than 25 years of experience running operations for leading companies in the electronics industry. Most recently, Cotner served as general manager of North American production for Kyocera, where he enjoyed a distinguished 15-year career. During his time at Kyocera, Cotner led the company through a major transformation, which included upgrading the company's manufacturing systems in the USA and Mexico.



▲ David W. Runton

Nitronex has named **David W. Runton** as its new vice president of engineering. Runton has almost 20 years of RF power semiconductor experience with six years in GaN specific product development, including design, assembly, qualification and packaging. Runton most recently served as director of high power engineering for RFMD where he led an engineering product release team and developed long term product strategy. He has also held engineering leadership positions at Freescale and Motorola Semiconductor.

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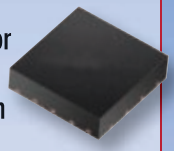
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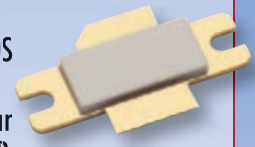
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- Obsolete Parts Replacement • Custom Product Development

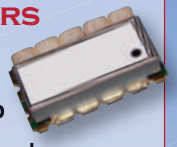
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- Semiconductor
- Mechanical
- High Isolation
- High Power
- GaN • Die

RF Amplifiers

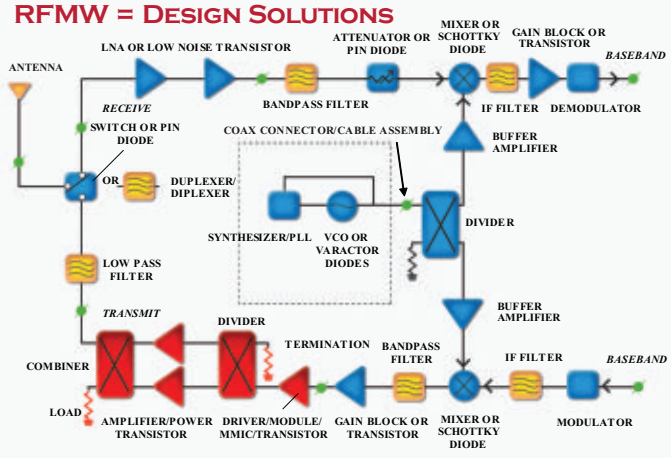
- Gain Blocks
- Coaxial Module
- Low-Noise
- Linear Drivers
- High Power
- Variable Gain

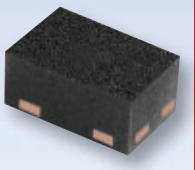
RF Transistors

- GaN
- LDMOS
- GaAs
- Bipolar
- High Power
- High Frequency

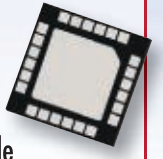
RF Filters

- Monoblock
- SAW / BAW
- HP / LP / BP
- Ceramic Resonator
- Duplexer / Diplexer
- Cavity

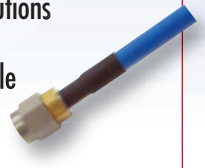
RF Oscillators

- OCXO
- VCXO
- TCXO
- PLL Synthesizers
- RF Generators

RFMW = Design Solutions


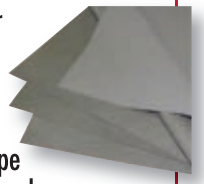
RF Diodes

- PIN
- Schottky
- Varactor
- Limiter
- Gunn

RF Attenuators

- Fixed
- Digital
- Coaxial
- Chip
- Voltage Variable
- Temperature Variable

RF Cable Assemblies

- High-Performance Test
- In-Box Solutions
- Pigtails
- Conformable
- Flexible
- Semi-Rigid

Test & Measurement

- USB Controlled
- Signal Generators
- Power Meters
- Switches • Attenuators
- Vector Modulators
- Cable Assemblies
- Coax Components

EMI / RFI

- RF Absorber
- RF Gaskets
- Wire Mesh
- Fingerstock
- Shelding Tape
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- Shielded Windows

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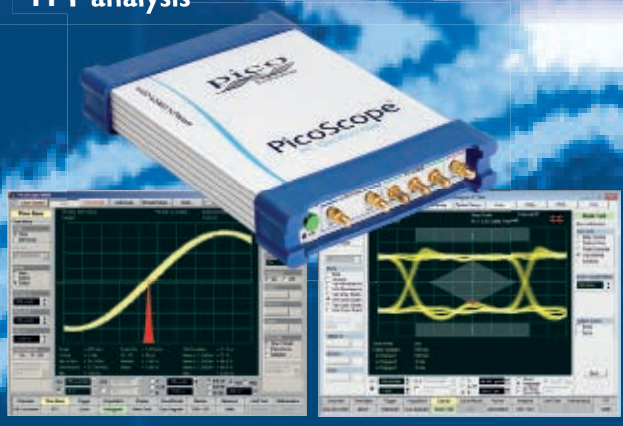
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- High speed serial data analysis
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USB port	●	●	●	●
LAN port		●		●
Mask testing	●	●	●	●
Histogram analysis	●	●	●	●
Clock recovery trigger		●	●	●
Pattern sync trigger		●		●
Dual signal generator outputs		●		●
Electrical TDR/TDT analysis		●		●

www.picotech.com/RF927

Around the Circuit



▲ *Thomas Lingel*

Dielectric Laboratories Inc. (DLI) announced the appointment of **Thomas Lingel** as its new director of engineering. Lingel joined DLI in January after spending the past 13+ years at Anaren Microwave. Prior to that, he was working with Dornier Satellite Systems GmbH and Siemens while obtaining his PhD in electrical engineering. DLI also welcomes **Brian G. Nagle** as applications engineer manager. Nagle has over 11 years' experience at DLI with his most recent position as quality engineer. Nagle will be serving customers globally with technical application inquiries providing insight and guidance in the application and use of DLI's capacitor products.



▲ *Brian G. Nagle*



▲ *Eddie Ahn*

Link Microtek has appointed **Eddie Ahn** as microwave design engineer. He joins the company after having completed an MSc in microwave engineering and wireless subsystems design at the University of Surrey. Prior to that, he was employed as an antenna engineer by LG Mobile, where he was responsible for the design of antennas for new mobile phone products. In his new position, Ahn will be involved in design and testing of the diverse range of microwave components that the company manufactures, including rotary joints, antennas, filters, power dividers and ortho-mode transducers (OMT).

REP APPOINTMENTS

AR Modular RF announced that **Acudata Inc.** is now the company's sales representative in TX, OK, AR and LA and **MMS Technical Sales** is its new representative in New England and upstate New York.

Auriga announced the signing of **Gap Wireless**, headquartered in Mississauga, Ontario, and **Mushko Electronics**, headquartered in Islamabad, Pakistan, as resellers for Auriga in Canada and Pakistan, respectively.

MegaPhase announced the appointment of **Patriot Technical Sales** to represent its products in the six New England states (CT, ME, MA, NH, RI and VT).

Renesas Electronics Europe has appointed **PT Electronics** as its distributor in Russia, effective immediately.

Link Microtek has been appointed as a representative for **United Monolithic Semiconductors** in the UK and Ireland.

XMA Corp.-Omni Spectra announced the appointment of **High-tech Sales** as its New England manufacturing representatives.

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- Compact Size
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- Frequency Range: 100 to 5000 MHz

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- Frequency Range: 400 to 5500 MHz

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- **Linear Tuning**
- Low Cost
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- Frequency Range: 800 to 4000 MHz

RFVC-6400 thru 6599 (UMS)

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- Low Phase Noise
- 0.5″ x 0.5″ SMT
- Frequency Range: 25 to 3000 MHz

RFVC-6600 thru 6799 (UMJ)

- **Ultra-Low Phase Noise**
- Low Power Consumption
- Internal Buffer
- 0.5″ x 0.5″ SMT
- Frequency Range: 10 to 400 MHz

RFVC-6800 thru 6999 (UMT)

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- Linear Tuning
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- Frequency Range: 1000 to 8000 MHz

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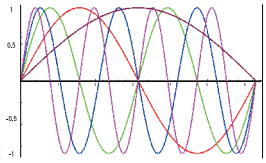
WiFi 5.8 GHz 15W



Inmarsat 1.6 GHz 15W



CATV, FTTH, & BTS / RRH E-pHEMT MMIC



Wideband 20~2000 MHz 10W

WiFi / Backhaul / CCTV / PTP Radio 50Ω SMT GaN Hybrid

Part Number	Frequency (GHz)	Pout (W)	802.16 OFDM (W)	Efficiency (%)	Stage	Package (Type)
HS5758-10A	5.8	15	1.5	45	2	NP-26
HS7179-20A	7.1 ~ 7.9	20	11	33	1	NP-18
HS109115-20A	1.9 ~ 11.5	20	8	33		
HS139142-18A	13.9 ~ 14.2	18	6	35		



NP-18
15 x 10 x 5.4mm



NP-1E
20.5 x 15 x 4.8mm

Inmarsat / Iridium 50Ω SMT GaN Hybrid

Part Number	Frequency (GHz)	Pout (W)	PAverage (W)	Efficiency (%)	Stage	Package (Type)
RNC16010-10	1.6	15	8	50	2	NP-1E



NP-1A
21.1 x 10.6 x 2.5mm



NP-26
20.5 x 15 x 4.8mm

Ultra Wideband 50Ω SMT GaN Hybrid

Part Number	Frequency (MHz)	Pout (W)	Gain (dB)	Efficiency (%)	Stage	Package (Type)
TG2000-10	20 ~ 2000	10	14	45	1	NP-18
HM0220-05A	200 ~ 2000	5	35	40	2	NP-1E
HM0525-10A	500 ~ 2500	10	20	35	2	NP-1A

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CATV, G-PoN, FTTH, RFoG E-pHEMT MMIC

Part Number	Gain (dB)	N.F (dB)	Vdd (V)	CH @Vo (Flat / dBμV)	Package (Type)
AE410	20	2.1	5	135@80	SOT-89
AE607	13	3.5	8	79@100	SOIC-8
AE618	20	3.0	12	79@107	



QFN3x3
3 × 3 × 1 mm

Active Divider E-pHEMT MMIC

Part Number	Gain (dB)	N.F (dB)	Vdd (V)	Splitter	Package (Type)
AD211	8	3.5	3 ~ 5	2 Way	QFN3x3
AD311	8	4	3 ~ 5		



SOIC-8
5 × 6 × 1.52mm

BTS / RRH / Repeater E-pHEMT MMIC

Part Number	Gain (dB)	N.F (dB)	Pout (dBm)	WCDMA 4FA (dBm)	Package (Type)
AE367	15	3.5	27	18.5	SOT-89
AE368	13	2.9	30	21	SOIC-8
AE379	12	2.3	33	23	



SOT-89
4.5 × 4 × 1.5mm

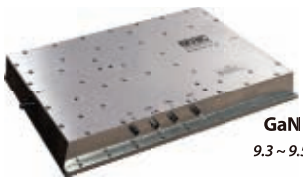
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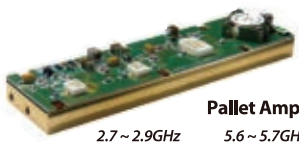


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9.3 ~ 9.5 GHz 200W



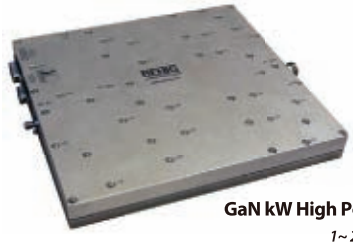
Pallet Amplifier

2.7 ~ 2.9GHz	*5.6 ~ 5.7GHz*	*9.2 ~ 9.5GHz*
200~ 400W	*200W*	*50 ~ 100W*



GaN SMT/SMD Type phase Array

2.7 ~ 2.9GHz	*9.2 ~ 9.5GHz*
50W	*25W*



GaN kW High Power Amplifier
1~ 2kW

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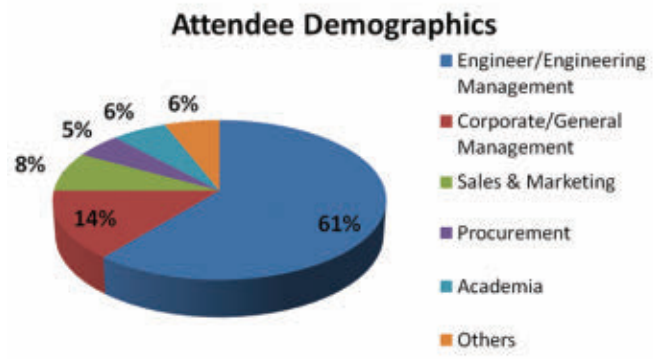
The Premier of EDI CON

Multi-National Companies Connect with Electronic Design Engineers in China



EDI CON 2013 First Year Highlights

- **2489** total attendees
- **1255** unique delegates
- **248** exhibitors
- **53** exhibiting companies
- **22** attending media organizations
- **23** countries of origin



Approximately 2000 attendees gathered over 2 ½ days in Beijing, China for the inaugural Electronic Design Innovation Conference (EDI CON) held in March at the Beijing International Convention Center. The event, organized by *Microwave Journal China*, parent company Horizon House and publishing partner – ACT International, was developed in collaboration with leading multi-national, RF/microwave companies to provide a technical program and exhibition targeting working Chinese engineers. As an industry-driven conference, the program emphasized training and applied techniques in the areas of device measurements and computer-based modeling, design, system integration and use of commercial products. State-of-the-industry content provided by participating companies attracted engineers from Beijing and beyond eager to learn from visiting and regional experts.

THE PLENARY SESSION

The opening day ceremony began with a two hour keynote session on design innovation in China and abroad featuring perspectives from academia, private industry, a leading mobile communications market research firm and the European Space Agency. EDI CON 2013 Honorary Chair Dr. Professor Song Junde of the Beijing University of Posts & Telecommunications set the stage with his 20 minute talk on the "Present and Future of RF/Microwave and High-Speed Digital Devices and Systems." As a leading telecommunication expert in China, Dr. Song regularly advises the Beijing government and private industry on technology trends and programs throughout China, from wireless industrial monitoring to the development of wireless smart cities. Dr. Song discussed his country's need to leverage China's manufacturing strengths with a developing culture of "indigenous innovation" to create the engineering resources necessary to meet the country's future information technology needs.

This theme was reinforced by the president of Agilent Technologies Electronic Measurement Group, Guy Séné, who provided a historical perspective of the company's 20+ year commitment to supporting high technology innovation in China and throughout the world. A presentation on business opportunities for the new age of the mobile broadband market in China was delivered by senior analyst, Guang Yang from the Strategy Analytics' Beijing office. Speaking in his native Mandarin, Guang Yang encouraged the standing room only crowd that they had chosen a field with considerable technical challenges and opportunities ahead. With 1.1 billion mobile subscribers in China, mobile penetration is over 80 percent, yet broadband penetration is only at 13 percent. This news also bodes well for multinational and domestic IC manufacturers looking for a promising market opportunity.

After discussing technology and markets in China, the next keynote moved on to a global perspective of the satellite communication developments that are being spearheaded by the European Space Agency as described in a talk by Bertram Arbesser-Rastburg, head of ESA-ESTEC. With several papers on satellite communications and navigation systems slated for the technical program, Arbesser-Rastburg's presentation helped highlight the global interest in space.

The first plenary session recessed

David Vye
Microwave Journal *Editor*

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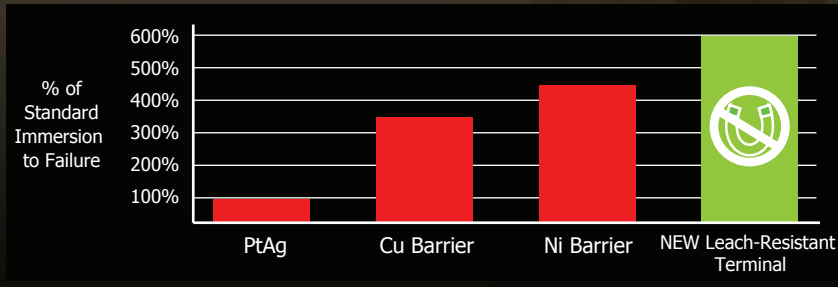
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for a tea/coffee break held in the exhibition space, giving attendees their first opportunity to engage with the nearly 50 exhibitors participating in this first-ever event. The aisles between the exhibition stands were full to capacity as delegates made their first tour of the vendors offering solutions in test & measurement equipment, design software, semiconductor devices, IC modeling solutions, a variety of active and passive components, materials, prototype manufacturing equipment, cables and connectors.

Back in the main conference hall, the second half of the plenary session commenced with three talks emphasizing design innovation within China. Representing telecommunication trends and future requirements from the perspective of a major Chinese carrier, Dr. Gaungyi Liu, senior researcher for China Mobile Research Institute, gave a talk, "Microwave Technology from Backhaul to Access – Opportunity for Mobile Communications." Discussing the business need for carriers to reduce their cost per bit under the increasing demand for broadband accessibility, Dr. Liu provided the context for developing a number of approaches that may help carriers achieve 10× spectrum efficiency.

Providing more detail at the hardware level for the systems described by Dr. Liu, Deng Jie, general manager of ZTE Microwave Products Group, gave a talk on "Microwave Radios, Today and Tomorrow." Jie provided insights into current 3G/4G macro network backhaul and small cell backhaul systems that are currently being developed and deployed. Deng Jie also presented future radio trends in high throughput/high output power systems and low power consumption/low cost systems which are being pursued at ZTE Microwave.

The final keynote talk to the plenary gathering was focused on some of the research being conducted at one of the very important government-supported research institutes in Beijing. Feng Keming, director of the Beijing Institute of Radio Metrology and Measurement (BIRMM) gave a talk on recent progress in metrology of radio and time/frequency sources at BIRMM. Feng discussed the institute's work in radiometer calibration, standardization of microwave power and use of terahertz pulse for time do-

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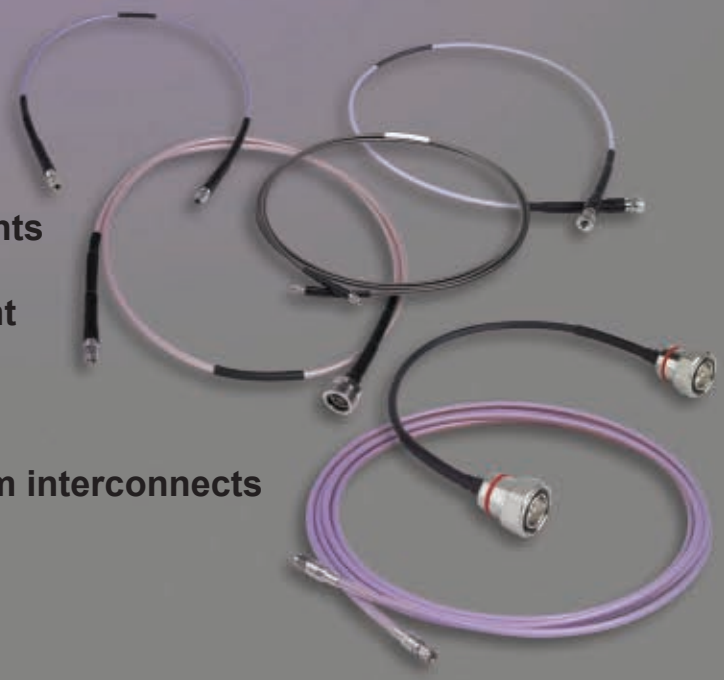
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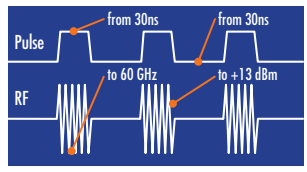
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main calibration. Feng is an engaging speaker and highly respected technologist who kept the audience's attention as he discussed the institute's work in active and passive hydrogen masers and rubidium atomic clocks for satellite applications.

WELCOME RECEPTION AND AN EARLY RISE

Ideally, conferences offer an opportunity to exchange knowledge and perspectives between all participants. During the keynote talks and technical sessions, it is the presenter providing the lion's share of information to the audience. But during the question and answer periods and the social events, it is the attending delegation that gets to share their insights with speakers and each other. Thus, social events at conferences serve an important role in supporting the spread of information. The welcome reception sponsored by Agilent Technologies brought together technologists from around the world, in many cases for the first time ever.

In this setting, exhibitors, delegates, speakers and VIPs were able to introduce themselves in a less formal environment and conduct some personal networking. Entertained with traditional live Chinese music, paper cutting and a buffet, reception attendees were able to share their thoughts on some of the topics raised during the keynote talks, meet some of the presenters on deck and discover the common bonds of being a member of the global high-frequency electronics industry.

Challenging the local electronic design community to get ahead of the notorious Beijing morning traffic, the technical sessions began at 08:30 with peer reviewed papers presented in 20 minute sessions occurring across four concurrent tracks. Content was organized by track theme addressing 1. Design, 2. Measurement/Modeling, 3. System Engineering and 4. Commercial Resources. Individual topics ranged from specific circuit design areas such as power amplifiers or VCOs/PLLs to calibration techniques to fundamentals of specific communication standards.

While the majority of papers could be considered classical RF and microwave in nature, at least a third of the papers focused on high-speed digital design and the remainder covered EMI/EMC topics. Presentations were

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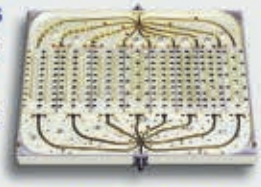
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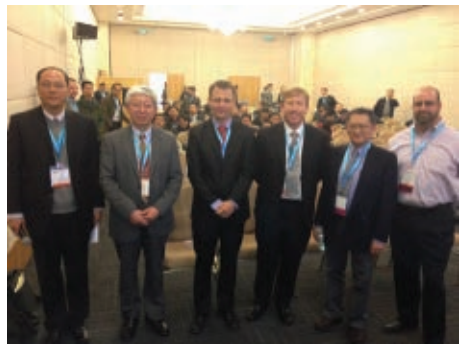
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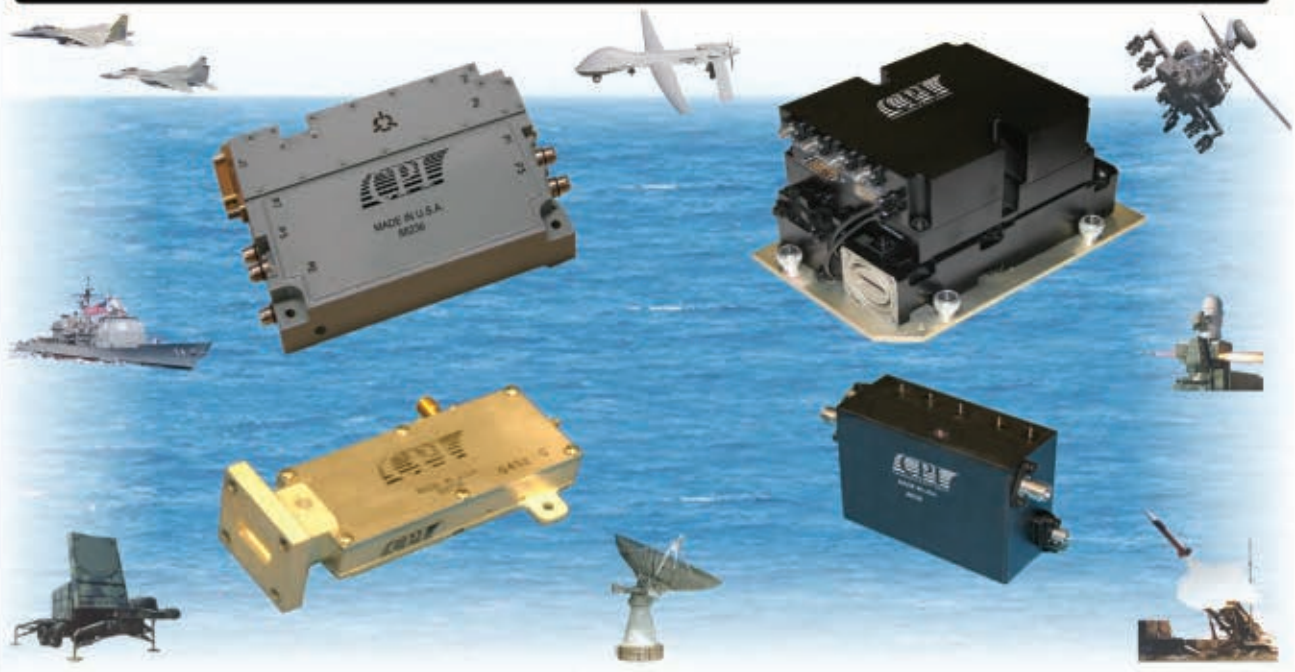
either delivered in Mandarin by local engineers or in English by company representatives that had travelled from the U.S., Europe, Singapore or other English-speaking region. The event organizers arranged for translators to provide real-time English to Chinese audio for Chinese engineers attending an English language talk.

TEA BREAKS, WORKSHOPS AND EXHIBITION TIME

The first tea break was scheduled to start with the opening of the exhibition for its first full day. As delegates and exhibition visitors poured into the exhibition hall located right next to the conference rooms, vendors started their morning with a wave of engineers looking for information on the latest and greatest in RF/microwave commercial technology. Taking place in mid-March, EDI CON 2013 closely follows Mobile World Congress (February) in Barcelona and DesignCon (January/February) in Santa Clara, CA. As a result, a number of vendors were showcasing products that had just recently been introduced onto the world stage and at EDI CON were making their premier appearance in China. Vendors such as Agilent, Anritsu, National Instruments, Rohde & Schwarz, LeCroy and Tektronix were each able to unveil new products to attendees and around 30 invited members of the press.

Following the morning sessions of papers and delegate lunch, certain exhibitors and event sponsors took the stage to conduct individual workshops and panel sessions on a host of topics. RF CMOS and UltraCMOS technologies were discussed in workshops from TowerJazz and Peregrine Semiconductor, respectively; advances in compound semiconductor technology was the topic covered in a workshop by WIN Semiconductors and OMMIC; nonlinear design and load-pull techniques were presented by vendors Maury Microwave and Focus Microwaves. MMIC design; power amplifier design, Doherty PAs, envelope tracking and digital pre-distortion workshops were distributed throughout both afternoons of workshops as were workshops on measurement techniques for RF and high-speed digital design, on- and off-wafer calibration methods, MIMO beamforming and modeling antenna systems to name a few.

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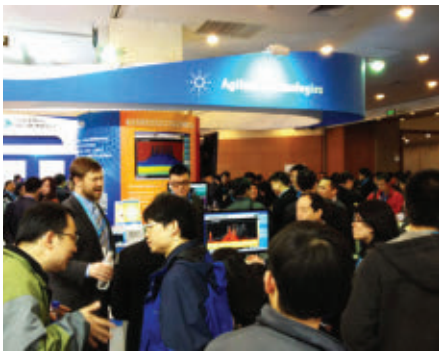
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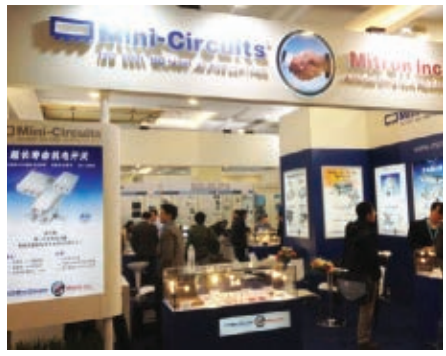
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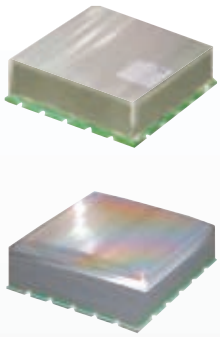
Closing out both full days of the conference were several sponsored marquee panel sessions that offered attendees the chance to directly engage with experts. The special panels discussed GaN technology, EDA design flows and integration featuring Agilent, AWR, ANSYS and CST, connectivity technology sponsored by Mini-Circuits and Mitron, digital pre-distortion (Altera and Texas Instruments). For each panel, individual speakers provided a technology overview followed by a moderated conversation between the panelist and audience.

Richardson RFPD sponsored a standing room-only (180+) session on GaN technology with panelists from Freescale, M/A-COM Technology Solutions, Microsemi, Nitronex, TriQuint and Scintera offering different perspectives on the state of GaN. Spirent Communications sponsored the panel session on MIMO OTA measurement techniques featuring Spirent, ETS-Lindgren, Bluetest, and the China Academy of Telecommunication Research – TMC. This highly specialized topic drew an intimate audience, many of whom stayed past the end of the conference to engage the speakers with questions and comments offline.

WRAP-UP

First year events present various challenges and unknowns for organizers, sponsors and attendees alike. Aside from the basic infrastructure that needs to be built – the website, registration, sales and promotion organization, marketing, technical committee and paper management systems – new shows ask people to take a leap of faith. *Microwave Journal China* and Horizon House asked our clients and readers to believe in a new type of conference, one that relied on the industry itself for the bulk of the technical program and our supporters' ideas for a more engaging delegate/exhibitor experience. The standing room-only attendance, the professionalism of delegates and exhibition visitors and their knowledge, experience levels and great interest in the technology being presented in the conference and on the exhibition floor indicate that this formula works. We look forward to your thoughts on how to expand and improve the EDI CON program well into the future. That's what industry-driven is all about. ■

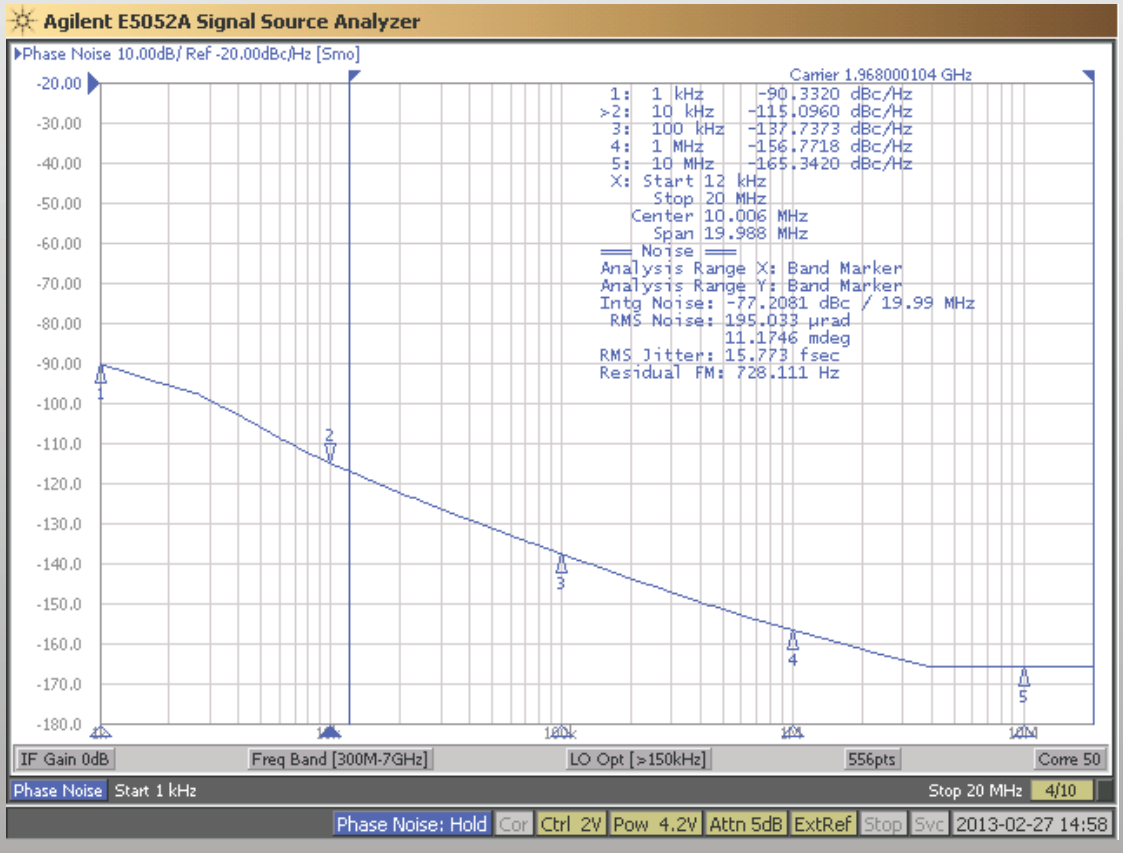




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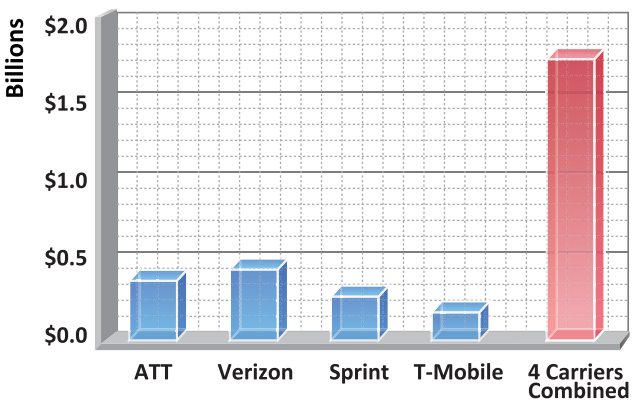
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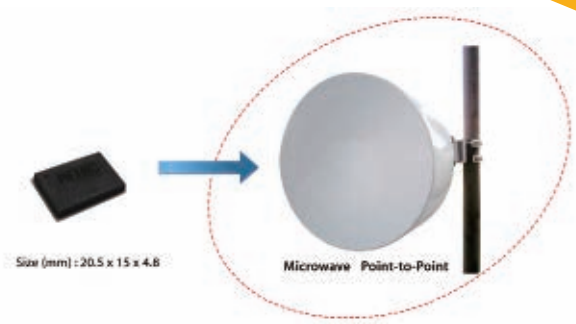
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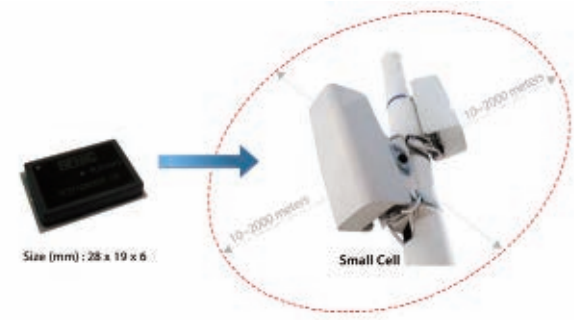
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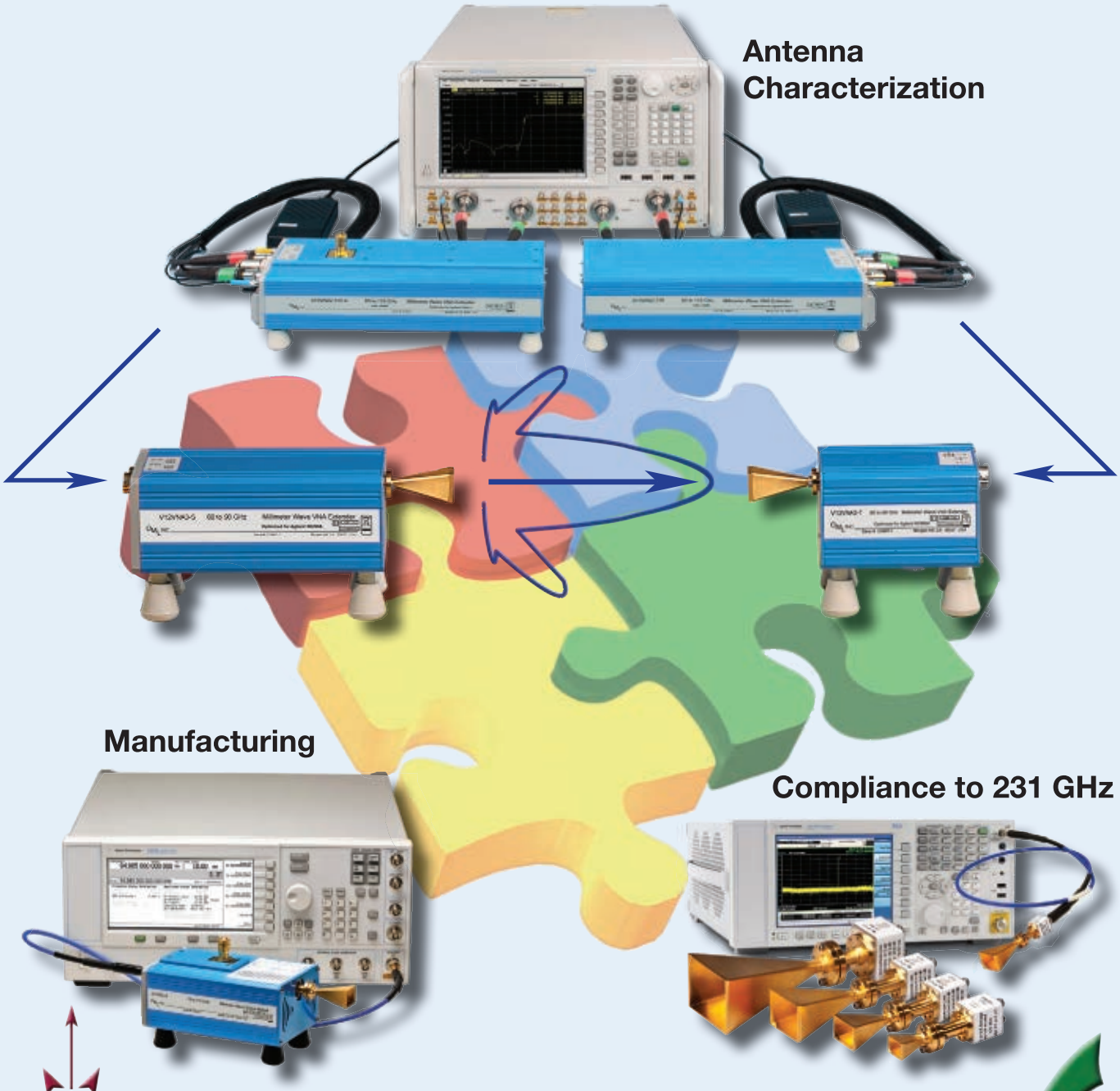
This article presents an efficiency improvement method for RF power amplifiers, using an integrated digitally-controlled dynamic bias switching (DDBS) circuit. The DDBS IC dynamically selects two different drain bias voltages for the power amplifier, using its switching stage according to the limited envelope signal. To maximize the efficiency improvement, the optimum threshold voltage and bias levels were determined after analytic consideration for the statistical distribution of the envelope signal. For verification, a DDBS IC was designed and fabricated using a 0.18 µm CMOS process. The fabricated DDBS IC was evaluated using an OFDM signal, which has a center frequency of 2.6 GHz, a bandwidth of 9.4 MHz and a PAPR of 9.6 dB. The DDBS IC considerably increases the power amplifier's PAE from 21.3 to 32.2 percent, at an average output power level of 25 dBm, while good linearity performance with an EVM of less than 4 percent is maintained.

Modern wireless communication systems utilize spectrally efficient modulation methods, such as orthogonal frequency-division multiplexing (OFDM) signals. These modulated signals have a wide bandwidth and high peak-to-average power ratio (PAPR or PAR) for a higher data rate. The signals with high PAPR cause the power amplifier (PA) to have low average efficiency because the PA should be operated in output back-off. A low efficiency of the PA means that the battery life is shorter.[1-3]

Various researches have been carried out to improve the average efficiency of the PA.[3-15] Especially, bias modulation methods for the drain or collector are very straightforward and effective.[4] Envelope elimination and restora-

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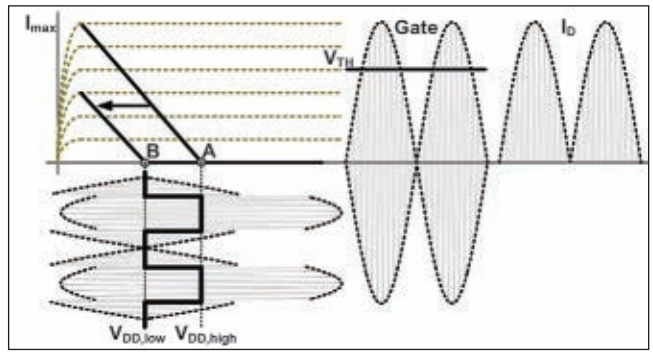
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tion (EER), hybrid-EER and envelope tracking (ET) techniques utilize a continuous envelope signal to control or modulate the drain or collector bias of the amplifier.[4-7] Continuously modulated drain/collector biases allow the PA to operate near to saturation, which is a high-efficiency region, according to the envelope level. Hence, the average efficiency can be improved. However, continuous drain/collector bias modulation techniques require a very high-speed DC-DC converter to modulate the bias voltage with the speed of the envelope signal. They generally have a complex structure and require a large off-chip inductor.[4-7]

An alternative solution could be a discrete bias modulation technique, known as dynamic bias switching (DBS).[8-10] It has two or more different bias voltage levels, which can be dynamically supplied to the drain of the PA according to the envelope level. A low supply voltage is applied to the drain of the PA when the envelope signal is lower than the threshold voltage. When the input voltage exceeds the threshold voltage, a high supply voltage is instantly selected and is provided to the drain of the PA. The supply modulator for DBS consists of a simple switching circuit, which is much simpler than the high-speed DC-DC converter for the continuous bias modulation methods. Because of the higher operating speed of the simple switching circuits of the DBS, the supply modulator can be applied to wideband modulated signals. In addition, the binary control signal used to select the bias voltage can be made by a digital signal processing technique.

In this article, a CMOS digitally-controlled dynamic bias switching integrated circuit (DDBS IC) is presented to enhance the efficiency of power amplifiers. The designed DDBS IC has a very simple structure, which does not need the envelope detection circuit, envelope processing circuit and high-speed DC-DC converter. A two-level control signal for the high-speed bias switch in the DDBS IC is generated from the real-time envelope signal using a properly optimized threshold voltage. The high-speed bias switch dynamically selects the bias voltage between the lower and normal bias voltages according to the control signal. Because the threshold voltage and lower bias voltage are important for efficiency enhancement, they are analytically optimized.



▲ *Fig. 1 Operation of the Class B PA with a dynamic switching method.*

The DDBS IC was fabricated using a 0.18 µm CMOS process and was evaluated using an OFDM signal in the 2.6 GHz band. It is applied to a commercial InGaP/GaAs HBT power amplifier, to validate its capability for performance improvement. The results were compared to the case without the DDBS IC.

OPERATION PRINCIPLE OF DDBS

An operation of the dynamic bias switching can be described as:

$$v_{DD}(t) = \begin{cases} V_{DD,high}, \text{if } V_{ENV}(t) > V_{TH} \\ V_{DD,low}, \text{if } V_{ENV}(t) \le V_{TH} \end{cases} \quad (1)$$

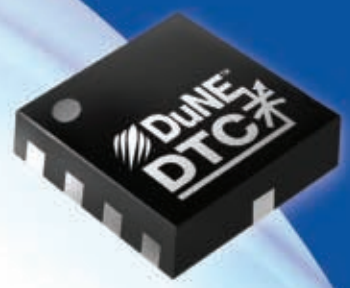
where $v_{DD}(t)$ is an instantaneous drain bias voltage, which has one of the two DC voltages ($V_{DD,low}$ and $V_{DD,high}$). $V_{ENV}(t)$ and V_{TH} are instantaneous output envelope voltage and an output-referred threshold voltage, respectively. If the envelope is greater than V_{TH}, the PA has a drain bias voltage of $V_{DD,high}$. Otherwise, the bias voltage is instantly switched to $V_{DD,low}$.

Figure 1 describes the operation of the DDBS on an ideal Class B PA. The envelope signal for the modulated input voltage waveform is compared



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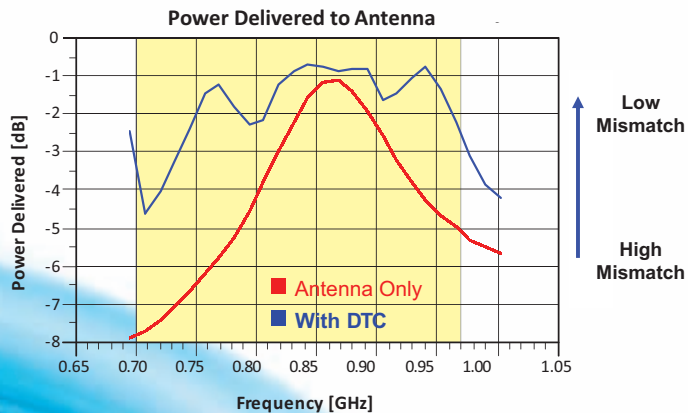
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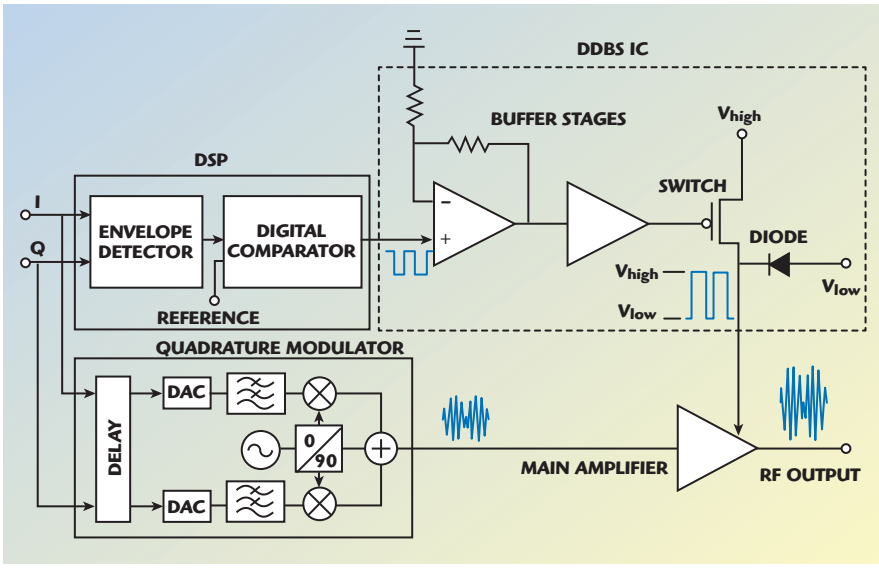


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▲ *Fig. 2 Schematic diagram of the power amplifier with a DDBS IC.*

with the constant threshold voltage. For the envelope signal greater than the threshold voltage, the PA operates at point 'A' on the I-V plane and its voltage waveform is presented below the I-V curve. If the envelope level becomes lower than the threshold, the bias point instantly shifts to point 'B' so that the voltage waveform also shifts down. The efficiency can then be improved because the DC power consumption is reduced for an envelope signal lower than the threshold.

Figure 2 shows a schematic diagram of the power amplifier with a DDBS IC. From the digital I/Q signal, the envelope signal is extracted and is digitized using a digital comparator with a given threshold level. The two-level digitized signal is applied to the DDBS IC and is used to control the switch to select the bias voltage between $V_{DD,high}$ and $V_{DD,low}$. The DDBS IC is very simple because the envelope signal is processed in the digital domain.

The DDBS IC consists of buffer stages, a switch driver, a PMOS switch and a diode. The buffer and switch driver stages are designed to have rail-to-rail output characteristics in order that the PMOS switch can be fully turned on or off. The size of the PMOS switch and diode should be large enough to drive the required current from the PA. The PMOS switch is designed in consideration of a trade-off between its frequency response and current handling capability. The diode is designed using a native NMOSFET, which has a very low turn-on threshold so that a voltage drop can be low over the diode.

According to the control signal, the voltage $V_{DD,high}$ is supplied to the drain of the PA when the PMOS switch is turned on. The voltage $V_{DD,low}$ is supplied through the diode when the PMOS switch is turned off. The input signal of the PA is the modulated RF signal of which the envelope signal should be accurately synchronized with the dynamic drain bias voltage in time using a time delay block.

One of the most important considerations in the DDBS system design is how to determine the threshold voltage and $V_{DD,low}$ for the best efficiency improvement because $V_{DD,high}$ is generally given by the system. In the next section, the effect of the threshold and $V_{DD,low}$ on the efficiency of the DDBS system will be analyzed. The optimum values for both the threshold and $V_{DD,low}$ will be found.

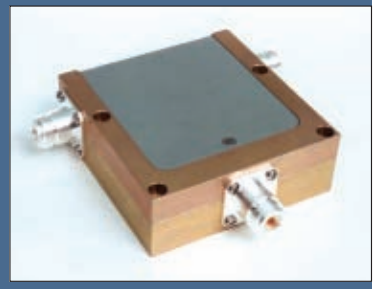
OPERATION CONDITIONS

Efficiency of the Class B PA

The threshold voltage gives a reference to bisect and limit the envelope signal, and then composes a control signal for the DDBS IC. Because it is very important to determine the threshold voltage and $V_{DD,low}$ for the performance optimization, they are analyzed based on the ideal Class B amplifier.



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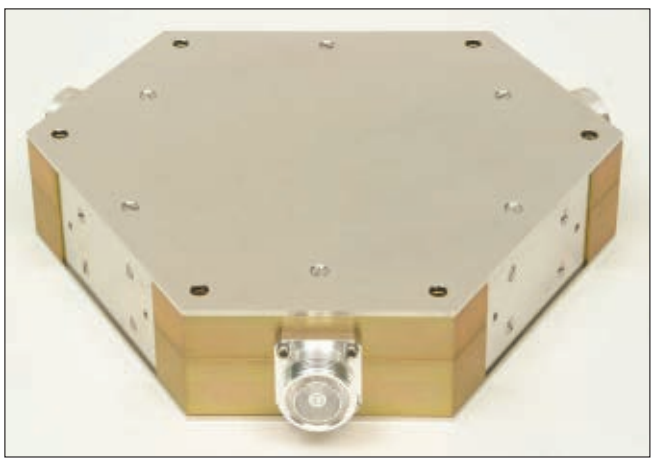


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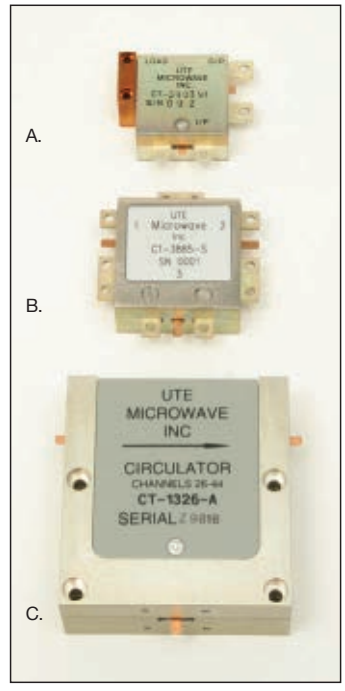
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The fundamental output power is given by

$$P_{out}(v) = \frac{v^2}{4} V_{max} I_{max} \quad (2)$$

where V_{max} and I_{max} are the peak amplitudes of the output voltage and current, respectively. v is a normalized envelope voltage. Thus, v^2 is an output power back-off and is defined as P_{out}/P_{max}, where P_{max} is $V_{max}I_{max}/4$. The DC power consumption is then given by

$$P_{DC}(v) = \frac{v}{\pi} V_{max} I_{max} \quad (3)$$

Hence, the drain efficiency becomes:

$$\eta_D = \frac{P_{out}}{P_{DC}} = \frac{\pi}{4} v \quad (4)$$

With no output power back-off, where v = 1, the ideal Class B PA has an efficiency of 78.5 percent. If the drain bias continuously varies according to the output power back-off level, the maximum efficiency will be maintained. This condition is given as:

$$V_{DD} = vV_{max} \quad (5)$$

For the continuous bias modulation methods, such as EER, hybrid EER and ET, Equation 5 is the ideal condition for the drain bias modulation. However, for the DDBS, a single value of $V_{DD,low}$ with the threshold voltage should be selected for efficiency optimization.

Optimum $V_{DD,low}$ and the Threshold Voltage

For the modulated signals such as OFDM, the average efficiency of the PA, rather than the peak efficiency, is meaningful, because the PA operates on a low or mid power region for the greater part of the time. Therefore, statistical distribution of the normalized envelope voltage should be considered to optimize the average efficiency. ***Figure 3*** shows a probability density function (PDF) of the up-link OFDM signal based on the 64-quadrature amplitude modulation (64-QAM). Relatively high statistical distribution can be observed for the normalized envelope voltage between 0.1 and 0.5 V. Figure 3 also plots the drain efficiency of the ideal Class B amplifier.

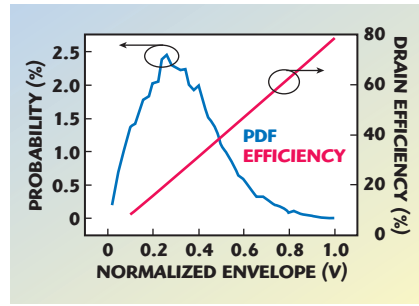


Fig. 3 PDF of the up-link 64 QAM OFDM signal and an ideal efficiency of the Class B amplifier according to the normalized envelope voltage.

For the time-varying envelope signals, the average efficiency can be defined as:

$$\eta_{D,avg} = \frac{\int_{V_{min}}^{V_{max}} p(v) P_{out}(v) dv}{\int_{V_{min}}^{V_{max}} p(v) P_{DC}(v) dv} \quad (6)$$

where p(v) is a probability density function of the envelope, $P_{out}(v)$ is a fundamental output power and $P_{DC}(v)$ is a DC power consumption. The knee voltage of the transistor was assumed to be zero.

The average efficiency of the DDBS system which has two different bias voltages can be expressed as:

$$\eta_{D,avg} = \frac{\int_{0}^{V_{TH}} p(v) P_{out}(v) dv + \int_{V_{min}}^{V_{max}} p(v) P_{out}(v) dv}{\int_{V_0}^{V_{TH}} p(v) P_{DC,low}(v) dv + \int_{V_{TH}}^{V_{max}} p(v) P_{DC,high}(v) dv} \quad (7)$$

where

$$P_{DC,low}(v) = \frac{v}{\pi} V_{DD,low} I_{max} \quad (8)$$

$$P_{DC,high}(v) = \frac{v}{\pi} V_{DD,high} I_{max} \quad (9)$$

$V_{DD,high}$ is the same as V_{max}, due to the zero knee voltage. $P_{out,avg}$ is an average output power. In order to avoid saturation in the low power region for the linear operation, the following condition should be satisfied:

$$\frac{V_{DD,low}}{V_{DD,high}} \geq \frac{V_{TH}}{V_{max}} \quad (10)$$

Here, the maximum efficiency improvement can be achieved if the left and right sides of Equation 10 are the same.

Figure 4 presents the calculated relative average DC power consumption and an average efficiency according to the normalized threshold



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NTWPA-00000010011000	0.00001~0.01	60
NTWPA-00000010013000	0.00001~0.01	65
NTWPA-00000010015000	0.00001~0.01	67
NTWPA-001011000	0.01~0.1	60
NTWPA-001013000	0.01~0.1	65
NTWPA-001015000	0.01~0.1	67
NTWPA-008031000	0.08~0.3	60
NTWPA-008032000	0.08~0.3	63
NTWPA-0310700	0.3~1.0	58
NTWPA-03101000	0.3~1.0	60
NTWPA-00305100	0.03~0.512	50
NTWPA-00305200	0.03~0.512	53
NTWPA-000110100	0.001~1.0	50
NTWPA-00810100	0.08~1.0	50
NTWPA-00810200	0.08~1.0	53
NTWPA-0510100	0.5~1.0	50
NTWPA-0510200	0.5~1.0	53
NTWPA-0510500	0.5~1.0	57
NTWPA-05101000	0.5~1.0	60
NTWPA-0710100	0.7~1.0	50
NTWPA-0710200	0.7~1.0	53
NTWPA-0710500	0.7~1.0	57
NTWPA-1822100	1.8~2.2	50
NTWPA-1822200	1.8~2.2	53
NTWPA-1822500	1.8~2.2	57
NTWPA-2327100	2.3~2.7	50
NTWPA-2327200	2.3~2.7	53
NTWPA-2327500	2.3~2.7	57
NTWPA-0822100	0.8~2.2	50
NTWPA-0822200	0.8~2.2	53
NTWPA-0822500	0.8~2.2	57
NTWPA-0727100	0.7~2.7	50
NTWPA-0727200	0.7~2.7	53
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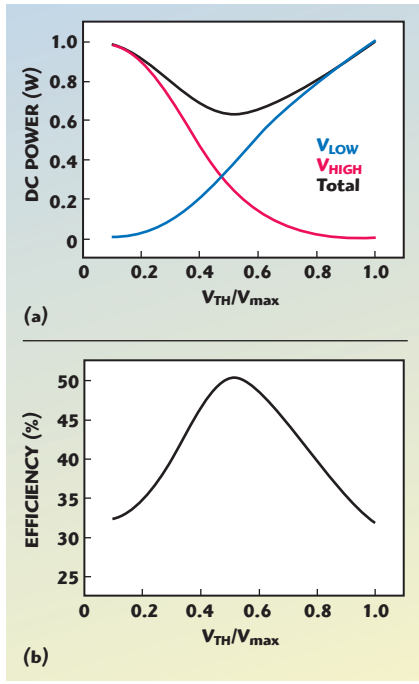


Fig. 4 Relative average DC power consumption (a) and average efficiency according to V_{TH}/V_{max} (b).

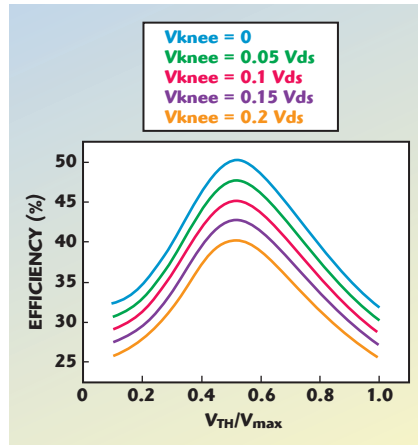


Fig. 5 Calculated average efficiency with various knee voltage as a parameter.

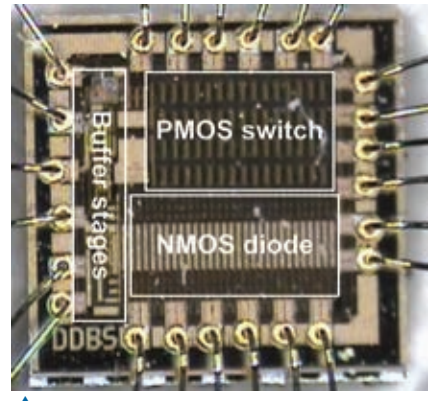


Fig. 6 Photograph of the implemented DDBS IC.

voltage which is V_{TH}/V_{max}. The calculation was done under the condition that V_{TH} is equal to $V_{DD,low}$ for maximum efficiency improvement. If V_{TH}/V_{max} is 0, $V_{DD,low}$ and its occurrence are 0 so that only $V_{DD,high}$ is supplied to the drain of the PA. When V_{TH}/V_{max} is 1, $V_{DD,low}$ should be the same with $V_{DD,high}$ or V_{max}. Therefore, the drain bias has only $V_{DD,high}$ all the time. For both cases, the average efficiencies are approximately 31 percent. The obtained optimum value of V_{TH}/V_{max} is approximately 0.52, which means that the $V_{DD,low}$ is 0.52 times $V_{DD,high}$. The maximum average efficiency is almost 50 percent for the DDBS system.

For a more practical solution, the knee voltage of the transistor can be considered. It is linear with the drain to source voltage or drain current if a constant on-resistance is assumed. The voltage swing of the fundamental component is restricted by the knee voltage. Calculated efficiencies, with the knee voltages as a parameter, are plotted in ***Figure 5***. A non-zero knee voltage degrades the average efficiency, but the optimum value of V_{TH}/V_{max} is not changed, as shown.

Experimental Validation

The designed DDBS IC is fabricated using the TSMC's 0.18 µm CMOS process, with the dimensions of 1×1 mm^2, including pads. ***Figure 6*** shows a photograph of the implemented DDBS IC. To verify the feasibility of the DDBS system, the DDBS IC is applied to Anadigics's AWT6261R, which is a PA for mobile WiMAX application, based on InGaP/GaAs HBT technology. ***Figure 7*** shows the test setup for the overall DDBS system. The upper signal generator provides the DDBS IC with the real-time binary control signal, which is synchronized with the modulated RF signal from the lower signal generator. The binary control signal for the DDBS IC is generated by the PC. The RF modulated signal, which has a center frequency of 2.6 GHz, a bandwidth of 9.4 MHz and a PAPR of 9.6 dB, is applied to the PA.

Figure 8 presents the measured results of the DDBS IC with a load resistor of 30 Ω, which is connected to the switch rather than to a PA. Based on the envelope of the OFDM signal, the generated binary control signal is applied to the DDBS IC. $V_{DD,low}$ and $V_{DD,high}$ are 2.0 and 3.3 V, respectively. For this case, V_{TH}/V_{max} is approxi-

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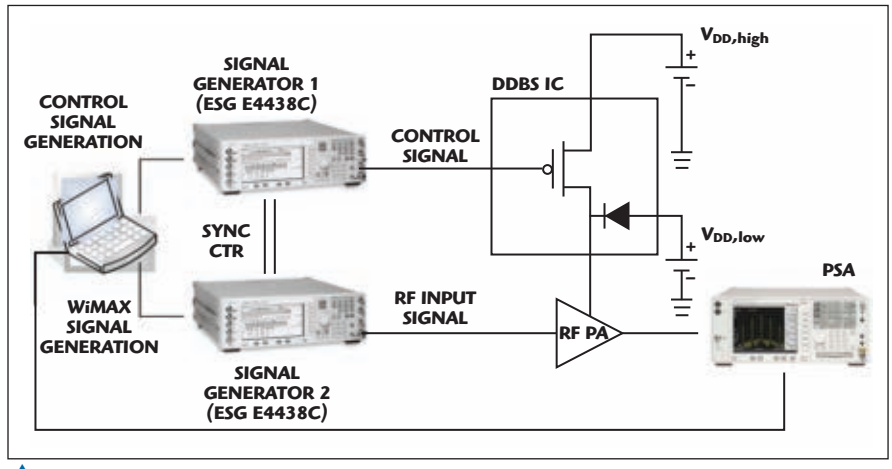


Fig. 7 Test setup for the DDBS system.

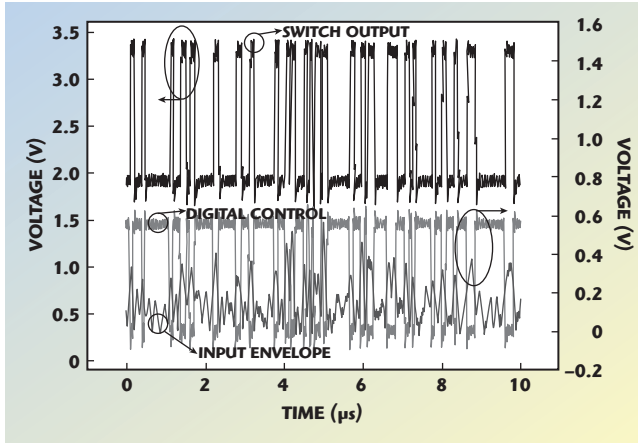


Fig. 8 Measured time-domain envelope and its binary control signals for the DDBS IC.

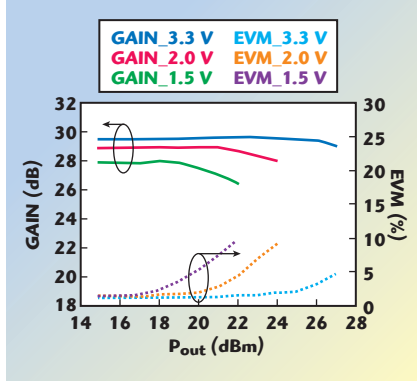


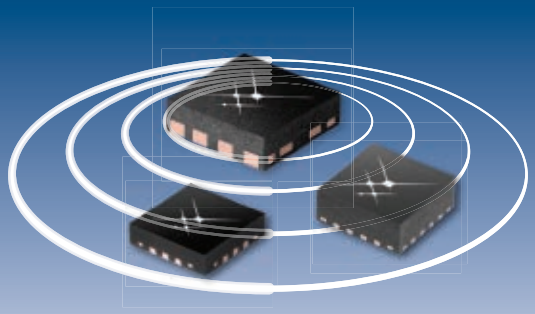
Fig. 9 Measured gain and EVM of the power amplifier.

mately 0.45 because a knee voltage of 0.5 V is considered. The measured voltage drop of the diode is as small as 0.08 V.

Figure 9 shows the test results of the PA for various fixed drain voltages of 1.5, 2 and 3.3 V. The measured gain is 29.5 dB for the bias voltage of 3.3 V. Gain degradations of 0.6 and 1.6 dB are observed for the supply voltages of 2 and 1.5 V, respectively. The measured EVM performances are almost the same and are approximately 1.2 percent at an output power of 15 dBm. However, the EVM performance is quickly degraded as the output level increases. The lower bias voltage causes earlier degradation in EVM performance due to a signal clipping.

Figure 10 shows the measured PAE and EVM of the power amplifier with the DDBS IC. The measurements were carried out with two different $V_{DD,low}$ voltages of 1.5 and 2 V and a fixed $V_{DD,high}$ of 3.3 V. In order to compose a control signal for the bias switch, V_{TH}/V_{max} was experimentally refined from its initial value of 0.52 to 0.45 for the best trade-off between the efficiency and linearity of the DDBS system.

For the DDBS system with a very low $V_{DD,low}$ of 1.5 V, a high PAE of 43.6 percent was achieved with a slightly degraded EVM of 8.4 percent at an average output power of 25 dBm. The degraded EVM could be improved using a digital predistortion technique. However, if the voltage level of $V_{DD,low}$ is slightly increased, the additional circuit for linearity improvement such as digital predistorter is not required. The DDBS system with a $V_{DD,low}$ of 2 V with V_{TH}/V_{max} of 0.45 has an increased PAE from 21.3 to 32.28 percent with a good linearity performance, that is an



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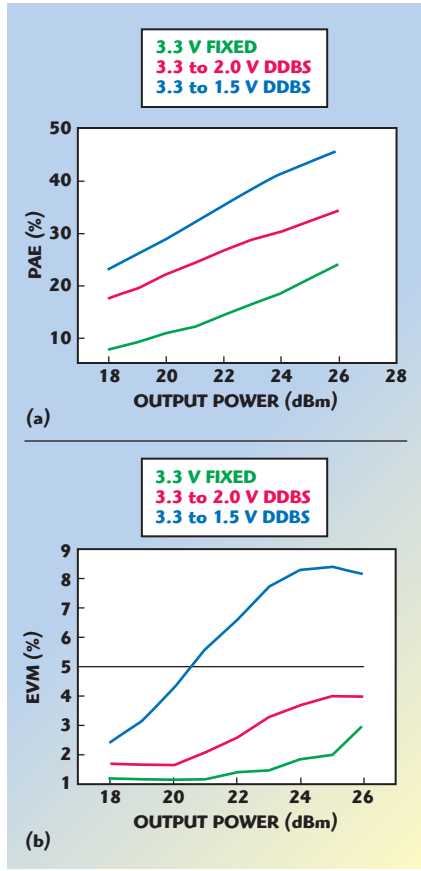


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▲ *Fig. 10 Measured results of the power amplifier with the DDBS IC. PAE (a) and EVM (b).*

EVM of less than 4 percent, at an output power level of 25 dBm. These performances are compared to the representative previous works in ***Table 1***.

CONCLUSION

In this article, an efficiency enhancement technique for the power amplifiers based on an DDBS IC is presented. Considering a statistical power distribution of the signal envelope, optimum operation condition of the system is analyzed for the threshold and bias conditions. To verify the performance, the DDBS IC was designed and implemented, using 0.18 µm CMOS technology. It was tested with an InGaP/GaAs HBT PA using the 2.6 GHz band up-link m-WiMAX signal.

The measured results show that a high improvement of PAE by 11 percent was achieved for the $V_{DD,low}$ of 2 V with a good EVM performance of less than 4 percent at an output power level of 25 dBm. The DDBS system has a very simple circuit and provides an effective way to enhance the average efficiency of the PA for the signals having high PAPR. ■

ACKNOWLEDGMENT

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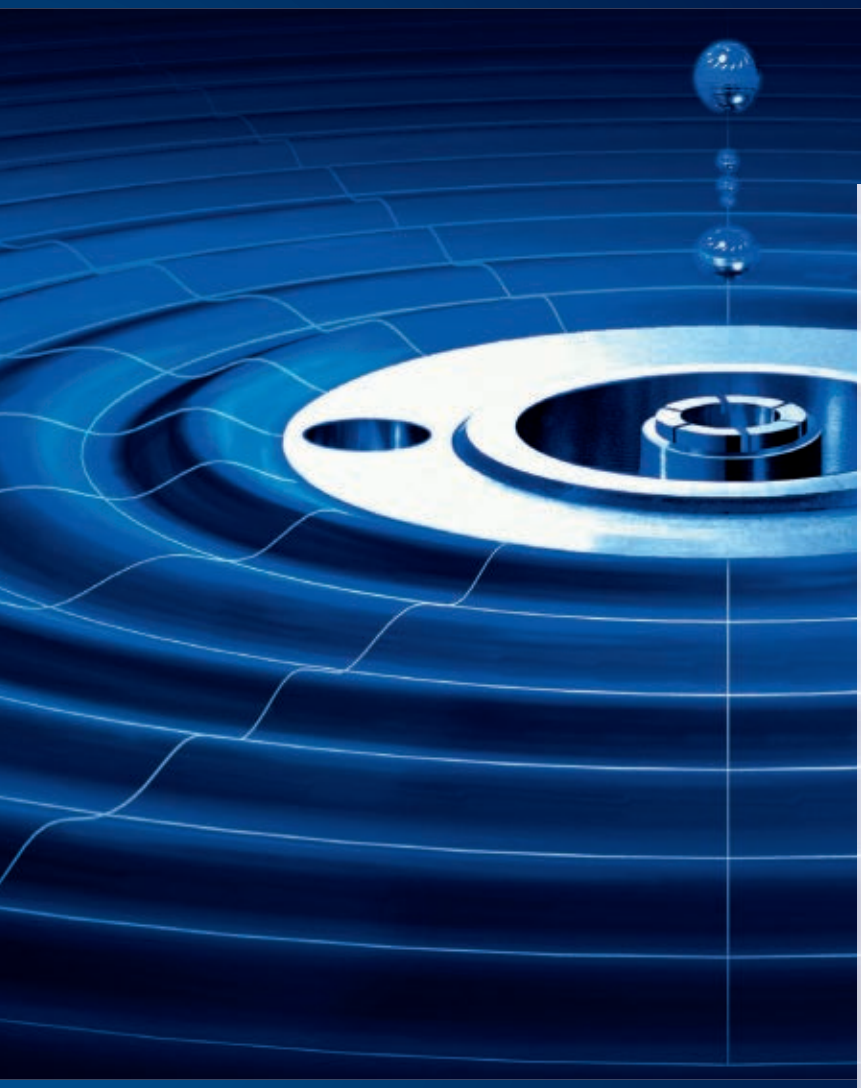
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TABLE I
PERFORMANCE COMPARISON WITH PREVIOUS WORKS

REF	[4] ET	[6] ET	[13] EER	[14] ET+Doherty	[15] Digitally Modulated PA	This Work DDBS	
Freq. (GHz)	2.4	2.3	2	1.88	1.92	2.6	
Bandwidth (MHz)	20	8.75	20	5	5	9.4	
Pout (dBm)	20	17.4	19.6	24.2	15.3	25	
PAE (%)	28	33	22.6	38.6	22	43.6	32.2
EVM (%)	5	4.9	2.5	3.64	1.53	8.4	4
Digital Predistortion	Y	N	N	N	Y	N	
Process Technology	0.18 µm SiGe BiCMOS	0.18 µm SiGe BiCMOS	0.13 µm CMOS	0.13 µm CMOS, 2 µm InGaP/GaAs	0.13 µm SOI CMOS	0.18 µm CMOS, InGaP/GaAs	

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Compact Tri-Band Bandpass Filter Using Short-Circuited Stub-Loaded SIR

A compact microstrip, tri-band, bandpass filter (BPF) using short-circuited stub-loaded stepped impedance resonators (SIR) is proposed in this article. First, the hairpin SIR generates a dual-mode, dual-band response by loading a short-circuited stub. The nature of the proposed resonator is investigated through the even-odd mode analysis. Second, a pair of extended feedlines adds a new transmission path to produce the third passband. The proposed SIR and extended feedlines are folded and thus result in a compact size for the filter. Three passbands are designed to operate at 1.57, 3.5 and 5.2 GHz, respectively. All the theoretical analysis has been successfully verified by experiment results.

In recent years, the rapid development of multiple band operations for wireless communication applications has attracted the attention of many researchers. Compact triple-band bandpass filters have been studied extensively as a key circuit block in tri-band wireless communication systems.[1-3] In multiband communication systems, the bandpass filter (BPF) plays an important role in the RF front-end of the communication system. To design a multiband BPF, two-section stepped impedance resonators (SIR) have been used as a building block.[4] However, this results in a larger circuit size and a more complex BPF configuration. A triple-band BPF was constructed using conventional λ/4 SIRs.[5] Chu and Lin presented a triple-section SIR for triple-band BPF design.[6] Design techniques for triple-band filters based on several parallel- and cross-coupled resonators have been used, but they are still challenging to the designer because it is difficult to fit the specifications at three bands due to the limited degrees of freedom in the design parameters.

In this article, a triple-band filter is proposed using a short-circuited stub-loaded SIR, which is explained by an even-odd mode method. The triple-band filter has a small size, only extending a set of feedlines without increasing the circuit size. Simulations and measurements are given to prove this improved structure of the filter.

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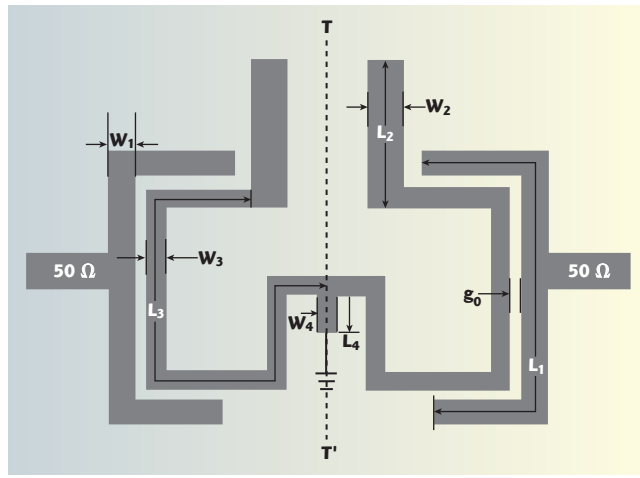
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DUAL-MODE DUAL-BAND SHORT-STUB LOADED SIR

As shown in ***Figure 1***, a compact microstrip BPF is composed of the proposed dual-mode, dual-band short-circuited stub-loaded SIR and two transmission lines with characteristic impedance of 50 Ω, which act as input and output ports.[7] Since the proposed SIR is a symmetrical structure, even-odd mode theory can be adopted to implement it and its equivalent circuits are described in ***Figure 2***. For the odd and even mode excitation, the symmetry plane TT" is considered as a short end and an open end, respectively. The input admittance Y_{ineven}, Y_{inodd} of the even- and odd-mode resonator can be extracted:



▲ *Fig. 1 Schematic of the dual-band dual-mode, SIR loaded with a short-circuited stub.*

$$Y_{inodd} = -jY_1 \frac{Y_2 - Y_1 \tan\theta_1 \tan\theta_2}{Y_2 \tan\theta_1 + Y_1 \tan\theta_2} \quad (1)$$

$$Y_{ineven} = jY_1 \frac{Y_1 \tan\theta_1 - Y_2 \dfrac{Y_3 - Y_2 \tan\theta_2 \tan\theta_3}{Y_2 \tan\theta_3 + Y_3 \tan\theta_2}}{Y_3 + Y_2 \dfrac{Y_3 - Y_2 \tan\theta_2 \tan\theta_3}{Y_2 \tan\theta_3 + Y_3 \tan\theta_2} \tan\theta_1} \quad (2)$$

According to the resonance condition of $Y_{inodd} = 0$ and $Y_{ineven} = 0$, the resonant frequencies can be expressed as:

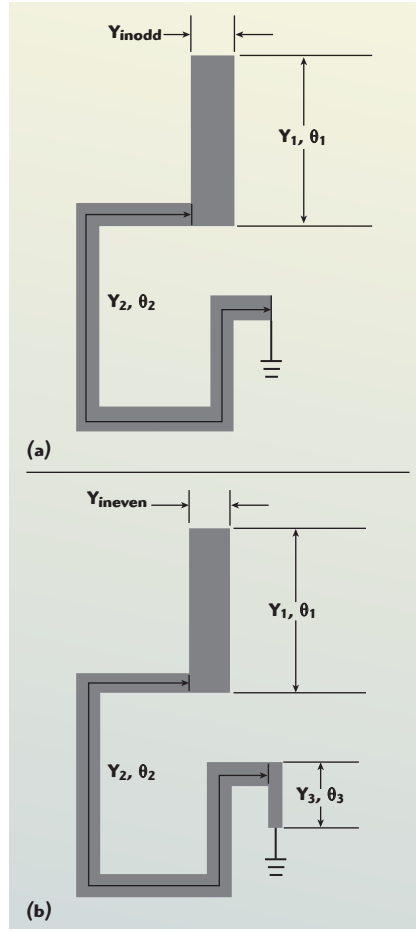
$$Y_1 \tan\theta_1 \tan\theta_2 - Y_2 = 0 (\text{at } f = f_{odd}) \quad (3)$$

$$Y_2 Y_3 - Y_2^2 \tan\theta_2 \tan\theta_3 - Y_1 Y_2 \tan\theta_1 \tan\theta_3 - Y_1 Y_3 \cdot \tan\theta_1 \tan\theta_2 = 0 (\text{at } f = f_{even}) \quad (4)$$

where Y_i (i = 1, 2, 3) are the characteristic admittances of the widths W_i (i = 2, 3, 4), and θ_i (i = 1, 2, 3) are electrical lengths of the three sections of the length L_i (i = 2, 3, 4), respectively.

From Equation 3, it can be seen that the odd-mode resonant frequencies (f_{o1}, f_{o2}) are determined by θ_1, θ_2, Y_1 and Y_2. Thus, by reasonably designing these parameters, the resonant frequencies f_{o1} and f_{o2} are approximately allocated in the first and second passbands, respectively. Also, the total electrical length θ of the odd mode resonator is defined:

$$\theta = \theta_1 + \theta_2 = \theta_1 + \arctan\left(\frac{R}{\tan\theta_1}\right) \quad (5)$$



▲ *Fig. 2 Equivalent circuits (a) odd-mode and (b) even-mode.*

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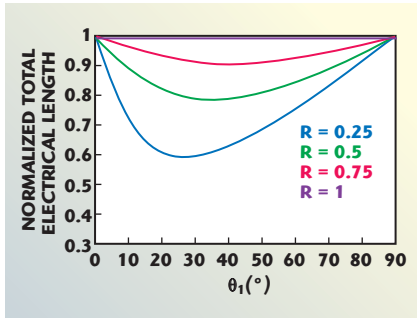


Fig. 3 Normalized total electrical length (θ) with varied θ_1.

where R is the impedance radio Y_2/Y_1. The relation between the normalized total electrical length θ versus θ_1 with R as a parameter is shown in ***Figure 3***. There are various solutions for θ, which are dependent on the choice of R and θ_1.[8] From the figure, it can be seen that a compact size may be obtained by having an appropriated θ_1 and small impedance ratio R.

From Equation 4, the even-mode resonant frequencies depend exclusively on θ_3, Y_3. Furthermore, as the electrical length θ_3 decreases, the even-mode resonant frequencies (f_{e1}, f_{e2}) will correspondingly get close to the odd-mode resonant frequencies (f_{o1}, f_{o2}), whereas the odd-mode resonator frequencies (f_{o1}, f_{o2}) remain stationary. Hence, the four resonant frequencies can be allocated within the desired passbands to realize a dual-band, dual-mode filter by reasonably choosing the parameters of SIR and short stub, respectively.

To verify the theoretical analysis, a dual-mode dual-band filter has been designed, which works in the GPS band (1.57 GHz) and the WLAN band (5.2 GHz). The proposed filter is simulated by Ansoft HFSS 10. The substrate has a thickness of h = 0.8 mm and a relative dielectric constant of ε_r = 4.5. Its dimensions are as follows: L_1 = 14.45 mm, L_2 = 5 mm, L_3 = 19.05 mm, L_4 = 1.056 mm, W_1 = 0.65 mm, W_2 = 1.2 mm, W_3 = 0.6 mm W_4 = 1 mm and g_0 = 0.2 mm. The simulated frequency responses are shown in ***Figure 4***. It is clearly observed that the center frequencies are generated at 1.57 and 5.2 GHz. The return losses within the two passbands are below 20 dB.

TRI-BANDS BPF DESIGN AND RESULTS

Based on the dual-mode, dual-band discussion, a triple bandpass response can be achieved by adding an additional transmission path at a different resonant frequency. In this article, the extended feedlines are folded outside to produce the third bandpass, without significantly increasing the circuit size. The schematic of the proposed tri-band BPF is shown in ***Figure 5***. Besides, the resonator frequency of the extended feedlines can be independently tuned to the desired passband (WiMAX, 3.5 GHz). It is approximately given by:

$$f \approx \frac{c}{2L_5\sqrt{\varepsilon_{eff}}} \quad (6)$$

where L_5 is the length of the extended feedlines. The electric field distributions at the resonant frequencies of the tri-band BPF are illustrated in ***Figure 6***. It is evident that the odd modes have an electric field distribution similar to that of the single SIR. Hence, the tapping point of the short stub is actually a virtual ground for the odd modes. As a consequence, the short stub does not affect the odd-mode characteristic, including its resonant frequencies. On the contrary, the short stub can affect the even characteristic, which can be demonstrated in the electric field distribution at even-mode frequencies. That is the reason why the change of θ_3 controls

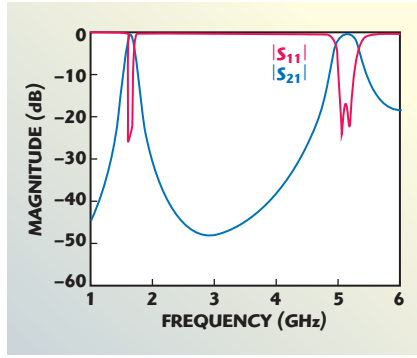


Fig. 4 Simulated frequency responses of the proposed SIR.

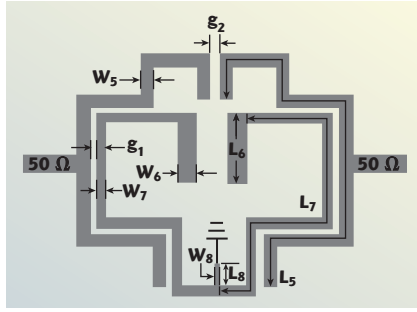
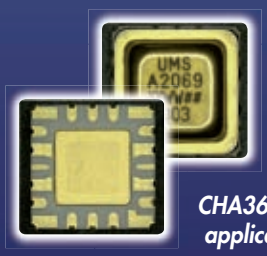


Fig. 5 Schematic view of the proposed tri-band BPF.

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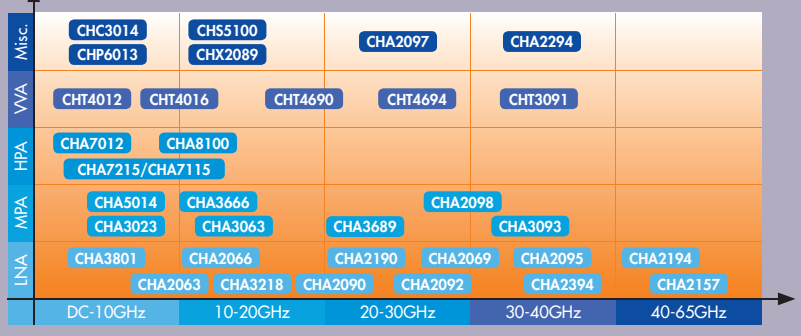
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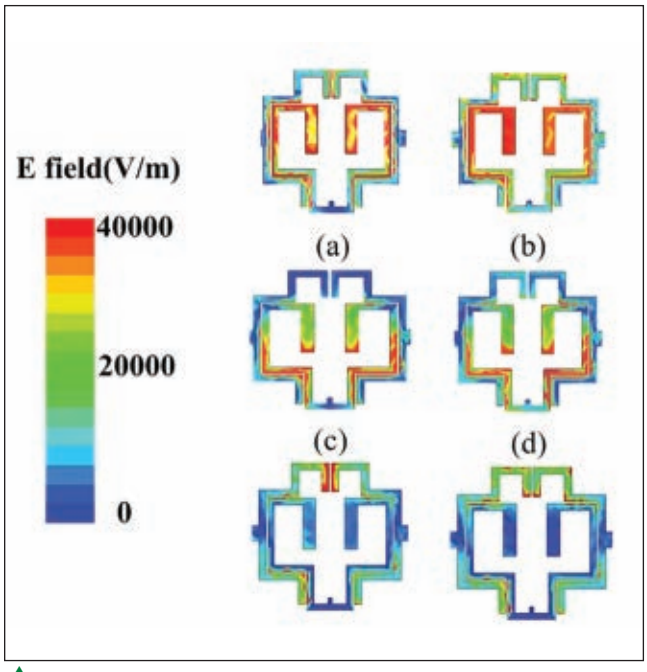


Fig. 6 Simulated electric field distribution at resonant frequencies (a) f_{o1}, (b) f_{e1}, (c) f_{o2}, (d) f_{e2}, (e) and (f) for the two poles of the extended line.

the resonant frequencies of the even mode. Figures 6 (e) and (f) show that the electric field is mainly concentrated in the extended feedlines.

