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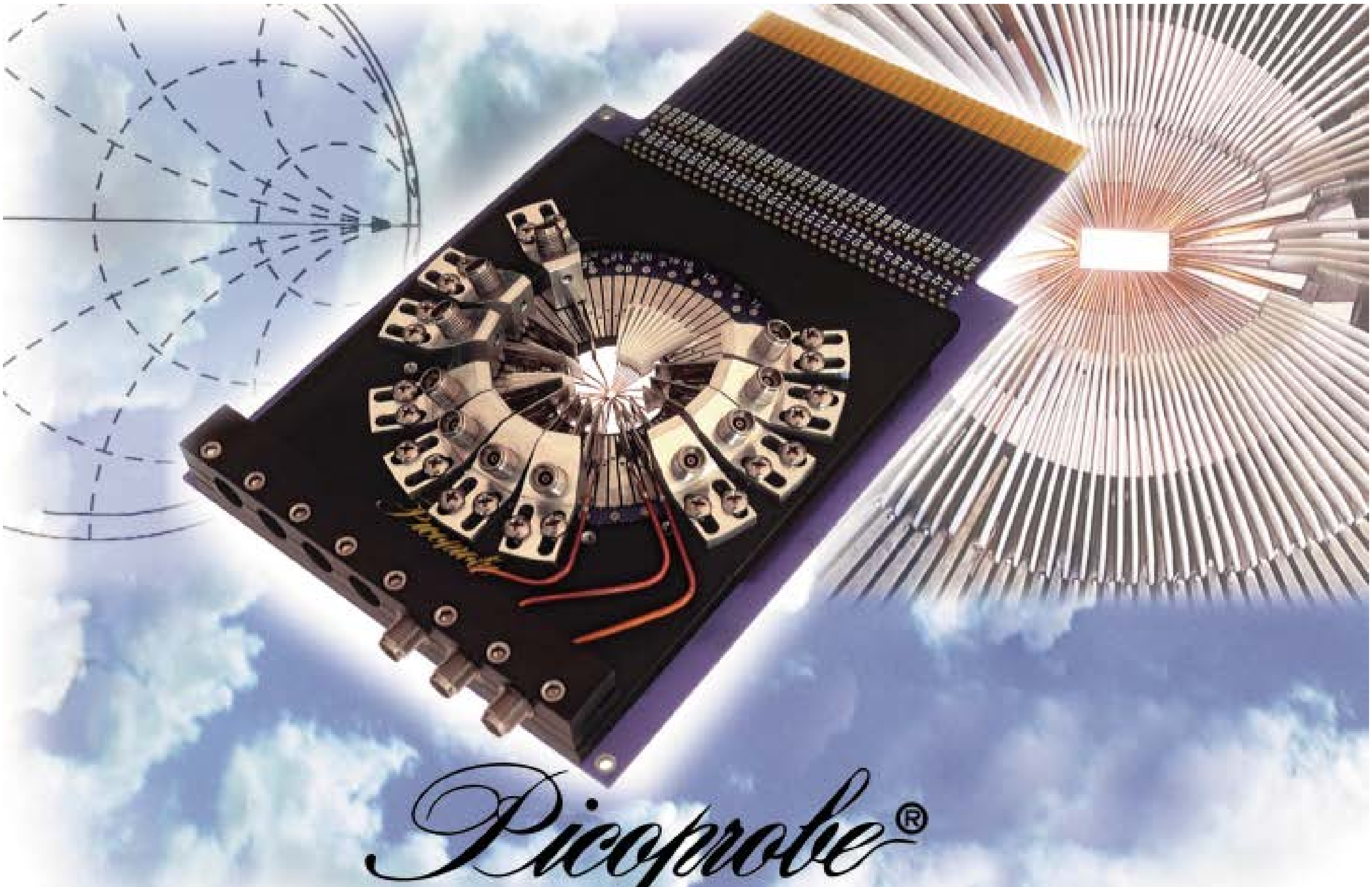

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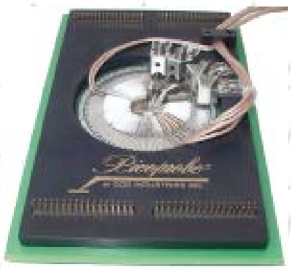

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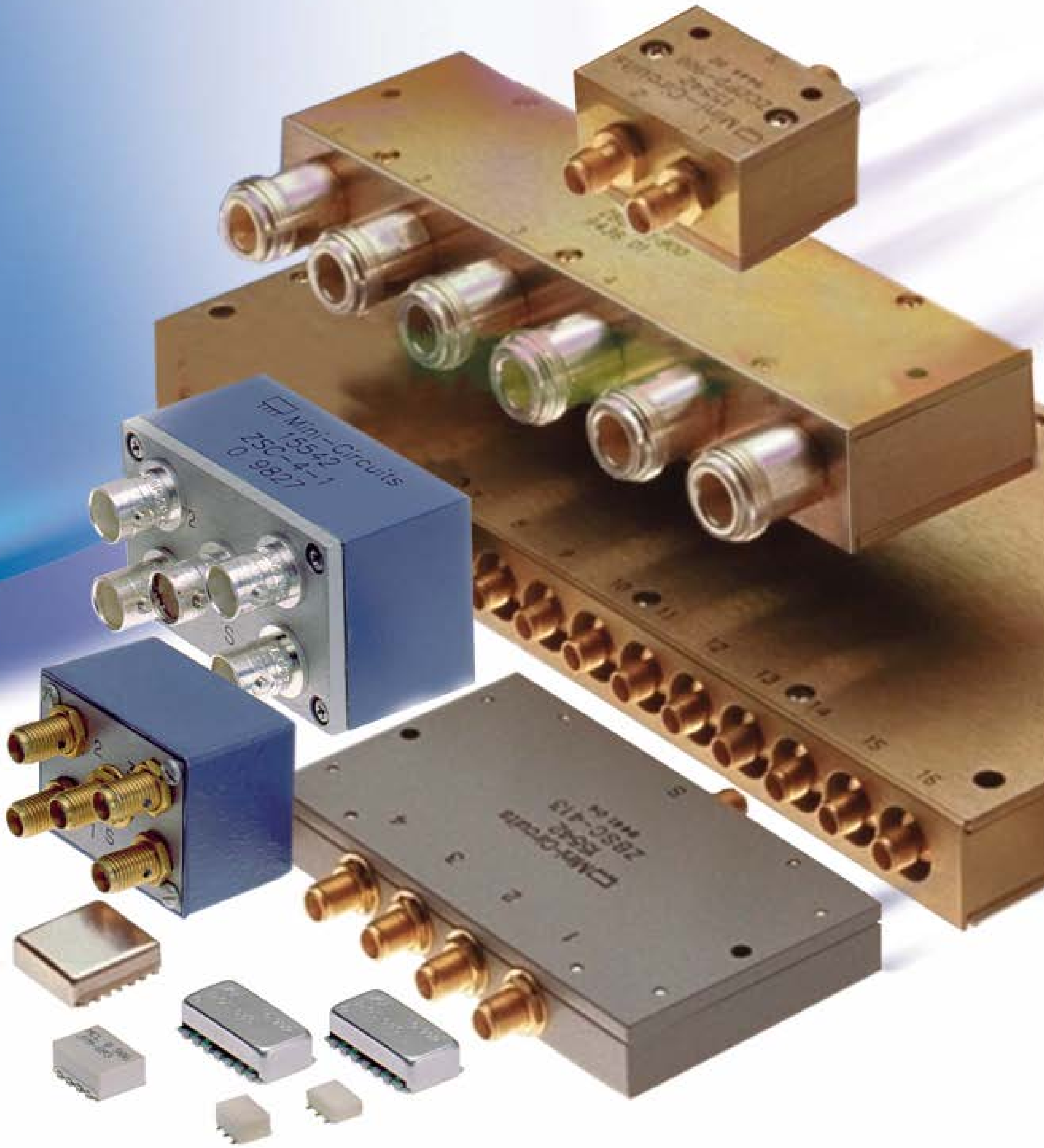
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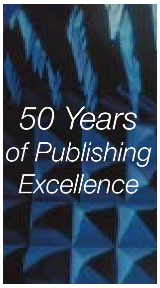
JUNE 2007 VOL. 50 • NO. 6

FEATURES

COVER FEATURE

TECHNICAL FEATURES



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FEATURES

PRODUCT FEATURES

DEPARTMENTS

Cover design by Igor Valdman

THIS MONTH ON THE WEB

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IEEE MTT-S International Microwave Symposium June 3–8, 2007 Honolulu, HI

A complete wrap-up of all news, information and product announcements at this year's IEEE MTT-S International Microwave Symposium, including a detailed look at the new products on display at IMS 2007.

Solving Co-location Interference Problems by Using Narrowband Filters

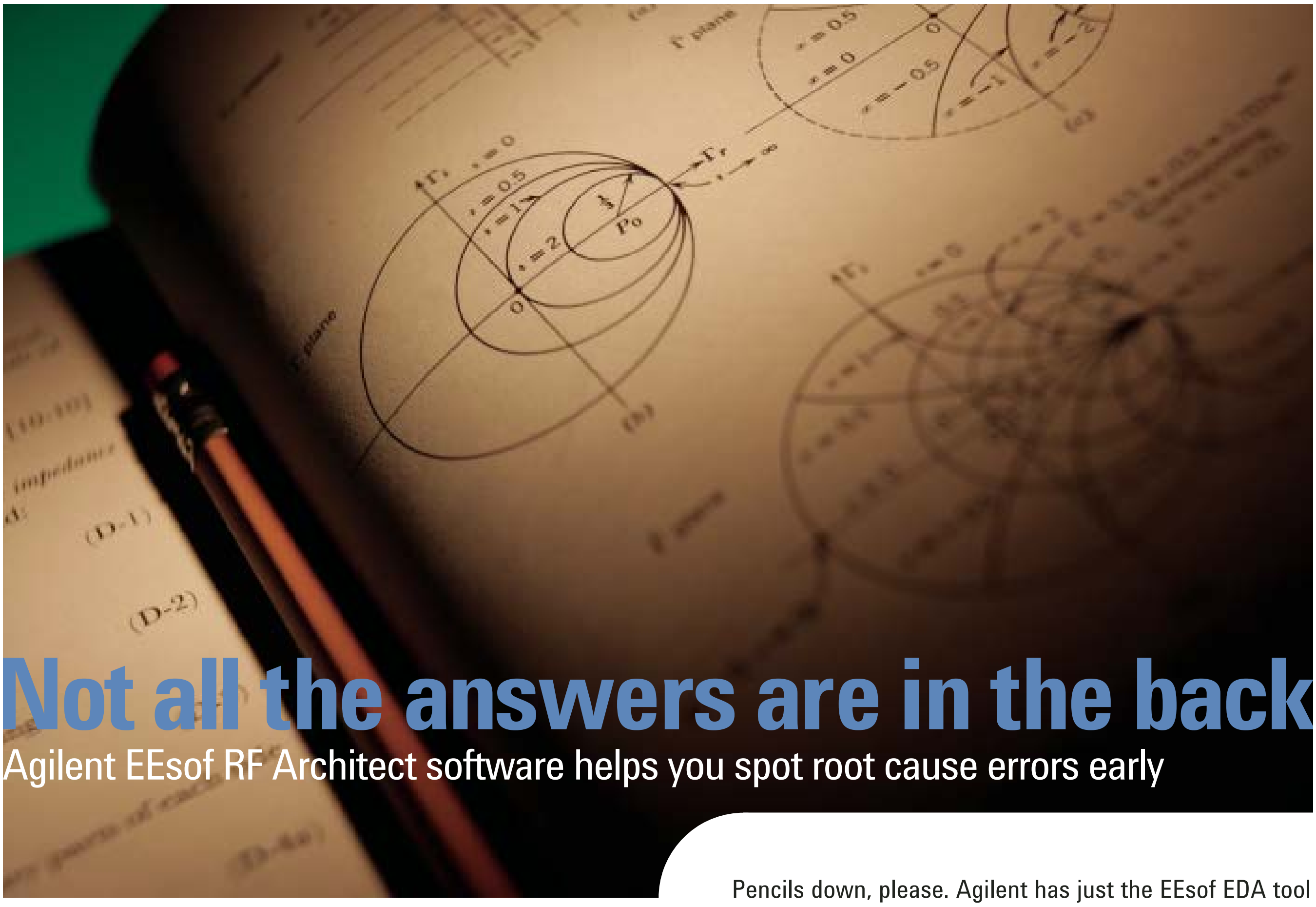
By Manny Assurian, Ray Hashemi and Jim Assurian
Reactel Inc.

Exploration of the different methods and solutions used for solving co-location interference problems with narrowband bandpass and band-reject filters.

GaAs Device Market Expansion of 76 Percent Through 2011

Cellular Handsets and Wi-Fi Drive GaAs Demand Engine

The Strategy Analytics annual five-year outlook for the gallium arsenide microelectronics industry, "GaAs Industry Forecast: 2006–2011," forecasts that this market will enjoy a CAAGR of 12 percent, growing from $3 B in 2006 to over $5 B by 2011.



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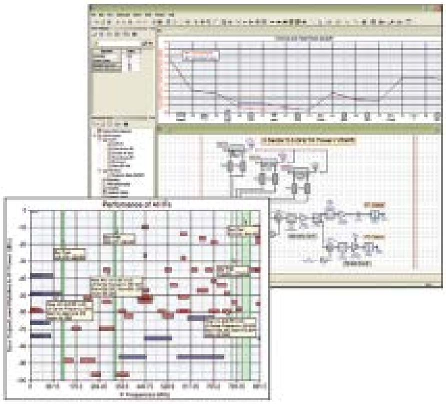

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Ask Harlan

How it works: Harlan has selected one question from his "Ask Harlan" column to be featured in the magazine. Please visit www.mwjournal.com/askharlan to provide an answer to this month's featured question (see below). Harlan will be monitoring the responses and will ultimately choose the best answer to the question. Although all of the responses to the featured question will be posted on our web site, we plan to publish the winning answer in the August issue. All responses must be submitted by **July 6, 2007**, to be eligible for the participation of the June question.

The winning response will win a free book from Artech House, along with an "I Asked Harlan!" t-shirt. In addition, everyone who submits a legitimate response will be sent an "I Asked Harlan!" t-shirt.

April Question and Winning Response

The April question was submitted by Satyajit Chakrabarti from SAMEER Kolkata Centre:

Dear Harlan,

How can a single antenna be made to operate at three or four frequencies? Is there any bandwidth limitation?

The winning response to the April question is from Milan Motl of Flextronics Design:

Dear Satyajit,

There are two kinds of antennas that can operate on more frequencies. The first is designed to operate at several frequency bands. They are called multi-band antennas. These antennas are designed to have resonances in the operating frequency bands to obtain good matching. The gain must also be sufficient. The second kind of antennas are wideband. These antennas can operate in a very wide frequency range, which means they can operate at several frequencies if the frequencies are inside the frequency range of the antenna. These antennas are not based on the resonance principle; they are wideband by principle. There is no proportion that could be scaled to the wavelength. Typical representative is a self-complementary antenna, like a spiral antenna.

Harlan's response:

Dear Satyajit,

Some antennas—like parabolic reflectors—have no bandwidth limitation. Others, including dipoles and printed arrays, are generally limited but can be adapted to cover several frequency bands by the addition of tuning structures. A good reference is *Antenna Theory* by C. Balanis, Wiley, 2005, ISBN#0-471-66782-X.

This Month's Question of the Month

(answer on-line at www.mwjournal.com/askharlan)

Eric Hakanson from Anritsu Co. has submitted this month's question:

Dear Harlan,

In your opinion, what's missing from today's microwave spectrum analyzers? What could be done that people would value significantly more than what is currently available?

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August 7–9, 2007 • Austin, TX
www.ni.com/niweek

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OCTOBER

EUROPEAN MICROWAVE WEEK (EUMW 2007)
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AOC INTERNATIONAL SYMPOSIUM AND CONVENTION
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■ **Contact:** CST-Computer Simulation Technology +49 6151 7303-0 or e-mail: info@cst.com.

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■ **Site:** Aurora, IL

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■ **Contact:** For more information, visit www.vectorfields.com.

Far-field, Anechoic Chamber, Compact and Near-field Antenna Measurements

■ **Topics:** This course presents the state-of-the-art in antenna measurements, including far-field, anechoic chamber, compact and near-field measurements. The course also includes range evaluation, compensation techniques and microwave holography. For more information, visit www.pe.gatech.edu.

■ **Site:** Atlanta, GA

■ **Dates:** October 22–26, 2007

■ **Contact:** Georgia Institute of Technology, Professional Education, PO Box 93686, Atlanta, GA 30377 (404) 385-3500.

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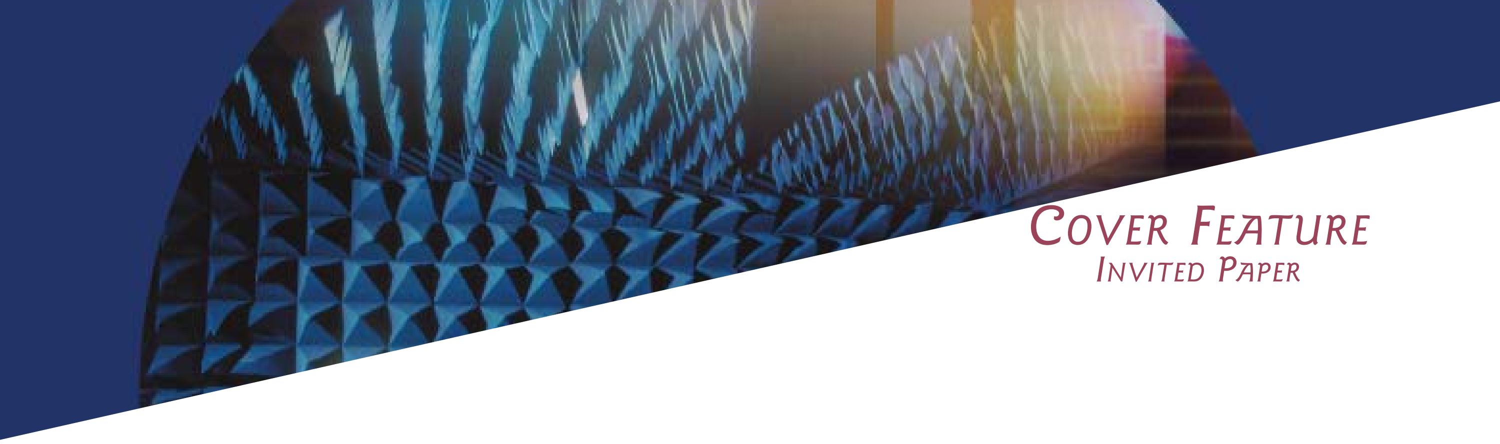


COVER FEATURE
INVITED PAPER

EMI TESTING FOR IEC 61000-4-3 EDITION 3

The IEC 61000-4-3 has been used for many years as the basic test standard for radiated electromagnetic field immunity testing in order to satisfy one of many European Union requirements for the CE mark. This standard is usually used in conjunction with a product standard that will specify this and other test standards, detailing the requirements the product must meet. The product standard may give additional guidance on how this test standard is used, including test level severity and changes to procedure. The object of this standard is to establish a common reference for immunity to radio frequency (RF) radiation caused by any source. Electronic products need to be designed and tested to have immunity from these sources. RF radiation can come from many sources such as other electronic devices, electric motors and intentional transmitters such as walkie-talkies and cell phones. The introduction of more wireless devices in the past couple of years has increased the need for this testing, not only to satisfy governmental requirements, but also to increase product reliability, which increases customer satisfaction.

Note: This document should not be used in conjunction with or instead of the official released publication. It is only intended to provide guidance and information on the possible changes. One should always refer to the latest standards: IEC 61000-4-3: Electromagnetic compatibility (EMC)—Part 4-3: Testing and measurement techniques—Radiated, radio frequency, electromagnetic field immunity test. Edition 3 has been approved and released ahead of schedule. ***Table 1*** shows the current status.

TABLE I

SCHEDULE FOR RELEASE OF IEC 61000-4-3 EDITION 3

Stage Code	Meaning	Actual Completion Date	Projected Completion Date
CDIS	final draft issued for final vote	11-4-05	11-30-05
APUB	draft approval for publication	1-13-06	2-28-06
BPUB	print of the publication	2-7-06	3-31-06
PPUB	issue of the final standard	2-7-06	4-30-06

JASON SMITH
AR Worldwide
Souderton, PA

MAJOR CHANGES IN IEC 61000-4-3 EDITION 3

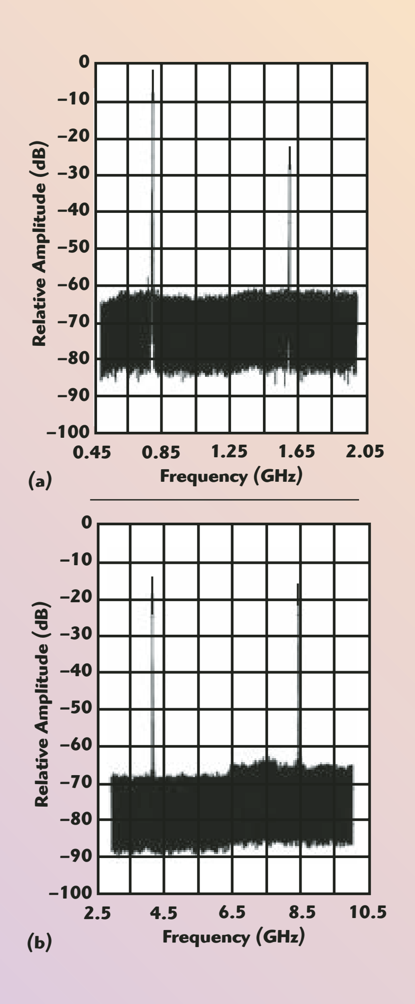
The major changes to IEC 61000-4-3 Edition 3 include:

- New harmonic distortion requirement for the test setup: better than 6 dBc.
- New linearity check to make sure the RF amplifier is not operating in compression.
- New extension of the frequency range up to 6 GHz.
- New test table material requirement.

These changes could have a big effect on some facilities and test equipment.

HARMONIC DISTORTION

Harmonic distortion is the level difference in decibels between the fundamental frequency and its harmonics. The new standard calls for a harmonic distortion of better than –6 dBc for the test setup. This means that all harmonics must be 6 dB below the fundamental out of the transmitting antenna, which could become a problem when using RF amplifiers in compression or when using traveling wave tube (TWT) amplifiers. TWT amplifiers have been used historically for testing above 1 GHz when high power is required and can offer significant cost/performance benefits at very high power levels. Since the introduction of solid-state amplifiers in this frequency range, many of the limitations of TWT amplifiers have been overcome and, at lower power levels, solid-state amplifiers are readily available. TWT amplifiers can still be used for high power testing, but care must be taken to satisfy the standard. Some TWT amplifiers include methods for harmonic reduction by combining tubes or switching-in filters. For most other TWT amplifiers, RF filters can be attached externally to block these unwanted harmonics. ***Figure 1*** shows an example of the harmonic content of a solid-state and a TWT amplifier (each rated 20 W). The solid-state amplifier has an excellent harmonic level of –24 dBc while the TWT amplifier's level is only –0.8 dBc. The harmonic of the TWT will contribute to the calibration level since a broadband RF field probe is used and cannot distinguish between a desired and unwanted signal. In addition, the antenna gain usually increases over its operating band. The antenna gain can be as much as 5 dB higher at the harmonic frequency. In the above case, the –0.8 dBc harmonic distortion of the TWT will result in a much higher field level at the harmonic than at the fundamental. These harmonics will result in a significant error in field level and RF filters will be required. The consequence of using filters will be some loss in power and loss of productivity while switching these filters in and out. The amplifier used will dictate what frequency range(s) the filter will need to cover, or if multiple filters will be needed. The solid-state amplifier will not need filtering for this reason. High harmonic content can also have an unwanted adverse effect on the equipment under test (EUT). The harmonic could be at a frequency that causes the EUT to fail. Since the test personnel are testing at the fundamental frequency, they will mark this frequency as the failure, which is not the case. It is quite possible that this harmonic may be outside the intended test frequency range and therefore should not even be part of the test. From the EUT manufacturer's point of view, harmonics are very much unwanted since this signal can cause failures and is not part of the test.



▲ *Fig. 1 Spectra of two amplifiers; (a) solid state and (b) TWT.*

If one works backwards, an acceptable amplifier harmonic content rating can be estimated:

Maximum antenna gain between harmonic and fundamental = 5 dB

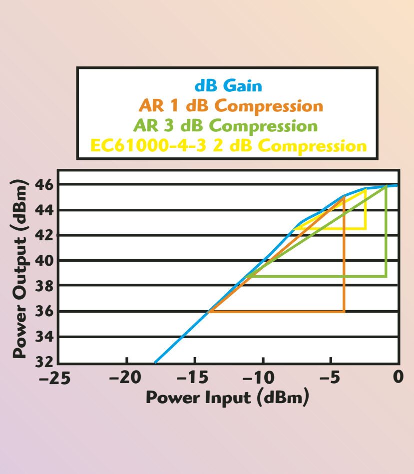
Other effects from setup and room (safety factor) = 3 dB

Required by specification = 6 dB

Total = 14 dB

Therefore, a harmonic content for the amplifiers better than –14 dBc will be more than acceptable. This would be a more than safe harmonic content requirement for the amplifier, guaranteeing an acceptable harmonic level during testing.

Note: The amplifier should not be operated into compression and filters can be used to reach this requirement.

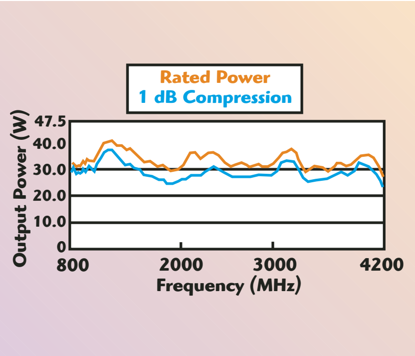


▲ *Fig. 2 Compression points for a solid-state amplifier at 1.5 GHz.*

LINEARITY CHECK

The linear region of an amplifier is the power range in which there is a 1:1 ratio (in decibels) input change to output change. As the amplifier starts to saturate, this will no longer be true. AR's solid-state amplifiers are specified at both 1 and 3 dB compression points. Below the 1 dB compression point, the amplifier's response is referred to as linear. Above the 3 dB compression point, the am-

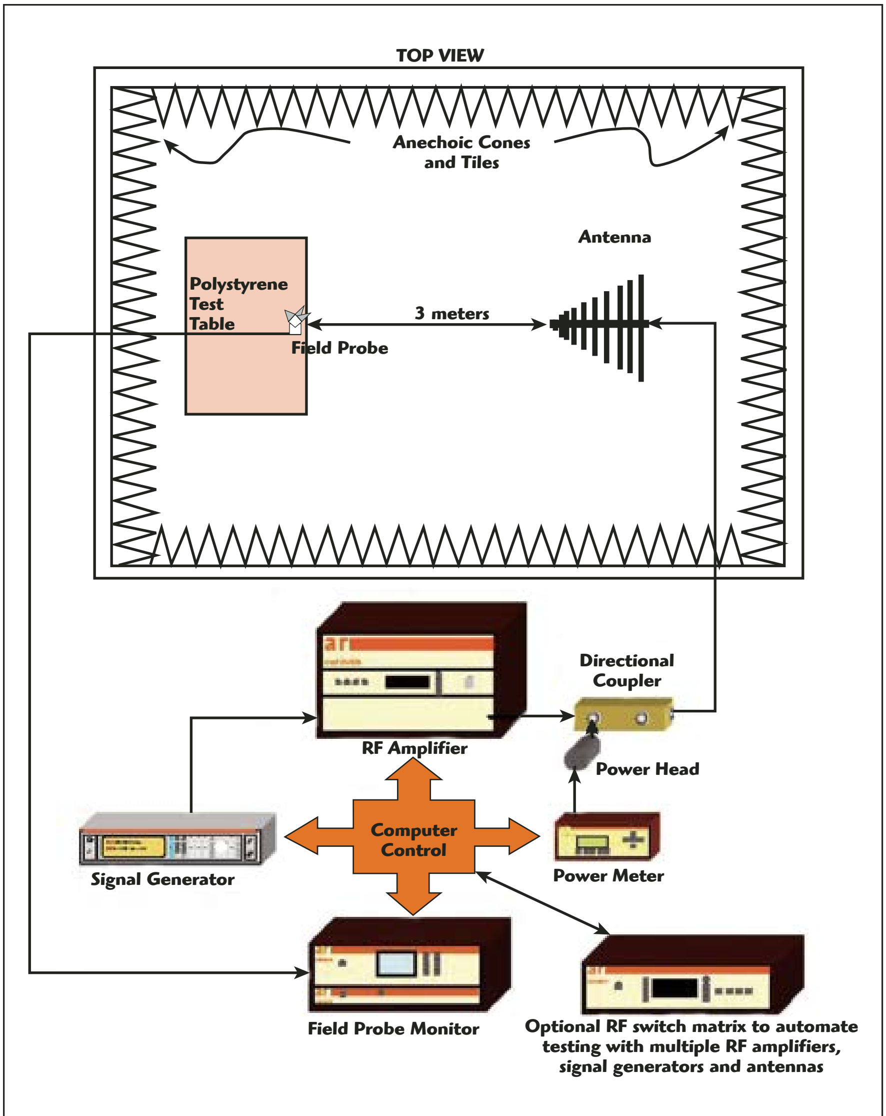
plifier is in full compression. There are two main reasons why this is important. First, if amplifiers are being run while in compression, the output signal will be distorted. This means a sine wave will start to resemble a square wave. In the case of the IEC 61000-4-3, the amplitude modulation (AM) will also be distorted, possibly causing different unrepeatable test results. Second, when an amplifier is being run close to saturation, the harmonic content will increase. ***Figure 2*** shows one of AR's solid-state amplifiers and how AR finds its 1 and 3 dB compression points. Basically, the point where an increase of 10 dB in input power results in only a 9 dB change of output power is the 1 dB compression point (orange triangle). The point where the input is increased by 10 dB results in only a 7 dB change on the output is the 3 dB compression point (green triangle). The new specification calls for a check for a 2 dB compression point (yellow triangle), while connected to the antenna. If the load impedance (antenna) on the amplifier is a pure 50 Ω, then amplifier manufacturers could easily specify this new 2 dB compression point to be used as a reference when calculating one's requirements. Since any antenna, which is used during testing is not a pure 50 Ω load, but an unknown complex load, the compression point may vary slightly. For this reason, it is best to size amplifiers based on the manufacturer's supplied 1 dB compression point to allow for some margin of error. This will be a concern when using a TWT amplifier since they are normally not as linear as solid-state amplifiers. The 1 dB compression point is usually approximately 50 percent of its rated power; therefore, a 20 W TWT amplifier will have a 1 dB compression rating of approximately 10 W. In the case of a 25S1G4A solid-state amplifier, the minimum output power rating is 25 W with a minimum 1 dB compression rating at approximately 20 W. The actual production testing done on one of these 25S1G4A amplifiers at 1.5 GHz is shown in ***Figure 3***. The amplifier is actually rated at 38 W, with a 1 dB compression rating of approximately 30 W. It is always best to check the amplifier's specification or to contact the manufacturer directly for this information and assistance with the selection of the product that will meet the requirements.



▲ *Fig. 3 Output power of a 25S1G4A amplifier.*

INCREASED FREQUENCY RANGE

The frequency range increase from 2 to 6 GHz is directly in response to the use of more of the RF spectrum by the communication industries. In different countries and locations, the RF spectrum is being divided up depending on each country's laws. Based on where the equipment under test (EUT) is being used, not all frequency bands may need to be tested. In addition, not all communication standards use the same signal strengths. This is why this new test standard is leaving this further definition up to forthcoming product standards. Product standards will specify what additional frequencies to cover in the communications bands: 800 to 960 MHz and 1.4 to 6.0 GHz. Product standards will also specify test levels that may not be consistent throughout the bands. The current 80 MHz to 1 GHz requirement should remain the same. The test chamber



▲ *Fig. 4 Typical radiation immunity test setup.*

setups may have to change because of this higher frequency requirement. Many laboratories have only a ferrite-lined chamber. This works well when testing at less than 1 GHz, but as the frequency rises it will become increasingly difficult to meet the field uniformity requirements. This is because the ferrite is not very absorbent above 1 GHz and will reflect the RF field. Annex C of IEC 61000-4-3 Edition 3 explains this situation and gives good advice and options on correcting this problem. A fully lined anechoic chamber with ferrite and absorber material will work fine.

TEST TABLE

A low permeability material is now specified for the test table. Rigid polystyrene is one material that is suggested. In the past, many laboratories used wood, which is fine when testing at lower frequencies. Now that the test frequencies can be as high as 6 GHz, wood will start to have some unwanted properties. High frequencies will be reflected, making it difficult to meet the uniform field requirement. The reflections will also make test results less repeatable.

GENERAL TEST TIPS

The above new requirements could require laboratories to upgrade and purchase new equipment. Some helpful hints may increase the likelihood of success.

If harmonic content is an issue: RF filters on the amplifier's output may fix the problem.

- Make sure the additional losses of the filters do not force the amplifier into saturation.
- Switching filters in and out will increase test time.

If working in saturation: Reduce all RF losses in the system.

- Use good low loss RF cables and connectors.
- Make sure all connections are tight.
- Make sure all connectors are clean.
- Shorten RF cables (may require the amplifier to be moved closer to the antenna).
- Use a different RF antenna.
- Higher gain antennas will require less power.
- Keep in mind that a narrow beam width may not cover the full window of 1.5 m × 1.5 m uniform field calibration requirement (See ***Appendix A*** for antenna coverage calculations). Calibration to a smaller window is allowed above 1 GHz.
- Horn antennas will direct the energy forward better than log antennas, resulting in better field performance.
- Move the antenna in closer, not less than 1 meter.

If the above considerations are taken into account and the requirements can still not be met, a new amplifier may be needed.

CONCLUSION

The increased frequency range of this standard has brought some common test problems to light as to their contribution to test error. Continuing efforts must be taken to maintain a

consistently repeatable test. Both harmonic distortion and amplifier linearity are issues that, until now, have been overlooked by this standard. All RF amplifiers can run in compression and produce harmonics. If the amplifier is running in compression and if the antenna and cables cannot be improved upon, a new higher power amplifier will be needed. If harmonic content becomes an issue, RF filters will be needed to block out these harmonics. With low noise solid-state amplifiers, filters will not be needed. It is also a good idea to ask manufacturers for examples of test data taken from production units. This data can aid in product selection and give a better level of confidence of the manufacturer's ability to meet their published specifications. Quality of testing and repeatability should be the goal of every EMC test lab. If repeatability was not important, then these international test standards would be useless. Once this IEC standard is published, there will be an overlap period before the previous standard is removed from use. The main procedural changes will be harmonic distortion, linearity check and test table. Depending on the setup, the test setup may need to be changed and/or possibly new equipment purchased. ***Figure 4*** shows the diagram of a typical radiation immunity test setup.

Jason Smith *earned his BS degree in engineering technology from the University of Delaware in 1997. After college he started working for Candes Systems Inc., Harleysville, PA, as a computer specialist for TEMPEST computer systems. He was subsequently promoted to a test engineer position with its sister company Radiation Sciences Inc. and quickly became the EMC lab manager of the company's independent EMC test house. He moved on to work for Omega Engineering Inc. as the company's EMC lab manager for its commercial EMC test lab, Analab Llc. Smith has seven years of EMC testing experience with military, avionics, commercial, medical, telecom and automotive testing. He joined AR RF/Microwave Instrumentation in February 2004. His current position is supervisor application engineering. In this position he is product applications support to customers, technical training and technical writing, and provides guidance for product development for AR RF/Microwave Instrumentation's full range of products.*

APPENDIX A

Using basic geometry, the window size (spot size) can be calculated from the 3 dB beam width of the antenna. (See ***Figure A1*** and ***Table A1***.)

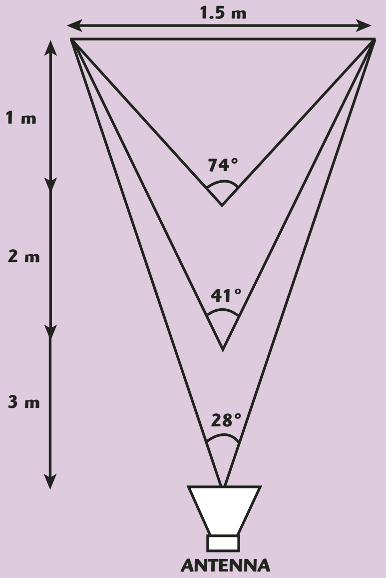
$$\Theta = 2\tan^{-1}\left[\frac{W}{2D}\right]$$

$$W = 2D\tan\left[\frac{\Theta}{2}\right]$$

$$D = \frac{W}{2\tan\left(\Theta/2\right)}$$

where

Θ = 3 dB beam width of the antenna at the specified frequency
W = window width
D = antenna distance



▲ *Fig. A1 Diagram for calculation of window size.*

TABLE A1
WINDOW SIZES AT DIFFERENT FREQUENCIES

Frequency (GHz)	1	4	4	6	6	6	4	6	4
3 dB Beam Width (°)	75	50	13	33	17	40	27	18	17
Distance Needed for 1.5 Meter Window (m)	1.0	1.6	6.6	2.5	5.0	2.1	3.1	4.7	5.0
Window @1 m	1.5	0.9	0.2	0.6	0.3	0.7	0.5	0.3	0.3
Window @3 m	4.6	2.8	0.7	1.8	0.9	2.2	1.4	1.0	0.9

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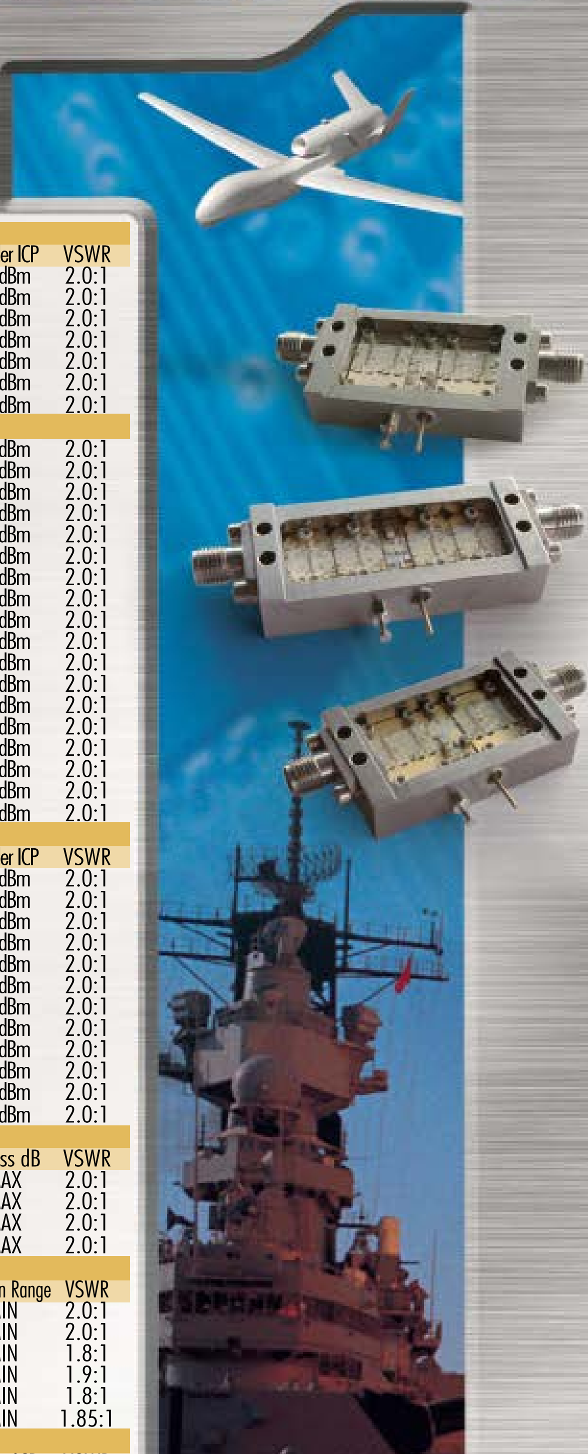

OCTAVE BAND LOW NOISE AMPLIFIERS

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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Raytheon Tallies $100 M in Awards for Upgrades of Patriot Missiles

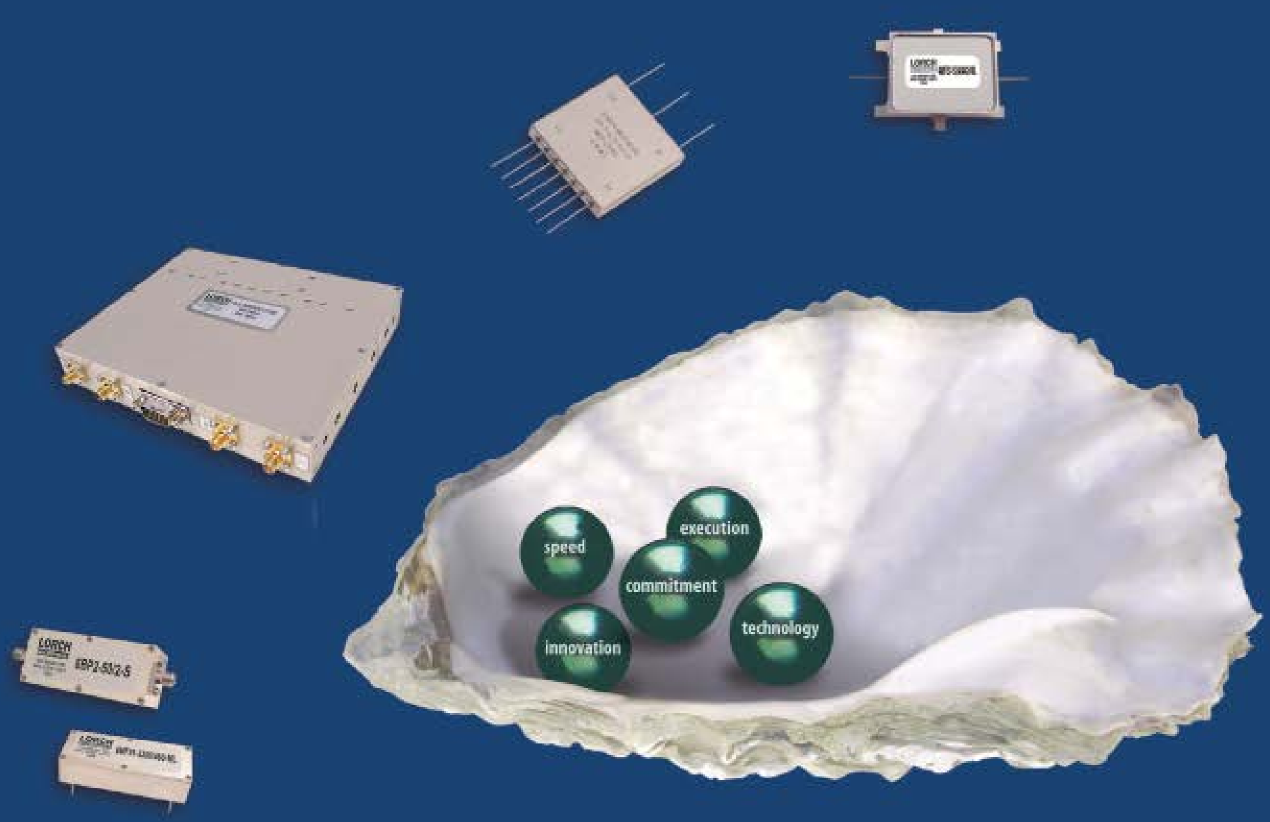
Raytheon Co.'s Patriot Guidance Enhanced Missile-T (GEM-T) upgrade program reached its first-ever $100 M sales award. This award includes orders for the US Army and a Foreign Military Sales contract for 230 GEM-T upgrades, plus spares. This is the largest order received to date for GEM-T and bolsters Raytheon's upgrade output to levels not seen since the mid-1990s. This large order benefits both customers with significant price reductions. For successive awards, Raytheon has successfully reduced the acquisition unit price for the US Army. "As the global war on terror wages on and budgets tighten, we are proud to be able to provide our war fighters with an affordable, highly accurate missile that can be counted on the first time, every time," said Pete Franklin, vice president for National and Theater Security Programs at Raytheon Integrated Defense Systems. "This GEM-T upgrade enables our troops to continue to rely on Raytheon's Patriot system to identify, track and eliminate airborne threats into the future." GEM-T is a significant upgrade over the existing Patriot Advanced Configuration-2 (PAC-2) missile and, when fielded in conjunction with the Patriot Advanced Configuration-3 (PAC-3) system, provides a robust capability against ballistic missiles, cruise missiles, aircraft and remotely piloted vehicles. GEM-T provides the US Army and its allies with enhanced accuracy at a low cost. GEM-T missiles are PAC-2 missiles that are refurbished and modernized at Raytheon's Integrated Air Defense Center, Andover, MA. Through the upgrade process, older components are replaced, new technology inserted and reliability increased. Raytheon is the prime contractor for the Patriot system and the system integrator for the PAC-3 system that included the GEM-T missile. As system integrator, Raytheon IDS ensures that all Patriot system components provide the war fighter a reliable and lethal capability to defeat the threats in current and future combat environments. The Patriot PAC-3 program is managed by the US Army Program Executive Office for Missiles and Space and executed by the Lower Tier Air and Missile Defense Project Office, Huntsville, AL.

