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July 2011

Microwave Journal

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2 – 18	SW1-020180RN1NF	3	80	2:1	10/10	20	35	35/70
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SP2T								
0.2 – 2	SW2-002020RN1NF	1.5	70	1.6:1	10/10	20	35	60/60
2 – 8	SW2-020080RN1NF	1.8	80	1.7:1	10/10	20	35	60/60
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2 – 18	SW2-020180RN1NF	2.8	80	2:1	10/10	20	35	60/60
1 – 18	SW2-010180RN1NF	3	70	2:1	10/10	20	35	60/60
SP3T								
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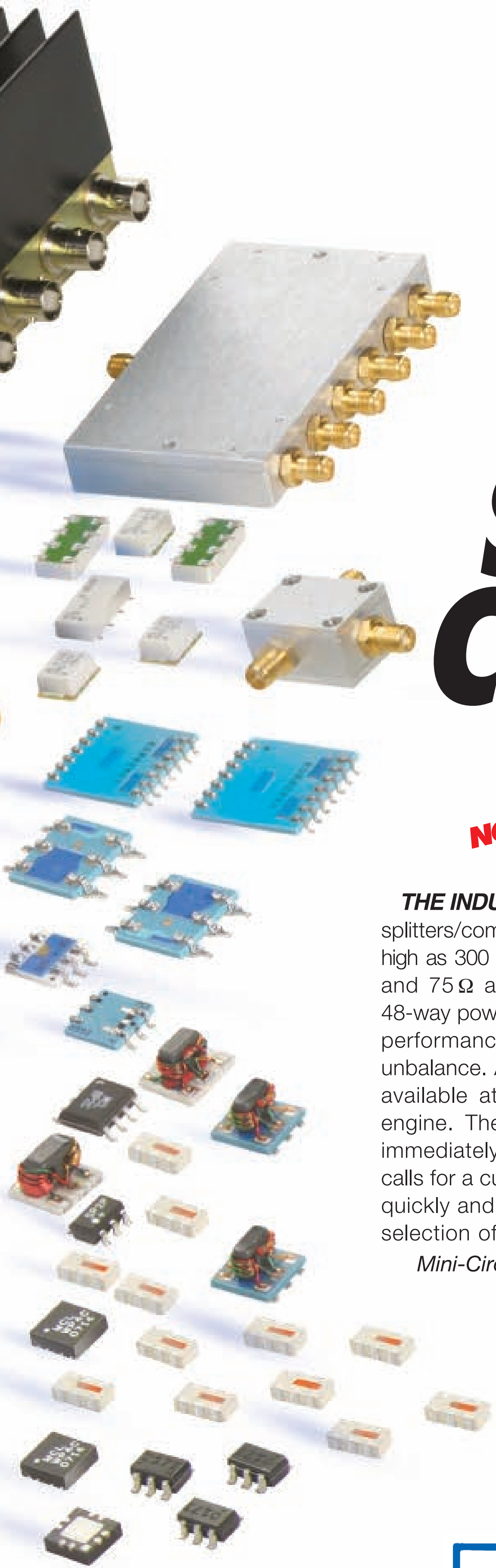


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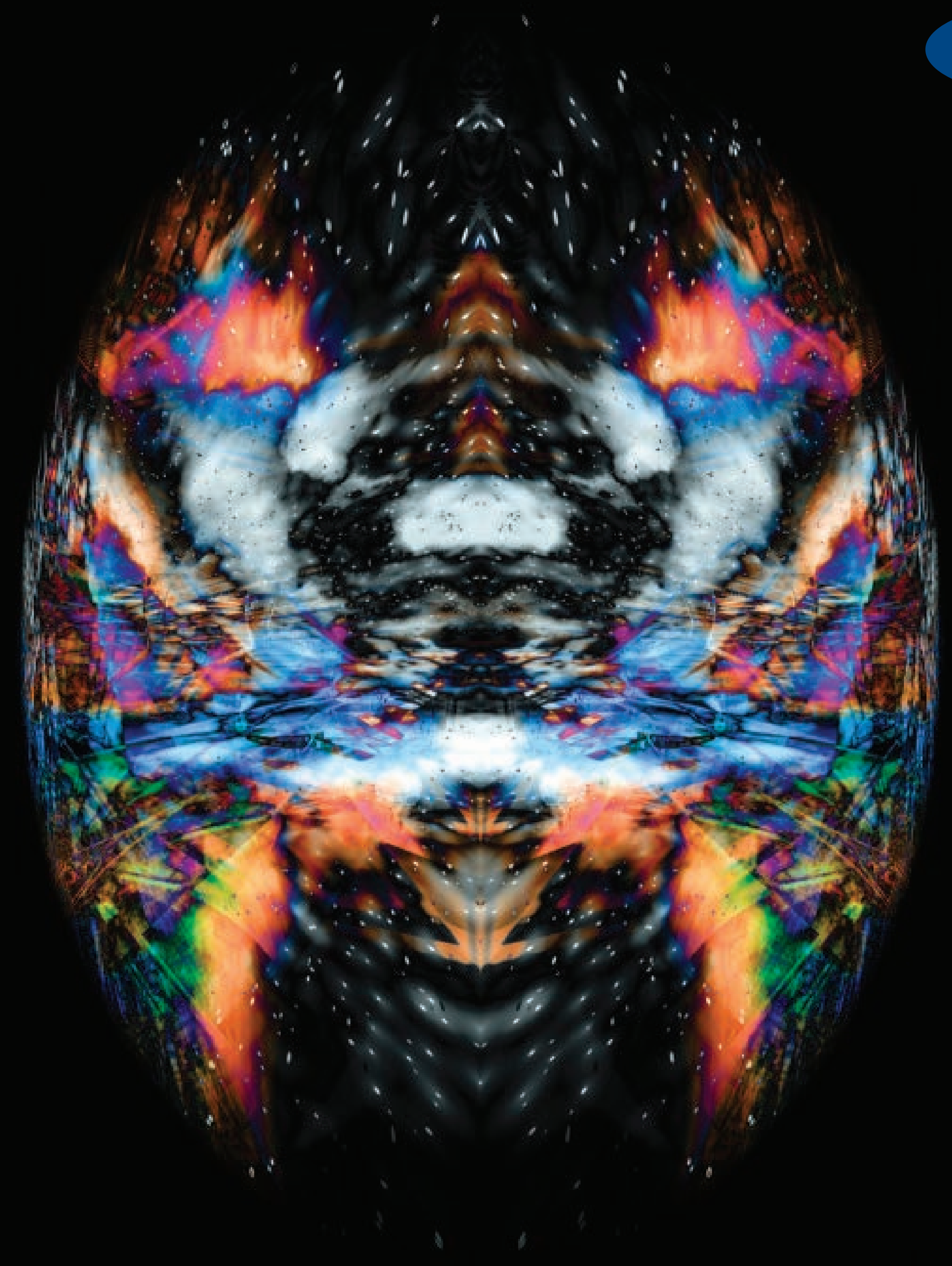

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Greg Skidmore, Jamie Infantalino, Jim Stack, Remcom

Electronically Scanned Arrays for Fast Testing of Large Antennas
L. Durand, L. Duchesne, L.J. Foged, Microwave Vision Group

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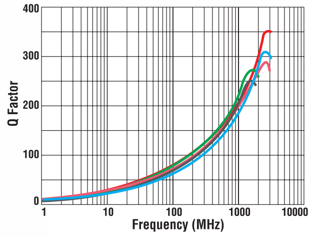

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7	8	9	10 **Webinar:** **Optimizing Battery Operating Time** Agilent Technologies	11	12 **Call for Papers** MILCOM **Deadline**	13
14	15	16	17 **AUVSI Unmanned Systems N. America 2011** Washington DC EMC 2011 **IEEE International Symposium on Electromagnetic Compatibility** Long Beach, CA	18	19	20
21	22	23	24	25	26	27
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FEBRUARY

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Cover Feature

EMI by the Dashboard Light

As the automobile industry bounces back from the great recession, manufacturers are designing their next generation of cars with an eye on fuel economy and telematics (information and communication technologies). Increasingly, the cars being designed today represent the latest frontier in the wireless revolution. While luxury cars have been integrating RF/microwave sensors, navigation and communication systems for several years now, delivering enhanced safety, traffic management and in-car entertainment through car-to-car and car-to-network communication is on the rise in cars of all prices.

At Mobile World Congress last February, chip maker Qualcomm announced a partnership with Audi to develop capability that would provide a "bubble of connectivity" for travelers, allowing them to access web-based services at high speeds of travel. The Audi A8 will feature the Mobile Media Interface Plus in-car navigation system, which will act as a mobile "hotspot," enabling passengers to connect Wi-Fi enabled devices to the Internet.

The satellite navigation system will have Google Earth built-in, providing drivers with high resolution, three-dimensional satellite imagery. Audi has stated that the system, when combined with a street atlas and other online content, can provide real-time route planning, location-specific points of interest or local restaurant reviews, as well as up-to-the-minute traffic information. The system utilizes Qualcomm's UMTS technology to provide the high speed data network that will make it possible for Internet-enabled devices to connect to the web while moving at highway speeds. Audi said the first UMTS-enabled A8s would go on sale later this year.

Ford has also been at the forefront of developing market leading telematics and infotainment services for its vehicles. This wireless connectivity is being driven in part by the challenges of introducing a fleet of electric cars to a market that has evolved around petroleum-fueled vehicles. In March, Ford Motor Co. and AT&T announced their collaboration to wirelessly connect Ford's first all-electric passenger car. Using an embedded AT&T wireless connection and the "MyFord" mobile smartphone app, vehicle owners will be able to send and receive data about their electric car, providing command and control of vehicle settings remotely. This will enable owners to plan trips, monitor the vehicle's state of charge, receive various alerts for vehicle charging, as well as other features designed to support electric vehicle ownership.

Ford also unveiled a new range of specialized car-to-car WiFi networks intended to allow cars to automatically negotiate following distances and lane changes in an effort to avoid potential traffic hazards. According to the automaker, the technology works over a short-range WiFi system on a secure channel allocated by the FCC and allows 360 degree traffic coverage even without direct line of sight. This latest implementation of "collision avoidance radar" includes predicting collision courses with unseen vehicles, seeing sudden stops, and spotting

(continued on page 22)

David Vye
Microwave Journal *Editor*

traffic pattern changes.

With the introduction of wireless systems and the increase in the vehicle electronics, electromagnetic interference (EMI) problems understandably are on the rise. EMI issues range from on-board AM and FM radio interference to catastrophic failure of an engine control module due to power transients. EMI has been considered a potential cause of the recent inexplicable acceleration of certain Toyota models. The problems are expected to get worse as system clock speeds and logic edge rates increase, due to increased EMI emissions and decreased EMI immunity.

Vehicle electrical systems are a rich source of power transients. Seven of the most severe have been characterized and have become a suite of standard EMI test pulses, as described in SAE J1113, "Electromagnetic Susceptibility Procedures for Vehicle Components." These transients include pulses that simulate both normal and abnormal conditions, including inductive load switching, ignition interruption or turnoff, voltage sag during engine starting, and the alternator "load dump" transient.

With vehicles acting as a platform for land mobile radio transmitters, the onboard electronics systems also may be exposed to very high radio frequency (RF) electromagnetic field levels and can even be exposed to high levels from external threats, such as high powered radio stations or airport radar systems that can easily reach 50 ±100 Volts/meter. Since typical failure levels for unprotected electronic systems are in the 1 ±10 Volt/meter range, substantial RF protection must be provided for electronic systems operating in the automotive environment.

Designing the next generation of automotive telematics in such a hostile electrical environment requires engineering tools and techniques that can help identify and mitigate EMI problems. This month's cover feature includes three invited papers from a few leaders in the area of automotive EMI simulation and test systems – ANSYS, CST and ETS-Lindgren. Each author was asked to provide an update on the challenges for integrated wireless systems into the next generation of automobiles and recent changes to their tools that will help address EMI by the dashboard light. ■

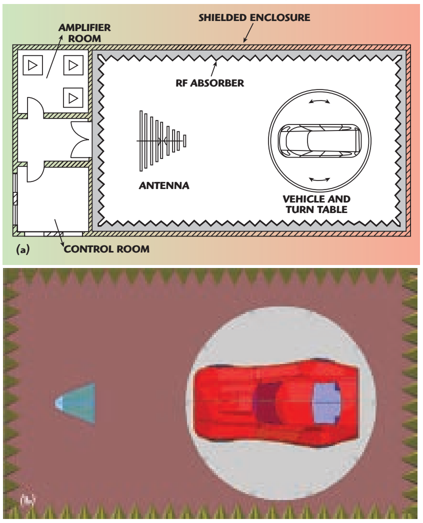
EMI BY THE DASHBOARD LIGHT

AUTOMOTIVE EMI/EMC SIMULATION

The term electromagnetic compatibility (EMC) often conjures up images of FCC test labs, computing and/or wireless devices. However, in the automotive industry, the unintentional creation and reception of electromagnetic fields, a definition of electromagnetic interference (EMI), is becoming an ever greater concern. As automobiles become mobile hotspots and as the electronic content (wireless links, multimedia devices, electronic control modules, electric hybrid drives, etc.) of automobiles continues to increase, the control of and design for EMI and EMC become ever more important.

As a result of this rapid electrification of automobiles, a number of applicable standards have come into existence. One of the earliest of the industry directives was issued in Europe in 1972 as Automotive Directive 72/245/EEC. This directive was created to deal with the electronic spark plug noise. Since that time, the International Standards Organization, the Society of Automotive Engineers, and CISPR have created a variety of standards specifically for the automotive industry.

These standards are designed to ensure that all on-board systems continue to function properly during exposure to EMI or automatically return back to normal operating conditions after exposure or by a manual reset operation. A major concern for automotive EMI engineers is that a car can contain as much as five kilometers of wires. While cabling is an obvious source of EMI in a car, there are a number of other sources, especially in modern cars, which are packed with electronic devices. Lastly, it is important to note that drivers also introduce potential EMI sources in the form of cell phones or smart phones, tablets and other Bluetooth-enabled devices.



▲ *Fig. 1 ISO 11451-2 test setup (a) and HFSS virtual test chamber (b).*

For the above reasons, conventional EMI/EMC procedures and techniques may not be appropriate for these new components and electronic devices. To address this, there are a few automotive standards trying to reduce the probability of EMI occurring in vehicles by making use of one of several laboratory tests. One of the most important of these standards is ISO 11451-2. This standard specifies that the electical performance of all electronic subsystems remains unaffected by electromagnetic disturbances that are generated by a source antenna, radiating the vehicle-under-test inside an anechoic chamber.

The international standard ISO 11451-2 applies to road vehicles and is meant to determine the immunity of private and commercial vehicles to electrical disturbances from off-vehicle radiation sources, regardless of the vehicle propulsion system, including hybrid electric vehicles (HEV). The test procedure prescribes that the test be performed on a full vehicle in an absorber-lined shielded enclosure, which is meant to create a test environment that simulates open field testing. For this test, it is typical that the floor is not covered with absorbing material, but such covering is allowed. An example of a rectangular shielded enclosure is shown in ***Figure 1a***. ***Figure 1b*** shows a virtual test chamber as modeled in a 3D electromagnetic simulation software package (i.e. HFSS™).

Testing for the ISO 11451-2 standard consists of generating radiated electromagnetic fields using a source antenna with radio frequency (RF) sources capable of producing the desired field strengths ranging from 25 V/m to 100 V/m and beyond. The test covers the range of frequencies from 10 kHz up to 18 GHz. During the test, all embedded electronic equipment must perform flawlessly. This flawless performance also applies to the frequency sweep of the source antenna.

Performing the ISO 11451-2 standard test can be a very time consuming process, requiring expensive equipment and access to a very expensive test facility. Hence, numerical simulation can be a cost-effective means to reduce the design cycle of the product as well as its associated R&D costs. Full vehicle Finite Element Method (FEM) simulation has become possible within the past few years by using the domain decomposition method (DDM) that was pioneered by and available within the ANSYS® HFSS product. The DDM process parallelizes the entire simulation domain by creating a number of sub-domains, each of which are solved on different computing cores or various computers connected to a network. While the DDM procedure allows engineers to simulate entire vehicles, recent developments in simulation technology offer a superior approach to solving large electromagnetic structures. The technique is called the hybrid Finite Element Boundary Integral (FE-BI) methodology and has been made available in the ANSYS HFSS product within the last year (featured as a technical article in the January 2011 issue of *Microwave Journal*).

FE-BI is a numerical method that uses an Integral Equation (IE) based solution as a truncation boundary for the FEM problem space. This combination of solution paradigms allows users to dramatically reduce the solution volume that needs to be solved by the FEM method, resulting in a faster and more efficient simulation approach. ***Figure 2*** shows how FE-

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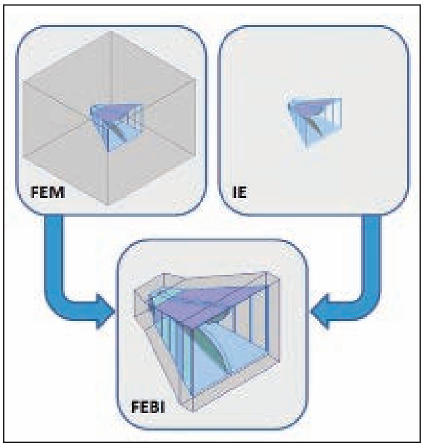
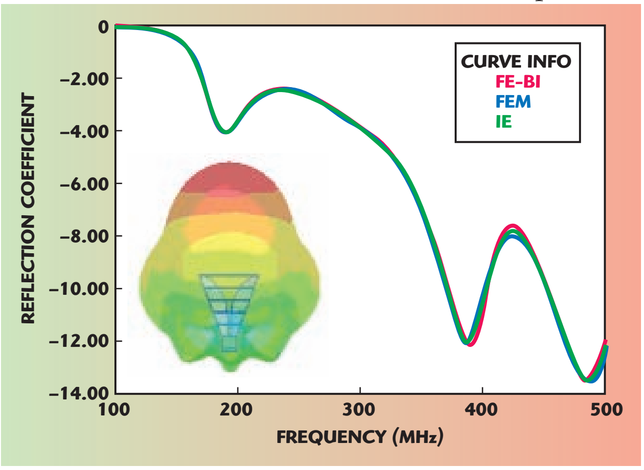


▲ *Fig. 2 Comparison of FEM, IE and FE-BI models.*

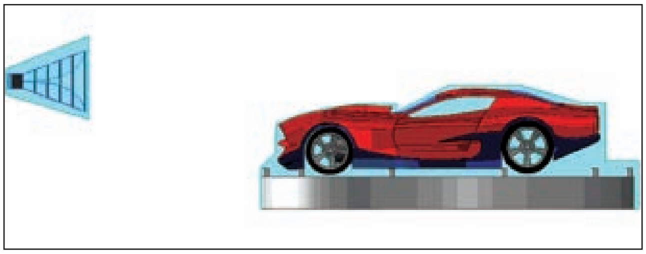
BI can be used to reduce the solution volume required by a simulation. It is important to note that the distance from radiator to FE-BI boundary can be arbitrarily small and is often less than lambda by 10. This reduced solution space then leads to a decrease in the simulation time and reduces the overall computational effort.

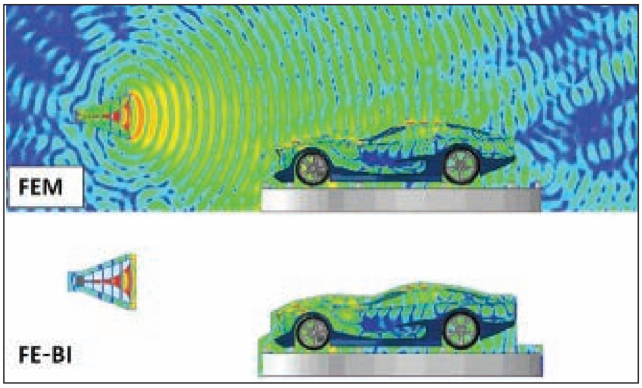
In order to demonstrate the capability of the FE-BI methodology, this article presents a full vehicle simulation using the FE-BI capability applied to the ISO 11451-2 standard to determine the EMI of an electronic subsystem. To prove the accuracy between the traditional and FE-BI methods, a comparison of previously validated far-field behavior is shown in ***Figure 3***. The large air region that comprises the entire test chamber was reduced to two much smaller air boxes, which were very conformal to the structures they contained. The surfaces of the conformal air regions are now extremely close to the antenna and the vehicle. The two sub-domains of the FE-BI models are shown in ***Figure 4***.

The absorber elements of the anechoic chamber were not modeled in this simulation because the IE boundary in FE-BI is equivalent to a free space simulation, which is equivalent to absorbing material used in a physical measurement. This reduction in volume reduces the size of the problem to be solved and thereby leads to a faster simulation. For this simulation, the total computation time was 28 minutes, which represents an 11× reduction in time compared to



▲ *Fig. 3 Comparison of validated far-field behavior using three different methods.*


▲ *Fig. 4 Two sub-regions used to simultaneously solve using FE-BI solver.*



▲ *Fig. 5 Electric field on the surface and cross-section of a vehicle for FEM and FE-BI.*

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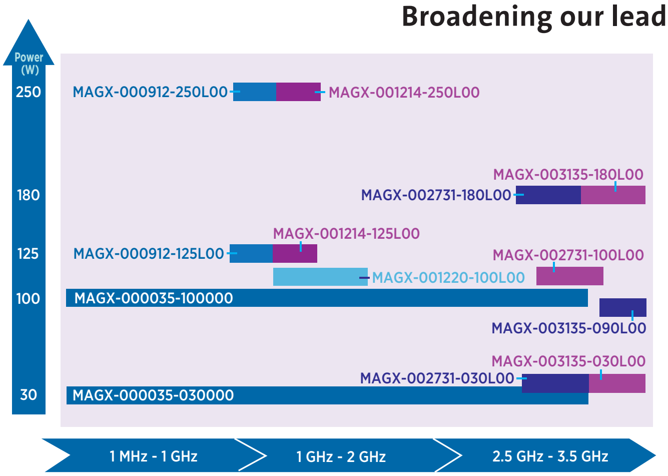

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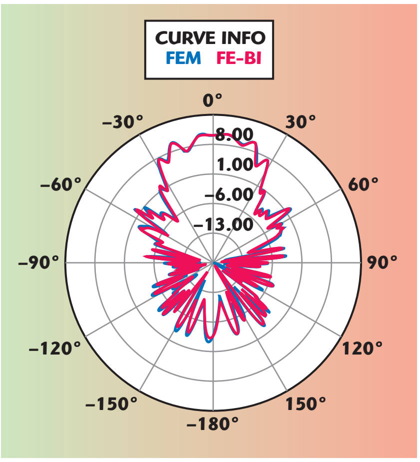
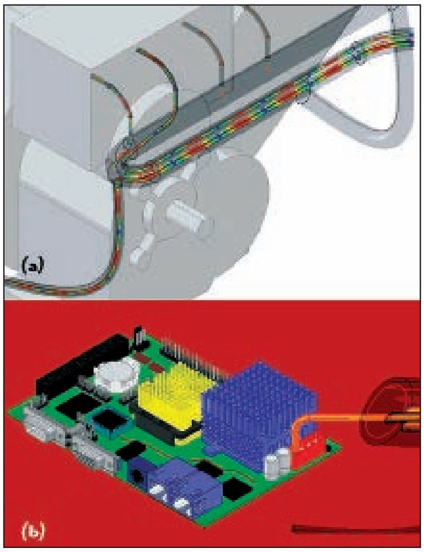


▲ *Fig. 6 Antenna far-field pattern at ϕ = 90° comprising the whole model.*



▲ *Fig. 7 Cable harness showing electric fields in wiring harness (a) and wiring harness attachment to PCB (b).*

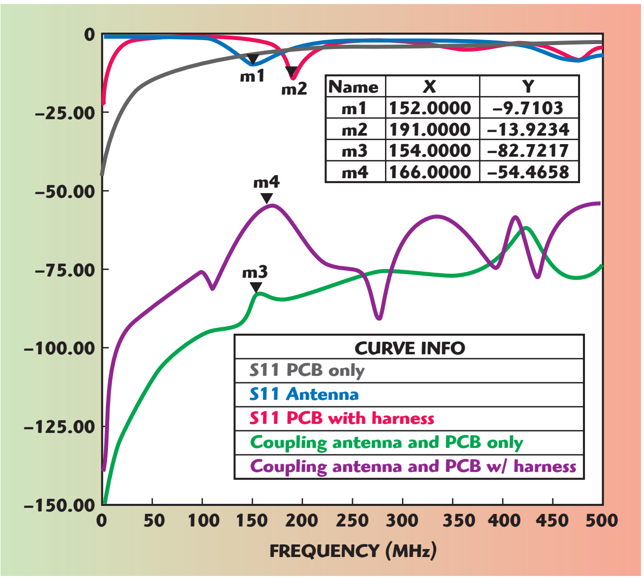
the FEM solution based on the simulation of the entire anechoic chamber. The total amount of RAM for the FE-BI simulation was 6.8 GB and, again, represents an almost 11× decrease in RAM requirements.

For reference, both the FE-BI and traditional FEM results are shown in ***Figures 5*** and ***6***. As is clearly seen, the agreement between the two solution methods is excellent. The accuracy of the results can be observed in Figure 5, where the electric field on the surface of the vehicle and in the cross-section is very similar. Figure 6 shows the total far-field pattern predicted by both FEM and FE-BI of the entire model, which indicates a very good agreement as well.

The same FE-BI approach can also be used to test the immunity of embedded control unit (ECU) modules. In order to demonstrate this capability, a printed circuit board (PCB) that is connected to the engine wiring harness is introduced into the simulation. The transmitted signal travels from a sensor, located at the bottom of the engine, to the PCB via a wiring harness. The wiring harness is routed from the PCB and around the engine as shown in ***Figure 7a***. The sensor is located to the left of the graphic and the PCB is located to the right of the graphic.

The wiring harness end is attached to the red four-way connector shown in ***Figure 7b***. One of the four-way connector pins is soldered to a trace that begins in the top side of the PCB on the connector side and then goes through a via to the bottom side where it is connected to the microcontroller. For simplicity and clarity, only a single on-board diagnostic (OBD) protocol CAN J1913 signal was analyzed.

Because conductors with any given length can act as a radiation source, the wiring harness plays a vital role in EMI. To better understand the effect of the wiring harness, two simulations were performed.



▲ *Fig. 8 S-matrix with the PCB alone and PCB connected to wire harness.*

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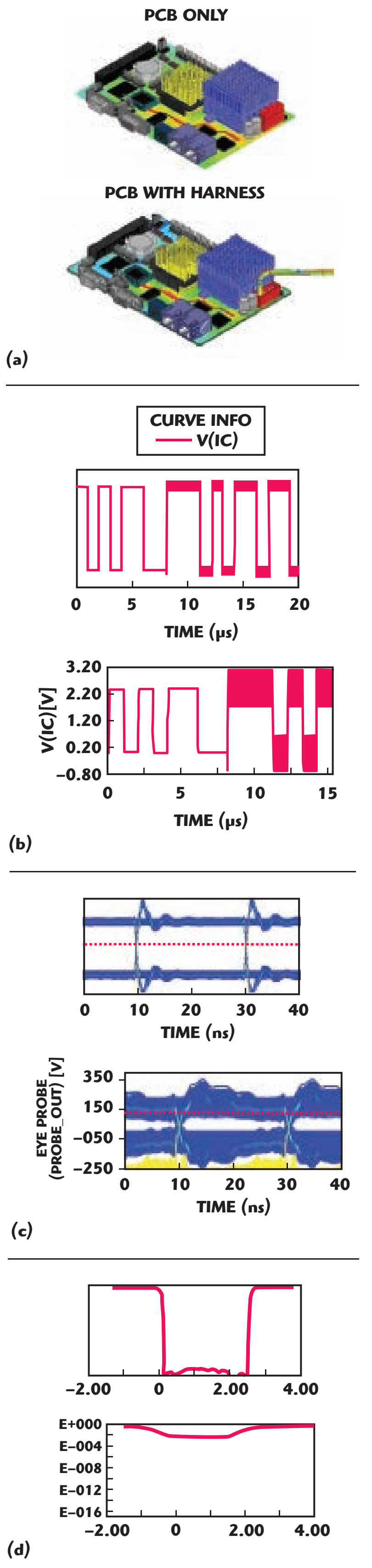
The first simulation contains all the above mentioned geometry as well as the car and source antenna. ***Figure 8*** shows the results of the first simulation of the electric field based on a configuration of three wiring harness cables. For the second simulation the wiring harness is removed and, the random CAN J1939 signal is applied directly into the connector on the PCB instead of at the sensor location at the bottom of the engine. The electromagnetic fields as well as the scattering parameter of the two simulations (with and without wiring harness) are easily calculated using the FE-BI solver and are plotted in Figure 8.

It is possible to observe a resonance on the PCB when it is connected to the wiring harness. The frequency of this resonance is a function of the cable length that is attached to the PCB. Additionally it is seen that the coupling between source antenna



▲ *Fig. 9 Compilation of results of both methods.*

and PCB is increased when the cable harness is attached to the PCB. In this case, the wire harness increases the coupling between source antenna and PCB by over 30 dB between 152 and 191 MHz.

For further analysis, the electromagnetic model was dynamically linked to a circuit solver in order to simulate the CAN J1939 signal in the wiring harness and PCB. This allows engineers to seamlessly combine the frequency domain field results with time-based signals using the circuit simulator. This combination of field solver and circuit simulator makes it possible to specify all the various signals that excite the antenna and the wiring harness. For these simulations, the antenna excitation was set to a constant 150 V sinusoidal signal, with a delay of 8 μs, and a frequency sweep varying from 10 to 500 MHz. The initial time delay was set in order to clearly see the effect of the EMI on the transmitted signal. The CAN J1939 signal is generated at the sensor end of the harness for the first simulation, and injected directly at the connector (no wire harness present) for the second simulation. ***Figure 9*** is a compilation of results for both simulations. The electric field plot distribution on the surface of the PCB substrate and at the cable is observed in Figure 9a.

The transient signal received by the microcontroller is detailed in Figure 9b. In this figure it is possible to observe the EMI from the source antenna that occurs after 8 μs. The interference is most pronounced when the PCB is connected to the harness. This is in clear agreement with the previous S-Matrix frequency response results. Figure 9c shows the eye diagram of the received signal at the microprocessor. Lastly, the bathtub diagram for the signal being received at the microcontroller for both simulations is shown in Figure 9d. As is clearly seen, the bathtub curve is greatly affected by the EMI source having a final bit error rate of 1E-2. This implies that one bit out of every 200 will be incorrectly interpreted by the microcontroller. This simulation indicates that the overall sensor system performance is going to be greatly affected by any incoming radiation at a near band that goes from 152 to 191 MHz.

With the introduction of electromagnetic numerical techniques such as HFSS FE-BI with an order of magnitude improvement in simulation speed and reduction in computational effort, simulation of a full vehicle according to automotive EMC standards is feasible. It is therefore, now possible for EMI/EMC engineers to begin to simulate entire vehicles and their subsystems in virtual anechoic chambers according to accepted EMC and EMI standards. Using simulations will also allow for accurate "what if" analysis and help engineers to determine potential EMI issues caused by driver or passenger introduced EMI/EMC sources (cell phones, Bluetooth devices, etc.). It will also allow engineers to begin to understand transient noise issues caused by the myriad of motors that are part of every vehicle. ■

EMI BY THE DASHBOARD LIGHT

3D EMC/EMI SIMULATION OF AUTOMOTIVE MULTIMEDIA SYSTEMS

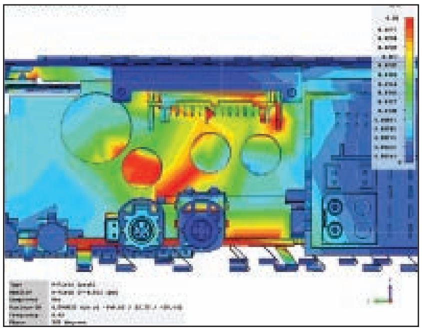
A key challenge in automotive product design is the compliance to electromagnetic compatibility (EMC) and interference (EMI) requirements in a cost-driven project environment. Traditionally, EMC and EMI issues are solved in the EMC lab, often without getting a full understanding of the underlying effects. The adoption of 3D field simulation provides an insight into the root causes of electromagnetic resonance effects occurring in the product, enabling fast design cycles and high product quality.

The most sensitive electronic device from a customer point of view is the car radio. Any internal or external noise sources lead to unwanted disturbances. The automotive OEM's spend a considerable amount of time and money to avoid such effects or reduce them to a minimum. Without special filtering, a significant disturbance signal in GSM D-net can be measured between 890 and 940 MHz.

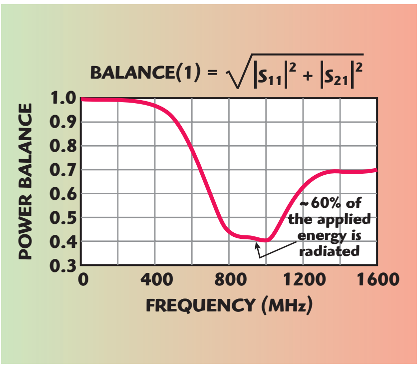
This article shows an example of using 3D EM simulation with CST Microwave Studio for solving a GSM immunity issue. After setting up a model with the relevant electrical and mechanical components, a combination of several effects that introduce disturbances to the system has been found. The system could then be optimized within a few days by simulating the whole device architecture, leading to a reliable and cost-effective solution.

These signals also propagate to the loudspeaker lines. The GSM pulse (217 Hz) from a GSM mobile phone is demodulated in the audio amplifier. In the car, the GSM pulse can be heard clearly, which is not acceptable for the customer.

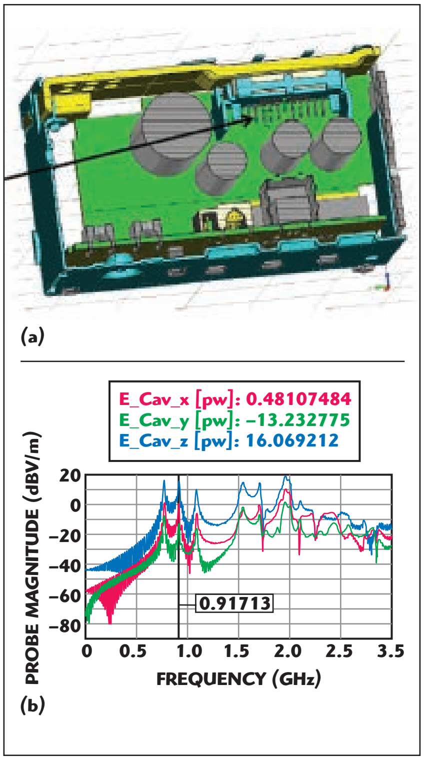
In order to investigate these effects and to come up with corresponding techniques, the device is simulated with 3D simulation software. The CAD model (e.g. from CATIA) is imported and the material properties of the different parts are adjusted for 3D field calculation. As a first step, the bare electronic device (car radio) is illuminated with a plane wave in the frequency range of interest.



▲ *Fig. 1 3D magnetic field plot at 920 MHz inside the radio enclosure.*



▲ *Fig. 2 Power balance plot for aluminum cooling bracket.*



▲ *Fig. 3 EM wave propagation direction (a) and E-field magnitude vs. frequency for the amplifier region (b).*

Figure 1 shows a 3D magnetic field plot at 920 MHz inside the radio enclosure. The red color highlights areas with high magnetic field strength; the blue color indicates regions with small or zero magnetic field strength. Shown by the red regions in Figure 1, there is a resonance effect in the metallic enclose. Now the real work begins for EMC engineers: Why does this resonance occur at all?

Experience tells us that the resonance effect might come from the audio amplifier surround with its aluminum cooling bracket. There is a resonance cavity, created by the amplifier holder, the electrolyte capacitors, the PCB structure and the cooling bracket (made of aluminum).

As a first step, it is interesting to check what happens if the aluminum cooling bracket is fed with a wideband signal and how much energy is lost due to emission effects. This can be easily done by investigating the power balance, i.e. the relation of applied power and the power that is coupled out through all ports in the system. If the power balance is equal to 1, all the energy is kept in the system and there is no emission effect. If the power balance is smaller than 1, there is radiation of EM fields by the structure. In case of the aluminum cooling bracket, there is actually an imbalance of power in frequency range above 200 MHz. A maximum of about 60 percent of the applied energy is radiated in frequency range between 800 MHz and 1 GHz as shown in ***Figure 2***.

Since one weakness of the system is known, one can concentrate on this in more detail. All parts that are not relevant for the further investigations can be removed from the model to increase simulation speed. Some probes are placed into the amplifier region in

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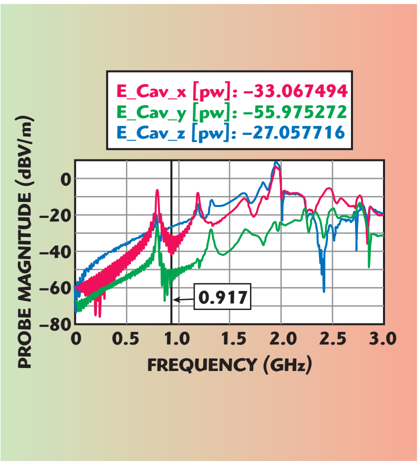
order to calculate the electric field in the cavity. The structure is illuminated with an electromagnetic plane wave again as shown in ***Figure 3a***.

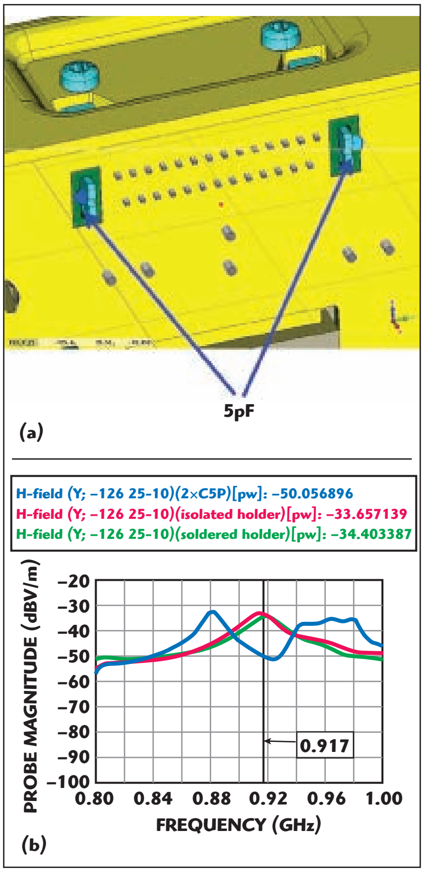
There is a strong resonance at 917 MHz for all three geometrical E-field components x, y and z as shown in ***Figure 3b***. What is causing the resonance at 917 MHz? Maybe the electrolyte capacitors?

One can try it again, removing them in a second simulation. The results are shown in ***Figure 4***. There is no resonance anymore at 917 MHz for all three geometrical E-field components so this is an improvement. This information is quite helpful in order to tune the resonance cavity. Instead of crimping the amplifier holder directly to the PCB (and to the PCB GND structure), the idea is to connect the holder by means of 5 pF capacitors to PCB GND as shown in ***Figure 5a***.

As an effect, the capacitance between the crimp pad and PCB GND reduces the impedance between the housing and PCB GND around 900 MHz and reduces the quality of the cavity as shown in ***Figure 5b***. There is no resonance effect left. That had not been possible by isolating or soldering the holder to PCB GND. The effect



▲ *Fig. 4 E-field magnitude vs. frequency without electrolyte capacitors.*



▲ *Fig. 5 Location of capacitors added to PCB GND (a) and E-field magnitude vs. frequency plot (b).*

can be also seen in the 3D field plot at 920 MHz, shown in ***Figure 6***.

Removing the audio input filter capacitors from the floor of the cavity reduced the coupling from the mobile phone to the car radio tremendously. The basic idea of soldering the amplifier holder to the PCB GND system by means of a 5 pF capacitor could be verified by a series of simulations. Final measurements of the loudspeaker spectrum proved the simulation results to be correct. The loudspeaker spectrum of the original system is shown in ***Figure 7a*** compared to the loudspeaker spectrum after performing the changes shown in ***Figure 7b***.

In summary, there were several problems that led to the EMC problems in the car radio:

- Aluminum cooling bracket and amplifier holder act as 900 MHz broadband antenna
- The space between audio amplifier/holder, cooling bracket, and electrolyte capacitors of the power supply act as resonance cavity at 917 MHz and amplifies the disturber
- Contact of housing-GND to PCB-GND has an impact on the cavity resonance quality and frequency
- Capacitors placed in the resonance cavity pick up the disturber and feed it to the amplifier

It is important to note that only a deep understanding of all of these effects helped the engineers find a solution because every effect took part in the EMC problem. Without accurate simulation, it had not been possible to optimize the system. ■

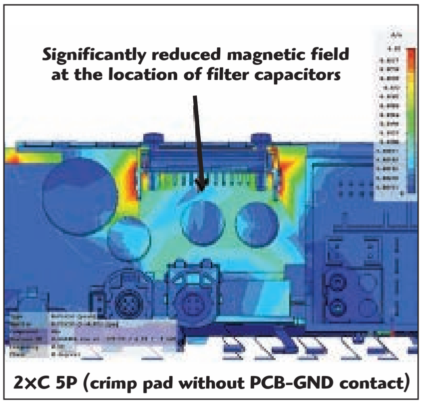


Fig. 6 3D magnetic field plot at 920 MHz inside the radio enclosure after improvements.

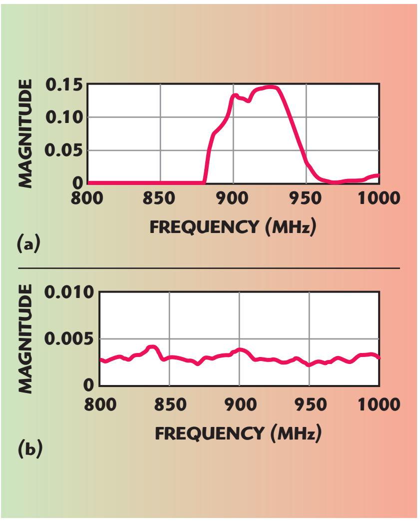


Fig. 7 The loudspeaker spectrum before changes (a) and after improvements (b).

EMI BY THE DASHBOARD LIGHT

An Update on Automotive EMC Testing

Electronic components are increasingly critical in the safety and functional features of automotive vehicles. Moreover, the world is also increasingly connected through electromagnetic communications. Electromagnetic compatibility (EMC) of various electronic parts internal to automobiles as well as compatibility to the environment that they operate in are becoming more challenging to designers in automotive industries. EMC testing at both full vehicle and component levels serves as one of the critical links to the overall integrity and functional verification of automotive vehicle designs. This article provides an overview of the recent trends in the industry and EMC testing requirements.

INTRODUCTION

Starting from the mid-1990s, electronic components had already outweighed their mechanical counterparts in the overall content of a vehicle. This trend continues and there is no reason that it will stop. "Today's cars are 4-wheel vehicles with dozens of computer systems," summarized Professor Todd Hubing of Clemson University at the 2011 Asia Pacific EMC (APEMC) Symposium. "Tomorrow's cars will be computer systems with 4 wheels," he added.[1] Owing to the extensive design and testing efforts by the auto industries, today's cars are safer than ever, but there is also room for further improvements.

A sharp increase of fossil fuel burning cars in the recent years has stressed the world's limited supply of fossil fuels. Sparked by the rising cost of fossil fuels, green vehicles and related technological developments are increasingly desired. Hybrid and electric vehicles are strongly incentivized by governments and welcomed by consumers around the world. One of the most common approaches to increasing the energy efficiency is to recover kinetic energy and to convert it into electric energy to store in batteries. The stored energy can then be converted to kinetic energy on demand. Throughout the process, a series AC/DC, DC/DC, and DC/AC conversions will be required. To enhance the efficiency in the conversions, faster switching time is desired. However, abrupt switching during the conversions will generate harmonic components that might emit unintentional electromagnetic energy through interface wires and/or through radiations. These may generate internal and external EMC problems in a vehicle design. Additional design effort and verification testing are required to ensure optimum balance is achieved.

On the other hand, vehicles with advanced safety features and intelligent cars are in demand by consumers. These additional safety and operational features are most commonly achieved through the use of electronic systems installed in the vehicle. EMC challenges for the critical safety and operational functions are also new topics to designers in the auto industries.

Facing the increased complexity of the automotive EMC challenges, both system and component designers of automotive vehicles are relying more and more on both signal integrity planning on the PCB and module levels to reduce the risk level of EMC issues, and on testing for final verifications. Although EMC testing is not the final solution of the automotive EMC problems, it serves as an early warning system to detect system design EMC problems, and provides a means to simulate post-accident problems to aid the development of solutions. Therefore, EMC testing also plays an increasingly important role in automotive system developments.

AUTO EMC TESTING REQUIREMENTS UPDATES

Automotive EMC testing requirements can be separated into two distinctive categories, full vehicle or component levels. The full vehicle testing requirements are most commonly practiced by major automakers, while the component level testing

TABLE I

AUTOMOTIVE EMC TEST STANDARDS

Standard Bodies		Applied Testing			
		Vehicle	Comp.	EMI	EMS
ISO	ISO-11451	Yes	No	No	Yes
	ISO-11452	Yes	Yes	No	Yes
	ISO-7637	No	Yes	No	Yes
	ISO-10605	Yes	Yes	No	Yes
CISPR	CISPR 12	Yes	Yes	Yes	No
	CISPR 25	Yes	Yes	Yes	No
EC	95/94/EC	Yes	Yes	Yes	Yes
	ECE R.10.3	Yes	No	Yes	Yes
IEC	61000/3/4/6	Yes	Yes	Yes	Yes
SAE	J551	Yes	No	Yes	Yes
SAE	J1113	No	Yes	Yes	Yes
GM	GMW 3091	Yes	No	Yes	Yes
	GMW 3097	No	Yes	Yes	Yes
	GMW 3103	No	Yes	Yes	Yes

requirements are applied primarily by suppliers of electronic parts contracted by the automakers. Most automotive testing requirements are defined and issued by regional organizations, i.e. European Union (EC) and American (SAE), international (CISPR, IEC and ISO), and manufacturers (GM, Ford, VW, etc.). More detailed illustrations of these EMC test standards and their recent development can be found in articles and symposium digests by Wiles[2] and Shin.[3]

Among the standards shown in ***Table 1***, recent development activities have focused on automatic EMC testing in the ISO, CISPR, and IEC standard bodies more than the other regional bodies. These standard bodies are focused on EMC issues on electric vehicles and/or fossil fuel electric hybrid vehicles. The ISO-series of test standards are focused on the immunity issues while the CISPR-series test standards are focused on the emission limits on these vehicles at charging modes. Also noted is that the European communities are faster in developing test standards address-

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SPDT (R)	0.02–3.0	0.40	23.0	43	30	AS179-92LF
SPDT (R)	0.02–6.0	0.35	24.0	50	30 (0.5 dB)	SKY13351-378LF
SPDT (R)	0.10–2.5	0.55	17.0	56	37	AS193-73LF
SPDT (A)	0.50–6.0	0.6–1.0	27–24	52	37	SKY13348-374LF
SPDT (A)	0.50–6.0	0.7–1.15	31–24	55	39	SKY13370-374LF
SP3T (R)	0.02–6.0	0.60	25.0	50	29	SKY13317-373LF
SP3T (R)	0.10–3.5	0.5–0.6	39–25	57	33	SKY13385-460LF
SP4T (R)	0.02–6.0	0.60	26.0	51	30	SKY13322-375LF
DPDT (R)	LF–6.0	0.95	22.0	60	34	SKY13318-321LF
DPDT (R)	0.10–6.0	0.60	23.5	55	33	SKY13355-374LF
DPDT (R)	0.10–6.0	0.60	22.0	62	37	SKY13381-374LF

Smart Energy, Broadband, Cellular Infrastructure, Test & Measurement, Military (COTS)

Description	Frequency (GHz)	Insertion Loss (dB)	Isolation (dB)	Input IP3 (dBm)	Input $P_{1\,dB}$ (dBm)	Part Number
SPDT (R)	0.0003–2.5	0.3–0.4	25–24	48	30	AS169-73LF
SPDT (R)	0.1–2.5	0.3–0.55	30–17	56	37 (0.1 dB)	SKY13270-92LF
SPDT (A)	0.1–6.0	0.8–1.5	62–42	46	30	SKY13286-359LF
SPDT (R)	3.0–8.0	0.7–0.9	25–22	47	26	SKY13298-360LF
SP3T (A)	0.5–2.5	0.9–1.2	62–55	43	30	SKY13277-355LF
SP4T (A)	0.5–3.0	0.4–0.9	45–25	40	26	AS204-80LF

DBS/LNB 4 x 2 Matrix Switch

Description	Frequency (GHz)	Insertion Loss (dB)	Isolation (dB)	Input $P_{1\,dB}$ (dBm)	Part Number
LNB/DBS (A)	0.25–2.15	7.5–8.5	40–31	15	SKY13272-340LF

UHF/VHF (48–1000 MHz)

Description	Insertion Loss f = 48 MHz (dB)	Isolation f = 48 MHz (dB)	Input $P_{1\,dB}$ f = 48 MHz (dBm)	Insertion Loss f = 1 GHz (dB)	Isolation f = 1 GHz (dB)	Input $P_{1\,dB}$ f = 1 GHz (dBm)	Part Number
SPDT (R)	0.15	56	29	0.3	25	34	AS179-92LF
SPDT (R)	0.2	55	28	0.35	24	30 (0.5 dB)	SKY13351-378LF
SPDT (R)	0.3	42	38.5 (0.1 dB)	0.4	29	38.5 (0.1 dB)	SKY13299-321LF
SPDT (R)	0.3	44	39.8 (0.8 dB)	0.45	23	40.5 (0.1 dB)	SKY13290-313LF
SP3T (R)	0.3	49	26	0.45	27	29	SKY13317-373LF
SP4T (R)	0.3	49	26	0.6	28	30	SKY13322-375LF
SP4T (R)	0.3	54	41	0.45	24	38 (0.1 dB)	SKY14151-350LF

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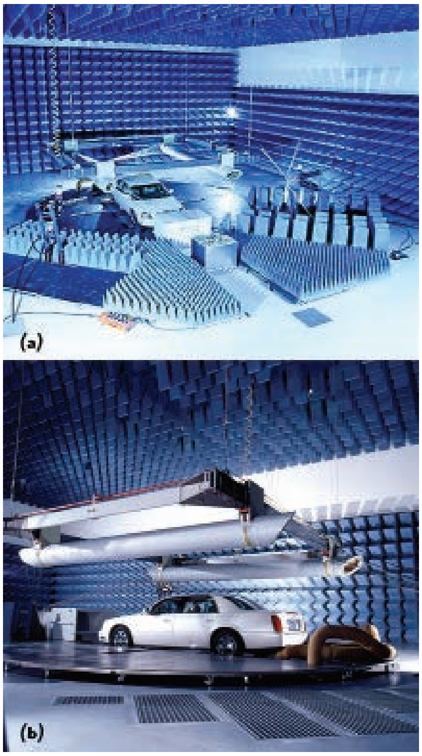
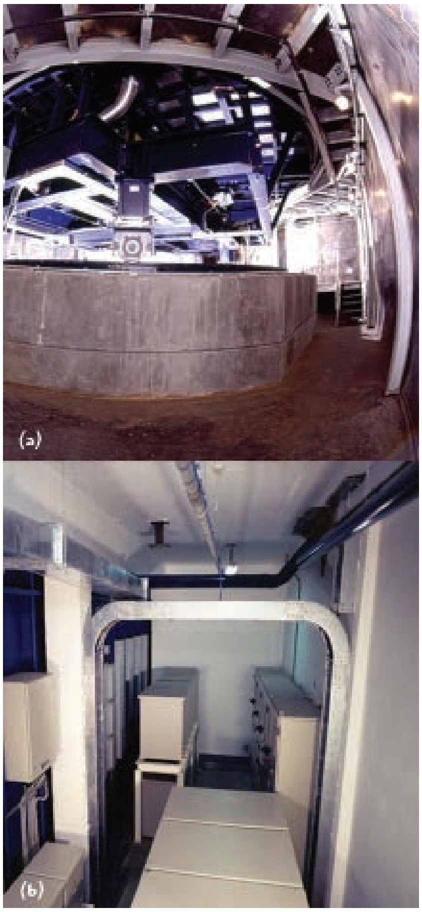


▲ *Fig. 1 One of four General Motors' Milford full vehicle EMC test chambers. (Image courtesy of ETS-Lindgren.)*

ing the advent of the EMC problems presented by the electric vehicles and by their operating environment.