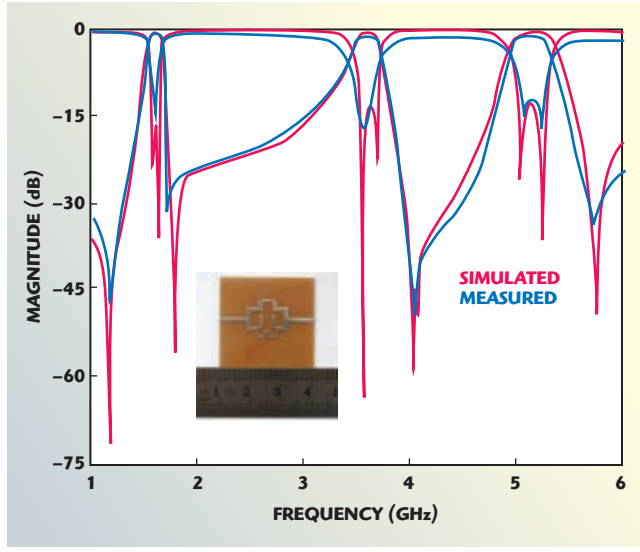


Fig. 7 Simulated and measured results of the fabricated filter and its photograph.

The proposed filter is fabricated on the same substrate as mentioned previously. The physical dimensions of the filter are chosen as follows: L_5 = 21.5 mm, L_6 = 5 mm, L_7 = 19.05 mm, L_8 = 0.6 mm, W_5 = 0.65 mm, W_6 = 1.2 mm, W_7 = 0.6 mm, W_8 = 0.4 mm, g_1 = 0.2 mm and g_2 = 0.2 mm. The fabricated proposed filter occupies only about 13.7 × 14.55 mm (approximately 0.13 λg × 0.14 λg, where λg is the guided wavelength at the center frequency of the first passband).





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Simulated and measured results for the proposed tri-band filter with its photograph are compared in ***Figure 7***. The results show that the three passbands are centered at 1.57, 3.5 and 5.2 GHz, with fractional bandwidth of 8.92, 8 and 8.46 percent, respectively. The maximum insertion loss within the passband is less than 1.18 dB, which would be mainly attributed to the conductor and dielectric loss. The configuration also displays extra transmission zeros at 1.18, 1.80, 4.03 and 5.74 GHz. The designed filter shows excellent performance for GSP, WiMAX and WLAN applications. Good agreement between the simulated and measured results demonstrates the proposed structure performance.

CONCLUSION

In this article, a miniature tri-band BPF using a short-stub loaded SIR has been proposed. Based on the proposed SIR, a compact tri-band BPF with extended feed lines is implemented to achieve the miniaturization. Furthermore, four transmission zeros are produced and greatly improve the selectivity and stopband suppression. The measured result agrees with the electromagnetic (EM) simulation. For a system integrating GPS, WiMAX and WLAN, this concept could be applied to filter signals among these commercial bands. ■

ACKNOWLEDGMENTS

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Technique to Minimize Phase Noise of Crystal Oscillators

Excellent oscillator performance can be expensive. Recent publications[1-7] describe the design implementation-techniques of low phase noise crystal-oscillator circuits using, high Q-factor, expensive crystal resonators that show inferior phase noise. Fortunately, approaches have been developed[8] to design and optimize the performance of voltage-controlled crystal oscillators (VCXO), even those with relatively low-Q-factor resonators, to achieve excellent phase-noise and frequency stability. Novel crystal oscillator circuits are reported, using medium Q-factor and inexpensive crystal resonator, by which the phase noise of the crystal oscillator at close-in as well as far offset from the carrier, can be minimized using self-injection and mode-locking techniques. The CAD simulated and experimental results are presented to validate the proposed methodology.

A typical oscillator consists of a tuned circuit and an active device such as a transistor. Ideally, the tuned circuit provides a high loaded Q, generally from less than 100 for simple circuits to more than 1 million for crystal-resonator-based circuits. Noise arises from the active device as well as from resonator losses. Noise from a bipolar transistor, for example, stems from base and collector contributions and from device parasitic elements, such as the base-spreading resistor. The filtering effect of the resonator tends to remove the device noise, with higher Qs delivering greater filtering effects. The standard Leeson equation relates these noise effects (Equation 1[1]).

$$\pounds(f_m) = 10\log\left\{\left[1+\frac{f_0^2}{(2f_mQ_L)^2}\right]\cdot\left(1+\frac{f_c}{f_m}\right)\frac{FkT}{2P_{sav}}+\frac{2kTRK_0^2}{f_m^2}\right\} \quad (1)$$

where:

$\pounds(f_m)$ = the ratio of sideband power in a 1 Hz bandwidth at f_m to total power (in dB); f_m = frequency offset; f_0 = center frequency; f_c = flicker frequency; Q_L = loaded Q of the tuned circuit; F = noise factor; kT = 4.1×10^{-21} at 300 K_0 (room temperature); P_{sav} = average power at oscillator output; R = equivalent noise resistance of tuning diode (typically 50 Ω - 10 kΩ); K_0 = oscillator voltage gain.

Equation 1 is limited by the fact that the loaded Q typically must be estimated; the same applies to the noise factor. The following equations, based on this equivalent circuit, are the

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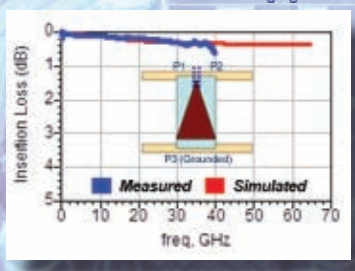
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exact values for P_{sav}, QL, and F, which are required for the Leeson equation. ***Figure 1*** shows a typical simplified Colpitts oscillator circuit for use in providing insight into a novel noise calculation approach. The noise factor can be calculated by:

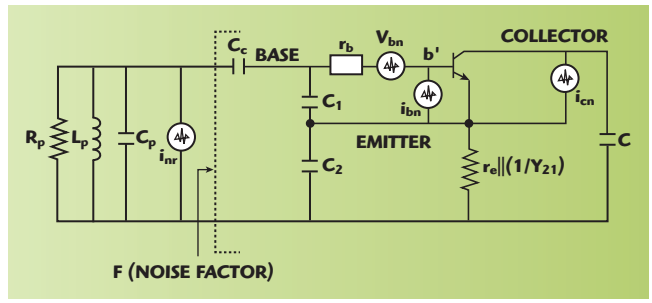


Fig. 1 Equivalent configuration of the Colpitts oscillator circuit including noise contribution.[3]

$$F = 1 + \frac{Y_{21}^{+} C_2 C_c}{(C_1 + C_2) C_1} \cdot \left[r_b + \frac{1}{2 r_e \beta} \left(r_b + \frac{(C_1 + C_2) C_1}{Y_{21}^{+} C_2 C_c} \right)^2 + \frac{r_e}{2} + \frac{1}{2 r_e} \left(r_b + \frac{(C_1 + C_2) C_1}{Y_{21}^{+} C_2 C_c} \right)^2 \left(\frac{f^2}{f_T^2} \right) \right] \quad (2)$$

After approximation (simplification in analysis[3]):

$$F \approx 1 + \frac{Y_{21}^{+} C_2 C_c}{(C_1 + C_2) C_1} \cdot \left[r_b + \frac{1}{2 r_e} \left(r_b + \frac{(C_1 + C_2) C_1}{Y_{21}^{+} C_2 C_c} \right)^2 \cdot \left(\frac{1}{\beta} + \frac{f^2}{f_T^2} \right) + \frac{r_e}{2} \right] \quad (3)$$

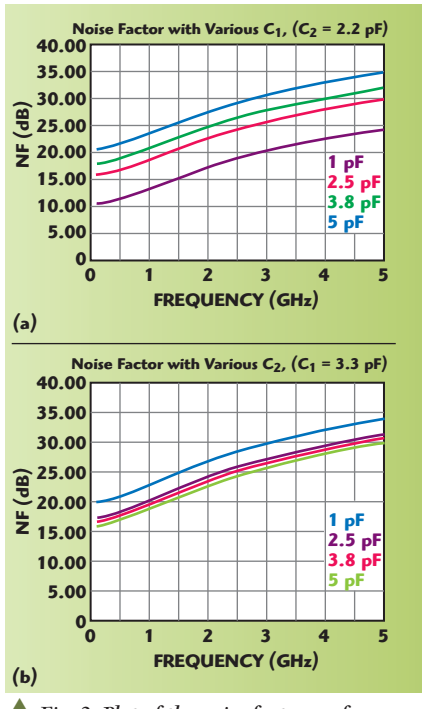


Fig. 2 Plot of the noise factor vs. frequency for various values of C_1 (a) and C_2 (b).

where Y_{21}^{+} is a large signal Y-parameter for a given oscillator circuit operating condition.

Figures 2a and ***2b*** illustrate the dependency of the noise factor (NF) on the feedback capacitors C_1 and C_2. From Equation 1, the phase noise of the oscillator circuit can be minimized by optimizing the noise factor terms as given in Equation 3, with respect to the feedback capacitors C_1 and C_2.

Equation 4 can be found by substituting $1/r_e$ for Y_{21}^{+} (+ sign denotes the large signal Y-parameter)[3]:

$$F = 1 + \frac{C_2 C_c}{(C_1 + C_2) C_1 r_e} \cdot \left[r_b + \frac{1}{2 r_e \beta} \left(r_b + \frac{(C_1 + C_2) C_1 r_e}{C_2 C_c} \right)^2 + \frac{r_e}{2} + \frac{1}{2 r_e} \left(r_b + \frac{(C_1 + C_2) C_1 r_e}{C_2 C_c} \right)^2 \left(\frac{f^2}{f_T^2} \right) \right] \quad (4)$$

When adding an isolating amplifier, the noise of an oscillator circuit is determined by Equation 5:

$$S_\phi(f_m) = \left[a_R f_0^4 + a_E \left(f_0 / (2Q_L) \right)^2 \right] / f_m^3 + \left[(2GFkT / P_0) \left(f_0 / (2Q_L) \right)^2 \right] / f_m^2 + \left(2 a_R Q_L f_0^3 \right) / f_m^2 + a_E / f_m + 2GFkT / P_0 \quad (5)$$

where G = the compressed power gain of the loop amplifier; F = the noise factor of the loop amplifier; k = the Boltzmann's constant; T = the temperature (in degrees K); P_0 = the carrier power level (in W) at the output of the loop amplifier; f_0 = the carrier frequency (in Hz); f_m = the carrier offset frequency (in Hz); $Q_L = (\pi F_0 \tau_g)$ = the



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LS0560 P40B	0.5 - 6.0	1.3	1.5:1	+21
LS05012P40B	0.5 - 12.0	1.7	1.7:1	+21
LS1020 P40B	1.0 - 2.0	0.6	1.4:1	+21
LS1060 P40B	1.0 - 6.0	1.2	1.5:1	+21
LS1012P40B	1.0 - 12.0	1.7	1.7:1	+21
LS2040P40B	2.0 - 4.0	0.7	1.4:1	+20
LS2060P40B	2.0 - 6.0	1.3	1.5:1	+20
LS2080P40B	2.0 - 8.0	1.5	1.6:1	+20
LS4080P40B	4.0 - 8.0	1.5	1.6:1	+20
LS7012P40B	7.0 - 12.0	1.7	1.7:1	+18

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loaded Q of the resonator in the feedback loop; a_R and a_E = the flicker noise constants for the resonator and loop amplifier, respectively.

To calculate the loaded Q_L in Equations 1 and 5, it is necessary to consider the unloaded Q (Q_0) and the loading effect of the active device circuits and tuning networks. There, the influence of Y_{21}^+ has to be considered. The inverse of Y_{21}^+ is responsible for the loading and reduction of the resonator Q-factor[3]:

$$Q_L = \frac{Q_0 \times Q^*}{Q_0 + Q^*};$$

$$Q^* = \frac{\omega_0 \times \left|\frac{1}{Y_{21}^+}\right| (C_1 + C_2)}{1 - \omega_0^2 C_1 L(Q = Q_0)} \quad (6)$$

Based on the transformation of the loading of the device emitter's differential impedance (resistance), it is possible to calculate the noise factor of the transistor under large-signal conditions.

The explicit expression for the phase noise $\pounds(\omega)$ in dBc/Hz in terms of the known oscillator circuit parameters for the circuit shown in Figure 1 can be described by:[3]

$$\pounds(\omega) = 10 \log \left(\left(\frac{4kTR_L + 4qI_c g_m^2 + \frac{K_f I_b^{AF}}{\omega} g_m^2}{\omega_0^2 C_1^2 (\omega_0^2 (\beta^+)^2 C_2^2 + g_m^2 \frac{C_2^2}{C_1^2})} \right) \cdot \left[\frac{\omega_0^2}{4\omega^2 V_{cc}^2} \right] \left[\frac{Q_u^2}{Q_L^2} + \frac{[C_1 + C_2]^2}{C_1^2 C_2^2 \omega_0^4 L^2 Q_L^2} \right] \right) \quad (7)$$

with

$$\beta^+ = \left[\frac{Y_{21}^+}{Y_{11}^+} \right] \left[\frac{C_1}{C_2} \right]^p;$$

$$g_m = \left[Y_{21}^+ \right] \left[\frac{C_1}{C_2} \right]^q \quad (8)$$

where Y_{21}^+, Y_{11}^+ is the large signal [Y] parameter of the active device, K_f is the flicker noise coefficient, AF is the flicker noise exponent, R_L is the equivalent loss resistance of the tuned resonator circuit, I_c is the RF collector current, I_b is the RF base current, V_{cc} is the RF collector voltage, C_1, C_2 are the feedback capacitors, g_m is the transconductance, Q_u and Q_L are unloaded and loaded Q factors, and p and q (p = 1.3 to 1.6; q = 1 to 1.1) are the drive level dependent constant across base-emitter of the device.

Given an ideal resonator with no long-term drift, aging, or variation due to temperature, the tuning circuit would not be needed for a fixed frequency reference oscillator to correct the frequency drift, but in reality this is not the case. For practical applications, the resonator requires corrective measures to keep the frequency stable. In tunable crystal oscillator circuits, this is achieved through the use of tuning diodes with capacitance values that change as a function of applied voltage.

High stability, low phase noise signal sources typically use quartz crystals as the resonator in the Colpitts and alternatively a Meissner type oscillator arrangement. Since the Colpitts oscillator uses a capacitive voltage divider, the crystal has to act as a high Q inductor; this means it is slightly detuned from its series resonant condition. Crystals have a Q from 50,000 (poor quality factor) to several million. Since they are mechanical resonators that are driven by the piezoelectric effect, they have fundamental, 3rd, 5th, 7th, and even 11th over tone modes. Unfortunately, due to undesired mode jumping, even in well-planned circuit design, it can become quite tricky to obtain the appropriate mode without jumping to other modes, which requires that special circuitry be added to the VCXO circuits. For example, if the fifth overtone mode is desired, a poorly designed oscillator may jump to the third overtone mode unexpectedly. One simple technique is to minimize the mode-separation by mode-locking techniques for preventing the mode-jumping and improving the stability of the crystal oscillator circuits. ***Figures 3a*** and ***3b*** show the typical block diagram and phase noise plots of mode-coupled injection-locked 128 MHz OCXO, which may not be the best performance, but reasonably good for low cost OCXO and VCXO solutions and offer low-cost stable signal source solutions, applicable to both low and high Q-factor crystal resonator. While crystal oscillators have been used for many years, most oscilla-

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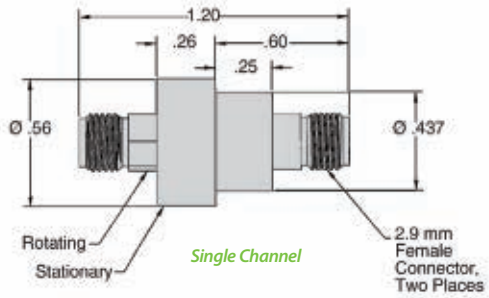
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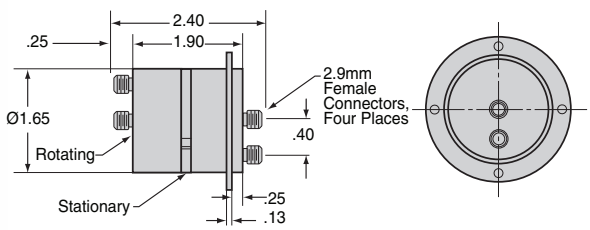
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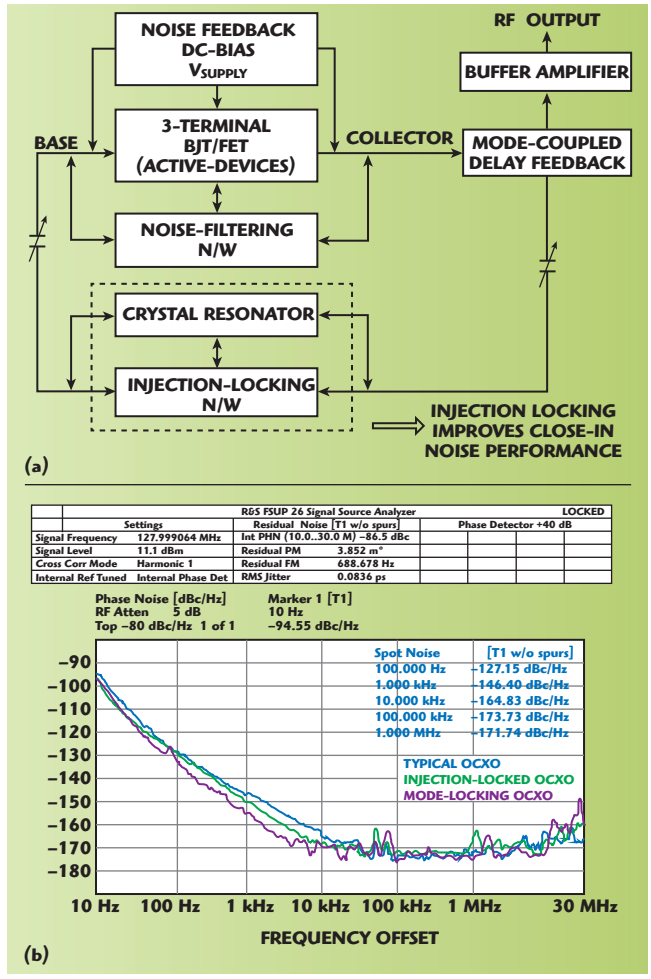
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tion optimization was done empirically rather than analytically. The demand for very high performance crystal oscillators with the ability to compensate for aging as a result of high drive levels, which are required for the improved phase noise, has triggered a new look at the possibility of applying new oscillator optimization techniques.

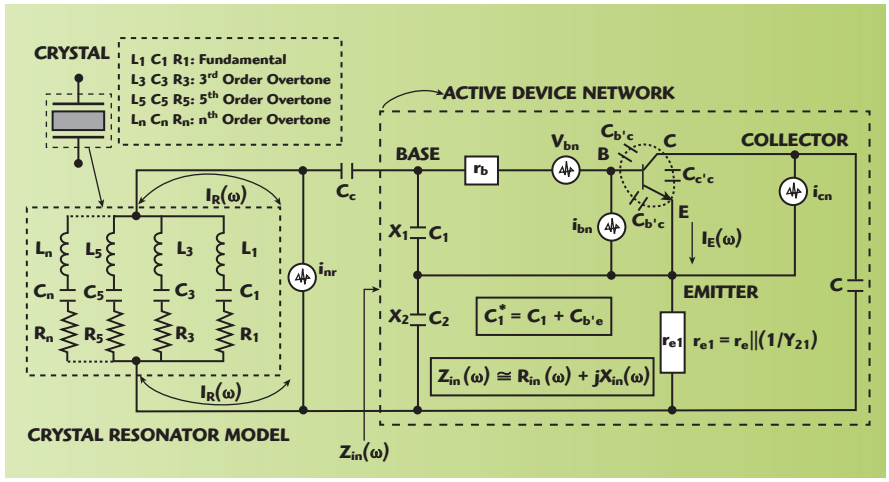
CRYSTAL OSCILLATOR DESIGN EXAMPLES

For high stability crystal oscillator operation, a method is needed to select a particular resonance mode, so that undesired modes are suppressed. One simple technique is to maximize the negative resistance generated from the active device network for a given particular mode and maximize the positive value of resistance for the unwanted modes. ***Figures 4*** and ***5*** show typical overtone mode crystal oscillator circuit, illustrating the active device noise contributions and mode-coupling dynamics.



▲ *Fig. 3 Typical block diagram (a) of a mode-coupled injection-locked 128 MHz crystal oscillator circuit (crystal Q = 80,000) and its measured phase noise (b).*

To understand the design criteria for overtone mode selection, the input impedance of the transistor can be considered. From Figure 4, the input impedance $Z_{in}(\omega)$ can be described by



▲ *Fig. 4 Typical crystal oscillator including noise contributions and odd order overtone modes.*

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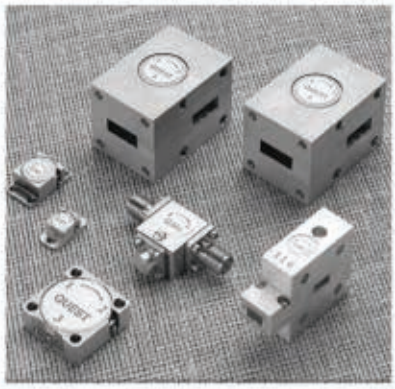
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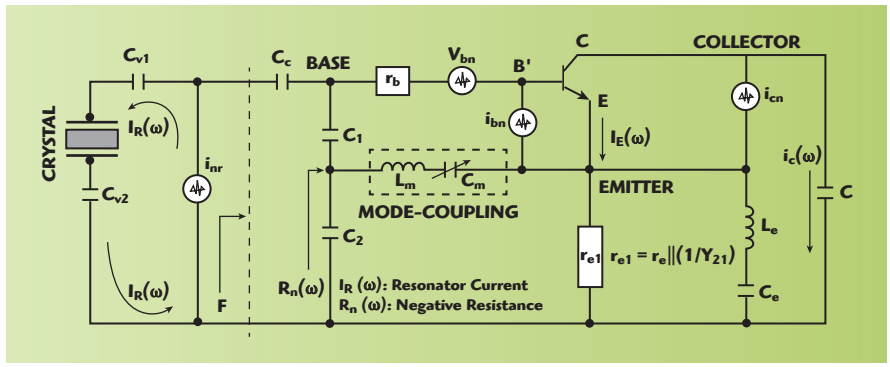


Fig. 5 Typical crystal oscillator including mode coupling network for preventing mode-jumping.

$$Z_{in}(\omega) \cong R_{in}(\omega) + jX_{in}(\omega) = -\left[\frac{Y_{21}}{\omega^2 C_1^* C_2}\right] + \frac{1}{j\omega}\left[\frac{1}{C_1^*} + \frac{1}{C_2}\right] \quad (9)$$

where $C_1^* = C_1 + C_{b'e}$

From Equation 9, the negative resistance and resonator drive level at the steady-state for the circuit shown in Figure 4 is given by:

$$R_n(\omega) = -\left[\frac{Y_{21}(x)}{\omega^2 C_1^* C_2}\right] = \left[\frac{Y_{21}(x)}{\omega^2 (C_1 + C_{b'e}) C_2}\right] \quad (10)$$

$$I_R(\omega) \cong \frac{2I_E(\omega)}{\omega C_2 R_n(\omega)} \quad (11)$$

with

$$Y_{21}| = G_m(x) = \frac{qI_{dc}}{kTx}\left[\frac{2I_1(x)}{I_0(x)}\right]_{X=\frac{g_m I_R(\omega)}{\omega(C_1 + C_{b'e}) I_E(\omega)}} \quad (12)$$

where $I_1(x)$ and $I_2(x)$ are modified Bessel functions of order 0 and 1, respectively. From Equations 10 and 11, the resonator current drive level $I_R(\omega)$ can be lowered by increasing the value of feedback capacitor C_2 for a given current $I_E(\omega)$, but at the cost of reduction in the value of negative resistance $R_n(\omega)$, which is very much necessary for compensating the loss resistance associated with the desired higher overtone modes of the crystal resonator for realization of high frequency stable oscillation condition. Lower value of negative resistance $R_n(\omega)$ will require very high Q-factor crystal resonator, therefore it is not a cost-effective solution.

In order to maintain the same value of negative resistance $R_n(\omega)$ needed to compensate the loss resistance of the crystal resonator at steady-state oscillation, the value of the feedback capacitor C_1 has to be reduced. There is a practical limitation of the minimum value of the C_1, to be decided by a specified value of the load capacitance of the crystal resonator, which includes the intrinsic base-emitter capacitor ($C_{b'e}$) of the transistor. Moreover, drive-level parameters determine the overall nonlinearity,

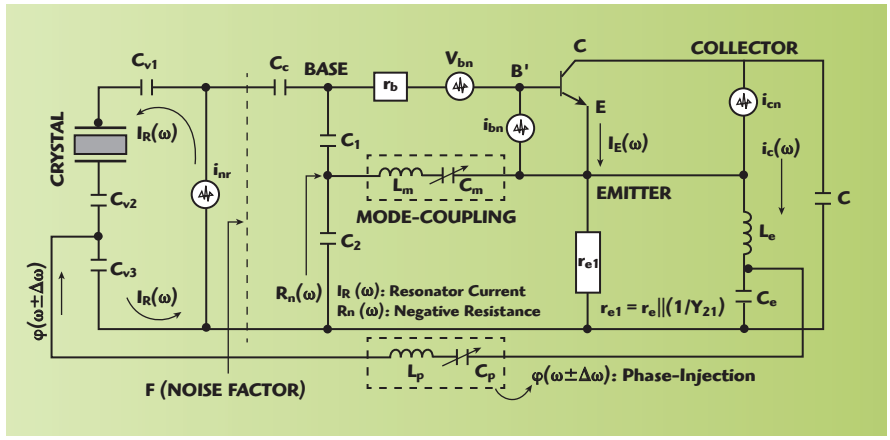


Fig. 6 Typical mode-coupled phase-injected $\varphi(\omega \pm \Delta\omega)$ crystal oscillator, including noise contributions (transistor and resonator).

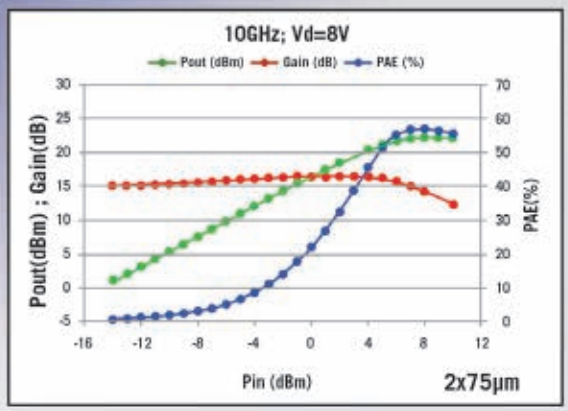
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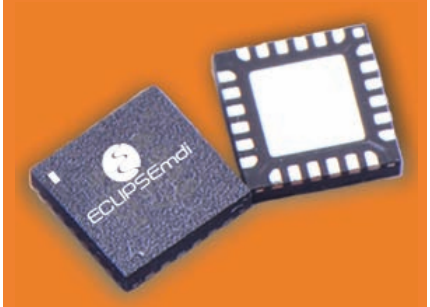
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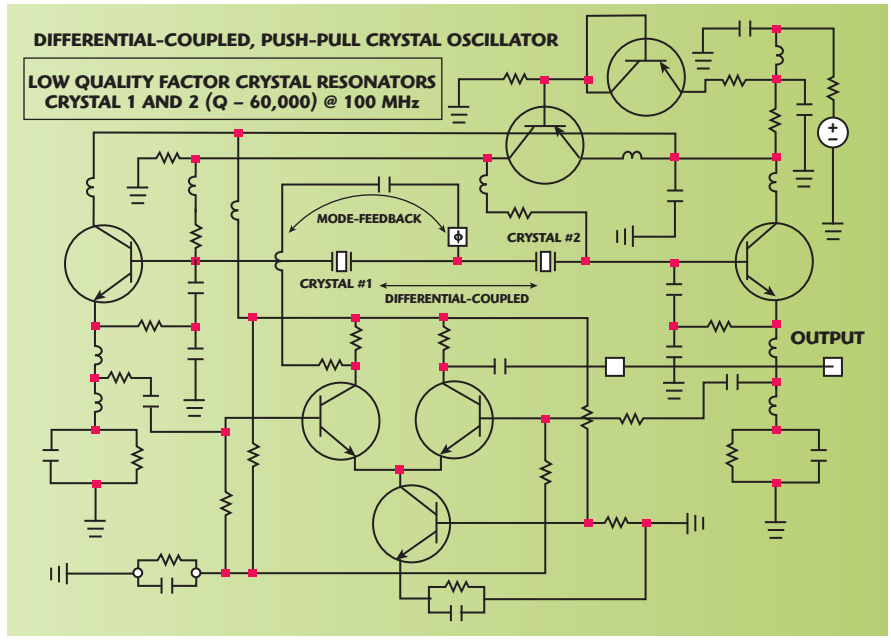


Fig. 7 Schematic of a 100 MHz differential-coupled, push-pull, crystal oscillator circuit using inexpensive crystal resonators (Q ≅ 60,000).

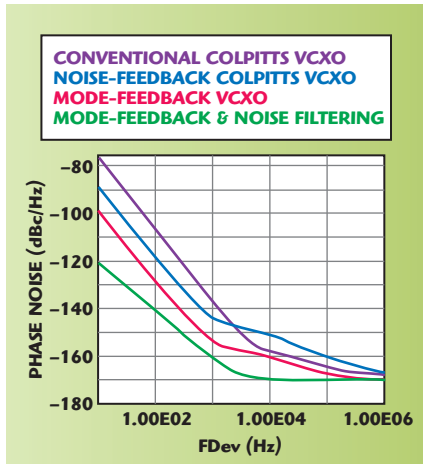


Fig. 8 CAD simulated phase noise plots for 100 MHz crystal oscillators using different modes.

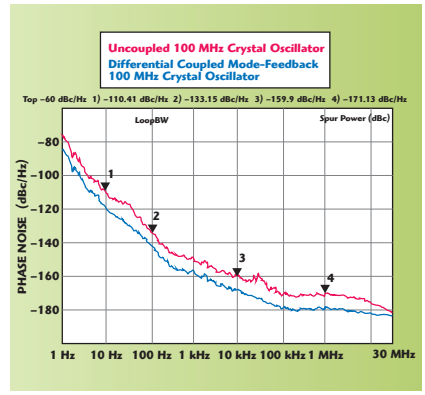


Fig. 9 Measured phase noise plots for an enhanced-performance 100 MHz crystal oscillator circuit.

which causes amplitude-frequency effect and degrades the 1/f noise performances.

To demonstrate the new approach, a typical Colpitts configuration of crystal oscillator circuit was used as an example to apply the concept of phase-injection and mode-locking. This optimization can be accomplished by using mode-coupling (tuning the L_m-C_m at higher order modes) and a phase-injection $\varphi(\omega \pm \Delta\omega)$ mechanism for a given mode-coupling and drive-level $I_R(\omega)$ (see ***Figure 6***). The capacitor C_{V1} provides sufficient coupling for the oscillation growth (without C_{V2} and C_{V3}), but at the cost of slow start-up characteristics and high drive level $I_R(\omega)$. As shown in the figure, higher order modes are coupled through the output path and feedback to the point where frequency-drive sensitivity of the crystal resonator shows maximum group delay and faster slew rate, resulting in improved stability with reduced drive-level $I_R(\omega)$.

For a low-cost, low-phase-noise crystal oscillator, self-injection-locking can be realized by a delay network in conjunction with the phase-injection network. A self-injection-locked oscillator has the ability to adjust its frequency to follow the locking signal, resulting in a comparatively higher locking range as compared to an external reference for a given figure of merit. The typical locking range of the self-injection-locked crystal oscillator can be described in terms of maximum

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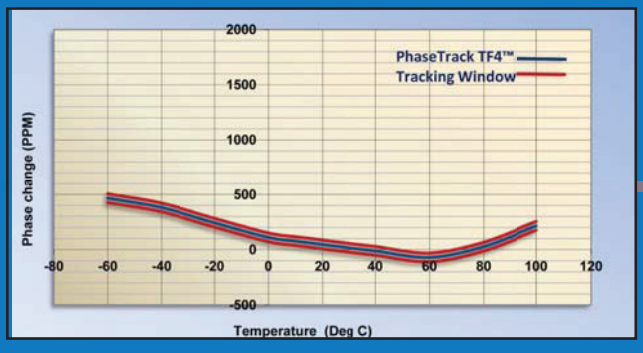


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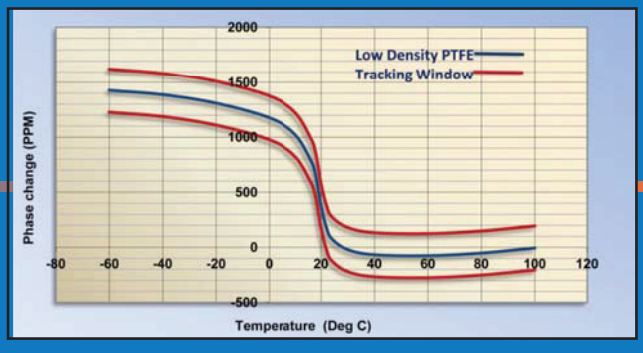
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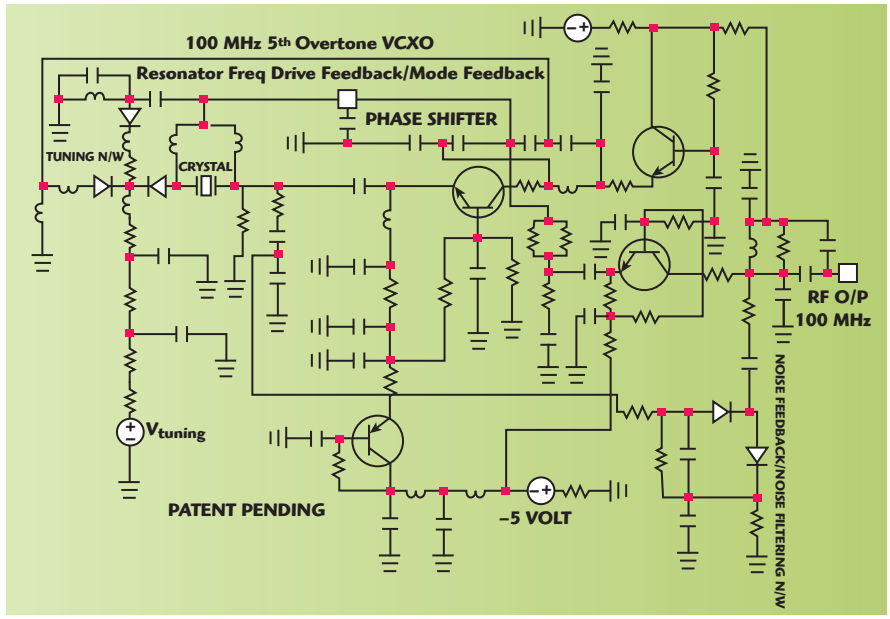


Fig. 10 Typical schematic of 5th overtone mode 100 MHz VCXO circuit.

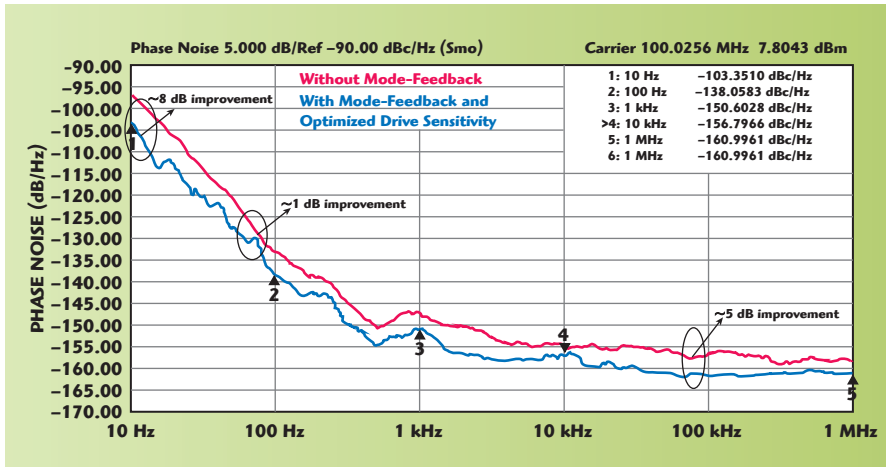


Fig. 11 Measured phase noise of the 5th overtone mode 100 MHz VCXO circuits.

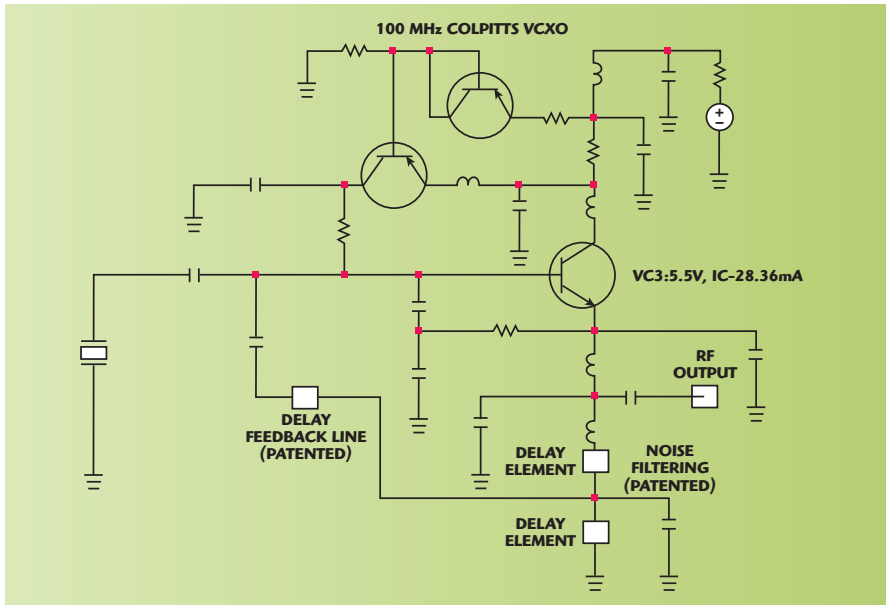


Fig. 12 Typical schematic of a low phase noise, stable 100 MHz crystal oscillator using a mode-coupling mechanism.

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change in frequency for given operating conditions as

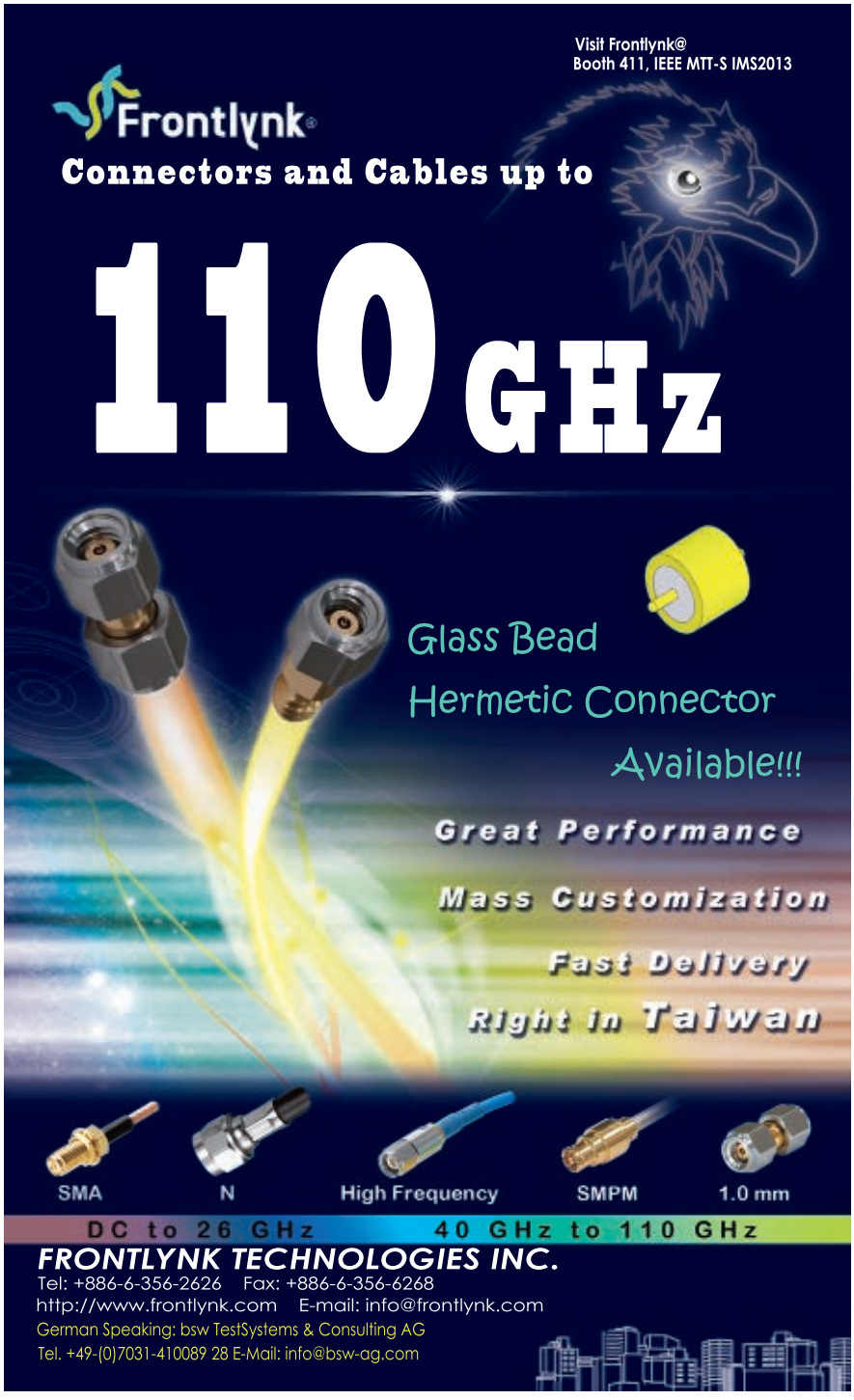
$$f_0 = \frac{1}{2\pi\sqrt{LC}} \rightarrow f_0 + \Delta f = \frac{1}{\sqrt{(L+\Delta L)C}} \approx f_0\left[1 - \frac{1}{2}\frac{|\Delta L|}{L}\right] \underset{\Delta L \ll L}{\rightarrow}$$

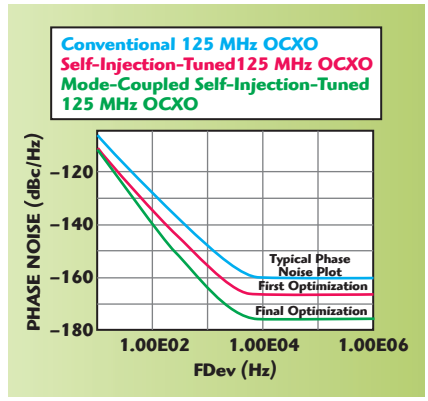
$$|\Delta f| \cong f_0\left[\frac{1}{2}\frac{|\Delta L|}{L}\right]_{\Delta L \ll L} \quad (13)$$

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \rightarrow f_0 + \Delta f = \frac{1}{\sqrt{L(C+\Delta C)}} \approx f_0\left[1 - \frac{1}{2}\frac{|\Delta C|}{C}\right] \underset{\Delta C \ll C}{\rightarrow}$$

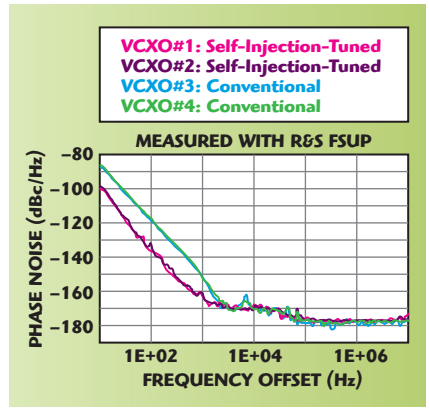
$$|\Delta f| \cong f_0\left[\frac{1}{2}\frac{|\Delta C|}{C}\right]_{\Delta C \ll C} \quad (14)$$

where ΔL and ΔC are the maximum change of the effective inductance and capacitance of the resonator tank circuit due to the injection-locking signal (realized by using a delay-line phase shifter and Δf is the maximum frequency shift that governs the locking range of the crystal oscillator). From Equations 13 and 14, the locking range is proportional to the maximum amount of the change of the inductance (ΔL) or capacitance (ΔC) caused by the injected signal through the delay line for achieving phase synchronization. For a given oscillator circuit topology and operating DC bias condition, it is important to note that the ratio of inductance to capacitance (L/C) of the resonator tank influences the drive-level and time-jitter fluctuations characteristics. The trick is to dynamically suppress the intrinsic random fluctuation and mode-jumping dynamics by optimizing the mode-coupling network in conjunction with phase-injection techniques. ***Figure 7*** shows the simplified schematic for an enhanced-performance 100 MHz crystal oscillator circuit by incorporating techniques described in Equations 1 to 14. ***Figure 8*** shows the simulated phase noise plots of crystal oscillator circuits using different topologies for a comparative analysis. ***Fig-***



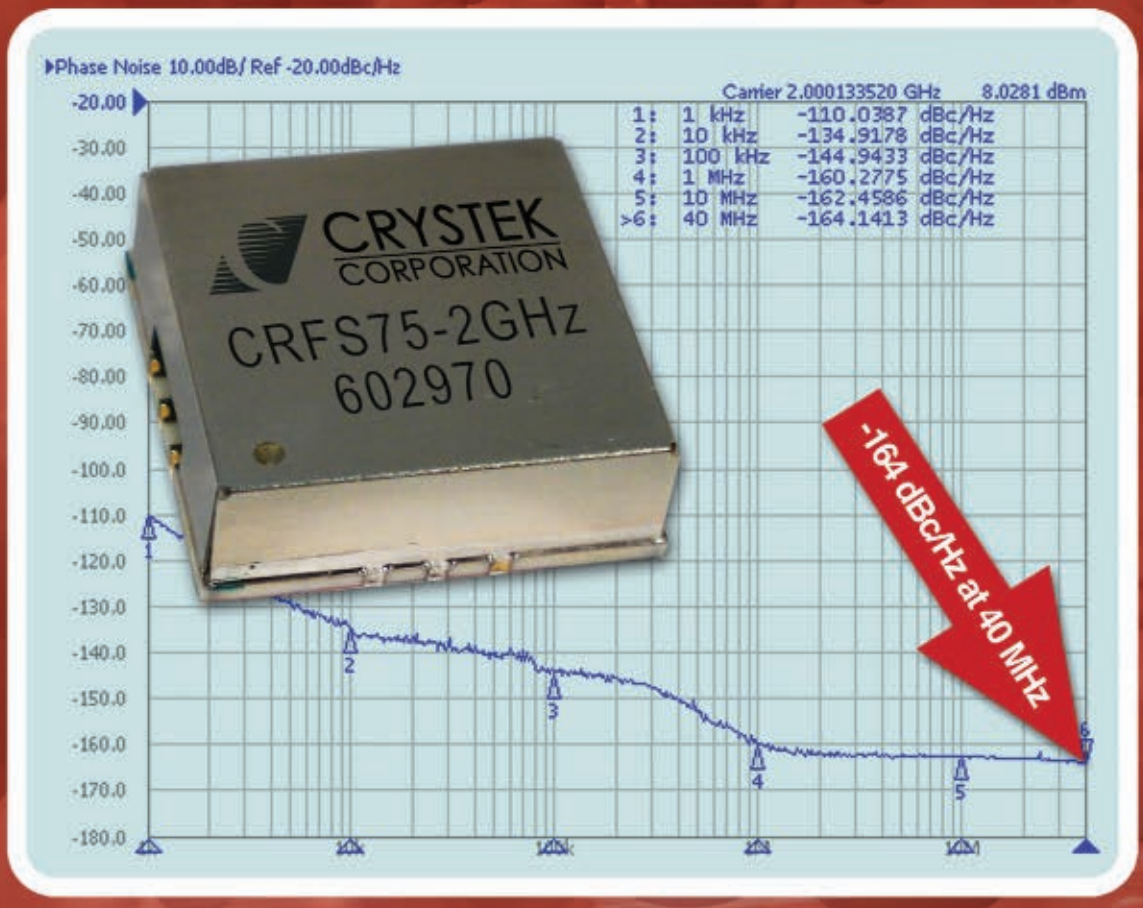


▲ *Fig. 13 Typical CAD-simulated phase-noise plot of the 125 MHz OCXO circuit.*



▲ *Fig. 14 Measured phase-noise plots of the 125 MHz OCXO circuits.*

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ure 9 shows the measured phase noise plots for an enhanced-performance 100 MHz crystal oscillator circuit.

Figures 10 and ***11*** show the schematic and phase noise plots of a 5th overtone mode 100 MHz VCXO circuit to demonstrate the noise minimization techniques as described in Equations 1 to 14. For overtone modes, the equivalent circuit of crystal in the overtone branch can be computed by scaling the values of R, L and C in the fundamental resonant branch. If 'f_1' is the fundamental frequency then the nth overtone frequency should be computed as

$$f_n = n \times f_1 = \frac{1}{2\pi\sqrt{L_n C_n}} = \frac{n}{2\pi\sqrt{L_1 C_1}} = \frac{1}{2\pi\sqrt{L_1 \frac{C_1}{n^2}}};$$

$$\text{where } \left(L_n = L_1, C_n = \frac{C_1}{n^2},\right.$$

$$\left.\text{n is overtone number}\right) \quad (15)$$

Wide pull VCXOs typically utilize fundamental crystals with large motional capacitance C_1. Overtone operation is precluded if wide tuning range is desired. Also the resistor for the overtone branch gets scaled as $R_n = R_1 n^2$, which implies that the negative resistance required to get oscillations on overtone is much larger than the value for fundamental mode. The fundamental frequency (lowest-mode) response is the most active due to a lowest value of R_n. If a large negative resistance is provided for the fundamental resonance, it could result in exciting an overtone mode also. For designing high frequency crystal oscillators, generally the crystal is excited on its overtone mode and care should be taken to suppress the unwanted fundamental resonance in such cases.

Figure 12 shows the typical schematic of the mode-coupled 100 MHz crystal oscillator circuits by incorporating delay line noise filtering techniques. This approach is being applied to the development of high-performance VCXOs and can be extended to higher frequencies by incorporating phase-injection stubs across the crystal resonator at the desired operating frequency.

Described is an approach to overcome the uncertainty associated with crystal resonator modeling and suggest the unified topology using differential-phase-shift-injection-locking (DPSIL) methods in conjunction with mode-coupled-delay-feedback (MCDF) technique that enables low cost low phase noise solutions for both fundamental and overtone-modes crystal oscillator circuits. DPSIL improves the close-in phase noise performance, whereas MCDF prevents mode-jumping and improves the stability and far out phase noise performance. ***Figure 13*** compares the simulated 125 MHz OCXO with a first-pass optimization and with the best results from these new techniques. The CAD simulated results were validated with theory and measurements (see ***Figure 14***). As shown, the phase noise plots of the 125 MHz OCXO circuit using the following topologies: without optimization (conventional topology), first optimization (self-injection-tuned topology) and final optimization (mode-locking-injection-tuned using delay line) are illustrated for comparative insights about the phase noise performance.



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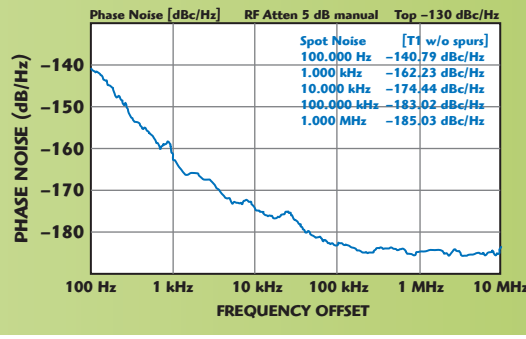
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▲ *Fig. 15 Measured phase noise plot of the 125 MHz DPSIL-MCDF OCXO circuit.*

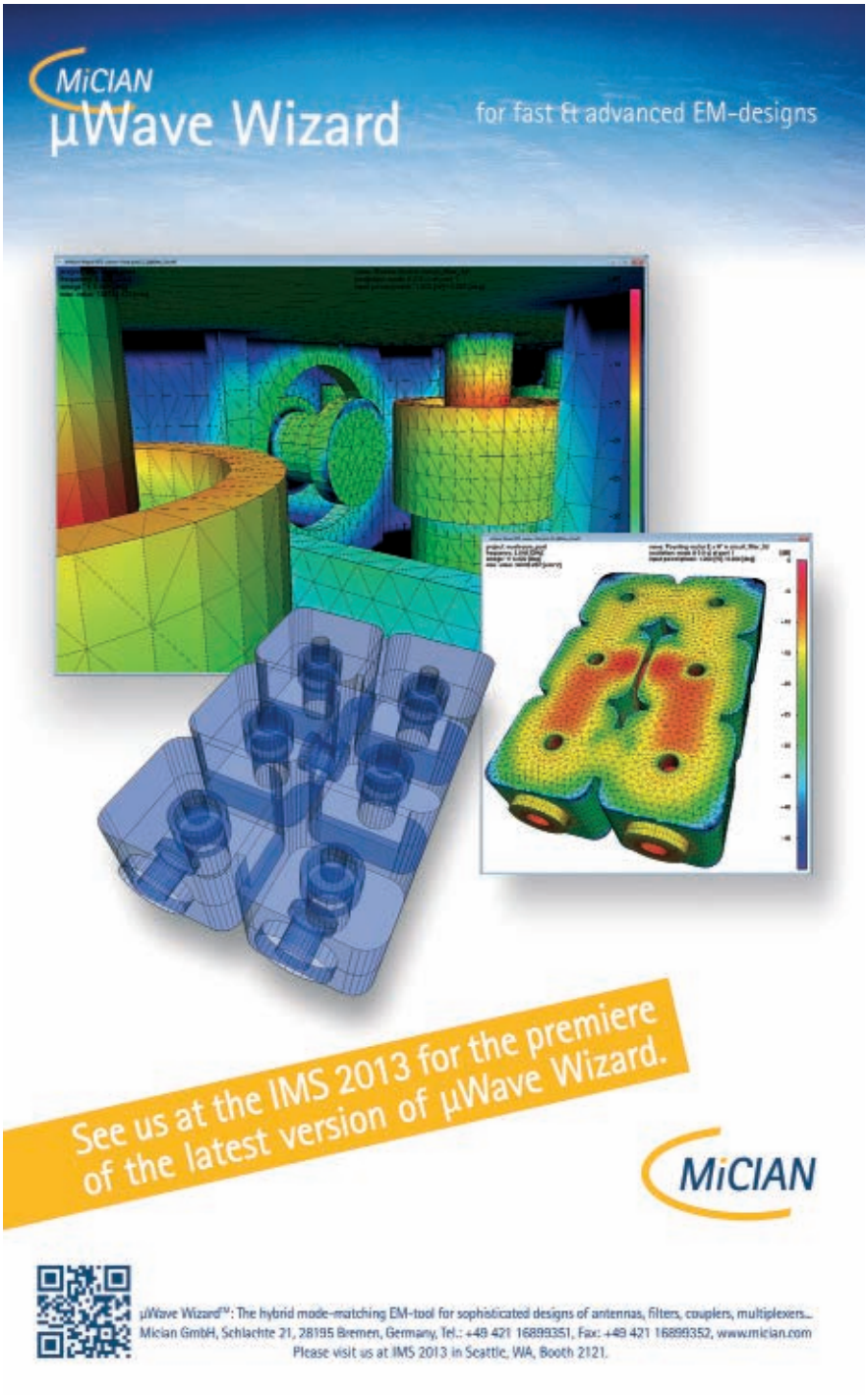


Figure 15 shows the measured phase noise plots for a 125 MHz OCXO circuit using DPSIL topology for the validation of the examples shown. The adaptive filtering techniques described, in conjunction with DPSIL-MCDF, suppress the intrinsic 1/f noise of crystal resonator, thereby improved close-in phase noise performance of 125 MHz OCXO circuits.

To the author's knowledge, the reported phase noise performance of 125 MHz OCXO is the best performance to date, using crystal of unloaded Q = 80,000 for a given class and figure of merit. (See ***Table 1*** online at www.mwjournal.com/OCXOresults for a summary of the measurements.) ■

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Dual Passband Filter with Hybrid Microstrip and Coplanar Waveguide Resonators

This article presents a new dual passband filter using hybrid microstrip split ring resonators and coplanar waveguide (CPW) quarter wavelength resonators. Its equivalent RLC circuit model is presented, in which the parameters are extracted from the theoretical analysis and the measured S-parameters. The proposed filter has two passbands with center frequencies of 2.44 and 3.5 GHz. Good agreement between the equivalent circuit (EC), the electromagnetic (EM) simulated and the measured results is demonstrated.

Filters with multiple passbands are an essential element for communication systems, which could achieve higher speed and higher capacity data transmission capabilities.[1,2] In initial investigations, the dual passband filter has attracted much attention, and several design approaches have been proposed. Dual passband filters have been realized by parallel connection of two bandpass filters with different center frequencies.[3,4] However, this configuration increases the size of the circuit. Another dual passband filter was obtained by using stepped impedance resonators (SIR) and quarter wavelength resonators,[5] but it is difficult to achieve two adjacent passbands using SIRs. Besides, the short end of the microstrip quarter wavelength has to be realized via a drilled hole.

In fact, coplanar waveguide (CPW) is a much more attractive approach for quarter wavelength short circuit stubs, due to its uniplanar structure. It has been getting more and more attention for its advantages, such as easy connections in series and shunt without via holes, insensitivity to substrate thickness and low dispersion effect in microwave and millimeter wave circuits' design.[6-8]

Here, a dual passband filter is presented, using hybrid microstrip split ring resonators and

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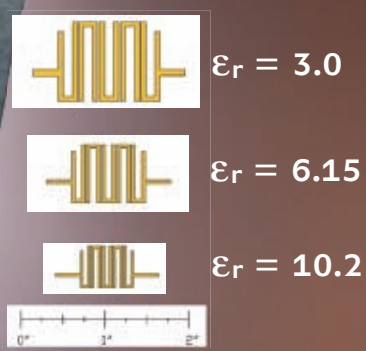
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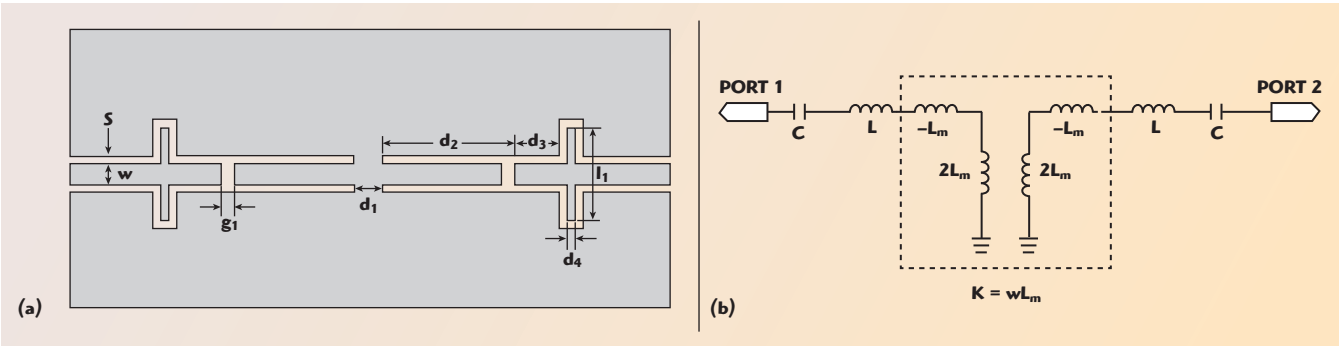


Fig. 1 Structure of the bandpass filter with CPW quarter wavelength resonators (a) and its equivalent circuit (b).



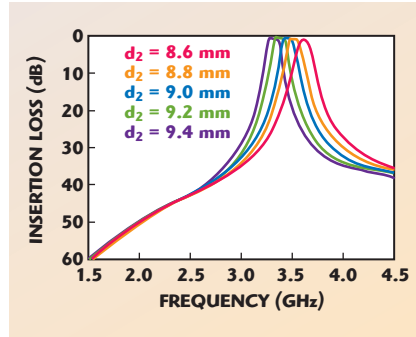


Fig. 2 Bandpass characteristic as a function of d_2.

coplanar waveguide quarter wavelength resonators. The microstrip split ring resonators and the CPW quarter wavelength resonators are symmetrically distributed on the top and bottom layers. A CPW input/output feed line is adopted in this structure. Finally, the filter is fabricated, with center frequencies of 2.44 and 3.5 GHz, which could be used for wireless local area network (WLAN) and WiMAX. The EM simulated and measured results are offered to demonstrate the characteristics of the proposed dual passband filter.

FILTER DESIGN

CPW Quarter Wavelength Resonators

The structure of the bandpass filter with CPW quarter wavelength resonators is shown in ***Figure 1***. One end of the resonator is terminated by an open gap and the other end is terminated by a short circuited stub. The two neighboring resonators are inductively coupled and its coupling circuit can be expressed by K-inverters.[9] The equivalent circuit of this structure is also shown in the figure. Its external quality factor is controlled by adjusting the width g_1 of the coupling gap, while the coupling coefficient of the two neighboring resonators is adjusted by varying the width d_1 of the coupling length.

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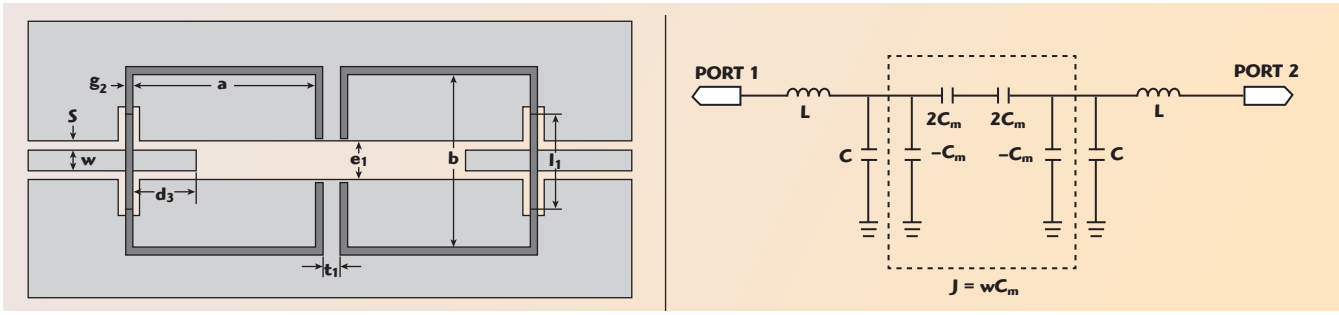


Fig. 3 Structure of the bandpass filter with SIRs (a) and its equivalent circuit (b).

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BCP040T	0.25x400	1 - 26.5	120	14.0	26	65
BCP060T*	0.25x600	1 - 26.5	180	12.0	28.0	60
BCP060T2	0.25x600	1 - 26.5	180	12.0	29.0	65
BCP080T*	0.25x800	1 - 26.5	240	10.5	30.0	60
BCP080T2	0.25x800	1 - 26.5	240	11.5	30.0	65
BCP120T	0.25x1200	1 - 26.5	350	11.0	32.0	60
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The bandpass characteristic of this filter is shown in ***Figure 2***, with the dimensions: w = 1.6 mm, s = 0.5 mm, g_1 = 0.2 mm, d_1 = 1 mm, d_3 = 5.1 mm, d_4 = 0.5 mm, l_1 = 6.7 mm and d_2 is varied from 8.6 to 9.4 mm. The simulated results show that the center frequency of the filter is controlled by the resonant stub, which is approximately one quarter waveguide length.

Microstrip Split Ring Resonator with CPW Feeding Line

The structure of the bandpass filter with microstrip split ring resonators and CPW feeding line is illustrated in ***Figure 3***. It is realized by a conventional microstrip split ring resonator on the top layer, with capacitive coupling to the CPW feeding line at the bottom layer. The input and output CPW feeding lines are connected by a slotline at the bottom of the split ring.

The two microstrip split rings are electrically coupled and the coupling circuit can be expressed by J-inverters.[9] The equivalent circuit of this structure is also shown in the figure. The external quality factor is mainly decided by the coupling length l_1 between the top split ring and the bottom CPW feeding structure. The coupling intensity is mainly affected by the separation distance t_1.

The bandpass characteristic of this filter is shown in ***Figure 4*** with the

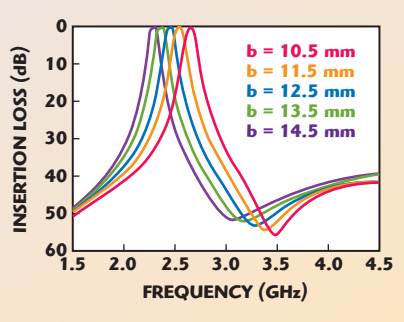
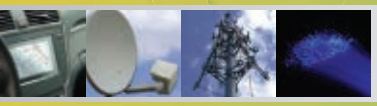


Fig. 4 Bandpass characteristic as a function of b.

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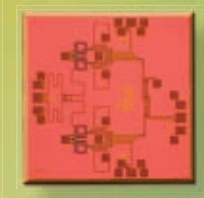
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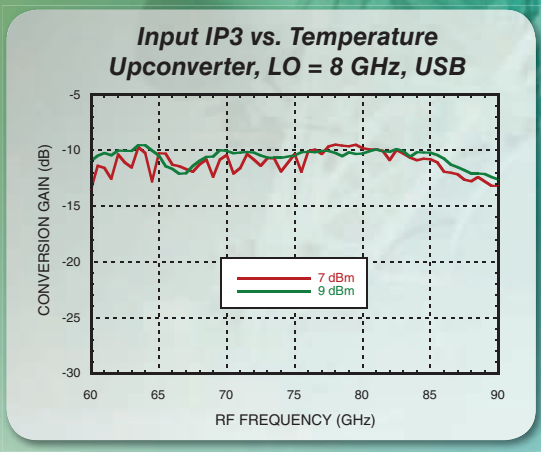


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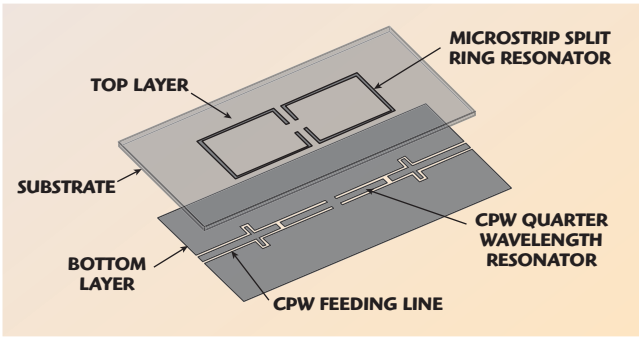


Fig. 5 Layout of the proposed dual passband filter.

dimensions: w = 1.6 mm, s = 0.5 mm, g_2 = 0.5 mm, d_3 = 5.1 mm, l_1 = 6.7 mm, e_1 = 3 mm, t_1 = 1.2 mm, a = 13.2 mm and b varied from 10.5 to 14.5 mm. It is found that the center frequency of the filter is influenced by the perimeter of the microstrip split ring resonator, which is approximately one half of the guided wavelength.

Dual Passband Filter Design

When the two bandpass filters analyzed here are connected together with CPW input and output feeding lines, a dual passband can be achieved. The layout of the proposed dual passband filter is shown in ***Figure 5***. It is composed of a pair of coupled microstrip split ring resonators on the top layer and CPW quarter wavelength resonators at the bottom layer. A CPW feeding structure is introduced to feed this configuration.

Following the general theory of couplings, the bandpass design parameters are calculated by:[10]

$$\begin{cases} Q_{e1} = \dfrac{g_0 g_1}{FBW}, Q_{en} = \dfrac{g_n g_{n+1}}{FBW} \\ k_{i,i+1} = \dfrac{FBW}{\sqrt{g_i g_{i+1}}} \text{ for i=1 to n-1} \end{cases} \quad (1)$$

where Q_{e1} and Q_{en} are the external quality factors of the resonators at the input and output, while $k_{i,i+1}$ are the coupling coefficients between the neighboring resonators.

Using the commercial software Ansoft HFSS, based on the finite element method, the desired physical dimensions of the proposed dual bandpass filter could be determined. The external quality factor and the coupling coefficient are achieved by:[11]

$$Q_e = \frac{f_0}{\Delta f_{\pm 90^\circ}} \quad (2)$$

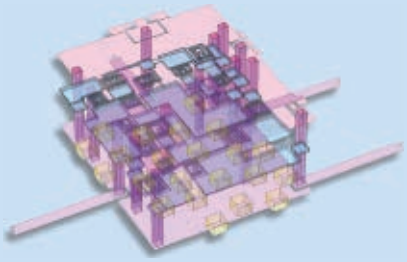
$$K = \frac{f_{p2}^2 - f_{p1}^2}{f_{p2}^2 + f_{p1}^2} \quad (3)$$

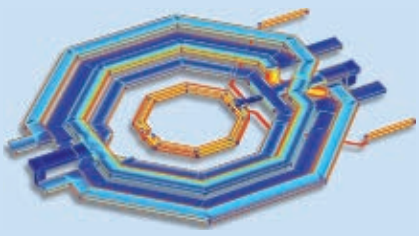
where f_0 is the resonator frequency; $\Delta f_{\pm 90^\circ}$ is the absolute bandwidth between the ±90° point; and f_{p1} and f_{p2} are defined to be the lower and higher of the two resonator frequencies, respectively. After simulation, the final optimized parameters of the filter are as follows: w = 1.6 mm, s = 0.5 mm, g_1 = 0.2 mm, g_2 = 0.5 mm, d_1 = 1 mm, d_2 = 9.1 mm, d_3 = 5.1 mm, d_4 = 0.5 mm, l_1 = 6.7 mm, a = 13.2 mm, b = 12.5 mm, t_1 = 1.2 mm and e_1 = 3 mm.

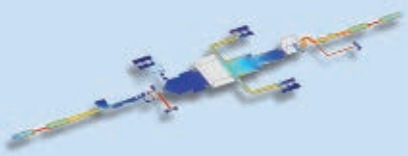
Figure 6 illustrates the equivalent circuit of the proposed dual passband filter. The inductive coupling circuit and the capacitive coupling

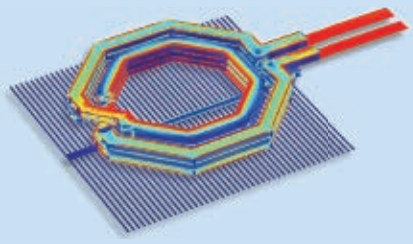


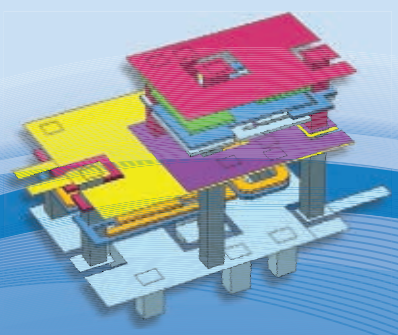












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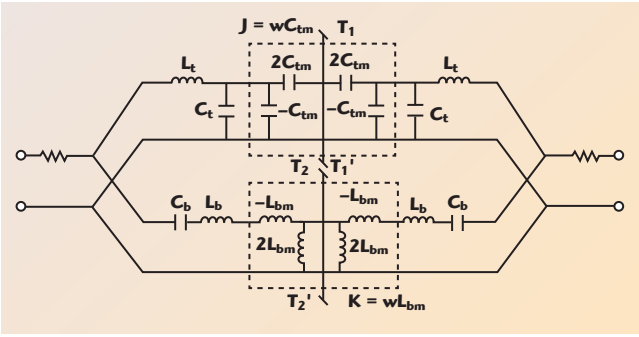


Fig. 6 Equivalent circuit of the proposed dual passband filter.

circuit are expressed as K- and J-inverter, respectively. The K-inverter is equivalent to a T inductance network, while the equivalent circuit of the J-inverter is a π capacitance network.

According to the theory of coupled resonator circuits, the inductive values of the equivalent circuit are described by:[11]

$$\frac{R}{w_0 L} = \frac{1}{Q_e} \tag{4}$$

where w_0 is the center frequency of the passband and R is the input impedance, which is set as 50 Ω.

Here the coupled-resonator circuits of the proposed filter are synchronously tuned. Then, in the odd model, the symmetry planes T_1-T_1' and T_2-T_2' are replaced by an electric wall, the resultant circuits have the respective resonant frequencies:

$$f_{ot} = \frac{1}{2\pi\sqrt{L_t\left(C_t + C_m\right)}} \text{ and}$$

$$f_{ob} = \frac{1}{2\pi\sqrt{\left(L_b - L_{bm}\right)C_b}} \tag{5}$$

Equation 5 shows that the resonant frequency is lower than that of an uncoupled single resonator in the electrical coupling structure, while the resonant frequency is higher in the magnetic coupling. Similarly, in the even model, by replacing the symmetry planes T_1-T_1' and T_2-T_2' with a magnetic wall, the circuits have the respective resonant frequencies:

$$f_{et} = \frac{1}{2\pi\sqrt{L_t\left(C_t - C_{tm}\right)}} \text{ and}$$

$$f_{eb} = \frac{1}{2\pi\sqrt{\left(L_b + L_{bm}\right)C_b}} \tag{6}$$

In this case, it turns out that the resonant frequency is increased in the electrical coupling, while in the magnetic coupling, the frequency is shifted down. From Equations 5 and 6, the mutual capacitance C_{tm} in the electric coupling circuit model and mutual inductive L_{bm} in the magnetic coupling circuit model are computed by:[9]

$$k_e = \frac{f_{ot}^2 - f_{et}^2}{f_{ot}^2 - f_{et}^2} = \frac{C_{tm}}{C_t} \text{ and}$$

$$k_m = \frac{f_{ob}^2 - f_{eb}^2}{f_{ob}^2 + f_{eb}^2} = \frac{L_{bm}}{L_b} \tag{7}$$

where k_e is the coupling coefficient of the electric coupling model and k_m is the relevant parameter of the magnetic coupling model. Their values can be achieved by using Equation 1.

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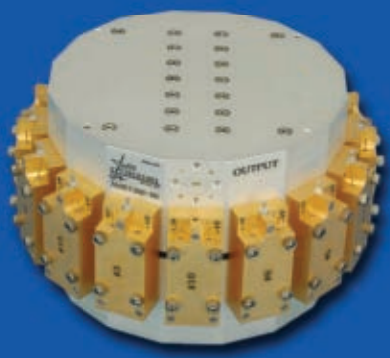
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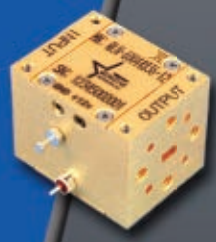
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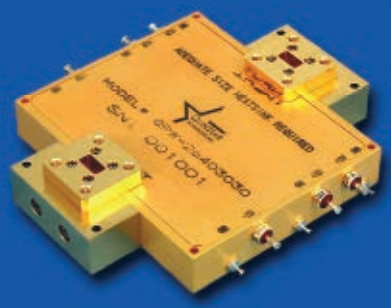


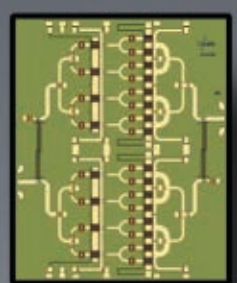


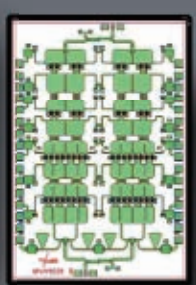




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The center frequencies of each passband are calculated by:

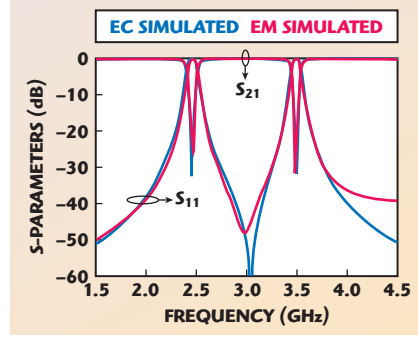
$$w_0 = \frac{1}{2\pi\sqrt{LC}} \quad (8)$$

On the basis of the analysis illustrated, the values of the parameters in the equivalent network are obtained. First, by using Equation 1, the external quality factor and coupling coefficient of each passband are achieved. Then by substituting these values into Equations 4 and 8, the values of L_t, C_t, L_b and C_b are obtained. Finally, by inserting the obtained values into Equation 7, the mutual capacitance C_{tm} and mutual inductive L_{bm} are obtained.

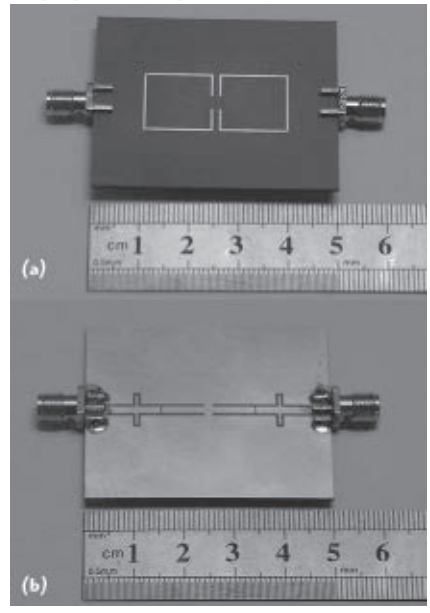
Using the Advanced Design System (ADS) for the proposed dual passband filter, the values of the parameter in the equivalent network are: R = 50 Ω, C_b = 0.01755 pF, L_b = 118.52 nH, L_{bm} = 2.2249 nH, L_t = 106.02 nH, C_t = 0.03971 pF and C_{tm} = 0.001195 pF. The EM and EC simulated results of the proposed dual passband filter are shown in ***Figure 7***. It depicts a dual passband filter with center frequencies of 2.44 and 3.5 GHz and the 3 dB fractional bandwidths are 4.17 and 2.86 percent, respectively. Good agreement between the analysis of the equivalent circuit model and the electromagnetic simulated proves the validity of the design method.

EXPERIMENT AND RESULTS

In order to validate the proposed dual passband filter, it was fabricated on a substrate with a relative dielectric of 9.6 and a thickness of 1 mm. The input/output impedance of the feeding lines is equal to 50 Ω, corresponding to the coplanar waveguide, which has a central strip width w = 1.6 mm and a slot width s = 0.5 mm. ***Figure 8*** shows the photograph of the fabricated dual passband filter with dimensions of 40 × 50 mm.



▲ *Fig. 7 EM and EC simulation results of the proposed dual passband filter.*



▲ *Fig. 8 Photographs of the proposed dual passband filter. Top view (a) and bottom view (b).*

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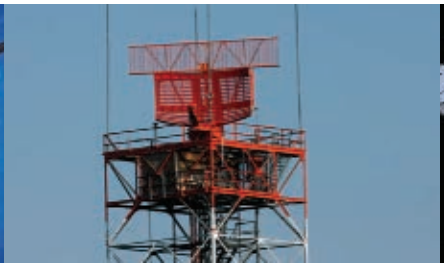
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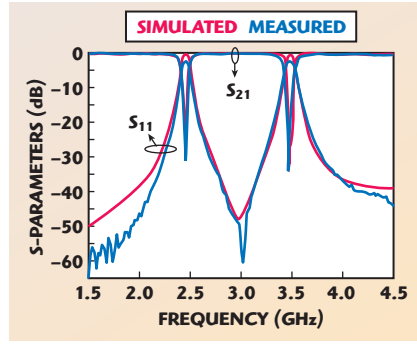
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The experimental results were obtained from an Agilent vector network analyzer N5230A. The simulated and measured S-parameters are illustrated in ***Figure 9***. The two passbands are centered at 2.44 and 3.5 GHz, which are used for WLAN and WiMAX. The return losses are better than 30 and 34 dB at the respective passband. The measured minimum insertion losses are approximately 1.91 and 1.74 dB in the lower and upper passbands, respectively. Comparison between simulated and measured results indicates a good agreement.

CONCLUSION

In this article, a dual passband filter using hybrid split ring resonators and CPW quarter wavelength resonators is modeled in theory and verified with experiment. An equivalent circuit is given to demonstrate the characteristics of the proposed filter. Its corresponding parameters are also extracted from the theoretical analysis. A dual passband filter covering center frequencies of 2.44 and 3.5 GHz was fabricated to validate the design process. The measured results have shown good agreement with the EM and EC simulated results. The proposed dual passband filter is useful in dual band wireless transmitting systems. ■



▲ *Fig. 9 Measured and simulated frequency responses for the dual passband filter.*

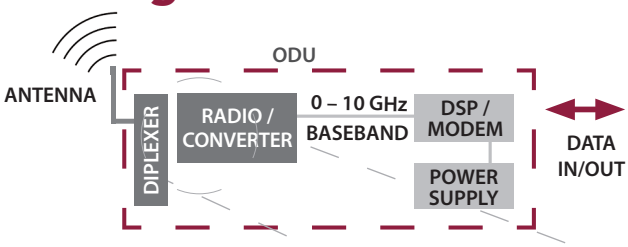
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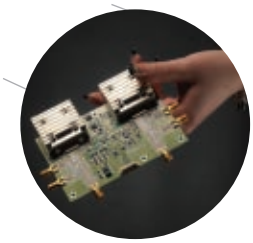
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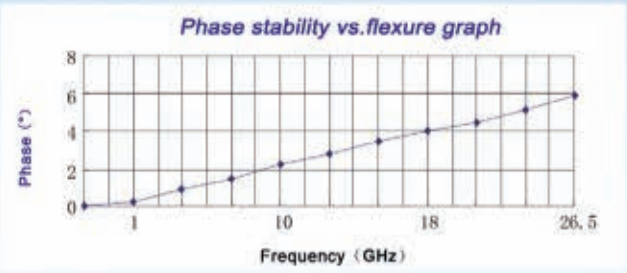
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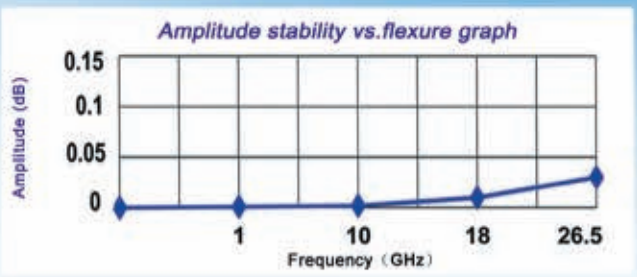
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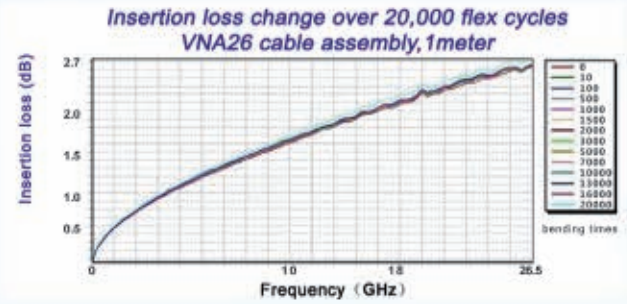


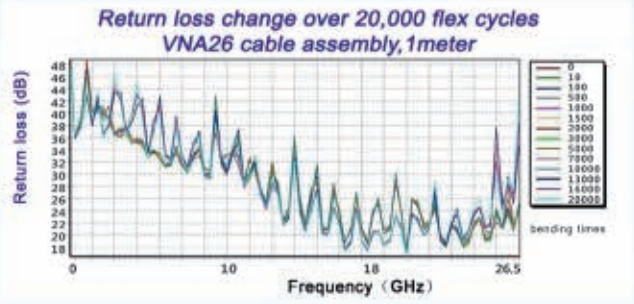
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Ku-Band Push-Push VCO Based on Substrate Integrated Waveguide Resonator

A Ku-Band push-push voltage-controlled oscillator (VCO) based on a substrate integrated waveguide (SIW) resonator is presented. The push-push oscillator configuration is chosen to realize a fundamental oscillator and a frequency doubler in one circuit. A varactor-loaded SIW resonator is designed to achieve electrical tunability. In order to ensure accuracy and reliability, all the designs are simulated with a full electromagnetic (EM) wave simulator. As the experimental results show, the range of the output frequency is from 13.98 to 14.09 GHz, with a frequency tuning range of 110 MHz. The output power is –1.85 dBm, while the suppression of fundamental frequency and the third harmonic are –15.37 dBc and –23.80 dBc, respectively, and the phase noise is –101.27 dBc/Hz.

