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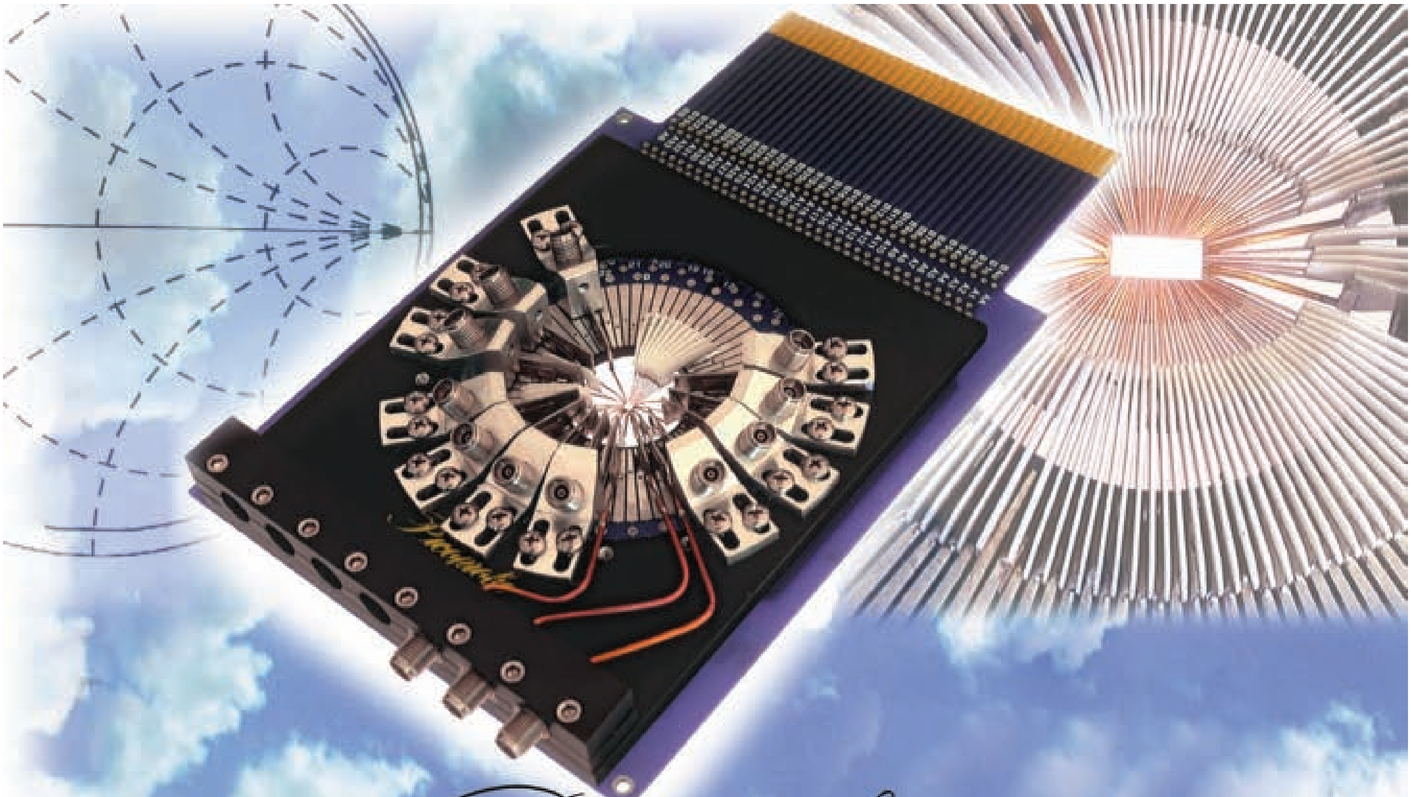

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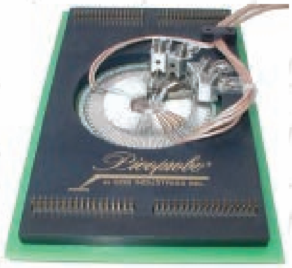

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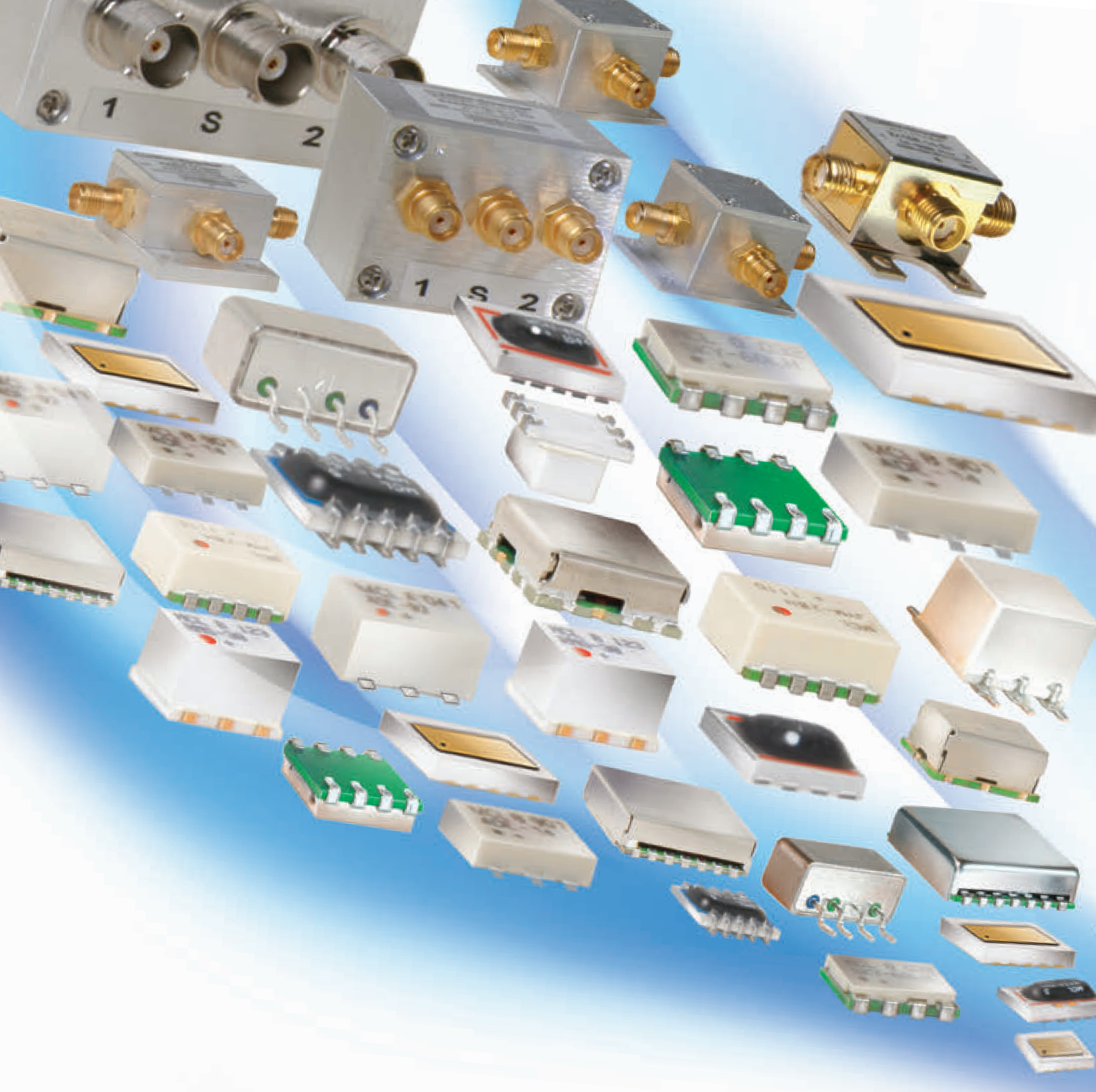

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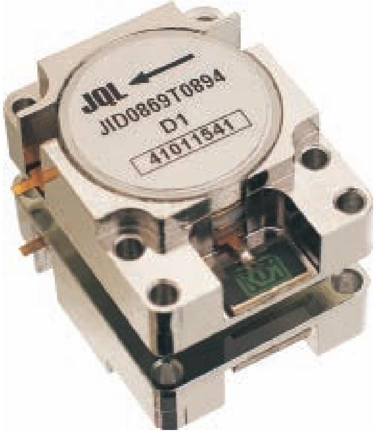

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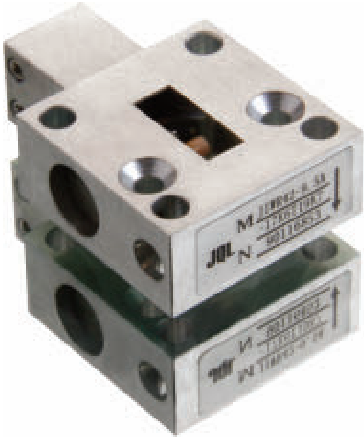

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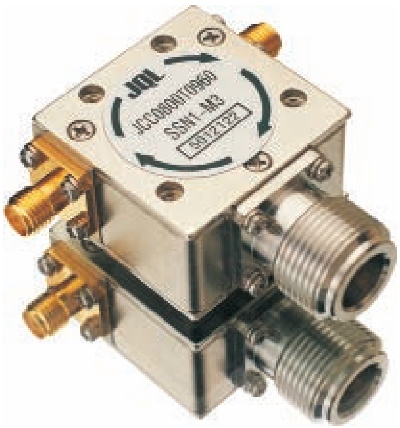

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NOTE FROM THE EDITOR

COVER FEATURE

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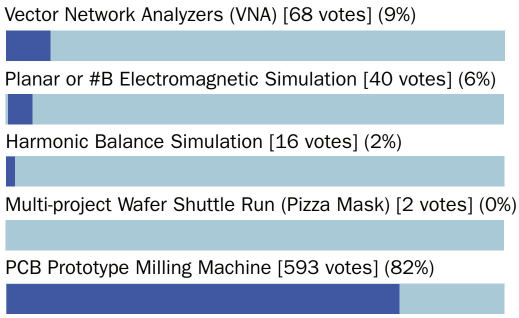
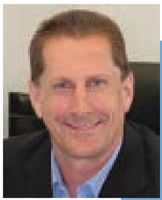
April Survey

"What's the most important tool in your design arsenal?"





Executive Interview

Greg Straiton, General Manager of Amphenol RF, discusses Amphenol RF's tradition of innovation in the connector industry, new products and global approach to manufacturing.

White Papers

Radio Channel Emulation for LTE User Equipment Testing
White Paper, Aeroflex

Solutions for 802.11ad Physical Layer Testing–Enabling Quick and Accurate Simulation, Generation and Analysis of 60 GHz Signals with 2 GHz Modulation Bandwidth
White Paper, Agilent Technologies

RF Amplifier Output Voltage, Current, Power and Impedance Relationship
Jason Smith and Pat Malloy, AR RF/Microwave Instrumentation

Small-signal Intermodulation Distortion in OFMD Transmission Systems
Application Note, RFMD

RF Substrate Technologies for Mobile Communications
Stéphane Laurent and Eric Desbonnets, Soitec

Community Watch

Linked-in member Steve asked…

"What's the ratio of children, boys to girls, for RF Engineers who worked in a lab with exposure to RF signals?"

Over **130** voted in Steve's online poll and there were over **46** comments.

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For complete coverage of the IMS 2012 conference, event news, exhibitor product information and special reports from the editors of Microwave Journal, visit www.mwjournal.com/IMS2012.

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www.amta.org

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DECEMBER

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EDI CON Electronic Design Innovations Conference 电子设计创新会议 2013

Eye on EDI CON

Last month, Microwave Journal and Horizon House announced the launch of the annual Electronic Design Innovations Conference – EDI CON, to take place in Beijing in 2013. Prior to launch, we presented our concepts for an industry-driven conference to a handful of companies that are at the forefront of new technology and frequently discuss their work in the Journal, in webinars and at conferences. The response has been overwhelmingly positive as these companies have committed to support the event financially and with technical content. Both types of support will prove critical to the event's success – for delegates, sponsors, and exhibitors alike.

With its focus on practical education for RF/microwave and high-speed digital designers, the EDI CON technical program will be developed through this collaboration with industry, with the goal of providing timely and useful technical information to working engineers. Under the guidance of the Microwave Journal editorial staff, an EDI CON technical advisory committee consisting of experts from a variety of specialized areas is currently being organized.

The technical advisory committee will solicit invited papers from well-respected technologists among EDI CON sponsors/participants, industry luminaries, regular MWJ contributors and Chinese academics. Many of the advisory committee members are Chinese nationals working for international companies. Leveraging their native status and in-country connections will help EDI CON technical advisors select the highest quality technical papers and ensure relevance to a local audience. In addition, EDI CON has announced a Call for Papers to the Chinese engineering community at large. Over the years, Microwave Journal has published many papers from academic circles in China and EDI CON will give accepted speakers the opportunity to present their material in a conference setting.

Microwave Journal and its parent company, Horizon House have a long and successful history of managing major trade events such as IMS and EuMW, as well as industry related pavilions within mega-shows, such as the RF/Microwave, M2M and Mobile Backhaul Zones at CTIA. Over the past few years, the Journal has been organizing technical tracks in partnership with industry leading companies at each one of these conferences. We now believe the time is right to expand the format to encompass an entire show.

Imagine EDI CON representing this entire magazine as a live event - with the technical articles, cover stories, and special reports co-existing side by side with the latest product information from industry. There will be considerable benefits to gathering together our readers, authors and advertisers in one place to share their knowledge, discuss their needs and connect individuals to technical solutions and business opportunities. That is our vision for EDI CON, an event whose content and participants will directly reflect what we offer in this magazine, online and through our webinars every month of the year.

David Vye
Microwave Journal Editor

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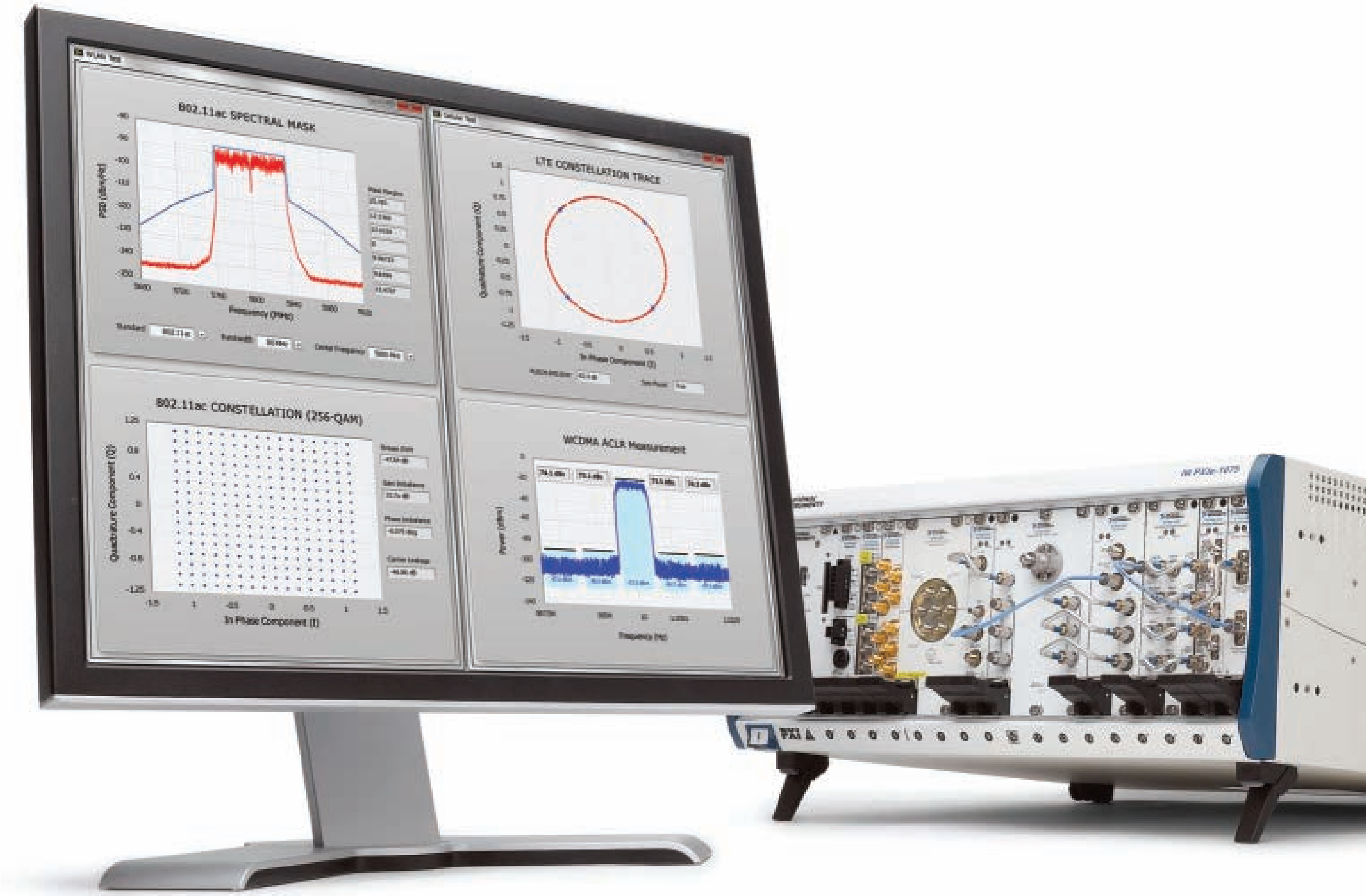

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Future RF Market Opportunities for GaN

Microwave Journal and Strategy Analytics have put together a special panel session for IMS 2012 in Montréal taking place on Wednesday, June 20 from 8 AM to 10:00 AM in room 516 of the Palais des Congrès de Montréal. It will feature industry experts providing their view on where the future market opportunities are for GaN. The experts will be from Strategy Analytics, Cree, Nitronex, NXP, RFMD, TriQuint and UMS. Each organization will present their viewpoint followed by a question and answer session with the audience. The event is free and open to everyone with complimentary breakfast provided by Strategy Analytics.

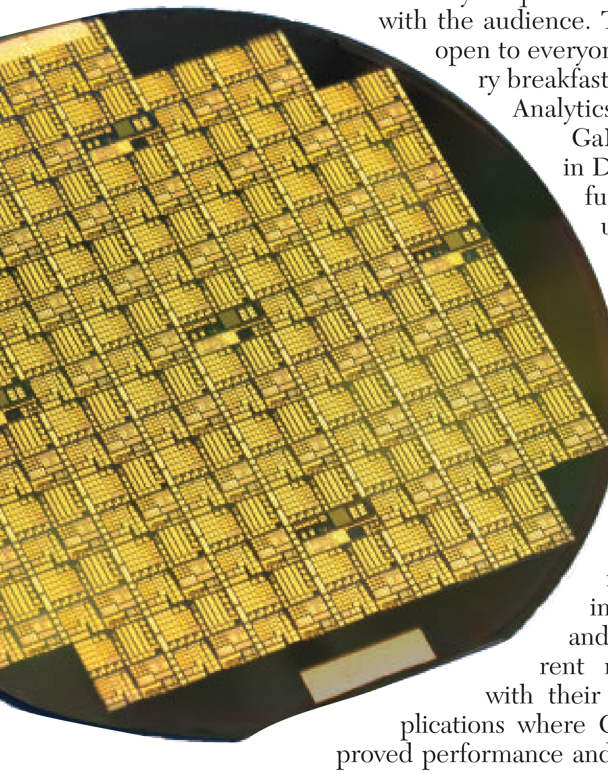


Photo courtesy of TriQuint Semiconductor

GaN had its beginnings in Defense industry R&D funding and is being used or designed into many high power, wideband applications such as electronic warfare (EW), improvised explosive device (IED) jammers, communications and radar. Most of the companies participating in this forum are involved in military applications and will cover these current market trends along with their views on future applications where GaN will provide improved performance and other benefits. They will debate the slots where GaN has advantages over GaAs and travelling wave tubes (TWT) amplifiers that have been utilized in most high power military systems to date. The debate of GaN replacing TWTs is interesting as it was originally thought that GaN would have a significant impact in TWT replacement but this has yet to materialize in a significant manner. We will see what the following experts think about this subject, including if and when, GaN will replace these other technologies.

In the commercial sector, it was long thought that GaN would replace Si LDMOS solutions for high power base stations as the main opportunity for GaN in the high volume applications. The experts will address if this has happened and if there are now other commercial opportunities that have a larger potential than cellular base stations. The experts will look at the cost and performance of GaN versus LDMOS (and other Si technologies) to assess the possibility of GaN infiltrating various commercial markets, in addition to any potential improvements in efficiency and energy savings. As future 4G systems demand wider bandwidths, they will predict where GaN might have advantages in future cellular systems.

Most GaN suppliers use a SiC substrate as it provides the best thermal properties, but it is expensive relative to other options. Nitronex is currently the only major supplier using Si as a substrate so the experts will address their viewpoints if Si or SiC is a better substrate from a cost

PATRICK HINDLE
Microwave Journal *Technical Editor*

and performance perspective. It will be interesting to see if there is any shift in substrate use in the future.

GaN has displayed significant performance advantages in devices other than high power amplifiers, so the experts will cover which other device types could emerge in the future and what advantages GaN has in those functions. These other device types could open up new markets and applications for future GaN based products.

The following articles provide a summary of the industry expert viewpoints on the future GaN market opportunities as seen by Strategy Analytics and many of the major GaN semiconductor suppliers. These articles are overviews of the information that will be presented at the IMS 2012 special panel session.

WHERE ARE THE EMERGING RF MARKET OPPORTUNITIES FOR GaN?

Asif Anwar and Eric Higham, Strategy Analytics, London, UK and Boston, MA

The unique material properties possessed by GaN translate into the ability to deliver high power at high frequencies, and to withstand high temperatures. As with many emerging compound semiconductor technologies, the theoretical advantages are well known, but the practical realization of GaN-based microelectronic devices within a mature supply-chain environment remains at an early stage.

The outstanding performance of GaN devices stems largely from intrinsic physical properties: its wide bandgap (3.4 eV), high breakdown voltage, high power density and high gain at microwave frequencies all lead directly to favorable device characteristics. Excellent thermal conductivity also makes GaN ideally suited for high power applications and extreme environments. When produced on semi-insulating (SI) SiC substrates, thermal management is further improved due to the high thermal conductance of SiC although some work has shown that thin Si substrates can also provide good thermal performance. A comparison of some basic physical properties of GaN with other common semiconductor device materials is shown in ***Table 1***.

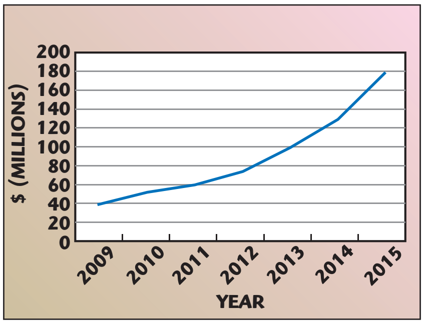
TABLE I
PHYSICAL PROPERTIES OF SEMICONDUCTORS

	Si	GaAs	InP	SiGe	SiC	GaN
Lattice Constant (Å)	5.4	5.7	5.9	5.5	3.1	3.2
Saturation Velocity (cm/s)	1×10^7	0.8×10^7	2.2×10^7	–	2×10^7	2.5×10^7
e- mobility (cm^2/Vs)	1350	8000	10,000	3000	900	1500
E_g Bandgap (eV)	1.1	1.4	1.3	0.7-1.1	3.3 (4H)	3.4
F_t (GHz) FET	20	150	300	50	20	150
Power Density (W/mm)	0.2	0.5	–	0.3	10	>30
Thermal Conductivity (W/cmK)	1.5	0.5	–	–	4.9	~2.0
Emission Wavelength (µm)	N/A	0.6-0.9	1.0-1.5	N/A	N/A	0.4

Source: Strategy Analytics

The wide bandgap enables GaN devices to support peak internal electric fields approximately five times higher than either silicon or GaAs. It also results in low intrinsic carrier concentrations at device operating temperatures, which in turn allows high-temperature operation and high radiation stability. Another performance advantage of GaN is higher electric field strength. This results in higher breakdown voltages, which is a critical attribute for handling high-power requirements and for achieving higher electrical efficiencies using higher supply voltages.

Previous industry sentiment forecast that the commercial market for RF GaN devices would be initiated by demand from wireless infrastructure (see ***Figure 1***). The thought was that the rollout of 4G networks, including WiMAX and LTE, would drive demand for smaller base stations without compromising on power output, linearity and efficiency requirements. Although this network architecture trend is developing, a couple of factors have delayed the market penetration of GaN: the continued advances in competitive technologies, particularly silicon LDMOS and the hesitation by service providers to deploy a relatively immature technology before there is a proven reliability history.



▲ *Fig. 1 GaN device market outlook (source: Strategy Analytics).*

While GaN cannot currently compete with LDMOS in terms of price per watt of RF output, future implementation of amplifiers with pre-distortion optimized for GaN transistors may ultimately provide a lower overall cost of ownership than LDMOS. In commercial applications like CATV, where GaN is capturing market share, operators are embracing the reduction in operating expenses resulting from reduced power dissipation and cooling.

Recent progress in extending the lifetime and reliability of GaN-based RF devices has been significant and with silicon LDMOS technology continuously improving, cost appears to be the primary factor to target for wider GaN amplifier deployment. Conversations with companies trying to get a foothold for GaN in this market suggests that, in high volume, Si LDMOS chips are available at prices as low as ~$0.2 per W, while the lowest GaN price reported is ~$0.5 to 0.6 per W. It is worth noting that some companies do not believe these GaN prices are sustainable using GaN-on-SiC

technology. They believe if GaN devices are to compete directly with LDMOS chips in narrowband applications, the technology must migrate to a GaN-on-Si strategy.

Implementation of GaN in satellite communication and other RF markets such as CATV infrastructure represents the earliest commercial applications of GaN-based RF components. With CATV deployments reaching significant volumes during 2012 and beyond, the combined value of these niche segments will account for almost 14 percent of the market through 2015.

While Strategy Analytics forecasts relatively strong growth overall, the long-term development of the commercial GaN device market will also remain linked to adoption in applications where other technologies simply cannot compete, for example direct replacement of Travelling Wave Tubes (TWT) in military, digital TV transmitter and commercial satellite communications.

Over the short to mid-term, military applications in EW jammers in particular, but also air defense and surveillance radar, EHF SATCOMs, smart munitions and missile transmitters will constitute the bulk of demand for GaN devices and military applications will still account for nearly 68 percent of the total GaN microelectronics market in 2015.

GaN BENEFITS: CREE VIEWPOINT

Jim Milligan, Cree, Durham, NC

Since Cree released its first 28 V, 0.4 µm GaN/SiC HEMT production process in 2006, early adopters have developed and fielded systems in volume (largely military). As a result, GaN/SiC HEMT technology has earned an excellent track record of fielded reliability. The GaN/SiC HEMT fielded FIT rate is less than 10 which rivals any other power FET technology. More recently, GaN/SiC HEMT prices have improved to the point where commercial segments are beginning to adopt the technology in favor of GaAs or silicon solutions for specific applications where the cost/value trade is favorable. To date, high power amplifier designers have developed and deployed GaN/SiC HEMT amplifier solutions under Class A, A/B, as well as switched mode Classes (D, E, F, Inv F, J) in addition to Doherty class HPAs. The approaches deployed are based on the best trade of efficiency, linearity, power and bandwidth requirement for the specific application.

In general, the adoption rate will track the systems benefits and the value of the benefits relative to the price of the technology. In rough order, the system benefit can be outlined into four areas: Enabling benefits, feature enhancements, bill of material savings and operational savings. Enabling benefits means that the application requirements are such that the target performance can only be accomplished exclusive to the technology. A good example of this for GaN/SiC HEMT is electronic warfare. Ground based equipment requires high power, multi-octave bandwidths under CW conditions while operating in extremely harsh VSWR mismatch conditions. The classical way of satisfying this is to combine a large number of GaAs MESFET devices to achieve the necessary power levels. Si LDMOS can address low frequency broadband applications but can still experience issues due to the required high VSWR mismatch conditions. The only practical method of addressing the 25 to 100 W CW performance from DC thru C-Band in small form factors and rugged VSWR mismatch conditions is GaN/SiC HEMT. The transmitter form factors usually only allow for two transistors housed in the output stage and the high breakdown of GaN/SiC provides a rugged device capable of withstanding challenging VSWR mismatch conditions either operationally or as a result of damage to the antenna.

Another good example of enabling benefits is software defined radios. These radios require multi-octave bandwidth with good linear performance. The modulation schemes range from constant envelop to complex waveforms across HF thru C-Band. Examples are military tactical radios and instrumentation amplifiers. GaN/SiC HEMT has allowed these radios to extend their frequency range beyond UHF bands.

As 0.25 micron GaN/SiC HEMT technology has emerged, solid state power amplifier (SSPA) applications requiring both high frequency and high power simultaneously is another enabling segment. Currently, multi hundred to greater than 1 kW transmitter applications in L-, S-, C-, X- and Ku-Band are viable with GaN HEMT SSPAs. The classical TWTAs with their ultra high voltage power supplies and required linearization schemes are more expensive and less reliable than GaN HEMT SSPAs. As a result, ground based satellite communications, military systems, and civil radar are adopting GaN/SiC HEMT SSPAs.

Feature enhancement is another system driver. We see adoption drive in radar systems, UAVs and point-to-point radios where the high power benefits of GaN/SiC HEMT helps extend the system range compared with GaAs based HPAs. Another feature is HPA size. In general, a smaller SSPA footprint usually corresponds to improved ease of installation and lower system integration costs. Examples of these systems are telecom remote radio heads and military/commercial radar systems. Weight is also a vitally important feature to be minimized for airborne, naval, portable and tower mount applications. The high power density of GaN/SiC HEMT and improved efficiency allow for system size and weight reduction. GaN/SiC HEMTs in a MMIC process now allow for multi-function HPA circuits to be miniaturized onto a single die.

GaN/SiC HEMT technology offers high F_t, high power density, low parasitic capacitances, high breakdown and high voltage operation which lends itself to high efficiency HPAs in either saturated or linear operational modes. It helps with size and weight reduction but also allows for other significant reductions in bill of material and operational expenses (OPEX).

Bill of material savings can be realized with high efficiency transmitters utilizing GaN/SiC HEMT transistors. The result is lower cost for DC/DC converters, AC/DC converters and reduced heat sink costs. The improved power and efficiency also reduces the cost for other bill of material items in the system including but not limited to power combiners, printed circuit boards and the enclosure itself.

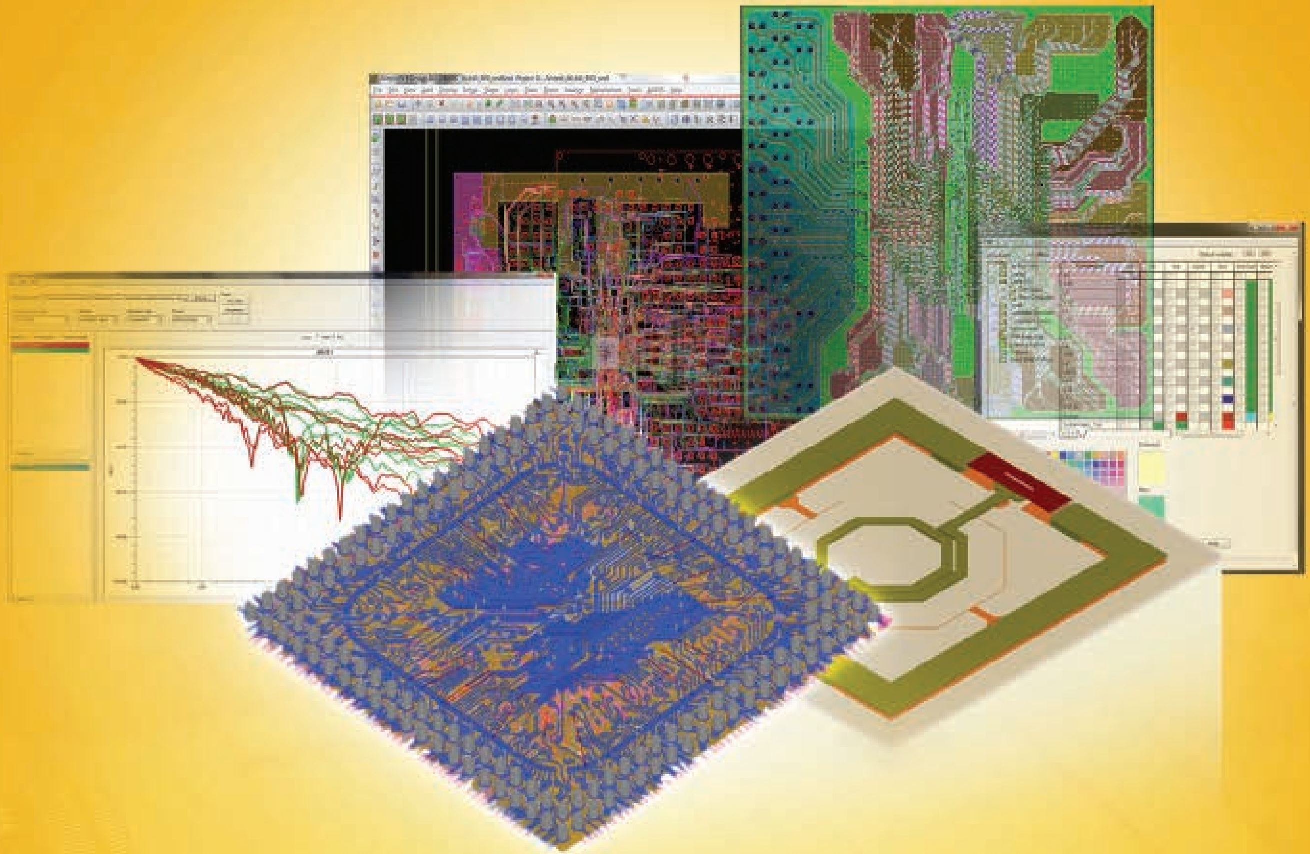
High efficiency also offers tremendous benefits in terms of the cost of operating the system (OPEX). Even a modest transmitter efficiency improvement can yield significant operational cost benefits both for commercial and military systems. The cost of energy savings can be the most significant benefit. As awareness grows and the world economy and governments drives their green initiatives, Cree considers operational expenses the single most important adoption factor. For most applications, GaN/SiC HEMT will help realize a lower cost of ownership for system operators when compared with Si LDMOS, GaAs PHEMT or GaAs MESFET HPAs. For some market segments, such as commercial telecom, the increased performance can also result in improved system operational performance (e.g. fewer dropped calls), which improves the quality of service (QoS) for the end item consumer.

Cree continues to see an increasing adoption rate of GaN/SiC HEMT technology in military (radar, ground based EW, airborne EW, tactical radios, ground based and airborne datalinks) and commercial systems including LTE base stations, point-to-point radios, CATV line drivers, Civil Radar and Satellite communications. GaN/SiC HEMT technology is poised for healthy growth based on a wide mix of system and operational benefits.

Si SUBSTRATE BASED GaN: NITRONEX VIEWPOINT

Walter Nagy, Nitronex Corp., Durham, NC

The addressable RF GaN market is growing at a moderate pace as it becomes more established as a high performance, reliable, cost-effective alternative to incumbent technologies. GaN has played a dominant role in improvised explosive devices (IED) jammers and new military communications systems, and has begun to emerge in several other markets including CATV infrastructure, instrumentation amplifiers, radar and wireless infrastructure. Any new semiconductor technology has



a slower adoption rate than desired due to the high initial cost and lack of long term reliability data; however, this is now subsiding in the GaN marketplace.

The first users of GaN technology were military based, where its unique combination of high power, robustness and wide bandwidth were highly valued by the end customer. Applications in broadband jammers were critical in protecting personnel against IED's where functionality was of utmost importance. Military communications' adoption of GaN centered on the broadband ability GaN provided for radios, allowing a single PA to cover extended band operation to support new functionality such as high data rate transfers. As the market gains confidence that GaN suppliers can meet performance, reliability, production and cost requirements, it will become a more mainstream technology and gain significant market share across both military and commercial applications.

Future military markets for GaN include low noise amplifiers (LNA) where GaN's robustness provided by its high breakdown voltage enables LNA's to be driven 20 dB into compression with no significant degradation in performance. This characteristic intrinsically provides front end protection to the receiver without requiring any limiting circuitry. Another obvious and very large market for RF GaN is the military and commercial radar markets. Production ramp and large volumes are still quite a few years out due to the slow nature of radar system development and deployment. In the interim, there has been recent activity surrounding the replacement of silicon bipolar devices for S-Band radar where GaN provides much higher gain, drain efficiency and power levels and these advantages will eventually lead to the demise of silicon bipolar for these radar applications.

Much has been made of using GaN as a TWT replacement but this will be a significant challenge for GaN due to the extremely high power and efficiency that TWT technology inherently provides. As such, the forecasted elimination of this stalwart RF technology at very high power levels is premature at best. GaN's usefulness in replacing TWT's in the 10's of kW region is not achievable for the near future so will be limited to applications requiring less than 10 kW of power. The upper limit on a usable power density and associated heat dissipation of GaN devices will limit the power one can obtain from a single device to less than a kW. Multiple devices will need to be power combined to achieve power levels in the multiple kW range which results in power and efficiency losses thus limiting the number of devices that can reasonably be combined.

Activity in the wireless infrastructure market is picking up once again for GaN in both high power PA's and LNA applications. Historically, the PA's in wireless infrastructure have had no need for the wide bandwidth capabilities of GaN since the addressable BW is limited by government spectrum allocation to less than 200 MHz therefore the chief advantage GaN offers is PA efficiency. GaN based high efficiency PA architectures such as Doherty and Envelope Tracking (ET) have demonstrated PA efficiencies in the 50 to 70 percent range while operating with multicarrier WCDMA and WiMAX signals and meeting linearity and spectral re-growth specifications. Significant cost and performance competition from legacy LDMOS based PA's has historically limited GaN's adoption into this marketplace, however, with increased user data traffic driving ever more bandwidth and a preference for high efficiency the advantages of GaN based high efficiency PA's may take hold.

Instrumentation PA manufacturers are beginning to roll out GaN based broadband PA's where the broadband and linear characteristics offer compelling advantages over legacy technologies. Broadband multi-stage GaN MMICs delivering 50+ W are emerging and will find niche applications for broadband jammers, instrumentation and broadband driver amplifiers for numerous military and radar applications. Adoption of these GaN MMICs will be hindered by high initial costs but Nitronex believes that using a Silicon substrate will significantly reduce these costs and provide a significant cost advantage versus GaN on a SiC substrate without sacrificing RF performance.

MAKING GaN MAINSTREAM: NXP VIEWPOINT

Mark Murphy,
NXP Semiconductors,
Eindhoven, The Netherlands

RF GaN technology has held a great promise for the future for a long time. The physical properties of this wide bandgap material show evident advantages to those of silicon for RF applications. This has stimulated lots of research and technology development in numerous institutes and companies worldwide. The performance advantages are unfortunately accompanied by a large price difference compared to ordinary silicon RF devices. Therefore, GaN has not been more than a promise for more than a decade. Recently, however, the market for RF GaN is starting to take off in several market segments: first in the aerospace and defense market, soon to be followed by cellular communications, energy transfer and sensing/imaging.

Application of GaN in cellular infrastructure (base stations) is still modest due to limited performance benefits in linear power amplifiers that are offset by large price differences with conventional silicon LDMOS transistors. To take RF GaN technology mainstream, NXP has developed a digital power amplifier using GaN switching transistors that offer more than 10 percent higher efficiency than linear amplifiers. Moreover, these digital power amplifiers can be used in multiple bands without modification of the hardware. The input pulses to the GaN switches are produced by using NXP's patented signal control architecture which allows the operating frequency of the amplifier to be changed on the fly using software. This architecture offers the benefits of extra efficiency, small size and tuneability for both marco cells as well as the emerging small cell space.

Another area where the performance of GaN could play a major role is in the area of energy transfer. These applications use narrowband continuous wave (CW) signals to transfer RF energy to a specific target. These applications may range from solid state cooking (microwave cooking) to plasma lighting, car ignition, oil extraction and medical applications like tissue ablation. NXP has built a series of highly efficient and highly integrated GaN power amplifiers with high performance for such applications, resulting in a small form factor and reduced heat dissipation, which is important in many applications.

A third very interesting area for GaN is the sensing and imaging markets that include applications such as AESA radars and even MRI scanners. This type of application can utilize several frequency bands. NXP has demonstrated very efficient and high frequency power amplifiers in very small form factors.

All the applications above have varying specifications and challenges

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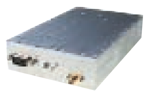
NEW LZY-22+	0.1-200	43	+42.0	+45.0	8.9	+52	24	6.0	1495	1470
LZY-1+	20-512	43	+45.7	+47.0	8.6	+54	26	7.3	1995	1895
LZY-2+	500-1000	46	+45.0	+45.8	8.0	+54	28	8.0	1995	1895
ZHL-5W-1	5-500	44	+39.5	+40.5	4.0	+49	25	3.3	995	970
ZHL-5W-2G+	800-2000	45	+37.0	+38.0	8.0	+44	24	2.0	995	945
ZHL-10W-2G	800-2000	43	+40.0	+41.0	7.0	+50	24	5.0	1295	1220
ZHL-16W-43+	1800-4000	45	+41.0	+42.0	6.0	+47	28	4.3	1595	1545
• ZHL-20W-13+	20-1000	50	+41.0	+43.0	3.5	+50	24	2.8	1395	1320
ZHL-30W-252+	700-2500	50	+44.0	+46.0	5.5	+52	28	6.3	2995	2920
ZHL-30W-262+	2300-2550	50	+43.0	+45.0	7.0	+50	28	4.3	1995	1920
• ZHL-50W-52	50-500	50	+46.0	+48.0	6.0	+55	24	9.3	1395	1320
• ZHL-100W-52	50-500	50	+47.0	+48.5	6.5	+57	24	10.5	1995	1920
• ZHL-100W-GAN+	20-500	42	+49.0	+50.0	7.0	+60	30	9.5	2395	2320
ZVE-3W-183+	5900-18000	35	+34.0	+35.0	5.5	+44	15	2.2	1295	1220
ZVE-3W-83+	2000-8000	36	+33.0	+35.0	5.8	+42	15	1.5	1295	1220

• ***Protected under U.S. Patent 7,348,854***

For models without heat sink, add ***X suffix*** *to model No. (Example: LZY-1+, LZY-1X+)*


ZHL-16W-43X+
ZHL-30W-252X+
ZHL-30W-262X+


ZHL-5W-1X
ZHL-5W-2GX+


LZY-1X+
LZY-2X+
LZY-22X+
ZHL-10W-2GX
ZHL-50W-52X
ZHL-100W-52X
ZHL-100W-GANX+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IF/RF MICROWAVE COMPONENTS

that need to be supported through a broad portfolio of high performance GaN and LDMOS products and in some situation a mix of GaN and LDMOS, NXP offers unbiased choices thus enabling fully optimized designs in the applications. NXP collaborates with the Fraunhofer IAF Institute in Freiburg, Germany, and with United Monolithic Semiconductors (UMS) in Ulm, Germany, in the research, development and industrialization of GaN technology.

The partnership establishes a Europe based supply chain for RF GaN technology that is vital not only for Europe's RF related industry but for Europe's industry in general. GaN process technology features high linearity while at the same time allowing designers to maintain power, ruggedness and efficiency. This enables an uncompromised amplifier design that can reduce component count and reduce amplifier footprint. State-of-the-art back-end assembly technology consistently leverages the high power density of GaN into smaller and more broadband circuitry.

APPLICATION SPECIFIC GaN: RFMD VIEWPOINT

David Aichele, RFMD, Greensboro, NC

Historically, the RF semiconductor market, which is a multi-billion dollar industry, has been serviced evenly by both Si and GaAs technologies. Over the past five years there are a handful of emerging markets that are adopting new GaN-SiC RF power solutions and expectations are that the number of markets and adoption rate will accelerate in the near future. The military market, one of the early adopters, which includes applications such as radar, military communication and electronic warfare, recognized GaN-SiC technology advantages offering improved bandwidth, higher power, higher efficiency and reduction in overall footprint. Lower cost GaN technologies have enabled penetration of this new technology in commercial applications such as CATV, Professional Mobile Radio, Air Traffic Control and Weather Radar, Cellular Wireless Infrastructure and Test & Measurement.