AUTOMOTIVE EMC TEST FACILITIES

Full vehicle EMC test facilities are normally built by major automakers and government agencies around the world. ***Figure 1*** shows one of the General Motors' full vehicle EMC test chambers with most of the vehicle electromagnetic immunity test setups released. The EC directive and some manufacturers' internal standards also require that the vehicle's Electromagnetic Immunity (Susceptibility, EMS) be tested at simulated motion speed(s) and at braking mode. This will require that the full vehicle EMC test chamber be equipped with a chassis dynamometer turntable. As shown in ***Figure 2***, the chassis dynamometer and its driving system will add to a substantial amount of complexity of the overall facility construction. In addition, to accommodate the required EMC testing on electrical and/or hybrid vehicles, the charging station and its interfaces to vehicle at charging mode will be needed to complete the full vehicle test capability. The full vehicle test chambers and its test instrumentation



▲ *Fig. 2 Chassis dynamometer turntable (a) and its support filtered AC/DC power system (b). (Image courtesy of ETS-Lindgren.)*

are most frequently used for EMS testing, especially the safety features of the vehicles at most known test conditions. Therefore, efficiency in test setups for EMS test is often the most critical utilization factors of the test facility.

The component test chambers are also often called Absorber Lined Shielded Enclosures (ALSE) and a detailed definition of ALSE dimensions and absorber treatment requirements can also be found in the references.[4,5,6] To incorporate the EMC test capability on the electric motor/generator module of the electric/hybrid vehicle, a shielded drive shaft will be needed to provide the drive/load simulation for testing the EMC of the control unit in the motor generator module. The shielded shaft must be designed to transfer and withstand the maximum torque output by the electric motor through ALSE

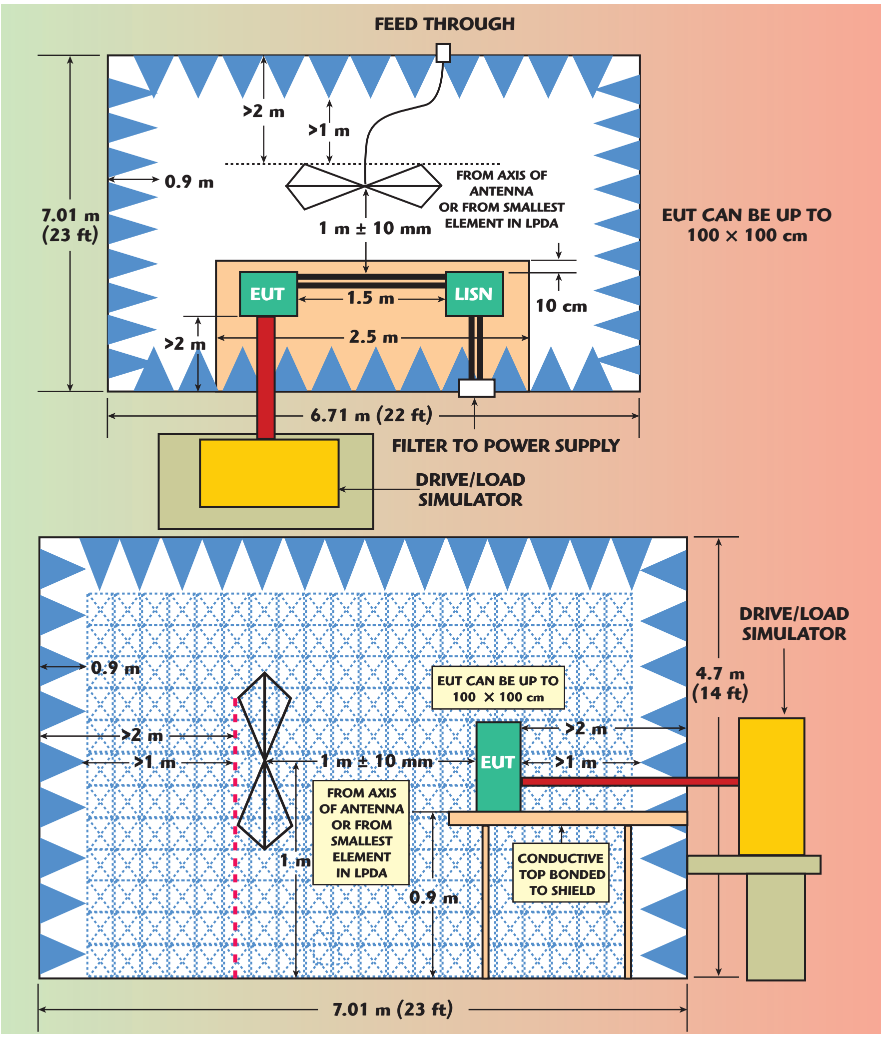
As shown in ***Figure 3***, the ALSE room is generally setup for near-field test distance at 1 m separation between the antenna and the EUT interface cables.

The ALSE specifications for the absorber treatment only start at 80 MHz and above. The specification assumes that the near-field coupling dominates the overall energy transfer between the test antenna and the test object in the frequency range below 80 MHz. However, a simple electric field dipole coupling model analysis presented by Liu[7] shows a different result. ***Figure 4a*** presents the ratio of the total amount of transferred energy to the energy from the radiating component of two electrically small dipoles at 1 m separation distance. As presented, the near-field coupling overwhelmingly dominates the energy transfer for test frequencies below 20 MHz (greater than 10 dB). Above 200 MHz, the radiating far-field component dominates the energy ratio (by more than 10 dB since the ratio shows <-10 dB). To examine the transition frequency range between 20 and 200 MHz, a ratio of reactive energy to the radiating components demonstrates an alternating variation of radiating energy in this frequency range with a peak at 50 MHz. Again, at above 100 MHz, the near-field coupling diminishes to an insignificant amount.

Figure 4 (a and b) illustrates the importance of good ALSE boundary conditions in the overall measurement uncertainty component EMC testing in an ALSE in the frequency range of 20 to 200 MHz. Since most of the electric inverters and converters for electric and/or hybrid vehicles operate in lower MHz frequency range, a good ALSE room that provides good termination conditions of the shielded wall can be very important for improving the measurement uncertainty and the repeatability of the test results. Thus, an ALSE treated with ferrite tile-based hybrid absorbers can be a preferred choice for automotive component test chambers, especially for testing such vehicles' components between 20 to 80 MHz.

In addition to ALSE and anechoic chambers, reverberation chambers have also been introduced for automotive EMC testing. The reverberation chambers, test method has been adopted into SAE J1113-27 and the IEC 61000-4-21:2011. The most common use of reverberation chambers is for radiated immunity testing because the reverberation chambers are capable of generating high field intensity level requiring much lower amplifier

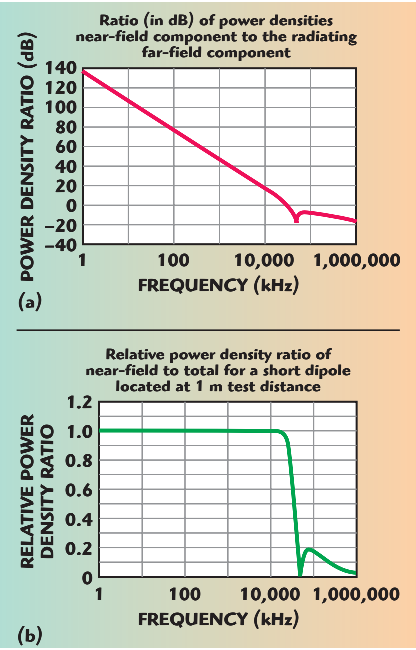
power than that of free space test setup. A well-built reverberation chamber is capable of generating >25 V/m using just 1 W of drive power at the antenna port at prior to EUT loading. Large test volume of up to 8 percent total space of the chamber can also be achieved through the introduction of one or more stirrers. ***Figure 5*** shows typical configuration of automotive EMC testing utilizing reverberation methods for both component and full vehicle radiated immunity testing. Typical constructions of reverberation chambers are for testing frequencies above 80 MHz to be efficient in both cost and building space utilization.



▲ *Fig. 3 Simplified component level ALSE test chamber with drive/load simulator interface.*

CONCLUSION

Widespread use of computer and energy conversion systems present new EMC challenges in modern car



▲ *Fig. 4 Total electric field vs. tangential and radial components.*

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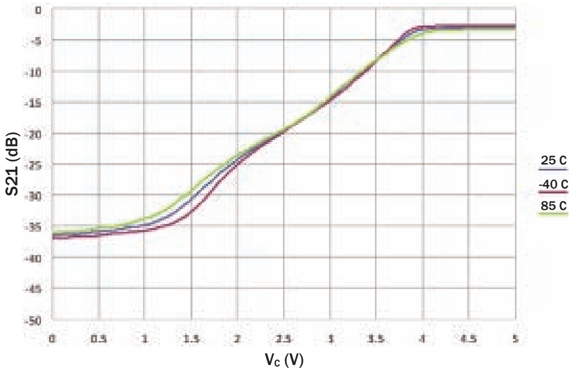
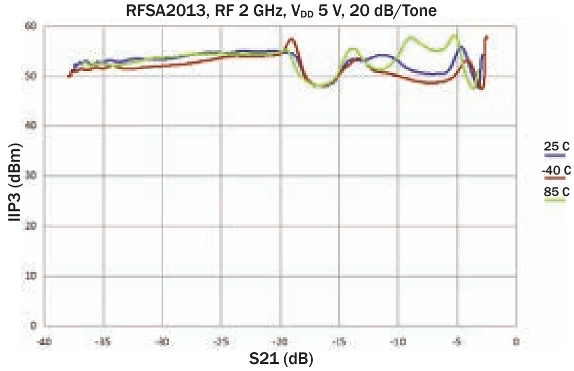
  - 3.3V for RFSA2023
- Linear in dB control characteristic
- Internal temperature compensation
- Class 1C ESD (1000V)
- Complete solution in small 3 x 3mm QFN package
- Applications include: cellular, 3G infrastructure; WiBro, WiMAX, LTE; microwave radio; high-linearity power control

Insertion Loss vs V_C
RFSA2013, RF 2 GHz, V_{DD} 5 V



Input IP3 vx Attenuation
RFSA2013, RF 2 GHz, V_{DD} 5 V, 20 dB/Tone



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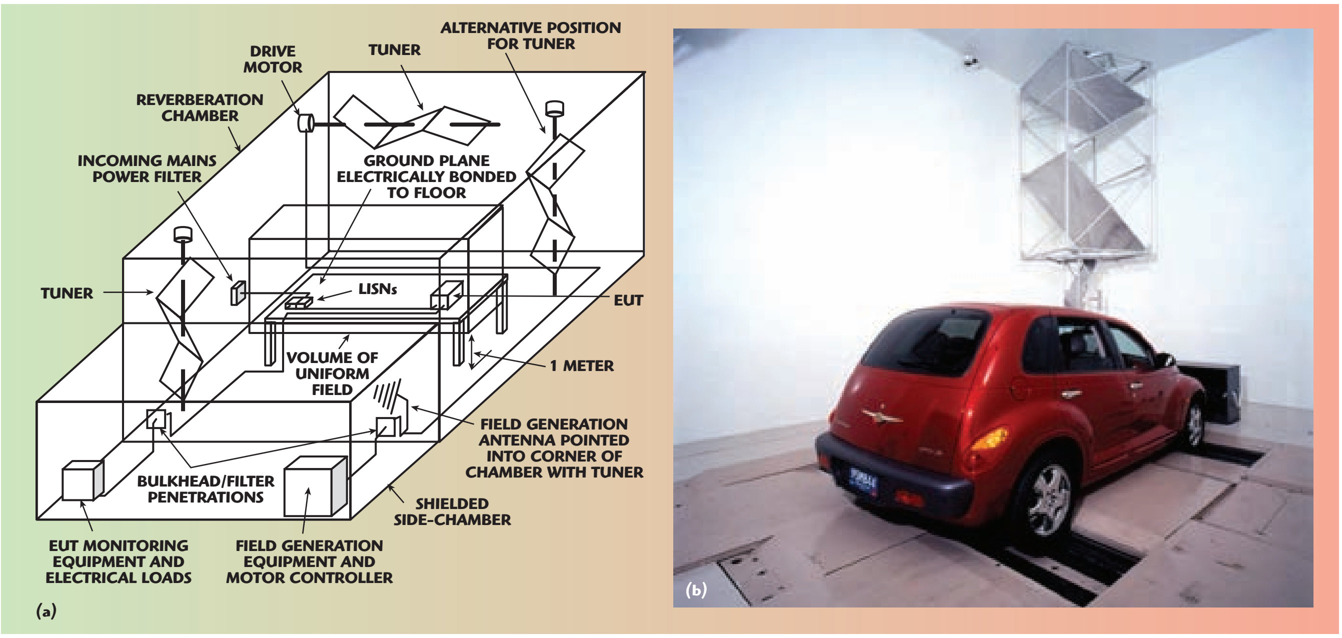

▲ *Fig. 5 Component (a) and full vehicle reverb test chambers (b). (Image courtesy of ETS-Lindgren.)*

design. An efficient EMC test facility can provide fast-track design validation for faster completion of both component and full vehicle integrity. Just as traffic laws cannot avoid auto accidents, EMC design planning and testing cannot totally eliminate the automotive EMC problems as the electronic systems in the car get more and more complex. However, we can minimize automotive system malfunctions due to EMC problems through our design and testing efforts. Having said that, it does not mean that the cars we drive are not safe because of EMC issues. On the contrary, cars are much safer and much more fuel efficient than before due to the introduction of electronic control systems. Our efforts in automotive EMC are to aid the speedier introduction of more sophisticated computer systems to the car for further improvement in the safety and efficiency of the future vehicles. ■

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70 kHz to 110 GHz VNA Redefines Market

Anritsu Co. has developed the ME7838A broadband vector network analyzer (VNA) system that provides single-sweep coverage from 70 kHz to 110 GHz with operation from 40 kHz to 125 GHz, and utilizes an advanced design that eliminates the need for large, heavy millimeter-wave (mmWave) modules and coax combiners. The ME7838A provides engineers, designers and researchers with a system that conducts highly accurate and efficient broadband device characterization of active and passive microwave/mmWave devices, including those designed into emerging 60 GHz wireless personal area networks (WPAN), 40 Gbps and higher optical networks, 77 and 94 GHz automotive radar, digital radio links, 94 GHz imaging mmWave radar, and Ka-band satellite communications.

The ME7838A is also well suited for conducting signal integrity measurements on emerging high speed designs, such as 28 Gbps serializer/deserializer (SerDes) transceivers used on servers, routers and other networking, computing and storage products. The ME7838A, equipped with the 3743A mmWave module, can accurately measure 28 Gbps SerDes transceivers at the higher frequencies required for proper analysis.

PERFORMANCE

Among the many advantages of the ME7838A is improved RF performance, due to an industry first, real-time power leveling control that provides the industry-leading power accuracy and stability to power levels as low as -55 dBm in the millimeter-wave band. The approach employed in the ME7838A takes less time, is less tedious, and more accurate than the conventional method of adjusting power level in the millimeter band through the use of electronically controlled mechanical attenuators and power linearity correction tables. The VectorStar® broadband system provides an accurate and fast real-time method to sweep power for compression measurements. The result is that the ME7838A performs highly accurate gain compression measurements of high frequency active devices.

With the ME7838A design, mmWave modules can be mounted close to or directly on the wafer probe. The ME7838A offers the widest dynamic range in its class, 107 dB at 110 GHz and 92 dB

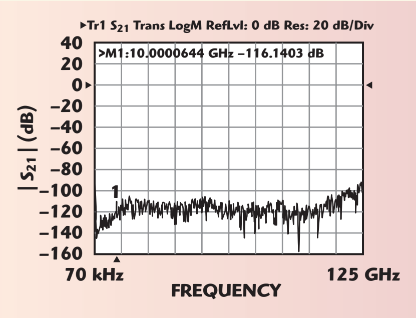
ANRITSU CO.
Morgan Hill, CA

TABLE I

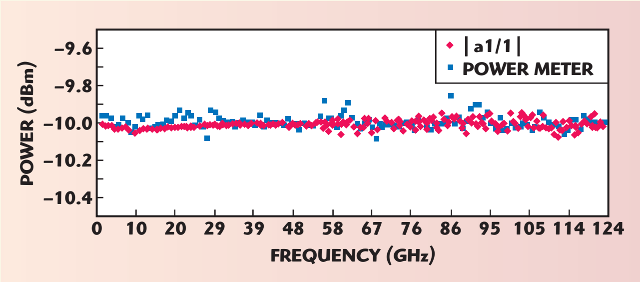
DYNAMIC RANGE AND NOISE FLOOR PERFORMANCE VERSUS FREQUENCY

Frequency Range	System Dynamic Range (dB)		Receiver Dynamic Range (dB)		Noise Floor (dBm)	
	ME7838A	ME7838A Option 062	ME7838A	ME7838A Option 062	ME7838A	ME7838A Option 062
70-300 kHz	93	90	89	86	-83	-80
0.3-2 MHz	103	100	103	102	-93	-90
2-10 MHz	115	112	115	114	-105	-102
0.01-2.5 GHz	120	117	121	122	-110	-109
2.5-24 GHz	110	105	121	121	-110	-108
24-54 GHz	110	107	124	123	-114	-113
54-60 GHz	108	108	122	122	-112	-112
60-67 GHz	108	108	117	117	-107	-107
67-80 GHz	108	108	120	120	-110	-110
80-85 GHz	107	107	123	123	-113	-113
85-90 GHz	107	107	121	121	-111	-111
90-105 GHz	107	107	117	117	-107	-107
105-110 GHz	107	107	122	122	-112	-112
110-120 GHz*	98	98	115	115	-110	-110
120-125 GHz*	92	92	112	112	-107	-107

* 110-125 GHz frequency range is available as operational



▲ *Fig. 1 Dynamic range of ME7838A system at the W1 1 mm coaxial test port.*



▲ *Fig. 2 Power accuracy comparison of power meter and ME7838A a1 receiver.*

at 125 GHz. ***Table 1*** shows the ME7838A performance over frequency.

The ME7838A is the first broadband VNA to provide good raw directivity throughout the entire frequency range, due to its innovative design and elimination of the MUX combiners used in traditional systems. Best-in-class raw performance allows the ME7838A to offer engineers and designers improved calibration and consistent measurement stability of 0.1 dB magnitude and 0.5° phase across the entire 70 kHz to 110 GHz frequency range over a 24-hour period. Measurement speed is 55 ms for 201 points at 10 kHz IF bandwidth, 10 times faster than comparable broadband VNA systems.

The design of the ME7838A provides users with configuration advantages, as well. Its use of smaller, lighter RF and mmWave modules reduces the need for large bulky positioners that add expense. The modules are also more cost-efficient, and free bench space that can be used for other probes and devices necessary for wafer measurements. The 3743A millimeter-wave module weighs less than 0.27 kg and is 21.5 × 54 × 55.3 mm in size (total outer dimensions).

MEASUREMENT EXAMPLES

Figure 1 shows the dynamic range of ME7838A system at the W1 1 mm coaxial test port from 70 kHz to 125 GHz, demonstrating the high dynamic range of the VNA over the entire frequency range.

Figure 2 shows an example of power accuracy, power sensor measurement using thermal and waveguide sensors versus the ME7838A a1 reference receiver also over the entire frequency range.

In addition to characterizing high frequency devices for communications designs, the overall performance of the ME7838A makes it well suited for many other applications. It is an excellent tool for analyzing devices used in spectroscopy-based homeland security systems, as well as radio astronomy. The ME7838A is a highly accurate tool for passive device designers in need of broadband coverage, such as connector and test fixture designers.

The ME7838A broadband VNA provides single-sweep coverage from 70 kHz to 110 GHz with operation from 40 kHz to 125 GHz and introduces real-time power leveling control that provides the industry-leading power accuracy and stability to power levels as low as -55 dBm. The ME7838 provides high performance for many applications from RF to microwave to mmWave and high speed electronics.

VENDORVIEW

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THE 60 GHZ RADIO MARKET AND TECHNOLOGY

The ever-increasing demand for high capacity data communication, in particular last mile communication, is asking serious questions of operators and the technology they employ. Radio bands allocated for data communication have restrictions and are, with few exceptions, subject to a national license. These licenses are in high demand, expensive and their attainment can often require a lot of paperwork and be subject to bureaucracy.

License-free bands, such as the 2.4 and 5 GHz bands, see WLAN (IEEE 802.11 a/b/g/n) and PAN (Bluetooth) competing for the allocated bandwidth and neither Quality of Service (QoS) nor security can be guaranteed in this congested environment. All parties are on the same frequency band and are relying on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). Many applications demand communication links to have a combination of high speed and security, while also being license-free and inexpensive with instant set up. All of this cannot be achieved via traditional wireless license exempt bands.

LICENSE-FREE V-BAND

There is a band that is just coming on stream that can meet all of these requirements – namely the worldwide license-free V-band at 60 GHz. Radios operating in this 60 GHz band have unique characteristics that make them significantly different from radios operating in the traditional 2.4 and 5 GHz license free bands. These qualities give 60 GHz millimeter-wave band radios operational advantages not found in other wireless systems.

This article provides an overview of these advantages and argues why 60 GHz millimeter-wave radio technology presents the optimal opportunity, which translates into reliable and affordable gigabit-plus wireless connections. The main advantages are:

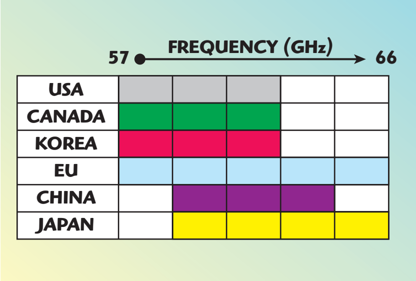
- Spectral availability to achieve gigabit-plus data rates
- High transmit power for solid signal strength and range
- Worldwide availability and acceptance
- License exempt operation
- Narrow beamwidth and oxygen absorption for interference immunity and highly secure operation.

SHANNON'S LAW

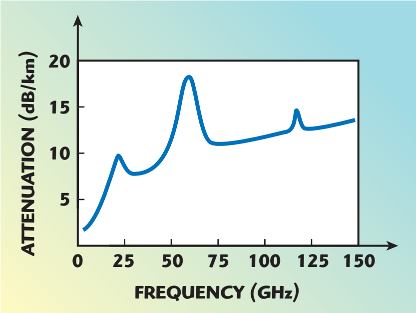
Large bandwidth coupled to high transmit power equals high data rates. Sufficient spec-

HANS O JOHANSSON
Sivers IMA, Kista, Sweden

trum has been allocated in the 60 GHz band to make multi-gigabit wireless links possible. In the US, the Federal Communications Commission (FCC)



▲ *Fig. 1 The 60 GHz frequency allocation in various countries/regions worldwide.*



▲ *Fig. 2 Attenuation behavior for 60 GHz signals.*

set aside a block of 7 GHz of license exempt spectrum between 57 and 64 GHz. The majority of the globe has done the same at varying points between 57 and 66 GHz.

Partly because of oxygen's absorption characteristics at 60 GHz, various regulators across Asia, Europe and the Americas allow for 10s to 100s of Watts of Equivalent Isotropic Radiated Power (EIRP) for wireless transmissions in this band. The wide bandwidth and high transmit power facilitate multi-gigabit wireless transmissions.

Shannon's Law states that the maximum possible data rate is given by:

Shannon Capacity = (Channel Bandwidth) [log(Power/Noise)]. Put simply, the maximum possible data rate increases with increasing channel bandwidth and effective transmit power. So, the 60 GHz band is capable of achieving 80 times the maximum possible data rate of the 802.11a/b/g/n MAC layer.

WORLDWIDE AVAILABILITY

As previously stated, the majority of the globe has allocated 7 GHz of continuous unlicensed spectrum at varying points between 57 and 66 GHz. ***Figure 1*** shows the 60 GHz frequency allocation in various countries/regions worldwide. Within these points, the countries have 5 GHz of continuous spectrum in common. Therefore, products that operate in this frequency will not encounter regulatory problems from country to country.

A major factor, which has commercial ramifications, is that the spectrum is unlicensed. Therefore, 60 GHz links can be deployed without expensive permits, paperwork, public notices or license fees. This makes it easier for companies to launch worldwide products requiring minimal homologation. All of these factors allow companies to maintain operational efficiencies while delivering high performance wireless products.

INTERFERENCE-FREE AND SECURE

Let's consider the technology – oxygen attenuates 60 GHz signals that travel over large distances, meaning that oxygen absorbs radio emissions – a property that is unique to the 60 GHz spectrum. This absorption weakens the 60 GHz signals over distance, so that signals cannot travel far beyond their intended recipient. While this limits distances that they can cover, it also offers interference and security advantages when compared to other wireless technologies.

Another consequence of oxygen absorption is that radiation from one particular 60 GHz radio link is quickly reduced to a level that will not interfere with other 60 GHz links operating in the vicinity. This reduction offers the opportunity for more 60 GHz radio enabled devices to successfully operate within one location.

FREQUENCY RE-USE

The particular attenuation behavior for 60 GHz signals (shown in ***Figure 2***) can thus be used to define a primary usable range for the link in question. Of course, this range varies with the hardware parameters – EIRP, bandwidth, noise figure, modulation and acceptable QoS.

Beyond this range lies a zone that can be visualized as a spatial guard band. In this zone, the emitted power

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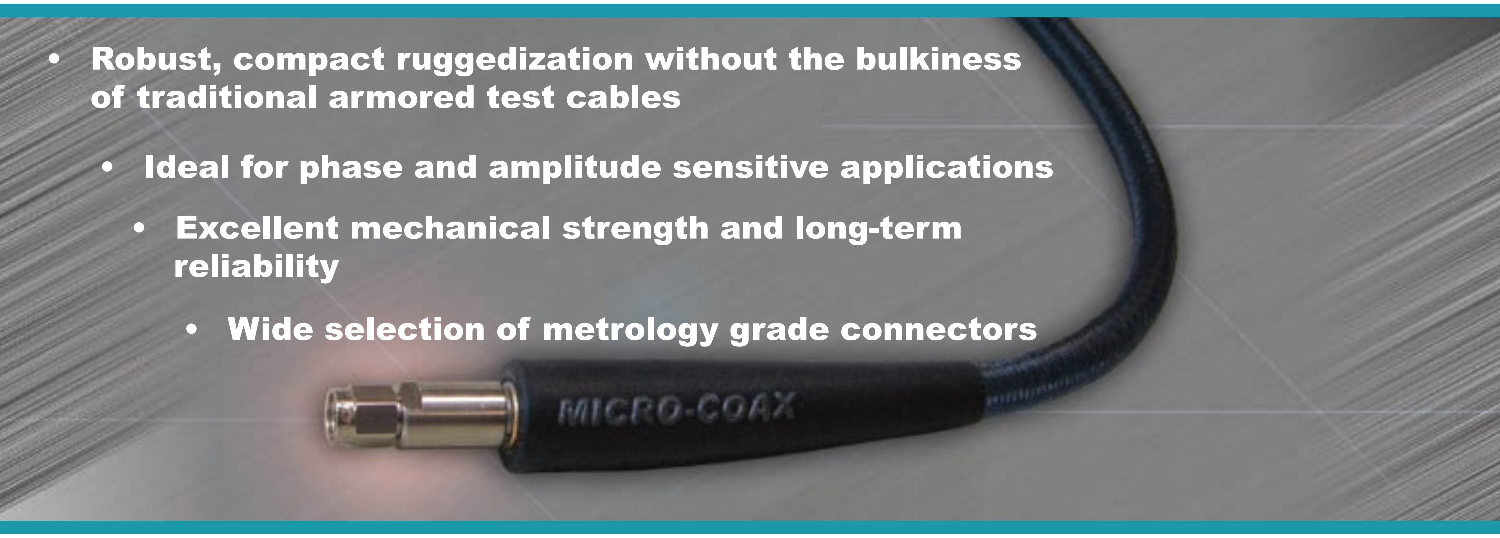

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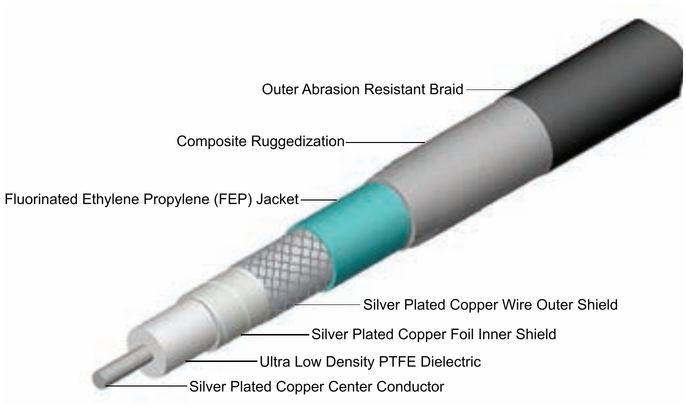
Insertion Loss (dB/ft)		
1 GHz	0.11	0.09
5 GHz	0.23	0.20
10 GHz	0.33	0.28
18 GHz	0.45	0.38
26.5 GHz	0.55	0.47
40 GHz	0.68	—



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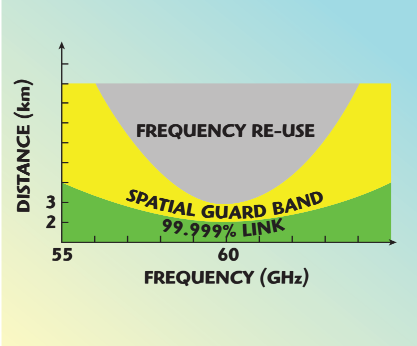

Fig. 3 Illustration of frequency re-use and the spatial guard band.

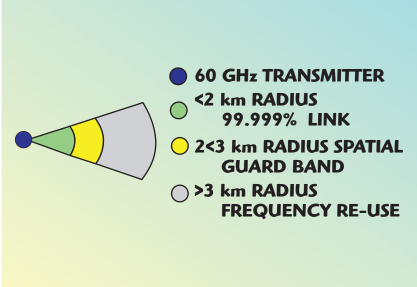

Fig. 4 Frequency re-use.

from a transmitter gradually falls off to a level where the received signal level no longer yields an acceptable QoS. As the distance is increased, the received signal will fall below the level for interference criteria, and as distance is further increased, the signal will virtually disappear below the noise floor.

Depending on how the system is configured, a safe operating range for frequency re-use can be calculated. This is efficient from a frequency allocation perspective and is especially useful for dense high capacity links.

The most efficient frequency re-use can be expected exactly where the atmospheric attenuation peaks and is concentrated in a fairly narrow band around 60 GHz. This is depicted in ***Figures 3*** and ***4***, with typical figures for moderate data transfer rates.

The high antenna gains that are typical for 60 GHz systems come, in part, from the Friis Equation for Path Loss. This equation, also known as Friis' Law, states that the gain possible from an antenna of any given size increases by the frequency squared.

60 GHZ MARKET OPPORTUNITY

The market for 60 GHz products is not readily defined and is only being populated with products from a handful of players. However, the market can be divided into three segments; Wireless Gigabit (WiGig) is an indoor-embedded high capacity technology for household components like consumer electronics, handheld devices and PCs.

The distance will be around 10 m, with speeds in the gigabit range; RF communication outdoors at high speed using highly directive antennas means that distances of up to several kilometers can be bridged; finally, other applications utilize a variety of user interfaces like video, telemetry, data, and radio.

The 60 GHz technique for outdoor communication is not in reach for all R&D departments of potential customers. But, there are many vendors of Wi-Fi products who would have a strong desire to get into the 60 GHz band and be able to offer a more complete license-free band product.

CONCLUSION

The 60 GHz band is a good choice for wireless applications requiring gigabit-data rates, especially considering the large bandwidth and high transmit power. Out of all the available wireless technologies, millimeter-wave brings the world closer to the promise of gigabit and multi-gigabit wireless speeds at the longer range required for bandwidth intensive applications. ■

Hans O Johansson *has been in the data communication business for 30 years and in wireless communication since 1996. He founded and ran GlobalCast Internetworking AB, which was the first to establish a public high speed wireless data network in Sweden. The company was sold to Telia, in 1998, forming Telia GlobalCast Internetworking AB, with Johansson as the company's president. In 2000, Johansson left Telia GlobalCast and founded Wireless Matrix AB to exploit the wireless networks on a European and worldwide basis and the introduction WiMAX in Europe. Since 2005, he has worked with a market leader in mobile communication with multiplexers and base station TMAs and is now acting as product manager of mm-wave products for Sivers IMA AB, Kista, Sweden.*

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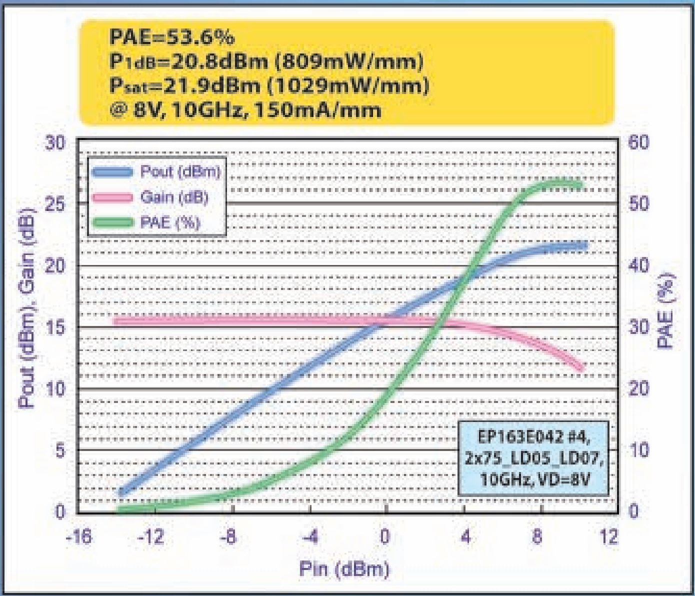

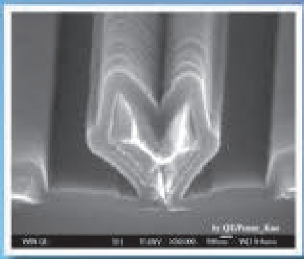

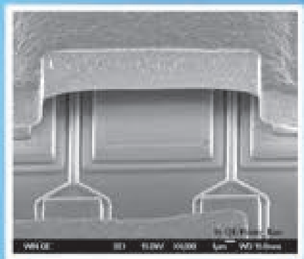

Comparison Table for 0.1µm, 0.15µm, 0.25µm and 0.5µm pHEMT

	PP10	PP15	PP25-21	PP50-11
Vto (V)	-0.9	-1.2	-1.2	-1.4
Idss (mA/mm)	450	500	345	350
Idmax (mA/mm)	720	650	460	480
GM (mS/mm)	750	495	380	310
VDG (V)	9	10	19.2	20
ft (GHz)	130	85	65~72	32
Fmax (GHz)	175	180	160	85
P1dB (mW/mm)	533.25 (3.5V)	670 (5V)	809 (8V)	587 (8V)
Psat (mW/mm)	764.3 (3.5V)	820 (5V)	1029 (8V)	851 (8V)
Gain (dB)	14.35	18.1	15.6	15.5
PAE (%)	53.57	55	53.6	53.5
Frequency	29 GHz	10 GHz	10 GHz	10 GHz

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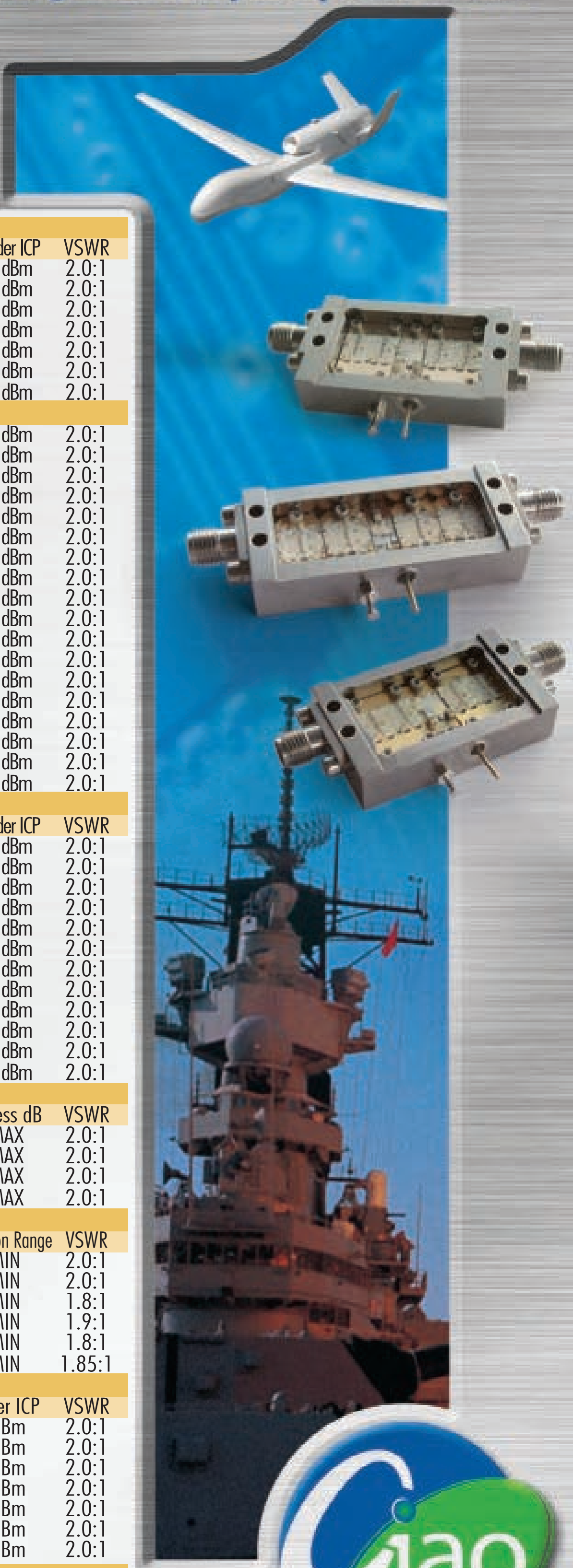

OCTAVE BAND LOW NOISE AMPLIFIERS

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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Northrop Grumman Receives Authorization from US Air Force to Begin Work on Defense Weather Satellite System

Northrop Grumman Corp. has received authorization and funding to proceed on a Department of Defense weather satellite system projected for launch in 2018. The Defense Weather Satellite System (DWSS) will leverage the accomplishments and momentum of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program. The company announced it received authorization from the US Air Force Space and Missile Systems Center (SMC) at Los Angeles Air Force Base, CA, to transition work from the NPOESS contract and proceed under the DWSS program. DWSS will provide enhanced weather information critical to battlefield operations, and deliver it more quickly to the warfighter than current systems.

"For DWSS, we have defined an effective program plan that leverages the high level of maturity achieved on the spacecraft and sensors that are already in production, and we continually work closely with the Air Force to pursue efficiencies throughout the program," said Linnie Haynesworth, Vice President and DWSS Program Director for Northrop Grumman Aerospace Systems. "Our team is prepared to immediately execute a successful and affordable program to bring this critical capability to the warfighter."

"Our team is prepared to immediately execute a successful and affordable program to bring this critical capability to the warfighter."

The DWSS is a critical successor to the Defense Meteorological Satellite Program (DMSP), which has been delivering weather data for military use since the mid-1960s. Timely completion of DWSS is essential to maintain continuity with the current DMSP satellites and establish a backup in the event of a launch or satellite failure on orbit for the remaining two DMSP satellites. Time-sensitive weather data delivered promptly is critical to military operations planning and warfighter and weapons deployment.

The DWSS is required to provide reliable, high-fidelity, near real time information about weather and environmental conditions around the world to inform aviation, naval, and coastal marine operations and land assets. DWSS will also provide information needed to protect space-based assets from solar and other space weather conditions.

Lockheed Martin Submits Proposal for Joint Air-to-Ground Missile

Lockheed Martin announced it submitted a proposal in response to the government's Request for Proposal for the next phases of the Joint Air-to-Ground Missile (JAGM) program. "Lockheed Martin's JAGM builds on HELLFIRE, LONGBOW and Javelin, three of the most trusted precision-guided weapons on the battlefield today," said Frank St. John, Vice President of Tactical Missiles at Lockheed Martin Missiles and Fire Control. "Our JAGM offering will provide US Army, Navy and Marine Corps warfighters with the next product in that line, an affordable weapon that will offer the decisive edge in combat."

The US Army Aviation and Missile Command issued the RFP for Engineering and Manufacturing and Low-Rate Initial Production for the JAGM program on April 13, with a submittal deadline of June 6. "Our proposed JAGM weapon system can provide significant performance advantages to help save warfighter lives," St. John said. "And with hot, high volume production lines already in place for HELLFIRE, Javelin and the M299 launcher family, we can provide a critically needed capability at an affordable price and with best value over program life."

"Our proposed JAGM weapon system can provide significant performance advantages to help save warfighter lives..."

Lockheed Martin is partnered with some of the industry's leading suppliers on the JAGM program. Aerojet, a GenCorp company, will provide the JAGM rocket motor for all six threshold JAGM platforms. GenCorp is headquartered in Sacramento, CA, with production facilities in Camden, AR. Marvin Engineering, headquartered in Inglewood, CA, will provide launchers for all six threshold platforms. General Dynamics Ordnance and Tactical Systems, a business unit of General Dynamics, will provide the multi-purpose warhead with significant HELLFIRE commonality. GD-OTS is headquartered in Saint Petersburg, FL, with production in Niceville, FL. Work on the JAGM program will be performed in Orlando and Ocala, FL, and Troy, AL, as well at suppliers' facilities across the US Contract award is expected during fourth quarter 2011.

Advanced Firefinder Radar System Supporting US Troops

ThalesRaytheonSystems announced that advanced Firefinder radars have been fielded in theater supporting and protecting US troops and allies. Reliability and maintainability improvements have been added to the AN/TPQ-37 Firefinder Weapon Locating Radar sys-

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tem that supports an extended service life with reduced life-cycle costs. Currently fielded in Iraq, upgraded Firefinders are scheduled to be deployed into Afghanistan in the coming months.

ThalesRaytheonSystems, in conjunction with Tobyhanna Army Depot, is delivering modernized radars that include a new modular, air-cooled transmitter; a new Operations Control shelter; and a new common radar processor applied across the US Army's entire fleet of AN/TPQ-37 Firefinder systems. It is known as the Reliability Maintainability Improvement (RMI) program. Forty percent of deliveries are complete with final delivery scheduled in 2013.

"These RMI systems can be deployed with confidence for effective operations in challenging environmental conditions," said Kim Kerry, Chief Executive Officer, ThalesRaytheonSystems, US Operations. "The Firefinder modernization provides the US Army and allies around the world with the capabilities needed for detection and troop protection."

Firefinders are precise detection and location systems designed to find enemy artillery, mortar and rocket firing positions. The radar also predicts impact zones and transmits data to friendly forces, allowing time for effective counter-fire tactics. Nearly 400 Firefinders are deployed by 18 nations worldwide. Sized for easy transport, they are prized for their accuracy, mobility, reliability and low life-cycle costs. Along with its Improved Sentinel Battlefield Air Defense Radar (AN/MPQ-64F1) and the AN/TPQ-36 Firefinder Weapon Locating Radar, ThalesRaytheonSystems' radar capabilities are currently unmatched by prototypes and other unproven technologies too costly and cumbersome to meet 21st century battlefield requirements.

Raytheon Receives Contract to Produce Additional APG-79 AESA Radars

Raytheon Co. has received a contract from Boeing for the second procurement in the four-year Multi-Year III program to produce and deliver APG-79 active electronically scanned array radars for F/A-18 Super Hornet tactical aircraft. The APG-79 AESA radar hardware has a 10 to 15 times greater reliability, compared to mechanically scanned array radars. This reliability and easy maintainability makes AESA radars more affordable over the service life of the unit.

"In addition to lower failure and maintenance rates, APG-79 AESA radars provide the US Navy leading-edge technology for situational awareness," said Eric Ditmars, Raytheon's F/A-18 Program Director, Tactical Airborne Systems. "The long-range capability allows aircrews more time to process, share and assess information."

This procurement contract is for the production of 42 APG-79 AESA radars and will be completed at Raytheon facilities in El Segundo, CA; Andover, MA; Forest, MI; and Dallas, TX.


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Richard Mumford, International Editor

EU Funds Action on the Development of Graphene

The use of graphene-based electronic devices for RF and microwave applications has become high profile and the subject of cutting edge research, various aspects of which were outlined at the 2011 IEEE MTT-S IMS in June. Recognising the importance of the material, the European Commission is funding a coordinated action on graphene to develop plans for a 10-year, €1,000 M Future and Emerging Technology (FET) flagship.

"…exploiting the full potential of graphene will have huge impacts on society…"

The research effort of individual European research groups pioneered graphene science and technology, but a coordinated European level approach is needed to secure a major role for EU in this ongoing technological revolution. The graphene flagship aims to bring together a large, focused, interdisciplinary European research community, acting as a sustainable incubator of new branches of ICT applications, ensuring that European industries will have a major role in this radical technology shift over the next 10 years. An effective transfer of knowledge and technology to industries will enable product development and production.

The graphene flagship already includes more than 130 research groups, representing 80 academic and industrial partners in 21 European countries. The coordinated action is lead by a consortium of nine partners who pioneered graphene research, innovation and networking activities. It is being headed by Chalmers University of Technology, Sweden.

"We are convinced that exploiting the full potential of graphene will have huge impacts on society at large, and thrilled that the EU Commission shares our view and believes in our focused and open approach to moving forward," said Professor Jari Kinaret of Chalmers University of Technology.

Europe Prepares for October Launch of Galileo

The launch date for the first two satellites of Europe's Galileo global navigation satellite system will be 20 October 2011. This will be the first of a series of Galileo satellite launches by Arianespace from Europe's Spaceport in French Guyana. The announcement follows a detailed review, under the chairmanship of Jean-Jacques Dordain, the Director General of the European Space Agency (ESA), with the participation of Arianespace and industrial prime contractors, which concluded that the space and ground elements will be ready for a launch in October.

"The October launch will be a perfect example of European and international cooperation."

The Galileo programme is Europe's initiative for a state-of-the-art global satellite navigation system, providing a highly accurate, guaranteed global positioning service under civil control. The first two Galileo satellites will be deployed using a Soyuz launcher and the launch will mark the inaugural Soyuz flight from its new launch facilities in French Guyana.

Emphasising the significance of the launch, Dordain said, "The October launch will be a perfect example of European and international cooperation. On one side we will have the first operational Galileo satellites in orbit, resulting from the cooperation between the European Union and ESA. On the other side, this is the first launch of Soyuz from French Guyana, a programme made possible through the cooperation between ESA and Russia."

"Arianespace is both proud and honoured to be contributing to this innovative project, reflecting the innovative technologies that are constantly being developed in Europe for the benefit of all citizens," said Jean-Yves Le Gall, Chairman and CEO of Arianespace.

Cassidian Delivers Telecommunications Harmonisation for French Military

Cassidian has delivered the third phase of the Réseaux de Desserte Terre et Marine (RDTM) project as the military base in Toulon, France, enters operation. The objective of the RDTM project is to harmonise the voice systems currently in place at the French land army bases (MTGT system) and at the French naval bases (RVDM system), to create a single system in accordance with the new structure of Direction Interarmées des Réseaux d'Infrastructure et des Systèmes d'Information de la défense (DIRISI), the operator of the RDTM system. A further objective of this measure is to reduce network maintenance costs.

RDTM makes it possible to centralise the control and monitoring of systems…

RDTM makes it possible to centralise the control and monitoring of the systems and networks at the new control centres and of the local maintenance facilities in France. The unification of the telecommunication networks at all French army and navy bases covers a total of 180,000 users at nearly 800 locations.

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The third phase of the RDTM project, which is one of the most difficult to accomplish, covers the commissioning of the telecommunication network at the military base in Toulon. It affects 23,000 users distributed across a network with 35 sites and many different operational units. A team of approximately 20 people worked for 14 months to deploy the system in order to meet the delivery deadlines agreed to in the contract.

The next major phases of the project will involve updating the software at the land army bases (MTGT) and at the naval bases in Lorient and Paris, and the operational commissioning of the telecommunication networks at French overseas military bases in French Polynesia, Guadeloupe, Martinique, Réunion, Mayotte and French Guyana.

IET Urges UK Government to Think 'Small'

The Institution of Engineering and Technology (IET), Europe's largest engineering body is calling on the UK government to ensure its procurement policies are used to maximum effect to drive innovation through the use of the Small Business Research Initiative (SBRI). The call to action from the IET follows its hosting of a high level meeting, which brought together officials from across government to discuss the role of engineering companies in SBRI.