Recently, with the increase of the operating frequency in modern communication systems, the requirements for the local oscillator (LO) have become more strict. Therefore, the study of microwave and millimeter wave oscillators have become more popular. But since there is a limit to the available frequencies of active devices, new methods are needed to increase the operating frequency. The push-push configuration provides an acceptable approach to solve this problem.[1]

In addition to the operating frequency, the phase noise of an oscillator is also a critical performance parameter. In theory, as the frequency increases, the phase noise becomes worse. So in the high-frequency oscillator design, a high-Q resonator is used to reduce the phase noise. In practice, a voltage-controlled dielectric resonator oscillator (DRO) is widely used in microwave bands.[2] The high performance of a DRO is mainly due to the use of a high-Q dielectric resonator. However, the defects of traditional DROs are also obvious. As the external working environment changes, the dielectric resonator may fall off the surface of the substrate. Then, the system cannot work reliably. In addition, the volume of a DRO is sometimes not acceptable in some uses.

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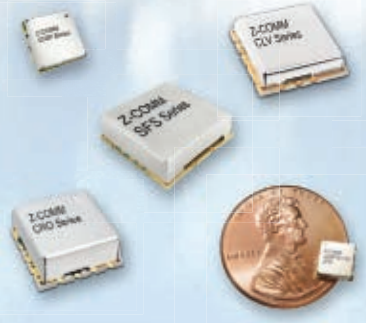


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The substrate integrated waveguide (SIW) is a new transmission structure proposed in recent years.[3] The components based on SIW technology not only have the advantages of high-Q value, low insertion loss and low cost, but also can be integrated easily with other planar circuits.[4,5] So a resonator based on SIW technology is suitable for the design of a highly reliable planar VCO. A Ku-Band push-push VCO based on a SIW resonator is investigated theoretically and experimentally in this article.

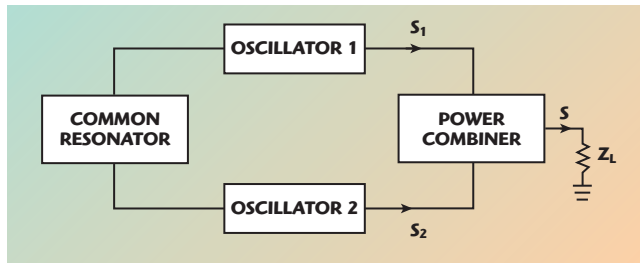


Fig. 1 Push-push oscillator schematic.

THEORY

The general configuration of a push-push oscillator is composed of a common resonator, a power combiner and two identical fundamental oscillators, as shown in ***Figure 1***. Here, S_1 and S_2 are the signals generated by the two identical oscillators.

S is the signal combined by S_1 and S_2. The basic theory of push-push oscillator is to cancel out the odd harmonic frequencies and enhance the even harmonic frequencies.[6] It means that the push-push oscillator can realize the functions of the oscillator and frequency doubler. In other words, the second harmonic frequency is the output frequency. In order to reach this function, the signals generated by two identical oscillators should be out of phase at the fundamental frequency. The process can be expressed as follows:[6]

$$S_1 = a_1 e^{j\omega_0 t} + a_2 e^{j2\omega_0 t} + a_3 e^{j3\omega_0 t} + a_4 e^{j4\omega_0 t} + \cdots \quad (1)$$

$$S_2 = a_1 e^{j\omega_0 (t-\Delta t)} + a_2 e^{j2\omega_0 (t-\Delta t)} + a_3 e^{j3\omega_0 (t-\Delta t)} \cdots \quad (2)$$

These two signals are identical in frequency and amplitude, but a phase difference $\omega_0 \Delta t$ is added on signal S_2. With a phase difference of π, the output signal $S = S_1 + S_2$ can be expressed by:

$$S = 2a_2 e^{j2\omega_0 t} + 2a_4 e^{j4\omega_0 t} + 2a_6 e^{j6\omega_0 t} + \cdots \quad (3)$$

As Equation 3 shows, the odd harmonic frequencies (ω_0, $3\omega_0$, $5\omega_0$, …) of combined signal S are suppressed, while the even harmonic frequencies ($2\omega_0$, $4\omega_0$, $6\omega_0$, …) are enhanced.

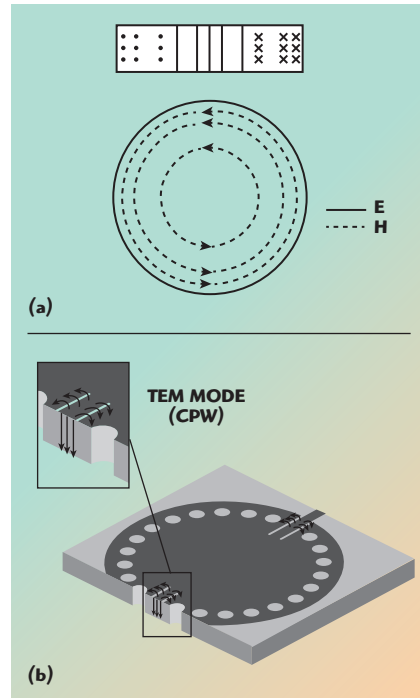


Fig. 2 The cylindrical SIW resonator (a) E-field distribution of TM_{010} and (b) SIW-CPW transition.

DESIGN APPROACH

The Varactor-Loaded SIW Resonator

The dominant mode of a cylindrical SIW resonator is TM_{010}, and the high-order mode is TM_{110}.[7] The electromagnetic field distribution of TM_{010} and the transition of SIW-CPW[8] are shown in ***Figure 2***. Because the resonance frequency of TM_{110} is much higher than TM_{010} and the coupling of TM_{110} by the SIW-CPW transition is so weak, there is no need to care about the high-order mode in the resonator. By analyzing the field distributions of TM_{010} and of the SIW-CPW transition, it is obvious that the induced currents in the two coupling microstrips are in-phase. According to the theory of push-push oscillator, the common cylindrical SIW resonator should be designed at the funda-

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S01-24762-03	Premium Rugged ONYX IV OCXO	100 MHz	-95	-127	-152	-165	-172	±5E-7, -20 to +70°C	≤ 2E-10	1 x 1 x 0.5"



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S01-21081	Multiplied PLOCXO (100 MHz x 10)	1 GHz	-79	-109	-136	-153	-154	≤ 5E-10	10 MHz	3.45 x 4 x 1"
S01-24229	Multiplied OCXO (100 MHz x 100)	10 GHz	-57	-87	-113	-131	-132	≤ 5E-10	N/A	4.16 x 4 x 1"
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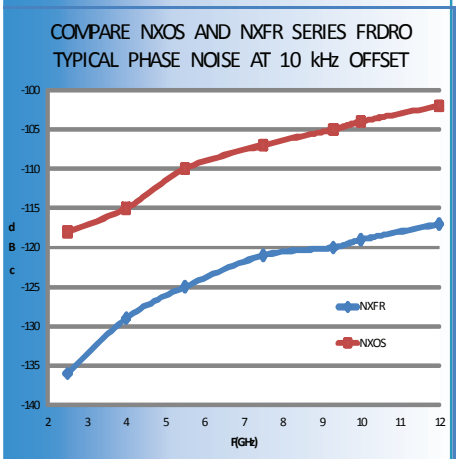
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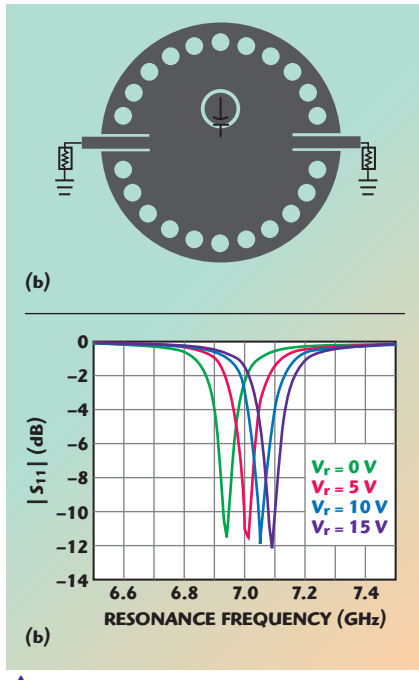


Fig. 3 Simulation of the varactor loaded SIW resonator (a) and simulated S_{11} results (b).

mental frequency. Since the field distribution of SIW is similar to that in a traditional metallic waveguide, the dimensions of cylindrical SIW resonator can be calculated by Equation 4[7] and the empirical Equation 5:[9]

$$f_r = \frac{c_0}{2.62r\sqrt{\varepsilon_r}} \quad (4)$$

$$r = r_{SIW} = 1.08\frac{D^2}{P} + 0.1\frac{D^2}{r_{SIW}} \quad (5)$$

where f_r is the resonance frequency, c_0 is the velocity of light in free space, ε_r is the permittivity of substrate, r is the radius of corresponding metallic waveguide cavity, r_{siw} is the radius of the cylindrical SIW resonator, D is the diameter of the metallic via holes and P is the distance between two vias.

In order to achieve the electrical tunability, a varactor should be added properly into the resonator. But since the SIW top and bottom surfaces are connected by the metallic via holes, the varactor cannot be added directly to the surface of SIW. Therefore, if a circle is etched on the surface, then the bias of the varactor can be achieved. Furthermore, the circle can realize the coupling between the varactor and resonator.[10]

The EM simulation model of varactor-loaded SIW resonator and the simulated results are shown in ***Figure 3***. The varactor model is replaced

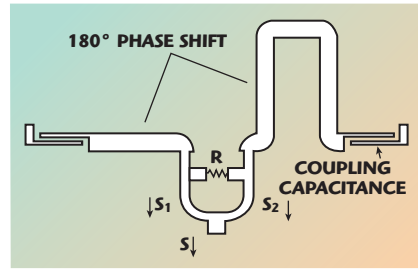


Fig. 4 Configuration of an anti-phase 3 dB Wilkinson combiner.

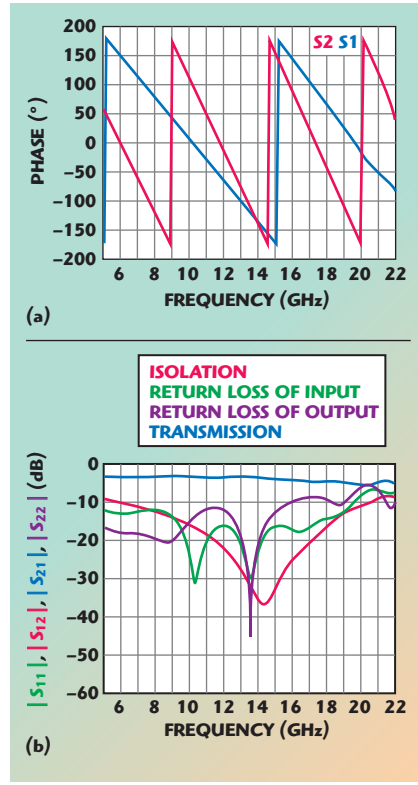


Fig. 5 Simulated results of (a) phase and (b) amplitude.

by an ideal tunable capacitance. The selection of the capacitance value is based on the datasheet of the varactor SMV1233 (Skyworks). The simulated resonance frequency of the varactor-loaded SIW resonator is from 6.94 to 7.09 GHz, with a tuning range of 150 MHz.

The Anti-Phase 3 dB Wilkinson Combiner

When designing a push-push oscillator, the most important point is to ensure that the two oscillators are strictly symmetrical and independent. So the isolation of two oscillators is critical. According to the analysis of the SIW resonator, the signals generated by two identical fundamental oscillators will be in-phase, which is due to the in-phase induced currents.

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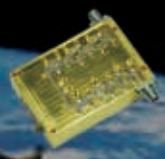
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So a 180° phase shift delay line should be added to one branch of the power combiner. This is the difference with the traditional push-push oscillator.

The configuration of an anti-phase 3 dB Wilkinson combiner and the simulated results are shown in ***Figures 4*** and ***5***, respectively. Additionally, a first-order coupled-line filter is designed to block the DC. Furthermore, the filter can transmit the second harmonic frequency to the output port as a high-Q coupling capacitance. The line length is a quarter-wavelength at the second harmonic frequency. As Figure 5 shows, two signals are anti-phase at 7 GHz and in-phase at 14 GHz, after using the 180° phase shifter. Furthermore, the isolation of the two signals is above 30 dB and the return loss is above 20 dB at the input and output ports.

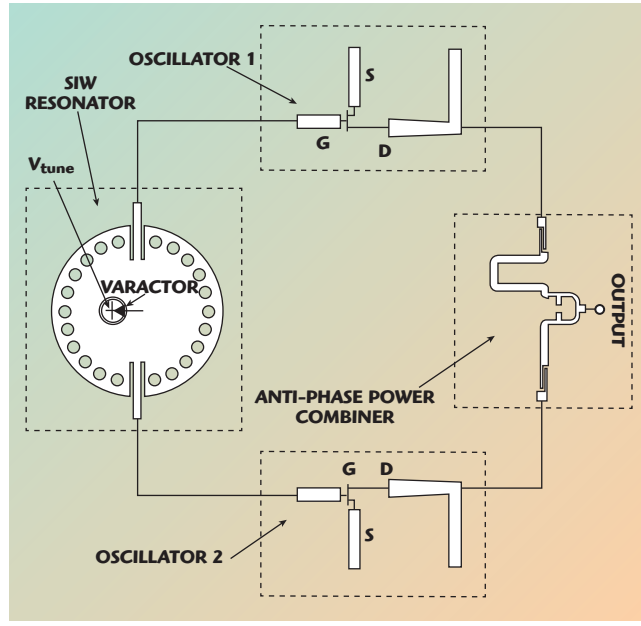


Fig. 6 SIW push-push VCO configuration.

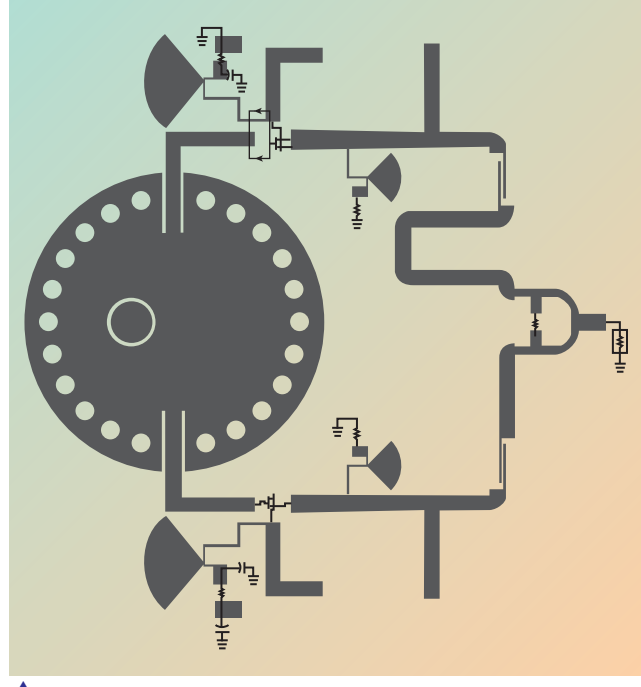


Fig. 7 Co-simulation in the EM simulator.

The Negative Resistance Oscillator

In the microwave band, there are two types of oscillators: the series feedback and parallel feedback.[7] The oscillators used in a push-push oscillator are the series feedback type and the design method is based on the theory of a negative resistance oscillator.[11]

According to the theory of the series feedback oscillator, a microstrip open-circuited stub, added to the source of the FET, can achieve negative resistance characteristics by tuning the length of the stub until the reflection coefficient G_{in} is greater than 1 at the fundamental frequency, as seen from the gate of the FET. It means the transistor is unstable at the desired frequency.

In order to suppress the fundamental frequency, the output matching network is matched at the second harmonic. As a result, the isolation of two oscillators at fundamental frequency can be enhanced. Then the frequency offset of one oscillator, due to the interference of the other oscillator, can be minimized. At the output port of

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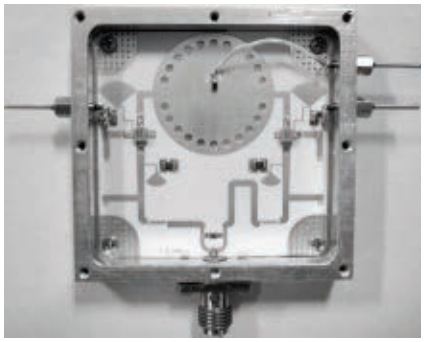


Fig. 8 Photograph of the SIW push-push VCO.

the matching network, a λ/4 open-circuited stub is added to achieve further suppression at the fundamental frequency (λ is the wavelength at the fundamental frequency).

The configuration of the proposed SIW push-push VCO is shown in ***Figure 6***. It is composed of a varator-loaded SIW resonator, two identical fundamental oscillators and an anti-phase power combiner. The simulation of the oscillator is done with an EM simulator.[12] Through the connection between the schematic and layout simulator, the model of the layout can be added to the schematic, a process which ensures the accuracy and reliability of the design. The EM simulation of the SIW push-push VCO is shown in ***Figure 7***.

EXPERIMENTAL RESULTS

The circuit was fabricated on a Rogers 4350 substrate, with a dielectric constant ε_r = 3.66, and a thickness = 20 mil. A photograph of the SIW push-push VCO is shown in ***Figure 8***. The GaAs FET is a MGF1801 (Mitsubishi), whose maximum available frequency is 12 GHz. The VCO

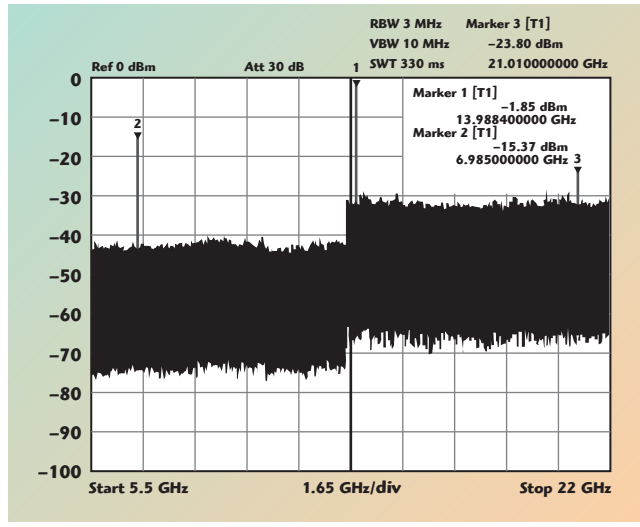


Fig. 9 Measured spectrum when V_r = 0 V.

is measured using a spectrum analyzer (R&S FSP40), with a phase noise measurement function. The measured performance parameters include the output frequency, the output power, the phase noise, the fundamental frequency and third harmonic frequency suppression, as well as the tuning range. The operating voltage and current of each FET are 3 V and 55 mA, respectively.

As shown in ***Figure 9***, the output frequency is 13.98 GHz and the output power is −1.85 dBm (V_r = 0 V). The fundamental frequency and third harmonic frequency sup-



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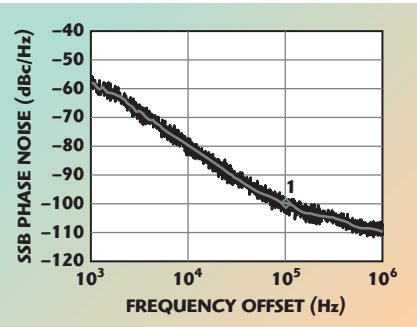
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▲ *Fig. 10 Measured SSB phase noise spectrum.*

pression are –15.37 dBc and –23.80 dBc, respectively. Also, the output frequency of the VCO is from 13.98 to 14.09 GHz, with a frequency tuning range of 110 MHz, which is enough for application in a phase-locked loop (PLL) single point frequency source. ***Figure 10*** shows the measured phase noise spectrum when V_r = 0 V. The SSB phase noise can achieve –101.27 dBc/Hz.

CONCLUSION

A SIW push-push VCO is designed and fabricated. By using the resonator based on SIW technology, the proposed push-push VCO reaches the goal of low phase noise. The tuning range is also enough for a single point PLL synthesizer, where a DRO is usually used. The reliability of the proposed VCO is higher and the volume lower than a traditional DRO. The proposed VCO, based on SIW technology, can be designed and simulated in an EM simulator. It ensures the accuracy of design and decreases the time of test. Because of its advantage of breaking through the available frequency of active devices, the push-push VCO provides a promising approach for the oscillators in microwave and millimeter waves. ■

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A Tri-Mode Bandpass Filter Using Capacitive and Inductive Source-Load Coupling

This article presents a compact microstrip bandpass filter (BPF), which consists of a circular tri-mode resonator (CTMR) and two meandering feed lines with both capacitive and inductive S-L couplings to obtain good harmonic suppression and multiple transmission zeros. A prototype of the proposed BPF, centered at 4.1 GHz, has been designed and fabricated. The measured results are in good agreement with the full-wave simulated ones.

Bandpass filters are essential building blocks for communication systems. To make the filters more compact, one can modify the traditional resonator to generate additional modes. Dual-mode resonators are attractive because each resonator can be used as a doubly tuned circuit and the number of resonators required for a given degree of filter is reduced by half, resulting in a reduced-size filter structure, which has been analyzed in depth.[1,2] Triple-mode or other multi-mode resonator microstrip planar filters are developed from the simple dual-mode filters, as can be seen in the literature.[3-7] With respect to feed-line coupling to resonators, there are also many coupling types. A compact dual-mode H-shaped filter with S-L coupling has been described.[8] In addition, BPFs with only inductive S-L coupling and only capacitive S-L coupling have been proposed.[9,10] However, these filters, using these conventional feeding types, generated at most four transmission zeros.

In this article, a compact BPF, using circular tri-mode resonator (CTMR), based on both capacitive and inductive S-L couplings, is demonstrated for the first time. The designed filter can generate six transmission zeros to suppress harmonics effectively by introducing capacitive and inductive cross-couplings between the input and output ports.

RESONATOR ANALYSIS AND FILTER DESIGN

As shown in ***Figure 1***, the CTMR consists of a circular half-wavelength resonator, a pendulum-shaped open stub and two short stubs. Since the CTMR is symmetrical to the dashed line, it can be analyzed by even- and odd-mode methods as shown in the figure. ***Figure 2*** shows the EM simulated frequency responses of the CTMR under weak coupling. When the

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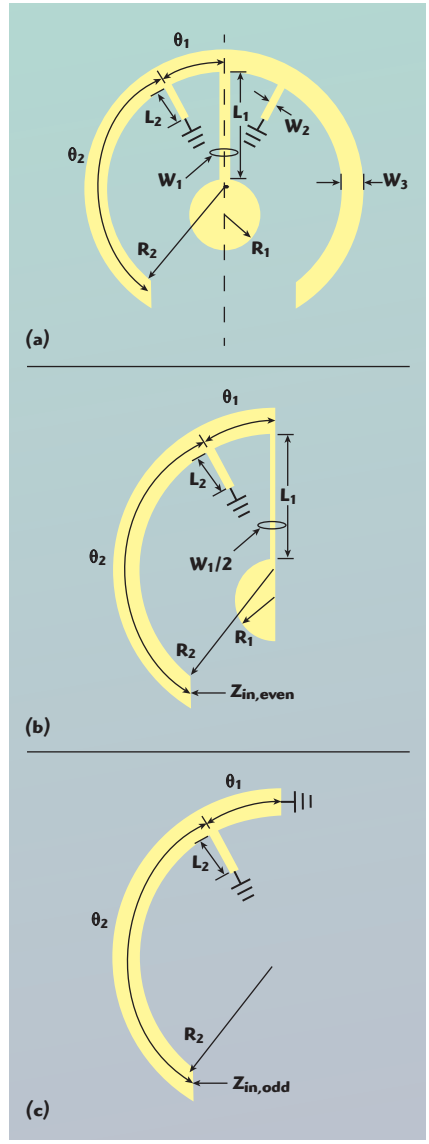


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open-stub length L_1 increases, f_{odd1} is constant and f_{even1} barely varies, while f_{even2} moves toward a lower frequency within a wide range. When the short-stub length L_2 increases, f_{even2} is fixed and f_{odd1} almost does not change, but f_{even1} decreases. According to the analysis, the first odd-mode resonant frequency f_{odd1} is independent of the open stub and the short stub, which is mainly determined by the electrical length ($2(\theta_1+\theta_2)$) of the circular resonator. The first (f_{even1}) and second (f_{even2}) even-mode resonator frequencies are mainly determined by the short stub and the open stub, respectively. So in the filter design, the basic structure parameters (such as R_2, W_3, θ_1 and θ_2) of the CTMR can be first decided to obtain the desired center frequency. Then, the open stub parameters (L_1, W_1 and R_1) and the short stub parameters (L_2 and W_2) can be changed to realize the desired upper frequency and low frequency of the passband, respectively. The bandwidth of the filter, therefore, can be mainly determined by the structure parameters of the pendulum-shaped open stub and of the two short stubs.



▲ *Fig. 1 Layout of circular tri-mode resonators (a) CTMR, (b) even-mode equivalent circuit and (c) odd-mode equivalent circuit.*

Based on the CTMR, three BPFs with different S-L coupling types were designed as shown in ***Figure 3***, where the dimensions of three CTMRs and the gaps between each coupling arm and CTMR were all the same. First, filter A was designed using CTMR with only capacitive S-L coupling and then filter B, using CTMR with only inductive S-L coupling. Both filters A and B demonstrate filtering characteristics with an inherent finite frequency transmission zero on the upper side of

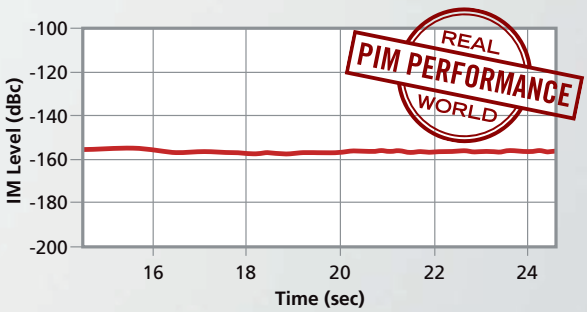
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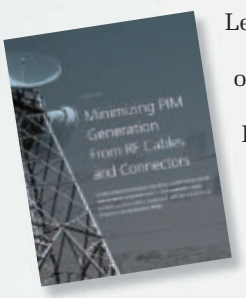
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the passband and two additional transmission zeros located on each side of passband. However, the disadvantage of using these two coupling types is that the harmonic passband suppression is not good enough. There are, in both, undesired harmonic passbands at 10.7 GHz, which can be seen in ***Figure 4***. Finally, an improved filter (filter C), with both capacitive and inductive S-L coupling, is proposed. It could generate more transmission zeros than filters A and B. Meanwhile, the 2nd harmonic passband at 10.7 GHz can be effectively suppressed to obtain a desirable upper stopband attenuation characteristic, achieving higher selectivity.

The circuit model of the proposed tri-mode BPF, based on both capacitive and inductive source-load coupling, is shown in ***Figure 5***. The signals transmitting from Port 1 (Source) to Port 2 (Load) have three paths. Path 1: the signal from Port 1 to Port 2 is mainly coupled into the CTMR



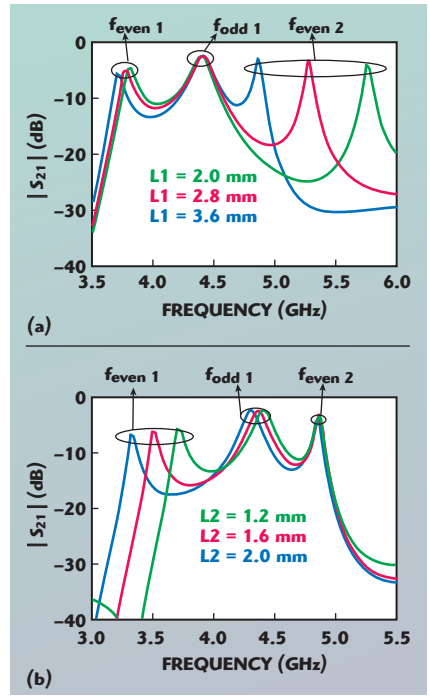


Fig. 2 Simulated insertion loss of CTMR under weak coupling when varying L1 (a) and L2 (b).

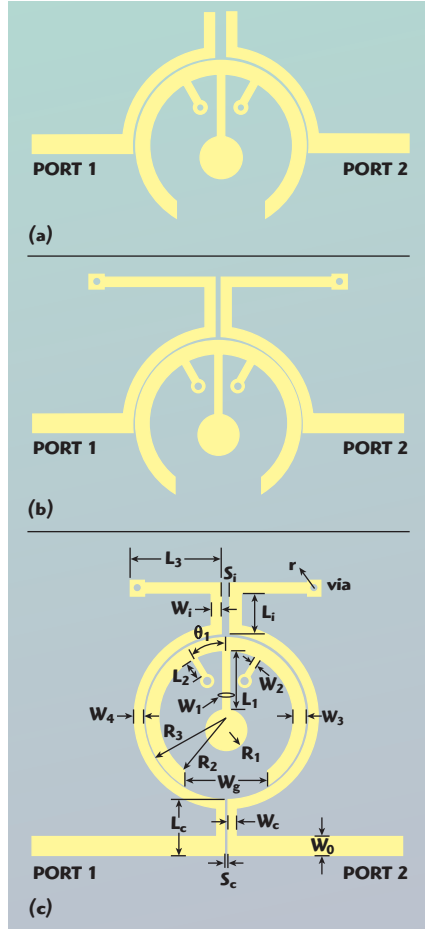
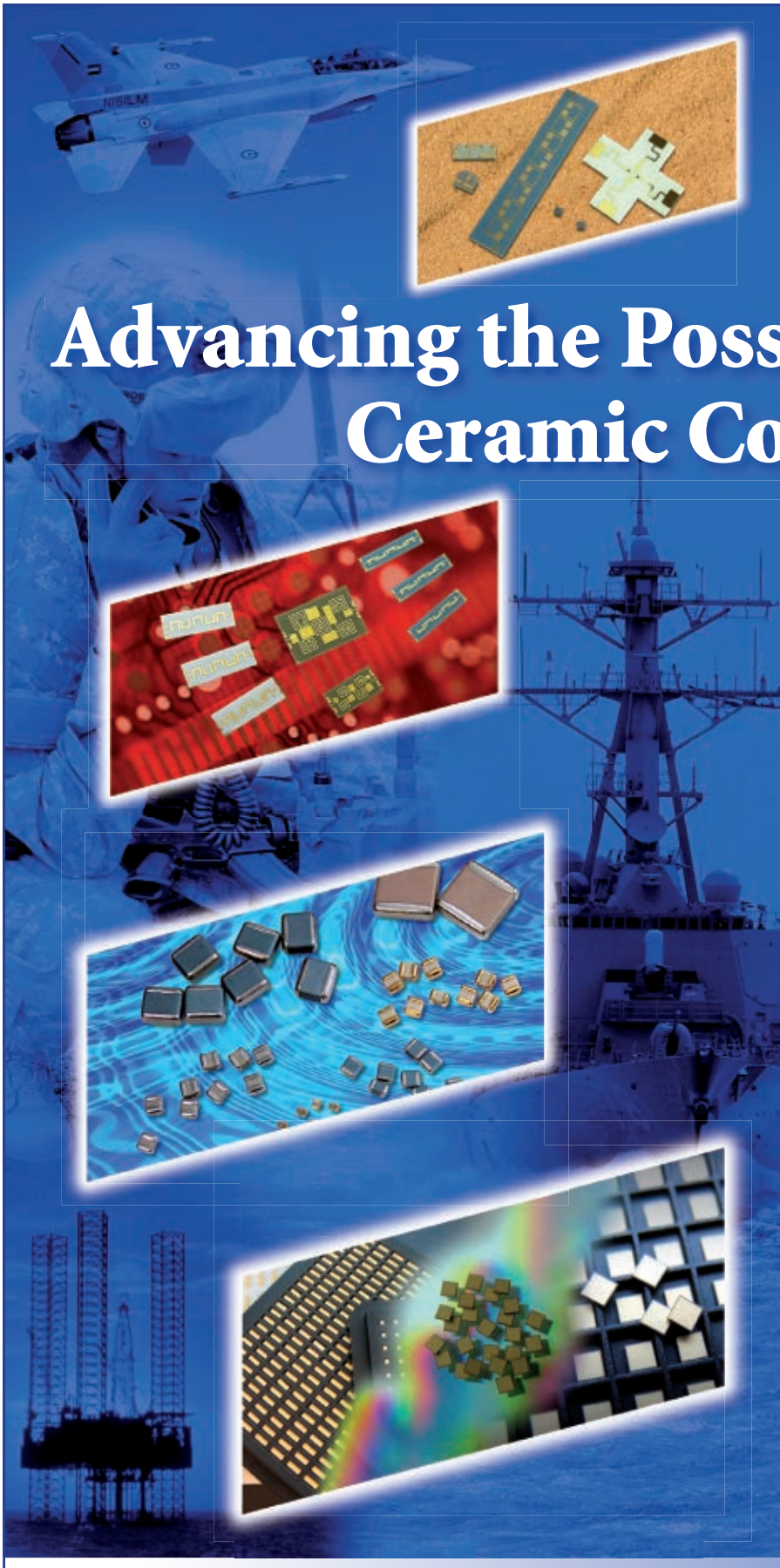


Fig. 3 Layout of the tri-mode filters with different S-L couplings (a) only capacitive S-L coupling, (b) only inductive S-L coupling and (c) both capacitive and inductive S-L couplings.

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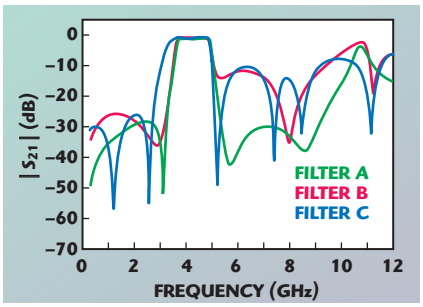
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through a parallel coupling-line structure; Path 2: the signal from Port 1 directly to Port 2 through a series capacitor is coupled weakly and exerts little influence on the passband; Path 3: the signal from Port 1 to Port 2 through a series inductor is also coupled weakly and exerts little influence on the passband. However, the interaction of the signals from the two sets of paths (Path 1 and Path 2, Path 1 and Path 3) may both generate finite transmission zeros beyond the passband. So this type of filter cannot only realize the tri-mode response, but also generate more transmission zeros than the other two BPFs using two conventional feeding styles, that is only capacitive S-L coupling and only inductive S-L coupling. The total admittance matrix of the filter can be given by:[1]

$$[Y]=[Y_1]+[Y_2]+[Y_3] \quad (1)$$

where $[Y_1]$, $[Y_2]$ and $[Y_3]$ are the admittance matrices of the Path 1, Path 2 and Path 3, respectively. In terms of the calculated admittance matrix, S_{21} of the filter can be derived by:[1]

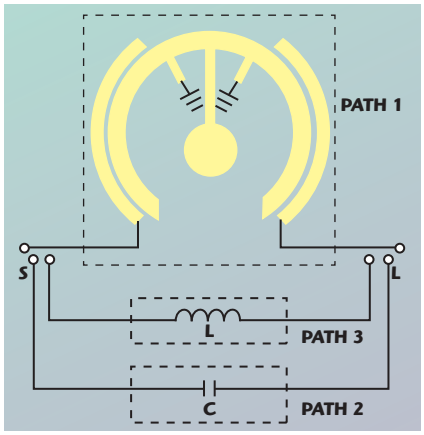


▲ *Fig. 4 Simulated S_{21} of the three filters with different S-L couplings.*

$$S_{21}=-\frac{2Y_{21}Y_0}{(Y_{11}+Y_0)(Y_{22}+Y_0)-Y_{21}Y_{12}} \quad (2)$$

The finite transmission zeros are located at the angular frequencies where Y_{21} = 0 or Y_{211} = -Y_{212} - Y_{213}, where Y_{211}, Y_{212} and Y_{213} are the Y_{21} of the Path 1, Path 2 and Path 3, respectively. At these frequencies, the signals through two sets of coupling paths are all nearly out-of-phase.

Except for the inherent transmission zero, five additional transmission zeros are created by introducing capacitive S-L coupling and inductive S-L coupling. The location of these



▲ *Fig. 5 Circuit model of the proposed filter based on both capacitive and inductive S-L couplings.*

five transmission zeros can be controlled by the amount of the cross-coupling capacitance or inductance, which can be illustrated clearly in ***Figure 6***. The gap Sc and the coupling line length Lc can adjust the amount of the capacitive S-L coupling, while the gap Si and the coupling line length Li adjust the amount of the inductive S-L coupling. As shown in the figure, when Lc, Sc, Li and Si vary, the inher-

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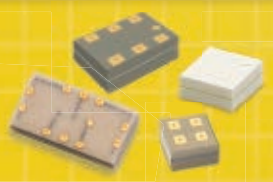


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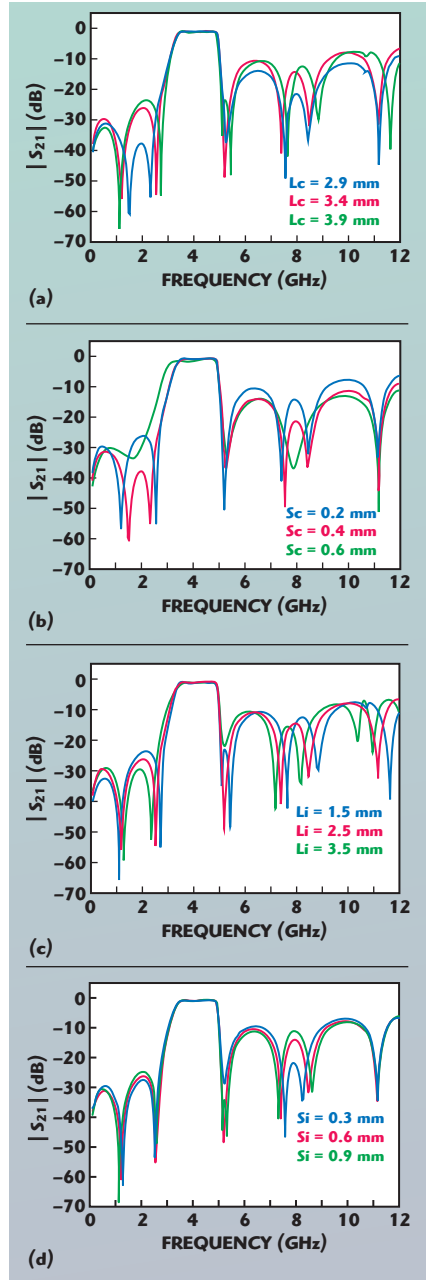
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ent transmission zero barely changes, while some of the five additional transmission zeros will move. Therefore, the proper amount of the cross-coupling capacitance and inductance can be selected to adjust the location of the transmission zeros and to meet the required frequency selectivity.

EXPERIMENTAL RESULTS

The proposed circular tri-mode BPF with both capacitive and inductive S-L coupling centered at 4.1 GHz has been fabricated on an RF-35 substrate with a relative dielectric constant of 3.5 and a thickness of 0.508 mm. The characteristic impedance of the input/output microstrip is taken as 50 Ω. The dimensions (mm) of the filter are chosen as follows: L_1 = 3.6, L_2 = 1.2, L_3 = 5.4, Li = 2.5, Lc = 3.4, W_0 = 1.1, W_1 = 0.4, W_2 = 0.3, W_3 = 0.8, W_4 = 0.6, Wg = 5, Wi = 0.6, Wc = 0.5, R_1 = 1.2, R_2 = 4, R_3 = 4.9, Si = 0.6 and Sc = 0.2. θ_1 = 28.3° and via radii are all r = 0.25 mm. The simulation and measurement are accomplished by using HFSS 13.0 and 8757D network analyzer, respectively. As shown in ***Figure 7***, the measured results are in good agreement with the full-wave simulated ones. Slight deviations are observed, which could be attributed to fabrication error. At the center frequency of 4.1 GHz, the measured 3 dB bandwidth of the BPF is found to be 1.55 GHz (37.8 percent). The insertion losses, including the losses from two SMA connectors, are approximately 1.3 dB at the passband and the return losses within the passband are above 15.1 dB. Six



▲ *Fig. 6 Simulated S_{21} of the filter vs. values of Lc (a), Sc (b), Li (c) and Si (d).*

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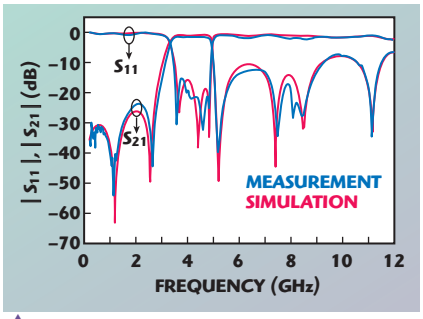


Fig. 7 Measured and simulated results of the designed filter.

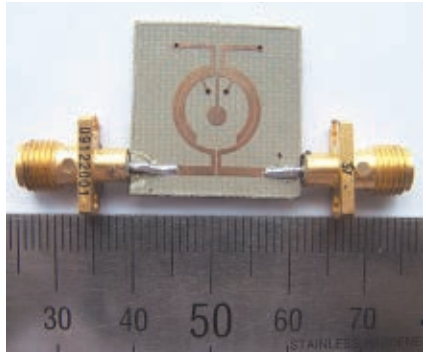


Fig. 8 Photograph of the fabricated filter.

transmission zeros are located at 1.13, 2.63, 5.17, 7.48, 8.44 and 11.14 GHz. ***Figure 8*** shows a photograph of the fabricated filter.

CONCLUSION

A tri-mode BPF based on both capacitive and inductive S-L coupling with six transmission zeros is presented. Compared with the other two BPFs using two conventional feeding types, that is only capacitive S-L coupling and only inductive S-L coupling, this type of BPF cannot only possess a good tri-mode response, but also generate more transmission zeros to suppress the undesired harmonic passband. ■

ACKNOWLEDGMENT

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Compact LTCC Two-Band Bandpass Filter Using Dual-Layer SIRs

A compact, two-band bandpass filter, exploiting dual-layer hexagonal shape, open-loop folded, step-impedance-resonators (SIR), for Bluetooth and WLAN applications, using low temperature co-fired ceramic (LTCC) technology, has been designed and fabricated. The filter is composed of three hexagonal shape open-loop SIRs embedded in multilayer thin ceramic to produce a compact size. The proposed topology is demonstrated with a design operating at 2.40 GHz with a bandwidth of 400 MHz and 5.20 GHz with a bandwidth of 200 MHz. More than 30 dB of spurious suppression from 5.8 to 7 GHz is demonstrated in the experimental results.

Current trends in wireless communication systems are miniaturization and high integration. Filters with compact size, low cost and good performance have attracted much research interest in recent years. Many approaches have been proposed to design wideband bandpass filters (BPF) for wireless applications.[1,2] For example, dual-band BPFs have been designed using the stepped impedance resonator (SIR) method and several individual resonators in parallel configurations, which require a large size. A stack loop resonator structure with microstrip patch perturbation for a dual-mode dual-band filter has been reported.[3] Embedded microstrip dual-mode resonators with microstrip patch perturbation have also been adopted for dual-band design.[4] However, designs of wideband BPF with compact size remain a challenge. Among several technologies to realize highly integrated components and modules, LTCC is one of the most efficient methods owing to its 3D structure and low cost. Therefore, many RF filters with LTCC technology have been presented recently.[5]

In this article, a dual-layer hexagonal shape SIR is introduced, to design a compact two-band LTCC BPF. Moreover, the resonator is printed on multilayer thin ceramic, which can reduce the size of the component efficiently. Finally, this proposed filter is verified by simulation and measurements. Good agreement between the simulation and experiment results is achieved.

DUAL-LAYER HEXAGONAL OPEN-LOOP SIR

The pentagonal shape open-loop SIR, shown in ***Figure 1***, is simply a SIR with its two low-impedance sections and high-impedance sections being printed on different layers, which can reduce the area of the circuit. The two low-impedance sections are bent to form an open-end capacitance. Tight coupling is purposely established between the two ends to provide a sufficiently large capacitance and an alternative path for the signal traveling from input to output port.[6] The advantage of using a hexagonal resonator is that it has more sides

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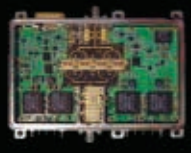
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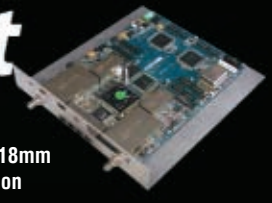
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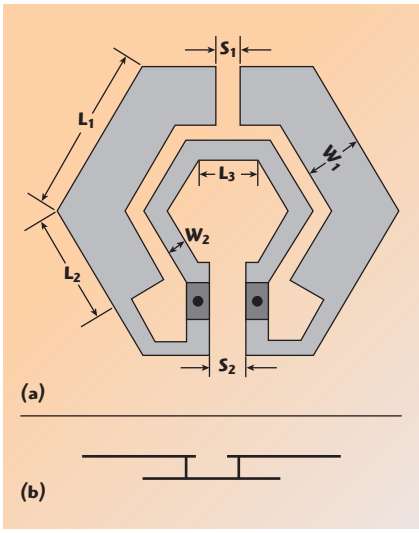


Fig. 1 Structure of the dual-layer hexagonal shape SIR (a) top view and (b) front view.

than the square resonator, allowing a high degree of coupling. The front view of the resonator is also shown. The characters of this kind of resonator have been analyzed theoretically and experimentally.[6]

LTCC FILTER DESIGN

The configuration of the proposed filter is shown in ***Figure 2***. The filter consists of three identical SIRs. The high-impedance sections of the first and second resonators are printed on the first layer, the thickness of which is 0.4 mm. The low-impedance sections of the first and the second resonators are printed on the second layer, the thickness of which is 0.1 mm. The high-impedance section of the third resonator is printed on the third layer and the thickness of this layer is 0.1 mm. The low-impedance section of the third resonator is printed on the fourth layer, the thickness of which is 0.1 mm also. As shown, the low-impedance section of the first resonator

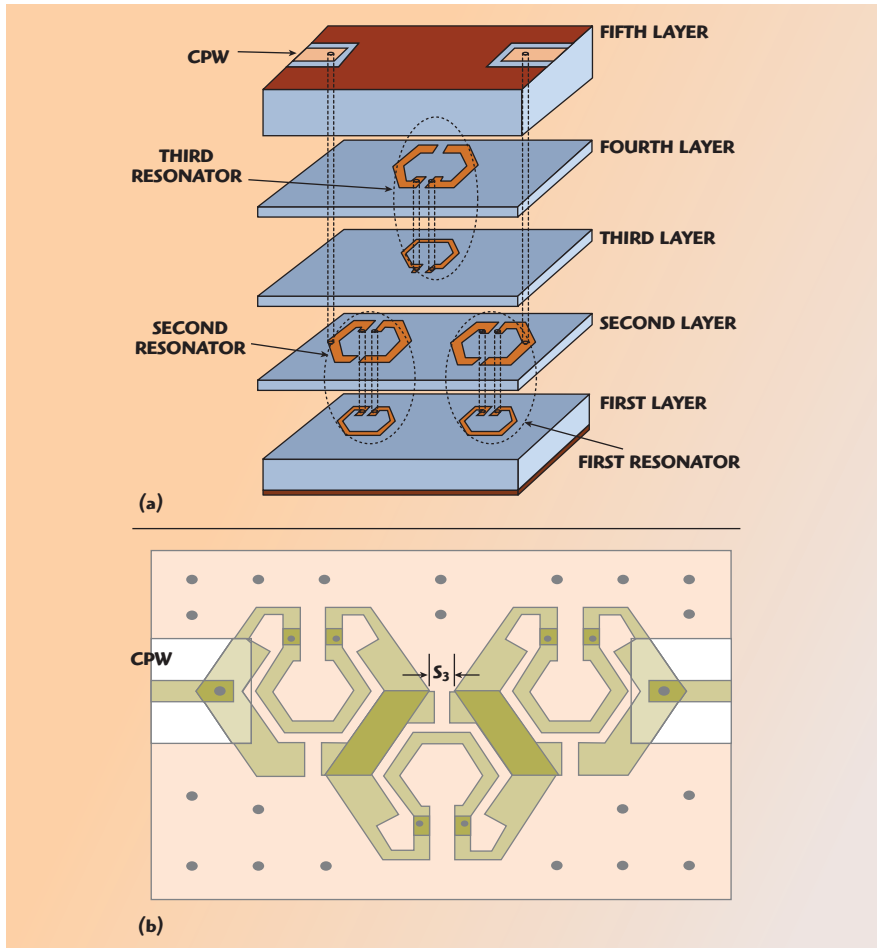


Fig. 2 Layout of the proposed two-band BPF (a) three-dimensional view and (b) top view.





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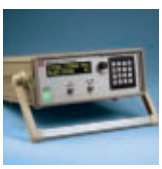
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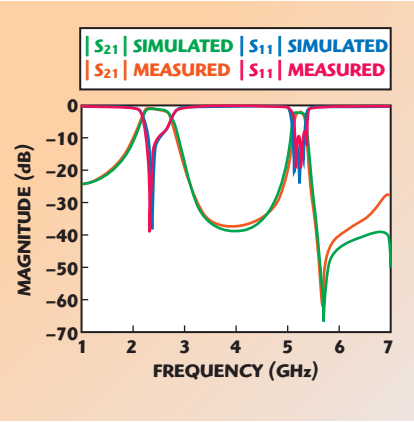


Fig. 3 Simulated and measured results of the proposed filter.

is overlapped with the low-impedance sections of the second and third resonators. The first and second resonators are connected with coplanar wave guide (CPW) printed on the fifth layer through metal vias and the CPWs are used as input/output ports. The thickness of the fifth layer is 0.3 mm. In order to equalize the electric potential between the upper and lower ground planes of the stripline (SL) structure, ground vias are placed around the filter and metal is printed on the front and back sides of the filter.

To validate the above design approach, the proposed filter was fabricated in multilayer ceramic, with a total component thickness of 1 mm. The relative dielectric constant of the ceramic is 27. After simulation and optimization by Ansoft HFSS, the geometric dimensions are determined as follows: L_1 = 1.4 mm, L_2 = 0.90 mm, W_1 = 0.48 mm, W_2 = 0.17 mm, S_1 = 0.2 mm, S_2 = 0.3 mm, L_3 = 0.5 mm and the distance between the first and second resonators is L_5 = 0.6 mm.

The overall size of the fabricated filter is 7 × 5 × 1 mm. The simulated and measured responses are compared in ***Figure 3***. The passbands are centered at 2.45 and 5.25 GHz with bandwidths of 400 and 200 MHz, respectively. The measured minimum insertion losses, including the loss from the transition between the CPW and SL, are 1.20 dB, with the passband return loss better than 10 dB at 2.45 GHz and with an insertion loss of 1.78 dB and a return loss better than 10 dB at 5.25 GHz. The attenuation level is more than 30 dB from 5.8 to 7 GHz. The measured results are in close agreement with the simulated ones.

CONCLUSION

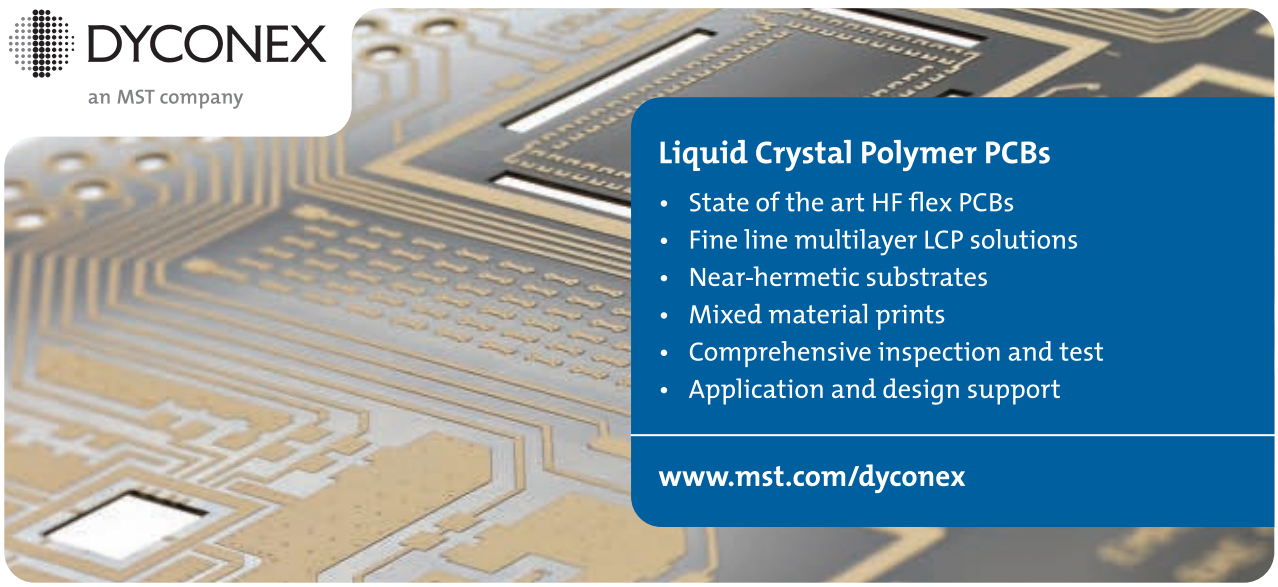
A compact, two-band LTCC filter for Bluetooth and WLAN applications has been presented. The filter employs dual-layer hexagonal shape SIRs printed on two ceramic layers, which has a volume of 7 × 5 × 1 mm. The filter operates at 2.45 and 5.25 GHz with bandwidths of 400 and 200 MHz, respectively. More than 30 dB of spurious suppression from 5.8 to 7 GHz is obtained. The simple multilayer planar structure, as well as compact size, makes it attractive for wireless communication applications. ■

ACKNOWLEDGMENT

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Understanding Analyzer Choices: Spectrum, Signal, Vector and Real-Time

These days, engineers face a myriad of choices when seeking a solution for signal characterization: spectrum analyzers, signal analyzers, vector signal analyzers and real-time analyzers. When assessing the alternatives, several questions may come to mind: What's the best choice for a specific set of measurements? How effective is it to get two or more analyzer types in a single instrument? Is it more cost-effective to buy one type initially then upgrade later when needed?

Architecturally, all four types have much in common. This article begins with a look at the similarities and differences. From there it describes each type and the possible combinations of capabilities that can address a variety of requirements.

THEY'RE ALL "SIGNAL ANALYZERS"

The common usage of the term signal analyzer has come to include several evolved versions of the traditional spectrum analyzer. Swept-tuned spectrum analyzers have been around for more than 40 years and have become a common tool for engineers who work with RF and microwave signals.

Figure 1 shows a simplified block diagram of a traditional swept-tuned analyzer — and this provides a foundation for understanding the other types of analyzers. The architecture uses a superheterodyne receiver in which a swept frequency oscillator and broadband mixer downconvert the incoming RF or microwave signal to an intermediate frequency (IF). The resulting signal can be more easily filtered and its magnitude directly measured using an analog envelope detector.

The lower portion of Figure 1 shows a recent variation: many of today's signal analyzers combine a superheterodyne architecture with an analog-to-digital converter (ADC) and digital signal processing (DSP) to implement a digital IF section. In this approach, DSP replaces — and improves on — troublesome analog functions such as bandwidth filtering, log scaling and video averaging. This digital approach also provides the opportunity for a seemingly infinite variety of new functionality.

SWEPT SPECTRUM ANALYSIS, ENHANCED

A signal analyzer with a digital IF allows either swept-tuned or fixed-tuned measurements. The swept-tuned mode is the traditional approach: the analyzer's downconverting local oscillator (LO) is swept across a range of frequencies. Fixed-tuned mode is similar to the zero-span mode found on traditional spec-

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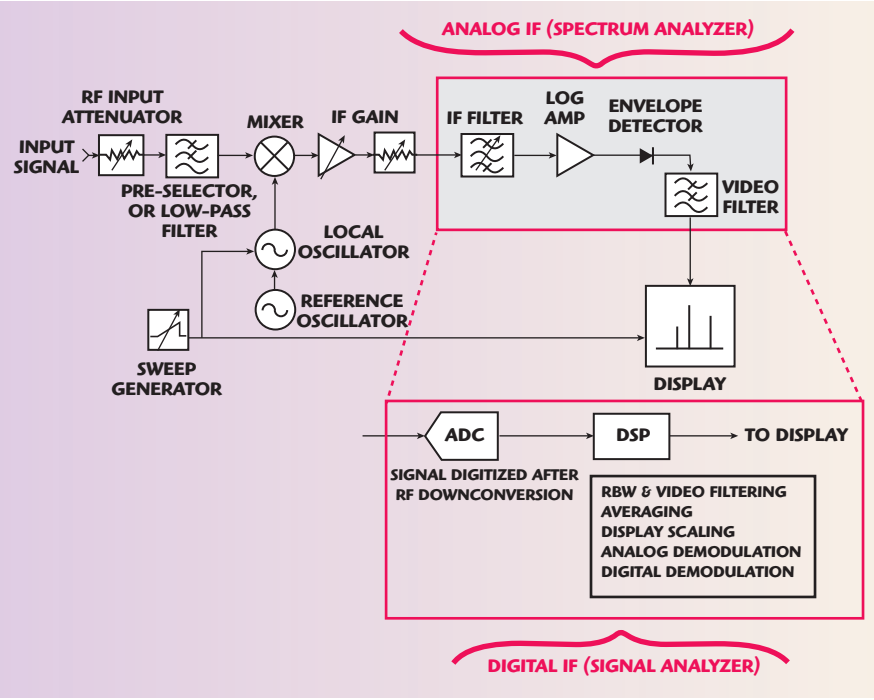
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▲ *Fig. 1 Traditional spectrum analyzer downconversion architecture with a digitized IF version.*

trum analyzers. In fixed-tuned mode, the LO frequency remains stationary and a band of frequencies is digitized by the ADC.

Figure 2 shows a fixed-tuned measurement of a wideband communication system: the upper trace shows spectrum or power versus frequency; the lower trace shows RF envelope or power versus time. In this example, the waveform was digitized during a 75 microsecond period and the analyzer calculated the spectrum using a fast Fourier transform (FFT). These measurements are scalar: power spectrum or RF envelope power. This equates to the functionality of a spectrum analyzer and is a starting point for the capabilities provided by several types of signal analyzers.

VECTOR SIGNAL ANALYZERS

The first major extension of signal analysis based on the sampled digital IF was the vector signal analyzer (VSA), which was introduced in the early 1990s. In a VSA, the digitizing process utilizes complex or in-phase/quadrature (I/Q) sampling, and this preserves all signal characteristics that occur within the digitized bandwidth. As a result, a VSA can provide a full range of time-, frequency- and modulation-domain analysis capabilities, including demodulation and modulation-quality assessments. ***Figure 3*** shows an example of digital demodulation of an LTE signal. The VSA version of the digital IF architecture often adds two more features: time capture and playback, and IF magnitude triggering. These capabilities are useful in the characterization of complex signals and dynamic signal environments.

In time capture operations, the analyzer saves a gap-free stream of I/Q samples from the IF in a large memory buffer. Because the buffer is typically much larger than that needed for a single measurement, it is easy to implement a continuous playback operation during post-capture processing. Replay can be controlled in several ways: adjusting replay speed, selecting specific portions of the buffer for analysis, and more. One key feature of post-processing is the ability to change the type of analysis: any type of vector measurement or demodulation can be performed without acquiring new data. What's more, any measurement parameter can be changed to optimize the measurement or extract new information.

VSA software, such as the Agilent 89600, can provide an enhance-



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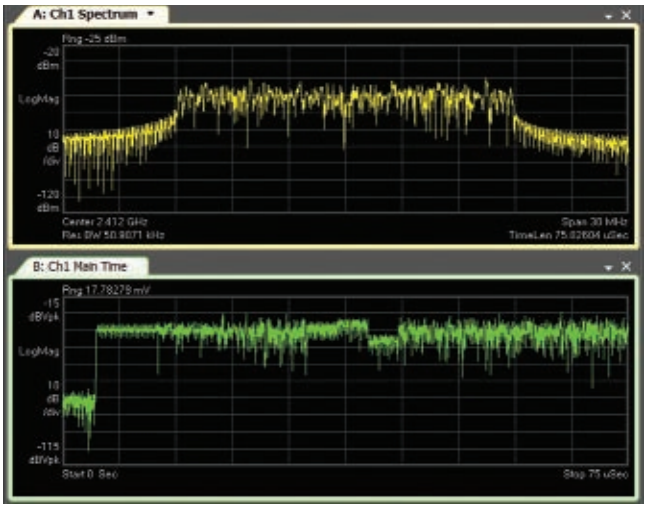


Fig. 2 Operating in fixed-tuned mode, a signal analyzer can display magnitude vs. frequency (upper trace) and magnitude vs. time (lower trace).



Fig. 3 In VSA, digitized IF data can be used to perform demodulation with typical displays such as constellation diagrams, error vector magnitude (EVM) and automatic detection of channel resources.

ment to this post-processing flexibility that is especially useful when the capture buffer contains multiple signals: the ability to change the center frequency and analysis span. These "tune" and "zoom" operations are second nature to RF engineers, and in VSA post-processing they even allow digital modulation — at the same or different center frequencies — of multiple signals from a single capture.

In a VSA, memory and high-speed DSP also provide an IF magnitude trigger. ASICs or FPGAs calculate the total magnitude of the IF signal in real time (i.e., without gaps) and test it against user-specified trigger parameters. When the trigger is reached, a single measurement or time capture is automatically initiated. With acquisition memory arranged as a circular buffer, it is possible to implement both negative (pre-trigger) and positive (post-trigger) delays. This also makes it possible to provide oscilloscope-like trigger functions such as adjustable trigger polarity and holdoff.

EVOLUTION: VECTOR SIGNAL ANALYSIS AS APPLICATION SOFTWARE

The first vector signal analyzers were a dedicated combination of measurement hardware and embedded software. In subsequent years, the introduction of new types of signal samplers for RF signals meant that vector sampled data was available from many different sources.

About 12 years ago, the availability of these new samplers led to a splitting of the analyzer hardware and the vector signal analysis functions — and now the term "signal analyzer" is increasingly used to reflect the hardware platform that downconverts and digitizes RF and microwave signals. The separate VSA application can also be used on signals acquired with digital oscilloscopes, logic analyzers and modular digitizers, and on signals created with math or simulation software.

REAL-TIME ANALYZERS: FAST, GAP-FREE PROCESSING

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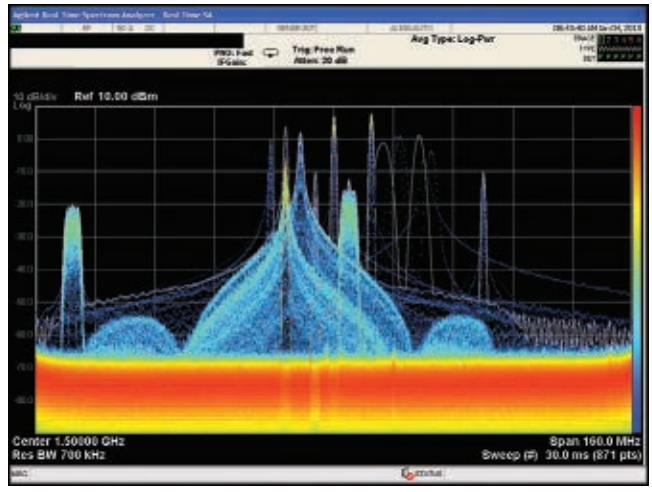
sible to continuously compute basic power spectra from a digitized data stream. Although this gap-free analysis is scalar rather than vector or demodulation, it allows the analyzer to keep up with highly dynamic spectrum behavior and is the foundation of the category called real-time analyzers.

Real-time analyzers are especially useful for understanding dynamic spectral environments and agile signals, and for the detection of unexpected and infrequent signal behavior. There is one caveat: a real-time analyzer produces a tremendous amount of spectral data in a short period. The solutions are advanced, data-dense displays and frequency-mask triggering (FMT).

ADVANCED DISPLAYS FOR MORE AND FASTER DATA

Whether generated from real-time spectral calculations or gap-free time captures, the calculation of thousands of measurements per second requires intuitive representation of rapidly changing data. Here's why: The human eye can detect about 30 images per second; in contrast, a typical real-time analyzer may produce almost 300,000 spectra per second. Thus, in a default configuration, each display must represent about 10,000 spectra in a meaningful way.

For many years, similar challenges have been met with displays such as spectrograms and waterfalls. Recently, various frequency-of-occurrence displays — density or cumulative history — have been introduced with descriptions such as digital phosphor or digital persistence. ***Figure 4*** shows a density (or histogram) display of a wideband environment that contains several agile signals containing



▲ *Fig. 4 Advanced displays of real-time data can reveal signal behavior over time.*

pulses and digital modulation. Color is used to indicate how often specific signal values (e.g., a specific amplitude/frequency point) occur over the course of millions of spectrum measurements.

FREQUENCY-MASK TRIGGERING

Another way to make efficient use of rapid, gap-free spectra is to evaluate them individually against a frequency mask that uses upper limits, lower limits or both. By combining limit testing with logic functions, conditional triggers can be defined that initiate measurements

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TABLE I

REVIEW OF THE MAJOR BENEFITS OF EACH ANALYZER TYPE

Swept Spectrum Analyzer	*Signal Analyzer (Digital IF)*	*Vector Signal Analysis Software*	*Real-Time Analyzer*
Familiar measurements and user interface	All attributes of a swept spectrum analyzer plus the following	Complete and detailed vector analysis and demodulation	Ability to reveal elusive signals
Compatibility with standards and established measurement practice	Maximum accuracy, dynamic range and sensitivity	Signal capture with flexible playback and post-processing for signal selection and reuse	Detection of unknown signals and signal behavior
Flexibility through independent control of span, RBW and VBW	Measurement flexibility with applications for phase noise, noise figure, ACPR, EMI, and more	Single user interface for analysis of data from multiple instrument types	Spectrum monitoring and measurement triggering on specific spectral shapes and activities (FMT)
	Supports VSA software running inside or outside instrument	Multi-channel capabilities	Tools for analysis of agile signals such as pulses

when, for example, a signal exhibits some combination of entering, leaving or re-entering the mask.

In a real-time analyzer, FMT typically initiates one or more spectrum measurements. When a real-time analyzer is combined with VSA software, the trigger can initiate any number of measurements: spectrum, demodulation, time capture and more. If FMT is combined with time capture and pre-trigger delay, it is possible to detect specific spectral behavior such as switching anomalies and then capture the entire event for multiple types of post-processing analysis.

CHOOSING THE BEST COMBINATION

The preceding passages have described the architectures and general measurement capabilities of the principal types of signal analyzers. To make it easier to choose one or more to meet a specific set of needs, ***Table 1*** summarizes the major attributes of each type.

Whichever type of analyzer is most appropriate, the primary purpose is to allow engineers to follow their instincts and deductions — and make measurements that help them determine cause and effect, or optimize a signal or system. This is one of the key ideas behind the availability of real-time spectrum analyzer capabilities as an upgradeable option to new or existing signal analyzers. Further, the ability to enhance a signal analyzer with VSA software enables engineers to go even deeper with other types of real-time and post-processing analysis of highly elusive signals. ■

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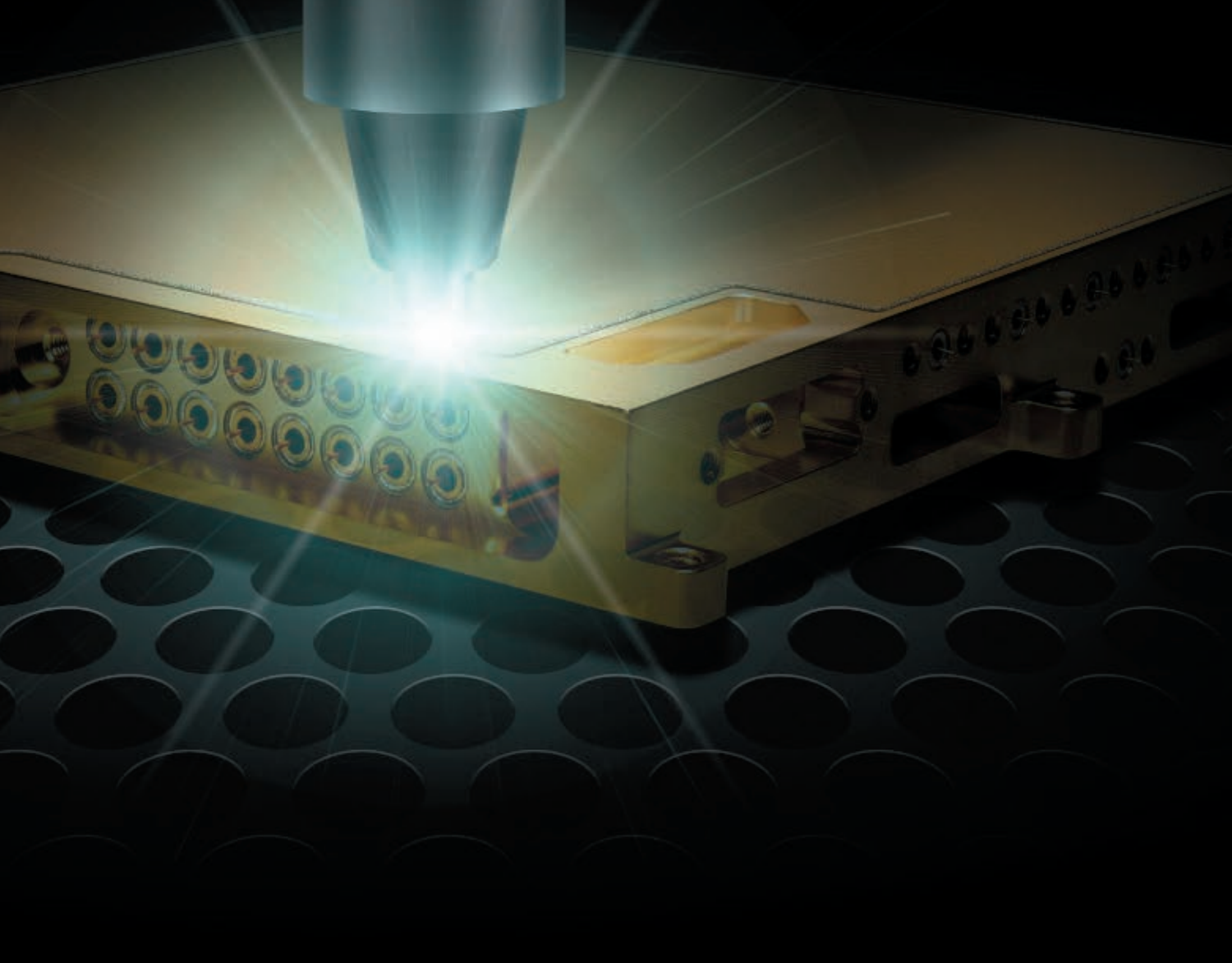


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Device Characterization Methods for Advanced RF/ Microwave Design

Successful RF and microwave circuit design using active devices requires accurate modeling of nonlinear behavior. This is especially important in the telecommunications industry where nonlinear device behavior contributes to interference issues and a reduction in effective bandwidth.

Thus, a vendor agnostic, nonlinear behavioral model that accurately accounts for all of a device's nonlinear effects and works with a variety of RF and microwave simulators is very valuable to designers. In fact, the focus on developing accurate nonlinear behavioral models has produced so many options that the nonlinear behavioral modeling world can be somewhat confusing. This article serves to bring some sense and structure to this space by presenting an overview of all the different nonlinear behavioral model types and comparing the effects they capture, the simulators they support, and the relative ease-of-extraction and distribution.

MODELING DOMAINS

It is important to understand the two different RF and microwave simulation domains in which designers typically want nonlinear behavioral models to run. The first is standard circuit-level simulation, which includes linear simulation and nonlinear simulation technologies like harmonic balance, transient or SPICE, and circuit envelope techniques. With these simulation engines, the behavioral models can be formatted in either the time domain or frequency domain and the typical simulation output is voltage and current.

The second option is that of system-level simulation, which usually involves a fixed time step time-domain simulator that commonly relies upon an underlying technology known as "data flow." A more practical way of thinking about system-level simulation is to associate it with the creation and analysis of modulated signals or to think about the typical system-level simulation results such as error vector magnitude (EVM) — important for quantifying the performance of a digital radio transmitter or receiver — and adjacent channel power ratio (ACPR) — for determining the amount of spectral spreading.

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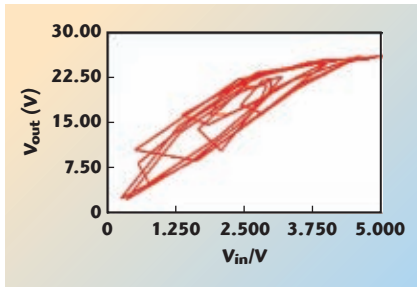


Fig. 1 Nonlinear memory effects cause the current operation condition to be a function of the previous operating conditions.

MODELING EFFECTS

Non-ideal effects typically seen in active circuits include both linear memory effects and nonlinear memory effects. Linear memory effects are simply the frequency-dependent behavior of an active device caused by linear capacitances and inductances. RF and microwave engineers have been dealing with linear memory effects for years, so they are not as exciting to designers these days as nonlinear memory effects.

Nonlinear memory effects, on the other hand, occur when the active device's current operating condition is dependent on its previous operating condition. In other words, when a device starts to display hysteresis. One relatively straightforward way to see this is in an amplifier by looking at its AM to AM, or V_{out} versus V_{in} curves, where the input power level is swept up and down between random points. If there were no nonlinear memory effects present, the output would be the standard "smooth" AM to AM curve. However, in the presence of nonlinear memory effects, the result is a curve much like the one shown in ***Figure 1***, where the trajectory taken to get from the starting input voltage to the final input voltage depends on the previous operating conditions of the amplifier. Nonlinear memory effects can be caused by a variety of sources, but the most common are low-frequency mixing products from the bias circuit, device self-heating and trapping.

MODEL TYPES

It is important to understand the different kinds of models that exist, the effects that they are capable of capturing and the simulators in which they work. The y-axis in ***Figure 2*** shows model memory and ranges from those without memory effects — or a model that does not even capture frequency dependence — to those with fully nonlinear memory effects. The x-axis in Figure 2 describes the operating region of the device and spans from purely linear to strongly nonlinear, or in other words, very deep into compression for an amplifier. The different box colors indicate the simulator engines in which the models are most appropriate (converge to a timely and accurate solution).

S-PARAMETER MODELS

S-parameter models are well known and widely used by almost all RF and microwave engineers. From the color and position of the S-parameter box in Figure 2, it can be seen that S-parameter models can be used with all circuit-level simulation engines, that they support linear memory or

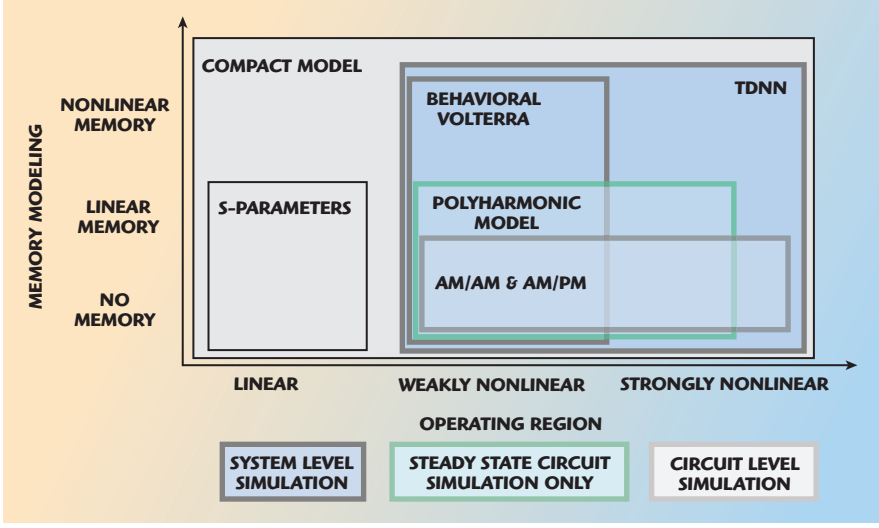


Fig. 2 Types of models, including memory range and operating region range, and the relevant simulator technology.





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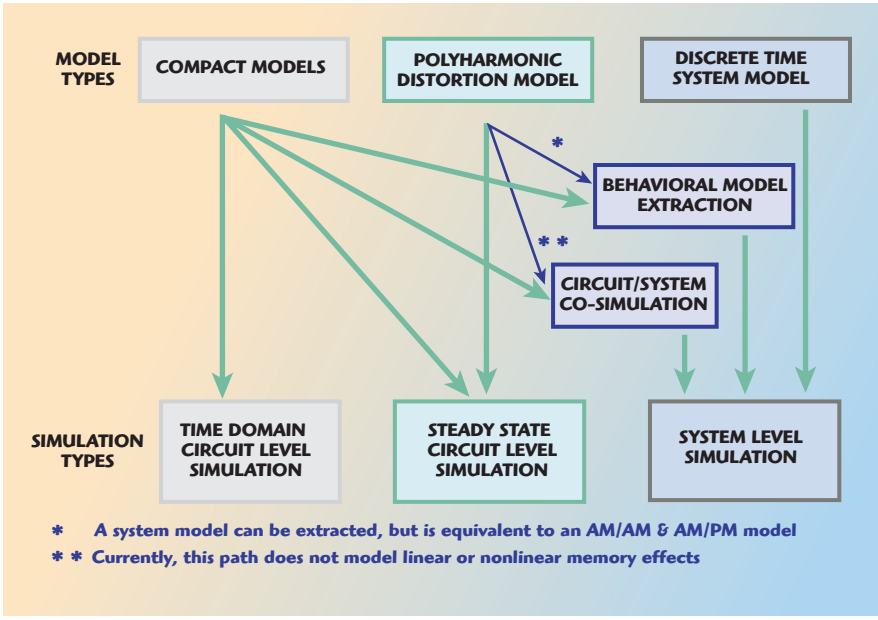


Fig. 3 Simulator capability.

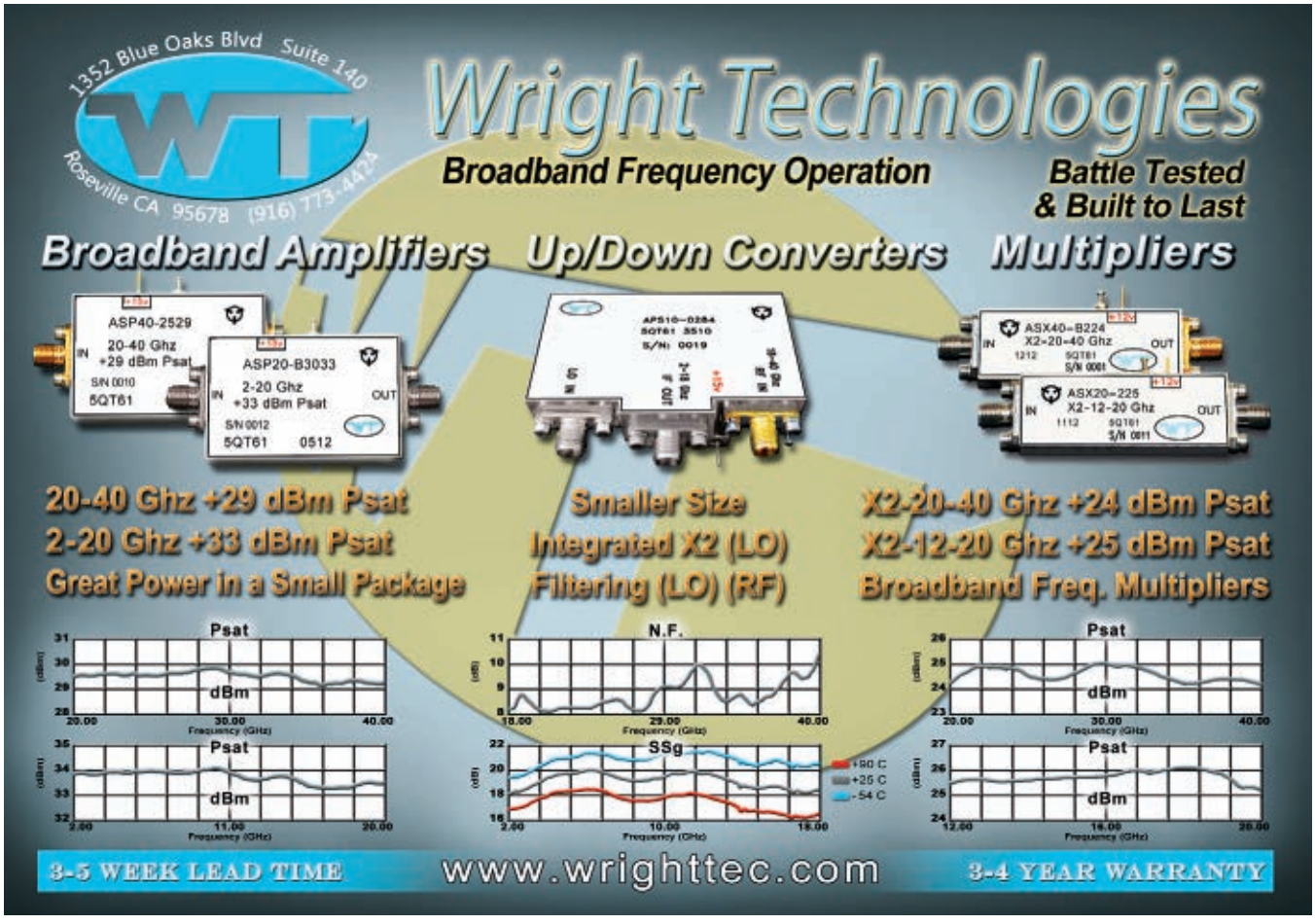
frequency-dependent behavior, and that they only model a linear device-operating region. This should be of no surprise to the RF and microwave engineer.

COMPACT MODELS

Compact models include Materka, VBIC, Angelov, BSIM3 and others. As shown in Figure 2, these models work with all of the circuit-level simulation engines and have the capability to capture all memory effects and cover all device operating regions. One important caveat is that an individual compact model will only be as good as the data from which it was extracted and the data ranges in which it was extracted over. Thus, the theoretical capability of a compact model might not be reflected in the ones that designers work with on a regular basis.

PHD MODELS

On the circuit-level simulation front, polyharmonic distortion (PHD) models include Agilent's X-parameters®, S-functions, the Cardiff model and others. These nonlinear behavioral models are interesting in that from a user perspective, they seem to be S-parameters that also capture nonlinearities. In doing so, they cover an expanded device-operating region when compared to S-parameters. Presently, however, they are still limited to linear memory effects, or frequency-dependent behavior. In addition, they only really support steady-state or harmonic balance circuit-level simulation.



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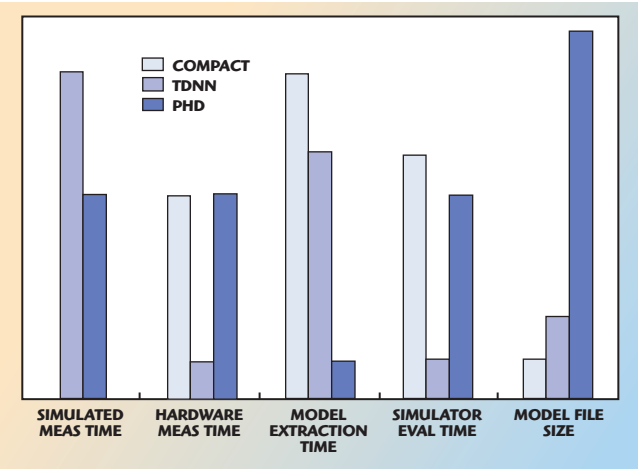


Fig. 4 Comparison chart showing relative performance of compact, TDNN and PHD models.

SYSTEM MODELS

A standard way to represent an active device in a system simulator is with AM to AM and AM to PM curves. This approach is good in that it captures all the operating point nonlinearities, but it has limited linear memory effect capability and no nonlinear memory effect capability. The behavioral Volterra model, on the other hand, can capture all of the memory effects, including the nonlinear ones, but is somewhat constrained with regard to device operating region because of the practical limits on the number of model coefficients. Time delay neural network (TDNN) models, as Figure 2 shows, have the capability to handle all memory effects and all device operating regions, which makes these models very exciting from a system-level simulation perspective.

SIMULATOR COMPATIBILITY

Although models are designed to work in a specific simulation engine or domain, there are often paths that will enable them to work in others as well. As shown in ***Figure 3***, compact models work directly in time-domain circuit-level simulators and steady-state circuit-level simulators, but can also be used in system-level simulators through circuit-level co-simulation or behavioral modeling extraction. In fact, using some of the modeling definitions presented earlier in this paper, compact models can be extracted as AM to AM and AM to PM models, behavioral Volterra models or TDNN models for use in system-level simulation.