Lockheed Martin Completes Major Design Review for TSAT

A Lockheed Martin team has successfully completed a key design revue of the Transformational Satellite Communications System (TSAT) Space Segment, signaling the team's readiness to proceed with the next development phase of the program. TSAT will provide thousands of users with wideband, highly mobile, beyond line-of-sight protected communications to support network-centric operations for the future battlefield. Nearly 300 government representatives from the US Air Force Military Satellite Communications Systems Wing and user communities, including representatives from all services within the Department of Defense, recently completed a three-day Space Segment Design Revue (SSDR) at Lockheed Martin Space Systems facilities in Sunnyvale, CA. During the review, the team detailed its planned architecture and design approach for TSAT, which will employ high speed optical communications, Internet protocol network routing and communications-on-the-move technologies to deliver a dramatic increase in connectivity, speed and mobility to the war fighter. A highlight of the review was an extensive exhibit hall that featured a number of demonstrations and exhibits that summarized technology risk reduction efforts and the system engineering and integration expertise that is being applied to TSAT. An integrated end-to-end systems and payload testbed demonstrated critical communications-on-the-move and intelligence, surveillance and reconnaissance capabilities. "We are extremely pleased with the outcome of this important review," said Joanne Maguire, executive vice president of Lockheed Martin Space Systems. "Our TSAT solution builds upon technologies we have pioneered and matured to provide significantly improved, flexible communications for the war fighter. Our team is poised to help our customer achieve mission success on this vitally important program." TSAT represents the next step toward transitioning the Department of Defense wideband and protected communications satellite architecture into a single network comprising multiple satellite, ground and user segment components. The system ultimately will replace the Milstar and Advanced Extremely High Frequency (AEHF) programs and provide the Global Information Grid network extension to mobile war fighters, sensors, weapons and command, control and communications nodes located on unmanned aerial vehicles, piloted aircraft, on the ground, in the air, at sea or in space. The Lockheed Martin/Northrop Grumman TSAT space segment team is currently working under a $540 M contract for the Risk Reduction and System Definition phase. This effort will culminate with a multi-billion dollar development contract to be awarded to a single contractor in late 2007.

Intelsat to Test Internet Routing in Space for US Military

Intelsat General Corp. announced that it has been selected for an industry-government collaboration to demonstrate the viability of conducting military communications through an Internet router in space. The Department of Defense project to test Internet routing in space (IRIS) will be managed by Intelsat General and the payload will convert to commercial use once testing has been completed. The IRIS project is one of seven projects—out of hundreds of applicants—funded and announced in fiscal 2007 as a Joint Capability Technology Demonstration (JCTD) by the Department of Defense (DoD). Intelsat is the first commercial satellite company to be awarded a JCTD program. The IRIS JCTD is a three-year program that allows the DoD to collaborate with Intelsat General and its industry team to demonstrate and assess the utility of the IRIS capability. Cisco, the global networking leader based in San Jose, CA, will provide commercial IP networking software for the on-board router. In addition, SEAKR Engineering Inc. of Denver, CO, will manufacture the space-hardened router and integrate it into the IRIS payload. Concerto Advisors, a financial advisory firm based in Iowa City, IA, is organizing equity financing for a new company to provide the funds to design, build and operate the equipment used for the demonstration. Following the JCTD testing period, Concerto's affiliate will own the equipment and Intelsat will operate the equipment on Concerto's behalf to provide services for government and commercial users. Intelsat previously announced that Space Systems/Loral of Palo Alto, CA, will manufacture the satellite scheduled to carry the IRIS payload. The satellite, IS-14, is set for launch in the first quarter of 2009. It will be placed in geostationary orbit at 45° West longitude with coverage of Europe, Africa and the Americas. Representing the next generation of space-based communications, IRIS will serve as a computer processor in the sky, merging communications being received on various frequency bands and transmitting them to multiple users based on data instructions embedded in the uplink. The IRIS payload will support network services for voice, video and data communications, enabling military units or allied forces to communicate with one another using Internet protocol and existing ground equipment. The IRIS payload will interconnect one C-band and two Ku-band coverage areas. The IRIS architecture and design allow for flexible IP packet (layer 3) routing or multicast distribution that can be reconfigured on demand. With the on-board processor routing the up and down communications links, the IRIS payload is expected to enhance satellite performance and reduce signal degradation from atmospheric conditions. The Defense Information Systems Agency will have overall responsibility for coordinating use of the IRIS technology among the government users and for developing means of leveraging the IRIS capability once the satellite is in space. ■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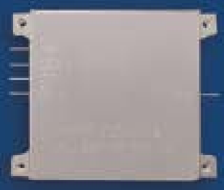

INEX Joins DMD's Development Programme

Diamond Microwave Devices (DMD), a subsidiary of Element Six Ltd. (E6), has signed a contract with INEX to provide the processing technology for its electronic component development programme. DMD is working on the next generation of high power, high temperature semiconductor devices for microwave power electronics.

Based within the University of Newcastle, INEX is one of the UK's leading research and commercialisation centres for microsystems and nanotechnologies. The agreement marks the next important step in the development of electronic devices fabricated in single crystal diamond synthesised using chemical vapour deposition (CVD).

In December 2006, E6 signed a collaboration agreement with Filtronic to work with DMD on diamond-based microwave devices. The two companies are combining their strengths in materials, semiconductor devices and circuit design to create novel diamond devices that could transform microwave power electronics. INEX will work closely with DMD, E6 and Filtronic to develop new processing techniques and to fabricate prototype devices based on the E6 proprietary diamond material and a device design as provided by Filtronic.

The goal is to exploit the exceptional properties of CVD diamond as an advanced engineering material. Initially, the aim is to demonstrate a practical MESFET using CVD diamond grown by E6, and providing useful power at microwave frequencies.

Consortium Secures UK MoD contract

A QinetiQ led consortium has been awarded the Enabling Secure Information Infrastructure (ESII) programme by the UK MoD's (Ministry of Defence) Research Acquisition Organisation (RAO). The initial four tasks are worth in excess of £5 M and form the first research packages let under a three and a half year enabling contract.

The consortium, comprising 23 leading British defence contractors, Small Medium Enterprises and top British universities, will assist the MoD in maximising its communications capability. As part of the Defence Industrial Strategy and Defence Technology Strategy, this contract will research ideas and technologies to improve the flexibility, efficiency, resilience and security of the MoD's Communication and Information Services (CIS) systems.

The first tasks will be to evaluate the benefits of wideband mobile communications and policy and infrastructure management to support end-to-end voice/data convergence. A spiral development approach using commercial off the shelf (COTS) technologies as well as Command & Information Systems Planning and Traffic Management will allow the MoD to incrementally shape and direct the research, adapting to ongoing technological developments across military and commercial systems.

The other two tasks in this first package will make an assessment of the security properties of different technologies in a military context and the impact of their use on security policy and to scope future research for the Global Information Infrastructure (GII).

UK and India Collaborate on UAV Research

An award of up to £500,000 has been awarded to BAE Systems' research partner Leicester University, to carry out research in conjunction with leading Indian research institutions aimed at the development of new control technologies for Unmanned Air Vehicles. The grant was awarded by the UK India Education and Research Initiative (UKIERI), co-ordinated by the British Council. The project is titled *Towards Reliable and Smart Air-vehicles*, and aims to develop control technologies for UAVs and micro-satellites to be used in search and rescue scenarios.

BAE Systems is one of four 'corporate champions' helping to sponsor the UKIERI's collaborative education projects between the UK and India, along with BP, GlaxoSmithKline and Shell. This project will draw upon the research capabilities of the two countries, establishing stronger links between the research communities, which will be important for future collaboration.

Leicester University and BAE Systems will be working in partnership with the Indian Institute of Science at Bangalore, the National Aerospace Laboratories (Bangalore) and the Indian Institute of Technology Bombay. BAE Systems will be bringing its skills in successfully applying knowledge in a commercial environment to contribute to the innovative, cutting-edge research that Leicester University and its Indian partners will produce.

UMC Joins Power Forward Initiative

Global semiconductor foundry UMC has joined the Power Forward Initiative (PFI). The Initiative, made up of more than 20 industry-leading electronics companies, is sponsored by Cadence and was formed in May 2006 to advance the adoption of the Common Power Format (CPF), which captures essential design intent for power and links the design, implementation and verification domains.

The goal of the PFI is to enable the design and production of more power-efficient electronic devices. The Advisory

Group consists of representative companies across the design chain from microprocessors to IP to foundries and semiconductor companies, which UMC now joins.

"UMC has developed one of the industry's most comprehensive low power solution packages to help our customers effectively design for low power and power management applications targeting the consumer, wireless and communication segments," said Patrick Lin, SoC chief architect at UMC. "In order to extend our expertise to support broader, industry-wide low power efforts, we have joined the Power Forward Initiative and expect that the Common Power Format will streamline the entire low power design process to help customers accelerate the migration to advanced process nodes."

EC Adopts European Space Policy

The European Commission has adopted the European Space Policy, which reflects the key strategic importance that space systems and space applications have for Europe, in order to live up to its global leadership aspirations in selected areas. This communication marks a milestone for the development of space policy in Europe providing a European identity to space. It is a joint policy document of the European Commission and the Director General of the European Space Agency (ESA).

The joint document aims to preserve EU autonomous access to space and to allow the EU to exert its global responsibility in selected areas in accordance with European interests and values. For the first time, a European Space Programme will be established and space activities at national and European level will be coordinated to achieve transparency and complementary actions.

More synergy and coordination between defence and civil space programmes and technologies will be developed, in full respect of respective competencies, so that each sector can take maximum advantage of the investments of the other. A joint international relations strategy will be developed between ESA and EU Member States.

This will ensure the integration of space policy into a range of the EU's relationships with third countries and a more coherent European approach to partners. In the area of satellite applications the EU and ESA have established GALILEO and GMES. The strategic value of these systems will be greatly enhanced if the information they provide can be integrated, together with satellite communications and terrestrial networks. ■

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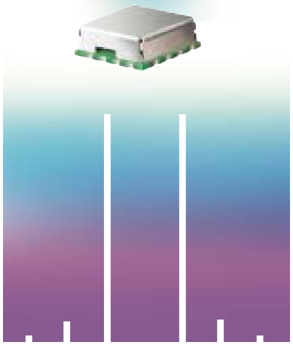

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TYPICAL SPECIFICATIONS

Model No.	Frequency (MHz) RF	LO	IF	LO Pwr. (dBm)	IP3 (dBm)	1dB Comp. (dBm)	Conv.Loss (dB)	Isolation (dB) L-R	L-I	Price $ ea. Qty.(1-9)
LAVI-9VH+	820-870	990-1040	120-220	+19	+36	+23	7.2	46	46	15.95
LAVI-10VH+	300-1000	525-1175	60-875	+21	+33	+20	6.3	50	45	22.95
LAVI-17VH+	470-1730	600-1800	70-1000	+21	+32	+20	6.8	52	50	22.95
LAVI-22VH+	425-2200	525-2400	100-700	+21	+31	+20	7.7	50	45	24.95
LAVI-2VH+	2-1100	2-1100	2-1000	+23	+34	+23	7.5	48	47	24.95
LAVI-25VH+	400-2500	650-2800	70-1500	+23	+32	+20	7.5	50	45	24.95

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SBTC-2-25+	1000-2500	50 Ω	3.49
SBTC-2-10-75+	10-1000	75 Ω	3.49
SBTC-2-15-75+	500-1500	75 Ω	3.49
SBTC-2-10-5075+	50-1000	50/75 Ω	3.49
SBTC-2-10-7550+	5-1000	50/75 Ω	3.49

U.S. Patent No. 6,963,255

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RF/IF MICROWAVE COMPONENTS

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Cellphone Strength Unabated

Strategy Analytics, the research and consulting company, released "RF Industry Review October–December 2006," which notes that leading suppliers of RF components continued to report significant profits in Q4 on strong wireless handsets and wireless system demand. In the fourth quarter of 2006, the majority of RF component suppliers reported strong profits, but profits dropped slightly from the previous quarter, signaling possible weakness in early 2007. According to Chris Taylor, director of the RF and Wireless Component service, "A seasonal decline in handset shipments after the holidays could mean flat sales and lower profits for top RF and wireless component suppliers such as Texas Instruments, Qualcomm and Infineon in early 2007." Stephen Entwistle, vice president of the Strategy Analytics Strategic Technologies Practice, added, "The long-term outlook for the RF sector remains positive. For example, VC funding of RF component start-ups exceeded $280 M in the quarter, the highest level of the past few years."

USB Cellular Modem Shipments to Exceed 22 Million Units by 2012

Since the end of 2006, several modem vendors have launched or announced development of USB cellular modems. A new study from ABI Research reveals a growing and increasingly competitive market and forecasts shipments of these modems in excess of 22 million by 2012. According to principal analyst Dan Shey, "Proliferation of 3G networks is the primary driver of growth in cellular modems, regardless of form factor. However, new companies are jumping into the USB modem market because the installed base of devices for USB modems includes not only laptops but also desktops. Desktop PCs are ubiquitous around the world and will continue shipping in large volumes, exceeding 140 million units per year through 2011." In a market characterized by increasing competition, cellular modem shipments, including PC cards and Express Cards USB modems, internal modems and 3G/WiFi routers, will grow to over 68 million units by 2012, representing a compound annual growth rate of 53 percent. The market dynamics affecting USB modem growth will be very different from those that affect the other modem form factors. This will create opportunities and challenges for all value chain players. Says Shey, "There are two factors to watch which will affect the USB modem market. First, the newer companies entering this market are in the Asia-Pacific region, a territory with notoriously price-competitive companies. Second, since the USB modem attaches externally to the computer, the device has no space or shape limitations. This fact allow modem vendors to differentiate their products by on body design and functional features, providing for interesting marketing opportunities." ABI Research's study, "Expanding Cellular Broadband Connectivity to the Laptop," provides a comprehensive overview of the market for cellular modems. The report analyses the factor both driving and inhibiting growth and illustrates how changes in the market are creating both opportunity and complexity for the value chain participants, including chipset manufacturers and wireless operators, as well as producers of modems, laptops and connection client software. In depth analysis is also applied to the value-creating role of the connection client and its impact on the value chain participants. Finally, this report provides comprehensive market share and forecast information. Forecasts are provided for each of five different form factors by worldwide region, technology standard and air interface and average selling price.

High Powered RFICs Rewriting the Power Amplifier Rulebook

According to Lance Wilson, research director, semiconductors, at ABI Research, "High power radio frequency ICs have been 'flying under the radar' for the last couple of years. There are a lot more being sold than people realize. Readers of a new study we have just published will be very surprised when they find exactly how many. High power RFICs are going to be a major force in the RF power market for base stations and will grab a good chunk of this market in the next five years." Over the past two years, this new breed of high powered RFICs—primarily geared for use in base stations for cellular and other infrastructures—has been quietly grabbing significant market share, and will continue to do so at an increasing pace. That is one of the surprise conclusions contained in a new study just released by ABI Research. Low powered radio frequency ICs have been around for a long time, most commonly used in the power amplifiers of mobile phone handsets. But these new RFICs are a different matter entirely. In the past, they have been both underpowered and expensive, but according to Wilson, that has now changed. "It is hard to get people to sign up for a new solution that costs more, even though it may be easier to use," he said. "But this year, RFICs have reached the same power levels as devices built around discrete transistors. They have also become much more price-competitive compared to the conventional solution. The accepted wisdom about high power RFICs simply no longer applies." As one might expect, the vendors who are most fully engaged in making high power RFICs are the Big Three of RF power devices for wireless infrastructure: Freescale, NXP Semiconductors and Infineon Technologies. However, notes Wilson, the research has revealed some eye-opening facts about their relative market shares. The new report, "High-Power RFICs," is included in ABI Research's RF Power Devices Research Service, which includes other research reports, ABI insights and analysis inquiry support.

Si and MEMS Solutions Vendors Facing Challenges in Timing Device Industry

Vendors of solutions based on silicon and microelectromechanical systems (MEMS) face an uphill battle to make a dent in the huge market for timing devices, according to a study from ABI Research. The market was and is dominated by quartz crystal oscillator technology. Most of the largest crystal oscillator vendors—Epson Toyocom, NDK, Kyocera and KDS—are Asia-Pacific-based companies and they rule the market mass-producing low cost crystal oscillators to feed the huge regional consumer electronics industry. That situation will continue beyond the end of the forecast period in 2011. However, MEMS and silicon timing device vendors do enjoy certain advantages, if they target their efforts wisely. "They are trying to climb a Mount Everest of an industry that is already established," notes senior analyst Douglas McEuen. "That said, the MEMS solution, like the computer and wireless industries, is based on a silicon CMOS chip. The benefits of a silicon CMOS chip are huge: the electronics industry has 30 years of established procedures, processes and understanding of the silicon solution, which creates an opportunity for these companies—mainly innovative start-ups such as SiTime and Discera—to make up ground." Silicon solutions are less expensive as well, and MEMS technologies are extremely rugged and well suited to low jitter applications such as military and aerospace equipment where resistance to shock and vibration are at a premium. The ABI Research study, "The Timing Solution Market: Quartz Crystal, Crystal and SAW Oscillators, and Silicon Timing Devices," identifies the trends and strategies driving each of these market segments and focuses on detailed market share data and quantification of the market according to engineering parameters such as package type, tuning type, stability and application. It forms part of the company's Wireless Handset Semiconductors Research Service, which includes other research reports, online databases, research briefs, market data, ABI insights and analyst inquiry support. ■

Broadband Amplifiers by AML Communications

To Order Call: (805)388-1345 ext. 203

Model	Frequency (GHz)	Gain (dB)	Flatness (dB) max	NF (dB) max	P1dB (dBm) min	VSWR (In/Out)	DC Current @ +12/+15VDC
Broadband Low Noise Amplifiers							
AML016L2802	0.1 – 6.0	28	±1.25	1.3*	+7	2.0:1	190
AML48L3001	4.0 – 8.0	30	±1.0	1.2	+10	1.8:1	150
AML412L3002	4.0 – 12.0	30	±1.5	1.5	+10	1.8:1	150
AML218L0901	2.0 – 18.0	9	±1.0	2.2	+5	2.5:1	60
AML0518L1601-LN	0.5 – 18.0	16	±1.0	2.7	+8	2.2:1	100
AML0126L2202	0.1 – 26.5	22	±2.25	3.5*	+8	2.2:1	170
AML1226L3301	12.0 – 26.5	33	±2.0	2.8	+8	2.5:1	200
Broadband Medium Power Amplifiers							
AML0016P2001	0.01 – 6.0	21	±1.25	3.2*	+23*	2.0:1	480
AML26P3001-2W	2.0 – 6.0	28	±2.5	6	+33	1.8:1	1500
AML28P3002-2W	2.0 – 8.0	30	±2.0	5.5	+33	2.0:1	2000
AML218P3203	2.0 – 18.0	32	±2.5	4	+25	2.0:1	450
AML618P3502-2W	6.0 – 18.0	35	±2.5	4	+33	2.0:1	1850
Narrow Band Low Noise Amplifiers							
AML23L2801	2.8 – 3.1	28	±0.75	0.7	+10	1.8:1	150
AML1414L2401	14.0 – 14.5	24	±0.75	1.5	+10	1.5:1	130
AML1718L2401	17.0 – 18.0	24	±0.75	1.6	+10	1.8:1	150

Low Phase Noise Amplifiers — Phase noise (dBc/Hz) at offset

Part Number	Frequency (GHz)	Gain (dB)	Output Power (dBm)	100Hz	1KHz	10KHz	100KHz
AML811PN0908	8.5 – 11.0	9	17	-154	-159	-167	-170
AML811PN1808	8.5 – 11.0	18	18	-152.5	-157.5	-165.5	-168
AML811PN1508	8.5 – 11.0	15	28	-145.5	-153.5	-158.5	-164.5
AML26PN0904	2.0 – 6.0	9	20	-150	-165	-165	-178
AML26PN1201	2.0 – 6.0	11	15	-155	-160	-160	-175

High Dynamic Range Amplifiers

Part Number	Frequency (MHz)	Gain (dB)	P1dB (dBm)	OIP3 (dBm)	DC
AR01003251X	2 – 32	21	32	52	+28V @ 470mA
AFL30040125	50 – 500	23	28	53	+28V @ 700mA
BP60070024X	20 – 2000	32	30	43	+15V @ 1100mA

*Above 500MHz.

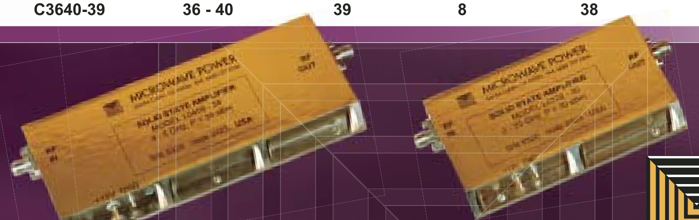
Power Amplifiers by Microwave Power

To Order Call: (408)727-6666 ext. 42

Model	Frequency (GHz)	Psat (dBm)	Psat (W)	P1dB (dBm)	Gain (dB)	DC Current(A) @ +12V or +15V
Broadband Microwave Power Amplifiers						
L0104-43	1 - 4	42.5	17.8	41.5	45	14
L0204-44	2 - 4	44	25	42.5	45	14
L0206-40	2 - 6	40	10	38.5	40	8.5
L0208-41	2 - 8	41	12	40	40	17
L0218-32	2 - 18	32	1.4	31	35	5
L0408-43	4 - 8	43	20	41.5	45	17
L0618-43	6 - 18	43	20	41.5	45	22
L0812-46	8 - 12	46	40	45	45	28
Millimeter-Wave Power Amplifiers						
L1826-34	18 - 26	34	2.5	33	35	4
L1840-27	18 - 40	27	0.5	26	30	2
L2240-28	22 - 40	28.5	0.7	27	30	3
L2630-39	26 - 30	39	8.0	38	40	15
L2632-37	26 - 32	37	5.0	36	38	10
L2640-31	26 - 40	31	1.2	30	30	5
L3040-33	30 - 40	33	2.0	32	33	9
L3337-36	33 - 37	36	4.0	35	40	12
L3640-36	36 - 40	36	4.0	35	40	10

High-Power Rack Mount Amplifiers

Model	Frequency (GHz)	Psat (dBm)	Psat (W)	P1dB (dBm)	Pac (kW)	Height (in)
C071077-52	7.1 - 7.7	52.5	170	51.5	1.8	10.25
C090105-50	9 - 10.5	50	100	49	1	8.75
C140145-50	14 - 14.5	50.5	110	49.5	2	10.25
C1416-46	14 - 16	46	40	45	0.35	5.25
C1820-43	18 - 20	43	20	41.5	0.25	5.25
C2326-40	23 - 26	40	10	39	0.25	5.25
C2630-45	26 - 30	45	30	44	0.45	5.25
C3236-40	32 - 36	40	10	39	0.25	5.25
C3640-39	36 - 40	39	8	38	0.24	5.25



AML Communications

Camarillo, CA (805)388-1345 ext. 203

Over 1000+ amplifiers at

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Microwave Power

An AML Communications Company

Santa Clara, CA (408)727-6666 ext. 42

INDUSTRY NEWS

▲ Fred Miller

■ **Fred Miller**, founder of West Bond Inc., passed away on April 21, 2007, from complications a week after a fall. Over 40 years ago, in 1966, Miller bootstrapped his own company West Bond, which became West Bond Inc. in 1968, giving the microelectronic world the first X-Y-Z micromanipulator breakthrough technology. Holding 48 design patents such as the "Deep Access" wire feed, he gave operators the ability to bond gold and aluminum wire as fine as 0.0007" in small, tight and deep access packages. He brought end users of his product (in his words) "a control mechanism with a single input for a human to direct microscopic movements intuitively. The immediate justification for this invention was fine wire bonding of transistors, where we could add the caveat that the human be isolated from the task of applying the delicate force required." With over 18,000 machines sold, 146 models in six different machine generations all over the world, thousands of companies have been able to design and build circuits and make fine wire connections that once were thought to be impossible. After Miller's retirement in 2005 West Bond has been proud to carry on the motto "continuing a tradition of quality" in product and service. Many of his original inventions and designs are still working today, over 40 years later.

■ **Endwave Corp.**, a provider of high frequency RF modules for telecommunications networks, defense electronics and homeland security systems, announced the acquisition of privately-held **ALC Microwave Inc.** for approximately $6.6 M in cash. ALC is a provider of logarithmic amplifier subsystems to many US and international defense prime contractors. ALC delivers these unique amplifier products for use in early warning radars, threat detection equipment, electronic countermeasures and missile guidance systems. ALC, with approximately 40 employees, is located in El Dorado Hills, CA, in close proximity to Endwave's Diamond Springs, CA operation. ALC's revenues were approximately $5.5 M in 2006.

■ **Tyco Electronics** announced a strategic alliance with **OATSystems** to provide a series of radio frequency identification (RFID) solutions to a variety of vertical markets that include aerospace and defense, transportation, and industrial segments.

■ **RF Micro Devices Inc.** (RFMD), a leader in the design and manufacture of high performance radio systems and solutions for applications that drive mobile communications, announced the addition of a research and development (R&D) center in the company's Shanghai facility. The new center will expand RFMD's product development capacity to support original design manufacturers (ODM), original equipment manufacturers (OEM), and local and international handset manufacturers throughout the Far East. Increasing RFMD's internal design capacity of front-end solutions and transceivers will allow for significantly improved design cycle times and reduced manufacturing and shipping costs to customers.

■ **Microsorb Technologies**, a manufacturer of RF absorbers and dielectric materials, has moved to a new location in Woonsocket, RI. Microsorb Technologies started in 1992 by a group of microwave material engineers and has become a worldwide supplier of RF absorbers and dielectric materials for both commercial and military applications. The company offers custom design and fabrication of engineered parts, with experienced technical service assistance. Microsorb Technologies' new address is Woonsocket Industrial and Technology Center, 32 Mechanic Avenue, Unit 211, Woonsocket, RI 02895 (401) 767-2242, fax: (401) 767-2255, e-mail: engineering@microsorbtech.com or visit: www.microsorbtech.com.

■ **SolidWorks Corp.**, a leader in 3D CAD technology, and **COMSOL**, a leader in multiphysics simulation software, have strengthened their ties: SolidWorks has named COMSOL as one of its select Solutions Partners. This program provides SolidWorks users with access to integrated products and services that can further boost productivity.

■ **Mini-Systems Inc.** (MSI) Thin Film Division has been recognized once again by **Northrop Grumman Space Technology** (NGST) as a "GOLD" Supplier. MSI has achieved NGST's highest rating of "GOLD" for the third consecutive year. In order to be a recipient of this status, suppliers must maintain an increased level of product quality and on-time delivery of 99 percent. In 2005, that percentage was at 98 percent. With about 1000 vendors, MSI was one of only 71 suppliers to receive the 2006 "GOLD" Supplier Award.

■ Providing design engineers with several product options to best suit their applications, **TT electronics IRC Advanced Film Division** announced it will continue to offer both RoHS-compliant and leaded versions of the majority of its products. This offering applies to IRC's low value current sense components, precision chips and networks.

CONTRACTS

■ **Agilent Technologies Inc.** announced that it has been awarded a $94 M contract by the US Army Aviation and Missile Command Redstone Arsenal. Under the contract, Agilent will deliver its AN/PRM-35 Radio Test Set (RTS) over six years, beginning in 2008, to the US Army Product Manager Test, Measurement and Diagnostic Equipment organization.


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■ **Superconductor Technologies Inc.** (STI) announced it was awarded a contract from the US Air Force to develop Semiconductor-Tuned High Temperature Superconducting Filters for Ultra-Sensitive Radio Frequency Receivers (SURF). The funded contract amount is $4.7 M. Upon successful completion of the initial contract, the US Air Force has an option to extend the contract for the delivery of a prototype rack-mountable system incorporating a reconfigurable, ultra-fast tuned filter. If exercised, the value of this contract extension option is $5.4 M and would be recognized over 12 months.

■ **Herley Industries Inc.** announced that it has received a $2.4 M contract award from **Composite Engineering Inc.** (CEi), Sacramento, CA, for its avionics suite for the BQM-167A Air Force Sub-scale Aerial Target (AFSAT). The contract includes Gulf Range Drone Control System (GRDCS) transponders, Identification Friend or Foe (IFF) transponders, Electro-Explosive Devices (EED), Integrated Flight Controllers (IFC), Radar Altimeters and Power Management Units (PMU).

■ **Cascade Microtech Inc.** announced that **Peregrine Semiconductor Corp.** has placed a multi-million dollar order for Cascade Microtech's Pyramid Probe® cards for its advanced RF CMOS integrated circuit production. The probe cards, which have begun to ship to Peregrine, will be used to test Peregrine's latest generation UltraCMOS™ high power antenna switches. According to Peregrine, Cascade Microtech was selected due to the high quality advanced RF performance and reliability of its production probe card solutions.

■ **TRAK Microwave Corp.** announced that it has received a production contract from **Ball Aerospace** (Broomfield, CO) for the continuation of the Army Tactical Missile System (ATACMS) program. TRAK will supply its custom-designed switch network assembly that is integrated with the Ball Aerospace antenna system and then delivered to the prime contractor, Lockheed Martin. The TRAK integrated subsystem consists of a filter/limiter, low noise amplifier and switch network. The contract award was in excess of $600 K for this production phase release.

■ **LNX Corp.** announced that it has been recently selected by **BAE Systems** and **MiKES** to supply sophisticated RF/microwave control components, valued in excess of $2 M, for the Self-Protection Electronic Warfare System (SPEWS II).

FINANCIAL NEWS

■ **Credence Systems Corp.** reports sales of $118.8 M for the first quarter of fiscal 2007 ended February 3, 2007, compared to $121.8 M for the same period in 2006. Net loss for the quarter was $11 thousand ($0.00/per share), compared to a net loss of $4 M ($0.04/per share) for the first quarter of last year.

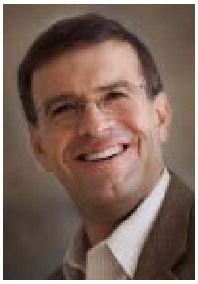
■ **ANADIGICS Inc.** reports sales of $49.6 M for the first quarter of 2007 ended March 31, 2007, compared to $34.7 M for the same period in 2006. Net loss for the quarter, including discontinued operations, was $1.2 M ($0.02/per share), compared to a net loss of $4.6 M ($0.12/per share) for the first quarter of last year.

■ **Merrimac Industries Inc.** reports sales of $6.2 M for the fourth quarter of 2006 ended December 30, 2006, compared to $7 M for the same period in 2005. Net loss for the fourth quarter was $1.7 M ($0.55/per share), compared to a net income of $117,000 ($0.04/per share) for the fourth quarter of 2005.

NEW MARKET ENTRY

■ **Innovative Micro Technology** (IMT) announced it has begun offering getter deposition services for wafer-level packaging of MEMS and other devices that require hard vacuum for device performance. In exhaustive testing, IMT has demonstrated vacuum levels equal to or surpassing other established getter deposition services. Using IMT's proprietary getter (patent pending), IMT has routinely achieved vacuum levels below 10 mTorr in production of inorganic devices for such applications as IR emission and sensing and for resonant oscillators in biological and chemical hazard detection applications.

PERSONNEL



▲ Avi Katz

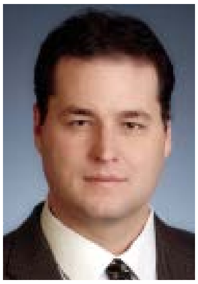
■ iTerra Communications announced the appointment of **Avi Katz** as president and chief executive officer, and member of the board of directors. Katz brings to iTerra a track record of extraordinary results in leading public and private electronics manufacturers in fiercely-competitive environments. He also has detailed knowledge of the compound semiconductor technology that is the basis of iTerra's products. Katz has managed and conducted global businesses in the US, China, India, Asia Pacific and Europe for many years, and was the chief executive officer of hardware and software companies prior to joining iTerra.

▲ Sohail Khan

■ SiGe Semiconductor announced the appointment of **Sohail Khan** as president and chief executive officer. Khan will lead SiGe Semiconductor in its next stage of development, as the company expands its position as a leading supplier of RF front-end solutions and GPS receivers to the consumer electronic markets. Sohail Khan has more than 25 years of experience in the communications and semiconductor industry, with a track record of building large, successful global businesses, creating new products and developing new markets. Khan comes to SiGe Semiconductor from Bessemer Venture Partners, where he served as an entrepreneur in residence and operating partner, responsible for evaluating communications deals and providing assistance to portfolio companies.

■ RF Monolithics Inc. (RFM) announced that **Joseph E. Andrulis** has been appointed senior vice president and group manager to lead the company's Wireless Solutions Group. The Wireless Solutions Group encompasses Aleier's Enterprise Asset Management Solutions with Condition-Based Maintenance Management software, Cirronet's embedded modules and RFM's Virtual Wire and RFICs. Andrulis previously served as vice president of marketing for RFM, a position he has held since joining the company in December of 2004.

■ Applied Wave Research Inc. (AWR®) announced that **Sherry Hess** has been named vice president of marketing. Hess will oversee all marketing activities including corporate, product and strategy in order to further drive the company's business worldwide. Hess joins AWR with nearly 20 years of senior management experience in the semiconductor and EDA industries. Prior to AWR, Hess was with CebaTech Inc., a startup that specializes in EDA/electronic system-level (ESL) and telecommunication intellectual property (IP). As vice president of business development, she was responsible for sales, marketing and support activities as the company transitioned from stealth R&D to successful product introduction. Before CebaTech, Hess spent more than 15 years at EDA developer Ansoft Corp., where she most recently held the position of vice president of marketing, with responsibility for internal and external marketing.


▲ Rich Weatherford

■ Crane Aerospace & Electronics, a segment of Crane Co., announced the appointment of **Rich Weatherford** as vice president of operations for the Electronics Group. In this position, Weatherford will be responsible for operations of all Electronics Group sites including locations in Redmond, WA; Fort Walton Beach, FL; Chandler, AZ; Beverly, MA; Daventry, England; and Kaohsiung, Taiwan. He will be located in Redmond. Weatherford joins Crane from Rexnord Industries Inc., Downers Grove, IL. He has over 13 years of experience building and leading manufacturing operations and is a lean manufacturing process expert.

■ California Eastern Laboratories (CEL) announced that **Jeremy Dietz** has joined the company as director of its fiber optics and optical semiconductor business unit. Dietz will be responsible for the marketing and business management of CEL's rapidly-expanding fiber optic and optical isolation product lines. Dietz has broad experience in all of CEL's distribution channel models: factory direct, distribution and manufacturers' representative. He comes to CEL from Sharp Microelectronics, where he served as optoelectronics product manager.

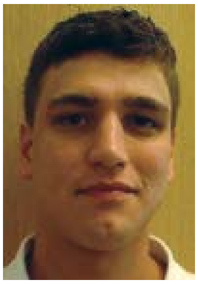
■ I.F. Engineering Corp., a manufacturer of high performance RF and microwave components and distribution systems, announced the appointment of **Sean Gordon** as director, international sales. Based in Jerusalem, Israel, Gordon will be responsible for creating and managing I.F. Engineering's international channel program. The Jerusalem office will afford I.F. Engineering's clients and channel partners a location more suitable for customer and technical service. Gordon brings over 20 years sales and marketing experience, with the last 14 years in high tech RF and satellite systems. He was one of the founders and vice president of sales at Foxcom Inc. Gordon has experience in launching RF products into new territories and markets—he was responsible for setting up Foxcom's distribution network in Europe and Asia.


▲ John Taunton

■ Lorch Microwave announced the appointment of **John Taunton** as European sales manager. Taunton has more than 20 years experience in the RF and microwave industry, having held senior filter engineering positions with K&L Microwave, ERA Technology and BSC Filters. Taunton will be based out of the European sales office located near York, England.

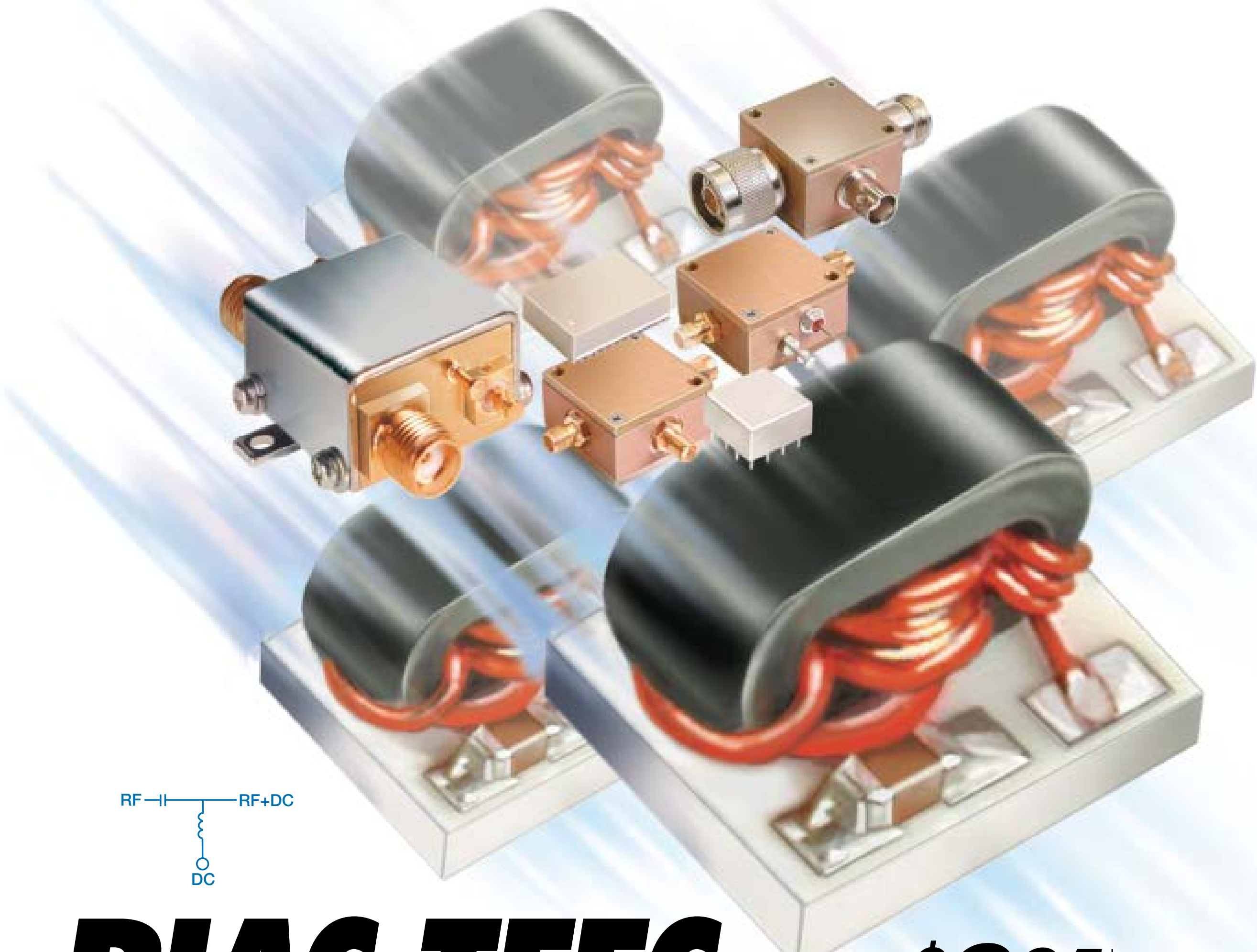

▲ Tom Eichelberger

■ AR RF/Microwave Instrumentation announced that **Tom Eichelberger** has joined the company in the role of a regional sales manager. Eichelberger has replaced John Whitney, who has been promoted to general sales manager. Eichelberger brings 28 years of experience with leading technology companies including Bell Laboratories, AT Microelectronics, Lucent Technologies and Agere Systems. His education includes BS and MS degrees in physics from Ohio State University, and an MSE degree in technology management from the Executive Master's in Technology Management (EMTM) program at the University of Pennsylvania.


▲ Shane Delmore

■ Renaissance Electronics announced the appointment of **Shane Delmore** to the position of product group manager, RF subsystems. Delmore joined Renaissance Electronics in August 2004 just after graduating from MIT with a bachelor of science degree. At Renaissance, he started as a member of the RF subsystems group and had a primary focus on Sprint/Nextel business development. The Renaissance Electronics RF subsystems product group has realized significant growth over the past two years. Delmore has developed plans for major expansion of the company's RF subsystems business in 2007 and 2008.

■ Andrew Corp., a leader in communications systems and products, has named two of its engineers as Andrew Fellows, the company's highest level of technical achievement in engineering. **Jeffrey Strahler** and **Simon Hamparian**, who are senior principal engineers at Andrew's Columbus, OH and Warren, NJ facilities, respectively, together bring more than 45 years of key industry experience to the company. Their numerous accomplishments have not only contributed greatly to Andrew's success, but have advanced the science of telecommunications engineering as well.



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TCBT-6G	50-6000	0.7	28	1.20	9.95
TCBT: LTCC, Actual Size .15"x.15", U.S. Patent 7,012,486.					**Qty.1-9**
JEBT-4R2G	10-4200	0.6	40	1.10	39.95
JEBT-4R2GW	0.1-4200	0.6	40	1.10	59.95
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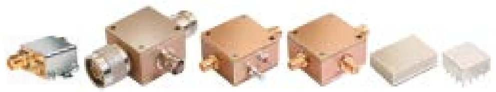
PBTC-1GW	0.1-1000	0.3	33	1.10	35.95
PBTC-3GW	0.1-3000	0.3	30	1.13	46.95
ZFBT-4R2G	10-4200	0.6	40	1.13	59.95
ZFBT-6G	10-6000	0.6	40	1.13	79.95
ZFBT-4R2GW	0.1-4200	0.6	40	1.13	79.95
ZFBT-6GW	0.1-6000	0.6	40	1.13	89.95
ZFBT-4R2G-FT	10-4200	0.6	N/A	1.13	59.95
ZFBT-6G-FT	10-6000	0.6	N/A	1.13	79.95
ZFBT-4R2GW-FT	0.1-4200	0.6	N/A	1.13	79.95
ZFBT-6GW-FT	0.1-6000	0.6	N/A	1.13	89.95
ZNBT-60-1W	2.5-6000	0.6	45	1.10	82.95
ZX85-12G+	0.2-12000	0.6	N/A	1.20	99.95

ZX85: U.S. Patent 6,790,049.

Note: Isolation dB applies to DC to (RF) and DC to (RF+DC) ports.



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▲ *Isik C. Kizilyalli*

■ For contributions in the field of integrated circuit technology, **Isik C. Kizilyalli**, director of technology at Nitronex, has been selected as a 2007 Fellow by the Institute of Electrical and Electronic Engineers (IEEE). At Nitronex, a developer and manufacturer of high performance GaN RF power transistors, Kizilyalli manages the process and device technology development department.

REP APPOINTMENTS

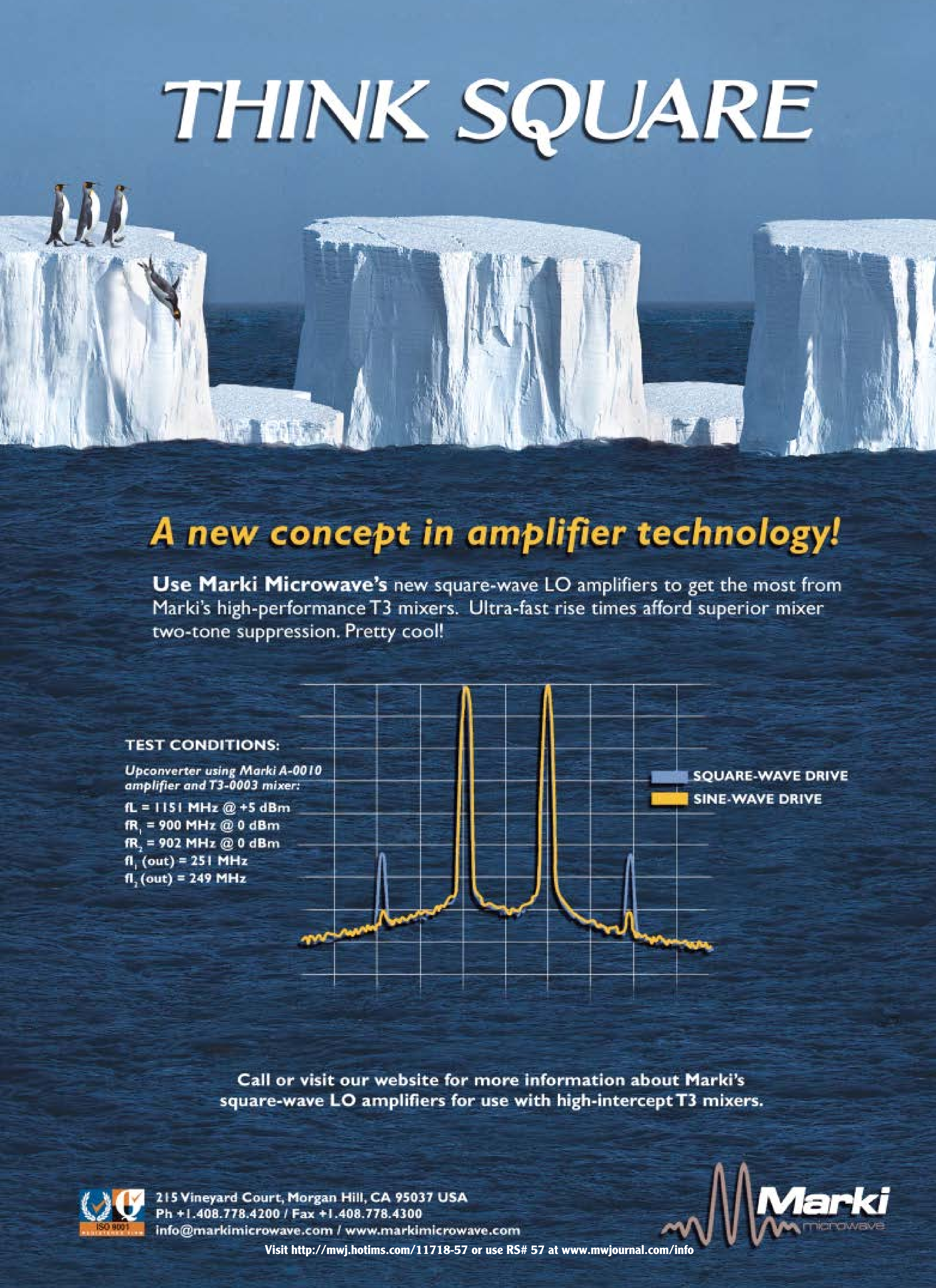
■ **Aeroflex** and **AT4 wireless** have entered into a worldwide distribution agreement for the sale and support of the WiMAX RF Conformance Test (WiMAX RCT MINT T2110) and WiMAX Protocol Conformance Test (WiMAX PCT MINT T223x) systems. Under the terms of the distribution agreement, Aeroflex will provide the worldwide sales and support channel for both conformance test systems to all WiMAX technology customers, including the accredited WiMAX test laboratories. The PCT is being co-developed by the two companies under their ongoing collaborative development agreement while the RCT is being developed by AT4 wireless.