RFMD has taken the approach to develop two GaN-SiC processes with a breakdown voltage greater than 300 V but optimized for different applications. RFMD's GaN1 process has high power density > 6.5 W/mm optimized for peak power and efficiency and GaN2 has power density > 2.5 W/mm optimized for linearity. RFMD continues to advance the performance of in-house GaN-SiC processes and is currently in development of GaN3 targeting improved efficiency and gain for RF and millimeter-wave applications. RFMD's approach has been to design processes optimized for different performance parameters so they are best suited for the chosen market application.

RFMD is currently shipping GaN-based CATV hybrid amplifiers to CATV

equipment suppliers in Europe, Japan and North America with volumes greater than 250,000 units shipped today. Operators of hybrid fiber coax (HFC) networks are installing fiber capacity deeper into their networks ("fiber deep" networks) in order to address the increasing demand for higher throughput video and broadband services. GaN CATV hybrid amplifiers provide industry-leading RF output levels, and cable operators using GaN can reduce the number of amplifiers required in emerging architectures and achieve up to 20 percent cost savings in fiber deep networks. The performance of GaN CATV amplifiers is on par with other industry-leading GaAs CATV power doublers but with 20 percent lower current consumption (24 V/380 mA). With these "green" energy-saving benefits, these products enable designers to fulfill growing requirements for lower energy consumption and assist network operators in their drive to reduce the overall cost of operating CATV networks (see ***Table 2***).

TABLE II

KEY CATV AMPLIFIER PARAMETERS VERSUS TECHNOLOGY

Parameter	GaAs MESFET	GaN
Frequency Bandwidth (GHz)	1	1.6
High Output Levels (dBmV)	58	61
Low Current Capability (mA)	450	380-450
Ruggedness (V)	200	1000
Thermal (Tmax @ 100°C)	180°	150°
Distortion (dB)	65-68	70-73
Noise Figure (dB)	5.5	4

Military and commercial radar manufacturers are incorporating GaN-based amplifiers in next generation systems and using similar devices as replacement or field upgrades in deployed systems used in ground based, sea-borne or air-borne applications. The requirement for improved sensitivity, enhanced image resolution, increased coverage and reduction in size and weight are main drivers in the rapid adoption of the GaN-based amplifiers.

Software Defined Radio (SDR) architectures are playing an increasingly important role in emerging radio configurations with requirements for supporting multi-band and multi-standard operation. SDRs have a wide range of applications such as Professional Mobile Radios (PMR) used by law enforcement personnel and emergency responders, military communications (MILCOM) such as Joint Tactical Radio System (JTRS), and cellular base station transceivers (BTS). The key enablers for SDR include wideband linear front-end components such as the power amplifier (PA), which are critical to the ability of the SDR to adapt to multiple bands, modulation formats, and radio standards. For systems like the JTRS and PMR, power amplifiers need to operate over multi-decade bandwidth covering VHF, UHF, and L-Bands, and need to be highly efficient and compact, especially when the amplifier is used in a handheld or mobile unit. By using a single wideband PA instead of individual narrowband amplifiers for each band, significant cost savings are obtained. Utilizing a GaN process that is optimized for the best linearity has resulted in devices that

provide peak power 30 to 90 W with ability to achieve IM3 better than -50 dBc backed off in power.

EVERYDAY GaN: TRIQUINT VIEWPOINT

Dean White, TriQuint Semiconductor, Hillsboro, OR

GaN-based technologies continue to emerge in the global marketplace through new product innovations that span the gamut of consumer, high-performance commercial and defense systems. GaN has proven its frequency, power and wide bandwidth capabilities in applications that range from light-emitting diodes to relatively low-frequency communications and power applications, and to emerging solutions for bio-mechanical/medical applications. TriQuint has focused on high-power/high-frequency innovations that have made GaN technology a mainstay for advanced radar, communications and electronic warfare (EW) programs.

TriQuint Semiconductor began its gallium nitride development in 1999, starting with a combination of government and internal funding. TriQuint's 0.25 µm GaN on SiC high-power/high-frequency process is ideal for wide and narrowband communications, radar, EW and related applications. More recently, the company's E/D-mode (enhancement-depletion) GaN on SiC process is seeing increased utilization for contracts that support ambitious programs funded by DARPA and the tri-service laboratories. TriQuint began developing a 0.15 µm GaN process to address emerging commercial and defense millimeter-wave (mmW) applications in parallel with its 0.25 µm DARPA WBGS and Title III programs.

TriQuint sees opportunities for GaN across many different applications from handheld radios to satellites, and from compact UAV radars to large-scale traveling wave tube (TWT) replacements. EW applications such as signal jammers are also a perfect fit for GaN because of the need for high power across broad bandwidths.

Defense communication products benefit from GaN's ability to provide high power added efficiency (PAE) at high power levels, making the technology suitable for radios operating from UHF to W-Band. At lower frequencies, GaN holds an advantage over LDMOS in that it is much easier to match over several decades of bandwidth. The need to increase the range and capability of UAVs has resulted in a need for smaller, higher power transmitters. GaN is a superior choice because of its high power density and efficiency. Communication systems benefit in prime power and weight reductions enabled by GaN's higher PAE and compact circuit size at Ku- and Ka-Bands.

Utilizing GaN for radar applications can lead to smaller, higher power radar systems from L- to Ku-Bands. GaN is being used to replace TWTs due to the technology's ability to offer a smaller footprint and higher reliability. Solid-state GaN power amplifiers have a higher MTTF and require lower cost/less complex DC power supplies when compared to current TWT solutions.

A largely untapped application for GaN is utilization in high dynamic

range low noise amplifiers (LNA). With a comparable noise figure (NF) to GaAs, GaN LNAs can provide a low noise figure solution along with higher TOI and higher RF survivability. This allows the selection of lower cost / lower loss limiters where receiver protection is required, since the LNA can tolerate higher RF leakage through the limiter. The utilization of GaN LNAs in some designs may make it possible to eliminate a discrete limiter component. Other areas of interest for GaN technology are found in high dynamic range mixers, RF and DC-DC switches. Advanced high-power, ultra-fast switches are in development for government contracts. TriQuint is exploring ways that GaN will change many 'everyday' RF, switch and control product applications for consumer electronics and mobile devices, all the way to satellites.

SPECIALIZED FOR DEFENSE GaN: UMS VIEWPOINT

Jean Pierre Viaud,
United Monolithics Semiconductors,
Villebon-sur-Yvette, France

The main initial driver for the development of GaN technologies within UMS is the requirement of the European Defence & Space market for systems offering enhanced performance. This is directly related to the position of UMS as the main European provider of strategic technologies for these applications. In addition to this, the Defence sector particularly has been an early adopter of GaN technology and products for applications in S- and C-Band radar systems for the replacement of TWTs and Si-based HPAs. In the longer term, GaN will enter EW systems offering a greater bandwidth and power capability and active antenna T/R modules replacing both the current GaAs HPAs and LNAs. Prototype products, with state-of-the-art performance, have already been demonstrated for each of these markets, and system evaluations are underway.

In the commercial telecom markets, the push towards broader bandwidths, higher power levels and reduced power consumption will see GaN products being progressively adopted. Applications here will include cellular base stations, VSAT terminal and point-to-point radio links. Of course, it will be essential to fully demonstrate that GaN can provide a solution with the right level of reliability and overall system cost saving to be able to displace existing mature technologies, e.g. LDMOS in base stations.

As well as these classical applications, the inherent power capability of GaN will open up completely new markets, particularly in the industrial area. However, we must keep in mind that the GaN technology is an emerging technology and is less mature and more expensive than GaAs and LDMOS for the time being. Therefore the market penetration of GaN technology is driven by two main aspects:

- System performances which cannot be obtained by existing less expensive technologies
- Cost saving at system level by architecture simplification due to the use of high performances components

UMS launched the development of in-house GaN technologies and products around seven years ago based on a close cooperation with various research labs (IAF and 3-5 Lab) and the support of European, French and German Defence and Space agencies. This activity has been focused on both a 0.5 µm (GH50) and 0.25 µm (GH25) technology on silicon carbide substrates. The former is targeted for the design of lower frequency very high power transistors, whereas the 0.25 µm version is intended for the development of MMIC products with frequency operation up to 20 GHz. The GaN and GaAs technologies are manufactured in the same facility and benefit from UMS' extensive heritage and background.

The introduction of this disruptive technology will enable companies to reinforce their existing market position in MMIC power devices and foundry services, and also to penetrate new markets through the creation of a brand new family of packaged high power transistors. At UMS, both GaN technologies are reaching the level of maturity required for market introduction. The 0.5 µm technology has undergone extensive reliability testing and is fully qualified (this technology is also being used by NXP to offer power transistor products to the market). The 0.25 µm technology is frozen and qualification has started.

General purpose unmatched power transistors are available for a wide range of applications including: military communication, radar, jammer, commercial telecom, SATCOM, industrial sensors with power levels from 15 to 80 W, operating up to 6 GHz. In addition, 50 Ohm internally matched transistors tunable over S- and C-Bands for SATCOM and radar applications and available in a fully hermetic metal ceramic package.

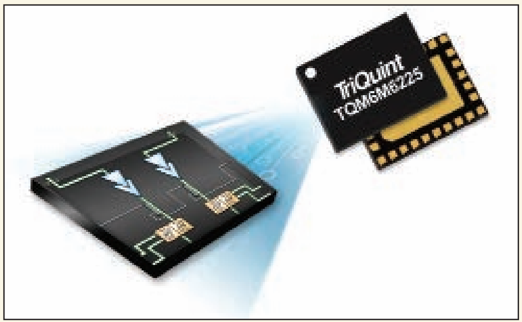
The 0.25 µm MMIC technology has now entered the qualification phase. A preliminary design kit including electrical and layout data is available for starting early access foundry cooperation, and has already been successfully used in many European Space and Defence projects. UMS has also developed several MMIC demonstrators on GH25 technology in order to validate the performance of the technology and to allow the release of products, once the qualification is completed:

- X-Band PA: 25 W / 50% PAE
- X-Band PA: 35 W / 45% PAE
- 6 to 18 GHz PA: 10 W / 20% PAE

The next steps in the development are planned and include continuous improvement of the production yield and performance of the existing technologies, including the transition from 3 inch to 4 inch wafers.

- Full qualification of 0.25 µm technology and full process release for foundry services
- Space evaluation of GaN technologies
- Release of new power transistors products: 150 W L-Band, 100 W C-Band, 7 W general purpose
- Release of first MMICs: 30 W X-Band, 10 W 6-18 GHz ■

Most Valuable Product



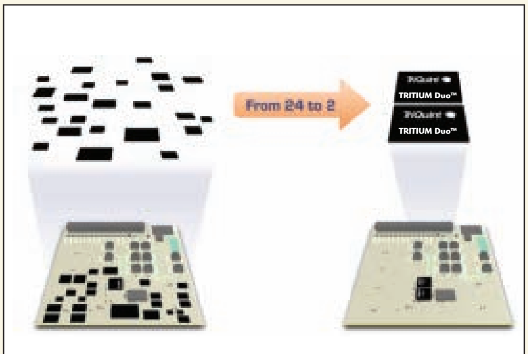
Dual-Band PADs for Next-Gen Mobile Devices

As next-generation mobile devices evolve, designers of smartphones, tablets and other handheld wireless products face daunting challenges. The seemingly insatiable demand for anytime, anywhere connectivity and high-speed data communications is driving a dramatic increase in front-end radio content. As new LTE networks deploy, many next-generation smart phones will contain up to 14 frequency bands for quad-band 2G roaming, quad-band 3G voice & data, dual- or tri-band 4G data, dual-band Wi-Fi, receive diversity, Bluetooth, GPS and FM radio. How do design engineers squeeze more RF content into small handheld devices without sacrificing performance and battery life?

TWO PADS REPLACE 24 DISCRETES FOR QUAD-BAND OPTIMIZATION

To help them accomplish this feat, TriQuint leverages its broad technology portfolio and integration expertise to combine active and passive components into compact modules, shrinking the precious PCB real estate occupied by RF components. To address the interference issues that arise with more radios, the modules match efficient power amplifiers (PA) with advanced filter technology to achieve lower insertion loss with higher noise rejection.

These small yet powerful integrated solutions deliver compelling advantages over discrete parts. An integrated power amplifier-duplexer module (PAD) or transmit module (TXM) can replace a handful of discrete parts with a far smaller footprint, while delivering greater efficiency, lower power consumption and better value.



▲ *Fig. 1 Two of TriQuint's dual-band TRITIUM Duo PADs can replace up to 24 discrete parts.*

Mobile device manufacturers have embraced these streamlined, high-performance solutions, and the combined PAD + TXM architecture has become the chosen solution for some wireless communications designs. During the past three years alone, TriQuint shipped more than half a billion PADs and nearly 150 million TXMs. This trend toward integration is expected to continue as new LTE networks drive band count even higher.

DRIVING RF INTEGRATION

Taking integration to new levels, TriQuint recently introduced what is reported to be the industry's first family of dual-band PADs for next-generation 3G and 4G smartphones, tablets and other mobile devices. The ultra-small TRITIUM Duo modules combine two high-performance PADs in the space of one. At 6 × 4.5 mm, TriQuint's new dual-band modules fit into a slightly smaller space than a standard single-band PAD of 7 × 4 mm (i.e., 27 mm^2 compared to 28 mm^2).

The industry's first 2-in-1 PADs integrate two band-specific power amplifiers and duplexers, voltage regulation circuits and an RF output detector — replacing up to 12 discrete components. A quad-band solution with two TRITIUM Duos is about 50 mm^2, half the footprint of a comparable discrete solution as shown in ***Figure 1***. By reducing design and assembly complexity, the modules speed time-to-market, a critical factor for mobile device manufacturers as product lifecycles become ever shorter in today's highly competitive global market. A lower BOM also can produce significant savings in inventory, qualification and manufacturing.

The 2-in-1 TRITIUM Duo modules optimize the PA and duplexer match to deliver greater overall system efficiency, optimal RF front-end performance and longer battery life. Unlike discrete parts, TriQuint's dual-band PADs do not need to match circuits between the interstage filter and power amplifier, or between the amplifier output and the duplexer input. This removes production variations that can result from the need to manually match discrete components on a phone board for every band and vendor combination.

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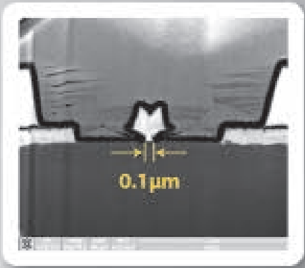
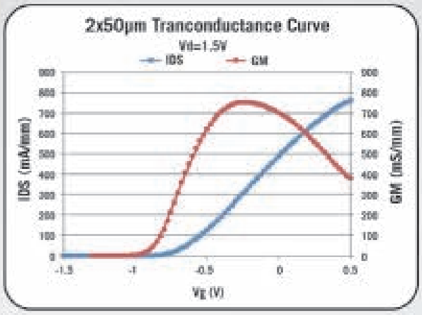
WIN is the world's largest and leading 6" GaAs foundry

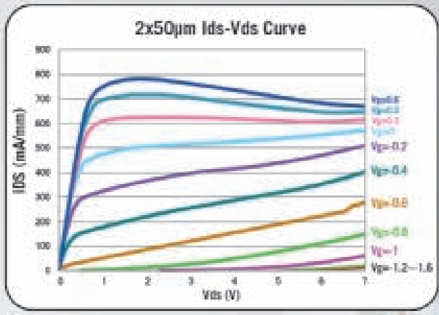
- 0.1μm gate length pHEMT technology
- 9V off-state breakdown voltage for power application
- Wafer thickness options of 50um (PP10-10) and 100um (PP10-11) available
- 860 mW/mm P_{sat} at 29GHz with Vd=4V
- 400 mF/mm^2 capacitor for design flexibility



PP10-10, 11 Tranconductance Curve



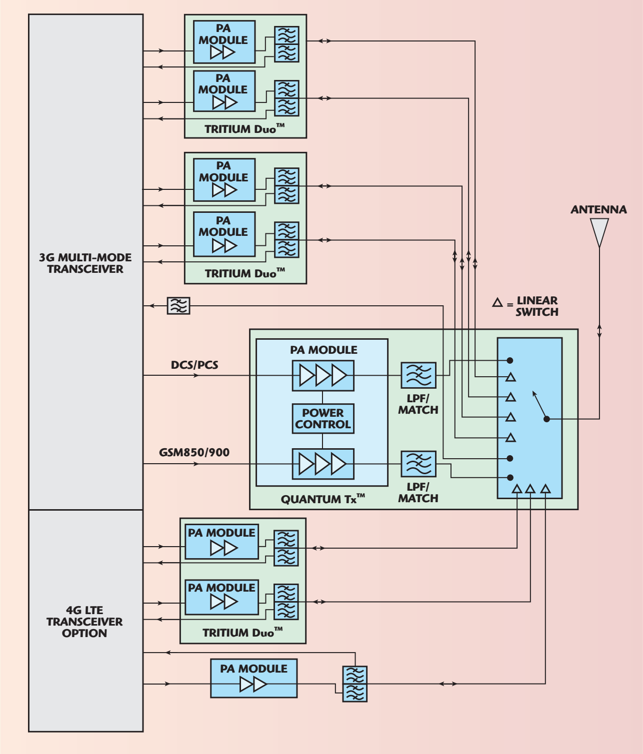
PP10-10, 11 I-V Curves



Comparison of WIN's millimeter wave pHEMT technologies

	PP25-21	PP15-50/51	PP10-10/11
Gate length	0.25μm	0.15μm	0.1μm
Operating Frequency	Up to 20GHz	Up to 30 GHz	Up to 90GHz
Max Drain Bias	8V	6V	4V
Max Id (Vg=0.5V)	490 mA/mm	630 mA/mm	760 mA/mm
IDSS (Vg=0V)	340 mA/mm	470 mA/mm	520 mA/mm
Max Gm	410 mS/mm	460 mS/mm	725 mS/mm
Vto	-1.15 V	-1.35 V	-0.95 V
Von (Diode turn on)	0.8 V	0.8 V	0.9 V
BVGD	20V (18V min)	16V (14V min)	9V (8V min)
f_T	65 GHz	90 GHz	130 GHz
f_{max}	190 GHz	185 GHz	180 GHz
Power Density (2x75μm)	1100 mW/mm @ 8V, 10GHz	870 mW/mm @ 6V, 29GHz	860 mW/mm @4V, 29GHz (2x50μm)

WIN SEMICONDUCTORS CORP. Tel:+886-3-397-5999 Fax:+886-3-397-5069 http://www.winfoundry.com



▲ *Fig. 2 TRITIUM Duo PADs and QUANTUM Tx transmit module are a complete RF solution.*

TABLE I

TRIQUINT'S VERSATILE TRITIUM DUO™ PADS INTEGRATE POPULAR BAND PAIRS

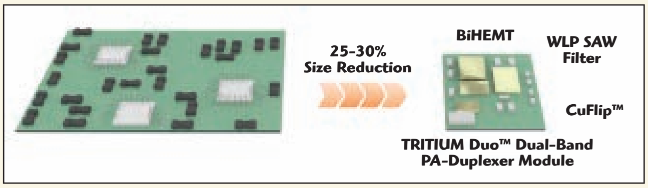
TriQuint TRITIUM Duo™ PA-Duplexers		
Band Pairs	***Duo Part #***	***Geographies Served***
Bands 1 & 4	TQM6M6214	North America, Europe, Africa & Asia
Bands 1 & 8	TQM6M6218	Europe, Africa & Asia
Bands 2 & 5	TQM6M6225	North & South America, Japan & Australia

The TRITIUM Duo's PAs are mated to the duplexers using only a single-section matching network, reducing loss by 1 dB and current consumption by 20 percent. For battery-powered devices, this is a significant benefit. In addition, the balanced Rx outputs make these modules ideal for use with the latest RF transceivers without the need for an external balun.

MIX-AND-MATCH BANDS FOR DESIGN FLEXIBILITY

TriQuint's TRITIUM Duo product family includes three distinct modules, each integrating two commonly used bands in one small footprint, as shown in ***Table 1***. The band pairs offered in the three products provide global coverage for regional variations across mobile device platforms. Designers can combine the integrated 2-in-1 TRITIUM Duo PADs to add or remove bands as needed to meet the needs of a specific wireless carrier.

The dual-band modules provide a scalable, mix-and-match solution. All three TRITIUM Duo modules share a common 6 × 4.5 mm size, giving designers the flexibility to use a similar, ultra-small footprint to support multi-band, multi-mode operations across multiple mobile product platforms. Mobile device manufacturers can capitalize on the dramatic size reductions to include more features or larger batteries in thinner, lighter form factors with all the performance needed for CDMA, 3G and 4G networks.



▲ *Fig. 3 Integration technology delivers ultra small 2-in-1 PAD.*

Paired with TriQuint's QUANTUM Tx™ family of transmit modules, the dual-band PADs form a complete RF front-end solution for multi-band, multi-mode smartphones and other mobile devices (see ***Figure 2***). Using its integration expertise to reduce PCB space requirements even further, TriQuint recently introduced two new QUANTUM Tx transmit modules that are 40 percent smaller than the previous generation, enabling more PCB layout flexibility.

DUAL-BAND PAD BENEFITS

TriQuint's TRITIUM Duo family provides several key benefits to mobile device vendors:

- **Smallest Size, Highly Integrated**
  - Two PAs and two duplexers in a module smaller than a single-band PAD
  - A quad-band solution (two TRITIUM Duos) is ~ 50 mm^2, half the footprint of a comparable discrete solution
- **Increased Flexibility**
  - Common family footprint simplifies design, speeds overall time to market
  - Mix & match popular band combinations across platforms
- **Lower Parts Count**
  - Replace up to 12 discrete parts with 1 PAD
  - Reduce BOMs: improve manufacturing & supply chain efficiency
- **High Performance**
  - Optimized for each of its two bands, no switching is required after amplification – unlike configurable architectures

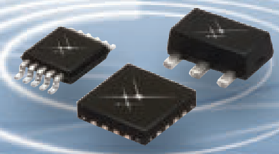
The dual-band TRITIUM Duo implements proprietary TriQuint CuFlip™ technology to replace wire bonds with copper bumps. This reduces PCB real estate and enables superior system performance by eliminating noise-radiating wires. The copper bumps also dissipate heat better than traditional interconnect techniques. The integrated CuFlip BiHEMT power amplifier die achieves low current consumption to provide maximum talk-time and thermal efficiency critical for smartphone applications (see ***Figure 3***).

The new TRITIUM Duo also employs a wafer level packaging (WLP) technique that eliminates bulky ceramic packages, significantly reducing size and increasing performance. The filter die is encapsulated within a polymer seal to create a protective air cavity around the filter area. This permits high-frequency operation and provides mechanical protection for the filter, enhancing performance. The approach also eliminates the ceramic cavity that would normally be needed around the duplexer, reducing overall size.

The dual-band modules feature two output power modes (high power mode/mid power mode), and low off and standby currents. This means longer talk times in portable applications, even without a DC/DC converter. The 2-in-1 PADs operate from a nominal battery voltage of 3 to 4.2 V. All control inputs are fully CMOS compatible and will interface easily with any modern baseband processor.

The TRITIUM Duo family is slated for production in September 2012.

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



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Handsets and Mobile Devices

Part Number	Description	Frequency (GHz)	Package (mm)
SKY65534	WLAN / Bluetooth® Front-End Module with Integrated PA, Filter, LNA, and T/R Switch	2.4	QFN 20L 2.5 x 2.5 x 0.45
SKY65535	WLAN Front-End Module with Integrated PA with Filter, LNA, and SPDT Switch	5.0	QFN 16L 2.5 x 2.5 x 0.45
SKY77701-16	High PAE Power Amplifier Module for CDMA / WCDMA / HSPA+ / LTE – Band I	1.92–1.98	10-pin MCM 3 x 3 x 0.9

WiFi Connectivity

Part Number	Description	Frequency (GHz)	Package (mm)
SE5516A	802.11ac Dual-Band Front-End Module with PA, LNA, and SP2T Switch	2.4, 5.0	LGA 4 x 4 x 1
SE5003L1	802.11ac Matched Power Amplifier with Harmonic Filter	5.0	QFN 20L 4 x 4 x 0.9
TT20P6-0709P0-1825E	High Power Infrastructure Filter can be Configured in a Pass Band Design	0.7–2.1	5" x 1.9" x 1"

Wireless Infrastructure

Part Number	Description	Frequency (GHz)	Package (mm)
SKY12210-478LF	High Power (100 W) T/R SPDT Switch, 44 dB Isolation @ 2.6 GHz	0.9–4.0	QFN 16L 4 x 4 x 1.5
SKY13419-365LF	CMOS DBS Switch Matrix with Tone/Voltage Detector High Isolation 40 dB @ 900 MHz	0.25–2.15	QFN 20L 4 x 4 x 0.9
SKY65185	Dual-Channel Variable Gain Amplifier Front-End Module with 31.5 dB Control Range	1.7–2.7	32-pin MCM 7 x 7 x 1.35
SKY65373-11	Variable Gain Low Noise Amplifier with High Linearity @ 35 dB and Low NF @ 1 dB	1.7	16-pin MCM 8 x 8 x 1.3
SKY67130-396LF	High Linearity Amplifier Driver with +16 dBm $OP_{1\,dB}$ and 39.5 dBm OIP3 @ 22 mA	0.7–2.7	DFN 8L 2 x 2 x 0.75
SKY73208	Wideband Rx Mixer with Integrated Integer-N PLL and VCO	0.35–5.0	36-pin MCM 6 x 6 x 1.35
SKYFR-000782	Single Junction Circulator with Very Low Insertion Loss of 0.08 dB Typical	2.11–2.17	Drop-in 19 mm
SKYFR-000827	Single Junction Circulator with Very Low Insertion Loss of 0.12 dB Typical	2.3–2.4	SMT – Robust Lead, 23 mm

Smart Energy—Connected Home and Automation 802.15.4, ISM, and ZigBee®

Part Number	Description	Frequency (GHz)	Package (mm)
SE2435L	High Power RF Front-End Module, 1 W High Efficiency with Integrated PA, LNA, and Diversity Switch	0.86–0.93	QFN 24L 4 x 4 x 0.9
SE2436L	High Power 0.5 W Front-End Module for ISM band applications, with PA, LNA, Bypass and Antenna Diversity	2.4	QFN 24L 4 x 4 x 0.9
SE2438T	Ultra Low Power ZigBee® Front-End IC with PA, LNA, Tx/Rx Bypass	2.4	QFN 20L 3 x 3 x 0.5
SKY65367-11	High Power / High Efficiency Tx/Rx Front-End Module with Integrated PA and Bypass	0.17	16-pin MCM 4 x 4 x 0.9
SKY67012-396LF	Low Noise Amplifier with < 0.85 dB NF and < 5 mA Current @ 3.3 V	0.3–0.6	DFN 8L 2 x 2 x 0.75

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Cold Cathode Magnetrons: Yesterday, Today and Tomorrow

M.N. Zybin
JSC Pluton, Moscow, Russia

One of the most important achievements in the microwave vacuum devices field over the last 30 years is the design and mass production of magnetrons with non-incandescent (cold) cathodes. In the U.S., these magnetrons are known as 'magnetrons with field cathode emission,' although they do also have secondary-electron emission.

The usage of the cold cathode magnetrons has particular advantages with regards to designing and developing new equipment which has certain advantages, such as:

- Instant availability without using the attendant and forced incandescence modes, which reduces reliability and shortens the equipment's lifetime.
- Possibility of short-range commutation and switching off equipment modes, including repeated changes of duty cycles as much as 100 times or more.
- Improved lifetime and dependability of the equipment, even under increased cathode loads because of the utilization of 'cold' cathodes.
- No heater chain failures, heater transformers or heater relays and switches means greater reliability and extended life.
- As there is no heater current and therefore no electromagnetic field, there is no modulation of the magnetron's electron stream and its frequency spectrum modulation.
- Simplified design results in reduced weight and size and subsequent cost savings.

JSC Pluton began to develop cold cathode magnetrons in 1974, with serial production starting in 1984. It seems strange that in 25 years of industrial production of magnetrons, the technology of non-incandescent magnetrons has not expanded greatly while other similar breakthroughs (such as multi-beam klystrons) have.

One reason is that the first cold cathode magnetrons did not have a long lifetime because they were built using impregnated secondary-emission emitters, which failed to work properly even in incandescent magnetrons when the temperature was lower than 900°C. In 1990, impregnated emitters were substituted for new palladium-barium emitters to provide a longer lifespan and greater stability. Until 2000, about 10 different types of non-incandescent magnetrons in the 2 and 3 cm wave range were built, some of which have a lifetime of 5,000 to 10,000 hours.

The development of the first 8 mm wave range magnetron with a cold cathode was completed in 2002. The testing of this model showed that the magnetron could have a life span of up to 5,000 hours. Up until now, JSC Pluton has developed and manufactured more than five different models of magnetron in the 8 mm wave range (12 inclusive of all modifications) with different output power levels.

Now, different types of non-incandescent magnetrons are produced. They have a frequency range of 8 to 40 GHz, pulse power of 1.5 to 50 kW and anode voltage of 4.5 to 12.5 kW. Modern magnetrons exhibit a great difference in the duty modes: the pulse length of new models is 0.05 to 6 μs, with a duty cycle from 0.005 to 0.0002.

The characteristics of cathode magnetrons mean they can compete with incandescent magnetrons and also have the advantage of instant readiness, longer lifetime, good reliability and economical operation. Presently, coaxial, ligament and rising-sun non-incandescent magnetrons with fixed or agile (tunable) frequency are manufactured.

The design and production technology of magnetrons are constantly being enhanced. Considerable invest-

▲ *Fig. 1 Ka-Band non-incandescent magnetron.*

ment and effort is required to support and develop the complex cathode technology, which is necessary for building more powerful and more short-wave non-incandescent magnetrons. Therefore, it should be noted that the complicity of the cathode technology, its connection to construction parameters of magnetrons and interaction space peculiarity do not allow the license-free production of non-incandescent magnetrons. ***Figure 1*** shows a Ka-Band non-incandescent magnetron with a minimal pulse power of 16 kW and the maximum weight of 360 g.

The growth in the production of cold cathode magnetrons can be achieved in several ways. The first is the development of more powerful magnetrons in frequency ranges that have already seen magnetron development. By increasing a magnetron's output power, the anode voltage will also be increased, providing better conditions for cathode field emission. However, due to their heavy weight, high cost and complexity of use, along with the high power anode voltage, the demand for such powerful magnetrons is quite low.

The second way is to develop magnetrons in the 80 to 150 GHz frequency range. This approach has great potential but needs significant investment in the development of a cathode which will be able to produce the necessary emission current density.

The third and probably the most feasible option is to find new, effective methods of cold cathode magnetron application that exploit its advantages of instant readiness, high pulse power allied to low supply voltage, small dimensions and weight, mass production, easy operation, high efficiency and low cost of operation.

A prime example of this is the production of millions of microwave oven magnetrons in different countries all over the world. In the author's opinion, a good prospect would be the use of cold cathode magnetrons for fuel ignition in car engines. According to the Patent Appl. U.S. 2007/0240660 A1, the CO blowout will decrease by ten times and the fuel flow will decrease by three times when using the non-incandescent magnetron for fuel ignition in the engine combustion chamber.

It is estimated that in big cities alone Light Motor Vehicles (LMV), will have an economy of 500 liters of fuel in the first 10,000 km, which equates to approximately $1,000. Through mass production of such cold cathode magnetrons (with the power supply included) the manufacturing cost will be much lower and the magnetron's life span of 5,000 to 10,000 hours would result in an expectancy of journeys of around 200,000 to 500,000 km without magnetron replacement.

Thus, if LMVs can be built using the energy efficiency and ecological engines utilizing the microwave energy of cold cathode magnetrons, they would make a considerable contribution to addressing big cities' ecological problems. On top of that, the necessary investment would be much lower than those required for making all vehicles electric and generating the associated extra power that will be needed to run them.

Examples such as these illustrate the potential for developing highly efficient non-incandescent magnetrons for different projects in various fields with the design of more powerful and high frequency cold cathode magnetrons and their application remaining of major significance. ■

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OCTAVE BAND LOW NOISE AMPLIFIERS

Model No.	Freq (GHz)	Gain (dB) MIN	Noise Figure (dB)	Power-out @ P1-dB	3rd Order ICP	VSWR
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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Cobham Awarded U.S. $39 M U.S. Navy Program for AN/ALQ-99 Low Band Transmitters

Cobham has been awarded a U.S. $39 million contract from the U.S. Naval Air Systems Command (NAVAIR) to manufacture the AN/ALQ-99 Low Band Transmitter-Antenna Group (LBT-AG) for U.S. Navy and Marine Corps EA-6B and EA-18G electronic warfare aircraft. The contract is a modification to a previously awarded firm fixed price full rate production contract to exercise an option for 48 low band transmitters; 13 vertically polarized antennas; and 28 horizontally polarized antennas associated with the AN/ALQ-99 low band transmitter antenna group. The contract's initial award procured 60 low band transmitters and an associated number of antenna assemblies in a variety of configurations. "Cobham's low band transmitter has a legacy of reliability and operational excellence," said Jill Kale, vice president of Cobham Sensor Systems. "Activating this option to the fixed price contract is aligned with the Navy's acquisition strategy, and capitalizes on our expertise."

> *"Cobham's low band transmitter has a legacy of reliability and operational excellence..."*

The AN/ALQ-99 LBT-AG, developed by Cobham Sensor Systems, has been in production since 2005. The LBT is designed to protect strike aircraft, ships, and ground troops by disrupting enemy radar and communications. It is flown on U.S. Navy EA-6B Prowler and EA-18G aircraft and Marine Corps EA-6B aircraft, and has been used in combat operations. All work will be performed in Lansdale, PA and is expected to be completed by August 2014.

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Raytheon's JLENS and Patriot Systems Prove Integration in Successful Intercept Tests

Two Raytheon Co. systems, the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) and the Patriot Air and Missile Defense System, demonstrated their ability to work together to detect, track and shoot down a test target simulating a hostile cruise missile during an exercise at the Utah Training and Test Range. This test reinforces the ability of Raytheon systems to integrate in support of a comprehensive air and missile defense strategy involving multiple sensors and interceptors.

"When systems like JLENS, Patriot and others work together, the capability of our nation's air and missile defenses is significantly improved," said David Gulla, vice president of Global Integrated Sensors for Raytheon's Integrated Defense Systems business. "In simple terms, our defenses are tighter and harder to penetrate, resulting in greater protection for warfighters, civilian populations, critical assets and infrastructure."

In addition to destroying the target drone, initial indications are that the JLENS-Patriot systems integration met test objectives. The JLENS surveillance system was evaluated on its capabilities to detect and track a long-range threat and then cue the fire control radar. In turn, the fire control system was evaluated on its ability to track and transmit target data to Patriot computers. All data from the exercise will be analyzed closely against test parameters.

> *"When systems like JLENS, Patriot and others work together, the capability of our nation's air and missile defenses is significantly improved..."*

JLENS is designed primarily to detect and track hostile cruise missiles; however, it is also capable of detecting and tracking low-flying aircraft and unmanned aerial systems. JLENS also incorporates the capability to detect and track ballistic missiles, large caliber rockets and surface targets on land and sea. A JLENS system, referred to as an orbit, consists of two tethered 74-meter aerostats with radar and communications systems incorporated on each. The aerostats elevate the radar and communications systems to 10,000 feet. The surveillance radar provides 360° coverage and the fire control radar provides sectored precision tracking for hundreds of miles over land and sea.

The Patriot Air and Missile Defense System, the other major player in the integrated fire control exercise, is combat-proven and a key component in the air and missile defenses of 12 nations. Patriot is effective against a full range of advanced threats, including enemy aircraft; tac-

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tical ballistic missiles; cruise missiles, as demonstrated in this exercise; and unmanned aerial systems. Raytheon is the prime contractor for JLENS and domestic and international Patriot systems, as well as systems integrator for Patriot Advanced Capability-3 missiles.

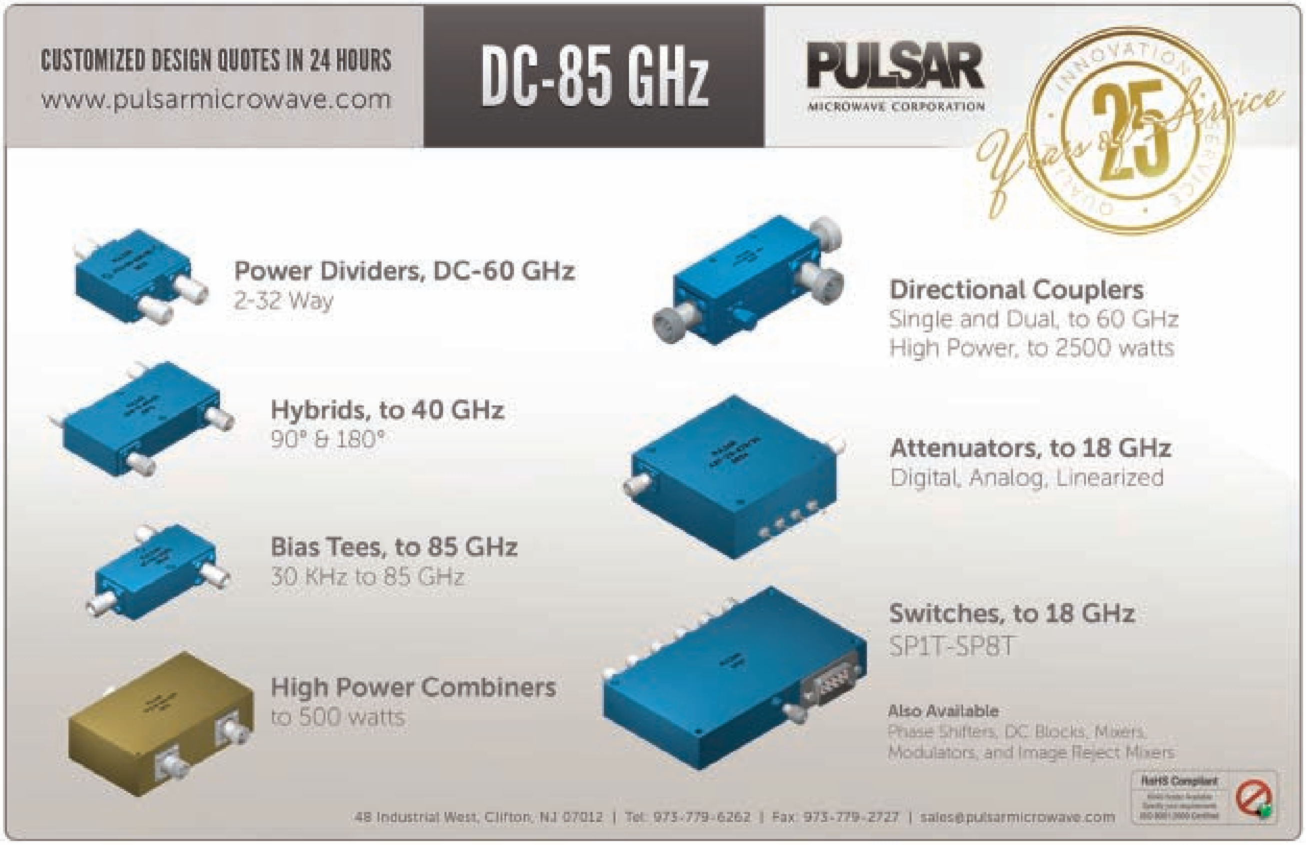
U.S. Army Awards Lockheed Martin $391 M for Counterfire Radar Production

The U.S. Army awarded Lockheed Martin $391 million in production orders for a new radar system that provides soldiers with enhanced 360º protection from rocket, mortar and artillery fire. The orders represent the execution of two contract options for a total of 33 AN/TPQ-53 (Q-53) counterfire target acquisition radars – formerly designated EQ-36 during their development and initial production – to be delivered by the end of 2014. The options include spares, testing and training materials. If all options are exercised, 38 additional low- and full-rate production systems could be added and the total contract value would exceed $800 million.

"The Q-53 is in production and has been battlefield-proven by the U.S. Army in Iraq and Afghanistan," said Lee Flake, program director for counterfire target acquisition radar programs at Lockheed Martin's Mission Systems & Sensors business. "The radar detects, classifies and tracks enemy indirect fire, as well as locating its source, in either 360º or 90º modes that give soldiers greater protection than ever before."

"The radar detects, classifies and tracks enemy indirect fire, as well as locating its source, in either 360º or 90º modes that give soldiers greater protection than ever before."

Mounted on a five-ton truck, the Q-53 can be rapidly deployed, automatically leveled and remotely operated with a laptop computer or from a fully equipped climate-controlled command vehicle. Lockheed Martin won the competitive development contract for the EQ-36 radar in 2007. Responding to urgent needs statements from theater and following early program successes, the Army awarded the company an accelerated contract for 12 initial production systems in July 2008 and a contract with options for an additional 20 systems in April 2010. In the fall of 2010, the Army began deploying EQ-36 systems to combat in Iraq and Afghanistan. Lockheed Martin submitted its bid for this current contract in open competition in September 2011. Work on the Q-53 radar contract will be performed at Lockheed Martin facilities in Syracuse, N.Y., Moorestown, N.J., Akron, Ohio, and Clearwater, Fla.



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Chalmers Receives SEK 50 Million for New Research Infrastructure

Chalmers University of Technology will receive just over SEK 50 million from the Knut and Alice Wallenberg Foundation, the largest private financier of research in Sweden. In 2012, the foundation will concentrate on nanotechnology and life science – two of Chalmers' Areas of Advance. Chalmers Nanofabrication Laboratory will receive SEK 22 million that will be used for new nanolithography equipment, while the Onsala Space Observatory will use their funds for two new radio telescopes.

The Chalmers Nanofabrication Laboratory will purchase the equipment needed for Swedish nanotechnology research to maintain its world-class position. The funds will primarily be used for a new electron beam lithography (EBL) system, which is a technology used to produce electronics components and other nanosized structures. Chalmers is the node for electron beam lithography within Myfab, the Swedish national research infrastructure. The technology is very important within nanotechnology and has been a prerequisite for several important research breakthroughs from Chalmers recently.

"The grant will allow us to purchase the latest technology to ensure that Swedish nanotechnology research stays at the cutting edge of development," said Peter Modh, department head at the Nanofabrication Laboratory. "Amongst other things, we will be able to use the equipment to cut the size of the smallest producible features in half."

Onsala Space Observatory will receive SEK 29.7 million to build two new radio telescopes. "The two antennas, each 12 metres in diameter, will work together in a network of similar telescopes currently being built and planned all over the world," said Robert Cumming, astronomer and communication officer at Onsala Space Observatory. "By observing galaxies billions of light years away, the twin telescope and its siblings around the world will be able to determine their positions on the Earth – and in space – with ten times better precision than is possible today."

TSB Sets Up Satellite Applications Catapult

The UK government has taken the next step to establish an innovation centre for satellite technology and applications. The Satellite Applications Catapult centre, which will help UK businesses develop new satellite-based products and services, will be established by a consortium of industry pioneers including: Surrey Satellite Technology Ltd. (SSTL), Logica, Astrium GEO-Information Services, Nottingham Scientific Ltd. (NSL) and Inmarsat Navigation Ventures Ltd.

A delivery team will be established with the consortium members, the International Space Innovation Centre (ISIC), UKspace and the University of Surrey. The Technology Strategy Board is the government agency that oversees the establishment of the Catapult. It will work with the consortium to help establish the centre, which is expected to open later in 2012.

Iain Gray, chief executive of the Technology Strategy Board said: "Satellite services are expected to be an important growth area for the UK economy in the next decade and beyond. Worldwide, the Space sector is expected to grow to £400 B by 2030. The Satellite Applications Catapult will work with the UK Space Agency to achieve targets set out in the UK Space Innovation and Growth Strategy to grow UK market share from 6 to 10 percent by 2030 and create 100,000 new high value jobs."

"Satellite services are expected to be an important growth area for the UK economy..."

Paul Febvre, project director for the consortium said: "We are looking forward to actively working with SMEs and wider UK space community to create a world-leading centre of expertise and facilities for satellite data processing and product development." He continued: "The UK already has a world-class capability across the space sector, especially in the areas of advanced manufacturing, satellite operations, telecommunications and Earth observation. The new Catapult will ensure that the UK is in a position to consolidate and strengthen its position."

JSC Guide to Costs and Benefits of Smart Grid Projects

The Joint Research Centre (JRC) has released a set of guidelines for conducting cost-benefit analysis (CBA) of smart grid projects. The report extends to smart grids the recent JRC work on guidelines for CBA of smart metering deployment, which served as a technical basis for the European Commission (EC) Recommendation on smart metering deployment, adopted in March 2012.