PHD models, on the other hand, are slightly more constrained. They only work directly in steady-state circuit-level simulators, and, while there are paths to use them with system-level simulators, there are a couple of issues to consider. The first is that when they are extracted as system-level behavioral models, the resulting behavioral model will always have the same model fidelity as the model from which it was extracted, regardless of its potential capability. Since PHD models do not model nonlinear memory effects, the resulting system models do not contain nonlinear memory effects. Another consideration

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is that when used in a co-simulation mode between circuit-level simulation and system-level simulation, neither linear nor nonlinear memory effects are considered due to the model formulation and the co-simulation engine characteristics.

EXTRACTION AND DISTRIBUTION

So how do the models mentioned previously compare to one another with regard to extraction and distribution? The comparison chart in ***Figure 4*** shows the relative performance of the compact model, TDNN and PHD models, including the time to gather enough simulation data to make the model, the time to measure enough data on the test bench to make the model, the time required to extract the model from the input data, the average target simulator evaluation time and model file size. With reference to both time and file size, it goes without saying that shorter and smaller are always better.



OBSERVATIONS

Simulated Measurement Time

For the compact model, the data input for the model extraction is always from a test bench and never from a simulation, so it does not have a simulated measurement time. The TDNN model needs modulated signal waveforms so it has a longer simulated measurement time than the PHD model, which uses a series of harmonic balance simulations as an input.

Hardware Measurement Time

With test bench hardware, however, things are a little different. The compact model and the PHD model require a fair number of measurements so they take relatively more time to measure than the TDNN model, which simply needs to capture modulated waveforms on a vector signal analyzer (VSA).

Model Extraction Time

Once the data is gathered for model extraction, compact models usually employ an iterative series of calculations and optimizations, which are relatively time consuming. The TDNN has a neural network that needs to be trained, which means there is some time investment involved, but overall it's simpler than compact model development. The PHD model has a very low extraction time, in part because it is calculated as the data is being gathered so there are no explicit extraction steps that the model creator needs to run.

Simulator Performance

With regard to simulator performance, there is some apples-to-oranges comparison here, but in general compact models and PHD models run at the same speed, assuming that poorly formulated or poorly written compact models are not considered. The TDNN runs nearly instantaneously in system-level simulation (i.e., it runs at the same speed as any system level model).

Model File Size

For model file size, compact models are as good as it gets. They only require the storage of tens or hundreds of numbers. The TDNN model is also

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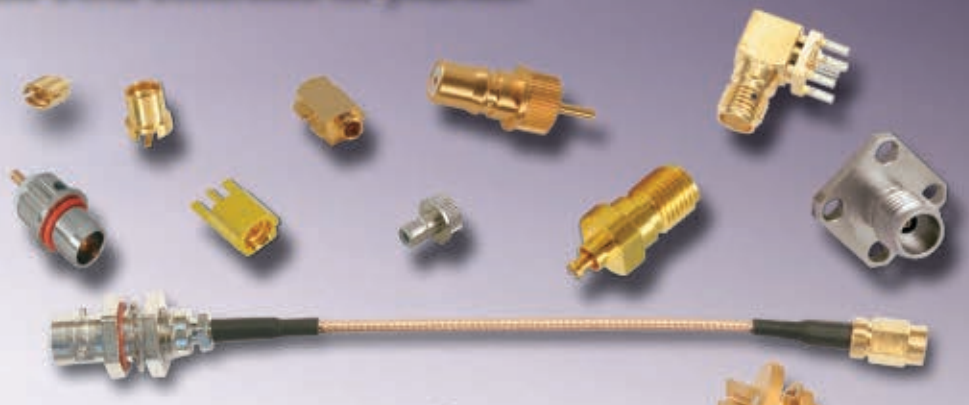
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relatively compact, often generating files that are only tens of kilobytes. The PHD model, on the other hand, can quickly grow to become quite large. A model with 40 load and source impedance points, 10 input power points, 20 frequency points, three harmonics, and five source and drain bias points is approximately 2 GB. To make matters worse, for many devices, that number of points might not be sufficient.

CONCLUSION

The world of nonlinear behavioral modeling is fluid, complicated and, at least today, there is not a-one-size-fits-all solution to the problem. In a way, it could be compared to the Beta versus VHS debate of decades ago, but with a lot more options and a lot less capability overlap. Despite the confusion, however, there are still some important conclusions that can be drawn.

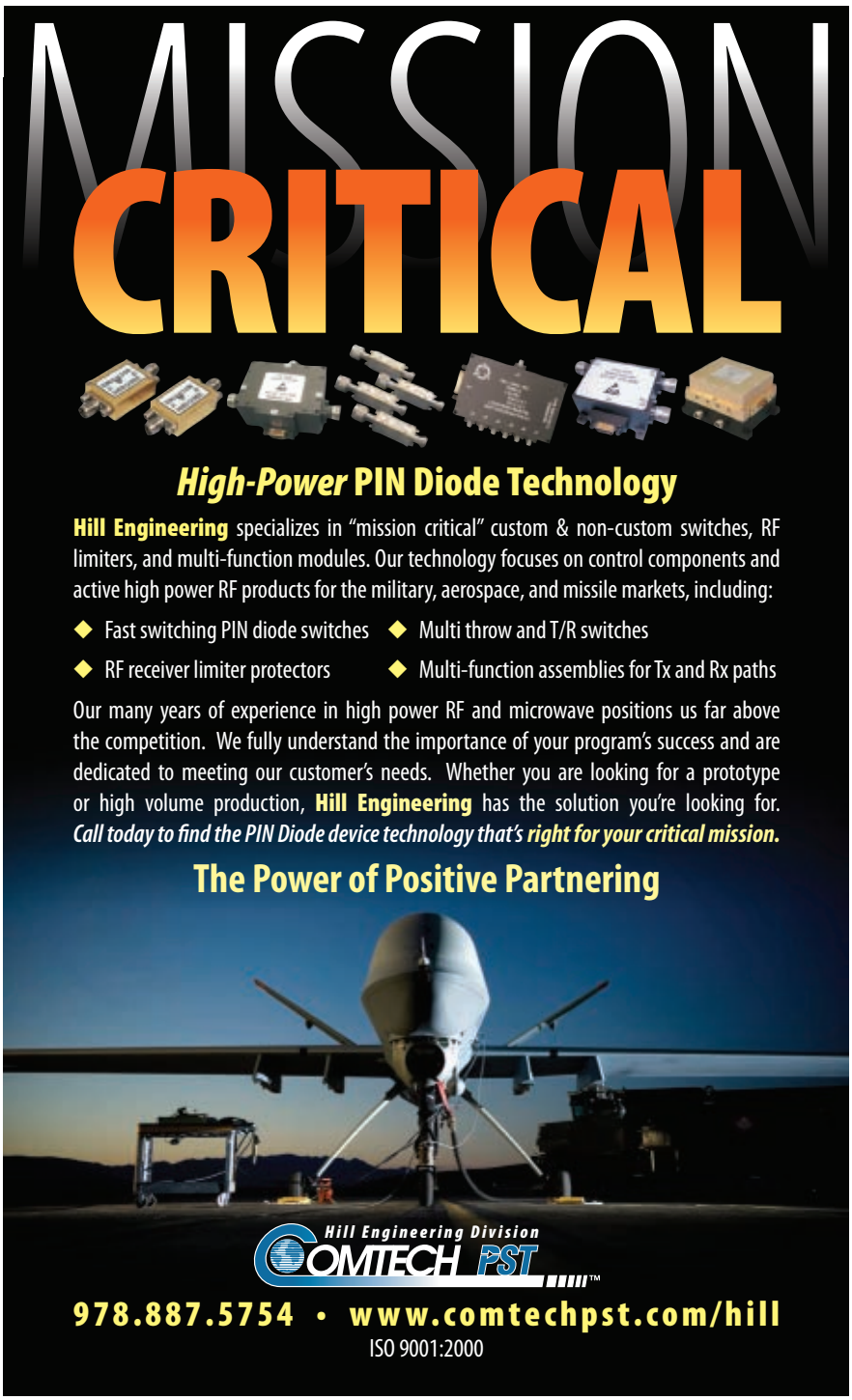
First, simulation tool support is very important. With all the model choices, designers need to be able to choose the model with the best availability and capability and know that their design tools will support it. Some companies support all of the models and the breadth of simulation engines as shown in Figure 2.

Second, PHD models, generally speaking, are in light demand at present as component-level simulation blocks, but not for discrete parts. Industry feedback is that this is due to file size issues, as previously mentioned, and the measurement and extraction complexity for adequate device models. Even for component-level simulation blocks, the lack of model fidelity when co-simulated with a system simulator presents an issue to designers trying to work with modulated signals or analyze system-level impairments. Compact models, although complex to create and not always formulated to maximize performance in a simulator, are very much the dominant model for circuit-level simulation.

Third, system-level modeling is a hot topic of late. As previously shown, there are several system-level models that offer more model fidelity in a system-level simulator than using circuit-level behavioral models in a system-level simulator. With the exception of S-parameters, system-level behavioral models are also much easier to extract from hardware than circuit-level models.

Lastly, it appears feasible to have a relatively simple test bench setup in a single PXI chassis that would allow any user to extract a TDNN model that handles all device operating regions and accounts for all nonlinear memory effects in a very reasonable amount of time and without any specialty model development knowledge. The advantage of a TDNN approach is not only a robust model but also an efficient model/solution within this domain.

While several solutions exist today that link RF and microwave design tools with test and measurement equipment, enabling engineers to produce a simulation model of their active device and providing the ability to build, test and validate design cases earlier in the product design cycle, more are surely on the way. ■



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Secondly, several carriers are grouped together and simultaneously used for information transmission. LTE-Advanced, for example, defines aggregation of up to five carriers, yielding a total bandwidth of 100 MHz. All modern wireless communications standards are based on MIMO to increase spectral efficiency, leading to the development of higher-order MIMO (4×2, 4×4, 8×2).

As a result, transmit and receive units of wireless devices and base stations are becoming increasingly complex. A wide variety of different wireless standards and bands must be supported. All of these advances are producing new T&M challenges: Developing and verifying products requires signal generators that are able to meet new requirements and are easy to operate, even with complex tasks. Rohde & Schwarz has addressed these requirements with the new R&S SMW200A vector signal generator.

SIMPLE SETUP

The R&S SMW200A generates signals in the 100 kHz to 3 or 6 GHz frequency ranges. It features an extremely powerful and flexible baseband section, making it a good tool for generating digitally modulated signals required for the development of wideband communications systems and the verification of 3G and 4G base stations. Thanks to its modular design, the new vector signal generator can be customized to meet user requirements. Any configuration is possible, from a classic single-path vector signal generator to a multichannel MIMO receiver tester.

The R&S SMW200A can be equipped with two internal baseband modules, four fading simulator modules and two RF paths. This concept yields two full-featured vector signal generators in a single unit. Signals can be internally added with frequency, level and phase offset, so that signal scenarios such as wanted signal + interferer, dual cell and Tx/Rx diversity with real time fading can be created very easily.

If necessary, the baseband section provides up to eight independent signal sources and up to 16 logical faders. This makes the R&S SMW200A suitable for generating multicarrier and multi-standard test signals required for LTE Advanced carrier aggregation and the simulation of interferer scenarios. 2×2 MIMO, 8×2 MIMO for TD-LTE or simultaneous 2×2 MIMO for two LTE-Advanced component carriers – even complex MIMO scenarios can be implemented using a single device. ***Figure 1*** shows an example of how to configure an LTE-A carrier aggregation scenario with two carriers and 2×2 MIMO.

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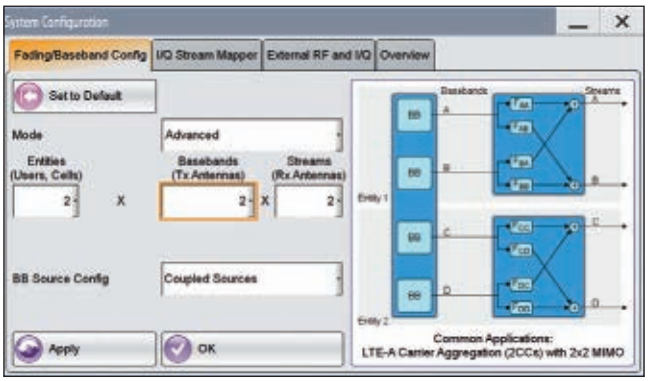


Fig. 1 System configuration menu for selecting the required test setup.

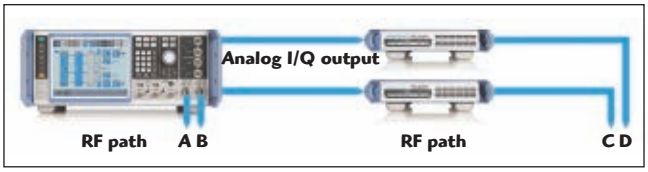


Fig. 2 Compact 4 × 4 MIMO solution, consisting of an R&S SMW200A and two R&S SGS100As.

generator modules. These modules are remote controlled via USB or LAN directly from the R&S SMW200A and seamlessly integrate into its user interface. This compact solution takes up only five height units, as shown in ***Figure 2***, and is ideal for applications such as 4×4 MIMO, providing correctly encoded baseband signals, real time MIMO channel simulation, AWGN generation and, if necessary, phase-locked coupling of multiple RF paths.

SPEEDING UP DEVELOPMENT

When the R&S SMW200A user interface was designed, special emphasis was placed on ergonomics. Its intuitive user guidance and numerous help functions make it very easy to operate, even with complex signal scenarios. The generator is equipped with a graphical block diagram that can be operated from a high-resolution touch screen. The signal flow can be seen at a glance at any time since the GUI adapts itself to the selected operating mode.

Graphical signal monitoring (spectrum, I/Q, CCDF, etc.) makes it possible to monitor the generated signal at practically any point of the signal flow. The required test signals can be configured directly via the GUI, eliminating the need for external PC software. Together with predefined settings and test models for all major digital standards as well as test case wizards for 3GPP FDD and LTE base station conformance testing, this helps to speed up work.

The context-sensitive help system including remote commands (SCPI) and further information assists users during everyday work. Functions such as marking all changes to settings after a preset or selective preset for individual parameters are extremely useful. The R&S SMW200A is equipped with an innovative SCPI macro recorder for generating remote control code (e.g., plain SCPI, Matlab®, etc.) from manual operating steps, enabling users to create an executable remote program within seconds. The macro playback engine makes it possible to run sequences directly on the signal generator, speeding up development processes and saving resources.

BETTER PRODUCT RESULTS

In an environment that is characterized by high levels of competition, product quality is one of the key distinguishing features. The R&S SMW200A offers good signal quality and is suited for developing and optimizing high-end RF and baseband modules. When it is equipped with the R&S SMW-B22 option, the SSB phase noise has a value of only –139 dBc (typical) at 1 GHz carrier frequency and 20 kHz offset (see ***Figure 3***). At the same time, non-harmonics are suppressed with up to 90 dB or more (see ***Appendix 1*** online listing the key specifications at www.mwjournal.com/RandSappendix).

The internal baseband has a 0.05 dB I/Q modulation frequency response over 160 MHz bandwidth, as shown in ***Figure 4***. With wideband signals such as 256 QAM modulated WLAN IEEE 802.11ac, an EVM of –49 dB (measured) is achieved at the signal generator's RF output. The R&S SMW200A makes it possible to generate standard-compliant wireless communications signals at a very high level.

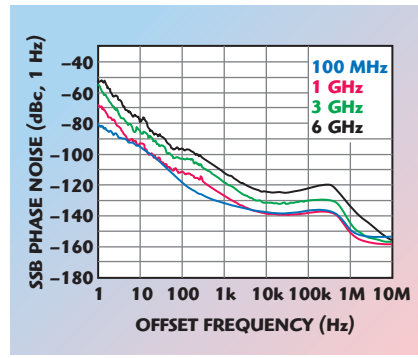


Fig. 3 SSB phase noise (with R&S SMW-B22 option).

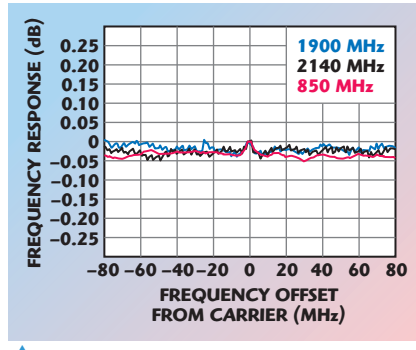


Fig. 4 I/Q modulation frequency response with internal baseband.

With the R&S SMW200A, Rohde & Schwarz has significantly reduced test setup complexity in today's increasingly complex wireless world. Since the R&S SMW200A combines the functions of several instruments in a single signal generator, many potential error sources such as remote operation, cabling and synchronization are a thing of the past. Its scalable platform allows users to tailor the signal generator exactly to their applications and to upgrade it as required. This helps to save investment costs and makes the R&S SMW200A a very safe investment for the future. The intuitive operating concept helps users accomplish their tasks faster, regardless of their complexity. The new vector signal generator provides the ideal framework for quickly and efficiently making high-quality products ready for market.

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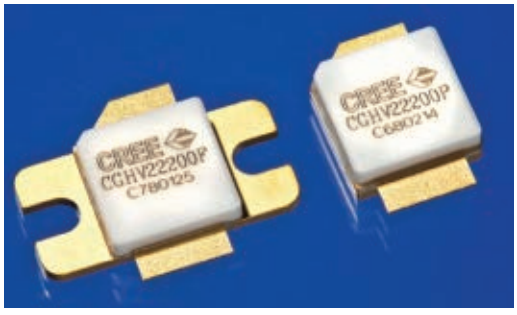
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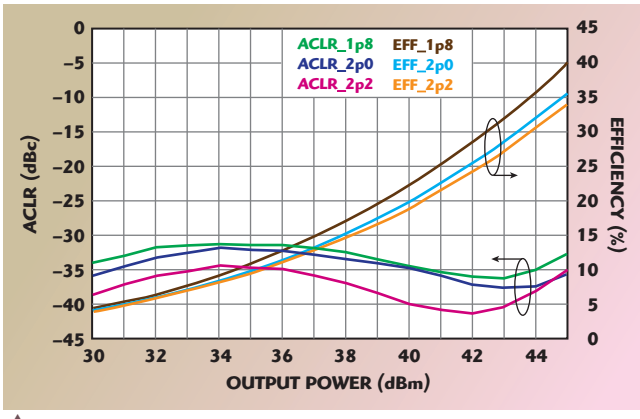
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50 V Telecom GaN Transistors

With the advent of telecommunication applications requiring higher RF peak and average power levels in most of the frequency bands covering 700 MHz to almost 3 GHz, GaN HEMTs with higher operating voltages are gaining popularity. Until recently, most GaN HEMT technologies were limited to operating drain voltages of 28 V. Cree has introduced a range of 50 V GaN HEMT transistors that provide significant advantages over their 28 V siblings. They provide higher power, improved bandwidths and a larger number of parts per wafer for the same power level reducing costs and increasing volume throughput. In addition to these advantages, the new 50 V devices exhibit minimum drain-to-source breakdown voltages of 125 V providing ruggedness when operating into 10:1 output VSWRs with arbitrary phase angles.



▲ *Fig. 1 Typical drain efficiency and ACLR vs. output power of the CGHV22100 measured in CGHV22100-TB amplifier circuit (V_{DS} = 50 V, I_{DS} = 0.5 A, 1c WCDMA, PAR = 7.5 dB).*

The first devices in the 50 V family, specifically designed for cellular infrastructure applications, are the CGHV22100, 27100, 22200 and 27200. These devices operate in the 1.8 to 2.2 GHz and 2.5 to 2.7 GHz bands, with peak output power levels in excess of 100 and 200 W. A summary of the linear performance of these transistors is shown in ***Table 1***. All four transistors are available in the 440161 and 440162 earless (pill) and eared (flange) style metal/ceramic packages. These transistors have internal input matching consisting of wire-bonds and shunt capacitors to raise the real part of the input impedance to approximately 10 ohms making PCB matching relatively simple and straightforward. The output of the transistor does not require internal matching (partially owing to the results of 50 V operation on the output load-lines). An additional advantage of this approach is that harmonic matching may also be applied at the PCB level to enhance efficiency.

The internal input matching is highly reproducible owing to the employment of fully automated, programmable wire-bonders that define wire length, loop height and profile as well as automatic die placement and attachment. The design of the internal matching circuitry is provided by the use of 3D electromagnetic simulation including the transition

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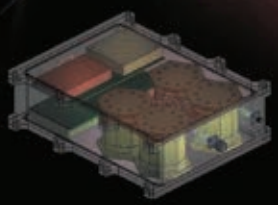
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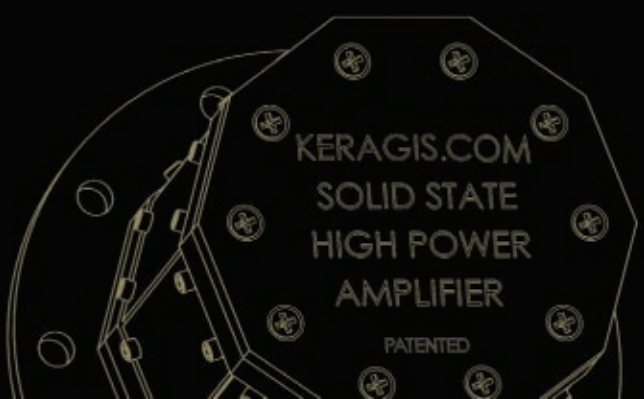
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from the inside to the outside of the package through the package ceramic ring frame.

Figure 1 shows the typical drain efficiency and adjacent channel leakage ratio (ACLR) for the CGHV22100F measured in an evaluation board at 1.8, 2 and 2.2 GHz. Typical drain efficiency at an average output power of 44 dBm (1 carrier 3GPP signal with 5 MHz channel bandwidth with a peak-to-average ratio (PAR) of 7.5 dB) is 32 percent at an ACLR of –37 dBc. Power gains are in excess of 21 dB. This compares with a power gain of 15 dB for a 28 V "equivalent" transistor such as the CGH21120F. The significant power gain increase is a direct result of operation at 50 V.

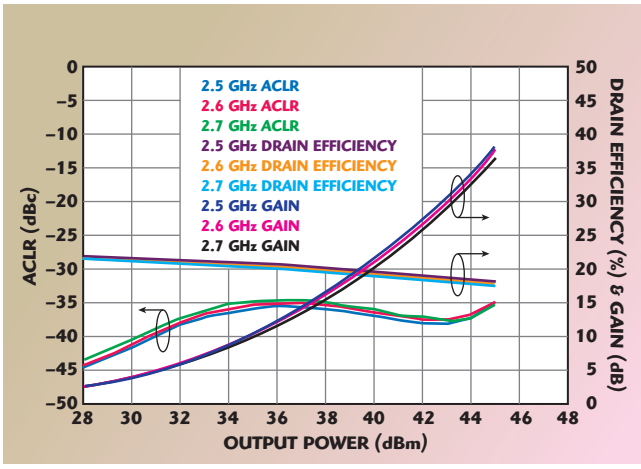
Figure 2 shows power gain, drain efficiency and ACLR plots for the CGHV27100F transistor which covers the 2.4 to 2.7 GHz band. Drain efficiencies are again over 30 percent in Class A/B operation at an average output power of 44 dBm with an accompanying ACLR of –37 dBc. Power gains are over 18 dB and again can be compared to a typical power gain of 13 dB for a 28 V "equivalent" transistor such as the CGH25120F.

Figure 3 shows power gain, drain efficiency and ACLR performance

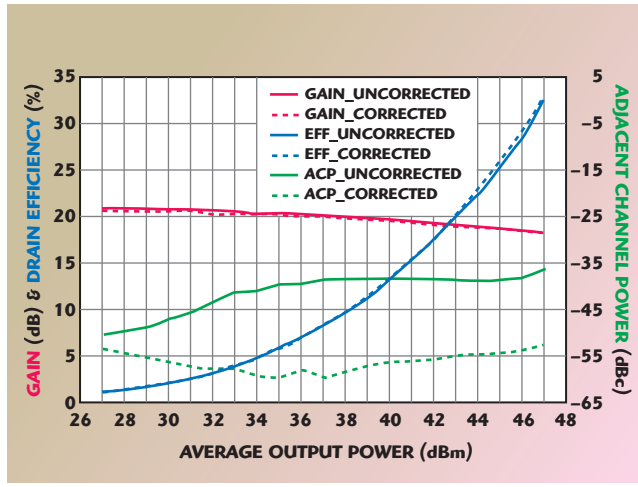
TABLE I

SUMMARY OF THE LINEAR PERFORMANCE OF THE 50 V GaN TRANSISTOR FAMILY

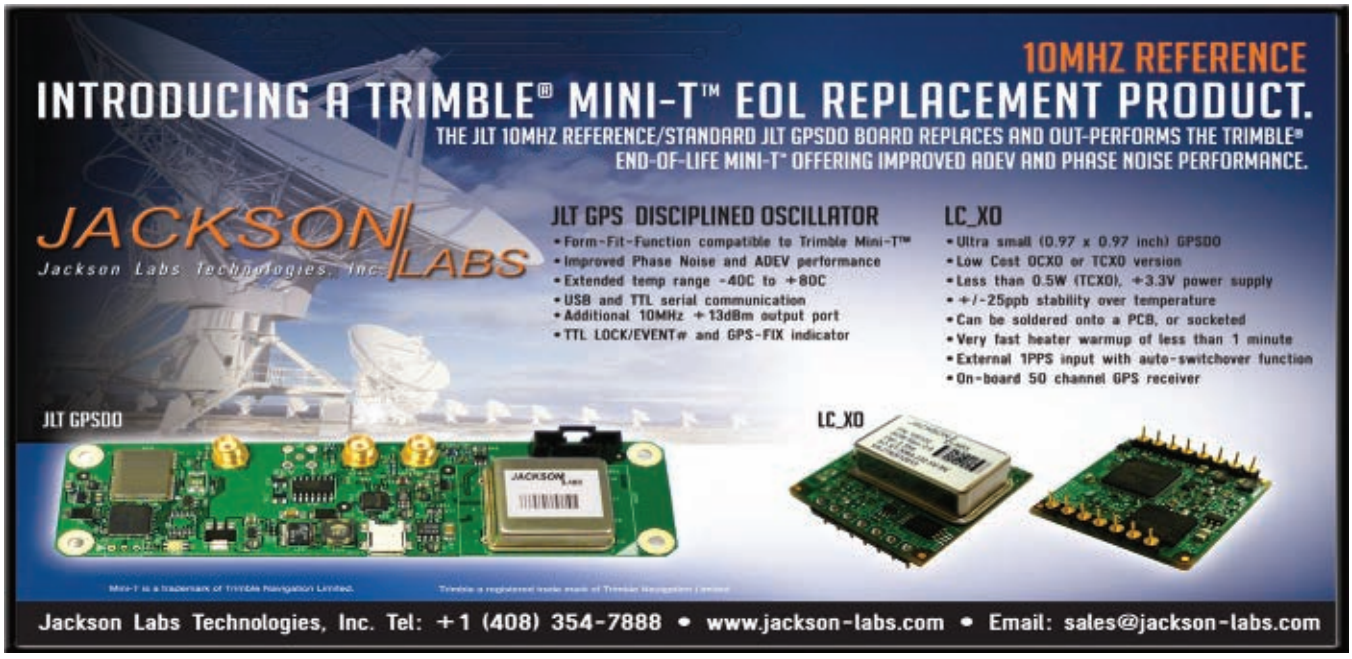
Transistor	*Frequency Range*	*Typical Gain at 7.5 dB Power Back-off*	*Typical ACLR at 7.5 dB Power Back-off*	*Typical Drain Efficiency at 7.5 dB Power Back-off*
CGHV22100	1.8 to 2.2 GHz	21 dB @ 44 dBm	-37 dBc @ 44 dBm	32% @ 44 dBm
CGHV27100	2.5 to 2.7 GHz	18 dB @ 44 dBm	-37 dBc @ 44 dBm	33% @ 44 dBm
CGHV22200	1.8 to 2.2 GHz	19 dB @ 47 dBm	-37 dBc @ 47 dBm	32% @ 47 dBm
CGHV27200	2.5 to 2.7 GHz	16 dB @ 46.5 dBm	-37 dBc @ 46.5 dBm	29% @ 46.5 dBm



▲ *Fig. 2 Typical gain, drain efficiency and ACLR vs. output power of the CGHV27100 measured in CGHV27100-TB amplifier circuit (V_{DS} = 50 V, I_{DS} = 0.5 A, 1c WCDMA, PAR = 7.5 dB).*



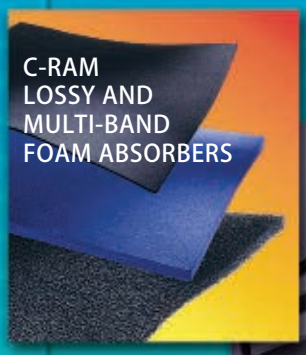
▲ *Fig. 3 CGHV22200 typical linearity under DPD vs. output power (V_{DD} = 50, I_{DQ} = 1.0 A, Freq = 2.14 GHz, 1c WCDMA 7.5 PAR).*



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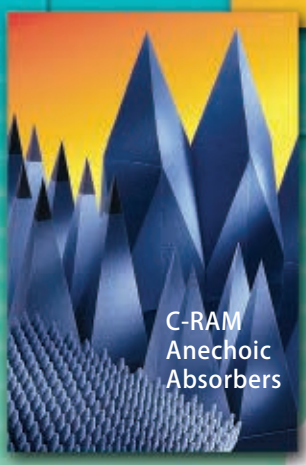


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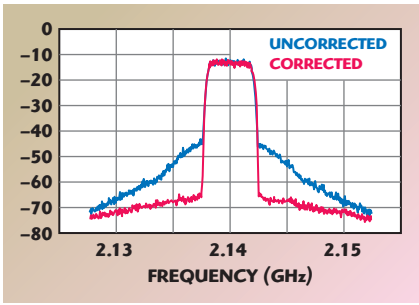
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plots for the CGHV22200F transistor as a function of frequency and output power. This part produces 47 dBm of average output power under the same signal stimulus as described previously, again providing drain efficiencies of over 30 percent in Class A/B operation. Figure 3 also shows the correctability of the 50 V transistors under digital predistortion (DPD). ACLR in this case is corrected from –37 to –54 dBc at 50 W of average output power (well within the required specification). ***Figure 4*** shows a spectral plot for the uncorrected and corrected signals at 50 W of average output power.

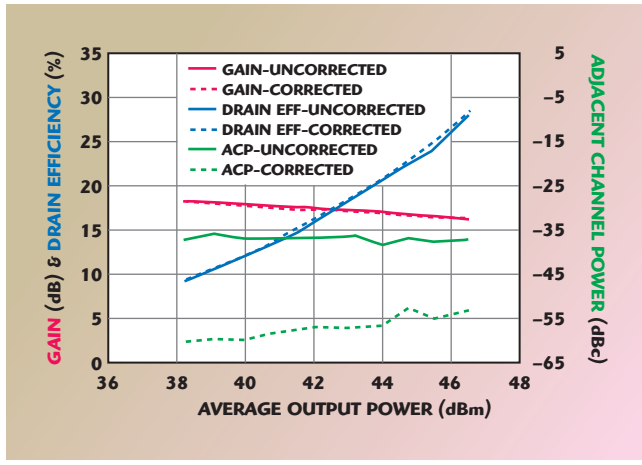


▲ *Fig. 4 CGHV22200 spectral mask at P_{AVE} = 47 dBm with and without DPD (V_{DD} = 50, I_{DQ} = 1.0 A, Freq = 2.14 GHz, 1c WCDMA 7.5 PAR).*



▲ *Fig. 6 CGHV27200F evaluation board.*

Figure 5 shows the equivalent plots for the CGHV27200F transistor as a function of frequency and average output power. Power gains of 16 dB are available in the 2.63 to 2.69 GHz band, for example. This high gain is useful in reducing the driver stage requirements lowering the cost of a complete PA line-up. Figure 5 also shows the correctability of the CGHV27200F at 45 W average output power where DPD correction of 20 dB is possible.



▲ *Fig. 5 CGHV27200 typical linearity under DPD vs. output power (V_{DD} = 50 V, I_{DQ} = 1.0 A, Freq = 2.6 GHz, 1c WCDMA 7.5 dB PAR).*

Figure 6 shows a typical evaluation printed circuit board (for the CGHV27200F) indicating that the additional matching required at the board level is relatively simple and straightforward. Both the CGHV22100/CGHV22200 and CGHV27100/CGHV27200 transistors have been employed in asymmetric two-way Doherty power amplifier (DPA) demonstrators providing 45 W of average power under W-CDMA signal stimulation with a 7.5 dB PAR in the 2.11 to 2.17 GHz and 2.63 to 2.69 GHz frequency bands, respectively. Drain efficiencies of 50 percent have been achieved for these DPAs (CDPA22300 and CDPA27300) with DPD correction that meet relevant specifications. The power gains for these DPAs is 19 to 20 dB at 2.14 GHz and 15 to 16 dB at 2.66 GHz. In addition to high DPA gains the 50 V transistors provide lower drain-to-source capacitance per watt compared to 28 V operation. This impacts the off-state impedance of the peaking amplifier which, in turn, loads the main (carrier) amplifier resulting in increased overall efficiency and operating bandwidth.

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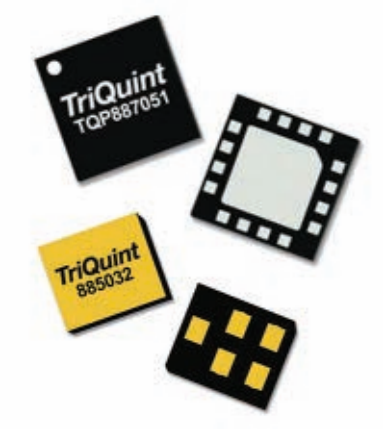






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802.11ac Modules and WLAN/LTE Filters

As demand for Wi-Fi increases, consumers have developed an ever-growing appetite for faster mobile data rates to support video streaming and other multimedia applications. With data rates up to 1.3 gigabits per second, the new IEEE 802.11ac standard will enable transfer rates three to four times faster than current-generation 802.11n Wi-Fi.

TriQuint Semiconductor introduced its first 802.11ac ready module for mobile devices last year. The dual-band product has been selected by a major manufacturer for its next-generation smartphone and is included on a reference design by a leading chipset supplier.

Now, TriQuint is enabling next-generation 802.11ac Wi-Fi with the introduction of three new high-performance WLAN front-end modules and two advanced Wi-Fi/4G coexistence filters. The company has captured smartphone design wins with its two 5 GHz 802.11ac Wi-Fi RF modules, as well as its new 2.4 GHz product. Thanks to advances in output power technology, all three TriConnect™ Wi-Fi modules provide extended operating ranges when compared with earlier products. For Wi-Fi users, that means the freedom of wireless connectivity across longer distances.

The TQP887051 is a 5 GHz WLAN PA and low noise amplifier with a bypass mode plus an SP2T switch MMIC and directional detector. It covers 802.11a, n and ac applications and is packaged in a module that is 2.5 × 2.5 × 0.4 mm in size. ***Figure 1*** shows the EVM performance

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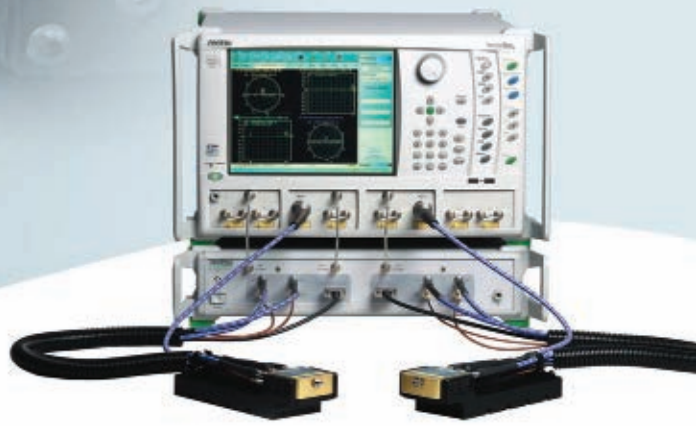
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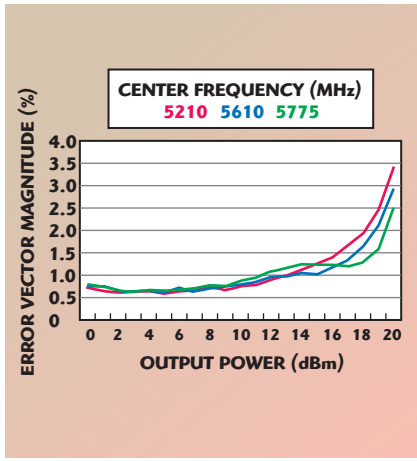


Fig. 1 TQP887051 802.11ac performance (MCS9/VHT80-DEVM).

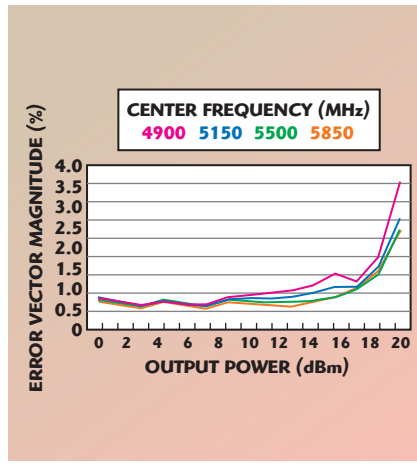


Fig. 2 TQP887052 802.11ac performance (MCS9/VHT80-DEVM).

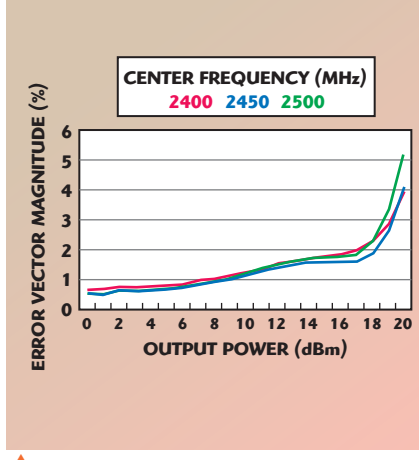


Fig. 3 TQF9046 802.11n performance (MCS7/HT20-DEVM).

of the TQP887051. The TQP887052 is also a 5 GHz WLAN PA and SP2T switch MMIC packaged in a 2.5 × 2.5 × 0.4 mm module covering 802.11a, n and ac applications. ***Figure 2*** shows the EVM performance of this module. The TQF9046 is a 2.4 GHz WLAN PA and low noise amplifier with a bypass mode plus an SP3T switch MMIC for a Bluetooth® Path and directional detector. It covers 802.11b, g and n applications and is packaged in a module that is 2.5 × 2.5 × 0.4 mm in size. ***Figure 3*** shows the EVM performance of this module.

In addition to power amplifier modules that enable faster speeds, demand is surging for high-performance Wi-Fi/LTE coexistence filters. Today's high-end smartphones contain a growing number of cellular and Wi-Fi bands to support 2G/3G/4G voice and data services, as well as global roaming. At the same time, the global spectrum crunch is leading governments around the world to squeeze new 4G bands next to pre-existing Wi-Fi spectrum, often with minimal guard bands. Advanced filter technology is needed to mitigate the resulting interference issues.

TriQuint is expanding its WLAN product line with two new specialty 4G/Wi-Fi coexistence filters. These high-performance filters serve as electronic traffic guards to keep signals in the crowded 2.4 GHz spectrum isolated from one another. They leverage TriQuint's advanced bulk acoustic wave (BAW) technology to address some of the industry's toughest filtering challenges.

The 885032 is an LTE/Wi-Fi coexistence filter with bands 7/41 rejection and low loss. It covers 2.4 GHz WLAN application and is 1.4 × 1.2 × 0.5 mm in size. The 885033 is an LTE/Wi-Fi coexistence filter with bands 38/40 rejection and low loss. It covers 2.4 GHz WLAN applications and is 1.4 × 1.2 × 0.5 mm in size. Both products address coexistence issues for bands 38/40/7/41; however, the 885032 is optimized to provide the best performance for bands 7/41 while the 885033 is optimized for bands 38/40.

TriQuint's broad portfolio of WLAN modules and coexistence filters are designed to meet the most challenging needs of mobile device manufacturers today. Leveraging both its MMIC and BAW filter expertise allows it to control the complete design and manufacturing process to deliver high-performance solutions.

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Hillsboro, OR,
info-networks@tqs.com,
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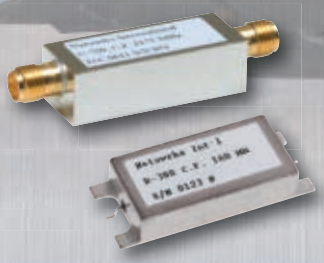
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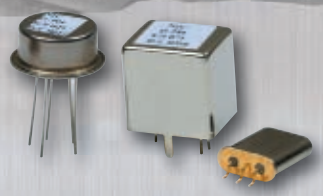
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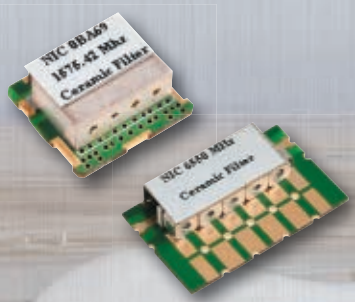
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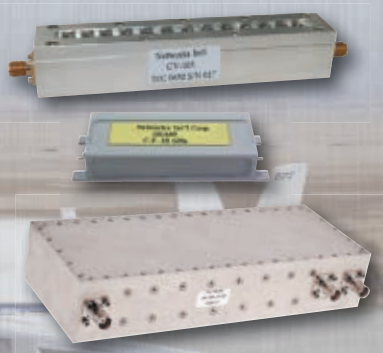
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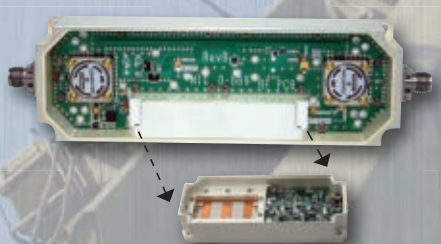
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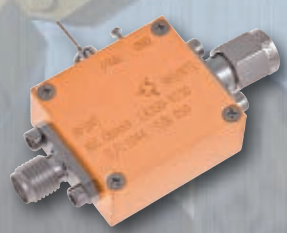
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10 W, 100 MHz to 20 GHz Amplifier

The Giga-tronics GT-1000B microwave power amplifier incorporates the CAP Wireless patented Spatium™ spatial combining architecture solid-state amplifier. The Spatium technology amplifier is based on a solid-state parallel MMIC technology with exceptionally wide bandwidth and high power. The unique circuit topology is highly reliable, with performance that excels where extremes of bandwidth and power are demanded.

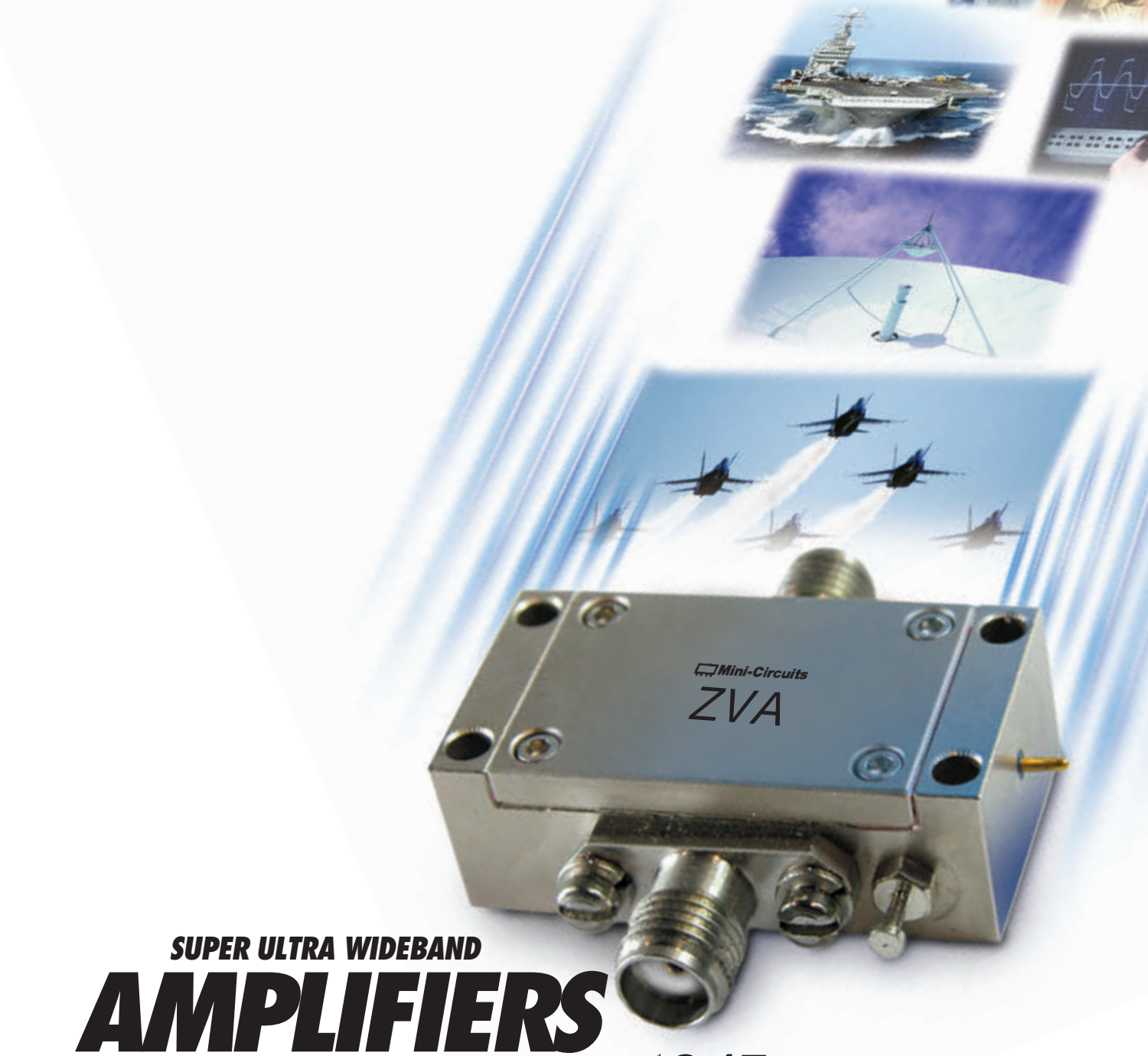
The Giga-tronics GT-1000B provides excellent pulse fidelity, low intermodulation distortion, high linearity and superior gain flatness without the warm-up time, drift or aging issues of traveling wave tube amplifiers (TWTA). The GT-1000B features low noise figure, low harmonics and spurious content, and is highly tolerant to load mismatch.

The microwave power amplifier offers linear high-power amplification across multi-octave bands. It is ideal for testing in EMC, wireless communications applications and defense EW systems. For EMI/EMC and standards laboratories, the GT-1000B with 100 MHz to 20 GHz frequency range allows broadband testing without band switching or swapping narrow band amplifiers resulting in faster and more accurate testing (see ***Figure 1***). The product complies with the essential requirements of the following applicable European Directives, and carries the CE mark accordingly: 89/336/EEC and 73/23/EEC EMC, EN61010-1 (1993) and EN61326-1 (1997).

The amplifier can be used in wireless communications and component testing wherever a highly linear amplifier is needed, such as testing RFICs and MMICs, or testing base station transmitters with high crest factor signals and high peak-to-average power levels. The GT-1000B provides high power for testing limiters, step recovery diodes (SRD) or driving traveling wave tubes (TWT).

This microwave power amplifier with excellent pulse fidelity is well suited for many

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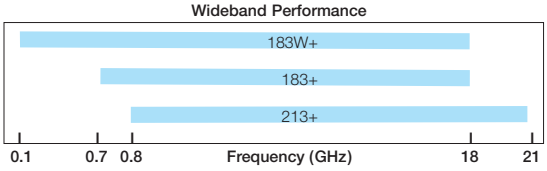
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Model	Frequency (GHz)	Gain (dB)	P1dB (dBm)	IP3 (dBm)	NF (dB)	Price $ * (Qty. 1-9)
NEW ZVA-183WX+	0.1-18	28±3	27	35	4.0	1345.00
ZVA-183X+	0.7-18	26±1	24	33	3.0	845.00
ZVA-213X+	0.8-21	25±2	24	33	3.0	945.00

* Heat sink must be provided to limit base plate temperature.To order with heat sink, remove "X" from model number and add $50 to price.

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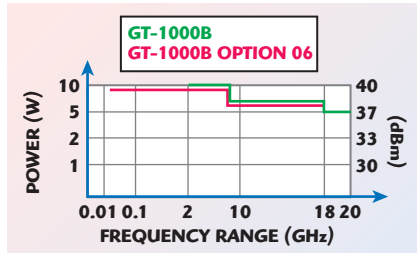


Fig. 1 GT-1000B and GT-1000B, option 06 power vs. frequency.

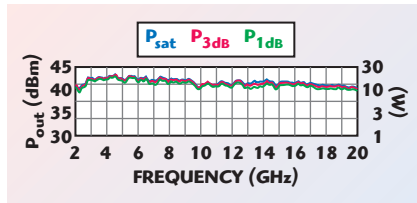


Fig. 2 GT-1000B output power vs. frequency (typical).

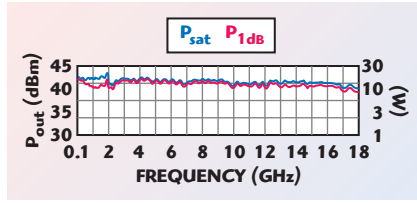


Fig. 3 GT-1000B option 06 output power vs. frequency.

aerospace and defense applications, including EW, ECM, ECCM, radar and satellite system signal simulation and testing. The GT-1000B is an ideal ATE system building block for boosting test signals to overcome cable and connector loss whenever long cable runs are needed in assembly bays, environmental test chambers or field locations.

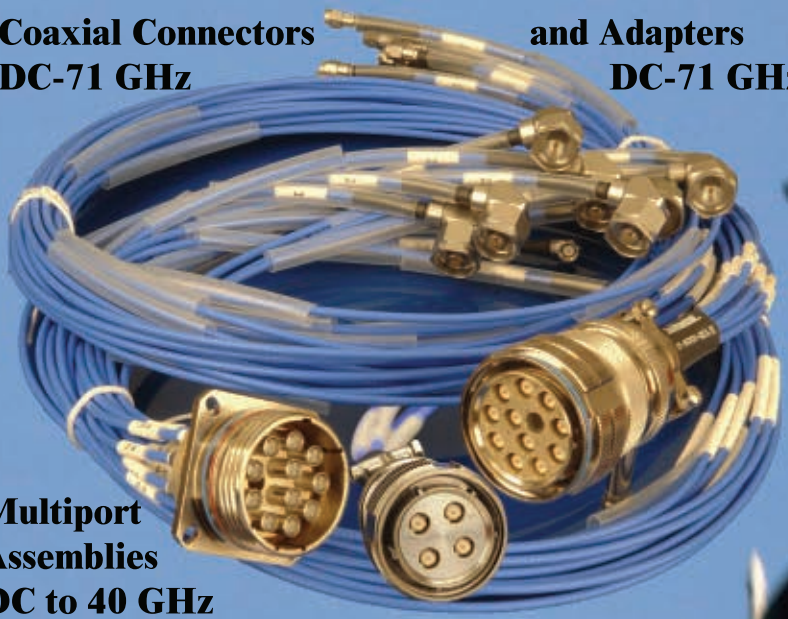
The amplifier provides up to 40 dB of gain over the 100 MHz to 20 GHz frequency range (see ***Figures 2*** and ***3***). An optional coupler/detector is available for external power monitoring or for external leveling a companion microwave signal generator. The GT-1000B can be paired with a Giga-tronics 2520B microwave signal generator, increasing the overall output power while preserving the synthesizer's fast switching speed, modulation, and high signal fidelity. The microwave power amplifier offers linear high-power amplification across multi-octave bands and is ideal for many testing applications.

VENDORVIEW

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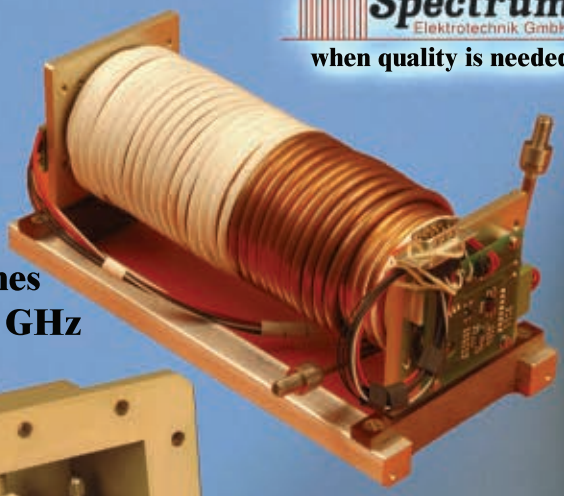
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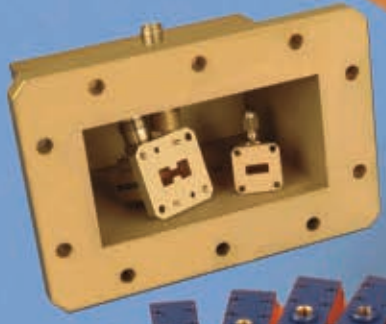
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Dow-Key Microwave offers switch matrices with flexible and efficient architecture allowing for combining multiple switch configurations in a single box, in addition to, offering trouble-free maintenance for field upgrades and repairs due to modularity. This product line offers COTS switch solutions with a fast switching time of 50 ms maximum. Starting with the most basic model, the MS-series is populated with individual coaxial switches with a wide selection of SP2T through SP12T switches mounted either onto the rear panel or inside a chassis, and can be combined to meet any type of switching needs. For a multiplexing requirement, where one input is routed to multiple outputs, Dow-Key's MP-series is best suitable; ranging from 1×13 up to 1×143. For a more advanced switching requirement, where any input needs to be switched to any output, Dow-Key's crossbar CB-series is the perfect solution with configurations starting at 2×2 in 2U-chassis up to 12×12 outfitted in 3U-chassis.

All solutions are bi-directional and can be selected with terminated ports. Switches are available with frequencies of DC to 18 GHz, and with DC to 26.5 GHz and DC to 40 GHz for some configurations. In terms of software, matrices can be manually controlled from the front panel via a LCD/keypad for 1U solutions or via a touch screen LCD with GUI for 2U-4U designs. Remotely, all systems are equipped with RS-232 and USB controls, with a choice between GPIB and Ethernet with built-in website.

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(800) 266-3695,
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Broadband Bi-Directional Amplifier for Data Links

Triad RF Systems has introduced the model TTRM1010 bi-directional amplifier module for commercial and military data links and other communications applications in which the ability to "bolt on" additional RF output power to a low-powered transceiver while increasing its receive performance can dramatically expand the host system's range. It delivers 5 W (+37 dBm) from 30 MHz to 3 GHz in a compact, rugged enclosure measuring only 3.25" × 2" × 1". Specific applications include remotely-controlled mobile robots that search disaster sites (or a building suspected of housing the enemy), small UAVs increasingly used for police surveillance and various non-law enforcement scenarios, and enterprise voice, data, and video surveillance or communications networks that need to serve a larger area than when they were installed.

The TTRM1010 combines high-performance transmit as well as receive sections, high-speed T/R switching, a power supply with a wide input voltage range of +9 to +36 VDC, and protection circuits for high load mismatch (VSWR) and over-temperature conditions. The transmitter employs a GaAs MMIC-based amplifier lineup and the receive section achieves a noise figure of 4 dB. The module can be specified for indoor or outdoor use and operates over a temperature range of –20° to +85°C and an altitude up to 30,000 feet.

The transmit section has a typical third order intercept point (OIP3) of +47 dBm, gain of 23 dB±1 dB, and typical harmonic and spurious signal rejection of –60 dBc. The receive section has gain of 20 dB±1.5 dB and a noise figure of 4 dB. Switching time from transmit to receive is less than 2 µs, and typical return loss of both sections ranges from –14 to –16 dB. The module is switched to transmit or receive via a TTL input and an analog voltage output is provided for temperature monitoring.

Triad RF Systems Inc.,
East Brunswick, NJ
(855) 558-1001,
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USB-4SPDT-A18	4	0.25	1.2	80	10	1180.00
NEW USB-8SPDT-A18	8	0.25	1.2	80	10	2495.00

* See data sheet for an extensive list of compatible software.

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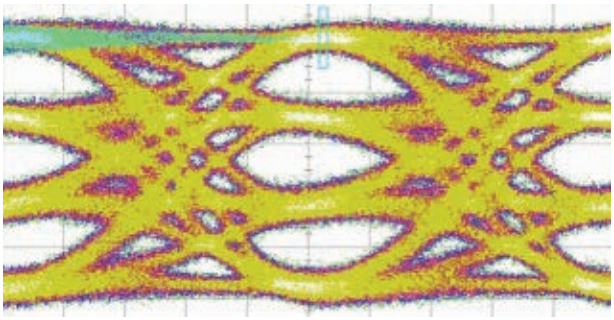
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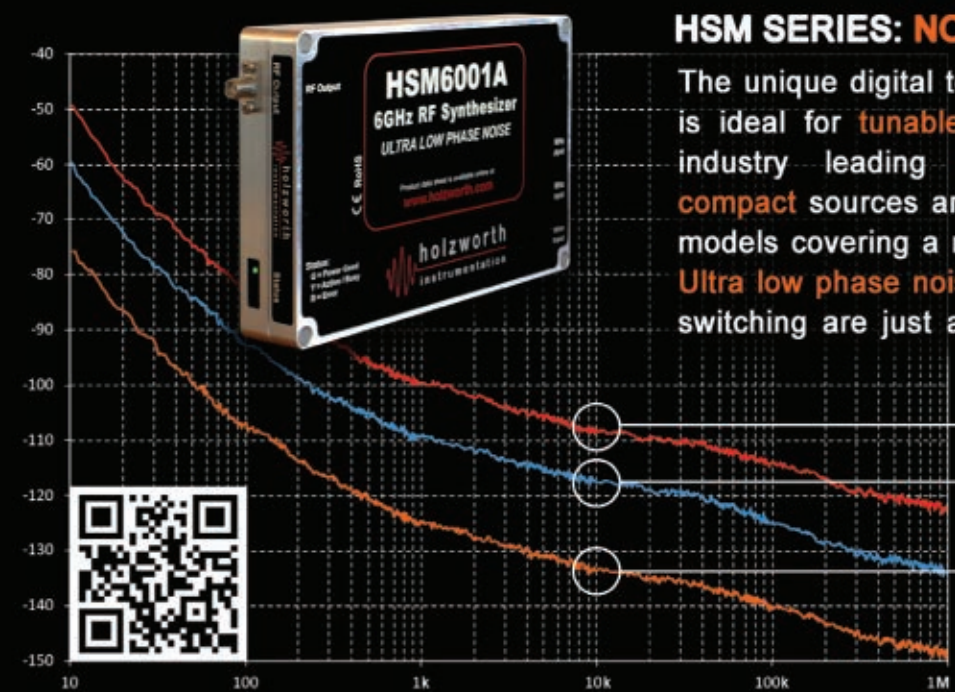
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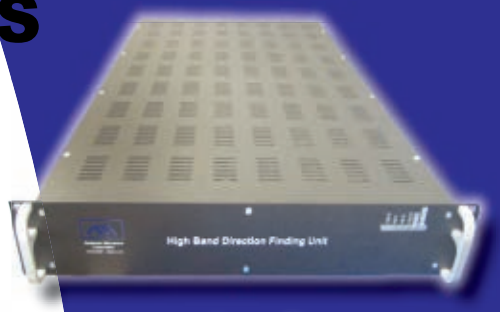
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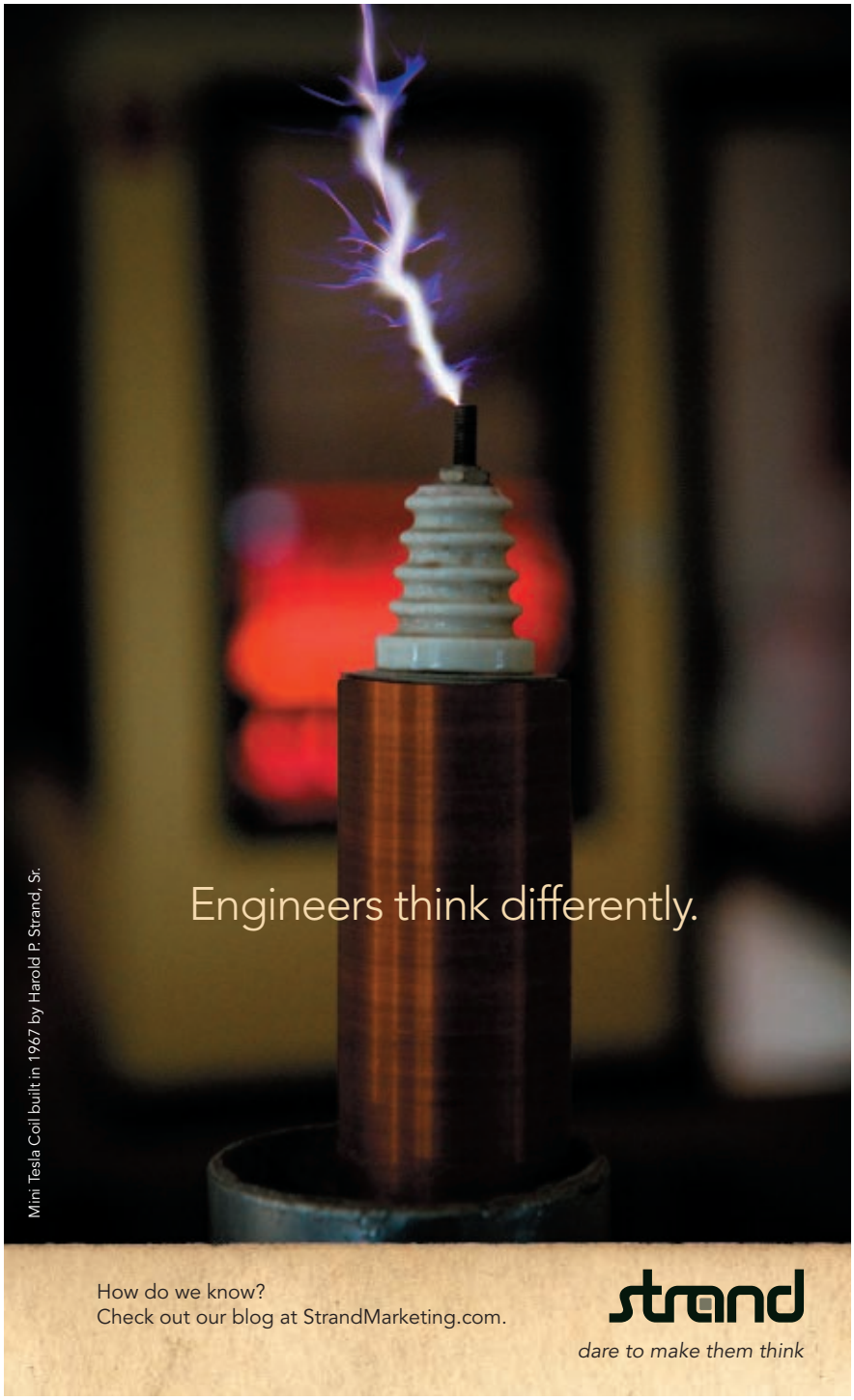
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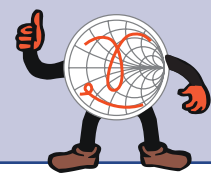
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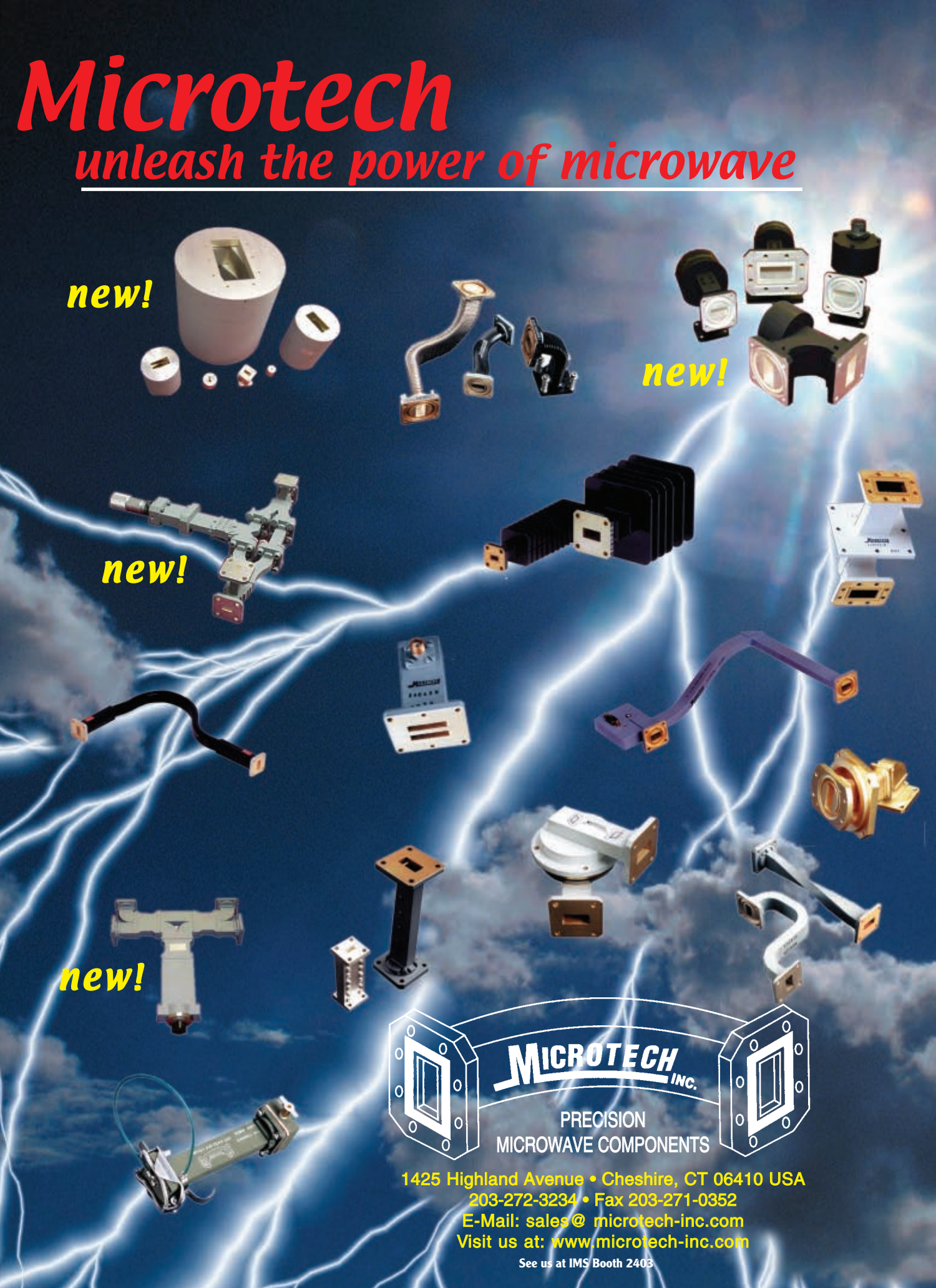
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Booth 201
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Booth 323
Advanced Test Equipment Rentals
RF Amplifier

Booth 209
Norden Millimeter Inc.
Frequency Multipliers

Booth 119
Massachusetts Bay Technologies Inc.
Attenuator Pads

Booth 326
Intercept Technology Inc.
PCB Layout Software

Booth 244
SignalCore
IQ Transceiver

Booth 130
RF Techniques
Cellular Applications Components

Your Product Guide to the Show Floor

Shaded exhibitors have a product featured in the IMS Product Showcase pages to follow. Look for these products at this year's IMS 2013.



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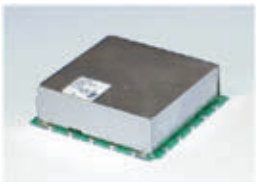
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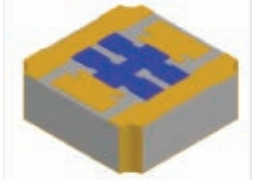


APA Wireless half-inch PLLs provide all of the functionality of a full synthesizer in a half-inch package. Single frequency, coaxial resonator based or wideband – available in a package that can be customized to your unique requirements. Choose from a variety of standard frequencies up to 6 GHz or customize a unit for frequency and output power. These low power units are programmed via a standard three line interface and operate over the industrial temperature range.

www.apawireless.com

Massachusetts Bay Technologies Inc. — Booth 119

Attenuator Pads

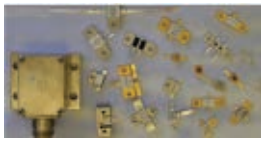


The Massachusetts Bay Technologies aluminum nitride fixed attenuator chips are fabricated using state-of-the-art thin film process and advanced photolithography technology. All devices are available in chip form with a metalized ground connection on the back. This ground is wrapped around on the four corners of the chip so additional ground bonding ribbon is not required. The chips may be attached using conductive epoxy or solder preform. Gold contacts on the input and output pads make assembly fast and reliable.

www.massbaytech.com

RF Techniques — Booth 130

Cellular Applications Components



RFT's technical staff has extensive experience in the design of high power RF/microwave amplifiers, combiners and other components for cellular applications. This gives RFT a unique capability to meet customers' custom component requirements. A wide range of high reliability power resistor packages are available in Alumina, AlN and BeO substrates. RF Techniques uses a high temperature brazing process which yields a lower thermal resistance path and higher power handling capability and power derating up to 250°C.

www.rftechniques.com

Eclipse Microwave — Booth 201

Custom Components

Eclipse Microwave designs and manufactures a wide selection of microwave products for the aerospace, defense and commercial wireless communication industries. Its website lists a complete line of standard products. The company specializes in custom components. It encourages its customers to discuss their applications, special mechanical configuration and/or unique electrical requirements.

www.eclipsemicrowave.com

Norden Millimeter Inc. — Booth 209

Frequency Multipliers



Need to multiply a frequency source, but keep it clean? Norden has produced X8 frequency multipliers that are -60 dBc clean of the undesired multiples. Norden has vast experience producing frequency multipliers for test equipment systems as well as ELINT, ECM and communication systems. Norden can incorporate attenuation control, output power detectors, temperature compensation and other features if needed.

www.nordengroup.com

SignalCore — Booth 244

IQ Transceiver

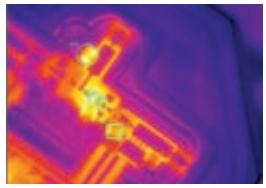


SignalCore introduced a 400 MHz to 6 GHz RF front-end IQ transceiver that features wide IF bandwidth (160 MHz) and high dynamic range. The transceiver is comprised of a dual independent channel 6 GHz signal source, an IQ demodulator and an IQ modulator. The transceiver meets the wide signal bandwidth requirement for modern wireless applications such as wireless test systems, software defined radio and multichannel coherent systems. The dual channel source provides the flexibility of transmitting and receiving on different frequency bands.

www.signalcore.com

Mercury Systems — Booth 304

High Power Switches



Mercury Systems introduced its line of high power switches from SP1T to SP3T devices up to 1 kW CW for reflective configurations and input matched topologies up to 400 W CW. Each is available in octave bandwidths from 20 MHz to 18 GHz with as low as 0.4 dB insertion loss and 40 to 60 dB isolation. Custom transfer and cross matrices through 24 ports and SWaP optimized solutions combining switches with control functions are available, as well as the company's catalog products.

www.mrcy.com

Advanced Test Equipment Rentals — Booth 323

RF Amplifier



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www.atecorp.com

Intercept Technology Inc. — Booth 326

PCB Layout Software



Intercept's award-winning Pantheon PCB layout software with specialized RF and Hybrid user flows is now more affordable than ever. Integrated with a full CAD/CAE environment flow, Intercept's software includes bidirectional RF simulation interfaces to HFSS and AWR, RF models, reuse blocks, multi-board capabilities, panel arrays, artwork panelization, layout driven design and prototyping, automatic drawing creation, design automation, DFM checking, artwork verification, 35+ database translators and more. Visit the company at Booth 326 for a demo.

www.intercept.com

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No signal is invisible

AV4036G Spectrum Analyzer



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CETC 41

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Frequencies of wave guide components up to 325 GHz



Attenuator
Frequency up to 67GHz
Max attenuation up to 40dB

Power Divider
Up to 67GHz
High Isolation
Amplitude Balance: ±0.2

Coaxial Switch
Frequency up to 67GHz
Long life: >1 million cycles
Isolation: 80dB

Amplifier
Frequency up to 100GHz
Gain: 45dB

Mixer
Frequencies up to 325GHz
Fundamental wave and harmonic mixer

Microwave/millimeter wave filter
Frequency up to 110GHz
Insertion Loss: <1.5

Please visit www.ei41.com for more information

The 41st Institute of China Electronics Technology Group Corporation

Address: No. 98, Xiangjiang Rd, Economy & Technology Development Zone, Qingdao, China
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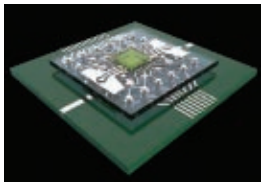
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Shanghai Viewtran Exhibition Co., Ltd.
Tel: +86-21-32516618 E-mail: expo@vtexpo.com.cn
Website: www.imwexpo.com

IMS PRODUCT SHOWCASE: AISLES 300-400

AWR Corp. Booth 330

Software Demos

Stop by Booth 330 to catch a preview of AWR V11. In addition to many new MMIC specific features and enhancements in AWR's flagship Microwave Office® software, its Analyst™ 3D FEM EM software will also be debuting a new 3D CAD editor. Visual System Simulator™ (VSS) software and AXIEM® 3D planar EM software will also be on display, as well as joint design and test solutions with parent company National Instruments.



VENDORVIEW

www.awrcorp.com

Aeroflex/Weinschel Inc. Booth 340

MMIC Digital Attenuators



Aeroflex/Weinschel's model 4205 series of MMIC digital attenuators operate over the 0.2 to 6 GHz frequency range and is in a variety of attenuation ranges up to 95.5 dB in 0.5 dB steps. These units can be controlled using either standard TTL or USB interfaces. These units are ideal for automated test equipment (ATE), WiMAX, 3G fading simulators, engineering/production test lab environments.

VENDORVIEW

www.aeroflex.com/weinschel

Logus Microwave Booth 415

Coaxial Switch

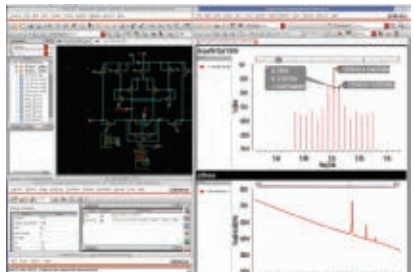


Logus Microwave added another space qualified, high power SPDT TNC coaxial switch to its extensive line of space qualified products. Available in many frequency bands, this (320 W multipaction free) design operates from 1160 to 1220 MHz at 160 W CW. Boasting return loss > 20 dB, insertion loss < 0.15 dB and isolation > 65 dB, this unit also performs flawlessly from 24 to 43 V DC over the -25° to +85°C operating temperature range all while drawing less than 150 milliamps.

www.logus.com

Cadence Design Systems Booth 427

RFIC Simulation



Cadence's Spectre® RF is a production proven, accurate and high performance RFIC simulation solution, with support for industry standard models. Integrated in the Virtuoso Analog Design Environment, Spectre RF delivers a unique and comprehensive set of analyses in both the time and frequency domains with proprietary Smart Harmonic Balance and Shooting Newton engines for simulation of nonlinear and linear behavior of RF application circuits. The latest release features support for new passive components and improved scalable multi-core performance.

www.cadence.com

National Instruments Booth 430

Vector Signal Transceiver



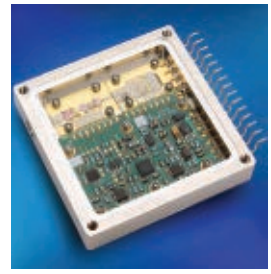
The NI PXIe-5645R is built on a software-designed architecture that engineers can modify with LabVIEW to meet their specific needs. The new vector signal transceiver adds a high-performance, differential or single-ended I/Q interface to test both the RF and baseband signals of a device with a single instrument for faster test times using the latest PC and FPGA technologies; with frequency coverage from 65 MHz to 6 GHz, 80 MHz of bandwidth and a user-programmable FPGA.

VENDORVIEW

www.ni.com

Phase Matrix Booth 430

Integrated Microwave Assembly



Phase Matrix's custom integrated microwave assembly (IMA) capabilities will be on display in Booth 430. The Phase Matrix team designs assemblies using the most advanced technology available to achieve high operating frequencies up to 67 GHz. Example assemblies include frequency converters, diplexers, filters, amplifiers, transceivers, QuickSyn® synthesizers and various oscillator assemblies. In addition to IMAs, Phase Matrix designs and manufactures custom RF/MW components and microwave instruments and is a wholly owned subsidiary of National Instruments.

www.phasematrix.com

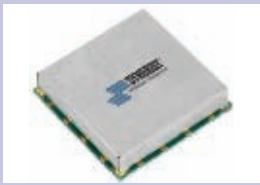
Synergy Microwave Corp. Booth 404

DROs



Synergy Microwave introduced standard free running DROs operating at X-Band. These DROs produce phenomenal phase noise of -111 dBc/Hz at 10 kHz offset and have electronic tuning capability that allow for connection in phase locked sources that are also available. They can also be mechanically tuned for optimal output frequency with up to 3 MHz of typical tuning range. These products are ideal for radar applications, M-QAM modulation in LTE, LMDS, fixed PTP digital radio/Satellite links and research labs.

SAW Oscillators

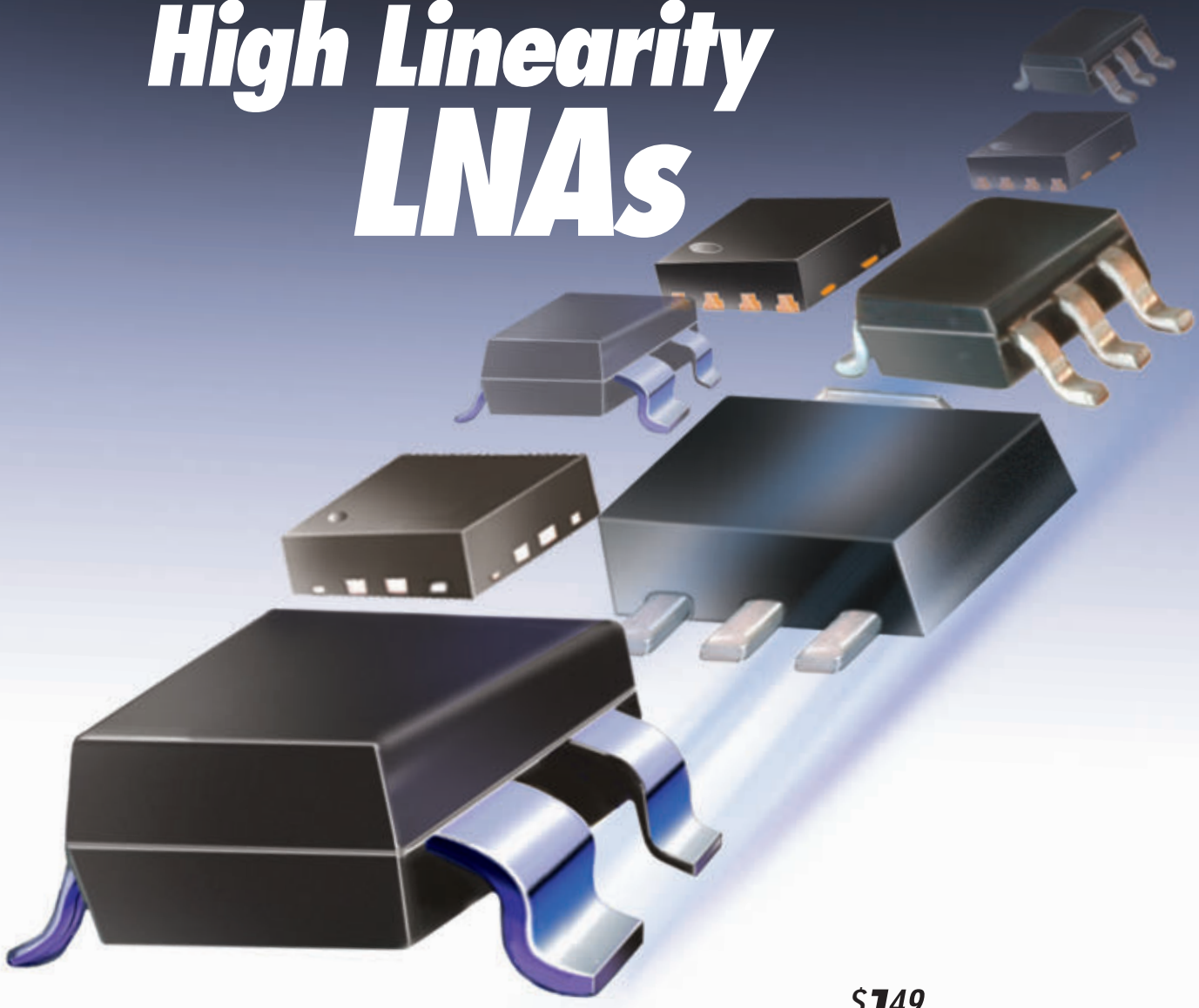


Ultra-low phase noise SAW oscillators and SAW phase locked oscillator sources are proudly displayed by Synergy Microwave Corp. These products can limit noise to -150 dBc/Hz at 10 kHz offset in optimized frequency bands in the range of 500 through 1000 MHz. They are used in single carrier frequency generation such as clock translators for SONET, ADC, DDS, instrumentation and RADAR. These SAW-based solutions offer significant noise floor improvements and are ideal replacements for multiplied crystal oscillator solutions.

www.synergymwave.com



High Linearity LNAs



NF as low as 0.5 dB • IP3 up to 43 dBm • DC current 20 mA and up

from $1.49 ea. (qty. 20)

Pick your parameters, and meet your needs at Mini-Circuits! With over 20 low noise/high linearity amplifier models to choose from, you'll likely find the output power, gain, DC current, and broad bandwidths required to upgrade almost any 3-to-5V circuit—from cellular, ISM, and PMR to wireless LANs, military communications, instrumentation, satellite links, and P2P—and all at prices that preserve your bottom line!

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RoHS compliant

Model	Freq. (MHz)	Gain (dB)	NF (dB)	IP3 (dBm)	P_{out} (dBm)	Current (mA)	Price $ (qty. 20)
PMA2-162LN+	700-1600	22.7	**0.5**	**30**	20	55	2.87
PMA-5452+	50-6000	14.0	**0.7**	**34**	18	40	1.49
PSA4-5043+	50-4000	18.4	**0.75**	**34**	19	33 (3V) 58 (5V)	2.50
PMA-5455+	50-6000	14.0	**0.8**	**33**	19	40	1.49
PMA-5451+	50-6000	13.7	**0.8**	**31**	17	30	1.49
PMA2-252LN+	1500-2500	15-19	**0.8**	**30**	18	25-55 (3V) 37-80 (4V)	2.87
PMA-545G3+	700-1000	31.3	**0.9**	**33**	22	158	4.95
PMA-5454+	50-6000	13.5	**0.9**	**28**	15	20	1.49

Model	Freq. (MHz)	Gain (dB)	NF (dB)	IP3 (dBm)	P_{out} (dBm)	Current (mA)	Price $ (qty. 20)
PGA-103+	50-4000	11.0	**0.9**	**43**	22	60 (3V) 97 (5V)	1.99
PMA-5453+	50-6000	14.3	**0.7**	**37**	20	60	1.49
PSA-5453+	50-4000	14.7	**1.0**	**37**	19	60	1.49
PMA-5456+	50-6000	14.4	**0.8**	**36**	22	60	1.49
PMA-545+	50-6000	14.2	**0.8**	**36**	20	80	1.49
PSA-545+	50-4000	14.9	**1.0**	**36**	20	80	1.49
PMA-545G1+	400-2200	31.3	**1.0**	**34**	22	158	4.95
PMA-545G2+	1100-1600	30.4	**1.0**	**34**	22	158	4.95
PSA-5455+	50-4000	14.4	**1.0**	**32**	19	40	1.49



PSA PMA PGA

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U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

506 rev C

See us at IMS Booth 2311

Rohde & Schwarz — Booth 440

Thermal Power Sensor



The R&S NRP-Z58 is the first power sensor that covers the frequency range continuously from DC to 110 GHz. The sensor's high speed of over 300 measurements per second in buffered mode allows especially fast power measurements, in addition to offering the largest dynamic range (55 dB). It can be connected directly to a PC via a USB interface, the R&S NRP2 base unit or be used with nearly any generator or analyzer from Rohde & Schwarz.