■ **Auriga Measurement Systems LLC** announced an exclusive agreement with **Accelonix** of Europe. Accelonix, a supplier of microelectronics capital equipment and services, will distribute Auriga's product line in France, Portugal and Spain.

■ **Digi-Key Corp.** and **Linear Technology Corp.** announced the expansion of the companies' distribution contract from a North American contract to a global contract. Linear Technology products stocked by Digi-Key include a wide range of integrated circuits. These products are featured in both its print and on-line catalogs and are available for purchase directly from Digi-Key. The distribution agreement between Linear Technology and Digi-Key enable the distributor to fulfill both the prototype and production quantity needs of its diverse customer base.

■ **TestEquity**, a manufacturer of environmental chambers, announced a new partnership agreement with **Test-Mart**, a leading marketplace operator and service provider for the IT, network maintenance, and test and measurement industries. The agreement authorizes Test-Mart to present a catalog of benchtop and floor standing environmental chambers.

■ **Richardson Electronics** announced a worldwide partnership to distribute a new frequency-hopping spread spectrum (FHSS) embedded wireless module developed by Radiotronix of Oklahoma City, OK. The Wi.232FHSS-250™ is the first of a new family of RF embedded modules based on the Analog Devices ADF702x RF transceiver chips.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MINIMIZATION OF PHASE NOISE IN SCALED DEVICE COUPLED MODE RF OSCILLATORS

This article describes the impact of device scaling on phase noise in coupled oscillators, which have recently emerged as strong contenders for radio frequency (RF) and mixed-signal applications.

As the frequency band for wireless communication shifts higher and higher, the generation of power efficient, low phase noise, broadband and configurable compact signal sources (oscillators) with low cost has become more and more challenging, due to the frequency limitations of the devices (transistors). The performance of communication systems depends on the speed of the devices used, and is typically specified by two figures-of-merit (FOM). The first FOM is the transistor cut-off frequency f_T; the second FOM is the maximum oscillation frequency f_{max} (defined as the frequency at which the current gain and the power gain become unity, respectively). To meet this challenge, the transistor geometric profile needs to be scaled for higher f_T and f_{max}. Technology scaling has driven this momentum to a high level of integration.[1] Device scaling has been the critical driving force behind high speed integrated RF (radio frequency) and MW (microwave) solutions. Since the operating frequency of the oscillator is limited by the f_T of the transistors, RF and MW integrated circuits are often designed using GaAs HBTs, which offer high f_T, but typically exhibit higher flicker corner frequency (f_c) and are power hungry, and are therefore not suitable for low phase noise and power efficiency in signal generation applications.[1–19] Si BJTs typically have a low flicker corner frequency, but do not have sufficient gain to sustain stable oscillation at RF and microwave frequencies because of their limited f_T and f_{max}.[14] SiGe HBTs offer lower f_c and comparable f_T to GaAs HBTs, making them the favorable choice for low phase noise and power-efficient RF and MW signal generation applications.[13,14] The oscillator phase noise performance is one of the areas where SiGe HBT devices outperform III-V devices.[16,17] SiGe HBT has progressed over the last decade from a digitally oriented technology to one well suited for RF and microwave applications (due to its superior analog and RF performance and its CMOS integration capability).[13–19] Hence, SiGe HBT technology is a promising contender among Si-based technology, due to its advantages over CMOS technology such as higher f_T, lower noise and power-efficient performance. This article discusses the impact of scaling on phase noise and the minimization of phase noise in SiGe HBTs coupled voltage-controlled oscillators (VCO).

U.L. ROHDE AND A.K. PODDAR
Synergy Microwave Research
Paterson, NJ

SCALING AND NOISE PERFORMANCE CHARACTERISTICS

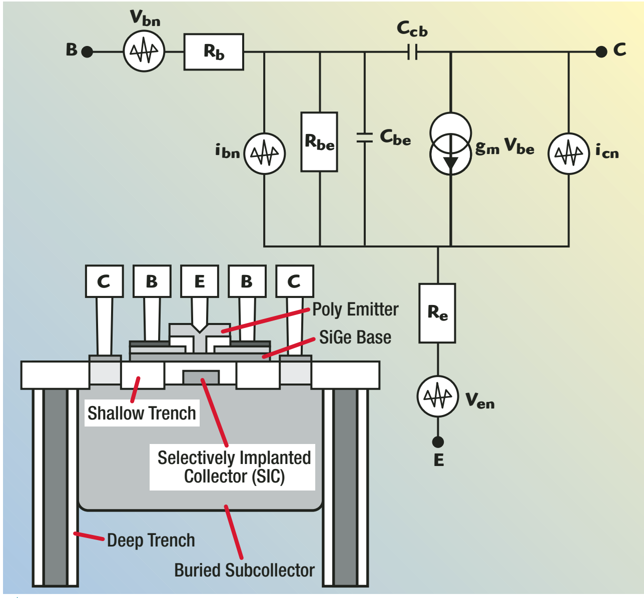
Figure 1 shows the typical simplified common emitter equivalent circuit broadband noise model of the SiGe HBT transistor.[17] The f_T and f_{max} of SiGe HBT can be given by

$$f_T \cong \left[\frac{1}{2}\left[\frac{1}{g_m}\left(C_{be}+C_{cb}\right)+\tau_b+\tau_e+\tau_{bc}\right]\right]^{-1} \quad (1)$$

$$f_{max} \cong \sqrt{\frac{f_t}{8\pi R_b C_{cb}}} \quad (2)$$

where

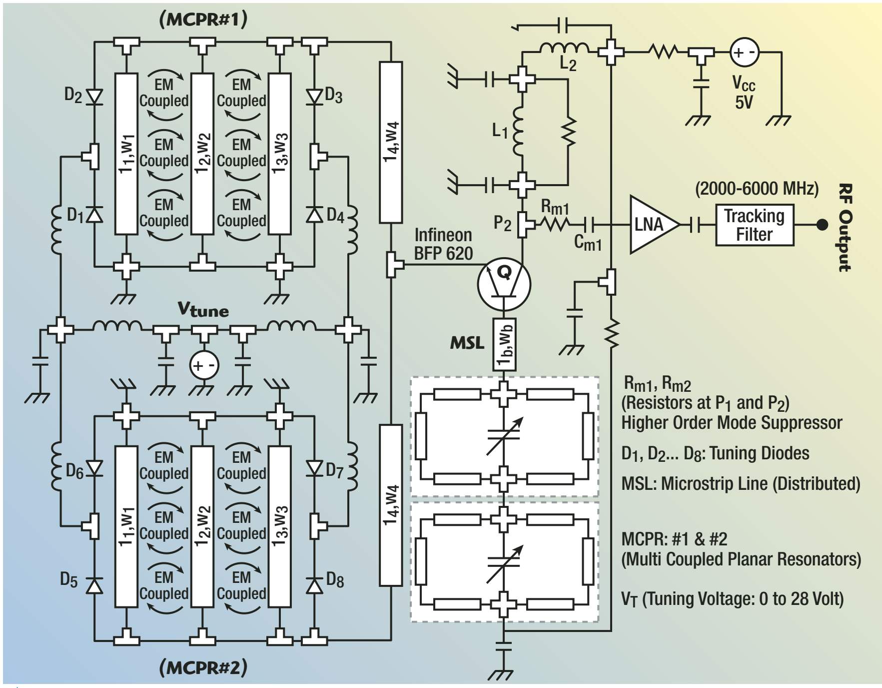
C_{be} = parasitic emitter base junction capacitance
C_{cb} = parasitic collector base junction capacitance
R_b = parasitic base resistance
g_m = device transconductance
τ_b = base transit time
τ_e = emitter delay time
τ_{bc} = base collector junction depletion layer time



▲ *Fig. 1 CE equivalent circuit noise model of the SiGe HBT transistor.*

All are technological scaling sensitive device parameters and can be optimized for higher f_T and minimum noise figure for high frequency low noise oscillator applications.

Active devices (bipolar transistor) contribute their own set of problems for the oscillator designer due to their inherent nonlinearities, noise properties and temperature variations. The designer has limited control over the noise sources in transistor, and only has a choice of device selection, oscillator topology and operating bias point. For better insight into the noise effects in the oscillator design, it is necessary to understand how the noise arises in transistor and oscillator circuits. Noise in the active device is characterized as a broadband noise (base and collector current shot noise, and base resistance thermal noise) and low frequency noise (1/f noise), which are sensitive to the scaling of the active device[3]



▲ *Fig. 2 Schematic of the 2 to 6 GHz coupled resonator VCO (patent pending).*

BROADBAND NOISE (THERMAL AND SHOT NOISE)

The broadband noise in a bipolar transistor is due to the base current shot noise $2qI_B$, the collector current shot noise $2qI_C$, the base resistance thermal noise $4kTR_b$ and the emitter resistance thermal noise $4kTR_e$. The mean square values of the broadband noise generator (scaling sensitive parameters), as shown in the figure for a frequency interval Δf, can be described by

$$\overline{i_{bn}^2} = 2qI_B\Delta f \Rightarrow S\left(i_{bn}\right) = \frac{\overline{i_{bn}^2}}{\Delta f} = 2qI_b = \frac{2KTg_m}{\beta} \quad (3)$$

$$\overline{i_{cn}^2} = 2qI_C\Delta f \Rightarrow S\left(i_{cn}\right) = \frac{\overline{i_{cn}^2}}{\Delta f} = 2qI_c = 2KTg_m \quad (4)$$

$$\overline{v_{bn}^2} = 4kTR_b\Delta f \Rightarrow S\left(v_{bn}\right) = \frac{\overline{v_{bn}^2}}{\Delta f} = 4KTR_b \quad (5)$$

$$\overline{v_{en}^2} = 4kTR_e\Delta f \Rightarrow S\left(v_{en}\right) = \frac{\overline{v_{en}^2}}{\Delta f} = 4KTR_e \quad (6)$$

From Equations 1 to 4, the base and collector current shot noise can be reduced by increasing the current gain β and cut-off frequency f_T for a given profile of a SiGe HBT technology. Increasing the doping profile of the base and reducing the emitter width can minimize the thermal noise generated due to the base resistance.[1] From Equations 1 to 6, maximizing the current gain β, the cutoff frequency f_T, and lowering the base resistance R_B in SiGe HBT, make the technology promising for low phase noise signal sources (oscillator/VCOs).[13–19]

Low Frequency Noise (1/f Noise: Flicker Noise)

The major contribution of low frequency noise is due to the flicker noise (1/f noise), which lies in the base current of the SiGe HBTs.[17] For a spectral pure signal source, a lower 1/f noise is desired to minimize the phase noise. However, the reduction of 1/f noise in semiconductor technology is challenging, because it is sensitive to defects, particularly in scaled technologies with low thermal cycles.[1] The origins of 1/f noise are varied, but in bipolar devices, traps associated with contamination and crystal defects in the emitter-base depletion layer cause 1/f noise. These traps capture and release carriers in a random fashion and the time constants associated with the process give rise to a scaling sensitive noise signal that describes a spectral density of the form[17]

$$S_{I_b,1/f} = \left[\frac{\overline{i^2_{1/f}}}{\Delta f}\right] = \left[\frac{K}{A_e}\right]\left[\frac{I_B^a}{f^b}\right] \qquad (7)$$

where

Δf = narrow frequency bandwidth at frequency f
I_B = base current
K = constant for a particular device and technology
A_e = emitter area
a = flicker noise exponent (≅2 for SiGe HBTs)
b = flicker noise frequency shaping factor whose value is approximately unity

The mechanism for up-conversion of 1/f noise is caused by the nonlinear nature of the circuits. The 1/f noise plays an important role in determining the close-in carrier phase noise, which is unconverted to the carrier frequency, resulting in a $1/f^3$ region near the carrier frequency. The SiGe HBTs transistors exhibit typically a 3 to 4 times lower 1/f noise, compared to Si devices.[16]

Oscillator Phase Noise $\mathcal{L}(f_m)$ and Noise Factor F

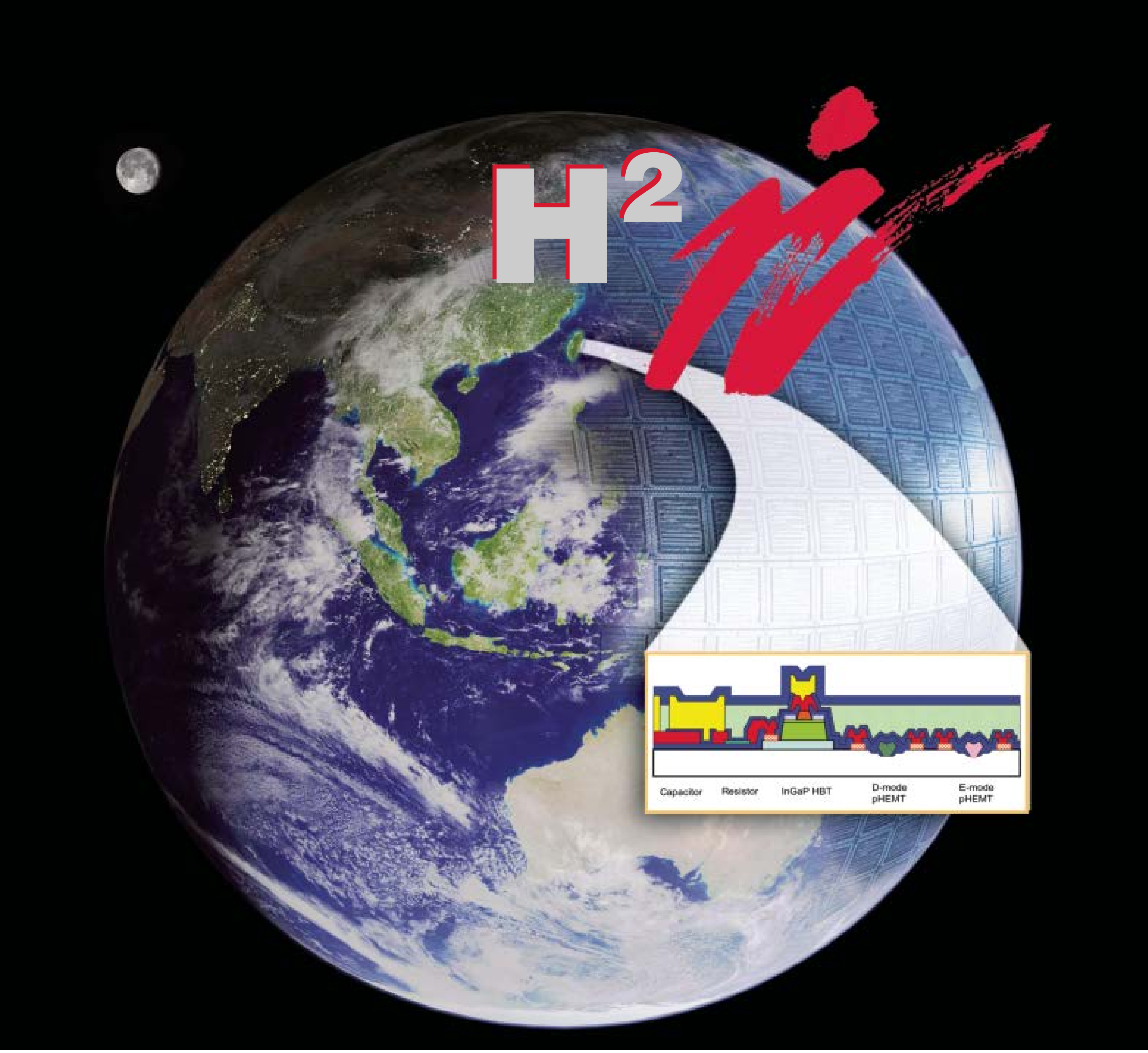
The oscillator phase noise can be given by[3]

$$\mathcal{L}(f_m) = 10\log\left\{\left[1+\frac{f_0^2}{(2f_mQ_0)^2\, m^2(1-m)^2}\right]\left(1+\frac{f_c}{f_m}\right)\frac{FkT}{2P_0} + \frac{2kTRK_0^2}{f_m^2}\right\} \qquad (8)$$

where

m = ratio of the loaded to unloaded Q
Q_0 = unloaded Q
Q_L = loaded Q
f_0 = oscillation frequency
f_c = flicker corner frequency
f_m = offset frequency from the carrier
F = noise factor
K_0 = oscillator voltage gain
R = noise resistance of the tuning diode
k = Boltzman's constant
T = temperature in degree K

From Equation 8, the minimum phase noise can be obtained by minimizing the noise factor F for a given oscillator topology, operating frequency and tuning range. The mini-



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HBT	Ft	30 GHz
HBT	Fmax	110 GHz
HBT	Vceo	21 V
E-PHEMT	Gm	550 mS/mm
E-PHEMT	IDSS	0.02 uA/mm
E-PHEMT	VP	0.35 V
E-PHEMT	Fmin	0.5 dB @3GHz
E-PHEMT	Ft	30 GHz
E-PHEMT	Fmax	90 GHz
D-PHEMT	Gm	330 mS/mm
D-PHEMT	IDSS	230 mA/mm
D-PHEMT	VP	-1.0 V
D-PHEMT	Ron	1.7 Ohms-mm
D-PHEMT	Ft	30 GHz
D-PHEMT	Fmax	80 GHz

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mum noise factor F_{min}, for the circuit shown, can be described by[13–19]

$$F_{min} \cong 1+\frac{n}{\beta}+\sqrt{\frac{2I_C}{V_T}\left(R_b+R_e\right)\left(\frac{f^2}{f_T^2}+\frac{1}{\beta}\right)+\frac{n^2}{\beta}} \quad (9)$$

$$F_{min} \cong 1+\sqrt{\frac{2I_C}{V_T\beta}R_B}$$

for

$$f << \frac{f_T}{\sqrt{\beta}} \quad (10)$$

$$F_{min} \cong 1+f\sqrt{\frac{2}{V_T}R_B\left(\frac{I_C}{f_T^2}\right)}$$

for

$$f >> \frac{f_T}{\sqrt{\beta}} \quad (11)$$

where

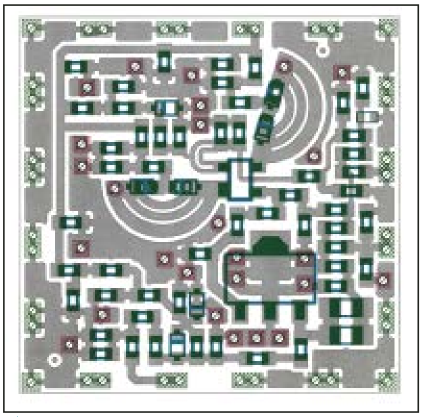
$$V_T = \frac{kT}{q}$$

$$\beta = \frac{I_C}{I_B} > 100$$

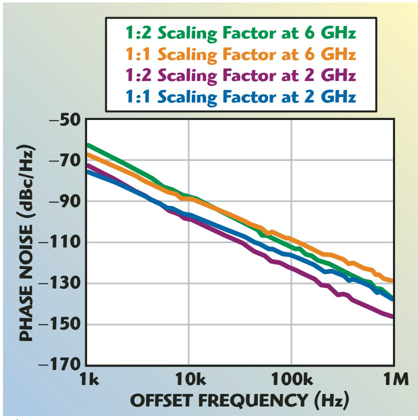
$$R_B > R_E$$

$$n \cong 1$$

From Equation 10, F_{min} at low frequency can be minimized by increasing the value of the current gain β and reducing the values of R_B at a given device bias ($I_C = I_{DC1}$) condition. However, F_{min} at low frequencies can be improved by increasing β, but is limited by the negative impact on the breakdown voltage BV_{CEO}. From Equation 11, at high frequencies, F_{min} can be minimized by decreasing the value of R_B and increasing f_T at a given device bias ($I_C = I_{DC2}$). In SiGe HBTs, the parasitic emitter base junction capacitance C_{be} and the parasitic base resistance R_b vary linearly with emitter width w_e, allowing F_{min} at low and high fre-



▲ *Fig. 3 Layout of the 2 to 6 GHz coupled resonator VCO (patent pending).*



▲ *Fig. 4 Measured phase noise plot of a 2 to 6 GHz VCO for scaling 1:1 and 1:2.*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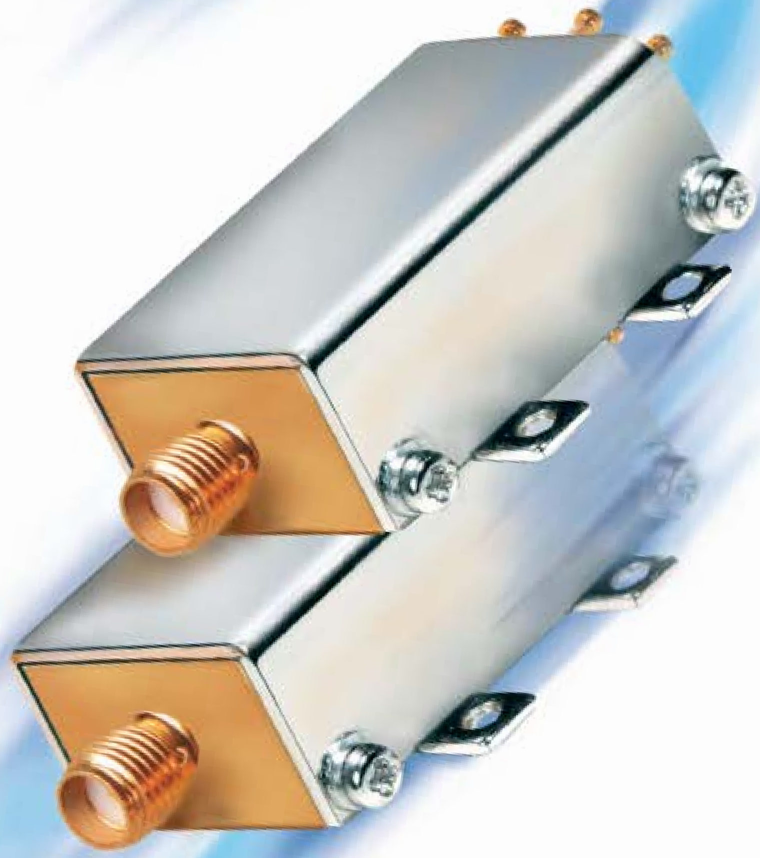

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ZX95-400	200-380	10.0	-104	17	-25	21	39.95
ZX95-535	300-520	6.0	-101	17	-25	21	39.95
ZX95-765	485-765	8.0	-98	16	-35	22	40.95
ZX95-1200W	612-1200	10.0	-96	18	-16	30	49.95
ZX95-1410	850-1410	8.0	-101	11	-17	30	44.95
ZX95-1600W	800-1600	9.0	-99	24	-22	35	44.95
ZX95-1700W	770-1700	9.0	-100	24	-25	35	49.95
ZX95-1900V	1450-1900	8.0	-104	20	-20	25	42.95
ZX95-2150VW	970-2150	4.0	-99	25	-22	26	54.95
ZX95-2500	1600-2500	7.5	-91	14	-17	28	46.95
ZX95-2650	2165-2650	5.0	-101	19	-12	25	43.95

*Phase Noise: SSB at 10 kHz offset, dBc/Hz.

U.S. Patent Number 6,790,049

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VLF-80	DC-80	145	200	VLF-1525	DC-1525	1750	2040
VLF-95	DC-95	165	220	VLF-1575	DC-1575	1875	2175
VLF-105	DC-105	180	250	VLF-1700	DC-1700	2050	2375
VLF-120	DC-120	195	280	VLF-1800	DC-1800	2125	2425
VLF-160+	DC-160	230	330	VLF-2250	DC-2250	2575	2900
VLF-180+	DC-180	270	370	VLF-2500	DC-2500	3075	3675
VLF-190+	DC-190	280	400	VLF-2600	DC-2600	3125	3750
VLF-225	DC-225	350	460	VLF-2750	DC-2750	3150	4000
VLF-320	DC-320	460	560	VLF-2850	DC-2800	3300	4000
VLF-400	DC-400	560	660	VLF-3000	DC-3000	3600	4550
VLF-490	DC-490	650	800	VLF-3800+	DC-3900	4850	6000
VLF-530	DC-530	700	820	VLF-4400+	DC-4400	5290	6700
VLF-575	DC-575	770	900	VLF-5000	DC-5000	5580	6850
VLF-630	DC-630	830	1000	VLF-5500+	DC-5500	6200	7200
VLF-800	DC-800	1075	1275	VLF-5850+	DC-5850	6540	7600
VLF-1000	DC-1000	1300	1550	VLF-6000	DC-6000	6800	8500
VLF-1200	DC-1200	1530	1865	VLF-6400+	DC-6400	7200	8300
VLF-1400	DC-1400	1700	2015	VLF-6700	DC-6700	7600	9300
VLF-1450	DC-1450	1825	2025	VLF-7200+	DC-7200	8150	9500
VLF-1500	DC-1500	1825	2100				

U.S. Patent Numbers 6,790,049 & 6,943,646

High Pass *VHF Models $24.95 ea. (1-9)*

Model	Passband (MHz)	fco, Nom. Loss 3 dB (MHz) Typ.	Stopband Loss >20 dB (MHz) Min.	Model	Passband (MHz)	fco, Nom. Loss 3 dB (MHz) Typ.	Stopband Loss >20 dB (MHz) Min.
VHF-650	710-2490	650	480	VHF-2275	2450-7000	2275	1770
VHF-740	780-2800	740	550	VHF-2700	2650-6500	2500	1800
VHF-880	950-3200	880	640	VHF-2700A+	2900-8700	2700	2150
VHF-1200	1220-4600	1180	940	VHF-3100+	3400-9900	3100	2450
VHF-1300	1400-5000	1300	930	VHF-3500+	3900-9800	3500	2800
VHF-1320	1400-5000	1320	1060	VHF-3800	4250-10000	3800	3200
VHF-1500	1600-5500	1550	1250	VHF-4400+	5000-10100	4400	3500
VHF-1600	1650-5000	1600	1290	VHF-4600+	5000-11000	4600	3800
VHF-1760	1900-5500	1760	1230	VHF-5050+	5500-10000	5050	4200
VHF-1810	1900-4750	1810	1480	VHF-5500	6000-11500	5500	4500
VHF-1910	2000-5200	1910	1400	VHF-7150+	7900-11000	7150	6150
VHF-2000	2260-6250	2000	1530	VHF-8400	9000-13000	8400	6000
VHF-2100	2200-6000	2100	1530				

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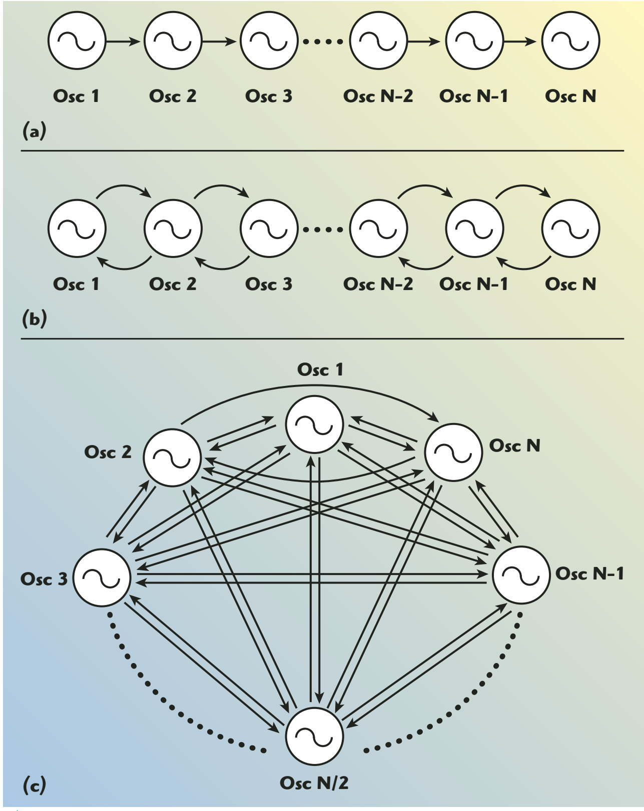
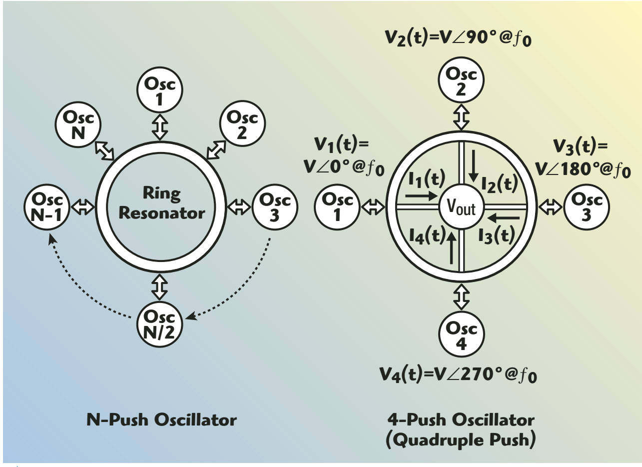


▲ *Fig. 5 Systems of N-push oscillators: (a) nearest neighbor unilateral coupling; (b) nearest neighbor bilateral coupling; and (c) global coupling.*

quency regions to continue scaling down linearly with w_e. The parasitic emitter base junction capacitance C_{be} and the parasitic base resistance R_b decrease proportionally to the emitter strip length L_e, whereas C_{be} and R_b increase proportionally to the emitter width w_e. The noise factor F is a technological scaling sensitive parameter and can be optimized with respect to the transistor geometric profile of the scaled SiGe HBTs to obtain the minimum noise figure for low phase noise oscillator applications.

SCALED DEVICE MULTI-COUPLED RESONATOR VCO (2 TO 6 GHz)

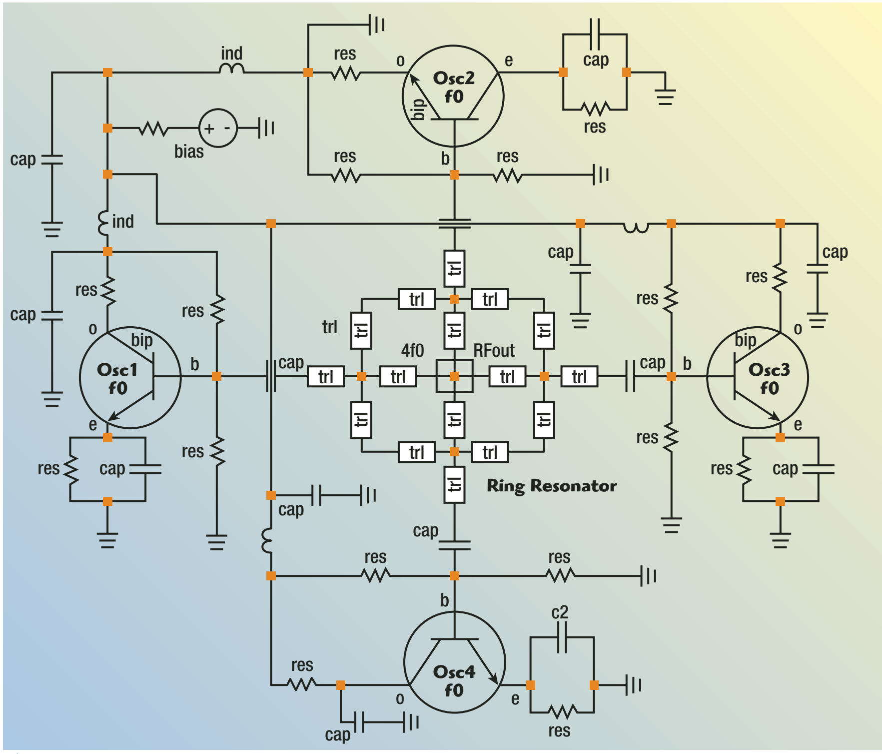
For high frequency applications, vertical scaling is done by reducing the base and collector transit times of the SiGe HBT technology, which requires a narrow and heavily doped base profile, with a higher Ge mole fraction. Therefore, it results in a lower thermal budget, and an increase in 1/f noise.[1] ***Figures 2*** and ***3*** illustrate the schematic and layout of the multi-coupled resonator-based VCO for a 2 to 6 GHz frequency band (patent pending). ***Figure 4*** shows the measured phase noise for scaling factors 1:1 and 1:2. As depicted, the device scaling increases the contribution from 1/f noise



▲ *Fig. 6 N-coupled mode oscillators.*

(near the carrier), whereas it decreases the contribution from base current shot noise and base resistance thermal noise (far from the carrier).

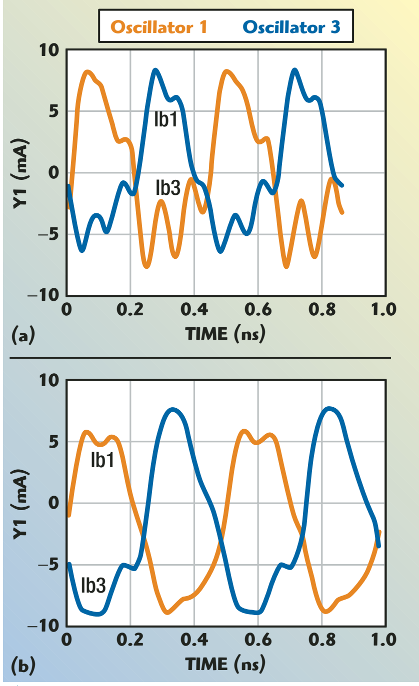
As shown, the degradation at 1 kHz offset from the carrier frequency is 3 to 6 dB, whereas the improvement at a 1 MHz offset frequency is 6 to 12 dB. Therefore, by analyzing the noise behaviors at near and far carrier frequency offsets, due to the device scaling, the designer can improve the noise performance by optimizing the conduction angle for a given size of the device.[2–5] The VCO design approach based on scaling demonstrated in this work enables power-efficient (5 V, 20 mA), extended frequency operation, lower phase noise performance with a minimum 5 dBm power output over the band (2 to 6 GHz), which is attractive for present and future generations of wireless applications.[5]



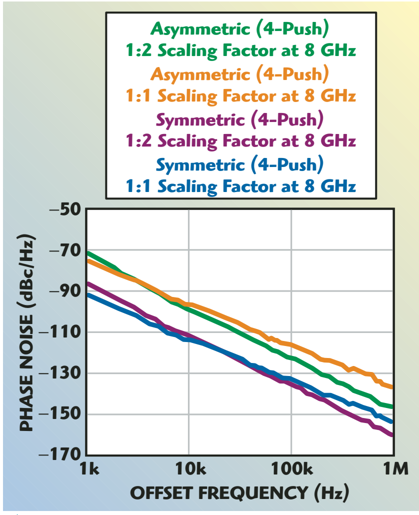
▲ *Fig. 7 Schematic of an N-push (N=4) coupled oscillator.*

COUPLED MODE OSCILLATORS (N-PUSH)

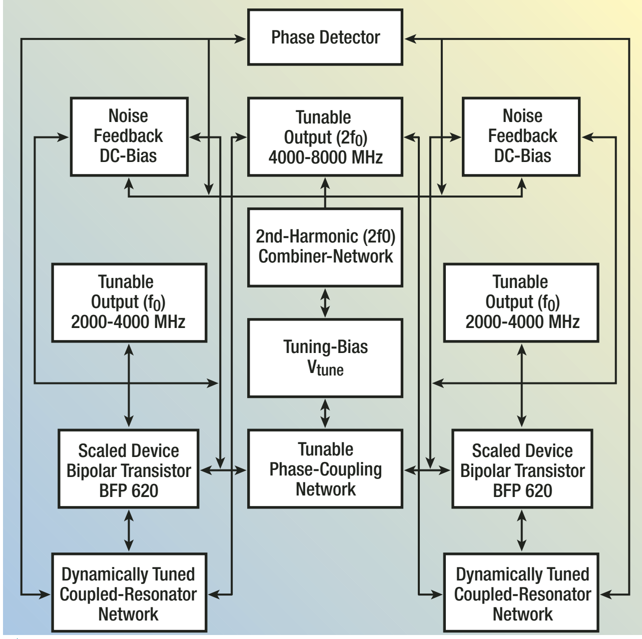
A high frequency oscillator signal can be generated, based on either a scaled device (higher cut-off frequency f_T) operating at a fundamental frequency or using a multiplier (frequency doubler).[2–10] A typical oscillator operating at the fundamental frequency suffers from a low Q factor, insufficient device gain, lower device breakdown voltage and higher phase noise at a high frequency of operation.[3] The frequency doubler and other means of up-conversion may provide a practical and quick solution to generate high frequency signal from oscillators operating at a lower frequency, but it introduces distortions and has poor phase noise performances.[1–24] This limitation has made it more attractive to pursue alternative approaches such as N-Push VCOs, RF-MEMS (radio frequency micro electromechanical system) VCOs, OEO (opto-electronic oscillator), YIG (yttrium-iron-garnet) VCOs and others.[18–21] Recently, an approach based on a coupled oscillator principle in an N-Push (N = 2, 3, 4…k) configuration has brought much attention because this principle allows for an extended operating frequency range of active devices.[7] The coupled oscillator N-Push approach improves the phase noise performance by a factor of N (N is the number of the oscillators sub-circuits), and extends the operating frequency beyond the limitation caused by the cut-off frequency of available active devices. ***Figure 5*** shows the system of N-coupled oscillators coupled through the arbitrary coupling network as unilateral coupling, bilateral coupling and global coupling.[3] The coupled oscillators approach discussed in this work minimizes the phase noise and extends the operat-



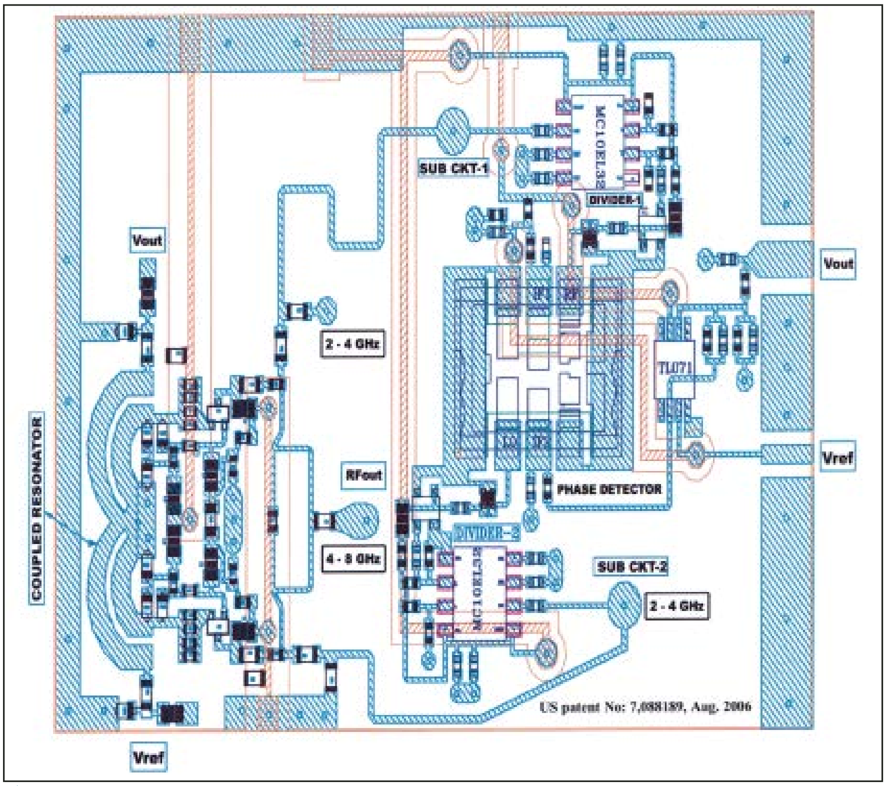
▲ *Fig. 8 Simulated RF output current waveforms of the 4-push VCO; (a) asymmetrical and (b) symmetrical.*



▲ *Fig. 9 Measured phase noise of the coupled 4-push VCO.*



▲ *Fig. 10 Block diagram of a coupled mode 2-push, 2 to 8 GHz VCO (patented).*



▲ *Fig. 11 Layout of a coupled mode 2-push, 2 to 8 GHz VCO (patented).*

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AMF-4D-00100200-40-27P	0.1–2	40	1.5	4	27	2:1/2.3:1	750
AMF-4D-00100800-40-28P	0.1–8	37	1.5	4	28	2:1	800
AMF-2B-02000800-70-27P	2–8	15	1.5	7	27	2:1	560
AMF-3B-02000800-55-27P	2–8	25	1.5	5.5	27	2:1	660
AMF-4B-02000800-45-27P	2–8	36	1.5	4.5	27	2:1	720
AMF-5B-08001800-80-27P	8–18	20	2	8	27	2:1	1200
AMF-6B-08001800-70-27P	8–18	25	2	7	27	2:1	1300
AMF-7B-08001800-60-27P	8–18	30	2	6	27	2:1	1400
AMF-9B-08001800-70-29P	8–18	30	2.5	7	29	2:1	3000
AMF-1B-01000200-40-25P	1–2	10	1	4	25	2:1	250
AMF-2B-01000200-13-25P	1–2	30	1	1.3	25	2:1	300
AMF-3B-01000200-10-25P	1–2	42	1	1	25	2:1	360
AMF-2B-02000400-30-25P	2–4	22	1	3	25	2:1	330
AMF-3B-02000400-15-25P	2–4	35	1	1.5	25	2:1	400
AMF-4B-02000400-13-25P	2–4	47	1	1.3	25	2:1	440
AMF-3B-04000800-25-25P	4–8	25	1	2.5	25	2:1	450
AMF-4B-04000800-15-25P	4–8	36	1	1.5	25	2:1	490
AMF-5B-04000800-15-25P	4–8	47	1	1.5	25	2:1	540
AMF-6B-12001800-45-25P	12–18	33	1.5	4.5	25	2:1	740
AMF-5B-12001800-60-28P	12–18	18	2	6	28	2:1	1600
AMF-6B-12001800-50-28P	12–18	24	2	5	28	2:1	1700
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ing frequency.[5] The drawback of coupled oscillator (N-Push) topology is the presence of higher order nth harmonic components, which may introduce significant 1/f noise up-conversion due to the asymmetrical output waveform in the subsequent N oscillator sub-circuits that forms the N-Push configuration. The expression for the oscillator phase noise can be given by[6]

$$\mathscr{L}(f_m) = \begin{cases} 10\log\left[\left(\frac{C_0^2}{q_{max}^2}\right)\left(\frac{i_n^2/\Delta f}{8f_m^2}\right)\left(\frac{\omega_{1/f}}{f_m}\right)\right] \\ \frac{1}{f^3} \rightarrow \text{region} \\ 10\log\left[10\log\left[\left(\frac{\Gamma_{rms}^2}{q_{max}^2}\right)\left(\frac{i_n^2/\Delta f}{4f_m^2}\right)\right]\right] \\ \frac{1}{f^2} \rightarrow \text{region} \end{cases} \quad (12)$$

$$\Gamma_{rms}^2 = \frac{1}{\pi}\int_0^{2\pi}\left|\Gamma(x)\right|^2 dx = \sum_{n=0}^{\infty} C_n^2 \quad (13)$$

$$\Gamma(x) = \frac{C_0}{2} + \sum_{n=1}^{\infty} C_n \cos(nx + \theta_n)$$

$$x = \omega_0 t \quad (14)$$

$$\omega_{1/f^3} = \omega_{1/f}\left[\frac{C_0^2}{\Gamma_{rms}^2}\right] \quad (15)$$

where

$(i_n^2/\Delta f)$ = noise power spectral density
Δf = noise bandwidth
$\Delta f\Gamma_{rms}^2$ = root mean square value of $\Gamma(x)$, the impulse sensitivity function (ISF)
C_n = Fourier series coefficient
x = $\omega_0 t$
C_0 = 0th order of the ISF (Fourier series coefficient)
θ_n = phase of the nth harmonic
f_m = offset frequency from the carrier
$\omega_{1/f}$ = flicker corner frequency of the device
q_{max} = maximum charge stored across the energy storing capacitor in the resonator

From Equation 15, the 1/f noise up-conversion is closely related to the symmetry property of the oscillator signal waveforms, and the 1/f noise up-conversion can be reduced by minimizing the value of C_0 and by optimizing the slope and symmetry of the rise and fall time of the oscillator output waveform.