Tony Whitehead, Director of Policy at the IET said, "Although SBRI has already been successful, more government departments need to make use of the scheme if it is to expand and reach its full potential. The UK's engineering sector includes many high-tech, innovative SMEs who can help government departments by creating technological solutions to some of the challenges faced in delivering better, cost effective public services.

"SBRI provides a way for the government to support high-tech start-ups and SMEs which are key..."

"SBRI provides a way for the government to support high-tech start-ups and SMEs which are key both for stimulating economic growth and rebalancing the economy. The challenge now is to increase the extent to which government departments make use of SBRI."

SBRI is based on the US government's National Science Foundation scheme, which has provided numerous new innovative solutions for public services as well as providing many companies with a financial basis on which they can then build. Companies involved in the schemes have generated cumulative total sales of $2.2 B directly and $6.9 B indirectly attributable to their involvement in the scheme.

Commercial Market

Dan Massé, Associate Technical Editor

In-Building Wireless Development Revenue to Approach $10 B in 2012

In-Building Wireless (IBW) systems are showing solid adoption rates and, according to the latest forecasts from ABI Research, should register almost $10 B worth of deployments next year. Corporate campuses, airports and railway stations, and retail shopping centers (in that order) are the leading verticals where the need for good indoor cellular coverage and throughput is driving the IBW market. Healthcare facilities follow close behind. The economic recovery now under way in many regions has meant the resumption of deployments that were shelved during the worst of the slump.

The question "who's buying?" may have different answers from building to building, depending on who has most to gain: enterprises, building owners, transport authorities, mobile operators, or others. There is also a role for managed service providers. The majority of deployments will continue to be found in the Asia-Pacific region, but while the Asia-Pacific region accounts for the majority of IBW deployments, most innovation is coming from North America.

To learn more about the IBW, visit ABI Research's "In-building Wireless Systems" study, which covers DAS (Distributed Antenna Systems both active and passive), repeaters, and the role currently played by picocells and femtocells in IBW. It includes a detailed breakdown of revenue, deployments, and shipments by region, system type, vertical type and building size.

Microwave Backhaul Equipment Market to Surpass $12 B by 2016

The microwave backhaul equipment market is expected to surpass US$12 B by 2016, according to the second edition of Maravedis' "Wireless Backhaul Market from an All-IP Perspective" report.

During 2010 the PtP microwave backhaul market reached $4.74 B, representing an 18.9 percent decrease year-over-year. During the next five years the microwave market will continuously grow, mainly driven by the need for operators to deploy new base stations to provide good quality of experience over LTE networks. Despite a recent slowdown in all-outdoor radio shipments, Maravedis believes those radios will see great market demand. "Compact-size 60 GHz radios will become a key asset for backhaul links between lampposts and the sides of buildings, where small cells will be installed," said Esteban Monturus, author of the report. "Assuming a growing percentage of the network will need the complement of several small cells per macrocell, the number of 60 GHz links is thus expected to grow to $792 M shipments by 2016."

Now that the evolution toward pure packet microwave technology is maturing, multiple enhancements are being introduced by vendors to leverage the flexibility of packet transmission. "New features, such as support for upper protocol layer compression, service-aware routing and G.8032 Ethernet resiliency, are now focusing the attention of vendors," said Maravedis Research Director Adlane Fellah.

Key Findings:

- CALA was the only region where microwave shipments increased in 2010, while EMEA continued to represent the largest share of microwave shipments (48.8 percent).
- Shipments of radios in the 15 to 28 GHz range have been the greatest in 2010.
- Shipments of hybrid radios accounted for 72 percent of the total shipments.
- Ericsson remained the market leader with 26 percent market share in 2010.
- Shipments of TDM radios increased 16 percent and 27 percent in Q3 and Q4 2010, respectively, despite the IP migration trend.
- Pure packet will account for 90 percent of annual microwave radio shipments by 2016.
- Intensive integration efforts enable equipment vendors to double equipment reliability (measured by MTBF, mean time between failures). All the microwave vendors will be forced to follow this strategy to remain price competitive.

The report provides a complete quantitative and qualitative analysis of the wireless backhaul market, including vendor SWOT analysis for Alcatel-Lucent, Aviat, BridgeWave, Ceragon, DragonWave, E-Band Communications, ECI Telecom, Ericsson, Exalt, Huawei, Intracom, NEC, Nokia Siemens and Siklu.

Microelectronic Revenues Continue Strong Growth

Recent financial reports from companies in the microelectronics portion of the compound semiconductor industry indicate continued sharp revenue growth. The Strategy Analytics GaAs and Compound Semiconductor Technologies Service (GaAs) viewpoint, "Compound Semiconductor Industry Review April 2011: Microelectronics," reports the latest revenue results for leading companies in the microelectronics segment of the compound semiconductor industry, such as RFMD, Skyworks Solutions, Fairchild, Fujitsu, Hittite Microwave, TriQuint Semiconductor, Soitech and WIN Semiconductors.

"The strong revenue reports which Strategy Analytics saw in April show continued compound semiconductor market expansion," noted Eric Higham, Director of the Strategy Analytics GaAs and Compound Semiconductor Technologies Service. "Growth in this industry is broadly-based as both gallium arsenide (GaAs) and silicon manufacturers are showing strong year-on-year revenue gains."

Asif Anwar, Director, Strategy Analytics Strategic Tech-

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nologies Practice, added, "Increasing data consumption is driving development in consumer electronics and networks."

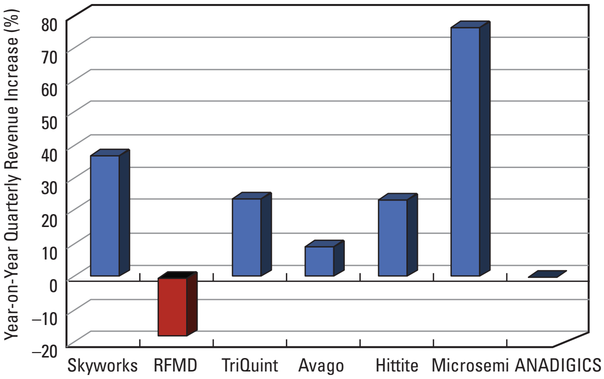
Hingham, author of "Compound Semiconductor Industry Review April 2011: Microelectronics," told *Microwave Journal* that a few trends are notable in the report.

"Most of the year-on-year revenue comparisons were positive and substantial, with GaAs manufacturers Hittite and TriQuint reporting 24 percent growth, Skyworks reporting 37 percent growth and Silicon manufacturer Microsemi leading them all with 73 percent quarterly revenue growth. This is important because it shows the growth is broadly based, with both Silicon and GaAs suppliers demonstrating strong results," Hingham said. "It is important to note that 2010 was a banner year for the compound semiconductor industry. Strategy Analytics believes revenue in the industry grew by 35 percent in 2010, so strong quarterly revenue gains in 2011 indicate continued strength in the compound semiconductor industry."

Another trend provides a cautionary note, however, Hingham said. "Two of the leading GaAs suppliers in the industry, RFMD and ANADIGICS both saw year-on-year declines in quarterly revenue. Both companies attribute this to challenges at major handset customers," he said. "Previous reports from Strategy Analytics have captured how diligently compound semiconductor companies have been working to develop products for a variety of other market applications. This is certainly the case at RFMD and ANADIGICS, but it underscores how important the handset market segment is to the overall compound semiconductor industry."

This viewpoint summarizes April 2011 financial, product, contract and employment developments from major GaAs and silicon suppliers, addressing a variety of commercial and military applications that require gallium arsenide (GaAs), gallium nitride (GaN), silicon carbide (SiC) and complementary metal-oxide-semiconductor (CMOS) technologies.

GaAs and Silicon Suppliers



* *Courtesy of Strategy Analytics*

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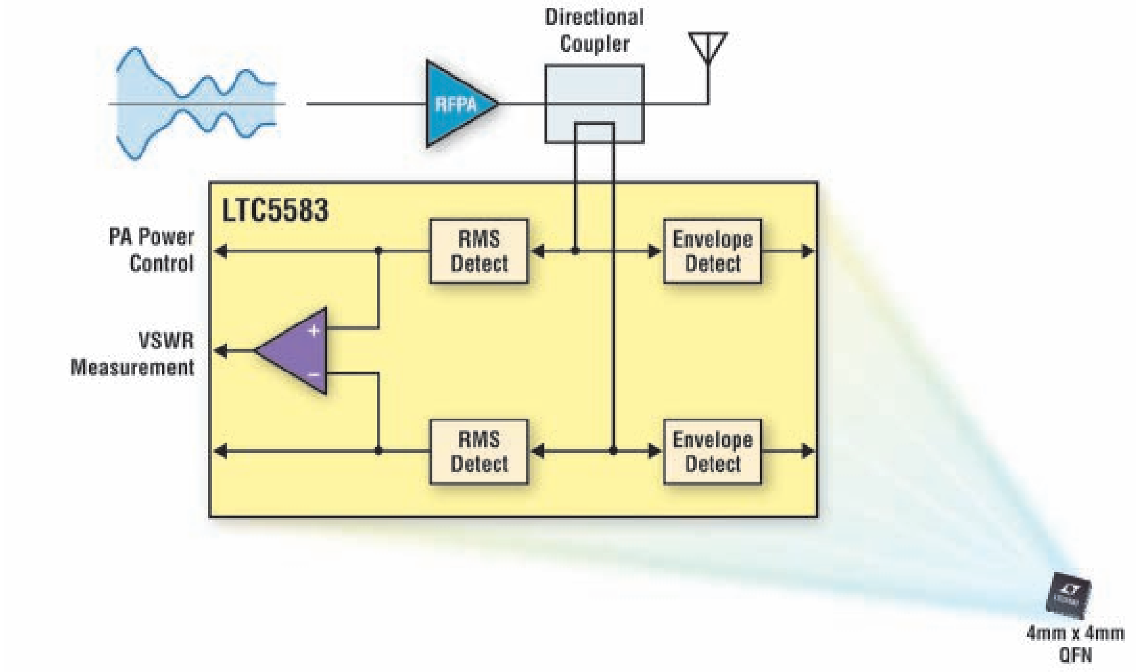

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Measurement Accuracy (–40°C to 85°C)	±0.5dB	±0.5dB	±1dB	±1dB
Output Interface	Log-Linear Voltage	Log-Linear Voltage	Log-Linear Voltage	12-Bit Serial ADC
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Around the Circuit

Kerri Germani, Staff Editor

INDUSTRY NEWS

Skyworks Solutions Inc. signed a definitive agreement to purchase **Advanced Analogic Technologies Inc.,** an analog semiconductor company focused on enabling energy-efficient devices for consumer electronics, computing and communications markets. This acquisition expands Skyworks' portfolio with highly complementary analog semiconductor products, including battery chargers, DC/DC converters, voltage regulators and LED drivers. Skyworks has entered into a definitive agreement to acquire Advanced Analogic Technologies for a nominal price of $6.13 per share, representing a 52 percent premium to Advanced Analogic Technologies' 30-day trailing average.

Integral Systems Inc. announced that it has entered into a definitive agreement under which it will be merged with a subsidiary of **Kratos Defense & Security Solutions Inc.** in a cash-and-stock transaction for an enterprise value of approximately $266 M. Kratos is a specialized national security technology business providing mission critical products, services and solutions for national security priorities. The Boards of Directors of both companies have unanimously approved the combination. The combined company will provide differentiated, integrated technology that addresses the most critical national security priority areas. Combining the two highly complementary technology and customer portfolios is designed to uniquely position the merged company to bring advanced Command, Control, Communications, Computing, Combat Systems, Intelligence, Surveillance and Reconnaissance (C5ISR) platforms to market.

API Technologies Corp. announced the successful completion of its acquisition of **Spectrum Control Inc.** API completed the acquisition through a merger of a wholly-owned subsidiary with and into Spectrum. As a result of the merger, all outstanding shares of Spectrum common stock were converted into the right to receive $20.00 per share in cash, without interest and less any required withholding taxes. The closing of the acquisition of Spectrum allows API to gain significant expertise in RF, sensors and measurement, and power systems management technology. It also provides significant scale, manufacturing capacity and product diversity.

AMETEK Inc. announced that it has acquired **Coining Holding Co.,** a supplier of custom-shaped metal preforms, microstampings and bonding wire solutions for interconnect applications in microelectronics packaging and assembly, for $148 M in cash. Coining, acquired from an investor group led by Chattanooga, TN-based River Associates Investments LLC, has estimated annual sales of approximately $65 M.

Vanguard EMS and **Tektronix Component Solutions** have signed a joint marketing agreement to formalize their collaboration and the joint offering of their capabilities to customers in the defense, aerospace, medical and industrial equipment markets. While companies in these markets frequently seek to control costs through outsourced manufacturing, finding suitable suppliers can be challenging due to the high-complexity and high-reliability requirements of their products. Through the collaboration of Vanguard and Tektronix, customers now have access to the engineering, manufacturing and test services needed to support their assembly requirements from the microelectronics level to final system build and test.

Rosenberger of North America LLC and **Toth Technologies** have formed a strategic alliance. Under the agreement, Toth will do business as Rosenberger TOTH and will operate from TOTH's Pennsauken, NJ headquarters. Founded in 1958, TOTH Technologies is a technology leader in custom machining, complex electromechanical "contract assembly" and hermetics to the military, aerospace and instrumentation markets.

Litron, an Agawam, MA supplier to the aerospace and medical industries for services in laser welding, laser systems, hermetic sealing, and electronic packaging, has invested more than $1 M to purchase a 9500-square-foot facility just four doors down from its existing 23,500-square-foot facility and to upgrade and expand upon its equipment and service offerings. The new 45 Bowles Road facility will allow Litron to break out its service offerings based on its two most prominent industries, medical and aerospace. The existing 207 Bowles Road facility will service the medical clientele, while the new 45 Bowles Road building will service the aerospace clientele.

M2 Global Technology Ltd. was presented with the US Small Business Administration (SBA) 2011 Region VI Subcontractor of the Year award during the SBA's National Small Business Week events in Washington, DC in May. This award is given to companies in recognition of the small-business sector's contributions as subcontractors for large federal prime contracts that provide vital products and services to military and civilian customers. The award was presented by SBA Administrator, Karen Mills, to Douglas Carlberg, M2 Global's President and CEO, at the National Awards Breakfast on May 19. In the SBA event information, M2 Global was lauded for rising above challenges and expanding its customer base to include companies such as Lockheed Martin, General Dynamics and Raytheon.

TriQuint Semiconductor Inc. announced its Chief Financial Officer, Steve Buhaly, was named "CFO of the Year" at *The Portland Business Journal*'s annual awards program. Buhaly received the honor in the public company category. Buhaly is a consultant to TriQuint's business units

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and functional departments. His responsibilities include investor relations, corporate accounting and legal, to information technology, tax and treasury services. Since joining the company in September 2007, he has inspired operational improvements and empowered his senior managers with skill and thoughtfulness.

Mark Holm of **Selex**, an experienced user of AWR's Microwave Office™, AXIEM® and Visual System Simulator™ software, is the first winner of AWR's 'stop waiting and start designing™ ad campaign'. The challenge runs through March 31, 2012 and winners of the iPad2 will be chosen monthly. To be eligible for the challenge and the chance to win an iPad2, current customers must share a story of their design success with AWR by way of an online survey while prospective customers must download and activate a free 30-day trial.

TriQuint Semiconductor and **Agilent Technologies Inc.** announced results for building next-generation RF solutions. This includes enhanced TriQuint process design kits with support for Agilent's Advanced Design System 2011 EDA software and the development of an ADS RF module PDK for TriQuint's RFIC/MMIC and RF module integrated design flow. The upgraded ADS Foundry PDKs enable both TriQuint's foundry customers and in-house design engineers to take advantage of new capabilities in ADS 2011. Specifically, the PDKs provide a fully integrated front-to-back product design flow with customized DRC and LVS solutions. This offers the design engineer a unified suite of EDA software for schematic capture, simulation, layout and layout verification.

A.T. Wall Co., a supplier of superior precision tubing and fabricated metal components, announced that it is celebrating its 125th anniversary in business. From its founding in 1886 as a jewelry finding manufacturer, A.T. Wall has grown and expanded to become a global supplier of seamless cold drawn specialty tubing, high quality waveguide tubing, and metal stampings that include drawn and coined products, to the medical, aerospace, telecommunications, electronics and automotive industries.

Modelithics Inc., a provider of high-precision measurements and models for RF/microwave design simulation, is celebrating its 10-year anniversary. Entrepreneurs Tom Weller and Larry Dunleavy founded Modelithics in 2001 to better address the industry-wide need for improved simulation models for RF and microwave circuit design. What started as an incubator company on the University of South Florida campus now provides characterization services and models across the globe. Their premier product – The Modelithics COMPLETE Library – is a software compilation of linear and nonlinear models for electronic design automation software like the Agilent Advanced Design System and Genesys suites and AWR's Microwave Office. The Modelithics COMPLETE Library now represents more than 6500 active and passive devices.

Danaher, a Washington, DC based science and technology company, announced that its test and measurement subsidiaries, **Tektronix**, **Fluke** and **Keithley**, have joined the Higher Engineering Education Alliance Program (HEEAP) with a $300,000 donation of laboratory test equipment and cash scholarships for faculty training. The goal is to help provide increased opportunities for engineering students to obtain practical, hands-on experience using electrical and electronic testing and measurement in manufacturing and research and development applications. Tektronix, Fluke and Keithley are global leaders in the test and measurement industry and have a long history of working with universities and vocational schools to help develop the next generation of highly skilled engineers.

Australia's Minister for Innovation, Industry, Science and Research, Senator Kim Carr, announced funding for **Nitero**, a company formed by researchers from National ICT Australia (NICTA). The AU$1.43 M grant is part of an effort to bring Nitero's high speed gigabit wireless communications technology ('GiFi') to market. Intended for use in a wide range of devices, including personal computers, tablets and smart phones, the gigabit wireless chipset has been in development for five years. Led by NICTA and the Victoria Research Laboratory, the chipset could eventually replace HDMI cables and is potentially up to 10 times faster than current Wi-Fi chips, with speeds of up to 7 Gbps. The AU$1.43 M grant comes from Commercialisation Australia, a government initiative to accelerate the business building process for Australian companies, entrepreneurs, researchers and inventors.

Pinnacle Quality Assurance announced that another one of its clients, **ESM Cable Corp.,** is in the process of achieving compliance to the AS9100 Rev C Standard. The company expects to achieve full certification within 2011. ESM is one of a select few firms in the industry to have taken this step. The certification is a program of the International Organization for Standardization. The AS9100 Rev C standard provides a framework for an organization's structure, management and operational systems and procedures.

Automotive safety is evolving from passive systems such as seat belts, airbags and crash detection to active sensing networks capable of collision avoidance and accident prevention. Radar is an especially promising active safety improvement and has the potential to significantly reduce the number and severity of distracted driving accidents. **Analog Devices Inc.,** whose integrated inertial sensing iMEMS® technology helped make airbags a standard automotive safety feature more than 15 years ago, is introducing an affordable, high performance, radar analog front-end (AFE) IC. ADI's highly integrated AD8283 automotive radar AFE IC includes the receive path signal conditioning and data capture circuitry to enable end systems for adaptive cruise control, blind spot detection and other radar-based detection and avoidance applications.

Tektronix Inc. announced that validation of ASICs designed in IBM's 8HP silicon germanium (SiGe) BiCMOS Specialty Foundry technology are exceeding target specifications for a planned new performance oscilloscope capable of greater than 30 GHz bandwidth across multiple channels while minimizing noise found in older chip sets. The new oscilloscope platform will meet electronic designers' needs for more accurate characterization of high speed serial data beyond 10 Gb/s, and enhance optical modula-

tion analysis of 100GbE where complex signaling requires accurate bit capture.

Nitronex announced that it has shipped more than 500,000 production devices since introducing its first production-qualified products in 2006. Nitronex's patented SIGANTIC® GaN-on-Si process is the only production-qualifed GaN process using an industry standard silicon substrate.

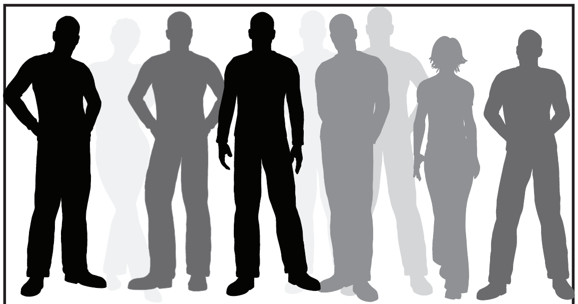
CONTRACTS

Raytheon Co. has been awarded a $58.3 M contract for Patriot Guidance Enhanced Missile-Tactical, or GEM-T, missiles. The US Army Aviation and Missile Command (AMCOM), Redstone Arsenal, AL, issued the contract to upgrade 131 Patriot Advanced Capability-2 missiles to the GEM-T configuration. This is a follow-on contract as part of AMCOM's Patriot missile continuous technology refreshment program initiated in 2000. The Patriot GEM-T missile upgrades include the replacement of select components that increase reliability and extend the service life of the missile.

Harris Corp. announced three big contract awards in May. It has received a $19.9 M order from the US Army for Falcon II® AN/VRC-104(V)(3) radio systems to provide high frequency communications in multiple variants of Mine Resistant Ambush Protected vehicles (MRAP). Also, Harris received a $10 M order to provide RF-310M-HH multiband handheld software-defined radios to a central Asian nation in support of interoperable secure communications with coalition partners. In addition, Harris has received a $5.9 M order from the US Navy for its KIK-11 Tactical Key Loader – a new lightweight device that simplifies the process of loading classified key fill material into military radios and other end cryptographic units. The initial delivery order was placed against a recently signed $59.7 M indifinite delivery, indefinite quantity contract.

The Joint Program Executive Office, Joint Tactical Radio System (JPEO JTRS) of the Department of Defense announced a contract award to **Scalable Network Technologies Inc**. (SNT), Los Angeles, CA. The $11 M contract is for a product called JNE (JTRS Network Emulator) to be used by numerous DoD programs/agencies. JNE is a virtual laboratory that supports real-time emulation of large-scale communication networks of current and future force radios and associated waveforms. Based on SNT's EXata™ emulation engine, JNE is used to create "hybrid" networks that can emulate the intensity and distribution of traffic typical of battlefield deployments, and perform with all the complexity and realism of an actual large-scale network. This high degree of fidelity makes it possible to integrate a JNE network into live exercises using real hardware, real users and real applications connected to operational networks.

VTI Instruments Corp. announced that it has been selected to deliver the high-fidelity core switching solution for **Custom Systems Integration's** (CSI) semiconductor



manufacturing test system. VTI's 3U high power switching mainframe (EX1208) and 72-channel multiplexer (EX1200-3072) provides 556 channels of core switching capability for CSI's Multi-Core Tester (MCT). Proven repeatability and reliability were key switch system characteristics that enabled uninterrupted testing, ultimately resulting in lower development costs, faster time-to-market, and a sustained competitive advantage. CSI's MCT is a high performance test system used by leading global semiconductor manufacturers to perform device temperature profiling.

Aeroflex Ltd. has received orders from 4G chipmaker **Sequans Communications** for a significant number of its 7100 LTE Digital Radio Test Sets. The initial order has been shipped and will be used across a range of applications in research and development of Sequans LTE chips and software, in LTE TDD pre-conformance testing, and by the company's field applications engineers to give technical support to its customers.

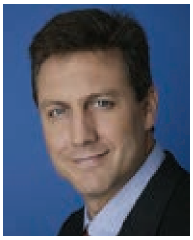
PERSONNEL


▲ *Michael Dys*

M/A-COM Technology Solutions announced that **Michael Dys** joined the company as Corporate Controller, reporting to Conrad Gagnon, Chief Financial Officer. Dys will be responsible for all global accounting functions, budgeting and forecasting, as well as financial planning and analysis. He will also provide financial perspective to other business leaders toward optimizing M/A-COM Tech's operational efficiency. Dys most recently served as Controller at Aeroflex/Micro-Metrics. He previously served as Vice President and Corporate Controller at Skyworks Solutions.


▲ *Bill Dolloff*

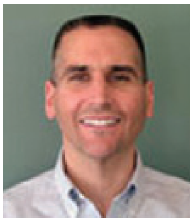
TRM Microwave has announced the addition of **Bill Dolloff**, who will serve as the company's dedicated Boeing Program Manager. He brings extensive experience in implementing quality systems, customer support and aftermarket sales in commercial aviation products, along with government contract administration. Dolloff will play a strategic role in supporting the demands of TRM's growth. He retired after 20 years of service in the US Marine Corps and received a BS in Management from Park College and an MS in Management from Central Michigan University.


▲ *Kevin Gage*

The **National Association of Broadcasters** announced that **Kevin Gage**, a 20-year veteran with experience developing digital platforms in television and music, has been selected as the new executive vice president and chief technology officer for the association. Gage, 49, will lead NAB's technology efforts, including oversight of the staff that represents NAB on a variety of standard-setting organizations,

and which serves as the liaison to the engineering and technology community. Gage's career includes stints at Warner Bros. Studios, where he helped develop the DVD Specification and production facilities at the film studio. While at Warner Bros., Gage helped launch The WB Network, and was a founding member of the Advanced Television Enhancement Forum, a cross-industry initiative that developed standards for interactive TV. Gage later became head technologist at Warner Music Group, where he oversaw creation of new digital platforms and standards for products that included iTunes.

▲ Henry Hu



▲ Nick Weidick

Giga-tronics announced the addition of two new Regional Sales Managers covering the USA, Asia and EMEA. **Henry Hu** will focus on the Western US and Asia, and **Nick Weidick** will focus on the Eastern US and EMEA. Hu has more than 10 years of experience in the industry with a strong background in RF and microwave engineering. His career started in engineering and marketing at Kulicke and Soffa, a semiconductor equipment company, and most recently, Hu was the Asia Sales Manager for Aeroflex/Metelics. Nick Weidick has more than 20 years of experience in the industry with a strong background in RF and microwave test and measurement. His career started in wired and wireless communications working for such companies as Anritsu, Tektronix and AT&T. Most recently, Weidick was a Business Development Manager for MI Technology.

REP APPOINTMENTS

RFMW Ltd. and **RFaxis Inc.** announced a distribution agreement for the Americas, Europe, the Middle East, and Africa. RFaxis is a semiconductor company with focus on developing highly integrated, silicon-based single-chip, single-die RF front-end integrated circuits (RFeIC) that significantly simplify the design task and substantially improve the range, receive sensitivity and data throughput for all major wireless communications protocols.

TRM Microwave announced **Bradford RF Sales** has been named to represent the TRM lines in the New England territory. With this latest addition, the company continues to affirm its strategic initiative to provide customers with local design and engineering support, and easy access to its broad offering of custom power dividers, couplers, hybrids, beamformers and integrated assemblies.

WEBSITE

East Coast Microwave Distributors has launched a new online website (www.adaptercity.com) to locate nearly every RF/microwave coax adapter. The website allows you to choose from a wide range of manufacturer's adapters, by separating commercial-grade adapters from mil-grade ones.

ACCOUNTING FOR DYNAMIC BEHAVIOR IN FET DEVICE MODELS

Today's engineer faces a range of challenges, including inadequate nonlinear device models that contribute heavily to inaccurate large-signal high frequency simulation. Because of this, designers need to know if a model they are given is suitable for their application before they commit a design to manufacture. Unfortunately, the hurdle for pre-qualifying a nonlinear model is often perceived as high, so few engineers will even ask the question: "Is my model good enough?" Failure to accurately take into account the dynamic behavior of a device in its electrical model can have a detrimental effect on an application. Therefore, modeling such behavior is essential to accurate nonlinear simulation.

A powerful simulation-based qualification method now offers designers a viable means of testing field-effect transistor (FET) device models for critical large-signal, high frequency behavioral characteristics at the operating point required by an application. This early insight is critical in allowing designers to avoid costly and time consuming design iterations and their consequences.

UNDERSTANDING DYNAMIC BEHAVIOR

To better understand why taking a device's dynamic behavior into account is so critical, it is first important to understand exactly what this behavior is. Dynamic behavior occurs when an object gives measured results that are a function of when a change started (implying memory of past conditions) and/or for how long the change was applied (process/mechanism time constants). It may be exhibited by all semiconductor devices in response to appropriate changes in electrical stimuli, but is particularly prevalent in applications where large-signal, high frequency signals are present (that is RF power amplifiers, mixers, oscillators and high speed digital circuits). Device technology and size do impact a device's dynamic behavior, but it is unreasonable to assume that an application employing the latest deep sub-micron silicon process will be any less likely to exhibit dynamic behavior than a 50 W GaN device.

Essentially, when a device in a quiescent (steady) state experiences a change in electrical conditions, that change does not instantly result in a new steady-state condition. Rather, physical processes, each with differing time constants, begin to respond. The observed result is a time variant change in the electrical conditions observed at the device terminals.

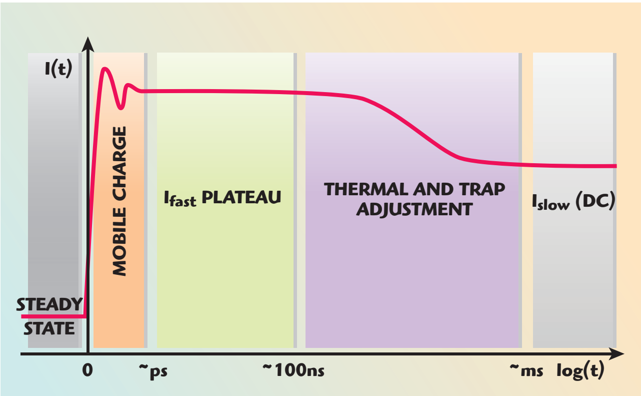
Consider the case shown in ***Figure 1***, which depicts an Id(t) response of a FET to a step change in applied voltage. After t = 0, the mobile charge in the channel responds rapidly and then I(t) settles down to the "I_{fast} Plateau" current region. Next, the change in conditions affect the channel temperature and, in some device technologies, the charge state of traps

GRAHAM RILEY
Agilent EEsof EDA, West Lake Village, CA

(dislocations/imperfections in device material lattice that show up as discrete energy levels in the material band gap). In turn, changes in channel temperature and trap states affect the apparent mobility of carriers in the channel and cause the current flow to adjust until it reaches equilibrium (I_{slow}). This change over time can also be viewed as the device responding in a different way to different applied frequencies or dispersion.

The relationship between I(V), taken at different effective pulse lengths, and the step response in Figure 1 is shown in ***Figure 2***. Note that the device I(V) characteristic measured at "DC" is not the same I(V) characteristic seen by a high frequency signal.

From the I(V) curves in Figure 2, it is possible to infer that derivatives of I with respect to V are time dependant. Consider the partial derivative $\partial id/\partial vg$, or gm. Clearly the gain will be different for a high frequency signal compared to a slow moving one. Likewise, harmonic generation and intermodulation products are dependent on I-V derivatives and so are other key quantities like ACPR, AM-PM, EVM and PAE. An inappropriate model description for the rate dependence of the I-V plane will produce incorrect answers for these critical metrics.



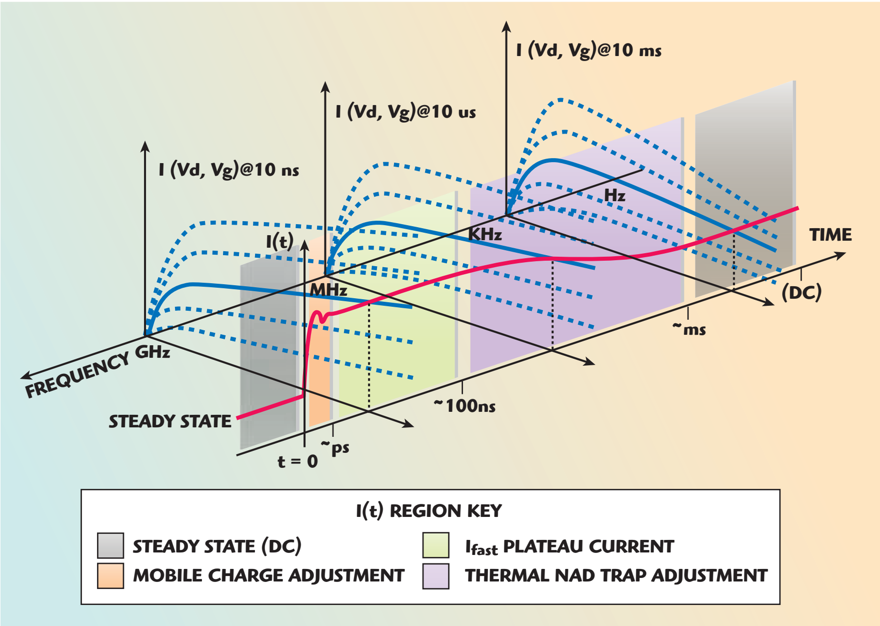
▲ *Fig. 1 I(t) changing response to a step change in voltage at t = 0.*

MODELING DYNAMIC BEHAVIOR

While several approaches have been developed to allow the inclusion of dynamic behavior in semiconductor device models, determining if a model is well fitted to appropriate measured data remains challenging. A model only fitted to DC I(V) and quasi-static S-parameters is highly unlikely to give accurate large-signal, high frequency performance. Large-signal high frequency information must be used as part of model fitting. Moreover, large-signal high frequency simulated tests are needed to evaluate how well a model has been fitted.

Simulated testing of a FET device model for large-signal, high frequency behavior, can be carried out in many ways. The easiest, quickest and most insightful method is to test the dynamic capabilities and fit of a model by comparing DC I(V) with fast-pulse i(v). Examining critical areas of a fast-pulse i(v) characteristic can yield vital information on the general suitability of a model for a given task. For example, it can determine if appropriate dynamic behavior is modeled, if the model is well fitted for large-signal high frequency use in a specific application, and examine the model's valid range of use.

It may also be useful to look at the device's step response characteristic i(t) to see if it behaves rationally. Pre-configured simulation testers and measurements, like those available for Agilent Technologies' Advanced Design System software, make it possible to quickly and comprehensively look at a device's time-dependant behavior. Three such tests are the single shot pulse i(v), continuous time pulse i(v) and step i(t). With the single shot pulse i(v), equal length pulses, starting from the Q-point, are sent simultaneously to both gate and drain terminals. Terminal currents are then measured at a user defined intra-pulse sample point to provide the fast-pulse i(v) values for plotting. Continuous time pulse i(v) uses the same basic methodology except that each pulse is applied as part of a single time sweep, rather than individual per pulse time sweeps. In a step i(t) tester, terminal voltages are simultaneously changed from the Q-point to a desired "step-to" point and held for the duration of the test with terminal currents monitored over time.



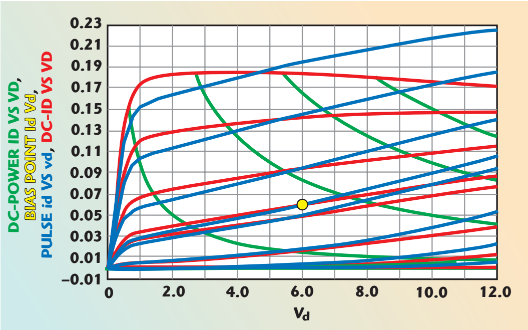
▲ *Fig. 2 The step response relationship between I(V) and I(t).*

TESTING A MODEL USING FAST-PULSE SIMULATION

A number of qualitative tests can be used to check the primary characteristics of a model related to dynamic behavior. While these tests do not guarantee accurate circuit simulation results, they will quickly identify suspect model behaviors that require further investigation. These tests include:

Output Conductance

The I-V plot in ***Figure 3*** shows differences between the DC I(V) (red) and pulsed i(v) (blue) and DC power (green) curves. Examining the pulsed i(v) set above the knee shows



▲ *Fig. 3 I-V plane showing DC I(V), pulsed i (v) and DC power curves.*

a relatively constant positive value of output conductance for all constant vg traces. The DC I(V) set shows differing values of output conductance across the plane, with negative values at higher power dissipation. This difference is the result of the DC I(V) curves containing a "hidden" dependence on channel temperature and trap state.

Overall Shape of i(v) Curves (Q-Point Dependence)

For any given bias Q-point, the combination of power dissipation and the charge state of traps is unique. The shape of the pulsed i(v) curves will vary according to that Q-point. The ability to track this critical behavior is a major challenge for a device model. Some models are fitted to data for a specific characterization Q-point and only accurately replicate the device's dispersive behavior when operated at that Q-point. Using the model at an operating point away from that Q-point usually leads to a degraded characteristic. How important this degradation is to overall accuracy is application dependant. Few, if any, empirical models are able to accurately cover the general case and, if not fitted using data from multiple Q-points, will be inaccurate.

Pinch-Off

As with the DC I(V) characteristics, the pulsed i(v) results should show the device pinch-off as a function of gate voltage. Generally speaking, while the values of Vg at pinch-off may differ, and the shape of the curves may be different approaching this region, the device model should still pinch-off to Id = 0 for both DC and pulsed data.

Drain Current Offset at the Origin

Some device models cannot accurately predict behavior away from their pulsed i(v) characterization bias. This can be seen in an offset at the origin of the pulsed i(v) curves. In cases where an obvious offset can be seen, the designer must examine the effect of this artifact on the target application.

Bias Point

The coincident nature of the bias point on both DC I(V) and pulsed i(v) characteristics is a given. This condition is both logical and necessary because the DC I(V) characteristic is effectively the set of quiescent bias points from which any pulse measurement can be taken.

Transconductance – Gm

The differences between DC and pulsed measurement values of Gm are readily apparent in ***Figure 4***, and highlight the importance of correctly modeling the dispersive nature of a device. Higher order derivatives, which give indications as to intermod-

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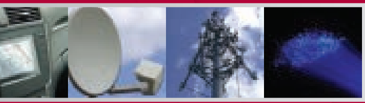

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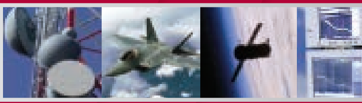

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- *Die & SMT Versions Available From Stock*

IN-STOCK ANALOG PHASE SHIFTERS

	Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd Harmonic Pin = -10 dBm (dBc)	Control Voltage Range (Vdc)	Package	Part Number
	2 - 4	Analog	3.5	480° @ 2 GHz 450° @ 4 GHz	-40	0V to +13V	LP5	**HMC928LP5E**
NEW!	2 - 20	Analog	4	270° @ 2 GHz 180° @ 20 GHz	-45	0.5 to +11V	LP5	**HMC935LP5E**
	4 - 8	Analog	4	450° @ 4 GHz 430° @ 8 GHz	-40	0V to +13V	LP4	**HMC929LP4E**
	5 - 18	Analog	4	500° @ 5 GHz 100° @ 18 GHz	-80	0V to +10V	Chip	**HMC247**
	6 - 15	Analog	7	750° @ 6 GHz 500° @ 15 GHz	-40	0V to +5V	LP4	**HMC538LP4E**
	8 - 12	Analog	3.5	425° @ 8 GHz 405° @ 12 GHz	-35	0 to +13V	LP4	**HMC931LP4E**
	12 - 18	Analog	4	405° @ 12 GHz 385° @ 18 GHz	-40	0 to +13V	LP4	**HMC932LP4E**
	18 - 24	Analog	4.5	495° @ 18 GHz 460° @ 24 GHz	-37	0 to +13V	LP4	**HMC933LP4E**

IN-STOCK 4, 5 & 6-BIT DIGITAL PHASE SHIFTERS

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Input (Vdc)	Package	Part Number
8 - 12	4-Bit Digital	6.5	22.5 to 360	37	0 / -3V	LC4B	**HMC543LC4B**
15 - 18.5	5-Bit Digital	7	11.25 to 360	40	0 / -3	LC5	**HMC644LC5**
1.2 - 1.4	6-Bit Digital	4	5.625 to 360	45	0 / +5V	LP6	**HMC936LP6E**
2.5 - 3.1	6-Bit Digital	4	5.625 to 360	54	0 / +5	LP6	**HMC647LP6E**
2.9 - 3.9	6-Bit Digital	5	5.625 to 360	45	0 / +5	LP6	**HMC648LP6E**
3 - 6	6-Bit Digital	8	5.625 to 360	44	0 / +5	LP6	**HMC649LP6E**
9 - 12	6-Bit Digital	7	5.625 to 360	38	0 / -3	LC5	**HMC643LC5**
9 - 12.5	6-Bit Digital	7	5.625 to 360	41	0 / +5	LC5	**HMC642LC5**

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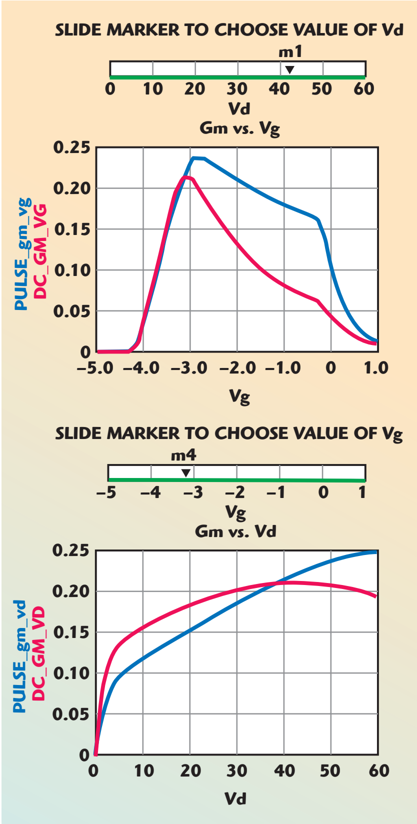
ulation products and harmonic generation, also behave in similar ways.

Memory Effects

When a device's response is dependent on its operating history, it is said to "remember" the past and hence, has memory effects. For a device model without any memory capability, simulation results will be identical for a given point on the pulse i(v) plane, irrespective of the number of pulses, their order or coverage of the I-V plane. This is not true for a device exhibiting memory, where the same pulse stimulus conditions can result in different responses.

Step Response

This test looks for the behavior shown in Figure 1. It also tests the time constants associated with a particular device or its model. This test is often performed to make sure the simulated fast-pulse i(v) measurements use a sufficiently fast pulse to correctly characterize the high frequency plateau described in Figure 1.



▲ *Fig. 4 Gm curves from DC and pulsed simulations.*

CONCLUSION

Taking into account the dynamic nature and behavior of a FET device in any electrical model is essential for accurate nonlinear simulations. Fortunately, designers can now use a powerful simulation-based qualification method to test FET device models for critical, large-signal high frequency behavioral characteristics at an operating point required by their application. Additionally, straightforward qualitative simulated tests can be used to quickly test the "goodness" and fit of the dispersive behavior of a given FET model. Such early insight is critical to avoiding costly, time-consuming problems at a later date. ■

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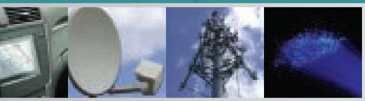

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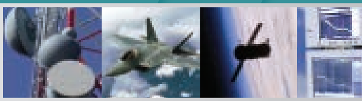

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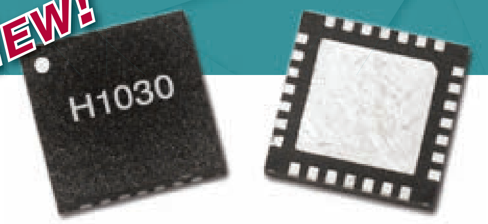

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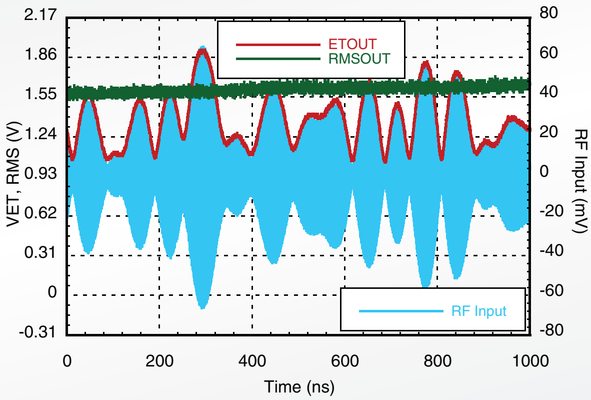

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	DC - 3.9	RMS	60 ±1	37	-69	+5V @ 50mA	LP4	**HMC1010LP4E**
	DC - 3.9	RMS, Single-Ended	72 ±1	35	-68	+5V @ 50 mA	LP4	**HMC1020LP4E**
	DC - 3.9	RMS, Single-Ended	71 ±1	35	-68	+5V @ 70 mA	LP4	**HMC1021LP4E**
NEW!	DC - 3.9	Dual RMS, Single-Ended	70 ±1	38.5	-66	+5V @ 143mA	LP5	**HMC1030LP5E**
	DC - 5.8	RMS, Single-Ended	40 ±1	37	-69	+5V @ 42mA	LP4	**HMC909LP4E**
	50 Hz - 3.0	Log Detector / Controller	74 ±3	19	-66	+3.3V @ 29mA	LP4	**HMC612LP4E**
	0.001 - 8.0	Log Detector / Controller	72 ±3	-25	-65	+5V @ 113mA	LP4	**HMC602LP4E**
	0.001 - 10.0	Log Detector / Controller	69 ±3	-25	-65	+5V @ 106mA	LP4	**HMC611LP4E**
	0.01 - 4.0	Log Detector / Controller	70 ±3	19	-68	+3.3V @ 30mA	LP4	**HMC601LP4E**
	0.05 - 8.0	Log Detector / Controller	54 ±1	17.5	-55	+5V @ 17mA	LP3	**HMC713LP3E**
	0.1 - 2.7	Log Detector / Controller	54 ±1	17.5	-52	+5V @ 17mA	MS8	**HMC713MS8E**
	1 - 23	mmW Log Detector	54 ±3	14.2	-52	+3.3V @ 91mA	LP3	**HMC948LP3E**
	8 - 30	Log Detector	54 ±3	13.3	-55	+3.3V @ 88mA	LP3	**HMC662LP3E**
	0.1 - 20	SDLVA	59	14	-54	+3.3V @ 83mA	LC4B	**HMC613LC4B**
	0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80mA	Chip	**HMC913**
	0.6 - 20	SDLVA	59	14	-54	+3.3V @ 80mA	LC4B	**HMC913LC4B**
	1 - 20	SDLVA	59	14	-67	+12V @ 86mA	C-10 / SMA	**HMC-C052**
	1 - 26	SDLVA	55	14.5	-53	+3.3V @ 135mA	Chip	**HMC813**
	2 - 20	SDLVA	50	45	-45	+12V @ 370mA -5V @ 20mA	C-21 / SMA	**HMC-C078**

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PROGRAMMING A NETWORK ANALYZER FOR THIRD-ORDER INTERCEPT POINT MEASUREMENT

A third-order intercept point (IP3) measurement technique using a network analyzer is proposed in this work. Using network analyzers to measure IP3 is becoming a trend for modern measurement instruments.[1-3] Generally speaking, extra sources and controlling programs are needed to fulfill this measurement task. The novelty of the proposed measurement method rests upon its ability to perform IP3 measurements, employing a two-tone excitation with a wide frequency spacing in the range of a few hundred megahertz, which, for example, is used in power amplifier memory effects related research and development.[4,5] Plus, the industry bandwidth drive potentially demands an IP3 measurement with wide two-tone separations, for future wideband devices. The two-tone amplitude imbalance related to this method is calibrated out based upon arithmetic average. The detailed multiple external sources and network analyzer receiver programming techniques are presented in this article. The agreement between the measured results of an amplifier using this method and the conventional method using a spectrum analyzer confirms the functionality and effectiveness of the proposed method. With extra power level calibrations at different frequency bands, this programming technique also can be extended to mixer IP3 points measurement.

Recent research on power amplifiers and their memory effects requires the measurement of intermodulation distortion (IMD) products as a function of the modulation bandwidth. Consequently, a common measurement adopted in this field is to measure the amplifier outputs, including fundamentals and IMDs, with different tone spacings for a two-tone input excitation.[4-5] Using a conventional measurement approach, with a spectrum analyzer plus two sources, can provide the required measurement,[6] but it is inefficient and tedious to get the third-order intercept point (IP3) information over a band of frequencies. This is because the lack of certain automation of the two external sources, which should sweep frequency synchronously. Using network analyzers can provide the control of external sources without extra controlling computers. Previously, a third-order IMD measurement method using a network analyzer has been available. This uses a network analyzer as a controller to control two external sources, providing a certain amount of automation.[2] The reported method makes use of a network analyzer to control two external sources as well as a tuned receiver of the network analyzer to measure IMD products, therefore offering a scheme for IP3 measurement over a band of frequency. This method performs best, when the two tones are spaced

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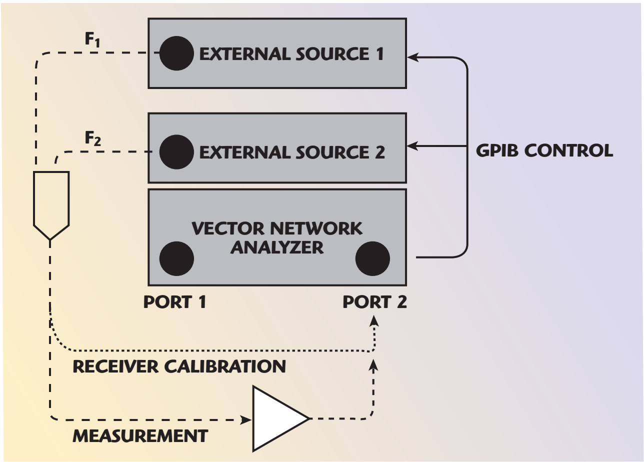

Fig. 1 An IP3 measurement setup for an amplifier, using a network analyzer.

not very far away from each other, that is in the range of a few megahertz.[2] This is because amplitude imbalance will be inevitable, if the two tones are widely spaced. Therefore, inaccuracy could be generated if this method is applied to the measurement of IMD with a wide two-tone spacing. In this work, a novel measurement method for IP3 is presented, which provides the ability to measure the third-order IMD with two-tone frequency widely separated in the range of a few hundred megahertz. The introduced amplitude imbalance is calibrated out based on an arithmetic average. Plus, compared with the conventional method,[2] the proposed method can obtain IP3 information with only one frequency sweep instead of two sweeps, which could potentially reduce measurement time and be of interest to manufacturers with a large volume of measurement tasks.

NETWORK ANALYZER CALIBRATION AND MULTIPLE SOURCE CONSOLE

The measurement instruments hardware setup is similar to the one published in Anritsu Application Note,[2] where a power combiner is used to combine the two input tones, while minimizing the interference between them, as shown in ***Figure 1***.

Two external sources are controlled by the network analyzer through a general-purpose-interface-bus (GPIB). The detailed network analyzer calibration and multiple source console programming techniques are explained step by step as follows.