Broadband Amplifier



The new R&S BBA 150 broadband amplifier enables EMC testing in the microwave range. These compact, lightweight amplifiers with their state-of-the-art design are optimized for high frequencies starting at 0.8 GHz. The first model in the R&S BBA150 family covers the 0.8 to 3 GHz frequency band and is available with an output power ranging from 30 to 200 W. The modular concept protects customer investments and makes it possible to extend the amplifier's power and frequency range.

Handheld Spectrum Analyzers



The R&S FSH family of handheld spectrum analyzers has been extended with two new models: the R&S FSH13 covering the range from 9 kHz to 13.6 GHz and the R&S FSH20 covering the range to 20 GHz. The compact platform has a rugged lightweight design and integrates numerous measurement functions that can be used to analyze transmit signals and interference, measure performance and much more.

Vector Signal Generator



With the R&S SMBV100A signal generator, manufacturers of WLAN IEEE 802.11ac chipsets, components and devices can now easily generate signals up to 160 MHz bandwidth. The R&S SMBV100A is also the only signal generator directly supporting high-speed modes for WLAN IEEE 802.11ac. An external PC is not needed. In the 5 GHz ISM band, the R&S SMBV100A offers exceptional signal performance (0.44 percent EVM) for 160 MHz signals.

RF and Microwave Signal Generator



New harmonic filter options are now offered for the R&S SMB100A microwave signal generator. These filters make it possible to achieve a harmonic suppression of more than -50 dBc over a wide frequency range (150 MHz to 40 GHz), or at frequencies below 3 GHz up to -58 dBc, improving the signal quality of the signal generator and consequently the measurement accuracy.

VENDORVIEW

www.rohde-schwarz.com

MITEQ — Booth 504

Compliance Testing Amplifiers



MITEQ's new TTA series are high performance broadband low noise amplifiers specially developed for electromagnetic (EMC) compliance testing. Complete frequency coverage from 1 MHz to 40 GHz is possible with three separate TTA amplifiers. They are enclosed in a small (5.1" × 3.5" × 1.9") lightweight EMI/RFI case and can be used easily in the EMC test setup. A universal wall plug-in power supply is included with each TTA which operates from 50 to 60 Hz/100 to 240 VAC.

VENDORVIEW

www.miteq.com

TRU Corp. — Booth 512

Cable Assemblies



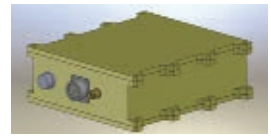
TRUcore™ series cable assemblies offer a new level of RF and microwave performance combined with superior mechanical and environmental durability. TRUcore series assemblies are available for 18, 26.5, 40 and 50 GHz broadband electrical performance. TRUcore series cable assemblies utilize an innovative core design that provides excellent phase stability over temperature and offers greater than two times the crush and torsional resistance of industry specifications even while remaining under load conditions.

www.trucorporation.com

Keragis Corp. — Booth 517

X-Band Amplifier

Keragis Corp. has a new 1000 W (KHPA0811-1000 WPA) pulsed X-Band amplifier in a small package. The package size is approximately 8" × 6.5" × 2.75" (not including heat sinks). The unit is all solid-state and can provide up to 20 percent duty cycle. The unit is ideal for radar applications from 8 to 11 GHz.



www.keragis.com

San-tron — Booth 520

Low PIM Cables



San-tron has extended its line of SRX™ cable assemblies for low PIM requirements. The SRX line is an engineered suite of low PIM cable assemblies designed to support system integrators. Several different deployment scenarios encompassing cabinet integration, short cable runs or jumper applications, long haul cable runs, indoor use, outdoor use, riser and plenum environments have been accommodated for and include interconnect options for SMA, N, 7/16 and TNC mating.

VENDORVIEW

www.santron.com

Ciao Wireless — Booth 523

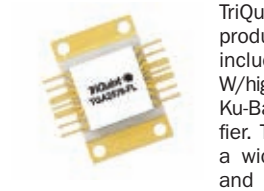
Amplifiers and Assemblies

Ciao Wireless specializes in the design/manufacture of RF and microwave amplifiers/assemblies for both the defense and commercial industries, from 30 kHz to 44 GHz, including the various narrow and ultra-broadband frequencies in between. Ciao offers a complete catalog product line and "custom" designs in order to meet all of your exact microwave amplifier and subsystem needs. Ciao features 1 to 2 week ARO delivery for most catalog and custom parts.

www.ciaowireless.com

TriQuint Semiconductor — Booth 530

GaN Product Solutions



TriQuint's new GaN product solutions will include the rugged 25 W/high-gain TGA2579-FL Ku-Band power amplifier. TriQuint will debut a wide range of GaN and GaAs PAs, GaN transistors, SAW/BAW filters and related integrated assembly services for broadband/PtP/small cell/infrastructure/defense communications, radar and EW applications.

www.triquint.com

RF&Microwave Circuit & Crystal Oscillator manufacturer



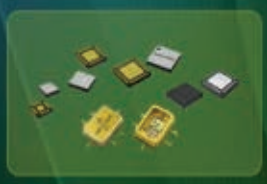
BOWEI is one of the leading RF/microwave solution providers in China. For more than twenty years, BOWEI has been a major supplier of high performance, cost effective and high reliability products for the most telecommunication applications.

Certified ISO9001-2000, BOWEI designs & manufactures a full line of RF/microwave products including amplifiers, VCOs, filters, attenuators, power splitters /combiners, switches, MMIC and crystal oscillators to satisfy bothcommercial and high reliability demand.

BOWEI constantly devotes itself to build a company capable of delivering innovative, high reliable microwave and RF solution to system manufacturers all around the world prompt response and excellent customer service.



1. MMIC（DC~40GHz）



- Gain Blocks
- Low Noise Amplifiers
- Power Amplifiers
- Switches
- Digital Attenuators
- Mixers
- VCOs
- Frequency dividers
- Power splitters
- Filters
- Amplitude equalizers
- Multi functions MMIC

2. GaN Power Amplifier



- Frequency Range： L~X band
- Broadband, high efficiency
- 50Ω impedance, easy to cascade
- Miniature metal package

3. Crystal Oscillator



OCXO
- Frequency range： 10~120MHz
- Frequency stability Vs.Temperature： ±0.01～±0.5ppm
- Phase noise SΦ(dBc/Hz ,100 MHz)： -165/1KHz

TCXO
- Frequency output： 10~40MHz
- Frequency stability Vs.Temperature： ±0.28～±3ppm
- Phase noise SΦ(dBc/Hz ,10 MHz)： -145/1KHz

4. PDRO



- Frequency output： 1~40GHz
- Power output： 7~15dBm
- Phase noise： 20lg (N) +3 (fm<100kHz)
- Dimension： 40x40x12.8mm

5. Miniature MCM Synthesizer PLS series



- Frequency output： 1~18GHz
- Control： Serial or parallel
- Power output： 8~12dBm
- Dimension： 15x12x3mm

6. MKF series Broadband Amplifier



- Frequency range(GHz)： 1~4/2~8/6~18/2~18
- Small signal gain： 10~32dB
- Gain flatness： ≤±15 dB
- Internal Regulator chip, hermetic design
- No external components need, high reliability

7. Microwave Limiting Amplifier



- Frequency range： 0.1~18GHz （sub band）
- Small signal Gain： ≥20 dB
- Input/Output VSWR： ≤1.5:1
- Power Handling： 1500W（P band)/500W（S band）/100W（X band）
- Hermetic package, high reliability

BOWEI INTEGRATED CIRCUITS CO.,LTD.

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- Email: cjian@cn-bowei.com
  lrl@cn-bowei.com
- http://www.cn-bowei.com

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See us at IMS Booth 2504

IMS PRODUCT SHOWCASE: AISLES 500-700

Teledyne Relays — Booth 540

COAX Switches



Teledyne Coax Switches has products for test and measurement, medical, industrial, defense (military) and space (HI-REL) applications. Teledyne products range from SPDT, transfer and multi-throw coaxial switches as high as SP10T. Teledyne coax switches are available to cover most of the RF spectrum from DC to 40 GHz (selected models) and are available with SMA, mini-SMB, TNC or N connectors.

www.teledynerelays.com

Teledyne Microwave Solutions — Booth 540

Ka-Band HPA



Teledyne Microwave Solutions introduced its 502 W peak Ka-Band HPA. It features high linear power, 502 W peak power and a robust design. It has the option of an integral L-Band BUC and is built around TMS's MEC-5530 traveling wave tube. Visit Teledyne Microwave Solutions in Booth 540 to learn more.

www.teledynemicrowave.com

Florida RF Labs — Booth 541

VNA Test Cables



Florida RF Labs has expanded its line of high-performance VNA test cables. ASR-F is a flexible version of the already popular ASR, a semi-flexible test assembly. These high frequency test cables feature a durable, yet extremely flexible monocoil protection and abrasion-resistant jacket for long-lasting performance. Featuring durable interfaces and a special low-loss cable construction for excellent stability over flexure and temperature, they are available in standard 12", 18" and 24" lengths with a wide variety of connector interfaces.

VENDORVIEW

www.emc-rflabs.com

Richardson RFPD Inc. — Booth 620

Electronic Component Distributor

Richardson RFPD Inc., an Arrow Electronics company, is a global leader in the RF and wireless communications, power conversion and renewable energy markets. Relationships with the industry's top component suppliers enable Richardson RFPD to meet the total engineering needs of each customer. Whether it's designing components or engineering complete solutions, Richardson RFPD's worldwide design centers and technical sales team provide support for all aspects of customers' go-to-market strategy, from prototype to production.

VENDORVIEW

www.richardsonrfpd.com

Skyworks Solutions Inc. — Booth 630

Low Noise Amplifier

The SKY67151-396LF is a broadband, 0.7 to 3.8 GHz LNA with best-in-class 0.25 dB noise figure, high linearity, excellent return loss and >18 dBm output compression point. Its on-die, active bias design ensures consistent performance and unconditional stability over the extended -40° to +105°C temperature range. Four band-specific external tuning networks utilizing a common PCB layout cover the full 3 GHz device operating bandwidth. Visit Skyworks at IMS 2013 Booth 630 for more information on this new high performance discrete LNA.



VENDORVIEW

www.skyworksinc.com

Dielectric Laboratories Inc. — Booth 704

Dielectric Material

Dielectric Laboratories Inc. announced a product line extension of Z type plating (Sn over Ni) in the C04 (0402) case size with its ultra-low ESR UL dielectric material. Previously the C04 product line was only available in "S" type plating (Au flash over Ni). Both termination types are fully RoHS compliant. Dielectric Laboratories Inc. C04 case size meets the EIA 0402 footprint, which is perfectly suited for high frequency decoupling type of applications.

www.dilabs.com

Dow-Key Microwave — Booth 715

Switching Systems



Dow-Key Microwave manufactures and custom designs switches and switching systems for the commercial, military and space industries. Its products include broadband RF coaxial and waveguide switches operating from DC to 70 GHz, electromechanical and solid state switch matrices and fiber-optic switching systems, in addition to programmable attenuators and delay lines. Visit Dow-Key at Booth 715 to learn more about its new low PIM switches, next generation matrices and custom matrix solutions.

VENDORVIEW

www.dowkey.com

Molex — Booth 719

Plug to Plug Cable Assembly



Molex offers a 40 GHz, 2.92mm plug to plug cable assembly, using its Temp-Flex ultra-low loss cable with a typical VSWR of 1.35:1 maximum to 40 GHz. The RF business unit offers standard cables in 2 to 3 inch increments. Other versions and lengths are also available with SMA, SMP, SMPMS and Type N. See Molex in Booth 719 at IMS 2013.

www.molex.com

Herley General Microwave — Booth 723

Phase Shifter



Herley General Microwave further presents its digitally programmable model 7929 phase shifter. It is an ideal solution for today's military airborne systems. It operates over the 18 to 40 GHz frequency range, provides 360° phase shift with accuracy of < ±15° and switching time of < 500 nanoseconds. It features phase control via 10 bit TTL providing high resolution of 0.35° and guaranteed monotonic.

www.herley.com

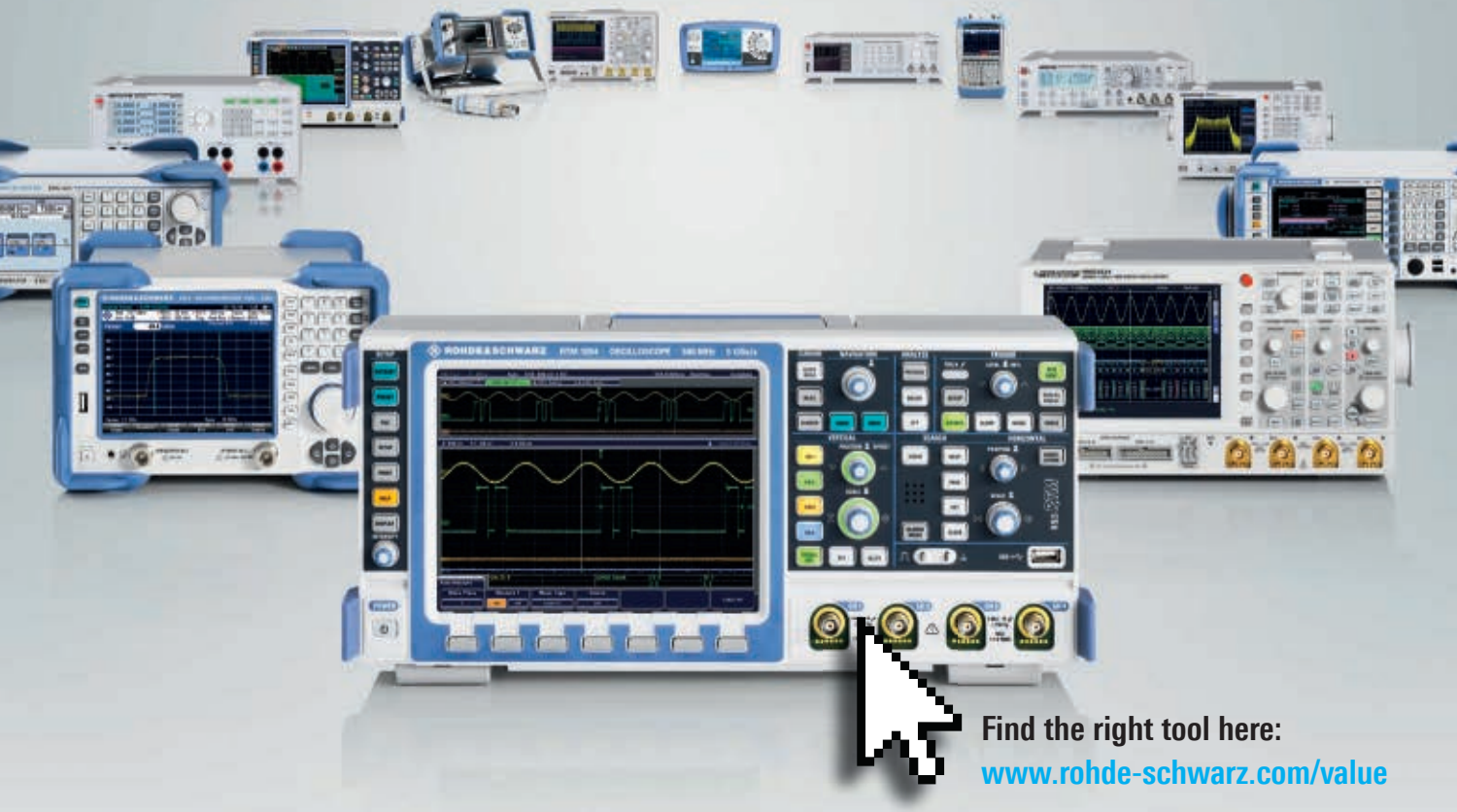
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Please visit us at the **IMS** in Seattle, Washington State Convention Center, Booth 440



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Wenzel Associates Inc. Booth 745

Integrated Frequency Multipliers



Wenzel Associates offers low noise integrated frequency multipliers (IFM Series) that convert fixed input frequencies between 5 MHz up to 7.5 GHz to output frequencies from 10 MHz to 15 GHz. Single IFM packages can be configured with 1 to 6 cascaded multiplier stages (×2, ×3, ×5 and ×7) to provide multiplication factors from ×2 to ×300 for ultra-low phase noise and excellent spectral purity. 4" × 1.1" to 4" × 3" package footprints depending on number of integrated multiplier stages.

www.wenzel.com

Reactel Inc. Booth 800

Small Form Factor Filters



Reactel will feature a line of small form factor filters suitable for densely populated boards, portable systems or any application where size is at a premium. These tiny units are available in discrete component, ceramic, cavity or combline designs. They feature profiles as low as 1/8". They are available across a frequency range of 100 MHz to 20 GHz with bandwidths of 5 to 100 percent and are available in four to 12 sections.

VENDORVIEW

www.reactel.com

SV Microwave Booth 804

High Frequency Connectors



SV Microwave just released its new QuarterBack™ line of high frequency connectors. This line utilizes a quarter turn bayonet style coupling nut with a locking feature for standard SMP/SMPM interfaces. The QuarterBack connectors are ideal for high vibration and test applications that require a large number of mating cycles. Come by the company's booth (804) for more information on these and other products.

www.svmicro.com

QuinStar Technologies Inc. Booth 813

Waveguide Switches

QuinStar Technologies Inc. announced the release of the QWZ family of electromechanical waveguide switches for use in automated test setups and system applications where remotely controlled transfer switching is



required. The QWZ product series includes a full waveguide band, high isolation/low loss, and accurate positioning, and it is bi-directional. Full specifications are available on the website. Please contact sales@quinstar.com for more product and applications information.

www.quinstar.com

Z-Communications Booth 816

VCO

Z-Communications Inc. announces a new RoHS compliant VCO model USSP1325-LF in the L-Band. This VCO operates at 1250 to 1400 MHz with a tuning voltage range of 0.5 to 4.5 V DC. This miniaturized VCO features phase noise of -100 dBc/Hz at 10 kHz offset while operating off a 5 V DC supply and typically drawing only 25 mA of current.

www.zcomm.com

Microwave Electronics Corp. of America Booth 901

Power Splitters

MECA announced the launch of a new line of unequal power splitters or tappers, developed to unevenly split high power signals



for in-building DAS applications and designs. The line consists of six models offering a 2, 3, 4, 6, 8 or 10:1 signal-split ratio respectively, over 698 to 2700 MHz (cellular, PCS, AWS, and BRS/EBS frequencies) and feature low PIM ratings (-155 dBc typical), with ultra-low VSWR and minimal coupling variation over the entire frequency band. They handle high power levels of 300 W (CW).

VENDORVIEW

www.e-meca.com

Lark Engineering Booth 910

Switch Filter Bank



Lark Engineering is proud to announce its latest ultra-thin product offering. With a maximum height of 0.09", the ultra-thin, switch filter bank (SFB) is surface mountable and designed for commercial and military applications. Lark's ultra-thin SFBs are available with a frequency range from 1 to 6 GHz with an offering of 2, 3 or 4 channels. For more information contact Lark Engineering at sales@larkengineering.com.

www.larkengineering.com

American Microwave Corp. Booth 915

EW Test Station



AMC designed and manufactured a highly complex electronic warfare test station. AMC supplied 8 high and 8 low band direction finding assemblies (for signal tracking) plus a high band and low band calibration assembly – a total of 18 separate rack mounted chassis. The units consist of 14 stages of switched delay line "blocks" mounted on a center web that is installed in a 2U height rack mounted chassis with filter banks, switches, attenuators, power dividers and phase shifters.

VENDORVIEW

www.americanmic.com

Charter Engineering Inc. Booth 916

Terminated RF Switch

CEI model T12P-941518 is a SP12T internally terminated latching switch with indicator circuitry operating from DC to 15 GHz.



The ultra low PIM switch features a –160 dBc minimum third order IM. The T12 series is also offered as a failsafe or normally open switch along with various actuator and mounting options. CEI offers a complete line of coaxial RF switches for ATE, matrix, and critical switching systems. The low PIM specifications are available with all CEI switches.

www.ceiswitches.com

Remcom Inc. Booth 920

3D Electromagnetic Simulation Software



XFdtd is a full wave 3D EM solver that simplifies the analysis of complex EM problems and leads the market in FDTD-based modeling and simulation. Applications include microwave devices such as waveguides, power dividers and filters, antenna design and placement, EMI/EMC testing, static discharge, signal integrity, SAR validation, radar and scattering, and photonics. Key features include XStream GPU Acceleration, XACT Accurate Cell Technology, CAD Merge, XTend Script Library, MPI technology for both CPU and GPU clusters, and Unlimited Memory Support.

VENDORVIEW

www.remcom.com



Electronic Assembly Manufacturing, Inc.
126 Merrimack St.
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F: 978-374-6375
www.eamcableassemblies.com

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CTS Electronic Components Inc. — Booth 918

Oven Controlled Crystal Oscillators



Model 148 is an ultra low power shock resistant miniature OCXO. It has very low power consumption of less than 0.23 W. Its mechanical construction enables durability of up to 500 G of mechanical shock. Its SC cut crystal is housed inside a TO-8 vacuum package and is DIL-8 compatible, thus reducing its weight, power consumption and warm-up time (60 seconds). The part is highly stable with phase noise as low as -166 dBc/Hz floor at 10 MHz.



Model 122 is an ultra-high stability OCXO. The oscillator utilizes the doubleoven and IHR technologies to provide less than 1 W power consumption. It is also capable of holding high frequency stability to ±0.2 ppb over -10° to +60°C and ±0.2 ppb/day aging (for 10 MHz). The device is housed in a 20 × 20 mm packaging. Frequencies are available from 8 to 100 MHz. Typical applications for this part include rubidium standard replacement, GPS disciplined frequency standards, instrumentation and communication systems.

www.ctscorp.com

M/A-COM Technology Solutions — Booth 930

GaN in Plastic



M/A-COM introduces three high performing power transistors packaged in plastic packages for radar applications. These transistors offer real-estate constrained customers significant space savings. Unlike competing transistors, M/A-COM's GaN in plastic boasts high power and gain, allowing customers to reduce the number of stages in the cascade of amplifiers, resulting in extremely high power. Available as 15, 50 and 90 W transistors, these devices are ideal for customers looking for a high power, lightweight, cost effective and small solution.

www.macomtech.com

Boonton — Booth 931

USB Power Sensors

Boonton, a Wireless Telecom Group company, has added a new platform to its industry standard power meter line, the new 55 series wideband USB power sensors. The new line enables high performance, real-time testing of wideband signals up to 40 GHz. Boonton's Real-Time Power Processing™ eliminates the acquisition latency associated with traditional peak power meters and sensors, yielding lightning-fast performance in a brand new USB platform. It is ideal for laboratory or field use, for wireless and telecom signals or radar work.

www.boonton.com

Micro Lambda Wireless Booth 941

Bench Test Filters



Micro Lambda Wireless MLBFP series bandpass and MLBFR series band reject bench test filters are available covering 500 MHz to 50 GHz and 500 MHz to 20 GHz, respectively. They are ideal for production test sets, lab tests and test equipment racks where filtering of microwave signals is essential. Units are very simply plugged into a standard electrical outlet and you are ready to go. Tuning is accomplished via tuning knob, keyboard, USB or ethernet.

www.microlambdawireless.com

Anritsu Co. — Booth 938

Signal Analyzer



The 26.5 and 43 GHz models of the MS2830A signal analyzer/spectrum analyzer will be displayed by Anritsu Co. at IMS 2013 (Booth 938). Frequency coverage can be extended to 110 GHz on both models with an external mixer. Providing high-end performance at economical prices, the instruments have high-speed sweeping capability and 159 dB dynamic range (at 26.5 GHz). A vector signal analysis function allows the MS2830A to pinpoint phenomena missed by sweep spectrum analyzers.

VNA System



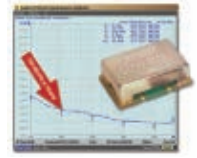
Anritsu will exhibit its VectorStar® ME7838A mm-wave VNA system with real-time power leveling, as well as best-in-class stability with the widest power level control. The mm-wave system detects IF and RF power and provides correction to the mm-wave power in real time and without the need for software correction feedback. The method delivers stable mm-wave power even at low levels and reduces the risk of overdriving power-sensitive mm-wave devices.

VENDORVIEW

www.anritsu.com

Crystek Corp. — Booth 1016

SAW Clock Oscillator



Crystek Crystals announces the release of a 250 to 1090 MHz surface acoustic wave (SAW) clock oscillator (in single frequency band), the CCSO-914X. Crystek designed the module using proprietary circuitry and SAW resonator technology to provide ultra-low jitter/phase noise performance with true SineWave output. The resulting oscillator (250 MHz variant) features -153 dBc/Hz phase noise at 10 KHz offset and a noise floor of -173 dBc/Hz. It has been verified with Analog Devices' AD9467 – a 16-bit, monolithic, IF sampling ADC.

www.crystek.com

Tahoe RF Semiconductor Inc. — Booth 1017

Receiver/Digitizer

TRFS15013 is an integrated GPS/GNSS receiver/digitizer that provides simultaneous reception of both upper and lower GPS/GNSS bands. A high dynamic range (60 dB, 12 bit) mode and a low resolution low power (3 bit output) modes are supported. The part is programmed using a three wire SPI. Available in a 72-pin QFN. Key specifications: 75 dB gain, -17 dBm IIP3, 7 dB NF, 4 pS jitter. It can be used for surveying, agriculture, avionics, telematics or other high performance applications.

www.tahoerf.com

Delta Electronics Manufacturing — Booth 1021

Bullet Adapter



Delta Electronics Manufacturing has developed a new spring loaded SMP F-F "bullet" adapter. Currently available in three different lengths, 0.375 (0.300 compressed), 0.675 (0.600 compressed), and 1.075 (1.00 compressed). Designed in accordance with Mil-STD-348, all three models feature a six slot "low insertion" SMP female interface on one side and a four slot SMP female interface on the other. The compression load on the interfaces enable these "bullets" to achieve consistent VSWR, even at higher frequencies.

www.deltarf.com

CTS®
ELECTRONIC COMPONENTS
OVEN CONTROLLED CRYSTAL OSCILLATORS

IMS 2013
International Microwave Symposium
IEEE 2-7 June 2013, Seattle, WA MTT-S

BOOTH #918

Ultra-Low Power Shock Resistant OCXO



DIL-8
MODEL 148

- Low Power Consumption
  - 0.23W
- Fast Warm-Up Time
  - 45s
- Shock & Vibration Resistant
  - up to 500G

Scan to download data sheet

Ultra-Stable 20 x 20 mm OCXO

Scan to download data sheet

- Enhanced Stability for LTE
  - ±0.2ppb over -10°C to +60°C
- Low Phase Noise
  - -170 dBc/Hz @ noise floor
- Frequency Range
  - 8MHz to 100MHz



20 x 20 mm
MODEL 122

Low Phase Noise and Ultra-Low Power OCXO



DIL-14
MODEL 144

- Ultra-Low Power Consumption
  - 0.15W
- Fast Warm-up Time
  - 30s
- Low Phase Noise
  - -170 dBc/Hz @ noise floor

Scan to download data sheet

www.ctscorp.com/components • +1-508-435-6831 • frequencysales@ctscorp.com

IMS PRODUCT SHOWCASE: AISLES 1100-1500

Maury Microwave Booth 1139

Measurement and Modeling Solutions



Maury Microwave will be demonstrating state-of-the-art measurement and modeling solutions including: a patent-pending noise parameter system, a pulsed IV/S-Parameter and compact modeling system, a hybrid-active harmonic loadpull solution based on the PNA-X, and a patented mixed-signal active loadpull system capable of up to 1000 impedance/power measurements per minute and 120 MHz of instantaneous impedance control. Maury's component division will showcase its new Stability line of amplitude- and phase-stable cable assemblies as well as calibration kits, metrology and instrument-grade adapters and test essentials.

Ruggedized Cable Assemblies

Maury Microwave's Stability™ series sets the standard for high-performance ruggedized cable assemblies. Designed specifically for phase-stable and amplitude-stable applications, Stability offers excellent measurement repeatability even after cable flexure. With a ruggedized, durable construction, Stability will outlast and outperform other assemblies resulting in a reduced total cost-of-test. Stability's light weight, superior flexibility and small form factor make it ideal for daily use with VNAs, test instruments, bench-top testing and ATE systems.

www.maurymw.com

AR RF/Microwave Instrumentation Booth 1144

Linear Amplifier



AR has now complemented its previous line of 4 to 18 GHz hybrid power modules (HPM) and bench top units with new designs to instantaneously cover the entire 0.7 to 6 GHz frequency range in one amplifier. The 1 to 6 GHz modules have output powers up to 25 W Class A and 40 W Class AB, while bench top Class A units produce over 100 W. Typical applications are EMC wireless testing and military EW.

VENDORVIEW

www.arworld.us

Agilent Technologies Inc. Booth 1230

Spectrum Analysis



Adding real-time spectrum analyzer capabilities to new and existing Agilent N9030A PXA signal analyzers enables engineers to see, capture and understand the most elusive signals. Features include the ability to detect signals as short as 5.0 ns, measuring down to 3.57 µs with 100 percent probability of intercept and full amplitude accuracy; scan with 160 MHz real-time bandwidth up to 50 GHz frequency range; and see small signals in the presence of large ones with up to 75 dB spurious-free dynamic range.

VENDORVIEW

www.agilent.com/find/RTSA

OML Inc. Booth 1332

Boss and Jack Waveguide Flange



OML demonstrates patented boss and jack flange technology for S-parameter measurements beyond 110 GHz. The demonstration consists of network analyzer, VNA modules, waveguide calibration kit (including shim) and accessories. The most precise and repeatable mm-wave measurements are now possible by eliminating the need for precision dowel pins. This patented technology is 100 percent compatibility with the existing MIL-DTL-3922/67D (UG-387) standard.

www.omlinc.com

Microwave Development Labs Inc. Booth 1430

Waveguide Components

At IMS 2013, MDL's representatives will be showing examples of its low-loss passive waveguide components for ground, air, sea and space applications from 1 to 50 GHz including waveguide couplers, power dividers/combiners, rotary joints, switches and waveguide assemblies. MDL will feature on display new high frequency coax and waveguide rotary joints, loop couplers, adapters and microwave investment castings using the latest rapid prototype process. Staff members will be on hand to discuss the company's extensive in-house design and manufacturing capabilities.

www.mdllab.com

Microsemi Booth 1455

RF Transistor

Microsemi's 2729GN-500 RF transistor is based on GaN on SiC technologies and targeted at high-power air traffic control airport surveillance radar applications. It delivers unparalleled performance of 500 W of peak power with 12 dB of power gain and 53 percent drain efficiency over the band 2.7 to 2.9 GHz to provide maximum power in a single device covering this band. Key features include standard pulse burst format of 100 µs, 10 percent DF (microseconds) and high power gain of >11.5 dB minimum.



www.microsemi.com

Rogers Corp. Booth 1459

Laminates



For applications demanding greater electrical stability at elevated temperatures, Rogers developed RO4835™ laminates. The newest member of the highly successful RO4000® family, RO4835 laminates are up to 10× more resistant to oxidation than other RF thermoset materials. Similar to RO4350B laminates, these low loss materials can be fabricated using standard epoxy/glass (FR-4) processes. RO4835 laminates utilize RoHS compliant flame-retardant technology for applications requiring UL 94V-0 certification. These materials conform to the requirements of IPC-4103, slash sheet /11.

VENDORVIEW

www.rogerscorp.com

SAGE Millimeter Inc. Booth 1505

W-Band Mixer

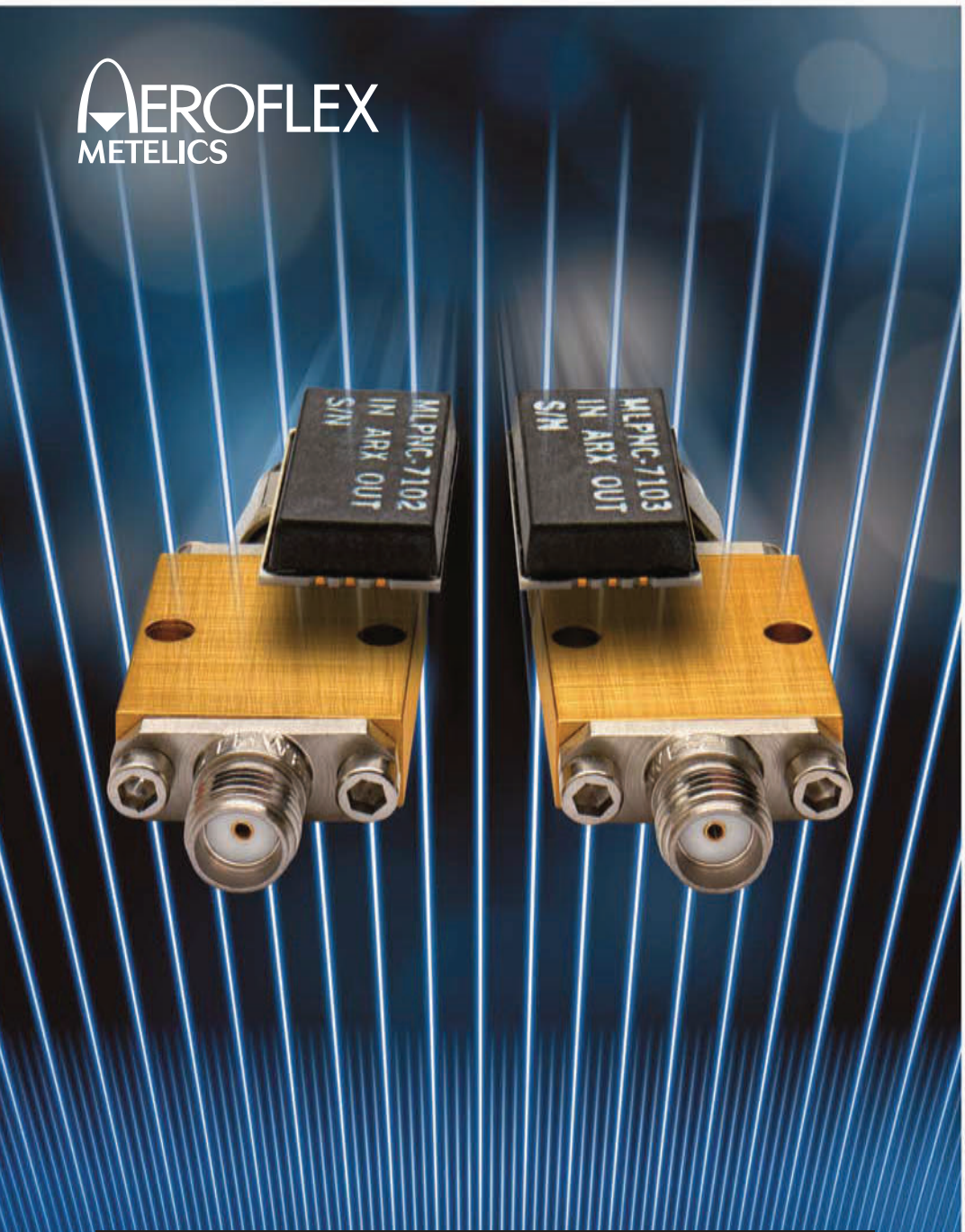
Model SFS-75311416-10VFSF-N1 is a W-Band, subharmonically pumped mixer. The mixer employs high performance GaAs Schottky beamlead diodes, balanced configuration to produce superior RF performance. It is capable of full RF waveguide band operation for RF frequencies from 75 to 110 GHz with half of the LO frequency: 37.5 to 55 GHz. The conversion loss measured was 12 to 16 dB at +13 dBm LO pumping level typically. The subharmonically pumped mixer family also includes the mixers in frequency bands such as Q, U, E, V, F and D.



VENDORVIEW

www.sagemillimeter.com

Control the comb.
Control the clarity.



The sensitivity and the distance you've been striving for from your radar or surveillance receiver is now within reach. New GaAs comb generators from Aeroflex / Metelics are a best-in-class, non-linear-transmission-line (NLTL) innovation that provides 10 to 18 dB lower phase noise for better sensitivity than Si step recovery diode (SRD) comb generators. Offering phase noise as low as -135 dBc/Hz at 100 Hz offset from the 12 GHz harmonic, the MLPNC series creates clean, low conversion loss harmonics to 30 GHz over variable input frequencies from 400 to 1300 MHz. Their variable input power from 21 to 23 dBm make them easy to drive and operate. They provide ultimate system design flexibility and the opportunity to simplify your system architecture.

Visit our website or call **888-641-7364**.

www.aeroflex.com/metelicscomb

See us at IMS Booth 340

Non-linear-transmission-line (NLTL) GaAs Comb Generators

Part Number	Power (dBm)		Output Harmonics (dBm)*		
	Minimum	Maximum			
MLPNC-7102-SMA800	21 @ 400 MHz	23 @ 600 MHz	> -8 @ 4 GHz	> -16 @ 12 GHz	> -20 @ 20 GHz
MLPNC-7102-SMT680	21 @ 400 MHz	23 @ 600 MHz	> -8 @ 4 GHz	> -16 @ 12 GHz	> -20 @ 20 GHz
MLPNC-7103-SMA800	21 @ 800 MHz	23 @ 1300 MHz	> -5 @ 6 GHz	> -15 @ 18 GHz	> -20 @ 30 GHz
MLPNC-7103-SMT680	21 @ 800 MHz	23 @ 1300 MHz	> -5 @ 6 GHz	> -15 @ 18 GHz	> -20 @ 30 GHz

* Contact the factory for additional information or for products not covered in the table.

AEROFLEX
A passion for performance.

IMS PRODUCT SHOWCASE: AISLES 1500-1800

Copper Mountain Technologies — Booth 1518

VNA



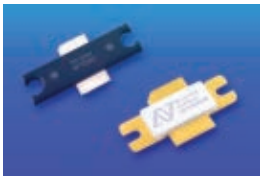
PLANAR 808/1 is a four-port lab quality VNA that provides high performance at a great value for R&D and manufacturing applications in the frequency range from 100 kHz to 8 GHz. Standard features include fixture simulation, balanced measurements, time domain with gating and many more. With two independent signal sources and the built-in frequency offset mode, the 808/1 is a complete solution for mixer and converter measurements.

VENDORVIEW

www.coppermountaintech.com

Nitronex — Booth 1522

GaN RF Power Devices

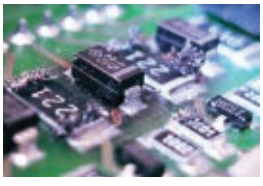


Nitronex announces a family of new 48 V GaN RF power devices in plastic and ceramic packages, with Psat from 12 to 100 W. The NPT2021 is a 12 W HEMT in a 3 × 6 mm DFN plastic package. The NPT2020 and NPT2010 offer 50 and 100 W Psat, respectively, with excellent RF and thermal performance in ceramic packages. The NPT2023 and NPT2022 offer 50 and 100 W Psat, respectively, and deliver excellent value and performance in a low-cost plastic TO-272.

www.nitronex.com

AEM Inc. — Booth 1530

Tin Whisker Migration Process

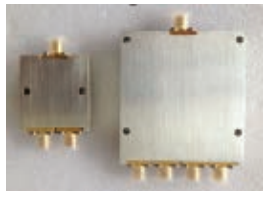


AEM Inc. is an award-winning high-tech company with its leading technologies in proprietary materials, patented processes and specialty equipment for the manufacturing of high reliability electronic components providing solutions that continue to set the standard for quality, value and performance. AEM provides products and services to aerospace, defense and other "Hi-Rel" industries that require the highest quality level for circuit protection, EMI signal filtering and tin/lead conversion applications.

www.aem-usa.com

Nanjing Guangshun Network Communication Engineering Co. Ltd. — Booth 1543

Splitter/Coupler



SMA series power divider is a 0° power divider with SMA connector, whose frequency covers 0.5 to 18 GHz. It features a compact size, low insertion loss and VSWR, and high isolation. Quality conformity can be guaranteed even under mass production. It can be customized according to specific needs. The frequency of the coupler is 698 to 2700 MHz. Learn more at Booth 1543.

www.njgrownsun.com

Emerson Connectivity Solutions — Booth 1615

Quick Turn Program

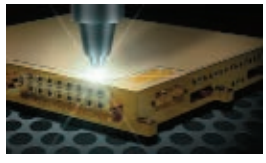


The Quick Turn program from Emerson Connectivity Solutions offers the precision low-loss Semflex HP series cable assemblies to ship from the factory within 48 hours of receipt of order. The cable assemblies offered consist of the HP120, 160, 190 and 305 series with available connectors of SMA, 2.92mm, 2.4mm and Type N. Performance is up to 50 GHz. Stop by the company's booth to discuss this new program.

www.emersonconnectivity.com

Thunderline-Z — Booth 1615

Laser Services



Thunderline-Z, a manufacturer of feedthrus and hermetic packages, now offers laser services to its customers. With a new state-of-the-art laser center, Thunderline-Z is able to offer both laser lidding and component installation, as well as fine and gross leak testing. Thunderline-Z's laser technicians are highly skilled in delivering consistent, repeatable seals on time, every time. To find out more, contact Thunderline-Z at (603) 329-4050 or email: sales@thunderlinez.com.

www.thunderlinez.com

Amphenol RF — Booth 1625

Connectors and Accessories



Amphenol RF is pleased to announce its 50 Ω HD-BNC line of connectors and accessories. Like the 75 Ω HD-BNC, the 50 Ω has the same footprint, which is 4× smaller compared to traditional BNCs, but still maintains positive locking BNC style functionality. The 50 Ω HD-BNC is engineered to perform at 30 dB at 6 GHz with a calibration kit. For more information, visit Amphenol RF's website.

www.amphenolrf.com

Pivotone — Booth 1638

Quadruplexer

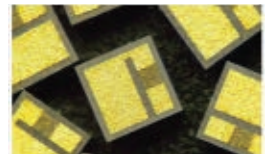


Pivotone introduced its LTE700/AMPS/PCS/AWS quadruplexer covering: 698 to 790 MHz, 824 to 896 MHz, 1850 to 1990 MHz and 1710 to 1755 and 2110 to 2155 MHz bands. This high-performance part is designed for multi-band, co-located sites. Although it is relatively small in size, it has low insertion loss and allows for DC and AISG Issue 2.0 Passthru on selected ports. This Quadruplexer is available to mount on the wall or poles. It is suitable for outdoor and indoor applications. For more information contact sales@pivotone.com.

www.pivotone.com

Tecdia Inc. — Booth 1721

Integrated Resistor-Capacitor



Combining an SLC capacitor and thin film resistor on a single ceramic chip is a Tecdia innovation that pays big dividends. The IRC or integrated resistor and capacitors are available in a variety of sizes and values to help engineers shrink designs, improve installation efficiency and lower materials costs with superb quality. These parts can be customized to your specific application. Visit Booth 1721 to discover this and other new ceramic components for your demanding applications.

VENDORVIEW

www.tecdia.com/us

UTE Microwave — Booth 1806

High Power Circulators



CT-849-D is one of a series of 2 KW CW circulators that cover 75 to 125 MHz with 5 percent minimum bandwidths. Peak power options are also available. Typical applications are medical, scientific and FM transmitters. Operating at 80 MHz, the unit provides 20 dB minimum isolation with less than 0.3 dB loss and 1.25 maximum VSWR. Operating temperature is 10° to 60°C case temperature with conduction cooling. The unit size is 9" × 9" × 2". DIN 7/16 connectors are standard with options for 7/8 EIA flanges.

www.utemicrowave.com

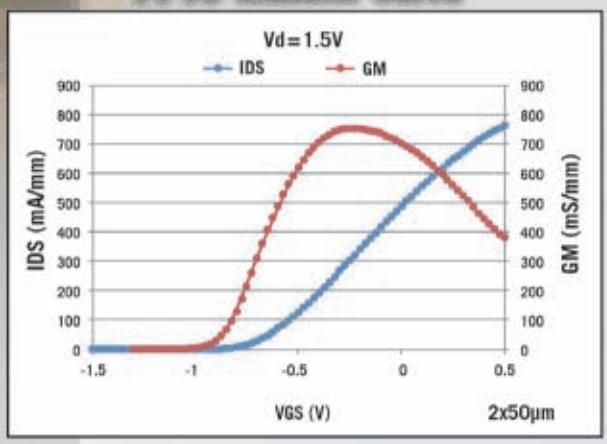
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Leading Global Communications

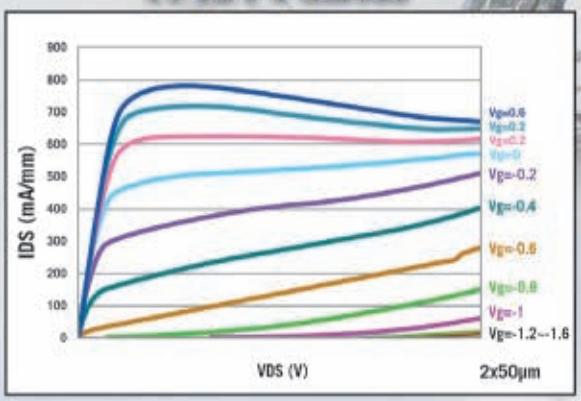
PP10-10/-11 0.1µm Power pHEMT

- 0.1µm high performance power / low noise process
- 50µm and 100µm thickness are standard
- Useable gain to 110GHz
- 4V operation - Psat > 800mW/mm, > 50% PAE, and 13dB Gain at 29GHz

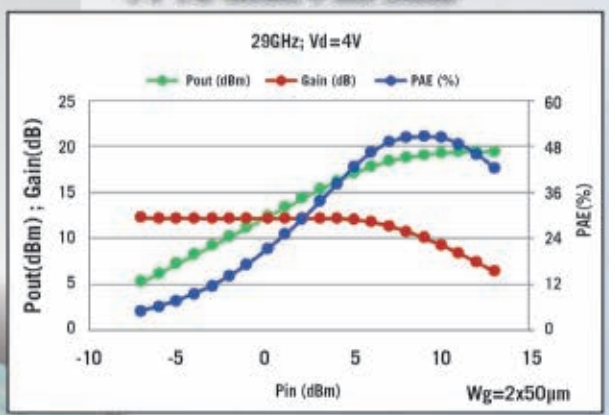
PP10 Transfer Curve



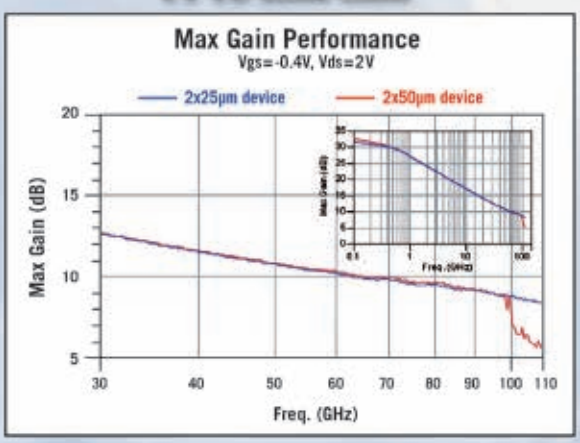
PP10 I-V Curves



PP10 Load Pull Data



PP10 Max Gain



WIN SEMICONDUCTORS CORP. Tel:+886-3-397-5999 Fax:+886-3-397-5069 http://www.winfoundry.com

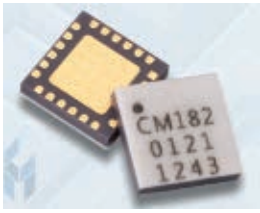
See us at IMS Booth 1431

IMS PRODUCT SHOWCASE: AISLES 1800-1900

Custom MMIC — Booth 1807

I/Q Mixer

The CMD182C4 can be used as an image reject mixer or single sideband modulator, with 5.5 dB of conversion loss and 30 dB of image rejection/sideband suppression while supporting an IF bandwidth of DC to 3.5 GHz. It features very low LO to RF leakage of -35 dBm and an input P1dB of +9 dBm. A much smaller alternative to higher-cost, hybrid image-reject mixers and single-sideband upconverter assemblies, this mixer is ideal for point-to-point, point-to-multipoint, digital radios and VSAT terminals.



VENDORVIEW

www.custommmic.com

Narda Microwave — Booth 1821

Waveguide Products



Responding to continued customer demand, Narda's expanded waveguide product line features 130 new models in four distinct categories. Included in the product line expansion are waveguide-to-coaxial adapters (1.7 to 40 GHz), gain horns (1.7 to 40 GHz), terminations (low and medium power), and crossguide directional couplers (SMA and Type N connectors). Most components are in stock for immediate shipment. Please plan to visit Booth 1821 at IMS 2013 and see many of these new components.

VENDORVIEW

www.narda.com

Empower RF Systems — Booth 1827

Broadband High Power Amplifiers



Empower RF will be showcasing one of three different broadband models from its family of "Size Matters," 1 kW in a 5U chassis, high power amplifier product platforms. Built with a common architecture that drives consistency in manufacturing and outstanding operational performance, Empower will be conducting live demonstrations of a fully operational unit at the booth and also showcasing a remote interface connection which will be operating another unit back at the factory.

VENDORVIEW

www.empowerrf.com

Coleman Microwave Co. — Booth 1835

Harmonic Filter



Coleman introduced CMC P/N 809250-3, a C-Band high power reflective/absorptive harmonic filter. Developed for the weather radar industry, this low pass filter combines both reflective and absorptive elements to achieve 500 kW peak power handling at fundamental frequencies and greater than 60 dB of attenuation at harmonic frequencies. This unique hybrid approach maximizes power handling, while minimizing insertion loss, size, weight and cost.

www.colemanmw.com

Dfine Technology — Booth 1838

Tuning-Free Waveguide Filter



Dfine Technology's new waveguide filter, JDWHF128133, is designed to be high reliability especially in vibration-heavy environments. It covers a frequency range of 12.80 to 13.30 GHz with low insertion loss at 0.22 dB and power at 40 W. Alloy junction is used to reduce weight to only 100 g and no tuning screws are needed on the filter.

VENDORVIEW

www.dfine-mw.com

Communications & Power Industries LLC — Booth 1906

X-Band SSPA



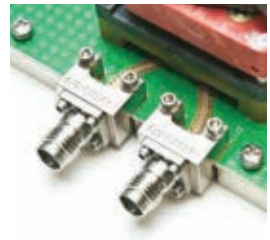
CPI extends its product line of high-power solid-state power amplifiers (SSPA) with a 1 kW peak power amplifier at X-Band. The 1 kW modules utilize state-of-the-art gallium nitride HEMTs for the most compact and efficient design. This SSPA is designed to produce a reliable, air-cooled amplifier for mobile, airborne and ground installation radar requirements. It is designed to be rack mounted with combining structures to provide output powers from 1 to 16 kW.

www.cpii.com

Southwest Microwave Booth 1909

Test Equipment

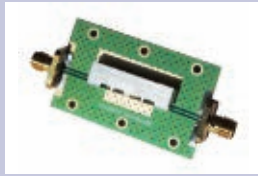
Southwest Microwave is the leader in high-performance microwave products for microwave and millimeter-wave applications. In addition to standard testing, Southwest Microwave offers special hirel testing to meet critical SCD and DPA requirements. Stringent controls assure that all parameters are met. Test department equipment includes multiple VNA/PNA to 67 GHz plus offsite capability to 110 GHz.



www.southwestmicrowave.com

RFMW Ltd. — Booth 1903

Anti-Aliasing Filters



Digital pre-distortion (DPD), anti-aliasing filters from Sangshin Elecom improve system performance. 400, 360 and 300 MHz bandwidths are available for all popular cellular frequencies. Insertion loss is < 3 dB and these filters handle up to 1 W CW. An interactive DPD product matrix is available to assist the selection of center frequency and bandwidth for specific applications.

RF Filters



RF filters for ADS-B, UAT and TCAS avionics applications are available from Sangshin Elecom. These ceramic monoblock filters offer minimum attenuation of 37 dB at 50 MHz offset from their center frequency. Insertion loss is < 2.8 dB. Three new filters have been introduced in this series with center frequencies of 978, 1030 and 1090 MHz. All three are offered in a small 11 × 9 × 4.5 mm package and are available on tape and reel.

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IMS PRODUCT SHOWCASE: AISLES 1900-2100

RFHIC Corp. Booth 1935

Amplifiers



RFHIC has developed and delivered this 1.5 kW S-Band (2.7 to 3.1 GHz), RRM291K5-10, within 6 short months from a customer's order. This COTS solution can be used for various applications including airport traffic radar. It has 15 percent duty cycle, 200 µs, more than 60 dB of gain, and 34 percent of typical overall efficiency. This is the most cost effective 1.5 kW S-Band solution in the world. Send your request to rfsales@rfhic.com for more information, pricing and availability.



Accommodating the future of 4G/LTE small cells, RFHIC introduces RTH series (Asymmetrical Doherty configurations) and HT series (cascaded) amplifiers fabricated using an advanced high power density GaN semiconductor process. This high performance amplifier achieves high efficiency and powers of 5 to 10 W, while covering typical telecom LTE frequency ranges such as from 2610 to 2690 MHz. These power amps are packaged in a very small form-factor on AIN (aluminum nitride) board which provides excellent thermal dissipation.



As the 2.4 GHz spectrum is getting saturated, the demand of using 5.8 GHz spectrum for Wi-Fi has exploded. RFHIC has a perfect solution: the HS5758-10A amplifier has 18.5 dB of gain and 41 dBm of typical Psat with a drain efficiency of 45 percent. The incredibly small size is only 20.5 × 15 × 4.8 mm, and the cost is even smaller. Lower than a comparable GaAs solution, the HS5758-10A is the ideal amplifier for Wi-Fi applications.



HM0220-05A is a wideband power amplifier designed for general continuous-wave applications. Using an advanced GaN semiconductor process, this high-performance 5 W (typical) amplifier achieves PAE of 30 percent minimum over a large instantaneous bandwidth. This new GaN hybrid IC is 50 Ω input/output matched packaged in a very small form factor (20.5 × 10 × 2.3 mm) AIN board that provides excellent thermal dissipation. It operates in the 200 to 2000 MHz range. The amplifier is equipped with metal lid which can also release heat upwards.

www.rfhicusa.com

Shanghai Huaxiang Computer Communication Engineering Co. Ltd. Booth 1942

Serial Switch Matrix

SHX serial switch matrix has a frequency range up to 26.5 GHz and is widely used in wireless communication systems with remote control with LAN, RS-232 and USB interfaces, or in local control with LCD display and keypad and knob. The switches include relay or solid-state with fast switching speed (ms or ns). Different configurations such as 8 × 16, 8 × 8, 4 × 4, 4 × 2, and 3 × 6 are available in modular designs with flexibility. Custom designed products are also available.



www.shx-sh.com

Freescale Semiconductor Booth 2003

Low Noise Amplifier

The MML09231H is a single-stage ultra low noise amplifier with active bias and high isolation for use in cellular infrastructure, tower-mounted amplifiers and small cell applications. It operates from 700 to 1400 MHz with a noise figure of 0.36 dB and P1dB of 24 dBm. It can be biased with a single 5 V supply and includes a bias-enabled pin. The MML09231H is suitable for ISM, 3G, W-CDMA and 4G LTE transmit protocols.



Integrated Module



The MMDS20254H is an integrated module designed to enable accurate alignment of phase and amplitude on the carrier and peaking paths of high power Doherty amplifiers. The MMDS20254H enables superior linearity-efficiency trade-off while improving output power. It contains a coupler, digitally-selectable phase shifters and step attenuators, and operates from a single voltage supply. The MMDS20254H is suitable for transmit protocols such as W-CDMA and LTE using frequencies from 1800 to 2200 MHz, and is controlled using a SPI interface.

www.freescale.com

Sumitomo Electric Device Innovations Booth 2120

SATCOM GaN Products



Sumitomo Electric introduces new devices to its line of high power GaN products for Ku-Band SATCOM applications. The Ku-Band products are available in 25 or 50 W GaN IMFETs. These devices operate in frequencies from 13.75 to 14.5 GHz and are optimized for high output power, gain and PAE in a 50 Ω system. The devices are available now.

www.sei-device.com

Crane Aerospace & Electronics Microwave Solutions Booth 2135

VITA VPX Components



Crane Aerospace & Electronics Microwave Solutions introduces a family of VITA VPX form modular components for use in electronic warfare systems. The devices include IF up and down converters, a stepped fixed IF local oscillator and a stepped fixed RF local oscillator. Low noise and exceptional performance are the major performance factors for these units. Rugged designs are employed to meet challenging operating environments. Visit the company at IMS Booth 2135.

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See us at IMS Booth 2003

JFW Industries Inc. Booth 2202

RF Attenuators



JFW Industries is pleased to announce two new additions to its series of mini-benchtop, programmable attenuator assemblies. The 50BA-011-95 offers 0 to 95 dB of attenuation in 1 dB steps from 2 to 6 GHz, while the 50BA-010-127 gives 0 to 127 dB and operates 700 to 3000 MHz. Other configurations are also available. Please visit JFW Industries' website for more information.

www.jfwindustries.com

Times Microwave Systems Booth 2207

Coaxial Cable Assemblies

SPP-250-LLPL 50 Ω low loss plenum rated coaxial cable assemblies employ a corrugated copper tube outer conductor over a tape wrapped low density PTFE dielectric core, resulting in an exceptional combination of low loss, light weight and flexibility. Superior in copper cable asembly electrical performance, SPP-250-LLPL cables are the perfect in-building solution for PIM-sensitive installations and system interconnects. Meeting the fire resistance requirements of UL 910 for plenum rated applications, these assemblies are suitable for in-building jumpers and system interconnects up to 18 GHz.



www.timesmicro.com



LPKF Laser & Electronics AG Booth 2215

UV Laser System



Winner of a 17th annual SMT Vision Award, the ProtoLaser U3 is a UV laser system that etches circuitry, drills holes, and depanels PCBs all in one step. Its precise, stress-free ablation method assures that iterations match even the most complex design data and it is also ideal for working with RF and microwave substrates. With its blazing processing speeds, the U3 is perfect for prototyping or small batch production.

www.lpkf.com

Networks International Corp. Booth 2307

Multi-Function Assemblies

NIC's engineering expertise in hi-reliability RF products has expanded to include a myriad of multi-function assemblies across frequencies ranging from 1 MHz to 20 GHz. These assembly types include: filter/LNAs, duplexer/LNAs, switch filter banks (2, 4, 6, 8 channel), multiplexers, phase shifters and Tx/Rx assemblies. Whether your challenge is a small form factor, high power or cost, NIC's unique integrated assemblies showcase a variety of creative solutions for all of your radar and communications needs. Please stop by Booth 2307 for additional information.



www.nickc.com

Aethercomm Booth 2310

Amplifier System



Aethercomm model number SSPA 5.10-5.25-50 is a high power, RF booster amplifier system that operates from 5100 to 5250 MHz minimum and is packaged in a rugged enclosure. This PA was designed with unmatched GaN devices and this allows us to tailor this amplifier for operation anywhere from UHF to X-Band with similar power and gain characteristics. Please contact the factory with your specific frequency operating requirements.

www.aethercomm.com



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Mini-Circuits **Booth 2311**

Ceramic Bandpass Filters



The CBP series of ceramic bandpass filters operates in a frequency range from 1170 to 1980 MHz. These filters feature excellent rejection, low passband insertion loss all in a miniature shielded package.

Wideband Frequency Mixer



SIM-193H+ is a ceramic surface mount frequency mixer with a wide bandwidth of 7.3 to 19 GHz. Features include: low conversion loss of 6.2 dB typical, high L-R isolation of 33 dB typical, excellent IF bandwidth of DC to 7.5 GHz, LTCC double balanced mixer, tiny size, low profile of 0.08", useable as up and down converter, aqueous washable and is protected under U.S. Patent 7,027,795. Applications include: fixed satellite, mobile and radio location. Price: $14.95 each, Qty: 10.

Image Reject Mixer



RCIR-161LH+ is a surface-mount image reject mixer that operates in a frequency range from 80 to 168 MHz. Features include: excellent image rejection of 32 dB typical, low conversion loss of 6.1 dB typical and is aqueous washable. Applications include: VHF, military and avionics. Price: $19.95 each, Qty: 10.

Precision Fixed Attenuators



YAT attenuators (RoHS compliant) are fixed value, absorptive attenuators fabricated using highly repetitive MMIC processing including thin film resistors on GaAs substrates. YAT attenuator die contain through wafer Cu metallization vias to realize low thermal resistance and wideband operation. YATs are available with nominal attenuation values of 0 to 10 dB (in 1 dB steps), and 12, 15, 20, and 30 dB. Packaged in tiny 2 × 2 mm MCLP™ package fits into tiny spaces. Features include: exceptional power handling of up to 2 W, wide bandwidth of DC to 18 GHz and a small size of 2 × 2 mm.

High Power Bi-Directional Coupler

The ZGBDC35-93HP+ is a 35 dB DC pass high power bi-directional coupler that operates in a wide frequency range of 900 to 9000 MHz. Features include: good coupling flatness of ±0.8 dB typical, high directivity of 25 dB typical, good VSWR of 1.10:1 typical, high power of up to 250 W and DC current pass through input to output. Applications include: cellular, PCN, lab use, GSM, WiMAX and ISM.



Coaxial High Pass Filters

ZFHP-0R12+ is a high pass filter in a connectorized package. This low frequency cutoff high pass filter eliminates noise that feed into RF/baseband circuits from low frequency sources. Features include: low insertion loss, high rejection, passband from kHz range and connectorized package. These coaxial high pass filters operate in a frequency range from 0.12 to 1000 MHz. Price: $39.95, Qty: 1-9.



Coaxial High Pass Filters



The ZX75HP series of coaxial high pass filters operate in a frequency range from 95 to 3000 MHz. Features include: passband from 100 MHz, low insertion loss and high rejection. ZX75HP-44+ is a high pass filter in a rugged connectorized package covering 95 to 1800 MHz. This filter will find its application in TV Broadcast, point-to-point military radio and cordless telephones. It has repeatable performance across production lots and consistent performance across temperature. Price: $54.95, Qty: 1-9.

16 W Signal Tap



The ZARC-20-52+ operates in a frequency range from DC to 500 MHz and offers 20 dB coupling, 50 Ω. Features include: excellent mainline loss of 0.9 dB typical, excellent VSWR of 1.2 typical and input power up to 20 W at room temperature. Applications include: instrumentation and amateur radio.

Voltage Variable Equalizer



The VAEQ-1000+ is a 50 Ω voltage variable equalizer built into a shielded case. Size: 0.394" × 0.394" × 0.150". This model offers excellent performance over a wide frequency range of 50 to 1000 MHz with the variable slope providing great flexibility in a small package. The VAEQ-1000+ is often used to compensate RF chain gain flatness or cable loss versus frequency. The voltage variable equalizer offers adjustable attenuation slope, IP3 +45 dBm typical and minimal deviation from linear loss of ±0.4 dB.

High Frequency Mixers



The HJK series of high IP3 frequency mixers operate in a frequency range from 120 to 4100 MHz. The HJK-412H+ in this series operates in a frequency range from 2400 to 4100 MHz. Features include: high IP3 of 25 dBm typical, good L-R isolation of 30 dB typical and L-I isolation of 35 dB typical. Applications include: radar, fixed microwave, industrial scientific and medical, broadcast and amateur radio. Price: $9.95 each, Qty: 10.

Low Noise MMIC Amplifiers



The PGA-106 series of 75 Ω, flat gain, high dynamic range, low noise MMIC amplifiers operate in a frequency range from 5 to 2150 MHz. PGA-106-75+ (RoHS compliant) is an advanced wideband amplifier fabricated using E-PHEMT technology and offers extremely high dynamic range over a broad frequency range with low noise figure and flat gain. Lead finish is SnAgNi. It has repeatable performance from lot to lot and is enclosed in a SOT-89 package for very good thermal performance. Price: $2.64, Qty: 20.

www.minicircuits.com

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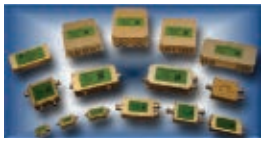
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See us at IMS Booth 825

Werlatone Booth 2312

Combiners and Directional Couplers

Werlatone's high power combiners and directional couplers include a growing product line, supporting a full 20 to 1000 MHz bandwidth. The new low loss combers address



power requirements ranging from 5 to 1000 W CW and tolerate severe power unbalances while maintaining excellent port-to-port isolation. The company's new line of dual directional couplers provides a low loss solution for broadband amplifier manufacturers seeking non-connectorized couplers at the module level or connectorized components at the amplifier output.

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www.werlatone.com

West•Bond Booth 2320

Assembly and Test Equipment



Since 1966, West•Bond Inc. has been a designer and manufacturer of assembly and test equipment for the microelectronic industry in Southern California. Its products include automatic, semiautomatic and manual ESD protected bonders with ultrasonic, thermosonic and thermocompression wire/ribbon capability. Included in the company's product lines are eutectic and epoxy die bonders, insulated wire bonders and pull testers with its patented X-Y-Z, 8/1 ratio micromanipulator.

www.westbond.com

Cernex Inc. Booth 2326

Frequency Multipliers (Extenders)



Cernex offers a full line of these full waveguide band frequency multipliers from WR90 (8 to 12 GHz) up to WR110 (75 to 110 GHz). The input power is 0 dBm, the output power can be 0 dBm up to 30 dBm depending on the frequency bands. The DC voltage is 12 to 15 V. The interfaces can be coax (up to 75 GHz) or waveguides. These multipliers have built-in filters to reduce the harmonics.

www.cernex.com

CTT Inc. Booth 2409

Solid-State Power Amplifiers



CTT Inc. introduced a new line of over 30 durable, compact, GaN-based solid-state power amplifiers capable of pulsed and continuous-wave (CW) power levels to 40 W at the frequencies used in defense radar, DF, and EW systems, from 2 to 18 GHz. Whether narrowband, wideband or ultra-wideband, operating in pulsed or CW mode, CTT's GaN power amplifiers are an especially attractive choice for new multifunction radar systems that effectively conserve weight, space and power consumption.

www.cttinc.com

CETC 41st Booth 2421

Vector Signal Generator



The AV1443 vector signal generator has a wide frequency range of 250 kHz to 44 GHz and excellent vector modulation signal: EVM (% RMS) < 2.5% (Symbol Rate 4 MHz), Origin Offset < -40 dBc. The wideband vector modulation signal output is 80 MHz (internal baseband) and 160 MHz (external I/Q). The external wideband I/Q input modulation function supports external arbitrary waveform from generator of 500 MHz modulated bandwidth.

www.ei41.com

BOWEI Integrated Circuits Co. Ltd. Booth 2504

Silicon Cavity Filter Chip



Since 2009, BOWEI has pushed brand new silicon cavity filter chips to the market, and a volume of 50 k per year has been used by module level customers. Now it has a second new generation of these products with TSV GND Hole design, resulting in an additional 30 percent reduction on size and up to nearly 80 dB stopband attenuation. Both pure chip and chips with kovar carrier are available.

www.cn-bowei.com

KRYTAR Inc. Booth 2511

Directional Coupler



KRYTAR's new directional coupler expands its family of superior performance products offering ultra-broadband coverage. Model 101065013 is a multi-purpose, stripline design that exhibits excellent coupling over the 1 to 65 GHz frequency band. Coupling (with respect to output) is 13 dB ±1.0 dB, frequency sensitivity of ±1 dB (1 to 30 GHz) and ±2.0 dB (30 to 65 GHz). Directivity specifications are >15 dB (1 to 20 GHz), >10 dB (20 to 30 GHz), and >7.2 dB (30 to 65 GHz).

www.krytar.com

RLC Electronics Booth 2521

Programmable Step Attenuators

RLC Electronics offers the smallest binary controlled programmable step attenuators available with a frequency range of DC to 26.5 GHz, supporting both military and commercial



applications. RLC offers attenuation ranges of 0 to 15 dB in 1 dB steps or 0 to 70 dB in 10 dB steps. These values can be customized as well to meet your unique, specific system requirements. The attenuators are available in both failsafe and latching operating mode and are also offered with a TTL driver.

www.rlcelectronics.com

Accel-RF Instruments Corp. Booth 2703

Accelerate RF Solutions



Ensure that you have the best possible accuracy of all high power RF measurements with the RF Attenuation Unit from Accel-RF Instruments. Standard fixed attenuators undergo variation in attenuation factor under higher incident powers, which negatively impacts accuracy. Using a novel approach, the RF Attenuation Unit shows negligible change in performance up to 100 W incident over a wide frequency band (1 to 10 GHz) in a compact, bench-top module.

www.accelrf.com

Holzworth Booth 2715

Synthesis and Phase Noise Analysis

Holzworth Instrumentation is a global provider of high performance RF synthesis and phase noise analysis products. Holzworth's



broadband (250 kHz to 20 GHz) RF synthesizer module designs are based on a proprietary non-PLL architecture that is optimized for ultimate stability, switching speed and ultra low phase noise performance. Holzworth's phase noise analyzer products are of the same innovative design philosophy optimized for speed, accuracy and reliability. Exciting new products will be launched at IMS 2013. Visit the Holzworth booth for a live demo.

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www.holzworth.com

Marki Microwave Booth 2817

Surface Mount Balun



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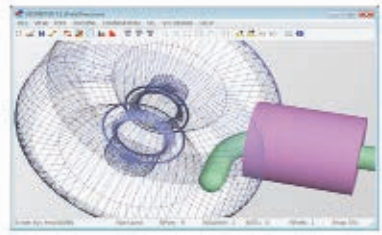
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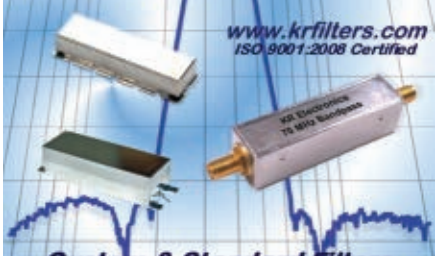


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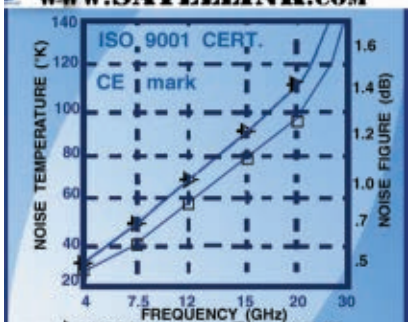
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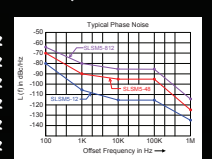
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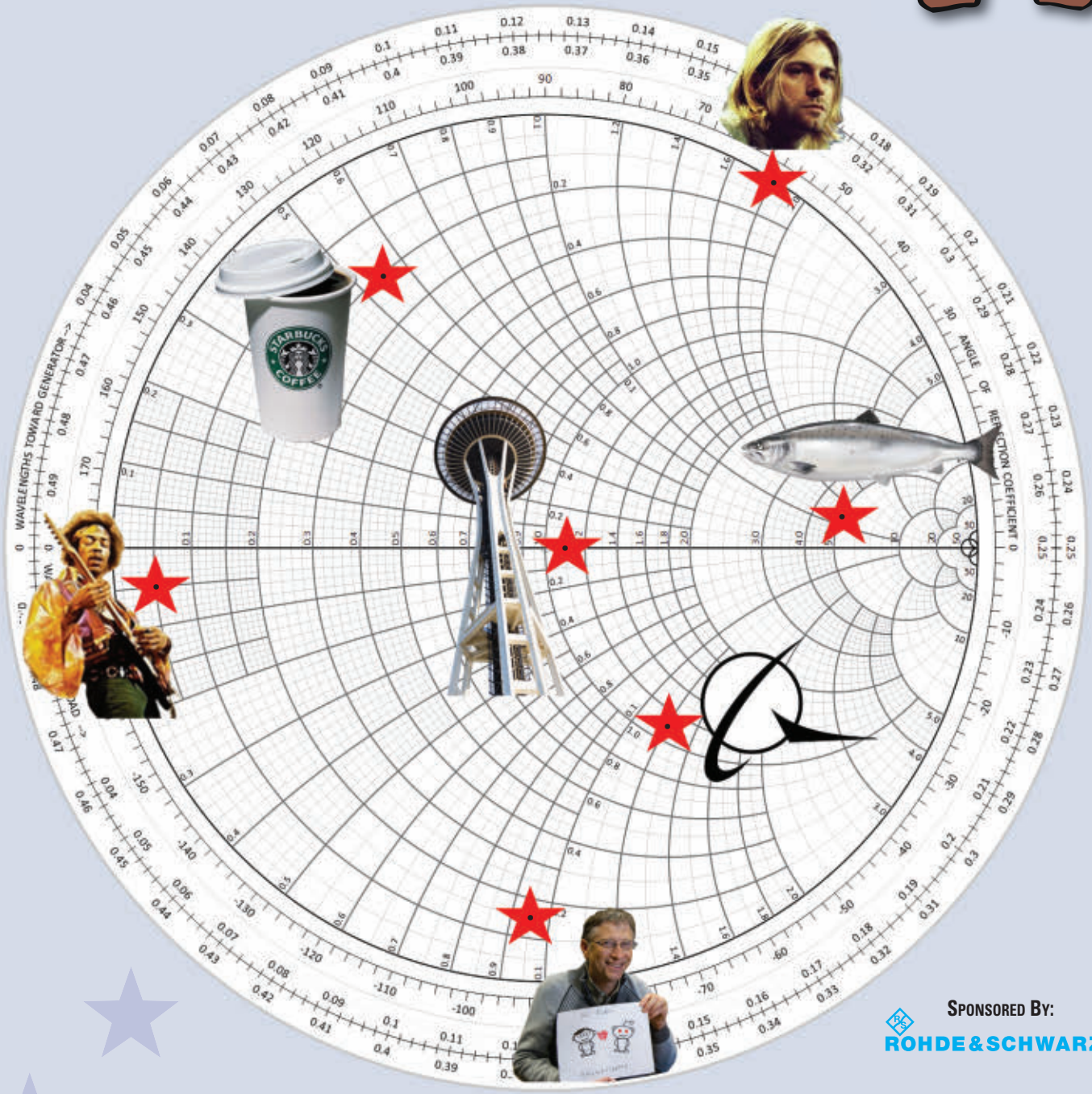
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D8632	2-Way	20-1000	50	2.2 x 2.02 x 1.5	0.7	1.40:1	20
D8300	2-Way	20-1000	100	2.45 x 2 x 0.91	0.5	1.35:1	20
D8544W*	2-Way	20-1000	100	2.85 x 2.5 x 1	0.5	1.35:1	18
D8682	2-Way	20-1000	500	5.2 x 2.65 x 1.8	0.6	1.35:1	15
D8851W*	2-Way	20-1000	500	5.6 x 3.05 x 1.8	0.6	1.35:1	15
D7365	4-Way	20-1000	100	5 x 2 x 1	0.75	1.35:1	20
D7439	4-Way	20-1000	250	5 x 5 x 1.5	0.75	1.35:1	18
D8746	4-Way	20-1000	500	7.2 x 3.5 x 1.4	0.7	1.35:1	15
D9048	4-Way	20-1000	500	5 x 4.7 x 1.4	0.6	1.35:1	17
D9075	4-Way	20-1000	1000	5.7 x 4.7 x 1.75	0.65	1.35:1	15

* "W" references a Watertight Design

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Model	Coupling (dB)	Frequency (MHz)	Power (WCW)	Size (Inches)	Insertion Loss (dB)	VSWR	Directivity (dB)
C8858	40	10-1000	250	2.09 x 1.16 x 0.57	0.4	1.30:1	20
C9191	30	20-1000	100	1.76 x 1.16 x 0.565	0.7	1.25:1	20
C8631*	40	20-1000	150	1.5 x 0.95 x 0.5	0.35	1.25:1	20
C8696	40	20-1000	150	1.76 x 1.16 x 0.57	0.35	1.25:1	20
C8686	40	20-1000	500	5.2 x 2.7 x 1.7	0.35	1.25:1	20
C9107	53	20-1000	10000	4.45 x 2.4 x 1.59	0.4	1.30:1	20

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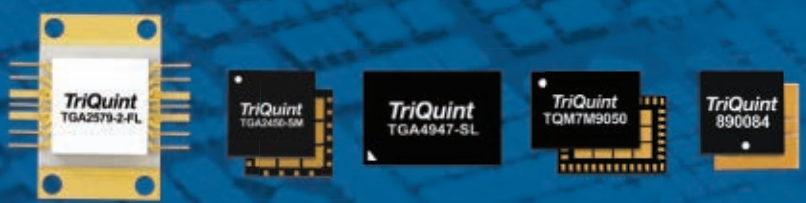


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Our guide lists over 700 standard products and highlights 130 new releases, showcased in our New Products section.

Products are organized both by key market applications and product types. Included is a growing defense & aerospace market section with updated product tables sorted by GaN, electronic warfare, radar, space and comms. We've also incorporated block diagrams identifying TriQuint product functionality with blue symbols and TriQuint integrated product functions in green blocks to indicate where TriQuint solutions exist.

We invite you to visit our website at triquint.com to obtain full product specifications. TriQuint's online resource section offers additional insights for simplifying RF connectivity through a growing collection of technical resources. While visiting our website, click on 'subscribe' to receive TriQuint's quarterly e-newsletter and new product announcements.

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About TriQuint

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Committed to innovation and speed, TriQuint designs, develops and manufactures advanced RF solutions. We reach further, with solutions that boost performance and extend range while reducing size, cost and bill of materials. We reach faster, utilizing our broad technology portfolio to simplify complex RF challenges and enable our customers a better time to market. **Customers count on TriQuint to solve their toughest RF challenges, today and tomorrow.**

TriQuint's advanced research and extensive government grants have bolstered our technology portfolio. In the last three decades we've pioneered and refined industry-leading power and filter processes, including gallium arsenide (GaAs), gallium nitride (GaN), surface acoustic wave (SAW), and bulk acoustic wave (BAW) technologies. TriQuint uniquely integrates many of the world's most advanced RF solutions to deliver solid customer value. These solutions can enable quicker design turns, streamlined manufacturing and lower overall system costs. TriQuint high-efficiency solutions can extend battery life in mobile devices and can reduce electrical consumption in networks, defense and aerospace systems.

Our product portfolio of power, control and acoustic filter technologies serves start-up firms as well as the world's



largest companies across commercial and defense manufacturers. Customers can access our award-winning RF solutions through standard products like those in this catalog and custom designs fabricated in our advanced foundries. TriQuint also offers in-house assembly services that can place die-level devices into single and multi-chip packages.

TriQuint was founded on RF innovation which continues today through our advanced technology programs that are setting new benchmarks in high-performance GaN solutions. Our acoustic filter technologies embrace the latest temperature compensation techniques and wafer level packaging. We are well positioned to serve the growing needs of wireless, fiber optic, telecom, CATV and defense / aerospace manufacturers around the world.

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- GaAs can operate efficiently at higher breakdown voltages compared to silicon-based semiconductor technologies while generating less noise in frequencies in excess of 250 MHz. GaAs offers high efficiency, linearity and good wideband performance.
- GaN offers greater power handling and density than GaAs across a wider frequency range. Intrinsic GaN technology advantages enable unprecedented performance, or at a given power level, a solution using fewer or smaller devices. GaN offers excellent efficiency, linearity and noise figures, plus greater wideband capability.
- SAW filter technology offers excellent performance and economy through 2.5 GHz. Our temperature-compensated SAW products expand this versatile technology's capabilities to meet more demanding performance requirements for new and emerging applications.
- BAW filters offer superior low-loss and strong ESD performance as well as greater resistance to temperature effects from 2.5 to 6 GHz and beyond. BAW is ideal for challenging applications such as co-existence filter requirements, defense and aerospace where precise performance is most valued.



Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
CATV Gain Block	0.05 - 1	– / 39.5	16	2.7 / –	5 / 130	SOT89	TAT7461-X
CATV 12V Power Doubler MMIC	0.05 - 1	–	11	4 / –	12 / 570	SOIC16W	TAT8801A1H
CATV 12V Power Doubler	0.05 - 1.003	34 / 49	21	4.5 / –	12 / 650	5x7 QFN	TAT8804D1H
E-pHEMT LNA Gain Block	0.05 - 4	23 / 37	22	– / 0.55	5 / 115	2x2 DFN	TQP3M9035
30W HPA	6 - 12	(45) / –	30	– / 30	25 / 1100	Die	TGA2590
2.8W Wideband PA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	GSG Flange	TGA2501-GSG
10W HPA	7.5 - 12	(41) / –	30	– / 25	12 / 3000	GSG Flange	TGA2517-GSG
7W HPA	9 - 11	(38.5) / –	22	– / 40	9 / 1050	7x7 QFN	TGA2704-SM
20W HPA	9.5 - 11	(43) / –	30	– / 30	25 / 720	Die	TGA2608
7W HPA	9.5 - 12	(38.5) / –	22	– / 36	9 / 1050	7x7 QFN	TGA2710-SM
4W Ku-Band HPA	13 - 15	(36) / –	25	– / 30	7 / 1300	Die	TGA2502
3.6W Ku-Band HPA	13 - 16	(35.6) / –	25	– / 27	7 / 1300	GSG Flange	TGA2502-GSG
5W HPA	13.5 - 16	(37) / –	25	– / 20	8 / 2600	GSG Flange	TGA2536-FL
2W HPA	17 - 20	33 (34.5) / 42	21	–	6 / 1430	5x5 QFN	TGA4534-SM
2W HPA	21 - 24	32 (34) / 41	22	–	6 / 1430	5x5 QFN	TGA4535-SM
3.5W HPA	30 - 38	(35) / –	18	– / 20	6 / 2100	Carrier	TGA2575-TS
37 - 40 GHz Power Amplifier	37 - 40	30 (32) / 38	26	– / 18	6 / 900	Die	TGA4542
40.5 - 43 GHz Power Amplifier	40.5 - 43.5	28.5 (30) / 38	23	– / 14	6 / 900	Die	TGA4543

Variable Gain Amplifiers

Description	Frequency Range (GHz)	P1dB / OIP3 (dBm)	Gain (dB)	Gain Range (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Digital Variable Gain Amplifier	0.4 - 4	24 / 42.5	32	31.5	5 / 176	6x6 QFN	TQM879026
Digital Variable Gain Amplifier	0.4 - 4	27.3 / 45	33	31.5	5 / 230	6x6 QFN	TQM879028
Variable Gain Amplifier	0.5 - 2 .7	16 / 29	38	30	5 / 95	5x5 QFN	TQM8M9079

Gain Block Amplifiers

Description	Frequency Range (GHz)	Psat (dBm)	Gain (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Gain Block	2 - 12	20	30	5 / 200	8x8 QFN	TGA3500-SM

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
LNA, Balanced E-pHEMT FET	0.5 - 1.5	21.5 / 20.7	18	0.5	4.35 / 57	4x4 QFN	TQP3M9039
E-pHEMT LNA Gain Block / Bypass Mode	0.7 - 1	20 / 16	19	0.6	5 / 68	3x3 DFN	TQL9042**
LNA, Balanced E-pHEMT FET	1.5 - 2.3	21.8 / 21.8	18	0.54	4.35 / 57	4x4 QFN	TQP3M9040
E-pHEMT LNA Gain Block / Bypass Mode	1.7 - 2.3	20 / 17	19	0.6	5 / 68	3x3 DFN	TQL9043**
E-pHEMT LNA Gain Block / Bypass Mode	2 - 2.7	20 / 17	17.7	0.7	5 / 68	3x3 DFN	TQL9044**
LNA, Balanced E-pHEMT FET	2.3 - 4	22.5 / 20.2	18	0.75	4.35 / 57	4x4 QFN	TQP3M9041
S-Band LNA	2.5 - 4	18 / –	17	1.2	6 / 110	5x5 QFN	TGA2614-SM
S-Band LNA	2.7 - 3.8	– / 42.5	12.5	2	6 / 320	Die	TGA2613
S-Band LNA	2.7 - 3.8	18 / –	17	0.95	6 / 100	Die	TGA2614
4 - 20 GHz Limiter / LNA	4 - 20	18 / 28	17	2	5 / 100	7x7 QFN	TGM2543-SM

NOTES: ** = Coming Soon

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	PAE (%)	Voltage / Current (V / mA)	Package Style	Part Number
35W HEMT	DC - 3.5	(45.6)	14	54	32 / 150	Ceramic Flat Lead	T2G4003532-FS
35W HEMT	DC - 3.5	(45.6)	14	54	32 / 150	Ceramic Flat Lead	T2G4003532-FL

Discrete Transistors (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	PAE (%)	Voltage / Current (V / mA)	Package Style	Part Number
60W HEMT	DC - 3.5	(48.2)	14	51	32 / 200	Ceramic Flat Lead	T1G4006032-FS
60W HEMT	DC - 3.5	(48.2)	14	51	32 / 200	Ceramic Flat Lead	T1G4006032-FL
120W HEMT	DC - 3.5	(50.8)	14	52	32 / 575	Ceramic Flat Lead	T1G4012032-FS
120W HEMT	DC - 3.5	(50.8)	14	52	32 / 575	Ceramic Flat Lead	T1G4012032-FL
10W HEMT	DC - 6	(40.5)	15	52	32 / 50	5x5 QFN	T1G6001032-SM
30W HEMT	DC - 6	(44.7)	12	50	28 / 200	Ceramic Flat Lead	T2G6003028-FL
0.18mm Pwr pHEMT	DC - 20	22	14	55	8 / 29	Die	TGF2018
0.25mm Pwr pHEMT	DC - 20	24	14	60	8 / 41	Die	TGF2025
0.4mm Pwr pHEMT	DC - 20	26	13	55	8 / 65	Die	TGF2040
0.6mm Pwr pHEMT	DC - 20	28	12	55	8 / 97	Die	TGF2060
0.8mm Pwr pHEMT	DC - 20	30	11.5	60	8 / 130	Die	TGF2080
1.2mm Pwr pHEMT	DC - 20	32	11	60	8 / 194	Die	TGF2120
1.6mm Pwr pHEMT	DC - 20	33.2	10.4	60	8 / 258	Die	TGF2160

Frequency Converters & Mixers

Description	Frequency Range (GHz)	Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Ku-Band Upconverter	10 - 16	17	25	15	5 / 300	5x5 QFN	TGC2510-SM
K-Band Upconverter	17 - 27	13	40	19	5 / 340	5x5 QFN	TGC4510-SM
K-Band Downconverter	17 - 27	15	40	3	3 / 230	5x5 QFN	TGC4610-SM

Voltage Controlled Oscillators

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	Voltage / Current (V / mA)	Package Style	Part Number
8.9 - 9.8 GHz VCO with Divide by 2	8.9 - 9.8	9	-112	5 / 170	5x5 QFN	TGV2561-SM
9.5 - 10.3 GHz VCO with Divide by 2	9.5 - 10.3	9	-111	5 / 170	5x5 QFN	TGV2562-SM
9.7 - 10.8 GHz VCO with Divide by 2	9.7 - 10.8	9	-111	5 / 170	5x5 QFN	TGV2563-SM
10.3 - 11.1 GHz VCO with Divide by 2	10.3 - 11.1	9	-111	5 / 170	5x5 QFN	TGV2564-SM
10.7 - 11.5 GHz VCO with Divide by 2	10.7 - 11.5	9	-111	5 / 180	5x5 QFN	TGV2539-SM
11.3 - 12.3 GHz VCO with Divide by 2	11.3 - 12.3	10	-110	5 / 180	5x5 QFN	TGV2565-SM
12.5 - 13.5 GHz VCO with Divide by 2	12.5 - 13.5	7	-110	5 / 165	5x5 QFN	TGV2529-SM
12.6 - 13.8 GHz VCO with Divide by 2	12.6 - 13.8	9	-110	5 / 170	5x5 QFN	TGV2584-SM
13.4 - 14.4 GHz VCO with Divide by 2	13.4 - 14.4	9	-110	5 / 175	5x5 QFN	TGV2566-SM

Signal Conditioning

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range dB or (Deg.)	Supply Voltage (V)	Package Style	Part Number
6-Bit Phase Shifter	6 - 18	>10	(354)	0 / -5	Die	TGP2105

SAW – Non-Dispersive Delay Lines

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
NDL 1.5 µsec	1000	675	34	SE / SE	70 @ 1625	25.4x12.7	857162
NDL 1.5 µsec	1000	425	26.5	SE / SE	65 @ 1550	25.4x12.7	857163
NDL 1.5 µsec	1000	340	24	SE / SE	65 @ 1550	25.4x12.7	857164
NDL 1.75 µsec	1000	675	35	SE / SE	70 @ 1625	25.4x12.7	857165
NDL 2 µsec	1000	675	36.5	SE / SE	70 @ 1625	25.4x12.7	857166
NDL 2.5 µsec	1000	675	40	SE / SE	70 @ 1625	25.4x12.7	857167
NDL 2.75 µsec	1000	675	41	SE / SE	70 @ 1625	25.4x12.7	857168
NDL 3 µsec	1000	675	43	SE / SE	70 @ 1625	25.4x12.7	857169

SAW Filters

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
IF Filter	70	2.4	10	SE / SE	45 @ 85	13.3x6.5	856980
IF Filter	70	4.9	25.5	SE / SE	45 @ 82	19x6.5	857174
IF Filter	70	5.7	24	SE / SE	40 @ 82	19x6.5	857175
IF Filter	140	1.5	25	SE / SE	45 @ 142	19x6.5	857177
IF Filter	140	28.5	21	SE / SE	40 @ 160	9x7	857176
IF Filter - Multi-Standard	184.32	25	7.8	BAL / BAL	25 @ 36	7x5.5	857124
IF Filter - Multi-Standard	192.5	65	17	BAL / BAL	35 @ 74	7x5.5	857071
IF Filter - Multi-Standard	242.5	25	9	BAL / BAL	32.2 @ 35	7x5.5	857072
IF Filter - Multi-Standard	397.5	66.7	16.6	BAL / BAL	35 @ 71.7	7x5.5	857073
IF Filter - Multi-Standard	447.5	25	14.1	BAL / BAL	35 @ 34.2	7x5.5	857074
B13 Notch Filter for SVLTE App.	782	15	0.6	SE / SE	24 @ 782	2.5x2	857061
RF Filter High Attenuation	810	5	5.5	SE / SE	50 @ 770	3x3	857191
BC0 Notch Filter for SVLTE App.	826	10	0.5	SE / SE	32 @ 826	2.5x2	857031
IFF RF Filter	1090	10	5.8	SE / SE	50 @ 1050	3.8x3.8	857179
GPS L5 Ultra Low Loss	1176.45	20	0.5	SE / SE	21 @ 1226	1.4x1.2	857143
GPS L5 High Attenuation Filter	1176.45	20	2	SE / SE	21 @ 1226	1.4x1.2	857144
GPS L2 Ultra Low Loss Filter	1227.6	20	0.5	SE / SE	21 @ 1177	1.4x1.2	857141
GPS L2 High Attenuation Filter	1227.6	20	2.1	SE / SE	21 @ 1177	1.4x1.2	857142
GPS RF Filter	1575.42	2	1.25	SE / SE	30 @ 1625	2.0x1.5	856584
GPS L1 Ultra Low Loss Filter	1575.42	20	0.6	SE / SE	21 @ 1625	1.4x1.2	857139
GPS L1 High Attenuation Filter	1575.42	20	2.6	SE / SE	21 @ 1625	1.4x1.2	857140
RF Filter - DPD Path	1960	160	3	SE / SE	29 @ 380	3x3	857145

BAW Filters

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
B25 Diversity Rx Filter	1962.5	65	2.5	SE / SE	–	2.0x1.6	885051
B40 Tx / Rx Filter	2350	100	1.3	SE / SE	45 @ 2427	1.4x1.2	885049
LTE / Wi-Fi Coexist Filter	2442	79	1.7	SE / SE	55 @ 2370	1.4x1.2	885033
LTE / Wi-Fi Coexist Filter	2442	79	1.7	SE / SE	59 @ 2570	1.4x1.2	885032
LTE B38 Tx / Rx Filter	2595	50	1.4	SE / SE	39 @ 2500	1.4x1.2	885026

SAW and BAW – Duplexers, Diplexers, Diplexed Duplexers and Dual Filter Modules

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Package Size (mm)	Part Number
Diplexer, High Attenuation, SAW	1176.45 / 1575.42	20.46	3.5	SE / SE	5x5	890086
Diplexer, Low Loss, SAW	1176.45 / 1575.42	20.46	0.9	SE / SE	5x5	890087
Diplexer, High Attenuation, SAW	1227.6 / 1575.42	20.46	3.5	SE / SE	5x5	890084
Diplexer, Low Loss, SAW	1227.6 / 1575.42	20.46	0.9	SE / SE	5x5	890085
Duplexer Bank – Diplexed Duplexer for BC1 / BC0, BAW / SAW	1880 / 1960 832 / 877	60 / 60 34 / 34	–	SE / SE	2.8x4.7	TQQ0101
Duplexer, B24 / BC14, BAW	1882.5 / 1962.5	65	2.8	SE / SE	3x3	TQM963001
Duplexer B25, BAW	1882.5 / 1962.5	–	–	SE / SE	2.0x1.6	TQM969002
Duplexer Bank – Diplexed Duplexer for B25 / 26, BAW / TC-SAW	1882.5 /1962.5 831.5 / 876.5	65/65 35 / 35	1.5/1.8 1.8 / 2	SE / BAL	2.8x4.7	TQQ2526
Diplexed Tx Filters for B38 / 40, BAW	2335 / 2595	70 / 40	2.5 / 2.5	SE / SE	2.0x1.5	885030
Dual Filter - B38 / 40 Rx Filters, BAW	2350 / 2595	100 / 50	3 / 1.9	SE / SE	1.7x1.3	885035

Integrated Products

Description	Features	Bands	Size (mm)	Part Number
GSM / GPRS Tx Module; PA / LPF / SP6T WGPRS Switch w/Dual-Band WCDMA Antenna Ports	Integrated QB GSM / GPRS & 2 WCDMA Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS & 2 WCDMA / LTE Bands	5.0x6.0x1.0	TQF9088

Integrated Products (cont.)

Description	Features	Bands	Size (mm)	Part Number
GSM / GPRS Tx Module; PA / LPF / SP8T WGPRS Switch with up to 4 WCDMA Antenna Switch Ports	Integrated QB GSM / GPRS & 4 WCDMA Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS & 4 WCDMA / LTE Bands	5.0x6.0x1.0	TQF9089
GSM / GPRS / EDGE / TD-SCDMA / TDD-LTE Tx Module; PA / LPF / SP8T Swith w/ up to 4 WCDMA Antenna Switch Ports	Integrated QB GSM / GPRS / EDGE / TD-SCDMA & 8 Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS, TD-SCDMA (Bands 34 & 39) + 4 WCDMA / LTE / TD-SCDMA / TDD-LTE Bands	5.0x6.0x0.8	TQM6M9098
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Penta-Band WCDMA / HSUPA / LTE PA Modules	1-Bit (Hi / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA & LTE B1, B2, B3 / 4, 5 & 8	5.0x7.0x1	TQM7M9050
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Penta-Band WCDMA / HSUPA / LTE PA Modules	1-Bit (Hi / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA & LTE B1, B2, B3 / 4, 5 & 8	5.0x7.0x1	TQP9058
Dual-Band WCDMA / HSUPA PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1 & 8	4.0x3.0x0.9	TQM7M6158
Dual-Broadband WCDMA / HSUPA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1, 2 & 5 & 8 (25 & 26) BC0, BC1 (BC10)	4.0x3.0x0.9	TQM7M6125
Dual-Band WCDMA / HSUPA PA Module, w/Coupler	1-Bit (High / Low Power Modes) Single LB / HB RF Input	Bands 1 & 8	4.0x3.0x0.9	TQM7M6018
Dual-Band WCDMA / HSUPA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Single LB / HB RF Input	Bands 2 & 5 (25 & 26) BC0, BC1 (BC10)	4.0x3.0x0.9	TQM7M6025
Dual-Broadband WCDMA / HSUPA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1, 2 & 5 & 8 (25 & 26) BC0, BC1 (BC10)	4.2x3.0x0.9	TQP6109
ASM SP10T 8 Linear GPIO	GPIO Controlled w/8 Linear Ports	3G / 4G / LTE	2.5x3.2x0.8	TQC9010
ASM SP12T 10 Linear GPIO	GPIO Controlled w/10 Linear Ports	3G / 4G / LTE	2.5x3.2x0.8	TQC9112
ASM SP12T 10 Linear MIPI	MIPI Controlled w/10 Linear Ports	3G / 4G / LTE	2.5x3.2x0.8	TQC9012
2.4 GHz WLAN PA + Low Noise Amplifier + SP3T Switch MMIC for Bluetooth® Path	ETSLP-16 Package, Coupler / Detector	802.11 b / g / n	2.5x2.5x0.4	TQF9046
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	ETSLP-16 Package	802.11 a / n / ac	2.5x2.5x0.4	TQF7062
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	ETSLP-16 Package, Detector / Coupler	802.11 a / n / ac	2.5x2.5x0.4	TQP887051
5 GHz WLAN PA + SP2T Switch MMIC	ETSLP-16 Package	802.11 a / n / ac	2.5x2.5x0.4	TQP887052

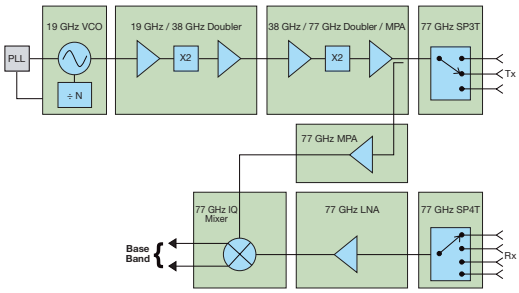
Optical Drivers

Description	Frequency Range (GHz)	Power (Vpp or dBm)	Gain (dB)	Voltage / Current (V / mA)	Package Style	Part Number
100 Gb/s Linear Dual Driver w/ Bias-T's inside	DC - 27	3-8Vpp	35	5 - 7 / 650	16x10.5x3.6 SL	TGA4894-SL**
200 Gb/s 16 QAM Linear Dual Driver w/Bias-T's Inside	DC - 27	3-5Vpp	24	5 - 7 / 500	12x10.5x3.6 SL	TGA4892-SL**
28 Gb/s 6V pp Diff In / Out Driver MMIC	DC - 28	4-8Vpp Diff	22 Diff	4 - 5 / 450	6x6 QFN	TGA4957-SM

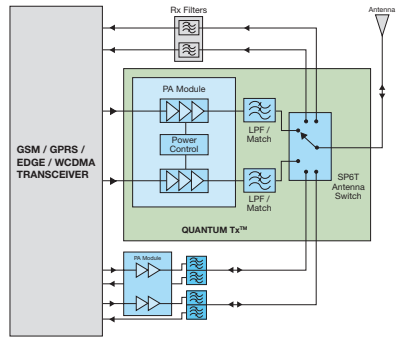
NOTES: ** = Coming Soon

Transimpedance Amplifiers (TIAs)

Description	Bandwidth (GHz)	Small Signal Gain (dB)	Differential Transimpedance Gain (ohm)	Differential Output Vpp (mV)	Equivalent Input Noise (pA / rtHz)	Voltage (V)	Current (mA)	Part Number
13 Gb/s Linear TIA with AGC	11	–	250 - 4800	200 - 900	24	3.3	175	TGA4861
32 Gb/s Linear TIA with AGC	28	–	250 - 4800	200 - 900	24	3.3	175	TGA4864
44.6 Gb/s Limiting TIA	36	–	2800	650	15	3.3	75	TGA4866
43 Gb/s Limiting TIA	30	40	4500	600	30	-5.2	85	TIA56
43 Gb/s Limiting TIA with PLD	27	36	3200	600	30	-5.2	85	TIA56A



Example of a 77 GHz Radar Front-End



Cellular & GPS Transceiver for Auto Telematics

Amplifiers & Low Noise Amplifiers

Description	Frequency Range (GHz)	Psat (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
77 GHz LNA	72 - 80	5	20	5	3.5 / 54	Die	TGA4705-FC
77 GHz MPA	76 - 80	14	12	–	3.5 / 75	Die	TGA4706-FC

Switches

Description	Frequency Range (GHz)	Insertion Loss	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SP3T	60 - 90	2.3	20	>-13	-5 / 1.35	Die	TGS4305-FC
SP4T	70 - 90	3	20	>-8	-5 / 1.35	Die	TGS4306-FC

Frequency Converters & Mixers

Description	Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	Psat (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
19 GHz VCO w/8:1 Prescaler	18.5 - 19.5	–	-105[+]	7.0	5 / 158	Die	TGV2204-FC
19 / 38 GHz Converter / MPA	36 - 40	9	–	14.5	3.5 / 65	Die	TGC4703-FC
77 GHz Down Converting I/Q Mixer	75 - 82	-13.5	22	–	1.1 / 7	Die	TGC4702-FC
38 / 77 GHz Converter / MPA	76 - 77	6	–	15.0	4 / 230	Die	TGC4704-FC

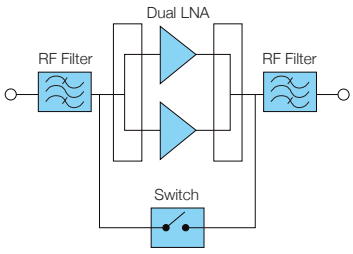
NOTES: [+] = Phase Noise (dBc / Hz @ 1 MHz Offset)

Integrated Products

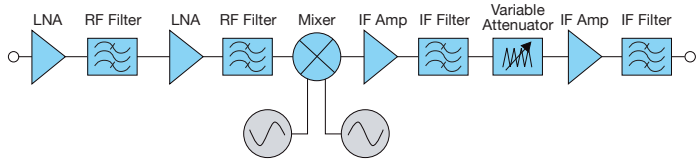
Description	Frequency Bands	Features	Package Size (mm)	Part Number
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 1	1-Bit (Hi / Low Power Modes)	7x4x1.1	TQM676021
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Low Power Modes)	7x4x1.1	TQM666022
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Bands 5 and 6	1-Bit (Hi / Low Power Modes)	7x4x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 8	1-Bit (Hi / Low Power Modes)	7x4x1.1	TQM626028L
GSM / GPRS Tx Module: PA / LPF / SP6T WGPRS Switch w/ Dual-Band WCDMA Antenna Ports	GSM900 / DCS or GSM850 / PCS & 2 WCDMA / LTE Bands	Integrated DB GSM / GPRS & 2 WCDMA Antenna Switch Ports	5x6x1	TQM6M9069
GSM / GPRS / EDGE-Linear Tx Module: PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA / LTE Ports	GSM900 / DCS or GSM850 / PCS & 4 WCDMA / LTE Bands	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch	5.25x6x1	TQM6M9085
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Med Power Modes)	4.5x3.5x1	TQM666052
Multi-Mode, Multi-Band Quad-Band GMSK / EDGE, Dual-Band WCDMA PA Module	GSM850 / 900, DCS / PCS & WCDMA B1 & B5 / 8	2-Bit (Hi / Med / Low Power Modes)	5x7x1	TQM7M9023
Multi-Mode, Multi-Band Quad-Band GMSK / EDGE, Dual-Band WCDMA PA Module	GSM850 / 900, DCS / PCS & WCDMA B1 & B5 / 8	1-Bit (Hi / Med / Low Power Modes)	5x7x1	TQM7M9053

Filters & Duplexers

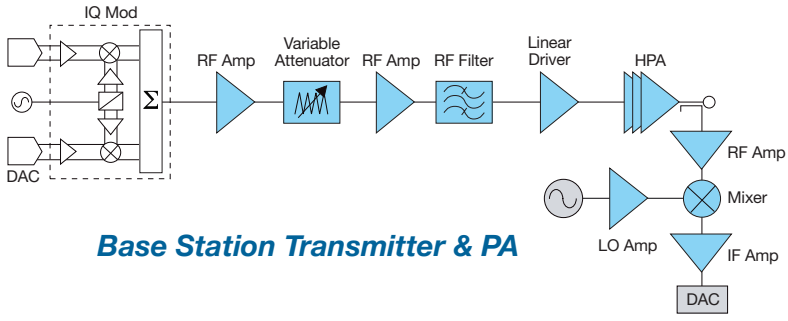
Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF Filter - Band 5 Uplink	836.5	25	2.3	SE / SE	50 @ 869	1.4x1.2	857038
Duplexer, Cell Band	836.5 / 881.5	25 / 25	1.9 / 1.9	SE / SE	–	3.8x3.8	856356
CDMA 2-in-1 Rx Filter	881.5 / 1960	25 / 60	1.6 / 2.2	SE / BAL	–	2x1.5	856565
GPS RF Filter	1575.42	2	1.25	SE / SE	30 @ 1624	2x1.5	856584
GPS RF Filter	1575.42	2	0.75	SE / SE	35 @ 1635	1.4x1.2	856561
GPS RF Filter	1575.42	2	1.1	SE / BAL	20 @ 1635	1.4x1.2	856576
GPS RF Filter	1575.42	2	0.6	SE / SE	21 @ Cell Bands	1.4x1.2	856793
GPS RF Filter, Auto	1575.42	2	1.8	SE / SE	45 @ 1637	3x3	856039
GPS RF Filter, Auto	1575.42	2	1.3	SE / SE	45 @ 1640	3x3	856139
GPS / SDARS Diplexer	1575.42 / 2332.5	3 / 25	0.6 / 0.08	SE / SE	GPS Port: 40 @ 2332 SDARS Port: 31 @ 1572	3x3	TQM2M9016
SDARS Filter	2332.5	45	1.7	SE / BAL	35 @ 2100	1.4x1.2	856604



Tower Mounted LNA



Base Station Receiver (Single Branch Shown)



Base Station Transmitter & PA

General Purpose Amplifiers

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
General Purpose Gain Block	DC - 3000	18.5 / 33	16.5	3.8	6 / 75	SOT89	AG603
General Purpose Gain Block	DC - 3500	18.5 / 33	13.6	4.4	6 / 75	SOT89	AG602
General Purpose Gain Block	DC - 6000	5.8 / 18.5	11	4.4	5 / 20	SOT86 / SOT363	AG201
General Purpose Gain Block	DC - 6000	7.5 / 19.5	17.7	3.1	5 / 20	SOT86 / SOT363	AG203
General Purpose Gain Block	DC - 6000	12 / 25	14.3	3.2	5 / 35	SOT86 / SOT363	AG302
General Purpose Gain Block	DC - 6000	12.5 / 25	18.4	3	5 / 35	SOT86 / SOT363	AG303
General Purpose Gain Block	DC - 6000	16 / 28.5	14.5	3.7	6 / 60	SOT86 / SOT89	AG402
General Purpose Gain Block	DC - 6000	16 / 28	18.9	3	6 / 60	SOT86 / SOT89	AG403
General Purpose Gain Block	DC - 6000	14.5 / 27.5	19.1	2.9	6 / 45	SOT86 / SOT89	AG503
Single-Ended Darlington	DC - 6000	19 / 33	18.2	3.5	6 / 75	SOT86 / SOT89	AG604

General Purpose Amplifiers (cont.)

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
General Purpose Gain Block	DC - 6000	15.2 / 29.8	15.7	3.6	5 / 45	SOT89	TQP369180
General Purpose Gain Block	DC - 6000	15.2 / 30	15.6	3.6	5 / 45	SOT363	TQP369181
General Purpose Gain Block	DC - 6000	16.1 / 29.6	22.3	3.9	5 / 45	SOT89	TQP369182
General Purpose Gain Block	DC - 6000	16.2 / 29.8	22	3.9	5 / 45	SOT363	TQP369184
General Purpose Gain Block	DC - 6000	19.8 / 32.3	20.4	4.7	5 / 75	SOT89	TQP369185
+5V Active Bias IF Gain Block	50 - 1000	20.5 / 44	19.5	5	5 / 95	SOT89	WJA1500
+5V Active Bias IF Gain Block	50 - 1000	20 / 47	14.4	5.4	5 / 95	SOT89	WJA1510
E-pHEMT LNA Gain Block	50 - 4000	20 / 37.5	21.5	1.1	5 / 85	SOT89	TQP3M9008
E-pHEMT LNA Gain Block	50 - 4000	21.4 / 37.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018
E-pHEMT LNA Gain Block	50 - 4000	22 / 40.5	24.7	0.9	5 / 125	SOT89	TQP3M9009
E-pHEMT LNA Gain Block	50 - 4000	22 / 40.5	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019
E-pHEMT LNA Gain Block	50 - 4000	21.5 / 40	15	2	5 / 85	SOT89	TQP3M9028
E-pHEMT LNA Gain Block	50 - 4000	21.5 / 40	15	2	5 / 85	3x3 QFN	TQP3M9038
E-pHEMT LNA Gain Block	50 - 4000	23 / 37	22	0.55	5 / 115	2x2 DFN	*TQP3M9035**
E-pHEMT LNA Gain Block	100 - 4000	22 / 34	19.4	0.8	5 / 55	3x3 QFN	TQP3M9005
E-pHEMT LNA Gain Block	100 - 4000	22.5 / 38.5	18.7	1	5 / 90	3x3 QFN	TQP3M9006
E-pHEMT LNA Gain Block	100 - 4000	23.5 / 41	18	1.3	5 / 135	SOT89	TQP3M9007

NOTES: ** = New*

High-Linearity Driver Amplifiers

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
29.5dBm HBT Amplifier	50 - 1500	30 / 47	19.4	6.3	5 / 220	SOT89	TQP7M9105
33.8dBm HBT Amplifier	50 - 1500	33 / 50	20.8	4.8	5 / 455	4x4 QFN	TQP7M9106
35.5dBm HBT Amplifier	400 - 2700	35.5 / 50	16	7	5 / 800	4x5 DFN	AH420
24.5dBm HBT Amplifier	400 - 4000	24.3 / 39.5	20.4	4	5 / 87	SOT89	TQP7M9101
27.5dBm HBT Amplifier	400 - 4000	27.5 / 44	21.9	4	5 / 137	SOT89	TQP7M9102
29.5dBm HBT Amplifier	400 - 4000	29.5 / 45.4	20.7	4.4	5 / 235	SOT89	TQP7M9103
33dBm HBT Amplifier	700 - 2700	33 / 50	27.5	7	5 / 680	5x5 QFN	AH323
39dBm HBT Amplifier	700 - 2900	39 / –	16.5	8	12 / 300	5x6 DFN	AP561
28dBm HBT Amplifier	700 - 3800	28 / 42	28.5	2.9	5 / 225	4x4 QFN	TQP8M9013
33.8dBm HBT Amplifier	700 - 4000	33.8 / 45	21	4.4	5 / 435	4x4 QFN	TQP7M9104
30dBm HBT Amplifier	1800 - 2700	30 / 46	24.6	5.5	5 / 400	SOIC-8	AH212-S8G

Variable Gain Amplifiers

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	Gain Range (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Digital Variable Gain Amplifier	50 - 4000	20.5 / 36.5	18	31.5	5 / 88	5x5 QFN	TQM8M9075
Digital Variable Gain Amplifier	50 - 4000	22 / 38.5	19.5	31.5	5 / 125	5x5 QFN	TQM8M9076
Digital Variable Gain Amplifier	50 - 4000	21.5 / 38.5	13	31.5	5 / 88	5x5 QFN	TQM8M9077
Digital Variable Gain Amplifier	400 - 4000	24 / 42.5	32	31.5	5 / 176	6x6 QFN	*TQM879026**
Digital Variable Gain Amplifier	400 - 4000	27.3 / 45	33	31.5	5 / 230	6x6 QFN	*TQM879028**
Variable Gain Amplifier	500 - 2700	16 / 29	38	30	5 / 95	5x5 QFN	*TQM8M9079**
Digital Variable Gain Amplifier	600 - 1000	24.3 / 40	31.7	31.5	5 / 174	6x6 QFN	TQM829007
Variable Gain Amplifier	700 - 2800	27.5 / 43	29	30	5 / 240	5x5 QFN	TQM8M9074
Digital Variable Gain Amplifier	1400 - 2700	24.5 / 43	31.7	31.5	5 / 174	6x6 QFN	TQM879006A
Digital Variable Gain Amplifier	1500 - 2700	27.3 / 47.5	41	31.5	5 / 285	6x6 QFN	TQM829008

NOTES: ** = New*

Low Noise Amplifiers

Description	Frequency Range (MHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
E-pHEMT LNA Gain Block	50 - 4000	20 / 17.5	21.5	1.1	5 / 85	SOT89	TQP3M9008
E-pHEMT LNA Gain Block	50 - 4000	21.4 / 17.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018
E-pHEMT LNA Gain Block	50 - 4000	21.8 / 15.8	24.7	0.9	5 / 125	SOT89	TQP3M9009
E-pHEMT LNA Gain Block	50 - 4000	21.8 / 15.8	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019
E-pHEMT LNA Gain Block	100 - 4000	22.3 / 18.7	15.3	0.8	5 / 55	3x3 QFN	TQP3M9005
E-pHEMT LNA Gain Block	100 - 4000	22.4 / 25	13.5	1	5 / 90	3x3 QFN	TQP3M9006
E-pHEMT LNA Gain Block	100 - 4000	23.5 / 18.5	18	1.3	5 / 135	SOT89	TQP3M9007
E-pHEMT LNA Gain Block	400 - 2000	20 / 16	20	0.45	5 / 68	2x2 DFN	TQP3M9036
LNA, Balanced E-pHEMT FET	500 - 1500	21.5 / 20.7	18	0.5	4.35 / 57	4x4 QFN	***TQP3M9039****
LNA, Balanced FET	700 - 915	20 / 13.5	20.5	0.55	4 / 70	4x4 QFN	TQP3M6004
LNA, Discrete FET	700 - 915	26 / 23.5	16	0.8	5 / 150	SOT89	TGF2021-04-SD
E-pHEMT LNA Gain Block / Bypass Mode	700 - 1000	20 / 16	19	0.6	5 / 68	3x3 DFN	***TQL9042***
LNA, Balanced FET	800 - 3000	21 / 11	22	0.4	4 / 100	2x2 QFN	TGA2602-SM
E-pHEMT LNA Gain Block	1500 - 2700	20 / 15	20	0.4	5 / 70	2x2 QFN	TQP3M9037
LNA, Balanced E-pHEMT FET	1500 - 2300	21.8 / 21.8	18	0.54	4.35 / 57	4x4 QFN	***TQP3M9040****
LNA, Balanced FET	1700 - 2000	21.6 / 14.4	18	0.55	3.5 / 50	4x4 QFN	TQP3M6005
E-pHEMT LNA Gain Block / Bypass Mode	1700 - 2300	20 / 17	19	0.6	5 / 68	3x3 DFN	***TQL9043****
E-pHEMT LNA Gain Block / Bypass Mode	2000 - 2700	20 / 17	17.7	0.7	5 / 68	3x3 DFN	***TQL9044****
LNA, Balanced E-pHEMT FET	2300 - 4000	22.5 / 20.2	18	0.75	4.35 / 57	4x4 QFN	***TQP3M9041****

NOTES: ** = New, ** = Coming Soon*

Control Products

Description	Frequency Range (MHz)	Insertion Loss (dB)	Isolation / Atten Range (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SP3T - Reflective	DC - 2000	0.6	22 / –	>34.5	2.6 / 0	2x2 QFN	TQP4M3019
6-Bit, Digital Attenuator, Parallel Ctrl	DC - 4000	1.3	– / 31.5	30	5 / 0	4x4 QFN	TQP4M9071
6-Bit, Digital Attenuator, Serial Ctrl	DC - 4000	1.3	– / 31.5	30	5 / 0	4x4 QFN	TQP4M9072
7-Bit, Digital Attenuator, Serial Ctrl	DC - 4000	1.3	– / 31.75	30	5 / 0	4x4 QFN	TQP4M9083
Through Line	DC - 6000	0.1	–	–	–	3x3 QFN	TQM4M9073
SPST - High Isolation, Absorptive	100 - 6000	0.4	48 / –	33	3 / 0	2x2 DFN	TQP4M0013
SPDT - High Isolation, Absorptive	100 - 6000	0.5	55 / –	30	3 / 0	4x4 QFN	TQP4M0010
SPDT - Reflective	100 - 6000	0.35	25 / –	33	3 / 0	2x2 DFN	TQP4M0008
SPDT - High Isolation, Reflective	100 - 6000	0.7	55 / –	30	3 / 0	MSOP8	***TQP4M0009****
SP3T - Reflective	100 - 6000	0.65	30 / –	30	3 / 0	3x3 QFN	TQP4M0011
SP4T - Reflective	100 - 6000	0.65	50 / –	35	3 / 0	3x3 QFN	***TQP4M0012****
SPDT - Reflective	1000 - 6000	0.6	28 / –	31.5	3 / 0	1.3x2 DFN	TQS5200
DPDT Switch	1000 - 6000	0.8	33 / –	33	3 / 0	3x3 QFN	TQS5202

NOTES: *** = Coming Soon*

Frequency Converters & Mixers

Description	Frequency Range (MHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage Current (V / mA)	Package Style	Part Number
WB Mixer, LO	500 - 2500	-5.7	8	24	3 - 6 / 6	MW6	CMY210
WB Mixer, LO, IF, Low Current	500 - 2500	9.5	10	10	3 - 6 / 8	SCT598	CMY213
Dual Branch Converter, LO, IF, SW, EN	680 - 920	9	33	25.5	5 / 295	6x6 QFN	TQP519021
Mixer, LO	700 - 1500	-9	17	36	5 / 50	MSOP-8	ML483
Mixer, LO	1500 - 3200	-8.5	2	35	5 / 45	MSOP-8	ML485
Dual Branch Converter, LO, IF, SW, EN	1700 - 2200	9	36	25.5	5 / 295	6x6 QFN	TQP569022

NOTES: EN = Enable / Disable Mode Amplifier, IF = IF Amplifier, LO = LO Amplifier, SW = LO Switch

Discrete Transistors

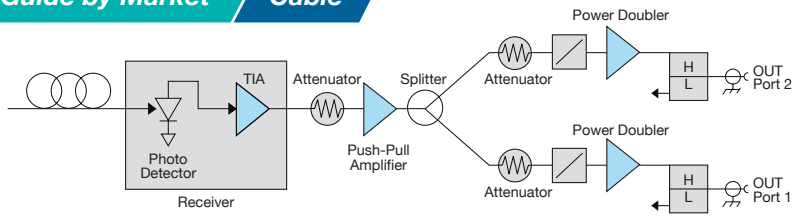
Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage Current (V / mA)	Package Style	Part Number
0.5W HFET	DC - 6000	28 / 40	18	3.2	8 / 100	SOT89	TGF2960-SD
MESFET	50 - 2500	30 / 40	11	1.7	5 / 350	SOT223	CLY5
MESFET	50 - 3000	27 / 37	15.5	1.5	5 / 180	MW6	CLY2

RF Filters

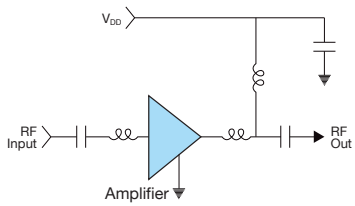
Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF SAW Filter - Band 12 Uplink	707	18	1.5	SE / SE	9 @ 728	3x3	856884
RF SAW - Band 12 Downlink	737	18	1.8	SE / SE	37 @ 708	3x3	856883
RF SAW Filter - Band 13 Downlink	751.5	11	1.5	SE / SE	40 @ 776	3x3	856794
BWA IF Filter	756	20	0.9	SE / SE	30 @ 716	3.8x3.8	856866
RF SAW Filter - Band 13 Uplink	781.5	11	1.5	SE / SE	38 @ 757	3x3	856764
RF SAW Filter - Band 13 Uplink	782	10	1.52	SE / SE	15 @ 765	3x3	856844
RF SAW Filter - Band 13 / 14 Uplink	787.5	22	2.75	SE / SE	40 @ 843	3x3	856977
RF SAW Filter - Band 5 Uplink	835	30	3	SE / SE	20 @ 869	3x3	857019
RF SAW Filter - Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	855729
RF SAW Filter - Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	856503
RF SAW Filter - Band 5 Uplink	836.5	25	1.9	SE / SE	35 @ 869	3x3	855821
RF SAW Filter - Band 5 Uplink	836.5	25	2	SE / SE	10 @ 869	3x3	856704
RF SAW Filter - Band 20 Uplink	847	30	1.3	SE / SE	10 @ 882	3x3	856932
EU ISM 875 Band RF Filter	875	13	2.4	SE / SE	55 @ 849	2x1.5	856963
RF SAW Filter - Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	856504
RF SAW Filter - Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	855728
RF SAW Filter - Band 5 Downlink	881.5	25	1.8	SE / SE	35 @ 849	3x3	855782
Cell Band Delay Filter, 450 ns	881.5	25	25	SE / BAL	–	7.x5.5	856716
RF SAW Filter - Band 8 Uplink	897.5	35	1.9	SE / SE	14 @ 930	3x3	856671
RF SAW Filter - Band 8 Uplink	897.5	35	1.5	SE / SE	15 @ 930	3x3	856657
RF SAW Filter - Band 8 Uplink	897.5	35	1.4	SE / SE	10 @ 984	3x3	856824
ISM 921.5 Band RF Filter	921.5	13	2.4	SE / SE	55 @ 825	2x1.5	856905
RF SAW Filter - Band 8 Downlink	942.5	35	2	SE / SE	5 @ 915	3x3	855820
RF SAW Filter - Band 8 Downlink	942.5	35	3.2	SE / SE	12 @ 915	3x3	855810
RF SAW Filter - Band 8 Downlink	942.5	35	2.5	SE / SE	25 @ 915	3x3	856528
RF SAW Filter - Band 11 Uplink	1445.4	35	1.25	SE / SE	20 @ 1495.9	3x3	856928
RF SAW Filter - Band 3 Uplink	1747.5	75	2	SE / SE	22 @ 1676	3x3	856654
RF SAW Filter - Band 3 Downlink	1842.5	75	1.9	SE / SE	10 @ 1785	3x3	855860
RF SAW Filter - Band 3 Downlink	1842.5	75	4.2	SE / SE	20 @ 1785	3x3	856934
RF SAW Filter - Band 2 Uplink	1880	60	2.4	SE / SE	7 @ 1930	3x3	855849
RF SAW Filter - Band 2 Uplink	1880	60	2.8	SE / SE	30 @ 1930	3x3	856530
RF SAW Filter - Band 2 Uplink	1880	60	2.2	SE / SE	15 @ 1806	3x3	856705
RF SAW Filter - Band 2 Uplink	1880	60	2.3	SE / SE	10 @ 1790	3x3	856880
RF BAW Filter - Band 2 Uplink	1880	60	3.5	SE / SE	30 @ 1920	3x3	885025
RF SAW Filter - Band 25 Uplink	1882.5	65	1.9	SE / SE	32 @ 2030	3x3	856992
RF Duplexer - B24 / BC14 Duplexer	1882.5 / 1962.5	65	2.8	SE / SE	20 @ 1922.5	3x3	*TQM963001**
RF SAW Filter - Band 1 Uplink	1950	60	2.2	SE / SE	40 @ 2110	3x3	856532
RF SAW Filter - Band 1 Uplink	1950	60	1.8	SE / SE	20 @ 2100	3x3	856678
RF SAW Filter - Band 2 Downlink	1960	60	2.1	SE / SE	10.3 @ 1910	3x3	855817
RF SAW Filter - Band 2 Downlink	1960	60	2.25	SE / SE	14 @ 1910	3x3	856531
RF SAW Filter - Band 2 Downlink	1960	60	2.9	SE / SE	15 @ 1910	3x3	855859
Delay Filter, PCS 450 ns	1960	60	25	SE / BAL	–	7x5.5	856717
RF BAW Filter - Band 2 Downlink	1960	60	3.7	SE / SE	34 @ 1920	3x3	885024
Delay Filter, UMTS 450 ns	2140	60	25	SE / BAL	–	7x5.5	856649
RF SAW Filter - Band 1 Downlink	2140	60	2.3	SE / SE	25 @ 1980	3x3	856738
RF BAW Filter - Band 7 Uplink	2535	70	1.3	SE / SE	41 @ 2620	3x3	885009

NOTES: ** = New*

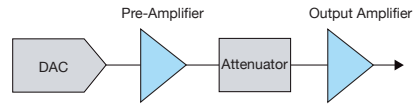
TriQuint offers a wide variety of base station IF filters. To view a selection of the most common filters, please go to the SAW filter section on pages 45 - 50.



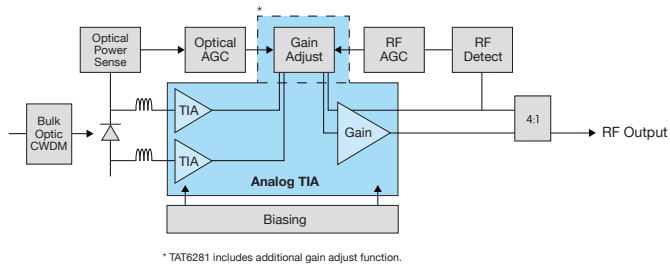
CATV Infrastructure



Subscriber Home Amplifiers



Edge QAM DOCSIS® 3.0



* TAT6281 includes additional gain adjust function.

FTTH / RFoG

Amplifiers

Description	Application	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
CATV Gain Block, Flex Gain	Home Amplifier	DC - 2000	21 / 38	16 - 21	2	5 - 8 / 100	SOT89	TAT7457
CATV Gain Block	Home Amplifier	50 - 1000	– / 39	16	2.7	6 / 130	SOT89	TAT7461
CATV Gain Block	General Purpose	50 - 1000	– / 39.5	16	2.7	5 / 130	SOT89	*TAT7461-X**
CATV Gain Block, High Gain	Home Amplifier, MOCA	50 - 1000	– / 39	18	2	6 / 145	SOT89	TAT7427
CATV Gain Block, High Gain	Home Amplifier, MOCA, Multitap	50 - 1000	– / 41	22.5	2	8 / 190	SOT89	TAT7430B
Single-Ended Darlington	General Purpose	DC - 2700	19 / 33	18	3.5	>6 / 75	SOT86 / SOT89	AG604
MESFET Amplifier	General Purpose	50 - 1000	20 / 40	14.8	3.5	5 / 150	SOT89	AH2
MESFET Amplifier	General Purpose	50 - 1500	30 / 50	10.4	5.3	9 / 400	SOT89	AH101
Dual HBT Amplifier	Return Path Amplifier, GP	DC - 1000	20 / 37	13.5	4.5	>7 / 165	SOIC-8	AG606
Return Path Variable Gain Amplifier	Return Path Amplifier	5 - 300	25 / 41	36	5	5 - 8 / 325	6x6 QFN	TAT3814
Fiber to the Home TIA + Output Amp	Fiber to the Home, High Output	50 - 1000	–	33	3.9 pA / rtHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254C
Fiber to the Home TIA + Output Amp	Fiber to the Home, RFoG	50 - 1000	–	32	3.9 pA / rtHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254D
Fiber to the Home TIA + Output Amp	Fiber to the Home, RFoG, Low Input	50 - 1000	–	38	2.9 pA / rtHz EIN	5, 12 / 200, 120	4x4 QFN	TAT6254B
Fiber to the Home Integrated TIA + Attenuator + Amp	Fiber to the Home	50 - 1000	–	33	3.8 pA/ rtHz EIN	5 / 290	6x6 QFN	TAT6281
CATV Gain Block, Wideband	CATV + SAT Wideband Amp / VONU	50 - 2600	– / 36	16.5	2.5	5 / 100	SOT89	TAT7460
Dual pHEMT Amplifier, Wideband	CATV + SAT Wideband Amp / VONU	50 - 2600	–	13	4.4	5 / 160	SOIC-8	TAT7464
On-Chip Linearized Amplifier	DOCSIS 3.0 Output	40 - 1000	– / 43	17	4.7	5 / 380	SOIC-8	TAT7467H
CATV Gain Block	DOCSIS 3.0 Output	40 - 1000	27 / 42	20	1.5	8 / 350	4x4 QFN	TGA2803-SM
CATV Gain Block	DOCSIS 3.0 Output	40 - 1000	27 / 46	20	1.5	8 / 350	5x5 QFN	TGA2806-SM
CATV Gain Block	DOCSIS 3.0 Output	40 - 1000	28 / 43	18.5	2.5	6 / 318	5x5 QFN	TGA2807-SM
DOCSIS 3.0 Edge QAM Variable Gain Amplifier	DOCSIS 3.0 Output	45 - 1003	28 / –	30	2.7	5 - 8 / 705 - 770	7x7 QFN	TAT2814A
CATV 12V Power Doubler MMIC	DOCSIS 3.0 Output / Infrastructure	50 - 1000	–	11	4	12 / 550	SOIC16W	TAT2801
Dual pHEMT Amplifier, High Gain	Infrastructure GP	50 - 1000	– / 38	17.5	3.2	5 / 235	SOIC-8	TAT7469
Dual pHEMT Amplifier	Infrastructure GP	50 - 1000	– / 41	13	4	6 / 190	SOIC-8	TAT7466
Dual MESFET Amplifier	Infrastructure GP	50 - 1000	25.5 / 43	11	4.5	5 / 320	SOIC-8	AH22S
CATV 12V Power Doubler MMIC	Infrastructure	50 - 1000	–	11	4	12 / 570	SOIC16W	*TAT8801A1H**
CATV 12V Power Doubler	Infrastructure	50 - 1003	34 / 49	21	4.5	12 / 650	5x7 QFN	*TAT8804D1H**
CATV Push Pull Infrastructure Amplifier MMIC	Infrastructure	50 - 1000	28 - 34	28-34	3	24 / 270 (12V Optional)	SOIC16W	TAT8858
CATV Power Doubler Line Amplifier MMIC	Infrastructure	50 - 1000	22 / 27	22-27	4	24 / 350 (12V Optional)	SOIC16W	TAT8857

NOTES: ** = New,* GP = General Purpose

Filters

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Cable IF Filter	36.15	8	19.7	SE / SE	38 @ 10.23	DIP	855748
Cable IF Filter	44	6	20.4	SE / SE	38 @ 7.6	DIP	855079
Cable IF Filter	202.75	1.2	6.6	SE / SE	40 @ 10	13.3x6.5	855068
Cable IF Filter	499.25	1	7	SE / SE	35 @ 6	9x7	855104
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	855964
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	856330
Tuner IF Filter	1090	10	5	BAL / BAL	50 @ 1050	3.8x3.8	856096
Tuner IF Filter	1216	8	3.75	BAL / BAL	12 @ 24	3x3	856365
Tuner IF Filter	1220	10	4.5	BAL / BAL	30 @ 60	3x3	856298
Tuner IF Filter	1220	50	3.9	BAL / BAL	33 @ 96	3.8x3.8	856598
Tuner IF Filter	1250	96	6	BAL / BAL	44 @ 1152	3x3	856653

Protector

Description	Application	Leakage Current (nanoAmps)	Trigger Voltage (V)	Series Capacitance (pF)	Package Area (mm^2)	Package Style	Part Number
CATV Protector	ESD & Secondary Protection	20 @ 1V, 500 @ 15V	18, 25, 41	0.29, 0.29, 0.22	1.8	T / SLP-3	TQP200002

Many listings in this product guide support both commercial and defense applications. The tables in this section are a partial listing of devices suitable for specific defense / aerospace applications. We have included product solutions based on RF GaN technology as a separate listing at the outset of this section. Although located here for easy reference, GaN products have wide-ranging applications across many commercial markets. Products listed throughout this guide may be specially screened to meet unique customer requirements including 100% electrical screening and visual inspection to either MILSTD-883 Class B or Class S. Please contact TriQuint with your requirements: **info-defense@triquint.com.**

Transistors

Description	Frequency Range (GHz)	Psat (dBm)	Gain (dB)	PAE (%)	Bias (V / mA)	Package Style	ECCN	Part Number
35W HEMT	DC - 3.5	45.6	14	54	32 / 150	Ceramic Flat Lead	EAR99	*T2G4003532-FS**
35W HEMT	DC - 3.5	45.6	14	54	32 / 150	Ceramic Flat Lead	EAR99	*T2G4003532-FL**
55W HEMT	DC - 3.5	47.2	12	50	28 / 200	Ceramic Flat Lead	EAR99	T2G4005528-FS
60W HEMT	DC - 3.5	48.2	14	51	32 / 200	Ceramic Flat Lead	EAR99	*T1G4006032-FS**
60W HEMT	DC - 3.5	48.2	14	51	32 / 200	Ceramic Flat Lead	EAR99	*T1G4006032-FL**
120W HEMT	DC - 3.5	50.8	14	52	32 / 575	Ceramic Flat Lead	EAR99	*T1G4012032-FS**
120W HEMT	DC - 3.5	50.8	14	52	32 / 575	Ceramic Flat Lead	EAR99	*T1G4012032-FL**
7W HEMT	DC - 6	39.5	12.5	50	28 / 50	Ceramic Flat Lead	EAR99	T2G6000528-Q3
10W HEMT	DC - 6	40.5	15	52	32 / 50	5x5 QFN	EAR99	*T1G6001032-SM**
18W HEMT	DC - 6	42.5	12	50	28 / 50	Ceramic Flat Lead	EAR99	T2G6001528-Q3
30W HEMT	DC - 6	44.7	12	50	28 / 200	Ceramic Flat Lead	EAR99	*T2G6003028-FL**
30W HEMT	DC - 6	44.7	12	50	28 / 200	Ceramic Flat Lead	EAR99	T2G6003028-FS
1.25mm HEMT	DC - 18	37.4	10.4	52	28 / 125	Die	EAR99	TGF2023-2-01
2.5mm HEMT	DC - 18	40.2	9.9	50	28 / 250	Die	EAR99	TGF2023-2-02
5mm HEMT	DC - 18	43	9.4	49	28 / 500	Die	3A001b.3b	TGF2023-2-05
10mm HEMT	DC - 18	45.8	8.9	47	28 / 1000	Die	3A001b.3b	TGF2023-2-10
20mm HEMT	DC - 18	48.6	8.4	46	28 / 2000	Die	3A001b.3b	TGF2023-2-20

NOTES: ** = New*

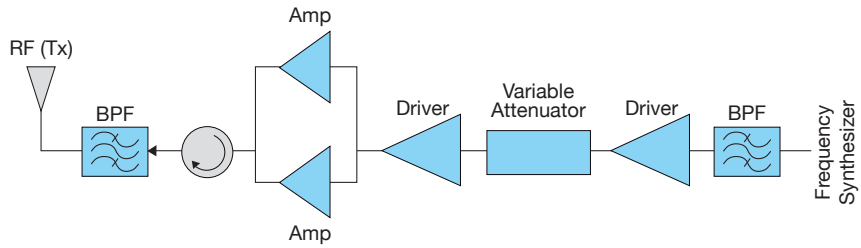
Amplifiers

Description	Frequency Range (GHz)	Psat (dBm)	Gain (dB)	PAE (%)	Bias (V / mA)	Package Style	ECCN	Part Number
10W HPA	0.03 - 3	39.5	19.5	40	30 / 360	Flange	ITAR	TGA2540-2-FL
10W HPA	2 - 18	40	9	25	30 / 500	Die	ITAR	TGA2573-2
10W HPA	2 - 18	40	9	25	30 / 500	Carrier	ITAR	TGA2573-2-TS
30W HPA	2.5 - 6	45	25	>30	30 / 1400	Flange	3A001.b.2.a	TGA2576-2-FL
30W HPA	6 - 12	45	30	30	25 / 1100	Die	TBD	***TGA2590****
20W HPA	9.5 - 11	43	30	30	25 / 720	Die	TBD	***TGA2608****
20W HPA	14 - 15.5	43	23	30	25 / 1000	Flange	ITAR	***TGA2579-2-FL****
16W HPA	14 - 16	42	23	>30	30 / 2000	Die	ITAR	***TGA2572-2****
16W HPA	14 - 16	42	23	>30	30 / 2000	Carrier	ITAR	***TGA2572-2-TS****
16W HPA	14 - 16	42	23	>30	30 / 2000	Flange	ITAR	***TGA2572-2-FL****

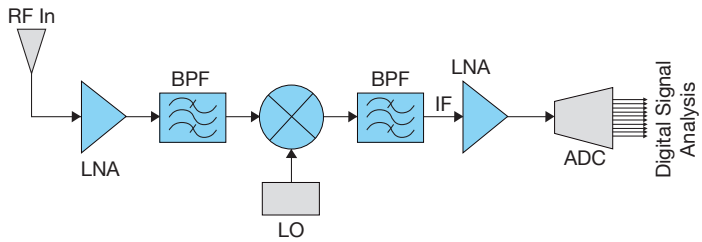
NOTES: *** = New***

Switches

Description	Frequency Range (GHz)	IL (dB)	ISO (dB)	P1dB (dBm)	Voltage (V)	Package Style	ECCN	Part Number
High Power SPDT Switch	DC - 6	0.8	-40	>45	0 / -40	Die	EAR99	TGS2351-2
High Power SPDT Switch	DC - 6	0.8	-40	>45	0 / -40	5x5 QFN	EAR99	TGS2351-2-SM
High Power SPDT Switch	DC - 12	<1	-35	>43	0 / -40	Die	EAR99	TGS2352-2
High Power SPDT Switch	DC - 18	1.5	-25	>40	0 / -40	Die	EAR99	TGS2353-2



Signal Jammer



Digital Receiver

Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
Wideband Driver	DC - 35	18 / –	12	–	5 / 135	Die	TGA4832
Ultra-Wideband Driver	DC - 78	3.5Vpp	8	5 / –	6 / 82	Die	TGA4803
10W Wideband HPA	0.03 - 3	(39.5) / 43	19.5	– / 40	35 / 360	Flange	TGA2540-2-FL
Gain Block, Self Bias	2 - 10	17 / –	17	6 / –	5 / 90	Die	TGA8810-SCC
Gain Block	2 - 12	(20) / –	30	–	5 / 200	8x8 QFN	***TGA3500-SM****
Wideband Gain Block	2 - 18	20 / –	7.5	5.5 / –	6 / 100	Die	TGA8300-SCC
10W Wideband HPA	2 - 18	(40) / –	9	– / 23	30 / 500	Die	TGA2573-2
10W Wideband GaN HPA	2 - 18	(40) / –	9	– / 23	30 / 500	Carrier	TGA2573-2-TS
Wideband PA, AGC	2 - 20	26 / –	8	–	8 / 440	Die	TGA8334-SCC
Wideband Gain Block, AGC	2 - 20	20 / –	7.5	7 / –	6 / 150	Die	TGA8622-SCC
Wideband PA, AGC	2 - 20	(29) / –	15	–	12 / 1100	Flange	TGA2509-FL
Wideband PA, AGC	2 - 22	28.5 (30) / 36	17	–	12 / 1100	Die	TGA2509
30W GaN HEMT	2.5 - 6	(45) / –	26	– / 35	30 / 1550	Flange	TGA2576-2-FL
30W HPA	6 - 12	(45) / –	30	– / 30	25 / 1100	Die	***TGA2590****
2.8W Wideband PA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Die	TGA2501
2.8W Wideband PA on Carrier	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Carrier	TGA2501-TS
2.8W Wideband PA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	GSG Flange	***TGA2501-GSG****
Wideband 0.5W PA	6 - 18	27 / –	11	8 / –	8 / 400	Die	TGA8014-SCC
Wideband Gain Block	6 - 18	12.5 / –	13	5 / –	5 / 80	Die	TGA8035-SCC
Wideband 2.8W PA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	Die	TGA9092-SCC
8W HPA	6.5 - 11.5	37 (39) / –	19	– / 35	7 - 9 / 1200	Die	TGA9083-SCC
16W HPA	6.5 - 12.5	42 / –	27	– / 35	12 / 3000	Die	TGA2517
16W HPA on Carrier	6.5 - 12.5	42 / –	27	– / 35	12 / 3000	Carrier	TGA2517-TS
Driver Amp	7 - 13	(30) / 37	25	– / 30	9 / 450	Die	TGA2700
10W HPA	7.5 - 12	(41) / –	30	– / 25	12 / 3000	GSG Flange	***TGA2517-GSG****
Wideband Driver Amp	8 - 18	13 / –	17	5 / –	4.5 / 50	Die	TGA8399C
HPA	10 - 12	33 (34.5) / 43	25	9 / –	6 / 1300	5x5 QFN	TGA2535-SM
Driver Amp, SB	11 - 17	17 / –	23	6 / –	6 / 75	4x4 QFN	TGA2507-SM
Driver Amp	12 - 16	26 (26.5) / 37	23	7 / –	5 / 300	3x3 QFN	TGA2524-SM
Driver Amp, SB	12 - 18	14 / –	17	–	6 / 40	Die	TGA2506
Driver Amp, SB	12 - 18	20 / –	28	6 / –	6 / 80	Die	TGA2507
Ku-Band 1W PA	12 - 19	30 / –	30	–	5 - 7 / 435	Die	TGA2508-SCC
Ku-Band PA	12 - 19	29 / –	25	–	5 - 7 / 435	4x4 QFN	TGA2508-SM
2W Ku-Band HPA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680	4x4 QFN	TGA2503-SM
2W Ku-Band HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510
2W Ku-Band HPA on Carrier	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Carrier	TGA2510-TS
6.5W Ku-Band HPA	13 - 16	(38) / –	24	–	8 / 2600	11.4x17.3 FL	TGA2514-FL
6.5W Ku-Band HPA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
HPA, AGC, PD	17 - 24	(29) / 38	22	–	5 / 712	4x4 QFN	TGA2522-SM

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

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
35W GaN HEMT	DC - 3.5	(45.6)	14	– / 54	32 / 150	Ceramic Flat Lead	***T2G4003532-FS****
35W GaN HEMT	DC - 3.5	(45.6)	14	– / 54	33 / 150	Ceramic Flat Lead	***T2G4003532-FL****
55W GaN HEMT	DC - 3.5	(47.2)	15	– / 50	28 / 200	Ceramic Flat Lead	T2G4005528-FS
60W GaN HEMT	DC - 3.5	(48.2)	14	– / 51	32 / 200	Ceramic Flat Lead	***T1G4006032-FS****
60W GaN HEMT	DC - 3.5	(48.2)	14	– / 51	33 / 200	Ceramic Flat Lead	***T1G4006032-FL****
120W GaN HEMT	DC - 3.5	(50.8)	14	– / 52	32 / 575	Ceramic Flat Lead	***T1G4012032-FS****
120W GaN HEMT	DC - 3.5	(50.8)	14	– / 52	32 / 575	Ceramic Flat Lead	***T1G4012032-FL****
4mm Pwr pHEMT	DC - 4	26.5	16	0.6 / –	5 / 150	SOT89	TGF2021-04-SD
24mm HFET	DC - 4	40	13	– / 51	8 / 2170	Die	TGF4124
7W GaN HEMT	DC - 6	(39.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6000528-Q3
10W GaN HEMT	DC - 6	(40.5)	15	– / 52	32 / 50	5x5 QFN	***T1G6001032-SM****

Discrete Transistors (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
18W GaN HEMT	DC - 6	(42.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6001528-Q3
30W GaN HEMT	DC - 6	(44.8)	15	– / 50	28 / 200	Ceramic Flat Lead	T2G6003028-FS
30W GaN HEMT	DC - 6	(44.7)	12	– / 50	28 / 200	Ceramic Flat Lead	*T2G6003028-FL**
4.8mm HFET	DC - 10.5	34	8.5	– / 53	8 / 200	Die	TGF4250-SCC
9.6mm HFET	DC - 10.5	37	9.5	– / 52	8.5 / 520	Die	TGF4260-SCC
1mm Pwr pHEMT	DC - 12	(31.5)	11	– / 55	12 / 75	Die	TGF2021-01
2mm Pwr pHEMT	DC - 12	(34.5)	11	– / 55	12 / 150	Die	TGF2021-02
4mm Pwr pHEMT	DC - 12	(37.5)	11	– / 55	12 / 300	Die	TGF2021-04
8mm Pwr pHEMT	DC - 12	(40.2)	11	– / 55	12 / 600	Die	TGF2021-08
12mm Pwr pHEMT	DC - 12	(42)	11	– / 52	12 / 900	Die	TGF2021-12
1.2mm HFET	DC - 12	28.5	10	– / 55	8 / 50	Die	TGF4230-SCC
2.4mm HFET	DC - 12	31.5	10	– / 56	8 / 100	Die	TGF4240-SCC
0.3mm MESFET	DC - 18	13	11	1.5 / –	3 / 15	Die	TGF1350-SCC
1.25mm GaN HEMT	DC - 18	(37.4)	13	– / 52	28 / 125	Die	TGF2023-2-01
2.5mm GaN HEMT	DC - 18	(40.2)	13	– / 50	28 / 250	Die	TGF2023-2-02
5mm GaN HEMT	DC - 18	(43)	13	– / 49	28 / 500	Die	TGF2023-2-05
10mm GaN HEMT	DC - 18	(45.8)	12	– / 47	28 / 1000	Die	TGF2023-2-10
20mm GaN HEMT	DC - 18	(48.6)	12	– / 46	28 / 2000	Die	TGF2023-2-20
0.6mm Pwr pHEMT	DC - 20	(29)	13	– / 56	12 / 45	Die	TGF2022-06
1.2mm Pwr pHEMT	DC - 20	(32)	13	– / 56	12 / 90	Die	TGF2022-12
2.4mm Pwr pHEMT	DC - 20	(35)	13	– / 58	12 / 180	Die	TGF2022-24
4.8mm Pwr pHEMT	DC - 20	(38)	13	– / 58	12 / 360	Die	TGF2022-48
6mm Pwr pHEMT	DC - 20	(39)	12.5	– / 53	12 / 448	Die	TGF2022-60
0.3mm pHEMT	DC - 22	16	13	0.8 / –	3 / 15	Die	TGF4350
30W LDMOS	0.5 - 2	45	10	– / 45	28 / 200	PowerBand™	T1L2003028-SP
10W pHEMT	0.5 - 3	40	10	– / 45	12 / 200	PowerBand™	T1P2701012-SP

NOTES: ** = New*

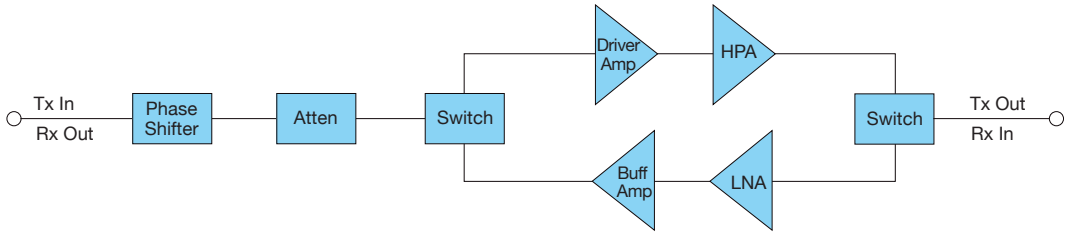
Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
SPDT - High Power GaN	0.1 - 6	<1	40	45	-40 / 0	Die	TGS2351-2
SPDT - High Power GaN	0.1 - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-2-SM
SPDT - High Power GaN	0.1 - 12	<1	35	43	-40 / 0	Die	TGS2352-2
SPDT - High Power GaN	0.1 - 18	<1	30	40	-40 / 0	Die	TGS2353-2
SP3T VPIN	1 - 20	0.5	35	23	–	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	–	Die	TGS2304-SCC
SP3T VPIN	4 - 18	1	35	20	+/- 2.7	Die	TGS2313
SPDT VPIN	4 - 20	0.9	35	>20	+/- 2.7	Die	TGS2302

Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB) or (Deg.)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
Through Line	DC - 6	0.1	–	–	–	3x3 QFN	TQM4M9073
Passive Wideband Limiter	2 - 12	<1	–	18	–	3x3 QFN	TGL2201-SM
Wideband Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-SCC
Passive Wideband Limiter	3 - 25	<0.5	–	18	–	Die	TGL2201
5-Bit Phase Shifter	6 - 18	9	(348)	–	6	Die	TGP6336
6-Bit Phase Shifter	6 - 18	<10	(354)	–	0 / -5	Die	*TGP2105**
Lange Coupler	12 - 21	<0.25	–	–	–	Die	TGB2001

NOTES: ** = New*



Radar Block Diagram

Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
Wideband Driver	DC - 35	18 / –	12	–	5 / 135	Die	TGA4832
Wideband Gain Block, SB	2 - 10	17 / –	17	6 / –	5 / 90	Die	TGA8810-SCC
Gain Block	2 - 12	(20) / –	30	–	5 / 200	8x8 QFN	TGA3500-SM
10W Wideband HPA	2 - 18	(40) / –	9	– / 23	30 / 500	Die	TGA2573-2
10W Wideband HPA	2 - 18	(40) / –	9	– / 23	30 / 500	Carrier	TGA2573-2-TS
Wideband Gain Block, AGC	2 - 20	20 / –	7.5	7 / –	6 / 150	Die	TGA8622-SCC
Wideband PA, AGC	2 - 22	28.5 (30) / 36	17	–	12 / 1100	Die	TGA2509
1W Wideband PA, AGC	2 - 22	(29) / –	15	–	12 / 1100	Flange	TGA2509-FL
30W HPA	2.5 - 6	(45) / –	26	– / 35	30 / 1550	Flange	TGA2576-2-FL
Driver Amp / PA, SB	3.4 - 3.8	30 / 42	24	–	6 / 770	5x5 QFN	TGA2703-SM
2W HPA	5.5 - 8.5	32 (34) / 41	30	7 / –	6 / 1260	5x5 QFN	TGA2706-SM
2.5W HPA	5.9 - 8.5	34 (35) / 42	18	7.5 / 37	6 / 1000	6x6 QFN	TGA2701-SM
30W HPA	6 - 12	(45) / –	30	– / 30	25 / 1100	Die	***TGA2590****
0.5W PA	6 - 18	27 / –	11	8 / –	8 / 400	Die	TGA8014-SCC
Gain Block	6 - 18	12.5 / –	13	5 / –	5 / 80	Die	TGA8035-SCC
2.8W Wideband HPA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Die	TGA2501
2.8W Wideband PA on Carrier	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Carrier	TGA2501-TS
2.8W Wideband PA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	GSG Flange	***TGA2501-GSG****
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	Die	TGA9092-SCC
8W HPA	6.5 - 11.5	37 (39) / –	19	– / 35	7 - 9 / 1200	Die	TGA9083-SCC
16W HPA	6.5 - 12.5	42 / –	27	– / 35	12 / 3000	Die	TGA2517
6.3W HPA	7 - 8.5	(38) / –	21	– / 42	7 / 2000	Die	TGA2701
Driver Amp	7 - 13	(30) / 37	25	– / 30	9 / 450	Die	TGA2700
16W HPA	7.5 - 11.5	42 / –	28	– / 35	9 - 12 / 2000	Carrier	TGA2517-TS
10W HPA	7.5 - 12	(41) / –	30	– / 25	12 / 3000	GSG Flange	***TGA2517-GSG****
Wideband Driver Amp	8 - 18	13 / –	17	5 / –	4.5 / 50	Die	TGA8399C
6.3W HPA	9 - 10.5	(38) / –	20	– / >38	4 - 9 / 2000	Die	TGA2704
7W HPA	9 - 11	(38.5) / –	22	– / 40	9 / 1050	7x7 QFN	***TGA2704-SM****
20W HPA	9.5 - 11	(43) / –	30	– / 30	25 / 720	Die	***TGA2608****
7W HPA	9.5 - 12	(38.5) / –	22	– / 36	9 / 1050	7x7 QFN	***TGA2710-SM****
2.8W HPA	10 - 12	33 (34.5) / 43	25	9 / –	6 / 1300	5x5 QFN	TGA2535-SM
6.3W HPA	10.5 - 12	(38) / –	19	– / >39	4 - 9 / 2000	Die	TGA2710
2W HPA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680	4x4 QFN	TGA2503-SM
2W HPA	12.7 - 15.4	34 (35) / 43	28	6 / –	6 / 1300	Die	TGA2533
6.5W HPA	13 - 16	(38) / –	24	–	8 / 2600	11.4x17.3 FL	TGA2514-FL
2W HPA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
6.5W HPA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
5W HPA	13.5 - 16	(37) / –	25	– / 20	8 / 2600	GSG Flange	***TGA2536-FL****
16W Ku-Band HPA	14 - 16	(42) / –	23	– / 30	25 / 2000	Flange	TGA2572-2-FL

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
16W Ku-Band HPA	14 - 16	(42) / –	23	– / 30	25 / 2000	Carrier	TGA2572-2-TS
1.25W HPA	17 - 24	31 (32) / 40	23	6 / –	7 / 720	Die	TGA4531
Driver Amp	17 - 24	22 / –	19	4 / –	5 / 270	4x4 QFN	TGA2521-SM
HPA, AGC, PD	17 - 24	(29) / 38	22	–	5 / 712	4x4 QFN	TGA2522-SM
MPA	17 - 27	29 / –	22	–	7 / 760	5x5 QFN	TGA4525-SM
Gain Block & 2x / 3x Multiplier	17 - 37	18 (22) / 26	20	7 / –	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	18 (22) / 24	22	7 / –	5 / 140	3x3 QFN	TGA4031-SM
Gain Block, Multiplier	17 - 43	22 / –	25	–	5 / 225	Die	TGA4040
Gain Block	19 - 38	(22) / 30	20	–	5 / 160	Die	TGA4036
MPA	25 - 35	25 / –	18	–	6 / 220	4x4 QFN	TGA4902-SM
1W Linear PA	28 - 30	30 (30.5) / –	20	–	6 / 420	5x5 QFN	TGA4539-SM
2W HPA	30 - 40	31.5 (33) / –	20	–	6 / 1050	Die	TGA4516
2W HPA	30 - 40	31.5 (33) / –	18	–	6 / 1050	Carrier	TGA4516-TS
2W HPA	31 - 35	31.5 (33.5) / –	19	–	6 - 7 / 1150	Die	TGA4514
3.5W HPA	31 - 37	(35.5) / –	20	–	6 / 2000	Die	TGA4517
MPA	32 - 45	24 (25) / 33	16	–	6 / 175	Die	TGA4521
2W HPA	33 - 36	31 (33) / –	17	–	6 - 7 / 880	Die	TGA1141
MPA	33 - 47	27 (27.5) / 36	18	–	6 / 400	Die	TGA4522
0.5W HPA	40 - 45	28 / –	9	–	7 / 500	Die	TGA4043
Driver Amp	41 - 45	18 / –	14	–	6 / 168	Die	TGA4042

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

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Ultra Wideband LNA / Gain Block	DC - 40	11.5 / 20	13	3.2	5 / 50	Die	TGA4830
Wideband LNA, AGC	2 - 18	18 / 29	17	2	5 / 75	Die	TGA2525
Wideband LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
Wideband LNA, AGC	2 - 20	19 / –	17.5	2.5	5 / 100	Die	TGA2526
Wideband LNA, AGC	2 - 20	16 / –	17	2.5	5 / 75	4x4 QFN	TGA2513-SM
4 - 20 GHz Limiter / LNA	2 - 20	18 (21) / 28	17	2	5 / 100	7x7 QFN	*TGM2543-SM**
Wideband LNA, AGC	2 - 23	17 / 26	17	2	5 / 75	Die	TGA2513
S-Band LNA	2.5 - 4	18 / –	17	1.2	6 / 110	5x5 QFN	*TGA2614-SM**
S-Band LNA	2.7 - 3.8	– / 42.5	12.5	2	6 / 320	Die	*TGA2613**
S-Band LNA	2.7 - 3.8	18 / –	17	.95	6 / 100	Die	*TGA2614**
LNA, SB, AGC	4 - 14	6 / 16	22	2.3	5 / 90	4x4 QFN	TGA2512-1-SM
LNA, AGC, GB	4 - 14	13 / 24	25	2.3	5 / 160	4x4 QFN	TGA2512-2-SM
LNA, SB, AGC	5 - 15	6 / 13	27	1.4	5 / 90	Die	TGA2512
LNA, SB	6 - 13	11 / –	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA, SB, AGC	6 - 14	6 / 12	20	1.3	5 / 90	Die	TGA2511

NOTES: ** = New,* AGC = Automatic Gain Control, GB = Gate Biased, PD = Power Detector, SB = Self Biased

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage /Current (V / mA)	Package Style	Part Number
35W GaN HEMT	DC - 3.5	(45.6)	14	– / 54	32 / 150	Ceramic Flat Lead	*T2G4003532-FS**
35W GaN HEMT	DC - 3.5	(45.6)	14	– / 54	33 / 150	Ceramic Flat Lead	*T2G4003532-FL**
55W GaN HEMT	DC - 3.5	(47.2)	15	– / 50	28 / 200	Ceramic Flat Lead	T2G4005528-FS
60W GaN HEMT	DC - 3.5	(48.2)	14	– / 51	32 / 200	Ceramic Flat Lead	*T1G4006032-FS**
60W GaN HEMT	DC - 3.5	(48.2)	14	– / 51	33 / 200	Ceramic Flat Lead	*T1G4006032-FL**
120W GaN HEMT	DC - 3.5	(50.8)	14	– / 52	32 / 575	Ceramic Flat Lead	*T1G4012032-FS**
120W GaN HEMT	DC - 3.5	(50.8)	14	– / 52	32 / 575	Ceramic Flat Lead	*T1G4012032-FL**

Discrete Transistors (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage /Current (V / mA)	Package Style	Part Number
4mm Pwr pHEMT	DC - 4	26.5	16	0.6 / –	5 / 150	SOT89	TGF2021-04-SD
24mm HFET	DC - 4	40	13	– / 51	8 / 2170	Die	TGF4124
7W GaN HEMT	DC - 6	(39.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6000528-Q3
10W GaN HEMT	DC - 6	(40.5)	15	– / 52	32 / 50	5x5 QFN	*T1G6001032-SM**
18W GaN HEMT	DC - 6	(42.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6001528-Q3
30W GaN HEMT	DC - 6	(44.8)	15	– / 50	28 / 200	Ceramic Flat Lead	T2G6003028-FS
30W GaN HEMT	DC - 6	(44.7)	12	– / 50	28 / 200	Ceramic Flat Lead	*T2G6003028-FL**
4.8mm HFET	DC - 10.5	34	8.5	– / 53	8 / 200	Die	TGF4250-SCC
9.6mm HFET	DC - 10.5	37	9.5	– / 52	8.5 / 520	Die	TGF4260-SCC
1.2mm HFET	DC - 12	28.5	10	– / 55	8 / 50	Die	TGF4230-SCC
2.4mm HFET	DC - 12	31.5	10	– / 56	8 / 100	Die	TGF4240-SCC
1mm Pwr pHEMT	DC - 12	(31.5)	11	– / 55	12 / 75	Die	TGF2021-01
2mm Pwr pHEMT	DC - 12	(34.5)	11	– / 55	12 / 150	Die	TGF2021-02
4mm Pwr pHEMT	DC - 12	(37.5)	11	– / 55	12 / 300	Die	TGF2021-04
8mm Pwr pHEMT	DC - 12	(40.2)	11	– / 55	12 / 600	Die	TGF2021-08
12mm Pwr pHEMT	DC - 12	(42)	11	– / 52	12 / 900	Die	TGF2021-12
0.3mm MESFET	DC - 18	13	11	1.5 / –	3 / 15	Die	TGF1350-SCC
1.25mm GaN HEMT	DC - 18	(37.4)	13	– / 52	28 / 125	Die	TGF2023-2-01
2.5mm GaN HEMT	DC - 18	(40.2)	13	– / 50	28 / 250	Die	TGF2023-2-02
5mm GaN HEMT	DC - 18	(43)	13	– / 49	28 / 500	Die	TGF2023-2-05
10mm GaN HEMT	DC - 18	(45.8)	12	– / 47	28 / 1000	Die	TGF2023-2-10
20mm GaN HEMT	DC - 18	(48.6)	12	– / 46	28 / 2000	Die	TGF2023-2-20
0.6mm Pwr pHEMT	DC - 20	(29)	13	– / 56	12 / 45	Die	TGF2022-06
1.2mm Pwr pHEMT	DC - 20	(32)	13	– / 56	12 / 90	Die	TGF2022-12
2.4mm Pwr pHEMT	DC - 20	(35)	13	– / 58	12 / 180	Die	TGF2022-24
4.8mm Pwr pHEMT	DC - 20	(38)	13	– / 58	12 / 360	Die	TGF2022-48
6mm Pwr pHEMT	DC - 20	(39)	12.5	– / 53	12 / 448	Die	TGF2022-60
0.3mm pHEMT	DC - 22	16	13	0.8 / –	3 / 15	Die	TGF4350

NOTES: ** = New*

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
Wideband SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
Wideband SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
High Power SPDT - GaN	0.1 - 6	<1	40	45	-40 / 0	Die	TGS2351-2
High Power SPDT - GaN	0.1 - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-2-SM
High Power SPDT - GaN	0.1 - 12	<1	35	43	-40 / 0	Die	TGS2352-2
High Power, Wideband SPDT - GaN	0.1 - 18	<1	30	40	-40 / 0	Die	TGS2353-2
Wideband SP3T VPIN	1 - 20	0.5	35	23	–	Die	TGS2303
Wideband SP4T VPIN	1 - 20	0.6	38	23	–	Die	TGS2304-SCC
Wideband SP3T VPIN	4 - 18	1	35	20	+/- 2.7	Die	TGS2313
Wideband SPDT VPIN	4 - 20	0.9	35	>20	+/- 2.7	Die	TGS2302
SPDT VPIN	24 - 43	<2	36	27	+/- 5	Die	TGS4301
SPDT VPIN	27 - 46	0.9	30	>34	+/ -5 / 15	Die	TGS4302
SPDT VPIN Absorptive	32 - 40	1	36	>33	+/- 5 / 18	Die	TGS4304

Frequency Converter

Description	Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Doubler (Input 10 - 20 GHz)	20 - 40	-12	25	18	–	Die	TGC1430F

Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB) or (Deg.)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
Analog Attenuator	DC - 30	2	17	–	0 to -2	3x3 QFN	TGL4203-SM
Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203
Discrete Thru (0dB Attenuator)	DC - 65	0	0	–	–	Die	TGL4201-00
Discrete Attenuators	DC - 65	–	2, 3, 6, 10	–	–	Die	TGL4201-02, 03, 06, 10
Passive Wideband Limiter	2 - 12	<1	–	18	–	3x3 QFN	TGL2201-SM
Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-SCC
Passive Wideband Limiter	3 - 25	<0.5	–	18	–	Die	TGL2201
5-Bit Phase Shifter	6 - 18	9	(348)	–	6	Die	TGP6336
6-Bit Phase Shifter	6 - 18	>10	(354)	–	0 / -5	Die	*TGP2105**
6-Bit Phase Shifter	8.5 - 11	5	(354)	–	0 / -5	Die	TGP2103
Lange Coupler	12 - 21	<0.25	–	–	–	Die	TGB2001
5-Bit Phase Shifter	18 - 20	5	(180)	–	-2.5	Die	TGP1439
Lange Coupler	18 - 32	<0.25	–	–	–	Die	TGB4001
Lange Coupler	27 - 45	<0.25	–	–	–	Die	TGB4002
5-Bit Phase Shifter	28 - 32	6	(348)	–	5	Die	TGP2100
5-Bit Phase Shifter	33 - 37	6	(348)	–	-5	Die	TGP2102
1-Bit Phase Shifter	34 - 36	4	180	–	0 / 5	Die	TGP2104

NOTES: ** = New*

BAW Filters

Description	Frequency Range (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Style	Part Number
RF Filter	1030	15	2.5	SE / SE	40 @ 45	3.81x2.54	880367
RF Filter	1090	15	2.5	SE / SE	40 @ 45	3.81x2.54	880374
GPS RF Filter, L5	1176	28	2.75	SE / SE	40 @ 140	3.26x1.6	880364
GPS L2	1227.6	25	2.5	SE / SE	20 @ 1200	3.26x1.6	880060
RF Filter	1280	20	3	SE / SE	40 @ 105	3.81x2.54	880368
GPS L1	1575.42	30	2.5	SE / SE	20 @ 1548	3.26x1.6	880094
RF Filter, MMDS	2560	30	3	SE / SE	40 @ 150	3.81x2.54	880157

Qualified Amplifiers

TriQuint has a rich history and strong track record of supplying highly reliable active and passive devices for space and aerospace programs including satellite and planetary missions. TriQuint supports MIL-STD-883 and performs 100% element electrical results, burn-in, 1000 hour life test and wafer-level lot acceptance testing for space qualification. Refer to our technical library on triquint.com to learn about our qualification processes. Most products throughout this Product Selection Guide may be considered for qualification. The tables below contain a sub-set of our products, fabricated with various production processes, that have been space qualified. Contact TriQuint prior to designing any of these parts into your space application as certain conditions apply. Write to us at info-defense@triquint.com to request more information.