The phase noise of the N-coupled oscillator in terms of a single uncoupled oscillator can be described by[8]

$$\left|\mathscr{L}_{total}(f_m)\right|^2_{N-Coupled} = \frac{1}{N^2}\left|\mathscr{L}_i(f_m)\right|^2_{Uncoupled}$$
$$i = 1,2,3,4\ldots N \quad (16)$$

From Equation 16, the N-coupled oscillator system improves the phase noise, compared to the single individual uncoupled oscillator, by a factor N, where N is the number of the uncoupled oscillators in the coupled N-Push topology.[5–8]

SCALED DEVICE COUPLED MODE 4-PUSH OSCILLATORS

Figure 6 shows typical simplified N-coupled oscillators, coupled

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MMP7076	200	0.7	3	0.8
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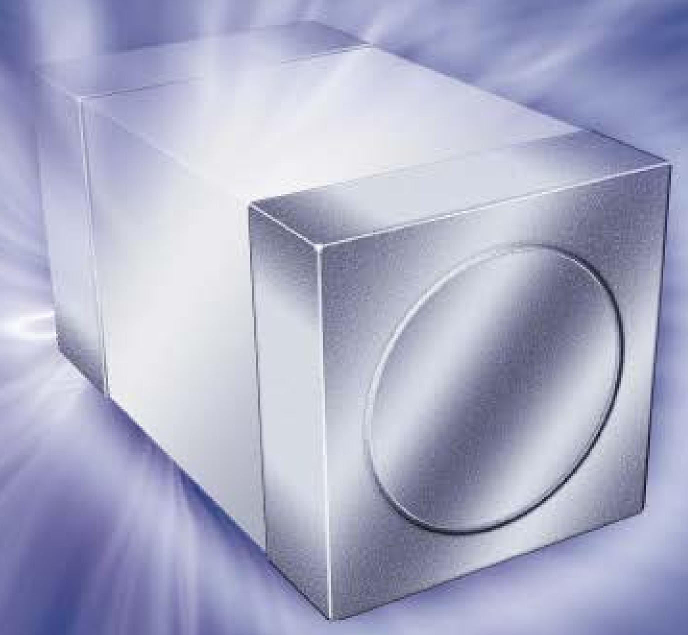

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through a common resonator and an example of a 4-Push oscillator. ***Figure 7*** shows the schematic of the 4-Push coupled oscillators operating at a fixed frequency of 8 GHz ($4f_0$). ***Figure 8*** depicts the simulated plot of the symmetrical and asymmetrical output waveforms for the N-Push (N = 4) VCO, using scaled SiGe HBTs (Infineon BFP620, scaling 1:2). For better insight about the coupled mode N-Push domain, it is necessary to know how the noise is affected by the scaling and symmetry of the waveforms. From Equations 15 and 16, the noise performance and 1/f noise up-conversion can be optimized by improving the symmetry of the waveform in N-Push topology for a given size of the device. ***Figure 9*** shows the improvement in phase noise performance for a scaled coupled mode 4-Push VCO. At 1 kHz offset, it is of the order of 6 to 10 dB, whereas at 1 MHz offset the improvement is of the order of 8 to 15 dB for a device area scaling factor of 1:2. ***Figures 10*** and ***11*** show the block diagram and layout of the scaled device coupled mode multi-octave band 2-Push VCO (2 to 8 GHz). The novel approach allows for a substantial reduction in phase noise by dynamically minimizing the phase error and noise impedance transfer function of the planar-coupled oscillators network over the operating frequency band.[7] The typical measured phase noise is better than –90 dBc/Hz at a 10 kHz offset from the carrier.[3] Competing other alternative semiconductor technologies may not deliver the same level performance in terms of cost, size, power, linearity, tunability, adaptability, reconfigurability and integrability for this class of VCOs using scaled devices.

CONCLUSION

The multi-octave band design approach based on device scaling and optimum symmetry of the signal waveforms demonstrated in this work enables wide tuning, extended frequency of operation and lower phase noise performance, which are attractive for present industry applications. ■

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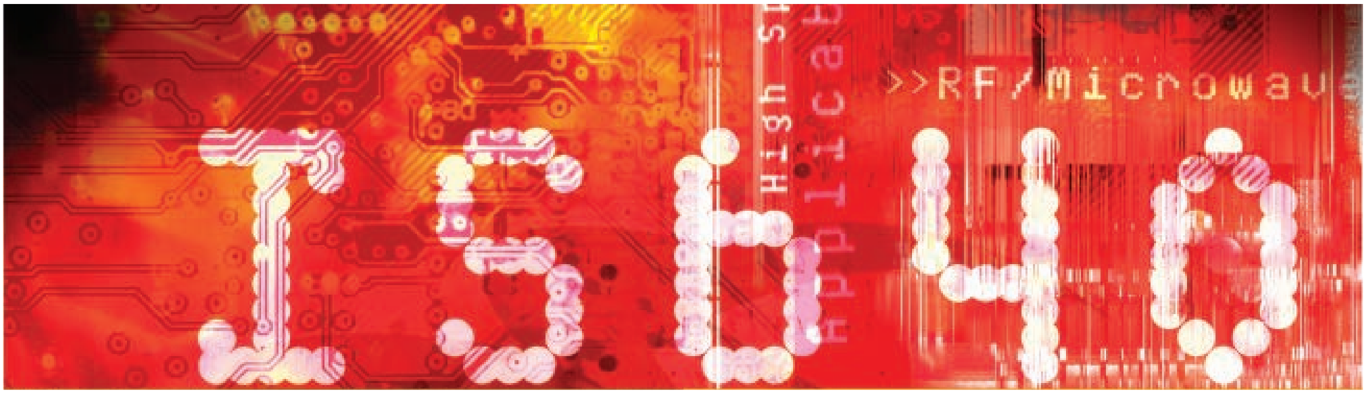

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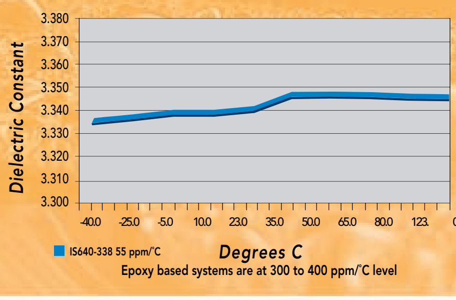
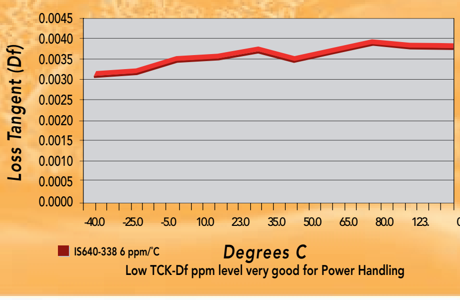
- IS640-320 = Dk 3.20, Df 0.0032
- IS640-300 = Dk 3.00, Df 0.0032
- IS640-280 = Dk 2.80, Df 0.0025

PREPREG DATA

Glass Style	Thickness	Dk 2, 5 and 10 GHz	Df 2, 5 and 10 GHz
106	0.0030"	2.80	0.0028
1080	0.0040"	2.90	0.0031
2113	0.0042"	3.29	0.0036
3070	0.0048"	3.29	0.0035
2116	0.0054"	3.26	0.0035
1652	0.0060"	3.46	0.0038
7628	0.0066"	3.49	0.0038





The data, while believed to be accurate and based on analytical methods considered to be reliable, is for information purposes only. Any sales of these materials will be governed by the terms and conditions of the agreement under which they are sold.

* Isola utilizes the IPC-TM650-2.5.5.5 Stripline Resonator to test material with thickness of 0.030 and above as a means of determining a nominal value for dielectric constant and loss tangent test frequency is set at 10 GHz. Please note that for laminate dielectric thickness below .030 the test method that is utilized to determine the Dk and Df values is referred to as the Bereskin Stripline Resonator method. The Bereskin Stripline Resonator test method lends itself to the test and measurement of Dk and Df values of thinner dielectric laminate materials as those that would fall below .030. In the event we are requested to test the Dk and Df of a dielectric laminate that is below .030 per the IPC-TM650-2.5.5.5 test method we would employ a buildingblock stack method to construct the test specimens in order to arrive at a laminate dielectric thickness that would be sufficient for the test to be conducted accurately. The effect of air gaps between the dielectric test specimens would then be back calculated out of the equation to provide for a more accurate result. Departures from these test methods and/or frequency may produce different values. Isola ensures the consistency and repeatability of the property sets in the product that we produce, however we encourage prospective users to conduct a thorough evaluation with appropriate modeling software during the design process to determine the value sets that are best suited for his/her application.

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SMART DESIGN PRACTICES ADDRESS EMI/EMC CHALLENGES

To produce more circuit functionality, leading-edge designs rely on high-speed devices, using the latest IC process nodes and advanced package technologies. As the complexity of these electronic products intensifies, constraining EM emissions within dense printed circuit boards (PCB), IC packages and even the IC itself requires careful engineering. With package pin counts in excess of 5000 and ever-smaller pitch spacing compressed into shrinking board space, the potential for electromagnetic interference is greatly increased. To meet both manufacturer's specifications and engineers' requirements for signal integrity, cross-talk and EMI compliance, designers must be able to identify and constrain critical high-speed signals at all stages of the design process.

With space and functionality at a premium, engineers may be forced to reduce or eliminate enclosure-level shielding vis-à-vis enhanced circuit segregation and noise suppression. At the same time, improving time-to-market and compliance costs will require a reduction in the number of design iterations. Achieving these goals requires the application of design best practices, EM/circuit co-simulation and early EMI/EMC test verification. By treating EMC as a design issue rather than a test and measurement issue, design teams will ultimately save development time. This article examines the challenges associated with EMC performance and some of the design rules being implemented.

ADDRESSING EMC AT THE EARLY PLANNING STAGES

Electromagnetic waves, conduction and inductive/capacitive coupling are all sources of EMI. Excessive emissions leading to EMC failure can be related to poor component shielding, enclosure design and/or cabling, which can couple energy from inside the system to the outside world. A harmonic signal

DAVID VYE
Microwave Journal

from a seemingly harmless low-amplitude clock may be at the right frequency to excite a resonance within a module or housing, resulting in elevated currents that will radiate through an aperture (dimension dependent) or cable. System-level EMC design must therefore adequately model the chassis, any venting/seams and cabling in addition to the PCB.

Designing for EMC at the system level should initially focus on defining and segregating functional blocks into high-speed, noisy, aggressor circuits, and sensitive, quiet, victim circuits. The likelihood of a circuit node being aggressive depends on its maximum dV/dt and/or dI/dt. The likelihood of a circuit node being a victim of EM phenomena depends on its signal levels and noise margins. Noisy components include clock generators, micro-controllers, switch-mode power transistors, rectifiers, heatsinks, etc. These noisy components should be somewhat isolated from sensitive ones such as analog ICs. Since EMI must reach the conductors in order to disturb the components, any conducting loops, long length and large surface areas are vulnerable to EMI. This vulnerability makes the PCB itself a leading target for EMC improvements. Decreasing noise source emissions, weakening the capacity of noise carriers and increasing the immunity to EMI in the most susceptible areas of the PCB are among the most effective ways to improve EMC performance.

Some common practices for improving EMC performance on the PCB include:

1. Placement of decoupling capacitors between power and ground on packages and printed circuits boards where voltage fluctuations are determined to exist. Multiple caps should be used in parallel depending on the frequency of the IC in consideration. Capacitors should be selected based on its self-resonant frequency (SRF).
2. Use of ferrites for decoupling power planes from power pins.
3. Power planes should be backed off from the edge of the board.
4. Adequate termination of all high-frequency clock lines.
5. Connectors need to be properly filtered.
6. Use of stitching vias at the board edges.
7. Tightly coupled forward and return path currents for critical nets.

To address EMC issues, PCB floor planning begins with a focus on circuit segregation followed by consideration for any shielding and filtering techniques that will need to be physically implemented. Layout of the mechanical assembly and physical component placement should come early in the product development lifecycle. As the density of electrical components increases and switching speeds move into the gigahertz range, tried and true techniques are less likely to be successful. Design teams may find it is faster to investigate the electrical behavior of individual structures at the new higher frequencies and establish a set of acceptable geometric guidelines for interconnects then troubleshoot a fully assembled yet non-compliant system.

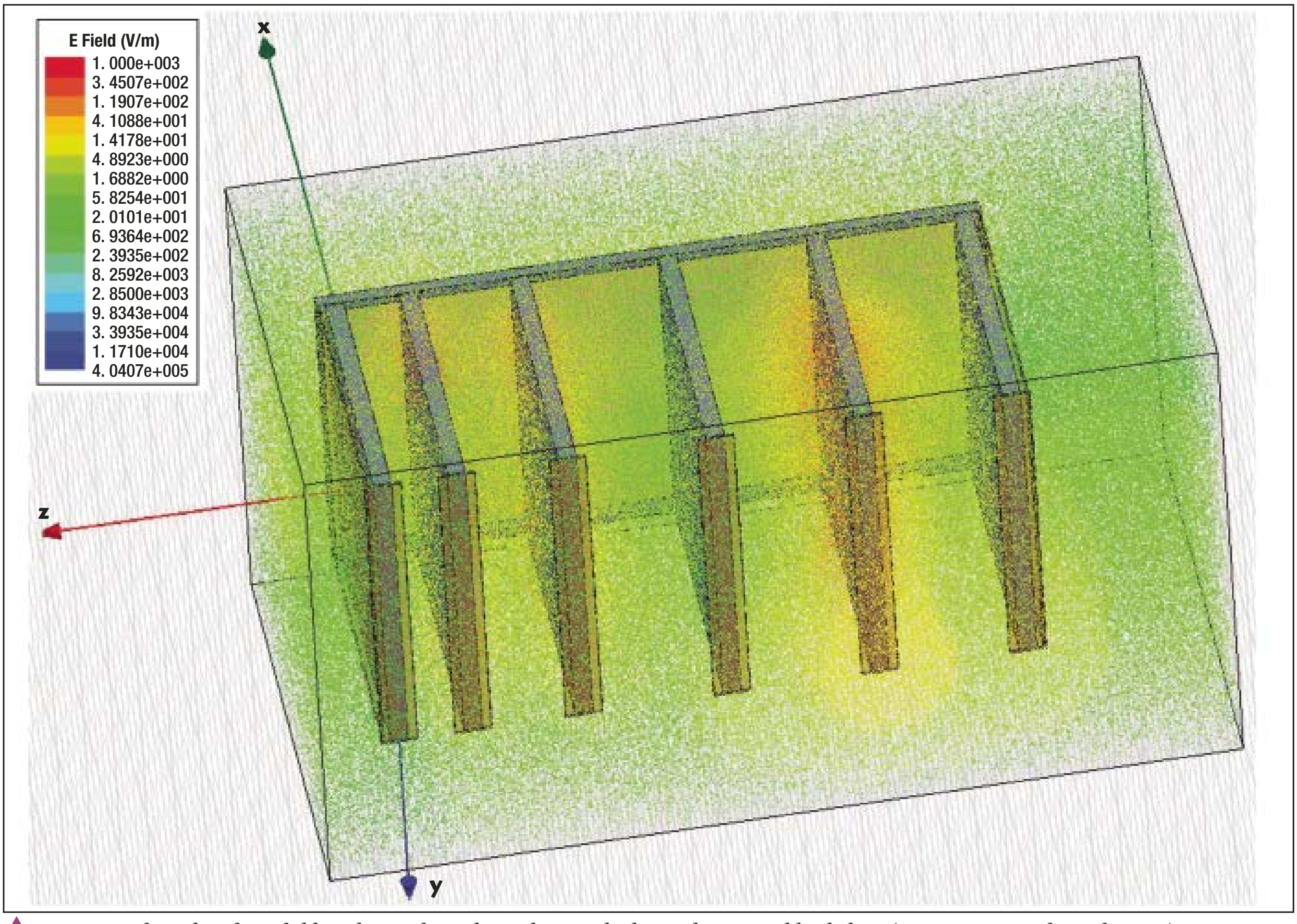

Fig. 1 3D "fog" plot of EM fields radiating from chassis housing high-speed PCBs and backplane (image courtesy of Ansoft Corp.).

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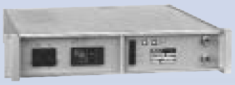

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Component-to-component interaction will still necessitate system-level testing and/or simulation. Since design layouts are generated using two-dimensional CAD, it is not uncommon to inadvertently create a final assembly with a very sensitive circuit in close proximity to a noisy circuit. The resulting signal quality problems may lead to EMC failure. To avoid troublesome EMI issues design teams should apply three-dimensional EM analysis to proposed final assembly drawings in order to verify proper behavior.

PCB MATERIALS

Relative to epoxy-glass substrates such as FR4, homogeneous substrates including teflon, pure polymers and liquid crystal polymer (LCP) generally offer a lower dielectric constant (k) and loss tangent. The lower k leads to a higher propagation velocity, while the lower losses benefit the transmission of high frequency signals over longer distances.

Low-k substrates can be employed to benefit EMC. Higher impedance transmission lines lower the currents flowing in them, thereby reducing their emissions. Higher impedance lines are created from thinner traces, which for thin substrate layers may require a trace width too small for low-cost manufacture. Lower-k dielectrics use wider traces for the same characteristic impedance, making it easier or less costly to use higher impedance transmission lines, thus reducing currents and lowering emissions. Of course, proper impedance matching between components is required to minimize standing waves.

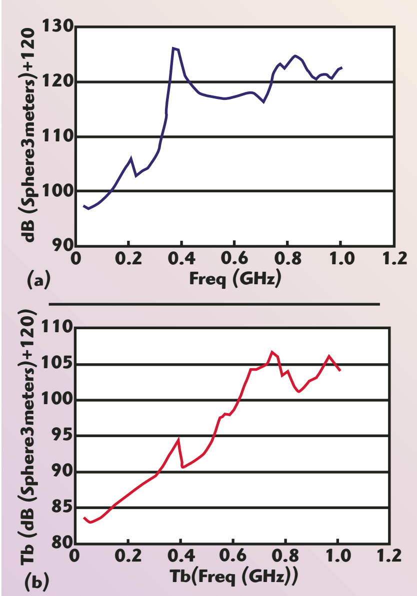
The use of low-k substrates has been commonplace in microwave applications such as satellite communications. As signal speeds increase, the EMC benefits of using low-k substrates would seem to favor their use in more mainstream PCBs, particularly PC motherboards and cellphones. However, many RF engineers have been able to devise designs that allow the continued use of low-cost FR4 and similar materials. When signals are 10Gb/s or more, traces on glass-fibre substrates like FR4 that exceed 600mm in length will have serious signal integrity and/or EMC difficulties.[1]

PCB DESIGN CONSIDERATIONS

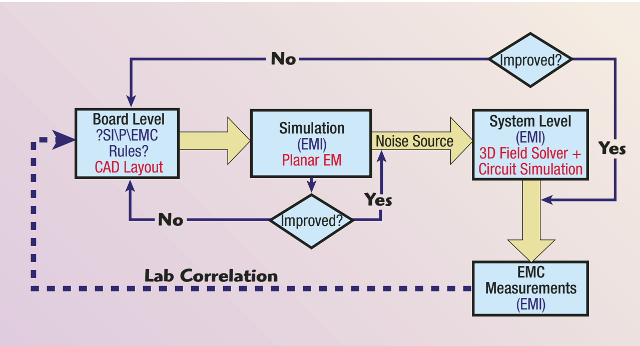
Some of the specific areas of PCB design that ultimately improve the overall EMC performance of the PCB include:

1. Reduction of inter-layer noise.
2. Optimization of the impedance between power and ground reference planes.
3. Minimization of transmission line cross-talk and reflections.
4. Improvements to the simultaneous switching output (SSO) response.
5. Alleviation of edge radiation.

Controlling the EM environment for a single PCB is easier than addressing the EM compatibility between



▲ *Fig. 2 Plots of simulated radiation fields at 3 meters (unshielded) for the original PCB (a) and modified for improved EMC (b).*



▲ *Fig. 3 Design flow for EMC compliance.*

multiple PCBs interconnected by wires and cables. The preferred, cost-effective way to meet EMC requirements is to use a single multi-layer PCB with separate layers dedicated to the ground and other layers for the power supply, resulting in good decoupling and shielding effects. When economical requirements prohibit the use of this type of board it becomes even more critical to pay special attention to the quality of the high-speed interconnect structures as well as the construction and location of the ground and power supply planes.[2]

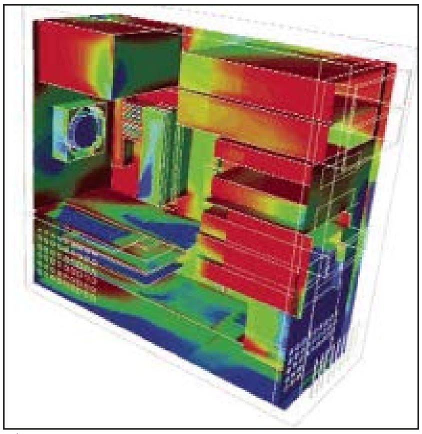
It is a common practice to include individual distribution of a 0 V reference plane to every block with a single point for gathering all returns. Loops should be avoided wherever possible or should at least have a minimum surface area. Because supply loops can act as an antenna, both emitting and receiving EMI, the power supply should be implemented close to the ground line and its surface area minimized. The location of power planes should be optimized and backed off from the edge of the board to reduce edge coupling. Filling all component-free surfaces of the PCB with additional grounding is a commonly used way to create additional shielding. As a safeguard, designers should apply EM simulation to these structures and look for unexpected resonances before physical prototypes are manufactured.

The noise between the power and ground planes of the structure is known as interlayer noise. It is possible to simulate this noise by exciting the region between the planes with a Gaussian source or pulse. The pulse propagates from the source location to the edge of the board and is reflected. Over a period of time, the peak noise or voltage at each location between power and ground can be plotted and visualized. It is possible to see, for example, that the voltage is markedly lower where decoupling caps or shorting vias are located.

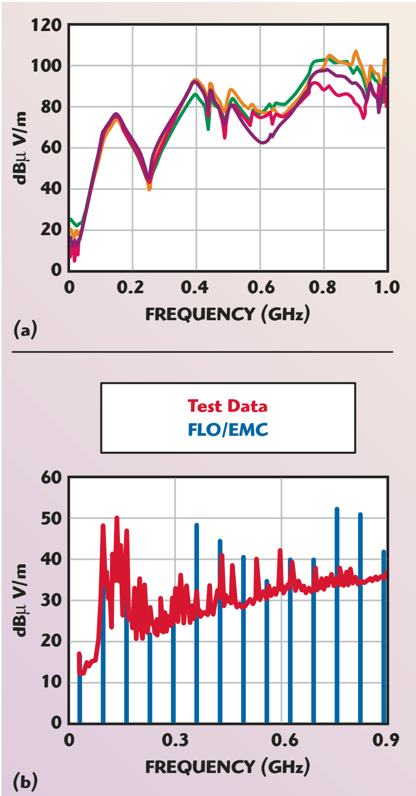
All PCB connectors carrying power and ground should use adjacent pins. For long connectors, a number of power/ground pin pairs should be spread along its whole length. For wide connectors, the power/ground pin pairs should be spread across the entire area, space permitting. Ideally there should be a power/ground pair adjacent to each signal pin or at least adjacent to critical interconnects carrying Gb/s signals. The use of differential pairs for high-speed channels relaxes this constraint to one power/ground pair for every two or more signals.[3]

PCBS AND SYSTEM-LEVEL EMC DESIGN

The worldwide printed circuit board market is driven by applica-



▲ *Fig. 4 Field visualization of a PC chassis including internal components and PCBs (image courtesy of Flomerics).*



▲ *Fig. 5 PC emissions versus frequency at 3 m front, rear, right and left side of PC chassis (a) and measured and simulated impulse spectrum and corresponding digital spectrum at 3 m from PC chassis (b) (image courtesy of Flomerics).*

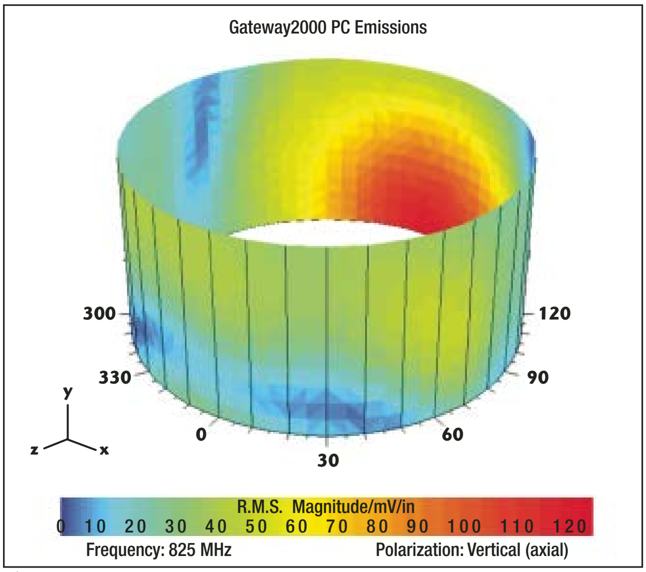
tions of wireless, communications and computing. Modern PCBs include mixed-signal functions with RF, digital, data conversion and high-performance digital signal processing (DSP). It is critical to be able to design such complex boards while maintaining signal integrity, power integrity and EMI/EMC performance. New simulation tools make it possible to combine board-level electromagnetic simulation with advanced circuit simulation to accurately predict PCB performance. Currents and voltages resulting from circuit-level simulations can then be applied within a full 3D EM field solver to predict EMC radiated emissions.

In an ADSL modem, for instance, there are challenges of the complexity of the mixed-signal design combined with the requirements for successful EMC compliance. The electromagnetic simulator from Ansoft called Siwave™ can read standard Cadence and Mentor board files and then compute full-wave fields, S-parameters and radiation. Using such a tool allows engineers the ability to locate and modify radiation sources. By coupling to a nonlinear circuit simulator, true nonlinear models for sources and loads on various circuit nodes can be computed. Frequency-dependent IBIS and SPICE circuits couple with the S-parameters to provide an accurate representation of the frequency-dependent voltages and currents within the PCB. Sources such as power and ground planes, clock traces, data traces and memory interfaces commonly produce electromagnetic radiation. Radiation from these sources can be computed in the near-field, at three meters, and in the far-field.

The above outlined procedure was followed to predict radiation emanating from an ADSL modem PCB. The initial design of that modem board provided excellent performance; however, an expensive shielding box over critical components was required to meet EMC compliance. The goal of this work was to redesign the PCB so that the shield was no longer necessary.

Seven such modem PCBs were then placed on a backplane chassis for evaluation in a true 3D environment. A model in the 3D full-wave solver (in this case Ansoft's HFSS™) uses the SIwave circuit plus board-level simulation results as the source for secondary radiation computation in HFSS. Invoking the equivalence principle,[4] electromagnetic fields computed by SIwave are placed on surfaces surrounding the individual PCBs in the HFSS model. HFSS then computes 3D radiated fields for the entire system containing the seven ADSL modem boards plus backplane chassis.

Figure 1 shows a plot of the electric near-fields surrounding the PCBs in a 3D "fog" plot. The density and color of the fog is mapped to the intensity of the electric field. Various hot spots between PCBs can be identified easily by observing this field plot.

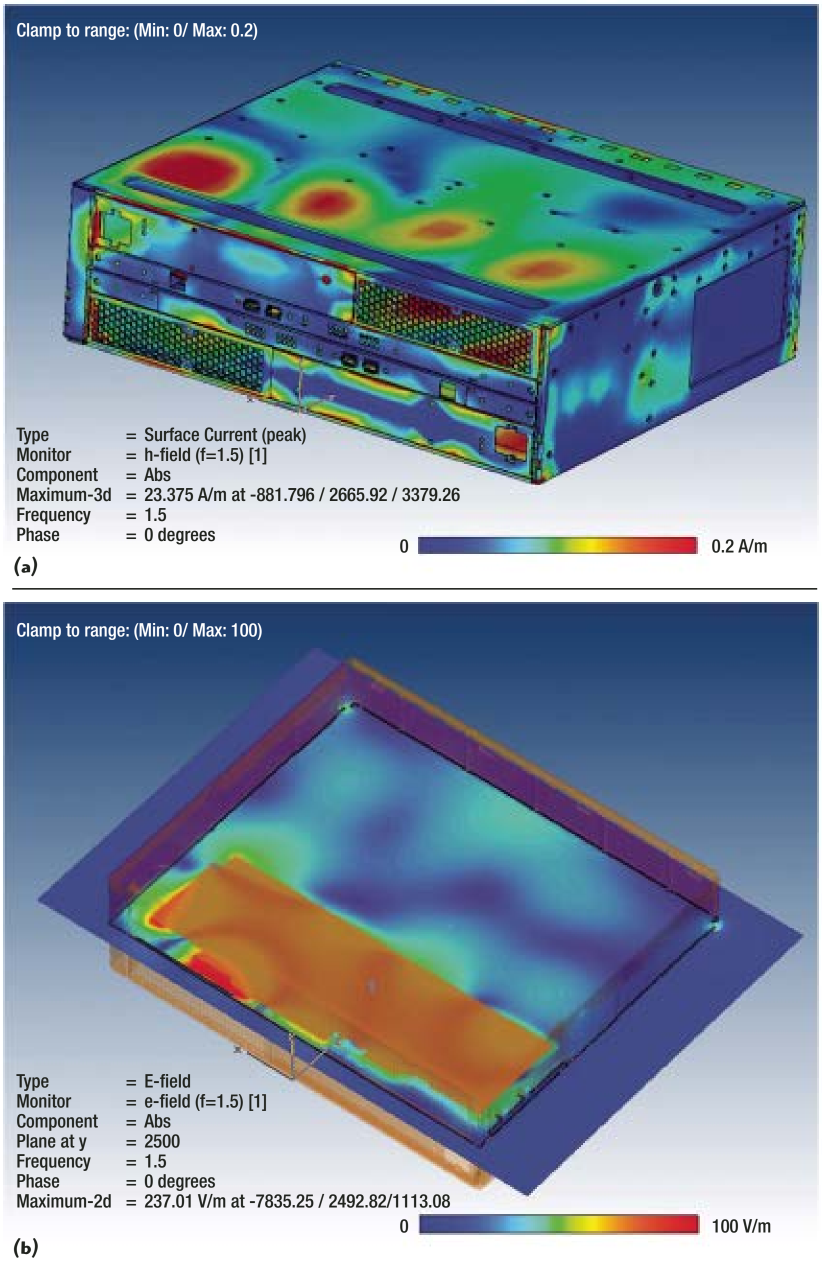


▲ *Fig. 6 Cylindrical scan around the PC at 825 MHz (image courtesy of Flomerics).*

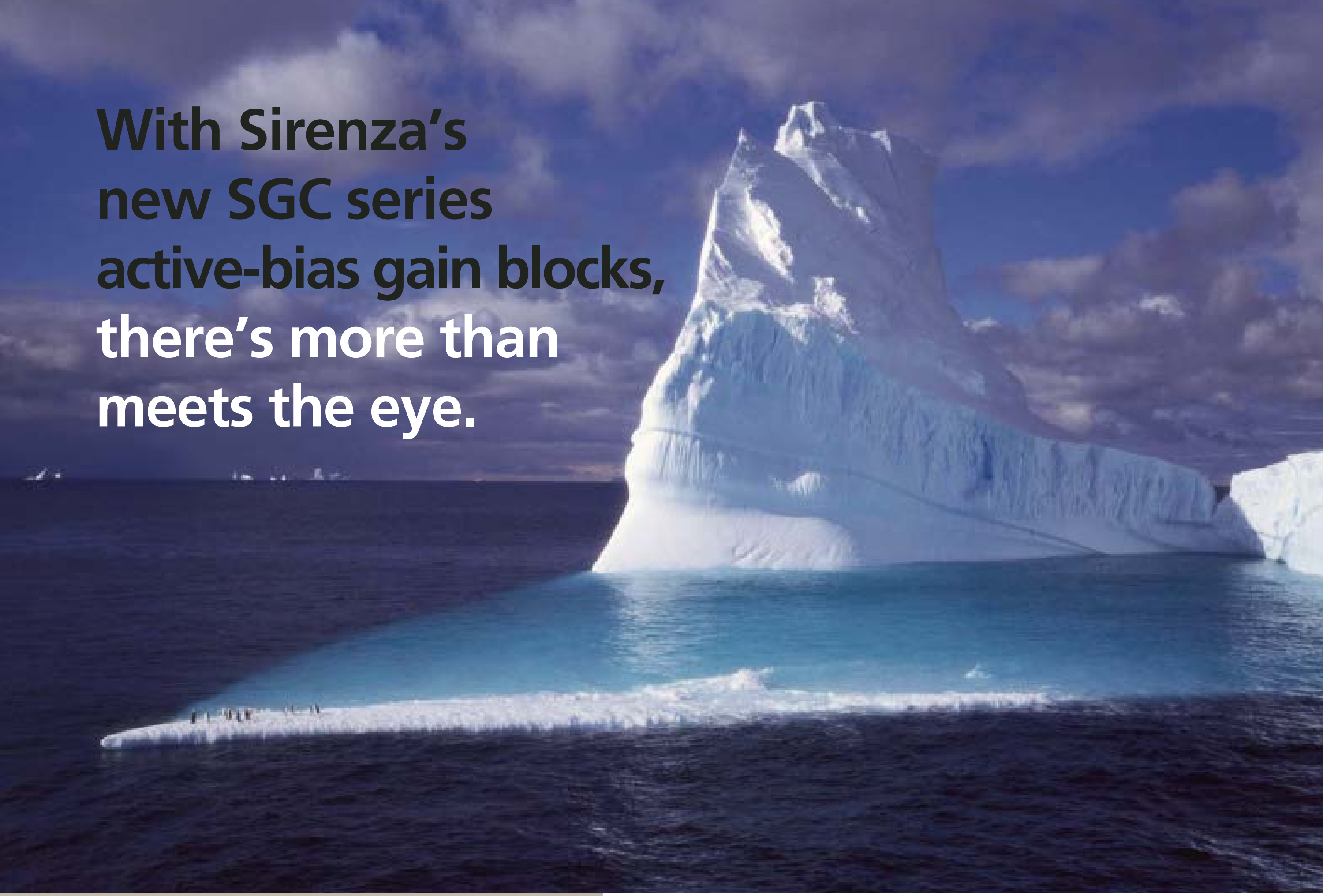
Figure 2a is a plot of the radiated fields at three meters versus frequency for the initial PCBs without the shield. A maximum radiation of 126 dB microvolts/meter occurs near 375 MHz. ***Figure 2b*** is a similar plot; however, design modifications to the PCBs, including impedance control, power/ground plane decoupling for power integrity and certain trace re-routing were included in a new design. As can

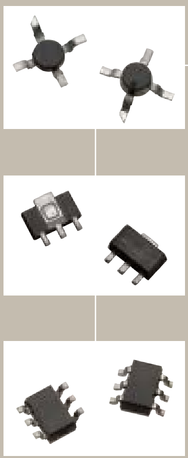
be seen in the figure, the radiation at all frequencies was reduced dramatically. Near 375 MHz, the new design produced 94.5 dB microvolts/meter, a reduction of over 31 dB. Maximum radiation of 106.5 dB microvolts/meter was pushed up to the higher 750 MHz frequency.[5]

Figure 3 summarizes a design flow based on coupled 3D electromagnetic plus circuit simulation and design for EMC compliance. Individual board-level simulations are performed using the 3D planar tool. Design rules can be developed so that engineers can design with EMC compliance in mind. Modifications to the layout design for signal integrity, power integrity and trace routing are made and simulations allow engineers to understand the effect on EMC. Results from individual board simulations become the noise source for simulations of full 3D system simulations of boards placed in a backplane and chassis. Redesign at all levels can be performed prior to PCB fabrication. Finally, verification of the final design can be made for EMC by lab measurements.



▲ *Fig. 7 Surface current distribution on a metallic enclosure used for telecommunication equipment due to a PCB located inside; (a) enclosure and (b) board (image courtesy of CST).*





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SHIELDS AND MODULE ENCLOSURES

Shielding, filtering and isolation techniques may be required to reduce the radiated and/or conducted EMI across segregated areas of the design down to acceptable levels. Selecting the most cost-effective methods for shielding each interface will depend on the given operational EM environment, the emissions/immunity characteristics of the circuits concerned, and the cost and size requirements. Connections to the outside world may need the full range of suppression techniques, including shielding, filters, isolating transformers and electrostatic discharge (ESD). Shielding may be applied to chips or areas of the PCB, the whole PCB, subassemblies of PCBs, entire assemblies of PCBs or the entire product.[6] Since radiation leakage from the PCB will almost always be minimized using shielding, the coupling between the PCB and the shield should be examined using 3D analysis.

Microwave absorbent material can be used to effectively dampen undesired cavity resonances by attenuating or absorbing high frequency energy. Microwave absorbers designed for damping cavity resonance are most often made from high-permeability materials with broad frequency magnetic loss (permeability) properties. They are usually available in thin elastomer sheets ranging in thickness from 0.010 inch (0.25 mm) to 0.040 inch (1.02 mm) that can be cut and formed to fit the conductive inside surface of the enclosure.

It is nearly impossible to eradicate all electromagnetic fields in the board design. Connections to the board and wires carrying RF currents in and out of the system will have electromagnetic fields associated with them. The conducted RF currents carrying the so-called "common mode" currents are often the most significant contributors to the electromagnetic emissions. Additional consideration should be paid to the shield or enclosure itself. If the wavelength is similar to the dimensions of any vents, seams or slot apertures, resonance will occur and electromagnetic fields will be efficiently radiated out. Shielding that relies on contact between extended surfaces is especially prone to EMI problems due to the formation of gaps. Intentionally designing irregularly spaced gaps into the shielding will minimize this problem and avoid the creation of a periodic resonating structure.

ANALYZING ENCLOSURES, SEAMS AND VENTS

Thorough analysis of the radiation from the PCB to other components in a system and the requirements/effectiveness of an enclosure or shield will require either a dedicated measurement system or 3D simulation tools such as MicroStripes from Flomerics, Microwave Studio from CST or HFSS from Ansoft. At the system level, today's 3D solvers use detailed internal structures to accurately capture the system resonances. Visualization of fields, currents and radiation patterns allows problem frequencies and emission sources to be readily found, including important details concerning the effects of seams, gaskets, cables and filtering on EMC. For example, MicroStripes and measurements were used in the analysis of a PC chassis (see ***Figure 4***). At the circuit board level, MicroStripes analyzed the field and current distributions within a module in order to identify EMI 'hot-spots' and resonances as well as the effects of component placement on related emissions and immunity. These studies can also be extended to cables and wires to investigate cable routing and filtering.

In the full system-level PC model, the electric and magnetic fields were sampled both inside the enclosure and at points 3 m away. The radiated electric field at 3 m in front, behind and to the sides of the PC displayed in ***Figure 5*** shows radiation peaks at 133, 390, 825 and 900 MHz. This impulse spectrum reveals the continuous broadband response of the PC. The actual PC generates discrete frequencies based on the fundamental clock frequency and its harmonics as shown. To validate the viability of this analysis, the specifications of this older, relatively slow processor were determined to be a 66 MHz bus clock and 0.15 to 1.5 ns rise/fall times based on the manufacturer's development guide. Near-field probing and visual inspection of the crystals revealed fundamental clock frequencies at 20, 24.3 and 33 MHz. The

simulation plot in figure 5b was obtained by multiplying the MicroStripes impulse spectrum by the spectrum of a 33 MHz clock with a 1ns rise/fall time. The numerical results are compared with the test data taken in an anechoic chamber performed by Curtis-Strauss Compliance laboratories.

Notice that the system is virtually within FCC Class B limits, even with the reset wire unshielded. In the MicroStripes simulation the chassis seam was treated as worst case or completely open exaggerating the emissions above 700 MHz. The EMC analysis also provides a cylindrical scan around the system on a 3M radius, mimicking the FCC EMC test configuration. The high radiation behind the PC, shown in ***Figure 6***, indicates that the radiation is vertically polarized, suggesting that the seams are responsible.[7]

An alternative time domain 3D EM simulator, Microwave Studio (MWS)

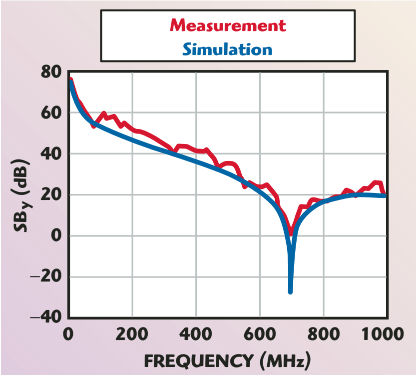

Fig. 8 SE evaluated by means of CST Microwave Studio (red curve) and comparison with measured/computed data.

from CST, can also be used for EMC/EMI analysis. The MWS software is based on a finite integration technique (FIT) solver, which provides direct transient analysis of typical interference signals from periodic and nonperiodic pulses, electrostatic discharge (ESD), lightning and nuclear electromagnetic pulse (LEMP, NEMP). Time domain EM simulators are well-suited for electrically large models and large bandwidth models wherein a single simulation excites a broad range of frequencies in the time domain.[7] The hexahedral mesh in conjunction with the perfect boundary approximation (PBA) and thin sheet technique (TST) avoids the use of a very fine mesh to accurately model slots and gaps located on the enclosure (see ***Figure 7***). Similar to the frequency domain code, MWS can be used by engineers to study an enclosure's shielding effectiveness (SE) by monitoring the field strengths inside an enclosure with respect to an external plane wave illumination (EMC) or the field strength outside an enclosure with respect to a radiating source inside the enclosure (EMI).[9]

For example, ***Figure 8*** illustrates the SE evaluated by means of CST Microwave Studio for a rectangular box of size (30 × 12 × 30 centimeters) with a rectangular aperture of size (10 × 0.5) located at the center of the frontal wall. Excellent agreement can be observed when comparing the computed data with measured results as well as with other numerical techniques.

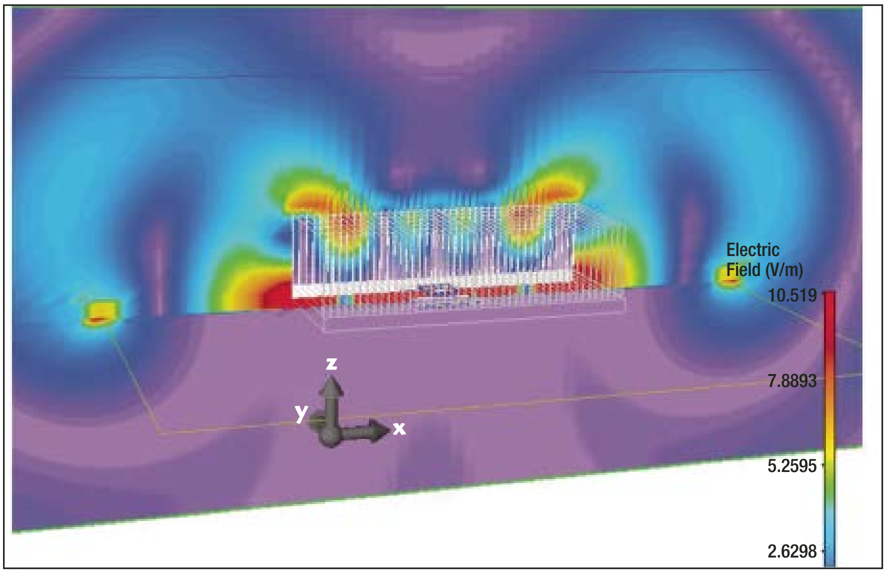

Fig. 9 Near-field (E) emission from a 4.5" × 1" metal heatsink mounted against an EM source (image courtesy of Flomeries).