The study serves as key input to the definition of an eli-

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gibility assessment framework for 'common interest' smart grid projects, according to the provisions of the EC proposal for a regulation on guidelines for trans-European energy infrastructure.

The proposed approach to the cost-benefit analysis comprises three main parts: the definition of boundary conditions (e.g. demand growth forecast, local grid characteristics) and of implementation choices (e.g. roll-out period, chosen functionalities), the identification of costs and benefits, and a sensitivity analysis of the CBA outcome to variations in key variables/parameters (e.g. discount rate, peak load transfer).

The study also provides guidance on the identification of externalities and social impacts (e.g. consumer inclusion, competitiveness) that can result from the implementation of smart grid projects but that cannot be easily monetised and factored into the cost-benefit computation.

EEN Partners with EUREKA to Boost SMEs

In its latest newsletter, Enterprise Europe Network (EEN) announced its close partnership with EUREKA, aiming to bring new technologies to SMEs. Specialising in services to SMEs, EEN has been helping to launch several research projects within the framework of the joint EUREKA-EU Eurostars programme. Eurostars is the first European funding and support programme to be specifically dedicated to R&D-performing SMEs. The first results of the collaboration are already visible and new innovative projects are being put on track every week.

The Commission is also working closely with three other European organisations – the European Space Agency (ESA), the Joint Research Centre (JRC) and the European Organisation for Nuclear Research (CERN) to help even more entrepreneurs enter new markets and explore technologies.

"…opening up new possibilities for cross-sectoral downstream technology transfers to SMEs."

"The idea is to use technology offers from these Technology Supplying Partners for the Network's partnership databases – opening up new possibilities for cross-sectoral downstream technology transfers to SMEs. Besides tweaking profiles for the Network's databases, they also plan to host representatives of the organisations at their meetings or involve them in brokerage events," reads EEN's newsletter.

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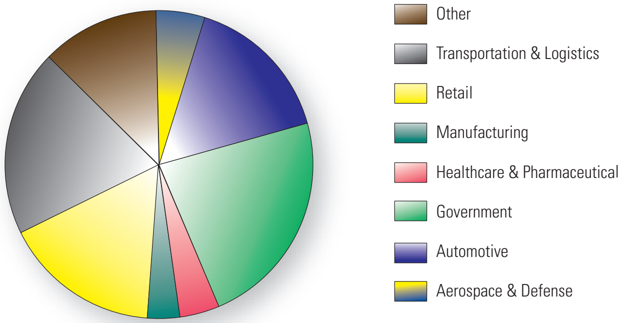
Dan Massé, Associate Technical Editor

The RFID Market Will Be Worth Over $70 B Across the Next Five Years

The market for RFID transponders, readers, software, and services will generate $70.5 billion from 2012 to the end of 2017. The market was boosted by a growth of $900 million in 2011 and the market is expected to grow 20 percent YOY per annum. Government, retail and transportation and logistics have been identified as the most valuable sectors, accounting for 60 percent of accumulated revenue over the next five years.

ABI Research's new study, "RFID Market by Application and Vertical Sector," provides a comprehensive overview and summary of the impact that the latest product launches, new entrants, and changing market dynamics will have on the future direction and evolution of the market. It provides an excellent introduction and guide for those new to the market, as well as a timely update for those experienced within the RFID market.

RFID System Revenue by Product Category
Worldwide Market: 2011



Source: ABI Research

63% of Asia's Carriers Have LTE Rolled Out, Are Conducting Trials, or Have Plans

In 2002, Asia-Pacific mobile operators lagged behind their North American and European counterparts in terms of service development. Fast forward to the present day and the situation is very different. Out of 110 networks, 10 operators (9 percent) have commercial 4G LTE networks up and running. Another 58 (53 percent) either have specific plans to roll out LTE or are conducting trials.

"We estimate total Asia-Pacific mobile capital expenditure to reach US$53.3 billion by the end of 2012," says Jake Saunders, vice president of forecasting. "62 percent is still very much earmarked for radio access network deployment. Other key investment areas include EPC and gateway upgrades to the core network at 9 percent, as well as improving in-building wireless coverage into dense urban centers at 5.7 percent."

Evidence for this equipment spend can be seen in a number of markets:

- In China, 4G licenses have yet to be issued, but that has not stopped China Mobile from making plans. In 2Q-2012, China Mobile announced that it had completed a six city TD-LTE trial. The 655 million subscriber operator plans to ramp up its TD-LTE base station count to over 20,000 TD-LTE base stations by December and 200,000 by 2013. China Unicom is focusing on accelerating its 3G network build-out, optimizing 2G network coverage, and expediting indoor coverage. China Telecom is focused on implementing telecom cloud and value-added services projects.
- Heavy RAN investment has been taking place in India. A number of operators are jockeying for position in a very competitive marketplace. On April 10, Bharti Airtel became the first operator to launch 4G LTE services in India, in Kolkata. Bharti Airtel hopes to launch 4G services in Bangalore. Equipment spend is not just occurring in 4G. The Indian operator, Idea, has continued to roll out 2,270 2G cell sites and 1,176 3G cell sites in the past year.
- Southeast Asia has seen a strong commitment to 4G, with commercial networks up and running in Malaysia (likely WIMAX over LTE), Singapore and the Philippines.

ABI Research's study, "Asia CapEx, Core & Radio Access Network Infrastructure Forecasts," focuses on the Asia-Pacific region and includes a range of wireless base station data.

Mobile Device Segment is a Shining Light in Lackluster Semiconductor Market

Mobile device semiconductors were one of the few bright spots in a chipset market that stalled in 2011. Revenue from chipsets designed for mobile devices increased by more than 20 percent to $35 billion, while the total semiconductor market limped out of 2011 with just 2 percent year-on-year growth.

"It's tempting to describe this industry as lackluster," says Peter Cooney, practice director, semiconductors. "But then, some segments of the semiconductor market are booming and vendors concentrating on the mobile device sector have delivered very healthy growth in 2011."

Shipments of mobile devices such as smartphones, media tablets, and e-book readers are growing fast and are driving growth for a range of semiconductor components including modems, applications processors, wireless connectivity ICs, MEMS sensors, and audio ICs.

Platform ICs (including modems, applications processors, RF components, and PMUs) account for the bulk of overall revenues, but are becoming an increasingly competitive section of the market. Suppliers including Qualcomm, ST-Ericsson, MediaTek, Intel, Texas Instruments, Broadcom, Marvell, and Renesas Mobile have positioned

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themselves as platform solution suppliers and the top 10 suppliers now account for more than 75 percent of total revenues and their dominance will continue to build as niche suppliers are acquired or muscled out of the market.

iPad and Tablets are Hot but Not Yet a Laptop Replacement

Amazon's Kindle Fire may have captured headlines in late 2011, but even after establishing a new key price point to help fuel strong sales/interest by consumers for media tablets beyond Apple, the device category has yet to quell interest in portable computers. One in three respondents in an ongoing tracking study said they plan to purchase a laptop computer in the first half of 2012.

Additionally, 16 percent of respondents to ABI Research's Technology Barometer also said they plan to acquire a media tablet. Consumers expressed greater purchase intent in both computing form factors compared to the previous survey. "U.S. consumers are holding on to home PCs longer," says consumer research group director Jeff Orr. "This has created a near-term opportunity for the incremental purchase of media tablets. Consumer interest also remains strong for laptops, which include the new, slimmer Ultrabook segment."

Media tablets, however, are taking market away from the U.S. netbook opportunities, which continue to see less purchase intention from consumers surveyed. Netbooks remain a significant contributor to emerging markets, where home PC penetration remains low.

U.S. PC desktop ownership fell, from 81 percent of respondents down to 75 percent in the latest results, while Windows PC laptop ownership climbed to 64 percent from 61 percent. Apple laptops also continue to gain share, capturing 11 percent of respondents in the most recent survey, up from the previous 9 percent. Amazon's Kindle Fire, as well as other lower-priced media tablets, helped boost Android's position, doubling its previous 3 percent share. Apple meanwhile boosted its iPad position to 8 percent of respondents (up from 5 percent).

"User experience and pricing are key levers for media tablet manufacturers when competing against Apple," says Orr. Amazon's Kindle Fire jumped to the second position behind Samsung for Android media tablet market share after less than one month on the market. "Apple's lead is safe for the time being, though the sheer number of competitors will continue to whittle away at the iPad's market share, particularly when more consumers embrace tablets as laptop alternatives."

ABI Research's two surveys, "Wave 3 US Computer Purchase Intent," and "Wave 3 US Computer Ownership," track consumer behavior, purchase intent, brand preferences, and devices within the digital home.

Around the Circuit
Laura Glazer, Staff Editor

INDUSTRY NEWS

Agilent Technologies Inc. and **Centellax** have signed a definitive agreement for Agilent to acquire the assets of Centellax's test and measurement business. Centellax designs and manufactures key technology and products such as bit-error ratio testers and signal generators used for testing high-speed digital communication systems and components. The acquisition will help Centellax's and Agilent's customers obtain comprehensive insight into their high-speed devices with a full spectrum of test solutions. Centellax's test and measurement business augments Agilent's current position and ongoing investments to cover all requirements in digital I/O and optical transceiver test from deep characterization in R&D to cost-effective test in manufacturing up to 32G and beyond.

DragonWave Inc. has reached an amended agreement for DragonWave's acquisition of **Nokia Siemens Networks**' microwave transport business including its associated operational support system and related support functions. The amended agreement simplifies the transaction, and is intended to provide both companies with greater flexibility to adapt to changing market environments and enhance the delivery of customer-valued product features. In accordance with the amended agreement the planned closing date was June 1, 2012, subject to closing conditions. Under the terms of the amended agreement, DragonWave becomes the preferred strategic supplier of packet microwave and related products to Nokia Siemens Networks and the two companies are to jointly coordinate technology development activities.

Indra has bought 100 percent of the shares in the air traffic management systems company **Park Air Systems Norway** from its owner **Northrop Grumman Denmark**. The transaction values Park Air Systems' Norway business at an enterprise value of €42 million. Park Air Systems Norway's global consolidation into Indra increases Indra's 2012 revenues growth target from 6.5 to 7.5 percent up to 8 to 9 percent, with all other targets remaining unchanged. Following the acquisition, the Norwegian company will operate as an independent Indra subsidiary and will be re-named Indra Navia, a return to using the name Navia Aviation under which it was originally founded.

Rosenberger of North America LLC has completed its acquisition of **Toth Inc.** The two companies formed a strategic alliance in May 2011 and announced that they were in talks to merge. The terms of the agreement were not announced. Toth Inc. will continue to operate from its Pennsauken, N.J. facilities with the current management team.

Thales has completed the acquisition of **Tampa Microwave**. The announcement follows completion of a review of the acquisition by the Committee on Foreign Investment in the United States and its determination that there are no national security concerns with respect to the transaction. Like many of Thales's own products, Tampa Microwave's manpack terminals were specifically designed for the dismounted soldiers who operate in dangerous environments.

ANSYS and **FMC Technologies** have executed a long-term strategic agreement for simulation software that can standardize design analysis and provide scalability for growth. ANSYS solutions provide multiphysics depth and breadth, accuracy, and high fidelity to deliver innovative products and processes.

PCTEL Inc. announced that the **U.S. Patent and Trademark Office** notified PCTEL that its patent application, which describes an invention that will protect antenna installations from vandalism, will issue as U.S. patent number 8,162,698. The patent, entitled "Vandal Proof NMO Antenna Mount" should have great value to the industry and PCTEL will introduce a new product line based upon the vandal-proof design. The inventor, Brandon Johnson, is a 2007 University of Michigan Engineering graduate who was recently promoted to director of PCTEL's China Manufacturing Operations. The new NMO Vandal Proof antenna mount (NMO-VP) applies to both vehicular and fixed station installations. The vandal-proof invention locks the antenna in place with a unique design that prevents removal from its base.

Officials with **QinetiQ North America**, **Wyle**, and **Kratos Defense & Security Solutions Inc.** through its wholly owned subsidiary of **Digital Fusion Solutions Inc.** announced forming **QWK Integrated Solutions LLC** (QWK) – a joint venture that combines the legacy of enduring local affiliations strengthened by the influence of extended corporate resources. The initial pursuit of QWK will be the D3I contract in support of SMDC/ARSTRAT.

Representatives from **IKE Micro** were presented with **Raytheon**'s 5 Star Award at the annual Supplier Excellence Awards and Dinner Event on May 15th. The 5 Star Award is given to suppliers who meet a minimum purchase requirement with Raytheon, have an acceptable D&B SER rating, and maintain a 100 percent on time delivery and 100 percent quality rating over a 12 month period. IKE Micro is one of 31 suppliers, of the thousands of worldwide Raytheon suppliers, to receive the prestigious award from the defense contractor.

CONTRACTS

Harris Corp. has been awarded an Indefinite Delivery, Indefinite Quantity (IDIQ) contract with a potential total value of $400 million to provide the U.S. Special Operations Command with next-generation communication capabilities. The new five-year IDIQ contract enables the Special Operations


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Mercury Computer Systems Inc. has received a contract from a major defense prime contractor to provide high performance digital signal processing modules and software to facilitate a technology refresh for the prime's airborne radar application. The Mercury solution and subsequent refresh will also protect the prime's significant investment in software development across a range of products. The design win is estimated to have a five-year probable revenue value of approximately $30 million.

TriQuint Semiconductor Inc. has been selected by the Defense Advanced Research Projects Agency (DARPA) to lead a $12.3 million development program focused on ultra-fast GaN switch technology for the Microscale Power Conversion (MPC) program. TriQuint's new GaN modulator has the potential to enable highly-efficient RF transmitters substantially smaller than current solutions. TriQuint was selected by DARPA as the prime contractor for MPC Technical Area I, which seeks to develop a high-speed, DC-to-DC switch (modulator) and related process technology based on the company's innovative enhancement-mode GaN transistors.

Thales Alenia Space Deutschland GmbH has signed a contract, worth up to €4 million, with **Thales Alenia Space-France** in the frame of the Meteosat Third Generation (MTG) weather satellites. This contract includes the development and the validation of the operations Satellite Simulator (SATSIM), as well as the Payload Data Generator for all the satellites.

Comtech Telecommunications Corp.'s Santa Clara, CA-based subsidiary, **Comtech Xicom Technology Inc.**, received a $4.5 million order from a domestic prime contractor to supply solid-state high-power amplifiers to support the U.S. military. These solid-state high-power amplifiers will be used in small transportable military tactical SATCOM terminals to support worldwide U.S. military missions in environmentally demanding locations.

Raytheon Co. has been awarded an 18-month, $1.8 million contract by DARPA to develop next-generation GaN devices bonded to diamond substrates. The technology, called Thermally Enhanced Gallium Nitride (TEGaN), seeks to increase the power handling capability of GaN devices by at least three times. TEGaN enables state-of-the-art transistors and MMICs to achieve their full performance potential by reducing thermal resistance.

Nitronex has been awarded a Phase I SBIR to develop a highly efficient 20 W X-Band GaN power amplifier MMIC for use in long range RF telecommunications. Since 2005, Nitronex has won 16 government contract awards that have funded the development of materials, devices, discretes, MMICs, and process technologies, as well as manufacturing maturation. This is the third X- or Ka-Band contract awarded to Nitronex, further enhancing Nitronex's state-of-the-art GaN-on-Si power amplifier technology.

PERSONNEL

XMA Corp.'s board of directors has appointed **James Doyle** as its new president and CEO. Doyle is an accomplished leader with a proven track record of creating well-targeted strategies that achieve business objectives. Most recently, Doyle worked as the Congressional Affairs Liaison for Emerson Embedded Computing in a Washington D.C. Fortune 100 company.

Rogers Corp. announced the appointment of **Helen Zhang** as president of Asia Region to oversee the company's growing business in Greater China and throughout the Asia-Pacific region. Zhang will be responsible for driving Rogers' growth strategy in Asia across the company's three core businesses of printed circuit materials, power electronics solutions and high performance foams. Zhang joins Rogers from Dow Chemical where she served most recently as global general manager for the Interconnect Technology business of Dow Electronic Materials. Prior to Dow, she spent 20 years with Rohm and Haas in leadership positions in its Paint & Coatings, Adhesives & Sealants, and Specialty Polymer businesses, and managed two Asian joint ventures.

▲ Michael Yantz

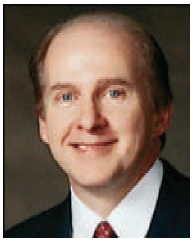
Teseq Inc. has hired **Michael Yantz** as its new vice president of business development. Yantz, a veteran in the EMC testing industry, will focus on cultivating new North American and international sales channels and opportunities for Teseq while expanding the company's reach into new markets. Before joining Teseq, Yantz worked for Instruments for Industry, where he served for more than 12 years most recently as a senior vice president. Prior to that he amassed 17 years with LogiMetrics in a variety of technical and managerial positions including customer service, engineering, sales and new product marketing.

CRFS, the Cambridge (UK) developer and manufacturer of RF spectrum management and surveillance systems has set up a U.S. subsidiary company, **CRFS Inc.**, to better serve and support the North American market. It has opened an office in California and recruited **Malcolm Levy** to head up its U.S. operation. Levy brings over 20 years' experience as a sales and marketing executive in test, measurement and wireless. An engineering background in RF and communications makes him ideally suited to the role.

▲ Nickolas Kingsley

Auriga Microwave announced the promotion of **Nickolas Kingsley** to director of engineering. Kingsley will assume responsibility for managing Auriga's RF/microwave engineering team while **Yusuke Tajima**, Auriga's CTO, will focus on driving Auriga to the elite heights of GaN- and GaAs-based RF microwave front-ends.

Around the Circuit



▲ Jerry Neal

RF Micro Devices Inc. announced that **Jerry Neal**, co-founder and executive vice president of marketing, has retired from RFMD. Neal has had a distinguished career in the communications technology industry, including the co-founding of RFMD and his role in the subsequent growth of RFMD. As a co-founder of RFMD, Neal was responsible for securing the company's initial venture capital investment, as well as multiple licensing deals, branding, and mergers and acquisitions. Neal was also primarily responsible for many of the company's corporate relationships, including TRW (now Northrop Grumman), Nokia, IBM, TowerJazz, and others.

REP APPOINTMENTS

Aeroflex Ltd. has signed a licensing agreement with **Qualcomm Inc.** to supply manufacturing test technology for RF devices. This worldwide commercial Factory Test Technology License gives Aeroflex the ability to provide Qualcomm customers with efficient automated manufacturing test solutions. Aeroflex will be able to validate its test solution against Qualcomm cellular mobile devices and provide data to Qualcomm's customers. Additionally, Aeroflex will have access to software tools and technical support direct from Qualcomm.

Anaren Inc. will be marketing its new family of Anaren Integrated Radio (AIR) modules with online electronics distributor **Digi-Key Corp.** The move to partner with Digi-Key is Anaren's first initiative to stock one of its technologies through the renowned online distributor and is expected to be a valuable sourcing option for AIR module customers.

Giga-tronics Inc. announced the appointment of **Bentive LLC** as new sales representatives for northern California, to cover its growing business in RF and microwave test and measurement equipment. The products include the company's high-performance microwave signal generators, broadband microwave power amplifiers, and extensive line of power meters and power sensors.

Richardson RFPD Inc. has completed a distribution agreement with **PriaTherm**, a European-based provider of reliable and innovative solutions in the thermal management industry. With this agreement, PriaTherm provides Richardson RFPD with a source to assist its European customers with fabricated heat sinks for high power RF, as well as energy and power management, applications.

Spacek Labs has appointed **The Thorson Co.** of Signal Hill, CA, to represent Spacek Labs in southern California. The Thorson Co. has over 50 years experience as sales representatives.

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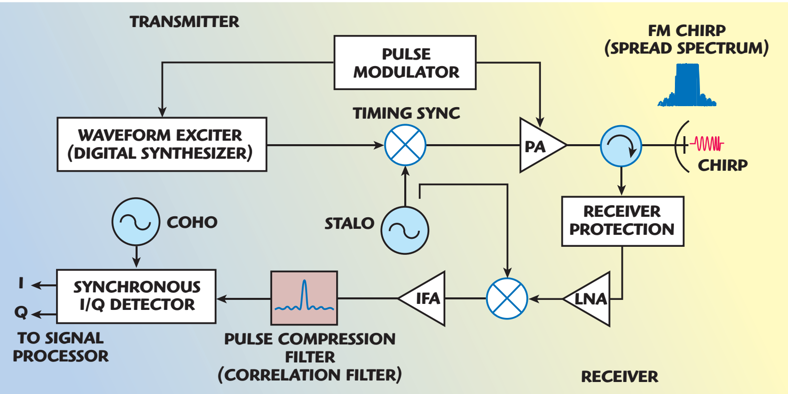
IF/RF MICROWAVE COMPONENTS

Techniques for Time Sidelobe Measurements with Pulse Compression Radar

In a radar system, the use of pulse modulation or "compression" provides enhanced spatial resolution as well as an extended range for a given output power level. Consequently, this technique is widely used in current- and next-generation radar systems. A simple block diagram of a compressed pulse radar system is shown in ***Figure 1***.

An expanded Linear Frequency Modulated (LFM) chirp pulse is one option for the transmitted pulse. The received pulse is down converted and processed by the matched or correlation filter, whose frequency response is a complex conjugate of the coded filter. The compression filter readjusts the relative phases of the frequency components with the appropriate delay so that a narrow compressed pulse is reproduced. This compressed pulse is also accompanied by sin(x)/x time sidelobes responses. Amplitude weighting functions are applied to the rising and trailing edges of the pulse to reduce the time sidelobe levels. If there are two closely spaced overlapping echoes, then they will be separated into distinct output pulses due to the processing of their modulation—so long as they are separated by a range the equivalent of half the compressed pulse (a round trip equal to the full compressed pulse).

Unfortunately, traditional RF pulse measurements become less effective predictors of performance in radars that use pulse compression. For example, the width of an uncompressed radar pulse is directly related to spatial



▲ *Fig. 1 Simple block diagram of a pulse compression radar system.*

John Hansen
Agilent Technologies, Santa Clara, CA

▲ *Fig. 2 Time domain representation of a chirp pulse after compression and how it might look on a PPI radar display.*

TABLE I

COMMONLY USED WINDOWING FUNCTIONS AND THEIR ATTRIBUTES

Windowing Function	*Peak Sidelobe Level (dB)*	*S/N Loss (dB)*
Uniform	-13.2	0
Hamming	-42.8	1.34
Hann	-32	1.4
Blackman	-58	2.37
Blackman-Harris (3 term)	-67	2.33

resolution. In contrast, the resolution depends on pulse width, chirp bandwidth and chirp linearity in a compressed radar system that uses LFM chirp pulses. Within the field of radar development, a technique called the time Sidelobe Level (SLL) measurement has emerged as a viable solution. This method distills a wide range of potential signal impairments down to a simple metric that can be used to determine if radar performance will fit the intended application.

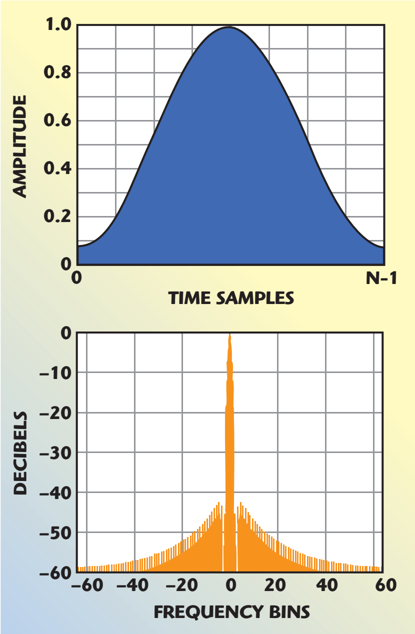
SLL is normally measured by illuminating a reference target and making the measurement at the radar receiver's pulse compression filter output. To make transmitter-only measurements, a Vector Signal Analyzer (VSA) can be used as an ideal radar pulse compression receiver. This is similar to Error Vector Magnitude (EVM) measurements commonly used with communication signals, where the VSA acts as an ideal demodulator and takes mathematically generated ideal waveforms, which are compared to the measured waveform.

Sometimes referred to as range sidelobes, time sidelobes are a result of using pulse compression techniques. They are produced when the ideal radar return is convolved with the response of the less than ideal correlation filter, during the compression process or when a non-ideal radar return (from a non-ideal transmitted pulse) is convolved with the response of the less than ideal correlation filter or some combination of the two. This causes some of the energy in the return pulse to lie outside the pulse bandwidth. In the time domain, this is indicated by a spreading in range (time) of the return pulse, particularly in the presence of ground clutter or transmit signal anomalies caused by imperfections in the transmitter path (see ***Figure 2***).

Windowing or amplitude weighting of the output signals is generally used to reduce the time sidelobes to an acceptable level. Simply measuring a signal for a finite time is equivalent to multiplying the signal by a uniform function or window of unit amplitude. Windowing involves multiplying the signal data by a function that smoothly approaches zero at both ends. The theoretical sidelobe level for a rectangular window (or no window) is –13.2 dB, whereas for the Hamming window, the theoretical level is –42.8 dB. In ***Figure 3***, the time and frequency domain representations of the Hamming windowing function are shown. Windowing can be applied in either domain. As a side effect, signal weighting will result in the loss of signal-to-noise ratio. Some of the more commonly used windowing functions are shown in ***Table 1*** with their suppression levels and signal-to-noise losses.

MAKING THE TIME SIDELOBE MEASUREMENT

The Agilent 89600 VSA software or MATLAB from Mathworks can perform a correlation filter function that correlates or compares the transmitter output signal to an ideal waveform. The ideal waveform can be built using MATLAB. It requires knowledge of



▲ *Fig. 3 Time and frequency domain graphs of the Hamming windowing function.*

the important parameters of the signal to be measured, such as FM bandwidth, pulse width and sample rate of the VSA during the measurement (VSA sample rate equals 1/ [1.28*VSA span]). The compressed pulse is a much narrower pulse compared to the transmitted pulse. The pulse compression ratio is a function of the time bandwidth product of the chirp and the window used for the correlation filter. The SLL represents the ability of the transmitter and receiver to separate small, close-by target return echoes from large ones.

The pulse waveform is created in MATLAB and then downloaded to the arbitrary waveform generator (AWG). The mathematically generated ideal pulse is also then available in a digital form for use when making just a single measurement, such as when characterizing the transmitter only for SLL. Alternatively, the ideal pulse could be measured at different points at the front end of the receiver to characterize filter performance. This would be done using two channels on an oscilloscope. Either an oscilloscope or signal analyzer can be used to correct the IQ waveform played from the AWG for phase and amplitude flatness across the bandwidth (BW) of the signal.

The next step is to look at the sidelobe level. For this, the VSA's Math Functions or MATLAB incorporated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into a User Defined Function on the oscilloscope will be used to perform a cross correlation between the measured pulse and the ideal pulse. This simulates the radar receiver correlator or compression filter. To simplify the calculation, the math identity of time correlation equals frequency domain multiplication will be used. Hamming windows are applied to both the measured and ideal waveform during the translation. For reference, the auto correlation of the ideal chirp is computed as well. This represents the best width and sidelobes that could be attained.

The measured frequency data (real and imaginary) is multiplied by the ideal pulse. This result is processed with the inverse fast Fourier transform (IFFT) function to produce the time cross correlation needed for the SLL measurement.

Measured(t) × Ideal(t) = IFFT [Measured(f) * conj[Ideal(f)]]

Where:

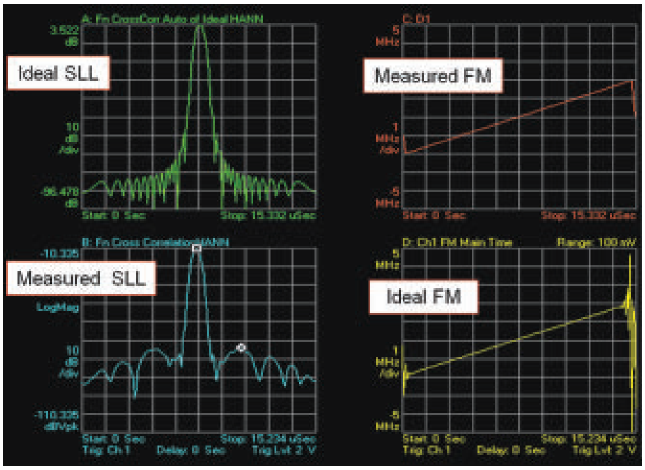
Measured(f) = window * FFT (Measured(t))

Ideal(f) = window * FFT (Ideal(t))

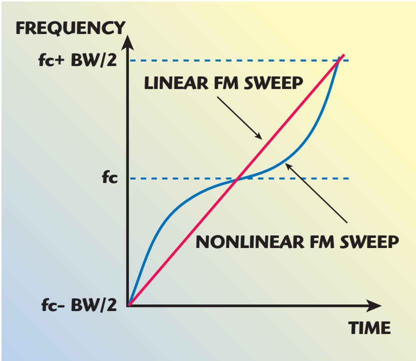
The measurement results are shown in ***Figure 4***.

A nonlinear FM waveform (see ***Figure 5***) provides advantages over the LFM one. The nonlinear FM waveform requires no weighting for time-sidelobe suppression since the FM modulation of the waveform is developed to provide the desired time and spectrum response. The nonlinear characteristics are chosen to accommodate FFT artifacts and imperfections in the system hardware or waveforms. The drawback of nonlinear FM systems is that they are complex and costly to implement.

Other types of pulse compression radars use pulses coded with a stream of bits. The bit pattern is chosen such that it has a high correlation peak and the receiver again performs a compression filter by cross correlating against the ideal transmitter waveform. The performance metrics used with these waveforms include EVM, modulation accuracy and SLL.



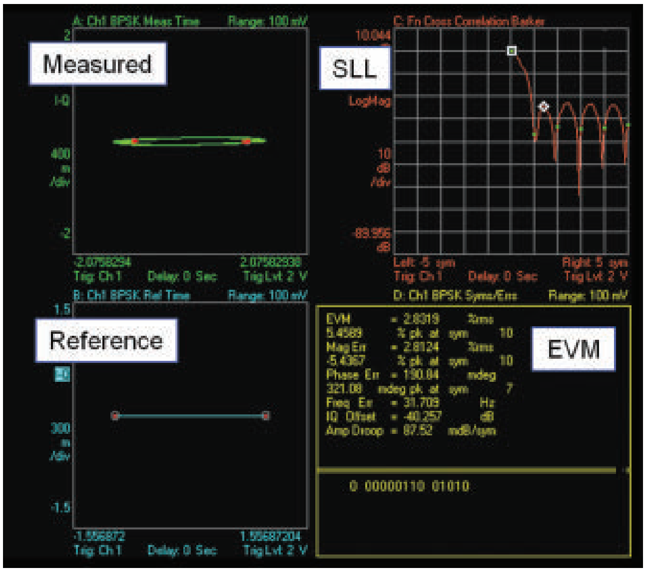
▲ *Fig. 4 SLL measurement results.*



▲ *Fig. 5 Frequency sweep across the width of a nonlinear FM chirp pulse.*

The waveform coding uses BPSK or QPSK modulation and can be treated as a short burst of digital communications-like signal. The flexible demodulator within the Agilent VSA software can be used to extract the EVM quality metric. In addition, numerous error and troubleshooting features can be exploited.

One useful modulation coding is the Barker, Frank and polyphase code trains. Barker codes are the binary phase codes with the property that the peak sidelobes of their autocorrelation functions are all less than or equal to 1/N in magnitude, where N is the code length and the correlator output peak is normalized to 1.0. The more bits within a code train, the lower the time sidelobe level. The VSA software's digital demodulator can be applied for simplifying the testing of the 13 bit Barker coded burst by considering it a short vector modulated



▲ *Fig. 6 SLL and EVM of a 13 bit Barker coded pulse.*

signal of symbol rate of 13/(pulse width). The theoretical SLL value of a 13 bit Barker coded pulse is –22.3 dB. ***Figure 6*** shows the measurement and calculation results.

Spatial resolution is often an essential part of the system acceptance criteria. Because the time from the main correlation lobe to the minimum discernable sidelobe is directly related to the minimum spatial resolution, SLL offers an effective go/no-go assessment of a radar system's field performance. SLL also provides assurance that no other internally generated sidelobe will affect the overall threshold performance of the radar. The correlation function is also directly tied to the probability of target detection. From this, a sufficiently low SLL value ensures the radar hardware under test will have a dynamic range wide enough to detect weak target signals.

At the component level, time sidelobe testing can help identify problems with analog microwave components. The typical approach is to patiently work through the process of measuring parametric characteristics and then sifting through the results and identifying potential problems. Instead, time sidelobe levels can be evaluated for impairments at any point within a system—and this makes it possible to rapidly assess if the radar pulses can deliver the desired level of performance.

This ability to assess pulse quality virtually anywhere within a radar system—from transmitter to receiver detector—makes SLL a valuable diagnostic tool. For example, one quick SLL measurement at the transmitter output can instantly pinpoint either the transmitter or receiver as the source of problems. Subsequent measurements can quickly isolate signal impairments that are preventing radar performance from meeting system requirements.

Time sidelobe measurements are easy to perform with popular Agilent signal analyzers, oscilloscopes and logic analyzers equipped with Agilent 89600 VSA software. Preparation for the measurement requires creation of the ideal pulse waveform, importation of the ideal pulse into the VSA software and some trace math. Once the setup is complete, time sidelobe measurements are easy to perform and can be used to gauge key performance traits, isolate signal impairments, diagnose system problems and find problems at the component level. ■

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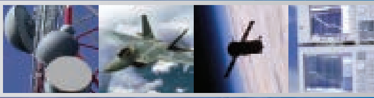

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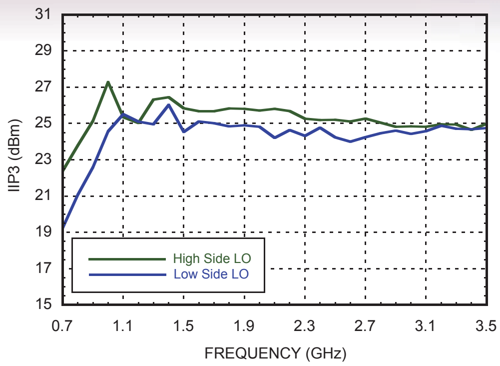
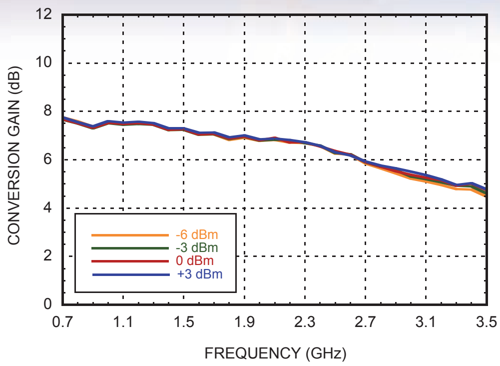


Conversion Gain vs. LO Drive @ VGATE = 4.8V



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	HMC683LP6CE	0.7 - 1.0	High IP3, Dual Downconverter	0.06 - 0.5	7.5	16	23
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	HMC421QS16E	1.4 - 2.3	High IP3 Downconverter	0.05 - 0.3	9	33	19
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GaN Powers High Speed Wireline Networks

TRENDS IMPACTING WIRELINE NETWORK OPERATORS

Wireline networks and their operators face pressure as they attempt to adapt and react to subscriber demand for high-quality multimedia content delivered to them anywhere, anytime, on any device. Trends and events shaping wireline networks include analog reclamation, higher order digital modulation, new and increased use of channel bonding, DOCSIS® and Euro-DOCSIS 3.0 compliant and otherwise, bandwidth expansion over copper using legacy passives, increased return path capacity, component and hardware size reductions enabling an avalanche of head-end (HE), super HE and hub unicast transmission capacity, mandated and dramatically reduced energy usage, delivery of bits on-demand via narrow- and unicast methods versus traditional multi-cast and delivery of artifact-free all-digital content using legacy components designed for analog video carriers. Until now, wireline network operators faced these opportunities armed with electron tube, silicon bipolar and gallium arsenide (GaAs) die-based amplifier technologies, none of which completely satisfies often conflicting requirements. Gallium Nitride (GaN) die-based amplifiers, a new technology to the wired broadband market, offer the opportunity to solve many of today and tomorrow's most vexing wired network performance "musts," without the compromise of alternatives. This article illustrates the wireline network specifications and requirements, describes how GaN die-based amplifiers solve operator needs, compares and quantifies GaN die-based solutions versus alternatives and provides a glimpse of future wireline network capabilities when GaN die is enabled.

ANALOG RECLAMATION

While nearly every wireline network operator and service provider in the world is embracing high definition television (HDTV) and other digital services, their available bandwidth (BW) to implement new services most often remains fixed. An option available to most wireline network operators is the conversion of bandwidth employed today for analog signal transmission, such as analog National Television Standards Committee (NTSC) or phase alternating line (PAL) video, to all-digital signal delivery. The math of analog reclamation is compelling. If a North America-based wireline network system operator converts 40 of the 79 typically deployed six MHz wide analog channels to digital and compresses them, it provides enough capacity for approximately 80 to 100 high definition (HD) channels, HD video on demand (VoD) and downstream (DS) data delivery service at download speeds up to 1 Gbps.[1]

So, if analog reclamation is such a good thing, why not just change some HE and hub signal processing, transmitter and receiver hardware, install new software and increase network capacity? Although the trend is shifting and reclaiming traditional analog bands to digital, many network operators are retaining an analog video service of 20 to 25 channels for the foreseeable future to service millions of analog television sets and video cassette re-

Kellie Chong
RFMD, Greensboro, NC

TABLE I

ANALOG VERSUS DIGITAL AMPLIFIER PERFORMANCE COMPARISON[2]

	Output Level in dBµV CENELEC 42 channels (CTB, CSO=60dB)	Maximum Output in dBµV 256 QAM 96-channels (BER<1e10-9)
Amp 1 (GaAs)	111	106
Amp 2 (**GaN**)	**114**	**110**
Amp 3 (Silicon)	98	98

▲ *Fig. 1 One GaN amplifier replaces two GaAs amplifiers in analog video, mixed signal and all digital wireline networks.*

corders operating throughout the world. Then, how does a GaN amplifier help in a traditional network?

Measurements were made to compare amplifier performance using three different primary device technologies, GaAs (referred to as "Amp1"), GaN ("Amp2") and Silicon ("Amp3") between an analog video loaded wireline network (42 analog PAL video channels of 8 MHz BW, measured against CENELEC standards[2]) and an all-digital loaded network (94 256 QAM channels of 8 MHz BW each from 40 to 862 MHz, measured against EN 60728-3-1 sub clause 4.1[3]). The goals of the measurements, made using an all-digital lineup, were to determine the maximum operating level in dBµV, referenced to a 75 Ω system, for BER free ($BER<1\times10^{-9}$) operation, in order to determine the behavior of the amplifiers with digital-only channel load, and find out rules for a system calculation of a HFC network with digital-only channel load. Measurements, for both analog video only and all-digital loading, were done with single amplifiers and a cascade of amplifiers using up to eight amplifiers.

The results, outlined in ***Table 1***, demonstrate that GaN technology-based amplifiers provide a 3 dB higher output power per carrier, when transmitting analog video at the same multi-carrier, a 3 dB higher output per analog video carrier at the same multi-carrier distortion level and a 4 dB higher output power per channel, when transmitting all-digital 256 QAM channels at the same BER versus a GaAs technology-equipped amplifier. The advantage of a GaN versus a silicon (Si) technology-based amplifier was 16 dB and 12 dB, respectively (analog and all-digital).

What this translates to, for the wireline network operator, is a new set of solution options that includes capital expense (capex) savings, through eliminating housed amplifiers within new ("Greenfield") installations (two for one in the case of GaN versus GaAs amplifiers, as shown in ***Figure 1***, and four or five to one in the case of GaN versus Silicon amplifiers) or reducing operating expense (opex) by replacing either GaAs or Si amplifiers with equivalent gain GaN amplifiers and operating the GaN amplifiers at 20 percent lower total power dissipation per device, with no sacrifice in multi-carrier distortion, CNR or BER performance, 15 years continuous operation between failures, or immunity to power supply surge and energy transients.

BANDWIDTH EXPANSION OVER COPPER USING LEGACY PASSIVES

One option wireline network operators would like to employ to improve their ability to meet demand from subscribers and consumers of high speed data (HSD), linear transcoded content and nonlinear, so called over-the-top (OTT), non-scheduled content, is expansion of legacy network BW without the replacement of installed plant coaxial cable, connectors and passives (including diplex filters, MoCA™ filters and taps (a.k.a. directional couplers)). Operators in North America have thousands of miles of coaxial cable installed within HFC networks rated to operate in the 54 to 750 MHz DS BW. What if an operator could replace a 750 MHz BW capable plant's amplifiers with 1002 MHz or higher frequency devices and upgrade subscriber consumer premises equipment (CPE) but not spend large amounts of capex replacing those miles of coaxial cable, connectors and installed passives originally specified for 750 MHz maximum upper frequency operation? This would permit adding 250 MHz or more of additional new BW at relatively low capex available for HSD, voice over Internet protocol (VoIP), 3DTV, compressed digital TV (DTV) and all forms of HDTV, including 3D-HDTV. Using present production GaN amplifiers, operators have the option to do just that. A latest generation GaN power doubler (PD) amplifier modules roughly 'double' the amplifier's RF P_{out} while providing lower multi-carrier distortion, improved composite intermodulation noise (CIN), better CNR and better BER.

- GaN PD amplifier modules make this option a reality through their ability to operate with a simultaneous set of desirable characteristics: Extremely high RF P_{out} capability (2 to 3 dB higher than most GaAs amplifier lineups, with the same distortion and BER performance) across the DS band (40 to 1600 MHz lineups using GaN are available commercially today). This ability permits the use of diplex filters and taps rated to 750 MHz, with relatively high insertion loss (IL) and attenuation above 750 MHz.
- Linear positive tilt of up to 18 dB from 40 to 1002 MHz (other positive tilt options are available at maximum frequencies to 1600 MHz). This type of tilt performance is available without penalty with regard to RF P_{out} and distortion performance at the highest rated frequency. This ability permits the continued use of installed coaxial cables and connectors, with significant and increasing attenuation as frequency increases above 750 MHz.[4]
- Wide range of gain options from 18 to 30 dB per GaN amplifier module. Combined with GaN amplifier high RF P_{out} capability, this feature allows most legacy 750 MHz capable DS plant to directly replace GaAs or Si amplifiers with GaN amplifiers, without re-spacing the existing installed housed amplifiers. This capability dramatically simplifies network upgrades with lower capex impact.
- Improved CNR performance at high RF P_{out} levels. This ability permits operators performing plant upgrades to employ high integer QAM in any portion or all of the DS BW, without affecting the delivered digital BER.

TABLE II

PHYSICAL CHARACTERISTICS OF SILICON (Si), GaAs AND WIDE BANDGAP SEMICONDUCTORS[18]

Property	Si	GaAs	6H-SiC	4H-SiC	GaN	Diamond
Bandgap, Eg (eV)	1.12	1.43	3.03	3.26	3.45	5.45
Electric Breakdown Field, Ec (kV/cm)	300	400	2500	2200	2000	10,000

$\varepsilon = \varepsilon_r \circ \varepsilon_o$ where $\varepsilon_o = 8.85 \times 10^{-12}$ F/m

MANDATED AND DRAMATICALLY REDUCED ENERGY USAGE

Today's typical HFC network HE consumes two to three million watts of electricity (that is 2 to 3 MW-hours) and operates with virtually no consideration of delivering subscriber content efficiently with a "bits delivered per \$ or €" metric in mind. Under the auspices of Sustainability Management Subcommittee (SMS), the Society of Cable Telecommunications Engineers (SCTE) is creating a "critical facility" focused specification titled "Adaptive Power System Interface Specification" (APSIS). SCTE SMS crosses wireline network industry boundaries (NCTA, CableLabs®, CENELEC, EU, OEMs) and is tasked in the relative short term to create a set of meaningful requirements documents modeled after Telcordia specifications that improve cable industry energy usage efficiency. SMS activities in the next year are focused on specifications impacting energy usage within "critical facilities" including HEs, super HEs and hubs.