The first step is to establish a 0 dBm power calibration line. This is essential because while the two sources are swept simultaneously, the network analyzer receiver response shows a different absolute power value at the same frequency. Therefore, the calibration is aimed to establish an interpretable power reading based upon the input of a known source power level. To do this, the two sources are set to sweep simultaneously with a frequency span of 2ΔF and a power level of 0 dBm, while the network analyzer receiver is programmed to receive the input signal consecutively, where ΔF is the desired two-tone excitation frequency spacing. By doing so, the network analyzer receiver real response to a known power level at different frequencies, including the two upper and lower IMD bands and two fundamental output bands, is accurately recorded. A 0 dBm power calibration line can be established by normalizing the recorded data to themselves.

The second step is to program the network analyzer into four different, consecutive frequency bands. This way, the network analyzer is programmed as a receiver, which is operated on four consecutive bands, F1 to F4. Each band is used to measure a different frequency component at the amplifier output, such as IMD1, OUT 1 (tone 1 output), OUT 2 (tone 2 output), IMD2. The complete multiple source programming details are listed in ***Table 1***, where $Band_i$ is a frequency band of interest, with a width of two interested products; F_i is a frequency band of interest, with a width of one interested product; ΔF is the frequency span separated by two tones.

In order to measure two fundamental output signals and two IMD products through one sweep, two external sources are programmed to sweep across the desired bandwidth synchronously, while the network analyzer receiver is programmed to receive four equal bandwidth output products (equal F_i), namely IMD1


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TABLE I

PROGRAMMING MULTIPLE SOURCE CONTROL FOR IIP3 MEASUREMENT OF AN AMPLIFIER

Frequency band setup	*External Source No. 1*	*External Source No. 2*	*Receiver*	*Physical Meaning*
0 dBm power calibration				
$Band_1$ $Band_2$	$Band_1$ $Band_2$-2ΔF	$Band_1$+2ΔF $Band_2$	$Band_1$ $Band_2$	Receiver tuned to measure absolute power level (including two fundamentals and two IMDs)
Sources and receiver programming for measurement				
F_1=IMD1	F_1+ΔF	F_1+2ΔF	F_1	Receiver tuned to measure IMD1 level
F_2=OUT1	F_2	F_2+ΔF	F_2	Receiver tuned to measure Tone1 output
F_3=OUT2	F_3-ΔF	F_3	F_3	Receiver tuned to measure Tone2 output
F_4=IMD2	F_4-2ΔF	F_4-ΔF	F_4	Receiver tuned to measure IMD2 level

(with frequency $2f_1$-f_2), OUT1 (f_1), OUT2 (f_2), and IMD2 ($2f_2$-f_1) consecutively. This is significantly different from the measurement method published by Anritsu.[2] This way, the amplifier gain, IMD level as well as the signal-to-IMD ratio are all measured and can be displayed at the same time.

The third step is to extract the related data segment, which represents the amplifier's different outputs and performs post processing. Because the two tones are widely separated in frequency, their amplitudes will inevitably have differences as shown in ***Figure 2***. As suggested by P. Vizmuller,[7] the amplitude imbalance can be calibrated out, based on arithmetic average. Therefore, the two different intermodulation distortion ratios are averaged and the amplifier input IP3 is calculated based on this averaged number.

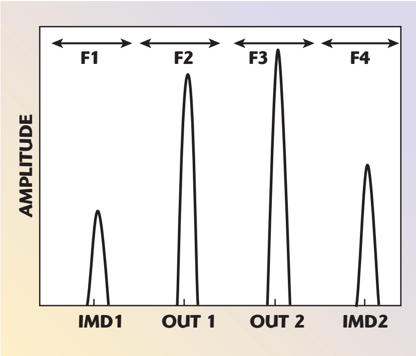

Fig. 2 Four consecutive bands used to measure four products of an amplifier output.

MEASUREMENT RESULTS

Anritsu network analyzer 37397C is used in this work. In fact, the above mentioned method applies both to Anritsu 37×××C and 37×××D series analyzers. The two external sources are Anritsu 68177C and 68037C. The amplifier used in this work is a packaged microwave integrated circuit (IC) HMC482 from Hittite Microwave Corp., which is biased at +7.0 V, 83 mA. The selection of input excitation tones power level should be high enough to be able to excite the third-order IMD products, and low enough not to reach the amplifier input P1dB point. This is because the arithmetic average used assumes that the outputs of the fundamental tones and IMD products are increased linearly with the inputs (when evaluated in dB). Because the datasheet suggests that the amplifier has an input 1 dB saturation point at approximately 2.5 dBm, the two input fundamental excitations are set to -5 dBm and 100 MHz spaced apart. The insertion loss of the power combining network is calibrated out during the 0 dBm absolute power calibration. It can also be measured in advance with the network analyzer following a standard S-parameter measurement and deducted in data post processing.

The individual power levels of the output signals and IMD products are extracted to perform the amplitude imbalance calibration.[7] The measured amplifier gain, third-order IMD and the extrapolated input IP3 (IIP3) are plotted in ***Figure 3***.

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IMAGE REJECTION MIXERS				
IRM0204(*)C2(**)	2 - 4	7.5	18	20
IRM0408(*)C2(**)	4 - 8	8	18	20
IRM0812(*)C2(**)	8 - 12	8	18	20
IRM1218(*)C2(**)	12 - 18	10	18	20
IRM0208(*)C2(**)	2 - 8	9	18	18
IRM0618(*)C2(**)	6 - 18	10	18	18
IR1826NI7(**)	18 - 26	10.5	18	20
IR2640NI7(**)	26 - 40	12	18	20

Model Number	RF/LO Frequency (GHz)	Conversion Loss (dB) Max.	Balance Phase (±Deg.) Typ./Max.	Balance Amplitude (±dB) Typ./Max.	LO-to-RF Isolation (dB) Min.
I/Q DEMODULATORS					
IRM0204(*)C2Q	2 - 4	10.5	7.5/10	1.0/1.5	20
IRM0408(*)C2Q	4 - 8	11	7.5/10	1.0/1.5	20
IRM0812(*)C2Q	8 - 12	11	5/7.5	.75/1.0	20
IRM1218(*)C2Q	12 - 18	13	10/15	1.0/1.5	20
IRM0208(*)C2Q	2 - 8	12	7.5/10	1.0/1.5	18
IRM0618(*)C2Q	6 - 18	13	10/15	1.0/1.5	18
IR1826NI7Q	18 - 26	13.5	10/15	1.0/1.5	20
IR2640NI7Q	26 - 40	15	10/15	1.0/1.5	20

SSB UPCONVERTERS OR I/Q MODULATORS

Model Number	RF Frequency (GHz)	Conversion Loss (dB) Max.	Carrier Suppression (dBc) Min.	Carrier Suppression Carrier - Fundamental IF (dBc) Min.
IF DRIVEN MODULATORS				
SSM0204(*)C2MD(**)	2 - 4	9	20	20
SSM0408(*)C2MD(**)	4 - 8	9	20	18
SSM0812(*)C2MD(**)	8 - 12	9	20	20
SSM1218(*)C2MD(**)	12 - 18	10	20	18
SSM0208(*)C2MD(**)	2 - 8	9	20	18
SSM0618(*)C2MD(**)	6 - 18	12	20	18

For Carrier Driven Modulators, please contact MITEQ.

MODEL NUMBER OPTION TABLE

(*) Add Letter	LO/IF Power Range	P1 dB C.P. (dBm) (Typ.)	(**) Add Letter	IF FREQUENCY OPTION (MHz)
L	10 - 13 dBm	+6	A	20 - 40
M	13 - 16 dBm	+10	B	40 - 80
H	17 - 20 dBm	+15	C	100 - 200
			Q	DC - 500 (I/Q)

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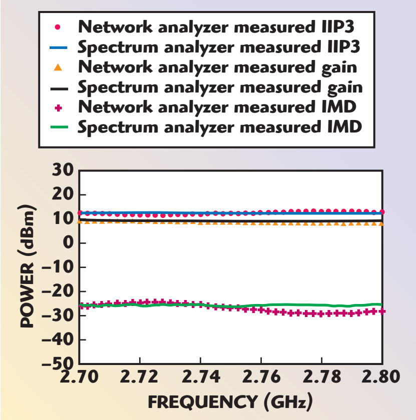


▲ *Fig. 3 Measured results of an amplifier using a network analyzer and a spectrum analyzer.*

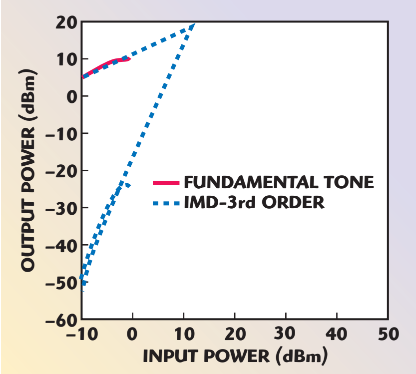
In order to verify the functionality of the proposed measurement technique, a spectrum analyzer is used to make the measurement with the same amplifier and power combining network setup. It is observed from Figure 3 that the results obtained from these two measurement methods generally agree, which confirms the functionality of the proposed method in this work.

Meanwhile, the network analyzer measurement setup can also be used to perform a swept power measurement at a fixed frequency point. For the same amplifier, the measured results are shown in ***Figure 4*** with the input power swept from -10 dBm to 0 dBm. The extracted IP3 number is approximately 15 dBm, which generally agrees with the results of the sweep frequency measurement and verifies the robustness of the proposed method.

It is worth pointing out that if extra 0 dBm absolute power line calibrations are done both at a radio-frequency band and an intermediate-frequency band, the same multiple source programming technique can also be used in a three-port mixer input IP3 measurement.

CONCLUSION

This article presents a network analyzer programming technique for IP3 measurement, using Anritsu network analyzer 37×××C, which is featured with the ability to perform a two-tone measurement with a wide frequency spacing in the range of a few hundred megahertz. The detailed network analyzer calibration and multiple source console programming procedures are given. To verify the functionality



▲ *Fig. 4 Measured results for swept power at a fixed frequency.*

of the proposed method, the classic spectrum analyzer approach is used as a comparison. The agreement between these two measurement methods confirms the effectiveness of the proposed method. ■

ACKNOWLEDGMENTS

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ANALYSIS OF 3G NOISE TO GPS IN 3G HANDSETS

In this article, an analysis of W-CDMA and GSM TX noises and their effects on global positioning system (GPS) performance inside a 3G mobile handset is introduced. The existence of GPS and other services and features in a mobile handset present a challenge to GPS performance. Particularly challenging are carriers like GSM and W-CDMA. The transmitter (TX) of the cellular service interferes with the performance of GPS, due to high TX power and TX band noise leaking into the GPS band. The degradation will be in the form of an increase in the total system noise figure (~5.5 dB). The total system noise figure will contribute a dB-for-dB in sensitivity degradation that is an approximately 5.5 dB loss in received signal strength. The loss in the received signal power leads to loss of reliable and accurate service and most importantly loss of service in areas where it is needed most.

Radio frequency (RF) interference in a mobile handset has many causes. Closeness of band spectrum, less spatial isolation due to smaller phone size, transmit power and transmitter noise due to filter characteristics are some of the elements that lead to unintentional interference. Because GPS service and cellular carriers exist in most phones, cellular interference affects GPS performance in the following ways:

Blocker interference: this type of interference can overload (saturate) the RF front-end of the GPS by driving it into compression. ***Table 1*** shows the services, with their TX frequency bands in MHz that could co-exist with the GPS service on the same phone. Any TX frequency or its harmonic generation with other frequencies could fall in the frequency band of GPS. The front-end filter will not be able to block it because its bandwidth is wide enough to let these types of frequencies go through.

Noise Floor (NF): From the Table, it can be seen that the DCS/W-CDMA B4 are the closest spectrum to the GPS band and therefore represent the major source of TX band noise due to their closeness to the GPS band with non-ideal transmit filter characteristics. The increased noise floor results from the fact that a W-CDMA transmitter is always on in a cell phone, which results in a rise in the noise floor of the total system that will have a one to one effect on the overall sensitivity. Since the GPS signal operates below the thermal noise floor within the given bandwidth, any increase in noise floor (Equation 1) due to out-of-band wideband noise (W-CDMA TX) would result in GPS performance degradation.

$$\text{NoiseFloor}=-174+10\log(2.046\ \text{MHz}) \cong -111\ \text{dBm} \quad (1)$$

The number -174 (in dBm-Hz) is the thermal noise power, which is the kT product of Boltzmann's constant and the absolute temperature in degrees Kelvin in a 1 Hz bandwidth: $k = 1.38 \times 10^{-23}$ J/K, T = 290K.

$$kT(1.38\times10^{-23}\ \text{J/K})290\ \text{K}=-204\ \text{dBW} \quad (2)$$

and -204 dBW = -174 dBm.

2.046 MHz is the typical GPS coarse ac-

TABLE I

SERVICES THAT COULD EXIST ON THE SAME PHONE

GSM 850	GSM900/ W-CDMA B8	GPS (L1)	DCS/W-CDMA B4	PCS	W-CDMA B1	ISM Bluetooth 2.4 GHz
824-849	880-915	1575	1710-1785	1850-1910	1920-1980	2400-2483

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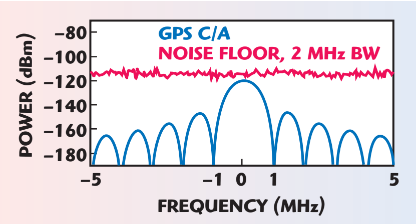
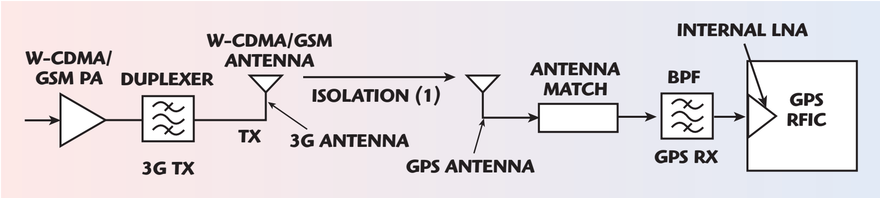


▲ *Fig. 1 GPS signal is below the noise floor (reprinted with permission[4]).*



▲ *Fig. 2 Typical co-existence 3G-GPS scenario.*

quisition (C/A) code bandwidth. The specification for a GPS C/A code signal strength at the GPS antenna is -160 dBW = -130 dBm, well below the noise floor as shown in ***Figure 1***.

When pulsed interference penetrates through the front-end within the GPS band, nonlinear gain stages (such as the LNA) could very well be driven into saturation (nonlinear operation). This situation is not desired, because of the fact that not only does the LNA stop providing constant gain, but intermodulation frequency products could be generated and hence provide more sources of interference to the GPS receiver. Depending on how strong the pulsed interference is, the LNA could be so deep in the saturation region that it will take it a longer time to go back and establish the linear operation again. As a consequence, one of the receiver nonlinear subsystem parameters is its recovery time, which is the time it takes the active stage in the receiver to go back to its linear operation after it was driven into saturation by an input power. For example, the recovery time specification of the internal LNA of the SiGe SE4120S GNSS Receiver IC is 1.3 µs, while it is 2 ms for the whole receiver system, based on some criteria such as the input overload signal level for the LNA and the initial value of the RMS level of the analog to digital converter for the receiver system.[1]

Other potential interference sources are the second harmonic input intercept point (IIP2) of the W-CDMA transmitter and the receiver phase noise. The IIP2 frequency could fall within the intermediate frequency bandwidth (IF) of the GPS receiver. Also, the phase noise frequency could mix with the interferer frequency and fall in the IF band.

NF has many sources. One source of contribution is the transmitter's noise, TX noise. The transmitter, which has a power amplifier (PA) as the major component, does not transmit only in the frequency (or bands of frequencies) it is designed for, but it transmits part of its power into other bands (in the form of spurious emissions, due to non-ideal transmit filter characteristics). Based on specifications or measurements, the PA would have tabulated numbers of TX band noise for each band such as GPS or L1 band. For example, 3G B4 (TX frequency: 1710 to 1755 MHz) PA. Its transmit frequency band is 1710 to 1755 MHz at approximately 28 dBm. But the transmitted signal goes through a bandpass filter with a realistic spectrum that does not stop the TX power infinitely at 1710 or 1755 MHz. Instead, part of the power will spill into other bands like GPS band (L1: 1575.42 MHz). As an example, the amount of power that goes into the L1 band, due to a 3G band 2 PA, is -141 dBm/Hz minimum and -138 dBm/Hz maximum.[2] This is the amount of noise of a band 2 PA that affects the system noise figure of the GPS receiver. Another example is the 3G B4 PA; -137 dBm/Hz typical and -134 dBm/Hz maximum[3] and so on.

Another source to the NF is the GPS receiver chain. It is known that each element in the chain has a power loss, which reduces the amount of power (P_{in}) that goes into the element to a power out (P_{out}). The total loss across the chain translates into a noise figure. ***Figure 2*** depicts a general representation of a 3G TX system and a GPS RX system.

ANALYSIS AND BACKGROUND

In the following, the background and analysis behind some of NF sources is presented.

NF Due to GPS RX System Hardware

The GPS RX hardware is made up of a chain of components and transmission lines (starting with the antenna match) that will have insertion loss and/or mismatch loss between two consecutive matching stages. By looking at the figure, let us denote the GPS RX filter (BPF is actually called Blocker filter) insertion loss as IL1. Let us denote the total noise figure of the RFIC as NF. The NF for the RX system, without the effect of 3G TX, is RX_NF (excluding the antenna and antenna match):

$$RX\_NF = IL1 + \left[(NF - 1)/IL1\right] \quad (3)$$

As an example, typical numbers for IL1 is 1 dB and NF = 2 dB. First, all the dB numbers have to be converted to ratios. Then, RX_NF = 10 log (2) = 3 dB

3G TX Power and Noise Contribution to NF

3G maximum TX power is usually specified at the antenna connector to be 24 dBm; let us denote the maximum TX power by P_{WTX}. The antenna to antenna isolation is denoted as I. The antenna to antenna isolation figure includes the gains/losses of both the 3G TX system and GPS RX system antennas, respectively. Denote the noise of the 3G TX into the GPS band as N_{WTX}. Then the NF due to TX noise into the GPS band ($NF_{TX\text{-}Noise}$) is calculated as follows:

$$NF_{TXNoise} = 10\log(1 + 10^{(174+P_{WTX}+N_{WTX}-I-A-RX\_NF)/10}) \quad (4)$$

where RX_NF is the receive noise figure, as shown above, a denotes the duplexer attenuation. In most 3G PA modules, the specified TX power includes the effect of the duplexer. Then a = 0. As an example, typical numbers for P_{WTX} is 24 dBm, N_{WTX} = -190 dBc/Hz, I = 15 dB and RX_NF = 3 dB, then $NF_{TXNoise} = 10\log \cdot (1+10^{(174+24-190-15-0-3)/10}) = 0.41$ dB

Based on the above two examples, the total noise figure (NF) of the whole system (due to TX band noise + RX_NF):Total NF = 3 + 0.41 = 3.41 dB

A typical number for a total NF, due to 3G TX noise and hardware chain, into L1 Band is 4 to 5 dB of NF, embodied in a rise in noise floor of the GPS RX system. That means the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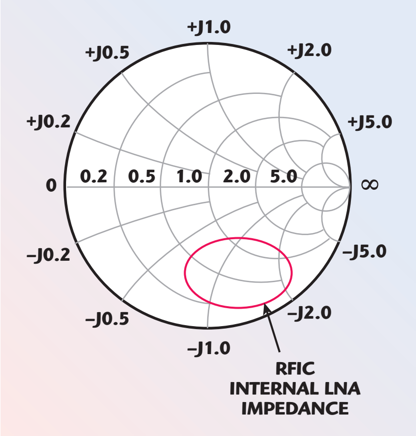


▲ *Fig. 3 Current GPS RFICs have a built-in internal LNA.*

desired signal is 4 to 5 dB lower than the noise floor. That would be a dB-for-dB of sensitivity degradation. The effect of raising the noise floor reflects on the tracking capability of the GPS receiver.

NF Due to Mismatch Loss (Return Loss)

Another source of NF is the mismatch loss. This is due to impedance mismatch between the source of the signal and the destination. These are usually assessed through measurements and/or simulations and then incorporated into the system NF equation. This could be incorporated in Equation 3 as well.

This discussion assumes a 50 Ω input impedance into the RF input of the RFIC. Usually, the RF input of the RFIC is the input impedance of the internal LNA of the RFIC, which changes based on its bias point conditions. This input impedance is seldom a 50 Ω system. Instead, most of the time, it falls way down in the capacitive region of the Smith chart, as shown in ***Figure 3***. On the other hand, a BPF is a 50 Ω input and output system. This dictates a matching circuit between the output of BPF (50 Ω in and out) and the input of the RFIC and the existence of a mismatch loss (ML), due to reflection. When the reflection is converted to dB, it is called return loss (RL).

In this case Equation 3 needs to incorporate the effect of ML:

$$RX\_NF = IL1 + \frac{ML-1}{IL1} + \frac{NF-1}{IL1 * ML} \quad (5)$$

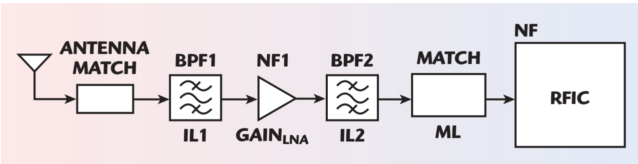
Mitigation Techniques

The above analysis shows that once the 3G transmitter is on, there is no way of suppressing its noise effect, unless a 3G PA is designed that has very stringent requirements on its TX noise N_{WTX} into the GPS band; say -200 dB/Hz, and reduce the 3G power P_{WTX} to a lower level, say 15 dBm, whenever an unsatisfactory level of sensitivity degradation is detected due to 3G TX noise. A third way is to reduce the RF front-end system noise figure by adding an LNA in the lineup, as shown in ***Figure 4***. Based on the architecture and analysis shown and Equation 6, there is approximately 2.5 dB of improvement due to adding the LNA in the front-end lineup.

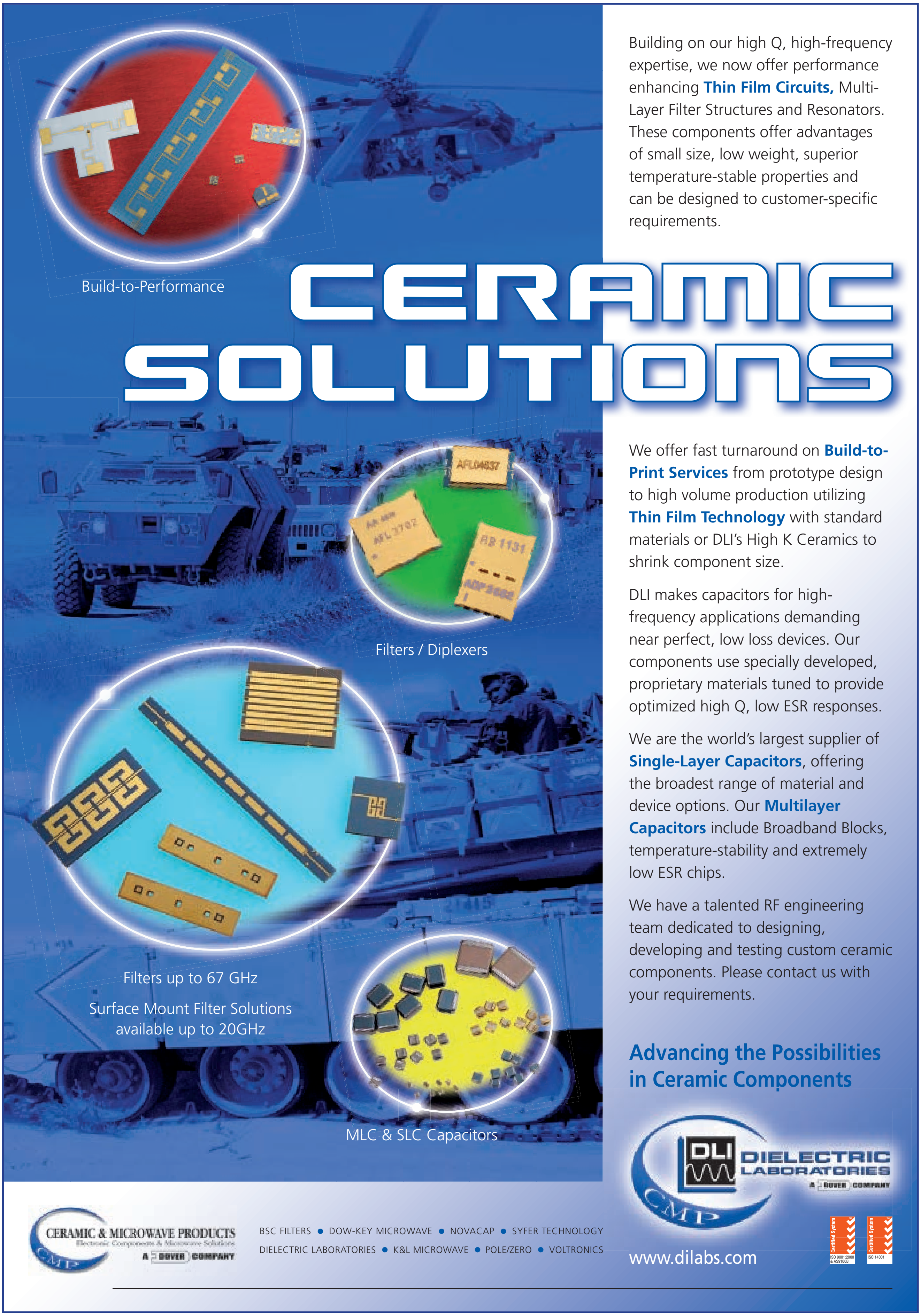
$$RX\_NF = IL1 + \frac{NF1-1}{IL1} + \frac{IL2-1}{(IL1)GainLNA} + \frac{ML-1}{(IL2)(IL1)(GainLNA)} + \frac{NF-1}{(ML)(IL2)(IL1)(GainLNA)} \quad (6)$$

CONCLUSION

The above analysis and results show that if a mobile handset product is chosen to offer both GPS and 3G services at the same time to its customers, design decisions have to be made and sacrifices have to be made. These sacrifices could be based on performance or cost. If loss of GPS service or sensitivity degradation is acceptable during a 3G call, then one might want the cheaper solution with no LNA in the lineup. If, on other hand, one would like to maintain a 3G call along with a better GPS performance, then one might want to make a cost and complexity decision, by adding the LNA in the front-end lineup. But the LNA is not the only component added. Its associated bias circuitry, matching circuitry and another bandpass filter in



▲ *Fig. 4 GPS receiver possible front-end.*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the lineup are needed in addition to dealing with board layout headaches to make sure the LNA is stable and performing to system level specifications. GPS performance, these days, is extremely important, where in some situations it is a safety issue. It should be mentioned, however, that other techniques such as pulse blanking offer a suboptimal solution to mitigate pulse interference.[5] Blanking does not only suppress the interfering pulse signal but also suppresses the desired GPS signal for the duration of the pulse. In some designs, pulse blanking leads to approximately 1 to 3 dB in signal to noise ratio degradation. ■

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3. Avago Technologies, "UTMS1700/2100 (1710 to 1755 MHz) and UMTS1700 (1750 to 1785 MHz)," *Datasheet*, 2009.
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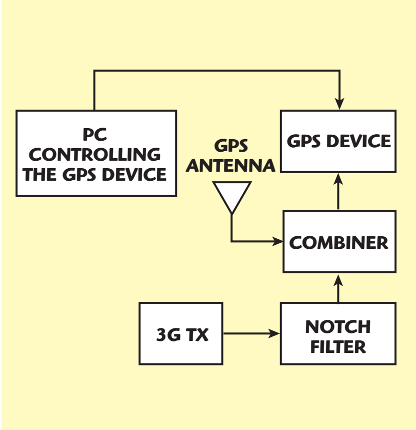
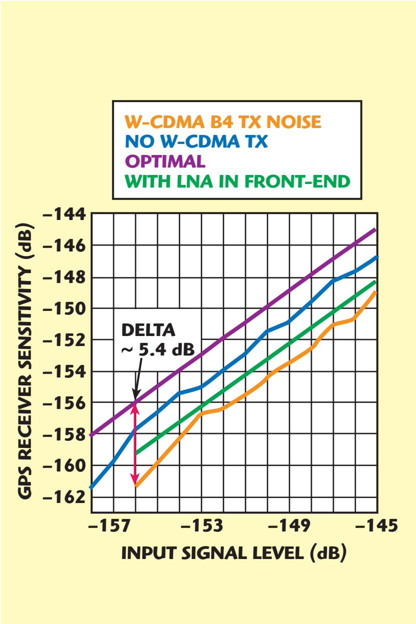
APPENDIX: MEASUREMENT PROCEDURE

Figure A1 shows an outline of the proposed measurement procedure and equipment needed.



▲ *Fig. A1 Proposed measurement procedure and equipment.*



▲ *Fig. A2 Impact of W-CDMA TX band 4 noise on the GPS receiver sensitivity.*

Apparatus needed:

1) A PC controlling the GPS device. 2) USB connection. 3) Any device with GPS service. 4) A GPS antenna. 5) A 3G transmit source. 6) A tunable notch filter that stops the fundamental. This filter will act as the selectivity of the GPS antenna. It should be set to approximately 40 dB of rejection. 7) A combiner that combines the GPS (desired) signal and 3G (Jammer) signal and feeds them into the input port SMA connector of the GPS device. 8) RF cables and connectors.

Procedure (see Figure A1):

1. The PC controls the GPS simulator to run at a certain power level.
2. The GSM/W-CDMA transmit source will transmit signal at the lowest channel (W-CDMA B4: Chan 1312 to 1712.4 MHz).
3. The fundamental in 2 gets attenuated by approximately 40 dB represented by the notch filter so it does not overload the front-end of the receiver.
4. The signals from 1 and 3 are combined using a power combiner.
5. The signal out of the combiner goes in the GPS SMA pig tail coax.

There is a 15 dB of isolation representing spatial isolation, I, b/w the GSM/W-CDMA antenna and the GPS antenna.

Results:

The results are shown in ***Figure A2*** for the case of 3G TX set to W-CDMA band 4 (W-CDMA B4) with the following observations:

Plot colors:

- The purple color is the theoretical (ideal) sensitivity (one-to-one); no losses whatsoever. This is without the presence of NF due to line up insertion loss (IL) or mismatch loss (ML).
- The blue color is sensitivity characterization, no W-CDMA TX noise. This is only due to hardware lineup.
- The orange color is sensitivity characterization due to TX Band 4 noise and hardware lineup.
- The green color is with external LNA place in the front-end lineup-equation (6).
- The GPS receiver stopped tracking satellites at input power levels of -156 dBm and lower.
- Worst case in loss of sensitivity is approximately 5.4 dB at -156 dBm of input power, which agrees with the sample calculations made. In other words, due to the presence of W-CDMA TX noise, the sensitivity of the GPS receiver dropped approximately 2.5 dB.
- One can use typical numbers of their system lineup in the equations above that would correlate with their measurements.

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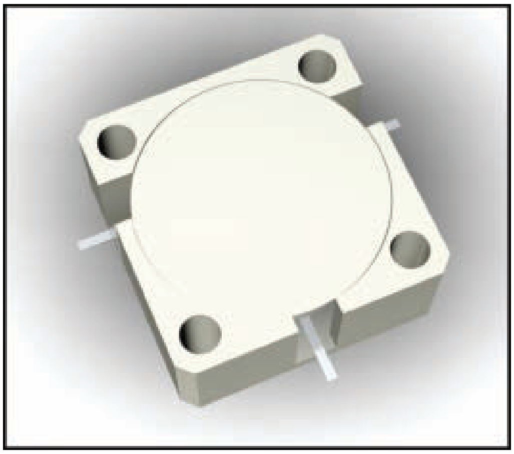
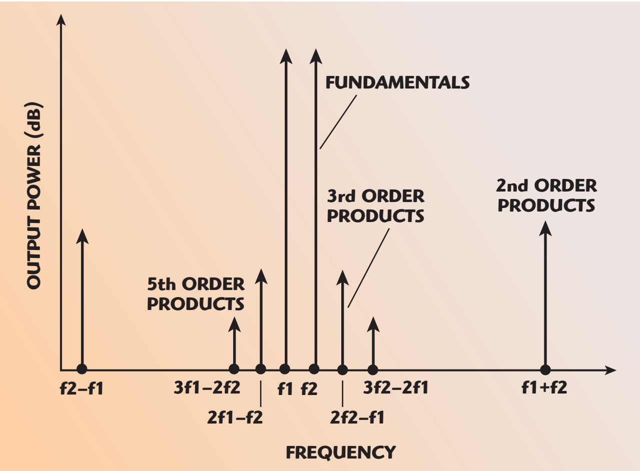
Yinchao Chen *currently is with the Department of Electrical Engineering, University of South Carolina as an Associate Professor. His current research interests include signal integrity for high speed circuits; computational electromagnetics; RF, millimeter-wave and microwave integrated circuits; wireless communication devices; electronic packaging modeling for VLSI devices; and antenna and scattering applications. Chen has published over 200 international publications. He is a co-author of the book, Multiresolution Time Domain Scheme for Electromagnetic Engineering, a contributor of nine book chapters, and a co-editor of two books.*



ISOLATOR/ CIRCULATOR WITH BEST-IN-CLASS INTERMODULATION DISTORTION PERFORMANCE

The increased use of multi-carrier radios in cellular infrastructure systems is driving the requirement for high linearity components, especially in the power amplifier chain. Isolators and circulators have historically been known to impact the overall intermodulation distortion (IMD) performance of a wireless transmission system and are therefore critical to specify. Engineering teams from Skyworks Solutions and Trans-Tech (a subsidiary of Skyworks Solutions) have successfully developed new materials/device designs for isolators and circulators that are optimized for IMD performance and offer the industry very low IMD specifications. The new SKYFR-000700 circulator has IMD performance better than –90 dBc with two +47 dBm tones.



▲ *Fig. 1 IMD products for a two tone signal with frequencies f1 and f2.*

IMD is a nonlinear effect of two or more signals mixing within a device to produce undesirable higher-order products. These unwanted signals may fall within the transmitting or receiving bands, causing interference as a result. These relationships are illustrated in ***Figure 1***, where f1 and f2 are two frequency tones.

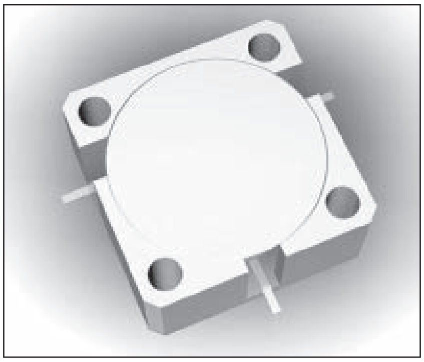
As the odd-numbered products occur at frequencies close to the fundamentals, they are the ones of greatest concern, with the third-order being the most dominant. An industry-standard test to measure the IMD performance

SKYWORKS
Cork, Ireland

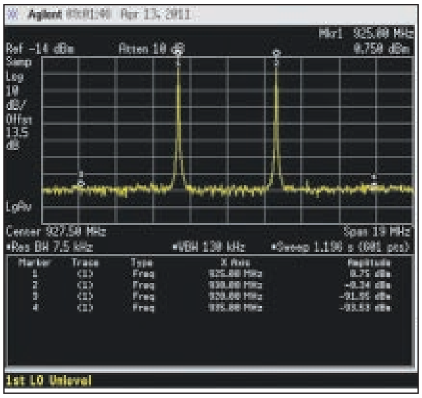
of a device uses two continuous wave (CW) tones, f1 and f2. These signals, separated by 5 MHz, are combined and input to the device. At the output, the third-order and fifth-order products are measured. The third-order products are at 2xf1 – f2 and 2xf2 – f1 and the fifth-order products at 3xf1 – 2xf2 and 3xf2 – 2xf1.

The SKYFR-000700 is a single junction circulator in a 25 × 25 mm housing (see ***Figure 2***), designed to operate in the standard GSM band of 925 to 960 MHz. This circulator can achieve IMD performance of better than –90 dBc with two CW tones of +47 dBm, spaced 5 MHz apart. Two test conditions were used, f1 = 925 MHz and f2 = 930 MHz, and f1 = 960 MHz and f2 = 965 MHz, with each frequency tone at +47 dBm.

The IMD performance of the SKYFR-000700 is compared to a competitive unit. The competitor's



▲ *Fig. 2 SKYFR-000700 image.*



▲ *Fig. 3 SKYFR-000700 two tone IMD measurement at 925 MHz.*

unit is designed for maximum IMD performance using industry-standard magnetic material. The competitive unit achieves IMD performance of –73 dBc versus the Skyworks unit that is better than –90 dBc. The actual performance is shown in ***Figure 3***.

The significant improvement, around 10 dB, in IMD performance of the SKYFR-000700 is the result of unique material selection and improved magnetic and electrical design in the circulator junction. This new approach to non linearity allows the circulator designer to achieve IMD performance of more than 10 dB improvement over existing products. It is expected that additional improvements will be offered in the future by further optimizing combinations of device and materials.

VENDORVIEW

Skyworks,
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HIGH PERFORMANCE 20 GHz MICROWAVE SIGNAL GENERATOR

In order to provide customers with a lightweight, compact, low cost alternative to high-end laboratory-grade instruments, AnaPico has developed the APSIN signal generator product line. The latest addition is the APSIN20G, which is a portable instrument that completes the product family with an instrument that extends the frequency coverage to 20 GHz. The APSIN20G is available with an optional internal rechargeable battery that makes it suitable for applications outside the lab, without any compromise in RF performance.

The microwave signal generator's key performance characteristics are summarized in ***Table 1***. With this instrument, users are able to benefit from leading-edge phase noise, fine frequency resolution, wide dynamic range, fast switching speeds and good analog modulation capabilities. Another key feature is ease of operation in a variety of applications, especially mobile or airborne applications, automated testing and manufacturing, military communications and radar, education and research labs and field testing.

TABLE I

KEY PERFORMANCE SPECIFICATIONS FOR APSIN20G

Parameter	Value
Frequency Range Resolution	9 kHz to 20 GHz 0.001 Hz
Level Resolution Accuracy	–90 to +13 dBm 0.05 dB ±1.3 dB
Harmonics	< –30 dBc
SSB Phase Noise at 10 GHz (20 kHz offset)	–110 dBc/Hz
Switching speed	< 200 microsec
Modulation (internal/external)	AM, DC/AC FM, PM, Pulse, Freq. Chips
Control	Front Panel, USB-TMC, LAN VXI-11, optionally GPIB, SCPI 1999

SIGNAL PURITY

The instrument produces a signal with excellent phase noise and low spurious and harmonic content. The measured phase noise is shown in ***Figure 1***. Single-sideband phase noise of -110 dBc/Hz at 10 GHz carrier and 20 kHz offset is measured, along with low spurious and good harmonic suppression. This makes the signal generator attractive for all applications that require spectrally pure signals.

The APSIN20G's analog modulation capabilities cover AM, FM, ΦM and pulse modulation. Multiple modulations can be combined with up to three internal modulation sources available. External modulation signals are provided through the rear panel connectors that are shown in ***Figure 2***. Wideband low-distortion DC-coupled FM, frequency chirps and user programmable pulse trains complete the instrument's key features.

The APSIN20G uses a temperature compensated ultra-stable 100 MHz OCXO as internal reference. This is divided up to provide a 10 MHz signal at the rear panel output. An exclusive feature, the internal reference can be programmed to phase lock to any external reference frequency from 1 to 250 MHz.

FAST SWITCHING

Today, most ATE applications require fast switching of power and frequency to maximize throughput in manufacturing and testing, and special care has be taken to minimize transients during switching from one frequency to another. With switching speeds of less than 200 µs, the APSIN20G provides a suitable solution. Even faster switching can be achieved with dedicated frequency and list sweeps.

List sweeps can be run with individual dwell

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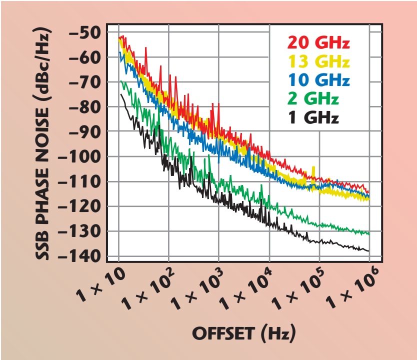
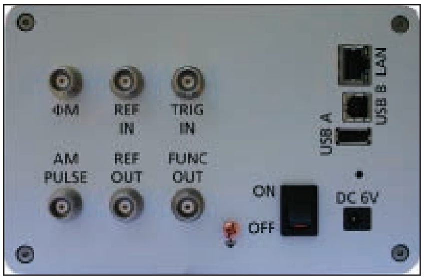
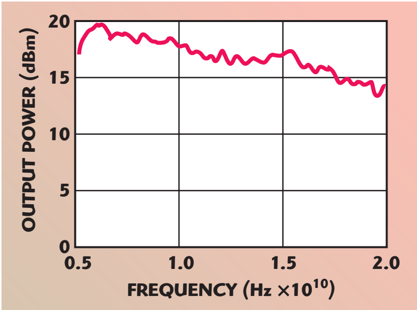


▲ *Fig. 1 Measured phase noise.*



▲ *Fig. 2 External modulation signals are provided through the rear panel connectors.*



▲ *Fig. 3 Measured maximum output power vs. frequency.*

time, off time and power level for each frequency. Even long lists can be loaded and executed with high timing accuracy because transients are taken into account and external triggering (via rear panel input or SCPI) allows full synchronization with the test environment.

In many applications (such as mixers with a high LO drive level), a high RF power is desirable to avoid complicated and costly setups with external power amplifiers. As standard, the APSIN20G provides high output power with low harmonic content. The level setting range is –90 to +13 dBm over the entire frequency range, with typical over-range greater than +15 dBm (see ***Figure 3***).

For applications requiring a level setting range not exceeding 35 dB, the output step attenuator can be omitted. The good level accuracy and repeatability of the instrument – level uncertainty typically < 0.5 dB – provides users with temperature stabilized signal amplitudes.

REMOTE CONTROL

Another key feature of the new instrument is that its ease of use helps to ensure that lab staff and manufacturers can use it very efficiently. User-friendly features include an intuitive front panel with an LCD display and a Windows-based graphical user interface (GUI). In addition to the front-panel controls, the APSIN20G includes Ethernet VXI-11, USB-TMC, and optionally GPIB interfaces for flexibility in setting up a test system with remote control. The USB device port may be used to attach a USB-powered power meter for on-site level calibration.

Setting up the APSIN20G in an automatic-test-equipment (ATE) application is straightforward. Each signal generator is supplied with instrument drivers, programming examples, as well as graphical-user-interface software. The low power and fan-less design is ideal for applications in space-limited and thermal-constraint ATE systems. Also, an optional rack-mount kit is available to simplify integration.

HANDHELD APPLICATIONS

The internal rechargeable battery and a handy soft bag make it a truly portable instrument, which is particularly attractive for service installation and maintenance applications. At just 3 kg, the APSIN20G is light enough to be easily carried around a laboratory or production facility for spot testing. Its good performance, combined with ease-of-use and broad functionality, makes it suitable for field environments and applications that require mobility such as site surveys, on-site system test or base station receive level calibration.

The APSIN20G provides state-of-the-art performance, a complete feature set for modulation, sweeping and triggering and extra features like battery operation. There is no noisy fan and a key feature is flexible reference locking. All of which come at an affordable price.

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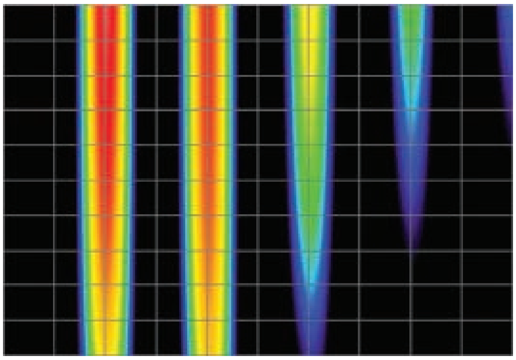
IF/RF MICROWAVE COMPONENTS

482 Rev. C



SPECTRO VNA™ ADVANCES VECTOR NETWORK ANALYZER CAPABILITIES

Spectro VNA™ vector network analyzer software brings the power of joint time-frequency domain processing to vector network analyzers (VNA). Many microwave engineers are familiar with joint time-frequency domain processing from spectrogram displays on vector signal analyzers. Spectrograms display the magnitude of a signal as a function of both time and frequency simultaneously. ***Figure 1*** shows a spectrogram of an 802.11g waveform.

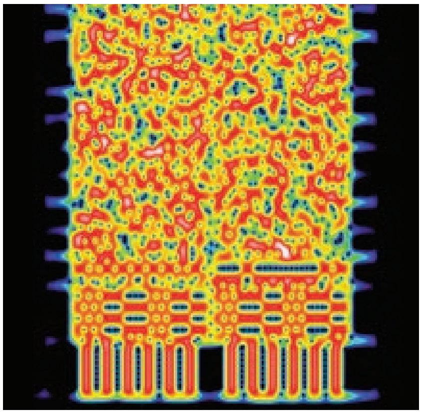


Fig. 1 Spectrogram of an 802.11g signal created with Spectro VSA™.

VISUALIZATION OF S-PARAMETERS

Introducing this technology to the VNA world enhances the visualization of S-parameters and increases the processing capabilities of VNAs. For VNAs, the data being visualized is not a signal, but a transfer function of a device. Traditional VNA views of S-parameters in the frequency domain show magnitude versus frequency. Time domain processing shows magnitude versus time. A joint time-frequency domain plot shows the frequency dependent behavior of individual responses.

Figure 2 shows a spectrogram for the S_{11} of a device. The horizontal scale is time; the vertical scale is frequency. The color represents the magnitude of S_{11} at a particular moment in time and at a particular frequency. The vertical stripe at 2 nsec shows a variation in color from lower frequency to higher frequency, indicating that the reflection is greater at higher frequencies. This is one of the principal values of joint time-frequency processing as applied to VNAs, namely, the ability to see the frequency response of a part of the device.

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TM1-0	0.3 - 1000	1:1	
TM1-1	0.4 - 500	1:1	
TM1.5-2	0.5 - 550	1.5:1	
TM2-1	1 - 600	2:1	
TM1-6	5 - 3000	1:1	
TM2-GT	5 - 1500	2:1	
TM4-GT	5 - 1000	4:1	
TM8-GT	5 - 1000	8:1	
TM4-1	10 - 1000	1:4	
TM4-4	10 - 2500	1:4	
TM1-2	20 - 1200	1:1	
TM1-9	100 - 5000	1:1	
TM1-8	800 - 4000	1:1	

SYNERGY® MICROWAVE CORPORATION

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Phone: (973) 881-8800 Fax: (973) 881-8361 E-mail: sales@synergymwave.com

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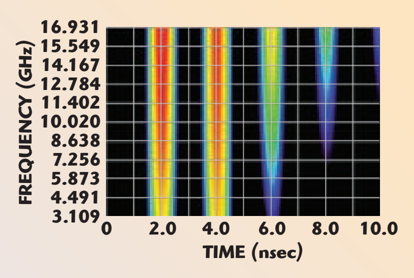
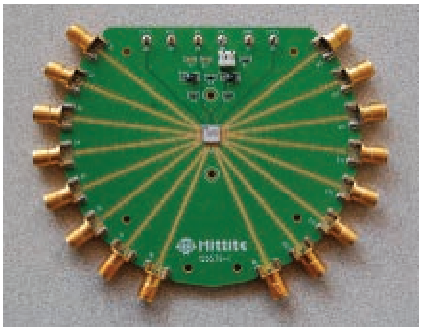


▲ *Fig. 2 Spectrogram of S_{11} produced with Spectro VNA™.*



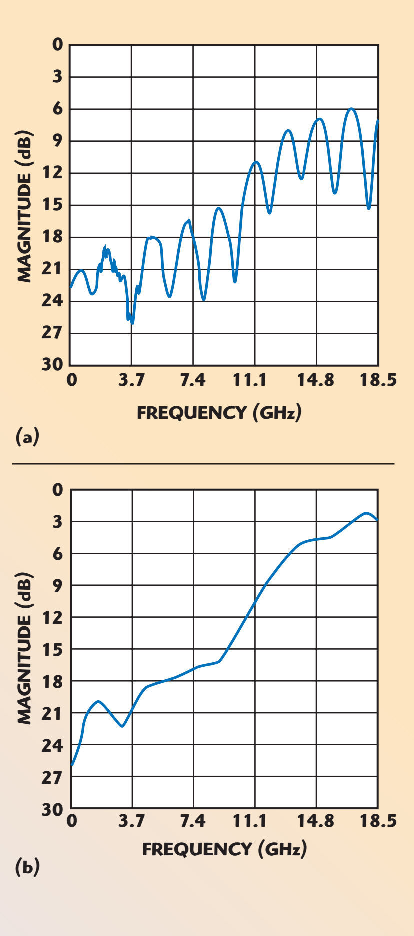
▲ *Fig. 3 PC board with SMA launches, lossy transmission lines and a device to be measured.*

S-PARAMETER WORKSPACE

While the visualization of a S-parameter in this way is valuable, a spectrogram is not merely a static image. It is a workspace that can be used to explore the characteristics of a device as both a function of frequency and time. The mathematics of joint time-frequency processing is not impaired by the problems associated with frequency gated by time mathematics typically found in VNA time domain processing. Individual points in the time-frequency space can be examined simply by clicking on the spectrogram. Individual slices can be taken across the frequency domain or time domain. Specific responses can be mathematically isolated and reconstructed using a tool that selects regions of the time-frequency space.

TIME DOMAIN SUBSTITUTION

In addition to generating powerful images, the mathematics of joint time-frequency domain processing enables simplified de-embedding. Time Domain Substitution is a technique for simplified de-embedding using a single standard. That standard can be a short or an open, depending on which standard is easiest to fabricate in the desired environment.



▲ *Fig. 4 $|S_{11}|$ as measured (a), and de-embedded (b) using time domain substitution.*

De-embedding with Time Domain Substitution is accomplished by making two measurements of each port. One measurement is performed on the device and the second is performed on a temporarily placed standard. Typically, it will be convenient to create a temporary short circuit near the device, as high quality short circuits are relatively easy to create. Once the two measurements have been obtained, Spectro VNA processes the results to remove undesirable effects, such as connectors and launches.

As an example, consider the PC board shown in ***Figure 3***. When measuring the input match of a pin of the device, the SMA launch corrupts the measurement. Using Time Domain Substitution, the effects of the launch and the loss of the transmission line between the launch and the device can be removed, leaving just the input match of the chip. ***Figure 4*** shows the measured S_{11} data measured at the SMA input to one pin of the device, and the de-embedded value of S_{11} for the chip. The de-embedded trace (b) has the ripple associated with the interaction of the device and the SMA launch removed, as well as the line loss from the transmission line. Extracting the device response from a measurement of a PC board with a mounted device is quick and easy using Time Domain Substitution. For this example, the measurements were all performed with the device soldered to the board; no socket was needed for additional calibration standards.