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HFCN-1300+	1400-5000	930	1.99		•
HFCN-1320+	1400-5000	1060	1.99		•
HFCN-1500+	1600-5500	1250	1.99	•	
HFCN-1600+	1650-5000	1290	1.99		•
HFCN-1760+	1900-5500	1230	1.99	•	
HFCN-1810+	1950-4750	1480	1.99		•
HFCN-1910+	2000-5200	1400	1.99		•
HFCN-2000+	2260-6250	1530	1.99	•	
HFCN-2100+	2200-6000	1530	1.99		•
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▲HFCN-4400+	5000-10100	3500	2.99		
▲HFCN-4600+	5000-11000	3800	2.99		
▲HFCN-5050+	5500-10000	4200	2.99		•
▲HFCN-5500+	6000-11500	4500	2.99		
▲HFCN-7150+	7900-11000	6150	2.99		
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LFCN-80+	DC-80	200	3.99			•		
LFCN-95+	DC-95	230	3.99			•		
LFCN-105+	DC-105	250	3.99			•		
LFCN-120+	DC-120	280	3.99			•		
LFCN-160+	DC-160	330	2.99					
LFCN-180+	DC-180	370	2.99					
LFCN-190+	DC-190	400	2.99					
LFCN-225+	DC-225	460	2.99	•		•		
LFCN-320+	DC-320	560	2.99	•		•		
LFCN-400+	DC-400	660	2.99	•		•		
LFCN-490+	DC-490	800	2.99	•		•		
LFCN-530+	DC-530	820	2.99	•		•		
LFCN-575+	DC-575	900	2.99	•		•		
LFCN-630+	DC-630	1000	2.99	•		•		
LFCN-800+	DC-800	1400	1.99		•		•	
LFCN-900+	DC-850	1275	1.99		•		•	
LFCN-1000+	DC-1000	1550	1.99		•		•	
LFCN-1200+	DC-1200	1865	1.99		•		•	
LFCN-1325+	DC-1325	2100	1.99		•		•	
LFCN-1400+	DC-1400	2015	2.99				•	
LFCN-1450+	DC-1450	2025	2.99				•	
LFCN-1500+	DC-1500	2100	2.99				•	
LFCN-1525+	DC-1525	2040	2.99				•	
LFCN-1575+	DC-1575	2175	2.99				•	
LFCN-1700+	DC-1700	2375	1.99		•		•	
LFCN-1800+	DC-1800	2425	2.99				•	
LFCN-2000+	DC-2000	3000	1.99		•		•	•
LFCN-2250+	DC-2200	2900	1.99		•		•	•
LFCN-2400+	DC-2400	3600	1.99		•		•	•
LFCN-2500+	DC-2500	3675	1.99					•
LFCN-2600+	DC-2600	3750	1.99					•
LFCN-2750+	DC-2750	4000	1.99					•
LFCN-2850+	DC-2800	4000	1.99					•
LFCN-3000+	DC-3000	4550	1.99					•
LFCN-3800+	DC-3900	6000	2.99					•
LFCN-4400+	DC-4400	6700	2.99					•
LFCN-5000+	DC-5000	6850	1.99		•		•	•
LFCN-5500+	DC-5500	7200	1.99					
LFCN-5850+	DC-5850	7600	1.99					
LFCN-6000+	DC-6000	8500	1.99		•		•	•
LFCN-6400+	DC-5400	8300	1.99					
LFCN-6700+	DC-6700	9300	1.99		•		•	•
LFCN-7200+	DC-7200	9500	1.99					
			Total number of units in kit:	35	60	55	90	65

LFCN Models: U.S. Patent 6,943,646 except LFCN-800+, -1325+, -2000+ & -2400+.

IC LEVEL CONCERNS

The IC design challenges for EMI reduction include high-speed inductance effects, coupling due to high bus complexity as well as package parasitics. EMI is often addressed by modification to the PCB components, the IC I/O design or both. When the silicon is in closer proximity to the 0 V plane in the PCB, the EMC performance is generally enhanced. This is a benefit shared by chip-scale packages (CSP) and chip-on-board assemblies (COB). For both types of IC packaging, the internal interconnects are smaller, thereby reducing their effectiveness as antennas. Chip-on-board construction also allows conductive ink shielding to be printed directly over its "blob top" epoxy resin or silicone shell for greater EMI protection.

Many integrated circuits and power semiconductors require a heatsink for thermal dissipation. Unfortunately, the stray capacitance between the IC and a metal heatsink gives rise to noise currents in the heatsink when the IC voltage fluctuates. Electric fields from the heatsinks can cause radiated emission or conducted emissions if they are coupled to a conductor. Connecting the heatsink to the reference voltage of the IC that is the source of the voltage fluctuation will improve the EMC behavior. Resonance effects for a heatsink occur when the dimension of the heatsink or the cavity(ies) it creates exceeds $\lambda/10$ at the highest frequency of concern. When a signal frequency or its harmonic coincides with a resonant frequency, emissions from can increase by 30 dB or more (see ***Figure 9***).[10]

CONCLUSION

As the demand for more functionality, in reduced-scale components leads to the crowding of high-frequency signals in tight spaces, the potential for EM interference is greatly increased. Coupled with the pressure to reduce design iterations, implement cost-effective EMC solutions and be first-to-market, engineering teams need to consider EMC through all stages of design. To resolve EMI issues expeditiously, engineers should turn to the growing wealth of EMC knowledge currently available in literature and on the web. EM simulation tools also play a critical role allowing EMC/EMI engineers to be more methodical in their approach to exposing potential problems and avoiding a costly re-spin. ■

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A DESIGN OF WIDEBAND FOLDED DUAL MONOPOLE ANTENNAS FOR WIRELESS COMMUNICATIONS

This article proposes a new structure for a wideband antenna, featuring omnidirectional radiation characteristics based on a single plane structure that can be used in integrated circuits. The proposed antenna is a folded dual monopole based on a monopole antenna structure, which was modified into a dual monopole structure in order to increase the impedance bandwidth. In this study, the dual monopole structure was folded at each end so as to change the reactance value caused by the coupling between lines. The impedance bandwidth of the proposed antenna covers from 1.98 to 4.05 GHz. The new antenna can therefore be used for WiBro and satellite DMB bands.

Nowadays, the information society is rapidly changing. Mobile communications and their technologies are increasingly parts of our daily lives. Mobile communications devices are becoming smaller in order to afford efficient mobility. Antennas, which are used to transmit and receive signals, are also increasingly required to become smaller and lightweight, while maintaining high gain characteristics. Generally, small antennas are electrically and physically undersized. A number of design methods can be used to fabricate such antennas. A method that is widely used at present to miniaturize geometrical structures and increase radiation uses a parasitic element. The quality factor of small-sized antennas increases due to the proximity of a grounding surface and the high electric current density, reducing the bandwidth. Meanwhile, an increase in the electric current density causes the impedance to rise, increasing Joule losses, and thereby decreasing the antenna's gain.[1] Existing dual monopole antennas generate a mutual inductance, typical of a radiator with a monopole structure. This has a negative influence on the radiation efficiency of the antenna, as it increases the reactance. Therefore, in this study, both ends of the monopole structure are folded in order to reduce the impedance value. This is accomplished by generating a capacitance from coupling between radiators, which results in a sufficient increase of antenna efficiency as well as operating bandwidth. A planar printed structure in the form of a microstrip antenna is also employed. This structure yields cost benefits, as it is capable of being mass-produced. The antenna also of-

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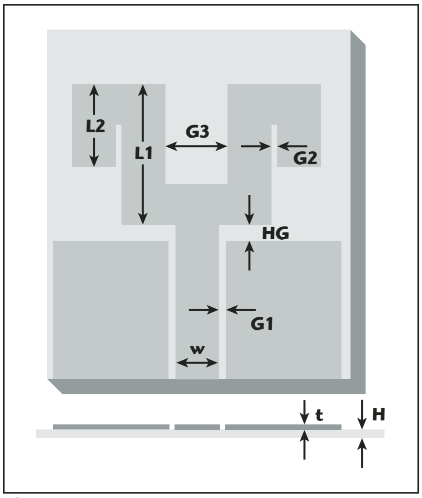
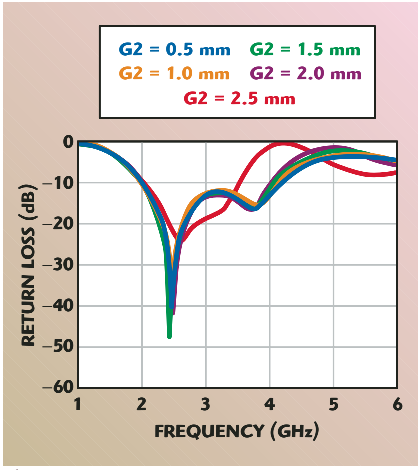
fers a wide range of application owing to its light weight, compact design and printed circuit board manufacturing technique.[2–4] An operating frequency bandwidth of 2.07 GHz (1.98 to 4.05 GHz) with a VSWR less than 2 was obtained. Consequently, the wideband dual monopole antenna can be used for WLL (wireless local loop), WLAN (wireless local area network), 2.4 to 2.48 GHz, satellite DMB (satellite digital mobile broadcasting) 2.63 to 2.655 GHz and ISM (industry science medical).

ANTENNA DESIGN

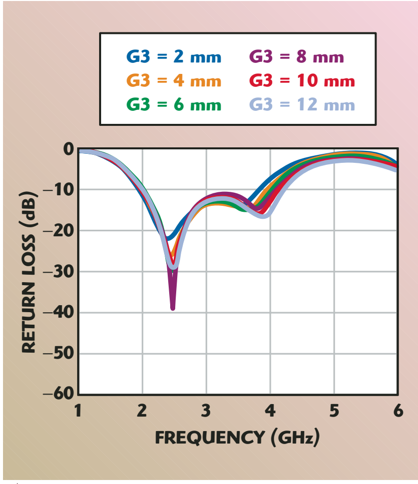
Figure 1 shows the geometry of the modified folded dual monopole antennas proposed in this article; h is the height of the dielectric substrate and t is the conductor thickness. The proposed antenna characteristics were analyzed with L1, L2, G1, G2 and HG as variables. A 0.8 mm thick FR-4 substrate with a dielectric constant of 4.6 was used for the proposed antenna design. The antenna has a dual monopole structure with a 50 Ω coplanar waveguide feed. The relative dielectric constant used for microstrip antennas is usually in the range of 2.2 to 12. Because the microwave circuits connected to the antenna require high dielectric constants and thin circuit boards, there are mutually exclusive requirements between good antenna performance and circuit design with a small structure. In the case of a small antenna, the impedance bandwidth is particularly narrow due to the high impedance. To allow for wideband characteristics, both ends of the dual monopole are folded, as shown in the figure. This, in turn, leads to the generation of coupling on the radiator, dispersing the current density and reducing the impedance, thereby enhancing the antenna's overall performance.



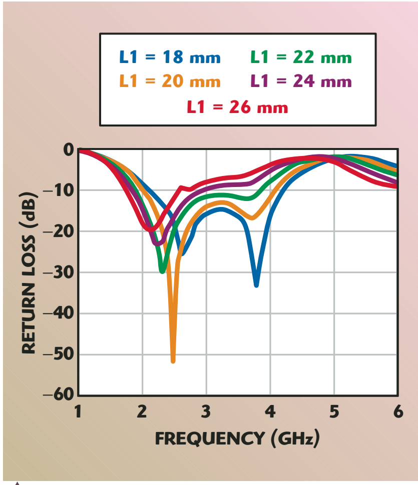
▲ *Fig. 1 Geometry of the proposed folded dual monopole antenna.*



▲ *Fig. 2 Simulated return loss as a function of G2.*



▲ *Fig. 3 Simulated return loss as a function of G3.*



▲ *Fig. 4 Simulated return loss as a function of L1.*

Characteristics of the Folded Monopole Structure

When the ends of a dual monopole are folded, the capacitance between the radiators increases, which enhances the gain and impedance bandwidth of the antenna. A comparison of the characteristics of the proposed antenna with those of a conventional antenna, in terms of reflection coefficients and radiation patterns, shows that the proposed antenna increases the operating impedance bandwidth by more than a factor of two. Generally, as dictated by the relationship between the Q value and bandwidth as given by Equation 1, when the ends of a radiator are folded the total inductance is reduced due to the mutual inductance, while the capacitance is increased due to coupling. The bandwidth (BW) increase can thus be identified through changes in L and C.

$$Q = \omega_o \frac{2\omega_m}{P_{loss}} = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 RC} \qquad (1)$$

$$\left| R + jRQ(BW) \right|^2 = 2R^2$$

or

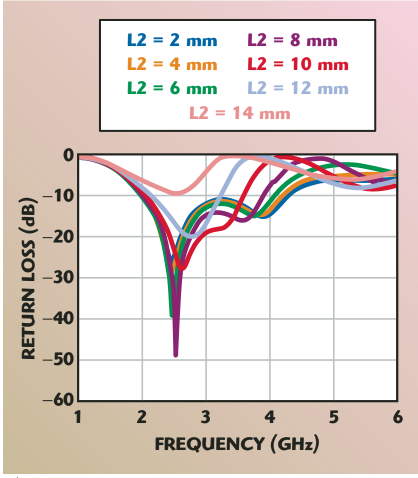
$$BW = \frac{1}{Q} \qquad (2)$$

In addition, with the folded radiator, the size of the antenna can be reduced.

FABRICATION AND MEASUREMENT

The proposed folded dual monopole structure was analyzed by varying the value of each parameter. ***Figure 2*** shows the simulated reflection coefficient as a function of G2 with G1 and HG fixed at 1.5 and 2 mm, respectively, while G2 varies from 0.5 to 2.5 mm. The best resonance characteristics were achieved when G2 was equal to 1.5 mm. While there was no significant change in bandwidth due to the changes of these values, the reflection coefficient did change. First, for G2 = 0.5 mm, the resonance characteristics were unfavorable, but they improved steadily as the value of G2 increased, showing the best resonance characteristics at 1.5 mm. They then started to deteriorate when the value exceeded the 1.5 mm level. ***Figure 3*** shows the reflection coefficient when the G3 value was changed from 2 to 12 mm. Here, the values of G1 and G2 are

fixed at 1.5 and 2 mm, respectively. As shown, when the value of G3 increased, the resonance band moved toward a higher frequency. ***Figure 4*** shows the reflection coefficient when the value of L1 was increased by increments of 2 mm from 18 to 26 mm. When the value of L1 was 18 mm, a satisfactory dual resonance characteristic was obtained, whereas when the value was greater than 20 mm, satisfactory resonance characteristics were found only at the lower frequency band. This is presumably because the length of L1 exhibited different characteristics at the higher and lower bands, due to different resonance conditions. Moreover, the increase in the L1 value resulted in resonance generated among lower frequency bands as the antenna's total length increased. Here, the G1, HG, G2 and G3 values were set at 1.5, 1.5, 2 and 2 mm, respectively. ***Figure 5*** shows the reflection coefficient as a function of L2. When the L2 value increased, the bandwidth decreased at the higher frequency. As was expected, this is attributable to the increasing length of the antenna. Also, with the changes in operating frequency bands, the resonance characteristics deteriorated, which can be explained by the

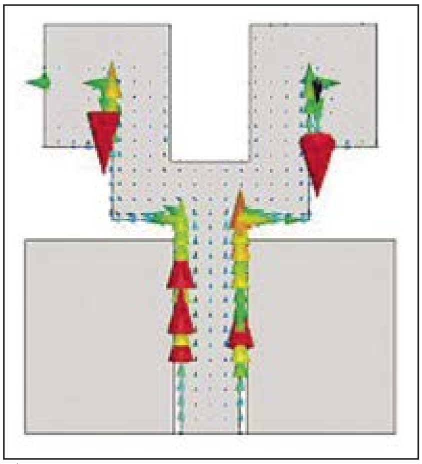


▲ *Fig. 5 Simulated return loss as a function of L2.*

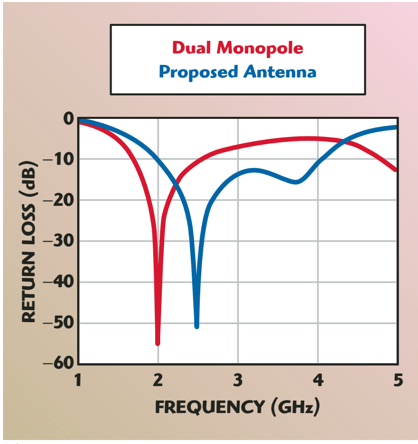
TABLE I

ANTENNA DESIGN SPECIFICATIONS

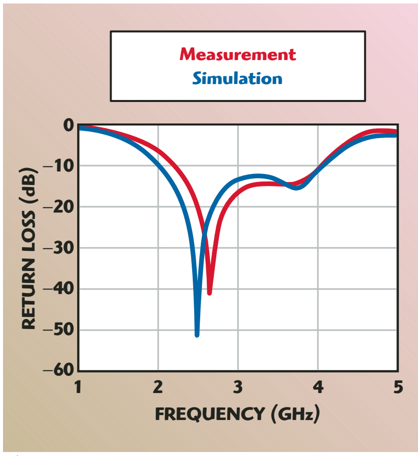
Parameter	(mm)
L1	20
L2	8
G1	1.5
G2=G3	2
HG	1.5
W	6



▲ *Fig. 6 Simulated current distribution in the proposed antenna.*



▲ *Fig. 7 Return loss comparison between a conventional dual monopole and the proposed antenna.*

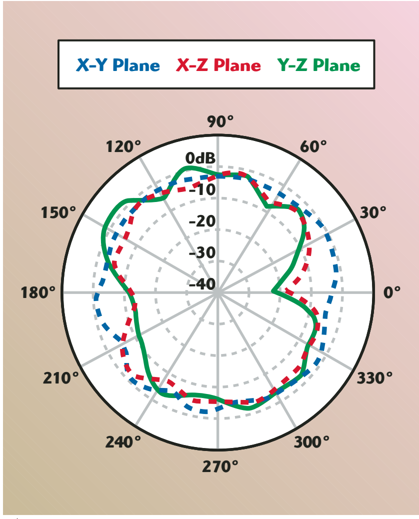


▲ *Fig. 8 Measured and simulated return loss of the proposed antenna.*

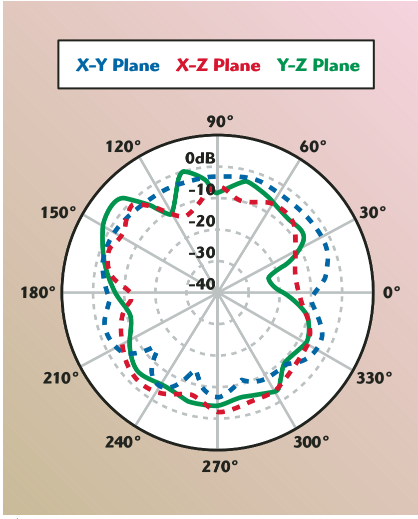
parasite elements generated between L1 and L2. ***Table 1*** gives the optimum values obtained from the simulations. ***Figure 6*** shows the current distribution within the proposed folded dual monopole antennas. As shown, the current density caused by coupling becomes particularly strong where the monopole is folded. ***Figure 7*** compares the reflection coefficient between a conventional structure and the proposed structure. As shown by the equation,

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

regarding frequency and reactance in a resonant circuit, a reduction of the inductance value increases the resonance frequency. As a result, while the conventional structure showed an impedance bandwidth of 600 MHz (1.8 to 2.4 GHz), the proposed structure resulted in a 2.04 GHz bandwidth (1.98 to 4.05 GHz). ***Figure 8*** compares the measured and simulated reflection coefficients of the proposed antenna. While the two sets of values are in close proximity, there are slight discrepancies. These are attributed to errors during the fabrication process in the laboratory. The antenna should have been constructed such that there is no difference in the phases between the two waveguides. ***Figures 9*** and ***10*** show the measured radiation patterns at each frequency band. As indicated by the solid line of the E-plane and the dotted line of the H-plane, they show a typical omni-directional radiation pattern as well as satisfactory pattern characteristics. The radiation patterns were measured using Star Gate-32.



▲ *Fig. 9 Measured radiation pattern of the proposed folded dual monopole antenna at 2.45 GHz.*



▲ *Fig. 10 Measured radiation pattern of the proposed folded dual monopole antenna at 2.63 GHz.*

CONCLUSION

In this article, a folded dual monopole antenna structure for wideband antennas with a single planar structure is proposed, designed and fabricated. The antenna fabrication, based on the proposed design, is 42 mm in length and 38 mm in width. The proposed antenna is a wideband antenna with a bandwidth of 2.09 GHz (1.98 to 4.05 GHz), which is suitable for use in ISM, WiBro and satellite DMB. The dual folded monopole antenna is a printed type, which offers the advantages of easy manufacturing and miniaturization. ■

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SEGMENTED MAGNETIC ANTENNAS FOR NEAR-FIELD UHF RFID

A simple loop antenna of less-than-resonant size is awkward to match and a resonant antenna contains opposing current flows and makes a poor magnetic antenna. Segmented antennas have been constructed that can operate at resonant diameters while still providing good magnetic coupling.

Conventional radiatively coupled, ultra-high frequency radio-frequency identification (UHF RFID) tags have certain limitations: they are physically large and do not operate well in or close to aqueous fluids. Recently, the use of tags configured to use inductive instead of, or as a supplement to, radiative coupling has been advanced as an alternative application model for UHF RFID. Inductively coupled tags require reader antennas that provide significant magnetic fields.

The mutual inductance between two loop antennas is strongly influenced by the antenna diameter. A small loop produces a strong magnetic field along its axis, but the field falls rapidly when the sensing coil is moved more than approximately one diameter above the larger loop. A large loop produces a more modest peak field, but the extent of the field is larger, scaling with its diameter. Therefore, there is an optimal size for best read range for any given peak loop current and coupling requirement.[1] Two obstacles are encountered when one attempts to design simple loop antennas for UHF (approximately 900 MHz) near-field readers. Antennas of intermediate diameter (between 2 and 5 cm) are awkward to match to a 50 Ω input, due both to low radiation resistance and high input impedance: loop antennas have a parallel resonance in this size range. As the antenna diameter approaches the series resonant size (approximately λ/π) the current distribution shifts to produce a change in sign of the current flow, and the antennas produce relatively little magnetic field on axis.[2,3]

SEGMENTED LOOP ANTENNAS

In order to address the problems cited above, a segmented loop antenna has been constructed. Each segment is composed of a metal line forming a polygonal face and a series capacitor to the next segment. Each segment forms a resonant line, avoiding the accumulation of inductive reactance that otherwise impedes matching. Because at resonance the voltage across the segment is real, phase does not accumulate around the loop, and the current around the loop remains approximately in phase and of the same sign, thus producing a substantial magnetic field along the axis. Example antennas are shown in ***Figures 1*** and ***2***.

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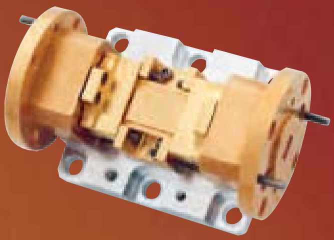

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Model Number	Frequency (GHz)	Gain (dB, Min.)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	In/Out VSWR (Max.)	Output Power at 1dB Comp. (dBm, Typ.)
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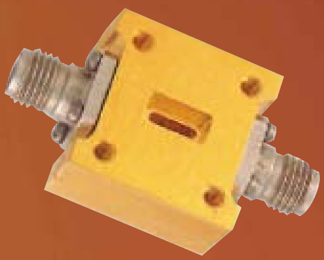
JSW4-26004000-28-5A	26-40	25	2.5	2.8	2.2:1/2.0:1	5
JSW4-18004000-35-5A	18-40	21	2.5	3.5	2.5:1/2.5:1	5
JSW4-33005000-45-5A	33-50	21	2.5	4.5	2.5:1/2.5:1	5
JSW5-40006000-55-0A	40-60	18	2.5	5.5	2.75:1/2.75:1	0

Higher output power options available.



MIXER/CONVERTER PRODUCTS

Model Number	Frequency (GHz)			Conversion Gain/Loss (dB, Typ.)	Noise Figure (dB, Typ.)	Image Rejection (dB, Typ.)	LO-RF Isolation (dB, Typ.)
	RF	LO	IF				
LNB-1826-30	18-26	Internal	2-10	42	2.5	25	45
LNB-2640-40	26-40	Internal	2-16	42	3.5	25	45
IR1826N17*	18-26	18-26	DC-0.5	11	9.5	25	25
IR2640N17*	26-40	26-40	DC-0.5	11	9.5	25	25
SBW3337LG2	33-37	33-37	DC-4	-7.5	8	N/A	25
TB0440LW1	4-40	4-42	.5-20	-10	10.5	N/A	20
DB0440LW1	4-40	4-40	DC-2	-9	9.5	N/A	25
SBE0440LW1	4-40	2-20	DC-1.5	-10	10.5	N/A	20

* For IF frequency options, please contact MITEQ.

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Model Number	Frequency (GHz)		Input Level (dBm, Min.)	Output Power (dBm, Min.)	Fundamental Feed Through Level (dBc, Min.)	DC current @+15VDC (mA, Nom.)
	Input	Output				
MAX2M260400	13-20	26-40	10	10	18	160
MAX2M200380	10-19	20-38	10	10	18	200
MAX2M300500	15-25	30-50	10	10	18	160
MAX4M400480	10-12	40-48	10	10	18	250
MAX3M300300	10	30	10	10	60	160
MAX2M360500	18-25	36-50	10	10	18	160
MAX2M200400	10-20	20-40	10	10	18	160
TD0040LA2	2-20	4-40	10	-3	30	N/A

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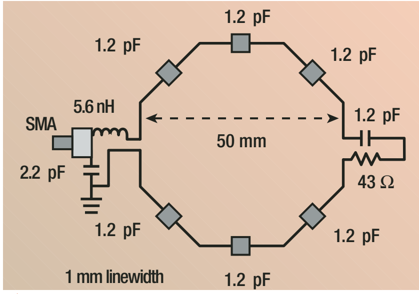
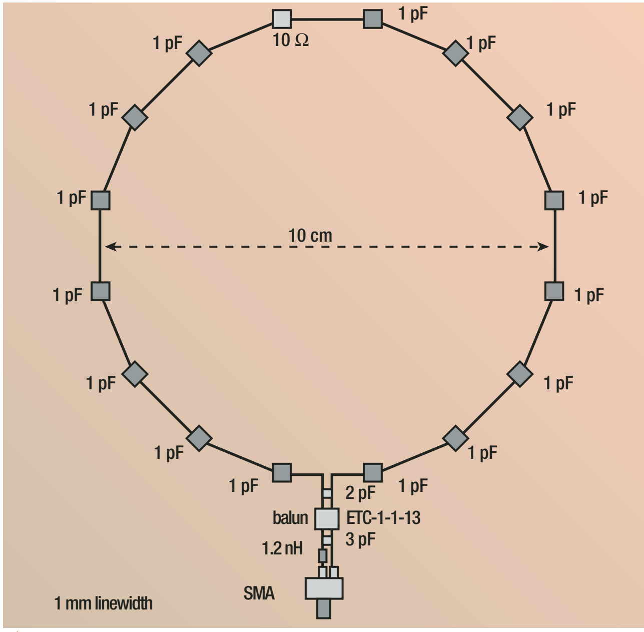
MODEL AND MEASUREMENT RESULTS

To simulate the loop resonance, a 2.5D electromagnetic solver software was used and an N-port S-parameter block was extracted. For example, for the 10 cm loop, a 32-port S-parameter file was extracted. This file was used in a linear simulator to determine the proper capacitances between segments, cascade the input of the loop with the S-parameter results of a balun and add matching components. Since the radiation resistance is very small compared to the 50 Ω coaxial feed line, the loop match is very sensitive to the reactance values. To make the matching more robust and attain better manufacturability, a resistor was mounted on the opposite side of the antenna feed to decrease the Q of the loop sufficiently. Commonly, a loop antenna with a length much smaller than its exciting wavelength is referred to as a small loop. Small loops have constant current phase along the loop wire and have the capability of generating a strong near-field magnetic field. On the other hand, due to the small circumference, the magnetic field tapers off very quickly beyond a distance equivalent to one loop diameter. Increasing the coil size will increase the read-distance of near-field tags but have the disadvantage that, at UHF frequencies and for practical read distances, the loop is not small compared to the wavelength. A 10 cm diameter coil, for example, is roughly one wavelength in perimeter and will have current nulling and a phase-inversion along the circumference. ***Figure 3*** shows the surface current along a 10 cm coil driven at 915 MHz. The top and bottom show current nulls and the left portion is out of phase with the right. Segmenting and combining the parasitic inductance of each section with a lumped capacitor will cause the large loop to behave electrically like a small one. The current will remain constant along the loop and provide a strong magnetic field (see ***Figure 4***). This physically large but electrically small loop has very little radiation resistance and thus can be driven with significant strong currents without violating government radiation limitations. Distributing the capacitances also relaxes the voltage breakdown requirements allowing stronger drive power. The measured return loss for the 5 cm loop is shown in ***Figure 5***, and for the 10 cm loop in ***Figure 6***, demonstrating the good bandwidth matching obtained with small and large loops.



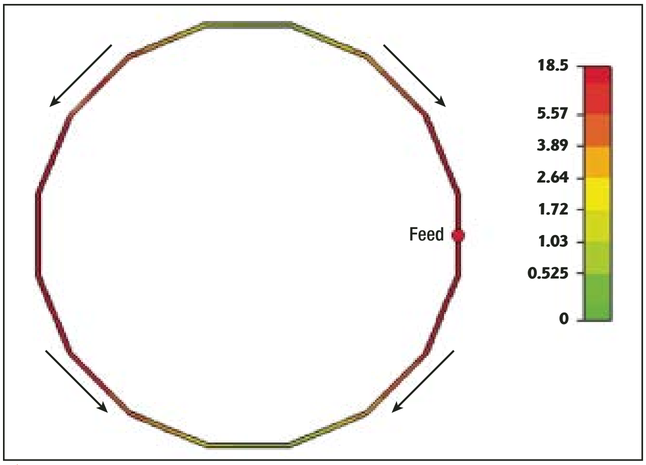
▲ *Fig. 1 A 5 cm diameter segmented loop.*



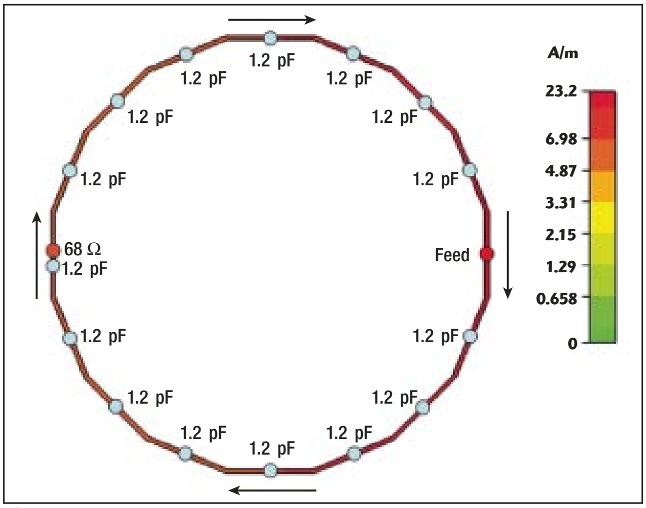
▲ *Fig. 2 A 10 cm diameter segmented loop.*

INDUCTIVE COUPLING IMPROVEMENT

The inductive coupling was measured using an 8 mm diameter simple loop, matched to 50 Ω. The small loop was matched to a 3 kΩ terminating resistor placed opposite the loop feed using a 1.3 pF capacitor. A loop of this diameter has a radiation resistance much less than 1 Ω, so coupling between the small and large loops ought to be almost purely inductive. The loop incorporated a wire-wound balun to avoid common-mode coupling between the antenna under test and the shield of the coaxial hookup cable.



▲ *Fig. 3 Surface current magnitude along a 10 cm coil driven at 915 MHz.*



▲ *Fig. 4 Surface current magnitude of a segmented 10 cm coil driven at 915 MHz.*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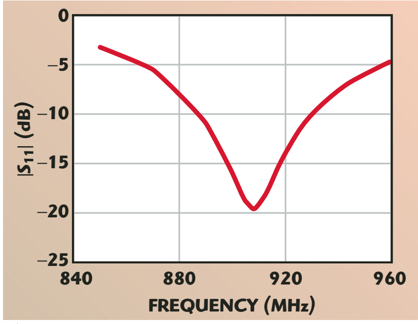
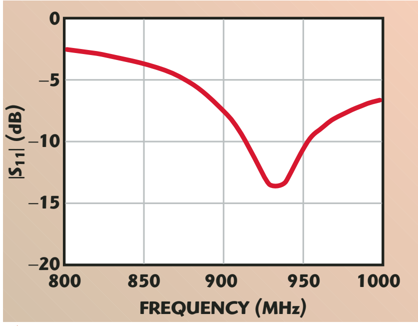
In each test the sense antenna was placed above and parallel to the plane of the larger loop antenna under test. A 10 cm diameter segmented loop was compared to a simple single-segment loop of the same size and shape. The results are shown in ***Figure 7***. The use of the segmented loop results in an approximately 20 dB increase in coupling to the small test loop. The return loss is sensitive to the environment, despite the fact that the antennas are excited through a balun. For example, the antenna is detuned if placed directly on a static-dissipative surface. The results reported in the next section are obtained with the antenna mounted in a polyethylene box several centimeters away from other surfaces. It seems likely that the use of a fairly high dielectric-constant baseplate combined with appropriate adjustment of the segment parameters will produce an antenna less affected by nearby objects, but this has not yet been confirmed by experiment or analysis.

READ RANGE

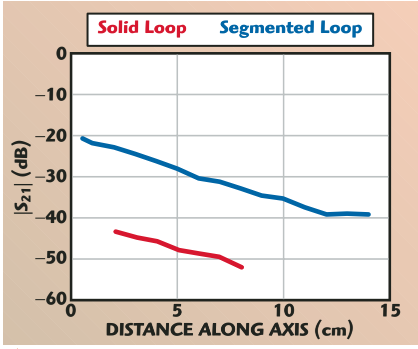
UHF RFID tags that couple inductively can be constructed using a



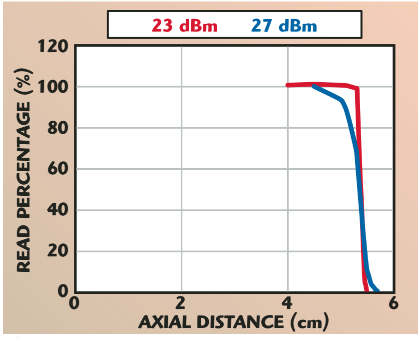
▲ *Fig. 5 Return loss of the 5 cm diameter loop.*



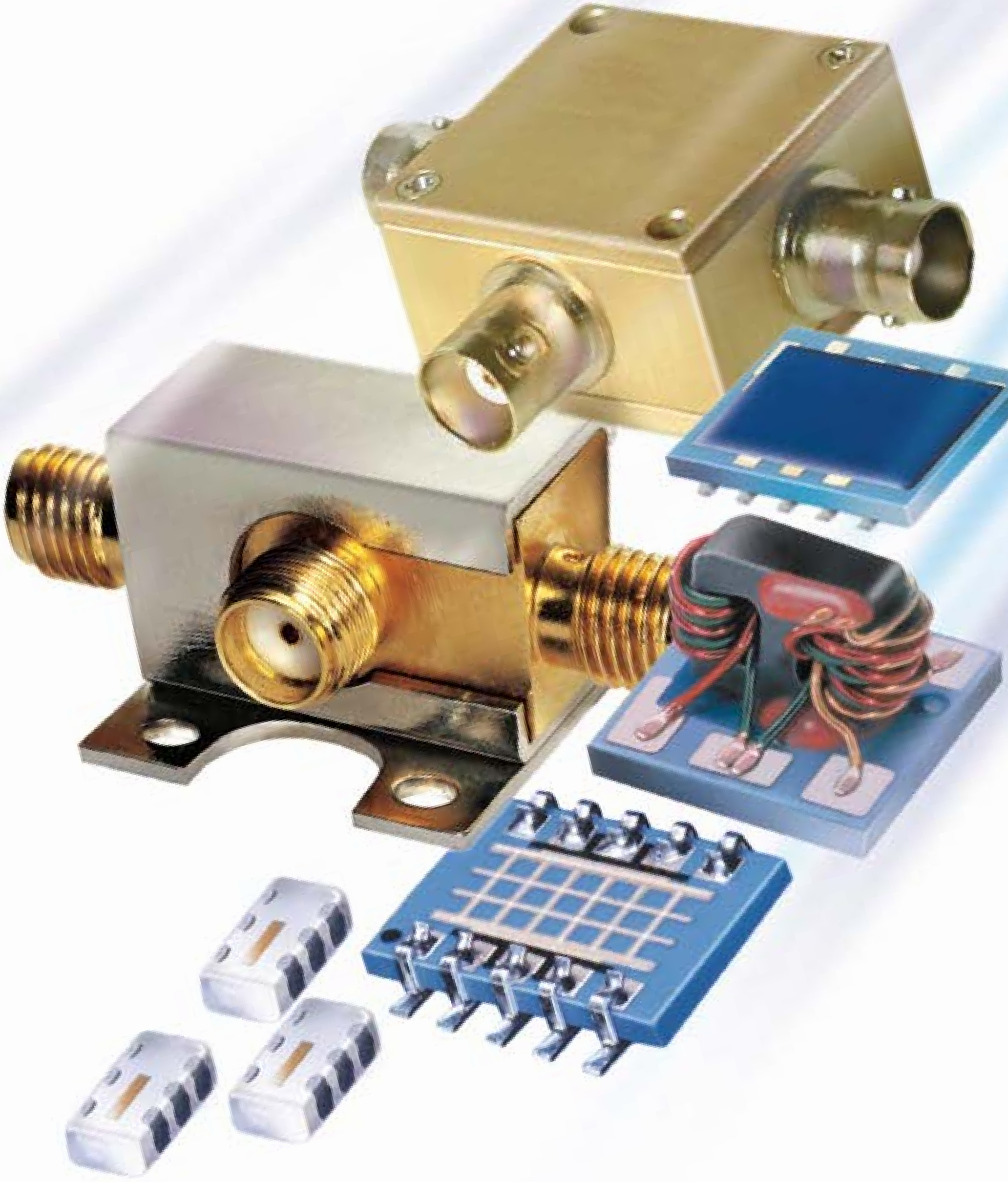
▲ *Fig. 6 Return loss of the 10 cm diameter loop.*



▲ *Fig. 7 Coupling to a small loop antenna placed above the plane of the larger loop under test.*



▲ *Fig. 8 Read percentage versus position for a 5 cm diameter segmented loop.*



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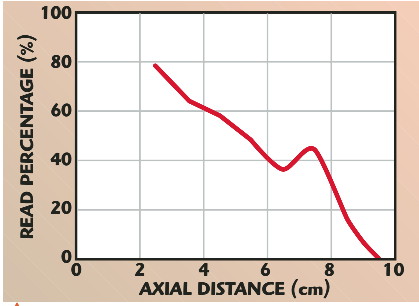

▲ *Fig. 9 Read percentage versus position for a 10 cm diameter segmented loop.*

loop antenna rather than the conventional short dipole; a test tag was constructed by removing the dipole from a conventional Texas Instruments Class 1 Generation 2 inlay, leaving only the 10 × 13 mm tuning loop. Using this type of tag, the read range of the segmented antennas was tested employing a conventional WJ Communications MPR6000 reader module. The 5 cm diameter segmented loop results in a sharply defined read range of approximately 5.5 cm on axis, as shown in ***Figure 8***. The read percentage for the 10 cm diameter segmented loop falls more gradually with distance, but reads are possible out to approximately 8.5 to 9 cm along the axis (see ***Figure 9***).

The detailed origins of the different behavior of the small and large antennas have not yet been examined, although since the peak magnetic field on axis is higher and the fall-off more abrupt for a small antenna, some difference in behavior is to be expected. The importance of reduced read rates is application-dependant. A single read using ISO 18000-6C-compliant tags with the inventory parameter Q = 0 or Q = 1, for instance, requires a few milliseconds. In some applications, it is only necessary that a tag be read once and an ample amount of time may be available, whereas in other usage models, a large number of tags may be present and must be read reliably. The authors have verified that at least in some circumstances reads are roughly Poisson-distributed, so to achieve 99 percent reliability for a single read, for example, a tag should average 6 to 8 possible reads. Therefore, the practical range resulting from the behavior shown for the 10 cm diameter segmented loop will vary depending on the exact application. It may also be possible to optimize the antenna performance to improve reads at the 6 to 8 cm range.

CONCLUSION

Inductive loop antennas can be constructed at sizes comparable to the resonant diameter by dividing the loop into individually resonant segments. ■

ACKNOWLEDGMENTS

The authors would like to thank Kendall Kelsen of WJ Communications for his assistance in constructing some of the antennas, and Ron Oliver of Impinj for helpful discussions.

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A SPACE-SAVING, SELF-SHIELDING MODULE WITH IMPROVED POWER SAVINGS FOR EDGE HANDSET APPLICATIONS

As cell phone manufacturers add more features to their products, there is less space for the cellular radio. What was the board area allocation for the cellular radio several years ago now must also include Wi-Fi, *Bluetooth*® and GPS radios. In addition, there is now the added complication associated with EMI and RFI issues of collocated radios. The RFMD POLARIS™ 3 TOTAL RADIO™ incorporates key innovative module packaging technologies and power savings circuit architectures that address EMI and RFI challenges while providing handset manufacturers a very compact power efficient radio solution, enabling shortened time to market and low cost of ownership.

POLARIS™ 3 follows up the industry leading POLARIS™ 2 TOTAL RADIO Solution for E-GPRS applications with a smaller, more advanced DigRF compliant EDGE radio. The solution consists of the RF6030, a transceiver module containing a single chip RF CMOS transceiver and RX SAW filters: the RF3251, a self RF shielded transmit power amplifiers (PA) with front-end switch module, and the groundbreaking RF9003 DC-DC Switch Mode Power Supply (SMPS). At less than 200 mm² footprint for the entire radio (270 mm² with the SMPS), POLARIS 3 is one of the smallest, most efficient and advanced quad-band EDGE radio solutions offered.

Some of the POLARIS™ 3 features include:

- Robust 3rd Generation Large Signal Polar Modulation EGPRS Radio
  - Two-module radio with very few external components—eases layout
- Fast Calibration
  - Less than seven seconds for TX path (inclusive for four bands, both GMSK/EDGE, all PCLs)

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- Validated in factory environment
- Patent-pending Auto RX image reject calibration circuits eliminates factory calibration

• Small Board Area < 200 mm^2
- Greater than 40 percent board area reduction over the previous radio generation

• Self-shielded TxM
- Patent-pending self-shield eliminates the need for external shield and speeds up development time

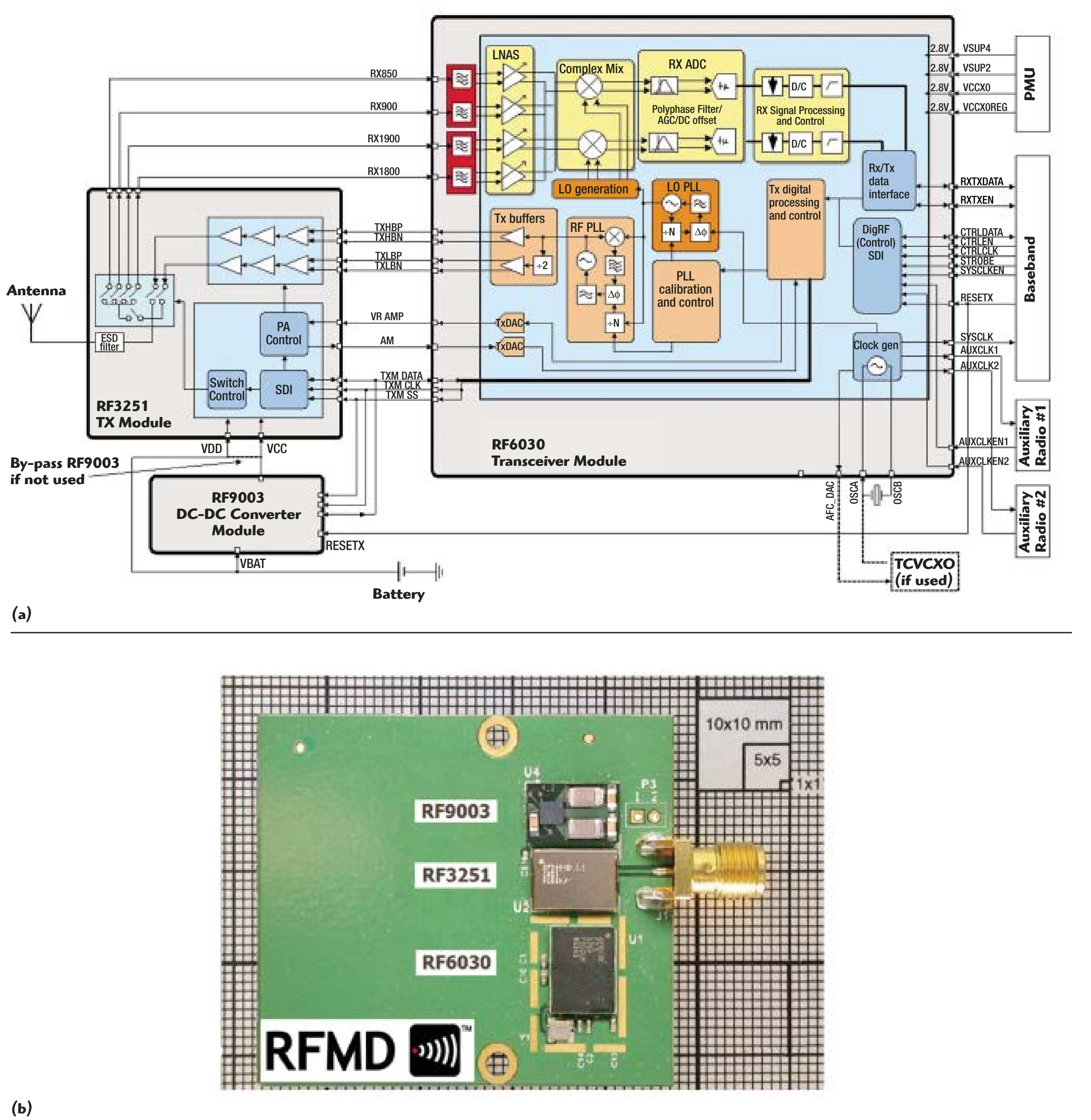
• Lower Power Consumption
- Open Loop Large Signal Polar Modulation for maximum transmit efficiency
- Additional 30 percent or more improvement when used with optional RF9003 SMPS

• Adaptive Power Control Feedback
- Addresses Total Radiated Power (TRP) and SAR challenge
- Reduces output power and current variation into changing antenna load

• True Digital AFC
- Supports free running, low tolerance crystal
- Shortens factory calibration time

• DigRF 2.5 Compliant Interface
- Compatible with many cellular base bands

The radio solution is quite compact. ***Figure 1*** shows there are very few external components, most of which are just decoupling capacitors. The RF modules offer improved design cycle time since the RF interfaces are pre-



▲ *Fig. 1 RFMD Systems Solution POLARIS 3 block diagram (a) and simple radio layout (b).*

matched and are less prone to parasitic board affects, thereby easing layout constraints. The self-shielded RF3251 TxM further reduces complications of coupling and detuning normally associated with external shields.