Amplifiers

Description	Frequency Range (GHz)	P1dB (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
Wideband Driver	DC - 18	24	16	3.5 / –	5 - 8 / 70 - 175	Die	TGA1328-XCC-SPACE
Wideband Gain Block, SB	2 - 10	17	17	6 / –	5 / 90	Die	TGA8810-XCC-SPACE
Wideband Gain Block	2 - 18	20	7.5	5.5 / –	6 / 100	Die	TGA8300-XCC-SPACE
Wideband Gain Block, AGC	2 - 20	20	7.5	7 / –	6 / 150	Die	TGA8622-XCC-SPACE
Wideband PA, AGC	2 - 20	26	8	–	8 / 440	Die	TGA8334-XCC-SPACE
0.5W PA	6 - 18	27	11	8 / –	8 / 400	Die	TGA8014-XCC-SPACE

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
8W HPA	6.5 - 11.5	37	19	– / 35	7 - 9 / 1200	Die	TGA9083-XCC-SPACE
Wideband Driver Amp	8 - 18	13	17	5 / –	4.5 / 50	Die	TGA8399C-XCC-SPACE
6.3W HPA	9 - 10.5	38	20	– / >38	4 - 9 / 2000	Die	TGA2704-XCC-SPACE
Driver Amp, SB	12 - 18	20	28	6 / –	6 / 80	Die	TGA2507-XCC-SPACE
4W HPA, Balanced	13 - 17	36	25	– / 30	6 - 7 / 1300	Die	TGA2502-XCC-SPACE
Gain Block	19 - 38	22	20	–	5 / 160	Die	TGA4036-XCC-SPACE
3.5W HPA	31 - 37	35.5	20	–	6 / 2000	Die	TGA4517-XCC-SPACE
MPA	32 - 45	24	16	–	6 / 175	Die	TGA4521-XCC-SPACE
HPA	36 - 40	30	14	–	6 - 7 / 500	Die	TGA1171-XCC-SPACE

NOTES: AGC = Automatic Gain Control, SB = Self Biased

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Wideband LNA, AGC	DC - 14	16	11	3.1	8 / 80	Die	TGA8349-XCC-SPACE
Wideband LNA, AGC	2 - 18	16	19	4	5 / 120	Die	TGA8344-XCC-SPACE
Wideband LNA, AGC	2 - 20	17.5	9	3.5	5 - 8 / 60	Die	TGA8310-XCC-SPACE
Wideband LNA, AGC	2 - 20	17.5	9	3.5	5 - 8 / 60	Die	TGA1342-XCC-SPACE
LNA, SB	6 - 13	11	26	1.5	5 / 65	Die	TGA8399B-XCC-SPACE
LNA	20 - 27	12	21	2.2	3.5 / 60	Die	TGA4506-XCC-SPACE
LNA	30 - 42	14	21	2.8	3 / 40	Die	TGA4508-XCC-SPACE

NOTES: AGC = Automatic Gain Control, SB = Self Biased

Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203-XCC-SPACE
Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-XCC-SPACE

Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
Wideband Driver	DC - 18	3 - 11 Vpp	16	2.5 / –	8 / 285	Die	TGA4807
Wideband Driver	DC - 35	4 / –	12	–	5 / 135	Die	TGA4832
Wideband MPA, AGC	DC - 78	–	8	5 / –	6 / 82	Die	TGA4803
10W Wideband HPA	0.03 - 3	(39.5) / 43	19.5	– / 40	35 / 360	Flange	TGA2540-2-FL
Wideband Gain Block	0.04 - 1	27 / 42	20	1.5 / –	8 / 350	4x4 QFN	TGA2803-SM
Wideband Gain Block	0.04 - 1	27 / 46	20	1.5 / –	8 / 350	5x5 QFN	TGA2806-SM
Wideband Gain Block, SB	2 - 10	17 / –	17	6 / –	5 / 90	Die	TGA8810-SCC
Gain Block	2 - 12	(20) / –	30	–	5 / 200	8x8 QFN	***TGA3500-SM****
Wideband Gain Block	2 - 18	20 / –	7.5	5.5 / –	6 / 100	Die	TGA8300-SCC
Wideband Gain Block, AGC	2 - 20	20 / –	7.5	7 / –	6 / 150	Die	TGA8622-SCC
Wideband PA, AGC	2 - 20	26 / –	8	–	8 / 440	Die	TGA8334-SCC
Wideband PA, AGC	2 - 22	28.5 (30) / 36	17	–	12 / 1100	Die	TGA2509
1W HPA, AGC	2 - 22	(29) / –	15	–	12 / 1100	Flange	TGA2509-FL
2W HPA	5.5 - 8.5	32 (34) / 41	30	7 / –	6 / 1260	5x5 QFN	TGA2706-SM
2.5W HPA	5.9 - 8.5	34 (35) / 42	18	7.5 / 37	6 / 1000	6x6 QFN	TGA2701-SM

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Die	TGA2501
2.8W HPA on Carrier	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Carrier	TGA2501-TS
2.8W Wideband PA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	GSG Flange	***TGA2501-GSG****
0.5W PA	6 - 18	27 / –	11	8 / –	8 / 400	Die	TGA8014-SCC
Gain Block	6 - 18	12.5 / –	13	5 / –	5 / 80	Die	TGA8035-SCC
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	Die	TGA9092-SCC
8W HPA	6.5 - 11.5	37 (39) / –	19	– / 35	7 - 9 / 1200	Die	TGA9083-SCC
6.8W HPA	7 - 8.5	(38) / –	21	– / 42	7 / 2000	Die	TGA2701
Wideband Driver Amp	8 - 18	13 / –	17	5 / –	4.5 / 50	Die	TGA8399C
6.8W HPA	9 - 10.5	(38) / –	20	– / >38	4 - 9 / 2000	Die	TGA2704
6.8W HPA	10.5 - 12	(38) / –	19	– / >39	4 - 9 / 2000	Die	TGA2710
Driver Amp, SB	11 - 17	17 / –	23	6 / –	6 / 75	4x4 QFN	TGA2507-SM
Driver Amp	12 - 16	26 (26.5) / 37	23	7 / –	5 / 300	3x3 QFN	TGA2524-SM
Driver Amp, SB	12 - 18	14 / –	17	–	6 / 40	Die	TGA2506
Driver Amp, SB	12 - 18	20 / –	28	6 / –	6 / 80	Die	TGA2507
1W HPA	12 - 19	30 / –	30	–	5 - 7 / 435	Die	TGA2508-SCC
HPA	12 - 19	29 / –	25	–	5 - 7 / 435	4x4 QFN	TGA2508-SM
2W HPA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680	4x4 QFN	TGA2503-SM
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Carrier	TGA2510-TS
2W HPA	12.7 - 15.4	34 (35) / 43	28	6 / –	6 / 1300	Die	TGA2533
2W HPA	12.7 - 15.4	33 (34.5) / 43	27	6 / –	6 / 1300	5x5 QFN	TGA2533-SM
4W HPA	13 - 15	(36) / 41	25	–	7 / 1300	17.8x8.4 FL	TGA8659-FL
4W Ku-Band HPA	13 - 15	(36) / –	25	– / 30	7 / 1300	Die	***TGA2502****
3.6W Ku-Band HPA	13 - 16	(35.6) / –	25	– / 27	7 / 1300	GSG Flange	***TGA2502-GSG****
6.5W HPA	13 - 16	(38) / –	24	–	8 / 2600	11.4x17.3 FL	TGA2514-FL
2W HPA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
6.5W HPA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
20W Ku-Band HPA	13.75 - 15.35	(43) / –	28	– / 30	25 / 1000	Flange	TGA2579-2-FL
16W Ku-Band HPA	14 - 16	(42) / –	23	– / 30	25 / 2000	Die	TGA2572-2
16W Ku-Band HPA	14 - 16	(42) / –	23	– / 30	25 / 2000	Flange	TGA2572-2-FL
16W Ku-Band HPA on Carrier	14 - 16	(42) / –	23	– / 30	25 / 2000	Carrier	TGA2572-2-TS
1.1W HPA	17 - 20	30.5 / 41	23	–	6 / 900	Die	TGA4532
1.8W HPA	17 - 20	31 (32.5) / 41	23	7 / –	6 / 900	4x4 QFN	TGA4532-SM
Driver Amp	17 - 24	22 / –	19	4 / –	5 / 270	4x4 QFN	TGA2521-SM
HPA, AGC, PD	17 - 24	(29) / 38	22	–	5 / 712	4x4 QFN	TGA2522-SM
1.6W HPA	17 - 24	31 (32) / 40	23	6 / –	7 / 720	Die	TGA4531
1.25W HPA	17 - 27	29 (31) / 37	22	–	7 / 760	Die	TGA4502-SCC
Gain Block & 2x / 3x Multiplier	17 - 37	18 (22) / 26	20	7 / –	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	18 (22) / 24	22	7 / –	5 / 140	3x3 QFN	TGA4031-SM
Gain Block, Multiplier	17 - 43	22 / –	25	–	5 / 225	Die	TGA4040
2W HPA	18 - 23	32 (33) / 39	26	–	7 / 840	Die	TGA4022
0.8W HPA	18 - 27	29 / 37	14	–	6 / 480	Die	TGA1135B-SCC
MPA	19 - 27	25 / 32	22	–	5 - 7 / 220	Die	TGA1073G-SCC
Gain Block	19 - 38	(22) / 30	20	–	5 / 160	Die	TGA4036
HPA	21 - 24	31 (32) / 41	22	6 / –	6 / 880	4x4 QFN	TGA4533-SM
MPA	25 - 35	25 / –	18	–	6 / 220	4x4 QFN	TGA4902-SM
MPA	26 - 35	25 (32) / –	19	–	5 - 7 / 220	Die	TGA1073A-SCC
MPA	27 - 32	24 / –	15	–	5 / 170	4x4 QFN	TGA4903-SM
HPA	27 - 32	28.5 / –	25	–	6 - 8 / 420	Die	TGA1073B-SCC
1W Linear PA	28 - 30	30 (30.5) / –	20	–	6 / 420	5x5 QFN	TGA4539-SM
Driver Amp	29 - 37	16 / –	16	–	6 / 60	Die	TGA4510

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
3.5W HPA	30 - 38	(35) / –	18	– / 20	6 / 2100	Die	TGA2575
3.5W HPA	30 - 38	(35) / –	18	– / 20	6 / 2100	Carrier	*TGA2575-TS**
2W HPA	30 - 40	31.5 (33) / –	20	–	6 / 1050	Die	TGA4516
2W HPA	30 - 40	31.5 (33) / –	18	–	6 / 1050	Carrier	TGA4516-TS
2W HPA	31 - 35	31.5 (33.5) / –	19	–	6 - 7 / 1150	Die	TGA4514
3.5W HPA	31 - 37	(35.5) / –	20	–	6 / 2000	Die	TGA4517
MPA	32 - 45	24 (25) / 33	16	–	6 / 175	Die	TGA4521
2W HPA	33 - 36	31 (33) / –	17	–	6 - 7 / 880	Die	TGA1141
MPA	33 - 47	27 (27.5) / 36	18	–	6 / 400	Die	TGA4522
HPA	36 - 40	26 / –	15	–	5 - 7 / 240	Die	TGA1073C-SCC
1W HPA	36 - 40	30 / –	14	–	6 - 7 / 500	Die	TGA1171-SCC
0.6W HPA	37 - 40	28 / 38	24	6 / –	5 / 600	Die	TGA4538
0.5W HPA	40 - 45	28 / –	9	–	7 / 500	Die	TGA4043
Driver Amp	41 - 45	18 / –	14	–	6 / 168	Die	TGA4042
2W HPA	41 - 47	(33) / –	16	–	6 / 2000	Die	TGA4046

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

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Wideband LNA, AGC	DC - 14	16 / –	11	3.1	8 / 80	Die	TGA8349-SCC
Wideband LNA / Gain Block	DC - 40	11.5 / 20	13	3.2	5 / 50	Die	TGA4830
Wideband LNA, AGC	2 - 18	18 / 29	17	2	5 / 75	Die	TGA2525
Wideband LNA, AGC	2 - 18	16 / –	19	4	5 / 120	Die	TGA8344-SCC
Wideband LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
Wideband LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA8310-SCC
Wideband LNA, AGC	2 - 20	16 / –	17	2.5	5 / 75	4x4 QFN	TGA2513-SM
Wideband LNA, AGC	2 - 20	19 / –	17.5	2.5	5 / 100	Die	TGA2526
Wideband LNA, AGC	2 - 23	17 / 26	17	2	5 / 75	Die	TGA2513
LNA, SB, AGC	4 - 14	6 / 16	22	2.3	5 / 90	4x4 QFN	TGA2512-1-SM
LNA, AGC, GB	4 - 14	13 / 24	25	2.3	5 / 160	4x4 QFN	TGA2512-2-SM
LNA, SB, AGC	5 - 15	6 / 13	27	1.4	5 / 90	Die	TGA2512
LNA, SB	6 - 13	11 / –	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA, SB, AGC	6 - 14	6 / 12	20	1.3	5 / 90	Die	TGA2511
LNA	20 - 27	12 / –	21	2.2	3.5 / 60	Die	TGA4506
LNA	28 - 36	12 / 21	22	2.3	3 / 60	Die	TGA4507
LNA	30 - 42	14 / –	21	2.8	3 / 40	Die	TGA4508
LNA	57 - 69	–	13	4	3 / 41	Die	TGA4600

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

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
35W GaN HEMT	DC - 3.5	(45.6)	14	– / 54	32 / 150	Ceramic Flat Lead	*T2G4003532-FS**
35W GaN HEMT	DC - 3.5	(45.6)	14	– / 54	33 / 150	Ceramic Flat Lead	*T2G4003532-FL**
55W GaN HEMT	DC - 3.5	(47.2)	15	– / 50	28 / 200	Ceramic Flat Lead	T2G4005528-FS
60W GaN HEMT	DC - 3.5	(48.2)	14	– / 51	32 / 200	Ceramic Flat Lead	*T1G4006032-FS**
60W GaN HEMT	DC - 3.5	(48.2)	14	– / 51	33 / 200	Ceramic Flat Lead	*T1G4006032-FL**
120W GaN HEMT	DC - 3.5	(50.8)	14	– / 52	32 / 575	Ceramic Flat Lead	*T1G4012032-FS**
120W GaN HEMT	DC - 3.5	(50.8)	14	– / 52	32 / 575	Ceramic Flat Lead	*T1G4012032-FL**
4mm Pwr pHEMT	DC - 4	26.5	16	0.6 / –	5 / 150	SOT89	TGF2021-04-SD

Discrete Transistors (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
24mm HFET	DC - 4	40	13	– / 51	8 / 2170	Die	TGF4124
7W GaN HEMT	DC - 6	(39.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6000528-Q3
10W GaN HEMT	DC - 6	(40.5)	15	– / 52	32 / 50	5x5 QFN	*T1G6001032-SM**
18W GaN HEMT	DC - 6	(42.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6001528-Q3
30W GaN HEMT	DC - 6	(44.8)	15	– / 50	28 / 200	Ceramic Flat Lead	T2G6003028-FS
30W GaN HEMT	DC - 6	(44.7)	12	- / 50	28 / 200	Ceramic Flat Lead	*T2G6003028-FL**
4.8mm HFET	DC - 10.5	34	8.5	– / 53	8 / 200	Die	TGF4250-SCC
9.6mm HFET	DC - 10.5	37	9.5	– / 52	8.5 / 520	Die	TGF4260-SCC
1mm Pwr pHEMT	DC - 12	(31.5)	11	– / 55	12 / 75	Die	TGF2021-01
2mm Pwr pHEMT	DC - 12	(34.5)	11	– / 55	12 / 150	Die	TGF2021-02
4mm Pwr pHEMT	DC - 12	(37.5)	11	– / 55	12 / 300	Die	TGF2021-04
8mm Pwr pHEMT	DC - 12	(40.2)	11	– / 55	12 / 600	Die	TGF2021-08
12mm Pwr pHEMT	DC - 12	(42)	11	– / 52	12 / 900	Die	TGF2021-12
1.2mm HFET	DC - 12	28.5	10	– / 55	8 / 50	Die	TGF4230-SCC
2.4mm HFET	DC - 12	31.5	10	– / 56	8 / 100	Die	TGF4240-SCC
0.3mm MESFET	DC - 18	13	11	1.5 / –	3 / 15	Die	TGF1350-SCC
1.25mm GaN HEMT	DC - 18	(37.4)	13	– / 52	28 / 125	Die	TGF2023-2-01
2.5mm GaN HEMT	DC - 18	(40.2)	13	– / 50	28 / 250	Die	TGF2023-2-02
5mm GaN HEMT	DC - 18	(43)	13	– / 49	28 / 500	Die	TGF2023-2-05
10mm GaN HEMT	DC - 18	(45.8)	12	– / 47	28 / 1000	Die	TGF2023-2-10
20mm GaN HEMT	DC - 18	(48.6)	12	– / 46	28 / 2000	Die	TGF2023-2-20
0.6mm Pwr pHEMT	DC - 20	(29)	13	– / 56	12 / 45	Die	TGF2022-06
1.2mm Pwr pHEMT	DC - 20	(32)	13	– / 56	12 / 90	Die	TGF2022-12
2.4mm Pwr pHEMT	DC - 20	(35)	13	– / 58	12 / 180	Die	TGF2022-24
4.8mm Pwr pHEMT	DC - 20	(38)	13	– / 58	12 / 360	Die	TGF2022-48
6mm Pwr pHEMT	DC - 20	(39)	12.5	– / 53	12 / 448	Die	TGF2022-60
0.3mm pHEMT	DC - 22	16	13	0.8 / –	3 / 15	Die	TGF4350
30W LDMOS	0.5 - 2	45	10	– / 45	28 / 200	PowerBand™	T1L2003028-SP
10W pHEMT	0.5 - 3	40	10	– / 45	12 / 200	PowerBand™	T1P2701012-SP

NOTES: ** = New*

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
Wideband SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
Wideband SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
High Power SPDT - GaN	0.1 - 6	<1	40	45	-40 / 0	Die	TGS2351-2
High Power SPDT - GaN	0.1 - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-2-SM
High Power SPDT - GaN	0.1 - 12	<1	35	43	-40 / 0	Die	TGS2352-2
High Power SPDT - GaN	0.1 - 18	<1	30	40	-40 / 0	Die	TGS2353-2
Wideband SP3T VPIN	1 - 20	0.5	35	23	–	Die	TGS2303
Wideband SP4T VPIN	1 - 20	0.6	38	23	–	Die	TGS2304-SCC
Wideband SP3T VPIN	4 - 18	1	35	20	+/- 2.7	Die	TGS2313
Wideband SPDT VPIN	4 - 20	0.9	35	>20	+/- 2.7	Die	TGS2302
SPDT VPIN	24 - 43	<2	36	27	+/- 5	Die	TGS4301
SPDT VPIN	27 - 46	0.9	30	>34	+/- 5 / 15	Die	TGS4302
SPDT VPIN Absorptive	32 - 40	1	36	>33	+/- 5 / 18	Die	TGS4304

Frequency Converters & Mixers

Description	Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Doubler w/Amplifier	16 - 30	18	30	22	5 / 150	Die	TGC4403
Doubler w/Amplifier	16 - 30	18	30	19	5 / 150	4x4 QFN	TGC4403-SM
Upconverting Mixer	17 - 26	-9	40	–	-0.9 / 0	4x4 QFN	TGC4402-SM
Upconverting Mixer	17 - 27	-9	35	18	-0.9 / 0	Die	TGC4402
Upconverter (Low Amp + Doubler)	21.5 - 32.5	-9	35	13	5 / 65	3x3 QFN	TGC4407-SM
Doubler w/Amplifier	28 - 34	15	25	20	5 / 150	4x4 QFN	TGC4406-SM

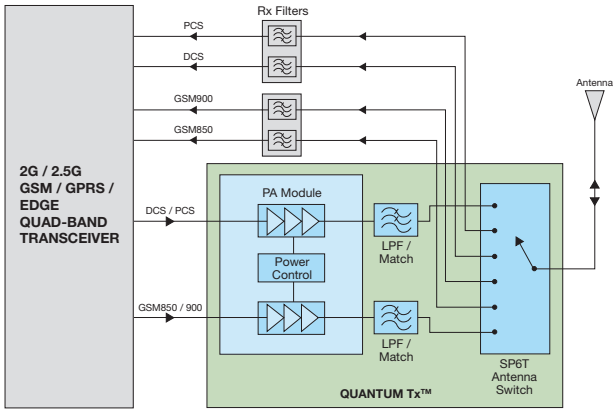
Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB) or (Deg.)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
Through Line	DC - 6	0.1	–	–	–	3x3 QFN	TQM4M9073
Wideband Analog Attenuator	DC - 30	2	17	–	0 to -2	3x3 QFN	TGL4203-SM
Wideband Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203
Discrete Thru (0dB Attenuator)	DC - 65	0	0	–	–	Die	TGL4201-00
Wideband Discrete Attenuators	DC - 65	–	2, 3, 6, 10	–	–	Die	TGL4201-02, 03, 06, 10
Passive Wideband Limiter	2 - 12	<1	–	18	–	3x3 QFN	TGL2201-SM
Wideband Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-SCC
Passive Wideband Limiter	3 - 25	<0.5	–	18	–	Die	TGL2201
5-Bit Phase Shifter	6 - 18	9	(348)	–	6	Die	TGP6336
6-Bit Phase Shifter	6 - 18	10	(354)	–	0 / -5	Die	*TGP2105**
6-Bit Phase Shifter	8.5 - 11	5	(354)	–	0 / -5	Die	TGP2103
Lange Coupler	12 - 21	<0.25	–	–	–	Die	TGB2001
5-Bit Phase Shifter	18 - 20	5	(180)	–	-2.5	Die	TGP1439
Lange Coupler	18 - 32	<0.25	–	–	–	Die	TGB4001
Lange Coupler	27 - 45	<0.25	–	–	–	Die	TGB4002
5-Bit Phase Shifter	28 - 32	6	(348)	–	5	Die	TGP2100
5-Bit Phase Shifter	33 - 37	6	(348)	–	-5	Die	TGP2102
1-Bit Phase Shifter	34 - 36	4	180	–	0 / 5	Die	TGP2104

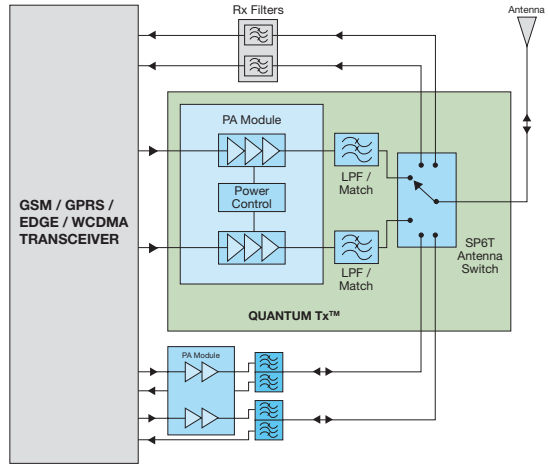
NOTES: ** = New*

BAW Filters

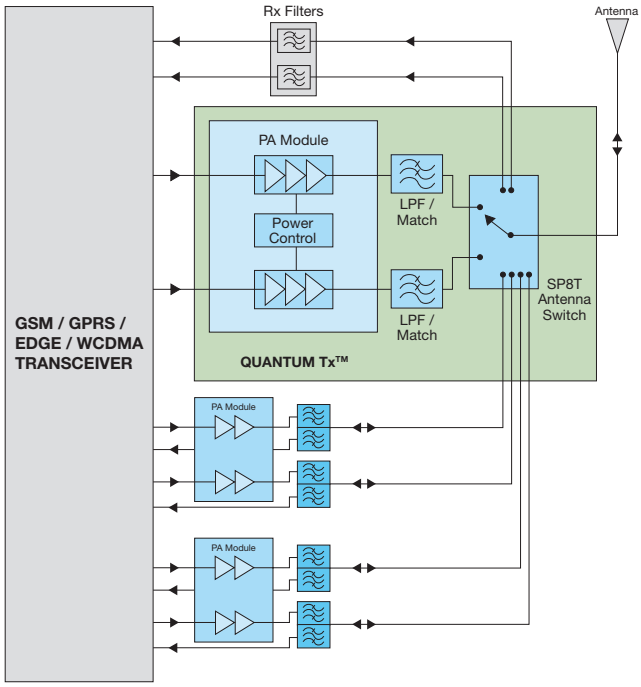
Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Style	Part Number
RF Filter	1030	15	2.5	SE / SE	40 @ 45	3.81x2.54	880367
RF Filter	1090	15	2.5	SE / SE	40 @ 45	3.81x2.54	880374
RF Filter	1280	20	3	SE / SE	40 @ 105	3.81x2.54	880368
GPS L2	1227.6	25	2.5	SE / SE	20 @ 1200	3.26x1.6	880060
GPS L1	1575.42	30	2.5	SE / SE	20 @ 1548	3.26x1.6	880094
RF Filter, MMDS	2560	30	3	SE / SE	40 @ 150	3.81x2.54	880157
GPS RF Filter, L5	1176	28	2.75	SE / SE	40 @ 140	3.26x1.6	880364
RF Filter	2106	35	4	SE / SE	–	3.26x1.6	880126
RF Filter	2324	38	3	SE / SE	40 @ 150	3.81x2.54	880148



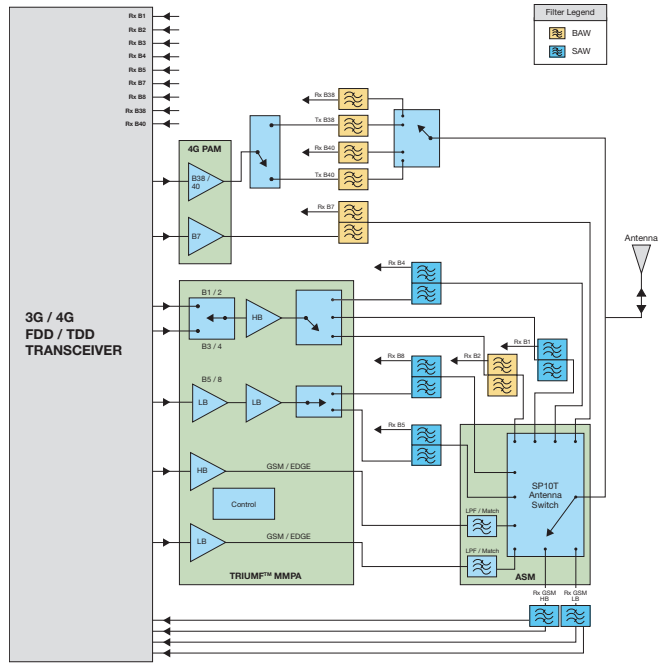
Quad-Band 2G Solution



Quad-Band 2G / Dual-Band 3G Solution



Quad-Band 2G and 3G Solution



High-End 2G / 3G / 4G Solution

QUANTUM Tx™ – GSM / GPRS

Description	Features	Bands	Size (mm)	Part Number
Dual-Band GSM / GPRS Tx Module; PA / LPF / SP4T Switch; Quad-Band Tx & Dual-Band Rx	High-Efficiency Broadband Tx, 2 Rx Ports	GSM900 / DCS or GSM850 / PCS	5.0x6.0x1.0	TQM6M4068

QUANTUM Tx™ Family – WGPRS / WEDGE

Description	Features	Bands	Size (mm)	Part Number
GSM / GPRS Tx Module; PA / LPF / SP6T WGPRS Switch w/Dual-Band WCDMA Antenna Ports	Integrated DB GSM / GPRS & 2 WCDMA Antenna Switch Ports	GSM900 / DCS or GSM850 / PCS & 2 WCDMA / LTE Bands	5.0x6.0x1.0	TQM6M9069
GSM / GPRS / EDGE-Linear Tx Module; PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA / LTE Ports	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch	GSM900 / DCS or GSM850 / PCS & 4 WCDMA / LTE Bands	5.25x6.0x1.0	TQM6M9085
GSM / GPRS Tx Module; PA / LPF / SP6T WGPRS Switch w/Dual-Band WCDMA Antenna Ports	Integrated QB GSM / GPRS & 2 WCDMA Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS & 2 WCDMA / LTE Bands	5.0x6.0x1.0	*TQF9088**
GSM / GPRS Tx Module; PA / LPF / SP8T WGPRS Switch with up to 4 WCDMA Antenna Switch Ports	Integrated QB GSM / GPRS & 4 WCDMA Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS & 4 WCDMA / LTE Bands	5.0x6.0x1.0	*TQF9089**
GSM / GPRS / EDGE / TD-SCDMA / TDD-LTE Tx Module; PA / LPF / SP8T Switch with up to 4 WCDMA Antenna Switch Ports	Integrated QB GSM / GPRS / EDGE / TD-SCDMA & 8 Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS, TD-SCDMA (Bands 34 & 39) + 4 WCDMA / LTE / TD-SCDMA / TDD-LTE Bands	5.0x6.0x0.8	*TQM6M9098**

NOTES: ** = New*

TRIUMF™ MMPA Family – GSM / GPRS / EDGE / WCDMA / HSUPA / LTE

Description	Features	Bands	Size (mm)	Part Number
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Dual-Band WCDMA PA Modules	2-Bit (Hi / Med / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA B1 & B5 / 8	5.0x7.5x1.0	TQM7M9023
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Dual-Band WCDMA PA Modules	1-Bit (Hi / Med Power Modes)	GSM850 / 900, DCS / PCS & WCDMA B1 & B5 / 8	5.0x7.5x1.0	TQM7M9053
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Penta-Band WCDMA / HSUPA / LTE PA Modules	1-Bit (Hi / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA & LTE B1, B2, B3 / 4, 5 & 8	5.0x7.0x1.0	*TQM7M9050**
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Penta-Band WCDMA / HSUPA / LTE PA Modules	1-Bit (Hi / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA & LTE B1, B2, B3 / 4, 5 & 8	5.0x7.0x1.0	*TQP9058**

NOTES: ** = New*

PA Modules – GSM / GPRS / EDGE

Description	Features	Bands	Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Linear PA Module	Low Band Ibatt < 1.5A @ Pcal w/PAE 55%	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5005H
Quad-Band GSM / GPRS / EDGE-Linear PA Module	Input Power Controlled for GMSK & 8PSK	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5013
Quad-Band GSM / GPRS / EDGE-Polar PA Module	+3 to +8dBm Pin Nominal	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5012H
Quad-Band GSM / GPRS / EDGE-Polar PA Module	+3 to +8dBm Pin Nominal	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5022
Quad-Band GSM / GPRS / EDGE-Linear PA Module	Input Power Controlled for GMSK & 8PSK	GSM900 / DCS & GSM850 / PCS	5.0x3.5x0.9	TQM7M5050

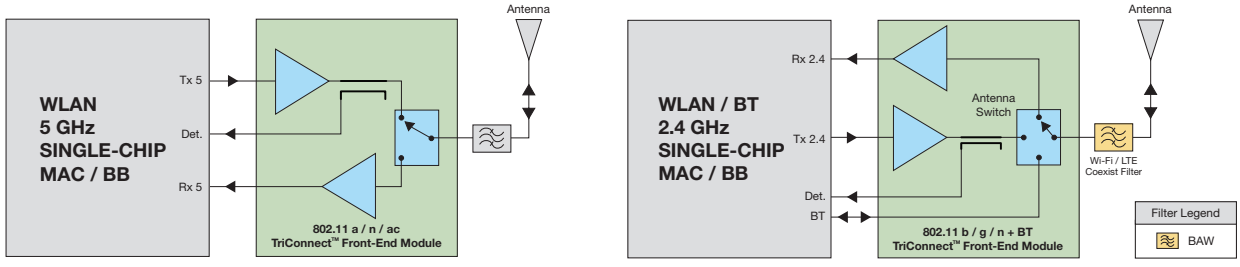
PA Modules – CDMA / WCDMA / HSUPA / LTE

Description	Features	Bands	Size (mm)	Part Number
WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	Band 1	3.0x3.0x0.9	TQM776011
WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	Band 8	3.0x3.0x0.9	TQM726018
CDMA & WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	PCS / Band 2	3.0x3.0x0.9	TQM766012
CDMA & WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	AWS / Band 4	3.0x3.0x0.9	TQM756014
CDMA & WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	Cellular / Band 5	3.0x3.0x0.9	TQM716015
LTE PA Module, w/Coupler	1-Bit (Hi / Low Power Modes)	Band 13	3.0x3.0x0.9	TQM700013
LTE PA Module, w/Coupler	1-Bit (Hi / Low Power Modes)	Band 17	3.0x3.0x0.9	TQM700017
Dual-Band WCDMA / HSUPA PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1 & 8	4.0x3.0x0.9	*TQM7M6158**
Dual-Broadband WCDMA / HSUPA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1, 2 & 5 & 8 (25 & 26) BC0, BC1 (BC10)	4.0x3.0x0.9	*TQM7M6125**
Dual-Band WCDMA / HSUPA PA Module, w/Coupler	1-Bit (High / Low Power Modes) Single LB / HB RF Input	Bands 1 & 8	4.0x3.0x0.9	*TQM7M6018**
Dual-Band WCDMA / HSUPA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Single LB / HB RF Input	Bands 2 & 5 (25 & 26) BC0, BC1 (BC10)	4.0x3.0x0.9	*TQM7M6025**
Dual-Broadband WCDMA / HSUPA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1, 2 & 5 & 8 (25 & 26) BC0, BC1 (BC10)	4.2x3.0x0.9	*TQP6109**

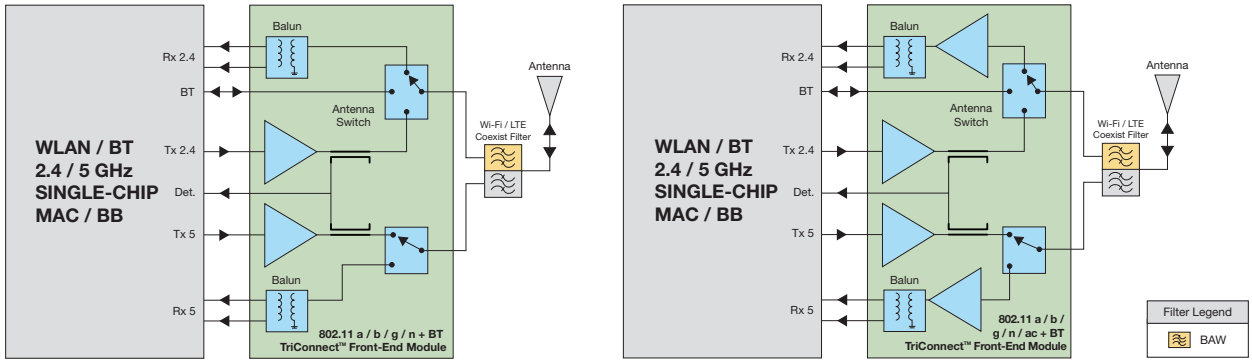
NOTES: ** = New*

TRITIUM™ PAD Family – WCDMA / HSUPA / LTE

Description	Features	Bands	Size (mm)	Part Number
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Band 1	7.0x4.0x1.1	TQM676021
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Band 2	7.0x4.0x1.1	TQM666022
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Bands 5 & 6	7.0x4.0x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Band 8	7.0x4.0x1.1	TQM626028L
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler	DC / DC, 1-Bit (Hi / Med Power Modes)	Band 2	4.5x3.5x1.0	TQM666052



Single-Band TriConnect™ WLAN Modules



Dual-Band TriConnect™ WLAN Modules

WLAN / 3G / 4G LTE Duplexers & Filters

Description	Features	Bands	Size (mm)	Part Number
LTE SE / BAL Duplexer - SAW	1.5dB (Tx) / 1.6dB (Rx) Insertion Loss	Band 13	2.5x2.0x0.6	856879
LTE SE / BAL Duplexer - TC-SAW	1.8dB (Tx) / 2.0dB (Rx) Insertion Loss	Band 17	2.5x2.0x0.6	856931
LTE SE / BAL Duplexer - SAW	High-Performance Temp. Comp. SAW	Band 20	2.5x2.0x0.6	856979
BC10 SE / BAL Duplexer - SAW	Excellent Triple Beat Performance	BC10 (PCS)	2.5x2.0x0.6	856999
BC0 Notch Filter for SVLTE Applications - TC-SAW	Low Loss, High Attenuation and High Linearity	BC0 / B13	2.5x2.0x0.6	*857031**
B13 Notch Filter for SVLTE Applications - TC-SAW	Low Loss, High Attenuation and High Linearity	BC0 / B13	2.5x2.0x0.6	*857061**
LTE SE / SE Duplexer - BAW	Excellent Triple Beat Performance	Band 25 (BC14)	2.5x2.0x0.9	TQM963014
PCS SE / SE Duplexer - BAW	Excellent Triple Beat Performance	Band 2 (PCS) (BC1)	2.5x2.0x0.9	TQM966002
LTE Diversity Receive Filter - BAW	2.6dB Insertion Loss and 40dB Tx Attenuation	Band 25	2.5x2.0x0.8	TQM966025
LTE Duplexer Bank - BAW / TC-SAW	Diplexed Duplexer for B25 / 26 Applications	Band 25 / 26	2.8x4.7x1.0	*TQQ2526**
LTE Duplexer Bank - BAW / SAW	Diplexed Duplexer for BC1 / C0 Applications	Band BC1 / BC0	2.8x4.7x1.0	*TQQ0101**
LTE B38 / B40 Diplex Tx Filter - BAW	Diplexed Tx Filters for B38 / 40 Applications	Bands 38 & 40	2.0x1.5x0.5	*885030**
LTE B38 / 40 Rx Filter - BAW	Rx Filters for B38 / 40 Applications	Band 38 + 40	1.7x1.3x0.5	*885035**
LTE B38 Tx / Rx Filter - BAW	Tx or Rx B38 Filter	Band 38	1.4x1.2x0.5	*885026**
LTE B40 Tx / Rx Filter - BAW	Tx or Rx B40 Filter	Band 40	1.4x1.2x0.5	*885049**
Duplexer B25 - BAW	SE Duplexer	Band 25	2.0x1.6x0.4	*TQM969002**
LTE B25 Diversity Receive Filter - BAW	B25 Rx Filter	Band 25	2.0x1.6x0.9	*885051**
LTE / Wi-Fi Coexist Filter - BAW	WLAN BPF Filter B38 / 40 Reject	WLAN	1.4x1.2x0.5	*885033**
LTE / Wi-Fi Coexist Filter - BAW	WLAN BPF Filter B7 / 41 Reject	WLAN	1.4x1.2x0.5	*885032**

NOTES: ** = New*

TriConnect™ WLAN RF Modules

Description	Features	Bands	Size (mm)	Part Number
5 GHz WLAN PA MMIC	ETSLP-16 Package, Detector, Hi / Low Linearity Mode	802.11 a / n	3.0x3.0x0.45	TQP787011
2.4 GHz WLAN Low Noise Amplifier + SP3T Switch w/WLAN Tx and Bluetooth® Path	LNA Bypass, ETSLP-12 Package	802.11 b / g / n	1.5x1.5x0.55	TQP879001A
2.4 GHz WLAN PA + Switch MMIC w/WLAN Rx Balun and Bluetooth® Path	ETSLP-16 Package, Coupler / Detector	802.11 b / g / n	3.0x3.0x0.45	TQM679002A
2.4 GHz and 5 GHz WLAN PA + Switch MMIC w/WLAN Rx Baluns and Bluetooth® Path	ETSLP-24 Package, Coupler / Detector	802.11 a / b / g / n	4.0x4.0x0.45	TQP6M9002
2.4 GHz and 5 GHz WLAN High-Performance PA + Switch MMIC w/WLAN 2.4 GHz and 5 GHz LNA + Rx Baluns and Bluetooth® Path	ETSLP-24 Package, Coupler / Detector	802.11 a / b / g / n / ac	4.0x4.0x0.45	TQP6M9017
2.4 GHz WLAN PA + Low Noise Amplifier + SP3T Switch MMIC for Bluetooth® Path	ETSLP-16 Package, Coupler / Detector	802.11 b / g / n	2.5x2.5x0.4	*TQF9046**

TriConnect™ WLAN RF Modules (cont.)

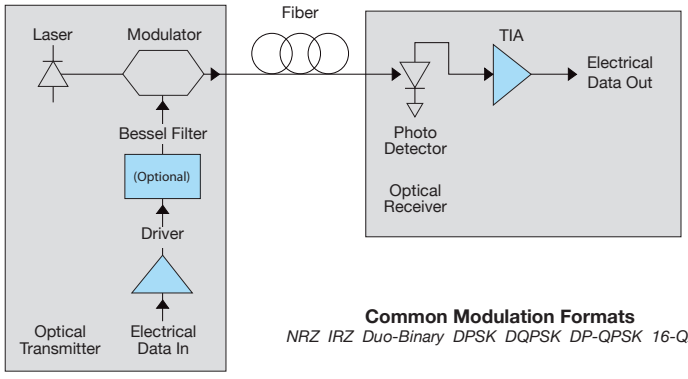
Description	Features	Bands	Size (mm)	Part Number
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	ETSLP-16 Package	802.11 a / n / ac	2.5x2.5x0.4	*TQF7062**
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	ETSLP-16 Package, Detector / Coupler	802.11 a / n / ac	2.5x2.5x0.4	*TQP887051**
5 GHz WLAN PA + SP2T Switch MMIC	ETSLP-16 Package	802.11 a / n / ac	2.5x2.5x0.4	*TQP887052**

NOTES: ** = New*

GPS RF Front-End Module & Filters

Description	Features	Bands	Size (mm)	Part Number
GPS Filter-LNA-Filter Module	Low Noise (1.56dB) and High Gain (16dB)	1575 MHz, GPS L1	3.0x3.0x1.0	TQM640002
GPS SAW Filter, SE / BAL	1.1dB Insertion Loss, High Rejection (Hermetic CSP)	1575 MHz, GPS L1	1.4x1.2x0.46	856576
GPS SAW Filter, SE / SE	0.75dB Insertion Loss (Hermetic CSP)	1575 MHz, GPS L1	1.4x1.2x0.46	856561
GPS SAW Filter, SE / SE	0.6dB Insertion Loss (Hermetic CSP)	1575 MHz, GPS L1	1.4x1.2x0.46	856793
GPS SAW Filter, SE / SE	1.25dB Insertion Loss (Hermetic CSP)	1575 MHz, GPS L1	2.0x1.5x0.76	*856584**

NOTES: ** = New*



Common Modulation Formats
NRZ IRZ Duo-Binary DPSK DQPSK DP-QPSK 16-QAM

Optical Systems (10, 40 & 100 Gb/s)

Drivers

Description	Frequency Range (GHz)	Power	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
9.9 - 12.5 Gb/s 3V - 7V Driver	DC - 13	3 - 7Vpp	32	–	3.3 - 5 / 115	8x8 QFN	TGA4956-SM
9.9 - 12.5 Gb/s Mod. Driver	DC - 16	3 - 10Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4953-SL
9.9 - 12.5 Gb/s Mod. Driver	DC - 16	3 - 9Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4954-SL
12.5 Gb/s NRZ Driver	DC - 18	3 - 11Vpp	16	2.5	8 / 285	Die	TGA4807
12.5 Gb/s NRZ Driver	DC - 18	6 - 8Vpp	16	3.5	5 - 8 / 70 - 175	Die	TGA1328-SCC
12.5 Gb/s NRZ Driver	DC - 18	4 - 8Vpp	16	3.5	8 / 175	8.9x8.9x2 SL	TGA8652-SL
15 Gb/s 10V Linear Mod. Driver	DC - 20	3 - 10Vpp	22	–	7 / 280	6x6 QFN	TGA4826-SM
200 Gb/s 16 QAM Linear Dual Driver w/Bias-T's inside	DC - 27	3-5Vpp	24	–	5 - 7 / 500	12x10.5x3.6 SL	*TGA4892-SL***
100 Gb/s Linear Dual Driver w/Bias-T's inside	DC - 27	3 - 8Vpp	35	–	5 - 7 / 650	16x10.5x3.6 SL	*TGA4894-SL***
40 & 100 Gb/s 8Vpp SE Driver	DC - 30	3 - 9Vpp	32	–	6 - 7 / 270	14.4x7x2 SL	TGA4943-SL
100 Gb/s 8Vpp Dual Channel Driver w/Bias-T's Inside	DC - 35	3 - 9Vpp	32	–	5 - 7 / 500	16x10.5x3.6 SL	TGA4947-SL
Wideband Driver (40 Gb/s)	DC - 35	4Vpp	12	–	5 / 135	Die	TGA4832
32 Gb/s 9Vpp Diff In / Out Driver MMIC	DC - 35	6 - 9Vpp Diff	25 Diff	–	5 - 6 / 500	10x7 SL	TGA4959-SL

Drivers (cont.)

Description	Frequency Range (GHz)	Power	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
28 Gb/s 6Vpp Diff In / Out Driver MMIC	DC - 28	4 - 8Vpp Diff	22 Diff	–	4 -5 / 450	6x6 QFN	*TGA4957-SM**
45 Gb/s 8Vpp SE Driver w/ Bias-T Inside	DC - 37	5 - 9Vpp	30	–	6 - 7 / 300	16x8 SL	TGA4942-SL
45 Gb/s 9Vpp Diff In / Out Driver MMIC	DC - 50	6 - 10Vpp Diff	27 Diff	–	5 - 6 / 500	Die	*TGA4959***
Ultra-Wideband Driver (50 Gb/s)	DC - 78	3.5Vpp	8	5	6 / 82	Die	TGA4803
10.7 - 12.5 Gb/s Linear Mod. Driver	0.03 - 8	12.5Vpp	20	–	8 / 310	8x8 QFN	TGA4823-2-SM

NOTES: ** = New, ** = Coming Soon*, SE = Single-Ended

Amplifiers

Description	Frequency Range (GHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
LNA / Gain Block (40 Gb/s)	DC - 40	11.5 / 20	13	3.2	5 / 50	Die	TGA4830
CATV TFA / Gain Block	0.04 - 1	27 / 42	20	1.5	8 / 350	4x4 QFN	TGA2803-SM

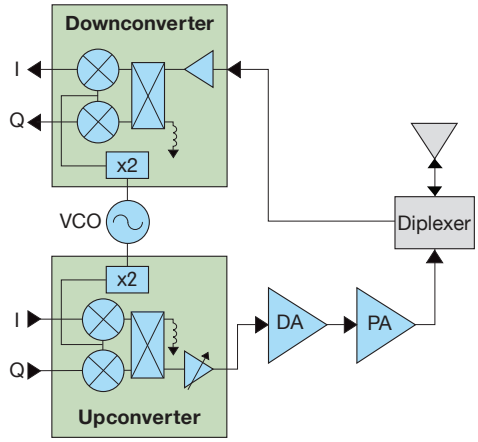
Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB)	Supply Voltage (V)	Package Style	Part Number
Analog Attenuator	DC - 30	2	17	0 to -2	3x3 QFN	TGL4203-SM
Analog Attenuator	DC - >50	2	17	0 to -2	Die	TGL4203
Discrete Thru (0dB Attenuator)	DC - 65	0	0	–	Die	TGL4201-00
Discrete Attenuators	DC - 65	–	2, 3, 6, 10	–	Die	TGL4201-02, 03, 06, 10
Bessel Filter	–	6, 7, 8, 9, 10 & 11 Cut-Off Freq	–	–	Die	TGB2010-00, -09 etc.
Bessel Filter	–	5, 6, 6.5, 7.5, 8 & 9 Cut-Off Freq	–	–	2x2 QFN	TGB2010-00, -90-SM etc.

Transimpedance Amplifiers (TIAs)

Description	Bandwidth (GHz)	Small Signal Gain (dB)	Differential Transimpedance Gain (ohm)	Differential Output Vpp (mV)	Equivalent Input Noise (pA / rtHz)	Voltage (V)	Current (mA)	Part Number
13 Gb/s Linear TIA with AGC	11	–	250 - 4800	200 - 900	24	3.3	175	*TGA4861**
32 Gb/s Linear TIA with AGC	28	–	250 - 4800	200 - 900	24	3.3	175	*TGA4864**
44.6 Gb/s Limiting TIA	36	–	2800	650	15	3.3	75	*TGA4866**
43 Gb/s Limiting TIA	30	40	4500	600	30	-5.2	85	*TIA56**
43 Gb/s Limiting TIA with PLD	27	36	3200	600	30	-5.2	85	*TIA56A**

NOTES: ** = New*



Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
2W HPA	5.5 - 8.5	32 (34) / 41	30	7 / –	6 / 1260	5x5 QFN	TGA2706-SM
2.5W HPA	5.9 - 8.5	34 / 42	18	7.5 / 37	6 / 1000	6x6 QFN	TGA2701-SM
HPA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	Die	TGA9092-SCC
Gain Block	6 - 18	12.5 / –	13	5 / –	5 / 80	Die	TGA8035-SCC
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Die	TGA2501
HPA	7 - 8.5	(38) / –	21	– / 42	7 / 2000	Die	TGA2701
Driver Amp	7 - 13	(30) / 37	25	– / 30	9 / 450	Die	TGA2700
Wideband Driver Amp	8 - 18	13 / –	17	5 / –	4.5 / 50	Die	TGA8399C
HPA	9 - 10.5	(38) / –	20	– / >38	4 - 9 / 2000	Die	TGA2704
HPA	10 - 12	33 (34.5) / 43	25	9 / –	6 / 1300	5x5 QFN	TGA2535-SM
HPA	10.5 - 12	(38) / –	19	– / >39	4 - 9 / 2000	Die	TGA2710
Driver Amp, SB	11 - 17	17 / –	23	6 / –	6 / 75	4x4 QFN	TGA2507-SM
Driver Amp	12 - 16	26 (26.5) / 37	23	7 / –	5 / 300	3x3 QFN	TGA2524-SM
Driver Amp, SB	12 - 18	14 / –	17	–	6 / 40	Die	TGA2506
Driver Amp, SB	12 - 18	20 / –	28	6 / –	6 / 80	Die	TGA2507
1W HPA	12 - 19	30 / –	30	–	5 - 7 / 435	Die	TGA2508
HPA	12 - 19	29 / –	25	–	5 - 7 / 435	4x4 QFN	TGA2508-SM
HPA	12.5 - 15.5	30 (31.5) / 41	25	7.5 / –	6 / 650	5x5 QFN	TGA2527-SM
2W HPA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680		TGA2503-SM
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510
2W HPA	12.7 - 15.4	34 (35) / 43	28	6 / –	6 / 1300	Die	TGA2533
2W HPA	12.7 - 15.4	33 (34.5) / 43	27	6 / –	6 / 1300	5x5 QFN	TGA2533-SM
2W HPA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
2W HPA	13 - 17	(34) / –	25	–	6 - 7 / 640	Die	TGA2505
4W HPA, Balanced	13 - 17	(36) / 44	25	– / 30	6 - 7 / 1300	Die	TGA2502
HPA	17 - 20	31 (32.5) / 41	23	7 / –	6 / 900	4x4 QFN	TGA4532-SM
HPA	17 - 20	30.5 / 41	23	–	6 / 900	Die	TGA4532
2W HPA	17 - 20	33 (34.5) / 42	21	–	6 / 1430	5x5 QFN	***TGA4534-SM****
Driver Amp	17 - 24	22 / –	19	4 / –	5 / 270	4x4 QFN	TGA2521-SM
HPA	17 - 24	31 (32) / 40	23	6 / –	7 / 720	Die	TGA4531
HPA, AGC, PD	17 - 24	(29) / 38	22	–	5 / 712	4x4 QFN	TGA2522-SM
HPA	17 - 27	29 (31) / 37	22	–	7 / 760	Die	TGA4502-SCC
Gain Block & 2x / 3x Multiplier	17 - 37	18 (22) / 26	20	7 / –	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	18 (22) / 24	22	7 / –	5 / 140	3x3 QFN	TGA4031-SM
Gain Block, Multiplier	17 - 43	22 / –	25	–	5 / 225	Die	TGA4040
2W HPA	18 - 23	32 (33) / 39	26	–	7 / 840	Die	TGA4022
HPA	18 - 27	29 / 37	14	–	6 / 480	Die	TGA1135B-SCC
MPA	19 - 27	25 / 32	22	–	5 - 7 / 220	Die	TGA1073G-SCC
Gain Block	19 - 38	(22) / 30	20	–	5 / 160	Die	TGA4036
HPA	21 - 24	31 (32) / 41	22	6 / –	6 / 880	4x4 QFN	TGA4533-SM
2W HPA	21 - 24	32 (34) / 41	22	–	6 / 1430	5x5 QFN	***TGA4535-SM****
MPA	25 - 35	25 / –	18	–	6 / 220	4x4 QFN	TGA4902-SM
MPA	26 - 35	25 (32) / –	19	–	5 - 7 / 220	Die	TGA1073A-SCC
1W HPA	27 - 31	30 / –	22	– / 25	4 - 6 / 420	Die	TGA4509
2W HPA	27 - 31	32.5 (33) / 36.5	20	–	6 / 840	Die	TGA4513
HPA	27 - 32	28.5 / –	25	–	6 - 8 / 420	Die	TGA1073B-SCC
1W HPA	28 - 31	30 / –	19	– / 25	6 / 420	4x4 QFN	TGA4509-SM
Driver Amp	29 - 37	16 / –	16	–	6 / 60	Die	TGA4510
2W HPA	30 - 40	31.5 (33) / –	20	–	6 / 1050	Die	TGA4516
MPA	32 - 45	24 (25) / 33	16	–	6 / 175	Die	TGA4521
MPA	33 - 47	27 (27.5) / 36	18	–	6 / 400	Die	TGA4522
HPA	36 - 40	26 / –	15	–	5 - 7 / 240	Die	TGA1073C-SCC
HPA	36 - 40	30 / –	14	–	6 - 7 / 500	Die	TGA1171-SCC
HPA	37 - 40	28 / 38	24	–	5 / 600	Die	TGA4538
37 - 40 GHz Power Amplifier	37 - 40	30 (32) / 38	26	– / 18	6 / 900	Die	***TGA4542****
40.5 - 43 GHz Power Amplifier	40.5 - 43.5	28.5 (30) / 38	23	– / 14	6 / 900	Die	***TGA4543****

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

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
LNA, AGC	2 - 18	18 / 29	17	2	5 / 75	Die	TGA2525
LNA, AGC	2 - 20	19 / –	17.5	2.5	5 / 100	Die	TGA2526
LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
LNA, AGC	2 - 20	16 / –	17	2.5	5 / 75	4x4 QFN	TGA2513-SM
LNA, AGC	2 - 23	17 / 26	17	2	5 / 75	Die	TGA2513
LNA, SB, AGC	4 - 14	6 / 16	22	2.3	5 / 90	4x4 QFN	TGA2512-1-SM
LNA, AGC, GB	4 - 14	13 / 24	25	2.3	5 / 160	4x4 QFN	TGA2512-2-SM
LNA, SB, AGC	5 - 15	6 / 13	27	1.4	5 / 90	Die	TGA2512
LNA, SB	6 - 13	11 / –	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA, SB, AGC	6 - 14	6 / 12	20	1.3	5 / 90	Die	TGA2511
LNA	20 - 27	12 / –	21	2.2	3.5 / 60	Die	TGA4506
LNA	28 - 36	12 / 21	22	2.3	3 / 60	Die	TGA4507
LNA	30 - 42	14 / –	21	2.8	3 / 40	Die	TGA4508
LNA	57 - 69	–	13	4	3 / 41	Die	TGA4600

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

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
24mm HFET	DC - 4	40	13	– / 51	8 / 2170	Die	TGF4124
18mm HFET	DC - 6	38.5	13.5	– / 53	8 / 1690	Die	TGF4118
12mm HFET	DC - 8	37	14	– / 55	8 / 750	Die	TGF4112
4.8mm HFET	DC - 10.5	34	8.5	– / 53	8 / 200	Die	TGF4250-SCC
9.6mm HFET	DC - 10.5	37	9.5	– / 52	8.5 / 520	Die	TGF4260-SCC
1.2mm HFET	DC - 12	28.5	10	– / 55	8 / 50	Die	TGF4230-SCC
2.4mm HFET	DC - 12	31.5	10	– / 56	8 / 100	Die	TGF4240-SCC
1mm Pwr pHEMT	DC - 12	(31.5)	11	– / 55	12 / 75	Die	TGF2021-01
2mm Pwr pHEMT	DC - 12	(34.5)	11	– / 55	12 / 150	Die	TGF2021-02
4mm Pwr pHEMT	DC - 12	(37.5)	11	– / 55	12 / 300	Die	TGF2021-04
8mm Pwr pHEMT	DC - 12	(40.2)	11	– / 55	12 / 600	Die	TGF2021-08
12mm Pwr pHEMT	DC - 12	(42)	11	– / 52	12 / 900	Die	TGF2021-12
0.3mm MESFET	DC - 18	13	11	1.5 / –	3 / 15	Die	TGF1350-SCC
0.6mm Pwr pHEMT	DC - 20	(29)	13	– / 56	12 / 45	Die	TGF2022-06
1.2mm Pwr pHEMT	DC - 20	(32)	13	– / 56	12 / 90	Die	TGF2022-12
2.4mm Pwr pHEMT	DC - 20	(35)	13	– / 58	12 / 180	Die	TGF2022-24
4.8mm Pwr pHEMT	DC - 20	(38)	13	– / 58	12 / 360	Die	TGF2022-48
6mm Pwr pHEMT	DC - 20	(39)	12.5	– / 53	12 / 448	Die	TGF2022-60
0.3mm pHEMT	DC - 22	16	13	0.8 / –	3 / 15	Die	TGF4350

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SP2T 802.11 a, b, g	DC - 6	0.6	28	31.5	3 / 0	1.3x2 DFN	TQS5200
SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
SP3T VPIN	1 - 20	0.5	35	23	–	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	–	Die	TGS2304-SCC
SP3T VPIN	4 - 18	1	35	20	+/- 2.7	Die	TGS2313
SPDT VPIN	4 - 20	0.9	35	>20	+/- 2.7	Die	TGS2302
SPDT VPIN	24 - 43	<2	36	27	+/- 5	Die	TGS4301
SPDT VPIN	27 - 46	0.9	30	>34	+/ -5 / 15	Die	TGS4302
SPDT VPIN Absorptive	32 - 40	1	36	>33	+/- 5 / 18	Die	TGS4304

Frequency Converters & Mixers

Description	Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Ku-Band Upconverter	10 - 16	17	25	15	5 / 300	5x5 QFN	*TGC2510-SM**
Doubler w/Amplifier	16 - 30	18	30	–	5 / 150	Die	TGC4403
Doubler w/Amplifier	16 - 30	18	30	–	5 / 150	4x4 QFN	TGC4403-SM
Upconverting Mixer	17 - 26	-9	40	–	-0.9 / 0	4x4 QFN	TGC4402-SM
Upconverting Mixer	17 - 27	-9	35	18	-0.9 / 0	Die	TGC4402
K-Band Upconverter	17 - 27	13	40	19	5 / 340	5x5 QFN	*TGC4510-SM**
K-Band Downconverter	17 - 27	15	40	3	3 / 230	5x5 QFN	*TGC4610-SM**
Gain Block & 2x / 3x Multiplier	17 - 37	9	–	6	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 37	9	–	6	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	9	–	2	5 / 140	3x3 QFN	TGA4031-SM

NOTES: ** = New*

Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
Analog Attenuator	DC - 30	2	17	–	0 to -2	3x3 QFN	TGL4203-SM
Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203
Discrete Thru (0dB Attenuator)	DC - 65	0	0	–	–	Die	TGL4201-00
Discrete Attenuators	DC - 65	–	2, 3, 6, 10	–	–	Die	TGL4201-02, 03, 06, 10
Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-SCC
Passive Wideband Limiter	3 - 25	<0.5	–	18	–	Die	TGL2201
Lange Coupler	12 - 21	<0.25	–	–	–	Die	TGB2001
Lange Coupler	18 - 32	<0.25	–	–	–	Die	TGB4001
Lange Coupler	27 - 45	<0.25	–	–	–	Die	TGB4002

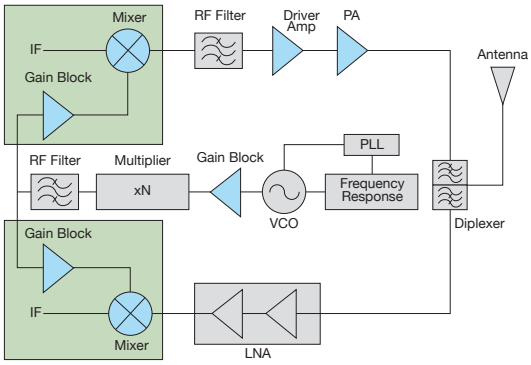
Voltage Controlled Oscillators

Description	Frequency Range (GHz)	Output Power (dBm)	Phase Noise @ 100kHz (dBc/Hz)	Voltage / Current (V / mA)	Package Style	Part Number
8.9 - 9.8 GHz VCO with Divide by 2	8.9 - 9.8	9	-112	5 / 170	5x5 QFN	*TGV2561-SM**
9.5 - 10.3 GHz VCO with Divide by 2	9.5 - 10.3	9	-111	5 / 170	5x5 QFN	*TGV2562-SM**
9.7 - 10.8 GHz VCO with Divide by 2	9.7 - 10.8	9	-111	5 / 170	5x5 QFN	*TGV2563-SM**
10.3 - 11.1 GHz VCO with Divide by 2	10.3 - 11.1	9	-111	5 / 170	5x5 QFN	*TGV2564-SM**
10.7 - 11.5 GHz VCO with Divide by 2	10.7 - 11.5	9	-111	5 / 180	5x5 QFN	*TGV2539-SM**
11.3 - 12.3 GHz VCO with Divide by 2	11.3 - 12.3	10	-110	5 / 180	5x5 QFN	*TGV2565-SM**
12.5 - 13.5 GHz VCO with Divide by 2	12.5 - 13.5	7	-110	5 / 165	5x5 QFN	*TGV2529-SM**
12.6 - 13.8 GHz VCO with Divide by 2	12.6 - 13.8	9	-110	5 / 170	5x5 QFN	*TGV2584-SM**
13.4 - 14.4 GHz VCO with Divide by 2	13.4 - 14.4	9	-110	5 / 175	5x5 QFN	*TGV2566-SM**

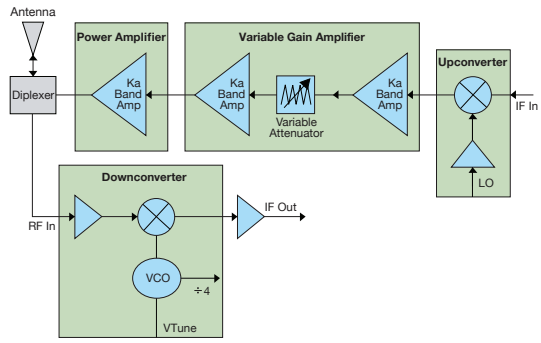
NOTES: ** = New*

Filters

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
High-Selectivity IF Filter	140	1.5	12.1	SE and BAL	48 @ 143	9.1x4.8	856691
High-Selectivity IF Filter	140	3	13.6	SE and BAL	46 @ 144	9.1x4.8	856692
High-Selectivity IF Filter	140	6	11	BAL / BAL	39 @ 147	9.1x4.8	856693
High-Selectivity IF Filter	140	7	13.6	SE and BAL	43 @ 147	9.1x4.8	856694
High-Selectivity IF Filter	140	10	10	BAL / BAL	41 @ 152.5	9.1x4.8	856695
High-Selectivity IF Filter	140	14	8.5	SE and BAL	43 @ 155	9.1x4.8	856696
High-Selectivity IF Filter	140	20	9.8	BAL / BAL	40 @ 158.5	9.1x4.8	856697
High-Selectivity IF Filter	140	28	18	SE and BAL	42 @ 168	9.1x4.8	856698



Multi-Band VSAT



Ka-Band VSAT

Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
Ku-Band 50mW Gain Block, SB	11 - 17	17 / –	23	6 / –	6 / 75	4x4 QFN	TGA2507-SM
Ku-Band 25mW Gain Block, SB	12 - 18	14 / –	17	–	6 / 40	Die	TGA2506
Ku-Band 50mW Gain Block, SB	12 - 18	20 / –	28	6 / –	6 / 80	Die	TGA2507
Ku-Band 0.8W PA	12 - 19	29 / –	25	–	5 - 7 / 435	4x4 QFN	TGA2508-SM
Ku-Band 1W PA	12 - 19	30 / –	30	–	5 - 7 / 435	Die	TGA2508
Ku-Band 1.6W PA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680	4x4 QFN	TGA2503-SM
Ku-Band 2W PA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510
Ku-Band 4W PA	13 - 15	(36) / 41	25	–	7 / 1300	8.4x17.8 FL	TGA8659-FL
Ku-Band 6.5W PA	13 - 16	(38) / –	24	–	8 / 2600	11.4x17.3 FL	TGA2514-FL
Ku-Band 1.6W PA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
Ku-Band 2.5W PA	13 - 17	(34) / –	25	–	6 - 7 / 640	Die	TGA2505
Ku-Band 4W PA	13 - 17	(36) / 44	25	– / 30	6 - 7 / 1300	Die	TGA2502
Ku-Band 6.5W PA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
Ka-Band 0.32W MPA	25 - 35	25 / –	18	–	6 / 220	4x4 QFN	TGA4902-SM
Ka-Band 1W PA	27 - 31	30 / –	22	– / 25	4 - 6 / 420	Die	TGA4509
Ka-Band 2W PA	27 - 31	32.5 (33) / 36.5	20	– / 25	6 / 840	Die	TGA4513
Ka-Band 0.25W MPA	27 - 32	24 / –	15	–	5 / 170	4x4 QFN	TGA4903-SM
Ka-Band 1W Linear PA	28 - 30	30 (30.5) / –	20	–	6 / 420	5x5 QFN	TGA4539-SM
Ka-Band VGA	28 - 31	23 / 31	33	–	5 / 330	6x6 QFN	TGA4541-SM
Ka-Band 1W PA	28 - 31	30 / –	19	– / 25	6 / 420	4x4 QFN	TGA4509-SM
Ka-Band 4W PA	28 - 31	36 (36.5) / –	22	– / 22	6 / 1600	5x5 QFN	TGA4906-SM
Ka-Band 4W PA	28 - 31	36 (36.5) / –	22	– / 22	6 / 1600	Die	TGA4906
Ka-Band 7W PA	28 - 31	(38.5) / –	22	– / 20	6 / 3200	Die	TGA4916
Ka-Band 50mW Gain Block	29 - 37	16 / –	16	–	6 / 60	Die	TGA4510

NOTES: SB = Self Biased

Frequency Converters & Mixers

Description	Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Doubler w/Amplifier	16 - 30	18	30	–	5 / 150	Die	TGC4403
Ka-Band Doubler + Driver Amp	16 - 30	15	25	–	5 / 150	4x4 QFN	TGC4406-SM
Ka-Band Downconverter (LNA + VCO + Mixer)	17 - 21	8	–	–	5 / 305	5x6 QFN	TGC4408-SM
Ka-Band Upconverter (Low Amp + Doubler)	21.5 - 32.5	-9	35	13	5 / 65	3x3 QFN	TGC4407-SM

Up to 1W

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage Current (V / mA)	Package Style	Part Number
Dual HBT Amplifier	DC - 1	20 / 37	13.5	4.5 / –	>7 / 165	SOIC-8	AG606
CATV Gain Block, Flex Gain	DC - 2	21 / 38	16 - 21	2 / –	5 - 8 / 100	SOT89	TAT7457
12.5 Gb/s NRZ Driver	DC - 18	24 / –	16	3.5 / –	5 - 8 / 70 - 175	Die	TGA1328-SCC
12.5 Gb/s NRZ Driver	DC - 18	25 / –	16	3.5 / –	8 / 175	8.9x8.9 SL	TGA8652-SL
Wideband Driver (40 Gb/s)	DC - 35	18 / –	12	–	5 / 135	Die	TGA4832
CATV TIA / Gain Block, SB	0.04 - 1	27 / 46	20	1.5 / –	8 / 350	5x5 QFN	TGA2806-SM
CATV Gain Block	0.04 - 1	28 / 43	18.5	2.5 / –	6 / 318	5x5 QFN	TGA2807-SM
On-Chip Linearized Amplifier	0.04 - 1	– / 43	17	4.7 / –	5 / 380	SOIC-8	TAT7467H
CATV 12V Power Doubler MMIC	0.05 - 1	–	11	4 / –	12 / 570	SOIC16W	*TAT8801A1H**
CATV Power Doubler Line Amplifier MMIC	0.05 - 1	22 / 27	22 - 27	4 / –	24 / 350 (12V Optional)	SOIC16W	TAT8857
CATV Push Pull Infrastructure Amplifier MMIC	0.05 - 1	28 / 34	28 - 34	3 / –	24 / 270 (12V Optional)	SOIC16W	TAT8858
MESFET Amplifier	0.05 - 1	20 / 40	14.8	3.5 / –	5 / 150	SOT89	AH2
Dual MESFET Amplifier	0.05 - 1	25.5 / 43	11	4.5 / –	5 / 320	SOIC-8	AH22S
Fiber to the Home TIA + Output Amp	0.05 - 1	–	38	2.9 pA / rtHz EIN	5 - 12 / 200, 120	4x4 QFN	TAT6254B
Fiber to the Home TIA + Output Amp (RFoG)	0.05 - 1	–	32	3.9 pA / rtHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254D
Fiber to the Home TIA + Output Amp (Hi Out)	0.05 - 1	–	33	3.9 pA / rtHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254C
Dual pHEMT Amplifier, High Gain	0.05 - 1	– / 38	17.5	3.2 / –	5 / 235	SOIC-8	TAT7469
CATV Gain Block, High Gain, MOCA Multitap	0.05 - 1	– / 41	22.5	2 / –	8 / 190	SOT89	TAT7430B
CATV Gain Block, High Gain, MOCA	0.05 - 1	– / 39	18	2 / –	6 / 145	SOT89	TAT7427
CATV Gain Block	0.05 - 1	– / 39	16	2.7 / –	6 / 130	SOT89	TAT7461
CATV Gain Block	0.05 - 1	– / 39.5	16	2.7 / –	5 / 130	SOT89	*TAT7461-X**
29.5dBm HBT Amplifier	0.05 - 1.5	30 / 47	19.4	6.3 / –	5 / 220	SOT89	TQP7M9105
Dual pHEMT Amplifier	0.05 - 2	– / 41	13	4 / –	6 / 190	SOIC-8	TAT7466
Dual pHEMT Amplifier, Wideband	0.05 - 2.6	–	13	4.4 / –	5 / 160	SOIC-8	TAT7464
CATV Gain Block, Wideband	0.05 - 2.6	– / 36	16.5	2.5 / –	5 / 100	SOT89	TAT7460
24.5dBm HBT Amplifier	0.4 - 4	24.3 / 39.5	20.4	4 / –	5 / 87	SOT89	TQP7M9101
27.5dBm HBT Amplifier	0.4 - 4	27.5 / 44	21.9	4 / –	5 / 137	SOT89	TQP7M9102
29.5dBm HBT Amplifier	0.4 - 4	29.5 / 45.4	20.7	4.4 / –	5 / 235	SOT89	TQP7M9103
28dBm HBT Amplifier	0.7 - 3.8	28 / 42	28.5	2.9 / –	5 / 225	4x4 QFN	TQP8M9013
Wideband PA, AGC	2 - 20	26 / –	8	–	8 / 440	Die	TGA8334-SCC
Wideband PA, AGC	2 - 20	(29) / –	15	–	12 / 1100	Flange	TGA2509-FL
Wideband PA, AGC	2 - 22	28.5 (30) / 36	17	–	12 / 1100	Die	TGA2509
WiMAX Driver Amp / PA, SB	3.4 - 3.8	30 / 42	24	–	6 / 770	5x5 QFN	TGA2703-SM
0.5W PA	6 - 18	27 / –	11	8 / –	8 / 400	Die	TGA8014-SCC
Driver Amp	7 - 13	(30) / 37	25	– / 30	9 / 450	Die	TGA2700
Wideband Driver Amp	8 - 18	13 / –	17	5 / –	4.5 / 50	Die	TGA8399C
Driver Amp	12 - 16	26 (26.5) / 37	23	7 / –	5 / 300	3x3 QFN	TGA2524-SM
1W HPA	12 - 19	30 / –	30	–	5 - 7 / 435	Die	TGA2508
HPA	12 - 19	29 / –	25	–	5 - 7 / 435	4x4 QFN	TGA2508-SM
HPA	12.5 - 15.5	30 (31.5) / 41	25	7.5 / –	6 / 650	5x5 QFN	TGA2527-SM
MPA	17 - 21	22 / –	18.5	–	7 / 66	Die	TGA9088A-SCC
Driver Amp	17 - 24	22 / –	19	4 / –	5 / 270	4x4 QFN	TGA2521-SM
HPA, AGC, PD	17 - 24	(29) / 38	22	–	5 / 712	4x4 QFN	TGA2522-SM
HPA	17 - 27	29 (31) / 37	22	–	7 / 760	Die	TGA4502-SCC
HPA	18 - 27	29 / 37	14	–	6 / 480	Die	TGA1135B-SCC
MPA	19 - 27	25 / 32	22	–	5 - 7 / 220	Die	TGA1073G-SCC
MPA	25 - 35	25 / –	18	–	6 / 220	4x4 QFN	TGA4902-SM

Up to 1W (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
MPA	26 - 35	25 (32) / –	19	–	5 - 7 / 220	Die	TGA1073A-SCC
1W HPA	27 - 31	30 / –	22	– / 25	4 - 6 / 420	Die	TGA4509
MPA	27 - 32	24 / –	15	–	5 / 170	4x4 QFN	TGA4903-SM
HPA	27 - 32	28.5 / –	25	–	6 - 8 / 420	Die	TGA1073B-SCC
1W HPA	28 - 31	30 / –	19	– / 25	6 / 420	4x4 QFN	TGA4509-SM
Driver Amp	29 - 37	16 / –	16	–	6 / 60	Die	TGA4510
MPA	32 - 45	24 (25) / 33	16	–	6 / 175	Die	TGA4521
MPA	33 - 47	27 (27.5) / 36	18	–	6 / 400	Die	TGA4522
HPA	36 - 40	26 / –	15	–	5 - 7 / 240	Die	TGA1073C-SCC
HPA	36 - 40	30 / –	14	–	6 - 7 / 500	Die	TGA1171-SCC
HPA	37 - 40	28 / 38	24	6 / –	5 / 600	Die	TGA4538
0.5W HPA	40 - 45	28 / –	9	–	7 / 500	Die	TGA4043
40.5 - 43 GHz Power Amplifier	40.5 - 43.5	28.5 (30) / 38	23	– / 14	6 / 900	Die	***TGA4543****
Driver Amp	41 - 45	18 / –	14	–	6 / 168	Die	TGA4042
77 GHz MPA	76 - 80	14 / –	12	–	3.5 / 75	Die	TGA4706-FC

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

1W to 4W

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
CATV 12V Power Doubler MMIC	0.05 - 1	–	11	4 / –	12 / 550	SOIC16W	TAT2801
CATV 12V Power Doubler	0.05 - 1	34 / 49	21	4.5 / –	12 / 650	5x7 QFN	***TAT8804D1H****
33.8dBm HBT Amplifier	0.05 - 1.5	33 / 50	20.8	4.8 / –	5 / 455	4x4 QFN	TQP7M9106
35.5dBm HBT Amplifier	0.4 - 2.7	35.5 / 50	16	7 / –	5 / 800	4x5 DFN	AH420
33dBm HBT Amplifier	0.7 - 2.7	33 / 50	27.5	7 / –	5 / 680	5x5 QFN	AH323
33.8dBm HBT Amplifier	0.7 - 2.7	33.8 / 45	21	4.4 / –	5 / 435	4x4 QFN	TQP7M9104
30dBm HBT Amplifier	1.8 - 2.7	30.5 / 46.5	27	5.5 / –	5 / 400	SOIC-8	AH212-S8G
2W HPA	5.5 - 8.5	32 (34) / 41	30	7 / –	6 / 1260	5x5 QFN	TGA2706-SM
2.5W HPA	5.9 - 8.5	34 (35) / 42	18	7.5 / 37	6 / 1000	6x6 QFN	TGA2701-SM
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Die	TGA2501
2.8W Wideband PA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	GSG Flange	***TGA2501-GSG****
2.8W Wideband PA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Carrier	TGA2501-TS
HPA	6 - 18	(34.5) / –	24	– / 20	8 / 1200	Die	TGA9092-SCC
HPA	10 - 12	33 (34.5) / 43	25	9 / –	6 / 1300	5x5 QFN	TGA2535-SM
2W HPA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680	4x4 QFN	TGA2503-SM
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Carrier	TGA2510-TS
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510
2W HPA	12.7 - 15.4	34 (35) / 43	28	6 / –	6 / 1300	Die	TGA2533
2W HPA	12.7 - 15.4	33 (34.5) / 43	27	6 / –	6 / 1300	5x5 QFN	TGA2533-SM
4W Ku-Band HPA	13 - 15	(36) / –	25	– / 30	7 / 1300	Die	***TGA2502****
4W HPA	13 - 15	(36) / 41	25	–	7 / 1300	17.8x8.4 FL	TGA8659-FL
3.6W Ku-Band HPA	13 - 16	(35.6) / –	25	– / 27	7 / 1300	GSG Flange	***TGA2502-GSG****
2W HPA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
2W HPA	13 - 17	(34) / –	25	–	6 - 7 / 640	Die	TGA2505
HPA	17 - 20	30.5 / 41	23	– / –	6 / 900	Die	TGA4532
HPA	17 - 20	31 (32.5) / 41	23	7 / –	6 / 900	4x4 QFN	TGA4532-SM
2W HPA	17 - 20	33 (34.5) / 42	21	– / –	6 / 1430	5x5 OFN	***TGA4534-SM****
HPA	17 - 24	31 (32) / 40	23	6 / –	7 / 720	Die	TGA4531
2W HPA	18 - 23	32 (33) / 39	26	–	7 / 840	Die	TGA4022
2W HPA	21 - 24	32 (34) / 41	22	– / –	6 / 1430	5x5 OFN	***TGA4535-SM****
HPA	21 - 24	31 (32) / 41	22	6 / –	6 / 880	4x4 QFN	TGA4533-SM
2W HPA	27 - 31	32.5 (33) / 36.5	20	– / 25	6 / 840	Die	TGA4513
1W Linear PA	28 - 30	30 (30.5) / –	20	–	6 / 420	5x5 QFN	TGA4539-SM
3.5W HPA	30 - 38	(35) / –	18	– / 20	6 / 2100	Die	TGA2575

1W to 4W (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
3.5W HPA	30 - 38	(35) / –	18	– / 20	6 / 2100	Carrier	***TGA2575-TS****
2W HPA	30 - 40	31.5 (33) / –	20	–	6 / 1050	Die	TGA4516
2W HPA	30 - 40	31.5 (33) / –	18	–	6 / 1050	Carrier	TGA4516-TS
2W HPA	31 - 35	31.5 (33.5) / –	19	–	6 - 7 / 1150	Die	TGA4514
3.5W HPA	31 - 37	(35.5) / –	20	–	6 / 2000	Die	TGA4517
2W HPA	33 - 36	31 (33) / –	17	–	6 - 7 / 880	Die	TGA1141
37 - 40 GHz Power Amplifier	37 - 40	30 (32) / 38	26	– / 18	6 / 900	Die	***TGA4542****
2W HPA	41 - 47	(33) / –	16	–	6 / 2000	Die	TGA4046

NOTES: *** = New***

More Than 4W

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	PAE (%)	Voltage / Current (V / mA)	Package Style	Part Number
10W HPA	0.03 - 3	(39.5) / 43	19.5	40	35 / 360	Flange	TGA2540-2-FL
39dBm HBT Amplifier	0.7 - 2.9	39 / –	16.5	–	12 / 300	5x6 DFN	AP561
10W Wideband HPA	2 - 18	(40) / –	9	23	30 / 500	Die	TGA2573-2
10W Wideband GaN HPA	2 - 18	(40) / –	9	23	30 / 500	Carrier	TGA2573-2-TS
30W HPA	2.5 - 6	(45) / –	26	35	30 / 1550	Flange	TGA2576-2-FL
30W HPA	6 - 12	(45) / –	30	30	25 / 1100	Die	***TGA2590****
HPA	6.5 - 11.5	37 (39) / –	19	35	7 - 9 / 1200	Die	TGA9083-SCC
16W HPA	6.5 - 12.5	42 / –	27	35	12 / 3000	Die	TGA2517
16W HPA on Carrier	6.5 - 12.5	42 / –	27	35	12 / 3000	Carrier	TGA2517-TS
HPA	7 - 8.5	(38) / –	21	42	7 / 2000	Die	TGA2701
10W HPA	7.5 - 12	(41) / –	30	25	12 / 3000	GSG Flange	***TGA2517-GSG****
HPA	9 - 10.5	(38) / –	20	>38	4 - 9 / 2000	Die	TGA2704
7W HPA	9 - 11	(38.5) / –	22	40	9 / 1050	7x7 QFN	***TGA2704-SM****
20W HPA	9.5 - 11	(43) / –	30	30	25 / 720	Die	***TGA2608****
7W HPA	9.5 - 12	(38.5) / –	22	36	9 / 1050	7x7 QFN	***TGA2710-SM****
HPA	10.5 - 12	(38) / –	19	>39	4 - 9 / 2000	Die	TGA2710
6.5W HPA	13 - 16	(38) / –	24	–	8 / 2600	11.4x17.3 FL	TGA2514-FL
4W HPA, Balanced	13 - 17	(36) / 44	25	30	6 - 7 / 1300	Die	TGA2502
6.5W HPA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
5W HPA	13.5 - 16	(37) / –	25	20	8 / 2600	GSG Flange	***TGA2536-FL****
20W HPA	13.75 - 15.35	(43) / –	23	30	25 / 1000	Flange	TGA2579-2-FL
16W HPA	14 - 16	(42) / –	23	30	25 / 2000	Die	TGA2572-2
16W HPA	14 - 16	(42) / –	23	>30	30 / 2000	Carrier	TGA2572-2-TS
16W HPA	14 - 16	(42) / –	23	30	25 / 2000	Flange	TGA2572-2-FL
4W HPA	28 - 31	36 (36.5) / –	24	22	6 / 1600	Die	TGA4906
4W HPA	28 - 31	36 (36.5) / –	22	22	6 / 1600	5x5 QFN	TGA4906-SM
7W HPA	28 - 31	(38.5) / –	21	20	6 / 3200	Die	TGA4916

NOTES: *** = New***

Variable Gain Amplifiers

Description	Frequency Range (GHz)	P1dB / OIP3 (dB)	Gain (dB)	Gain Range (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Return Path Variable Gain Amplifier	0.005 - 0.3	25 / 41	36	–	5 - 8 / 325	6x6 QFN	TAT3814
DOCSIS 3.0 Edge QAM Variable Gain Attenuator	0.045 - 1.003	28 / –	30	18	5 - 8 / 705 - 770	7x7 QFN	TAT2814A
Fiber to the Home Integrated TIA + Attenuator + Amp	0.05 - 1	–	33	3.8	5 / 290	6x6 QFN	TAT6281
Digital Variable Gain Amplifier	0.05 - 4	20.5 / 36.5	18	31.5	5 / 88	5x5 QFN	TQM8M9075
Digital Variable Gain Amplifier	0.05 - 4	22 / 38.5	19.5	31.5	5 / 125	5x5 QFN	TQM8M9076
Digital Variable Gain Amplifier	0.05 - 4	21.5 / 38.5	13	31.5	5 / 88	5x5 QFN	TQM8M9077
Digital Variable Gain Amplifier	0.06 - 1	24.3 / 40	31.7	31.5	5 / 174	6x6 QFN	TQM829007

Variable Gain Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB / OIP3 (dB)	Gain (dB)	Gain Range (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Digital Variable Gain Amplifier	0.4 - 4	24 / 42.5	32	31.5	5 / 176	6x6 QFN	*TQM879026**
Digital Variable Gain Amplifier	0.4 - 4	27.3 / 45	33	31.5	5 / 230	6x6 QFN	*TQM879028**
Variable Gain Amplifier	0.5 - 2.7	16 / 29	38	30	5 / 95	5x5 QFN	*TQM8M9079**
Variable Gain Amplifier	0.7 - 2.8	27.5 / 43	29	30	5 / 240	5x5 QFN	TQM8M9074
Digital Variable Gain Amplifier	1.4 - 2.7	24.5 / 43	31.7	31.5	5 / 174	6x6 QFN	TQM879006A
Digital Variable Gain Amplifier	1.5 - 2.7	27.3 / 47.5	41	31.5	5 / 285	6x6 QFN	TQM879008
Ka-Band Variable Gain Amplifier	28 - 31	23 / 31	33	–	5 / 330	6x6 QFN	TGA4541-SM

NOTES: ** = New*

Gain Block

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
General Purpose Gain Block	DC - 3	18.5 / 33	16.5	3.8	6 / 75	SOT89	AG603
General Purpose Gain Block	DC - 3.5	18.5 / 33	13.6	4.4	6 / 75	SOT89	AG602
General Purpose Gain Block	DC - 6	5.8 / 18.5	11	4.4	5 / 20	SOT86 / SOT363	AG201
General Purpose Gain Block	DC - 6	7.5 / 19.5	17.7	3.1	5 / 20	SOT86 / SOT363	AG203
General Purpose Gain Block	DC - 6	12 / 25	14.3	3.2	5 / 35	SOT86 / SOT363	AG302
General Purpose Gain Block	DC - 6	12.5 / 25	18.4	3	5 / 35	SOT86 / SOT363	AG303
General Purpose Gain Block	DC - 6	16 / 28.5	14.5	3.7	6 / 60	SOT86 / SOT89	AG402
General Purpose Gain Block	DC - 6	16 / 28	18.9	3	6 / 60	SOT86 / SOT89	AG403
General Purpose Gain Block	DC - 6	14.5 / 27.5	19.1	2.9	6 / 45	SOT86 / SOT89	AG503
Single-Ended Darlington	DC - 6	19 / 33	18.2	3.5	6 / 75	SOT86 / SOT89	AG604
General Purpose Gain Block	DC - 6	15.2 / 29.8	15.7	3.6	5 / 45	SOT89	TQP369180
General Purpose Gain Block	DC - 7	15.2 / 30	15.6	3.6	5 / 45	SOT363	TQP369181
General Purpose Gain Block	DC - 8	16.1 / 29.6	22.3	3.9	5 / 45	SOT89	TQP369182
General Purpose Gain Block	DC - 9	16.2 / 29.8	22	3.9	5 / 45	SOT363	TQP369184
General Purpose Gain Block	DC - 10	19.8 / 32.3	20.4	4.7	5 / 75	SOT89	TQP369185
LNA / Gain Block (40 Gb/s)	DC - 40	11.5 / 20	13	3.2	5 / 50	Die	TGA4830
CATV TIA / Gain Block, SB	0.04 - 1	27 / 42	20	1.5	8 / 350	4x4 QFN	TGA2803-SM
+5V Active Bias IF Gain Block	0.05 - 1	20.5 / 33	17.5	5	5 / 95	SOT89	WJA1500
+5V Active Bias IF Gain Block	0.05 - 1	20 / 36	14	5.4	5 / 95	SOT89	WJA1510
E-pHEMT LNA Gain Block	0.05 - 4	21 / 36	20	1.3	5 / 85	SOT89	TQP3M9008
E-pHEMT LNA Gain Block	0.05 - 4	21.4 / 37.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018
E-pHEMT LNA Gain Block	0.05 - 4	22 / 40	21.5	1.3	5 / 125	SOT89	TQP3M9009
E-pHEMT LNA Gain Block	0.05 - 4	22 / 40.5	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019
E-pHEMT LNA Gain Block	0.05 - 4	21.5 / 40	15	2	5 / 85	SOT89	TQP3M9028
E-pHEMT LNA Gain Block	0.05 - 4	21.5 / 40	15	2	5 / 85	3x3 QFN	TQP3M9038
E-pHEMT LNA Gain Block	0.05 - 4	23 / 37	22	0.55	5 / 115	2x2 DFN	*TQP3M9035**
E-pHEMT LNA Gain Block	0.1 - 4	22 / 34	19.4	0.8	5 / 55	3x3 QFN	TQP3M9005
E-pHEMT LNA Gain Block	0.1 - 4	22.5 / 38.5	18.7	1	5 / 90	3x3 QFN	TQP3M9006
E-pHEMT LNA Gain Block	0.1 - 4	23.5 / 41	18	1.3	5 / 135	SOT89	TQP3M9007
E-pHEMT LNA Gain Block	0.4 - 2.0	20 / 36	20	0.45	5 / 68	2x2 DFN	TQP3M9036
E-pHEMT LNA Gain Block / Bypass Mode	0.7 - 1.0	20 / 36	19	0.6	5 / 68	3x3 DFN	*TQL9042***
E-pHEMT LNA Gain Block	1.5 - 2.7	20 / 35	20	0.4	5 / 70	2x2 DFN	TQP3M9037
E-pHEMT LNA Gain Block / Bypass Mode	1.7 - 2.3	20 / 36	19	0.6	5 / 68	3x3 DFN	*TQL9043***
E-pHEMT LNA Gain Block / Bypass Mode	2 - 2.7	20 / 36	17.7	0.7	5 / 68	3x3 DFN	*TQL9043***
Gain Block, SB	2 - 10	17 / –	17	6	5 / 90	Die	TGA8810-SCC
Gain Block	2 - 12	(20) / –	30	–	5 / 200	8x8 QFN	*TGA3500-SM**
Gain Block	2 - 18	20 / –	7.5	5.5	6 / 100	Die	TGA8300-SCC
Wideband Gain Block, AGC	2 - 20	20 / –	7.5	7	6 / 150	Die	TGA8622-SCC
Gain Block	6 - 18	12.5 / –	13	5	5 / 80	Die	TGA8035-SCC
Driver Amp, SB	11 - 17	17 / –	23	6	6 / 75	4x4 QFN	TGA2507-SM

Gain Block (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Driver Amp, SB	12 - 18	14 / –	17	–	6 / 40	Die	TGA2506
Driver Amp, SB	12 - 18	20 / –	28	6	6 / 80	Die	TGA2507
Gain Block & 2x / 3x Multiplier	17 - 37	18 (22) / 26	20	7	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	18 (22) / 24	22	7	5 / 140	3x3 QFN	TGA4031-SM
Gain Block, Multiplier	17 - 43	22 / –	25	–	5 / 225	Die	TGA4040
Gain Block	19 - 38	(22) / 30	20	–	5 / 160	Die	TGA4036

NOTES: ** = New*, *** = Coming Soon*, AGC = Automatic Gain Control, SB = Self Biased