Although the example shown here is for one port de-embedding, Time Domain Substitution can be used to de-embed two port measurements. It can also be applied to n-port devices. A particular advantage for multi-port devices is that Time Domain Substitution does not require port-to-port standards to be able to de-embed multi-port measurements.

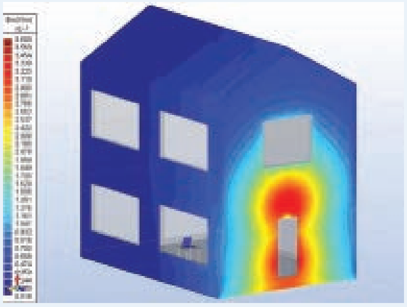
APPLICATIONS

Spectro VNA is useful when debugging device or measurement issues as it shows S-parameter values simultaneously in time and frequency. The de-embedding method, called Time Domain Substitution, is helpful for removing the effects of PC boards or other circuit elements that lie between the calibration reference plane of a VNA and the DUT.

AVAILABILITY

Spectro VNA is available as a purchase or subscription on a monthly basis. Using the subscription model, users only pay for the software when they need it. They can discontinue use for an arbitrary period of time and then resume later when the need arises. Spectro VNA can retrieve data directly from many brands and models of VNAs. The data can also be input from files using the S1P, S2P, S3P and S4P formats. It runs under Windows XP, Vista, or 7. No additional hardware or software is required.

Constant Wave,
Colorado Springs, CO
(719) 331-2442,
www.constantwave.com.



TIME DOMAIN SOLVER AND HIGH FREQUENCY MODELING AND SIMULATION

INTEGRATED Engineering Software has released CHRONOS, its new time domain solver and high frequency tool for modeling and simulating 3D RF and microwave applications. Its easy-to-use interface enables design engineers to model the geometry and assigns its physical properties, providing fast and accurate results in both time domain and frequency domain. Time domain results can be transformed and displayed with different parameters in the frequency domain using the powerful automatic post processing tools.

By adding CHRONOS, INTEGRATED now proudly offers a complete suite of electromagnetic tools, ranging from low frequency to light waves, from static to complete transient solutions. INTEGRATED's software programs can be seamlessly coupled to thermal analysis for an even-more thorough development.

In terms of variety of solvers, INTEGRATED now has added the Finite Difference Time Domain method; this is an addition to the Boundary Element and Finite Element solvers currently available in the company's software packages.

CHRONOS is ideal for the analysis and design of RF and antenna applications including:

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The move from Frequency Domain techniques into the Finite Difference Time-Domain (FDTD), combined with the parallelization of the program, brings significant time savings.

INTEGRATED Engineering Software, Winnipeg, MB, Canada (204) 632-5636, www.integratedsoft.com.

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484 Rev A

AFFORDABLE, HIGH PERFORMANCE SIGNAL GENERATOR

Stanford Research has developed a DC to 4 GHz high performance, affordable RF source, the SG384 4 GHz RF signal generator. The SG384 uses a unique, innovative architecture (Rational Approximation Frequency Synthesis) to deliver ultra-high frequency resolution (1 µHz), excellent phase noise (–116 dBc/Hz SSB phase noise at 20 kHz offset at 1 GHz), versatile modulation capabilities (AM, FM, ΦM, pulse modulation and sweeps) at a fraction of the cost of competing designs. The standard model SG384 produces sine waves from DC to 4.05 GHz. There is an optional frequency doubler (Opt. 02) that extends the frequency range to 8.10 GHz. Low-jitter differential clock outputs (Opt. 01) are available, and an external I/Q modulation input (Opt. 03) is also offered. For demanding applications, the SG384 can be ordered with a rubidium timebase (Opt. 04).

The SG384 is based on a new frequency synthesis technique called Rational Approximation Frequency Synthesis (RAFS). RAFS uses small integer divisors in a conventional phase-locked loop (PLL) to synthesize a frequency that would be close to the desired frequency (typically within ±100 ppm) using the nominal PLL reference frequency. The PLL reference frequency, which is sourced by a voltage-controlled crystal oscillator that is phase-locked to a dithered direct digital synthesizer, is adjusted so that the PLL generates the exact frequency. Doing so provides a high phase comparison frequency (typically 25 MHz) yielding low phase noise while moving the PLL reference spurs far from the carrier where they can be easily removed. The end result is an agile RF source with low phase noise, essentially infinite frequency resolution, without the spurs of fractional-N synthesis or the cost of a YIG oscillator.

Stanford Research Systems, Sunnyvale, CA (408) 744-9040, www.thinkSRS.com.


Mini-Circuits
ZVA-213X

Orange Book of Knowledge

VENDORVIEW

AR has recently released the fourth edition of The Orange Book of Knowledge. The book contains articles and application notes on a wide range of topics and applications, including a reference guide for coaxial connectors and cables and harmonic measurement for IEC 61000-4-3. Visit www.arworld.us to download your copy today or request one from your local sales associate.

AR RF/Microwave Instrumentation,
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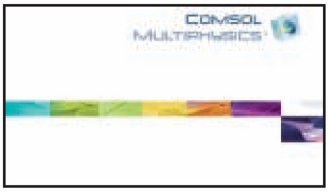
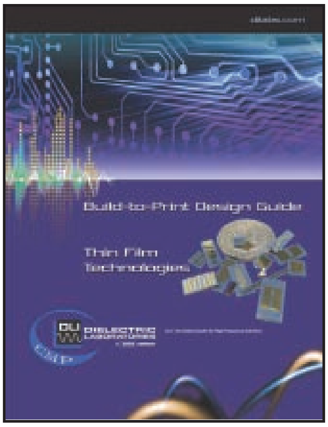


Guide to Multiphysics Simulation Tools

VENDORVIEW

The COMSOL Product Booklet 2011 is now available free of charge at www.comsol.com/activity/us_mjlist_mar11/1. It is a comprehensive guide to multiphysics simulation tools. This valuable resource provides an inside look at a technology that allows you to simulate designs in a quick, precise way. Highlights include multiphysics simulation, solvers and performance, specifications, and applications (CFD, structural mechanics, chemical engineering, electromagnetics).

COMSOL,
Burlington, MA (781) 273-3322, www.comsol.com.



Build-to-Print Design Guide

DLI offers Build-to-Print services designed to facilitate thin film product design, manufacturing and testing from prototype to high volume production. DLI's custom ceramics offer significantly better thermal performance than the majority of industry standard ceramics and have an added benefit of a sufficiently higher dielectric constant allowing miniaturization opportunities and temperature stable performance. Convert your Build-to-Print design to a Build-to-Performance specification where DLI can provide 100 percent tested products that guarantee performance.

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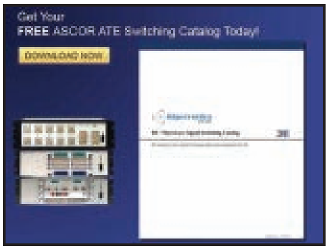
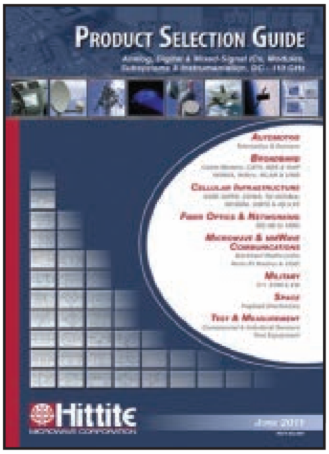


ATE Switching Catalog

This catalog highlights Giga-tronics ASCOR Common-Core based signal switching solutions. The Series 8800 provides a modular RF/LF/DC switching platform that is scalable and reconfigurable to meet existing and emerging test requirements, covering the DC to 50 GHz frequency range. Download the ASCOR Series 8800 Brochure at www.gigatronics.com/downloads/datasheets/ASCOR_Series8800_Brochure.pdf.

Giga-tronics,
San Ramon, CA (925) 328-4650, www.gigatronics.com.



Product Guide

VENDORVIEW

Hittite Microwave Corp., the world class supplier of complete MMIC-based solutions for communication and military markets, is pleased to announce the release of the June 2011 Product Selection Guide, summarizing more than 925 products, including 17 new products. This selection guide organizes Hittite's portfolio by product line as well as by market applications. Full specifications for each product are available at www.hittite.com. Click on "My Subscription" to receive the latest product releases.

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

Passive Components

International Manufacturing Services Inc. (IMS) has released its new, comprehensive, color catalog of passive components, showing the full range of IMS' product line in an easy-to-navigate format. The 16-page catalog contains information for IMS' resistors, thermal management devices, terminations, attenuators, power splitters and couplers, RF and microwave dividers, and low pass filters products groups. Applications charts, performance graphs and other specifications can be viewed online or downloaded and saved as a PDF.

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  - Saturday 8th October (16.00 – 19.00)
  - Sunday 9th October (07.30 – 17.00)
  - Monday 10th October (07.30 – 17.00)
  - Tuesday 11th October (07.30 – 17.00)
  - Wednesday 12th October (07.30 – 17.00)
  - Thursday 13th October (07.30 – 17.00)
  - Friday 14th October (07.30 – 10.00)

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Reduced rates are offered if you have society membership to any of the following: Eu*M*A, GAAS, IET or IEEE
Eu*M*A membership costs: Professional: £17/year - Student: £12/year
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EuMC + EuRAD	£503.00	£163.00	£654.00	£211.00
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EuMC + EuRAD	£653.00	£211.00	£849.00	£273.00
EuMIC + EuRAD	£557.00	£199.00	£724.00	£258.00
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Full day WITHOUT Conference registration	£135.00	£100.00	£175.00	£125.00

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All papers published for presentation at each conference will be on a CD-ROM, given out FREE with the delegate bags to those attending conferences. For additional CD-ROMS the cost is £42

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DVD Archive EuMC 2004-2008	£30.00	£106.00

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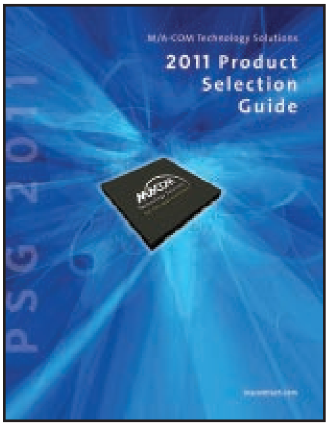


Product Selection Guide

VENDORVIEW

M/A-COM Technology Solutions Product Selection Guide (PSG) summarizes more than 3000 standard products that serve diverse markets, including cable TV, cellular backhaul, fiber optics, aerospace and defense, automotive, industrial, medical, and mobile devices. This latest edition features newly released products, including the Optomai Optoelectronics product line. In addition, you will find block diagrams that illustrate how M/A-COM Tech's products are integrated within major system architectures across various applications. For a print copy, visit www.macomtech.com/content/contactus.

M/A-COM Technology Solutions,
Lowell, MA (978) 656-2500, www.macomtech.com.

RF/Microwave Semiconductors Product Guide

Massachusetts Bay Technologies, an ISO-9001:2008 certified manufacturer of RF/microwave silicon diodes, has released a new RF/microwave Semiconductors Product Guide. This guide features new products, new part numbers and the company's complete line of silicon diode and thin film products. Please contact MBT sales or your local representative for a copy of the new MBT product guide.

Massachusetts Bay Technologies (MBT),
Stoughton, MA (781) 344-8809, www.massbaytech.com.

IF/RF Microwave Signal Processing Components Guide

VENDORVIEW

Mini-Circuits' new 164-page catalog includes over 750 new products and the industry's most comprehensive listing of RF/IF and microwave components and subsystems with more than 4100 products and more than 25 product lines, including state-of-the-art amplifiers, mixers, VCOs, synthesizers, filters, test accessories and USB Power Sensors. Mini-Circuits' website provides additional data, application notes, design tools and its powerful YONI search engine, which searches actual test data on thousands of units.

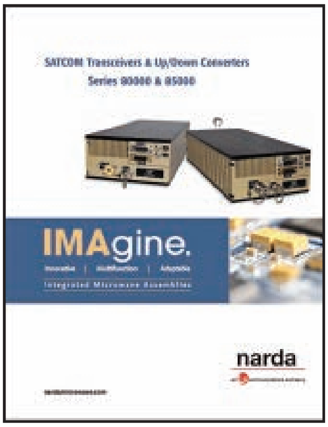
Mini-Circuits,
Brooklyn, NY (718) 934-4500, www.minicircuits.com.

Component CD Catalog

VENDORVIEW

MITEQ recently released its Spring 2011 full-line CD Components Catalog (CD-02M), which offers one of the most comprehensive displays of standard and custom capabilities in the industry. The CD includes thousands of pages of product specifications, outline drawings, test data, manufacturing flow diagrams, and a wide assortment of technical application notes.

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

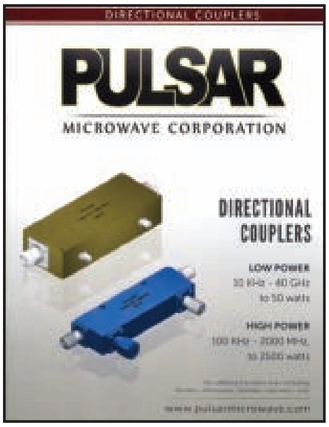


Product Catalog

VENDORVIEW

Narda has a new catalog dedicated to its Series 80000 and Series 85000 satellite communications transceivers and up- and downconverters. The Series 8000 includes the Model 81000 and 82000 transceivers that convert an L-band intermediate frequency to X- and Ku- or Ka-bands and are based on Narda's Ultimate SMT Integrated Microwave Assembly (IMA) technology. The Series 85000 downconverter subsystems include all of the conversion functions of the Series 8000 but are designed for applications in which an external RF power amplifier is desired, resulting in smaller, lighter enclosures.

Narda,
Hauppauge, NY (631) 231-1700, www.nardamicrowave.com/east.



Directional Couplers

Pulsar Microwave's directional couplers include lump element, microstrip, stripline and airline techniques in surface-mount, drop-in and connectorized configurations. The enormous library of designs makes it practical to offer modifications of catalog items quickly and as cost-effective as standard parts.

Pulsar Microwave Corp.,
Clifton, NJ (973) 779-6262, www.pulsarmicrowave.com.

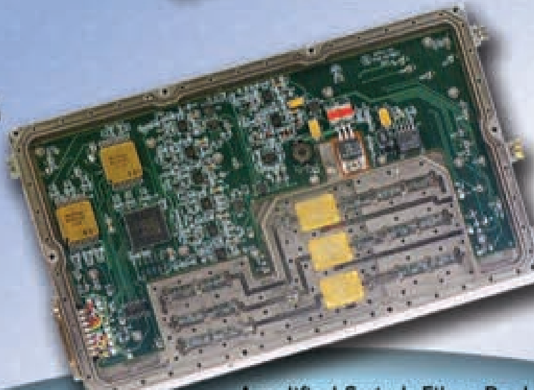
Integrated Microwave Assemblies

IMA Reality

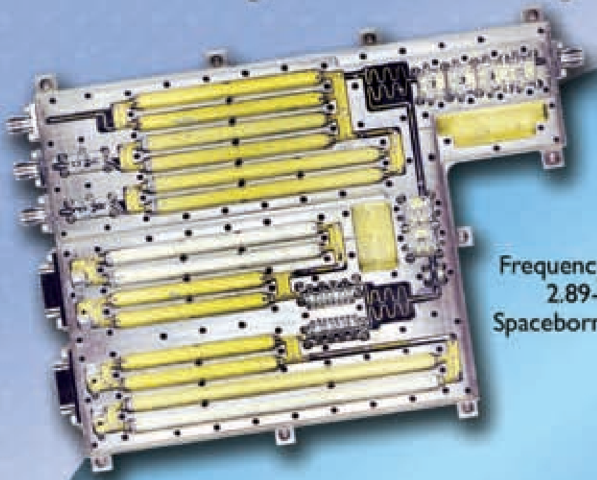
performance, not imagined

MITEQ is the IMA expert. Offering more than 40 years of resident engineering and manufacturing of every **IMA element and microwave component:** *amplifiers, mixers, control products, oscillators, frequency sources, fiber optic links, passive products, FPGA digital control, monitoring and communications circuits, all integrated into our state-of-the-art IMAs.* ***MITEQ is clearly set apart, as the Leader in Integrated Microwave Assembly Design and Manufacturing***!

L-Band
BUC/15W Ka-Band SSPA



Amplified Switch Filter Bank
9 Selectable Bands
5-18 GHz



Frequency Multiplexer
2.89-9.9 GHz
Spaceborne Application

Wideband
Synthesizer & LO Chain
Covering Both X- & Ku-Band

• State-of-the-Art Manufacturing And Design Facilities •
including five buildings totaling 340,000 square feet

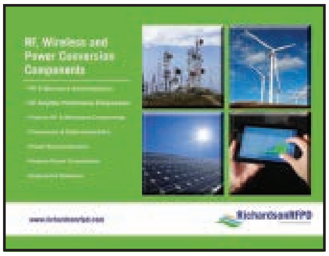
• Total Vertical Manufacturing And Design Integration •
from the simple feedthru to the most sophisticated IMA end item

• Extensive, Innovative Library Of IMA Designs •
collected from over **40 years of IMA Heritage**

• HiRel Space Qualified IMAs •

When Experience, Expertise and Resources all count, MITEQ has the Solution!
At MITEQ the only thing left to the imagination...
are the possibilities!

MITEQ
www.miteq.com • e-mail: components@miteq.com
100 Davids Drive, Hauppauge, NY 11788 • TEL: 631-436-7400, Fax: 631-436-7430



Supplier Line Card

Richardson RFPD Inc.'s 2011 supplier line card is a 16-page booklet that includes listings for more than 220 product categories from 78 of the industry's suppliers of discrete devices, components and assemblies used in RF and wireless infrastructure, networking, digital broadcasting, defense, microwave and power conversion. It lists Richardson RFPD suppliers of RF active component solutions, RF passive and electromechanical solutions, RF interconnect solutions, high power conversion passive products and power semiconductors for renewable energy and high power applications. The Richardson RFPD line card is available as a downloadable PDF from the company's website.

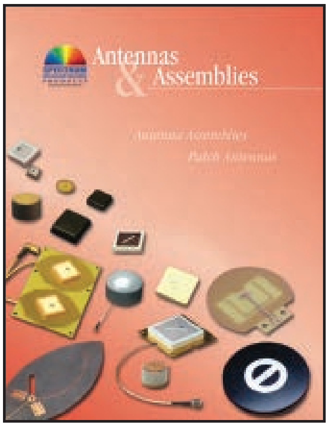
Richardson RFPD Inc.,
LaFox, IL (630) 208-2700, www.richardsonrfpd.com.

RF & Microwave Coaxial Connectors and Cable Assemblies Brochure

VENDORVIEW

San-tron's brochure features New S292™ connectors offering VSWR of < 1.18 through 40 GHz; improved Type N T connectors; solder-free Type N right angle adapters that perform up to 11 GHz; Type N panel receptacles that feature rugged single piece body construction; new eSMA cable assemblies that replace semi-rigid assemblies; field-replaceable SMAs that minimize loss from DC to 26.5 GHz; new Type N connectors that offer smooth electrical performance from DC to 18 GHz; and a 7/16 panel receptacle featuring -175 dBc intermodulation performance.

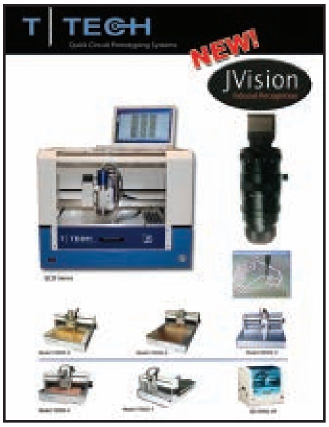
San-tron Inc.,
Ipswich, MA (978) 356-1585, www.santron.com.



Antennas and Assemblies Brochure

The antennas & assemblies brochure from Spectrum Advanced Specialty Products outlines Spectrum's complete vertical integration and extensive custom capabilities for antennas and antenna assemblies. The superior performance, high frequency and broadest bandwidth of Spectrum's antennas make them ideal for mission-critical applications. Antenna types include aperture, spiral, slot, planar, beam-forming static, switched array and more.

Spectrum Advanced Specialty Products,
Fairview, PA (814) 474-1571, www.specemc.com.



Prototyping Systems Guide

T-Tech offers a full line of Quick Circuit prototyping systems. With clients in more than 46 countries, and thousands of systems in the field, T-Tech's customers range from some of the world's largest corporations and research institutions, to academic institutions and small businesses. T-Tech's premier prototyping system, the QCJ5, features third axis motion control, up to 32 automatic tool change positions, automatic depth control, four-zone selectable precision vacuum table, and front-panel control of common system commands.

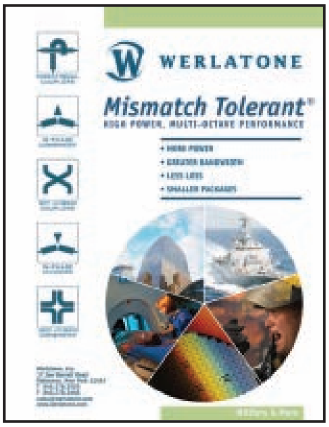
T-Tech Inc.,
Norcross, GA (770) 455-0676, www.t-tech.com.

Portable Signal Generators and Digital Attenuators Brochure

VENDORVIEW

Vaunix's six-page brochure details features and specifications of the Lab Brick Signal Generator, Lab Brick Digital Attenuator, and powered USB Hub product lines. Applications include use with automated test equipment (ATE) and in the engineering or production test labs. All Lab Brick signal generators and digital attenuators are USB powered and controlled with an easy-to-install-and-use graphical user interface (GUI) software. They are portable, light-weight, and are ideal for use on the bench and in the field.

Vaunix Technology Corp.,
Haverhill, MA (978) 662-7839, www.vaunix.com.



Product Brochure

VENDORVIEW

Since 1965, Werlatone has supplied a full range of high power combiners, dividers, 90° hybrid couplers and directional couplers. This brochure introduces a few of the company's newest products, while also providing tabular data on another 100 popular models. Werlatone's full library contains more than 2000 models, so please contact Werlatone at www.werlatone.com with your full specification. More than 65 percent of Werlatone's deliveries are custom in nature. Supporting the RF industry from 9 kHz to 6 GHz at 5 W to 20 kW.

Werlatone Inc.,
Patterson, NY (845) 278-2220, www.werlatone.com.

The 2011 Defence and Security Forum

At European Microwave Week, Manchester, UK
Wednesday, October 12th

The resounding success of the inaugural EuMW Defence/Security Executive Forum at EuMW 2010 in Paris has prompted expansion of the event into a full-day Forum at European Microwave Week 2011

The 2011 EuMW Defence and Security Forum will feature:

MORNING SESSIONS
Safety and Security - considering the application of the microwave technology that is being developed to increase security and address safety issues.

LUNCH AND LEARN
Provided to all attendees, courtesy of **Strategy Analytics**, who will present market data and analysis on the global defence market.

AFTERNOON SESSIONS
Radar and EW - focusing on the challenges and solutions for modern systems.

NETWORK RECEPTION
A brief reception will take place following the afternoon sessions and preceding the Executive Forum.

EXECUTIVE FORUM
Executives from government defence agencies and leading defence/security OEM contractors will consider how their organizations view future threats to global safety, security and defence and the role of technology in addressing these risks. A Q & A session will conclude the event.

Attendance is FREE
Register at www.eumweek.com

A limited number of sponsorships are available
Contact your sales representative or Carl Sheffres at csheffres@mwjournal.com for more information or to reserve your sponsorship

Microwave Journal
Frequency Matters.

EuMA
European Microwave Association

Components

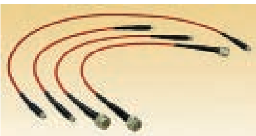
100 W SP3T Switches

Aeroflex introduces the MSW3200-320 and MSW3201-320 SP3Ts, covering frequencies of 10 to 1500 MHz and 200 to 4500 MHz, respectively. Both switches handle up to 100 W of CW input RF with an IIP3 of 65 dBm. Insertion loss is approximately 0.5 dB. For pulsed applications, these switches handle up to 500 W at 10 μ sec pulse and 1 percent duty cycle. Designed for durable, reliable use in military IED jammers and radar, applications also include military, commercial and industrial radios. Typical switching speed is 1 to 2 μ sec.

Aeroflex/Metelics,
Londonderry, NH (888) 641-7364,
www.aeroflex.com/metelics.

Coaxial Test Cables

VENDORVIEW



Available in 0.5 m increments from 0.5 m through to 5.0 m, the new ARC-CA18 series of coaxial test cables are designed for general purpose laboratory and equipment applications where durability, performance and affordability are key features. With velocity of propagation at 70 percent and a frequency range of DC to 18 GHz, the test cables feature the choice of either SMA or type N stainless steel connectors to MIL-C-39012 and achieve phase stability of ±2 degrees.

AtlanTecRF,
Braintree, UK +44 1376 550220,
www.atlantecrf.com.

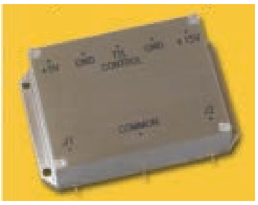
SMA Coaxial Attenuator

The 42XXF is a high performance, precision SMA coaxial attenuator value priced for high volume applications. This new and improved version of the 42XX series of SMA coaxial attenuators is offered in commercial or high reliability versions for a wide range of applications. EMC coaxial attenuators are manufactured with a stainless steel body and a standard SMA male/female interface, and are smaller and lighter weight than those on the market. This product is available in values from 0 to 20 dB in one dB increments and up to a maximum frequency range of 12.4 GHz.

EMC Technology,
Stuart, FL (772) 600-1620,
www.emc-rflabs.com.

Surface-mount Switch

The 50S-1887 SMT is a surface-mount switch that can handle up to 100 W (average RF input power) and is capable of hot-switching 20 W.



The 50S-1887 is designed to operate from 225 to 400 MHz, but other frequency ranges may be available upon request.

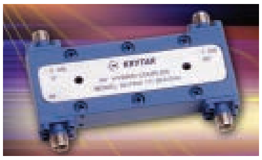
JFW Industries,
Indianapolis, IN (317) 887-1340,
www.jfwindustries.com.

2 mmWave Range Magnetron

This 2 mmWave range magnetron has a lifetime of 1000 hours. Having a forced-air cooling system rather than fluid cooling means that the input power is significantly reduced and that the dimensions of the radar station can be decreased. The magnetron's small dimensions and weight of only 2.6 kg mean that its applications are not just limited to land-based systems. Its pulsed output power is 4 kW. However, the company claims to be able to provide 10 kW output power at the customer's request, alongside other customization options.

JSC Pluton,
Moscow, Russia +7 (495) 916 87 01,
www.pluton.msk.ru.

Quadrature Hybrid Coupler



Model 3017360 is a multi-purpose, quadrature hybrid stripline design with applications including monopulse comparators, power combining/dividing, mixers, modulators and phased array antenna systems. KRYTAR's technological advances have extended the frequency range of this four-port unit from 1.7 to 36 GHz with coupling loss of 3 dB, greater than 12 dB isolation, ±1.7 dB amplitude imbalance and ±12-degrees of phase imbalance. The hybrid coupler exhibits insertion loss of less than 3.2 dB across the frequency range. Maximum VSWR is 1.85 and power rating is 20 W average and 3 kW peak. Model 3017360 is a compact package measuring 2.6 "(L) × 0.625" (W) × 0.50" (H), weighs only 1.6 ounces, and comes with 2.92 mm coaxial female connectors. Operating temperature is -54° to 85°C.

KRYTAR Inc.,
Sunnyvale, CA (408) 734-5999,
www.krytar.com.

Solid-state Attenuator

VENDORVIEW

The PMI model DTA-30M6G-60-CD-1 is a solid-state attenuator that operates in a frequency range from 30 MHz to 6 GHz. Features include mean attenuation range of 60 dB; insertion loss of 4.0 dB maximum; return loss of 8.5 dB maximum; minimum attenuation step is 0.25 dB; switching time is 5.0 usec maximium; control is 8-bit TTL; DC voltage is +12 VDC; connectors are SMA(F) ×2 and 15 Pin Micro-D. Size 2.0"L × 1.8"W × 0.5"H.

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

Directional Coupler

Pulsar model CS20-52-436-9 is a new 20 dB coupler covering the frequency range of 2 to 40 GHz with 1.6 dB insertion loss. Directivity is greater than 10 dB and flatness is ±0.5 dB, 2 to 20 GHz and ±1.0 dB, 2 to 40 GHz. The VSWR is 1.80:1 maximum and the unit can handle 20 W into a 1.20:1 load. Connectors are 2.92 mm female.

Pulsar Microwave Corp.,
Clifton, NJ (973) 779-6262,
www.pulsarmicrowave.com.

Miniature Discrete Component Filters

VENDORVIEW

Reactel offers its miniature discrete component filters in lowpass, highpass, bandpass, notch and diplexer configurations operating in a frequency range of 10 to 5000 MHz. These little powerhouses are perfect for mobile or man-pack systems, and are rugged enough to withstand the harshest of environments.

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

High Power Coaxial Coupler

R&D Microwave is introducing its new 1 to 18 GHz high power taperline coaxial couplers, featuring a combination of high performance specifications that are excellent for instrumentation test or system applications. Model C1-B12 covers the full frequency range with ±1 dB accuracy, including frequency flatness, in 20 or 30 dB coupling values. The unique tapered coaxial air dielectric structure has minimal insertion loss of typically 0.2 dB and is capable of handling power levels up to 600 W. Input return loss and directivity is better than 15 dB over the full frequency range, and typically 25 dB over most of the frequency range.

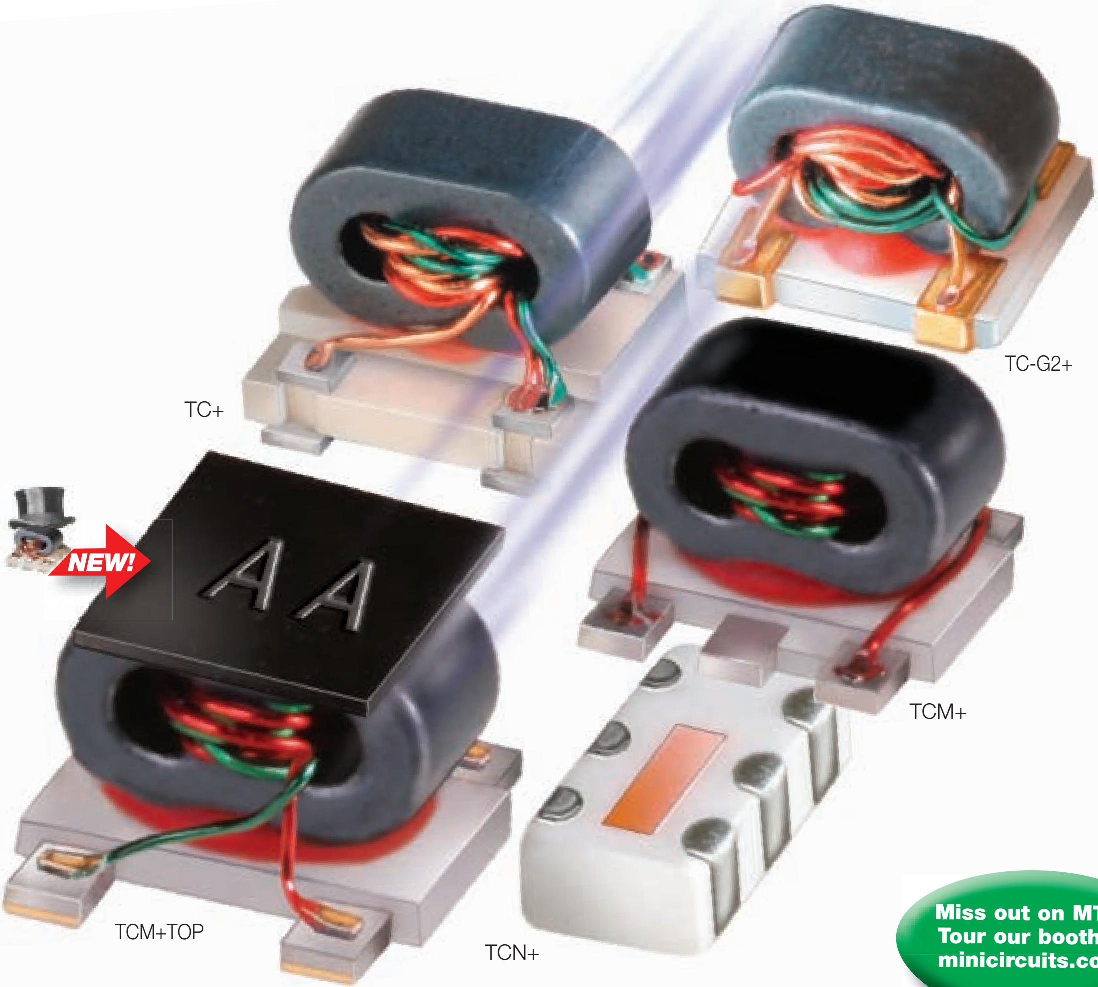
R&D Microwaves LLC,
East Hanover, NJ
(908) 212-1696,
www.rdmicrowaves.com.

Octave Band Drop-in Circulator

VENDORVIEW

Renaissance has designed a new octave band drop-in circulator, model 3G7BH, that

TINY RF & MICROWAVE
TRANSFORMERS



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0.15-6200 MHz *as low as* **99¢** each *(qty. 1000)*

Every transformer you need, right off the shelf!
Need an RF or microwave frequency transformer with a small footprint? Mini-Circuits has what you need, already in stock. Our TC-series transformers cover a wide variety of frequency ranges, with rugged construction, outstanding VSWR performance and several packages to fit your size, reliability and environmental requirements—and we can ship within a week of your order. Don't see what you need? Our engineers can customize a model to your needs at no extra charge.

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TC-G2+ Ceramic with gold-plated terminals for military and high-reliability requirements.

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TC+ and TCM+ All-welded construction and a plastic base for commercial applications.

TC-TOP Features a "top-hat" package with square top surface and model markings that can improve your manufacturing throughput.

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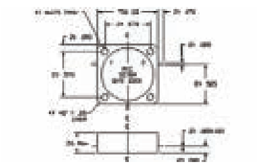
U.S. patent 7739260

IF/RF MICROWAVE COMPONENTS

377 rev V



covers a bandwidth of 5.2 to 11 GHz over -20° to +85°C. With insertion loss less than 0.95 dB over the entire band, the circulator is robust to handle 20 W of incident RF power. Return loss and isolation of 13 dB ensures better match to the RF circuitry where it is being placed. It is housed in a 0.75" square stainless steel housing for temperature stable performance. For more information, contact sales at 978-772-7774, sales@recusa.com or visit www.rec-usa.com.

Renaissance Electronics,
Harvard, MA
(978) 772-7774,
www.rec-usa.com.

RF323x Quad-band Transmit Module Family

RFMD's new RF3232, RF3233 and RF3234 quad-band transmit modules are ideal for the final portion of the transmitter section in multi-mode 3G entry handsets and connected devices. These modules are the core of RFMD's RF323x Power Platform and include 50 Ω matched input and output ports, eliminating the need for external PA-to-antenna switch module matching components. The RF323x quad-band transmit module family is for UMTS/WCDMA/TD-SCDMA applications.

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

STR-2 Series Expansion

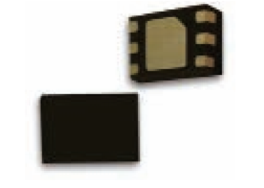
RLC Electronics Inc. has expanded the terminated single-pole double throw switch (STR-2 series) with a new 50 GHz version using 2.4 mm connectors. This model is optimized for excellent RF performance with an insertion loss of 1.1 dB maximum, VSWR 2:1 and an isolation of 50 dB. Standard operating modes are failsafe and latching with self cut-off; other options include TTL driver and indicators. Applications for this switch include high frequency test and measurement where excellent RF performance is necessary.

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

Two-way Power Dividers

VENDORVIEW

The VFPD200 series of miniature monolithic two-way zero degree power dividers consists of seven models spanning the frequency range of 700 MHz to 3.8 GHz and are offered in a miniature 1.5 × 2.0 mm leadless package. Valpey Fisher's RF/microwave passive products utilize a custom design and monolithic manufacturing process, which offer outstanding electrical performance and part-to-part repeatability when compared to today's existing solutions. Samples are available upon request.



Valpey Fisher Corp.,
Hopkinton, MA
(800) 982-5737,
www.vapleyfisher.com.

Two-way Combiner, 20 to 1000 MHz

VENDORVIEW

Model D8300, rated at 100 W at the sum port, is also rated for 10 W/input in a non-coherent combing application provided it is mounted to a proper heat dissipation surface. Designed for military and commercial applications, this unit will tolerate a full input failure, at rated power.

Werlatone Inc.,
Patterson, NY (845) 278-2220,
www.werlatone.com.

Amplifiers

26 to 40 GHz 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. Package size is 3.60" × 4.31" × 0.65", or the unit 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 maximum) via standard TTL command.

AML Communications,
Santa Clara, CA (408) 727-6666,
www.amlj.com.

High Power Pulsed Broadband Amplifier

Model BPHED27457-400 is a new high power pulsed broadband amplifier for Synthetic Aperture Radar (SAR) applications covering the frequency range of 25 to 450 MHz. This amplifier provides a high power pulsed RF output into one of three selectable antenna ports. The amplifier is designed to operate in an airborne Foliage Penetration (FOPEN) or Ground Penetrating Radar (GPR) SAR application. The amplifier is packaged in a single mountable assembly, which includes integrated T/R switches, a dummy load, harmonic filtering, and DC-to-DC converters. It is suited for payloads with limitations in size, weight and power. The entire assembly is just 12" × 12" × 24", weighs less than 60 pounds, and requires less than 700 W.

Comtech PST,
Melville, NY (631) 777-8900,
www.comtechpst.com.

Compact SSPA

CTT Inc. announces a new compact, solid-state power amplifier (SSPA) operating in the 6 to 18 GHz frequency range. This SSPA is a GaN-based MMIC design that offers 40 W of output power in a compact package. Additional specifications include a minimum of +46 dB of gain, maximum, gain flatness of ±2.5 dB, noise figure of 8.0 dB. Power saturation (Psat) performance is +44.5 dBm, minimum and +46.0 dBm. Typical applications include wideband jamming for both ship-based and airborne usage. The new SSPA is also suitable for next generation jamming designs. CTT model AGM/180-4646 is based on GaN MMIC technology with operating requirements of +36 V, DC and 6.6 A, typical of DC current. The package measures 4.14" × 3.0" × 0.68".

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

High Power Amplifier

VENDORVIEW

The 500 to 2500 MHz/100 W broadband high power amplifier module (SKU # 1189) model 1189 is a recent addition to the company's portfolio of building block designs incorporating the latest GaN device technologies and control functionality. The module delivers 100 W minimum, 125 W typical Psat over 500 to 2500 MHz at typical efficiencies of 45 percent. An industry leading, small form factor package (7.4 × 3.6 × 1.06) allows for easy integration in compact system designs. This building block module is well suited for use in defense, communications and test applications.

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

Compact, Ka-band Gain Controlled Amplifier

VENDORVIEW

AMF-3F-20002600-68-20P-GC is an amplifier that has over 23 dB of gain from 20 GHz to 26 GHz, in a one-inch long housing. Application of +5 V on the gain control pin decreases gain by 10 dB while maintaining flatness, which is a maximum of ±1.5 dB. This amplifier has a maximum noise

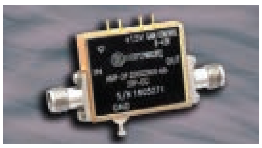


figure of 6.8 dB in the full band. It operates from -40° to +75°C of base temperature, has a P1dB of minimum of 20 dBm and a 500 output. Composite metal body with a CuW base provides excellent thermal characteristics while hermetic sealing is optional if required.

MITEQ Inc., Hauppauge, NY (631) 439-9469, www.miteq.com.

Connectorized Push-Pull Wideband Amplifier

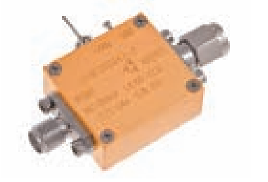
VENDORVIEW

Zx60-23LM+ offers ultra-low second harmonic (high IP2), built-in reverse-bias protection and a cost-effective design. This wideband amplifier is a very low-cost, high performance 500 MHz to 2 GHz device based upon a 50 Ω push-pull design. Built within Mini-Circuits' patented unibody construction, this amplifier features exceptionally low second-order harmonic distortion and is unconditionally stable. It is ideal for a wide range of wireless, small-signal, and lab and test equipment designs.

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

4.4 to 5 GHz Low Noise Amplifier

VENDORVIEW



NIC introduces a wideband LNA operating over the frequency range of 4.4 to 5 GHz, designed for use in C-band, radar and SATCOM applications. This LNA offers a high gain of 30 dB, sub 1 dB noise figure, low current consumption and input power protection, built in a small package size of 1.0" × 0.9" ×0.41". Custom designs are available up to Ku-band.

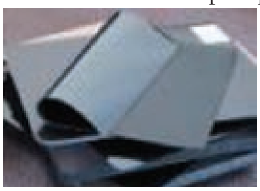
Networks International Corp., Overland Park, KS (913) 685-3400, www.nickc.com.

Material

Self-adhesive Foams

VENDORVIEW

Rogers has introduced two new self-adhesive foams. PORON Thin-Stik ShockSeal™ Foam: 79TS1-09021 successfully combines the compressibility of the ThinStik family of foams with the impact protection of the ShockSeal series. Additionally, this offering exhibits high z-axis tear strength and excellent sealing properties. PORON ThinStik Foam: 92TS1-09020 provides a winning combination of compressibility and tear strength. Additionally, 92TS1 products provide good protection against impact.



Rogers Corp., Rogers, CT (860) 774-9605, www.rogerscorp.com.

Semiconductor/ICs

C-band GaN RF Power Device

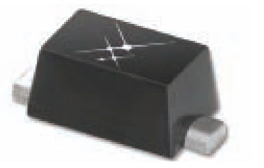
Intended for commercial C-band radar applications including weather radars, part number IGN5459M40 is a GaN/SiC HEMT that operates over the instantaneous bandwidth covering 5.4 to 5.9 GHz in the C-band frequency range. The IGN5459M40 is characterized under 300 μs pulse width and 10% duty cycle pulsing conditions and typically supplies a minimum of 40 W of peak output power and 50 % efficiency. This device is housed in a ceramic flanged package with partial impedance matching circuitry.

Integra Technologies Inc., El Segundo, CA (310) 606-0855, www.integratech.com.

Hyperabrupt Varactor Diode

VENDORVIEW

Skyworks introduces a hyperabrupt varactor diode with a wide tuning range and low phase noise for VCO and voltage tuned filter



applications. This general market diode targets WLAN, CATV LNB, energy management, wireless infrastructure and military applications. The new diode is designed for high-volume commercial and industrial OEMs, ODMs and contract manufacturers who also manufacture voltage-controlled phase shifters and tunable bandpass filters.
Skyworks Solutions Inc.,
Woburn, MA (781) 376-3000,
www.skyworksinc.com.

RF Power Transistor

VENDORVIEW

TriQuint's new packaged GaN discrete RF power transistor offers high PAE, gain and substantial wideband coverage. The T1G6001528-Q3 delivers more than 18 W of output power and greater than 50 percent efficiency across an exceptionally wide bandwidth (DC to 6 GHz). The innovative new T1G6001528-Q3 is ideal for narrow and wideband applications. The T1G6001528-Q3 offers >10 dB gain at 6 GHz and operates at 28 V; it is available in an earless ceramic package.
TriQuint Semiconductor,
Hillsboro, OR (503) 615-9000,
www.triquint.com.

Software

EM Software

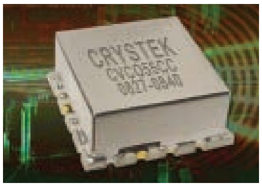
VENDORVIEW

Remcom announces an updated version of its electromagnetic simulation software, XFdtd Release 7 (XF7), which includes several geometric modeling additions and new performance efficiencies. The upgrade, which updates the software to Release 7.2, contains enhancements that simplify and speed overall usability including additional modeling capabilities that enable more precise control over cut geometries when sketching complex models. The upgrade also contains simplified sampling interval settings for Frequencies of Interest (DFT), simulations using averaged materials now exploit XStream GPU acceleration technology, and XFSolver intelligently records which XStream devices are being used for simulations, allowing multiple simultaneous XStream simulations on a single machine.
Remcom Inc.,
State College, PA (814) 861-1299,
www.remcom.com.

Sources

CVCO55CC-0827-0840 VCO

Crystek's CVCO55CC-0827-0840 VCO operates from 827 to 840 MHz with a control voltage range of 0.2 to 4.7 V. This VCO features a typical phase noise of -124 dBc/Hz at 10 KHz offset and has excellent linearity. Output power is typically -6.5 dBm. The model CVCO55CC-0827-0840 is packaged in the



industry-standard 0.5" × 0.5" SMD package. Input voltage is 5 V, with a maximum current consumption of 30 mA. Pulling and pushing are minimized to 0.05 MHz and 0.05 MHz/V, respectively. Second harmonic suppression is -18 dBc typical. The CVCO55CC-0827-0840 is ideal for use in applications such as digital radio equipment, fixed wireless access satellite communications systems, and base stations.
Crystek Corp.,
Ft. Myers, FL (800) 237-3061,
www.crystek.com.

Surface-mount Clock Oscillators

The PLXO series surface-mount phase-locked crystal oscillators are designed to operate at select custom frequencies from 5 to 500 MHz as reference clocks in military and commercial RF/microwave systems. Locked to an external frequency reference (or optional internal reference), the PLXO units feature very low RMS jitter (< 0.05 pSec, typical), excellent phase noise (Fout = 155 MHz, < -120 dBc/Hz at 1 KHz, typical) and low power consumption at +3.3, +5, +8 or +12 VDC. Housed in a miniature surface-mount package (0.9" × 0.9" × 0.15"), the PLXO units also feature no sub-harmonics and operate over an optional wide temperature range (-40° to +85°C).
EM Research Inc.,
Reno, NV (775) 345-2411,
www.emresearch.com.

Phase-locked Reference Source

The new PLOC10-10, a 10 MHz clean-up phase-locked reference source, is a small profile, low cost module. It is ideal for turning a marginal reference signal into a high quality extremely low phase noise reference for critical system applications. It is designed to phase-lock its internal 10 MHz OCXO to the input reference signal. The internal 10 MHz OCXO has exceptionally good phase noise performance [L(100Hz) = -145 dBc/Hz]. When phase-locked to a source with outstanding long term stability, such as an atomic standard or GPS, this module is an ideal 10 MHz frequency source.

Luff Research Inc.,
Floral Park, NY (516) 358-2880,
www.luffresearch.com.

CXOs with Timer Functionality

The RFPT200 is a 7 × 5 mm surface-mount DC-TCXO (digitally-controlled, temperature-compensated crystal oscillator), which brings together unrivalled frequency stability, digital frequency control, a separate low frequency output and embedded timer and alarm functionality, all controlled via a standard SPI interface. Its enhanced functionality allows the system it is used in to be switched off when not required and then switched on again at a predetermined time in the future. The RFPT200 uses Rakon's patented Pluto™ technology to provide a high stability reference frequency for use during receive and transmit.

Rakon Ltd.,
Auckland, New Zealand +64 9 571 9216,
www.rakon.com.

Voltage-controlled Oscillator

Z-Communications Inc.'s RoHS compliant VCO model SMV3727A-LF in S-band operates at 3710 to 3744 MHz with a tuning voltage range of 0.5 to 3 VDC. This VCO features a typical phase noise of -83 dBc/Hz at 10 KHz offset and a typical tuning sensitivity of 142 MHz/V. The SMV3727A-LF is designed to deliver a typical output power of 3 dBm at 2.7 VDC supply while drawing 10 mA (typical) over the temperature range of -40° to 85°C. This VCO features typical second harmonic suppression of -15 dBc and comes in Z-Comm's standard SUB-L package, measuring 0.3" × 0.3" × 0.08".
Z-Communications Inc.,
Poway, CA (858) 621-2700,
www.zcomm.com.

Test Equipment

8 GHz VNA Calibration Kit

This EcoCal calibration kit for SMA-female-connectors supports broadband VNA-measurements of microwave devices up to 8 GHz. This is achieved with three SMA-components for the four calibration measurements short (S), open (O), load (L) and thru (T). It is suitable for industrial departments and laboratories.

Heuermann HF-Technik GmbH, Aachen, Germany +49 2408/9379019, www.hhft.de.

Portable Signal Generator

VENDORVIEW

Designed to fulfill signal generation needs in the field or on the bench, and priced at $14,998, the HMC-T2220B provides the highest output power, lowest harmonic levels and broadest frequency range compared with portable signal generators of similar size and cost. Ideal for use in automated test and measurement environments and in research and development laboratories, the HMC-T2220B is a compact and lightweight frequency generator that delivers up to +28 dBm of CW output power in 0.1 dB steps over a better than 60 dB dynamic range. Harmonic rejection is better than -43 dBc at 2 GHz and spurious products are better than -65 dBc at 10 GHz. Phase noise is -119 dBc/Hz at 100 kHz offset from 1 GHz with insignificant deviation over the temperature range of 0° to +35°C.

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

Introduction to RF Design Using EM Simulators

Hiroaki Kogure, Yoshie Kogure and James Rautio

James Rautio is well known as the founder of Sonnet and his collaboration with the Kogures goes back to 1985. At the time, he had written an antenna analysis program for amateur radio operators that Aki and Yoshie promoted and sold in Japan. They have been working together ever since. As described in this book, a typical moderately high-end desktop computer has increased in speed by about 300 million times as applied to matrix inversion since then. With the huge increases in speed, the industry has also seen huge increases in the numbers of engineers who need to solve microwave problems.

The Kogures have been addressing this need for the last quarter-century in Japan by giving innumerable courses to help bring engineers new to our field up to speed quickly. While these students were eager and motivated, and very skilled in other areas, their knowledge of microwaves was often nearly nonexistent. This book, along with the companion antenna book, is the culmination of all those years of training Japan's new-found microwave engineers. It is intended for anyone who finds themselves in the same situation as the Kogures' Japanese students – lots of motivation, but little knowledge in this highly specialized field. It is for those who will go on to immerse themselves in equation-filled college text books but would like a quick, easy read to get the big picture, to get a fundamental understanding of what is happening before dealing with massive amounts of technical detail. It is also for those who deal with microwave designers, who would like to have a deeper understanding of exactly what is going on, rather than just trying to memorize a few impressive-sounding technical terms.