POLARIS 3 OPEN LOOP LARGE SIGNAL POLAR MODULATION ARCHITECTURE

RFMD was one of the first semiconductor companies to commercialize open loop large signal polar modulation with the successful introduction of POLARIS 2. This modulation approach is fundamentally the most efficient architecture since the power amplifier is always in saturation. POLARIS 3 improves upon the architecture by incorporating features inherent to large signal polar modulation to dramatically improve both factory calibration time and talk time.

As in a linear system, the raw TX symbol data is mapped into I and Q vectors and then is finite impulse response (FIR) filtered. After this step the I and Q vectors are converted to amplitude and phase. The amplitude and phase signals are aligned so that they will arrive at the antenna at the same time.

The phase signal is corrected for power amplifier impairments and is then pre-distorted and applied to the modulation port of a translational loop fractional N synthesizer. The output of the fractional N synthesizer is directly at the desired RF frequency and is amplified by a nonlinear power amplifier.

The amplitude signal is multiplied by the power control ramping, corrected for various power amplifier imperfections, and then D/A converted and used to drive the PA output level. In the case of POLARIS 3 this is accomplished with a linear regulator driving the collector of the power amplifier with the regulated voltage set by the D/A output voltage. As an option, the RF9003 SMPS may be used to efficiently convert the battery voltage to the operating voltage of the PA in the RF3251.

The system shown in ***Figure 2*** is mostly digital in implementation. The only non-digital areas are the filter of the D/A converter, the analog components of the fractional N synthesizer, the collector regulator and the power amplifier. Thus, much of the complex analog circuitry of the linear system has been replaced with inexpensive and easily integrated digital functionality.

In addition, the polar modulation system has lower current drain than the linear system. The IQ modulator is eliminated and the power amplifier can be run in a more efficient nonlinear mode.

Finally, the polar modulation system does not require any filtering between the VCO and the power amplifier. This is due to the low noise nature of the VCO output of the fractional N synthesizer.

This architecture lends itself to very fast and accurate TX calibration. Predistortion curves for both AM-AM and AM-PM are stored in RAM look up tables (LUT) on the RF6030 transceiver. The LUT curves along with an integrated TX calibration routine make it possible to dramatically improve TX calibration time. The built in calibration routine allows the transmitter amplitude and phase signature to be directly measured speeding up the TX calibration. Since the PA is always in saturation, both GMSK and 8PSK alignment information can be calculated from the same measurements, whereas other competing solutions such as Linear EDGE require separate measurements be taken in GMSK and 8PSK modes. Furthermore, POLARIS 3 is designed to use standard factory test equipment and requires no special data patterns to be generated. The chart shown in ***Figure 3*** compares the calibration time against a typical linear

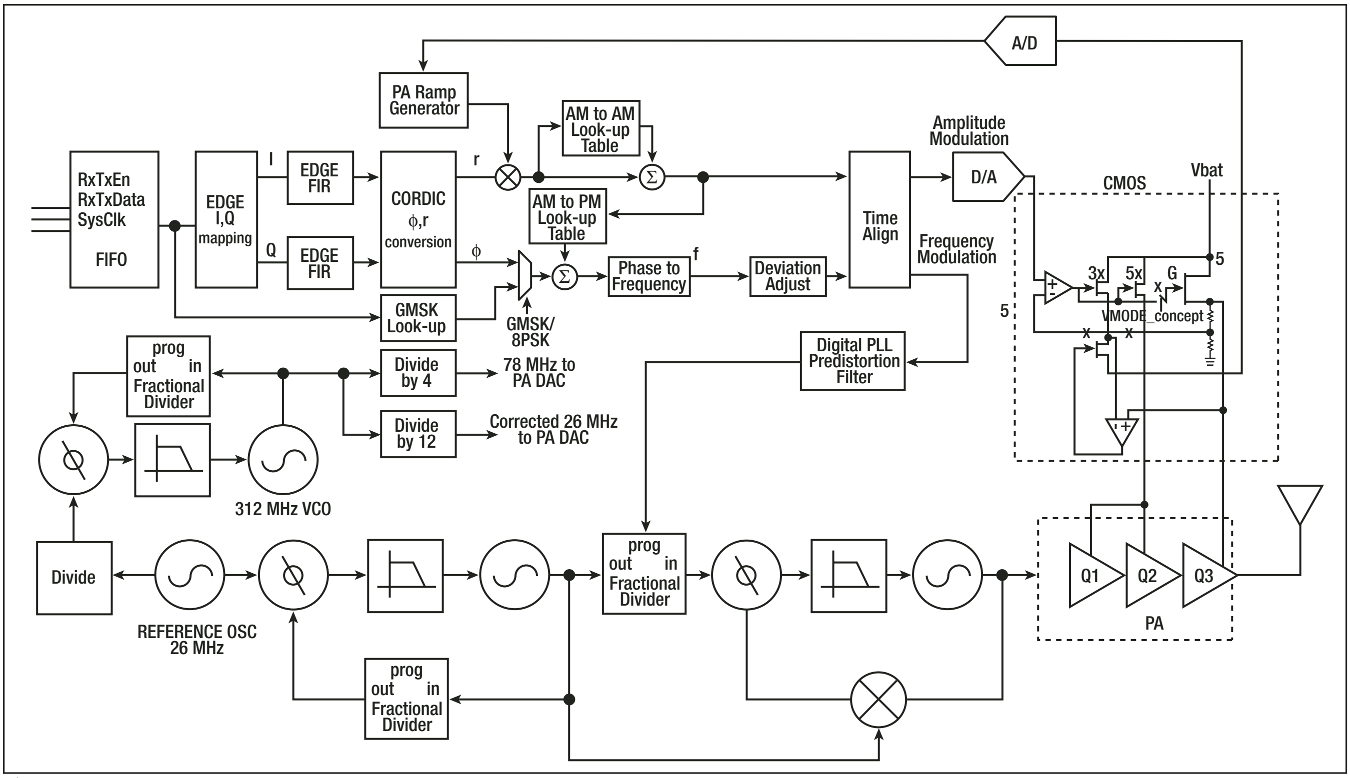


Fig. 2 POLARIS 3 modulation system.

Shown with optional equipment.

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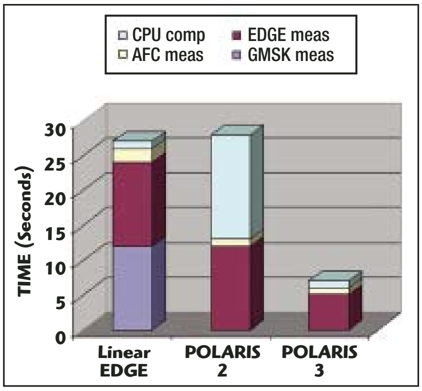
EDGE solution and the earlier generation POLARIS 2 calibration time.

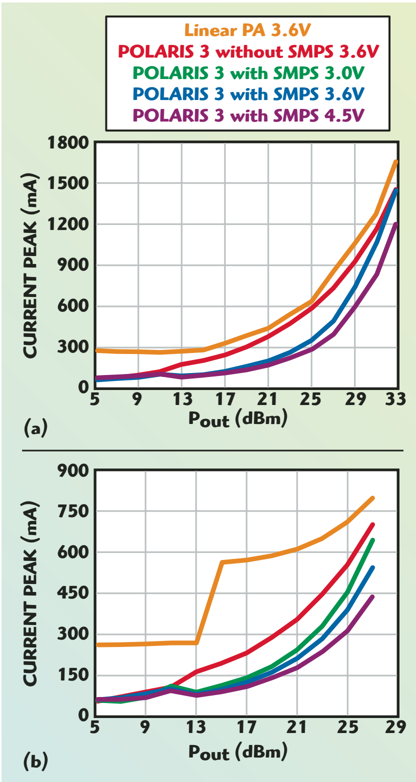
REAL POWER SAVINGS

When it comes to talk time and power dissipation, the trend to smaller and thinner handsets and correspondingly smaller batteries have become a major challenge confronting the handset designer. The RF9003 SMPS offers designers the ability to increase talk time over 30 percent without the need to increase the battery size, while taking up only 70 mm^2 of board area. This allows the handset designer to add functionality such as DVB-H TV for higher end smart phones with the existing battery size, or reduce the battery size and cost for very thin handsets.

As mentioned POLARIS 3 PA operates in saturation for both GMSK and EDGE modes. This fact makes it very easy to incorporate a SMPS for improved power savings. The RF9003 is designed to efficiently convert the higher battery voltage (typically 4.5 fully charged) to the operating voltage the PA requires for the corresponding output power, typically 3.2 to 1 VDC. The graphs in ***Figure 4*** show the POLARIS 3 radio battery current consumption with and without the RF9003 SMPS. Also shown is typical improvement the POLARIS large signal polar modulation architecture offers over a traditional linear EDGE radio architecture. As the graphs show, the battery current consumption improvement is



▲ *Fig. 3 TX calibration time comparison.*

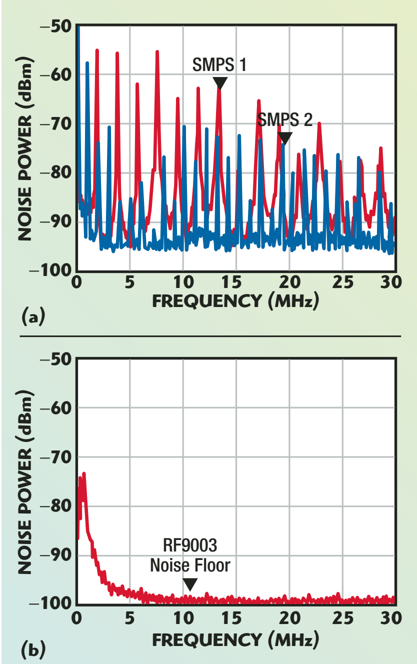


▲ *Fig. 4 Comparison of battery current versus output power at 897 MHz in GMSK (a) and EDGE (b) modes.*

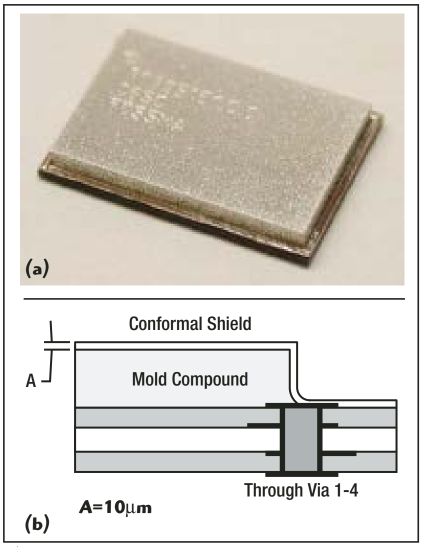
considerable when the battery is fully charged at around 4.5 V. The current consumption gradually increases as the battery is discharged. The RF9003 will go into a bypass mode when the battery voltage is too low to provide any benefit the SMPS would add.

To date, it has not been practical to use a SMPS to supply bias to GMSK power amplifiers used in handsets. The RF9003 SMPS is the first commercial solution that is best-in-class in both size and low noise suitable for use in E-GPRS handsets.

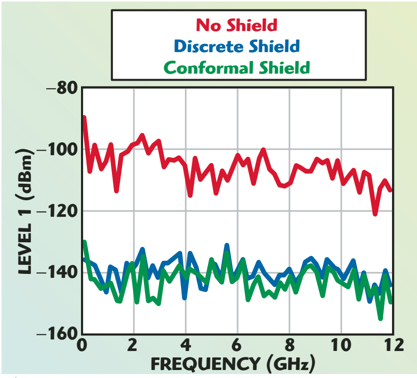
The RF9003 SMPS had to overcome the hurdle of being fast with slew rates on the order of microseconds to track the GMSK timing mask while being quiet enough to meet the regulatory ETSI noise requirements in the TX and RX bands. Reducing the clock switching speed would reduce the noise but response time would be compromised and would also require large switching induc-



▲ *Fig. 5 Typical (a) and RF9003 (b) SMPS noise power.*



▲ *Fig. 6 RFMD's Self-shielding Technology.*



▲ *Fig. 7 Average shielding effectiveness.*

tors. Conversely, increasing the clock switching frequencies reduces the switching inductor and response time at the expense of more noise. Instead, a novel clocking scheme is used to spread the clock noise over a wide enough bandwidth to meet the ETSI requirements. ***Figure 5*** shows the dramatic improvement in noise and spurs the RF9003 offers over traditional SMPS solutions.

SELF-SHIELDING EASES LAYOUT AND IMPROVES FACTORY YIELDS

Take apart any handset and chances are there will be multiple shields, sometimes referred to as cans on a board. Some manufacturers incorporate the shield in the plastics via a metallized coating. In either case, board area must be set aside for the shields. The need for the cans is due to the fact that most RF modules and practically all MMICs are unshielded and need to be protected from external interference as well as suppress any stray signals they may generate.

RFMD uses the self-shielding approach to develop modules that are self-shielded. This new exciting patent-pending technology is used on the POLARIS 3 RF3251 transmit module. The self-shielding is plated onto the existing module compound, as shown in ***Figure 6***. The module laminate is designed to allow the conformal layer to connect to ground vias spaced along the periphery of the module laminate.

This self-shielding technology offers significant benefits over other shielding methods:

Simplified phone PCB design
- No interference from module to module
- No interference from antenna to module
- No retuning required due to shield effects

Elimination of external shields from phone board
- Saves cost
- Saves board area (20 to 30 percent)
- Reduces module height (1.2 mm including shield)
- Minimizes rework costs
- More consistent results for better factory yields

The shielding effectiveness is shown in ***Figure 7***. As the data shows, the performance of the self-shield is as effective, if not more than, conventional metal shields.

As an RF solution provider, RFMD recognized that it had to continue to invest in advanced circuit architectures and packaging technologies that will enable phones to incorporate more features in a smaller footprint at competitive costs. To address the handset manufacturers' need for shortened time to market and lower cost of ownership, RFMD embarked on developing and/or incorporating several key technologies that include single chip RF CMOS transceivers, self-shielding and power management. POLARIS 3 is one of the first products to bear the fruit of the company's investment to develop these technologies.

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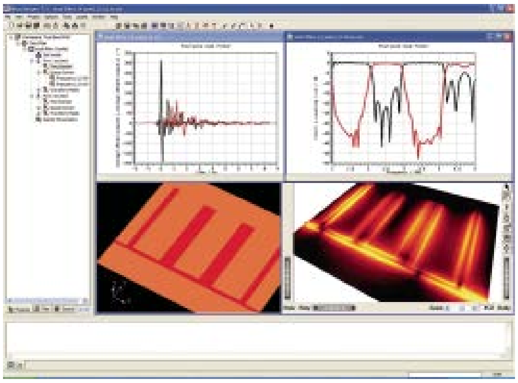

A COMPREHENSIVE 3D EM SIMULATION ENVIRONMENT

3D electromagnetic simulation is not only being used for the well established applications of antenna and microwave design, but issues associated with EMC, EMI, ESD and shielding also mean that it is playing an increasingly important role in the product development process across a wide range of applications. To extend its reach and to address these new areas of application the latest version of the MicroStripes full 3D electromagnetic solution—Version 7.5—boasts some major new additions.

As with its predecessors, Version 7.5 continues to use the robust and proven time domain-based Transmission Line Matrix (TLM) method for solving Maxwell's equations initially developed by Peter B. Johns. This highly efficient technique also brings advantages when looking at transient EMI issues such as lightning, electrostatic discharge (ESD) and electromagnetic pulse (EMP).

RF CIRCUIT INTEGRATION

Because 3D EM simulators play a supporting role to RF/microwave system and circuit design tools it is important that these 3D tools have the capability to be integrated seamlessly into existing RF/microwave design flows by working with the existing design tools. Typically, within the circuit design tools, models are built using a combination of circuit models, transmission line models and 'black box' devices. For more complex structures, 3D EM analysis is required for computing the device characteristics such as S-parameters that are to be used for the system analysis. This is especially important when the system being analyzed contains antenna elements and 3D geometry.

With the release of Version 7.5, the integration between the simulation software and AWR's Microwave Office® design suite has been realized. This allows the simulation software to be used from within the design environment for simulating the response of selected components within the RF/microwave circuit design. The interface automatically builds the simulation model, launches its analysis and

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▲ *Fig. 1 A four-element planar patch array as imported from Microwave Office into MicroStripes 7.5 where additional 3D geometry has been added.*

then passes the results back to the design suite when the simulation is complete. The design suite then uses the computed characterization of the component in the circuit simulation of the entire system.

Thus, the designer has complete access to the powerful MicroStripes feature set. This allows, amongst other things, full radiation conditions to be taken into account in the antenna analysis and crucially allows full 3D geometries to be included in the model. As an example, ***Figure 1*** shows a four-element planar patch array as imported from Microwave Office into Version 7.5, where additional 3D geometry has been added to account for the device on which the array is mounted, together with the radome.

The inclusion of the 3D geometry is critical in the antenna analysis. This is because it allows the interaction between the antenna elements and the device on which they are mounted to be accounted for in the simulation and for the fully installed characteristics to be computed.

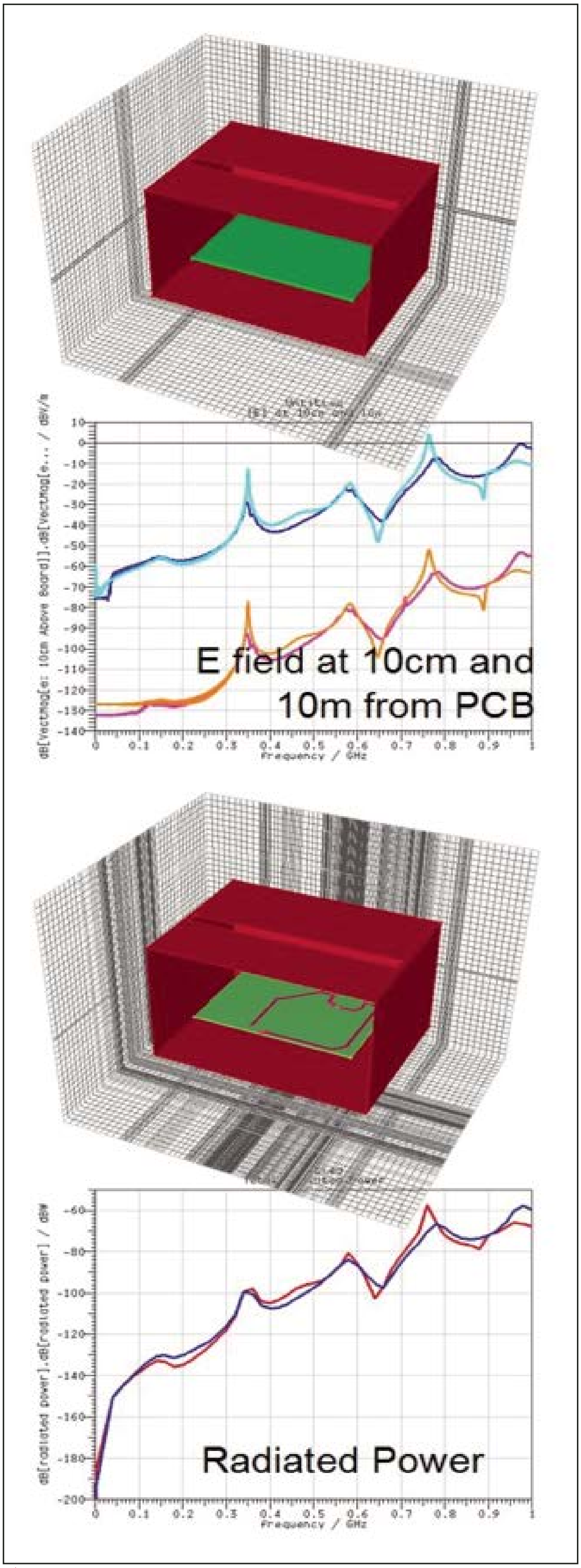
The result of this integration moves Flomerics' high frequency EM offering from a leading EM tool to a solution that can play a key part in a true RF/microwave integrated design environment.

EMC AND SHIELDING

Following the introduction of the EMC directive in Europe back in the mid-1990s, many organizations are now realizing the benefit of including 3D electromagnetic analysis in the EMC design process. EMC, of course, extends beyond the test and measurement requirements of the various standards and MicroStripes 7.5 is well suited to assist with a wide range of EMC issues such as enclosure shielding, component (heat sink, for example) emissions, trace and via impedances, cable coupling and system emission analysis.

When tackling the simulation of EMC issues in 3D, it is important that the system model contains all the features that are going to influence the performance. Quite often these can be geometrically very fine and therefore need to be represented in a very efficient computational way. As such, included within Version 7.5 are a series of compact models that allow geometrically fine but electrically important features to be included in the model without the need to locally refine them.

These include the ability to model wires and wire bundles, thin film materials, slots, seams and perforated plates. By using the compact models within the simulation software it is possible to account for these items and the coupling between them and the associated structures and fields much more efficiently than if they were modeled in detail.



▲ *Fig. 2 An illustration of how using compact sources to represent the complex frequency dependent distributed sources of PCBs produces efficient solutions.*

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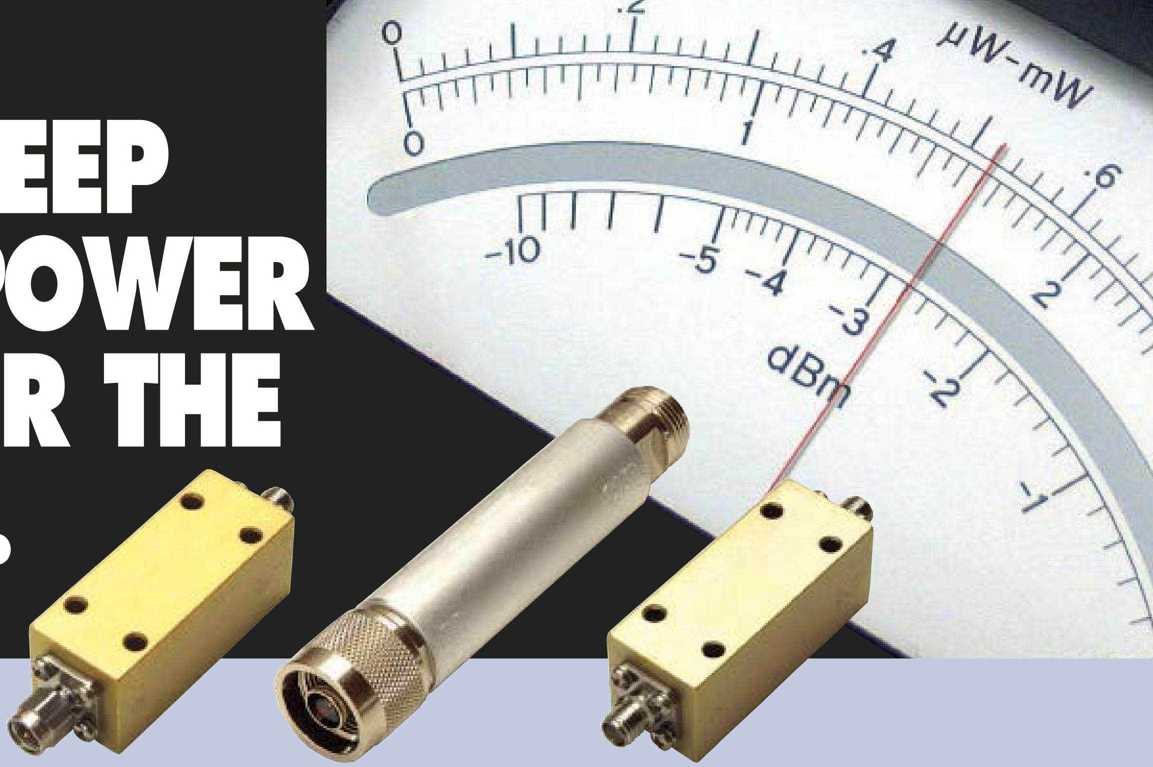

High Power RF Limiters

Frequency Range (MHz)	Part Number	Peak Input Power (kW)	CW Input Power (Watts)	Maximum Flat Leakage (CW Power +dBm)	Maximum Insertion Loss (+dB)	Maximum VSWR
0.5 - 30	ACLM-4869H	1	100	14	0.1	1.25:1
30 - 100	ACLM-4870H	1	100	14	0.1	1.25:1
10 - 500	ACLM-4827H	1	100	14	0.1	1.25:1
100 - 1300	ACLM-4871H	1	100	14	0.2	1.25:1
2 - 1500	ACLM-4932H	1	100	14	0.25	1.25:1
0.1 - 2000	ACLM-4897H	1	100	14	0.3	1.25:1
0.1 - 3000	ACLM-4896H	1	100	13	0.4	1.25:1
600 - 3100	ACLM-4891H	1	100	13	0.5	1.25:1
2000 - 4000	ACLM-4943H	1	100	13	1.2	2.0:1

* 60 W Version Also Available

RF & Microwave Limiters

Frequency Range (GHz)	Part Number	Peak Input Power (W)	CW Input Power (Watts)	Maximum Flat Leakage (CW Power +dBm)	Maximum Insertion Loss (+dB)	Maximum VSWR
0.5 - 2	ACLM-4538	100	2	18	0.4	1.4:1
0.1 - 4	ACLM-4637	100	2	17	0.5	1.4:1
1 - 4	ACLM-4581	100	2	17	0.5	1.4:1
2 - 4	ACLM-4531	100	2	17	0.5	1.4:1
1 - 8	ACLM-4597	100	2	17	0.9	1.5:1
2 - 12	ACLM-4535	100	2	18	1.5	1.6:1
2 - 18	ACLM-4537	100	1	18	1.8	1.9:1
18 - 26	ACLM-4765	100	1	21	2.5	2.0:1

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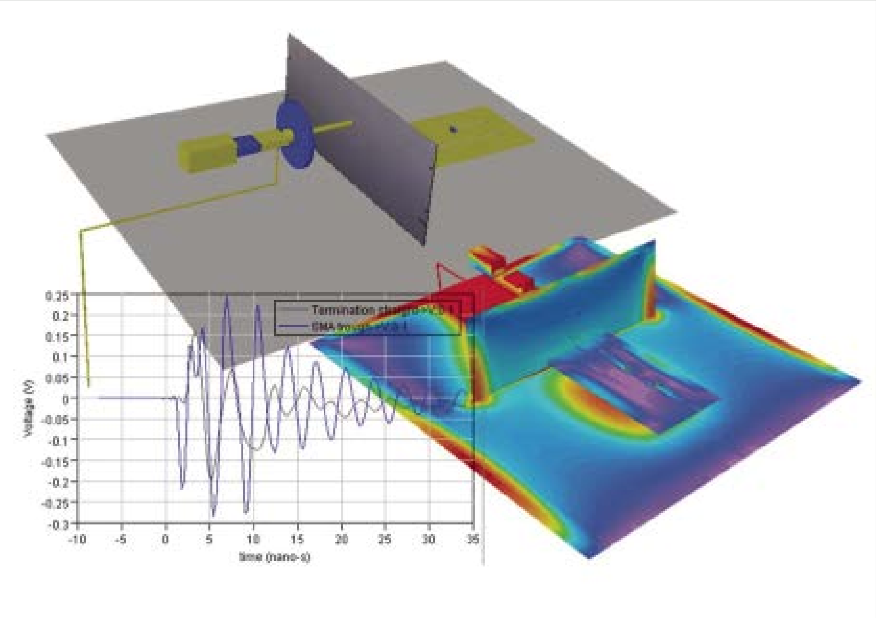


▲ *Fig. 3 The time domain-based TLM method allows transient issues such as ESD to be efficiently simulated.*

Also, PCBs, even if well designed, will inherently be a source of electromagnetic emission in an electronics system due to the components mounted on the board, exposed traces and interconnecting cables. Within a 3D electromagnetic environment, modeling the fully detailed PCB board is a computationally intensive and extremely challenging task. Not only are there many hundreds, if not thousands, of nets on the board, there could also be several layers and many components.

This results in some extremely fine geometric features, which make 3D analysis unsuitable for fully detailed PCB analysis. While in a 3D solution, the sources could be approximated by means of simple wire sources, which does not account for the complex, frequency dependant, distributed nature of the PCB source. However, Version 7.5 has the ability to import the frequency dependant, distributed EM characteristics of PCBs, to act as sources for the analysis.

Figure 2 shows how using compact sources to represent the complex frequency dependant distributed sources of PCBs results in more efficient solutions while maintaining the accuracy by replacing detailed geometric PCB models with an equivalent volume source that does not require geometric detail.

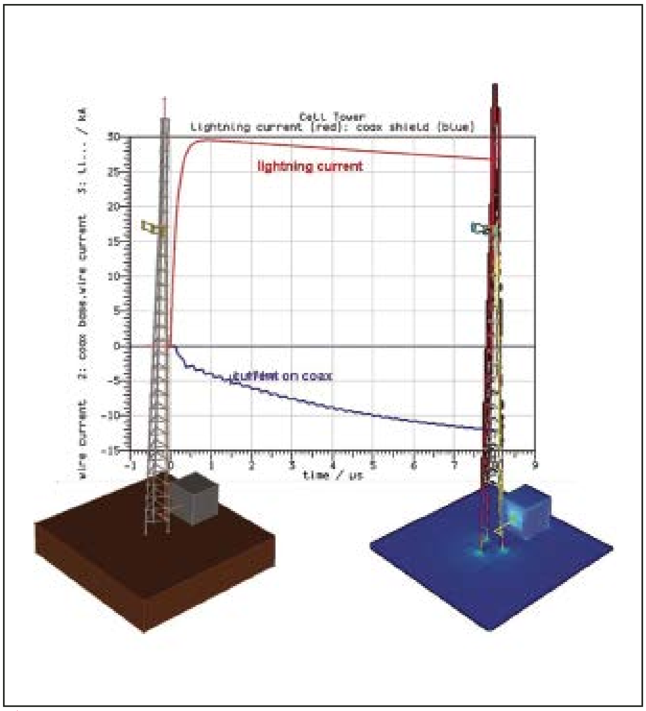
Not only does this provide a much more representative source for the system level calculation, it also allows the complex distributed source characteristics of PCBs to be included in larger system level models without having to model the details of the PCB, thereby making the simulation highly efficient.

This compact source technology can also be used directly within the simulation software, enabling designers to capture the response of an antenna and then use that response to drive an installed environment calculation. Once calculated, the compact source can be used time and time again without having to recalculate the characteristics. As such, the computational efficiency of simulations looking at antenna placement or radome effects can be dramatically improved.

As with the integration between MicroStripes and Microwave Office, this link with PCB-specific analysis tools such as PCBMod from SimLab, positions Version 7.5 firmly within the electronics EMC design flow. This allows designers to assess EMC issues much earlier in the product development process, making EMC a design issue rather than purely an end of design process test and measurement issue.

EMI

The ability to model for EMI issues is becoming increasingly important, especially for organizations in-



▲ *Fig. 4 Lightning strike analysis on a mobile phone antenna mast.*

volved in the military and aerospace sectors. The requirements being placed on electronic equipment means that they now have to assess their products for issues such as EMP and lightning. Both of these are time domain-based transient effects and the TLM solver technology used within Version 7.5 lends itself very effectively and efficiently to the solution of these problems. ***Figure 3*** illustrates how the time domain-based TLM method allows transient issues such as ESD to be efficiently simulated.

Typically, within a time domain-based solution, an impulsive excitation is used which allows a wide band frequency domain analysis to be very efficiently performed. This impulsive excitation effectively gives a constant amplitude excitation across the frequency band of interest. However, transient issues such as EMP and lightning are not impulsive in nature because they typically have a double exponential style of waveform. ***Figure 4*** demonstrates lightning strike analysis on a mobile phone antenna mast.

As such, with transient issues, the ability to be able to excite the model with the correct waveform is crucial as this then ensures that the calculated results will be representative. Within the MicroStripes solution, it is possible for the user to define their own time domain waveforms and attach them to the sources in the model.

By driving the simulation directly with the user specified waveforms, which can be created either from a series of predetermined waveforms or imported as a csv file, not only do the time domain results reflect that waveform but so do the field and surface current distributions at a specific moment in time, or at specific frequencies. This capability to perform transient analysis has been widely used for a range of different applications including EMP analysis of military vehicles and aircraft, lightning analysis of antenna masts and ships, as well as looking at ESD issues associated with electronic equipment.

CONCLUSION

The highly efficient TLM solver technology, developed over the past 30 years, remains at the core of MicroStripes 7.5 and continues to increase in efficiency, enabling users to tackle increasingly complex problems. The new and enhanced functionality within this latest version of the simulation software not only keeps the solution incredibly efficient for antenna and microwave analysis, but also allows it to be used for a greater range of EM issues such as those associated with EMC and EMI. By integrating with other leading design tools in the RF/microwave and electronics EMC design process, it is now part of a fully integrated design flow process.

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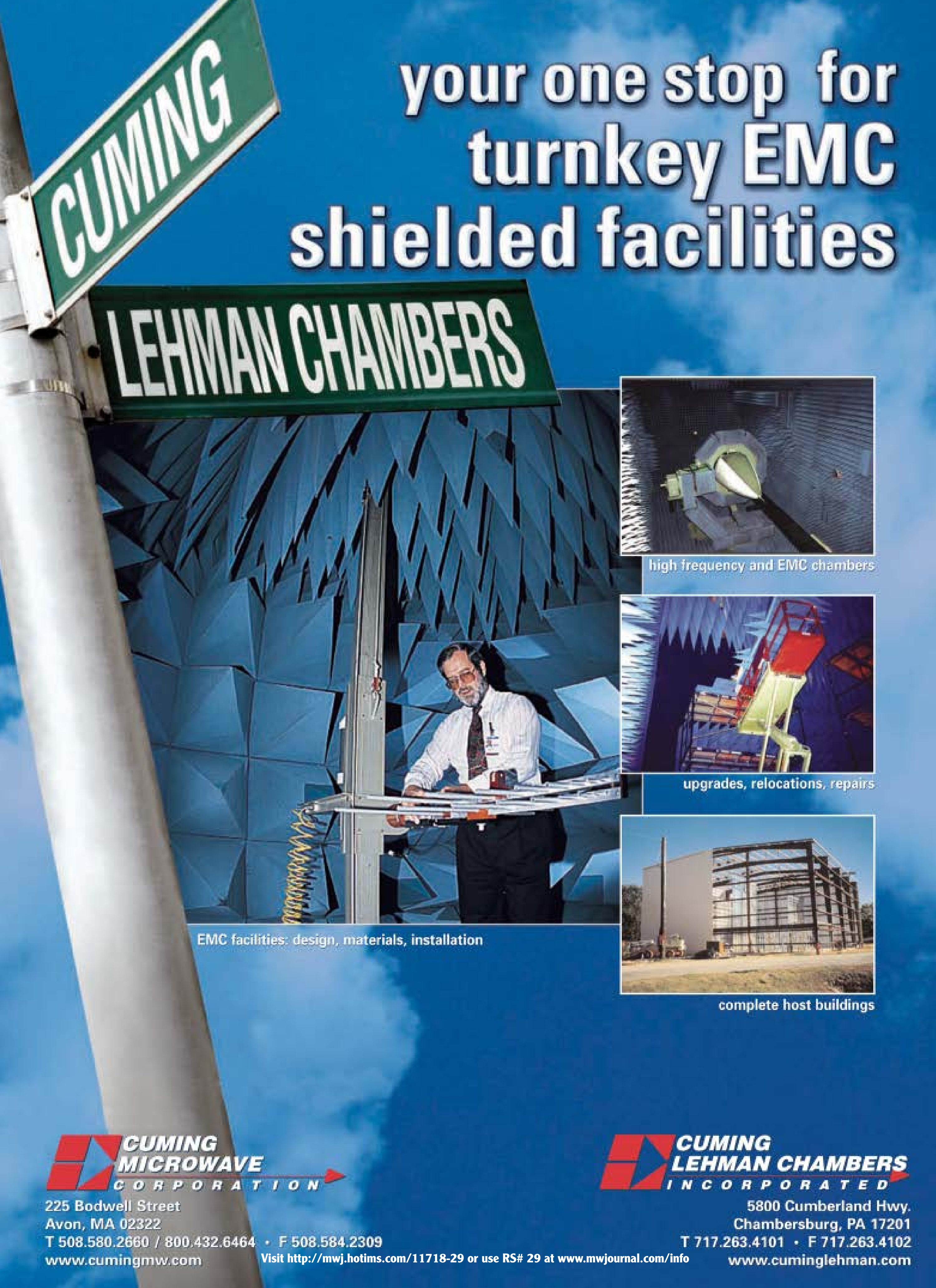
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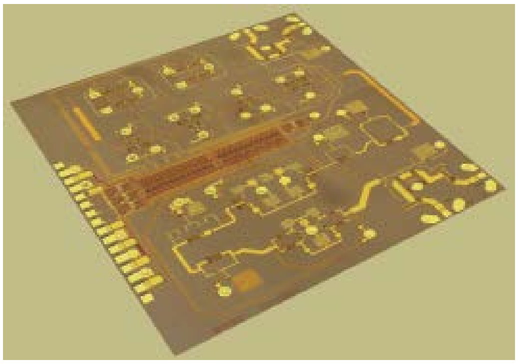
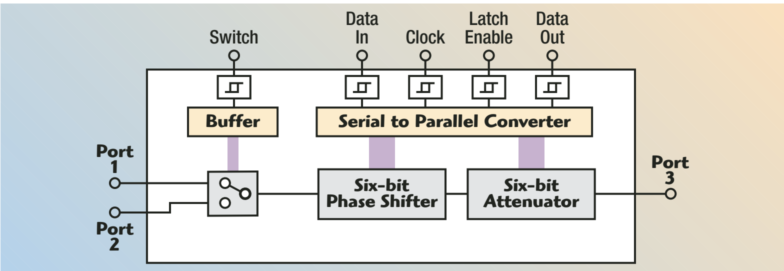


HIGHLY INTEGRATED MMIC SOLUTIONS FOR C-BAND APPLICATIONS

The technique of directing an antenna electronically rather than mechanically has been used for quite a number of years in the military domain and more recently for space applications. The numerous advantages of this technique, including lack of mechanical parts, small sized and lightweight antennas, fast positioning, beam agility, etc., has also lead to the adoption of the electronically steerable antenna or phased-array antenna to other applications. These include such diverse applications as weather radars, light radars for security, control and professional applications, radio-astronomy and in-car entertainment via satellite links.

Fig. 1 Block diagram of the CGY2175AUH device.



The technique is based on providing a correctly phased and dimensioned signal at each of the antenna dipoles forming the phased-array antenna. For this, digital phase shifters and attenuators are required along with low noise amplifiers and power amplifiers, while commutation between the transmit and receive modes is achieved by the use of RF switches.

GaAs MMICs have dominated these applications because of their superior performance. Previous generation systems have used individual MMICs for each of the functions (phase shifter, attenuator, gain block, LNA). However, to reduce size, manufacturing cost and weight, and to improve the cost effectiveness of the module, it is now necessary to move to fully integrated MMICs that include most or all of the above RF functions.

INTEGRATED SOLUTION

A typical block diagram is shown in ***Figure 1***, where the three-port MMIC has a common

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port and receive/transmit ports that are configured with the on-chip RF switches. All ports are matched to 50 Ω in all configurations. The low noise and power amplifiers are separate MMICs, which provide maximum performance while maintaining an optimum level of integration and flexibility. The positioning of the gain blocks in the system depends on the overall requirement in terms of linearity, output power, noise figure and power consumption.

To address these requirements OMMIC has developed the CGY2175AUH (Control Functions) and CGY2178UH (LNA), which are standard products that have been designed for phased-array applications in C-band (4.5 to 6.5 GHz). Both are manufactured using the company's ED02AH 0.18 µm PHEMT GaAs technology that provides excellent noise figure for the LNA, high gain and linearity for amplifiers, and good isolation for the switches, along with low loss for the phase shifters and attenuator.

DIGITAL INTERFACING

While classic D-mode GaAs technologies can provide solutions to the RF part of the control function MMIC, there is still the problem of interfacing to this MMIC, that is, providing the digital signals that will control the attenuator and phase shifter and possibly the switches. With a classic parallel interface, a MMIC with 6-bit phase shifting and 6-bit attenuation will require a minimum of 12 bits and up to 24 bits of parallel data with one bonding pad per bit, together with additional bonding pads for switch control, DC supply and RF interfacing.

These constraints make such a MMIC impractical for measurements, requiring many bonding wires, and would likely increase the size of the module compared to discrete solutions due to the need to get the large number of interfacing lines to the MMIC.

However, the solution considered here uses on-chip serial in, parallel out (SIPO) conversion that eliminates the requirement for a large number of bonding pads. The digital interfacing of the CGY2175AUH requires only three bonding pads for the digital interface : one for the Serial Data, one for the Clock and one for Latch Enable. The MMIC buffers then latch the data into on-chip registers where it is stored and used to control the state of the phase shifters and attenuators. The data that has been clocked through the registers is also buffered, is available at a bonding pad and can be used to further simplify the system architecture by allowing the cascading of a number of MMICs controlled by the same serial data stream. ***Figure 2*** shows a detailed photograph of the digital portion of the CGY2175AUH.

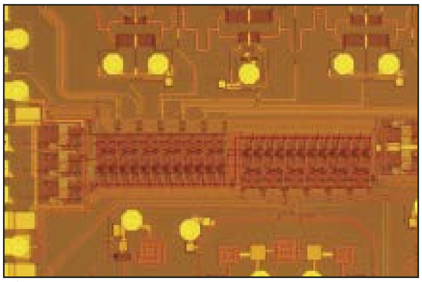

Fig. 2 The digital portion of the CGY2175AUH.

The RF switch is actuated by a separate, buffered, control line to allow very high speed switching between the transmit and receive modes (10 ns). However, this could also be integrated into the serial data for other applications. Also, the clocking speed capability of the SIPO is over 100 MHz.

THE TECHNOLOGY

The integration of the digital function with the RF circuits on the same MMIC is key to obtaining a highly integrated solution and to simplifying the interfacing to the MMIC, thereby reducing overall size and complexity, and obtaining a cost-effective solution.

To address these issues OMMIC's ED02AH commercial foundry process combines a high performance (f_t > 60 GHz) PHEMT depletion mode (negative V_t) transistor with an enhancement mode (positive V_t) transistor in the same integrated circuit. The depletion mode transistor is ideal for the RF functions, while the positive voltage only enhancement transistor can be used to make dense, low power consumption, robust and high yield digital circuits.

This technology, which is fully released and utilized for space flight level equipment, is used from 1 GHz to over 40 GHz and particularly for the C-band CGY2175AUH. The technology uses gold bonding pads and backside metallization and is fully protected with silicon nitride passivation to obtain the highest level of reliability.

CIRCUIT PERFORMANCE

The CGY2175AUH is a high performance three-port, 6-bit core chip GaAs MMIC operating in the C-band. It includes a 6-bit phase shifter, a 6-bit attenuator and T/R switch. As

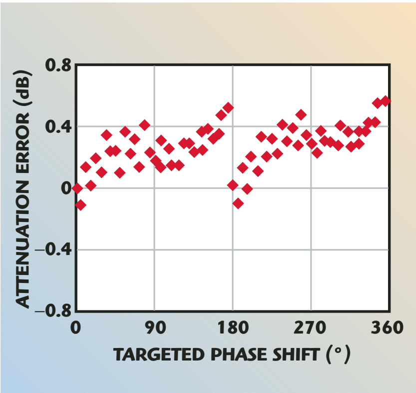

Fig. 3 Attenuation error versus phase shift at 5.4 GHz.

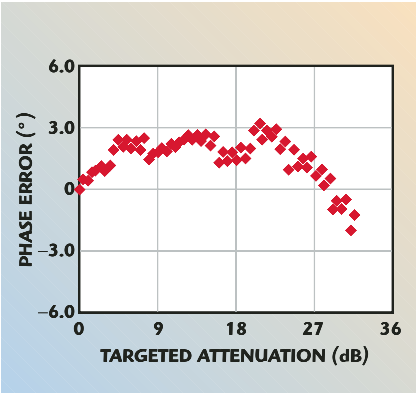

Fig. 4 Measured phase error versus attenuation shift at 5.4 GHz.

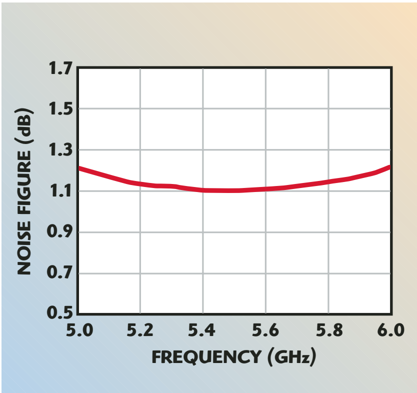

Fig. 5 Measured noise figure versus frequency (CGY2178UH).

has been mentioned, the on-chip series in, parallel out conversion of the control data minimizes the number of bonding pads and greatly simplifies the use of the CGY2175AUH compared to other devices without this capability.