Low Noise

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Wideband LNA, AGC	DC - 14	16 / –	11	3.1	8 / 80	Die	TGA8349-SCC
LNA / Gain Block (40 Gb/s)	DC - 40	11.5 / 20	13	3.2	5 / 50	Die	TGA4830
E-pHEMT LNA Gain Block	0.01 - 4	22.3 / 18.7	15.3	0.8	5 / 55	3x3 QFN	TQP3M9005
E-pHEMT LNA Gain Block	0.01 - 4	22.4 / 25	13.5	1	5 / 90	3x3 QFN	TQP3M9006
E-pHEMT LNA Gain Block	0.4 - 2	20 / 16	20	0.45	5 / 68	2x2 DFN	TQP3M9036
E-pHEMT LNA Gain Block	0.05 - 4	21 / 17.5	20	1.3	5 / 85	SOT89	TQP3M9008
E-pHEMT LNA Gain Block	0.05 - 4	21.4 / 17.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018
E-pHEMT LNA Gain Block	0.05 - 4	21.8 / 15.8	24.7	0.9	5 / 125	SOT89	TQP3M9009
E-pHEMT LNA Gain Block	0.05 - 4	21.8 / 15.8	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019
E-pHEMT LNA Gain Block	0.05 - 4	21.5 / 18.5	15	2	5 / 85	SOT89	TQP3M9028
E-pHEMT LNA Gain Block	0.05 - 4	21.5 / 18.5	15	2	5 / 85	3x3 QFN	TQP3M9038
LNA, Balanced E-pHEMT FET	0.5 - 1.5	21.5 / 20.7	18	0.5	4.35 / 57	4x4 QFN	*TQP3M9039**
E-pHEMT LNA Gain Block	0.5 - 4	23.5 / 18.5	18	1.3	5 / 135	SOT89	TQP3M9007
LNA, Balanced FET	0.7 - 0.92	– / 13.5	20.5	0.55	4 / 70	4x4 QFN	TQP3M6004
LNA, Discrete FET	0.7 - 0.92	26 / 23.5	16	0.8	5 / 150	SOT89	TGF2021-04-SD
E-pHEMT LNA Gain Block / Bypass Mode	0.7 - 1	20 / 16	19	0.6	5 / 68	3x3 DFN	*TQL9042***
LNA, Balanced FET	0.8 - 3	21 / 11	22	0.7	4 / 100	2x2 QFN	TGA2602-SM
LNA, Balanced E-pHEMT FET	1.5 - 2.3	21.8 / 21.8	18	0.54	4.35 / 57	4x4 QFN	*TQP3M9040**
E-pHEMT LNA Gain Block	1.5 - 2.7	20 / 15	20	0.40	5 / 70	2x2 DFN	TQP3M9037
LNA, Balanced FET	1.7 - 2	– / 14.4	18	0.55	3.5 / 50	4x4 QFN	TQP3M6005
E-pHEMT LNA Gain Block / Bypass Mode	1.7 - 2.3	20 / 17	19	0.6	5 / 68	3x3 DFN	*TQL9043***
E-pHEMT LNA Gain Block / Bypass Mode	2 - 2.7	20 / 17	17.7	0.7	5 / 68	3x3 DFN	*TQL9044***
LNA, AGC	2 - 18	18 / 29	17	2	5 / 75	Die	TGA2525
LNA, AGC	2 - 18	16 / –	19	4	5 / 120	Die	TGA8344-SCC
LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
LNA, AGC	2 - 20	19 / –	17.5	2.5	5 / 100	Die	TGA2526
LNA, AGC	2 - 20	17.5 / –	9	3.5	5 - 8 / 60	Die	TGA8310-SCC
LNA, AGC	2 - 20	16 / –	17	2.5	5 / 75	4x4 QFN	TGA2513-SM
LNA, AGC	2 - 23	17 / 26	17	2	5 / 75	Die	TGA2513
LNA, Balanced E-pHEMT FET	2.3 - 4	22.5 / 20.2	18	0.75	4.35 / 57	4x4 QFN	*TQP3M9041**
S-Band LNA	2.5 - 4	18 / –	17	1.2	6 / 110	5x5 QFN	*TGA2614-SM**
S-Band LNA	2.7 - 3.8	– / 42.5	12.5	2	6 / 320	Die	*TGA2613**
S-Band LNA	2.7 - 3.8	18 / –	17	0.95	6 / 100	Die	*TGA2614**
LNA, SB, AGC	4 - 14	6 / 16	22	2.3	5 / 90	4x4 QFN	TGA2512-1-SM
LNA, AGC, GB	4 - 14	13 / 24	25	2.3	5 / 160	4x4 QFN	TGA2512-2-SM
4 - 20 GHz Limiter / LNA	4 - 20	18 / 28	17	2	5 / 100	7x7 QFN	*TGM2543-SM**
LNA, SB, AGC	5 - 15	6 / 13	27	1.4	5 / 90	Die	TGA2512
LNA, SB	6 - 13	11 / –	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA, SB, AGC	6 - 14	6 / 12	20	1.3	5 / 90	Die	TGA2511
LNA	20 - 27	12 / –	21	2.2	3.5 / 60	Die	TGA4506
LNA	28 - 36	12 / 21	22	2.3	3 / 60	Die	TGA4507
LNA	30 - 42	14 / –	21	2.8	3 / 40	Die	TGA4508
LNA	57 - 69	–	13	4	3 / 41	Die	TGA4600
77 GHz LNA	72 - 80	–	20	5	3.5 / 54	Die	TGA4705-FC

NOTES: ** = New*, *** = Coming Soon,* AGC = Automatic Gain Control, GB = Gate Bias, SB = Self Biased

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
35W GaN HEMT	DC - 3.5	(45.6) / –	14	– / 54	32 / 150	Ceramic Flat Lead	*T2G4003532-FS**
35W GaN HEMT	DC - 3.5	(45.7) / –	14	– / 54	33 / 150	Ceramic Flat Lead	*T2G4003532-FL**
55W GaN HEMT	DC - 3.5	(47.2) / –	15	– / 50	28 / 200	Ceramic Flat Lead	T2G4005528-FS
60W GaN HEMT	DC - 3.5	(48.2) / –	14	– / 51	32 / 200	Ceramic Flat Lead	*T1G4006032-FS**
60W GaN HEMT	DC - 3.5	(48.3) / –	14	– / 51	33 / 200	Ceramic Flat Lead	*T1G4006032-FL**
120W GaN HEMT	DC - 3.5	(50.8) / –	14	– / 52	32 / 575	Ceramic Flat Lead	*T1G4012032-FS**
120W GaN HEMT	DC - 3.5	(50.8) / –	14	– / 52	32 / 575	Ceramic Flat Lead	*T1G4012032-FL**
24mm HFET	DC - 4	40 / –	13	– / 51	5 / 150	SOT89	TGF2021-04-SD
Pwr pHEMT	DC - 4	26.5 / –	16	0.6 / –	8 / 2170	Die	TGF4124
0.5W HFET	DC - 6	28 / 40	18	3.2 / –	8 / 100	SOT89	TGF2960-SD
18mm HFET	DC - 6	38.5 / –	13.5	– / 53	8 / 1690	Die	TGF4118
7W GaN HEMT	DC - 6	(39.5) / –	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6000528-Q3
10W GaN HEMT	DC - 6	(40.5) / –	15	– / 52	32 / 50	5x5 QFN	*T1G6001032-SM**
18W GaN HEMT	DC - 6	(42.5) / –	15	– / 50	28 / 50	Ceramic Flat Lead	T2G6001528-Q3
30W GaN HEMT	DC - 6	(44.8) / –	15	– / 50	28 / 200	Ceramic Flat Lead	T2G6003028-FS
30W GaN HEMT	DC - 6	(44.7) / –	12	– / 50	28 / 200	Ceramic Flat Lead	*T2G6003028-FL**
12mm HFET	DC - 8	37 / –	14	– / 55	8 / 750	Die	TGF4112
4.8mm HFET	DC - 10.5	34 / –	8.5	– / 53	8 / 200	Die	TGF4250-SCC
9.6mm HFET	DC - 10.5	37 / –	9.5	– / 52	8.5 / 520	Die	TGF4260-SCC
1.2mm HFET	DC - 12	28.5 / –	10	– / 55	8 / 50	Die	TGF4230-SCC
2.4mm HFET	DC - 12	31.5 / –	10	– / 56	8 / 100	Die	TGF4240-SCC
1mm Pwr pHEMT	DC - 12	(31.5) / –	11	– / 55	12 / 75	Die	TGF2021-01
2mm Pwr pHEMT	DC - 12	(34.5) / –	11	– / 55	12 / 150	Die	TGF2021-02
4mm Pwr pHEMT	DC - 12	(37.5) / –	11	– / 55	12 / 300	Die	TGF2021-04
8mm Pwr pHEMT	DC - 12	(40.2) / –	11	– / 55	12 / 600	Die	TGF2021-08
12mm Pwr pHEMT	DC - 12	(42) / –	11	– / 52	12 / 900	Die	TGF2021-12
0.3mm MESFET	DC - 18	13 / –	11	1.5 / –	3 / 15	Die	TGF1350-SCC
1.25mm GaN HEMT	DC - 18	(37.4) / –	13	– / 52	28 / 125	Die	TGF2023-2-01
2.5mm GaN HEMT	DC - 18	(40.2) / –	13	– / 50	28 / 250	Die	TGF2023-2-02
5mm GaN HEMT	DC - 18	(43) / –	13	– / 49	28 / 500	Die	TGF2023-2-05
10mm GaN HEMT	DC - 18	(45.8) / –	12	– / 47	28 / 1000	Die	TGF2023-2-10
20mm GaN HEMT	DC - 18	(48.6) / –	12	– / 46	28 / 2000	Die	TGF2023-2-20
0.18mm Pwr pHEMT	DC - 20	22 / –	14	1 / 55	8 / 29	Die	*TGF2018**
0.25mm Pwr pHEMT	DC - 20	24 / –	14	0.9 / 60	8 / 41	Die	*TGF2025**
0.4mm Pwr pHEMT	DC - 20	26 / –	13	1.2 / 55	8 / 65	Die	*TGF2040**
0.6mm Pwr pHEMT	DC - 20	28 / –	12	1.34 / 55	8 / 97	Die	*TGF2060**
0.8mm Pwr pHEMT	DC - 20	30 / –	11.5	– / 60	8 / 130	Die	*TGF2080**
1.2mm Pwr pHEMT	DC - 20	32 / –	11	– / 60	8 / 194	Die	*TGF2120**
1.6mm Pwr pHEMT	DC - 20	33.2 / –	10.4	– / 63	8 / 258	Die	*TGF2160**
0.6mm Pwr pHEMT	DC - 20	(29) / –	13	– / 56	12 / 45	Die	TGF2022-06
1.2mm Pwr pHEMT	DC - 20	(32) / –	13	– / 56	12 / 90	Die	TGF2022-12
2.4mm Pwr pHEMT	DC - 20	(35) / –	13	– / 58	12 / 180	Die	TGF2022-24
4.8mm Pwr pHEMT	DC - 20	(38) / –	13	– / 58	12 / 360	Die	TGF2022-48
6mm Pwr pHEMT	DC - 20	(39) / –	12.5	– / 53	12 / 448	Die	TGF2022-60
0.3mm pHEMT	DC - 22	16 / –	13	0.8 / –	3 / 15	Die	TGF4350
MESFET	0.05 - 2.5	30 / 40	11	1.7 / –	5 / 350	SOT223	CLY5
MESFET	0.05 - 3	27 / 37	15.5	1.5 / –	5 / 180	MW6	CLY2
30W LDMOS	0.5 - 2	45 / –	10	– / 45	28 / 200	PowerBand™	T1L2003028-SP
10W pHEMT	0.5 - 3	40 / –	10	– / 45	12 / 200	PowerBand™	T1P2701012-SP

NOTES: ** = New*

Frequency Converters & Mixers

Description	Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
WB Mixer, LO	0.5 - 2.5	-5.7	8	24	3 - 6	MW6	CMY210
WB Mixer, LO, IF	0.5 - 2.5	10	8	9	3 - 6 / 12	SCT598	CMY212
WB Mixer, LO, IF, Low Current	0.5 - 2.5	9.5	10	10	3 - 6 / 8	SCT598	CMY213
Dual Branch Converter, LO, IF, SW, EN	0.68 - 0.92	9	33	25.5	5 / 295	6x6 QFN	TQP519021
Mixer, LO	0.7 - 1	-9	17	36	5 / 50	MSOP-8	ML483
Mixer, LO	1.5 - 3.2	-8.5	2	35	5 / 40	MSOP-8	ML485
Dual Branch Converter, LO, IF, SW, EN	1.7 - 2.2	9	36	25.5	5 / 295	6x6 QFN	TQP569022
Ku-Band Upconverter	10 - 16	17	25	15	5 / 300	5x5 QFN	*TGC2510-SM**
Doubler w/Amplifier	16 - 30	18	30	22	5 / 150	Die	TGC4403
Doubler w/Amplifier	16 - 30	18	30	19	5 / 150	4x4 QFN	TGC4403-SM
Downconverter (LNA + VCO + Mixer)	17 - 21	8	–	–	5 / 305	5x6 QFN	TGC4408-SM
Upconverting Mixer	17 - 26	-9	40	–	-0.9 / 0	4x4 QFN	TGC4402-SM
Upconverting Mixer	17 - 27	-9	35	18	-0.9 / 0	Die	TGC4402
K-Band Upconverter	17 - 27	13	40	19	5 / 340	5x5 QFN	TGC4510-SM
K-Band Downconverter	17 - 27	15	40	3	3 / 230	5x5 QFN	TGC4610-SM
Gain Block & 2x / 3x Multiplier	17 - 37	9	–	6	5 / 140	3x3 QFN	TGA4030-SM
Gain Block & 2x / 3x Multiplier	17 - 40	9	–	2	5 / 140	3x3 QFN	TGA4031-SM
19 GHz VCO w/8:1 Prescaler	18.5 - 19.5	–	-105+	7	5 / 158	Die	TGV2204-FC
Upconverter (LO Amp + Doubler)	21.5 - 32.5	-9	35	13	5 / 65	3x3 QFN	TGC4407-SM
Doubler w / Amplifier	28 - 34	15	25	20	5 / 150	4x4 QFN	TGC4406-SM
19 / 38 GHz Converter / MPA	36 - 40	9	–	14.5	3.5 / 65	Die	TGC4703-FC
Down Converting I/Q Mixer	75 - 82	-13.5	22	–	1.1 / 7	Die	TGC4702-FC
38 / 77 GHz Converter / MPA	76 - 77	6	–	15	4 / 230	Die	TGC4704-FC

NOTES: ** = New*

Voltage Controlled Oscillators

Description	Frequency Range (GHz)	Output Power (dB)	Phase Noise @ 100KHz (dBc/Hz)	Voltage / Current (V / mA)	Package Style	Part Number
8.9 - 9.8 GHz VCO with Divide by 2	8.9 - 9.8	9	-112	5 / 170	5x5 QFN	*TGV2561-SM**
9.5 - 10.3 GHz VCO with Divide by 2	9.5 - 10.3	9	-111	5 / 170	5x5 QFN	*TGV2562-SM**
9.7 - 10.8 GHz VCO with Divide by 2	9.7 - 10.8	9	-111	5 / 170	5x5 QFN	*TGV2563-SM**
10.3 - 11.1 GHz VCO with Divide by 2	10.3 - 11.1	9	-111	5 / 170	5x5 QFN	*TGV2564-SM**
10.7 - 11.5 GHz VCO with Divide by 2	10.7 - 11.5	9	-111	5 / 180	5x5 QFN	*TGV2539-SM**
11.3 - 12.3 GHz VCO with Divide by 2	11.3 - 12.3	10	-110	5 / 180	5x5 QFN	*TGV2565-SM**
12.5 - 13.5 GHz VCO with Divide by 2	12.5 - 13.5	7	-110	5 / 165	5x5 QFN	*TGV2529-SM**
12.6 - 13.8 GHz VCO with Divide by 2	12.6 - 13.8	9	-110	5 / 170	5x5 QFN	*TGV2584-SM**
13.4 - 14.4 GHz VCO with Divide by 2	13.4 - 14.4	9	-110	5 / 175	5x5 QFN	*TGV2566-SM**

NOTES: ** = New*

Signal Conditioning

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range dB or (Deg.)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
6-Bit, Digital Attenuator, Parallel Ctrl	DC - 4	1.3	31.5	30	5 / 0	4x4 QFN	TQP4M9071
6-Bit, Digital Attenuator, Serial Ctrl	DC - 4	1.3	31.5	30	5 / 0	4x4 QFN	TQP4M9072
7-Bit, Digital Attenuator, Serial Ctrl	DC - 4	1.3	31.75	30	5 / 0	4x4 QFN	TQP4M9083
Through Line	DC - 6	0.1	–	–	–	3x3 QFN	TQM4M9073
Analog Attenuator	DC - 30	2	17	–	0 to -2	3x3 QFN	TGL4203-SM
Analog Attenuator	DC - >50	2	17	–	0 to -2	Die	TGL4203
Discrete Thru (0dB Attenuator)	DC - 65	0	0	–	–	Die	TGL4201-00
Discrete Attenuators	DC - 65	–	2, 3, 6, 10	–	–	Die	TGL4201-02, 03, 06, 10
Passive Wideband Limiter	2 - 12	<1	–	18	–	3x3 QFN	TGL2201-SM
Analog Attenuator	2 - 20	2	15	23	2.5	Die	TGL8784-SCC
Passive Wideband Limiter	3 - 25	<0.5	–	18	–	Die	TGL2201

Signal Conditioning (cont.)

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range dB or (Deg.)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
5-Bit Phase Shifter	6 - 18	9	(348)	–	6	Die	TGP6336
6-Bit Phase Shifter	6 - 18	>10	(354)	–	0 / -5	Die	***TGP2105****
Bessel Filter	–	6, 7, 8, 9, 10 & 11 Cut-Off Freq	–	–	–	Die	TGB2010-00, -09 etc.
Bessel Filter	–	5, 6, 6.5, 7.5, 8 & 9 Cut-Off Freq	–	–	–	2x2 QFN	TGB2010-00, -90-SM etc.
6-Bit Phase Shifter	8.5 - 11	5	(354)	–	0 / -5	Die	TGP2103
Lange Coupler	12 - 21	<0.25	–	–	–	Die	TGB2001
5-Bit Phase Shifter	18 - 20	5	(180)	–	-2.5	Die	TGP1439
Lange Coupler	18 - 32	<0.25	–	–	–	Die	TGB4001
Lange Coupler	27 - 45	<0.25	–	–	–	Die	TGB4002
5-Bit Phase Shifter	28 - 32	6	(348)	–	5	Die	TGP2100
5-Bit Phase Shifter	33 - 37	6	(348)	–	-5	Die	TGP2102
1-Bit Phase Shifter	34 - 36	4	180	–	0 / 5	Die	TGP2104

NOTES: **** = New***

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SP3T - Reflective	DC - 2	0.6	22	>34.5	2.6 / 0	2x2 QFN	TQP4M3019
SP2T 802.11 a, b, g	DC - 6	0.6	28	31.5	3 / 0	1.3x2 DFN	TQS5200
Diversity Switch 802.11 a, b, g	DC - 6	0.8	33	33	3 / 0	3x3 QFN	TQS5202
SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
SPDT - GaN	0.1 - 6	<1	40	45	-40 / 0	Die	TGS2351-2
SPDT - GaN	0.1 - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-2-SM
SPST - High Isolation Absorptive	0.1 - 6	0.4	48	33	3 / 0	2x2 DFN	TQP4M0013
SPDT - Reflective	0.1 - 6	0.35	25	33	3 / 0	2x2 DFN	TQP4M0008
SPDT - High Isolation Reflective	0.1 - 6	0.7	55	30	3 / 0	MSOP8	***TQP4M0009***
SPDT - High Isolation Absorptive	0.1 - 6	0.5	55	30	3 / 0	4x4 QFN	TQP4M0010
SP3T - Reflective	0.1 - 6	0.3	30	30	3 / 0	3x3 QFN	TQP4M0011
SP4T - Reflective	0.1 - 6	0.65	40	35	3 / 0	3x3 QFN	***TQP4M0012****
SPDT - GaN	0.1 - 12	<1	35	43	-40 / 0	Die	TGS2352-2
SPDT - GaN	0.1 - 18	<1	30	40	-40 / 0	Die	TGS2353-2
SP3T VPIN	1 - 20	0.5	35	23	–	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	–	Die	TGS2304-SCC
SP3T VPIN	4 - 18	1	35	20	+/- 2.7	Die	TGS2313
SPDT VPIN	4 - 20	0.9	35	>20	+/- 2.7	Die	TGS2302
SPDT VPIN	24 - 43	<2	36	27	+/- 5	Die	TGS4301
SPDT VPIN	27 - 46	0.9	30	>34	+/- 5 / 15	Die	TGS4302
SPDT VPIN Absorptive	32 - 40	1	36	>33	+/- 5 / 18	Die	TGS4304
SP3T	60 - 90	2.3	20	>-13	-5 / 1.35	Die	TGS4305-FC
SP4T	70 - 90	3	20	>-8	-5 / 1.35	Die	TGS4306-FC

NOTES: ***** = Coming Soon***

Protector

Description	Application	Leakage Current (nanoAmps)	Trigger Voltage (V)	Series Capacitance (pF)	Package Area (mm^2)	Package Style	Part Number
CATV Protector	ESD & Secondary Protection	20 @ 1V, 500 @ 15V	18, 25, 41	0.29, 0.29, 0.22	1.8	T / SLP-3	TQP200002

SAW

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
NDL 1.5 µsec	1000	675	34	SE / SE	70 @ 1625	25.4x12.7	*857162**
NDL 1.5 µsec	1000	425	26.5	SE / SE	65 @ 1550	25.4x12.7	*857163**
NDL 1.5 µsec	1000	340	24	SE / SE	65 @ 1550	25.4x12.7	*857164**
NDL 1.75 µsec	1000	675	35	SE / SE	70 @ 1625	25.4x12.7	*857165**
NDL 2 µsec	1000	675	36.5	SE / SE	70 @ 1625	25.4x12.7	*857166**
NDL 2.5 µsec	1000	675	40	SE / SE	70 @ 1625	25.4x12.7	*857167**
NDL 2.75 µsec	1000	675	41	SE / SE	70 @ 1625	25.4x12.7	*857168**
NDL 3 µsec	1000	675	43	SE / SE	70 @ 1625	25.4x12.7	*857169**

NOTES: ** = New*

SAW

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Cable IF Filter	36.15	8	19.7	SE / SE	38 @ 10.23	DIP	855748
Cable IF Filter	44	6	20.4	SE / SE	38 @ 7.6	DIP	855079
BWA / WiMAX IF Filter	70	8	12.95	SE / SE	35 @ 3.2	13.3x6.5	855677
Low Loss IF Filter	70	0.5	7.6	SE / SE	35 @ 1.28	19x6.5	854651
Low Loss IF Filter	70	1	7.3	SE / SE	40 @ 2.8	19x6.5	854652
Low Loss IF Filter	70	1.5	7.5	SE / SE	40 @ 3.2	19x6.5	854653
Low Loss IF Filter	70	2	7.85	SE / SE	40 @ 4.25	19x6.5	854654
IF Filter	70	2.4	10	SE / SE	45 @ 85	13.3x6.5	*856980**
Low Loss IF Filter	70	2.5	8.75	SE / SE	40 @ 4.6	19x6.5	854655
Low Loss IF Filter	70	3	6.95	SE / SE	35 @ 6.9	13.3x6.5	854656
Low Loss IF Filter	70	3.5	7.25	SE / SE	35 @ 7.2	13.3x6.5	854657
Low Loss IF Filter	70	4	6.8	SE / SE	40 @ 8.25	13.3x6.5	854658
Low Loss IF Filter	70	4.5	6.8	SE / SE	35 @ 8.5	13.3x6.5	854659
Low Loss IF Filter	70	5	7.25	SE / SE	40 @ 9.35	13.3x6.5	854660
Low Loss IF Filter	70	6	7.5	SE / SE	40 @ 10.2	13.3x6.5	854661
Low Loss IF Filter	70	7	8.5	SE / SE	40 @ 11.55	13.3x6.5	854662
Low Loss IF Filter	70	8	9	SE / SE	40 @ 13.25	13.3x6.5	854663
Low Loss IF Filter	70	9	9.75	SE / SE	40 @ 13.9	13.3x6.5	854664
Low Loss IF Filter	70	10	10	SE / SE	40 @ 15	13.3x6.5	854665
Low Loss IF Filter	70	12	11.5	SE / SE	40 @ 17.35	13.3x6.5	854666
Low Loss IF Filter	70	14	12.5	SE / SE	40 @ 19.5	13.3x6.5	854667
Low Loss IF Filter	70	16	12.5	SE / SE	40 @ 21.4	13.3x6.5	854668
Low Loss IF Filter	70	18	13.5	SE / SE	40 @ 23.4	13.3x6.5	854669
Low Loss IF Filter	70	20	14.5	SE / SE	40 @ 25.4	13.3x6.5	854670
Low Loss IF Filter	70	22	15	SE / SE	40 @ 27.25	13.3x6.5	854671
Low Loss IF Filter	70	24	16.25	SE / SE	40 @ 29.65	13.3x6.5	854672
Low Loss IF Filter	70	26	17	SE / SE	40 @ 32	13.3x6.5	854673
Low Loss IF Filter	70	28	17.6	SE / SE	40 @ 33.75	13.3x6.5	854674
Low Loss IF Filter	70	30	17.5	SE / SE	40 @ 37	13.3x6.5	854675
Low Loss IF Filter	70	36	20.2	SE / SE	40 @ 43.3	13.3x6.5	854678
Low Loss IF Filter	70	40	21.5	SE / SE	40 @ 47.25	13.3x6.5	854680
High Selectivity IF Filter	70	0.3	16.36	SE / SE	40 @ 0.9	24.6x9	855735
High Selectivity IF Filter	70	0.5	21.3	SE / SE	40 @ 1.63	24.6x9	855736
High Selectivity IF Filter	70	1	22.2	SE / SE	40 @ 2.11	24.6x9	855737
High Selectivity IF Filter	70	1.5	21.6	SE / SE	40 @ 2.52	24.6x9	855738

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
High Selectivity IF Filter	70	2	23	SE / SE	40 @ 3.4	24.6x9	855739
High Selectivity IF Filter	70	2.5	20.25	SE / SE	40 @ 4.3	24.6x9	855740
High Selectivity IF Filter	70	3	23	SE / SE	40 @ 4.46	24.6x9	855741
High Selectivity IF Filter	70	3.5	19	SE / SE	40 @ 6	15.3x6.5	855742
High Selectivity IF Filter	70	4	23	SE / SE	40 @ 6	19x6.5	855743
High Selectivity IF Filter	70	4.5	23.7	SE / SE	40 @ 6.64	19x6.5	855744
IF Filter	70	4.9	25.5	SE / SE	45 @ 82	19x6.5	*857174**
High Selectivity IF Filter	70	5.5	22.2	SE / SE	40 @ 7.84	19x6.5	855745
IF Filter	70	5.7	24	SE / SE	40 @ 82	19x6.5	*857175**
Medical IF Filter	73	0.3	6	SE / SE	45 @ 69.9	24.6x9	856152
BWA / WiMAX IF Filter	80	8	11.7	SE / SE	35 @ 14.25	13.3x6.5	855679
GSM IF Filter	86.6	0.4	5.3	SE / BAL	28 @ 1.58	19x6.5	854823
GSM IF Filter	125	0.4	5.9	SE / SE	20 @ 2.4	9.1x4.8	856444
Low Loss IF Filter	140	1.7	11	SE / SE	40 @ 3.5	19x6.5	855579
Low Loss IF Filter	140	4	10.85	SE / SE	40 @ 9.1	13.3x6.5	854909
Low Loss IF Filter	140	7	5.5	SE / SE	40 @ 11.1	13.3x6.5	854913
Low Loss IF Filter	140	10	8.3	SE / SE	35 @ 15	13.3x6.5	854916
Low Loss IF Filter	140	10	11	SE / SE	35 @ 15	13.3x6.5	856656
Low Loss IF Filter	140	12	8.87	SE / SE	35 @ 21.3	13.3x6.5	854917
Low Loss IF Filter	140	15	11	SE / SE	35 @ 22	13.3x6.5	856684
Low Loss IF Filter	140	16	8.4	SE / SE	35 @ 22	13.3x6.5	854919
Low Loss IF Filter	140	18	9.1	SE / SE	40 @ 48	13.3x6.5	854920
Low Loss IF Filter	140	18.4	9.1	SE / SE	36 @ 26.4	7x5.5	856929
Low Loss IF Filter	140	20	11	SE / SE	35 @ 24	13.3x6.5	856592
Low Loss IF Filter	140	24	11.3	SE / SE	35 @ 33.5	13.3x6.5	854923
Low Loss IF Filter	140	32	11.5	SE / SE	35 @ 44	13.3x6.5	854927
High Selectivity IF Filter	140	0.47	18.5	SE / SE	40 @ 2.4	19x6.5	855035
High Selectivity IF Filter	140	0.8	20.8	SE / SE	40 @ 1.93	19x6.5	856062
IF Filter	140	1.5	25	SE / SE	45 @ 142	19x6.5	*857177**
High Selectivity IF Filter	140	1.5	21.9	SE / SE	40 @ 3.5	19x6.5	856063
High Selectivity IF Filter	140	2	21.5	SE / SE	40 @ 3.45	19x6.5	856064
High Selectivity IF Filter	140	3	22.4	SE / SE	40 @ 4.86	19x6.5	856065
High Selectivity IF Filter	140	6	23	SE / SE	40 @ 8.34	13.3x6.5	856066
High Selectivity IF Filter	140	7	24.5	SE / SE	40 @ 9.15	13.3x6.5	856067
High Selectivity IF Filter	140	8	23.4	SE / SE	40 @ 11.28	13.3x6.5	856068
High Selectivity IF Filter	140	10	20.87	SE / SE	40 @ 13.17	13.3x6.5	856069
High Selectivity IF Filter	140	14	23.3	SE / SE	40 @ 18.26	13.3x6.5	856070
High Selectivity IF Filter	140	16	21.7	SE / SE	40 @ 20.69	13.3x6.5	856071
High Selectivity IF Filter	140	28	20	SE / SE	40 @ 37	9x7	856019
IF Filter	140	28.5	21	SE / SE	40 @ 160	9x7	*857176**
High Selectivity IF Filter	140	28.56	27.7	SE / SE	40 @ 44	13.3x6.5	856817
High Selectivity IF Filter	140	28.56	28.4	SE / SE	40 @ 44	13.3x6.5	857008
High Selectivity IF Filter	140	32	21.7	SE / SE	40 @ 40.7	9x7	856072
High Selectivity IF Filter	140	44	21.75	SE / SE	40 @ 54.1	9x7	856073
High Selectivity IF Filter	140	56	18.65	SE / SE	40 @ 75.6	9x7	856074
High Selectivity IF Filter	140	60	22.4	BAL / BAL	40 @ 74.7	9.1x4.8	856774
High Selectivity IF Filter	140	64	17.8	SE / SE	40 @ 84	9x7	856020
High Selectivity IF Filter	140	72	21	SE / SE	40 @ 102	9x7	856314
High Selectivity IF Filter	140	1.5	12.1	SE and BAL	48 @ 143	9.1x4.8	856691
High Selectivity IF Filter	140	3	13.6	SE and BAL	46 @ 144	9.1x4.8	856692
High Selectivity IF Filter	140	6	11	BAL / BAL	39 @ 147	9.1x4.8	856693
High Selectivity IF Filter	140	7	13.6	SE and BAL	43 @ 147	9.1x4.8	856694
High Selectivity IF Filter	140	10	10	BAL / BAL	41 @ 152.5	9.1x4.8	856695

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
High Selectivity IF Filter	140	14	8.5	SE and BAL	43 @ 155	9.1x4.8	856696
High Selectivity IF Filter	140	20	9.8	BAL / BAL	40 @ 158.5	9.1x4.8	856697
High Selectivity IF Filter	140	28	18	SE and BAL	42 @ 168	9.1x4.8	856698
CDMA IF Filter	141	1.18	11.7	SE / SE	42.5 @ 2.5	19x6.5	855395
High Selectivity IF Filter	144	75	21.2	SE / SE	40 @ 91.81	9x7	856727
CDMA IF Filter	150	1.18	18.6	SE / BAL	30 @ 4.5	19x6.5	854833-1
CDMA IF Filter	150	8	12.1	SE / SE	35 @ 14.25	13.3x6.5	855678
TDSCDMA / WCDMA IF Filter	153.6	15	10	SE / SE	40 @ 25	13.3x6.5	856748
Repeater IF Filter	161.5	25	22	SE / SE	50 @ 131	9x7	855886
WCDMA IF Filter	167	5	8	SE / SE	20 @ 11.8	9.1x4.8	856683
WCDMA IF Filter	168.5	20	8	SE / BAL	33 @ 190	5x5	856512
WCDMA IF Filter	172.8	8.84	12.5	SE / BAL	32 @ 16	7x5.5	856620
WCDMA IF Filter	172.8	20	8	SE / BAL	30 @ 194.3	5x5	856802
WCDMA IF Filter	172.8	21	8.2	BAL / BAL	50 @ 200	7x5.5	856893
CDMA IF Filter	183.6	1.26	11	SE / BAL	40 @ 3.4	7x5.5	856234
IF Filter - Multi-Standard	184.32	25	7.8	BAL / BAL	25 @ 36	7x5.5	*857124**
WCDMA IF Filter	190	5.5	9.8	SE / BAL	30 @ 7.6	13.3x6.5	855529
WCDMA IF Filter	190	5	8	SE / SE	25 @ 9	5x5	855770
GSM IF Filter	190	0.2	4.2	BAL / BAL	30 @ 12	7x5.5	855625
IF Filter - Multi-Standard	192	60	14.5	SE / BAL	38 @ 44	7x5.5	856731
IF Filter - Multi-Standard	192.5	65	17	BAL / BAL	35 @ 74	7x5.5	*857071**
GSM IF Filter	201	0.22	6.1	BAL / BAL	27 @ 0.8	13.3x6.5	856541
Cable IF Filter	202.75	1.2	6.6	SE / SE	40 @ 10	13.3x6.5	855068
IF Filter	205	1.3	22	SE / SE	40 @ 4	13.3x6.5	855816
GSM IF Filter	208	0.4	5.9	SE / SE	20 @ 2.4	9.1x4.8	856445
WCDMA IF Filter	208	3.84	11.5	BAL / BAL	17 @ 5.03	9.1x4.8	856496
GSM IF Filter	211	0.2	5.2	SE / SE	25 @ 0.8	13.3x6.5	856378
WCDMA IF Filter	219	20	9.6	BAL / BAL	35 @ 36	9x7	856795
WCDMA IF Filter	230	4	16.2	SE / SE	40 @ 10	13.3x6.5	855832
CDMA IF Filter	240	3.6	14.3	SE / SE	12 @ 5	13.3x6.5	855992
CDMA IF Filter	240	1.1	13	SE / SE	10 @ 1.8	19x6.5	856151
IF Filter - Multi-Standard	242.5	25	9	BAL / BAL	32.2 @ 35	7x5.5	*857072**
IF Filter	242.625	1.3	18.7	SE / SE	40 @ 5	19x6.5	855549
CDMA IF Filter	249.6	3.84	16.11	SE / SE	40 @ 11	7x5.5	855915
CDMA IF Filter	326.4	15	12.61	SE / SE	40 @ 25	7x5.5	855914
BWA IF Filter	310.7	3	3	SE / SE	46 @ 20	5x5	856140
BWA IF Filter	320	22	19.3	SE / SE	45 @ 38	9x7	855595
BWA IF Filter	320	22	19.4	SE / SE	45 @ 38	9x7	855596
BWA / WiMAX IF Filter	330	5.45	18.26	SE / SE	50 @ 13.6	15.3x6.5	855730
WCDMA / LTE IF Filter	344	65	9.5	BAL / BAL	45 @ 66.6	5x5	857004
BWA IF Filter	350	1.2	10.2	SE/SE	40 @ 3.3	13.3x6.5	854565
BWA / WiMAX IF Filter	350	1.7	13.7	SE / BAL	45 @ 6	13.3x6.5	855399
BWA / WiMAX IF Filter	350	1	8.2	SE / BAL	45 @ 15	7x5.5	855377
WCDMA IF Filter	358.4	19.2	10.1	BAL / BAL	25 @ 375.4	7x5.5	856771
WCDMA IF Filter	358.4	24.8	9	BAL / BAL	30 @ 335.8	7x5.5	856966
IF Filter - Multi-Standard	358.4	39.6	11.5	SE / BAL	30 @ 30	7x5.5	856882
WLAN IF Filter	374	17	8.5	SE / BAL	10 @ 33	7x5.5	855653
WLAN IF Filter	374	17	8.5	SE / BAL	35 @ 33	5x5	855898
WLAN IF Filter	374	17	9	SE / BAL	30 @ 33	3.8x3.8	856278
BWA / WiMAX IF Filter	374	10	9	BAL / BAL	10 @ 25	3.8x3.8	856466
WCDMA IF Filter	380	5.4	15.4	SE / BAL	30 @ 8.3	13.3x6.5	855530
BWA / WiMAX IF Filter	380	7	10	BAL / BAL	40 @ 20	7x5.5	856490
BWA / WiMAX IF Filter	380	10	8.7	BAL / BAL	40 @ 36	7x5.5	856631

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
IF Filter - Multi-Standard	397.5	66.7	16.6	BAL / BAL	35 @ 71.7	7x5.5	*857073**
WCDMA IF Filter	398	4.3	9.9	SE / SE	50 @ 36	9.1x4.8	855561
WCDMA / WiMAX IF Filter	398	15	7.5	SE / SE	30 @ 60	9.1x4.8	855559
BWA / WiMAX IF Filter	398	10	11.2	BAL / BAL	35 @ 388.5	5x5	856652
IF Filter - Multi-Standard	403.5	3	3	BAL / SE	20 @ 398	3x3	856990
BWA / WiMAX IF Filter	426	5.16	18.02	SE / SE	50 @ 14	13.3x6.5	855731
IF Filter - Multi-Standard	447.5	25	14.1	BAL / BAL	35 @ 34.2	7x5.5	*857074**
WiBRO IF Filter	456	8.75	7.9	BAL / BAL	36 @ 443.25	5x5	856549
BWA / WiMAX IF Filter	456	10	8.3	BAL / BAL	37 @ 440	7x5.5	856672
BWA / WiMAX IF Filter	456	10	8.3	BAL / BAL	37 @ 440	5x5	856638
WCDMA IF Filter	456	19	10	BAL / BAL	25 @ 439	7x5.5	856687
RF Filter	457.5	15	2.2	SE / SE	70 @ 472	3.8x3.8	856930
General Purpose IF Filter	460	3.75	11.1	SE / SE	35 @ 8	7x5.5	856282
BWA / WiMAX IF Filter	464	3.5	10.6	BAL / BAL	53 @ 417	7x5.5	856623
FRS RF or GPS IF Filter	465	6	1.43	SE / SE	40 @ 445	3x3	856288
WiMAX IF Filter	467	10	3	SE / SE	40 @ 438	3.8x3.8	856586
BWA / WiMAX IF Filter	479.75	9	19.5	SE / SE	35 @ 22	7x5.5	855271
BWA / WiMAX IF Filter	479.75	23	9.8	BAL / BAL	35 @ 36	7x5.5	855272
Cable IF Filter	499.25	1	7	SE / SE	35 @ 6	9x7	855104
BWA / WiMAX IF Filter	520	6	10.8	SE / SE	30 @ 514	5x5	856680
BWA / WiMAX IF Filter	520	11	9.5	SE / SE	35 @ 506	5x5	856625
WLAN IF Filter	549.5	1	11.6	SE / SE	40 @ 547.4	9x7	855985
WLAN IF Filter	549.5	10	11.8	SE / SE	40 @ 536.5	7x5.5	855959
BWA / WiMAX IF Filter	580	10	10.7	BAL / BAL	40 @ 36	5x5	856665
RF Filter - Band 12 Uplink	707	18	1.5	SE / SE	9 @ 728	3x3	856884
RF Filter - Band 12 Downlink	737	18	1.8	SE / SE	37 @ 708	3x3	856883
RF Filter - Band 13 Downlink	751.5	11	1.5	SE / SE	40 @ 776	3x3	856794
WiMAX IF Filter	756	10	1.9	SE / SE	30 @ 727	3.8x3.8	856690
BWA IF Filter	756	20	0.9	SE / SE	30 @ 716	3.8x3.8	856866
WLAN IF Filter	770	17	6.2	BAL / BAL	40 @ 750	5x5	855942-1
RF Filter - Band 13 Uplink	781.5	11	1.5	SE / SE	38 @ 757	3x3	856764
RF Filter - Band 13 Uplink	782	10	1.52	SE / SE	15 @ 765	3x3	856844
B13 Notch Filter for SVLTE App.	782	15	0.6	SE / SE	24 @ 782	2.5x2	*857061**
RF Filter - Band 13 / 14 Uplink	787.5	22	2.75	SE / SE	40 @ 843	3x3	856977
BWA IF Filter	810	5	6	SE / SE	32 @ 26	3x3	856534
RF Filter High Attenuation	810	5	5.5	SE / SE	50 @ 770	3x3	*857191**
BWA / WiMAX IF Filter	810	10	3.5	SE / SE	10 @ 31	3x3	856526
BC0 Notch Filter for SVLTE App.	826	10	0.5	SE / SE	32 @ 826	2.5x2	*857031**
RF Filter - Band 5 Uplink	835	30	3	SE / SE	20 @ 869	3x3	857019
RF Filter - Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	856503
RF Filter - Band 5 Uplink	836.5	25	2.7	SE / SE	28 @ 869	3x3	855729
RF Filter - Band 5 Uplink	836.5	25	2	SE / SE	10 @ 869	3x3	856704
RF Filter - Band 5 Uplink	836.5	25	1.9	SE / SE	35 @ 869	3x3	855821
RF Filter - Band 5 Uplink	836.5	25	2.3	SE / SE	50 @ 869	1.4x1.2	857038
RF Filter - Band 20 Uplink	847	30	1.3	SE / SE	10 @ 882	3x3	856932
RF Filter	860.5	19	1.1	SE / SE	31 @ 815	3x3	856606
EU ISM 875 Band RF Filter	875	13	2.4	SE / SE	55 @ 849	2x1.5	856963
RF Filter - Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	855728
RF Filter - Band 5 Downlink	881.5	25	1.8	SE / SE	35 @ 849	3x3	855782
RF Filter - Band 5 Downlink	881.5	25	2.7	SE / SE	40 @ 849	3x3	856504
Cell Band Delay Filter 450 NS	881.5	25	2.5	SE / BAL	–	7x5.5	856716
RF Filter - Band 8 Uplink	897.5	35	1.4	SE / SE	10 @ 984	3x3	856824
RF Filter - Band 8 Uplink	897.5	35	1.5	SE / SE	15 @ 930	3x3	856657

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF Filter - Band 8 Uplink	897.5	35	1.9	SE / SE	14 @ 930	3x3	856671
ISM 915 Band RF Filter	915	26	2.3	SE / SE	35 @ 882.5	2x1.5	856327
ISM 915 Band RF Filter	915	4.4	2.4	SE / SE	55 @ 849	3x3	856686
ISM 921.5 Band RF Filter	921.5	13	2.4	SE / SE	55 @ 825	2x1.5	856905
RF Filter - Band 8 Downlink	942.5	35	2	SE / SE	5 @ 915	3x3	855820
RF Filter - Band 8 Downlink	942.5	35	3.2	SE / SE	12 @ 915	3x3	855810
RF Filter - Band 8 Downlink	942.5	35	2.5	SE / SE	25 @ 915	3x3	856528
WLAN IF Filter	970	9	24	SE / SE	35 @ 945	9.1x4.8	856338
WLAN IF Filter	970	18	24.7	SE / SE	35 @ 945	7x5.5	856339
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	855964
Tuner IF Filter	1086	10	4	BAL / BAL	40 @ 1046	3x3	856330
Tuner IF Filter	1090	10	5	BAL / BAL	50 @ 1050	3.8x3.8	856096
IFF RF Filter	1090	10	5.8	SE / SE	50 @ 1050	3.8x3.8	*857179**
WLAN IF Filter	1150	16	4.4	BAL / BAL	20 @ 1170	3x3	856256
GPS L5 RF Filter	1176	20	2.4	SE / SE	20 @ 1226	2x1.5	856440
GPS L5 Ultra Low Loss	1176.45	20	0.5	SE / SE	21 @ 1226	1.4x1.2	*857143**
GPS L5 High Attenuation Filter	1176.45	20	2	SE / SE	21 @ 1226	1.4x1.2	*857144**
Tuner IF Filter	1216	8	3.75	BAL / BAL	12 @ 24	3x3	856365
Tuner IF Filter	1220	10	4.5	BAL / BAL	30 @ 60	3x3	856298
Tuner IF Filter	1220	50	3.9	BAL / BAL	33 @ 96	3.8x3.8	856598
GPS L2 RF Filter	1227.6	20	1.1	SE / SE	27 @ 1152	2x1.5	856700
GPS L2 Ultra Low Loss Filter	1227.6	20	0.5	SE / SE	21 @ 1177	1.4x1.2	*857141**
GPS L2 High Attenuation Filter	1227.6	20	2.1	SE / SE	21 @ 1177	1.4x1.2	*857142**
Tuner IF Filter	1250	96	6	BAL / BAL	44 @ 1152	3x3	856653
RF Filter - Band 11 Uplink	1445.4	35	1.25	SE / SE	20 @ 1495.9	3x3	856928
GPS RF Filter	1575.42	2	1.3	SE / SE	30 @ 1625	3x3	855969
GPS RF Filter	1575.42	2	0.75	SE / SE	35 @ 1635	1.4x1.2	856561
GPS RF Filter	1575.42	2	1.1	SE / BAL	20 @ 1635	1.4x1.2	856576
GPS RF Filter	1575.42	2	0.6	SE / SE	21 @ Cell Bands	1.4x1.2	856793
GPS RF Filter	1575.42	2	1.25	SE / SE	30 @ 1625	2.0x1.5	*856584**
GPS RF Filter, Auto	1575.42	2	1.8	SE / SE	45 @ 1637	3x3	856039
GPS RF Filter, Auto	1575.42	2	1.3	SE / SE	45 @ 1640	3x3	856139
GPS L1 Ultra Low Loss Filter	1575.42	20	0.6	SE / SE	21 @ 1625	1.4x1.2	*857139**
GPS L1 High Attenuation Filter	1575.42	20	2.6	SE / SE	21 @ 1625	1.4x1.2	*857140**
GPS RF Filter, GLONASS	1601.5	17	2.2	SE / SE	40 @ 1630	3x3	856909
RF Filter - Band 3 Uplink	1747.5	75	2	SE / SE	22 @ 1676	3x3	856654
RF Filter - Band 3 Downlink	1842.5	75	1.9	SE / SE	10 @ 1785	3x3	855860
RF Filter - Band 3 Downlink	1842.5	75	4.2	SE / SE	20 @ 1785	3x3	856934
RF Filter - Band 2 Uplink	1880	60	2.2	SE / SE	15 @ 1806	3x3	856705
RF Filter - Band 2 Uplink	1880	60	2.3	SE / SE	10 @ 1790	3x3	856880
RF Filter - Band 2 Uplink	1880	60	2.4	SE / SE	7 @ 1930	3x3	855849
RF Filter - Band 2 Uplink	1880	60	2.8	SE / SE	30 @ 1930	3x3	856530
RF Filter - Band 2 Uplink	1880	60	4	SE / SE	7 @ 1930	3x3	855849
RF Filter - Band 25 Uplink	1882.5	65	1.9	SE / SE	32 @ 2030	3x3	856992
Tuner IF Filter	1892	8	4.2	BAL / BAL	23 @ 1932	2.5x2	856236
RF Filter - Band 1 Uplink	1950	60	1.8	SE / SE	20 @ 2100	3x3	856678
RF Filter - Band 1 Uplink	1950	60	2.2	SE / SE	40 @ 2110	3x3	856532
RF Filter - Band 2 Downlink	1960	60	2.1	SE / SE	10.3 @ 1910	3x3	855817
RF Filter - Band 2 Downlink	1960	60	2.9	SE / SE	15 @ 1910	3x3	855859
RF Filter - Band 2 Downlink	1960	60	2.25	SE / SE	14 @ 1910	3x3	856531
RF Filter - DPD Path	1960	160	3	SE / SE	29 @ 380	3x3	*857145**
Delay Filter, PCS 450 ns	1960	60	25	SE / BAL	–	7x5.5	856717
Delay Filter, UMTS 450 ns	2140	60	25	SE / BAL	–	7x5.5	856649

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF Filter - Band 1 Downlink	2140	60	2.3	SE / SE	25 @ 1980	3x3	856738
SDARS Filter	2332.5	45	1.7	SE / BAL	35 @ 2100	1.4x1.2	856604
ISM / WLAN Passband	2437	66	2.1	SE / SE	34 @ 2550	1.4x1.2	857005
Bluetooth® RF Filter	2441	83.5	2.8	SE / SE	26 @ 2200	3x3	855916
Bluetooth® RF Filter	2441	83.5	2	SE / SE	28 @ 2300	1.4x1.2	856539

NOTES: ** = New*

BAW

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF Filter	710	20	2	SE / SE	50 @ 140	3.81x2.54	880370
RF Filter, ISM	915	15	3.5	SE / SE	40 @ 35	6.35x4.57	880371
RF Filter	1030	15	2.5	SE / SE	40 @ 45	3.81x2.54	880367
RF Filter	1090	15	2.5	SE / SE	40 @ 45	3.81x2.54	880374
GPS RF Filter, L5	1176	28	2.75	SE / SE	40 @ 140	3.26x1.6	880364
GPS RF Filter, L2	1227	15	3	SE / SE	40 @ 45	3.81x2.54	880372
GPS L2	1227.6	25	2.5	SE / SE	20 @ 1200	3.26x1.6	880060
RF Filter	1280	20	3	SE / SE	40 @ 105	3.81x2.54	880368
GPS RF Filter, L3 / L4	1380	30	3	SE / SE	40 @ 160	3.26x1.6	880365
GPS RF Filter, L1	1575	30	3	SE / SE	40 @ 160	3.26x1.6	880273
GPS RF Filter, L1	1575	18	1.5	SE / SE	40 @ 350	3.26x1.6	880085
GPS RF Filter, L1	1575	25	3	SE / SE	40 @ 60	3.81x2.54	880373
GPS L1	1575.42	30	2.5	SE / SE	20 @ 1548	3.26x1.6	880094
RF Filter - Band 2 Uplink	1880	60	3.5	SE / SE	30 @ 1920	3x3	885025
RF Filter - Band 2 Downlink	1960	60	3.7	SE / SE	34 @ 1920	3x3	885024
B25 Diversity Rx Filter	1962.5	65	2.6	SE / SE	–	2.5x2	TQM966025
B25 Diversity Rx Filter	1962.5	65	2.5	SE / SE	–	2.0x1.6	*885051**
RF Filter	2106	35	4	SE / SE	–	3.26x1.6	880126
RF Filter	2324	38	3	SE / SE	40 @ 150	3.81x2.54	880148
B40 Tx / Rx Filter	2350	100	1.3	SE / SE	45 @ 2427	1.4x1.2	*885049**
ISM Passband Filter for Coexistence	2436	72	2	SE / SE	20 @ 2495	1.7x1.3	885007
ISM Passband Filter for Coexistence	2436	72	1.8	SE / SE	20 @ 2495	1.4x1.2	885017
ISM Notch RF Filter for Coexistence	2440	72	1.5 (Out of Band IL)	SE / SE	25 @ 2440 (Notch Rej)	1.7x1.3	885008
ISM Notch RF Filter for Coexistence	2440	85	2 (Out of Band IL)	SE / SE	18 @ 2440 (Notch Rej)	1.7x1.3	885010
LTE / Wi-Fi Coexist Filter	2442	79	1.7	SE / SE	55 @ 2370	1.4x1.2	*885033**
LTE / Wi-Fi Coexist Filter	2442	79	1.7	SE / SE	59 @ 2570	1.4x1.2	*885032**
RF Filter - Band 7 Uplink	2535	70	1.3	SE / SE	41 @ 2620	3x3	885009
RF Filter, MMDS	2560	30	3	SE / SE	40 @ 150	3.81x2.54	880157
LTE B38 Tx / Rx Filter	2595	50	1.4	SE / SE	39 @ 2500	1.4x1.2	*885026**
RF Filter, ISM	5775	100	4.5	SE / SE	20 @ 350	3.26x1.6	880369

NOTES: ** = New*

SAW and BAW – Duplexers, Diplexers, Diplexed Duplexers and Dual Filter Products

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Duplexer, Band 17, SAW	710 / 740	12 / 12	1.2 / 1.8	SE / BAL	–	2.5x2	856931
Duplexer, Band 13, SAW	751 / 782	9 / 9	2.3 / 1.8	SE / BAL	–	2.5x2	856879

SAW and BAW – Duplexers, Diplexers, Diplexed Duplexers and Dual Filter Products (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Package Size (mm)	Part Number
Duplexer, B20, SAW	806 / 847	30 / 30	2.5 / 3	SE / BAL	2.5x2	856979
Duplexer, BC10, SAW	833 / 878	32 / 32	2.5 / 2.5	SE / BAL	2.5x2	856999
Duplexer, Cell Band, SAW	836.5 / 881.5	25 / 25	2.0 / 2.5	SE / SE	3.8x3.8	856908
Diplexer, High Attenuation, SAW	1176.45 / 1575.42	20.46	3.5	SE / SE	5x5	*890086* +*
Diplexer, Low Loss, SAW	1176.45 / 1575.42	20.46	0.9	SE / SE	5x5	*890087* +*
Diplexer, High Attenuation, SAW	1227.6 / 1575.42	20.46	3.5	SE / SE	5x5	*890084* +*
Diplexer, Low Loss, SAW	1227.6 / 575.42	20.46	0.9	SE / SE	5x5	*890085* +*
Diplexer, GPS / SDARS	1575.42 / 2332.5	3 / 25	0.6 / 0.8	SE / SE	3x3	TQM2M9016
Duplexer, PCS, BAW	1880 / 1960	60 / 60	1.32 / 1.52	SE / SE	3.8x3.8	TQM969001
Duplexer, BC1 / B2, BAW	1880 / 1960	60 / 60	1.8 / 1.9	SE / SE	2.5x2	TQM966002
Duplexer Bank - Diplexed Duplexer for BC1 / BC0 - BAW / SAW	1880 / 1960 832 / 877	60 / 60 34 / 34	–	SE / SE	2.8x4.7	*TQQ0101**
Duplexer, B24 / BC14, BAW	1882.5 / 1962.5	65	2.8	SE / SE	3x3	*TQM963001**
Duplexer B25 - BAW	1882.5 / 1962.5	–	–	SE / SE	2.0x1.6	*TQM969002**
Duplexer, BC14 / B25, BAW	1882.5 / 1962.5	65 / 65	1.8 / 2.2	SE / SE	2.5x2	TQM963014
Duplexer Bank - Diplexed Duplexer for B25 / 26 - BAW / TC-SAW	1882.5 / 1962.5 831.5 / 876.5	65/65 35 / 35	1.5/1.8 1.8 / 2.0	SE / BAL	2.8x4.7	*TQQ2526**
Diplexed Tx Filters for B38 / 40 - BAW	2335 / 2595	70 / 40	2.5 / 2.5	SE / SE	2.0x1.5	*885030**
Dual Filter - B38 / 40 Rx Filters - BAW	2350 / 2595	100 / 50	3 / 1.9	SE / SE	1.7x1.3	*885035**

NOTES: ** = New,* + = For additional Plug-and-Play diplexer capabilities and frequencies see TriQuint Diplexer Products brochure.

QUANTUM Tx™ Family – GSM / GPRS

Description	Features	Bands	Size (mm)	Part Number
Dual-Band GSM / GPRS Tx Module; PA / LPF / SP4T Switch; Quad-Band Tx & Dual-Band Rx	High-Efficiency Broadband Tx, 2 Rx Ports	GSM900 / DCS or GSM850 / PCS	5.0x6.0x1.0	TQM6M4068

QUANTUM Tx™ Family – WGPRS / WEDGE / TD-SCDMA / TDD-LTE / LTE

Description	Features	Bands	Size (mm)	Part Number
GSM / GPRS Tx Module; PA / LPF / SP6T WGPRS Switch w/Dual-Band WCDMA Antenna Ports	Integrated DB GSM / GPRS & 2 WCDMA Antenna witch Ports	GSM900 / DCS or GSM850 / PCS & 2 WCDMA / LTE Bands	5.0x6.0x1.0	TQM6M9069
GSM / GPRS / EDGE-Linear Tx Module; PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA / LTE Ports	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch	GSM900 / DCS or GSM850 / PCS & 4 WCDMA / LTE Bands	5.25x6.0x1.0	TQM6M9085
GSM / GPRS Tx Module; PA / LPF / SP6T WGPRS Switch w/Dual-Band WCDMA Antenna Ports	Integrated QB GSM / GPRS & 2 WCDMA Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS & 2 WCDMA / LTE Bands	5.0x6.0x1.0	*TQF9088**
GSM / GPRS Tx Module; PA / LPF / SP8T WGPRS Switch with Up to 4 WCDMA Antenna Switch Ports	Integrated QB GSM / GPRS & 4 WCDMA Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS & 4 WCDMA / LTE Bands	5.0x6.0x1.0	*TQF9089**
GSM / GPRS / EDGE / TD-SCDMA / TDD-LTE Tx Module; PA / LPF / SP8T Switch with Up to 4 WCDMA Antenna Switch Ports	Integrated QB GSM / GPRS / EDGE / TD-SCDMA & 8 Antenna Switch Ports, Low Rx Insertion Loss	GSM850, GSM900, DCS, PCS, TD-SCDMA (Bands 34 & 39) + 4 WCDMA / LTE / TD-SCDMA / TDD-LTE Bands	5.0x6.0x0.8	*TQM6M9098**

NOTES: ** = New*

TRIUMF™ MMPA Family – GSM / GPRS / EDGE / WCDMA / HSUPA / LTE

Description	Features	Bands	Size (mm)	Part Number
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Dual-Band WCDMA PA Modules	2-Bit (Hi / Med / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA B1 & B5 / 8	5.0x7.5x1.0	TQM7M9023
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Dual-Band WCDMA PA Modules	1-Bit (Hi / Med Power Modes)	GSM850 / 900, DCS / PCS & WCDMA B1 & B5 / 8	5.0x7.5x1.0	TQM7M9053
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Penta-Band WCDMA / HSUPA / LTE PA Modules	1-Bit (Hi / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA & LTE B1, B2, B3 / 4, 5 & 8	5.0x7.0x1.0	*TQM7M9050**
Multi-Mode Multi-Band PA Module w/ Quad-Band GMSK / EDGE and Penta-Band WCDMA / HSUPA / LTE PA Modules	1-Bit (Hi / Low Power Modes)	GSM850 / 900, DCS / PCS & WCDMA & LTE B1, B2, B3 / 4, 5 & 8	5.0x7.0x1.0	*TQP9058**

NOTES: ** = New*

PA Modules – GSM / GPRS / EDGE

Description	Features	Bands	Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Linear PA Module	Low Band Ibatt < 1.5A @ Pcal w/PAE 55%	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5005H
Quad-Band GSM / GPRS / EDGE-Linear PA Module	Input Power Controlled for GMSK & 8PSK	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5013
Quad-Band GSM / GPRS / EDGE-Polar PA Module	+3 to +8dBm Pin Nominal	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5012H
Quad-Band GSM / GPRS / EDGE-Polar PA Module	+3 to +8dBm Pin Nominal	GSM900 / DCS & GSM850 / PCS	5.0x5.0x1.0	TQM7M5022
Quad-Band GSM / GPRS / EDGE-Linear PA Module	Input Power Controlled for GMSK & 8PSK	GSM900 / DCS & GSM850 / PCS	5.0x3.5x0.9	TQM7M5050

PA Modules – CDMA / WCDMA / HSUPA / LTE

Description	Features	Bands	Size (mm)	Part Number
WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	Band 1	3.0x3.0x0.9	TQM776011
WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	Band 8	3.0x3.0x0.9	TQM726018
CDMA & WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	PCS / Band 2	3.0x3.0x0.9	TQM766012
CDMA & WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	AWS / Band 4	3.0x3.0x0.9	TQM756014
CDMA & WCDMA / HSUPA PA Module, w/Coupler	2-Bit (Hi / Med / Low Power Modes)	Cellular / Band 5	3.0x3.0x0.9	TQM716015
LTE PA Module, w/Coupler	1-Bit (Hi / Low Power Modes)	Band 13	3.0x3.0x0.9	TQM700013
LTE PA Module, w/Coupler	1-Bit (Hi / Low Power Modes)	Band 17	3.0x3.0x0.9	TQM700017
Dual-Band WCDMA / HSUPA PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1 & 8	4.0x3.0x0.9	*TQM7M6158**
Dual-Broadband WCDMA / HSU PA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1, 2 & 5 & 8 (25 & 26) BC0, BC1 (BC10)	4.0x3.0x0.9	*TQM7M6125**
Dual-Band WCDMA / HSUPA PA Module, w/Coupler	1-Bit (High / Low Power Modes) Single LB / HB RF Input	Bands 1 & 8	4.0x3.0x0.9	*TQM7M6018**
Dual-Band WCDMA / HSUPA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Single LB / HB RF Input	Bands 2 & 5 (25 & 26) BC0, BC1 (BC10)	4.0x3.0x0.9	*TQM7M6025**
Dual-Broadband WCDMA / HSU PA / EV-DO PA Module, w/Coupler	1-Bit (High / Low Power Modes) Separate LB / HB RF Inputs	Bands 1, 2 & 5 & 8 (25 & 26) BC0, BC1 (BC10)	4.2x3.0x0.9	*TQP6109**

NOTES: ** = New*

TRITIUM™ PAD Family – WCDMA / HSUPA / LTE

Description	Features	Bands	Size (mm)	Part Number
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Band 1	7.0x4.0x1.1	TQM676021
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Band 2	7.0x4.0x1.1	TQM666022
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Bands 5 & 6	7.0x4.0x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	1-Bit (Hi / Low Power Modes)	Band 8	7.0x4.0x1.1	TQM626028L
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler	DC / DC, 1-Bit (Hi / Med Power Modes)	Band 2	4.5x3.5x1.0	TQM666052

TriConnect™ WLAN RF Modules

Description	Features	Bands	Size (mm)	Part Number
5 GHz WLAN PA MMIC	ETSLP-16 Package, Detector, Hi / Low Linearity Mode	802.11 a / n	3.0x3.0x0.45	TQP787011
2.4 GHz WLAN Low Noise Amplifier + SP3T Switch w/WLAN Tx and Bluetooth® Path	LNA Bypass, ETSLP-12 Package	802.11 b / g / n	1.5x1.5x0.55	TQP879001A
2.4 GHz WLAN PA + Switch MMIC w/WLAN Rx Balun and Bluetooth® Path	ETSLP-16 Package, Coupler / Detector	802.11 b / g / n	3.0x3.0x0.45	TQM679002A
2.4 GHz and 5 GHz WLAN PA + Switch MMIC w/ WLAN Rx Baluns and Bluetooth® Path	ETSLP-24 Package, Coupler / Detector	802.11 a / b / g / n	4.0x4.0x0.45	TQP6M9002
2.4 GHz and 5 GHz WLAN High-Performance PA + Switch MMIC w/WLAN 2.4 GHz and 5 GHz LNA + Rx Baluns and Bluetooth® Path	ETSLP-24 Package, Coupler / Detector	802.11 a / b / g / n / ac	4.0x4.0x0.45	TQP6M9017
2.4 GHz WLAN PA + Low Noise Amplifier + SP3T Switch MMIC for Bluetooth® Path	ETSLP-16 Package, Coupler / Detector	802.11 b / g / n	2.5x2.5x0.4	*TQF9046**
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	ETSLP-16 Package	802.11 a / n / ac	2.5x2.5x0.4	*TQF7062**
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	ETSLP-16 Package, Detector / Coupler	802.11 a / n / ac	2.5x2.5x0.4	*TQP887051**
5 GHz WLAN PA + SP2T Switch MMIC	ETSLP-16 Package	802.11 a / n / ac	2.5x2.5x0.4	*TQP887052**

NOTES: ** = New*

GPS RF Front-End Module & Filters

Description	Features	Bands	Size (mm)	Part Number
GPS Filter-LNA-Filter Module	Low Noise (1.56dB) and High Gain (16dB)	1575 MHz, GPS L1	3.0x3.0x1.0	TQM640002

Drivers

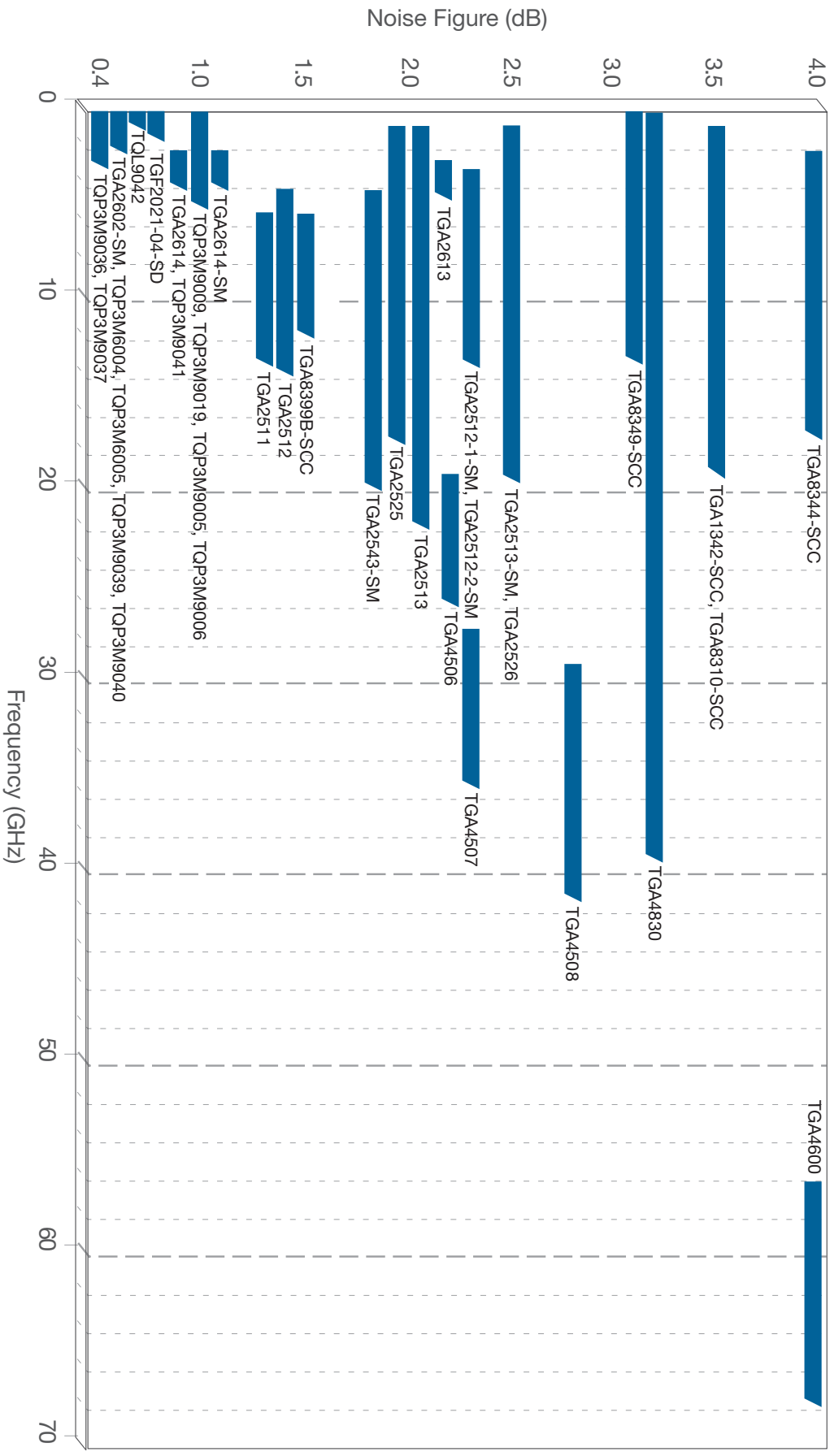
Description	Frequency Range (GHz)	Power (Vpp or dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
9.9 - 12.5 Gb/s 3V - 7V Driver	DC - 13	3 - 7Vpp	32	–	3.3 - 5 / 115	8x8 QFN	TGA4956-SM
9.9 - 12.5 Gb/s Modulator Driver	DC - 16	3 - 9Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4954-SL
9.9 - 12.5 Gb/s Modulator Driver	DC - 16	3 - 10Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4953-SL
12.5 Gb/s NRZ Driver	DC - 18	3 - 11Vpp	16	2.5	8 / 285	Die	TGA4807
12.5 Gb/s NRZ Driver	DC - 18	4 - 8Vpp	16	3.5	8 / 175	8.9x8.9x2 SL	TGA8652-SL
12.5 Gb/s NRZ Driver	DC - 18	6 - 8Vpp	16	3.5	5 - 8 / 70 - 175	Die	TGA1328-SCC
15 Gb/s 10V Linear Modulator Driver	DC - 20	3 - 10Vpp	22	–	7 / 280	6x6 QFN	TGA4826-SM
100 Gb/s Linear Dual Driver w/Bias-T's Inside	DC - 27	3 - 8Vpp	35	–	5 - 7 / 650	16x10.5x3.6 SL	***TGA4894-SL*****
200 Gb/s 16 QAM Linear Dual Driver w/Bias-T's inside	DC - 27	3 - 5Vpp	24	–	5 - 7 / 500	12x10.5x3.6 SL	***TGA4892-SL*****
28 Gb/s 6Vpp Diff In / Out Driver MMIC	DC - 28	4 - 8Vpp Diff	22 Diff	–	4 - 5 / 450	6x6 QFN	***TGA4957-SM****
40 & 100 Gb/s 8Vpp SE Driver	DC - 30	3 - 9Vpp	32	–	6 - 7 / 270	14.4x7x2 SL	TGA4943-SL
100 Gb/s 8Vpp Dual Channel Driver w/Bias-T's Inside	DC - 35	3 - 9Vpp	32	–	5 - 7 / 500	16x10.5x3.6 SL	TGA4947-SL
Wideband Driver (40 Gb/s)	DC - 35	4Vpp	12	–	5 / 135	Die	TGA4832
32 Gb/s 9Vpp Diff In / Out Driver	DC - 35	6 - 9Vpp Diff	25 Diff	–	5 - 6 / 500	SL	TGA4959-SL
45 Gb/s 8Vpp SE Driver w/Bias-T Inside	DC - 37	5 - 9Vpp	30	–	6 - 7 / 300	14.4x7 SL	TGA4942-SL
LNA / Gain Block (40 Gb/s)	DC - 40	11.5	13	3.2	5 / 50	Die	TGA4830
45 Gb/s 9Vpp Diff In / Out Driver MMIC	DC - 50	6 - 10Vpp Diff	27 Diff	–	5 - 6 / 500	Die	***TGA4959*****
Ultra-Wideband Driver (50 Gb/s)	DC - 78	3.5Vpp	8	5	6 / 82	Die	TGA4803
10.7 - 12.5 Gb/s Linear Modulator Driver	30 kHz - 8	12.5Vpp	20	–	8 / 310	8x8 QFN	TGA4823-2-SM

NOTES: **** = New, ** = Coming Soon***, SE = Single Ended

Transimpedance Amplifiers (TIAs)

Description	Bandwidth (GHz)	Small Signal Gain (dB)	Differential Transimpedance Gain (ohm)	Differential Output Vpp (mV)	Equivalent Input Noise (pA / rtHz)	Voltage (V)	Current (mA)	Part Number
13 Gb/s Linear TIA with AGC	11	–	250 - 4800	200 - 900	24	3.3	175	***TGA4861****
32 Gb/s Linear TIA with AGC	28	–	250 - 4800	200 - 900	24	3.3	175	***TGA4864****
44.6 Gb/s Limiting TIA	36	–	2800	650	15	3.3	75	***TGA4866****
43 Gb/s Limiting TIA	30	40	4500	600	30	-5.2	85	***TIA56****
43 Gb/s Limiting TIA with PLD	27	36	3200	600	30	-5.2	85	***TIA56A****

NOTES: **** = New***

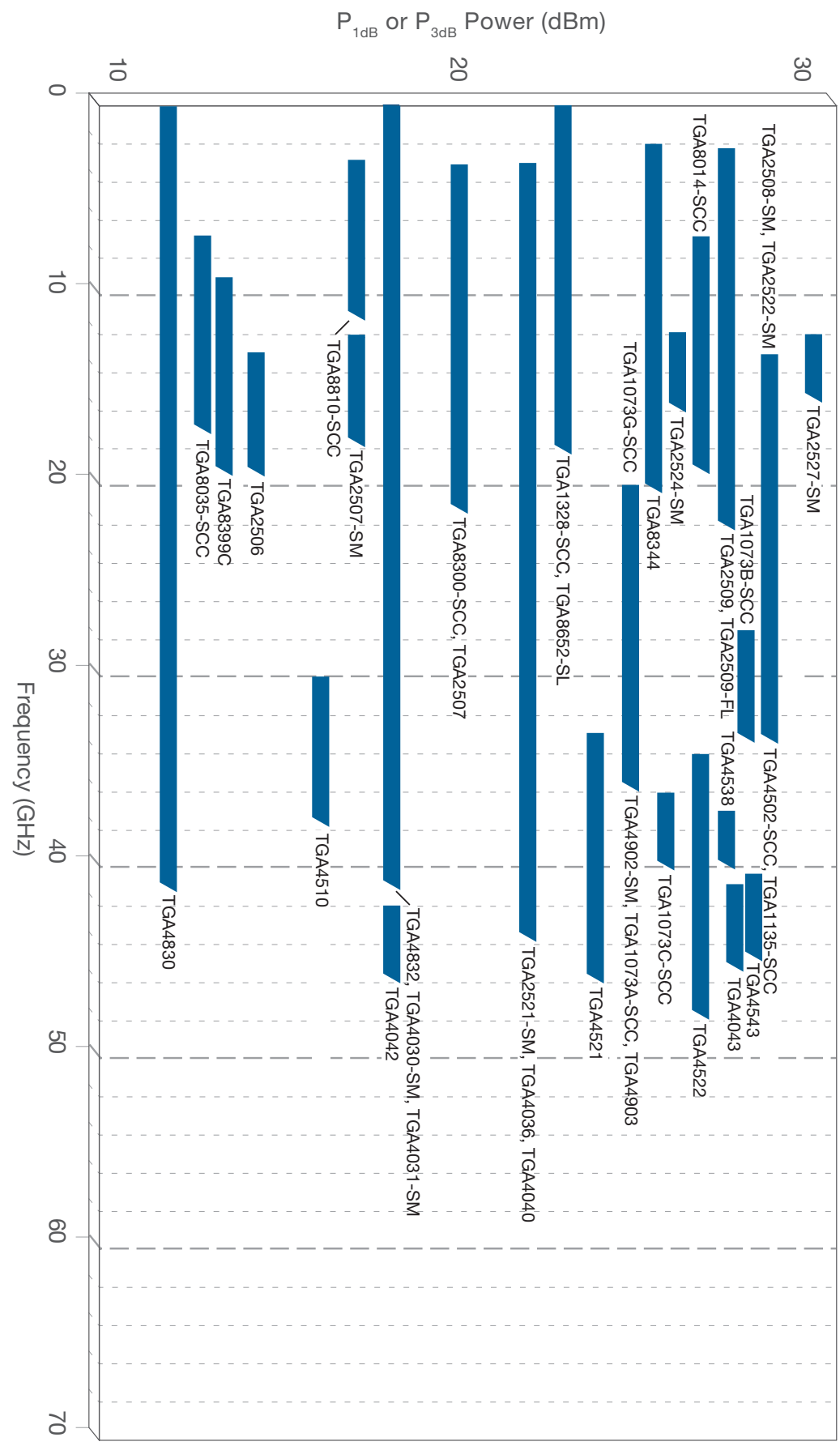


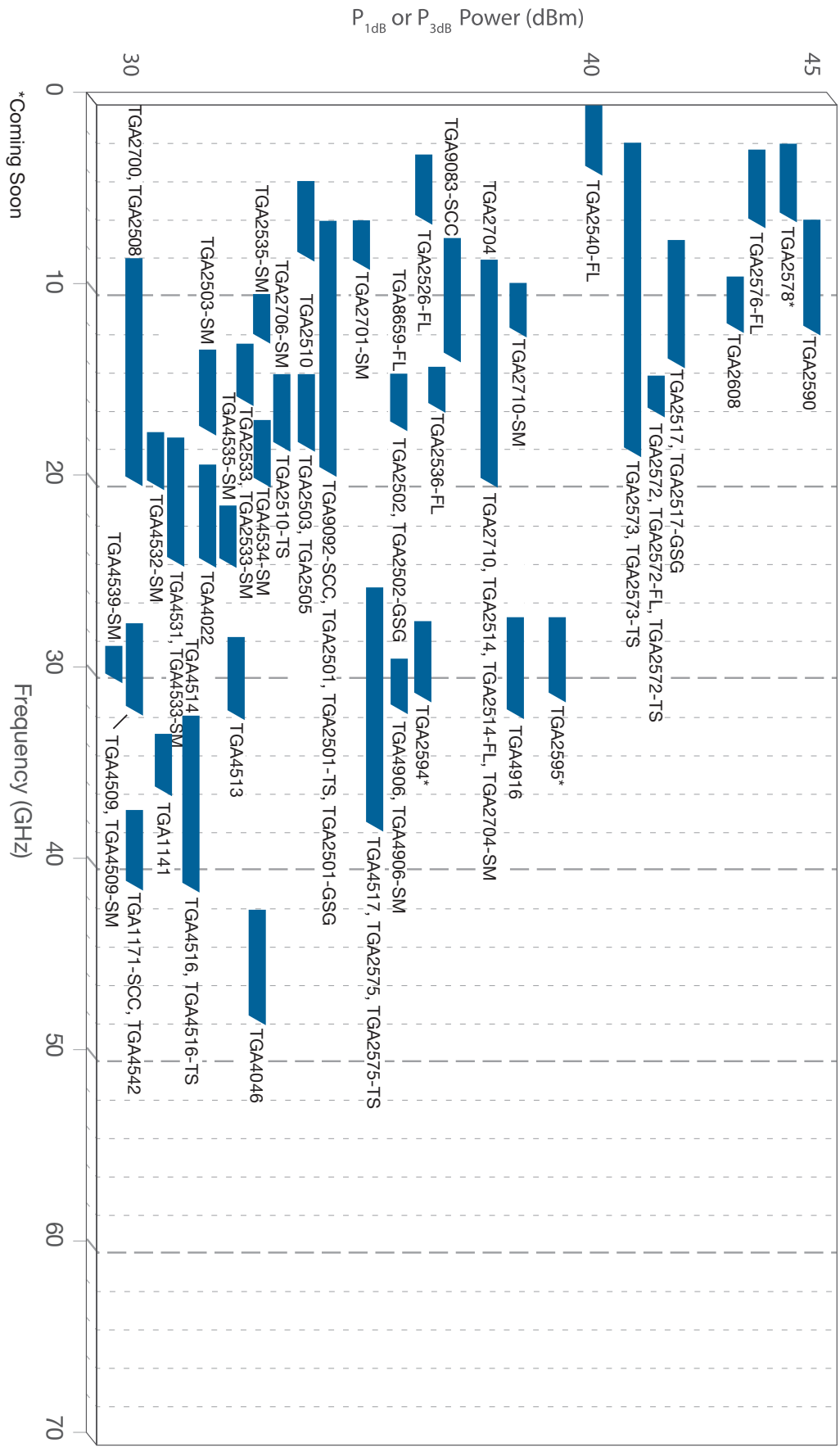
Select Low Noise Amplifiers, LNA Noise Figure vs. Frequency

For a complete list of low noise amplifiers, please refer to page 41.

Select Less Than 1W Higher Frequency Amplifiers, Power vs. Frequency

For a complete list of less than 1W amplifiers, please refer to pages 37 and 38.





Select More Than 1W Higher Frequency Amplifiers, Power vs. Frequency

For a complete list of more than 1W amplifiers, please refer to page 39.

Packaging

For detailed information on TriQuint product packaging, please visit our website at **www.triquint.com/prodserv.**

Ordering

TriQuint products can be purchased through:

- ***TriQuint Online Store:***
  Select TriQuint products are now available for purchase online at **http://store.triquint.com.**
- ***TriQuint Field Sales Offices:***
  We have regional sales offices across the globe to work closely with you on your next TriQuint product purchase. To identify the closest regional sales office, please go to our website at **www.triquint.com/sales.**
- ***Local Sales Representatives:***
  Local sales representatives are skilled at examining application needs from a variety of angles to aid the design process. Their insight and specialized experience, paired with your goals, can find the combination of products that best meet overall objectives. Since these representatives work with a variety of customers in many different design environments, their experience can be valuable in determining the right 'fit' for your particular application. To locate a sales representative, please visit our website at **www.triquint.com/sales.**
- ***Distributors - Buy / Resale Reps:***
  TriQuint products can be purchased from any one of the distributors or buy / resale reps listed on our website at **www.triquint.com/sales.**

Terms & Conditions

For a complete listing of TriQuint terms and conditions of sale, please visit our website at **www.triquint.com/sales.**

Export Compliance

Virtually all products TriQuint offers for sale as detailed in the Product Selection Guide are available for export subject to US government regulations. Please contact your TriQuint salesperson for details.

Product Support

- ***Product Data Sheets and Literature:***
  Detailed information on our products including datasheets and other literature can be found on the TriQuint website at **www.triquint.com/prodserv.**
- ***Applications Support:***
  Detailed product support information can be found on the TriQuint website at **www.triquint.com/prodserv.**

Reliability Programs

Our programs are in line with JEDEC and other industry standards.

Environmental, Health & Safety Policy

TriQuint is committed to driving continuous improvement; providing employees with a safe and healthy working environment; and being a role model for sound environmental stewardship and pollution prevention, while meeting or exceeding all applicable federal, state and local requirements.

Environmental Systems

- ISO-14001:2004 (Select Sites)

Quality Policy

Each of us at TriQuint is committed to zero defects, continuous improvement, quality and reliability to meet or exceed customer requirements.

Quality Systems

- ISO-9001:2008 Certified (Select Sites)
- ISO / TS 16949:2009 Certified (Select Sites)
- ISO / AS9100B Certified (Select Sites)

Quality Tools Utilized

- Design Failure Mode & Effects Analysis (DFMEA)
- Process Failure Mode & Effects Analysis (PFMEA)
- Process Control Plan (PCP)
- Production Part Approval Process (PPAP)
- Eight Discipline Problem Solving (8-D)
- Real Time Statistical Process Control (SPC)
- Measurement System Analysis (MSA)
- Advanced Product Quality Planning (APQP)

For further details on TriQuint quality and reliability information, please visit our website at **www.triquint.com/company/quality.**

Product Compliance Policies

TriQuint is committed to meeting all global product environmental regulations that affect its products. These regulations include:

- Directive 2002 / 95 / EC (RoHS Directive) and its recast Directive 2011 / 65 / EU
- Management Methods for Control of Pollution Caused by Electronic Information Products (China RoHS)
- Directive 94 / 62 / EC (Packaging Directive)
- Directive 2006 / 122 / EC (PFOS Directive)
- Regulation (EC) No 1907 / 2006 (REACH Regulation)
- Commission Decision 2009 / 251 / EC (Dimethylfumarate Ban)

All active TriQuint commercial standard products are compliant with these directives. Contact TriQuint for the RoHS compliance status of custom products, military products and products manufactured prior to June 2006. All new product designs are halogen-free since late 2008. TriQuint does not use any REACH Substances of Very High Concern (SVHCs) in its products or packaging materials above a concentration of 0.1% (at the product level). Also, TriQuint is committed to complying with Section 1502 (Conflict Minerals) of the Dodd-Frank Wall Street Regulation and Consumer Protection Act. We are actively surveying our supply chain to ensure that our products are “Conflict Free”, and as of April 2013 have not identified any Conflict Mineral derivatives from the Conflict Region in our products.

In addition to being compliant with the above product compliance laws and regulations, TriQuint participates in the following customer programs:

- Sony Green Partner
- Samsung Eco-Partner

Please contact TriQuint at **rohs_info@triquint.com** for any product compliance information requests. For further details on TriQuint environmental, health & safety information, please visit our website at **www.triquint.com/company/ehs.**

Notice

The data provided in this selection guide is subject to change without notice. TriQuint reserves the right to make changes to specifications and other information at any time.

Authorized Channel Partners:

RichardsonRFPD — An Arrow Company — *Global*

MOUSER ELECTRONICS — *Global*

RFMW — *Americas & EMEA*

AVNET 安富利电子元件 — *Asia*

JORJIN TECHNOLOGIES — *Taiwan*

tecnomic — *India*

MARUBUN CORPORATION — *Japan*

SINCE 1964 中电器材 — *China*

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