The Kogures performed the initial translation of this book, and then Rautio provided some polish to the prose and added a few points. The original content of the book is due to work performed by all three authors. The DVD included with this book includes a copy of Sonnet Lite and various files used for the examples in the book. It is highly recommended for beginners in this area of study.

To order this book, contact:

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800-225-9977;
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+44 (0)20 7596 8750

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Math, Science and Logic Puzzles for the 'Enginerd' in All of Us

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Congratulations to MECA on its 50th Anniversary

Einstein as a Speed Devil

How fast should you drive toward a red traffic light to see it appear as green?

Hint: Use Einstein's Theory of Relativity with standard wavelengths for red and green light

WiggleZ Project

The results from a major astronomical survey, project WiggleZ, which uses a cutting-edge technique, appears to have confirmed the existence of mysterious dark energy.

According to the study, what percentage of the universe is made up of dark energy, dark matter (does not reflect or emit detectable light) and ordinary matter?

Find the Way to Freedom

A serial killer is convicted and gets the death penalty. The judge allows him to say one last sentence in order to determine the way the penalty will be carried out. If he lies, he will be hanged; if he speaks the truth, he will be beheaded. The killer speaks one last sentence and to everybody's surprise, he is set free because the judge cannot determine his penalty.

What did the killer say?

ANSWERS AVAILABLE ONLINE AT WWW.MWJOURNAL.COM

Divisible from 1 to 9

Find a number consisting of 9 digits in which each of the digits from 1 to 9 appear only once. This number should satisfy the following requirements:

a. The number should be divisible by 9
b. If the most-right digit is removed, the remaining number should be divisible by 8
c. If then again the most-right digit is removed, the remaining number should be divisible by 7
d. Etc., until the last remaining number of one digit which should be divisible by 1

What is the number?

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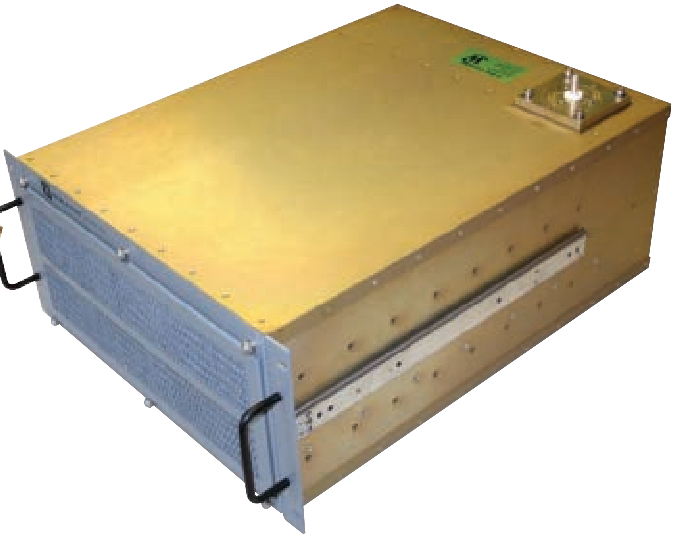

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A few of our Customer driven designs.

Model	Type	Frequency (MHz)	Power (W CW)	Insertion Loss (dB)	VSWR	Isolation (dB)	Size (Inches)
D8265	2-Way	1-50	5,000	0.3	1.25	20	15.5 x 15 x 5.25
D2075	2-Way	1.5-30	6,000	0.2	1.25	20	15.5 x 11.75 x 5.25
D8969	2-Way	1.5-30	12,500	0.2	1.25	20	17 x 17 x 8
D6139	4-Way	1.5-32	5,000	0.25	1.25	20	13 x 11 x 5
D6774	4-Way	1.5-32	20,000	0.3	1.20	20	21 x 17.25 x 11
D6846	6-Way	1.5-30	4,000	0.35	1.35	20	3 U, 19" Rack
D8421	8-Way	1.5-30	12,000	0.3	1.30	20	22.5 x 19.5 x 8.75
D7685	4-Way	2-100	2,500	0.5	1.30	20	14.75 x 13 x 7
D2786	4-Way	20-150	4,000	0.5	1.35	20	18 x 17 x 5
D6078	2-Way	100-500	2,000	0.25	1.20	20	13 x 7 x 2.25
H7521	2-Way (180°)	200-400	2,500	0.3	1.30	20	15 x 10 x 2
D7502	2-Way	400-1000	2,500	0.25	1.20	NI*	9.38 x 3.5 x 1.25

*NI = No Isolating Terminations

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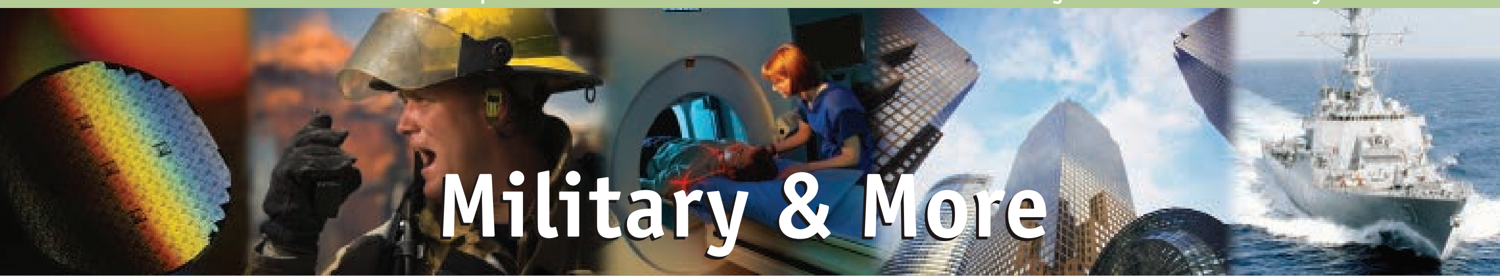

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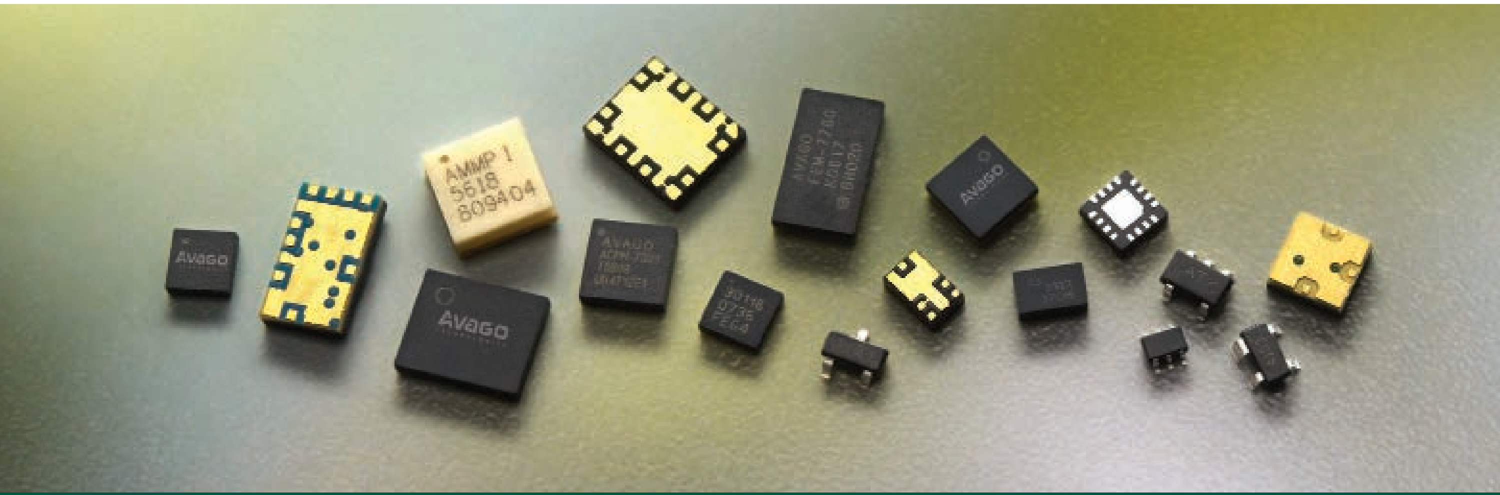
TECHNOLOGIES

Wireless Semiconductor Selection Guide

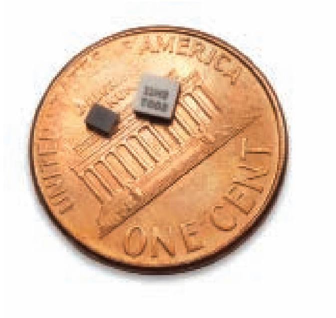


System Application Block Diagrams and Product Suggestions

Your Imagination, Our Innovation
Sense • Illuminate • Connect

Accelerating Progress in Wireless Communications

Mobile communications are changing the way industries and individuals manage their lives, homes, offices and businesses. Avago Technologies is at the forefront of the wireless revolution, offering a broad range of mobile connectivity and wireless solutions, and is the partner of choice for leading wireless manufacturers and service providers around the globe. Avago products add value to every stage in the wireless production cycle.



Avago Technologies' tiny RFICs have helped lead to smaller wireless products with increased battery life.

RF Component Solutions

Avago Technologies RF component innovations have been instrumental in driving the wireless revolution. Avago CoolPAM™ power amplifiers, Film Bulk Acoustic Resonator (FBAR) filters, and Enhancement-mode pHEMT low noise amplifiers have set new benchmarks for performance, size and battery life. Avago products combine innovative technology, three decades of microwave and RF design experience, and expertise in system, protocol and regulatory understanding to create solutions that can help customers meet the most demanding technical specifications and the most difficult regulatory tests around the world.

Manufacturing Technologies

- Film Bulk Acoustic Resonator
- Gallium Arsenide Heterojunction Bipolar Transistor
- Pseudomorphic High Electron Mobility Transistor
- Enhancement Mode Pseudomorphic High Electron Mobility Transistor
- Silicon

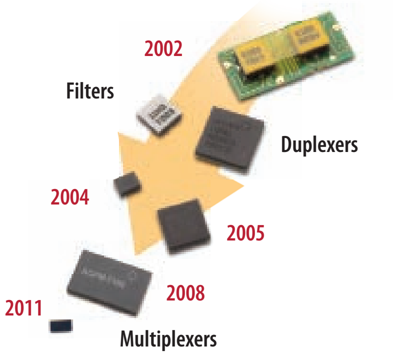
Product Offerings

- Filters, Duplexers, and Multiplexers
- Power Amplifier Modules for many standards, including GSM, CDMA, W-CDMA, TD-SCDMA, LTE, and WiMAX
- Low Noise Amplifiers
- Front End Modules including Power Amplifier – Duplexers and Filter-LNAs
- RFICs
- Schottky and PIN Diodes
- Field Effect and Bipolar Transistors
- Millimeter Wave MMICs

Film Bulk Acoustic Resonator (FBAR) Filters, Duplexers, Multiplexers and GPS Front-end Modules

Today's smartphones face many challenges, including support for difficult band plans and the need for coexistence between multiple radio systems. The exceptional performance of Avago FBAR filtering technology helps designers meet these challenges by providing low loss filtering with steep rejection characteristics. Microcap wafer-to-wafer bonding technology enables flexible, miniature packaging, including true chip-scale WaferCap filters. FBAR filters are also combined with EpHEMT LNAs to create a line of high performance modules that support demanding GPS applications.

Avago Technologies created a new filter technology with FBAR that helps designers solve tough filtering problems.



Features

- Steep roll-off
- Low insertion loss
- High Isolation
- Excellent power handling
- Low temperature coefficient

Benefits

- Supports more efficient use of spectrum
- Extends battery life
- Supports coexistence of simultaneously operating radio systems
- Improves phones sensitivity, enhancing data rate and network performance
- Can support multiple standards

FBAR Duplexer (Package size: 2 x 2.5 x 0.95 mm)

UMTS Band 1	UMTS Band 2 / CDMA PCS	UMTS/LTE Band 3	LTE/UMTS Band 4/CDMA AWS-1	LTE Band 7	UMTS Band 8
ACDM-7614	ACMD-7407	ACMD-6003	ACMD-7609	ACMD-6007	ACMD-7606
ACMD-7617	ACMD-7410				ACMD-7610
	ACMD-4102 (2 x 2.5 x 1.05 mm)				

FBAR Quadplexer

Part No.	Standard	Package Size
ACFM-7109	CDMA PCS & Cellular	3.0x5.0x1.05 mm
ACFM-7110	CDMA PCS & Cellular	3.0x5.0x1.05 mm
ACFM-7107	CDMA PCS & Cellular	4.0x7.0x1.2 mm
ACFM-7325	Extended PCS & Cellular (BC10/BC14)	4.0x7.0x1.2 mm

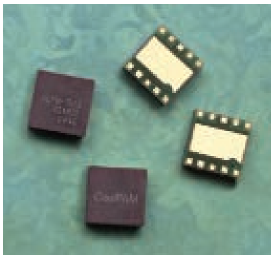
FBAR Filters

Part No.	Standard	Passband	Package Size
ACPF-7005	CDMA PCS+BC14/B25	1850-1915 MHz	1.6 x 2.0 x 1.1mm
ACPF-7024	ISM/WLAN/BT	2401-2482 MHz	1.6 x 2.0 x 0.95 mm
ACPF-7025	WiMAX B41	2496-2690 MHz	2.5 x 2.5 x 1.0 mm

GPS & GLONASS Front-End-Modules

Part No.	Passband	Configuration	Package Size
ALM-2712	1574.42-1576.42 MHz	Filter-LNA-Filter	3.0x2.5x1.0 mm
ALM-1712	1574.42-1576.42 MHz	Filter-LNA-Filter	4.5x2.2x1.1 mm
ALM-1912	1574.42-1576.42 MHz	Filter-LNA	2.9x2.0x1.0 mm
ALM-1412	1574.42-1576.42 MHz	LNA-Filter	3.3x2.1x1.1 mm
ALM-2412	1574.42-1576.42 MHz	LNA-Filter	3.3x2.1x1.1 mm
MGA-310G	1565-1606 MHz	LNA only	1.1x1.13x0.5 mm
MGA-24106	1565-1606 MHz	LNA only	1.5x1.2x0.5 mm
MGA-231T6	1565-1606 MHz	LNA only	2.0x1.3x0.4 mm

Power Amplifier Modules and PA-Duplexer Front End Modules



Avago Technologies CoolPAM and FEM technologies offer superior performance.

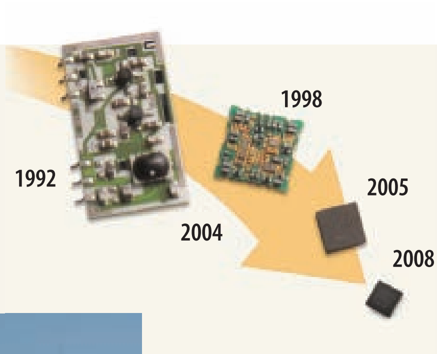
Battery life is one of the most important issues facing designers of next-generation mobile handsets. Not only is it inconvenient to frequently recharge the battery, but lower power consumption in the power amplifier frees more energy for other features like large displays. Avago has developed a technology called CoolPAM™ that helps to optimize battery life by only turning on as much of the power amplifier as is needed, thus greatly enhancing efficiency. Avago has over 15 years of design and manufacturing expertise in power products, and offers power amplifier modules for many different applications. Additionally, Avago has combined its industry-leading FBAR and CoolPAM. technologies to offer a range of integrated modules By combine multiple "best in class" technologies and optimizing partitioning and device interfaces, these devices can provide superior electrical performance, allowing designers get their products to market faster, with less risk and higher yields.

Features

- High Efficiency
- Integrated high directivity coupling
- Support for multiple standards, including CDMA, W-CDMA, GSM/EDGE, LTE, TD-SCDMA, and WiMAX
- Support for most major bands in a common footprint

Benefits

- Extends battery life
- Excellent power control
- Supports complex 3G and 4G architectures
- Can support multiple standards



Avago Technologies has more than 15 years of design and manufacturing expertise in power products resulting in smaller size and higher efficiency.

CDMA and TD-SCDMA Power Amplifiers

	CDMA Cell	CDMA PCS	CDMA Japan	TD-SCDMA	Package Size
Single Band	WS1105	WS1405		ACPM-5201	3 x 3mm PA
	WS1106			ACPM-2001	
			ACPM-7822	ACPM-7887	4 x 4 mm PA
	AFEM-7750	AFEM-7758			4 x 7mm FEM
	AFEM-7751				
Multi-Band	ACPM-7353	ACPM-7353			4 x 5mm PA
	ACPM-7351		ACPM-7351		
	ACPM-7354	ACPM-7354			3 x 5mm PA

UMTS and GSM/EDGE Power Amplifiers

	UMTS Band 1	UMTS Band 2	UMTS Band 4	UMTS Band 5	UMTS Band 8	GSM/EDGE	Package Size
Single Band	ACPM-5001	ACPM-5002	ACPM-5004	ACPM-5005	ACPM-5008		3 x 3mm PA
	ACPM-5201	ACPM-5202	ACPM-5204	ACPM-5205	ACPM-5208		
	ACPM-5501	ACPM-5502	ACPM-5504	ACPM-5505	ACPM-5508		
	ACPM-2001	ACPM-2002		ACPM-2005	ACPM-2008		
	ACPM-2101	ACPM-2102		ACPM-2105	ACPM-2108		
						ACPM-7868	5 x 5mm PA
						ACPM-7870	
Multi-Band	ACPM-5251			ACPM-5251			4 x 5mm PA
	ACPM-5281				ACPM-5281		
		ACPM-5252		ACPM-5252			
		ACPM-5552		ACPM-5552			3 x 5mm PA
	ACPM-5551			ACPM-5551			
	ACPM-5581				ACPM-5581		
Multi-Mode, Multi-Band CDMA LTE UMTS	ACPM-7281				ACPM-7281	ACPM-7281	5 x 7.5mm PA
	ACPM-7051			ACPM-7051		ACPM-7051	
	ACPM-7081				ACPM-7081	ACPM-7081	
	ACPM-7251			ACPM-7251		ACPM-7251	

LTE Power Amplifiers

	LTE Band 1	LTE Band 3/4	LTE Band 7	LTE Band 11	LTE Band 13	LTE Band 17	LTE Band 20	LTE Band 38	LTE Band 40	Package Size
Single Band	ACPM-5601	ACPM-5004	ACPM-5007	ACPM-5011	ACPM-5013	ACPM-5017	ACPM-5020	ACPM-5038	ACPM-5040	3x3mm PA

System Block Diagrams and Suggested Products

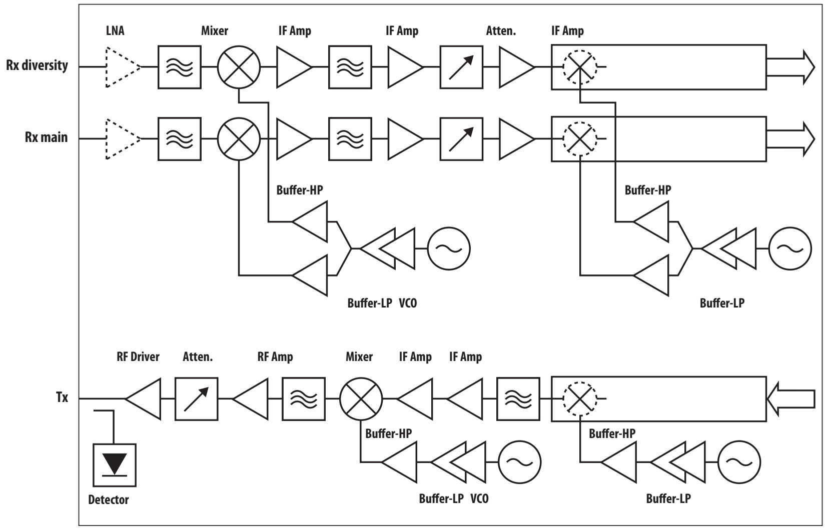
Wireless Infrastructure

VSAT

RFID

Product Selection Guides

Basestation Radiocard



Radiocard Suggested Components

Application	Part Number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @ 2GHz	P1dB/dBm[1] @ 2GHz	OIP3/dBm @ 2GHz	NF/dB[2] @ 2GHz	Device Type and Package (mm)
LNA	**MGA-13116**	5/55	0.4 - 1.5	38	23.3	41.4	0.51	QFN 4x4x0.85
	MGA-13216	5/53	1.5 - 2.5	35.8	23.6	40.5	0.61	QFN 4x4x0.85
	MGA-14516	5/45	1.4 - 2.7	31.7	–	23.5	0.66	QFN 4x4x0.85
	MGA-16516[8]	5/50	0.7 - 1.7	17.5	18.0	11.5 (IIP3)	0.45	QFN 4x4x0.85
	MGA-17516	5/50	1.7 - 2.7	17.2	21.5	13.7 (IIP3)	0.52	QFN 4x4x0.85
	MGA-53543	5/54	0.4 - 6	15.4	18.6	39.1	1.5	E-pHEMT MMIC, SOT343
	MGA-53589	5/52	0.05 - 3.0	15.8	18.2	37	1.7	SOT-89
	MGA-631P8[5]	4/60	0.4 - 1.5	17.5	18.0	33.1	0.53	E-pHEMT MMIC, LPCC 2x2
	MGA-632P8[5]	4/60	1.4 - 3	17.6	19.2	34.8	0.62	E-pHEMT MMIC, LPCC 2x2
	MGA-633P8	5/54	0.45 - 2	18	–	37	0.37	QFN 2x2x0.75
	MGA-634P8	5/48	1.5 - 2.3	17.4	22	36	0.37	QFN 2x2x0.75
	MGA-635P8	5/56	2.3 - 4.0	18	21.9	35.9	0.56	QFN 2x2x0.75
	MGA-636P8	4.8/105	0.45 - 1.5	18.5	23	41.5	0.5	QFN 2x2x0.75
	MGA-637P8	4.8/70	1.5 - 2.5	17.5	22	41.5	0.6	QFN 2x2x0.75
	MGA-638P8	4.8/90	2.5 - 4	17.5	22	39.5	0.8	QFN 2x2x0.75
	ATF-58143	3/30	0.45 - 6	16.5	19	30.5	0.5	E-pHEMT FET, SOT343
	ATF-54143	3/60	0.45 - 6	16.6	20	36.2	0.5	E-pHEMT FET, SOT343
	ALM-12124	5/227.7	1.880-2.025	39	23.5	36.5	0.85	MCOB 8.0x8.0x1.2
	ALM-12224	5/228.7	2.30-2.40	36.8	22.7	38.5	0.99	MCOB 8.0x8.0x1.2
	ALM-1222	5/280	1.8 - 2.2	31.0	27.5	43.7	0.62	MCOB 5.0x6.0x1.1
	ALM-1322	5/100	1.8 - 2.2	29.9	17	35.6	0.57	MCOB 5.0x6.0x1.1
	ALM-1522[9]	5/240	0.7 - 1.1	31	27.7	43	0.60	MCOB 5.0x6.0x1.1

Recommended Parts in **Bold**.

Notes:

1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. NFmin figures for discrete FETs.
3. High reverse isolation: 50dB typical.
4. Current adjustable: 20-60mA.
5. Both MGA-631P8 and MGA-632P8 come with integrated active bias circuit. MGA-631P8 data tested at 900MHz.
6. MGA-30116, ALM-31122 and ALM-32120 data tested at 900MHz.
7. MGA-30316, ALM-31322 and ALM-32320 data tested at 3.5GHz.
8. MGA-16516 data tested at 850MHz
9. ALM-1522 and ALM-80110 data tested at 900MHz
10. ALM-12124 data tested at 2018MHz
11. ALM-12224 data tested at 2400MHz

Wireless Infrastructure

Basestation Radiocard

Radiocard Suggested Components

Application	Part Number	Typ. Bias V/mA	Frequency Range/GHz	Gain/dB[1] @ 2GHz	P1dB/dBm[1] @ 2GHz	OIP3/dBm @ 2GHz	NF/dB[2] @ 2GHz	Device Type and Package (mm)
RF Amplifier	**MGA-30116**[6]	5/202.8	0.75 - 1	17	–	44.1	2	QFN 3x3
	MGA-30216	5/206	1.7 - 2.7	14.2	–	45.3	2.8	QFN 3x3
	MGA-30316[7]	5/198	3.3 - 3.9	12.8	–	44.4	2.7	QFN 3x3
	MGA-30489	5/97	0.25 - 3.0	13.3	23.3	39	3	SOT-89
	MGA-30689	5/104	0.04 - 2.6	14.6	22.5	40	3.3	SOT-89
	MGA-30789	5/100	2 - 6	11.7	–	41.8	3.3	SMT 4.5x4.1x1.5
	MGA-30889	5/65	0.04 - 2.6	15.5	–	38	1.9	SMT 4.5x4.1x1.5
	MGA-30989	5/51	2 - 6	12	–	36.8	2	SMT 4.5x4.1x1.5
	MGA-31189	5/111	0.05 - 2	21	24	42	3	SOT-89
	MGA-31289	5/124	1.5 - 3	18.7	24	41.8	3	SOT-89
	MGA-31389	5/73	0.05 - 2	21.3	22.2	38.6	2	SOT-89
	MGA-31489	5/69	1.5 - 3	19.5	21.9	37.3	1.9	SOT-89
	MGA-31589	5/146	0.45 - 1.5	20.4	27.2	45.3	1.9	SOT-89
	MGA-31689	5/168	1.5 - 3	18.1	27.6	44.9	1.9	SOT-89
	MGA-53543	5/54	0.4 - 6	15.4	18.6	39.1	1.5	E-pHEMT MMIC, SOT343
	MGA-53589	5/52	0.05 - 3.0	15.8	18.2	37	1.7	SOT-89
	MGA-545P8	3.3/127	0.05 - 7	18.6	21.7	34	2.7	E-pHEMT MMIC, LPCC
	MGA-61563[4]	3/41	0.5 - 4	15.5	15.1	31.7	1	E-pHEMT MMIC, SOT363
	ATF-52189	4.5/200	0.05 - 6	16	27	42	1.21	E-pHEMT FET, SOT89
	ATF-521P8	4.5/200	0.05 - 6	17	26.5	42	0.96	E-pHEMT FET, LPCC
	ATF-53189	4/135	0.05 - 6	15.5	23	40	0.62	E-pHEMT FET, SOT89
	ATF-531P8	4/135	0.05 - 6	20	24.5	38	0.6	E-pHEMT FET, LPCC
	ADA-4789	4.1/80	DC - 2.5	16.3	16.9	29	4.5	Si MMIC, SOT89
Variable Gain Amplifier	ALM-80110[9]	5/110	0.4 - 1.6	(-27) to 13.6	23.3	40.3	4.8	MCOB 5.0x5.0x1.1
	ALM-80210	5/110	1.6 - 2.6	(-25.5) to 9.8	23.6	40.8	5.3	MCOB 5.0x5.0x1.1
RF Driver	**MGA-30489**	5/97	0.25 - 3.0	13.3	23.3	39	3	SOT-89
	MGA-30689	5/104	0.04 - 2.6	14.6	22.5	40	3.3	SOT-89
	MGA-30789	5/100	2 - 6	11.7	–	41.8	3.3	SMT 4.5x4.1x1.5
	MGA-30889	5/65	0.04 - 2.6	15.5	–	38	1.9	SMT 4.5x4.1x1.5
	MGA-30989	5/51	2 - 6	12	–	36.8	2	SMT 4.5x4.1x1.5
	MGA-31189	5/111	0.05 - 2	21	24	42	3	SOT-89
	MGA-31289	5/124	1.5 - 3	18.7	24	41.8	3	SOT-89
	MGA-31389	5/73	0.05 - 2	21.3	22.2	38.6	2	SOT-89
	MGA-31489	5/69	1.5 - 3	19.5	21.9	37.3	1.9	SOT-89
	MGA-31589	5/146	0.45 - 1.5	20.4	27.2	45.3	1.9	SOT-89
	MGA-31689	5/168	1.5 - 3	18.1	27.6	44.9	1.9	SOT-89
	MGA-53589	5/52	0.05 - 3.0	15.8	18.2	37	1.7	SOT-89
	ATF-50189	4.5/280	0.05 - 6	15.5	29	45	1.1	E-pHEMT FET, SOT89
	ATF-501P8	4.5/280	0.05 - 6	14.7	28	45	–	E-pHEMT FET, LPCC
	ATF-511P8	4.5/200	0.05 - 6	14.8	30	41.7	1.4	E-pHEMT FET, LPCC
	ALM-31122[6]	5/394	0.7 - 1	15.6	–	47.6	2	MCOB 5.0x6.0x1.1
	ALM-31222	5/415	1.7 - 2.7	14.9	–	47.9	2.7	MCOB 5.0x6.0x1.1
	ALM-31322[7]	5/413	3.3 - 3.9	13.2	–	47.7	2.8	MCOB 5.0x6.0x1.1
	ALM-32120[6]	5/800	0.7 -1.0	14	–	52	2.5	MCOB 7.0x10.0x1.1
	ALM-32220	5/800	1.7 - 2.7	14.8	–	50	3.5	MCOB 7.0x10.0x1.1
	ALM-32320[7]	5/800	3.3 - 3.9	12.5	–	50	2.5	MCOB 7.0x10.0x1.1

Recommended Parts in **Bold**.

Notes:

1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. NFmin figures for discrete FETs.
3. High reverse isolation: 50dB typical.
4. Current adjustable: 20-60mA.
5. Both MGA-631P8 and MGA-632P8 come with integrated active bias circuit. MGA-631P8 data tested at 900MHz.
6. MGA-30116, ALM-31122 and ALM-32120 data tested at 900MHz.
7. MGA-30316, ALM-31322 and ALM-32320 data tested at 3.5GHz.
8. MGA-16516 data tested at 850MHz
9. ALM-1522 and ALM-80110 data tested at 900MHz

Basestation Radiocard

Radiocard Suggested Components

Application	Part Number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @2GHz	P1dB/dBm[1] @2GHz	OIP3/dBm @2GHz	NF/dB[2] @2GHz	Device Type and Package (mm)
Mixer	**IAM-92516**	5/26	0.4 - 3.5	6 (CL)	9	27 (IIP3)	12.5	E-pHEMT MMIC, LPCC(3x3)
Buffer-High Power	**MGA-565P8**[3]	5/67	0.1 - 3.5	21.8	20 (Psat)	–	–	E-pHEMT MMIC, LPCC
	ABA-54563	5/79	DC - 3.4	23	16.1	27.3	4.4	Si MMIC, SOT363
Buffer-Low Power	ABA-31563	3/14	DC - 3	21.5	2.2	13.1	3.8	Si MMIC, SOT363
	ABA-32563	3/37	DC - 3	19	8.4	19.5	3.5	Si MMIC, SOT363
	ABA-51563	5/18	DC - 3.5	21.5	1.8	11.4	3.7	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.5	9.8	19.9	3.3	Si MMIC, SOT363
	ABA-53563	5/46	DC - 3.5	21.5	12.7	22.9	3.5	Si MMIC, SOT363
	AVT-50663	5/36	DC-6000	15.3	12.5	25	4	SOT-363 (SC70)
	AVT-51663	5/37	DC-6000	19.6	12.9	25.1	3.2	SOT-363 (SC70)
	AVT-52663	5/45	DC-6000	15.3	12.7	27	4	SOT-363 (SC70)
	AVT-53663	5/48	DC-6000	19.6	15.1	26.5	3.2	SOT-363 (SC70)
	AVT-54689	5/48	0.05 - 6	17.1	17.4	29.6	4.1	SOT-89
	AVT-55689	5/75	0.05 - 6	17.2	19.5	32.5	4.3	SOT-89

Application	Part Number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @500MHz	P1dB/dBm[1] @500MHz	OIP3/dBm @500MHz	NF/dB[2] @500MHz	Device Type and Package (mm)
IF Amplifier	**MGA-30489**	5/97	0.25 - 3.0	18.8	22.7	37	3.3	SOT-89
	MGA-30689	5/104	0.04 - 2.6	14.4	22.2	44	3.0	SOT-89
	MGA-30789	5/100	2 - 6	11.7	–	41.8	3.3	SMT 4.5x4.1x1.5
	MGA-30889	5/65	0.04 - 2.6	15.5	–	38	1.9	SMT 4.5x4.1x1.5
	MGA-30989	5/51	2 - 6	12	–	36.8	2	SMT 4.5x4.1x1.5
	MGA-31189	5/111	0.05 - 2	21	24	42	3	SOT-89
	MGA-31289	5/124	1.5 - 3	18.7	24	41.8	3	SOT-89
	MGA-31389	5/73	0.05 - 2	21.3	22.2	38.6	2	SOT-89
	MGA-31489	5/69	1.5 - 3	19.5	21.9	37.3	1.9	SOT-89
	MGA-31589	5/146	0.45 - 1.5	20.4	27.2	45.3	1.9	SOT-89
	MGA-31689	5/168	1.5 - 3	18.1	27.6	44.9	1.9	SOT-89
	MGA-62563[4]	3/55	0.1 - 3	22	18	35	0.8	E-pHEMT MMIC, SOT363
	MGA-545P8	3.3/135	0.1 - 7	22	19	36	2	E-pHEMT MMIC, LPCC
	ADA-4789	4.1/80	DC - 2.5	17	18.8	35	4.2	Si MMIC, SOT89
	ADA-4743	(3.8)/60	DC - 2.5	16.5	17.1	34	4.2	Si MMIC, SOT343
	ADA-4643	(3.5)/35	DC - 2.5	17.3	14	29	4	Si MMIC, SOT343
	ADA-4543	(3.4)/15	DC - 2.5	15.5	2.4	15	3.7	Si MMIC, SOT343
	ABA-54563	5/81	DC - 3	23	18	32	3	Si MMIC, SOT363
	ABA-53563	5/46	DC - 3.5	21.5	15	27.5	2.9	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.8	12.5	28	2.7	Si MMIC, SOT363
Detector - Schottky Diodes	**HSMS-282x**	Ct max = 1pF @0V						SOT323/363/23/143
	HSMS-286x	Ct max = 0.3pF @0V						SOT323/363/23/143
Attenuator - PIN Diodes	**HSMP-381x**	Very low distortion, Ct typ. = 0.2pF @0V, see AN1048 & AN5262 pi-attenuator design						SOT323/23/25/SOD-323
	HSMP-386x	Lower current, low cost, Ct typ. = 0.2pF @0V, see AN1048 pi-attenuator design						SOT323/363/23/25/SOD-323
Attenuator - Module	ALM-38140	Low distortion, high dynamic range attenuator module						MCOB 3.8x3.8x1.0
Switch - Module	ALM-40220	High Power 10W SPDT switch for TD-SCDMA						MCOB 5.0x5.0x1.0

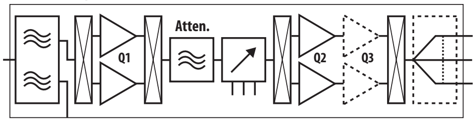
Recommended Parts in **Bold**.

Notes:

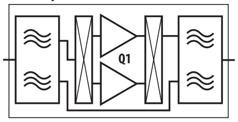
1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. NFmin figures for discrete FETs.
3. High reverse isolation: 50dB typical.
4. Current adjustable: 20-60mA.
5. Both MGA-631P8 and MGA-632P8 come with integrated active bias circuit. MGA-631P8 data tested at 900MHz.
6. MGA-30116, ALM-31122 and ALM-32120 data tested at 900MHz.
7. MGA-30316, ALM-31322 and ALM-32320 data tested at 3.5GHz.

Basestation Low Noise Amplifier (LNA)
Basestation Tower Mounted Amplifiers (TMA)

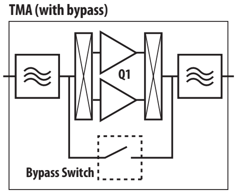
LNA/multicoupler



TMA/duplex



TMA (with bypass)



LNA & TMA Suggested Components

Application	Part Number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @ 2GHz	P1dB/dBm[1] @ 2GHz	OIP3/dBm @ 2GHz	NF/dB[2] @ 2GHz	Device Type and Package (mm)
Q1	**MGA-13116**	5/55	0.4 - 1.5	38	23.3	41.4	0.51	QFN 4x4x0.85
	MGA-13216	5/53	1.5 - 2.5	35.8	23.6	40.5	0.61	QFN 4x4x0.85
	MGA-14516	5/45	1.4 - 2.7	31.7	–	23.5	0.66	QFN 4x4x0.85
	MGA-16516[6]	5/50	0.7 - 1.7	17.5	18.0	11.5 (IIP3)	0.45	QFN 4x4x0.85
	MGA-17516	5/50	1.7 - 2.7	17.2	21.5	13.7 (IIP3)	0.52	QFN 4x4x0.85
	MGA-631P8[3]	4/60	0.4 - 1.5	17.5	18.0	33.1	0.53	E-pHEMT MMIC, LPCC 2x2
	MGA-632P8[3]	4/60	1.4 - 3	17.6	19.2	34.8	0.62	E-pHEMT MMIC, LPCC 2x2
	MGA-633P8	5/54	0.45 - 2	18	–	37	0.37	QFN 2x2x0.75
	MGA-634P8	5/48	1.5 - 2.3	17.4	22	36	0.37	QFN 2x2x0.75
	MGA-635P8	5/56	2.3 - 4.0	18	21.9	35.9	0.56	QFN 2x2x0.75
	ALM-11036	5/92	0.776 - 0.87	15.6	4	37.6	0.78	SMT 7x10
	ALM-11136	5/92	0.87 - 0.915	15.4	4.5	38.2	0.76	SMT 7x10
	ALM-11236	5/99	1.71 - 1.85	15.9	3.5	32.3	0.67	SMT 7x10
	ALM-11336	5/100	1.85 - 1.98	15.3	3.8	35.5	0.72	SMT 7x10
	ATF-58143	3/30	0.45 - 6	16.5	19	30.5	0.5	E-pHEMT FET, SOT343
	ATF-54143	3/60	0.45 - 6	16.6	20	36.2	0.5	E-pHEMT FET, SOT343
	ATF-55143	2.7/10	0.45 - 6	17.7	14	24.2	0.6	E-pHEMT FET, SOT343
	ATF-53189	4/135	0.05 - 6	15.5	23	40	0.62	E-pHEMT FET, SOT89
	ATF-531P8	4/135	0.05 - 6	20	24.5	38	0.6	E-pHEMT FET, LPCC
	ALM-1222	5/280	1.8 - 2.2	31.0	27.5	43.7	0.62	MCOB 5.0x6.0x1.1
	ALM-1322	5/100	1.8 - 2.2	29.9	17	35.6	0.57	MCOB 5.0x6.0x1.1
	ALM-1522[7]	5/240	0.7 - 1.1	31.0	27.7	43.0	0.60	MCOB 5.0x6.0x1.1
Q2/Q3	**MGA-30116**[4]	5/202.8	0.75 - 1	17	-	44.1	2	QFN 3x3
	MGA-30216	5/206	1.7 - 2.7	14.2	-	45.3	2.8	QFN 3x3
	MGA-30316[5]	5/198	3.3 - 3.9	12.8	-	44.4	2.7	QFN 3x3
	MGA-53543	5/54	0.4 - 6	15.4	18.6	39.1	1.5	E-pHEMT MMIC, SOT343
	MGA-53589	5/52	0.05 - 3.0	15.8	18.2	37	1.7	SOT-89
	MGA-636P8	4.8/105	0.45 - 1.5	18.5	23	41.5	0.5	QFN 2x2x0.75
	MGA-637P8	4.8/70	1.5 - 2.5	17.5	22	41.5	0.6	QFN 2x2x0.75
	MGA-638P8	4.8/90	2.5 - 4	17.5	22	39.5	0.8	QFN 2x2x0.75
	ATF-50189	4.5/280	0.05 - 6	15.5	29	45	1.1	E-pHEMT FET, SOT89
	ATF-501P8	4.5/280	0.05 - 6	14.7	28	45	–	E-pHEMT FET, LPCC
	ATF-511P8	4.5/200	0.05 - 6	14.8	30	41.7	1.4	E-pHEMT FET, LPCC
	ATF-52189	4.5/200	0.05 - 6	16	27	42	1.21	E-pHEMT FET, SOT89
	ATF-521P8	4.5/200	0.05 - 6	17	26.5	42	0.96	E-pHEMT FET, LPCC
	ATF-53189	4/135	0.05 - 6	15.5	23	40	0.62	E-pHEMT FET, SOT89
	ATF-531P8	4/135	0.05 - 6	20	24.5	38	0.6	E-pHEMT FET, LPCC
Bypass Switch - PIN Diodes	**HSMP-389x**	General purpose switch, Ct typ. = 0.4pF @0V						SOT-323/363/23/143/SOD-323
	HSMP-489x	Low inductance, shunt, Ct typ. = 0.4pF @0V						SOT323/23
	HSMP-386x	Higher linearity switch, Ct typ = 0.2pF @0V						SOT323/363/23/25/SOD-323
Attenuator - PIN Diodes	**HSMP-381x**	Very low distortion, Ct typ. = 0.2pF @0V, see AN1048 & AN5262 pi-attenuator design						SOT323/23/25/SOD-323
	HSMP-386x	Lower current, low cost, Ct typ. = 0.2pF @0V, see AN1048 pi-attenuator design						SOT323/363/23/25/SOD-323
Attenuator-Module	ALM-38140	Low distortion, high dynamic range attenuator module						MCOB 3.8x3.8x1.0

Recommended Parts in **Bold**.

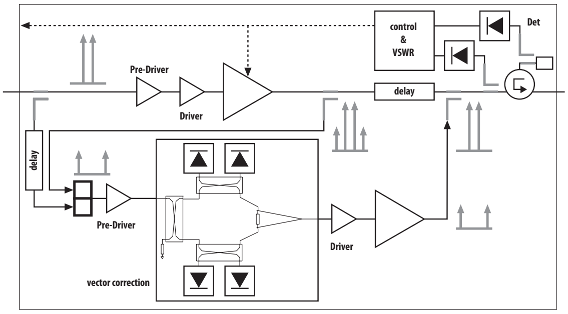
Notes:

1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. NFmin figures for discrete FETs.
3. Both MGA-631P8 and MGA-632P8 come with integrated active bias circuit. MGA-631P8 data tested at 900MHz.
4. MGA-30116 data tested at 900MHz.
5. MGA-30316 data tested at 3.5GHz.
6. MGA-16516 data tested at 850MHz
7. ALM-1522 data tested at 900MHz

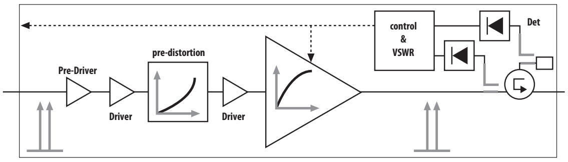
Wireless Infrastructure

Basestation Multi-carrier Power Amplifier (MCPA)

Feedforward example



Pre-distortion example



MCPA Suggested Compoments

Application	Part Number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @ 2GHz	P1dB/dBm[1] @ 2GHz	OIP3/dBm @ 2GHz	NF/dB[2] @ 2GHz	Device Type and Package (mm)
Pre-Driver	**MGA-30116**[3]	5/202.8	0.75 - 1	17	–	44.1	2	QFN 3x3
	MGA-30216	5/206	1.7 - 2.7	14.2	–	45.3	2.8	QFN 3x3
	MGA-30316[4]	5/198	3.3 - 3.9	12.8	–	44.4	2.7	QFN 3x3
	MGA-30489	5/97	0.25 - 3.0	13.3	23.3	39	3	SOT-89
	MGA-30689	5/104	0.04 - 2.6	14.6	22.5	40	3.3	SOT-89
	MGA-30789	5/100	2 - 6	11.7	–	41.8	3.3	SMT 4.5x4.1x1.5
	MGA-30889	5/65	0.04 - 2.6	15.5	–	38	1.9	SMT 4.5x4.1x1.5
	MGA-30989	5/51	2 - 6	12	–	36.8	2	SMT 4.5x4.1x1.5
	MGA-31189	5/111	0.05 - 2	21	24	42	3	SOT-89
	MGA-31289	5/124	1.5 - 3	18.7	24	41.8	3	SOT-89
	MGA-31389	5/73	0.05 - 2	21.3	22.2	38.6	2	SOT-89
	MGA-31489	5/69	1.5 - 3	19.5	21.9	37.3	1.9	SOT-89
	MGA-31589	5/146	0.45 - 1.5	20.4	27.2	45.3	1.9	SOT-89
	MGA-31689	5/168	1.5 - 3	18.1	27.6	44.9	1.9	SOT-89
	MGA-53543	5/54	0.4 - 6	15.4	18.6	39.1	1.5	E-pHEMT MMIC, SOT343
	MGA-53589	5/52	0.05 - 3.0	15.8	18.2	37	1.7	SOT-89
	MGA-545P8	3.3/127	0.05 - 7	18.6	21.7	34	2.7	E-pHEMT MMIC, LPCC
	ATF-52189	4.5/200	0.05 - 6	16	27	42	1.21	E-pHEMT FET, SOT89
	ATF-521P8	4.5/200	0.05 - 6	17	26.5	42	0.96	E-pHEMT FET, LPCC
	ATF-53189	4/135	0.05 - 6	15.5	23	40	0.62	E-pHEMT FET, SOT89
	ATF-531P8	4/135	0.05 - 6	20	24.5	38	0.6	E-pHEMT FET, LPCC
	ADA-4789	4.1/80	DC - 2.5	16.3	16.9	29	4.5	Si MMIC, SOT89
Driver	**ATF-50189**	4.5/280	0.05 - 6	15.5	29	45	1.1	E-pHEMT FET, SOT89
	ATF-501P8	4.5/280	0.05 - 6	14.7	28	45	–	E-pHEMT FET, LPCC
	ATF-511P8	4.5/200	0.05 - 6	14.8	30	41.7	1.4	E-pHEMT FET, LPCC
	ALM-31122[3]	5/394	0.7 - 1	15.6	–	47.6	2	MCOB 5.0x6.0x1.1
	ALM-31222	5/415	1.7 - 2.7	14.9	–	47.9	2.7	MCOB 5.0x6.0x1.1
	ALM-31322[4]	5/413	3.3 - 3.9	13.2	–	47.7	2.8	MCOB 5.0x6.0x1.1
	ALM-32120[3]	5/800	0.7 -1.0	14	–	52	2.5	MCOB 7.0x10.0x1.1
	ALM-32220	5/800	1.7 - 2.7	14.8	–	50	3.5	MCOB 7.0x10.0x1.1
	ALM-32320[4]	5/800	3.3 - 3.9	12.5	–	50	2.5	MCOB 7.0x10.0x1.1
Detector	**HSMS-282x**	Ct max = 1pF @0V						SOT323/363/23/143
- Schottky Diodes	**HSMS-286x**	Ct max = 0.3pF @0V						SOT323/363/23/143
Vector Correction	**HSMP-481x**	Low inductance, shunt, very low distortion, Ct typ. = 0.2pF @0V						SOT323/23
- PIN Diodes	HSMP-381x	Very low distortion, Ct typ. = 0.2pF @0V						SOT323/23/SOD-323

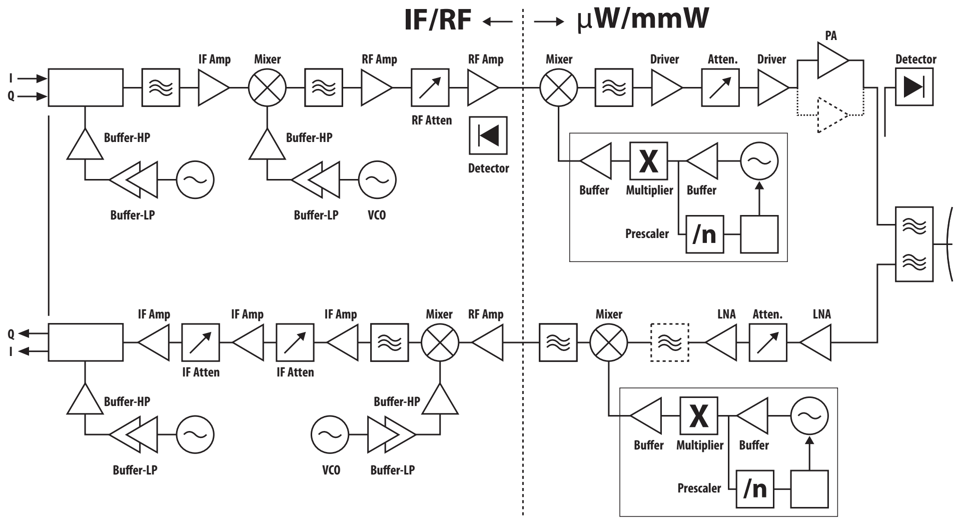
Recommended Parts in **Bold**.

Notes:

1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. NFmin figures for discrete FETs.
3. MGA-30116, ALM-31122 and ALM-32120 data tested at 900MHz.
4. MGA-30316, ALM-31322 and ALM-32320 data tested at 3.5GHz.
5. ALM-1522 data tested at 900MHz

Wireless Infrastructure

Microwave Link (Point-point/point-multipoint)



Microwave Link MMICs Suggested Components

Application	Part Number	Bias V/mA	Freq Range GHz	Typical Performance				Package (mm)
				Gain dB	P1dB dBm	OIP3 dBm	NF dB	
Power Amplifiers	AMMP-6408	5/650	6 -18	18	28	38	4.5	SM 5x5
	AMMC-6408	5/650	6 -18	19	29	38	4.3	chip
	AMMC-6425	5/900 - 0.6	18 - 28	18.5	28.5	38	/	chip
	AMMC-6431	5/0.65	25-33	19	28.5	38	/	chip
	AMMP-6441	5/450	36 - 40	20	26	32	/	SM 5x5
	AMMC-6442	5/0.7	37-40	23	30	18	/	chip
Driver/Buffer Amps[1]	AMMP-5618	5/107	6 - 20	13	19	30	4.4	SM 5x5
	AMMC-5618	5/107	6 - 20	14.5	19.5	26	4.4	chip
	AMMP-5620	5/95	6 - 20	17.5	15	22.5	5.1	SM 5x5
	AMMC-5620	5/95	6 - 20	19	15	23.5	4.2	chip
	AMMC-5040	4.5/300 - 0.45	20 - 45	25	19.5	30	/	chip
	AMMP-6333	5/230	18-33	22	23	30	/	SM 5x5
	AMMC-6333	5/230	18-33	22	23	30	/	chip
	AMMC-6345	5/480 - 0.7	20 - 45	20	24	32	/	chip
	AMMP-6421	5/600	13 -16	26	29	36	5	SM 5x5
Low Noise Amplifiers	VMMK-1225	2/20	0.5 - 26	11	8	23	1	SM
	VMMK-1218	3/20	0.5 - 18	10.7	12	12	0.81	SM 1x0.5
	AMMP-6220	3/55	6 - 20	22	10	20	2.5	SM 5x5
	AMMC-6220	3/55	6 - 20	23	9	19	2	chip
	AMMP-6222	4/120	7 -21	24	15.5	29	2.3	SM 5x5
	AMMC-6222	4/120	7 -21	25	16	29	2.1	chip
	AMMP-6232	4/138	18 - 32	23	18	29	3	SM 5x5
	AMMC-6232	4/138	18 - 32	24	19	29	2.8	chip
	AMMP-6233	3/65	18 - 32	23	8	19	2.6	SM 5x5
	AMMC-6241	3/60	26 - 43	20	10	20	2.7	chip
Travelling Wave Amplifiers	AMMP-5024	7/200	(30k) - 40	15	22	30	4.4	SM 5x5
	AMMC-5024	7/200 - 3	(30k) - 40	16	22.5	30	4.6	chip
	AMMC-5026	7/150 - 1	2 - 35	10.5	24	31	3.6	chip

Recommended Parts in **Bold**.