How can GaN device-enabled amplifiers help the wireline network operator meet new APSIS specifications, aimed at lowering overall energy usage? The wide range of GaN amplifier performance options, available today, offer operators several means of helping to meet APSIS requirements. Ultra linear GaN amplifiers, operating from 12 V DC and lower DC power supplies, will meet CMAP, DRFI and APSIS specifications simultaneously, while reducing installed volume footprint. GaN amplifiers based on very high breakdown voltage ($V_{bd} \geq 400$ V DC) are being shipped today, that have the capability to operate directly from any presently available wireline network power supply, with minimal power conversion or voltage regulation. Use of a "direct powered" GaN amplifier, within a next generation APSIS compliant network, simplifies network powering, while lowering energy usage. No other presently available amplifier technology can offer such a wide range of operating voltages.

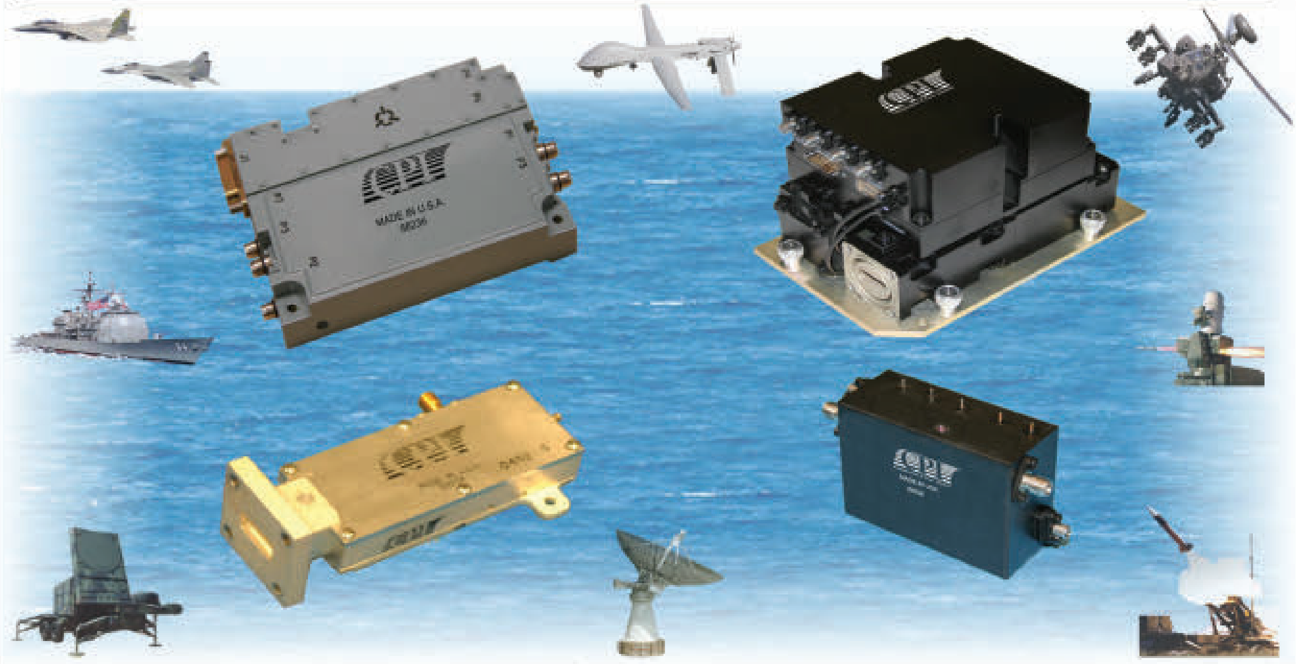
WHAT MAKES GaN "GOOD"

GaN is a "binary" III-V direct bandgap semiconductor used in light emitting diode (LED) manufacture since the 1990s. GaN is a very hard material with a Wurtzite crystal structure, which is non-centrosymmetric (lacks inversion symmetry), giving GaN piezoelectric and pyroelectric properties which centrosymmetric crystals lack. GaN's bandgap of 3.45 eV affords it special properties in optoelectronic, high power and high frequency (HF) devices. As compared to other available materials suitable for manufacturing linear amplifiers for broadband wireline network applications, such as GaAs or Silicon, GaN properties give it unmatched capabilities (see ***Table 2***).

WIDE BANDGAP

GaN advantages versus Si and GaAs start with its wider bandgap material properties. Materials with small atoms and strong electronegative atomic bonds are associated with wide bandgaps. Only diamond, in today's process technologies, possesses a wider bandgap than GaN (5.45 eV for diamond versus 3.45 eV for GaN) for material useful as the basis for linear amplification. A material's bandgap determines how electrons (and "holes") behave within an amplifier's physical structure and what relative energy it takes to get these electrons (and "holes") excited ("excited" in the sense that they are willing to give up their energy). Electrons in an atom of a semiconductor material, such as GaN, can be thought of as being in various "states," including energy level, momentum and spin, with different probabilities of being in a given state. Two electrons cannot be in the same state at the same

Integrated Microwave Assemblies



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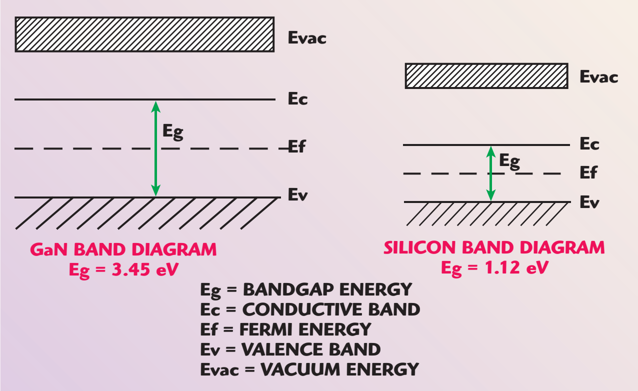

▲ *Fig. 2 Band diagram showing GaN wider bandgap energy (Eg).*

time, that is, at least one variable must differ. Some particular states are possible and some are forbidden by the laws of quantum mechanics. Sets of possible states form regions that are called bands. Sets of states that are not possible form regions between those bands and these are called bandgaps.

The higher energy gap of GaN material allows design and manufacture of amplifiers with the ability to operate at higher temperatures, withstand higher operating and transient voltages and to provide improved distortion performance at lower direct current (DC) power dissipation, versus amplifiers built using lower energy gap materials, such as silicon at 32 percent of GaN's energy gap level and gallium arsenide (GaAs) at 41 percent of GaN's energy gap level (see ***Figure 2***). Today's best amplifiers constructed using lower energy gap materials are reaching their limits of operating frequency, breakdown voltage and power density. GaN-based amplifiers have only begun to define performance boundaries. GaN's wide bandgap property has contributed to its ability to create linear and pulse application amplifiers, with demonstrated breakdown voltages (VBD) ≥ 400 VDC today and ≥ 1500 VDC in the future generation of devices. GaN's higher electric breakdown field allows more doping to be applied to the material, which further increases the gap between the upper breakdown voltage limits of the wide bandgap semiconductors compared to Si and GaAs.

THE FUTURE

GaN amplifiers, active switches, active splitters, laser drivers, detectors, modulators, ADC/DACs and DC-DC converter circuits will be operating in every part of future wireline networks. The operating voltages of these devices will span the range of less than 1 VDC to more than 1500 VDC (for DC-DC converter devices). Some of these GaN products will operate with usable bandwidths approaching a Terahertz (THz) for software defined radio (SDR) receiver front ends and ultra-high speed analog-to-digital converter (ADC) and digital-to-analog converter (DAC) applications. Wireline networks will enjoy the ability to power GaN circuitry directly from any available mains or distributed electrical power supply regardless of voltage level and voltage waveform type. Using GaN transmit power chains, all-digital content will be delivered to any multimedia display capable device anywhere in the world, artifact free. GaN circuitry will perform biocompatible radio frequency identification (RFID), monitoring and security functions and sophisticated sensor tasks, while operating from a fraction-of a volt with battery life measured in years not hours or days. ■

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A Center-Tapped CRLH ZOR UWB Bandpass Filter with Improved Stopband

As a miniaturized UWB bandpass filter (BPF), a center-tapped microstrip structure is designed, based on a composite right- and left-handed zero-order resonator (CRLH ZOR). The overall size of this BPF, including its impedance matching block, is 0.69 × 0.73 λg. It has a fractional bandwidth greater than 100 percent and its insertion loss is less than 1 dB, but its upper stopband has an $|S_{21}|$ just below –7.2 dB. So a compact ZOR bandstop filter (BSF) of 0.35 x 0.27 λg is proposed to be combined with the aforementioned BPF, to enhance the stopband and keep the entire geometry as small as possible. This improves the stopband to an $|S_{21}|$ below –20 dB and keeps the acceptable UWB performance in the predicted and measured results.

Various studies have been conducted to take advantage of UWB communications, since its unlicensed use was allowed to the public by the U.S. FCC. As one of many such research activities, design methods of BPFs have been reported. Araki et al[1] designed a UWB BPF whose bandwidth is formed by adding notches in sections of the transmission line. However, it shows very narrow stopbands. H. Wang et al[2] presented a microstrip-and-CPW UWB BPF, using a multi-mode resonator (MMR) in the form of multiples of quarter-wavelength to guarantee the 100 percent bandwidth and the enlarged suppression band. A composite UWB filter was designed by W. Menzel et al by combining lowpass and highpass filters as a suspended stripline structure with multi PCB layers.[3] Recently, the concept of metamaterials CRLH TL and ZOR has been used to reduce the filter size.[4-7] Gil et al[5] shows filters as periodic CSRRs and staggered capacitors. On the contrary, one-cell CRLH ZORs are coupled to be sub-wavelength BPFs by G. Jang et al.[6,7]

Here, a novel compact UWB BPF, with a remarkably improved stopband, is proposed. First, a center-tapped UWB BPF of 0.69 × 0.73 λg is designed, which has a ZOR due to the center-tapped and end-grounded interdigital coupled-lines as a CRLH circuit. The CRLH ZOR has a fractional bandwidth greater than 100 percent and its insertion loss is less than 1 dB, but the upper stopband has an $|S_{21}|$ just below –7.2 dB. Second, to enhance the stop band and suppress the unwanted size increase, a compact ZOR band stop filter (BSF) of 0.35 × 0.27 λg is proposed, to be cascaded with the BPF above. This BSF plays the duality of the CRLH equivalent circuit. It lowers

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University of Incheon, Incheon, Korea

RFMD.

CATV GaN Amplifier Modules

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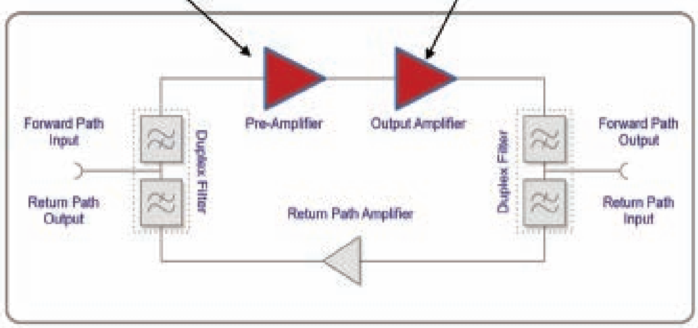
Freq Range (Min) (MHz)	*Freq Range (Max) (MHz)*	*Min Power Gain (dB at Max Freq)*	*Current (Max) (mA)*	*NF (dB)*	*CTB (dBc)*	*CSO (dBc)*	*Part Number*
40	1003	20.0	450	3.0	-77	-71	D10040200PH1
40	1003	22.5	450	3.0	-77	-71	D10040230PH1
40	1003	25.0	450	3.0	-77	-71	RFPD2710
40	1003	20.0	380	3.0	-70	-71	D10040200PL1
40	1003	22.5	380	3.0	-70	-71	D10040230PL1
40	1003	23.0	450	3.5	-78	-71	RFPD2650*
40	1003	25.0	450	3.0	-77	-71	RFPD2930*
40	1200	22.5	450	3.5	-77	-71	RFPD2580
40	1003	23.0	440	5.0	-75	-70	RFPD2660
40	1003	25.0	440	5.0	-75	-70	RFPD2670
40	1003	23.0	450	3.0	-77	-71	RFCM2680**
40	1003	28.5	270	4.5	-68	-75	RFPP2870

Refer to individual datasheet for test conditions.
* Features variable current control
** Surface mount package

Power Doubler
D10040200PH1/D100400200PL1
D10040230PH1/D100400230PL1
RFPD2710
RFPD2650/RFPD2930
RFCM2680

Driver Amplifier
RFPP2870



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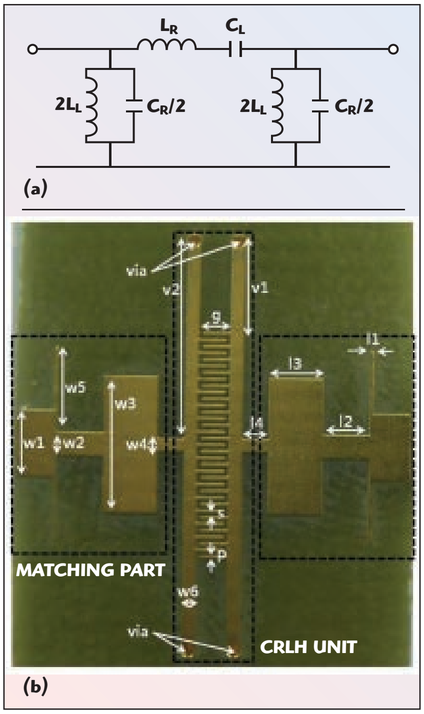


▲ *Fig. 1 Configuration of the center-tapped CRLH ZOR UWB bandpass filter (a) π equivalent circuit and (b) fabricated CRLH ZOR BPF.*

the $|S_{21}|$ in the stopband below –20 dB and keeps an acceptable UWB performance. This is verified by the predicted results agreeing well with the measured ones.

DESIGN AND RESULTS

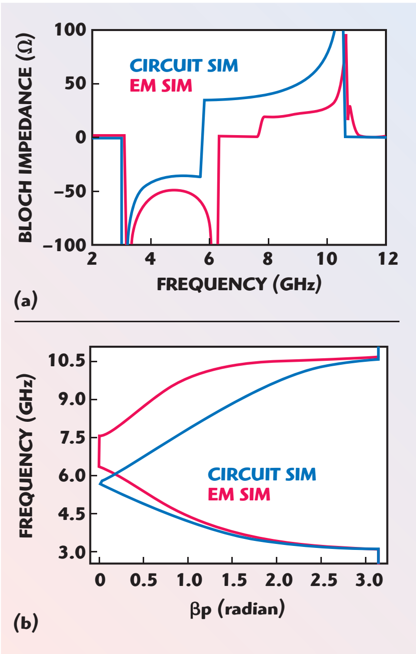
In the first step of the design, a one-cell CRLH circuit is used for the purpose of forming a passband of the UWB BPF. It can be expressed as a π-equivalent circuit, as shown in ***Figure 1***, and is realized by a new structure 'center-tapped ZOR,' which is the center-tapped and end-grounded interdigital coupled lines. Its dimensions are w1 = 2.47 mm, w2 = 0.91 mm, w3 = 5 mm, w4 = 0.5 mm, w5 = 3.1 mm, w6 = 0.5 mm, l1 = 0.12 mm, l2 = 1.7 mm, l3 = 1.98 mm, l4 = 0.95 mm, v1 = 3.6 mm, v2 = 7.49 mm, g = 1.12 mm, p = 0.12 mm and s = 0.12 mm. For the ZOR, a balanced CRLH case[4,6-7] is adopted to achieve a single broadband without any discontinuity between the cut-off frequencies of highpass and lowpass filtering. In the balanced case, four CRLH parameters are obtained and given as follows.

$$C_R = \frac{2}{Z_R\left(W_{cR} - W_{cL}\right)},$$

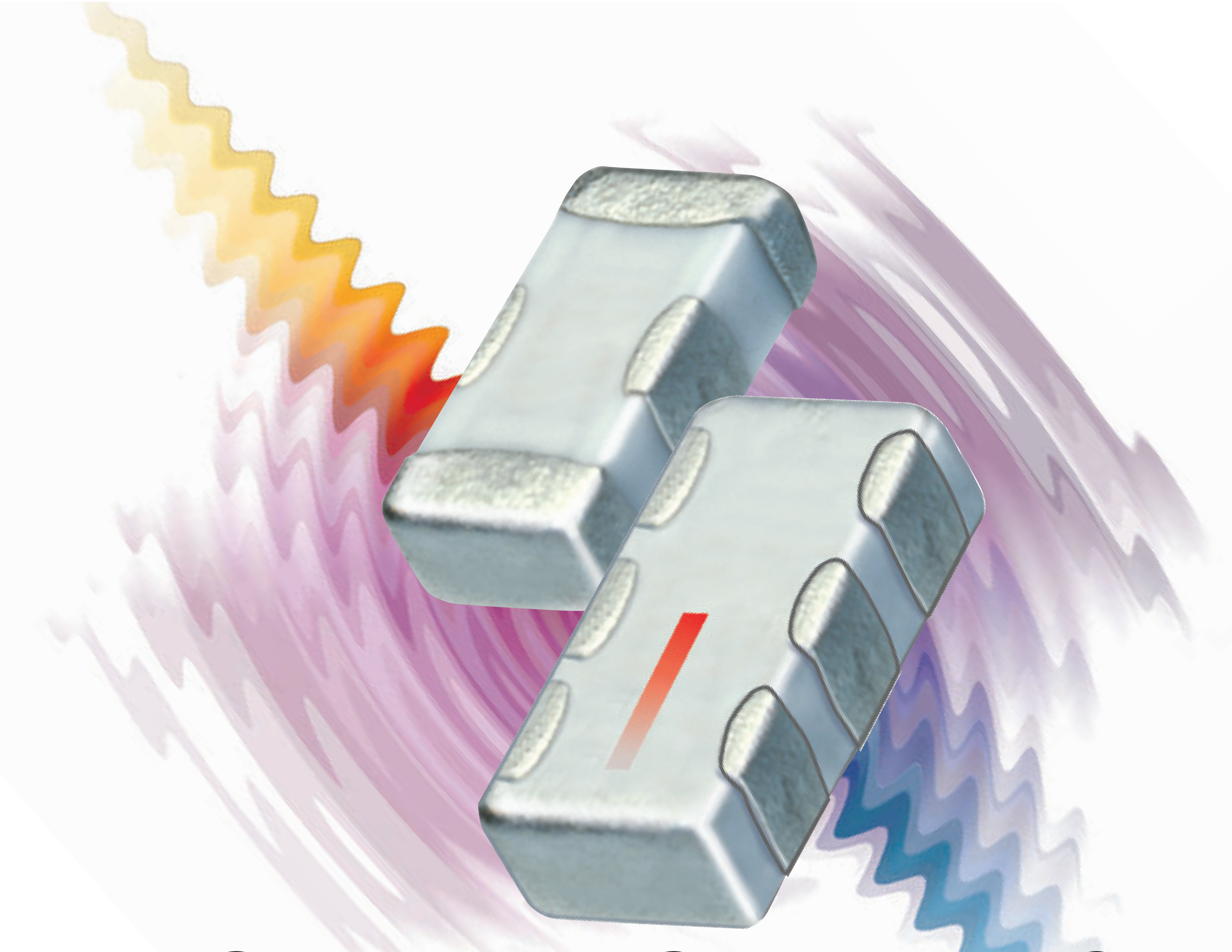
$$L_R = Z_R^2 C_R, C_L = \frac{C_R}{\left(\left(\frac{\left(W_{cR} + W_{cL}\right) Z_R C_R}{2}\right)^2 - 1\right)},$$

$$L_L = Z_L^2 C_L \qquad (1)$$

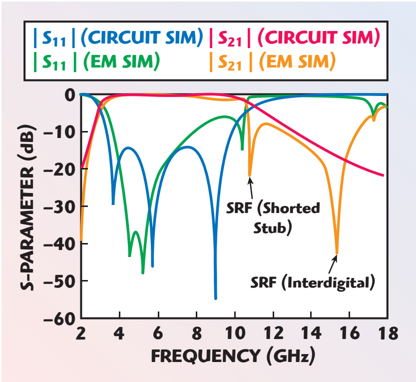
where Z_R, Z_L, W_{cR} and W_{cL} correspond to the RH impedance, LH impedance, the exact LH highpass and RH lowpass cutoff frequencies, respectively. Z_R and Z_L should be identical to Z_0, meeting the balanced condition. W_{cR} and W_{cL} determine the band of the CRLH BPF. The design is carried out with Z_0 = 45 Ω, W_{cL} = 3.1 GHz and W_{cR} = 10.6 GHz and the parameters in Equation 1 are calculated as C_R = 0.943 pF, L_R = 1.91 nH, C_L = 0.404 pF and L_L = 0.817 nH. To physically implement the equivalent circuit, a center-tapped ZOR BPF is assumed and the corresponding geometrical values are found through iterative electromagnetic (EM) simulations, using ADS Momentum. To check the performance of the circuit and the physical structure, the Bloch impedance and the dispersion diagram are depicted in ***Figure 2***. In the Bloch impedance graph, the ± means the characteristic impedance



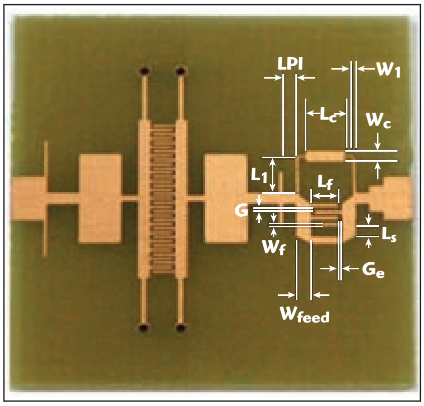
▲ *Fig. 2 The Bloch impedance (a) and dispersion diagram (b) of the CRLH ZOR UWB BPF.*



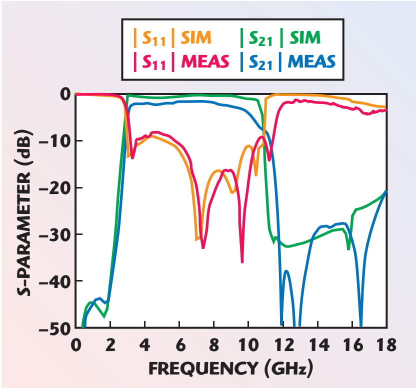
for positively and negatively traveling waves, respectively. The ZOR can be seen as a metamaterial property at the center frequency between the LH and RH regions. Particularly, the circuit and EM results have a gap, due to the mismatched Bloch impedance of zero and high magnitude over the passband and a discrepancy between the circuit and EM structures. To remove the gap, a matching part is added to the center-tapped ZOR and the total length of this BPF becomes 0.69 × 0.73 λg. Its S-parameters are shown in ***Figure 3***, with a fractional bandwidth greater than 100 percent and an insertion loss less than 1 dB. The return loss does not look perfect, but will get better by more tuning. The serious problem of this BPF is the stopband. Therefore, for its improvement, the second step of the design is carried out by suggesting a compact BSF to be combined with the BPF as shown in ***Figure 4***. The BSF is assumed as the duality of the CRLH to form a wide stopband, geometrically expressed as the shunt relation of interdigital coupled lines and a stepped impedance branch. The circuit of the BSF with cut-off frequencies of 10.8 GHz and 27 GHz is calculated with $C_{L,dual}$ = 0.2 pF, $C_{R,dual}$ = 0.15 pF, $L_{L,dual}$ = 0.3 nH and $L_{R,dual}$ = 0.62 nH. These result in L_f = 1.04 mm, L_c = 1.75 mm, L_l = 2 mm, L_{pl} = 0.6 mm, L_s = 0.6 mm, G = 0.19 mm, G_e = 0.16, W_f = 0.16 mm, W_{feed} = 0.17 mm, W_c = 0.17 mm and W_l = 0.12 mm. Using these elements, the BSF has the size of 0.35 ×



▲ *Fig. 3 Circuit and EM simulated S-parameters of the UWB BPF.*



▲ *Fig. 4 CRLH ZOR UWB BPF combined with a compact bandstop filter.*



▲ *Fig. 5 Simulated and measured S-parameters of the CRLH ZOR UWB combined with the compact bandstop filter.*

0.27 λg. The frequency response of its combination with the BPF is shown in ***Figure 5***. With a small change in the passband from the BPF, the stopband is improved significantly from 11 GHz up to 18 GHz where $|S_{21}|$ is lower than –20 dB.

CONCLUSION

A center-tapped ZOR UWB BPF has been designed to have an improved stopband by being cascaded with a compact BSF. The novel CRLH ZOR BPF has the size of 0.69 × 0.73 λg with a bandwidth greater than 100 percent and an insertion loss less than 1 dB. Its stopband has an enhanced $|S_{21}| \leq -20$ dB from –7.2 dB by the duality of a CRLH type BSF whose size is 0.35 × 0.27 λg. ■

ACKNOWLEDGMENT

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Practical Integrated Passive Device Technology on GaAs

An integrated passive device (IPD) technology has been developed in order to achieve lower cost, miniaturization and higher performance in RF and microwave devices applied to the front-end modules of wireless communication systems. Various kinds of high performance IPDs have been fabricated on a six inch GaAs wafer due to the well-developed, low cost RF passive manufacturing technology. Since this article is primarily about the practical design and fabrication of IPDs, it will discuss topics such as IPD fabrication technology, design flow, schematic circuit design and 3D EM simulation. Different kinds of IPDs such as baluns, power dividers, lowpass filters (LPF), and their measurement results are presented.

In the electrical device industry, there is a trend for the integration and miniaturization of electronic systems, while steadily increasing performance, reliability and yield and reducing cost. Owing to the fact that IPDs are generally fabricated using standard wafer fabrication technologies, such as thin film and photolithography processing, they can be manufactured with these advantages and widely used in front-end RF sections of the mobile phone, comparable to embedded passive devices in an organic substrate or in low temperature co-fired ceramic (LTCC) substrates.[1]

IPDs, which contain passive circuit components such as resistors, inductors and capacitors, are totally integrated and mounted on a semiconducting substrate.[2-4] Through IPD technology, it is possible to integrate individual passive components into an RF device or system.[5] IPDs can be applied to existing fields of applications, which use whole passive devices and have already been applied to the front-end modules of mobile systems. In mobile phone communication systems, many functional blocks, such as filters, baluns/transformers, diplexers, power combiners/dividers, and couplers can be realized by IPD technology.[6-10] In addition, the application of IPD technology to semiconductor processing is fully compatible with existing active devices and, thereby ensures semiconductor processing compatibility.

IPD DESIGN FLOW

There is a certain design flow that has been developed in order to simplify the design of IPDs. Specific design flows may vary among designers but, in general, almost all design flows are similar. In order to meet performance and cost targets, a general design methodology should be followed. This consists of the following steps: Choose the optimum topology and the right components from the design cell library that match the selected technology, and then perform the design by using software, such as ADS or AWR for a circuit-level simulation and a physical layout that fits the available

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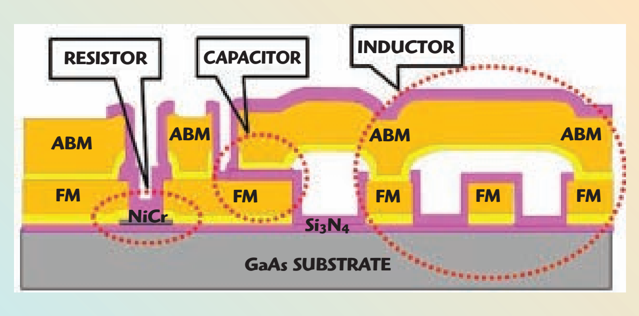
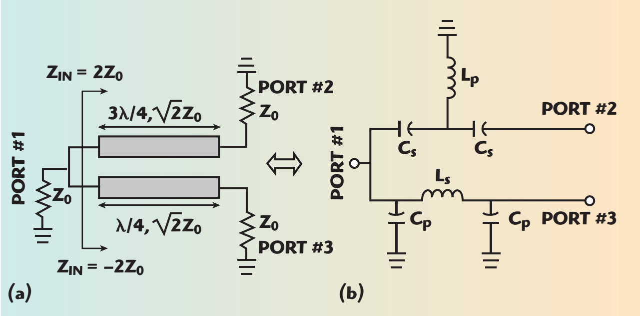
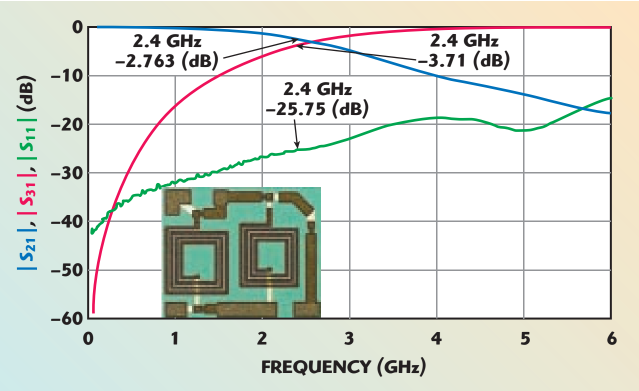


▲ *Fig. 1 Cross-sectional view of the GaAs IPDs.*



▲ *Fig. 2 Balun design using a transmission line (a) or lumped LCs (b).*



▲ *Fig. 3 Measured S-parameters for the fabricated WLAN balun.*

space. After the layout, an EM simulation employing software, such as CST, is performed in order to optimize the component interaction, the wire-bonding with the pads and the packaging. In the next step, the various devices are arrayed and the masks are made for aligning the patterning. The designed devices are then fabricated using the semiconductor manufacturing process. The fabricated wafer is then thinned, using a polishing process, sawn using an automatic dicing saw, and assembled by die-bonding, wire-bonding and the SOT packaging process. Finally, the IPDs are subjected to the measurement of their DC, RF and power performances.

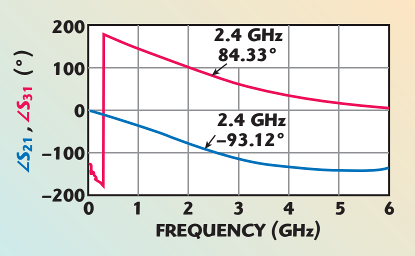
ADVANCED FABRICATION PROCESS OF INTEGRATED PASSIVE DEVICES

High-quality GaAs substrates and passive integration technology, characterized by accurate NiCr thin film resistors (TFR), high Q-factor spiral inductors and high-yield metal-insulator-metal (MIM) capacitors, enable the realization of fully integrated passive functional blocks. The proposed process starts with a first passivation layer, which is composed of SiN_x and is deposited by plasma-enhanced chemical vapor deposition (PECVD) up to a thickness of 2,000 Å. This layer is necessary to attain an even surface over the defects and roughness of the substrate surface. After SiN_x deposition, an e-beam-evaporated NiCr layer is deposited from a target consisting of 90 percent Ni and 10 percent Cr, in order to get the optimal performance. A Ti/Au 200 Å/800 Å layer, sputtered prior to plating process, is then used in order to increase the metal adhesion to the substrate. In the next step, the wafer is masked by photoresist to define the structures of the bottom metal layer. Then, a 4.5/0.5 µm-thick Cu/Au metal layer is formed by electroplating, which is used as the contact metal for the NiCr resistors, bottom metal layer for MIM capacitors, and metal feedline and coils for spiral inductors. Now the MIM capacitor middle dielectric part has to be realized, a SiN_x layer, 2,000 Å thick is deposited by PECVD and masked to define the structure. After the deposition step, a reactive-ion etching (RIE) step in O_2/SF_6 is performed to remove the undesired layer of the SiN_x. Next, a 1,000 Å-thick Ti/Au seed metal layer followed by an air-bridge post-photo process is deposited by sputtering. Then, an air-bridge photo process is performed prior to a Cu/Au (4.5 µm/0.5 µm) top metal definition and plating process, by which top metal and air-bridge are made for the capacitor, and air-bridge interconnections are formed at the coil paths around the metal feedline for the inductor. After the electroplating process, the air-bridge mask is stripped, and RIE of the Ti/Au seed metal is done. Finally, all components are passivated with a thickness of 0.3 µm SiN_x to protect the components from oxidation and moisture. The cross-sectional view of the GaAs IPDs is depicted in ***Figure 1***.

LUMPED L-C BALUN FOR WLAN APPLICATION

A balun provides balanced outputs from an unbalanced input. It is an important component in double-balanced mixers, push-pull amplifiers and the matching network placed between an antenna and the RF front-end system. Balanced output signals are defined as two output signals that have half of the input signal amplitude and are 180° out of phase.[11-12] Generally, the easiest way to obtain a phase difference is by controlling the length of the transmission line. However, it requires a large length (λ/2) to achieve a phase difference of 180° at 2.4 GHz. An artificial transmission line can be used to provide a 180° phase shift in a small size by using lumped inductors and capacitors.[13] This technique is used to convert the transmission line into lumped element circuits. A balun can be made using the relationship between the transmission line and the lumped element models, as seen in ***Figure 2.*** A compact 2.4 GHz wireless local area network (WLAN) balun designed and fabricated with a phase imbalance of less than 3° and very low insertion loss and high return loss is presented here.

After completing the layout, the circuit was fabricated using the GaAs IPD process created by NanoENS Co. Ltd. The fabricated chip was attached to the printed circuit board (PCB) using silver epoxy and bonded with gold wire. Measurements were then performed using a network analyzer over a frequency range of 100 MHz to 6 GHz. The insertion loss of the designed balun is affected by the core inductances of L_p and L_s; the design width of the core in-



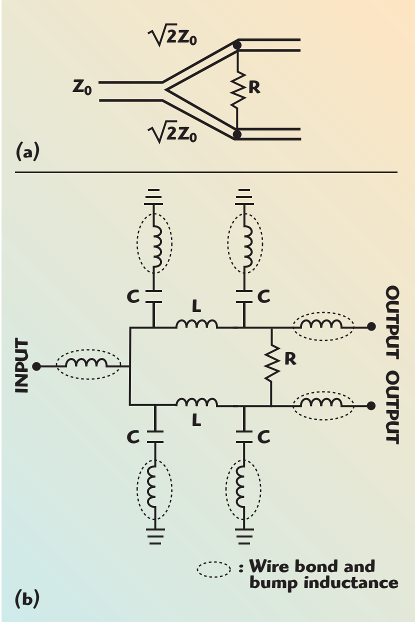
▲ *Fig. 4 Measured phase performance of the fabricated WLAN balun.*

ductors is 15 µm. The balun was fabricated with a die size of 800 × 700 × 200 µm. Its RF performances are shown in ***Figures 3*** and ***4***; the insertion loss and the return loss were below 0.25 dB and 25.75 dB, respectively. The phase imbalance was less than 3° and its amplitude imbalance was less than 0.5 dB.

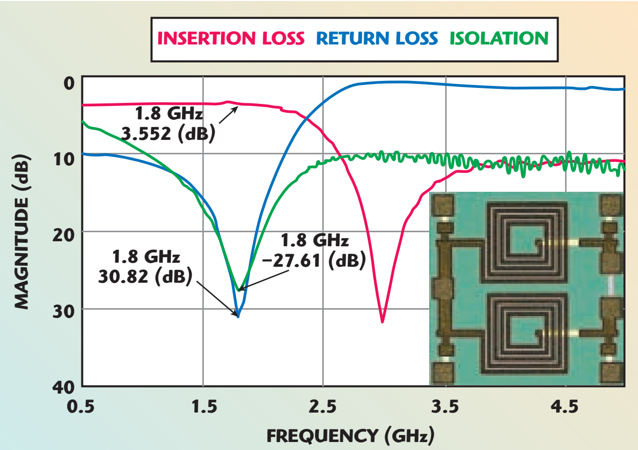
LUMPED L-C TYPE POWER DIVIDER FOR DCS APPLICATION

Power dividers are frequently used in transmitter and receiver systems, providing equal power division with an in-phase response. The power divider splits the input power into two or more output ports; it is a potentially lossless device, provided that no power is reflected from its output ports. Power dividers need to be matched at all ports; the output ports need to be isolated.[14-15] A typical two-way power divider includes an isolation resistor ($R = 2Z_0$) and two $\lambda/4$ transmission lines with an impedance of Z_0, where Z_0 is the characteristic impedance of the power divider. The schematic diagram of a typical two-way power divider is shown in ***Figure 5***. The power divider circuit can be converted, as seen in the figure, by using the relationship between the transmission lines and the lumped element models. The inductance effects of the interconnections between the output ports and ground also need to be taken into account. For the bond-wire and bump inductance, the required inductance values are 0.36 and 0.02 nH, respectively. To be able to achieve low losses and a wide bandwidth, inductors with relatively high resonant frequencies and large Q-factors are required. A small 1.8 GHz digital cellular system (DCS) power divider with a very low insertion loss, a high return loss and good isolation was designed and fabricated.

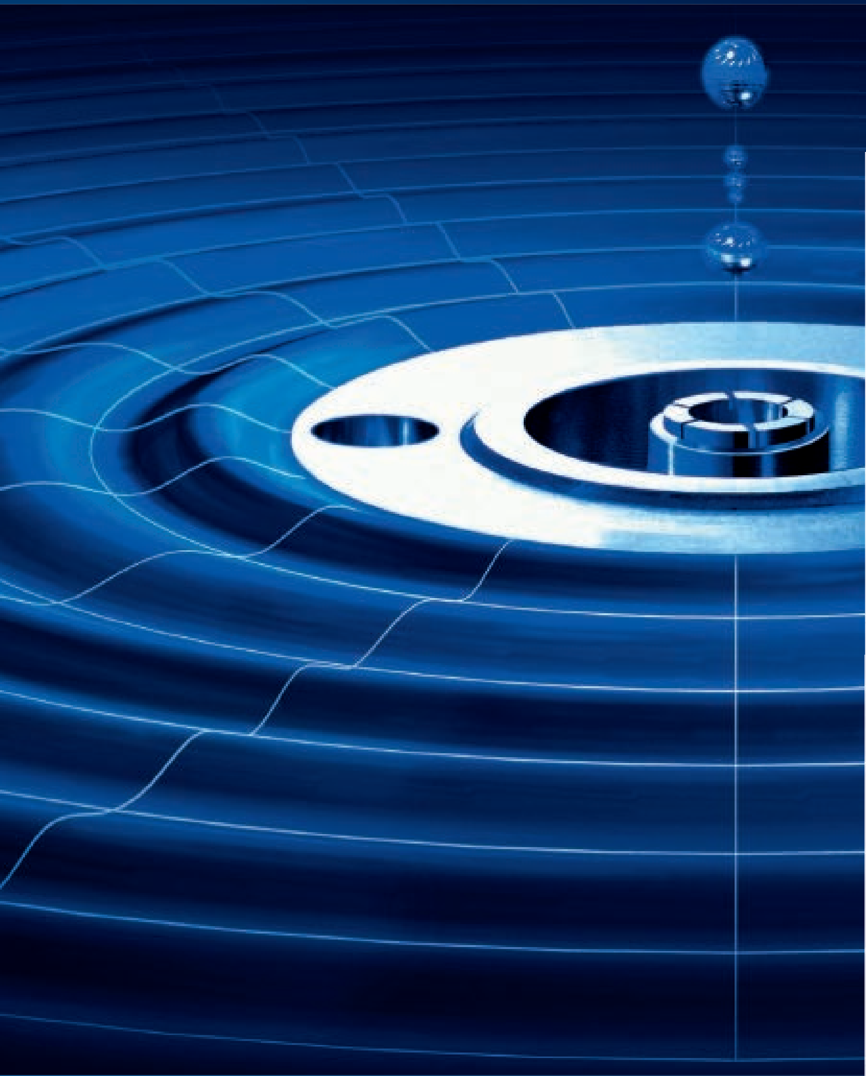
After completing the layout, the circuit was fabricated using the GaAs IPD process. The final required R, L, and C values were determined after optimization. The fabricated DCS power divider, with a die size of 850 × 750 × 200 µm, and its RF performances are shown in ***Figure 6***; the insertion loss is below 0.56 dB, the return loss is below 30 dB, and the isolation is better than 27.5 dB around



▲ *Fig. 5 Schematics of a typical power divider (a) and the designed DCS power divider (b).*



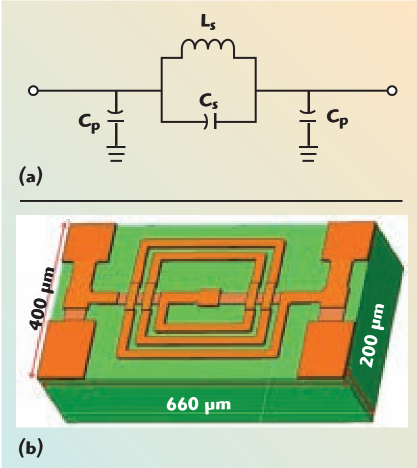
▲ *Fig. 6 Measured insertion loss, return loss and isolation for the fabricated DCS divider.*



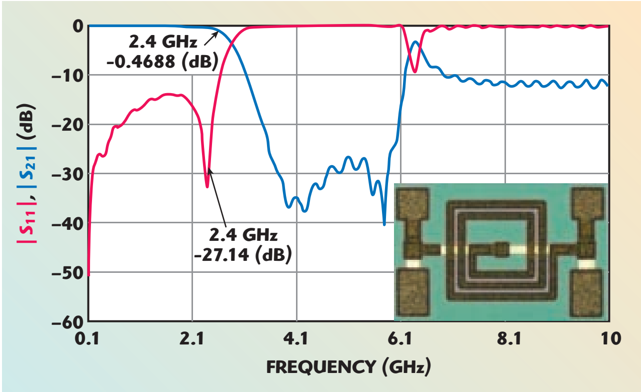
the center frequency. The amplitude imbalance between the output ports is approximately 0.1 dB; the phase difference is 1° at the operating frequency.

LUMPED L-C TYPE LOWPASS FILTER FOR WLAN APPLICATION

LPFs are an essential component in many electrical circuits for passing wanted signals and to eliminate or attenuate harmonics. The filter design starts from the synthesis of a standard third-order Butterworth LPF using lump elements.[16] A shunt capacitor C_s is added to the inductor L_s in order to create a transmission zero at approximately 5.6 GHz. Since there is only one spiral inductor in this filter design, only one capacitor can be added to create one resonant transmission zero. The inductance is also adjusted to achieve a good input-matching in the passband. The schematic circuit and 3D structure of the designed LPF are given in ***Figure 7***.



▲ *Fig. 7 Schematic of the designed WLAN LPF (a) and the CST simulation structure (b).*

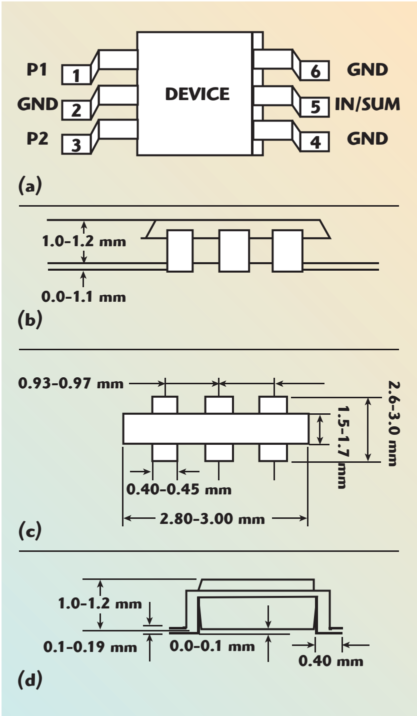


▲ *Fig. 8 Measured S-parameters for the fabricated WLAN LPF.*

There are many differences found between the circuit level simulation and the EM simulation results. In order to minimize this gap, a circuit-tuning method using the internal ports is used in this LPF design.[17] By using this optimization method, a response closer to the specifications was achieved. ***Figure 8*** shows a photograph of the 2.4 GHz WLAN LPF with a die size of 660 × 400 × 200 μm. The insertion loss was typically 0.56 dB at 2.4 to 2.5 GHz, and the return loss was below 27 dB. The attenuation level in the second-harmonic frequency was less than -25 dBc.