A separate on-chip high speed buffer allows a very fast 10 ns switching time between transmit and receive modes. The total power consumption of the MMIC, including Schmidt triggers for signal integrity, buffering, latches and level shifting is less than 100 mW. Furthermore, the MMIC is less than 18 mm² and is delivered as a tested, inspected known good die (KGD).

The CGY2175AUH has a phase shifting range of 0° to 360° and an attenuation setting range of 31.5 dB. It covers the frequency range from 4.5 to 6.5 GHz. The loss between input and output pads is typically 11.5 dB and the input and output matching (any port, any state) is better than –14 dB. Significantly, the phase and attenuation errors are very small: 1.5° and 0.2 dB, respectively (RMS values). The phase setting and amplitude setting errors are also very good and are typically better than ±3° and –0.2 to +0.7 dB, respectively. The performance of the MMIC at 5.4 GHz is shown in ***Figures 3*** and ***4***.

A key consideration is to achieve good RF isolation on the chip so as to isolate the transmit/receive channels and prevent cross talk on the chip that would introduce errors, particularly for the high attenuation levels. The CGY2178AUH satisfies these criteria as the isolation of the switch is typically better than 40 dB and the error on amplitude and phase remains good even with the full 31.5 dB of attenuation setting (see Figure 4). The worst-case output 1 dB compression point is better than 20 dBm for the nominal attenuation setting.

The CGY2178UH is a high gain, low noise figure MMIC amplifier designed for use with the manufacturer's integrated core chip MMIC family or as a general purpose low noise amplifier for C-band applications.

The device has all biasing, decoupling and output matching networks on chip, yet uses a very simple external matching circuit to provide good input matching (≤–15 dB) and low noise figure (typically 1 dB) between 5 and 6 GHz, as shown in ***Figure 5***. The on-chip output matching network gives a better than ≤–15 dB match. The use of the advanced 0.18 µm gate length PHEMT process contributes to the very low noise figure, along with very high gain (typically 30 dB) and low power consumption (40 mA at 3 V) in a small surface (1.5 × 1.4 mm). The output 1 dB compression point is of the order of 15 dBm.

CONCLUSION

High integration alone in a MMIC is not the solution to obtaining higher performance circuits. It is also necessary to simplify the use of the IC. In the case of the CGY2175AUH the inclusion of an on-chip digital circuit and the SIPO function, while at the same time integrating several RF functions (the switches, phase shifter and attenuator), has led to the size-performance-cost-improvement that is required for today's Electronically Steerable Antennas.

As for the associated LNA—the CGY2178UH—the good noise figure (1 dB) for C-band applications is achieved by using a very simple, small external matching circuit. In this case the combination of the integrated MMIC with an off-chip network produces not only a very high performance design but also a very robust one that can be optimized in a particular bandwidth if required.

These devices can also be used as building blocks for specific custom designs where, for example, on-chip amplification is added to the Control Function MMIC and the SIPO function is expanded to include separate on-chip registers for the transmit and receive settings of the phase shifter and attenuator.

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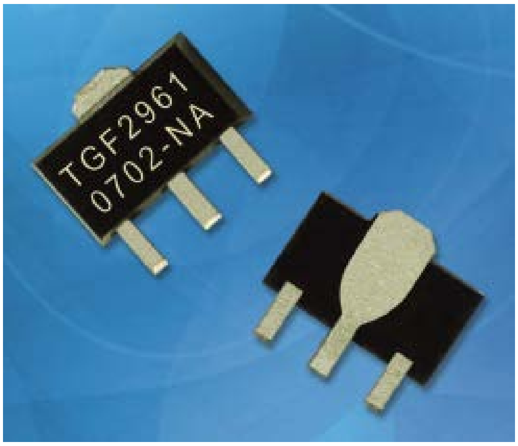


HFET TRANSISTORS WITH OUTSTANDING PERFORMANCE AND DURABILITY

Today's circuit designers are tasked with creating a high performance product that will stand out in a market crowded with competition. Yet relying on standard 50 Ω MMIC "gain block" devices makes it increasingly difficult for the RF designer to differentiate the specified performance of their radio product. One solution addressing this dilemma is found in discrete devices that have excellent performance and reliability, and can be easily optimized for an exact fit in a given application.

A heterojunction field effect transistor (HFET) is an excellent device for realizing efficient, reliable solutions with the high gain and high linearity needed by communications infrastructure manufacturers. Designers can optimize the performance of their system by using a discrete HFET transistor and enjoy the benefits of a mature and reliable GaAs process technology.

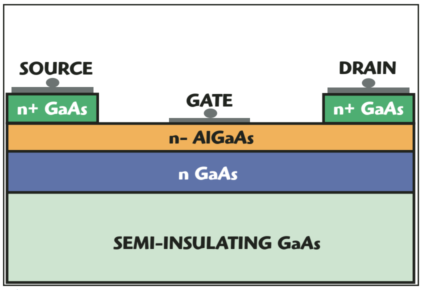
TriQuint has manufactured HFET devices for more than a decade and has optimized this GaAs process to provide industry-leading performance and durability. With a strong legacy of traditional HFET die and foundry products, the company is now creating a family of plastic-packaged products designed for use in a wide variety of end products. TriQuint's HFET GaAs process can operate with higher junction temperatures than other competitive solutions while still meeting the stringent MTTF goals that are common in applications such as cellular base stations, cable infrastructure and broadband wireless communications networks. Using the performance advantages that can be achieved with an optimized discrete transistor solution, circuit designers can now leverage the devices' key benefits to meet the demanding needs of their applications.

DESIGN BASICS

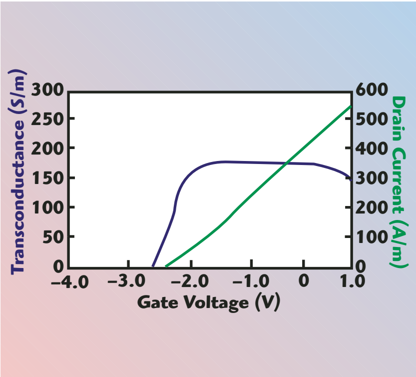
An HFET is constructed by creating a junction between two materials that have differing band-gap energies, commonly referred

TRIQUINT SEMICONDUCTOR INC.
Richardson, TX

to as a 'heterojunction.' In practice, a moderately thick layer of lightly-doped AlGaAs is placed on top of a thick layer of doped GaAs forming a heterojunction where the two layers meet (see ***Figure 1***). The HFET uses the wide band-gap AlGaAs layer effectively as an insulator. As current flows in the doped GaAs layer it is modulated by the gate situated on top of the AlGaAs layer. This structure allows HFET devices to operate at very high frequencies with high gain while providing both superior linearity and operating voltage range. The highly linear transfer characteristic of the HFET is illustrated by the flat transconductance curve of ***Figure 2***.



▲ *Fig. 1 HFET cross-sectional diagram.*



▲ *Fig. 2 Transconductance and drain current vs. gate voltage.*

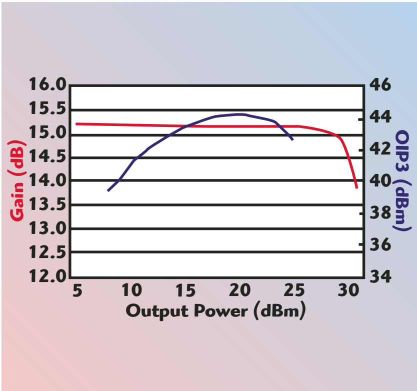
Market pressures have pushed more and more designers to use MMIC gain block devices instead of discrete parts in order to reduce time-to-market turnarounds. However, the cycle time advantage found in using these types of devices is offset by lower performance when compared to a well-optimized discrete solution. In cases where a designer is searching for the best possible performance and can afford the small amount of incremental time needed to optimize a discrete solution, the payoff can be significant. Typically, a discrete solution will be as good as or better than an MMIC solution in all RF parametric areas, and will have a significant advantage in terms of efficiency.

Characteristically high gain and excellent linearity make HFET devices a stand-out choice for highly linear applications that need to operate efficiently. Examples of such applications include use as a pre-driver or in the driver stages of cellular base station amplifiers, or as power amplifier stages for other broadband applications such as Wireless Local Loop (WLL), WiMAX, or enterprise-class WLAN access points or bridges. The high linearity and PAE of HFET devices also make them well-suited for use in downstream cable amplifiers.

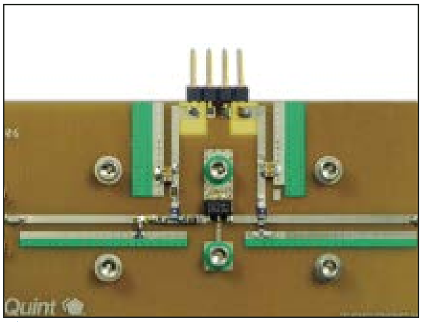
HFET devices are predecessors of the more complex PHEMT (pseudomorphic high electron mobility transistor) devices that are also available today. Compared to PHEMT, the HFET has a lower gate-source capacitance, making it easier to match due to higher input impedance. Additionally, the simplicity of the HFET structure (compared to PHEMT) means that parametric values are typically better controlled, allowing circuit designers to realize lower variances in key system performance parameters such as gain and OIP3.

TriQuint is releasing a pair of HFET transistors in industry standard SOT-89 packages. The devices' performance specifications are summarized in ***Table 1***. One product is a 0.5 W nominal (P1dB) device and the other a 1 W nominal device. Both parts achieve excellent gain for a single-stage device, approximately 20 dB maximum at 1 GHz. The devices are highly linear, with typical output third-order intercept points of 40 and 43 dBm for the TGF2960-SD and TGF2961-SD devices, respectively. As can be seen in the table, drain efficiencies as high as 62.5 percent are achievable at P1dB.

The high gain and linearity of these wideband devices across a sizeable range of output power can be seen in the performance graph shown in ***Figure 3***. This result was measured on an evaluation board that was tuned for the 2.14 GHz frequency band. The evaluation board layout can be seen in ***Figure 4***.



▲ *Fig. 3 Gain and OIP3 vs. output power.*



▲ *Fig. 4 Evaluation board layout.*

TABLE I

PERFORMANCE SUMMARY

	TGF2960-SD	TGF2961-SD	
Frequency range (GHz)	DC–6	DC–6	
Supply voltage (V_d) (V)	8	8	max
I_{ds} (mA)	100	200	typical
P1dB (dBm)	27	30	typical @ 1 GHz
Gain (dB)	20	20	max @ 1 GHz
OIP3 (dBm)	40	43	typical @ 1 GHz
Noise figure (dB)	4	4	typical @ 1 GHz

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TriQuint's 0.5 μm HFET process is widely acknowledged as extremely rugged. This depletion mode process technology is appropriate for a wide range of applications. An advantage of HFET compared to competing PHEMT technologies is the ability to operate with a higher channel temperature: up to a 175°C for a median lifetime of over 110 years. This makes it well suited for high reliability applications, or challenging thermal environments such as outdoor convection-cooled masthead amplifiers. The TGF series of discrete HFET devices is fabricated in an ISO9001 facility with 100 percent lot traceability and full statistical process control. This family of devices is treated with a surface passivation layer to ensure reliable operation in non-hermetic environments.

CONCLUSION

Engineers looking to wring the last dB of performance from a design in order to differentiate their product from the 'pack' should consider the robust performance offered by TriQuint HFET devices. A discrete solution will typically function as well or better than an MMIC design in all RF parametric areas while providing a significant efficiency advantage.

Heterojunction FET devices have a number of appealing characteristics for a wide range of communications applications. They can operate to very high frequencies, have excellent gain and linearity over the entire frequency range, and operate very efficiently. HFETs are dependably robust and are able to operate reliably in challenging thermal environments. Compared to competing PHEMT technologies, the HFET typically offers better MTTF reliability, higher breakdown voltages and excellent linearity.

TriQuint has a broad portfolio of HFET transistors designed with gate peripheries ranging from 1.2 to 24 millimeters. The TGA292x-SG family of high power packaged and pre-matched HFET devices are designed for specific frequency bands ranging from 2.6 to 6.0 GHz. The new general-purpose TGA2960-SD and TGF2961-SD HFET devices are designed to complement the existing product line and are both housed in Green/RoHS-compliant plastic SOT-89 packages. These devices exhibit output powers at 1 dB compression of 0.5 and 1 W, respectively. Both the TGF2961-SD 1 W device and the TGF2960-SD 0.5 W device are now available for sampling. High performance GaAs HFET devices with well-documented robustness are now easier to use than ever before, with industry standard SMT packaging and tuned evaluation boards available for commonly specified frequency bands. For more information, please e-mail: info-broadband@tqs.com.

TriQuint Semiconductor Inc., Richardson, TX (972) 994-8456, www.triquint.com.

RS No. 302

New Product Slideshow

AR RF/Microwave Instrumentation's home page now features a new product slideshow that features the latest AR products. Currently being featured is the family of 4 to 8 GHz solid-state amplifiers, the company's line of laser powered probes, the CI conducted immunity generators and the TGAR automotive transient generator system.

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

www.ar-worldwide.com

Microwave Products

This new corporate web site has been designed to enable current and potential customers, investors, job seekers and others to quickly and easily navigate through the site to find the up-to-date information they need. It features information on CPI's products, markets and divisions, as well as information about CPI as a whole. Users can also view all upcoming events, sales contacts and job openings for CPI company-wide.

CPI, Beverly Microwave Division,
150 Sohier Road,
Beverly, MA 01915

www.cpii.com

3D Electromagnetic Field Simulation Software

This recently updated web site features the company's 3D electromagnetic (EM) field simulation software for high frequency applications. New additions to the site include: Web-based videos demonstrating the state-of-the-art 3D EM simulator CST MICROWAVE STUDIO® 2006, applications articles, user forum, technical support area and downloads.

CST of America® Inc.,
10 Laurel Avenue, Suite 300,
Wellesley Hills, MA 02481

www.cst.com

Components and Subsystems

Endwave's innovative components and subsystems enable the transmission, reception and processing of RF, microwave and millimeter-wave signals in next generation wireless communications networks, defense and homeland security systems. Featured on the company's web site are a variety of single and multi-function solutions including: JCA amplifiers, oscillators, multipliers, up/downconverters, synthesizers, transceivers, switch arrays and custom multi-function assemblies.

Endwave Corp.,
130 Baytech Drive,
San Jose, CA 95134

www.endwave.com

ICs, Modules and Subsystems

This comprehensive, versatile web site has recently added new product pull-down menus and RoHS-compliant component pages. The web site details full specifications for over 480 products, application notes, quality assurance and product support tools including Product Cross Reference, Parametric Search, PLL Phase Noise and Mixer Spur Chart Calculators, and expanded e-commerce. The company's new Designer's Guide, product selection guide, newsletter and CD can also be requested from the site.

Hittite Microwave Corp.,
20 Alpha Road,
Chelmsford, MA 01824

www.hittite.com

RF Components and Test Systems

This completely revamped web site features the company's passive RF components and application specific test systems. A browser will find a completely new navigation and make it a snap to find RF products. Browse or download the company's latest catalog, download the free RF conversion tool and view the latest products from the new site. Learn about JFW's custom design capabilities and buy selected RF products on-line.

JFW Industries Inc.,
5134 Commerce Square Drive,
Indianapolis, IN 46237

www.jfwindustries.com

● Accessory Products

This web site features the company's accessory products for the electrical test of advanced semiconductor devices and packaging products, plus articles, data sheets and presentations on precision probing for non-coplanar test structures through precision low cost thin film network (TFN) "adapters," ProbePoints, and affordable microprobing test fixtures, personal probe stations and manual probe stations.

J microTechnology,
3744 NW Bluegrass Place,
Portland, OR 97229

www.jmicrotechnology.com

● High Frequency Electromagnetic Software

This totally redesigned web site showcases the newly introduced SONNET® Suites Professional™ Release 11. One of many new features in Sonnet Release 11 is an industry first: Co-calibrated™ Ports, which are based on a new de-embedding technology. The site provides additional technical information on other new features such as the 64-bit EM Solver, new and improved ADS and Microwave Office interfaces.

Sonnet Software,
100 Elwood Davis Road,
North Syracuse, NY 13212

www.sonnetsoftware.com

● RF Multifunction Subassemblies and Subsystems

Microwave Concepts (Micro-Con), a division of Micronetics Inc., offers significant experience in designing some of the most complex integrated RF multifunction subassemblies and subsystems in the industry. Visit the web site for product specifications, build-to-print services and test services.

Microwave Concepts Inc.,
12 Gardner Road,
Fairfield, NJ 07004

www.micro-con.com

● Component Search Tool

Yoni2 is a component search tool on the company's web site that searches millions of actual measured data points from thousands of models in the company's database. The search function allows a user to enter parametric specifications and then outputs results, which allows engineers to quickly match a component to an application. Yoni2 currently supports searches across amplifiers, directional couplers, frequency mixers, power splitters/combiners, RF transformers, voltage-controlled oscillators and filters.

Mini-Circuits,
PO Box 350166,
Brooklyn, NY 11235

www.minicircuits.com

● Online Filter RFQ Tool

Reactel Inc. has enhanced its web site, www.reactel.com, with an on-line filter RFQ tool. Filter quotes have never been easier, and are now just a click away. Additionally, the site includes RoHS-compliant offerings and features the company's full-line of RF/microwave filters, diplexers and sub-assemblies. Reactel's product catalog and data sheets are also available for download in support of its worldwide customer base.

Reactel Inc.,
8031 Cessna Avenue,
Gaithersburg, MD 20879

www.reactel.com

● Peak Performance Site

This relaunched web site focuses on 'peak performance' that not only applies to the company's high end microwave sources such as VCOs, FMCW subsystems, synthesizers, PLLs and custom designed products, but also to how it supplies them to its customers worldwide. The web site has improved menu systems to provide easy access to the comprehensive product line and also simplifies financial transactions with customers.

Sivers IMA AB (HQ),
Torshamnsgatan 9,
Kista, Sweden

www.siversima.com

RF Microwave Materials

This new web site provides details on the company's capabilities, product groups and technical data sheets on commercially available products. The company specializes in rubber and foam absorbers, loads and dielectric materials for commercial and military applications.

Microsorb Technologies,
32 Mechanic Avenue, Unit 211,
Woonsocket, RI 02895

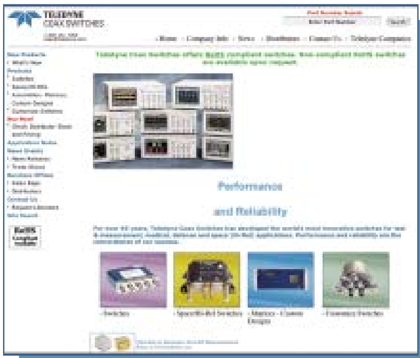
www.microsorbtech.com

Microwave Cable Assemblies

The microwave section of this site has been revised to streamline the RFQ procedure, providing improved navigation and a more informative RFQ screen. Users can also now review and update their contact information on site. These changes are part of an update program that will also bring enhanced product content to the site this fall.

Storm Products–Microwave,
10221 Werch Drive,
Woodridge, IL 60517

www.stormproducts.com/microwave

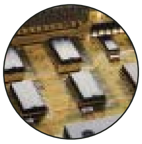


Coaxial Switches

This web site is designed to help engineers quickly obtain detailed information about standard and high reliability coaxial switches. The site, administered by Teledyne Coax Switches, offers innovative switches and matrices for test and measurement, medical, defense and space (hi-rel) applications. Design engineers can find technical information, buy products and even get e-mail responses within 24 hours.

Teledyne Coax Switches,
12525 Daphne Avenue,
Hawthorne, CA 90250

www.teledynecoax.com



COMPONENTS

100 W SPDT Switch

The model SWN-218-2DR-45068-MULTI-SPECTRAL is a SPDT reflective, solid-state

switch. It is designed to handle 100 W CW with low insertion loss over narrow bandwidths. Operating from 100 MHz to 2 GHz with an isolation of 40 dB and an insertion loss of only 1.5 dB the switch exhibits a VSWR of 2.0. The power supply provides +5 VDC at 100 mA maximum and –15 VDC at 80 mA maximum. The control is through a TTL toggle on the control pin where "0" = J1 to J2 and "1" = J1 to J3.

American Microwave Corp. Inc., Frederick, MD (301) 662-4700, www.americanmicrowavecorp.com/amc.

RS No. 216

Impedance Matching Pads

The model 851-879-FM2 is a 50 to 75 Ω impedance matching pad that eliminates imped-

ance discontinuity (mismatches) without introducing reflection to the circuit. This 1 W unit offers nominal insertion loss of 5.7 dB and VSWR of 1.40 with SMA female/F male connectors. Custom units are available in a variety of impedance and connector types from DC to 3 GHz. The company's impedance matching pads preserve signal integrity by matching virtually any transmission line.

BroadWave Technologies Inc., Franklin, IN (317) 346-6101, www.broadwavetech.com.

RS No. 217

SFP Transceiver Extraction Tool

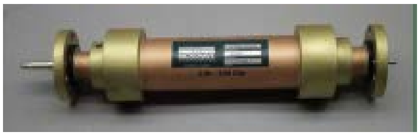
This extraction tool facilitates the removal of SFP transceivers LC transceivers from their metal

cages. These optical transceiver modules are typically equipped with an LC receptacle fully compatible with the industry standard LC connector. Thanks to its unhooking slide, the new tool enables smooth and safe removal. Customized versions provided with a label holder for easy identification are also available.

Compel Electronics SpA, Milan, Italy +39 039 61001, www.compel.it.

RS No. 219

Low Pass Filter



The model 618.0004 is a low pass filter that operates in a frequency range from 1000 to 2500 MHz. The passband is 1 to 2.5 GHz, with passband power to 1500 W, impedance of 50 ohms, insertion loss of 0.2 dB and VSWR of 1.25. Connectors are 7/8" EIA. Delivery: four weeks ARO or less if required.

Connecticut Microwave Corp., Cheshire, CT (203) 250-9678, www.connecticutmicrowave.com.

RS No. 220

SP8T Terminated RF Switch

The model M8N-542109 is a SP8T internally terminated latching switch with indicator cir-

cuitry operating from DC to 18 GHz. The low IM switch features a –130 dBc minimum third-order IM and –160 dBc minimum fifth-order IM. The M8 series is also offered as a failsafe switch along with various actuator and mounting options. Special materials allow for superior RF performance and outstanding switching characteristics across the band. The low IM specifications are available with all CEI switches. Delivery: stock to two weeks.

Charter Engineering Inc., Pinellas Park, FL (727) 525-1025, www.ceiswitches.com.

RS No. 218

Triple Output DC/DC Converter

The MWR Series™ of triple output DC/DC converters is a high density, high efficiency

product that operates over a wide input range of 14 to 50 VDC. This product can power both digital and analog systems with one converter. The 3.3 V main output with ±12 or ±15 V auxiliary outputs allows the user to power both digital (3.3 V) and analog (±12 or ±15 V) from the same converter. The MWR is also available with a 5 V main and ±12 or ±15 V auxiliaries. The MWR converters also feature an inhibit function, soft start and soft recovery. MWR converters have low output noise; typically around 0.5 percent up to 20 MHz bandwidth and high audio rejection adding up to a quiet product. The full operating temperature range is –55° to +125°C, case. The hermetically sealed case measures 1.950" × 1.350" × 0.415".

Crane Aerospace and Electronics, Electronics Group, Redmond, WA (425) 882-3100, www.craneae.com.

RS No. 221

Wideband Temperature Variable Attenuator

This wideband temperature variable attenuator (WTVA) operates in a frequency range from DC to 20 GHz. The WTVA is the newest extension of the popular Thermopad product line. The WTVA is the best to date for temperature compensation for mimics, amplifiers systems and any other subsystem that requires compensating for changes over temperature. The WTVA offers optimal performance over the entire frequency band up to 20 GHz and maximizes the amount of change of attenuation over temperature in the X-, Ku- and Ka-bands. This product is released and available now.

EMC Technology Inc., a Smiths business, Stuart, FL (772) 286-9300, www.emct.com.

RS No. 224

Hi-Q Non Magnetic Capacitors

This full line of non-magnetic, RoHS-compliant Hi-Q capacitors are available in four case

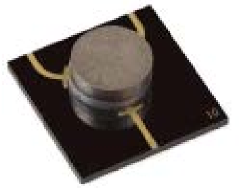
sizes: A case: 0.055 × 0.055 operational up to 300 W VDC; B case: 0.110 × 0.110 operational up to 1000 W VDC; C case: 0.225 × 0.225 operational up to 5000 W VDC; and E case: 0.390 × 0.390 operational up to 7200 W VDC. This non-magnetic series is available in two dielectric styles: 10 series (P90) or the 70 series (NPO). Products exhibit excellent performance (Q > 10,000) for non-magnetic body and surface coil applications.

Dalicap Corp./Passive Plus, Huntington Station, NY (631) 425-0938, www.passiveplus.com.

RS No. 222

Broadband X-band Circulator

The model 4CMB 10-1 is designed for the front-end of active phased array antennas in



X-band. This broadband microstrip circulator has a 40 percent bandwidth. The frequency range is 8 to 12 GHz. The insertion loss is 0.6 dB with isolation of 19 dB. The maximum VSWR is 1.30 at all ports. These units can handle 10 W of power and operate over the temperature range of –40° to +70°C. Circulators 4CMB10-1 feature compact dimensions (0.40" × 0.40" × 0.157").

Dorado International Corp., Seattle, WA (206) 574-0900, www.dorado-intl.com.

RS No. 223

500 W Flange Termination

This flange mount device dissipates 500 W while operating in a frequency range from DC

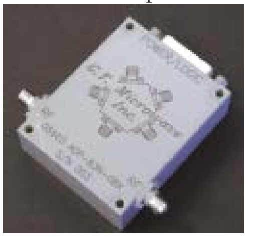
to 2.5 GHz. The termination has been tuned to achieve a maximum VSWR of 1.30, DC to 2 GHz and 1.50, 2 to 2.5 GHz. Available in Tin/Lead and RoHS-compliant versions: 32-1209 and 32A1209F. This device represents a significant increase in frequency range for a high power termination.

Florida RF Labs Inc., a Smiths business, Stuart, FL (800) 544-5594, www.rflabs.com.

RS No. 225

PIN Diode Attenuator

The model A0P-83N-0BX is a PIN diode attenuator that operates in a frequency range from 16 to 32 GHz. It is capable of a 32 dB dynamic range in monotonic 0.125 dB steps. The attenuation flatness is ±3.0 dB with a 2.0 VSWR and a 4 dB insertion loss. The attenuator is digitally-controlled via 8 bits of TTL compatible binary logic with switching speed less than 500 nsec. The attenuator handles +15 dBm CW or 1 W maximum. Size: 2" × 2.5" × 0.75".



G.T. Microwave Inc.,
Randolph, NJ (973) 361-5700,
www.gtmicrowave.com.

RS No. 226

Digital Phase Shifter

The model HMC543LC4B is a four-bit digital phase shifter that is rated for operation from 8 to 12 GHz, and provides 0 to 360 degrees of phase coverage with a LSB of 22.5 degrees. The HMC543LC4B provides a low RMS phase error of 5 degrees and extremely low insertion loss variation of ±0.8 dB across all phase states. This high accuracy phase shifter is controlled with complementary logic of 0/–3 V, and requires no fixed bias voltage. Simple external level shifting circuitry can be used to convert a positive CMOS control voltage into complementary negative control signals. This phase shifter is ideal for EW receivers, radar, satellite communications and beamforming subassemblies.

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

RS No. 227

Waveguide Low Pass Filters

The new AMQ-LP1 series of waveguide low pass filters has been designed to provide a rejection of better than 100 dB, falling to only 70 dB at band edges. The series comprises five standard parts using waveguide sizes WR340, WR137, WR112, WR90 and WR75 to deliver cut-off frequencies of 2.75, 8.15, 9.00, 10.40 and 13.50 GHz, respectively. They are particularly suited for use as transmit reject filters and are precision engineered to achieve a Chebyshev ripple response with sharp cut off, a maximum insertion loss of 0.6 dB and a minimum return loss of typically 20 dB.

Link Microtek Ltd. UK,
Basingstoke, UK +44 (0) 1256 355771,
www.linkmicrotek.com.

RS No. 228

2 to 18 GHz Power Dividers/Combiners

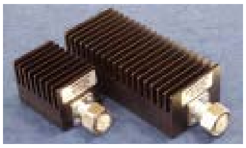
These compact, high performance Wilkinson power dividers/combiners are ideally suited for C-, X- and Ku-band systems applications. Two- and four-way SMA Female models feature high isolation, low insertion loss, exceptional VSWR and excellent phase/amplitude balance. These power dividers/combiners are available in octave bands and also broadband designs including 2 to 18 GHz. Delivery: from stock to four weeks ARO. Made in the USA.

MECA Electronics,
Denville, NJ (973) 625-0661,
www.e-meca.com.

RS No. 229

50 and 100 W Load Terminations

These high power terminations meet the low cost needs of the wireless market across the whole DC to 3 GHz band. The TB-70 (50 W) and the TB-75 (100 W) are both available with either N or 7-16 mm DIN, male or female connectors. Units have been designed using solder free mechanically stable connections and achieve a typical VSWR better than 1.10 across the whole frequency band.



Microlab/FXR,
Parsippany, NJ (973) 386-9696,
www.microlab.fxr.com.

RS No. 230

RF Terminations

The model TSM-2 is an SMA male termination that operates in a frequency range from DC to 18 GHz at 2 W and is currently overstocked. Higher power and Type N terminations are also available for immediate delivery.

Microwave Communications Laboratories Inc.,
St. Petersburg, FL (727) 344-6254,
www.mcli.com.

RS No. 232

40 GHz Terminators

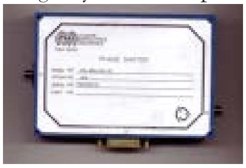
The WAMT and MSMW line of 40 GHz RF/microwave chip resistor terminators are manufactured using MSI's processes and materials to produce resistors with ultra-low parasitic capacitance and inductance. These designs were developed primarily for use in applications where the resistor terminator is placed in the same plane as the associated circuitry, thus reducing parasitic inductance and capacitance. Precision high frequency LASER trimming techniques produce superior high frequency resistors. The WAMT and MSMW line of chip resistors are offered in a 0.020" × 0.010" with resistor values from 3 to 400 Ω.

Mini-Systems Inc. (MSI),
Thin Film Division,
North Attleboro, MA (508) 695-0203,
www.mini-systemsinc.com.

RS No. 231

360° Digitally-controlled Phase Shifter

The PMI model PS-360-DC-1R Option 810 is a digitally-controlled phase shifter that operates from 8 to 10 GHz (other frequencies are available), the VSWR is 1.75 maximum and the phase accuracy is ±10°. Power handling is +20 dBm (+30 dBm survival) and this model offers a switching speed of 500 nsec and 10 bit TTL control. The size is 4.95" × 3.38" × 1.02" and power supply of ±12 or 15 V at ±100 mA.



Planar Monolithics Industries,
Frederick, MD (301) 631-1579,
www.planarmonolithicsindustries.com.

RS No. 233

Linearized Analog X-band Attenuator

The model AAT-30-479/5S is a 0 to 60 dB analog attenuator that covers a frequency range from 8 to 12.4 GHz with a maximum insertion loss of 3 dB and a maximum VSWR of 2:1. Attenuation is accomplished with a transfer function of 10 dB/V, typical. DC power required is +15 V at 100 mA. Size: 2.00 × 2.00 × 0.08.

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

RS No. 234

PCS Band Diplexer

The part number 2DP-PCS-75 is a diplexer with passbands of 1850 to 1910 and 1930 to 1990 MHz. Passband insertion loss comes in at less than 1 dB, with a passband return loss of less than 16 dB, minimum channel to channel isolation of 75 dB, and is rated for input power of up to 250 W. It has a stellar IMD performance of less than –120 dBc. This unit can come with most any RF connector and is sized at only 1.35" high × 6.5" wide × 8.7" long.

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

RS No. 235

Hermetic Switches

The RSMH (H for hermetic) series of switches offer the same dependability of the company's standard design in a truly hermetic laser welded package. All connectors and lugs are either glass-to-metal or metal-to-metal with no epoxy being used. The RSMH series switches are sealed in a dry environment and will operate at –55° to +85°C in the most severe conditions. Options include break before make, latching, pulsed latching and failsafe configurations.

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

RS No. 236

X-band Dual Conversion Receiver

This custom X-band dual conversion receiver is designed for military airborne requirements. This receiver includes an STC attenuator, low noise amplifier, RF bandpass filter, LO filters, ceramic bandpass filters in the first IF and lumped element filters in the second IF. Conversion gain is greater than 70 dB and all spurious signals are suppressed by 90 dB typical.

Rodelco Electronics Corp.,
Ronkonkoma, NY (631) 981-0900,
www.rodelcocorp.com.

RS No. 237

55 GHz Bandpass Filter

The model F55-4V is a bandpass filter with a 2 percent passband at 55 GHz. The filter assembly consists of four high-Q iris-coupled waveguide cavities with optional waveguide to coax adaptors at each end. The passband insertion loss is 2 dB. The rejection at 52.5 and 58 GHz is 30 dB minimum. The input/output connectors are 1.85 mm "V" type and are available in male or female. The orientation of the connectors can be in a "U" or "S" shape. This family of filters is available from 18 to 65 GHz.

Spacek Labs Inc.,
Santa Barbara, CA (805) 564-4404,
www.spaceklabs.com.

RS No. 238

Stainless Steel Adaptors

These *TuffGrip* adaptors are precision, high quality stainless steel adaptors that are more durable than typical nickel-plated brass adaptors. *TuffGrip* adaptors are competitively priced but made in the USA from high quality stainless steel. The Type N male and female bullet adaptors provide excellent performance to 18 GHz with exceptionally low VSWR. The 7-16 DIN adaptors are laboratory grade but designed to be rugged enough to provide long life in field applications. The coupling action on these large connectors is smooth and easy.

Times Microwave Systems,
Wallingford, CT (203) 949-8400, www.timesmicrowave.com.

RS No. 239

High Flex Cable Assemblies

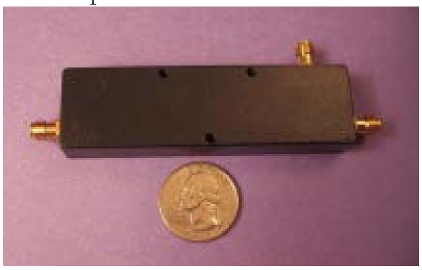
GORE™ FireWire® high flex round and flat cable assemblies provide motion control and vision systems with reliable flex life performance. These assemblies should be used to prevent lost data or data integrity issues. When reliable system performance and equipment uptime are critical, GORE FireWire high flex cable assemblies provide peace of mind. The attenuation increases significantly when these cables are flexed. GORE FireWire high flex cable assemblies maintain stable attenuation over the flex life. They are designed to meet the demands associated with motion control and vision systems. GORE FireWire high flex cable assemblies will flex with no bit errors or loss of data.

W.L. Gore & Associates Inc.,
Elkton, MD (800) 445-4673, www.gore.com.

RS No. 240

5 W Directional Coupler

The commercial grade, model XMADC5-8-2-ZS is a cost-effective directional coupler that features low insertion loss and 5 W of average power handling capability. The high directivity, directional coupler uses standard SMA connections and has a black finish. The 5 W coupler, XMADC5-8-2-ZS operates in a frequency range from 800 to 2000 MHz and offers an insertion loss of ≤ 1.8 dB based on a 6 dB unit. It has a maximum VSWR of ≤ 1.30 and an impedance of 50 Ω. Custom units are available upon request.



XMA Corp.,
Manchester, NH (603) 222-2256, www.xmacorp.com.

RS No. 241

AMPLIFIERS

High Power Amplifiers

These broadband maximally flat high power amplifiers are designed with MMIC technology, resulting in an economical and reliable solution. The model AMP800G2.5-23-35 is an 800 MHz to 2.5 GHz amplifier that features 23 dB gain with gain flatness better than ±1.25 dB. The amplifier outputs at least 2 W of power. Current draw is 650 mA from +24 V. Connectors are sma (f) and delivery is typically from stock. Other models are available that feature additional gain, different input voltages and frequency ranges.

Amplical Corp.,
Verona, NJ (201) 919-2088,
www.amplical.com.

RS No. 242

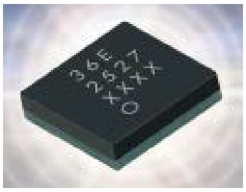
Solid-state Power Amplifier

The model BM1829-10 is a Class AB linear amplifier that operates over the full 100 to 2000 MHz frequency range; proving a minimum of 10 W over temperature and load VSWR variations. The amplifier is compact (4.0" × 2.5" × 1.35") and weighs less than 1 pound. This amplifier operates between 20 to 36 VDC for applications in mounted, dismounted and airborne systems.

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

RS No. 243

GaInP HBT Amplifier



Aimed at WiMAX applications, the MGFS36E2527 GaInP HBT amplifier module operates in the 2.5 to 2.7 GHz frequency range from a single 6 V power supply. With a footprint of just 4.5 mm by 4.5 mm and an overall height of 1 mm it is said to be the world's smallest amplifier in its class. The module provides gain of 32 dB and when used with 64 QAM it achieves good linearity up to an output power of more than 27 dBm (referring to 500 mW), while the error vector magnitude remains less than 2.5 percent.

Mitsubishi Electric Europe,
Ratingen, Germany +49 2102 4860,
www.mitsubishichips.com.

RS No. 244

ANTENNA

4.4 to 5 GHz Antennas

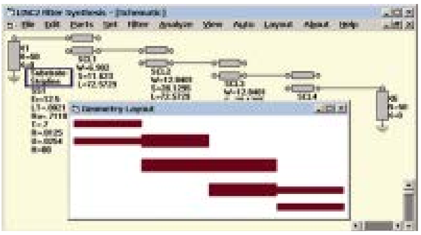
Increased interest in communication systems in the US defense frequency band 4.4 to 5 GHz (C-band) has resulted in the development of two high gain flat panel COTS antennas. The 'one-foot' FPA20-47V/1323 antenna has 20 dBi gain, 14° azimuth by 14° elevation beam pattern, and measures 225 mm square by 22 mm. The 'two-foot' FPA26-47V/1322 antenna has 26 dBi gain with 6° azimuth by 6° elevation beam pattern, and measures 600 mm square by 24 mm. These directional antennas have well defined, low sidelobe patterns for use within defense, military and homeland security applications for point-to-point single-hop data links and as the 'subscriber' in point-to-multipoint systems.

European Antennas Ltd.,
Cheveley, Newmarket, UK
+44 1638 731888,
www.european-antennas.co.uk.

RS No. 245

SOFTWARE

Filter Synthesis Software



ACS has recently released a new version of its LINC2 filter synthesis software. LINC2 Filter Pro designs lumped and distributed filters in both single-ended and differential configurations. Version 1.13 adds DXF export capability to its layout viewer for transferring layout files to other programs. LINC2 DXF layout files can be translated to Gerber format for PCB fabrication. Microstrip and stripline filters can be analyzed with the built-in circuit simulator or exported to Sonnet®'s EM simulation program for electromagnetic simulation. The wizard-like GUI quickly and effortlessly guides the user through the process of entering the specifications for the automatic synthesis of a wide variety of filters. Schematic capture and a high performance circuit simulator form the foundation on which LINC2 seamlessly integrates a comprehensive suite of circuit synthesis modules, including filter design, synthesis and layout.

Applied Computational Sciences (ACS),
Escondido, CA (760) 612-6988,
www.appliedmicrowave.com.

RS No. 246

Bipolar Amplifiers
AM-Series

FEATURES:
- .01 – 2500 MHz
- Low Cost
- Available From Stock
- Operating Temp.: -30 to +75°C

Model Number	Frequency (MHz)	Gain (dB) Min.	Gain (dB) Typ.	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	Output Power (dBm, Min.)	VSWR In/Out (Max.)	DC Power @ 15 to 30 VDC (mA, Nom.)
AM-1607-1000	.01 – 1000	40	41	0.75	3	12	2:1	110
AM-1607-2000	.01 – 2000	40	41	1	3	9	2:1	110
AM-1607-2500	.01 – 2500	40	41	1.5	3.2	7	2:1	110
AM-1616-1000	.01 – 1000	20	21	.5	3.2	12	2:1	60
AM-1616-2000	.01 – 2000	20	21	.75	3.2	9	2:1	60
AM-1616-2500	.01 – 2500	20	21	1	3.2	7	2:1	60

3 YEAR WARRANTY

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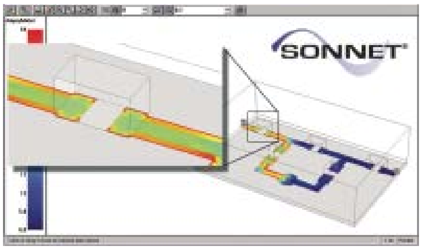
Visit http://mwj.hotims.com/11718-81 or use RS# 81 at www.mwjournal.com/info

High Frequency EM Simulation Software



The newly released Sonnet® Suites Release 11 offers perfectly calibrated internal ports that can be used for highly accurate attachment points for active or passive components. These Co-calibrated™ Ports enable full co-simulation within the EM analysis environment. Release 11 also includes a totally redesigned Agilent ADS Interface with a new GUI interface and a new 64-bit EM analysis engine.

Sonnet Software,
North Syracuse, NY (315) 453-3096,
www.sonnetsoftware.com.

RS No. 247

SERVICE

Electroless Plating Technology

The electroless nickel/gold plating technology is designed for low temperature co-fired ceramic (LTCC). This new process offers an alternative path to manufacture lower cost and high reliability components. The process offers the following features: wire bondable; solderable; 1,000 hour HTSL at 150°C on assembled product; HTSL = high temperature storage life; electroless nickel per MILC26074E; and electroless gold per MILG45204C.

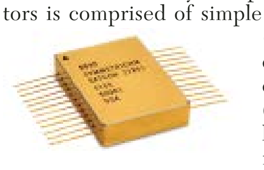
Barry Industries,
Attleboro, MA (508) 226-3350,
www.barryind.com.

RS No. 248

SOURCES

Hybrid Space Crystal Oscillators

The 9900 series of hybrid space crystal oscillators is comprised of simple clock oscillators (XO), voltage-controlled crystal oscillators (VXCO) and higher performance temperature compensated crystal oscillators (TCXO).



Based on proven designs and manufacturing techniques for high reliability in numerous space applications, the hybrid oscillators provide high performance and a wide range of output frequency with exceptional stability in a ruggedized, low power, lightweight package. The 9900 series comprises the models 9920, 9940 and 9960, providing the following features: 10 MHz to 1.2 GHz output frequency, MIL-PRF-38534 Class H or K Certified, fixed frequency and voltage-controlled, sine wave, PECL outputs and low aging and phase noise.

Symmetricom Inc.,
San Jose, CA (978) 232-1422,
www.symmetricom.com.

RS No. 250

Low Phase Noise Synthesizers

The MTS3000DS series of high performance, low phase noise synthesizers with 1 Hz resolution are designed for use as signal sources and generators in high end receive and transmit systems, TV and radio transmitters as well as test equipment.

Programming the synthesizer is made easy by a standardized interface via I2C, SPI, RS232 and optionally Ethernet. Only a single 12 V supply is required and different Reference options like TCXO or OCXO are available. System integration is as easy as plug-in as it comes standard in cassette that fits into 19" housings. The first product released to production covers the frequency range from 350 to 1050 MHz. Other frequency ranges from 5 MHz to 6 GHz are available based on Synergy's wideband VCO range.

Synergy Microwave Corp.,
Paterson, NJ (973) 881-8800,
www.synergymwave.com.

RS No. 251

Coaxial Voltage-controlled Oscillator

The model ZX95-3146+ is a coaxial SMA voltage-controlled oscillator (VCO) that features 5 V tuning for PLL integrated circuits (IC) and operates in a frequency range from 3000 to 3110 MHz.

This VCO offers high power output, +9 dBm typical, low phase noise, –144 dBc/Hz at 1000 kHz and low pushing. Applications include: R&D, lab, instrumentation and wireless communications. This model is RoHS-compliant in accordance with EU Directive. Price: $44.95 each (1–9).

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

RS No. 249

C-band Oscillator

The model CLV6115A-LF is a lead-free, RoHS-compliant oscillator in extended C-band (5940 to 6308 MHz) featuring low phase noise performance of –85 dBc/Hz at 10 kHz offset.

The unique design offers superior harmonic suppression of –20 dBc with a typical tuning sensitivity of 105 MHz/V. It is designed to operate at 8 VDC supply while drawing 23 mA (typical) over the extended operating temperature range of –40° to 85°C. The model CLV6115A-LF is ideally suited for applications that require low phase noise performance at microwave frequencies. Size: 0.50" × 0.50" × 0.22". Price: $24.95/VCO (five pcs min). Delivery: stock to four weeks.

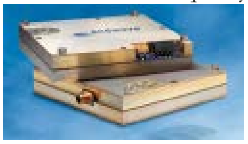
Z-Communications Inc.,
San Diego, CA (858) 621-2700,
www.zcomm.com.

RS No. 252

SUBSYSTEM

E-band Tx/Rx Modules

This transmit-receive module pair operates over the E-band frequency spectrum from 71 to 86 GHz. These modules enable broadband point-to-point radios to carry voice and data traffic at multi-gigabit per second rates.