Notes:
1. Also see Low Noise Amplifiers.

Microwave Link (Point-point/point-multipoint)

Microwave/Millimeter Wave Diode Suggested Components

Application	Part Number	Description	Package
Detector - Schottky diodes	HSCH-5310/5330	Si single, Ct=0.1pF, med. barrier/low barrier	Beamlead
	HSCH-5312/5332	Si single Ct=0.15pF, med. barrier/low barrier	Beamlead
Mixers - Schottky diodes	**HSCH-5310/5330**	Si single, Ct=0.1pF, med. barrier/low barrier	Beamlead
	HSCH-5312/5332	Si single Ct=0.15pF, med. barrier/low barrier	Beamlead
	HSCH-5531	Si series pair, Ct=0.15pF, low barrier/ Ct=0.1pF, med. barrier	Beamlead
Multiplier - Schottky diodes	**HSCH-5310/5330**	Si single, Ct=0.1pF, med. barrier/low barrier	Beamlead
	HSCH-5312/5332	Si single Ct=0.15pF, med. barrier/low barrier	Beamlead
	HSCH-5531	Si series pair, Ct=0.15pF, low barrier/ Ct=0.1pF, med. barrier	Beamlead
Attenuator - PIN diodes	HPND-4005	Si single, Ct=17fF, t=100ns	Beamlead
Switch - PIN diodes	HPND-4005	Si single, Ct=17fF, t=100ns	Beamlead
	HPND-4028/4038	Si single. Ct=45fF, t=36ns / Ct=65ns, t=45ns	Beamlead

Recommended Parts in **Bold**.

Microwave Link - RF Component Suggestions

Application	Part Number	Typ. Bias V/mA	Frequency Range/GHz	Gain (dB) @ 2GHz	P1dB (dBm) @ 2GHz	OIP3 (dBm) @ 2GHz	NF (dB) @ 2GHz	Device Type and Package (mm)
RF Amplifier	MGA-30489	5/97	0.25 - 3.0	13.3	23.3	39	3	SOT-89
	MGA-30689	5/104	0.04 - 2.6	14.6	22.5	40	3.3	SOT-89
	MGA-30789	5/100	2 - 6	11.7	–	41.8	3.3	SMT 4.5x4.1x1.5
	MGA-30889	5/65	0.04 - 2.6	15.5	–	38	1.9	SMT 4.5x4.1x1.5
	MGA-30989	5/51	2 - 6	12	–	36.8	2	SMT 4.5x4.1x1.5
	MGA-31189	5/111	0.05 - 2	21	24	42	3	SOT-89
	MGA-31289	5/124	1.5 - 3	18.7	24	41.8	3	SOT-89
	MGA-31389	5/73	0.05 - 2	21.3	22.2	38.6	2	SOT-89
	MGA-31489	5/69	1.5 - 3	19.5	21.9	37.3	1.9	SOT-89
	MGA-31589	5/146	0.45 - 1.5	20.4	27.2	45.3	1.9	SOT-89
	MGA-31689	5/168	1.5 - 3	18.1	27.6	44.9	1.9	SOT-89
	MGA-53543	5/54	0.4 - 6	15.4	18.6	39.1	1.5	E-pHEMT MMIC, SOT343
	MGA-53589	5/52	0.05 - 3.0	15.8	18.2	37	1.7	SOT-89
	MGA-545P8	3.3/127	0.05 - 7	18.6	21.7	34	2.7	E-pHEMT MMIC, LPCC
	MGA-61563[1]	3/41.6	0.1 - 6	15.5	15.1	31.7	1	E-pHEMT MMIC, SOT363
	ABA-53563	5/35	DC - 3.5	21.5	12.7	22.9	3.5	Si MMIC, SOT363
	ABA-54563	5/81	DC - 3	22.5	16	26	4.2	Si MMIC, SOT363
	ADA-4789	4.1/80	DC - 2.5	16.3	16.9	29	4.5	Si MMIC, SOT89
Mixer	IAM-92516	5/26	0.4 - 3.5	6 (CL)	9	27 (IIP3)	12.5	E-pHEMT MMIC, LPCC(3x3)
Buffer-High Power	MGA-565P8[2]	5/67	0.1 - 3.5	21.8	20 (Psat)	–	–	E-pHEMT MMIC, LPCC
	ABA-54563	5/81	DC - 3	22.5	16	27.3	4.4	Si MMIC, SOT363
Buffer-Low Power	ABA-31563	3/14	DC - 3	21.5	2.2	13.1	3.8	Si MMIC, SOT363
	ABA-32563	3/37	DC - 3	19	8.4	19.5	3.5	Si MMIC, SOT363
	ABA-51563	5/18	DC - 3.5	21.5	1.8	11.4	3.7	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.5	9.8	19.9	3.3	Si MMIC, SOT363
	ABA-53563	5/35	DC - 3.5	21.5	12.7	22.9	3.5	Si MMIC, SOT363
	AVT-50663	5/36	DC-6000	15.3	12.5	25	4	SOT-363 (SC70)
	AVT-51663	5/37	DC-6000	19.6	12.9	25.1	3.2	SOT-363 (SC70)
	AVT-52663	5/45	DC-6000	15.3	12.7	27	4	SOT-363 (SC70)
	AVT-53663	5/48	DC-6000	19.6	15.1	26.5	3.2	SOT-363 (SC70)
	AVT-54689	5/48	0.05 - 6	17.1	17.4	29.6	4.1	SOT-89
	AVT-55689	5/75	0.05 - 6	17.2	19.5	32.5	4.3	SOT-89

Recommended Parts in **Bold**.

Notes:
1. Current Adjustable: 20-60mA.
2. High Reverse Isolation: 50dB typical.

Wireless Infrastructure

Microwave Link (Point-point/point-multipoint)

Microwave Link - RF Component Suggestions

Application	Part Number	Features	Device Type and Package
Detector - Schottky Diodes	HSMS-282x	Ct max = 1pF @0V	SOT323/363/23/143
	HSMS-286x	Ct max = 0.3pF @0V	SOT323/363/23/143
RF Attenuator - PIN Diodes	HSMP-381x	Very low distortion, Ct typ. = 0.2pF @0V, see AN1048 & AN5262 pi-attenuator design	SOT323/23/25/SOD-323
	HSMP-386x	Lower current, low cost, Ct typ. = 0.2pF @0V, see AN1048 pi-attenuator design	SOT323/363/23/25/SOD-323
Attenuator - Module	ALM-38140	Low distortion, high dynamic range attenuator module	MCOB 3.8x3.8x1.0mm

Application	Part Number	Typ. Bias V/mA	Frequency Range/GHz	Gain (dB) @ 500MHz	P1dB (dBm) @ 500MHz	OIP3 (dBm) @ 500MHz	NF (dB) @ 500MHz	Device Type and Package
IF Amplifier	MGA-62563[1]	3/55	0.1 - 3	22	18	35	0.8	E-pHEMT MMIC, SOT363
	MGA-545P8	3.3/135	0.1 - 7	22	19	36	2	E-pHEMT MMIC, LPCC
	MGA-30489	5/97	0.25 - 3.0	18.8	22.7	37	3.3	SOT-89
	MGA-30689	5/104	0.04 - 2.6	14.4	22.2	44	3.0	SOT-89
	MGA-30889	5/65	0.04 - 2.6	15.5	–	38	1.9	SMT 4.5x4.1x1.5
	MGA-31189	5/111	0.05 - 2	21	24	42	3	SOT-89
	MGA-31389	5/73	0.05 - 2	21.3	22.2	38.6	2	SOT-89
	ADA-4789	4.1/80	DC - 2.5	17	18.8	35	4.2	Si MMIC, SOT89
	ADA-4743	(3.8)/60	DC - 2.5	16.5	17.1	34	4.2	Si MMIC, SOT343
	ADA-4643	(3.5)/35	DC - 2.5	17.3	14	29	4	Si MMIC, SOT343
	ADA-4543	(3.4)/15	DC - 2.5	15.5	2.4	15	3.7	Si MMIC, SOT343
	ABA-54563	5/81	DC - 3	23	18	32	3	Si MMIC, SOT363
	ABA-53563	5/46	DC - 3.5	21.5	15	27.5	2.9	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.8	12.5	28	2.7	Si MMIC, SOT363
	AVT-50663	5/36	DC-6000	15.3	12.5	25	4	SOT-363 (SC70)
	AVT-51663	5/37	DC-6000	19.6	12.9	25.1	3.2	SOT-363 (SC70)
	AVT-52663	5/45	DC-6000	15.3	12.7	27	4	SOT-363 (SC70)
	AVT-53663	5/48	DC-6000	19.6	15.1	26.5	3.2	SOT-363 (SC70)
	AVT-54689	5/48	0.05 - 6	17.1	17.4	29.6	4.1	SOT-89
	AVT-55689	5/75	0.05 - 6	17.2	19.5	32.5	4.3	SOT-89

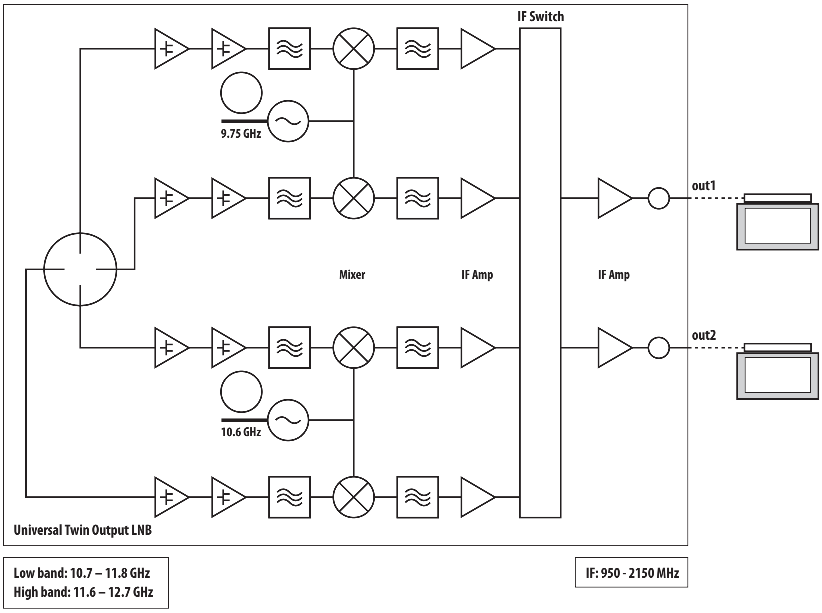
Application	Part Number	Features	Package
Attenuator - PIN Diodes	HSMP-381x	Very low distortion, Ct typ. = 0.2pF @0V, see AN1048 & AN5262 pi-attenuator design	SOT323/23/25/SOD-323
	HSMP-386x	Lower current, low cost, Ct typ. = 0.2pF @0V, see AN1048 pi-attenuator design	SOT323/363/23/25/SOD-323
Attenuator - Module	**ALM-38140**	Low distortion, high dynamic range attenuator module	MCOB 3.8x3.8x1.0mm

Recommended Parts in **Bold**.

Notes:

1. Current Adjustable: 20-60mA

DBS Satellite TV System

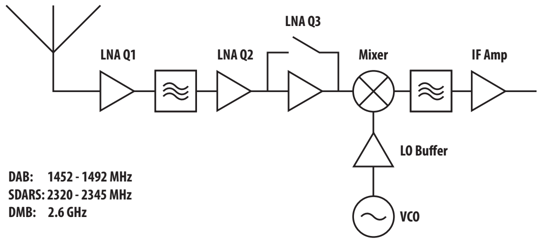


DBS Satellite TV System Suggested Components

Application	Part number	Typ. Bias V/mA	Frequency Range/GHz	Gain/dB @ 2GHz	P1dB/dBm @ 2GHz	OIP3/dBm @ 2GHz	NF/dB @ 2GHz	Device Type and Package
IF Amplifier	**ABA-31563**	3/14	DC - 3	21.5	2.2	13.1	3.8	Si MMIC, SOT363
	ABA-32563	3/37	DC - 3	19	8.4	19.5	3.5	Si MMIC, SOT363
	ABA-51563	5/18	DC - 3.5	21.5	1.8	11.4	3.7	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.5	9.8	19.9	3.3	Si MMIC, SOT363
	ABA-53563	5/46	DC - 3.5	21.5	12.7	22.9	3.5	Si MMIC, SOT363
	ABA-54563	5/79	DC - 3.4	23	16.1	27.8	4.4	Si MMIC, SOT363
	AT-41511	5/25	10GHz ft	12.5 (MAG)	14.5	25	2.5	Si BJT, SOT143
	AVT-50663	5/36	DC-6000	15.3	12.5	25	4	SOT-363 (SC70)
	AVT-51663	5/37	DC-6000	19.6	12.9	25.1	3.2	SOT-363 (SC70)
	AVT-52663	5/45	DC-6000	15.3	12.7	27	4	SOT-363 (SC70)
	AVT-53663	5/48	DC-6000	19.6	15.1	26.5	3.2	SOT-363 (SC70)
	AVT-54689	5/48	0.05 - 6	17.1	17.4	29.6	4.1	SOT-89
	AVT-55689	5/75	0.05 - 6	17.2	19.5	32.5	4.3	SOT-89
	MGA-61563	3/41	0.1 - 6	15.5	15.1	31.7	1.0	E-pHEMT MMIC, SOT363
IF Switch	**HSMP-386x**	Higher linearity switch, Ct typ = 0.2pF @0V						SOT323/363/23/SOD-323
	HSMP-389x	General purpose switch, Ct typ. = 0.4pF @0V						SOT323/23/SOD-323
	HMPS-389x	General purpose switch, Ct typ. = 0.4pF @0V						Minipak
Mixer - Schottky Diodes	**HSMS-8202**	Ct max = 0.26pF @0V						SOT23
		RD max = 14W @ IF=5Ma						

Recommended Parts in **Bold**.

Mobile DAB/SDARS/DMB-S Digital Receivers



Mobile DAB/SDARS/DMB-S Digital Receivers Suggested Components

Application	Part number	Typ. Bias V/mA	Gain/dB[1] DAB SDARS DMB-S	OIP3/dBm DAB SDARS DMB-S	NF/dB[2] DAB SDARS DMB-S	Device Type and Package (mm)
LNA Q1/Q2	**ATF-55143**	2.7/10	20.0 17.0 16.0	23.0 24.0 24.0	0.3 0.45 0.5	E-pHEMT FET, SOT343
	ATF-551M4	2.7/10	20.0 16.5 16.0	23.0 24.2 24.2	0.3 0.45 0.5	E-pHEMT FET, MiniPak
	MGA-21108	1.4/17	12.5 12.0 13.0	(-2) 0 1.0 (IIP3)	2.8 2.2 1.8	STSLP 2.5x2.5x0.55
	MGA-635T6	2.85/4.9	14.6 12.0 –	3.5 4.5 –	0.86 0.96 –	E-pHEMT, UTSLP 2x1.3x0.4
LNA Q3	**MGA-645T6**	3/7	– 15.0 14.2	– 7 7.8	– 1.1 1.15	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-71543[3]	3/10[4]	16.5 15.2 14.6	19.5 18.2 17.6	0.7 0.8 0.85	GaAs MMIC, SOT343
	MGA-72543[3]	3/20[4]	14.3 13.2 12.8	24.8 23.7 23.3	1.4 1.45 1.45	GaAs MMIC, SOT343
	MGA-725M4[3]	3/20[4]	16.6 15.3 14.6	26.5 25.2 24.5	1.2 1.3 1.3	GaAS MMIC, MiniPak
Mixer	**IAM-91563**	3/9 to 15	9.5 7.5 7.0	3.0 to 4.5	7.5 11.0 11.5	GaAs MMIC, SOT363

Notes:
1. Gain for discrete FETs when matched for best IP3.
2. NFmin figures for LNA parts.
3. LNA bypass switch included.
4. Current adjustable to set linearity performance

Application	Part number	Typ. Bias V/mA	Frequency Range/GHz	Gain/dB @ 2GHz	P1dB/dBm @ 2GHz	OIP3/dBm @ 2GHz	NF/dB @ 2GHz	Device Type and Package
LO Buffer	**ABA-31563**	3/14.5	DC - 3	21	2	13	3.8	Si MMIC, SOT363
	ABA-32563	3/38	DC - 2.5	18.5	8	19	3.4	Si MMIC, SOT363

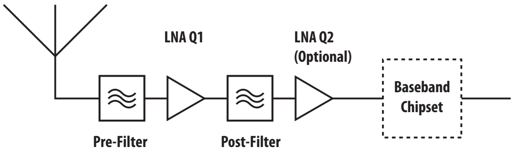
Recommended Parts in **Bold**.

DMB-T/ISDB-T Receivers Suggested Components

Application	Part number	Typ. Bias V/mA	Gain/dB @ 500MHz	OIP3/dBm @ 500MHz	NF/dB @ 500MHz	Device Type and Package (mm)
LNA Q1/Q2	**MGA-685T6**	3.0/10	18.9	18.7	0.93	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-68563	3.0/10	19.7	20.0	1.0	E-pHEMT MMIC, SOT363
LNA Q3	**MGA-785T6**	3.0/10	15.7	16.8	1.5	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-725M4	3.0/9	14	16.5	1.7	GaAs MMIC, MiniPak

Wireless Infrastructure

GPS Receivers



Mobile GPS Receivers Suggested Components

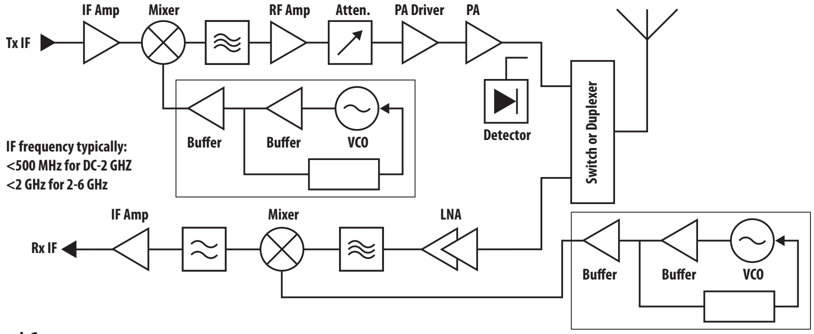
Application	Part Number	Typ. Bias V/ mA	NF/dB	Gain/dB	IIP3/dBm	Device Type and Package (mm)
LNA Q1/Q2	ALM-1106	2.85/8	0.8	14.3	4.7	E-pHEMT MMIC, MCOB 2 x 2
	ALM-2506	2.85/8	0.8	14.3	4.7	E-pHEMTF, MCOB 2x2x1.1
	MGA-231T6	2.85/6	0.9	18.5	2.0	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-24106	2.7/3.3	0.97	17.9	-2.0	uDFN 1.5x1.3x0.5
	MGA-61563	3.0/9	1.18	16	-3	E-pHEMT MMIC, SOT-363
	MGA-635T6	2.85/4.9	0.86	14.6	3.5	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-665P8	3.0/21	1.22	20.8	-0.5	E-pHEMT MMIC, LPCC 2 x 2
	*ATF-55143	2.0/10	0.6	17.4	-0.6	E-pHEMT FET, SOT343

Note:
*Refer to Application Note 1376.

Application	Part Number	Typ. Bias V/ mA	NF/dB	Gain/dB	IIP3/dBm	Cell-Band Rejection/dBc	PCS-Band Rejection/dBc	Device Type and Package (mm)
LNA Q1 with Integrated Post Filter	ALM-1412	2.85/8	0.82	13.5	7	54	63	MCOB 3.3x2.1x1.1
	ALM-1612	2.7/6	0.95	18.2	2	69	67	MCOB 3.3x2.1x1.0
	ALM-2412	2.85/9	0.85	13.5	6.1	63	65	MCOB 3.3x2.1x1.1
	ALM-2712	2.7/7.5	12.6	14.2	2	–	–	MCOB 3x2.5x1
LNA Q1 with Integrated Pre and Post Filters	ALM-1712	2.7/8	1.65	12.8	3	104	92.6	E-pHEMT & FBAR, MCOB 4.5x2.2x1.0
	ALM-1812	2.8/6	1.9	18.5	2	95	90	E-pHEMT & FBAR, MCOB 4.5x2.2x1.0
	ALM-1912	2.7/6	1.62	19.3	1.5	>57	>53	MCOB 2.9x2x1

Wireless Infrastructure

2-6 GHz Systems (including 802.11 a/b/g and 802.16)



2-6 GHz Systems Suggested Components

Application	Part Number	Typical Performance					Package (mm)
		Test Bias V/mA	Test Freq GHz	Gain[1] dB	Linear Pout dBm	EVM %	
PA	MGA-22003	–	2.5	35	–	–	Small Size 3x3x1
	MGA-23003	–	3.5	35	–	–	Small Size 3x3x1
	MGA-25203	–	5.4	30	–	–	Small Size 3x3x1
	MGA-412P8	3.3/95	2.452	25.5	19	3.0	E-pHEMT MMIC. LPCC
	MGA-425P8[2]	3.3/58	5.25	16.0	12	3.0	E-pHEMT MMIC. LPCC
	MGA-43228	5 /500	2.4	38.5	29.2	2.5	QFN 5x5x0.85
	MGA-43328	5 /470	2.6	37.3	29.3	2.5	QFN 5x5x0.85
	MGA-545P8	3.3/127	5.825	11.5	16	5.6	E-pHEMT MMIC, LPCC
	ALM-42216	3.3/240	2.5	30	23.5	2.5	MCOB 5.0x5.0x1.1
	ALM-42316	3.3/240	3.5	30	23	2.5	MCOB 5.0x5.0x1.1
	ALM-31222	5/415	2	14.9	–	–	MCOB 5.0x6.0x1.1
	ALM-31322	5/413	3.5	13.2	–	–	MCOB 5.0x6.0x1.1
	ALM-32220	5/800	2	14.8	–	–	MCOB 7.0x10.0x1.1
	ALM-32320	5/800	3.5	12	–	–	MCOB 7.0x10.0x1.1

Application	Part Number	Typical Performance						Package (mm)
		Test Bias V/mA	Test Freq GHz	Gain[1] dB	P1dB[1] dBm	OIP3 dBm	NF dB	
PA Driver	MGA-30216	5/206	2	14.2	–	45.3	2.8	QFN 3x3
	MGA-30316	5/198	3.5	12.8	–	44.4	2.7	QFN 3x3
	MGA-53543	5/54	1.9	15.4	18.6	39.1	1.5	E-pHEMT MMIC. SOT343
	ATF-501P8	4.5/280	2	15	29	45.5	1	E-pHEMT FET, LPCC
	ATF-511P8	4.5/200	2	14.8	30	41.7	1.4	E-pHEMT FET, LPCC
	ATF-521P8	4.5/200	2	17	26.5	42	1.5	E-pHEMT FET, LPCC
	ATF-531P8	4/135	2	20	24.5	38	0.6	E-pHEMT FET, LPCC
	ATF-541M4	3/60	2	17.5	21.4	35.8	0.5	E-pHEMT FET, MiniPak
	ATF-54143	3/60	2	16.6	20.4	36.2	0.5	E-pHEMT FET, SOT343
WiFi/WiMAX	AFEM-S257		2.5 - 2.7	16 QAM WiMAX EVM <-30dB min. (2.5%) at 24dBm				MCOB 5x7x1
	AFEM-S102		2.4 - 2.5	SP3T Switch 2.5GHz WiFi/Bluetooth Fem				Small Size 2.2x2.2x0.55
	AFEM-S105		5.1 - 5.9	EVM <-32.5dB at 15dBm, <-35dB at 12dBm				Small Size 3.2x3.2x0.6
	MGA-22103		2.5-2.7	16 QAM WiMAX EVM <-32dB (2.5%) at 25 dBm				Small Size 3x3x1

Notes:
1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. Current adjustable: 10 - 80mA.
3. Current adjustable 10 - 60mA.
4. High reverse isolation: 50dB typical.

2-6 GHz Systems (including 802.11 a/b/g and 802.16)

2-6 GHz Systems Suggested Components

Application	Part Number	Typical Performance						Package
		Test Bias V/ mA	Test Freq GHz	Gain[1] dB	P1dB[1] dBm	OIP3 dBm	NF dB	
RF Amplifier	MGA-61563[3]	3/41	2	15.5	15.1	31.7	1	E-pHEMT MMIC, SOT363
Buffer Amplifier	ABA-31563	3/14	2	21.5	2.2	13.1	3.8	Si MMIC, SOT363
	ABA-32563	3/37	2	19	8.4	19.5	3.5	Si MMIC, SOT363
	ABA-51563	5/18	2	21.5	1.8	11.4	3.7	Si MMIC, SOT363
	ABA-52563	5/35	2	21.5	9.8	19.9	3.3	Si MMIC, SOT363
	ABA-53563	5/46	2	21.5	12.7	22.9	3.5	Si MMIC, SOT363
	ABA-54563	5/79	2	23	16.1	27.8	4.4	Si MMIC, SOT363
	MGA-565P8[4]	5/67	2	21.8	20 (Psat)			E-pHEMT MMIC, LPCC
	MGA-61563[3]	3/41	2	15.5	15.1	31.7	1	E-pHEMT MMIC, SOT363

Application	Part Number	High Isolation, High Linearity switch with Detector	Package
Switch Deªtector Module	AFEM-S260	2 - 4	MCOB 3x4x1

Notes:
1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. Current adjustable: 10 - 80mA.
3. Current adjustable 10 - 60mA.
4. High reverse isolation: 50dB typical.

Application	Part Number	Test Bias	Test Freq	Gain[1]	P1dB[1]	OIP3	NF	Package (mm)
Low Noise Amplifiers	MGA-14516	5.0/45	1.95	31.7	23.5	38	0.68	QFN 4x4x0.85
	MGA-21108	1.4/17	3.5	17.6	5.3	20.9	1.4	STSLP 2.5x2.5x0.55
	MGA-61563[2]	3/41	2	15.5	15.1	31.7	1	E-pHEMT MMIC, SOT363
	MGA-632P8	4/60	1.95	17.6	18.3	35.4	0.6	LPCC 2x2
	MGA-645T6	3/7	2.4	15	9.0	22	1.1	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-655T6	3/10	3.5	14.7	12.0	20.2	1.17	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-665P8	3/20.5	5.25	16	11.4	18.2	1.45	E-pHEMT MMIC, LPCC
	MGA-675T6	3.0/10	5.5	17.8	(-10) IP1dB	(-3) IIP3	1.75	E-pHEMT, UTSLP 2x1.3x0.4
	MGA-64606	3/7	2.4	15.3	-3.0 (IP1dB)	20.3	0.95	UTSLP 2.0x1.3
	MGA-65606	3/7	3.5	15.3	-2.4 (IP1dB)	21	1.05	UTSLP 2.0x1.3
	MGA-71543[3]	2.4/10	2.01	15.9	7.4	18.9	1.1	pHEMT MMIC, SOT343
	MGA-85563	3/15	2	19	0.9	11.5	1.85	pHEMT MMIC, SOT363
	MGA-87563	3/4.5	2	14	-2	8	1.8	pHEMT MMIC, SOT363
	ATF-36077	1.5/10	12	12	5		0.5	pHEMT FET, ceramic
	ATF-36163	1.5	12	10	5		1.2	pHEMT FET, SOT363
	ATF-551M4	2.7/10	2	17.5	14.6	24.1	0.5	E-pHEMT FET, MiniPak
	ATF-55143	2.7/10	2	17.7	14.4	24.2	0.6	E-pHEMT FET, SOT343
	ALM-2812	3.3/15	2.45	16.7	(-5.8) IP1dB	6.1 IIP3	0.8	MCOB 3x3x1.1
		3.3/23.4	5.5	23.2	(-12.8) IP1dB	(-2.1) IIP3	1.4	MCOB 3x3x1.1
	VMMK-1218	3/20	10	10.7	12	12	0.7	SM 1x0.5
	VMMK-1225	2/20	12	11	8	23	0.9	SM 1x0.5
Mixers	IAM-91563	3/9	1.89	9	-8	-6	8.5	pHEMT MMIC, SOT363

Notes
1. Gain and P1dB performance for discrete FETs when matched for best IP3
2. Current adjustable 10 - 60mA
3. Source grounded configuration

2-6 GHz Systems (including 802.11 a/b/g and 802.16)

2-6 GHz Systems Suggested Components

Application	Part Number	Ct max @0V	Package
Detector	HMPS-282x	1pF	Schottky, MiniPak
	HSMS-282x	1pF	Schottky, SOT323/363/23/143
	HSMS-286x	0.3pF	Schottky, SOT323/363/23/143
Switch	HMPP-389x	0.35pF	PIN, MiniPak
	HSMP-389x/489x	0.4pF	SOT323/363/23/143/SOD-323
	HMPP-386x	0.2pF	PIN, MiniPak
	HSMP-386x	0.2pF	SOT323/363/23/SOD-323

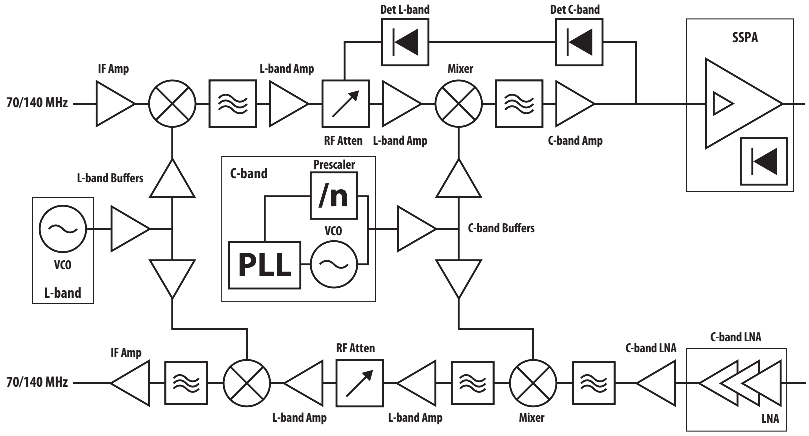
Application	Part Number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB @ 2GHz	P1dB/dBm @ 2GHz	OIP3/dBm @ 2GHz	NF/dB @ 2GHz	Device Type and Package
IF Amplifier	MGA-62563[1]	3/55	0.1 - 3	22	18	35	0.8	E-pHEMT MMIC, SOT363
	MGA-545P8	3.3/135	0.1 - 7	22	19	36	2	E-pHEMT MMIC, LPCC
	ADA-4789	4.1/80	DC - 2.5	16.3	16.9	29	4.5	Si MMIC, SOT89
	ADA-4743	(3.8)/60	DC - 2.5	16.5	17.1	34	4.2	Si MMIC, SOT343
	ADA-4643	(3.5)/35	DC - 2.5	17.3	14	29	4	Si MMIC, SOT343
	ADA-4543	(3.4)/15	DC - 2.5	15.5	2.4	15	3.7	Si MMIC, SOT343
	ABA-54563	5/81	DC - 3	23	18	32	3	Si MMIC, SOT363
	ABA-53563	5/46	DC - 3.5	21.5	15	27.5	2.9	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.8	12.5	28	2.7	Si MMIC, SOT363
	AVT-50663	5/36	DC-6000	15.3	12.5	25	4	SOT-363 (SC70)
	AVT-51663	5/37	DC-6000	19.6	12.9	25.1	3.2	SOT-363 (SC70)
	AVT-52663	5/45	DC-6000	15.3	12.7	27	4	SOT-363 (SC70)
	AVT-53663	5/48	DC-6000	19.6	15.1	26.5	3.2	SOT-363 (SC70)

Recommended Parts in **Bold**.

Notes

1. Current adjustable 20 - 60mA

C-Band



Tx/GHz: 5.880-6.425, 5.725-6.275, 6.725-7.025, 6.425-6.725
Rx/GHz: 3.625-4.200, 3.400-3.950, 4.500-4.800, 3.400-3.700

VSAT Suggested Components

Application	Part number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB @ 500MHz	P1dB/dBm @ 500MHz	OIP3/dBm @ 500MHz	NF/dB @ 500MHz	Device Type and Package
IF Amplifier	MGA-62563[1]	3/55	0.1 - 3	22	18	34.8	0.8	E-pHEMT MMIC, SOT363
	MGA-545P8	3.3/135	0.1 - 7	22	19	36	2	E-pHEMT MMIC, LPCC
	ADA-4789	4.1/80	DC - 2.5	17	18.8	35	4.2	Si MMIC, SOT89
	ADA-4743	(3.8)/60	DC - 2.5	16.6	17.1	34	4.2	Si MMIC, SOT343
	ABA-53563	5/46	DC - 3.5	21.5	15	27.5	2.9	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.8	12.5	28	2.7	Si MMIC, SOT363

Application	Part number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB @ 2GHz	P1dB/dBm @ 2GHz	OIP3/dBm @ 2GHz	NF/dB @ 2GHz	Device Type and Package
L-band Amplifier	MGA-53543	5/54	0.4 - 6	15.4	18.6	39.1	1.5	E-pHEMT MMIC, SOT343
L-band Buffer - Low Power	MGA-61563[1]	3/41.6	0.1 - 6	15.5	15.1	31.7	1	E-pHEMT MMIC, SOT363
	MGA-82563	3/84	0.1 - 6	13.2	17.3	31	2.2	GaAs MMIC, SOT363
	MGA-81563	3/42	0.1 - 6	12.4	14.8	27	2.8	GaAs MMIC, SOT363
	ABA-53563	5/46	DC - 3.5	21.5	12.7	22.9	3.5	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.5	9.8	19.9	3.3	Si MMIC, SOT363
	ABA-51563	5/18	DC - 3.5	21.5	1.8	11.4	3.7	Si MMIC, SOT363
	MGA-85563[3]	3/15 to 30	0.8 - 6	19	1 to 8	12 to 17	1.9	GaAs MMIC, SOT363
L-band Buffer-High Power	MGA-565P8[2]	5/67	0.1 - 3.5	21.8	20 (Psat)	–	–	E-pHEMT MMIC, LPCC
	MGA-82563	3/84	0.1 - 6	13.2	17.3	31	2.2	GaAs MMIC, SOT363

Recommended Parts in **Bold**.

Notes:

1. Current adjustable 10-60mA.
2. High reverse isolation: 50dB typical.
3. Reverse Isolation 40dB typical.

C-Band

VSAT Suggested Components

Application	Part Number	Description	Package
L-band/C-band Detector - Schottky Diodes	**HSMS-282x**	Ct max = 1pF @0V	SOT323/363/23/143
	HSMS-286x	Ct max = 0.3pF @0V	SOT323/363/23/143
RF Attenuator - PIN Diodes	**HSMP-381x**	Very low distortion, Ct typ. = 0.2pF @0V, see AN1048 pi-attenuator design	SOT323/23/25/SOD-323
	HSMP-386x	Lower current, low cost, Ct typ. = 0.2pF @0V, see AN1048 pi-attenuator design	SOT323/363/23/25/SOD-323
RF Attenuator - Module	ALM-38140	Low distortion, high dynamic range attenuator module	MCOB 3.8x3.8x1.0mm

Recommended Parts in **Bold**.

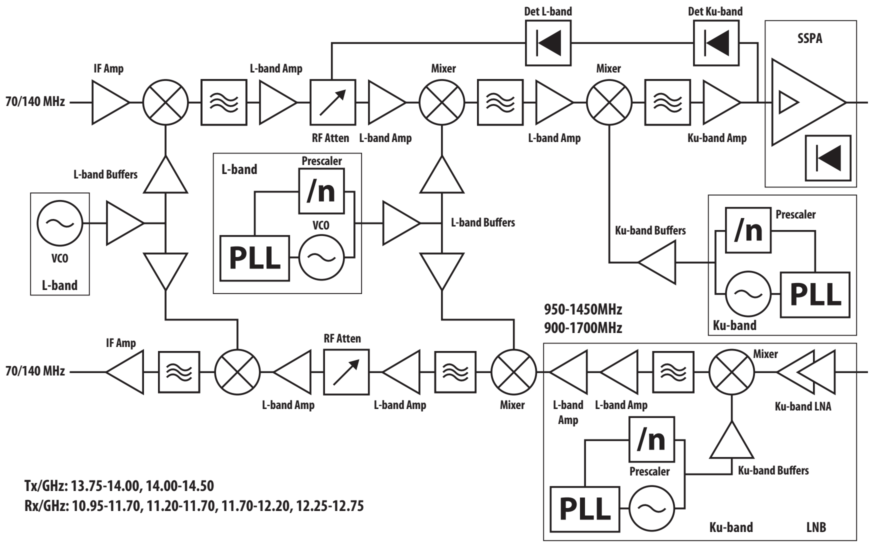
Application	Part number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @ 5GHz	P1dB/dBm[1] @ 5GHz	OIP3/dBm @ 5GHz	NF/dB[2] @ 5GHz	Device Type and Package
C-band LNA	ATF-36077	1.5/10	2 - 18	16	5	–	0.3	PHEMT FET, ceramic
	ATF-36163	1.5/10	1.5 - 18	15	5	–	0.61	PHEMT FET, SOT363
	ATF-551M4	2.7/10	0.5 - 6	12	14.5	24.5	0.75	E-pHEMT FET, MiniPak
	ATF-55143	2.7/10	0.5 - 6	12	13.5	24	0.9	E-pHEMT FET, SOT343
C-band Amplifier C-band Buffer	MGA-545P8	3.3/135	0.1 - 6	12	21	34	3.6	E-pHEMT MMIC, LPCC
	MGA-82563	3/84	0.1 - 6	9.5	17	31	2.6	GaAs MMIC, SOT363
	MGA-81563	3/42	0.1 - 6	10.5	14.5	27	3.2	GaAs MMIC, SOT363
	MGA-85563	3/15 to 30	0.8 - 6	16	1 to 8	12 to 18	1.6	GaAs MMIC, SOT363
	ATF-541M4	3/60	0.5 - 8	11	19.5	37.5	1.02	E-pHEMT FET, MiniPak
	ATF-54143	3/60	0.5 - 6	11	18	36	0.93	E-pHEMT FET, SOT343
	ATF-521P8	4.5/200	0.5 - 6	10	27	39	1.75	E-pHEMT FET, LPCC

Recommended Parts in **Bold**.

Notes:

1. Gain and P1dB performance for discrete FETs when matched for best IP3
2. NFmin figures for discrete FETs

Ku-Band



VSAT Suggested Components

Application	Part number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @ 12GHz	P1dB/dBm[1] @ 12GHz	OIP3/dBm @ 12GHz	NF/dB[2] @ 12GHz	Device Type and Package (mm)
Ku-band LNA	ATF-36077	1.5/10	2 - 18	12	5	–	0.5	PHEMT FET, Ceramic
	ATF-36163	1.5/10	1.5 - 18	9.4	5	–	1	PHEMT FET, SOT363
	AMMP-6220	3/60	6 - 20	23	10	23	2.2	SM 5x5
	VMMK-1225	2/20	0.5 - 26	11	8	23	0.9	SM 1x0.5
	VMMK-1218	3/20	0.5 - 18	10.7	12	12	0.7	SM 1x0.5
Ku-band Amplifier	AMMP-5618	5/107	6 - 20	13	19	30	4.4	SM 5x5
Ku-band Buffer	AMMP-6408	5/650	6 - 18	18	28	38	4.5	SM 5x5
Ku-band Mixer (IRM)	AMMP-6530	-1/0	5 - 30	-10	8	18	10	SM 5x5

Recommended Parts in **Bold**.
Notes:
1. Gain and P1dB performance for discrete FETs when matched for best noise.
2. NFmin figures for discretes FETs.

VSAT

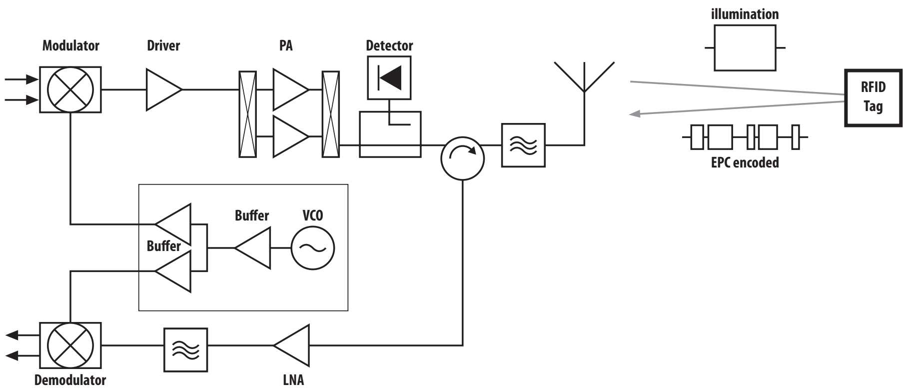
Ku-Band

VSAT Suggested Components

Application	Part Number	Description	Package
Ku-band Detector - Schottky diodes	**HSMS-286x**	Ct max = 0.3pF @0V	SOT323/363/23/143
	HSCH-5310/5330	Si single, Ct=0.1pF, med. barrier/low barrier	beamlead
	HSCH-5312/5332	Si single Ct=0.15pF, med. barrier/low barrier	beamlead
Ku-band Mixer - Schottky diodes	**HSMS-8202**	Si series pair, Ct=0.26pF, low-cost	SOT23
	HSCH-5312/5332	Si single Ct=0.15pF, med. barrier/low barrier	beamlead
	HSCH-5531	Si series pair, Ct=0.15pF, low barrier/ Ct=0.1pF, med. barrier	beamlead

Recommended Parts in **Bold**.

RFID 900 MHz Reader



RFID 900MHz Reader Suggested Components

Application	Part number	Typ. Bias V/ mA	Frequency Range/GHz	Gain/dB[1] @ 0.9GHz	P1dB/dBm[1] @ 0.9GHz	OIP3/dBm @ 0.9GHz	NF/dB[2] @ 0.9GHz	Device Type and Package (mm)
LNA	MGA-53543	5/54	0.4 - 6	17.4	19.3	39.7	1.3	E-pHEMT MMIC, SOT343
	MGA-72543[5]	3/20	0.1 - 6	14.8	12	23	1.35	E-pHEMT MMIC, SOT343
	ATF-54143	3/60	0.45 - 6	23.4	18.4	35.5	0.3	E-pHEMT FET, SOT343
	ATF-58143	3/30	0.45 - 6	23.1	18.1	28.6	0.3	E-pHEMT FET, SOT343
Driver Amplifier	MGA-53543	5/54	0.4 - 6	17.4	19.3	39.7	1.3	E-pHEMT MMIC, SOT343
	MGA-545P8	3.3/127	0.05 - 7	22.4	21.5	34	2.6	E-pHEMT MMIC, LPCC
	MGA-61563[4]	3/41	0.1 - 6	19.3	15.4	30.5	0.9	E-pHEMT MMIC, SOT363
	ATF-52189	4.5/200	0.05 - 6	16.5	27.2	42	1	E-pHEMT FET, SOT89
	ATF-521P8	4.5/200	0.05 - 6	17.2	26.5	42.5	0.7	E-pHEMT FET, LPCC
	ATF-53189	4/135	0.05 - 6	17.2	21.7	42	0.41	E-pHEMT FET, SOT89
	ATF-531P8	4/135	0.05 - 6	25	23	37	0.26	E-pHEMT FET, LPCC
	ADA-4789	4.1/80	DC - 2.5	16.9	18.8	33.2	4.3	Si MMIC, SOT89
	ADA-4743	3.8/60	DC - 2.5	16.5	17.1	32.6	4.2	Si MMIC, SOT343
Power Amplifier	ATF-50189	4.5/280	0.05 - 6	21.5	28.5	44	1	E-pHEMT FET, SOT89
	ATF-501P8	4.5/280	0.05 - 6	16.6	27.3	42	1	E-pHEMT FET, LPCC
	ATF-511P8	4.5/200	0.05 - 6	17.8	29.6	43	1.2	E-pHEMT FET, LPCC
Mixer	IAM-92516	5/26	0.4 - 3.5	6.5 (CL)	16 (IP1dB)	29.3 (IIP3)	7.1	E-pHEMT MMIC, LPCC(3x3)
Buffer-High Power	MGA-565P8[3]	5/67	0.1 - 3.5	28	22 (Psat)	–	–	E-pHEMT MMIC, LPCC
	ABA-54563	5/79	DC - 3.4	23	18	34	4.2	Si MMIC, SOT363
Buffer-Low Power	ABA-31563	3/14	DC - 3.5	21.3	3	15	3.8	Si MMIC, SOT363
	ABA-32563	3/37	DC - 2.5	20.5	9.5	22.5	3.1	Si MMIC, SOT363
	ABA-51563	5/18	DC - 3.5	21	3.5	15	3.4	Si MMIC, SOT363
	ABA-52563	5/35	DC - 3.5	21.3	12	26	2.9	Si MMIC, SOT363
	ABA-53563	5/46	DC - 3.5	21.5	14.5	26.5	3.1	Si MMIC, SOT363
Detector	HSMS-282x	Ct max = 1pF @0V						SOT323/363/23/143

Notes:
1. Gain and P1dB performance for discrete FETs when matched for best IP3.
2. NFmin figures for discrete FETs.
3. High reverse isolation: 50dB typical.
4. Current adjustable: 20-60mA.
5. Includes integral bypass function. Current adjustable between 5 – 60mA.