SOT PACKAGING AND POWER HANDLING MEASUREMENT

The use of semiconductor wafers is a cost-effective way to simultaneously fabricate many chips. Once all of the fabrication and testing is complete, the chips are separated from the wafer and assembled into the final integrated circuit (IC) package. The



▲ *Fig. 9 The SOT package schematic for the fabricated IPDs (a) full view, (b) side view, (c) top view and (d) front view.*

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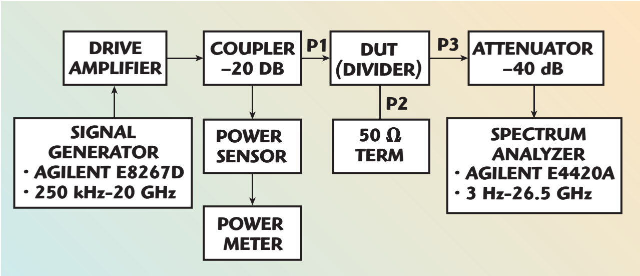
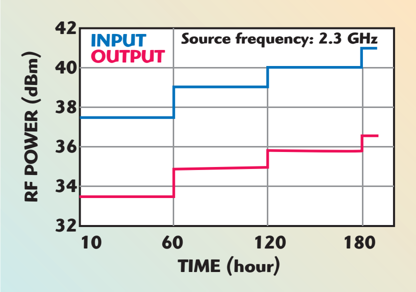


▲ *Fig. 10 Measurement system for the power handling evaluation.*



▲ *Fig. 11 Power handling measurement results.*

assembly and packaging process takes the approved electrical devices, places them in a package and interconnects the device bonding pads to the package leads. The packaging provides a means of protecting the chip from the environment and from handling damage, provides physical support for the chip heat dissipation, interconnection for the signals in and out of the chip, and for attaching it to a high assembly level.[18] In this work, SOT packages were used for the fabricated IPDs, which are small in size and allow a higher board density, leading to a higher electrical speed for system applications. The SOT packages are of the cheap surface-mount plastic-molded type, with leads on their two longer sides in order to achieve a low cost and a low profile. The SOT package schematics are illustrated in ***Figure 9***.

In general, power dividers and LPFs are usually located next to the power amplifier in order to split the power or remove the harmonic signals. Therefore, the power handling capacity is a very important factor in power dividers and LPFs. How to measure the power handling of the fabricated power dividers on the GaAs substrate will be shown as an example. ***Figure 10*** shows the system used for the power divider's power handling measurement. The incident power of the power divider can be measured by using a -20 dB coupler and the output power of the power divider by using a -40 dB attenuator and a spectrum analyzer. For the first test, 3.5 W of RF continuous wave power is injected into the input of the power divider. After 10 hours of operating time, the incident power is increased in 2 W steps. Due to its good thermal conductivity, the power divider on the GaAs substrate endured up to 12 W of incident power during the 60 hours step test. ***Figure 11*** shows the measurement results of the power divider after the 12 W power handling tests.

DISCUSSION

The IPDs measurement data are compared with other literature for similar devices using the same frequencies. The IPDs fabricated in this work show the lowest insertion loss and the best return loss characteristics with the smallest die size. This data shows the best results for the designed IPDs compared to the other IPDs. ***Tables 1*** and ***2*** show the WLAN balun, LPF and DCS power divider that were fabricated by NanoENS Co. Ltd.'s manufacturing process compared to other previously produced devices.

CONCLUSION

Compact-size RF IPDs were successfully fabricated on GaAs substrates with high power handling capability and low loss. The WLAN balun with a die size of 800 × 700 × 200 μm was fabricated, which showed an insertion loss of 0.25 dB and a return loss of 25.75 dB. The phase imbalance was measured to be less than 3°; the amplitude imbalance was less than 0.5 dB. The power divider for DCS application shows insertion loss of 0.56 dB, return loss of 30 dB, and isolation of 27.5 dB with a die size of 850 × 750 × 200 μm. An LPF is also fabricated for 2.4 GHz WLAN applications and has an insertion loss of 0.56 dB, a return loss of 27 dB and attenuation level at the second-harmonic frequency less than -25 dBc. The "cheap and compact" IPDs are achieved by us-

TABLE I
SUMMARY OF PUBLISHED WLAN (DB) BALUNS

Work	Insertion Loss (dB)	Return Loss (dB)	Magnitude Imbalance (dB)	Phase Imbalance (°)	Size (mm²)
[19]	0.8	14	0.5	3	2.22
[20]	0.5	16	0.3	3	2.22
[7]	1.8	12	0.8	6	1.20
[21]	1	20	0.45	2.8	1.26
[22]	0.7	21	0.8	5	6.75
This work	0.25	27	0.47	3	0.56

TABLE II
SUMMARY OF PUBLISHED WLAN LPFS AND DCS POWER DIVIDERS

Works	Insertion Loss (dB)	Return Loss (dB)	Isolation (dB)	Size (mm²)
LPF: [23]	0.5	20	-	1.44
LPF: [24]	2.8	22	-	2.56
LPF: [25]	0.3	20	-	420
This work	0.46	27	-	0.26
Divider: [26]	0.6	25	20	1.26
This work	0.5	30	27.5	0.48

ing passive integration technology on GaAs substrates and SOT packaging method, while maintaining their high power handling capability and RF performances. Such IPDs are suitable for use in various handheld modules and system applications that require an effective cost, stringent size and high performance. ■

ACKNOWLEDGMENT

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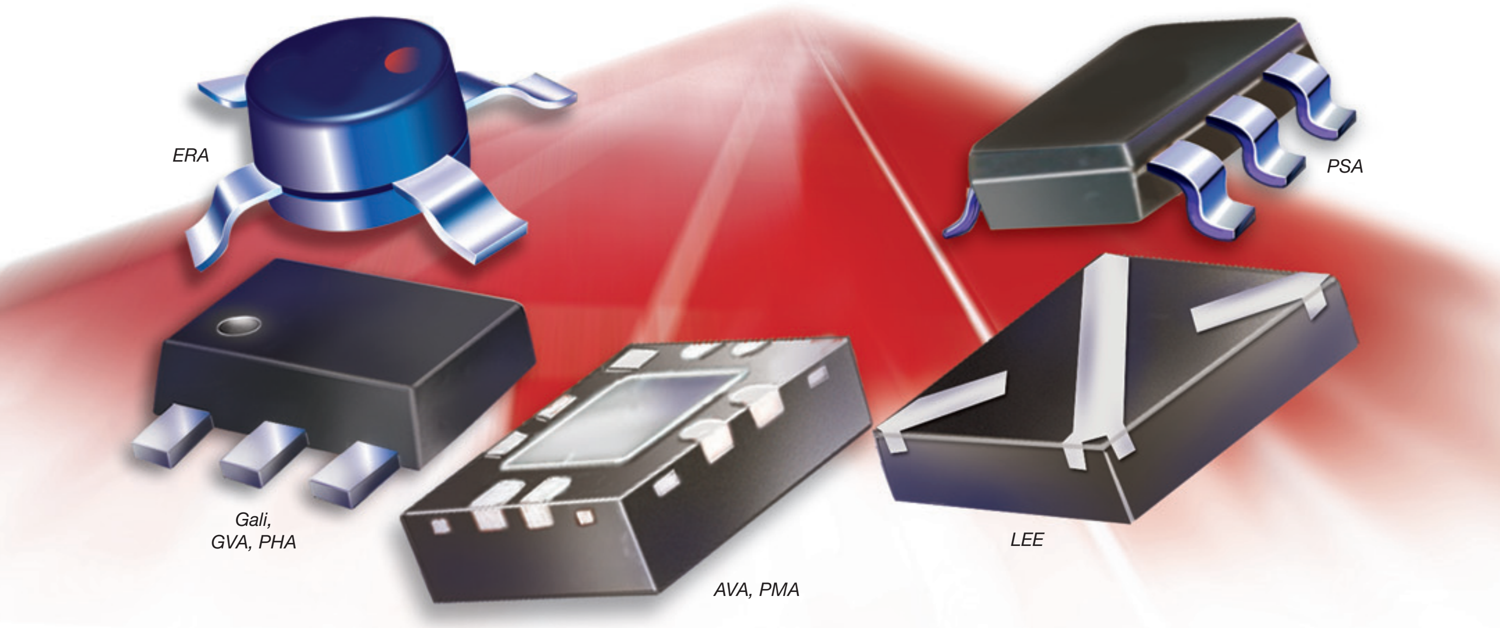

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500 W Plastic Packaged Doherty Amplifier

In the past, the cellular base station industry has primarily used 28 V LDMOS for high power amplifier transistors. The recent advance in multicarrier amplifiers implies that cellular signals are wider in nature. This has simultaneously driven the need for higher amplifier power to be generated. At the same time, the volumes requested by operators worldwide have exploded, due to the need for higher data rates and ubiquitous coverage. This is putting a lot of price pressure on the market.

Going forward, 48 V LDMOS is the natural answer to the three above requirements of larger signal bandwidth (35 MHz at 900 MHz and 75 MHz at 1.8 GHz), higher power target and lower price. Indeed, the switch from 28 to 48 V LDMOS allows for unmatched devices that can achieve higher signal bandwidth. The higher voltage operation also means doubling the power output inside the same package, allowing a drastic reduction in the number of output devices to be used. This, in turn, warrants a smaller overall footprint for the mechanics and the circuit. Altogether, the ability to double the power inside the same package warrants a lower cost solution to customers. Yet another advantage of 48 V LDMOS is the high gain associated with the technology (19 dB Doherty gain versus 16.5 dB for 28 V), which eases the power requirement on the driver devices. This translates into an overall boost in system power added efficiency.

Reported to be the first commercially available 48 V LDMOS transistor, specifically developed for the cellular application, it is a 500 W peak power transistor, housed in a cost effective plastic over-molded package. While this transistor can be used in broadband application, the focus of the design work has been centered around the 925 to 960 MHz GSM bandwidth.

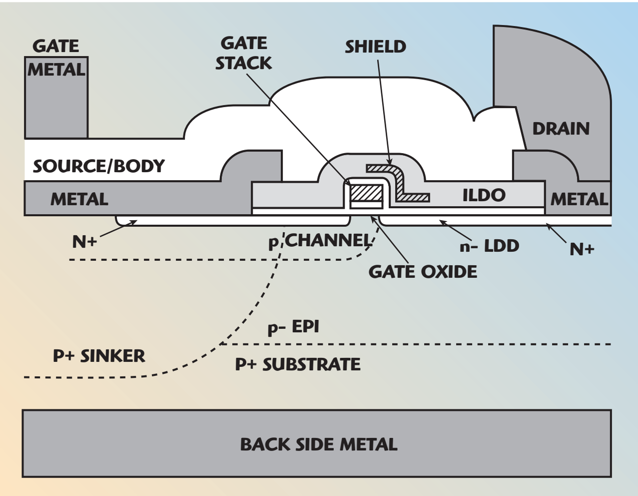

Fig. 1 LDMOS FET cross-section.

LDMOS TECHNOLOGY

Figure 1 shows a cross sectional diagram of a typical high power n-channel LDMOS FET finger from source to drain (left to right). The essential features that allow this device to operate under high drain supply potentials include the drain extension region or Lightly Doped Drain (LDD), and a thick lightly-doped epitaxial deposited layer on the starting substrate, both of which support high drain terminal potentials. 48 V LDMOS was commercially intro-

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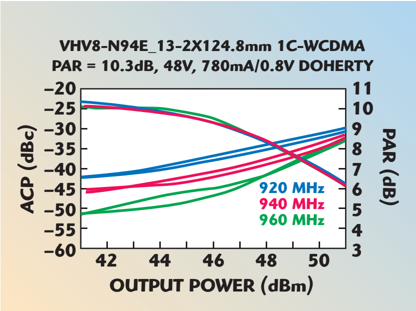
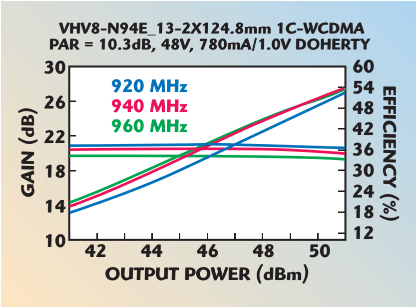
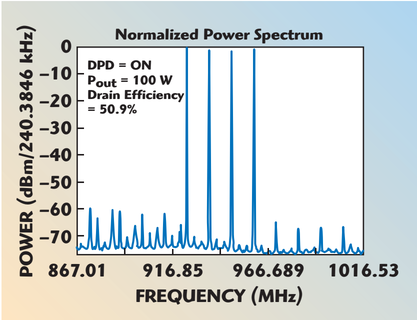


▲ *Fig. 2 ACP and PAR vs. output power.*



▲ *Fig. 3 Gain and efficiency vs. output power.*



▲ *Fig. 4 Linearized spectrum vs. frequency.*

duced in 2005, but has predominantly been applied in areas outside of cellular infrastructure, which continues to rely on 28 to 32 V LDMOS as the primary device technology. Fundamentally, the same device structural features can be used to create a 48 V LDMOS device structure suitable for cellular applications.

The key to designing a good LDMOS device for a Doherty application (or any other application) is a system view of the PA, where the design of the MOSFET, the internal and external matching networks and the linearization systems can be combined together to maximize the overall PA performance. From a device perspective, this will drive the optimum balance between the RF characteristics (gain, efficiency, raw linearity) and operational reliability characteristics (hot carrier injection, ruggedness, electro-migration) to offer the PA designer the widest latitude and flexibility to meet the PA performance and bandwidth requirements. A good example of the results of using this system level approach, using 48 V LDMOS, is the ruggedness improvements made for devices for industrial CO_2 laser systems. This same system approach, for a Doherty PA system, yields a 48 V LDMOS design optimized to provide similarly impressive performance in 900 MHz cellular applications.

AMPLIFIER DESIGN

The design of the internal on-die matching structures, in particular for high-power and wide RF bandwidth operation, has been a necessity for 28 V LDMOS FETs. By contrast, 48 V LDMOS FET technology, with higher Rp to deliver power and lower Cds-per watt, provides an opportunity that renders internal output matching structures unnecessary, thus avoiding frequency dispersion associated with such structures, and having the means to achieve higher signal bandwidths at higher powers. The internal input match is still needed in order to raise the input impedance to a user-friendly level, even though Cgs-per watt is lower relative to 28 V technology. The design of a complementing input Integrated Passive Device (IPD) was critical for this device. The IPD structures offer opportunities, to not only optimize the RF characteristics (in particular, gain and phase deviation) over the desired operating bandwidth, but also improve the stability of the part in the application, in particular with the added gain offered with 48 V LDMOS technology.

The Doherty amplifier technique has become a staple in the telecom base station arena. The efficiency enhancement that the Doherty amplifier provides is key to reducing the overall base station's power dissipation. At the same time, the amplifier needs to be linearized using digital pre-distortion (DPD). The off state impedance of the peaking amplifier becomes a factor as the Cds is increased with the added power and thus it loads the main amplifier and reduces the overall efficiency and operating bandwidth. In this regard, 48 V LDMOS technology bodes well as the Cds-per watt is significantly less than that of the 28 V technology.

Today's high power Doherty amplifiers are composed of two separate devices, which many times have different characteristics resulting in sub-par performance and undesirable factory yields. With the added power density offered by 48 V LDMOS technology, an in-package Doherty amplifier is a very good solution to address this issue. A dual path package is used for the in-package design, which has both the main and peaking amplifier with the associated IPDs. The FETs for the main and peaking amplifier will come from the same wafer and be from adjacent die, thus ensuring very good matching characteristics between the two. In addition, by housing the design in a plastic over molded package, the design will address both the cost and application footprint (power density in a given area), both of which are industry drivers in today's telecom base stations.

MEASUREMENT RESULTS

The measurement results shown are based on the plastic over molded, dual-path, in-package Doherty device, designed in a symmetric Doherty amplifier circuit covering the 920 to 960 MHz band. The Doherty amplifier circuit is tested under a single carrier W-CDMA signal, 10.3 dB PAR at CCDF = 0.01 percent for functional performance (see ***Figures 2*** and ***3***). It is also tested under a 4C-GMSK 35 MHz to demonstrate the linear DPD capability of the design.

The P3dB capability of the device and the Doherty amplifier is 57 dBm (500 W); at 50 dBm P_{out}, PAR = 7 dB. Also, the open loop ACP is in the mid –30 dBc range and respectable for correction with a DPD system. At 100 W (50 dBm), the average P_{out} efficiency is approximately 50 percent across the band with a Doherty gain of approximately 19 dB. ***Figure 4*** shows that the device and corresponding Doherty circuit can be linearized, with a DPD system, to –60 dBc or less under the 4C-GMSK 35 MHz signal.

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Wireless Power Meter

Power meters are essential to the telecommunications industry as the primary test and measurement equipment used by installation technicians and maintenance engineers. The current instrument market is mainly comprised of stationary meters built for laboratory countertops and portable power meters that tend to be rather large and bulky with troublesome cables. Neither of these options proves to be convenient or practical for outdoor use.

The RS2026 portable power meter features a wireless interface between a remote power unit and handheld display. This lightweight, digital device offers an innovative solution for any power meter application and would prove to be the clear choice for any maintenance and laboratory technicians and engineers. Designed to consistently provide exceptional performance, the RS2026 sets the standards high as the only power meter using wireless technology on the market as reported at the time of its release.

The RS2026 RemSensor is available in four versions of varying frequency. The 3 and 6 GHz versions are equipped with a type N male connector, the 20 GHz versions with a type N Female- or SMA (Male) connector, and the 26 GHz with SMA (Male) only.

Future models can be remotely controlled, include GPS capability, allow making measurements from multiple locations, be easily updated as needed, and have multiple remote sensor pairings capability. The wireless capabilities include a radio frequency of 2.4 GHz (unlicensed band) with a reach of up to 100 meters.

The remote power unit has a frequency range from 10 MHz to 20 GHz and a sensor-dependent power range between -23 and +10 dBm. It allows for both peak-hold and continuous power measurement and features a power accuracy of ±0.2 dB. Measurements are captured at four significant places and can be read in dBm or mW.

Both the handheld and remote units support a DC power input via a USB micro to AC adapter cable. The Handheld and RemSensor units are battery powered and provides intuitive user interface and data transfer through a USB micro interface. The handheld unit weighs 0.66 lbs with dimensions of 2.75 (W) × 1.40 (H) × 5.25 (L) inches. The RemSensor weighs 0.33 lbs and has dimensions of 2.2 (W) × 1.35 (H) × 3.0 (L) inches. The RemSensor operates within a temperature range of -25° to +45°C.

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Lab-Flex® 235SP	0.235	26.5 GHz
Lab-Flex® 335SP	0.335	18 GHz
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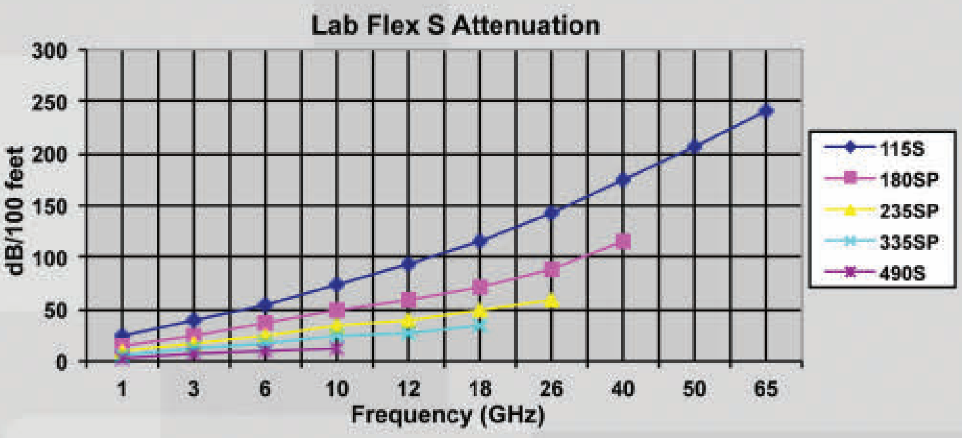


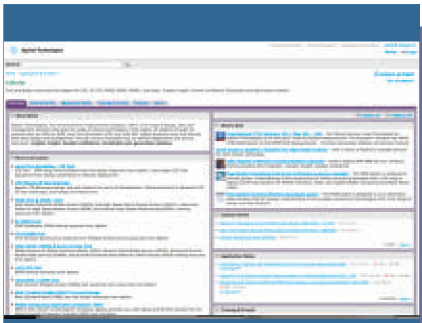
Common Connectors	115S	180SP	235SP	335SP	490S	Max Frequency
1.85 mm male straight	VMS					65 GHz
2.9 mm male straight	KMS	KMS				40 GHz
2.9 mm female straight	KFS	KFS				40 GHz
SMA male straight	SMS	SMS	SMS	SMS		18 GHz
SMA male right angle	SMR	SMR	SMR			18 GHz
Type N male straight		NMS	NMS	NMS	NMS	18 GHz
Type N male right angle		NMR	NMR	NMR	NMR	18 GHz
TNC male straight		TMS	TMS	TMS	TMS	18 GHz
TNC male right angle		TMR	TMR	TMR	TMR	18 GHz

Contact Us For Your
Cable Assembly Needs
sales@emc-rflabs.com

FLORIDA RF Labs

8851 SW Old Kansas Avenue, Stuart, FL 34997 USA
+1 772-286-9300 or 800-544-5594
www.emc-rflabs.com

FOR MORE NEW PRODUCTS, VISIT MWJOURNAL.COM/BUYERSGUIDE FEATURING VENDORVIEW STOREFRONTS



Cellular Matrix Web Page

VENDORVIEW

The newly updated cellular matrix web page shows Agilent's complete cellular design and test equipment offering for development, verification manufacturing and installation. Gain greater insight into cellular design and test solutions with the new 24/7 Agilent high-speed cellular matrix page. The page is available now at www.agilent.com/find/cellular.

Agilent Technologies,
5301 Stevens Creek Boulevard,
Santa Clara, CA 95051

agilent.com

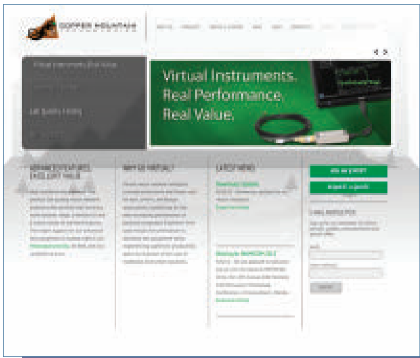
Bargain Corner

VENDORVIEW

AR RF/Microwave Instrumentation's bargain corner features discounted RF test instruments, including amplifiers, antennas, field probes and much more. Many models still include warranties.

AR RF/Microwave Instrumentation,
160 School House Road,
Souderton, PA 18964

ar-worldwide.com



Vector Analysis Software

VENDORVIEW

Copper Mountain Technologies (CMT) brings virtual-format testing to you – now in free, fully accessible online demos on its site, www.coppermountaintech.com. CMT serves your network analysis needs with virtual vector network analyzers in the frequency range of 300 KHz to 8 GHz. The rest of the newly unveiled site features a sleek design, easy navigation, a full menu of product exploration and engagement-centered updates.

Copper Mountain Technologies,
3905 Vincennes Road, Suite 105,
Indianapolis, IN 46268

coppermountaintech.com

Design Synthesis Software

Nuhertz Technologies has posted its new website at www.nuhertz.com. The new site features a logical comparative list of available design software, making it easy for the prospective user to make product and pricing decisions. As in the past, the site enables engineers to download products, either as freeware or as limited time trial licenses of all products.

Nuhertz Technologies,
1 East Camelback Road, Suite 550,
Phoenix, AZ 85012

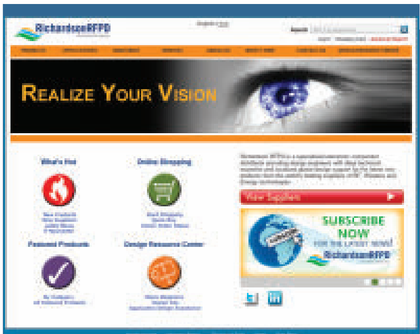
nuhertz.com

RF, Microwave and Fiber Optic Products

Pasternack's new website is designed to accommodate visitors' individual preferences for RF, microwave and fiber optic product searches. Product wizards, parameter search and filtered navigation have been developed to provide quick and accurate methods to locate any of the 30,000+ available parts without reaching "dead-end" results. With three effective ways to find Pasternack products, visitors to the website will be able to choose the methods that work best for their search.

Pasternack Enterprises Inc.,
17802 Fitch,
Irvine, CA 92614

pasternack.com



New Domain Name

VENDORVIEW

Richardson RFPD Inc. announced that its domain name is now richardsonrfpd.com, rather than the shared rell.com. This standalone website provides electronic design engineers and buyers with improved access and streamlined navigation to the latest new products from the industry's leading suppliers of RF, wireless and energy technologies. The previous website addresses are automatically redirecting users to the existing pages on the new domain for a period of six months.

Richardson RFPD Inc.,
40W267 Keslinger Road,
LaFox, IL 60147

richardsonrfpd.com


Integration
Technologies
Capacitor
Resistor
Via
InGaP HBT
d-Mode
pHEMT
e-Mode
pHEMT

Web Update

RF Supply Center

SemiGen announced its new RF Supply Center and is accepting online orders for immediate shipment of low volumes of popular epoxies, adhesive films, bonding tools, gold wire and other supplies. The center is fully stocked and located adjacent to the SemiGen manufacturing center. The launch of the RF Supply Center is in direct response to customer requests for quick delivery of their most commonly used supplies as well as to supply kits on the SemiGen manufacturing floor for turnkey build-to-print services.

SemiGen Inc.,
920 Candia Road,
Manchester, NH 03109

semigen.net

Microwave Connector Website

The newly redesigned website aims to enhance the customer experience by including a streamlined Product Finder with easy access to product information (including PDF downloads) and the ability to request quotes, manage projects and find Representative/Distributor contact information. More features include downloadable catalogs, technical papers and other reference materials as well as links to SMI news, events and the company's social media pages.

Southwest Microwave Inc.,
9055 S McKemy Street,
Tempe, AZ 85284

southwestmicrowave.com

Resource Center for Design Engineers

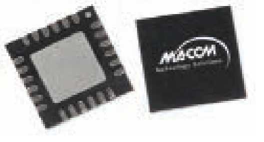
TE Connectivity's Aerospace, Defense & Marine business announces its new community-centered website for design engineers, www.DesignSmarterFaster.com. The new site is meant to be a resource center for design engineers to connect directly with TE subject matter experts (SME) who can advise and team up with them early in the design process to help bring their products and systems to market faster with smarter, better solutions.

TE Connectivity Ltd.,
Rheinstrasse 20, Ch-8200,
Schaffhausen, Switzerland

designsmarterfaster.com

Components

Digital Phase Shifters



M/A-COM introduced two new additions to its family of digital phase shifters for radar, communication, and electronic warfare (EW) applications. The phase shifters facilitate easy implementation in communication antennas, phased array radars, weather radars and EW receivers. The 3.5 to 6 GHz GaAs PHEMT 4-bit and 6-bit digital phase shifters meet the high performance requirements of communications and radar system manufacturers, optimizing for fast switching speed, low phase error, and serial or parallel control capability.

M/A-COM Technology Solutions Inc., Lowell, MA (978) 656-2896, www.macomtech.com.

Waveguide Mount Relay

RelComm compliments its product line by offering a new microstrip/coplaner waveguide mount relay in a 2P2T transfer configuration. This "pin out" device provides greater layout and packaging density measuring just 0.880" sq. × 0.575" high. The relay provides exceptional RF performance to 9 GHz (1.40:1 VSWR max, 0.40 insertion loss max, and 50 dB min isolation) and is silver plated for improved grounding and passive IM. Typical applications include 'standby applications,' 'input/output swapping' and developing switch matrices. It is available in 'failsafe' or 'latching' with optional configured 'circuit insertion' whereby one internal bridging contact is removed to provide a non-shorting circuit path.

RelComm Technologies Inc., Salisbury, MD (410) 749-4488, www.relcommtech.com.

Fixed Attenuator

This small and lightweight fixed attenuator is rated 100 W average power when mounted to the customer's heat sink. This 50 Ohm, DC to 1000 MHz, conduction cooled device features SMA female connectors. Attenuation accuracy is ± 0.5 dB maximum for 1 to 10 dB values, ±1 dB maximum for 11 to 20 dB values and ±1.5 dB maximum for 21 to 40 dB values. VSWR is 1.35: maximum. Standard attenuation values (3, 6, 10, 20, 30 and 40 dB) are typically available from stock. Other configurations, connector types and frequency ranges are available.

BroadWave Technologies Inc., Greenwood, IN (317) 888-8316, www.broadwavetech.com.

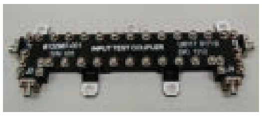
Hybrid Cables

Custom, application specific OptiFlex™ hybrid cabling solutions are perfect for wireless carriers updating their networks to 4G technologies, WiMAX and LTE, because they deliver optimal low loss performance with less cost than standard tower configurations. Time and money is saved in several ways: Fewer tower runs, deployment lengths up to 550 feet with < 10 percent voltage drop (based on radio power up to 950 W), reduced or eliminated tower hardware, and eliminated grounding cables. Cables arrive pre-terminated with appropriate breakouts, weatherized and ready to "plug and play" with standard tools and basic fiber and power testers.

Cables Unlimited, Yaphank, NY (800) 590-9965, www.cables-unlimited.com.

Input Test Coupler

Delta Microwave congratulates the U.S. Navy, Lockheed Martin, and United Launch Alliance for the successful launch of the first Mobile User Objective System (MUOS-1) satellite. Delta Microwave provides a UHF input test coupler for one of the payloads. Insertion loss is 0.12 dB max; coupling is 30 dB typ.; directivity is 15 dB; and VSWR is 1:25:1.



Delta Microwave, Oxnard, CA (805) 751-1100, www.deltamicrowave.com.

Electro-Mechanical Switches

EPX Microwave introduces low PIM SPDT, transfer, and multi-pole switches operating from DC to 3 GHz. The switches with 7/16 DIN connectors produce PIM below -160 dBc while still providing low insertion loss of 0.20 dB and 70 dB isolation to the off port. With Type N connectors the PIM is below -155 dBc and with SMA connectors below -140 dBc.

EPX Microwave, Santa Clara, CA (408) 727-7127, www.epxmicrowave.com.

Weatherproof Triaxial Connectors

Two new families of Triax connectors are available; the TRB series bayonet connectors and the TRT series featuring a threaded coupling. They are suitable for high or low volume applications, feature a high integrity clamp construction and are weatherproof. Key features include: low noise, isolated ground, non constant impedance and they can be used with both Twinax or Triax cable types. Triaxial connectors are commonly used in industrial, broadcast and medical applications. The standard double screening of Triax connectors makes them particularly suitable for military and aerospace applications as they provide high EMC integrity.

Intelliconnect (Europe) Ltd., Chelmsford, UK +44 (0) 1245 347145, www.intelliconnect.co.uk.

Cavity Filter

From K&L Microwave's new CS series, this 3-section narrowband cavity filter has a center frequency of 1521.5 MHz with an equiripple bandwidth of 2.6 MHz minimum, yielding an insertion loss of 3 dB maximum. The out-of-band attenuation for this 3-pole filter is 55 dB minimum from DC to 1500 MHz and 62 dB minimum at 1550 MHz. VSWR is less than 1.5:1 over the passband. The part measures 4.8" × 4.5" × 2.3" and is supplied with SMA female connectors, with other standard connector types available. Typical lead time is 5-6 weeks ARO.

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

Analog-to-Digital Converter

Linear Technology introduces the LTM9012, a quad 14-bit, 125 Msps µModule® analog-to-digital converter (ADC) with integrated fixed gain drivers, passive filtering and bypass capacitance. The integrated µModule converters offer dramatic reduction in board space for high channel-count applications as diverse as medical imaging systems and MIMO 4G base stations. This high level of integration enables smaller boards with greater density, while eliminating costly layout iterations often required to optimize the driver-to-ADC interface. This results in a significant reduction in design and debug time and faster time to market. The LTM9012 is in an easy-to-use 15 × 11.25 mm BGA µModule package.

Linear Technology, Milpitas, CA (408) 432-1900, www.linear.com.

Hybrid Ring Divider/Combiners

VENDORVIEW

MECA Electronics Inc. features their high power, Hybrid Ring Divider/Combiners designed to cover wireless bands from 0.810 to 6 GHz with average RF power handling capability of 1 kW (5 kW peak) for narrow band applications.

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Sweep or hop across wide frequency and power bands, use a pair for third-order intercept tests, or slip one into your laptop case and take it on the road! Our easy-to-use GUI will have you up and running in minutes. Compatible with most test software,* they add capabilities and increase efficiency, all without busting your budget!

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

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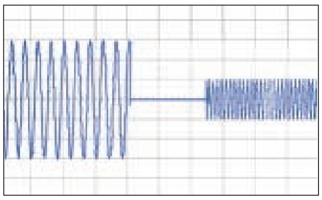
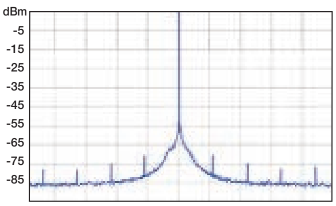


Frequency and power hopping.



Low spurious.

Model	Frequency (MHz)	Power (dBm)	Harmonics (dBc typ.)	Price ($ ea.)
SSG-4000HP	250-4000	-50 to +20	-40	1995.00
SSG-4000LH	250-4000	-60 to +10	-66	2395.00

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U.S. Patents 7739260, 7761442

IF/RF MICROWAVE COMPONENTS

New Products

Available from stock – four weeks ARO. Made in the USA. 36-month warranty. Additional specs can be found at www.e-meca.com/rf-directional-coupler/3-dB-hybrid-ring.php
MECA Electronics Inc.,
Denville, NJ (866) 444-6322,
www.e-meca.com.

Power Splitter

VENDORVIEW

A 9-Way power splitter? It's not something you run across every day, but Mini-Circuits meets and exceeds customer expectations for all sorts of "odd orders" — on a regular basis! The company's new ZC9PD-172+ is just another example, delivering 1.2 to 1.7 GHz signals with high isolation (up to 37 dB), low insertion loss (0.6 dB typ. above theoretical 9.6 dB), and excellent output VSWR (1.2:1 typ.).
Mini-Circuits,
Brooklyn, NY (718) 934-4500,
www.minicircuits.com.

LTE Band 14 Ceramic Duplexer

VENDORVIEW

NIC successfully built a high performance LTE ceramic duplexer for use in public safety communication and commercial cellular applications. This duplexer operates in Band 14 and offers low insertion and high isolation to enable clear communication of voice and data in the LTE network.
Networks International Corp.,
Overland Park, KS (913) 685-3400,
http://nickc.com.

TCXOs

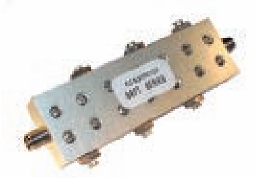
The RTX-A G uses Rakon's patented RGX technology, enabling the TCXO to perform with enhanced g-sensitivity performance in challenging environments. The G version includes all the other superb features of the RTX7050A and RTX5032A including typical phase noise of -154 dBc/Hz at 100 kHz offset for a 50 MHz TCXO. The RTX-A series employs an analogue IC for both the oscillator and temperature compensation. Frequencies are available from 5 to 52 MHz. With exceptional frequency stability down to ±0.1 ppm, the RTX-A series is available over a wide temperature range of -40° to +85°C.
Rakon Ltd.,
Auckland, New Zealand +64 9 571 9216,
www.rakon.com.

High Power Termination

Response Microwave announces the availability of its new high power termination for use in ATE and production applications. The new RMTE.3000Nm100 covers the DC to 3 GHz band offering typical electrical performance of 0.8 dB insertion loss and VSWR of 1.20:1.

Power handling is 100 W and the unit is operational over the -35° to +85°C range. Mechanical package is 4.72" × 3.95" × 2.36", plus N male connector. Heat sink is black anodized aluminum and connector is brass with low PIM ternary alloy plate.
Response Microwave Inc.,
Devens, MA (978) 772-3767,
www.responsemicrowave.com.

Bandstop and Cavity Filters



RLC Electronics now provides bandstop and cavity filters that can be re-adjusted by the customer to new center frequencies. These filters are tunable over a ±7.5 percent center frequency range with minimal change in bandwidth. Power rating: 2 W. Impedance: 50 ohms, VSWR: 1.5:1, fc to 2 × fc. Outlines: Per BRF series outlines. Temperature: -55° to +85°C. Environment: Mil-E-5400, Class 1A. Connectors: female.
RLC Electronics Inc.,
Mt. Kisco, NY (914) 241-1334,
www.rlcelectronics.com.

Directional Coupler

The new GC6-1 6 to dB wideband directional coupler has been designed with a small footprint and an open board layout, suitable for automatic assembly processes. Key specifications include a flat coupling loss over the operating frequency range from 10 to 500 MHz. Mainline loss is only 2 dB typical across that band. Directivity is typically 26 dB and maximum input power rating is 1 W. Size: 0.150" × 0.150" × 0.150".
Synergy Microwave Corp.,
Paterson, NJ (973) 881-8800,
www.synergymwave.com.

Lightning Protection Products

Times Microwave has expanded its Times-Protect™ LP-GTR series of DC pass RF lightning and surge protection products, adding the LP-GTR-N-35 series. The entire product range with either the type N or 7-16 DIN interface will now handle 50, 210 or 550 W. The LP-GTR product family is IP67 rated, bidirectional, suitable for outdoor as well as indoor installations and includes a universal grounding bracket. The N connector designs cover the entire frequency spectrum from DC through 3000 MHz while the 7-16 DIN types can be used from DC through 2500 MHz.
Times Microwave Systems,
Wallingford, CT (203) 949-8400,
www.timesmicrowave.com.

RF SAW Filters

TriQuint released three new RF SAW filters that can cost-effectively improve performance in 3G/4G network infrastructure and legacy

system applications. TriQuint's 856934, for Band 3 at 1842.5 MHz, provides 75 MHz bandwidth, a maximum 4.2 dB insertion loss and attenuation of 20 dB at 1785 MHz. Its new 857019, for an extended Band 5 at 835 MHz, offers 30 MHz bandwidth, a maximum 3 dB insertion loss and attenuation of 20 dB at 869 MHz. The 856977, for Bands 13 and 14 at 787.5 MHz, delivers 22 MHz bandwidth, a maximum 2.75 dB insertion loss and attenuation of 40 dB at 843 MHz.
TriQuint Semiconductor,
Hillsboro, OR (503) 615-9000,
www.triquint.com.

Power Divider

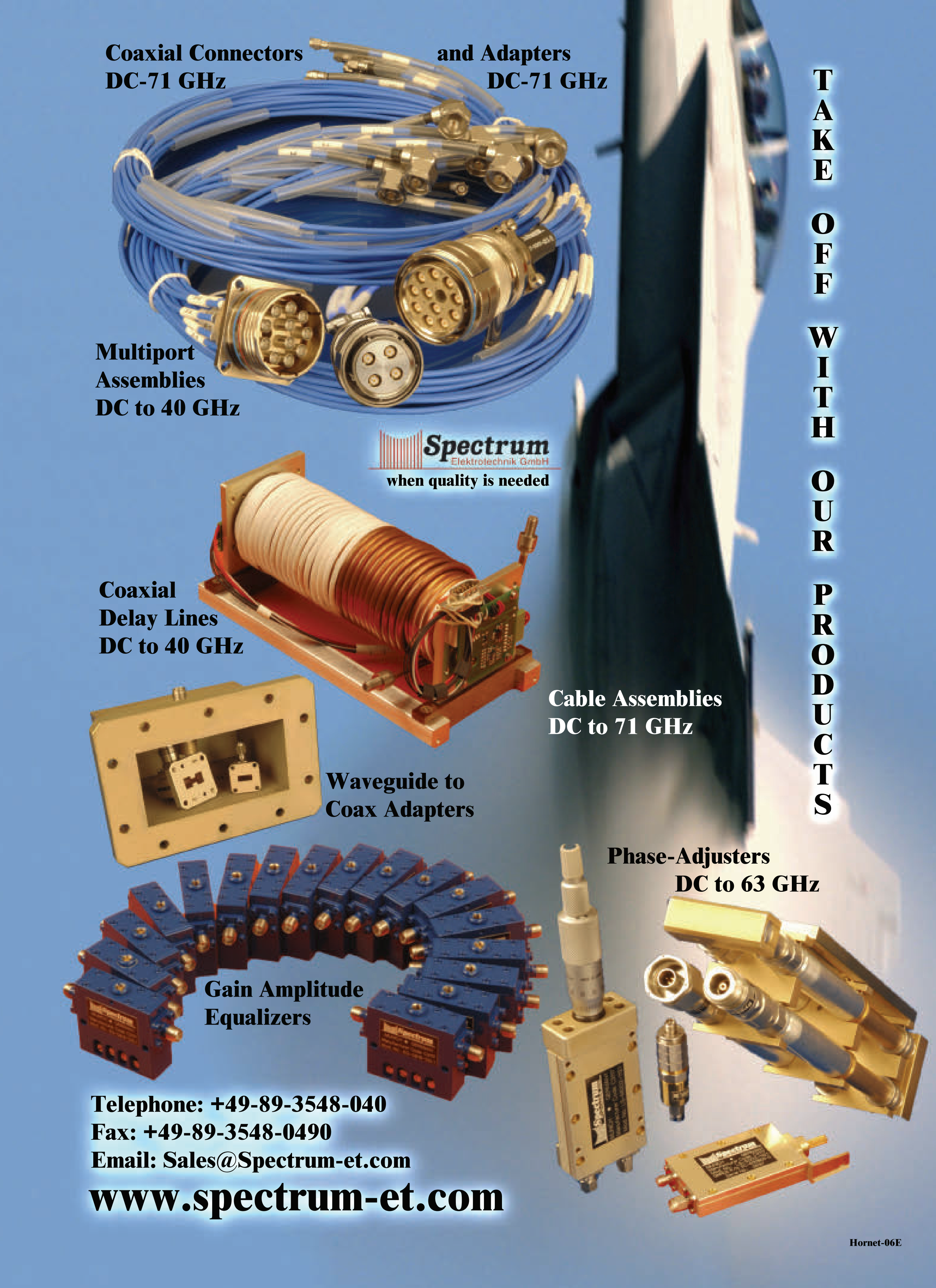
The DL 62030 is a six-way power divider well suited for radar and SATCOM applications. The maximum amplitude balance is ±1 dB while the phase balance is 5 degrees. Isolation between output ports is 18 dB minimum. Input/output VSWR is 1.80:1 and insertion loss is 5 dB maximum. Model DL62030 is rated for CW input power levels to +30 dBm. It is supplied in a mechanical package 4.25" × 2.0" × 0.25" with standard SMA connectors. The power divider is designed to operate in temperatures from 0 to +40°C.
TRM Microwave,
Bedford, NH (603) 627-6000,
www.trmmicrowave.com.

Precision Adapters

The P2RFA-4031-01 kit features three 3.5 mm precision adapters for microwave and RF use. They are housed in a compact, foam-lined, zippered case for convenience and protection of the components when not in use. These adapters and the RFA-4031-01 adapter kit have been added to the RF connector product line for use in microwave and RF applications. All 3.5 mm adapters in this series have 50 ohm impedance and are made of non-magnetic 303 stainless steel with beryllium copper contacts supported with a bead configuration.
RF Connectors,
San Diego, CA (800) 233-1728,
www.rfindustries.com.

Drop-In Circulator

VidaRF offers model VDC-04200450-3, a drop-in circulator. This model operates in a frequency range from 420 to 450 MHz, has 400 W, loss of 0.25 dB, VSWR of 1.20, isolation of 21 dB, and temperature range of -40° to +85°C. Circuit tab can be straight or bent flush with base for surface mounting. Dim: 1.375" × 1.375" × 0.560." The new rugged design uses a machined steel housing, screwed on cover and is fully tested to handle shock, vibration, thermal shock, and moisture.
VidaRF,
Huntersville, NC (704) 897-0558,
www.vidarf.com.


Coaxial Connectors
DC-71 GHz
and Adapters
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when quality is needed
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Cable Assemblies
DC to 71 GHz
Waveguide to
Coax Adapters
Phase-Adjusters
DC to 63 GHz
Gain Amplitude
Equalizers
Telephone: +49-89-3548-040
Fax: +49-89-3548-0490
Email: Sales@Spectrum-et.com
www.spectrum-et.com
Hornet-06E

New Products

Double-Sided Tape

Fujipoly introduced a new line of thermally conductive and electrically insulative double-sided tape. Sarcon® D-Tac is available in both an acrylic and silicone base formulation. Sarcon D-Tac 7A reinforced acrylic tape offers high adhesion strength with a thermal conductivity of 0.7 W/mK and a thermal resistance as low as 3.5°C cm²/W. This product is ideal for lower power densities. Sarcon D-Tac 9A silicone tape is perfect for higher operating temperatures and provides a thermal conductivity of 0.9 W/mK with a thermal resistance as low as 2.1°C cm²/W.

Fujipoly America Corp.,
Carteret, NJ (732) 969-0100,
www.fujipoly.com.