Product Selection Guides
RFICs (GaAs and Silicon)

GaAs RFICs

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idq (mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package
GaAs Fixed Gain Amplifiers	MGA-52543	0.4 - 6	1.9	5	53	1.9	14.2	+17.4	+32	SOT-343 (SC-70)
	MGA-53543	0.4 - 6	1.9	5	54	1.5	15.4	+18.6	+39	SOT-343 (SC-70)
	MGA-53589	0.05 - 6	1.9	5	52	1.66	15.8	+18.5	+37	SOT-89
	MGA-81563	0.1 - 6	2.0	3	42	2.8	12.4	+14.8	+27	SOT-363 (SC-70)
	MGA-82563	0.1 - 6	2.0	3	84	2.2	13.2	+17.3	+31	SOT-363 (SC-70)
	MGA-85563	0.8 - 6	2.0	3	15 to 30	1.9	18.0	+1 to +8	+12 to +17	SOT-363 (SC-70)
	MGA-86563	0.5 - 6	2.0	5	14	1.5	22.7	+4.1	+15	SOT-363 (SC-70)
	MGA-86576	1.5 - 8	4.0	5	16	1.6	23.1	+6.3	+16	SM Ceramic
	MGA-87563	0.5 - 4	2.0	3	4.5	1.6	14.0	-2	+8	SOT-363 (SC-70)

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idsat (mA)	PAE (%)	Gain (dB)	PSAT (dBm)	OIP3 (dBm)	Package (mm)
GaAs Medium Power Amplifiers	MGA-30789	2 - 6	3.5	5	100		11.7	–	41.8	SMT 4.5x4.1x1.5
	MGA-30889	0.04 - 2.6	0.9	5	65		15.5	–	38	SMT 4.5x4.1x1.5
	MGA-30989	2 - 6	3.5	5	51		12	–	36.8	SMT 4.5x4.1x1.5
	MGA-412P8	2.4 - 2.5	2.4	3.3	95	NA	25.5	+25.3	38	LPCC 2X2
	MGA-425P8	2 - 10	5.25	3.3	65	47.0	16.0	+20.3	32.9	LPCC 2x2
	MGA-545P8	0.05 - 7	5.825	3.3	92	46.0	11.5	+22	+34	LPCC 2x2
	MGA-83563	0.5 - 6	2.4	3	152	37.0	22.0	+22	+29	SOT-363 (SC-70)

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idq (mA)	NF (dB)	Gain (dB)	OP1dB (dBm)	OIP3 (dBm)	Package (mm)
GaAs Match-Pair Dual LNA	MGA-16516	0.7 - 1.7	0.85	5	50	0.45	17.5	18	11.5 (IIP3)	QFN 4x4x0.85
	MGA-17516	1.7 - 2.7	1.95	5	50	0.52	17.2	21.5	13.7 (IIP3)	QFN 4x4x0.85

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idq (mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
GaAs Smart Bias Amplifier	MGA-14516	1.4 - 2.7	1.95	5	45	0.66	31.7	23.5	38	QFN 4x4x0.85
	MGA-61563	0.1 - 6	2	3	41	1.2	16.6	+15.8	+28.5	SOT-363 (SC-70)
	MGA-62563	0.1 - 3	0.5	3	60	0.9	22.0	+17.8	+32.9	SOT-363 (SC-70)
	MGA-631P8	0.4 - 1.5	0.9	4	60	0.5	17.5	18	32.8	LPCC2x2
	MGA-632P8	1.4 - 3	1.95	4	60	0.6	17.6	18.3	35.4	LPCC2x2
	MGA-685T6	0.1 - 1.5	0.5	3	10	0.9	18.9	17.3	+18.7	UTSLP 2.0x1.3x0.4
	MGA-68563	0.1 - 1.5	0.5	3	11	1	19.7	17.5	20.7	SOT-363

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idq (mA)	NF (dB)	Gain (dB)	PAE (%)	OIP3 (dBm)	Package (mm)
GaAs High Linearity Amplifier	ALM-31122	0.7 - 1	0.9	5	394	2	15.6	52.5	47.6	MCOB 5.0x6.0x1.1
	ALM-31222	1.7 - 2.7	2	5	415	2.7	14.9	52.6	47.9	MCOB 5.0x6.0x1.1
	ALM-31322	3.3 - 3.9	3.5	5	413	2.8	13.2	51.5	47.7	MCOB 5.0x6.0x1.1
	ALM-32120	0.7 - 1.0	0.9	5	800	2.5	14	47	52	MCOB 7.0x10.0x1.1
	ALM-32220	1.7 - 2.7	2	5	800	3.5	14.8	47.5	50	MCOB 7.0x10.0x1.1
	ALM-32320	3.3 - 3.9	3.5	5	800	2.5	12	43	49	MCOB 7.0x10.0x1.1
	MGA-30116	0.75 - 1	0.9	5	202.8	2	17	47	44.1	QFN 3x3
	MGA-30216	1.7 - 2.7	2	5	206	2.8	14.2	48.9	45.3	QFN 3x3
	MGA-30316	3.3 - 3.9	3.5	5	198	2.7	12.8	51.3	44.4	QFN 3x3
	MGA-30489	0.25 - 3.0	1.9	5	97	3	13.3	–	39	SOT-89
	MGA-30689	0.04 - 2.6	1.95	5	104	3.3	14.6	–	40	SOT-89
	MGA-31189	0.05 - 2	0.9	5	111	3	21	42.5	42	SOT-89
	MGA-31289	1.5 - 3	1.9	5	124	2	18.7	36.4	41.8	SOT-89
	MGA-31389	0.05 - 2	0.9	5	73	2	21.3	41.2	38.6	SOT-89
	MGA-31489	1.5 - 3	1.9	5	69	1.9	19.5	39.1	37.3	SOT-89
	MGA-31589	0.45 - 1.5	0.9	5	146	1.9	20.4	45	45.3	SOT-89
	MGA-31689	1.5 - 3	1.9	5	168	1.9	18.1	48	44.9	SOT-89
	MGA-53589	50MHz - 6GHz	1.9	5	54	1.66	18.6	–	37	SOT-89

RFICs (GaAs and Silicon)

GaAs RFICs

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idsat (mA)	Isolation (dB)	Gain (dB)	Psat (dBm)	Package (mm)
GaAs LO Buffer Amplifier	MGA-565P8	0.1 - 3	2	5	67	50.0	21.8	+20	LPCC2x2

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vd/Id (V/mA)	Switch Insertion Loss (dB)	NF (dB)	Gain (dB)	P1dB (dBm @ mA)	IIP3 (dBm @mA)	Package (mm)
GaAs Amplifier with Bypass Switch	MGA-645T6	1.7 - 3	2.4	3/7	4.5	1.1	15.0	+9 @ 7	+7 @ 7	UTSLP 2.0x1.3x0.4
	MGA-64606	1.5 -3	2.4	3/7	4.5	0.95	15.3	-3.0(IP1dB)	+5@7	UTSLP 2.0x1.3
	MGA-655T6	2.5 - 4	3.5	3/10	4.2	1.17	14.7	+12 @ 10	+5.5 @ 10	UTSLP 2.0x1.3x0.4
	MGA-65606	2.5 - 4	3.5	3/7	4.2	1.05	15.3	-2.4(IP1dB)	+5.7@7	UTSLP 2.0x1.3
	MGA-71543	0.1 - 6	2	2.7/10	5.6	0.8	15.4	+7.4 @ 10	+3 @ 10	SOT-343 (SC-70)
	MGA-72543	0.1 - 6	2	2.7/20	2.5	1.4	13.6	+11.2 @ 20	+10.5 @ 20	SOT-343 (SC-70)
	MGA-725M4	0.1 - 6	2	2.7/20	1.6	1.3	15.7	+13.1 @ 20	+9.9 @ 20	MiniPak Package
	MGA-785T6	0.1 - 1.5	0.6	3/10	2.6	1.5	15.7	3.2 @ 10	+1.10 @ 10	UTSLP 2.0x1.3x0.4

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vd (V)	Id (mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
GaAs LNA with Power Down	MGA-665P8	0.5 - 6	5.25	3	21	1.5	16.5	11.1	15.4	LPCC2x2
GaAs LNA Module	MGA-13116	0.4 - 1.5	0.9	5	55	0.51	38	23.3	41.4	QFN 4x4x0.85
	MGA-13216	1.5 - 2.5	1.95	5	53	0.61	35.8	23.6	40.5	QFN 4x4x0.85
	MGA-21108	1.5 - 8.0	3.5	1.4	17	1.4	17.6	5.3	20.9	STSLP 2.5x2.5x0.55
	MGA-231T6	0.9 - 3.5	1.575	2.7	6	0.9	18.5	(-8) IP1dB	2 (IIP3)	E-pHEMT, UTSLP 2x1.3x.04
	MGA-24106	0.9 - 3.5	1.575	2.7	3.3	0.97	17.9	-9.7 (IP1dB)	-2.0 (IIP3)	uDFN 1.5x1.3x0.5
	MGA-633P8	0.45 - 2	0.9	5	54	0.37	18	22	37	QFN 2x2x0.75
	MGA-634P8	1.5 - 2.3	1.9	5	48	0.44	17.4		36	QFN 2x2x0.75
	MGA-635P8	2.3 - 4	2.5	5	56	0.56	18	21.9	35.9	QFN 2x2x0.75
	MGA-636P8	0.45 - 1.5	0.7	4.8	105	0.5	18.5	23	41.5	QFN 2x2x0.75
	MGA-637P8	1.5 - 2.5	1.7	4.8	70	0.6	17.5	22	41.5	QFN 2x2x0.75
	MGA-638P8	2.5 - 4	2.5	4.8	90	0.8	17.5	22	39.5	QFN 2x2x0.75
	MGA-635T6	0.9 - 2.4	1.575	2.85	4.9	0.86	14.6	1 (IP1dB)	3.5 (IIP3)	UTSLP 2.0x1.3x0.4
	MGA-675T6	4.9 - 6.0	5.5	2.7	5	0.9	16.3	NA	14.7	UTSLP
	ALM-11036	0.776 - 0.87	0.849	5	92	0.78	15.6	4	37.6	SMT 7x10
	ALM-1106	0.9 - 2.5	1.575	2.85	8	0.8	14.3	1.8 (IP1dB)	4.7 (IIP3)	MCOB 2x2x1.1
	ALM-11136	0.87 - 0.915	0.915	5	92	0.76	15.4	4.5	38.2	SMT 7x10
	ALM-11236	1.71 - 1.85	1.785	5	99	0.67	15.9	3.5	32.3	SMT 7x10
	ALM-11336	1.85 - 1.98	1.98	5	100	0.72	15.3	3.8	35.5	SMT 7x10
	ALM-2506	0.9 - 2.5	1.575	2.85	8	0.8	14.3	1.9 (IP1dB)	4.7 (IIP3)	MCOB 2x2x1.1

Component	Part Number	Test Freq. (GHz)	Vd/Id (V/mA)	NF (dB)	Gain (dB)	IP1dB (dBm)	IIP3 (dBm)	Cell-Band Rejection	PCS-Band Rejection	Package (mm)
GPS LNA/Filter Module	ALM-1412	1.575	2.85/8	0.82	13.5	2.7	7	54	63	MCOB 3.3x2.1x1.1
	ALM-1612	1.575	2.7/6	0.95	18.2	-8	2	69	67	MCOB 3.3x2.1x1.0
	ALM-2412	1.575	2.85/9	0.85	13.5	2.2	6.1	63	65	MCOB 3.3x2.1x1.1
	ALM-2712	1.575	2.7/7.5	12.6	14.2	5	2	–	–	MCOB 3x2.5x1
GPS Filter/LNA/Filter Module	ALM-1712	1.575	2.7/8	1.65	12.8	3	3	104	92.6	E-pHEMT & FBAR, MCOB 4.5x2.2x1.0
	ALM-1812	1.575	2.8/6	1.9	18.5	-8	2	95	90	E-pHEMT & FBAR, MCOB 4.5x2.2x1.0
	ALM-1912	1.575	2.7/6	1.62	19.3	-8	1.5	>57	>53	MCOB 2.9x2x1

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vd (V)	Id (mA)	NF (dB)	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	Package (mm)
Variable Gain Amplifier	ALM-80110	0.4 - 1.6	0.9	5	110	4.8	(-27) to 13.6	40.3	23.3	MCOB 5.0x5.0x1.1
	ALM-80210	1.6 - 2.6	1.9	5	110	5.3	(-25.5) to 9.8	40.8	23.6	MCOB 5.0x5.0x1.1

RFICs (GaAs and Silicon)

GaAs RFICs

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vd (V)	Id (mA)	NF (dB)	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	Package (mm)
WaferCap Amplifier	VMMK-2103	0.5 - 6.0	3	5	24	1.7	13.9	8 (IIP3)	0 (IP1dB)	1x0.5x0.25
	VMMK-2203	0.9 - 11	6	5	25	1.9	16.5	14	5	1x0.5x0.25
	VMMK-2303	0.5 - 6.0	6	1.8	20	1.9	14.1	22	9	1x0.5x0.25
	VMMK-2403	1.5 - 4.0	3	3	38	1.8	15	29	16.5	1x0.5x0.25
	VMMK-2503	1.0 - 12	6	5	65	3.3	14	27	17	1x0.5x0.25
	VMMK-3503	0.5 - 18	–	5	30	3.6	12	10	–	1x0.5x0.25
	VMMK-3603	1 - 6	–	5	35	1.5	17	25	9	1x0.5x0.25
	VMMK-3803	3 - 10	–	3	20	1.7	18.5	18	4.5	1x0.5x0.25

Component	Part Number	Freq. Range (GHz)	Bias (V@mA)	IRL (dB)	ORL (dB)	Insertion Loss (dB)	Directivity (dB)	Package (mm)
WaferCap Detector	VMMK-3113	2 - 6	1.5V@0.15mA	20	20	0.2 - 0.35	15	1x0.5x0.25
	VMMK-3213	6 - 18	1.5V@0.15mA	20	20	0.15 - 0.5	15	1x0.5x0.25
	VMMK-3313	15 - 33	1.5V@0.15mA	20	20	0.25 - 0.7	15	1x0.5x0.25
	VMMK-3413	25 - 45	1.5V@0.15mA	20	20	0.4 - 0.8	18 - 7	1x0.5x0.25

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Voltage (Vdg)	Current (mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
Mixers-Downconverter	IAM-91563	0.8 - 6	1.9	3	9	8.5	9.0	-8	-6	SOT-363 (SC-70)
	IAM-92516	0.4 - 3.5	1.9	5	26	12.5	-6.0	9	27 (IIP3)	LPCC 3x3

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idq (mA)	Gain (dB)	P1dB (dB)	Pout @ 2.5% EVM	Atten (dB)	Package (mm)
GaAs WiMAX Power Amplifier Module	ALM-42216	2.3 - 2.7	2.5	3.3	240	30	30	23.5	20	MCOB 5.0x5.0x1.1
	ALM-42316	3.3 - 3.8	3.5	3.3	240	30	30.5	23	18	MCOB 5.0x5.0x1.1
	MGA-43128	0.7 - 0.8	0.75	5	780	33.4	36	29.2	1.8	QFN 5x5
	MGA-43228	2.3 - 2.5	2.4	5	1023	38.5	36	29.1	23.8	QFN 5x5
	MGA-43328	2.5 - 2.7	2.6	5	1017	37.4	36	29.3	24.5	QFN 5x5
	MGA-43428	0.86 - 0.97	0.85	5	800	>30	36	28dBm@ 50dBc ACLR	–	MCOB 5x5
	MGA-43528	1.8 - 2.0	1.9	5	1000	>30	35		–	MCOB 5x5
	MGA-43628	2.0 - 2.2	2.1	5	1000	>30	35		–	MCOB 5x5

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	BCTRL	Gain (dB)	PAE of 19%	IP1dB (dBm)	Package (mm)
WiMAX/WiFi Amplifier Module	MGA-22003	2.3 - 2.7	2.5	2.8	35	19	31	Small Size 3x3x1
	MGA-22103	2.5 - 2.7	16 QAM WiMAX EVM <-32dB (2.5%) at 25 dBm					Small Size 3x3x1
	MGA-23003	3.3 - 3.8	3.5	2.8	35	18	31	Small Size 3x3x1
	MGA-25203	5.1 - 5.9	5.4	2.8	30	13	30	Small Size 3x3x1
	AFEM-S257	2.5 - 2.7	16 QAM WiMAX EVM <-30dB min. (2.5%) at 24dBm					MCOB 5x7x1
	AFEM-S102	2.4 - 2.5	SP3T Switch 2.5GHz WiFi/Bluetooth Fem					Small Size 2.2x2.2x0.55
	AFEM-S105	5.1 - 5.9	EVM <-32.5dB at 15dBm, <-35dB at 12dBm					Small Size 3.2x3.2x0.6

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd (V)	Idq (mA)	NF (dB)	Gain (dB)	IIP3 (dBm)	IP1dB (dBm)	Package (mm)
WiFi Dual Band LNA Module	ALM-2812	2.4 - 2.5	2.45	3.3	15	0.8	16.7	6.1	5.8	MCOB 3.0x3.0x1.1
		4.9 - 6.0	5.5	3.3	23.4	1.4	23.2	2.2	12.8	MCOB 3.0x3.0x1.1

InGap HBT

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vd (V)	Id (mA)	Gain (dB)	NF (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
Gain Block	AVT-50663	DC-6000	2	5	36	15.3	4	12.5	25	SOT-363 (SC70)
	AVT-51663	DC-6000	2	5	37	19.6	3.2	12.9	25.1	SOT-363 (SC70)
	AVT-52663	DC-6000	2	5	45	15.3	4	12.7	27	SOT-363 (SC70)
	AVT-53663	DC-6000	2	5	48	19.6	3.2	15.1	26.5	SOT-363 (SC70)
	AVT-54689	0.05 - 6	2	5	58	4.1	17.1	17.4	29.6	SOT-89
	AVT-55689	0.05 - 6	2	5	75	4.3	17.2	19.5	32.5	SOT-89

RFICs (GaAs and Silicon)

Silicon RFICs

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Voltage (Vdg)	Current (mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package
Silicon Broadband Amplifiers	ABA-31563	DC - 3.5	2.0	3	14.5	3.8	21.0	+2.0	13.0	SOT-363 (SC-70)
	ABA-32563	DC - 2.5	2.0	3	38	3.4	18.5	+8.0	19.0	SOT-363 (SC-70)
	ABA-51563	DC - 3.5	2.0	5	18	3.7	21.5	+1.8	11.4	SOT-363 (SC-70)
	ABA-52563	DC - 3.5	2.0	5	35	3.3	21.5	+9.8	19.9	SOT-363 (SC-70)
	ABA-53563	DC - 3.5	2.0	5	46	3.5	21.5	+12.7	22.9	SOT-363 (SC-70)
	ABA-54563	DC - 3	2.0	5	79	4.4	23.0	+16.1	27.8	SOT-363 (SC-70)
Silicon Darlington Amplifiers	ADA-4543	DC - 2.5	0.9	3.4	15	3.7	15.1	+1.9	15.0	SOT-343 (SC-70)
	ADA-4643	DC - 2.5	0.9	3.5	35	4.0	17.0	+13.4	28.3	SOT-343 (SC-70)
	ADA-4743	DC - 2.5	0.9	3.8	60	4.2	16.5	+17.1	32.6	SOT-343 (SC-70)
	ADA-4789	DC - 2.5	0.9	3.8	60	4.2	16.5	+17.1	32.6	SOT-89
Silicon Fixed Gain Amplifiers	MSA-0300	DC - 2.8	1 Typ	5	35	6	12.5	10	23	Chip
	MSA-0600	DC - 1	0.5 Typ	3.5	16	2.8	19.5	2	14.5	Chip
	MSA-0836	DC - 4	1.0	7.8	36	3.0	23.0	+12.5	27.0	35 Micro-X
	MSA-0870	DC - 4	1.0	7.8	36	3.0	23.5	+12.5	27.0	70 mil
	MSA-0886	DC - 4	1.0	7.8	36	3.3	22.5	+12.5	27.0	86 Plastic
	MSA-3111	DC - 0.5	1.0	4.5	29	3.5	18.4	+9	23.0	SOT-143
	MSA-3186	DC - 0.5	1.0	4.7	29	3.5	18.7	+9	21.0	86 Plastic
	MSA-2011	DC - 1.0	1.0	5	32	4.3	16.2	+9	22.0	SOT-143
	MSA-2086	DC - 1.1	1.0	5	32	3.7	16.6	+9	22.0	86 Plastic
	MSA-0711	DC - 1.9	1.0	3.8	22	5.0	12.0	+5.5	18.0	SOT-143
	MSA-0736	DC - 2.4	1.0	4	22	4.5	13.0	+5.5	19.0	35 Micro-X
	MSA-0770	DC - 2.5	1.0	4	22	4.5	13.0	+5.5	19.0	70 mil
	MSA-0786	DC - 2.0	1.0	4	22	5.0	12.5	+5.5	19.0	86 Plastic
	MSA-0986	0.1 - 5.5	2.0	7.8	35	6.2	7.2	+10.5	23.0	86 Plastic
	MSA-0236	DC - 2.7	1.0	5	25	6.5	12.0	+4.5	17.0	35 Micro-X
	MSA-0270	DC - 2.8	1.0	5	25	6.5	12.0	+4.5	17.0	70 mil
	MSA-0286	DC - 2.5	1.0	5	25	6.5	12.0	+4.5	17.0	86 Plastic
	MSA-0420	DC - 4.0	1.0	6.3	90	6.5	8.5	16	30.0	200 mil BeO
	MSA-0436	DC - 3.8	1.0	5.25	50	6.5	8.5	+12.5	25.5	35 Micro-X
	MSA-0470	DC - 4.0	1.0	5.25	50	6.5	8.5	+12.5	25.5	70 mil
	MSA-0486	DC - 3.2	1.0	5.25	50	7.0	8.0	+12.5	25.5	86 Plastic
	MSA-0505	0.02 - 2.3	1.0	8.4	80	6.5	7.0	18	29.0	05 Plastic
	MSA-0520	0.02 - 2.8	1.0	12	165	6.5	8.5	+23	33.0	200 mil BeO
	MSA-9970	DC - 2.0	1.0	7.8	35		16.0	+14.5	25.0	70 mil
	MSA-0311	DC - 2.3	1.0	4.7	35	6.0	11.0	+9	22.0	SOT-143
	MSA-0336	DC - 2.7	1.0	5	35	6.0	12.0	+10	23.0	35 Micro-X
	MSA-0370	DC - 2.8	1.0	5	35	6.0	12.0	+10	23.0	70 mil
	MSA-0386	DC - 2.4	1.0	5	35	6.0	12.0	+10	23.0	86 Plastic
	MSA-0611	DC - 0.7	0.5	3.3	16	3.0	18.0	+2	14.0	SOT-143
	MSA-0636	DC - 0.9	0.5	3.5	16	2.8	19.0	+2	14.5	35 Micro-X
	MSA-0670	DC - 1.0	0.5	3.5	16	2.8	19.5	+2	14.5	70 mil
	MSA-0686	DC - 0.8	0.5	3.5	16	3.0	18.5	+2	14.5	86 Plastic
	MSA-1105	0.05 - 1.3	0.5	5.5.	60	3.6	12.0	+17.5	30.0	05 Plastic
	MSA-1110	0.05 - 1.6	0.5	5.5	60	3.5	12.0	+17.5	30.0	100 mil
	MSA-1120	0.05 - 1.6	0.5	5.5	60	3.5	12.0	+17.5	30.0	200 mil BeO
	MSA-2111	DC - 0.5	0.9	3.6	29	3.3	17.5	10	20.0	SOT-143

Transistors

Transistors

Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Voltage (V)	NF (dB)	Gain (dB)	P1dB (dBm)	S21E (dB)	OIP3 (dBm)	Package
Silicon Bipolar Transistor	AT-30511	DC - 5	0.9	2.7	1.1	16.0	+7.0	17.9	17.0	SOT-143
	AT-30533	DC - 5	0.9	2.7	1.1	13.0	+7.0	15.2	17.0	SOT-23
	AT-31011	DC - 5	0.9	2.7	0.9	13.0	+9.0	19.1	20.0	SOT-143
	AT-31033	DC - 5	0.9	2.7	0.9	11.0	+9.0	15.8	20.0	SOT-23
	AT-32011	DC - 5	0.9	2.7	1.0	14.0	+13.0	18.9	24.0	SOT-143
	AT-32032	DC - 6	0.9	2.7	1.0	15.0	+13.0	11.5	23.0	SOT-323
	AT-32033	DC - 5	0.9	2.7	1.0	12.5	+13.0	15.1	24.0	SOT-23
	AT-32063	DC - 5	0.9	2.7	1.1	14.5	+12.0	17.0	24.0	SOT-363 (SC-70)
	AT-41435	DC - 6	2.0	8.0	1.7	14.0	+19.0	17.2		35 micro-X
	AT-41486	DC - 6	1.0	8.0	1.4	18.0	+18.0	17.5		86 mil Plastic
	AT-41535	DC - 6	2.0	8.0	1.7	14.0	19.0	11.0	–	35 micro-X
	AT-41500	DC - 6	2.0	8.0	1.7	12.5	18	11.0	–	Chip
	AT-41511	DC - 5	0.9	5.0	1.0	15.5	+14.5	15.8	25.0	SOT-143
	AT-41532	DC - 6	0.9	5.0	1.0	15.5	+14.5	13.3	25.0	SOT-323
	AT-41533	DC - 5	0.9	5.0	1.0	14.5	+14.5	13.9	25.0	SOT-23
	AT-41586	DC - 6	1.0	8.0	1.4	17.0	+18.0	17.0		86 mil Plastic
	AT-42000	DC - 6	2 Typ	8.0	1.9	14.0	21	11.5		Chip
	AT-42010	DC - 6	2.0	8.0	1.9	13.5	21	11.5	–	100 mil
	AT-42035	DC - 6	2.0	8.0	2.0	13.5	+21.0	11.0		35 micro-X
	AT-42036	DC - 6	2.0	8.0	1.9	13.5	+21.0	16.6		36 micro-X
	AT-42070	DC - 6	2.0	8.0	1.9	14.0	+21.0	17.3		70 mil stripline
	AT-42085	DC - 6	2.0	8.0	1.9	13.5	+20.5	17.0		85 mil Plastic
	AT-42086	DC - 6	2.0	8.0	1.9	13.0	+20.5	16.5		86 mil Plastic

Component	Part Number	Freq. Range (GHz)	Voltage (V)	Test Freq. (GHz)	P1dB (dBm)	G1dB (dBm)	Package
Medium Power Si Transistor	AT-64020	DC - 4	16	2	+28	10	200 mil BeO disk
	AT-64023	DC - 4	16	4	26.5	9.5	230 mil BeO disk
	AT-64000	DC - 4	16	4	26.5	9.5	Chip

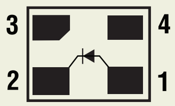
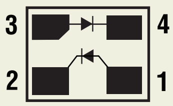
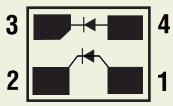
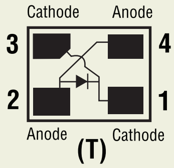
Transistors

Transistors

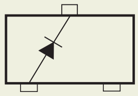
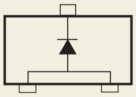
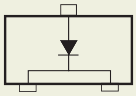
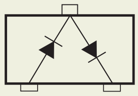
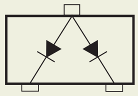
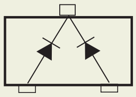
Component	Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vdd / Idq (V)	NF (dB)	Ga (dB)	P1dB (dBm)	OIP3 (dBm)	Gate Width (um)	Package (mm)
Single Voltage Low Noise GaAs E-pHEMTs	ATF-501P8	.05 - 6	2	4.5/280	1.8	14.6	+28	+47	6400	LPCC 2x2
	ATF-50189	.05 - 6	2	4.5/280	1.1	15.5	+29.1	+45.3	6400	SOT-89
	ATF-511P8	.05 - 6	2	4.5/200	1.4	14.8	+30	+42	6400	LPCC 2x2
	ATF-521P8	05 - 6	2	4.5/200	1.5	17.0	+26.5	+42	3200	LPCC 2x2
	ATF-52189	05 - 6	2	4.5/200	1.5	16.0	+27.0	+42	3200	SOT-89
	ATF-531P8	05 - 6	2	4.0/135	0.6	20.0	+24.5	+38	1600	LPCC 2x2
	ATF-53189	05 - 6	2	4.0/135	0.85	15.5	+23.0	+40	1600	SOT-89
	ATF-54143	.45 - 6	2	3.0/60	0.5	16.6	+20.4	+36	800	SOT-343 (SC-70)
	ATF-541M4	.45 - 10	2	3.0/60	0.5	17.5	+21.4	+36	800	MiniPak Package
	ATF-55143	.45 - 6	2	2.7/10	0.6	17.7	+14.4	+24	400	SOT-343 (SC-70)
	ATF-551M4	.45 - 10	2	2.7/10	0.5	17.5	+14.6	+24	400	MiniPak Package
	ATF-58143	.45 - 6	2	3.0/30	0.5	16.5	+19	+30.5	800	SOT-343 (SC-70)
Low Noise GaAs pHEMTS	ATF-33143	.45 - 6	2	4.0/80	0.5	15.0	+22	+33.5	1600	SOT-343 (SC-70)
	ATF-331M4	.45 - 6	2	4.0/80	0.6	15.0	+19	+31	1600	MiniPak Package
	ATF-34143	.45 - 6	2	4.0/60	0.5	17.5	+20	+31.5	800	SOT-343 (SC-70)
	ATF-35143	.45 - 6	2	2.0/15	0.4	18.0	+11	+21	400	SOT-343 (SC-70)
	ATF-38143	.45 - 6	2	2.0/10	0.4	16.0	+12	+22	800	SOT-343 (SC-70)
	ATF-36077	1.5 - 18	12	1.5	0.5	12.0	+5	–	200	70 mil SM
	ATF-36163	1.5 - 18	12	1.5	1.2	10.0	+5	–	200	SOT-363 (SC-70)
	VMMK-1218	0.5 - 18	–	3/20	0.7	10.7	12	12	–	SM 1x0.5
	VMMK-1225	0.5 - 26	–	2/20	0.9	11	8	23	–	SM 1x0.5

Diodes — PIN

MiniPak

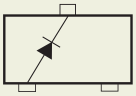
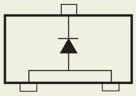
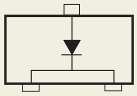
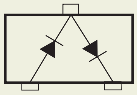
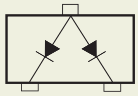
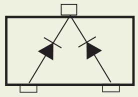
	Single	Anti-parallel	Parallel	Shunt Switch
Configuration	 (0)	 (2)	 (5)	 (T)
PIN	HMPP-3860	HMPP-3862	HMPP-3865	
	HMPP-3890	HMPP-3892	HMPP-3895	HMPP-389T

3 Lead Diodes SOT-3223 (SC-70)

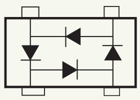
	Single	Dual Anode	Dual Cathode	Series Pair	Common Anode	Common Cathode
Configuration						
PIN	HSMP-381B		HSMP-481B	HSMP-381C	HSMP-381E	HSMP-381F
	HSMP-386B			HSMP-386C	HSMP-386E	HSMP-386F
	HSMP-389B	HSMP-489B		HSMP-389C	HSMP-389E	HSMP-389F
		HSMP-482B				

Diodes — PIN

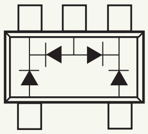
3 Lead Diodes SOT-23

	Single	Dual Anode	Dual Cathode	Series Pair	Common Anode	Common Cathode
Configuration						
PIN	HSMP-3810		HSMP-4810	HSMP-3812	HSMP-3813	HSMP-3814
	HSMP-3860			HSMP-3862	HSMP-3863	HSMP-3864
	HSMP-3890	HSMP-4890		HSMP-3892	HSMP-3893	HSMP-3894
	HSMP-3820	HSMP-4820		HSMP-3822	HSMP-3823	HSMP-3824
	HSMP-3830			HSMP-3832	HSMP-3833	HSMP-3834
				ASML-5822		
				ASML-5829		

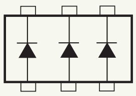
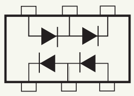
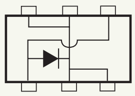
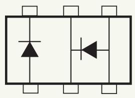
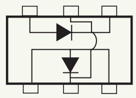
4 Lead Diodes SOT-143

	Unconnected Pair
Configuration	
PIN	HSMP-386D
	HSMP-389D

5 Lead Diodes SOT-25

	Pi Quad
Configuration	
PIN	HSMP-3816
	HSMP-3866

6 Lead Diodes SOT-363 (SC-70)

	Unconnected Trio	Dual Mode Switch	Low Inductance	Series Shunt Pair	High Frequency Series Shunt Pair
Configuration					
PIN	HSMP-386L				
	HSMP-389L	HSMP-389R	HSMP-389T	HSMP-389U	HSMP-389V

Diodes — PIN

PIN Diodes

Application	Part Number	C_t (pF) (max/typ)	RS (Ω) (max)	V_{BR} (V) (min)	T_{rr} (nS) (typ)	Lifetime (nS) (typ)
Low Distortion Attenuator	HSMP-381x	0.35/0.27	3.0	100	300	1500
Low Distortion/Low Inductance Attenuator	HSMP-481x	0.40/0.35	3.0	100	300	1500
Low Resistance Limiter	HSMP-382x	0.8/0.6	0.6	50	7	70
Low Inductance Limiter	HSMP-482x	1.0/0.75	0.6	50	7	70
Low Current Switch/ Attenuator	HSMP-383x	0.3/0.2	1.5	200	80	500
Low Current Switch/ Attenuator	HMPP/HSMP-386x	- / 0.2	1.5 typ	50	80	500
Low Resistance Switch	HMPP/HSMP-389x	0.30/0.20	2.5	50	–	200
Low Resistance/Low Inductance Switch	HSMP-489X	0.38/0.33	2.5	50	–	200

Beam Lead PIN Diodes

Part Number	C_t (pF)	RS (Ω)	V_{BR} (V)	T_{rr} (nS)	Lifetime (nS)	Configuration	Package
HPND-4005	0.017	4.7	120	n/a	100	Single	Beam Lead
HPND-4028	0.045	2.3	60	3	36	Single	Beam Lead
HPND-4038	0.065	1.5	60	2	45	Single	Beam Lead

Component	Part Number	Freq Range (MHz)	TX-ANT IL (dB)	ANT-RX IL (dB)	TX RL (dB)	RX RL (dB)	TX-ANT ISO (dB)	ANT-RX ISO (dB)	TX-RX ISO (dB)	RX-TX ISO (dB)	TX P0.1dB (dBm)	TX IIP3 (dBm)	Package (mm)
TD-SCDMA SPDT Switch	ALM-40220	2010-2025	0.45	0.6	25	25	27	40	40	26	41	60	5.0x5.0x1.0 5-PIN MCOB

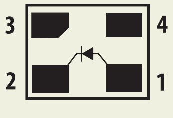
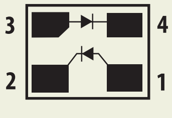
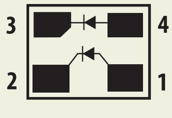
Component	Part Number	Freq Range (MHz)	IIP3 (dBm)	IP1dB (dBm)	Dynamic Range (dB)	IL (dB)	VSWR (dB)	Package (mm)
50MHz – 4GHz PIN Diode Variable Attenuator Module	ALM-38140	50-1000	50	28.8	38	2.8	1.4	3.8x3.8x1.0 MCOB
		1000-2000	48.9	35.6	36	3.2	1.4	

Component	Part Number	Freq Range (MHz)	IIP3 (dBm)	IP1dB (dBm)	ISO (dB)	IL (dB)	RL (dB)	Package
PIN Diode Diversity Switch	HSMP-386D	900	56.8	47.4	25.4	0.35	27.0	SOT-143
	HSMP-389D	900	55.4	46.3	25.7	0.36	28.0	

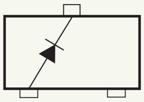
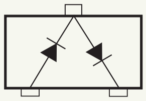
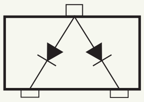
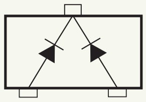
Component	Part Number	Freq Range (MHz)	OP1dB (dBm)	IL (dB)	RL (dB)	Package
Schottky Assisted PIN Diode Low Power Limiter	ASML-5822	900	2.85	0.85	10.9	SOT-323
	ASML-5829	900	6.05	0.33	15.6	

Diodes — Schottky Diode

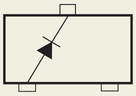
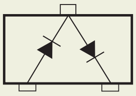
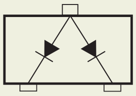
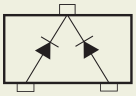
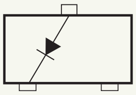
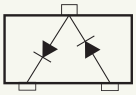
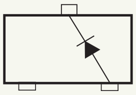
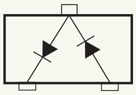
MiniPak

	Single	Anti-parallel	Parallel
Configuration	 (0)	 (2)	 (5)
Schottky	HMPS-2820	HMPS-2822	HMPS-2825

3 Lead Diodes SOT-323 (SC-70)

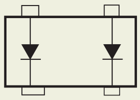
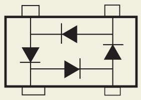
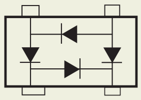
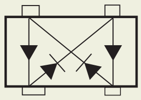
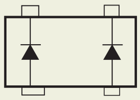
	Single	Series Pair	Common Anode	Common Cathode
Configuration				
Schottky	HBAT-540B	HBAT-540C		
	HSMS-270B	HSMS-270C		
	HSMS-280B	HSMS-280C	HSMS-280E	HSMS-280F
	HSMS-281B	HSMS-281C	HSMS-281E	HSMS-281F
	HSMS-282B	HSMS-282C	HSMS-282E	HSMS-282F
	HSMS-285B	HSMS-285C		
	HSMS-286B	HSMS-286C	HSMS-286E	HSMS-286F

3 Lead Diodes SOT-23

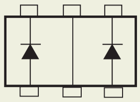
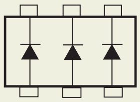
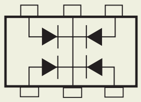
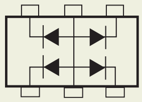
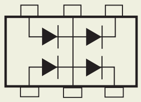
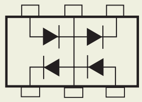
	Single	Series Pair	Common Anode	Common Cathode
Configuration				
Schottky	HBAT-5400	HBAT-5402		
	HSMS-2700	HSMS-2702		
	HSMS-2800	HSMS-2802	HSMS-2803	HSMS-2804
	HSMS-2810	HSMS-2812	HSMS-2813	HSMS-2814
	HSMS-2820	HSMS-2822	HSMS-2823	HSMS-2824
	HSMS-2860	HSMS-2862	HSMS-2863	HSMS-2864
				
	HSMS-2850	HSMS-2852		
				
	HSMS-8101	HSMS-8202		

Diodes — Schottky Diode

4 Lead Diodes SOT-143

	Unconnected Pair	Ring Quad	Bridge Quad	Crossover Quad
Configuration				
Schottky	HSMS-2805		HSMS-2808	
	HSMS-2815	HSMS-2817	HSMS-2818	
	HSMS-2825	HSMS-2827	HSMS-2828	HSMS-2829
	HSMS-2865			
		HSMS-8207		HSMS-8209
				
	HSMS-2855			

6 Lead Diodes SOT-363 (SC-70)

	High Isolation Unconnected Pair	Unconnected Trio	Common Cathode Quad	Common Anode Quad	Bridge Quad	Ring Quad
Configuration						
Schottky	HSMS-280K	HSMS-280L	HSMS-280M	HSMS-280N	HSMS-280P	HSMS-280R
	HSMS-281K	HSMS-281L				
	HSMS-282K	HSMS-282L	HSMS-282M	HSMS-282N	HSMS-282P	HSMS-282R
		HSMS-285L			HSMS-285P	
	HSMS-286K	HSMS-286L			HSMS-286P	HSMS-286R

Diodes — Schottky Diode

Schottky-Barrier Diodes

Application	Part Number	V_{BR} (V) (min)	V_F (mV) (max) IF = 1 mA	V_F @ I_F (V @ mA) (max)	C_t (pF) (typ)	R_D (Ω) (typ)	Volt. Sens. (Y) (mV/mW)			Rv (KΩ) (typ)
							900 MHz	2.45 GHz	5.8 GHz	
General Purpose Detector	HMPS/HSMS-282x	15	340	0.7 @ 30	1.0	12.0	–	–	–	–
Clipping/Clamping	HBAT-540x	30	–	800 @ 100	3.0	2.4	–	–	–	–
High Current Clipping/ Clamping	HSMS-270x	15	–	550 @ 100	6.7	0.65	–	–	–	–
Lowest flicker noise	HSMS-281x	20	400	1.0 @ 35	1.2	15.0	–	–	–	–
High V_{BR}	HSMS-280x	70	400	1.0 @ 35	2.0	35	–	–	–	–
Zero bias detector	HSMS-285x	–	250	0.15 @ 0.1	0.3	–	40	30	22	8
High frequency up to 14 GHz	HSMS-286x	4	350	0.25 @ 0.1	0.3	–	50	35	25	5
Mixer	HSMS-8x0x	4	350	0.25 @ 0.1	0.26	11.0	–	35	25	5

Beam Lead Schottky Diodes

Part Number	V_{BR} (V)	V_F (mV)	C_t (pF)	R_D (Ω)	Configuration	Package
HSCH-5310	4	500	0.1	20.0	Medium Barrier	Beam-Lead
HSCH-5312	4	500	0.15	16.0	Medium Barrier	Beam-Lead
HSCH-5314	4	500	0.15	16.0	Medium Barrier	Beam-Lead
HSCH-5330	4	375	0.1	20.0	Low Barrier	Beam-Lead
HSCH-5331	4	375	0.1	20.0	Batch Match	Beam-Lead
HSCH-5332	4	375	0.15	16.0	Series Pair	Beam-Lead
HSCH-5340	4	375	0.1	20.0	Low Barrier	Beam-Lead
HSCH-5531	4	375	0.1	20.0	Low Barrier	Dual Beam Lead

mmW MMICs

Millimeter Wave MMICs Selection Guide

Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
GaAs MMIC Low Noise Amplifier	AMMC-5024	30Khz - 40	4V @ 160	3.7	17.5	17.3	22.5	Chip
	AMMC-5026	2 - 35	7V @ 150	3.6	10.0	+24	31	Chip
	AMMC-6220	6 - 20	3V @ 55	1.8	23.0	9	19	Chip
	AMMC-6222	7-21	4V @ 120	2.4	25.0	16	29	Chip
	AMMC-6232	18 - 32	4V @ 135	2.8	27.0	18	29	Chip
	AMMC-6241	26 - 43	3V @ 60	2.7	20.0	10	20	Chip
	AMMP-6220	6 - 20	3V @ 55	1.9	23.0	10	21	SM 5x5
	AMMP-6222	7 - 21	4V @ 120	2.3	24	15.5	29	SM 5x5
	AMMP-6232	18 - 32	4V @ 138	3.0	23	18	29	SM 5x5
	AMMP-6233	18 - 32	3V @ 65	2.6	23	8	19	SM 5x5
	VMMK-1218	0.5 - 18	3/20	0.7	10.7	12	12	SM 1x0.5
	VMMK-1225	0.5 - 26	2/20	0.9	11	8	23	SM 1x0.5
GaAs MMIC Broadband Medium Power Amplifiers	AMMC-5040	20 - 45	4.5V @ 300	8	24	22	23	Chip
	AMMC-5618	6 - 20	5V @ 107	4.4	14.5	+19.5	26	Chip
	AMMC-5620	6 - 20	5V @ 95	4.2	19	+15	23.5	Chip
	AMMC-6333	18 - 33	5V@230mA	5	20	23	30	Chip
	AMMC-6345	20 - 45	5V @ 480	9.0	20.0	24	32	Chip
	AMMC-6408	6 - 18	5V @ 650	4.3	19.0	29	38	Chip
	AMMC-6425	18 - 28	5V @ 900	9.0	20.0	28	38	Chip
	AMMC-6431	25 - 33	5V@650mA	8.5	19	28.5	37	Chip
	AMMC-6442	37 - 40	5V@700mA	7.5	23	30	36.5	Chip
	AMMP-5618	6 - 20	5V @ 107	4.4	14.5	+19.5	30	SM 5x5
	AMMP-5620	6 - 20	5V @ 95	5.1	17.5	15	22.5	SM 5x5
	AMMP-6333	18 - 33	5V@230mA	5.5	20	23	30	SMT 5X5
	AMMP-6408	6 - 18	5V @ 650	4.5	18.0	28	38	SM 5x5
	AMMP-6442	37 - 40	5V@700mA	8	23	30	36	SMT 5X5

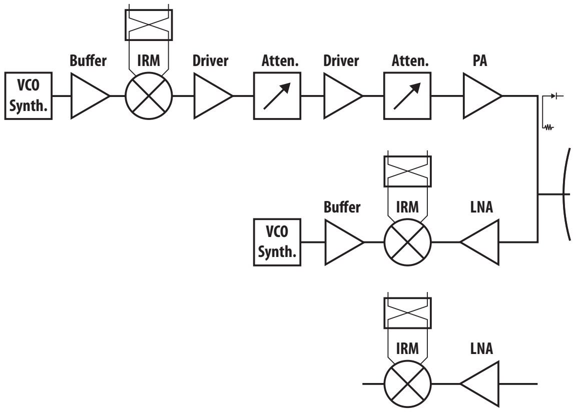
Component	Part Number	Freq. Range (GHz)	Insertion Loss (dBm)	Isolation dB	Input P1dB (dBm)	Control Input (Vdc)	Package
GaAs MMIC SPDT Switch	AMMC-2008	DC - 50	2.3	25	14	0 / -5	Chip

Component	Part Number	RF Freq. (GHz)	IF Freq. (GHz)	Conversion Gain (dB)	LO/RF Iso (dB)	IIP3 (dBm)	Image Reject	Package (mm)
GaAs MMIC Mixers	AMMC-3040	18 - 36	DC - 3	-9.5	31	23	–	Chip
	AMMC-6530	5 - 30	DC - 5	-10	22	18	15	Chip
	AMMP-6522	7 - 20	DC - 3.5	13		-4	15	SM 5x5
	AMMP-6530	5 - 30	DC - 5	-8	22	18	15	SM 5x5
	AMMP-6545	18-45	DC - 3.5	-11	30	11	–	SM 5x5

Component	Part Number	Input Freq. (GHz)	Output Freq. (GHz)	IP1dB (dBm)	Pout (dBm)	Fo (dBc)	Package (mm)
GaAs MMIC Doublers	AMMC-6120	4 - 12	8 - 24	2.0	15	25	Chip
	AMMC-6140	10 - 20	20 - 40	5.0	-1	30	Chip
	AMMP-6120	4 - 12	8 - 24	2.0	15	25	SM 5x5

Microwave Radio Link Application Circuit

Microwave Link Packaged Suggested Solution 7-8 GHz

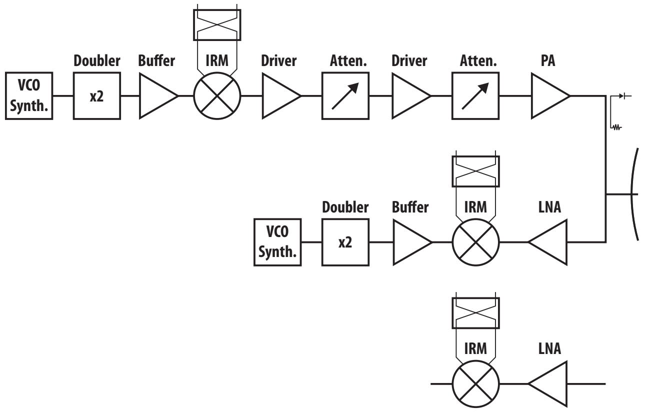


Microwave Link Packaged Suggested Solution 7-8 GHz

Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5

Microwave Radio Link Application Circuit

Microwave Link Packaged Suggested Solution 10-18 GHz



Microwave Link Packaged Suggested Solution 10-11 GHz

Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5

Microwave Link Packaged Suggested Solution 13-15 GHz

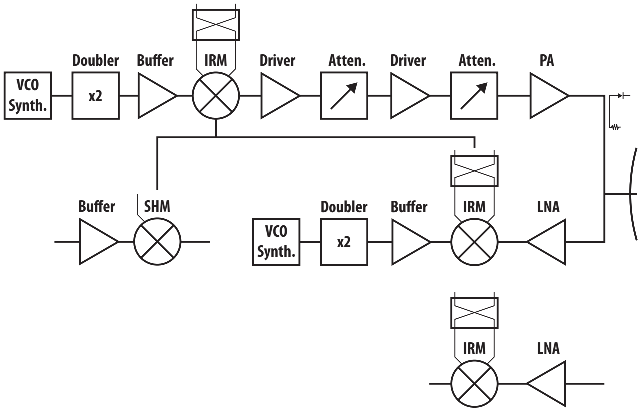
Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5

Microwave Link Packaged Suggested Solution 18 GHz

Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5
	AMMP-6232	18-32	4V @135	3.0	23	+18.0		5x5
	AMMP-6233	18-32	3V @ 65	2.6	23	+8.0		5x5

Microwave Radio Link Application Circuit

Microwave Link Packaged Suggested Solution 23-26 GHz



Microwave Link Packaged Suggested Solution 23 GHz

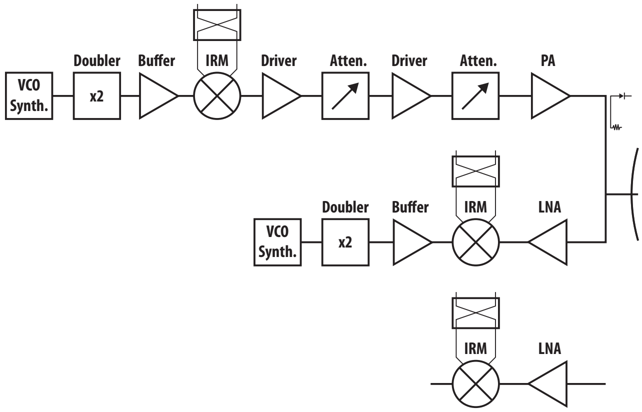
Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5
	AMMP-6232	18-32	4V @135	3.0	23	+18.0		5x5
	AMMP-6233	18-32	3V @ 65	2.6	23	+8.0		5x5
	AMMP-6333	18-33	5V@230mA	5.5	20	23	30	5X5

Microwave Link Packaged Suggested Solution 26 GHz

Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5
	AMMP-6232	18-32	4V @135	3.0	23	+18.0		5x5
	AMMP-6233	18-32	3V @ 65	2.6	23	+8.0		5x5
	AMMP-6333	18-33	5V@230mA	5.5	20	23	30	5X5

Microwave Radio Link Application Circuit

Microwave Link Packaged Suggested Solution 28-32 GHz



Microwave Link Packaged Suggested Solution 28 GHz

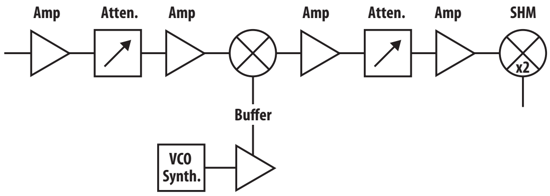
Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5
	AMMP-6232	18-32	4V @135	3.0	23	+18.0		5x5
	AMMP-6425	18-28	5V @ 650	-–	22	+28.0		5X5
	AMMP-6233	18-32	3V @ 65	2.6	23	+8.0		5x5
	AMMP-6333	18-33	5V@230mA	5.5	20	23	30	5X5

Microwave Link Packaged Suggested Solution 32 GHz

Component	Part Number	Freq. Range (GHz)	Bias condition (V @ mA)	NF (dB)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
	AMMP-5618	6-20	5V @ 107	4.4	14.5	+19		5x5
	AMMP-5620	6-20	5V @ 95	5.1	17.5	+15		5x5
	AMMP-6220	6-20	3V @ 55	2.5	22	+10.0		5x5
	AMMP-6222	7-21	4V @120	2.3	24	+15.5		5x5
	AMMP-6232	18-32	4V @135	3.0	23	+18.0		5x5
	AMMP-6233	18-32	3V @ 65	2.6	23	+8.0		5x5
	AMMP-6333	18-33	5V@230mA	5.5	20	23	30	5X5

Microwave Radio Link Application Circuit

IF 1st and 2nd Stage Radio Link Suggested Solution



Part Number	Freq. Range (GHz)	Test Freq. (GHz)	Vd (V)	Id (mA)	Gain (dB)	NF (dB)	P1dB (dBm)	OIP3 (dBm)	Package (mm)
ABA-53563	DC - 3.5	2	5	46	21.5	3.5	12.7	22.9	SOT-363 (SC70)
ABA-54563	DC - 3	2	5	79	23	4.4	16.1	27.8	SOT-363 (SC70)
ADA-4789	DC - 2.5	0.9	3.8	60	16.5	4.2	17.1	32.6	SOT-89
ATF-54143	0.45 - 6	2	3	60	16.6	0.5	20.4	36	SOT-363 (SC70)
ATF-541M4	0.45 - 10	2	3	60	17.5	0.5	21.4	36	MiniPak Package
AVT-50663	DC-6000	2	5	36	15.3	4	12.5	25	SOT-363 (SC70)
AVT-52663	DC-6000	2	5	45	15.3	4	12.7	27	SOT-363 (SC70)
AVT-53663	DC-6000	2	5	48	19.5	3.2	15.1	26.5	SOT-363 (SC70)
MGA-30489	0.25 - 3.0	1.9	5	97	13.3	3	–	39	SOT-89
MGA-30689	0.04 - 2.6	1.95	5	104	14.6	3.3	–	40	SOT-89
MGA-30889	0.04 - 2.6	0.9	5	65	15.5	–	–	38	SMT 4.5x4.1x1.5
MGA-565P8	0.1 - 3	2	5	67	21.8	–	–	–	LPCC2x2
MGA-62563	0.1 - 3	0.5	3	60	22	0.9	17.8	32.9	SOT-363 (SC70)
VMMK-2403	1.5 - 4.0	3	3	38	15	1.8	16.5	29	1x0.5x0.25
VMMK-2503	1.0 - 1.2	6	5	65	14	3.3	17	27	1x0.5x0.25

Part Number	Freq. Range (GHz)	IIP3 (dBm)	IP1dB (dBm)	Dynamic Range (dB)	IL (dB)	VSWR (dB)	Package (mm)
ALM-38140	50 - 1000	50	28.8	38	2.8	1.4	3.8x3.8x1.0 MCOB
	1000 - 2000	48.9	35.6	36	3.2	1.4	

Part Number	Freq. Range (GHz)	Test Freq. (GHz)	IIP3 (dBm)	Attenuation (dB)	Insertion Loss (dB)	Return Loss (dB)	Package (mm)
HSMP-3816	0.3 - 4	1	45	38	-3	-22	SOT - 25
HSMP-3866	0.3 - 4	1	30	36	-2.5	-18	SOT - 25

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