Uni-Directional Coupler

VENDORVIEW

Werlatone offers model C8188-102, a uni-directional coupler that covers a full 30 to 3000 MHz bandwidth and is rated at 20 W CW. Operating at a tight coupling factor of 20 dB, this model incurs only 2.4 dB of insertion loss, and supplies 18 dB minimum of directivity. The C8188-102 is designed for military and commercial applications and has an operating temperature of -55° to +85°C. It is 6" × 1.5" × 1.1" and is available with SMA female connectors.

Werlatone Inc.,
Patterson, NY (845) 278-2238,
www.werlatone.com.

Amplifiers

RF Amplifier System

Aethercomm model SSPA 0.1-0.5-400 is a high power RF amplifier system that operates from 100 to 500 MHz minimum. This transmit assembly is designed and manufactured for operation in harsh environments where communication systems are deployed. Typical output power is 400 W across the band in the linear region of operation. Nominal input power is 10 W but any input power range can be amplified as the system offers a very large dynamic range. Input and output VSWR is 2.0:1 maximum. It boasts CW, pulsed or high PAR stimulus, 28 VDC operation, and 1000 W internal TR switch.

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

RF Booster Amplifiers

VENDORVIEW

AR Modular RF offers the largest range of auto-tuning 30 to 512 MHz communications RF booster amplifiers with output powers from 20 to 200 W. The 50 W AR-50 vehicle unit is designed to carry existing legacy and emerging waveforms like IW and ANW2. It operates from 12/24 V vehicles or batteries, is JITC certified for the PSC-5D and PRC-117G, offers two antenna ports, one for LOS and one for SATCOM and has a switchable LNA plus SATCOM Rx bandpass filtering.

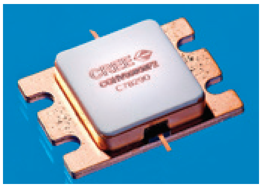
AR Modular RF,
Bothell, WA (425) 485-9000,
www.arworld.us.

Traveling Wave Tube Amplifier

Comtech Xicom Technology Inc. introduced a new high efficiency, 750 W peak power, Ku-Band traveling wave tube amplifier (TWTA) with the size, weight and prime-power consumption of standard 400 W amplifiers. The high power amplifier (HPA), model XTD-750KHE, is an antenna mountable TWTA designed for high linear power and high efficiency for Ku-Band SATCOM uplinks. The amplifier is in a compact, rugged package weighing only 56 pounds. It draws only 1450 W at 270 W of linear RF output power.

Comtech Xicom Technology Inc.,
Santa Clara, CA (408) 213-3300,
www.xicomtech.com.

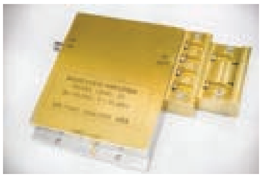
HEMT Amplifier



Cree is one of the first to commercially release high power X-Band GaN HEMTs to achieve 50 W output power. CGHV96050F2 provides high gain and efficiency – features of Cree's GaN HEMT technology. It is matched to 50 ohms in/out. CGHV96050F2 offers 35 percent more power gain and twice the power efficiency when compared to GaAs MESFET. Compared to traveling wave tube amplifiers, Cree GaN HEMT solid-state high power amplifiers have significantly lower CAPEX and OPEX from maintenance.

Cree Inc.,
Durham, NC (866) 924-3645,
www.cree.com.

Power Amplifier



Model L2640 is a Ka-Band high power amplifier operating over the 26 to 40 GHz bandwidth. This amplifier delivers 2 W minimum of output power across the entire bandwidth with greater than 35 dB of small signal gain. Its

HIGH POWER PRODUCTS

POWER DIVIDERS

Model #	Frequency (MHz)	Insertion Loss (dB) [Typ./Max.] ◊	Amplitude Unbalance (dB) [Typ./Max.]	Phase Unbalance (Deg.) [Typ./Max.]	Isolation (dB) [Typ./Min.]	VSWR (Typ)	Input Power (Watts) [Max.] ◦	Package
2-WAY								
CSBK260S	20 - 600	0.28 / 0.4	0.05 / 0.4	0.8 / 3	25 / 20	1.15:1	50	377
DSK-729S	800 - 2200	0.5 / 0.8	0.05 / 0.4	1 / 2	25 / 20	1.3:1	10	215
DSK-H3N	800 - 2400	0.5 / 0.8	0.25 / 0.5	1 / 4	23 / 18	1.5:1	30	220
P2D100800	1000 - 8000	0.6 / 1.1	0.05 / 0.2	1 / 2	28 / 22	1.2:1	5	329
DSK100800	1000 - 8000	0.6 / 1.1	0.05 / 0.2	1 / 2	28 / 22	1.2:1	20	330
DHK-H1N	1700 - 2200	0.3 / 0.4	0.1 / 0.3	1 / 3	20 / 18	1.3:1	100	220
P2D180900L	1800 - 9000	0.4 / 0.8	0.05 / 0.2	1 / 2	27 / 23	1.2:1	5	331
DSK180900	1800 - 9000	0.4 / 0.8	0.05 / 0.2	1 / 2	27 / 23	1.2:1	20	330
3-WAY								
S3D1723	1700 - 2300	0.2 / 0.35	0.3 / 0.6	2 / 3	22 / 16	1.3:1	5	316

◊ In excess of theoretical split loss of 3.0 dB
◦ With matched operating conditions

HYBRIDS

Model #	Frequency (MHz)	Insertion Loss (dB) [Typ./Max.] ◊	Amplitude Unbalance (dB) [Typ./Max.]	Phase Unbalance (Deg.) [Typ./Max.]	Isolation (dB) [Typ./Min.]	VSWR (Typ)	Input Power (Watts) [Max.]	Package
90°								
DQS-30-90	30 - 90	0.3 / 0.6	0.8 / 1.2	1 / 3	23 / 18	1.35:1	25	102SLF
DQS-3-11-10	30 - 110	0.5 / 0.8	0.6 / 0.9	1 / 3	30 / 20	1.30:1	10	102SLF
DQS-30-450	30 - 450	1.2 / 1.7	1 / 1.5	4 / 6	23 / 18	1.40:1	5	102SLF
CSDK3100S	30 - 1000	0.8 / 1.2	0.05 / 0.2	0.2 / 3	25 / 18	1.15:1	50	378
DQS-118-174	118 - 174	0.3 / 0.6	0.4 / 1	1 / 3	23 / 18	1.35:1	25	102SLF
DQK80300	800 - 3000	0.2 / 0.4	0.5 / 0.8	2 / 5	20 / 18	1.30:1	40	113LF
MSQ80300	800 - 3000	0.2 / 0.4	0.5 / 0.8	2 / 5	20 / 18	1.30:1	40	325
DQK100800	1000 - 8000	0.8 / 1.6	1 / 1.6	1 / 4	22 / 20	1.20:1	40	326
MSQ100800	1000 - 8000	0.8 / 1.6	1 / 1.6	1 / 4	22 / 20	1.20:1	40	346
MSQ-8012	800 - 1200	0.2 / 0.3	0.2 / 0.4	2 / 3	22 / 18	1.20:1	50	226
180° (4-PORTS)								
DJS-345	30 - 450	0.75 / 1.2	0.3 / 0.8	2.5 / 4	23 / 18	1.25:1	5	301LF-1

◊ In excess of theoretical coupling loss of 3.0 dB

COUPLERS

Model #	Frequency (MHz)	Coupling (dB) [Nom]	Coupling Flatness (dB)	Mainline Loss (dB) [Typ./Max.]	Directivity (dB) [Typ./Min.]	Input Power (Watts) [Max.] ◦	Package
KDS-30-30	30 - 512	27.5 ±0.8	±0.75	0.2 / 0.28	23 / 15	50	255 *
KFK-10-1200	10 - 1200	40 ±0.75	±1.0	0.4 / 0.5	22 / 15	150	376
KBS-10-225	225 - 400	10.5 ±1.0	±0.5	0.6 / 0.7	25 / 18	50	255 *
KDS-20-225	225 - 400	20 ±1.0	±0.5	0.2 / 0.4	25 / 18	50	255 *
KBK-10-225N	225 - 400	10.5 ±1.0	±0.5	0.6 / 0.7	25 / 18	50	110N *
KDK-20-225N	225 - 400	20 ±1.0	±0.5	0.2 / 0.4	25 / 18	50	110N *
KEK-704H	850 - 960	30 ±0.75	±0.25	0.08 / 0.2	38 / 30	500	207
SCS100800-10	1000 - 8000	10.5 ±1.5	±2.0	1.2 / 1.8	8 / 5	25	361
KBK100800-10	1000 - 8000	10.5 ±1.5	±2.0	1.2 / 1.8	8 / 5	25	322
SCS100800-16	1000 - 7800	16.8 ±1.5	±2.8	0.7 / 1	14 / 5	25	321
KDK100800-16	1000 - 7800	16.8 ±1.5	±2.8	0.7 / 1	14 / 5	25	322
SCS100800-20	1000 - 7800	20.5 ±2.0	±2.0	0.45 / 0.75	12 / 5	25	321
KDK100800-20	1000 - 7800	20.5 ±2.0	±2.0	0.45 / 0.75	14 / 5	25	322

* Add suffix - LF to the part number for RoHS compliant version.
◦ With matched operating conditions

Unless noted, products are RoHS compliant.

SYNERGY® MICROWAVE CORPORATION

Phone: (973) 881-8800 | Fax: (973) 881-8361
E-mail: sales@synergymwave.com
Web: WWW.SYNERGYMWAVE.COM
Mail: 201 McLean Boulevard, Paterson, NJ 07504

package size is 3.60" × 4.31" × 0.65", or it can be provided in an industry standard 19" rack mount chassis. RF connectors are K input and waveguide WR28 output, and the DC supply is +12 V at 5 amps. Many options can be specified, including very fast on/off switching (35 ns typical, 50 ns max) via standard TTL command.

Microsemi Corp.,
Santa Clara, CA (408) 727-6666,
www.microsemi.com/rfis

Low-Noise Amplifier

VENDORVIEW

PMI model no. PE2-4020-9R510R7-2R5-12-12-SFF-VVG is a voltage variable gain, low-noise amplifier that operates over the 9.5 to 10.7 GHz frequency range. This model provides 40 dB of small signal gain with a typical noise figure of 4 dB and an OP1 dB of +12 dBm. This model provides up to 20 dB of gain control range by applying a DC control voltage of 0 to +5 V. This amplifier operates on a single DC power supply between +12 and +15 V DC.

Planar Monolithics Industries Inc.,
Frederick, MD (301) 662-5019,
http://pmi-rf.com.

GaAs Amplifier

VENDORVIEW

RFCA3302 is a high performance InGaP HBT MMIC amplifier designed to run from a single +5 V supply without the need for an external dropping resistor. The high gain, high linearity and low distortion from 40 to 1008 MHz make this part ideal for broadband cable applications. An integrated bias circuit provides stable gain over temperature and process variations. It is offered in a small SOT-89 package and is RoHS compliant.

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

Power Amplifier Linearizer

The SC1889A-00B11 integrates the entire PMU function that would otherwise require up to three external devices consisting of a precision RMS power detector, an analog-to-digital converter and a microcontroller. The PMU delivers excellent measurement performance across cellular frequencies, RF power levels and operating conditions. Requiring only a single point of calibration, the simultaneous dual-RMS power detector provides an absolute accuracy (typical) of ±0.1 dB over the first 20 dB of the input range and ±0.5 dB over the last 10 dB of input range for the power amplifier (PA) lineup input and output.

Scintera Networks Inc.,
Sunnyvale, CA (408) 636-2600,
www.scintera.com.

Test & Measurement

Vector Signal Analyzer

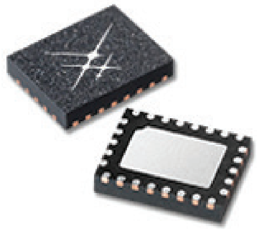
VENDORVIEW

Agilent announced the availability of the first dual-channel PXI vector signal analyzer that delivers high-bandwidth, independently tuned, two-channel, continuous data capture. The solution is ideal for troubleshooting wireless devices in either the lab or real-world environments. The dual-channel PXI vector signal analyzer, offers a unique combination of bandwidth, multichannel support, and gapless recording, with 250 MHz of analysis bandwidth, 26.5 GHz frequency coverage on two channels, and continuous streaming up to 100 MHz bandwidth. Both channels can be housed in an 18-slot, 4U PXIe chassis to provide excellent speed and scalability in a small form factor.

Agilent Technologies Inc.,
Santa Clara, CA (800) 829-4444,
www.agilent.com.

Antenna Switch Modules

VENDORVIEW

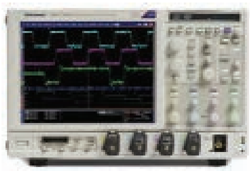


Skyworks Solutions Inc. expanded its family of antenna switch modules (ASM) for smartphones and tablets, offering solutions in up to 14 throw counts to meet handset manufacturers' layout preferences and design needs. Skyworks has also unveiled a full suite of complementary discrete LTE transmit and receive solutions covering SPDT through SP8T applications in a compact 2 × 2 mm footprint. Together, these latest devices support low cost 3G handsets, as well as high speed packet access/LTE-enabled data centric devices such as data cards and tablets.

Skyworks Solutions Inc.,
Woburn, MA (781) 376-3000,
www.skyworksinc.com.

Thunderbolt Test Solution

Tektronix Inc. announced a comprehensive test solution for Thunderbolt technology, a new, high-speed, multi-protocol I/O technology designed to provide headroom for next generation display and I/O requirements. The new solution for support includes a 20 GHz DSA70000 Series Oscilloscope, 12.5 Gb/s BSA Series BERTScope, and a DSA8300 Series Sampling Oscilloscope. The Tektronix solution serves the comprehensive needs of Thunderbolt physical layer testing and spec conformance validation. Thunderbolt's four channel 10.3 Gbps I/O archi-



New Products

tecture is the most significant advancement in PC I/O design ever introduced into the consumer level electronics industry.
Tektronix Inc.,
Beaverton, OR (800) 833-9200,
www.tek.com.

Comb/Pulse Generator

The Comb/Pulse Generator Module (PulsGen-M) is based on ECL-technology and generates 100 ps pulses and a jitter of only 20 ps. Low power instruments can drive this comb/pulse generator and the combination of arbitrary waveform generators along with high-speed D/D-converters or D/A-converters with the PulsGen-M enables the production of IQ-signals in the GHz range. Features include broadband input (30 MHz to 4 GHz) that allows the generation of single pulses, ECL compatible output with two differential comb/pulse outputs, very low output amplitude ripple and harmonics from 30 MHz to 18 GHz. It has a typical output harmonic level (for 200 MHz input) > -35 dBm at 4 GHz, a 100 to 200 MHz internal frequency synthesizer and a tunable step size of 400 kHz.
Heuermann HF-Technik GmbH,
Aachen, Germany +49 2408 9379019,
www.hhft.de.

Subsystems

Embedded Wi-Fi Modules

Get to know Murata's new class of 'Embedded Wi-Fi' products to cut your development cycle time in half. Features include FCC/IC certified, built-in Wi-Fi driver, security supplicant and network stack. These modules enable Wi-Fi operation with low power micro-controllers to simplify the systems integration efforts. Modules come in two options: with micro-controller build-in (SN8200) or for external micro-controllers (Type VK).
Murata Wireless Solutions,
Plano, TX (972) 202-8900,
www.murata-ws.com.

Full-band Receiver

Model MV-13X2 is a full-band receiver that downconverts all of V-Band (50 to 75 GHz) to an IF range of 1 to 26 GHz. Conversion loss is 6.5 dB typical, 11.5 dB max. The LO is derived from a customer-supplied 24.5 GHz signal at +15 to +17 dBm that derives a passive frequency doubler generating +5 dBm at 49 GHz. The mixer requires a bias of +15 V DC at 10 mA. The RF port of WR-15 waveguide and the LO and IF ports are 2.9 mm "K" (f) connectors.
Spacek Labs Inc.,
Santa Barbara, CA (805) 564-4404,
www.spaceklabs.com.

Sources

Frequency Sources

The new SMS surface-mount frequency sources operate up to 8 GHz and can be configured to be either programmable to step across a frequency range or as a fixed frequency source requiring no programming. These units operate on either an external 10 MHz reference or an internal TCXO and operates on a single +5 V supply. Offering excellent phase noise and spurious performance with a buffered and filtered output signal, these units are a great addition to any system requiring a miniature surface mountable frequency source.
Luff Research Inc.,
Floral Park, NY
(516) 358-2880,
www.luffresearch.com.

OCXO

The OX-501 OCXO from Vectron combines a small footprint with high stability, providing 20 ppb over the full industrial temp range in a compact industry standard 9 × 14 mm package. It has available output frequencies of 10 to 40 MHz. The OX-501 bridges the gap between AT cut based TCXOs and larger OCXO designs and provides improved phase noise and short term stability.
Vectron International,
Hudson, NH
(888) 328-7661,
www.vectron.com.

Erratum

Corrected data for: Synergy Microwave, Ultra Low-Noise Crystal Oscillators, p. 112 & 114, April 2012

The phase-noise performance of the LNXO100 is -135 dBc/Hz @ 100 Hz (-140 typ.), min. -160 dBc/Hz @ 1 KHz (-162 typ.) and the noise-floor is typically -183 dBc over the temperature range of -20° to +60°C.

The LNXO125 delivers a 125 MHz-signal with a minimum phase noise performance of -135 dBc/Hz @ 100 Hz (-140 typ.), min. -160 dBc/Hz @ 1 KHz (-162 typ.) and a noise-floor of typically -183 dBc over a temperature range of -20° to +60°C.

The complete Product Feature can be viewed at www.microwavejournal.com

Nonlinear Transistor Model Parameter Extraction Techniques

Edited by Matthias Rudolph, Christian Fager and David E. Root

Nonlinear Transistor Model Parameter Extraction Techniques covers accurate and reliable parameter extraction using a complete survey of state-of-the-art techniques and methods. The goal of the book is to provide a comprehensive overview of transistor model parameter extraction which it does very well. The book gives a broad perspective focusing on various issues and concepts but not restricting any particular concept to a single type of transistor.

This book is edited by leading experts in the field which include Matthias Rudolph of Brandenburg University of Technology, Christian Fager of Chalmers University of Technology, and David E. Root of Agilent Technologies. Each chapter represents an individual talk given at the IEEE MTT-S IMS workshop in 2009. The range of topics covers almost all the challenges in parameter extraction, from DC to small signal parameters, how to integrate small-signal parameters to obtain large-signal quantities such as charge and current, how to determine extrinsic element values, transistor package modeling and self-heating, dispersion effects, noise, statistics of transistor process, and overview of measurement techniques for extraction and validation.

It includes a variety of real-world industrial examples and measurement results show how the theories and methods presented can be used in practice. It is recommended as a high quality, practical text for anyone interested in this topic.

To order this book, contact:

Cambridge University Press
32 Avenue of the Americas
New York, NY 10013-2473
(212) 924-3900
www.cambridge.org/us

350 pages, $130
ISBN: 978-0-52176-210-6

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With an insertion loss as low as 0.23 dB typical, these hi-rel, wide-band limiters provide protection against high level signals from +5 dBm to +36 dBm input. The power out of the limiter is as low as 0 dBm typical, thus protecting the sensitive devices connected to the limiter output. *The surface mount RLM series* is housed in a miniature plastic case, 0.25" x 0.31" x 0.17", while the *VLM SMA connectorized series* is housed in a rugged, patented unibody package for easy connection to sensitive devices following the limiter.

Data sheets, performance curves, measurement data, and environmental specifications are available on our website, *minicircuits.com.* So why wait, order on our website and get delivery as quickly as the next day.

Unibody patent 6,943,646 ***RoHS compliant.***

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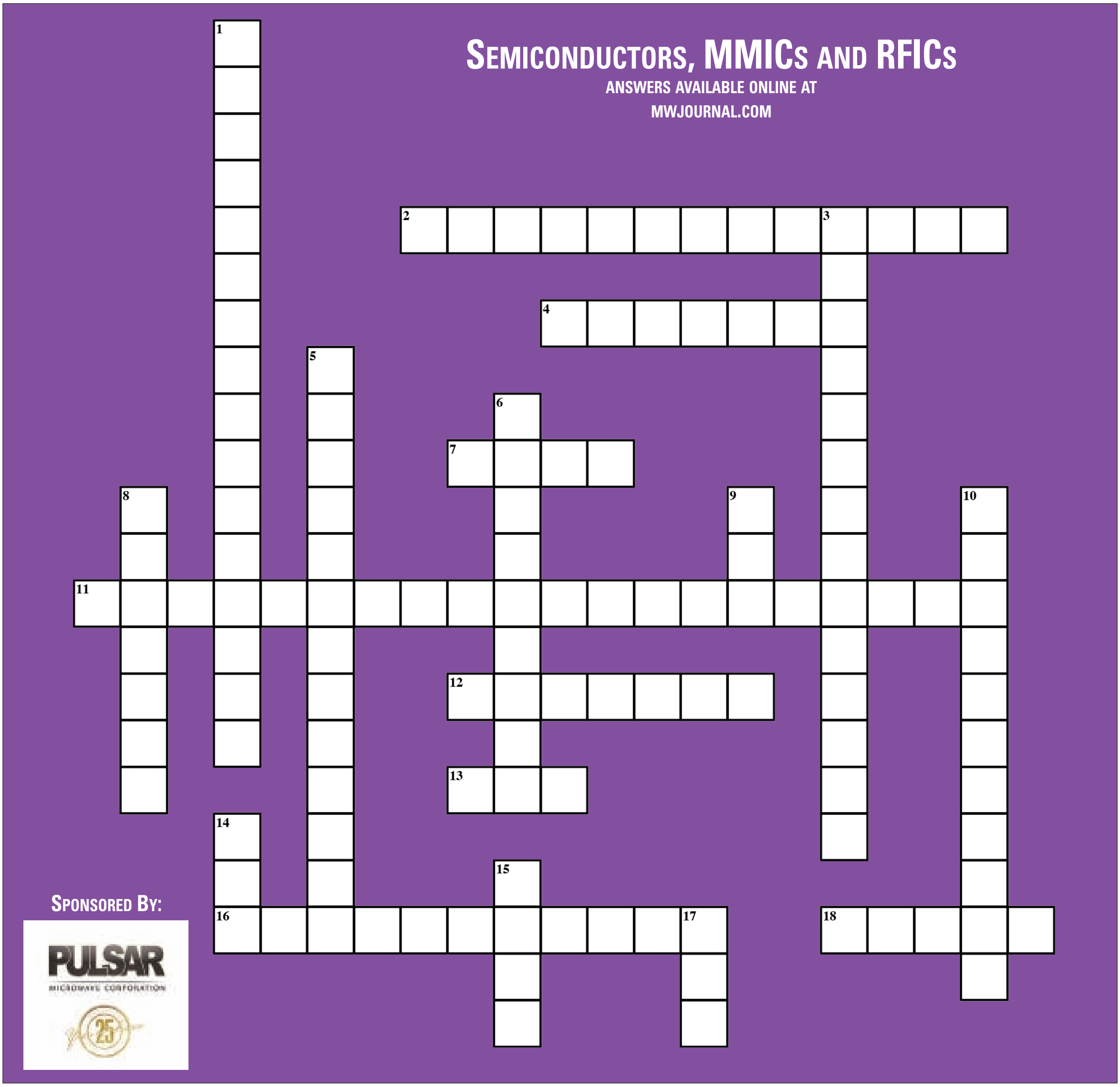
MWJ Puzzler



ACROSS

2 UWB (3 words)

4 Low cost substrate for GaN devices

7 Currently projected to be the largest commercial market for GaN

11 FFT (3 words)

12 Short for composite right- and left-handed zero-order resonator (2 words)

13 High stand off voltage and low noise characteristics make GaN a potential for this type of device

16 Another name for "non-incandescent cathode" magnetrons (2 words)

18 Competes well with GaN in high power cellular base station market

DOWN

1 Largest reverse voltage that can be applied without causing an exponential increase in the current (2 words)

3 BPF (3 words)

5 A viable mesurement to evaluate the performance of radars that use pulse compression (3 words)

6 High-powered vacuum tube that generates microwaves

8 Highest bandgap material that can be used for semiconductor devices

9 Solid-state technology that could replace high power TWTs amplifiers

10 Another word for pulse modulation

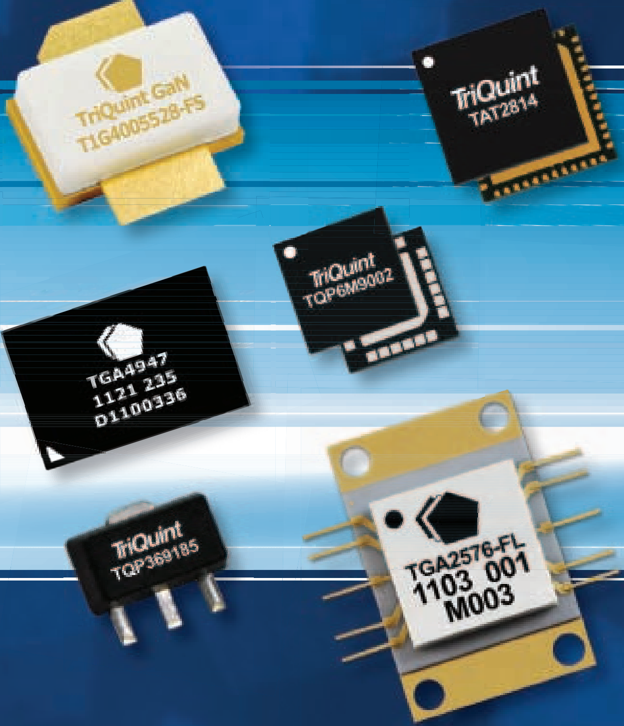
14 Most common substrate for GaN devices

15 Short for low temperature co-fired ceramic

17 Short for Error Vector Magnitude

2012-13

Product Selection Guide



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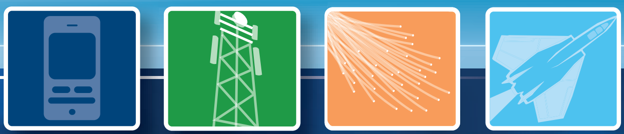


Connecting the Digital World to the Global Network®

TriQuint® SEMICONDUCTOR

Welcome to Our Product Selection Guide

Table of Contents

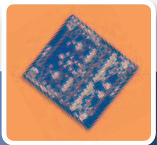
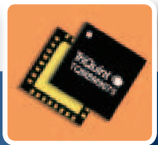
This guide contains a subset of the total selection of products available from TriQuint. If you are unable to locate the product you need, please contact your local sales representative or the factory for more information.

Welcome to TriQuint Semiconductor's 2012-13 Product Selection Guide. Our guide lists over 600 standard products and highlights 86 new releases, showcased for the first time in our New Products section.

Products are organized both by key market applications and product types. Included is a significantly expanded Defense & Aerospace market section with new product tables sorted by GaN, electronic warfare, radar, space and comms. We've also incorporated block diagrams with color coding to indicate where TriQuint product solutions exist.

We invite you to visit our website at **www.triquint.com** to obtain full product specifications and to utilize our interactive block diagrams which make it easy to drill down to specific products. TriQuint's Tech Connect page, **www.triquint.com/techconnect**, offers additional ways to simplify RF connectivity through a growing collection of technical resources for key applications. While visiting our website, click on 'subscribe' to receive TriQuint's quarterly e-newsletter and new product announcements.

TriQuint products are available through our worldwide sales, representative and distribution networks. Visit **triquint.com/sales** to connect with members of TriQuint's extended sales network serving your market.

About TriQuint Semiconductor

TriQuint's innovative, high-performance solutions are defining the future of RF technology.

Our integrated modules and assemblies reduce PCB areas and simplify manufacturing. TriQuint high-efficiency solutions extend battery life in mobile devices and can reduce electrical consumption in networks, defense and aerospace systems.

We design, develop and manufacture advanced RF solutions utilizing gallium arsenide (GaAs), gallium nitride (GaN), surface acoustic wave (SAW) and bulk acoustic wave (BAW) technologies. Our product portfolio of power, control and acoustic filter technologies serves global commercial and defense manufacturers.

TriQuint solutions, designed and crafted with the industry's largest RF technology portfolio, enable quicker design turns while lowering overall system costs. We are an award-winning provider of innovative RF products serving start-up firms as well as the world's largest, most innovative companies. We support custom solutions through the industry's widest selection of GaN and GaAs foundry processes backed by renowned and trusted service.

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 innovations including temperature compensation techniques and wafer level packaging. We are well positioned to serve the growing needs of wireless, fiber optic, telecom and defense / aerospace manufacturers around the world.

Key advantages of GaAs, GaN, SAW and BAW technologies:

- 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 wide 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, good linearity and noise figure, 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. BAW is ideal for challenging applications including co-existence filter requirements and aerospace needs.

New Products

Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (db) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
CATV Push Pull Infrastructure Amplifier MMIC	0.05 - 1	–	32	3 / –	24 / 270 (12v optional)	SOIC16W	TAT8858
CATV Power Doubler Line Amplifier MMIC	0.05 - 1	31 / 52	25	4 / –	24 / 350 (12v optional)	SOIC16W	TAT8857
29.5 dBm HBT Amplifier	0.05 - 1.5	29.6 / 48	20.7	4.4 / –	5 / 240	SOT89	TQP7M9105
33.8 dBm HBT Amplifier	0.05 - 1.5	32.8 / 50	20	4.8 / –	5 / 500	4x4 QFN	TQP7M9106
29.5 dBm HBT Amplifier	0.4 - 4	29.5 / 45.4	20.7	4.4 / –	5 / 235	SOT89	TQP7M9103
CATV 12v Power Doubler MMIC	0.5 - 1	30 / 51	11	4 / –	12 / 45	SOIC16W	TAT8801
CATV 12v Power Doubler MMIC	0.5 - 1	31.5 / 53	11	4 / –	12 / 550	SOIC16W	TAT2801
33.8 dBm HBT Amplifier	0.7 - 2.7	33.8 / 45	21	4.4 / –	5 / 435	4x4 QFN	TQP7M9104
10W GaN	2 - 18	41.5 / –	10	– / 23	35 / 1200	Carrier	TGA2573-TS
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Carrier	TGA2501-TS
16W HPA	6.5 - 12.5	42 / –	27	– / 35	12 / 3000	Carrier	TGA2517-TS
HPA	10 - 12	33 (34.5) / 43	25	9 / –	6 / 1300	5x5 QFN	TGA2535-SM
HPA	12.5 - 15.5	30 (31.5) / 41	25	7.5 / –	6 / 650	5x5 QFN	TGA2527-SM
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Carrier	TGA2510-TS
20W HPA	13 - 15	43 / –	19	– / 25	25 / 1000	Flange	TGA2593-GSG
20W HPA	14 - 15.5	43 / –	23	– / 30	25 / 1000	Flange	TGA2579-FL
20W HPA	14 - 16	(43) / –	23	– / 30	20 / 2000	Carrier	TGA2572-TS
16W HPA	14 - 16	(42) / –	27	– / 30	25 / 2000	Die	TGA2572
16W HPA	14 - 16	(42) / –	23	– / 30	25 / 2000	Flange	TGA2572-FL
MPA	17 - 27	29 / –	22	–	7 / 760	5x5 QFN	TGA4525-SM
1W Linear PA	28 - 30	30 (30.5) / –	20	–	6 / 420	5x5 QFN	TGA4539-SM
2W HPA	30 - 40	31.5 (33) / –	18	–	6 / 1050	Carrier	TGA4516-TS

Variable Gain Amplifiers

Description	Frequency Range (GHz)	P1dB / OIP3 (dBm)	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	–	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
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
Fiber to the Home Integrated TIA + Attenuator + Amp	0.5 - 1	–	33	3.8	5 / 220	6x6 QFN	TAT6281
Digital Variable Gain Amplifier	1.5 - 2.7	27.3 / 47.5	41	31.5	5 / 285	6x6 QFN	TQM879008
Ka-Band VGA	27 - 31.5	21 at max gain / –	29 (max)	–	5 / 280	6x6 QFN	TGA4541-SM

Gain Block Amplifiers

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 - 6	15.2 / 29.8	15.7	3.6	5 / 45	SOT89	TQP369180
General Purpose Gain Block	DC - 6	15.2 / 30	15.6	3.6	5 / 45	SOT363	TQP369181
General Purpose Gain Block	DC - 6	16.1 / 29.6	22.3	3.9	5 / 45	SOT89	TQP369182
General Purpose Gain Block	DC - 6	16.2 / 29.8	22	3.9	5 / 45	SOT363	TQP369184
General Purpose Gain Block	DC - 6	19.8 / 32.3	20.4	4.7	5 / 75	SOT89	TQP369185
E-pHEMT LNA Gain Block	0.05 - 4	21.5 / 40	15	2	5 / 85	3x3 QFN	TQP3M9038

New Products (cont.)

Low Noise Amplifiers

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
LNA, Single-Ended Matched Amp	0.4 - 1.5	20 / 16	19	0.45	5 / 60	2x2 DFN	TQP3M9036
LNA, Single-Ended Matched Amp	1.5 - 2.7	21 / 16	20	0.40	5 / 60	2x2 DFN	TQP3M9037

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	PAE (%)	Voltage / Current (V / mA)	Package Style	Part Number
30W GaN HEMT	DC - 6	44.8	15	50	28 / 200	Ceramic Flat Lead	T1G6003028-FS

Frequency Converters & Mixers

Description	Frequency Range (GHz)	Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Dual Branch Converter, LO, IF, SW, EN	0.68 - 0.92	9.3	33	25	5 / 310	6x6 QFN	TQP519021
Dual Branch Converter, LO, IF, SW, EN	1.7 - 2.2	9.3	35	25	5 / 310	6x6 QFN	TQP569022
Downconverter (LNA + VCO + Mixer)	17 - 21	8	–	–	5 / 305	5x6 QFN	TGC4408-SM
Upconverter (Lo Amp + Doubler)	21.5 - 32.5	-9	35	13	5 / 65	3x3 QFN	TGC4407-SM

NOTES: EN = Enable / Disable Mode Amplifier, IF = IF Amplifier, LO = LO Amplifier, SW = LO Switch

Signal Conditioning

Description	Frequency (GHz)	Insertion Loss (dB)	Control Range dB or (Deg.)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
7-Bit, Digital Attenuator, Serial Ctrl	DC - 4	1.3	31.75	30	5 / 0	4x4 QFN	TQP4M9083

Switches

Description	Frequency Range (GHz)	Insertion Loss (dB)	Isolation (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SPST - High Isolation Absorptive	0.1 - 6	0.4	48	33	3 / 0	2x2 DFN	TQP4M0013
SPDT - Reflective	0.1 - 6	0.3	30	33	3 / 0	2x2 DFN	TQP4M008
SPDT - High Isolation Reflective	0.1 - 6	0.5	50	31	3 / 0	MSOP8	TQP4M009
SPDT - High Isolation Absorptive	0.1 - 6	0.5	45	32.5	3 / 0	4x4 QFN	TQP4M010
SP3T - Reflective	0.1 - 6	0.3	30	30	3 / 0	3x3 QFN	TQP4M011
SP4T - Reflective	0.1 - 6	0.6	40	33	3 / 0	3x3 QFN	TQP4M012

SAW Duplexers & 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	28.56	28.4	SE / SE	40 @ 44	13.3x6.5	857008
IF SAW Filter - Multi-Standard	192	60	14.5	SE / BAL	38 @ 44	7x5.5	856731
IF SAW Filter - Multi-Standard	358.4	39.6	11.5	SE / BAL	30 @ 30	7x5.5	856882
MICS Band RF Filter	403.5	3	3	BAL / SE	20 @ 398	3x3	856990
RF SAW Filter	457.5	15	2.2	SE / SE	70 @ 472	3.8x3.8	856930
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 Filter - Band 5 Uplink	836.5	25	2.3	SE / SE	50 @ 869	1.4x1.2	857038
RF SAW Filter - Band 3 Downlink	1842.5	75	4.2	SE / SE	20 @ 1785	3x3	856934
RF SAW Filter - Band 25 Uplink	1882.5	65	1.9	SE / SE	32 @ 2030	3x3	856992
ISM / WLAN Passband	2437	66	2.1	SE / SE	34 @ 2550	1.4x1.2	857005

BAW Duplexers & Filters

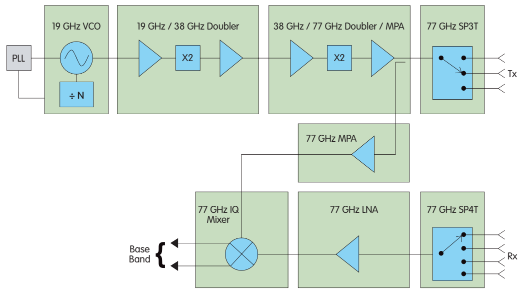
Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
Band 3 Duplexer	1747.5 / 1842.5	75 / 75	2.6 / 2.7	SE / SE	–	2.5x2	TQM956003
RF BAW Filter - Band 2 Uplink	1880	60	3.5	SE / SE	30 @ 1920	3x3	885025
PCS Duplexer	1880 / 1960	60 / 60	1.32 / 1.52	SE / SE	–	3.8x3.8	TQM969001
BC1 / B2 Duplexer	1880 / 1960	60 / 60	1.8 / 1.9	SE / SE	–	2.5x2	TQM966002
BC14 / B25 Duplexer	1882.5 / 1962.5	65 / 65	1.8 / 2.2	SE / SE	–	2.5x2	TQM963014
RF BAW 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
ISM Passband Filter for Coexistence	2436	72	1.8	SE / SE	20 @ 2495	1.4x1.2	885017
RF BAW Filter - Band 7 Uplink	2535	70	1.3	SE / SE	41 @ 2620	3x3	885009
Band 7 Duplexer	2535 / 2655	70 / 70	2.5 / 1.5	SE / SE	–	2.5x2	TQM976027

Integrated Products

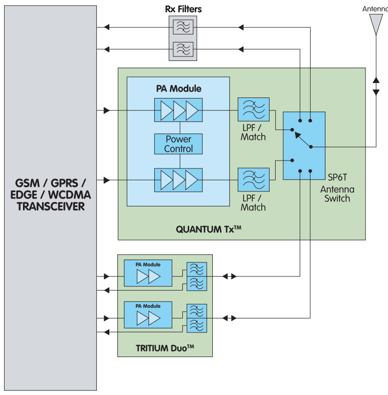
Description	Frequency Bands	Features	Package Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x5x1	TQM7M5033
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x3.5x1	TQM7M5050
LTE PA Module, w/Coupler	Band 17	LTE 1-Bit (Hi / Lo Power Modes)	3x3x0.9	TQM700017
Integrated 2-in-1 PA-Duplexer Module	Bands 1 & 8	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	TQM6M6218
Integrated 2-in-1 PA-Duplexer Module	Bands 2 & 5	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	TQM6M6225
Integrated 2-in-1 PA-Duplexer Module	Bands 1 & 4	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	TQM6M6214
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	DC / DC, 1-Bit (Hi / Med Power Modes)	4.5x3.5x1	TQM666052
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	5x6x1	TQM6M9085
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 Power Modes)	5x7.5x1	TQM7M9053
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	802.11 a, b, g, n, ac	ETSLP-24 Package, Coupler / Detector	4x4x0.45	TQP6M9017
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	802.11 a, n	ETSLP-16 Package, Coupler / Detector	2.5x2.5x0.4	TQP887016
2.4 GHz WLAN PA + Low Noise Amplifier + SP3T Switch MMIC for Bluetooth® Path	802.11 b, g, n	ETSLP-16 Package, Coupler / Detector	2.5x2.5x0.4	TQP879016

Optical Components – Drivers

Description	Frequency (GHz)	Power (Vpp or dBm)	Gain (dB)	Voltage / Current (V / mA)	Package Style	Part Number
100 Gb/s 8V pp Dual Channel Driver w/Bias-Ts inside	DC - 35	3 - 9Vpp	32	5 - 7 / 500	16x10.5 SL	TGA4947-SL
45 Gb/s 9Vpp Diff In / Out Driver MMIC	DC - 50	6 - 10Vpp Diff	27 Diff	5 - 6 / 500	Die	TGA4959



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

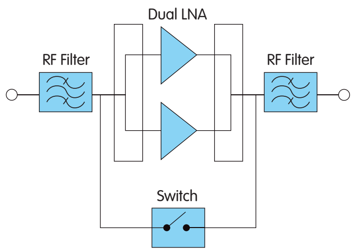
Description	Frequency Bands	Features	Package Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Polar PA Module	GSM900 / DCS & GSM850 / PCS	+3 to +8 dBm Pin Nominal	5x5x1	TQM7M5012H
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 1	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM676021
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM666022
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Bands 5 and 6	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 8	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM626028L
GSM / GPRS / EDGE-Linear TRP Tx Module: PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA / LTE Ports	GSM850 / 900, DCS / PCS & WCDMA B1, B2, B5 / 6, B8	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch Supporting WCDMA TRP	7x7.5x1.1	TQM6M9014

Filters & Duplexers

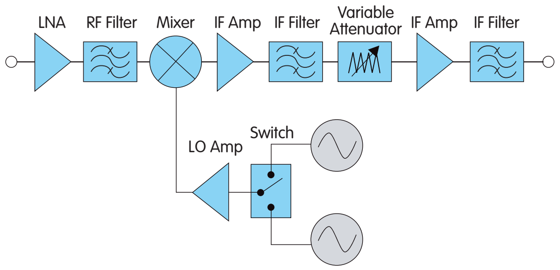
Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
RF Filter - Band 5 Uplink	836.5	25	2.3	SE / SE	50 @ 869	1.4x1.2	***857038****
Duplexer, Cell Band	836.5 / 881.5	25 / 25	1.9 / 1.9	SE / SE	–	3.8x3.8	856356
CDMA 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, 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

NOTES: ***** = New***

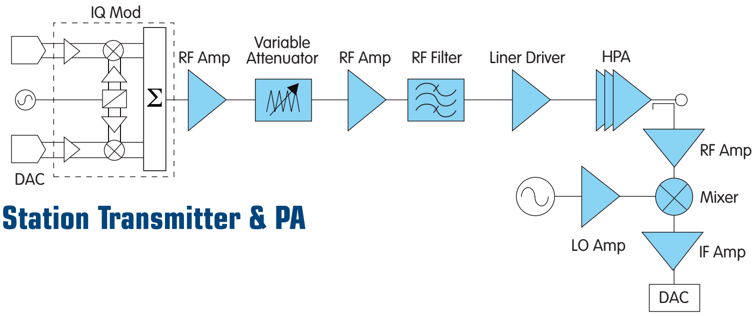
GUIDE BY MARKET | Base Station



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
General Purpose Gain Block	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	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
26.5 dBm MESFET Amplifier	50 - 1500	26.5 / 47	13.5	3.5	9 / 200	SOT89	AH101
29.5 dBm HBT Amplifier	50 - 1500	29.6 / 48	20.7	4.4	5 / 240	SOT89	***TQP7M9105****
33.8 dBm HBT Amplifier	50 - 1500	32.8 / 50	20	4.8	5 / 500	4x4 QFN	***TQP7M9106****
30 dBm MESFET Amplifier	50 - 2200	30 / 47	17	2.5	11 / 330	6x6 QFN	AH202
27 dBm MESFET Amplifier	60 - 2700	27 / 46	29	2.5	4.5; 9 / 275	SOIC-8	AH103A
27 dBm MESFET Amplifier	350 - 3000	27 / 46	14.5	3.1	9 / 200	SOT89	AH102A
35.5 dBm HBT Amplifier	400 - 2700	35.5 / 50	16	7	5 / 800	4x5 DFN	AH420
24.5 dBm HBT Amplifier	400 - 4000	24.3 / 39.5	20.4	4	5 / 87	SOT89	TQP7M9101
27.5 dBm HBT Amplifier	400 - 4000	27.5 / 44	21.9	4	5 / 137	SOT89	TQP7M9102
29.5 dBm HBT Amplifier	400 - 4000	29.5 / 45.4	20.7	4.4	5 / 235	SOT89	***TQP7M9103****
33 dBm HBT Amplifier	700 - 2700	33 / 50	27.5	7	5 / 680	5x5 QFN	AH323
39 dBm HBT Amplifier	700 - 2900	39 / –	16.5	8	12 / 300	5x6 DFN	AP561
28 dBm HBT Amplifier	700 - 3800	28 / 42	28.5	2.9	5 / 225	4x4 QFN	TQP8M9013
33.8 dBm HBT Amplifier	700 - 4000	33.8 / 45	21	4.4	5 / 435	4x4 QFN	***TQP7M9104****
30 dBm HBT Amplifier	1800 - 2700	30 / 46	24.6	5.5	5 / 400	SOIC-8	AH212

NOTES: **** = New***

Variable Gain Amplifiers

Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
Variable Gain Amplifier	50 - 2200	22 / 42	15.5	20	5 / 150	4x4 QFN	VG025
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	600 - 1000	24.3 / 40	31.7	31.5	5 / 174	6x6 QFN	***TQM829007****
Variable Gain Amplifier	700 - 1000	22 / 40	16	29	5 / 150	6x6 QFN	VG101
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	TQM879006
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 (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
LNA, Single-Ended Matched Amp	50 - 4000	21.8 / 15.8	24.7	0.9	5 / 125	SOT89	TQP3M9009
LNA, Single-Ended Matched Amp	50 - 4000	21.8 / 15.8	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019
LNA, Single-Ended Matched Amp	100 - 4000	22.3 / 18.7	15.3	0.8	5 / 55	3x3 QFN	TQP3M9005
LNA, Single-Ended Matched Amp	100 - 4000	22.4 / 25	13.5	1	5 / 90	3x3 QFN	TQP3M9006
LNA, Single-Ended Matched Amp	400 - 1500	20 / 16	19	0.45	5 / 60	2x2 QFN	***TQP3M9036****
LNA, Balanced FET Low Band	700 - 915	– / 13.5	20.5	0.55	4 / 70	4x4 QFN	TQP3M6004
LNA, Discrete Low Band High Linearity	700 - 915	26 / 23.5	16	0.8	5 / 150	SOT89	TGF2021-04-SD
LNA, Balanced FET	800 - 3000	21 / 11	22	0.4	4 / 100	2x2 QFN	TGA2602-SM
LNA, Single-Ended Matched Amp	1500 - 2700	21 / 16	20	0.40	5 / 60	2x2 QFN	***TQP3M9037****
LNA, Balanced FET Mid Band	1700 - 2000	– / 14.4	18	0.55	3.5 / 50	4x4 QFN	TQP3M6005

NOTES: ***** = New**

Control Products

Description	Frequency Range (MHz)	Insertion Loss (dB)	Isolation / Atten Range (dB)	P1dB (dBm)	Control Voltage (V)	Package Style	Part Number
SP3T Switch	DC - 2000	0.45	28 / –	>36.5	2.6 / 0	3x3 QFN	TQP4M3018
SP3T Switch	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
SPDT Switch	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: ***** = New**

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	9.3	33	25	5 / 310	6x6 QFN	***TQP519021****
Mixer, LO	700 - 1500	-9	17	36	5 / 50	MSOP-8	ML483
Single Branch Converter, RF, LO, IF	800 - 960	22	60	15	5 / 360	6x6 QFN	CV110-3A
Dual Branch Converter, LO, IF	800 - 960	10.5	14	18.5	5 / 390	6x6 QFN	CV210-3A
Mixer, LO	1500 - 3200	-8.5	2	35	5 / 45	MSOP-8	ML485
Dual Branch Converter, LO, IF, SW, EN	1700 - 2200	9.3	35	25	5 / 310	6x6 QFN	***TQP569022****
Single Branch Converter, RF, LO, IF	1700 - 2000	21	45	17	5 / 360	6x6 QFN	CV111-1A

NOTES: ***** = New,** EN = Enable / Disable Mode Amplifier, IF = IF Amplifier, LO = LO Amplifier, RF = RF Amplifier, SW = LO Switch

Discrete Transistors

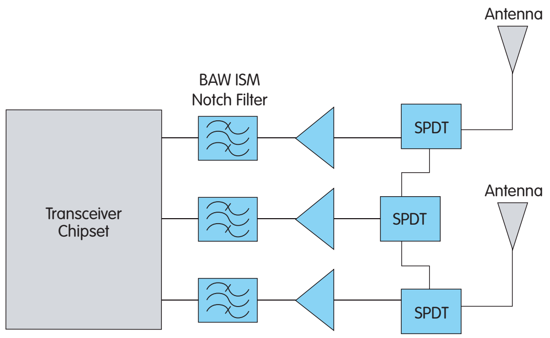
Description	Frequency Range (MHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage Current (V / mA)	Package Style	Part Number
0.5W HFET	DC - 6000	28 / 40	18	3.2	8 / 100	SOT89	TGF2960-SD
1W HFET	DC - 6000	31 / 43	16	4	8 / 200	SOT89	TGF2961-SD
MESFET	50 - 4000	21 / 42	19	2	5 / 140	SOT89	FH1
MESFET	50 - 4000	18 / 36	19	2	5 / 140	SOT89	FH101

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 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 Semiconductor 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 43 - 47.



Broadband Transceiver

Amplifiers

Description	Frequency Range (GHz)	P1dB / OIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
39 dBm HBT Amplifier	0.7 - 2.9	39 / –	16.5	8	12 / 300	5x5 QFN	AP561
WiMAX Driver Amp / PA, SB	3.4 - 3.8	30 / 42	24	–	6 / 770	5x5 QFN	TGA2703-SM

NOTES: SB = Self Biased

Discrete Transistors

Description	Frequency Range (GHz)	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
1W HFET	DC - 6000	31 / 43	16	4	8 / 200	SOT89	TGF2961-SD
MESFET	50 - 4000	21 / 42	19	2	5 / 140	SOT89	FH1
MESFET	50 - 4000	18 / 36	19	2	5 / 140	SOT89	FH101

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

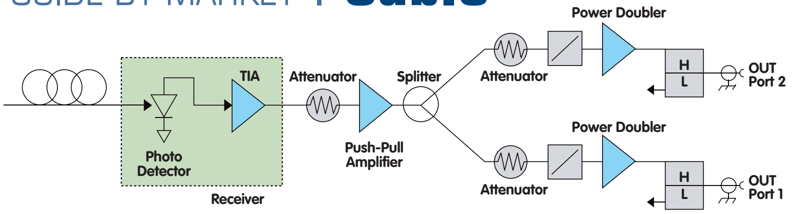
Filters For Coexistence

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
ISM Passband Filter for Coexistence	2436	72	1.8	SE / SE	20 @ 2495	1.4x1.2	***885017****
ISM Passband Filter for Coexistence	2436	72	2	SE / SE	20 @ 2495	1.7x1.3	885007
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

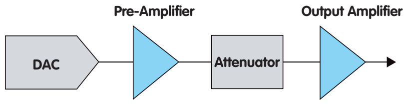
NOTES: **** = New***

IF Filters

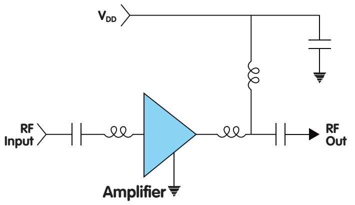
TriQuint Semiconductor offers a wide variety of BWA / WiMAX IF filters. To view a selection of the most common filters, please go to the SAW filter section on pages 43 - 47.



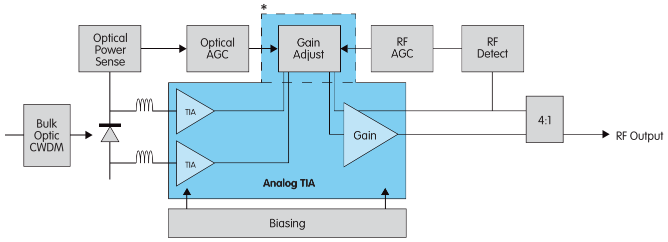
CATV Infrastructure



Edge QAM DOCSIS® 3.0



Subscriber Home Amplifiers



* New 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
Dual HBT Amplifier	General Purpose	DC - 2700	19 / 33	18	3.5	>6 / 75	SOT86 / SOT89	AG604
Return Path Variable Gain Amplifier	Infrastructure	5 - 300	25 / 41	36	5	8 / 325	6x6 QFN	***TAT3814****
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 / 46	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 / –	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 / –	18	2.7	5 - 8 / 705 - 770	7x7 QFN	***TAT2814A****
CATV Power Doubler Line Amplifier MMIC	Infrastructure	50 - 1000	31 / 52	25	4	24 / 350 (12v optional)	SOIC16W	***TAT8857****
Fiber to the Home Integrated TIA + Attenuator + Amp	Fiber to the Home	50 - 1000	–	33	3.8	5 / 220	6x6 QFN	***TAT6281****
CATV 12v Power Doubler MMIC	Infrastructure	50 - 1000	30 / 51	11	4	12 / 450	SOIC16W	***TAT8801****
CATV 12v Power Doubler MMIC	Infrastructure	50 - 1000	31.5 / 53	11	4	12 / 550	SOIC16W	***TAT2801****
CATV Push Pull Infrastructure Amplifier MMIC	Infrastructure	50 - 1000	–	32	3	24 / 270 (12v optional)	SOIC16W	***TAT8858****
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	11.1	4.5	5 / 320	SOIC-8	AH22S
Fiber to the Home TIA + Output Amp	Fiber to the Home, RFoG, Low Input	50 - 1000	-60 dBc CTB / CSO	38	2.9 pA / rtHz EIN	10 - 12 / 120	4x4 QFN	TAT6254B
CATV Gain Block, High Gain	Home Amplifier, MOCA Multi	50 - 1000	– / 41	22.5	2	8 / 190	SOT89	TAT7430B
CATV Gain Block, High Gain	Home Amplifier, MOCA	50 - 1000	– / 39	18	2	6 / 145	SOT89	TAT7427
CATV Gain Block	Home Amplifier	50 - 1000	– / 39	16	2.7	6 / 130	SOT89	TAT7461
MESFET Amplifier	General Purpose	50 - 1000	20 / 40	14.8	3.5	5 / 150	SOT89	AH2
Single-Ended Darlington	Return Path Amplifier	50 - 1000	20 / 37	13.5	4.5	>7 / 165	SOIC-8	AG606
Fiber to the Home TIA + Output Amp	Fiber to the Home, RFoG	50 - 1000	-62 dBc CTB / CSO	32	3.9 pA / rtHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254D
Fiber to the Home TIA + Output Amp	Fiber to the Home, High Output	50 - 1000	-63 dBc CTB / CSO	33	3.9 pA / rtHz EIN	5, 12 / 200, 130	4x4 QFN	TAT6254C
MESFET Amplifier	General Purpose	50 - 1500	30 / 50	10.4	5.3	9 / 400	SOT89	AH101
Dual pHEMT Amplifier, Wideband	CATV + SAT Wideband Amp / VONU	50 - 2600	-77 dBc CTB / -83 dBc CSO	13	4.4	5 / 160	SOIC-8	TAT7464
CATV Gain Block, Wideband	CATV + SAT Wideband Amp / VONU	50 - 2600	– / 36	16.5	2.5	5 / 100	SOT89	TAT7460

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 (mm²)	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

GUIDE BY MARKET | Defense & Aerospace

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@tqs.com.**

GaN

Transistors

Description	Frequency Range (GHz)	Psat (dBm)	Gain (dB)	PAE (%)	Bias (V / mA)	Package Style	ECCN	Part Number
55W HEMT	DC - 3.5	47.2	12	50	28 / 200	Ceramic Flat Lead	EAR99	T1G4005528-FS
9W HEMT	DC - 6	39.5	12.5	50	28 / 50	Ceramic Flat Lead	EAR99	T1G6000528-Q3
18W HEMT	DC - 6	42.5	12	50	28 / 50	Ceramic Flat Lead	EAR99	T1G6001528-Q3
30W HEMT	DC - 6	44.7	12	50	28 / 200	Ceramic Flat Lead	EAR99	***T1G6003028-FS****
1.25mm HEMT	DC - 18	37.4	10.4	52	28 / 125	Die	EAR99	TGF2023-01
2.5mm HEMT	DC - 18	40.2	9.9	50	28 / 250	Die	EAR99	TGF2023-02
5.0mm HEMT	DC - 18	43	9.4	49	28 / 500	Die	3A001b.3b	TGF2023-05
10mm HEMT	DC - 18	45.8	8.9	47	28 / 1000	Die	3A001b.3b	TGF2023-10
20mm HEMT	DC - 18	48.6	8.4	46	28 / 2000	Die	3A001b.3b	TGF2023-20

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-FL
10W HPA	2 - 18	40	9	25	30 / 500	Die	ITAR	TGA2573
10W HPA	2 - 18	40	9	25	30 / 500	Carrier	ITAR	***TGA2573-TS****
30W HPA	2.5 - 6	45	25	>30	30 / 1400	Flange	3A001.b.2.a	TGA2576-FL
20W HPA	13 - 15	43	19	25	25 / 1000	Flange	3A001.b.2.b	***TGA2593-GSG****
20W HPA	14 - 15.5	43	23	30	25 / 1000	Flange	ITAR	***TGA2579-FL****
20W HPA	14 - 16	43	23	>30	30 / 2000	Die	ITAR	***TGA2572****
20W HPA	14 - 16	43	23	>30	30 / 2000	Carrier	ITAR	***TGA2572-TS****
20W HPA	14 - 16	43	23	>30	30 / 2000	Flange	ITAR	***TGA2572-FL****

NOTES: ***** = New***

GaN (cont.)

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
High Power SPDT Switch	DC - 6	0.8	-40	>45	0 / -40	5x5 QFN	EAR99	TGS2351-SM
High Power SPDT Switch	DC - 12	<1	-35	>43	0 / -40	Die	EAR99	TGS2352
High Power SPDT Switch	DC - 18	1.5	-25	>40	0 / -40	Die	EAR99	TGS2353

ELECTRONIC WARFARE

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-FL
Gain Block, Self Bias	2 - 10	17 / –	17	6 / –	5 / 90	Die	TGA8810-SCC
Wideband Gain Block	2 - 18	20 / –	7.5	5.5 / –	6 / 100	Die	TGA8300-SCC
14W Wideband HPA	2 - 18	41.5 / –	10	– / 23	35 / 1200	Die	TGA2573
10W Wideband GaN HPA	2 - 18	41.5 / –	10	– / 23	35 / 1200	Carrier	***TGA2573-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
35W GaN HEMT	2.5 - 6	45.4	26	– / 35	30 / 1550	Flange	TGA2576-FL
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****
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
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	12.5 - 17	(33.5) / –	25	– / 25	7.5 / 650	6.4x9.4 SG	TGA2510-SG
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

ELECTRONIC WARFARE (cont.)

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
55W GaN HEMT	DC - 3.5	47.2	15	– / 50	28 / 200	Ceramic Flat Lead	T1G4005528-FS
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	T1G6000528-Q3
18W GaN HEMT	DC - 6	(42.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T1G6001528-Q3
30W GaN HEMT	DC - 6	(44.8)	15	– / 50	28 / 200	Ceramic Flat Lead	***T1G6003028-FS****
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 / 900	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	TGF2023-01
2.5mm GaN HEMT	DC - 18	(40.2)	13	– / 50	28 / 250	Die	TGF2023-02
5.0mm GaN HEMT	DC - 18	(43)	13	– / 49	28 / 500	Die	TGF2023-05
10mm GaN HEMT	DC - 18	(45.8)	12	– / 47	28 / 1000	Die	TGF2023-10
20mm GaN HEMT	DC - 18	(48.6)	12	– / 46	28 / 2000	Die	TGF2023-20
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 - High Power GaN	DC - 6	<1	40	45	-40 / 0	Die	TGS2351
SPDT - High Power GaN	DC - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-SM
SPDT - High Power GaN	DC - 12	<1	35	43	-40 / 0	Die	TGS2352
SPDT - High Power GaN	DC - 18	<1	30	40	-40 / 0	Die	TGS2353
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	10 mA	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	10 mA	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

ELECTRONIC WARFARE (cont.)

Control Products

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range (dB)	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
Lange Coupler	12 - 21	<0.25	–	–	–	Die	TGB2001

RADAR

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
10W Wideband PA	2 - 18	41.5 / –	10	– / 23	35 / 1200	Carrier	***TGA2573-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-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
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 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****
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
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
2W HPA	13 - 17	(34) / 40	33	–	5 - 8 / 680	6.4x9.4 SG	TGA8658-SG
2W HPA, PD	13 - 17	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-1-SG
6.5W HPA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
2W HPA, PD	13.75 - 14.5	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-2-SG
16W Ku-Band HPA	14 - 16	(42) / –	23	– / 30	25 / 2000	Flange	***TGA2572-FL****
20W Ku-Band HPA	14 - 16	(43) / –	23	– / 30	20 / 2000	Carrier	***TGA2572-TS****
1.25W HPA	17 - 24	31 (32) / 40	23	6 / –	7 / 720	Die	TGA4531

RADAR (cont.)

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
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 Ampifiers

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
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

NOTES: 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
55W GaN HEMT	DC - 3.5	47.2	15	– / 50	28 / 200	Ceramic Flat Lead	T1G4005528-FS
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	T1G6000528-Q3
18W GaN HEMT	DC - 6	(42.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T1G6001528-Q3
30W GaN HEMT	DC - 6	(44.8)	15	– / 50	28 / 200	Ceramic Flat Lead	***T1G6003028-FS****
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

RADAR (cont.)

Discrete Transistors (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage /Current (V / mA)	Package Style	Part Number
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 / 900	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	TGF2023-01
2.5mm GaN HEMT	DC - 18	(40.2)	13	– / 50	28 / 250	Die	TGF2023-02
5.0mm GaN HEMT	DC - 18	(43)	13	– / 49	28 / 500	Die	TGF2023-05
10mm GaN HEMT	DC - 18	(45.8)	12	– / 47	28 / 1000	Die	TGF2023-10
20mm GaN HEMT	DC - 18	(48.6)	12	– / 46	28 / 2000	Die	TGF2023-20
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
High Power SPDT - GaN	DC - 6	<1	40	45	-40 / 0	Die	TGS2351
High Power SPDT - GaN	DC - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-SM
High Power SPDT - GaN	DC - 12	<1	35	43	-40 / 0	Die	TGS2352
High Power, Wideband SPDT - GaN	DC - 18	<1	30	40	-40 / 0	Die	TGS2353
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
Wideband SP3T VPIN	1 - 20	0.5	35	23	10 mA	Die	TGS2303
Wideband SP4T VPIN	1 - 20	0.6	38	23	10 mA	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

RADAR (cont.)

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 (0 dB 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	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

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

NOTES: **** = New***

SPACE

Qualified Amplifiers

TriQuint has a proud space / aerospace history, supplying highly-reliable active / acoustic devices for satellite and planetary missions. Space qualification includes high-level visual inspection, 100% element electrical results and wafer lot qualification testing. See tables for standard products already space qualified; most foundry and standard products throughout this brochure may be space qualified.

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-SCC
Wideband Driver	DC - 35	18	12	–	5 / 135	Die	TGA4832
Wideband Gain Block, SB	2 - 10	17	17	6 / –	5 / 90	Die	TGA8810-SCC
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
0.5W PA	6 - 18	27	11	8 / –	8 / 400	Die	TGA8014-SCC
8W HPA	6.5 - 11.5	37 (39)	19	– / 35	7 - 9 / 1200	Die	TGA9083-SCC

SPACE (cont.)

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
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
Driver Amp, SB	11 - 17	17	23	6 / –	6 / 75	4x4 QFN	TGA2507-SM
Driver Amp, SB	12 - 18	20	28	6 / –	6 / 80	Die	TGA2507
4W HPA, Balanced	13 - 17	36	25	– / 30	6 - 7 / 1300	Die	TGA2502
MPA	17 - 21	22	18.5	–	7 / 66	Die	TGA9088A-SCC
Gain Block, Multiplier	17 - 43	22	25	–	5 / 225	Die	TGA4040
Gain Block	19 - 38	22	20	–	5 / 160	Die	TGA4036
3.5W HPA	31 - 37	35.5	20	–	6 / 2000	Die	TGA4517
MPA	32 - 45	24 (25)	16	–	6 / 175	Die	TGA4521
HPA	36 - 40	30	14	–	6 - 7 / 500	Die	TGA1171-SCC
HPA	37 - 40	28	24	6 / –	5 / 600	Die	TGA4538

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-SCC
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	TGA8310-SCC
Wideband LNA, AGC	2 - 20	17.5	9	3.5	5 - 8 / 60	Die	TGA1342-SCC
LNA, SB	6 - 13	11	26	1.5	5 / 65	Die	TGA8399B-SCC
LNA	20 - 27	12	21	2.2	3.5 / 60	Die	TGA4506
LNA	30 - 42	14	21	2.8	3 / 40	Die	TGA4508

NOTES: AGC = Automatic Gain Control, SB = Self Biased

Control Products

Description	Frequency (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 (0 dB 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

COMMS

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	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-FL
Wideband Gain Block	0.04 - 1	27 / 46	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

COMMS (cont.)

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (db) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
14W Wideband HPA	2 - 18	41.5 / –	10	– / 23	35 / 1200	Die	TGA2573
10W Wideband HPA on Carrier	2 - 18	41.5 / –	10	– / 23	35 / 1200	Carrier	***TGA2573-TS****
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****
30W HPA	2.5 - 6	(45) / –	26	– / 35	30 / 1550	Flange	TGA2576-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
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****
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	12.3 - 15.7	(31) / –	33	7 / –	6 / 850	Die	TGA2520
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	(33.5) / –	25	– / 25	7.5 / 650	6.4x9.4 SG	TGA2510-SG
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
6.5W HPA	13 - 16	(38) / –	24	–	8 / 2600	11.4x17.3 FL	TGA2514-FL
2W HPA, PD	13 - 17	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-1-SG
2W HPA	13 - 17	(34) / 40	33	–	5 - 8 / 680	6.4x9.4 SG	TGA8658-SG
2W HPA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
6.5W HPA	13 - 18	(38) / 44	24	–	8 / 3600	Die	TGA2514
2W HPA, PD	13.75 - 14.5	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-2-SG
16W Ku-Band HPA	14 - 16	(42) / –	27	– / 30	25 / 2000	Die	***TGA2572****
16W Ku-Band HPA	14 - 16	(42) / –	23	– / 30	25 / 2000	Flange	***TGA2572-FL****
16W Ku-Band HPA on Carrier	14 - 16	(42) / –	27	– / 30	25 / 2000	Carrier	***TGA2572-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
MPA	17 - 27	29 / –	22	–	7 / 760	5x5 QFN	***TGA4525-SM****
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

COMMS (cont.)

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (db) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
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
3.5W HPA	30 - 38	(35) / –	18	– / 20	6 / 2100	Die	TGA2575
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: **** = New,*** AGC = Automatic Gain Control, GB = Gate Biased, SB = Self Biased

COMMS (cont.)

Discrete Transistors

Description	Frequency Range (GHz)	P1dB (Psat) (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
55W GaN HEMT	DC - 3.5	47.2	15	– / 50	28 / 200	Ceramic Flat Lead	T1G4005528-FS
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	T1G6000528-Q3
18W GaN HEMT	DC - 6	(42.5)	15	– / 50	28 / 50	Ceramic Flat Lead	T1G6001528-Q3
30W GaN HEMT	DC - 6	(44.8)	15	– / 50	28 / 200	Ceramic Flat Lead	***T1G6003028-FS****
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 / 900	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	TGF2023-01
2.5mm GaN HEMT	DC - 18	(40.2)	13	– / 50	28 / 250	Die	TGF2023-02
5.0mm GaN HEMT	DC - 18	(43)	13	– / 49	28 / 500	Die	TGF2023-05
10mm GaN HEMT	DC - 18	(45.8)	12	– / 47	28 / 1000	Die	TGF2023-10
20mm GaN HEMT	DC - 18	(48.6)	12	– / 46	28 / 2000	Die	TGF2023-20
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
High Power SPDT - GaN	DC - 6	<1	40	45	-40 / 0	Die	TGS2351
High Power SPDT - GaN	DC - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-SM
High Power SPDT - GaN	DC - 12	<1	35	43	-40 / 0	Die	TGS2352
High Power SPDT - GaN	DC - 18	<1	30	40	-40 / 0	Die	TGS2353
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
Wideband SP3T VPIN	1 - 20	0.5	35	23	10 mA	Die	TGS2303
Wideband SP4T VPIN	1 - 20	0.6	38	23	10 mA	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

COMMS (cont.)

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	17 - 27	13	30	–	5 / 425	4x4 QFN	TGC4405-SM
Doubler (Input 10 - 20 GHz)	20 - 40	-12	25	18	–	Die	TGC1430F
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

NOTES: ***** = Coming Soon***

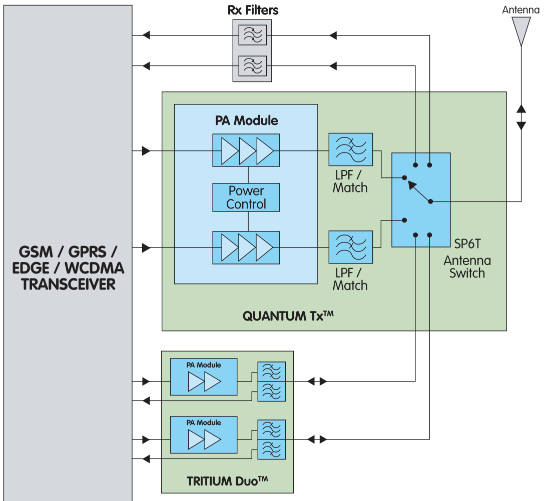
Control Products

Description	Frequency (GHz)	Insertion Loss (dB)	Control Range (dB)	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 (0 dB 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	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

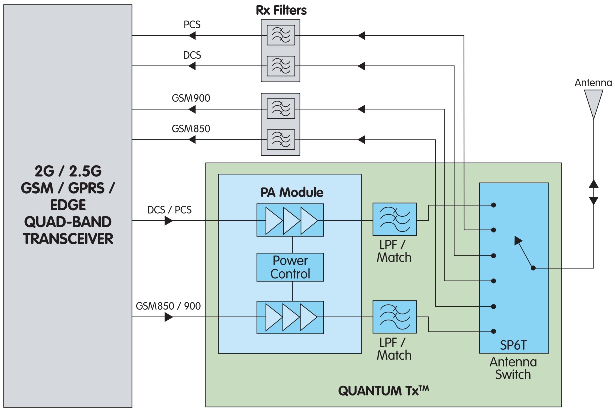
BAW Filters

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

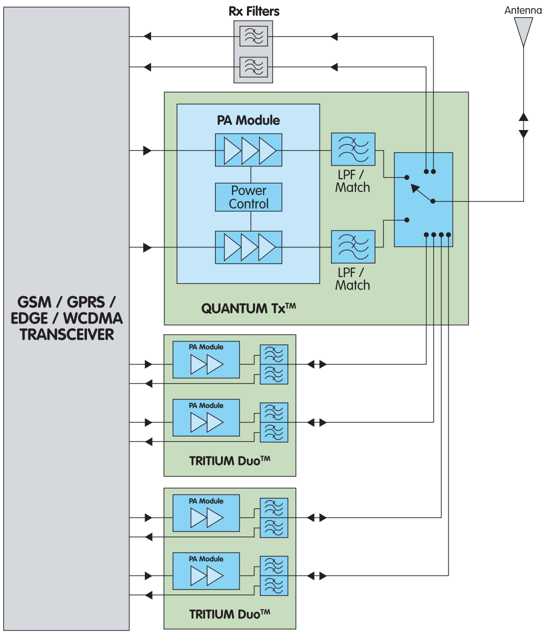
NOTES: ***** = New***



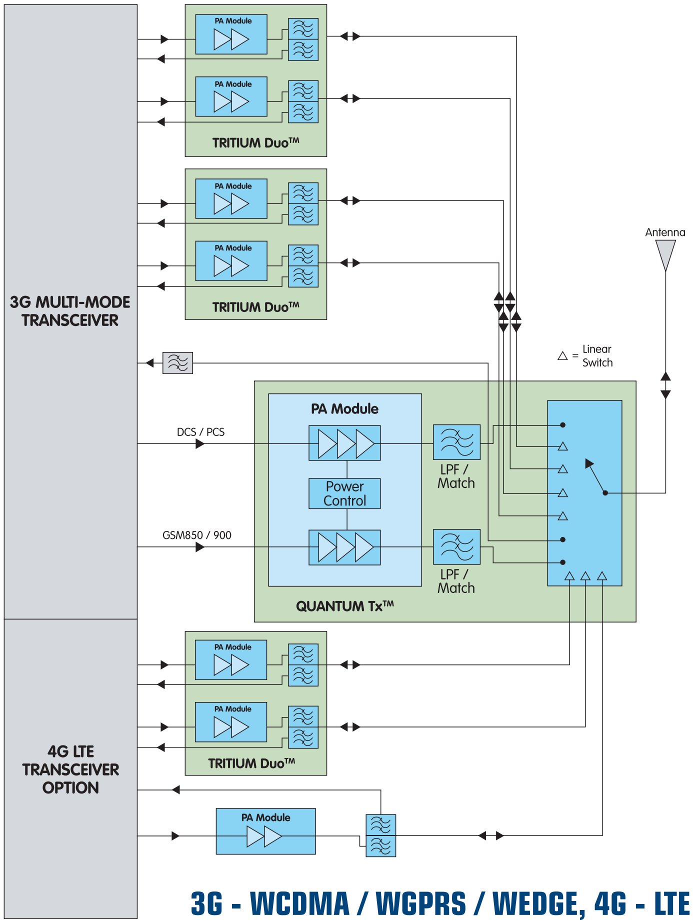
WPGRS / WEDGE



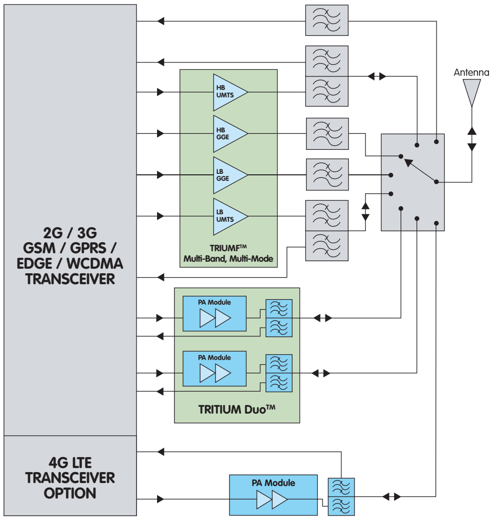
GSM / GPS / EDGE



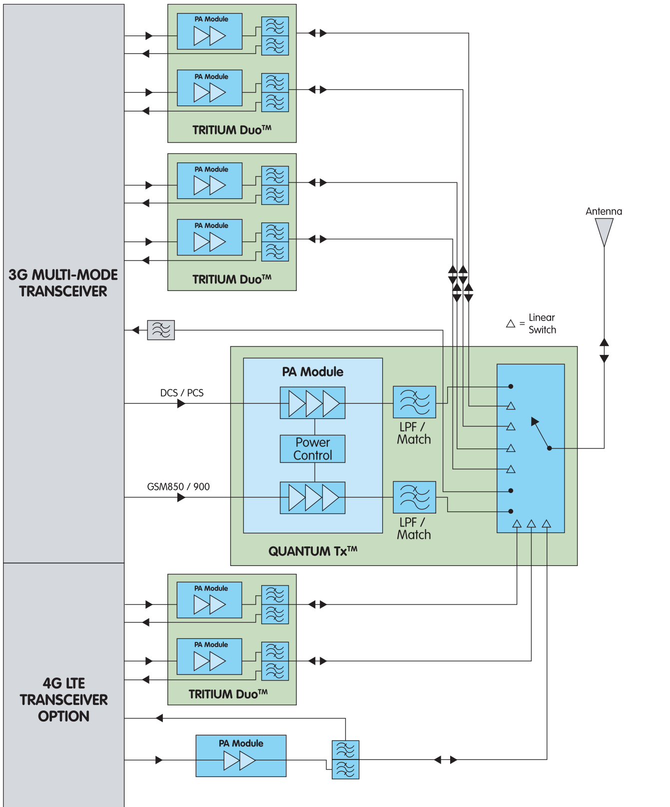
3G - CDMA / EV-DO, 4G - LTE



3G - WCDMA / WGPRS / WEDGE, 4G - LTE



3G - WGPRS / WEDGE, 4G - LTE



3G - WCDMA / WGPRS / WEDGE, 4G - LTE

QUANTUM Tx™– GSM / GPRS

Description	Bands	Features	Package Size (mm)	Part Number
Dual-Band GSM / GPRS Tx Module; PA / LPF / SP4T Switch; Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	5x6x1	TQM6M4068

QUANTUM Tx™ Family – WGPRS / WEDGE

Description	Bands	Features	Package Size (mm)	Part Number
GSM / GPRS / EDGE-Linear TRP Tx Module: PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA / LTE Ports	GSM850 / 900, DCS / PCS &WCDMA B1, B2, B5 / 6, B8	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch Supporting WCDMA TRP	7x7.5x1.1	TQM6M9014
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	5x6x1	***TQM6M9085****

NOTES: **** = New***

TRITIUM Duo™ Family – CDMA / WCDMA / HSUPA / LTE

Description	Bands	Features	Package Size (mm)	Part Number
Integrated 2-in-1 PA-Duplexer Module	Bands 1 & 8	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	***TQM6M6218****
Integrated 2-in-1 PA-Duplexer Module	Bands 2 & 5	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	***TQM6M6225****
Integrated 2-in-1 PA-Duplexer Module	Bands 1 & 4	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	***TQM6M6214****

NOTES: **** = New***

PA Modules – GSM / GPRS / EDGE

Description	Bands	Features	Package Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Low Band Ibatt < 1.5A @ Pcal w/PAE 55%	5x5x1	TQM7M5005H
Quad-Band GSM / GPRS / EDGE-Polar PA Module	GSM900 / DCS & GSM850 / PCS	+3 to +8 dBm Pin Nominal	5x5x1	TQM7M5012H
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x5x1	TQM7M5013
Quad-Band GSM / GPRS / EDGE-Polar PA Module	GSM900 / DCS & GSM850 / PCS	+3 to +8 dBm Pin Nominal	5x5x1	TQM7M5022
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x5x1	***TQM7M5033****
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x3.5x1	***TQM7M5050****

NOTES: ***= New***

PA Modules – CDMA / WCDMA / HSUPA / LTE

Description	Bands	Features	Package Size (mm)	Part Number
WCDMA / HSUPA PA Module, w/Coupler	Band 1	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM776011
CDMA & WCDMA / HSUPA PA Module, w/Coupler	PCS / Band 2	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM766012
CDMA & WCDMA / HSUPA PA Module, w/Coupler	AWS / Band 4	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM756014
CDMA & WCDMA / HSUPA PA Module, w/Coupler	Cellular / Band 5	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM716015
WCDMA / HSUPA PA Module, w/Coupler	Band 8	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM726018
LTE PA Module, w/Coupler	Band 13	LTE 1-Bit (Hi / Lo Power Modes)	3x3x0.9	TQM700013
LTE PA Module, w/Coupler	Band 17	LTE 1-Bit (Hi / Lo Power Modes)	3x3x0.9	***TQM700017****

NOTES: ***= New***

TRITIUM™ Family – WCDMA / HSUPA

Description	Bands	Features	Package Size (mm)	Part Number
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 1	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM676021
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM666022
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Bands 5 & 6	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 8	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM626028L
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	DC / DC, 1-Bit (Hi / Med Power Modes)	4.5x3.5x1	***TQM666052****

NOTES: ***= New***

TRIUMF™ Family – Multi-Mode, Multi-Band PA Modules

Description	Bands	Features	Package Size (mm)	Part Number
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 / Lo Power Modes)	5x7.5x1	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 Power Modes)	5x7.5x1	***TQM7M9053****

NOTES: ***** = New***

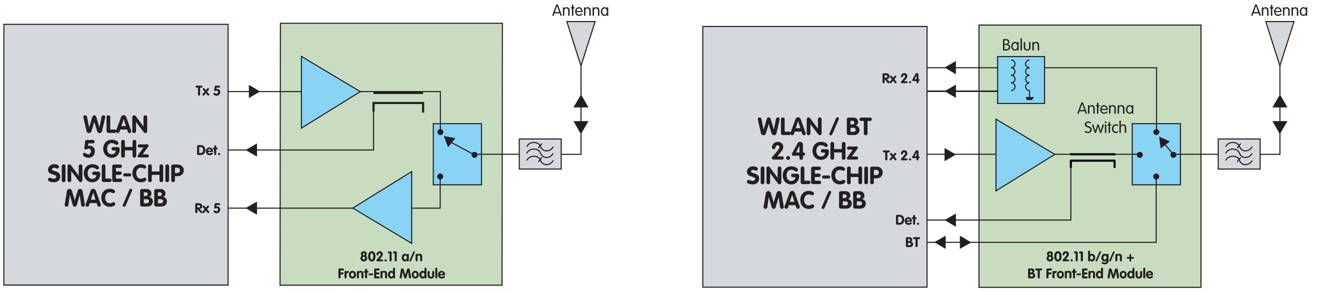
CDMA Switch

Description	Bands	Features	Package Size (mm)	Part Number
CDMA SP3T Switch	Cellular / PCS / AWS	Antenna Routing	2x2x0.6	TQP4M3019

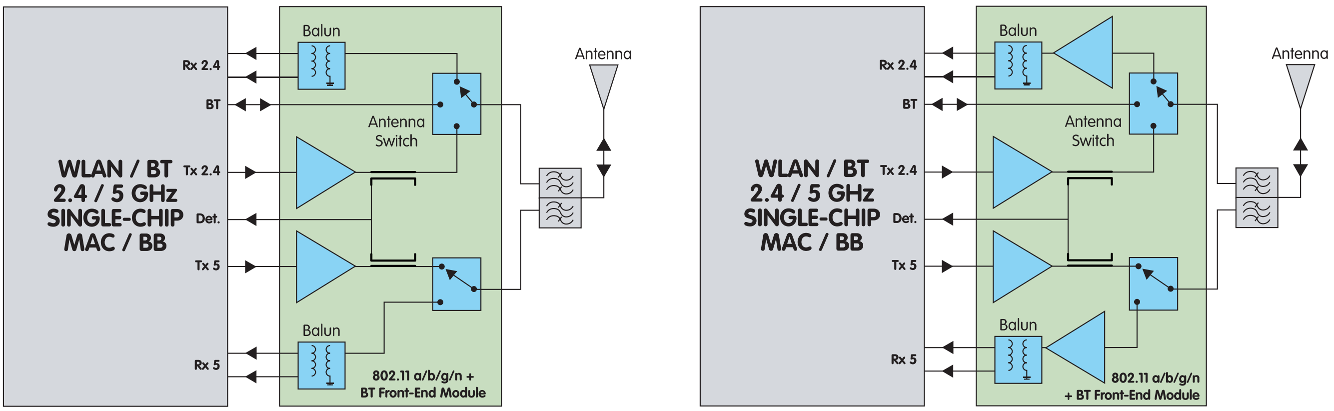
3G / 4G LTE Duplexers & Filters

Description	Bands	Features	Package Size (mm)	Part Number
LTE SE / BAL SAW Duplexer	Band 13	1.5 dB (Tx) / 1.6 dB (Rx) Insertion Loss	2.5x2x0.6	856879
LTE SE / BAL SAW Duplexer	Band 17	1.8 dB (Tx) / 2 dB (Rx) Insertion Loss	2.5x2x0.6	856931
LTE SE / BAL SAW Duplexer	Band 20	High-Performance Temp. Compensated SAW	2.5x2x0.6	856979
BC10 SE / BAL SAW Duplexer	BC10 (PCS)	Excellent Triple Beat Performance	2.5x2x0.6	856999
WCDMA / LTE SE / SE BAW Duplexer	Band 3	2.6 dB (Tx) / 2.7 dB (Rx) LTE Insertion Loss	2.5x2x0.9	***TQM956003****
BC14 SE / SE BAW Duplexer	BC14 (Cellular)	Excellent Triple Beat Performance	2.5x2x0.9	***TQM963014****
PCS SE / SE BAW Duplexer	Band 2 (PCS)	Excellent Triple Beat Performance	2.5x2x0.9	***TQM966002****
LTE Diversity Receive Filter	Band 25	2.6 dB Insertion Loss and 40 dB Tx Attenuation	2.5x2x0.8	***TQM966025****
LTE SE / SE BAW Duplexer	Band 7	Low Insertion Loss and Wi-Fi Co-Existence	2.5x2x0.9	***TQM976027****

NOTES: ***** = New***



Single-Band WLAN Modules



Dual-Band WLAN Modules

WLAN / Bluetooth® RF Front-End Modules

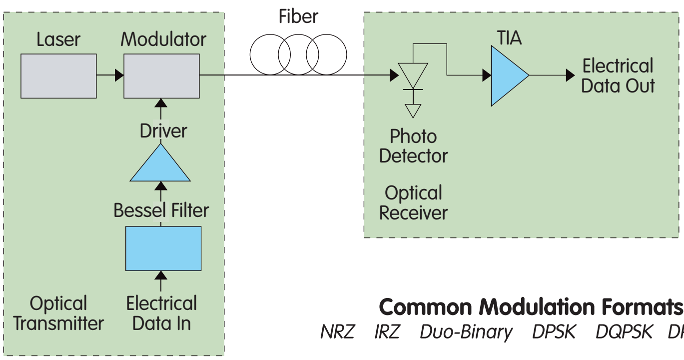
Description	Bands	Features	Package Size (mm)	Part Number
802.11 5 GHz WLAN PA MMIC	802.11 a, n	ETSLP-16 Package, Detector, Hi / Lo Linearity Mode	3x3x0.45	TQP787011
2.4 GHz WLAN LNA + SP3T Switch w/WLAN Tx & Bluetooth® Path	802.11 b, g, n	LNA Bypass, ETSLP-12 Package	1.5x1.5x0.55	TQP879001A
2.4 GHz WLAN PA + Switch MMIC w/WLAN Rx Balun & Bluetooth® Path	802.11 b, g, n	ETSLP-16 Package, Coupler / Detector	3x3x0.45	TQM679002A
2.4 GHz & 5 GHz WLAN PA + Switch MMIC w/WLAN Rx Baluns & Bluetooth® Path	802.11 a, b, g, n	ETSLP-24 Package, Coupler / Detector	4x4x0.45	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	802.11 a, b, g, n, ac	ETSLP-24 Package, Coupler / Detector	4x4x0.45	***TQP6M9017****
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	802.11 a, n	ETSLP-16 Package, Coupler / Detector	2.5x2.5x0.4	***TQP887016****
2.4 GHz WLAN PA + Low Noise Amplifier + SP3T Switch MMIC for Bluetooth® Path	802.11 b, g, n	ETSLP-16 Package, Coupler / Detector	2.5x2.5x0.4	***TQP879016****

NOTES: ***** = New**

GPS RF Front-End Module & Filters

Description	Bands	Features	Package Size (mm)	Part Number
GPS Filter-LNA-Filter Module	1575 MHz, GPS L1	Low Noise (1.56 dB) and High Gain (16 dB)	3x3x1	TQM640002
GPS SAW Filter, SE / SE	1575 MHz, GPS L1	0.75 dB Insertion Loss (Hermetic CSP)	1.4x1.2x0.46	856561
GPS SAW Filter, SE / BAL	1575 MHz, GPS L1	1.1 dB Insertion Loss (Hermetic CSP)	1.4x1.2x0.46	856576
GPS SAW Filter, SE / SE	1575 MHz, GPS L1	0.6 dB Insertion Loss (Hermetic CSP)	1.4x1.2x0.46	856793

GUIDE BY MARKET | Optical



Optical Systems (10, 40 & 100 Gb/s)

Common Modulation Formats

NRZ IRZ Duo-Binary DPSK DQPSK DP-QPSK

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	8.9x8.9 SL	TGA8652-SL
15 Gb/s 10V Linear Mod. Driver	DC - 20	3 - 10Vpp	22	–	7 / 280	6x6 QFN	TGA4826-SM

Drivers (cont.)

Description	Frequency Range (GHz)	Power	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
40 & 100 Gb/s 8 Vpp SE Driver	DC - 30	3 - 9Vpp	32	–	6 - 7 / 270	14.4x7 SL	TGA4943-SL
100 Gb/s 8V pp Dual Channel Driver / Out Driver	DC - 35	3 - 9Vpp	32	–	5 - 7 / 500	16x10.5 SL	***TGA4947-SL***
Wideband Driver (40 Gb/s)	DC - 35	4Vpp	12	–	5 / 135	Die	TGA4832
32 Gb/s 9V pp Diff In / Out Driver MMIC	DC - 35	6 - 9Vpp Diff	25 Diff	–	5 - 6 / 500	10x7 SL	TGA4959-SL
45 Gb/s 8V pp SE Driver w/ Bias-T Inside	DC - 37	5 - 9Vpp	30	–	6 - 7 / 300	16x8 SL	***TGA4942-SL***
45 Gb/s 9V pp 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: ** = ***Coming Soon***, SE = Single-Ended

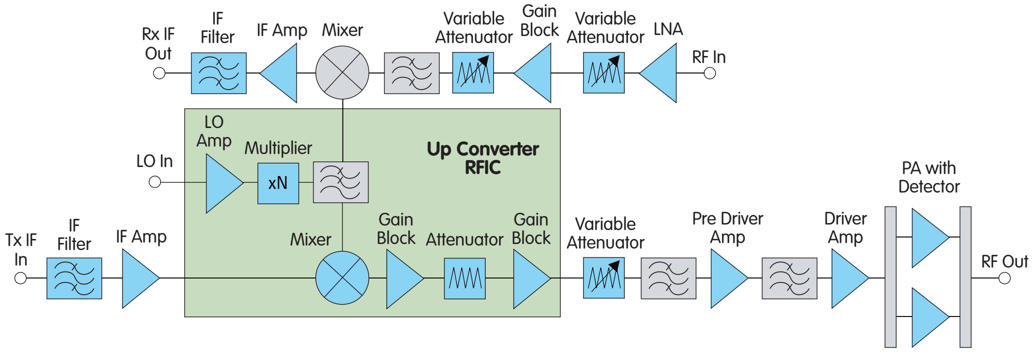
Amplifiers

Description	Frequency Range (GHz)	P1dB (Psat) / 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 / 46	20	1.5	8 / 350	4x4 QFN	TGA2803-SM

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 (0 dB 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, -09-SM etc.

GUIDE BY MARKET I **PtP Radio**



Point-to-Point Radio

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
2W HPA	12.3 - 15.7	(31) / –	33	7.0 / –	6 / 850	Die	TGA2520
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	4x4 QFN	TGA2503-SM
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Die	TGA2510
2W HPA	12.5 - 17	(33.5) / –	25	– / 25	7.5 / 650	6.4x9.4 SG	TGA2510-SG
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
2W HPA	13 - 17	(34) / –	33	–	5 - 8 / 680	17.8x8.4 FL	TGA2904-FL
2W HPA, PD	13 - 17	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-1-SCC-SG
2W HPA	13 - 17	(34) / 40	33	–	5 - 8 / 680	6.4x9.4 SG	TGA8658-SG
4W HPA, Balanced	13 - 17	(36) / 44	25	– / 30	6 - 7 / 1300	Die	TGA2502
2W HPA, PD	13.75 - 14.5	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-2-SCC-SG
1W HPA, PD	17 - 20	30 (32) / 42	20	–	5 - 7 / 825	Die	TGA4530
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
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	TGA1135-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
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

Amplifiers (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
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

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 / 900	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	10 mA	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	10 mA	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

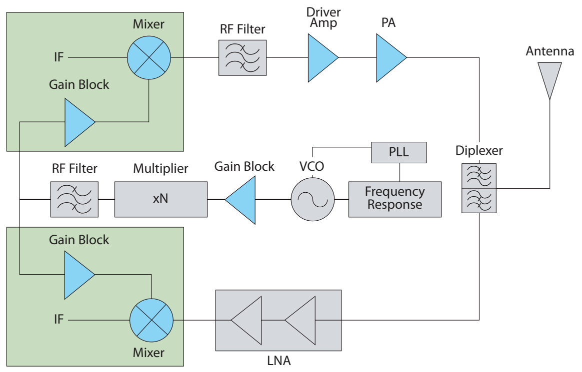
Description	Frequency Range (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	IIP3 (dBm)	Voltage / Current (V / mA)	Package Style	Part Number
Doubler w/Amplifier	16 - 30	18	30	–	5 / 150	Die	TGC4403
Doubler w/Amplifier	16 - 30	18	30	–	5 / 150	4x4 QFN	TGC4403-SM
Upconverting Mixer	17 - 26	-9	40	–	-0.9 / 0	4x4 QFN	TGC4402-SM
Upconverting Mixer	17 - 27	-9	35	18	-0.9 / 0	Die	TGC4402
Upconverter	17 - 27	13	30	–	5 / 425	Die	TGC4405
Upconverter	17 - 27	13	30	–	5 / 425	4x4 QFN	TGC4405-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
Doubler (Input 10 - 20 GHz)	20 - 40	-12	25	18	–	Die	TGC1430F

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 (0 dB 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

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



VSAT RF Subsystem

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 1.3W PA	12.3 - 15.7	(31) / –	33	7 / –	6 / 850	Die	TGA2520
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	(33.5) / –	25	– / 25	7.5 / 650	9.4x6.4 SG	TGA2510-SG
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 2W PA	13 - 17	(34) / –	33	–	5 - 8 / 680	8.4x17.8 FL	TGA2904-FL
Ku-Band 2W PA	13 - 17	(34) / 40	33	–	5 - 8 / 680	9.4x6.4 SG	TGA8658-SG
Ku-Band 2W PA, PD	13 - 17	(34) / 38.5	26	– / 30	7.5 / 650	9.4x6.4 SG	TGA2902-1-SG
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
Ku-Band 2W PA, PD	13.75 - 14.5	(34) / 38.5	26	– / 30	7.5 / 650	9.4x6.4 SG	TGA2902-2-SG
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 VGA	27 - 31.5	21 at max gain / –	29 (max)	–	5 / 280	6x6 QFN	***TGA4541-SM*****
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 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: ***** = Coming Soon,*** PD = Power Detector, 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 (Lo Amp + Doubler)	21.5 - 32.5	-9	35	13	5 / 65	3x3 QFN	***TGC4407-SM*****

NOTES: ***** = Coming Soon***

Up to 1W

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage Current (V / mA)	Package Style	Part Number
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 / –	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	30 / 51	11	4 / –	12 / 450	SOIC16W	***TAT8801****
CATV Power Doubler Line Amplifier MMIC	0.05 - 1	31 / 52	25	4 / –	24 / 350 (12v optional)	SOIC16W	***TAT8857****
CATV Push Pull Infrastructure Amplifier MMIC	0.05 - 1	–	32	3 / –	24 / 270 (12v optional)	SOIC16W	***TAT8858****
Dual HBT Amplifier	0.05 - 1	20 / 37	13.5	4.5 / –	>7 / 165	SOIC-8	AG606
MESFET Amplifier	0.05 - 1	20 / 40	14.8	3.5 / –	5 / 150	SOT89	AH2
Dual MESFET Amplifier	0.05 - 1	25.5 / 43	11.1	4.5 / –	5 / 320	SOIC-8	AH22S
Fiber to the Home TIA + Output Amp	0.05 - 1	-60 dBc CTB / CSO	38	2.9 pA / rtHz EIN	10 - 12 / 120	4x4 QFN	TAT6254B
Fiber to the Home TIA + Output Amp (RFoG)	0.05 - 1	-62 dBc CTB / CSO	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	-63 dBc CTB / CSO	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 Multi	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
29.5 dBm HBT Amplifier	0.05 - 1.5	29.6 / 48	20.7	4.4 / –	5 / 240	SOT89	***TQP7M9105****
MESFET Amplifier	0.05 - 1.5	26.5 / 47	13.5	3.5 / –	9 / 200	SOT89	AH101
Dual pHEMT Amplifier	0.05 - 2	– / 41	13	4 / –	6 / 190	SOIC-8	TAT7466
30 dBm MESFET Amplifier	0.05 - 2.2	30 / 47	17	2.5 / –	11 / 330	6x6 QFN	AH202
Dual pHEMT Amplifier, Wideband	0.05 - 2.6	-77 dBc CTB / -83 dBc CSO	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
MESFET Amplifier, 2-Stage	0.06 - 2.7	27 / 46	29	2.5 / –	4.5; 9 / 275	SOIC-8	AH103A
MESFET Amplifier	0.35 - 3	27 / 46	14.5	3.1 / –	9 / 200	SOT89	AH102A
24.5 dBm HBT Amplifier	0.4 - 4	24.3 / 39.5	20.4	4 / –	5 / 87	SOT89	TQP7M9101
27.5 dBm HBT Amplifier	0.4 - 4	27.5 / 44	21.9	4 / –	5 / 137	SOT89	TQP7M9102
29.5 dBm HBT Amplifier	0.4 - 4	29.5 / 45.4	20.7	4.4 / –	5 / 235	SOT89	***TQP7M9103****
28 dBm HBT Amplifier	0.7 - 3.8	28 / 42	28.5	2.9 / –	5 / 225	4x4 QFN	TQP8M9013
10W GaN	2 - 18	41.5 / –	10	– / 23	35 / 1200	Carrier	***TGA2573-TS****
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
2.8W HPA	6 - 18	(34.5) / –	24	– / 20	7 - 9 / 800 - 1200	Carrier	***TGA2501-TS****
16W HPA	6.5 - 12.5	42 / –	27	– / 35	12 / 3000	Carrier	***TGA2517-TS****
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****
2W HPA	12.5 - 17	(34) / –	26	– / 25	7.5 / 650	Carrier	***TGA2510-TS****
20W HPA	14 - 16	(43) / –	23	– / 30	20 / 2000	Carrier	***TGA2572-TS****
1W HPA, PD	17 - 20	30 (32) / 42	20	–	5 - 7 / 825	Die	TGA4530

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	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
MPA	17 - 27	29 / –	22	–	7 / 760	5x5 QFN	***TGA4525-SM****
HPA	17 - 27	29 (31) / 37	22	–	7 / 760	Die	TGA4502-SCC
HPA	18 - 27	29 / 37	14	–	6 / 480	Die	TGA1135-SCC
MPA	19 - 27	25 / 32	22	–	5 - 7 / 220	Die	TGA1073G-SCC
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
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
Driver Amp	41 - 45	18 / –	14	–	6 / 168	Die	TGA4042

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	31.5 / 53	11	4 / –	12 / 550	SOIC16W	***TAT2801****
33.8 dBm HBT Amplifier	0.05 - 1.5	32.8 / 50	20	4.8 / –	5 / 500	4x4 QFN	***TQP7M9106****
35.5 dBm HBT Amplifier	0.4 - 2.7	35.5 / 50	16	7 / –	5 / 800	4x5 DFN	AH420
33 dBm HBT Amplifier	0.7 - 2.7	33 / 50	27.5	7 / –	5 / 680	5x5 QFN	AH323
33.8 dBm HBT Amplifier	0.7 - 2.7	33.8 / 45	21	4.4 / –	5 / 435	4x4 QFN	***TQP7M9104****
30 dBm HBT Amplifier	1.8 - 2.7	30.5 / 46.5	27	5.5 / –	5 / 400	SOIC-8	AH212
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
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	12.3 - 15.7	(31) / –	33	7 / –	6 / 850	Die	TGA2520
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	(33.5) / –	25	– / 25	7.5 / 650	6.4x9.4 SG	TGA2510-SG
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
2W HPA	13 - 17	(34) / 40	32	–	6 - 7 / 680	Die	TGA2503
2W HPA	13 - 17	(34) / –	25	–	6 - 7 / 640	Die	TGA2505
2W HPA, PD	13 - 17	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-1-SG
2W HPA	13 - 17	(34) / –	33	–	5 - 8 / 680	17.8x8.4 FL	TGA2904-FL
2W HPA	13 - 17	(34) / 40	33	–	5 - 8 / 680	6.4x9.4 SG	TGA8658-SG
2W HPA, PD	13.75 - 14.5	(34) / 38.5	26	– / 30	7.5 / 650	6.4x9.4 SG	TGA2902-2-SG
20W HPA	14 - 16	(43) / –	23	– / 30	20 / 2000	Carrier	***TGA2572-TS****
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
HPA	17 - 24	31 (32) / 40	23	6 / –	7 / 720	Die	TGA4531
2W HPA	18 - 23	32 (33) / 39	26	–	7 / 840	Die	TGA4022
HPA	21 - 24	31 (32) / 41	22	6 / –	6 / 880	4x4 QFN	TGA4533-SM

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
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
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**
2W HPA	41 - 47	(33) / –	16	–	6 / 2000	Die	TGA4046
77 GHz MPA	76 - 80	14 / –	12	–	3.5 / 75	Die	TGA4706-FC

NOTES: ** = New*, PD = Power Detector

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-FL
39 dBm HBT Amplifier	0.7 - 2.9	39 / –	16.5	8	12 / 300	5x6 DFN	AP561
14W HPA	2 - 18	41.5 / –	10	23	35 / 1200	Die	TGA2573
30W HPA	2.5 - 6	(45) / –	26	35	30 / 1550	Flange	TGA2576-FL
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
HPA	7 - 8.5	(38) / –	21	42	7 / 2000	Die	TGA2701
HPA	9 - 10.5	(38) / –	20	>38	4 - 9 / 2000	Die	TGA2704
HPA	10.5 - 12	(38) / –	19	>39	4 - 9 / 2000	Die	TGA2710
20W HPA	13 - 15	43	19	– / 25	25 / 1000	Flange	*TGA2593-GSG**
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
20W HPA	14 - 15.5	43 / –	23	30	25 / 1000	Flange	*TGA2579-FL**
16W HPA	14 - 16	(42) / –	27	30	25 / 2000	Die	*TGA2572**
16W HPA	14 - 16	(42) / –	23	30	25 / 2000	Flange	*TGA2572-FL**
4W HPA	28 - 31	36 (36.5) / –	22	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) / –	22	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	–	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 / 220	6x6 QFN	*TAT6281**
Variable Gain Amplifier	0.05 - 2.2	22 / 42	15.5	20	5 / 150	4x4 QFN	VG025
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 Amplifier	0.7 - 1	22 / 40	16	29	5 / 150	6x6 QFN	VG101
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	TQM879006
Digital Variable Gain Amplifier	1.5 - 2.7	27.3 / 47.5	41	31.5	5 / 285	6x6 QFN	*TQM879008**
Ka-Band VGA	27 - 31.5	21 (max) / –	29 (max)	–	5 / 280	6x6 QFN	*TGA4541-SM***

NOTES: ** = New, ** = Coming Soon*

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
General Purpose Gain Block	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 / 46	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	0.1 - 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
Gain Block, SB	2 - 10	17 / –	17	6	5 / 90	Die	TGA8810-SCC
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
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***, 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
LNA, Single-Ended Matched Amp	0.01 - 4	22.3 / 18.7	15.3	0.8	5 / 55	3x3 QFN	TQP3M9005
LNA, Single-Ended Matched Amp	0.01 - 4	22.4 / 25	13.5	1	5 / 90	3x3 QFN	TQP3M9006
LNA, Single-Ended Matched Amp	0.05 - 4	21 / 36	20	1.3	5 / 85	SOT89	TQP3M9008
LNA, Single-Ended Matched Amp	0.05 - 4	21.4 / 37.5	22	1.1	5 / 85	3x3 QFN	TQP3M9018
LNA, Single-Ended Matched Amp	0.05 - 4	21.8 / 15.8	24.7	0.9	5 / 125	SOT89	TQP3M9009
LNA, Single-Ended Matched Amp	0.05 - 4	21.8 / 15.8	24.7	0.9	5 / 125	3x3 QFN	TQP3M9019
LNA, Single-Ended Matched Amp	0.05 - 4	21.5 / 40	15	2	5 / 85	SOT89	TQP3M9028

Low Noise (cont.)

Description	Frequency Range (GHz)	P1dB / IIP3 (dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
LNA, Single-Ended Matched Amp	0.4 - 1.5	20 / 16	19	0.45	5 / 60	2x2 DFN	***TQP3M9036****
LNA, Single-Ended Matched Amp	0.5 - 4	23.5 / 42	18	1.3	5 / 135	SOT89	TQP3M9007
LNA, Balanced FET Low Band	0.7 - 0.92	– / 13.5	20.5	0.55	4 / 70	4x4 QFN	TQP3M6004
LNA, Discrete Low Band	0.7 - 0.92	26 / 23.5	16	0.8	5 / 150	SOT89	TGF2021-04-SD
LNA, Balanced FET	0.8 - 3	21 / 11	22	0.7	4 / 100	2x2 QFN	TGA2602-SM
LNA, Single-Ended Matched Amp	1.5 - 2.7	21 / 16	20	0.40	5 / 60	2x2 DFN	***TQP3M9037****
LNA, Balanced FET Mid Band	1.7 - 2	– / 14.4	18	0.55	3.5 / 50	4x4 QFN	TQP3M6005
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, 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
77 GHz LNA	72 - 80	–	20	5	3.5 / 54	Die	TGA4705-FC

NOTES: **** = New***, 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
55W GaN HEMT	DC - 3.5	47.2 / –	15	– / 50	28 / 200	Ceramic Flat Lead	T1G4005528-FS
Pwr pHEMT	DC - 4	26.5 / –	16	0.6 / –	5 / 150	SOT89	TGF4124
0.5W HFET	DC - 6	28 / 40	18	3.2 / –	8 / 100	SOT89	TGF2960-SD
1W HFET	DC - 6	31 / 43	16	4 / –	8 / 200	SOT89	TGF2961-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	T1G6000528-Q3
18W GaN HEMT	DC - 6	(42.5) / –	15	– / 50	28 / 50	Ceramic Flat Lead	T1G6001528-Q3
30W GaN HEMT	DC - 6	(44.8) / –	15	– / 50	28 / 200	Ceramic Flat Lead	***T1G6003028-FS****
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 / 900	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	TGF2023-01
2.5mm GaN HEMT	DC - 18	(40.2) / –	13	– / 50	28 / 250	Die	TGF2023-02
5.0mm GaN HEMT	DC - 18	(43) / –	13	– / 49	28 / 500	Die	TGF2023-05
10mm GaN HEMT	DC - 18	(45.8) / –	12	– / 47	28 / 1000	Die	TGF2023-10
20mm GaN HEMT	DC - 18	(48.6) / –	12	– / 46	28 / 2000	Die	TGF2023-20

Discrete Transistors (cont.)

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) / (%)	Voltage / Current (V / mA)	Package Style	Part Number
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 - 4	18 / 36	19	2 / –	5 / 140	SOT89	FH101
MESFET	0.05 - 4	21 / 42	19	2 / –	5 / 140	SOT89	FH1
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
10W GaN	2 - 18	41.5 / –	10	– / 23	35 / 1200	Carrier	***TGF2021-04-SD****

NOTES: ***** = New***

GUIDE BY PRODUCT TYPE | Control Products

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 / 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	9.3	33	25	5 / 310	6x6 QFN	***TQP519021****
Mixer, LO	0.7 - 1	-9	17	36	5 / 50	MSOP-8	ML483
Single Branch Converter, RF, LO, IF	0.8 - 0.96	22	60	15	5 / 360	6x6 QFN	CV110-3A
Dual Branch Converter, LO, IF	0.8 - 0.96	10.5	14	18.5	5 / 390	6x6 QFN	CV210-3A
Mixer, LO	1.5 - 3.2	-8.5	2	35	5 / 40	MSOP-8	ML485
Single Branch Converter, RF, LO, IF	1.7 - 2	21	45	17	5 / 360	6x6 QFN	CV111-1A
Dual Branch Converter, LO, IF, SW, EN	1.7 - 2.2	9.3	35	25	5 / 310	6x6 QFN	***TQP569022****
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
Upconverter	17 - 27	13	30	–	5 / 425	Die	TGC4405
Upconverter	17 - 27	13	30	–	5 / 425	4x4 QFN	TGC4405-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
Doubler (Input 10 - 20 GHz)	20 - 40	-12	25	18	–	Die	TGC1430F
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, ** = Coming Soon***, + = Phase Noise (dBc / Hz @ 1 mHz Offset), EN = Enable / Disable Mode, IF = IF Amplifier, LO = LO Amplifier, SW = LO Switch

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

Signal Conditioning (cont.)

Description	Frequency Range (GHz)	Insertion Loss (dB)	Control Range dB or (Deg.)	P1dB (dBm)	Supply Voltage (V)	Package Style	Part Number
Discrete Thru (0 dB 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
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, -09-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 High Power CDMA	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 - GaN	DC - 6	<1	40	45	-40 / 0	Die	TGS2351
SPDT - GaN	DC - 6	<1	40	45	-40 / 0	4x4 QFN	TGS2351-SM
SPDT - GaN	DC - 12	<1	35	43	-40 / 0	Die	TGS2352
SPDT - GaN	DC - 18	<1	30	40	-40 / 0	Die	TGS2353
SPDT FET	DC - 18	1.5	36	27	-5	Die	TGS2306
SPDT FET	DC - 18	2	39	21	-7 / 0	Die	TGS8250-SCC
SPST - High Isolation Absorptive	0.1 - 6	0.4	48	33	3 / 0	2x2 DFN	***TQP4M0013****
SPDT - Reflective	0.1 - 6	0.3	30	33	3 / 0	2x2 DFN	***TQP4M0008****
SPDT - High Isolation Reflective	0.1 - 6	0.5	50	31	3 / 0	MSOP8	***TQP4M0009****
SPDT - High Isolation Absorptive	0.1 - 6	0.5	45	32.5	3 / 0	4x4 QFN	***TQP4M0010****
SP3T - Reflective	0.1 - 6	0.3	30	30	3 / 0	3x3 QFN	***TQP4M0011****
SP4T - Reflective	0.1 - 6	0.6	40	33	3 / 0	3x3 QFN	***TQP4M0012****
SP3T VPIN	1 - 20	0.5	35	23	10 mA	Die	TGS2303
SP4T VPIN	1 - 20	0.6	38	23	10 mA	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: **** = New***

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
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
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
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
High Selectivity IF Filter	70	5.5	22.2	SE / SE	40 @ 7.84	19x6.5	855745
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 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

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
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	0.8	20.8	SE / SE	40 @ 1.93	19x6.5	856062
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
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
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
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 SAW Filter - Multi-Standard	192	60	14.5	SE / BAL	38 @ 44	7x5.5	***856731****
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
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

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
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
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 / 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 / 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 SAW 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
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
MICS Band RF Filter	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
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 SAW 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
Duplexer, Band 17	710 / 740	12 / 12	1.2 / 1.8	SE / BAL	–	2.5x2	856931
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
Duplexer, Band 13	751 / 782	9 / 9	2.3 / 1.8	SE / BAL	–	2.5x2	856879
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
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
RF SAW Filter - Band 13 / 14 Uplink	787.5	22	2.75	SE / SE	40 @ 843	3x3	***856977****

SAW (cont.)

Description	Frequency (MHz)	Bandwidth (MHz)	Typical IL (dB)	I / O Configuration	Rejection {dB @ BW or Freq (MHz)}	Package Size (mm)	Part Number
BWA / WiMAX IF Filter	810	10	3.5	SE / SE	10 @ 31	3x3	856526
Duplexer, Band 20	806 / 847	30 / 30	2.5 / 3	SE / BAL	–	2.5x2	856979
Duplexer, BC10	833 / 878	32 / 32	2.5 / 2.5	SE / BAL	–	2.5x2	856999
RF SAW 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****
Duplexer, Cell Band	836.5 / 881.5	25 / 25	1.9 / 1.9	SE / SE	–	3.8x3.8	856356
RF 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 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
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
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
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
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, 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 / 0.8	SE / SE	GPS Port: 40 @ 2332 SDARS Port: 36 @ 1572	3x3	TQM2M9016
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 SAW 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

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 SAW Filter - Band 2 Uplink	1880	60	4	SE / SE	7 @ 1930	3x3	***855849****
RF SAW 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
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
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	30	2.75	SE / SE	40 @ 140	3.26x1.6	880272
GPS RF Filter, L2	1227	15	1.5	SE / SE	40 @ 250	3.26x1.6	880366
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****
Band 3 Duplexer	1747.5 / 1842.5	75 / 75	2.6 / 2.7	SE / SE	–	2.5x2	***TQM956003****
RF BAW Filter - Band 2 Uplink	1880	60	3.5	SE / SE	30 @ 1920	3x3	***885025****
PCS Duplexer	1880 / 1960	60 / 60	1.32 / 1.52	SE / SE	–	3.8x3.8	***TQM969001****
BC1 / B2 Duplexer	1880 / 1960	60 / 60	1.8 / 1.9	SE / SE	–	2.5x2	***TQM966002****
BC14 / B25 Duplexer	1882.5 / 1962.5	65 / 65	1.8 / 2.2	SE / SE	–	2.5x2	***TQM963014****
RF BAW 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****
RF Filter	2106	35	4	SE / SE	–	3.26x1.6	***880126****
RF Filter	2324	38	3	SE / SE	40 @ 150	3.81x2.54	880148
SDARS	2332.5	45	1.7	SE / BAL	35 @ 2100	1.4x1.2	856604
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
RF BAW Filter - Band 7 Uplink	2535	70	1.3	SE / SE	41 @ 2620	3x3	***885009****
Band 7 Duplexer	2535 / 2655	70 / 70	2.5 / 1.5	SE / SE	–	2.5x2	***TQM976027****
RF Filter, MMDS	2560	30	3	SE / SE	40 @ 150	3.81x2.54	880157
RF Filter, ISM	5775	100	4.5	SE / SE	20 @ 350	3.26x1.6	880369

NOTES: **** = New***

GPS

Description	Frequency Bands	Features	Package Size (mm)	Part Number
GPS Filter-LNA-Filter Module	1575 MHz, GPS L1	Low Noise (1.56 dB) and High Gain (16 dB)	3x3x1	TQM640002

GSM / GPRS / EDGE

Description	Frequency Bands	Features	Package Size (mm)	Part Number
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM850 / 900, DCS / PCS	Low Band Ibatt < 1.5A @ Pcal w/PAE 55%	5x5x1	TQM7M5005H
Dual-Band GSM / GPRS Tx Module; PA / LPF / SP4T Switch; Quad-Band Tx & Dual-Band Rx	GSM900 / DCS or GSM850 / PCS	High Efficiency Broadband Tx, 2 Rx Ports	5x6x1	TQM6M4068
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x5.x1	***TQM7M5033****
Quad-Band GSM / GPRS / EDGE-Linear PA Module	GSM900 / DCS & GSM850 / PCS	Input Power Controlled for GMSK & 8PSK	5x3.5x1	***TQM7M5050****

NOTES: **** = New***

3G – CDMA / EV-DO, 4G – LTE

Description	Bands	Features	Package Size (mm)	Part Number
LTE PA Module, w/Coupler	Band 13	LTE, 2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM700013
CDMA PA Module, w/Coupler	PCS	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM766012
CDMA PA Module, w/Coupler	AWS	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM756014
CDMA PA Module, w/Coupler	Cellular	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM716015
LTE PA Module, w/Coupler	Band 17	LTE 1-Bit (Hi / Lo Power Modes)	3x3x0.9	***TQM700017****

NOTES: **** = New***

3G – CDMA / WCDMA / HSUPA / LTE

Description	Bands	Features	Package Size (mm)	Part Number
Integrated 2-in-1 PA-Duplexer Module	Bands 1 & 8	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	***TQM6M6218****
Integrated 2-in-1 PA-Duplexer Module	Bands 2 & 5	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	***TQM6M6225****
Integrated 2-in-1 PA-Duplexer Module	Bands 1 & 4	DC / DC, 1-Bit (Hi / Med Power Modes)	6x4.5x1	***TQM6M6214****

NOTES: **** = New***

3G – WCDMA / WGPRS / WEDGE, 4G – LTE

Description	Bands	Features	Package Size (mm)	Part Number
QB GSM / GPRS / EDGE-Polar PA Module	GSM850 / 900, DCS / PCS	-90 dBm Typ Rx Noise, +3 to +8 dBm Pin Nom	5x5x1	TQM7M5012H
QB GSM / GPRS / EDGE-Linear PA Module	GSM850 / 900, DCS / PCS	Input Power Controlled for GMSK & 8PSK	5x5x1	TQM7M5013
QB GSM / GPRS / EDGE-Polar PA Module	GSM850 / 900, DCS / PCS	+3 to +8 dBm Pin Nominal, Current Limiter	5x5x1	TQM7M5022
WCDMA / HSUPA PA Module, w/Coupler	Band 1	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM776011
WCDMA / HSUPA PA Module, w/Coupler	Band 8	2-Bit (Hi / Med / Lo Power Modes)	3x3x0.9	TQM726018
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Band 1	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM676021
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Band 2	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM666022

3G – WCDMA / WGPRS / WEDGE, 4G – LTE (cont.)

Description	Bands	Features	Package Size (mm)	Part Number
WCDMA / HSUPA TRITIUM III PA-Duplexer Module™; SE Input w/Coupler, Detector	Bands 5 and 6	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM616025
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 8	1-Bit (Hi / Lo Power Modes)	7x4x1.1	TQM626028L
WCDMA / HSUPA PA-Duplexer Module; SE Input w/Coupler, Detector	Band 2	DC / DC, 1-Bit (Hi / Med Power Modes)	4.5x3.5x1	***TQM666052****
DB GSM / GPRS Tx Module: PA / LPF / SP6T WGPRS Switch w/Dual-Band WCDMA Antenna Pass-Through	GSM900 / DCS or GSM850 / PCS & 2 WCDMA Bands	Integrated DB GSM / GPRS & 2 WCDMA Antenna Switch Ports	5x6x1	TQM6M9069
QB GSM / GPRS / EDGE-Linear TRP QUANTUM II Tx Module™: PA / LPF / SP8T WEDGE Switch w/ Quad-Band WCDMA Antenna Pass-Through	GSM850 / 900, DCS / PCS & WCDMA B1, B2, B5 / 6, B8	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch Supporting WCDMA	7x7.5x1.1	TQM6M9014
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 & B8	Integrated QB GSM / GPRS / EDGE PA & Antenna Switch	5x6x1	***TQM6M9085****
Multi-Mode Quad-Band GMSK / EDGE / WCDMA TRIUMF PA Module	GSM850 / 900, DCS / PCS & WCDMA B1 & B8	2-Bit (Hi / Med / Lo Power Modes)	5x7.5x1	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 Power Modes)	5x7.5x1	***TQM7M9053****

NOTES: **** = New***

WLAN / Bluetooth® RF Front-End Modules

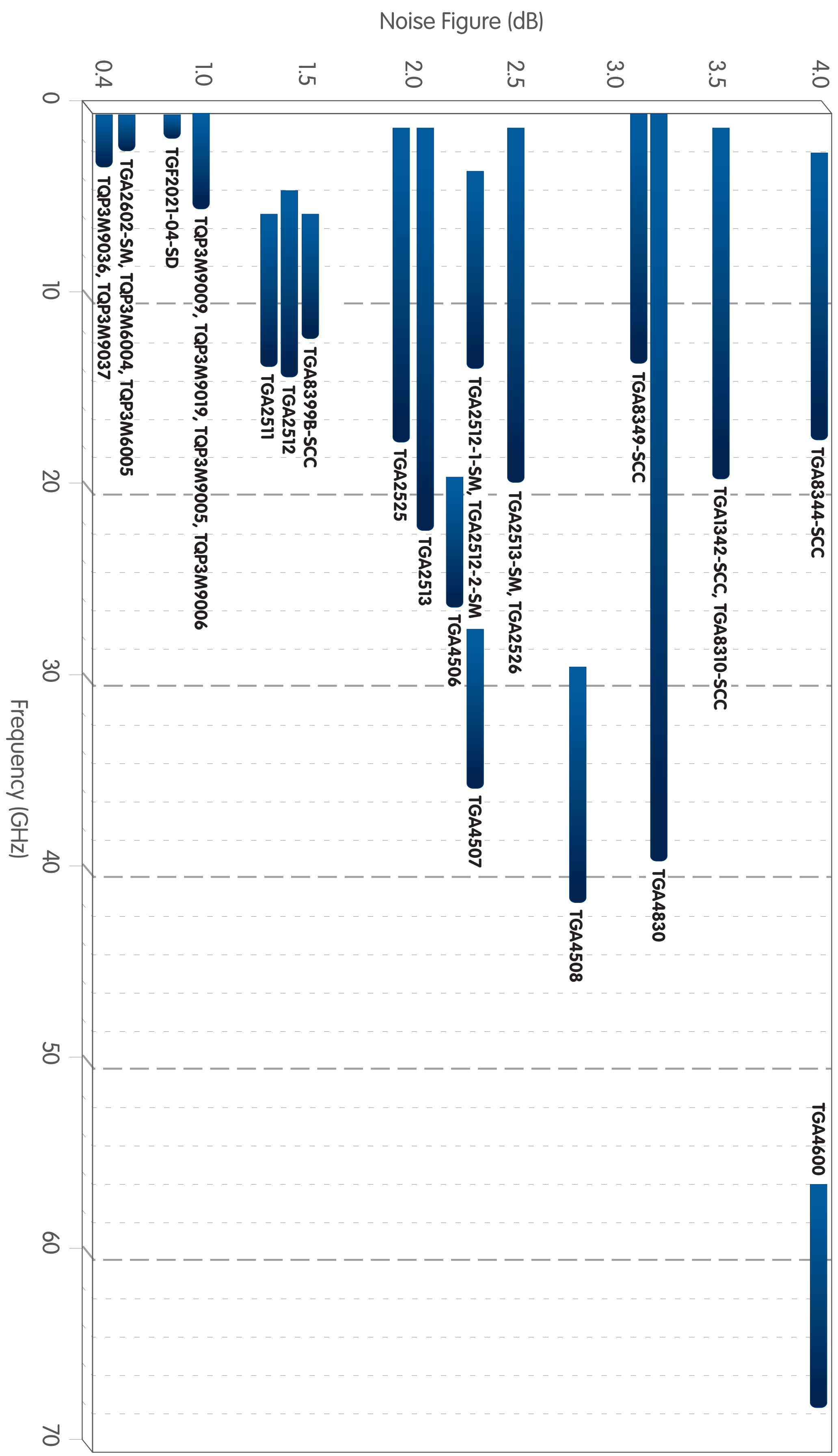
Description	Bands	Features	Package Size (mm)	Part Number
802.11 5 GHz WLAN PA MMIC	802.11 a, n	ETSLP-16 Package, Detector, Hi / Lo Linearity Mode	3x3x0.45	TQP787011
2.4 GHz WLAN LNA + SP3T Switch w/WLAN Tx & Bluetooth® Path	802.11 b, g, n	LNA Bypass, ETSLP-12 Package	1.5x1.5x0.55	TQP879001A
2.4 GHz WLAN PA + Switch MMIC w/WLAN Rx Balun & Bluetooth® Path	802.11 b, g, n	ETSLP-16 Package, Coupler / Detector	3x3x0.45	TQM679002A
2.4 GHz & 5 GHz WLAN PA + Switch MMIC w/WLAN Rx Baluns & Bluetooth® Path	802.11 a, b, g, n	ETSLP-24 Package, Coupler / Detector	4x4x0.45	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	802.11 a, b, g, n, ac	ETSLP-24 Package, Coupler / Detector	4x4x0.45	***TQP6M9017****
5 GHz WLAN PA + Low Noise Amplifier + SP2T Switch MMIC	802.11 a, n	ETSLP-16 Package, Coupler / Detector	2.5x2.5x0.4	***TQP887016****
2.4 GHz WLAN PA + Low Noise Amplifier + SP3T Switch MMIC for Bluetooth® Path	802.11 b, g, n	ETSLP-16 Package, Coupler / Detector	2.5x2.5x0.4	***TQP879016****

NOTES: **** = New***

Drivers

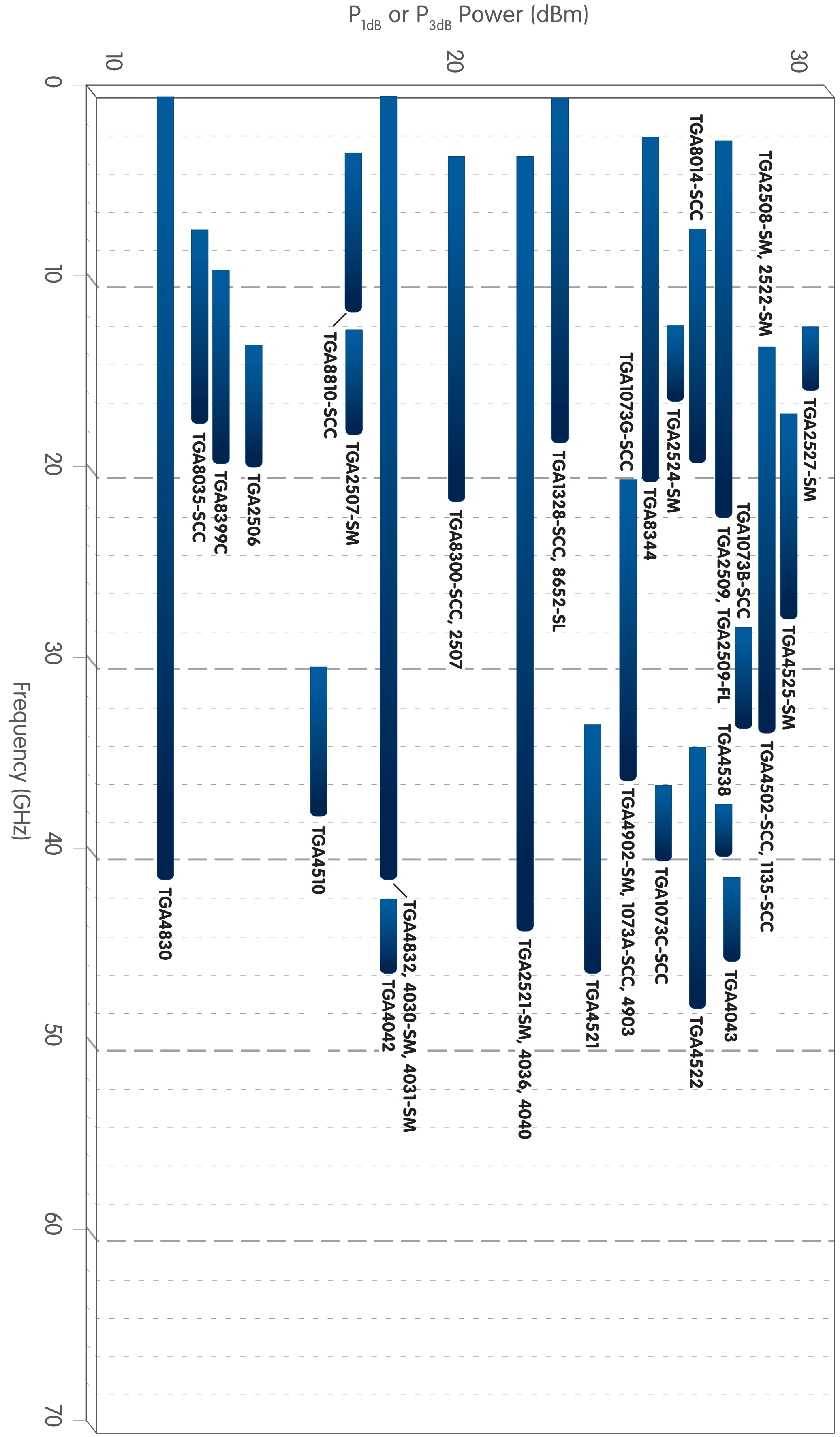
Description	Frequency (GHz)	Power (Vpp or dBm)	Gain (dB)	NF (dB)	Voltage / Current (V / mA)	Package Style	Part Number
9.9 - 12.5Gb/s 3V - 7V Driver	DC - 13	3 - 7Vpp	32	–	3.3 - 5 / 115	8x8 QFN	TGA4956-SM
9.9 - 12.5 Gb/s Modulator Driver	DC - 16	3 - 9Vpp	35	2.5	5.5 - 8 / 210	11.4x8.9 SL	TGA4954-SL
9.9 - 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	8.9x8.9 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
40 & 100 Gb/s 8Vpp SE Driver	DC - 30	3 - 9Vpp	32	–	6 - 7 / 270	14.4x7 SL	TGA4943-SL
100 Gb/s 8V pp Dual Channel Driver w/Bias-Ts Inside	DC - 35	3 - 9Vpp	32	–	5 - 7 / 500	16x10.5 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 8V pp 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: ***** = Coming Soon***, SE = Single-Ended



Selected Low Noise Amplifiers, LNA Noise Figure vs. Frequency

For a complete list of low noise amplifiers, please refer to page 39 and 40.

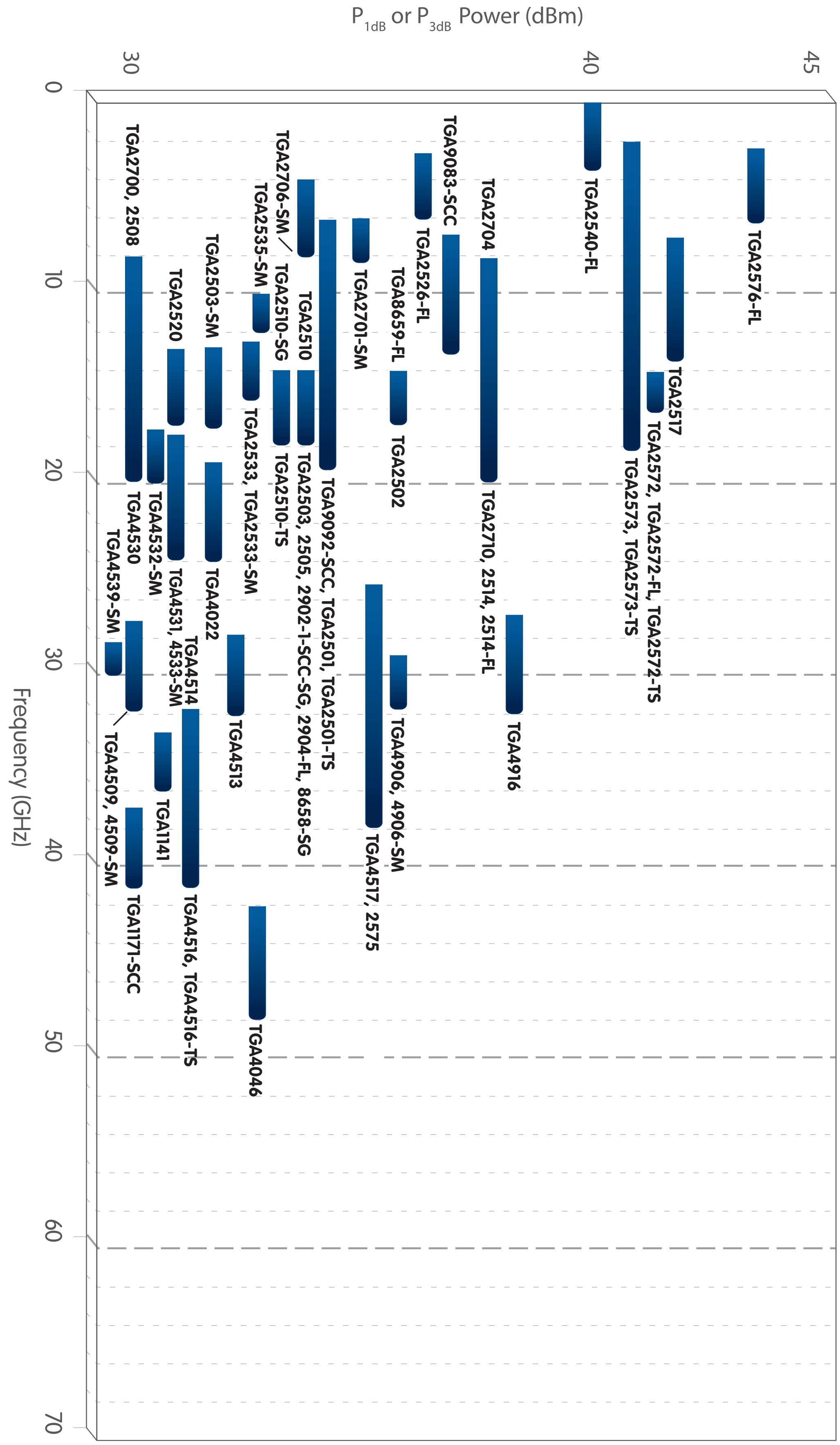


Selected Less Than 1W Higher Frequency Amplifiers, Power vs. Frequency

For a complete list of less than 1W amplifiers, please refer to pages 36 and 37.

Selected More Than 1W Higher Frequency Amplifiers, Power vs. Frequency

For a complete list of more than 1W amplifiers, please refer to pages 37 and 38.



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- 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% (as of May 2011). 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 2012 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@tqs.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.

TriQuint SEMICONDUCTOR®

Connecting the Digital World to the Global Network®

Below is a List of our Authorized Channel Partners:

RichardsonRFPD – An Arrow Company
Global

MOUSER ELECTRONICS – a tti company
Global

RFMW
Americas & EMEA

AVNET 安富利电子元件
Asia

JORJIN TECHNOLOGIES
Taiwan

tecnomic
India

MARUBUN CORPORATION
Japan

Versatech
China

For more information, visit **www.triquint.com/sales.**

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Visit **www.triquint.com/subscribe** and register for TriQuint product and process updates.