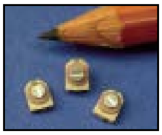


The typical performance of Endwave's transmit module includes a conversion gain of 15 dB and an output power of 16 dBm, with an integrated power detector on the Tx output. Higher-power transmitter options are also available upon request. Endwave's E-band receiver provides a noise figure of 9 dB, better than 25 dB of RF-to-IF conversion gain, and an input one dB compression point (P1dB) of –25 dBm. Separate models cover the 71 to 76 GHz and 81 to 86 GHz operating bands. Both Tx and Rx use an MLMS™ sub-harmonic mixer topology that provides a single level of conversion direct from E-band to IF.

Endwave Corp.,
San Jose, CA (408) 522-3100,
www.endwave.com.

RS No. 253

McQ512 Trimmer Capacitor



Tusonix's smallest Miniature All-Ceramic Surface Mount Trimmer Capacitor - the McQ 512 Series - is offered in an incredibly compact size for those applications that demand high Q and space-saving solutions. The state-of-the-art McQ 512 Trimmer is perfect for an endless variety of applications that require miniaturized capacitance trimming, including avionics apparatus, communications equipment, oscilloscopes, crystal oscillators and crystal filters.

New Product Alert!
Ceramic Coaxial Resonators

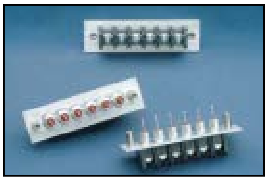
Tusonix's *New* Ceramic Coaxial Resonators are offered in three sizes and four dielectric constants with a frequency range from 800MHz to 6GHz. Our coaxial resonators are produced utilizing a proprietary metalization that provides excellent adherence and superior Q.

Typical applications include Voltage Controlled Oscillators (VCOs), Bandpass Filters, Wireless Devices and Duplexers. For more information, please visit us at www.tusonix.com.

Shoulder Feed-thru Capacitors

Tusonix is proud to offer another product that has an excellent cost/performance ratio. The UL Recognized, All-Ceramic Shoulder Feed-Thru Capacitor is finely designed to offer a very high AC/DC withstanding voltage and a working voltage up to 250Vac. With a coaxial feed-thru configuration and sturdy, solder-in design – this product is ideal for those design applications that demand space-saving solutions.

Back Plane Mount Terminal Blocks



Tusonix now offers Back Plane Mount Filtered Terminal Blocks. These cost effective, premium filtered terminal blocks provide excellent EMI/RFI filtering of power and control lines in various applications, which include telecommunications equipment and instrumentation. Available with 2-8 lines, our back plane mount terminal blocks (part no. 7602-551 through 7608-551) offer an effective insertion loss range from 10 MHz to 10 GHz. The capacitance range is 2000 pF to 5000 pF with a temperature range of -55°C to +105°C. And, each terminal block is tested for key parameters in efforts to ensure reliability.

Visit us at www.tusonix.com for part information and sales offices.

Visit http://mwj.hotims.com/11718-126 or use RS# 126 at www.mwjournal.com/info

SYSTEMS

Point-to-Point Data Link

The SENCITY® Link is an easy to install point-to-point data link for bridging distances of up

to 800 m. Designed for wireless broadband mm-wave communication, the link operates at a frequency of 60 GHz with a net data rate of 100 Mbps full duplex over a distance of up to 800 m. Measuring 16 by 16 cm its compact size is due to deep integration of its active and passive components and its ease of installation is facilitated by the simplicity of an optical pointing and alignment bracket. Applications include enterprise and campus connectivity, disaster recovery, fiber backup, replacement or extension, and high capacity internet protocol backhaul for emerging IP cellular and WiFi/WiMAX deployments.

Huber + Suhner AG,
RF Technology,
Herisau, Switzerland
+41 (0) 71 353 4111,
www.hubersuhner.com.

RS No. 255

Gigabit Ethernet Platform

The Horizon Compact integrates and enhances the functionality of traditional wireless indoor

and outdoor units in a single, native Gigabit Ethernet microwave transmission system. The Horizon Compact enhances the value proposition with 800 Mbps full duplex capacity at lower capital and operational costs for enabling Carrier Ethernet services. Horizon Compact will operate in the 11 to 38 GHz licensed radio frequencies, ensuring interference-free performance for wireless Carrier Ethernet traffic. This solution provides scalable, low latency, wire-speed native Gigabit Ethernet connectivity up to 800 Mbps. The system is extremely easy to deploy and manage, with a full suite of network-management options. Horizon Compact supports 50-ms switching and 99.999-percent service availability over point-to-point, ring and mesh network topologies.

DragonWave Inc.,
Ottawa, Canada (613) 599-9991,
www.dragonwaveinc.com.

RS No. 254

Placement and Bonding System

The KADETT is a high accuracy placement and bonding system especially configured for R&D laboratories, universities and pre-production environments. This semi-automatic device bonder is a flexible and open platform for accurate assembly and bonding of devices on a large variety of substrates, performing pick and place functions. A wide range of bonding processes including In-Situ Reflow, Thermo-Compression, Thermo-Sonic and Adhesive Bonding are available for forces up to 75 N. Accurate alignment is automatically achieved by a vision system which uses two independent high resolution video microscopes (chip and substrate) with a high resolution (0.1 μm) XY alignment stage.

SUSS MicroTec Device Bonder Division,
Saint Jeoire, France +33 450 35 83 92,
www.sussmicrotec.com.

RS No. 256

TEST EQUIPMENT

Test Systems

AR RF/Microwave Instrumentation has several complete test systems available that perform entire tests with just the press of a few buttons. The AS40000 Radiated Immunity Test System (800 to 40 GHz), for example, allows users to coordinate five amplifiers, a field monitor, two power meters, two system controllers, a signal generator and a 20-foot antenna mast with five antennas. AR also challenges users to bring them their most difficult test problems. The company has a wide variety of modules that it is able to customize with the desired power and frequency (from 10 kHz to 45 GHz).
AR RF/Microwave Instrumentation, Souderton, PA (215) 723-8181, www.ar-worldwide.com.

RS No. 257

Baseband Generator and Fader

The R&S AMU200A provides both a baseband signal generator and a two-path real time fader in a single instrument. Due to its modular design, it can also be configured exclusively as a fading simulator or as a baseband signal generator. Equipped with up to two fading simulators, the instrument can be used for channel simulation in the baseband. Features include up to 20 fading paths per channel (40 in total), time resolution of 0.01 ns, and predefined static and dynamic fading profiles. It also functions as a flexible baseband source for tests on baseband components of broadband communications equipment and generates signals for all of the important digital standards such as WLAN, WiMAX, GSM/EDGE, 3GPP FDD, HSPA and LTE.
Rohde & Schwarz GmbH & Co. KG, Munich, Germany +49 89 4129-13779, www.rohde-schwarz.com.

RS No. 258

Microwave Journal
CALL FOR PAPERS

To see one's work in print is the rightful reward of every creative engineer and scientist. The editors of *Microwave Journal* invite you to submit your technical manuscripts for consideration to be published in one of our upcoming issues. Technical articles, application notes and tutorial articles based on the monthly editorial themes are encouraged. Editorial themes include wireless, radar and antennas; RF components and systems; test, measurement and CAD; amplifiers and oscillators; semiconductors, MMICs and RFICs; satellite and mm-wave applications; communications and wireless applications; passive components; and control devices and modulation.

Design features should contain new and innovative technical ideas of practical use and interest to our predominantly engineering readers. Papers should be 14 to 16 double-spaced pages and contain 8 to 12 visual aids in the form of sketches, graphs, photographs or tables.

Papers should be submitted to the attention of the Technical Editor and will be reviewed promptly by our Editorial Review Board prior to acceptance. Articles outside of the monthly themes also will be encouraged.

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NEW LITERATURE

PRODUCT DATA SHEET

This data sheet provides complete detail on the company's 2 to 18 GHz miniature PIN diode absorptive switches with built-in TTL drivers. Product photographs, specifications for each model and optional screening information are also provided.

Advanced Control Components Inc.,
Eatontown, NJ (732) 460-0212,
www.advanced-control.com.

RS No. 200

WIMAX POSTER AND BROCHURE

Agilent now has available a new poster and brochure. The wall poster is designed as a reference tool to help engineers understand the evolving communication standard by describing detail and contrasting fixed and mobile WiMAX technologies. The eight-page full-color brochure describes Agilent's portfolio of design and test solutions for WiMAX covering the entire lifecycle from R&D, design verification & pre-conformance, conformance, manufacturing and installation & maintenance.

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

RS No. 201

DATA ACQUISITION HANDBOOK

The 220+ page data acquisition handbook, "Understanding New Developments in Data Acquisition, Measurement, and Control," is a practical guide to high performance test and measurement and is available for no charge at http://www.ggcomm.com/Keithley/MAR07DAQ_NR.html. The handbook is divided into nine sections that discuss issues influencing the selection of data acquisition and control equipment. The handbook also includes three appendices, including selector guides for plug-in boards, USB modules, PXI systems, and external data acquisition instruments, a glossary of commonly used terms, and a discussion of safety considerations.

Keithley Instruments Inc.,
Cleveland, OH (800) 688-9951,
www.keithley.com.

RS No. 203

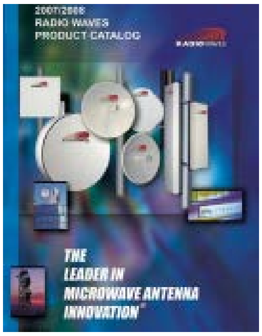
DESIGNER'S GUIDE

The 12th edition Designer's Guide catalog for 2007 includes full specifications for 482 components, 91 new RFIC and MMIC product data sheets, quality/reliability, application and packaging/layout information. New for 2007 the two-volume catalog format now includes: Volume 1: Amplifiers, Control Devices & Power Detectors; and Volume 2: Data Converters, Frequency Generation, Mixers & Modulators. To request a 2007 catalog two-volume set, visit www.hittite.com and select the "Submit Inquiry" button.

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

RS No. 202

PRODUCT CATALOG

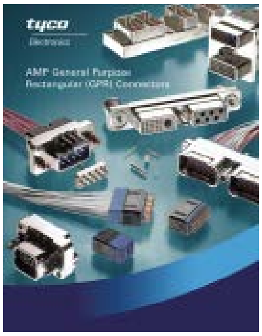


The 2007/2008 product catalog includes new products such as the company's complete family of WiMAX antennas, new sector antennas for 3.5 GHz fixed wireless networks, new 4.9 GHz series antennas for public safety, new high performance parabolic antennas for 5 GHz and new high frequency licensed band antennas. For a complimentary copy, please e-mail: sales@radiowavesinc.com.

Radio Waves Inc.,
N. Billerica, MA (978) 459-8800,
www.radiowavesinc.com.

RS No. 204

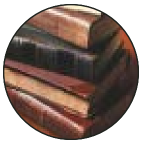
CONNECTORS CATALOG



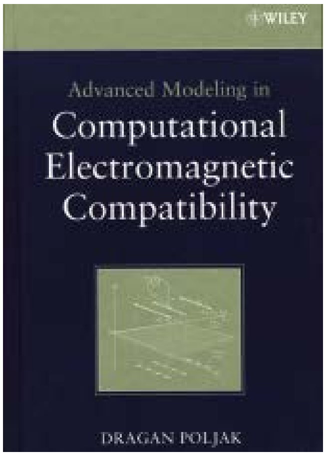
This catalog features the company's AMP general purpose rectangular (GPR) connectors that are high density connectors typically used in aerospace and defense electronics. The rectangular nature and integral mating mechanism make the packaging density of GPR connectors higher than similarly equipped circular MIL connectors. The 25-page catalog provides detailed information on the four shell sizes that GPR connectors are available in, as well as the wide range of shell inserts and contact arrangements.

Tyco Electronics Corp.,
Harrisburg, PA (800) 522-6752,
www.tycoelectronics.com.

RS No. 205



Advanced Modeling in Computational Electromagnetic Compatibility



Dragan Poljak
Wiley Interscience • 514 pages; $125
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Electromagnetic compatibility (EMC) is the applied discipline within the science of electromagnetism including almost all relevant areas of theoretical (computational) and experimental electromagnetics. Theoretical methods in electromagnetics can be classified as analytical or numerical and this book is strictly related to the numerical methods in EMC. The book starts by providing a crash course in fundamentals of electromagnetic theory and numerical modeling, then covers a frequency and time domain wire antenna analysis, and finally deals with modeling of a broad range of EMC problems of interest. The book is divided into three parts. The first part deals with introductory topics in EMC, namely the fundamentals of electromagnetic theory, basics in numerical modeling and simple computational models in the analysis of static, quasi-static and scattering problems. The second part deals with an analysis of the wire antennas, using the frequency domain (FD) and the time domain (TD) integral equation formulation, respectively. The analysis of wire antennas in the frequency and time domain using numerical methods is presented through Chapters 7 to 9. The third part of the book deals with the solution of some specific EMC problems by means of the wire antenna theory presented in Part II. The applications of antenna models are related to above ground and below ground transmission lines, respectively, and grounding systems and the interaction of the human body with electromagnetic radiation. Chapters 10 to 12 deal with above ground and below ground cables, while the analysis of vertical and horizontal electrodes is undertaken in Chapter 13. The book contains several numerical examples pertaining to academic and real world problems.

Dielectric Resonator Antenna Handbook

Aldo Petosa
Artech House • 319 pages; $119, £66
ISBN-13: 978-1-59693-206-7

To order this book, contact:
Artech House
685 Canton St.
Norwood, MA 02062
(781) 769-9750 ext. 4030; or
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London SW1V 1HH, UK
+44 (0) 207-8750

This book brings together the rapidly growing body of knowledge on dielectric resonator antennas (DRA) into a single comprehensive volume. It serves as a good introductory text, providing detailed explanations of the modes of operation and radiation behavior of DRAs, describes the main methods of excitation and provides a thorough survey of the major advances in DRA technology. Chapter 1 begins with a brief history of DRAs, highlighting the main developments in this emerging technology. Chapter 2 introduces the three basic shapes of the DRA: hemispherical, cylindrical and rectangular, which are the most commonly used. Chapter 3 offers a brief review of coupling theory and an examination of the internal fields within rectangular and cylindrical DRAs. In Chapter 4, a survey of other DRA shapes is presented. Many of these DRAs are derived from the three basic shapes and are grouped accordingly. Chapter 5 examines the theoretical and practical lower limits of the Q-factor for cylindrical and rectangular DRAs and surveys the various techniques that have been used to enhance the operational bandwidth. Chapter 6 describes the techniques used to design low profile or compact DRAs. Chapter 7 examines DRAs designed for either circular or dual-linear polarization. Chapter 8 is devoted to DRAs that are fabricated from microwave ferrite materials for which the radiation properties can be electronically controlled by applying a magnetic field. Chapter 9 examines various configurations of linear and planar arrays of DRAs, highlights their performance and points out some of the challenges that exist. Chapter 10 considers various practical aspects associated with the fabrication and implementation of DRAs. Extensive bibliographies are given after each chapter.

IEEE MTT-S
International Microwave Symposium
Microwaves on My Mind

June 15-20, 2008
Atlanta, Georgia
www.ims2008.org

Call for Papers

The IEEE MTT-S International Microwave Symposium 2008 (IMS 2008) will be held in Atlanta, Georgia, Sunday, June 15 through Friday, June 20, 2008, as the centerpiece of Microwave Week 2008. Technical papers describing original work in research, development, and application of RF and microwave theory and techniques are solicited.

Microwave Week 2008: The IMS 2008 technical sessions will run from Tuesday through Thursday of Microwave Week. Workshops will be held on Sunday, Monday, and Friday. In addition to IMS 2008, a microwave exhibition, a historical exhibit, the RFIC Symposium (www.rfic2008.org), and the ARFTG Conference (www.arftg.org) will also be held in Atlanta during Microwave Week 2008.

Electronic Paper Submission: Technical papers for this symposium must be submitted via the IMS 2008 website, www.ims2008.org. Complete information on how to submit a paper and register for the conference, as well as other important information, can be also found at the IMS 2008 website.

Proposals Invited: Workshop (Tutorial through Expert level), Special Session (Focused and Honorary), and Panel/Rump Session proposals are invited. To suggest topics, or to volunteer to help organize or participate in a Workshop, Special Session, or Panel Session, contact the appropriate committee member listed on this page.

Atlanta, Georgia, is home to many fun and exciting activities for you and your family to experience. Visit the world's largest aquarium with eight million gallons of fresh and marine water and more than 100,000 animals from around the globe. Browse the world's largest collection of Coca-Cola memorabilia and hunt for the "secret formula" at the brand new World of Coke. Stroll through Centennial Olympic Park on your way to experience world news live on the CNN Studio Tour. Catch the latest action in MLB baseball with an Atlanta Braves game at Turner Field or experience the world's largest laser light show at Stone Mountain Park. All of these adventures and more await you on the IMS 2008 guest tour roster. For additional information please visit www.atlanta.net.

Electronic Submission Deadlines

Proposals for short courses, workshops, panels, and special sessions:	September 14, 2007
Manuscripts for review:	December 7, 2007
Final manuscripts:	March 7, 2008
All submissions must be made through the IMS 2008 portal:	www.ims2008.org

ALL SUBMISSIONS MUST BE IN PDF FORMAT **Hard copies not accepted**

The authors are responsible for formatting. Font embedding must be IEEE Xplore compatible.

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S6W2	S6W5	N6W5	6	±0.40
S7W2	S7W5	N7W5	7	-0.4, +0.9
S8W2	S8W5	N8W5	8	±0.60
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S12W2	S12W5	N12W5	12	±0.60
S15W2	S15W5	N15W5	15	±0.60
S20W2	S20W5	N20W5	20	-0.5, +0.8
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CMM1434-SM	Power Amplifier	13.5-14.5	31.0	+34.5 (Psat)
CMQ1432-QH	Power Amplifier	13.5-15.5	32.0	+32.0 (Psat)
XR1002-BD	Receiver	18.0-34.0	2.0-14.0	NF = 3.0 dB
XL1000-BD	Low Noise Amplifier	20.0-40.0	20.0	NF = 2.0 dB
XP1026-BD	Power Amplifier	27.0-32.0	22.0	+33.0 (Psat)
XP1027-BD	Power Amplifier	27.0-33.0	21.0	+36.0 (Psat)
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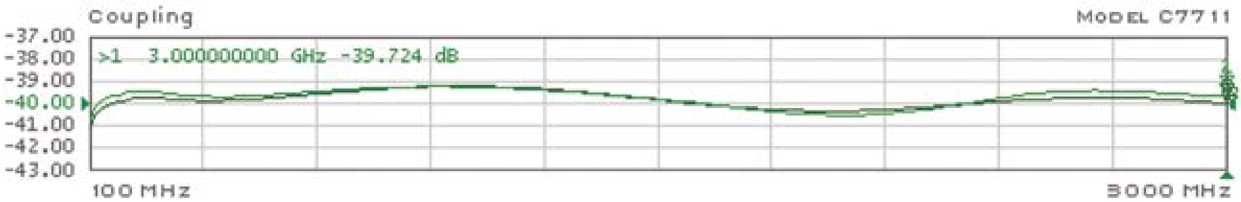

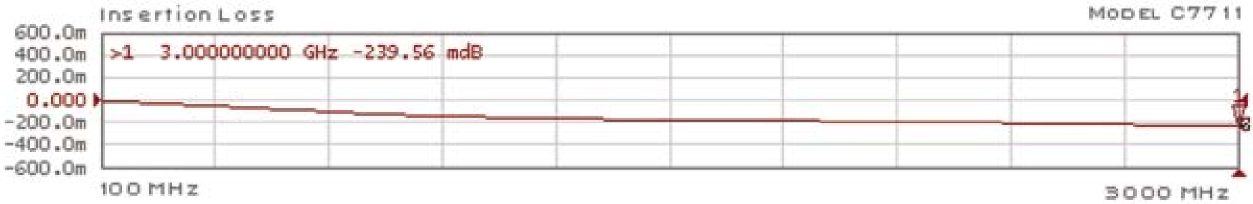

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C7148	Bi Directional	60-600	200	10	±1.0	0.35	1.20:1	20	6.0 x 4.0 x 0.75
C7711	Dual Directional	100-3000	100	40	±1.0	0.35	1.25:1	18	3.0 x 2.2 x 0.7
C7783	Bi Directional	200-1000	200	20	±0.75	0.2	1.20:1	20	3.0 x 1.5 x 0.53
C6600	Bi Directional	200-2000	200	20	±1.2	0.25	1.25:1	18	4.0 x 2.0 x 0.72
C7152	Bi Directional	300-3000	100	20	±1.0	0.35	1.20:1	15	3.7 x 2.0 x 0.75
C7811	Dual Directional	500-2500	100	40	±0.5	0.2	1.25:1	20	3.0 x 2.0 x 0.6
C7753	Bi Directional	700-4200	100	20	±1.0	0.35	1.25:1	18	1.8 x 1.0 x 0.6

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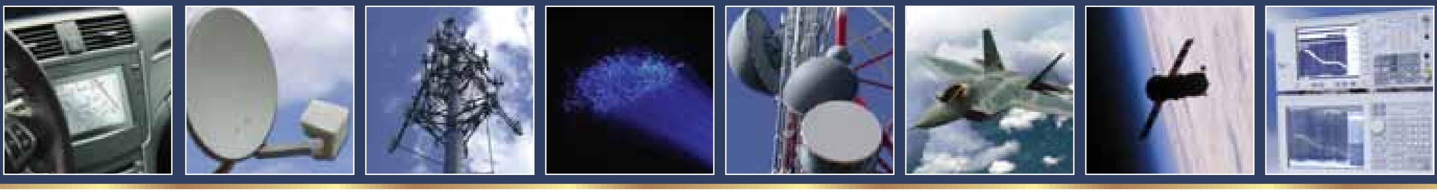

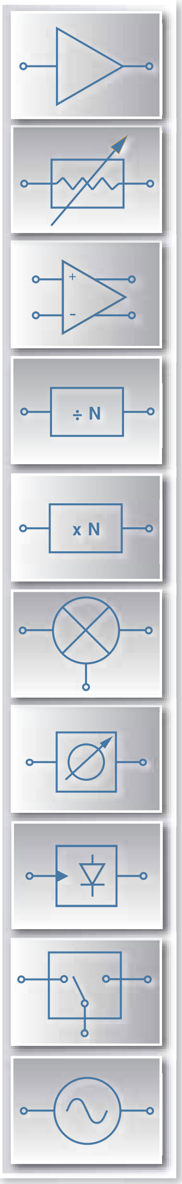

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2 - 4	Low Noise	10	36	3	21	+6V @ 100mA	LC3B	HMC594LC3B
2 - 4	Low Noise	20.5	36	3	21	+6V @ 170mA	Chip	HMC609
2 - 4	Low Noise	20.5	35	3.5	22	+6V @ 170mA	LC4	HMC609LC4
2.3 - 2.7	Low Noise w/ Bypass	20	31	1.1	17	+5V @ 74mA	LP3	HMC605LP3E
3.3 - 3.8	Low Noise w/ Bypass	19	35	1.2	16	+5V @ 40mA	LP3	HMC593LP3E
3.5 - 7.0	Low Noise	15	28	3	16	+5V @ 65mA	LH5	HMC392LH5
Broadband Gain Blocks *(Listed by P1dB Output Power)*								
DC - 4.0	HBT Gain Block	21	33	4	21	+5V @ 82mA	ST89	HMC589ST89E
DC - 1.0	HBT Gain Block	22	37	2.8	22	+5V @ 88mA	ST89	HMC580ST89E
Linear & Power Amplifiers								
6 - 9.5	Power Amplifier, 1 Watt	20	40	-	31	+7V @ 820mA	LP5	HMC590LP5E
6 - 9.5	Power Amplifier, 2 Watt	18	41	-	33	+7V @ 1340mA	LP5	HMC591LP5E
6 - 10	Power Amplifier, 1 Watt	25	41	-	31	+7V @ 820mA	Chip	HMC590
6 - 10	Power Amplifier, 2 Watt	23	43	-	33	+7V @ 1340mA	Chip	HMC591
10 - 13	Power Amplifier, 1 Watt	19	39	-	31	+7V @ 750mA	Chip	HMC592
Wideband (Distributed) Amplifiers								
2 - 20	Wideband LNA w/AGC	14	28	2.5	18	+5V @ 60mA	LH250	HMC463LH250
2 - 18	Wideband, Low Phase Noise	14	27	4.5	15	+5V @ 64mA	Chip	HMC606
2 - 18	Wideband, Low Phase Noise	13.5	27	5	15	+5V @ 64mA	LC5	HMC606LC5

FREQUENCY DIVIDERS (PRESCALERS) - CONNECTORIZED

Input Freq. (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
0.5 - 8	Divide-by-5	-15 to +10	-1	-155	+5V @ 80mA	C-1 Module	HMC-C039
0.5 - 18	Divide-by-10	-15 to +10	-1	-155	+5V @ 152mA	C-1 Module	HMC-C040

FREQUENCY MULTIPLIERS - ACTIVE

Input Freq. (MHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
4000 - 10500	Active x2	8 - 21	5	17	-139	Chip	HMC561
4000 - 10500	Active x2	8 - 21	5	14	-139	LP3	HMC561LP3E

I/Q MIXERS / IRMs - CONNECTORIZED

RF/LO Freq. (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	Input IP3 (dBm)	Package	Part Number
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	35	25	C-4 Module	HMC-C041
8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-8	28	25	C-4 Module	HMC-C042
11 - 16	I/Q Mixer / IRM	DC - 3.5	-9	30	28	C-4 Module	HMC-C043
15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	30	25	C-4 Module	HMC-C044

MIXERS

RF Freq. (GHz)	Function	IF Freq. (GHz)	Conversion Gain (dB)	LO/RF Isol. (dB)	Input IP3 (dBm)	Package	Part Number
2.3 - 4.0	High IP3, +4 LO	DC - 1.0	-10	15	35	LP4	HMC615LP4E
0.8 - 2.7	High IP3 Wideband Downconverter	0.001 - 0.6	-1	48	26	LP4	HMC334LP4E
6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	24	LH5 Hermetic	HMC144LH5
24 - 34	Sub-Harmonic	DC - 3	-11	33	13	LC3B	HMC338LC3B

POWER DETECTORS

Frequency (GHz)	Function	± 3 dB Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package	Part Number
0.001 - 8.0	Log Detector	70	-25	-61	+5V @ 113mA	LP4	HMC602LP4E
0.01 - 4.0	Log Detector	70	19	-68	+3.3V @30mA	LP4	HMC601LP4E
0.1 - 3.9	True RMS Detector	69*	37	-60	+5V @ 65mA	LP4	HMC610LP4E

***** ±1 dB Dynamic Range***

PHASE SHIFTERS - Digital

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Input (Vdc)	Package	Part Number
8 - 12	4-Bit Digital	5	22.5 to 360	40	0 / -3V	Chip	HMC543
8 - 12	4-Bit Digital	6.5	22.5 to 360	37	0 / -3V	LC4B	HMC543LC4B

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
DC - 6	SPDT, Hi Isolation	1.4	46	27	0 / -5V	G7	HMC607G7
DC - 15	SPDT, Hi Isolation	1.7	60	26	0 / -5V	Chip	HMC607
DC - 8	SP4T	2.0	45	26	0 / -5V	LC3	HMC344LC3
DC - 3.5	SP8T	1.2	36	24	TTL / CMOS	LC4	HMC253LC4
0.2 - 3.0	4x2 Matrix	6.5	43	22	TTL / CMOS	LP4	HMC596LP4E

VARIABLE GAIN AMPLIFIERS

Frequency (GHz)	Function	Gain Control Range (dB)	NF * (dB)	Input IP3 * (dBm)	P1dB (dBm)	Bias Supply	Package	Part Number
DC - 6	Digital, 0.5 dB LSB	-11.5 to 20	5.2	13	20	+5V @ 87mA	LP5	HMC625LP5E

***** Max Gain State***

VOLTAGE CONTROLLED OSCILLATORS - CONNECTORIZED

Output Freq. (GHz)	Function	Output Power (dBm)	10kHz SSB Phase Noise (dBc/Hz)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
4 - 8	Wideband VCO	20	-75	-95	+12V @ 185mA	C-1 Module	HMC-C028
5 - 10	Wideband VCO	20	-64	-93	+12V @ 195mA	C-1 Module	HMC-C029
8 - 12.5	Wideband VCO	21	-59	-83	+12V @ 195mA	C-1 Module	HMC-C030

VOLTAGE CONTROLLED OSCILLATORS WITH Fo/2 OUTPUT

Fo Frequency (GHz)	Fo/2 Frequency (GHz)	Function	Fo Output Power (dBm)	100KHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
9.5 - 10.8	4.75 - 5.4	VCO with Fo/2 & ÷4	11	110	+5V @ 350mA	LP5	HMC530LP5E
9.6 - 10.8	4.8 - 5.4	VCO with Fo/2 & ÷4	9	111	+5V @ 330mA	LP5	HMC512LP5E
11.1 - 12.4	5.55 - 6.2	VCO with Fo/2 & ÷4	9	110	+5V @ 350mA	LP5	HMC582LP5E

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Introducing The June 2007 Selection Guide!

Hittite Microwave Corporation is pleased to introduce our June 2007 Product Selection Guide summarizing over 500 products including 25 new products not included in Hittite's 2007 Designer's Guide Catalog. This selection guide organizes Hittite's portfolio by product line as well as by market applications including: Broadband, Cellular, Microwave & mmWave, Military and Space. A catalog containing full specifications for each product is available on CD-ROM and at www.hittite.com.

AMPLIFIERS

	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
	Low Noise Amplifiers								
	0.04 - 0.96	Low Noise, Dual Output	5	27	3.5	12	+5V @ 120mA	MS8G	HMC549MS8GE
	0.3 - 3.0	Low Noise, High IP3	15	37	1.5	22	+5V @ 90mA	SOT26	HMC374E
	0.35 - 0.55	Low Noise	17	35	1	21	+5V @ 104mA	LP3	HMC356LP3E
	0.7 - 1.0	Low Noise	14.5	34	1	21	+5V @ 100mA	LP3	HMC372LP3E
	0.7 - 1.0	Low Noise	15	36	0.7	21	+5V @ 73mA	LP3	HMC376LP3E
	0.7 - 1.0	Low Noise w/ Bypass	14	35	0.9	21	+5V @ 90mA	LP3	HMC373LP3E
	1.2 - 3.0	Low Noise	28	21	1.2	11	+5V @ 21mA	LP3	HMC548LP3E
	1.7 - 2.2	Low Noise	17.5	34	0.9	18	+5V @ 136mA	LP3	HMC375LP3E
	1.7 - 2.2	Low Noise	15	30	1	16	+5V @ 67mA	LP3	HMC382LP3E
NEW!	2 - 4	Low Noise	10	36	2.6	21	+6V @ 100mA	Chip	HMC594
NEW!	2 - 4	Low Noise	10	36	3	21	+6V @ 100mA	LC3B	HMC594LC3B
NEW!	2 - 4	Low Noise	20.5	36	3	21	+6V @ 170mA	Chip	HMC609
NEW!	2 - 4	Low Noise	20.5	35	3.5	22	+6V @ 170mA	LC4	HMC609LC4
	2.3 - 2.5	Low Noise	17	13	1.8	5	+3V @ 8.5mA	SOT26	HMC286E
	2.3 - 2.5	Low Noise	22	7	2.5	3	+3V @ 9mA	MS8	HMC287MS8E
NEW!	2.3 - 2.7	Low Noise w/ Bypass	20	31	1.1	17	+5V @ 74mA	LP3	HMC605LP3E
	2.4 - 2.5	Transceiver, Front End	13	10	3	5	+3V @ 24mA	MS8G	HMC310MS8GE
NEW!	3.3 3.8	Low Noise w/ Bypass	19	35	1.2	16	+5V @ 40mA	LP3	HMC593LP3E
	3.4 - 3.8	Low Noise w/ Bypass	15	18	2	7	+3V @ 9mA	LP3	HMC491LP3E
	3.5 - 7.0	Low Noise	15.5	28	2.4	16	+5V @ 50mA	Chip	HMC392
NEW!	3.5 - 7.0	Low Noise	15	28	3	16	+5V @ 65mA	LH5	HMC392LH5
	5 - 6	Low Noise	9	13	2.5	2	+3V @ 6mA	MS8G	HMC318MS8GE
	5 - 6	Low Noise	12	8	2.5	9	+3V @ 25mA	MS8G	HMC320MS8GE
	6 - 20	Low Noise	22	20	2.4	10	+3V @ 53mA	Chip	HMC565
	6 - 20	Low Noise	20	20	2.6	10	+3V @ 53mA	LC5	HMC565LC5
	7 - 13.5	Low Noise	17	24	1.8	12	+3V @ 51mA	Chip	HMC564
	7 - 14	Low Noise	17	25	1.8	13	+3V @ 51mA	LC4	HMC564LC4
	7 - 17	Low Noise	21	20	1.8	15	+3V @ 65mA	Chip	HMC516
	9 - 18	Low Noise	20	25	2	14	+3V @ 65mA	LC5	HMC516LC5
	13 - 25	Low Noise	21	13	3.5	5	+3V @ 41mA	Chip	HMC342
	13 - 25	Low Noise	22	20	3.5	9	+3V @ 43mA	LC4	HMC342LC4
	17 - 26	Low Noise	19	24	2.2	11	+3V @ 65mA	Chip	HMC517
	17 - 26	Low Noise	19	24	2.5	13	+3V @ 67mA	LC4	HMC517LC4
	18 - 32	Low Noise	15	22	2.8	12	+3V @ 65mA	Chip	HMC519
	20 - 32	Low Noise	14	24	2.8	12	+3V @ 65mA	Chip	HMC518
	21 - 29	Low Noise	13	19	3	8	+3V @ 35mA	LC3B	HMC341LC3B
	24 - 30	Low Noise	13	16	2.5	6	+3V @ 30mA	Chip	HMC341
	24 - 36	Low Noise	23	13	2.3	6	+3V @ 58mA	Chip	HMC263
	29 - 36	Low Noise	21	23.5	2.8	12	+3V @ 80mA	Chip	HMC566
	12 - 16	Medium Power LNA	23	34	2.5	25	+5V @ 200mA	LP5	HMC490LP5E

AMPLIFIERS *(Continued)*

	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
	12 - 17	Medium Power LNA	26	35	2.2	26	+5V @ 200mA	Chip	HMC490
	Broadband Gain Blocks *(Listed by P1dB Output Power)*								
	DC - 6	SiGe Gain Block	15.5	22	3	8	+5V @ 25mA	MP86	HMC474MP86E
	DC - 6	SiGe Gain Block	20	25	2.5	12	+5V @ 35mA	MP86	HMC476MP86E
	DC - 10	HBT Gain Block	15	24	4.5	13	+5V @ 56mA	Chip	HMC397
	DC - 10	HBT Gain Block	15	25	4	13	+5V @ 50mA	Chip	HMC405
	DC - 6	HBT Gain Block	17	27	6.5	14	+5V @ 50mA	SOT26	HMC313E
	DC - 8	HBT Gain Block	12	30	6	14	+5V @ 56mA	Chip	HMC396
	DC - 4	HBT Gain Block	15	28	4.5	15	+5V @ 54mA	Chip	HMC395
	DC - 6	HBT Gain Block	14.5	30	4.5	15	+5V @ 56mA	LP3	HMC311LP3E
	DC - 6	HBT Gain Block	15	30	4.5	15	+5V @ 54mA	ST89	HMC311ST89E
	DC - 4	SiGe Gain Block, +5V	22	32	2	18	+5V @ 62mA	MP86	HMC478MP86E
	DC - 4	SiGe Gain Block, +5V	22	30	3	18	+5V @ 62mA	ST89	HMC478ST89E
	DC - 5	SiGe Gain Block	14	34	4	18	+8V @ 72mA	MP86	HMC479MP86E
	DC - 5	SiGe Gain Block	15	34	4	18	+8V @ 75mA	ST89	HMC479ST89E
	DC - 5	SiGe Gain Block	20	33	3.5	19	+8V @ 79mA	ST89	HMC481ST89E
	DC - 5	SiGe Gain Block	19	34	2.9	20	+8V @ 82mA	ST89	HMC480ST89E
	DC - 5	SiGe Gain Block	20	33	3.5	20	+8V @ 74mA	MP86	HMC481MP86E
NEW!	DC - 4.0	HBT Gain Block	21	33	4	21	+5V @ 82mA	ST89	HMC589ST89E
NEW!	DC - 1.0	HBT Gain Block	22	37	2.8	22	+5V @ 88mA	ST89	HMC580ST89E
	DC - 5	SiGe Gain Block	19	36	4	22.5	+8V @ 110mA	ST89	HMC482ST89E
	DC - 4.5	HBT Gain Block	21	35	3.5	22	+8V @ 110mA	ST89	HMC475ST89E
	DC - 5	Dual SiGe Gain Block	15	34	4	18	+8V @ 75mA	MS8G	HMC469MS8GE
	DC - 5	Dual SiGe Gain Block	20	34	3.2	20	+8V @ 80mA	MS8G	HMC471MS8GE
	Driver Amplifiers								
	0.8 - 3.8	Driver	18	30	7.5	17	+5V @ 53mA	SOT26	HMC308E
	3.0 - 4.5	HBT Driver	21	36	5	23.5	+5V @ 130mA	MS8G	HMC326MS8GE
	Linear & Power Amplifiers								
	0.4 - 2.5	High IP3 Amp, 1/2 Watt	12.5	42	6	27	+5V @ 150mA	ST89	HMC454ST89E
	1.7 - 2.5	High IP3 Amp, 1/2 Watt	13	42	6	27	+5V @ 150mA	LP3	HMC455LP3E
	0.8 - 1.0	Medium Power Amp	26	40	8	26	+4V @ 310mA	QS16G	HMC450QS16GE
	1.6 - 2.2	Medium Power Amp	22	40	5.5	27	+3.6V @ 270mA	QS16G	HMC413QS16GE
	4.9 - 5.9	Medium Power Amp	20	32	6	23	+3V @ 285mA	LP3	HMC415LP3E
	5 - 6	Medium Power Amp	18	38	6	26	+5V @ 300mA	MS8G	HMC406MS8GE
	5 - 7	Medium Power Amp	15	40	5.5	25	+5V @ 230mA	MS8G	HMC407MS8GE
	5 - 20	Medium Power Amp	22	30	6.5	20	+5V @ 127mA	Chip	HMC451
	5 - 20	Medium Power Amp	19	30	7	19	+5V @ 127mA	LC3	HMC451LC3
	6 - 18	Medium Power Amp	16	32	4.5	20	+5V @ 95mA	Chip	HMC441
	6 - 18	Medium Power Amp	17	32	4.5	20	+5V @ 95mA	LC3B	HMC441LC3B
	6.5 - 13.5	Medium Power Amp	14	29	4.5	18	+5V @ 95mA	LP3	HMC441LP3E
	7 - 15.5	Medium Power Amp	16	32	4.8	20	+5V @ 95mA	LH5 Hermetic	HMC441LH5
	7 - 15.5	Medium Power Amp	16	30	4.5	19	+5V @ 95mA	LM1	HMC441LM1
	12 - 30	Medium Power Amp	16	25	7	16	+5V @ 101mA	Chip	HMC383
	12 - 30	Medium Power Amp	16	25	7.5	16.5	+5V @ 101mA	LC4	HMC383LC4
	17 - 24	Medium Power Amp	24	34	4	25	+5V @ 250mA	Chip	HMC498
	17 - 24	Medium Power Amp	22	36	4	25	+5V @ 250mA	LC4	HMC498LC4
	17 - 40	Medium Power Amp	21	26	10	18	+3.5V @ 300mA	Chip	HMC283
	17 - 40	Medium Power Amp	20	27	10	18	+3.5V @ 300mA	LM1	HMC283LM1
	17.5 - 24	Medium Power Amp	14	27	6.5	21.5	+5V @ 85mA	LM1	HMC442LM1
	17.5 - 25.5	Medium Power Amp	13	27	8	22	+5V @ 84mA	LC3B	HMC442LC3B
	17.5 - 25.5	Medium Power Amp	15	28	5.5	22	+5V @ 85mA	Chip	HMC442

AMPLIFIERS (Continued)

	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
	21 - 32	Medium Power Amp	16	33	5	24	+5V @ 200mA	Chip	HMC499
	21 - 32	Medium Power Amp	15	33	5	24	+5V @ 200mA	LC4	HMC499LC4
	0.4 - 2.2	Power Amplifier, 1 Watt	16	48	7	30	+5V @ 510mA	ST89	HMC452ST89E
	0.4 - 2.2	Power Amplifier, 1.6 Watt	14.5	50	7	32	+5V @ 725mA	ST89	HMC453ST89E
	0.45 - 2.2	Power Amplifier, 1 Watt	16	48	7	30	+5V @ 485mA	QS16G	HMC452QS16GE
	0.45 - 2.2	Power Amplifier, 1.6 Watt	14.5	50	7	32	+5V @ 725mA	QS16G	HMC453QS16GE
	1.7 - 2.2	Power Amplifier, 1 Watt	26	46	5.5	30.5	+5V @ 500mA	QS16G	HMC457QS16GE
	1.7 - 2.2	Power Amplifier, 1 Watt	12	45	6	29.5	+5V @ 300mA	LP3	HMC461LP3E
	2.2 - 2.8	Power Amplifier, 1/2 Watt	20	39	7	27	+5V @ 300mA	MS8G	HMC414MS8GE
	3 - 4	Power Amplifier, 1/2 Watt	21	40	5	27	+5V @ 250mA	MS8G	HMC327MS8GE
	3.3 - 3.8	Power Amplifier, 1 Watt	31	45.5	5.8	30.5	+5V @ 615mA	LP4	HMC409LP4E
	5.1 - 5.9	Power Amplifier, 1 Watt	20	43	6	30	+5V @ 750mA	LP3	HMC408LP3E
NEW!	6 - 9.5	Power Amplifier, 1 Watt	20	40	-	31	+7V @ 820mA	LP5	HMC590LP5E
NEW!	6 - 9.5	Power Amplifier, 2 Watt	18	41	-	33	+7V @ 1340mA	LP5	HMC591LP5E
NEW!	6 - 10	Power Amplifier, 1 Watt	25	41	-	31	+7V @ 820mA	Chip	HMC590
NEW!	6 - 10	Power Amplifier, 2 Watt	23	43	-	33	+7V @ 1340mA	Chip	HMC591
	7 - 9	Power Amplifier, 2 Watt	26	40	6.5	33	+7V @ 1.3A	Chip	HMC486
	7 - 9	Power Amplifier, 2 Watt	22	40	7	32	+7V @ 1.3A	LP5	HMC486LP5E
	9 - 12	Power Amplifier, 2 Watt	20	36	8	32	+7V @ 1.3A	LP5	HMC487LP5E
NEW!	10 - 13	Power Amplifier, 1 Watt	19	39	-	31	+7V @ 750mA	Chip	HMC592
	12 - 16	Power Amplifier, 1 Watt	13	34	9	31	+7V @ 1.3A	LP5	HMC489LP5E
	Wideband (Distributed) Amplifiers								
	DC - 20	Wideband LNA	14	28	2.5	16	+8V @ 60mA	Chip	HMC460
	2 - 20	Wideband LNA	15	26	2.5	15	+5V @ 63mA	Chip	HMC462
	2 - 20	Wideband LNA	13	25	2.5	14	+5V @ 66mA	LP5	HMC462LP5E
	2 - 20	Wideband LNA w/AGC	14	28	2.5	16	+5V @ 60mA	Chip	HMC463
	2 - 20	Wideband LNA w/AGC	13	26	3	18	+5V @ 60mA	LP5	HMC463LP5E
NEW!	2 - 20	Wideband LNA w/AGC	14	28	2.5	18	+5V @ 60mA	LH250	HMC463LH250
NEW!	2 - 18	Wideband, Low Phase Noise	14	27	4.5	15	+5V @ 64mA	Chip	HMC606
NEW!	2 - 18	Wideband, Low Phase Noise	13.5	27	5	15	+5V @ 64mA	LC5	HMC606LC5
	DC - 20	Wideband Driver	17	30	2.5	22	+8V @ 160mA	Chip	HMC465
	DC - 20	Wideband Driver	15	28	3	23	+8V @ 160mA	LP5	HMC465LP5E
	2 - 35	Wideband Driver	12	25	4	17	+8V @ 80mA	Chip	HMC562
	DC - 18	Wideband PA	17	32	3	25	+8V @ 290mA	Chip	HMC459
	DC - 20	Wideband PA	14	36	4	28	+10V @ 400mA	Chip	HMC559
	2 - 20	Wideband PA	16	30	4	26	+8V @ 290mA	Chip	HMC464
	2 - 20	Wideband PA	14	30	4	26	+8V @ 290mA	LP5	HMC464LP5E
	Connectorized Amplifier Modules								
	2 - 20	Wideband LNA	15	24	2.2	14	+12V @ 65mA	C-1 Module	HMC-C001
	2 - 20	Wideband LNA	14	26	2	18	+12V @ 60mA	C-2 Module	HMC-C002
	2 - 20	Wideband LNA	14	27	2	16	+8V @ 75mA	C-2B Module	HMC-C022
	7 - 17	Wideband LNA	22	25	2.5	14	+8V @ 93mA	C-1 Module	HMC-C016
	17 - 27	Wideband LNA	18	25	3	14	+8V @ 96mA	C-1B Module	HMC-C017
	29 - 36	Wideband LNA	20	22	2.9	11	+3V @ 80mA	C-10 Module	HMC-C027
	0.01 - 20	Wideband Driver	16	33	3	23	+12V @ 195mA	C-3 Module	HMC-C004
	0.01 - 20	Wideband Driver	15	30	3	23	+12V @ 225mA	C-3B Module	HMC-C024
	2 - 35	Wideband Driver	11	26	4	16	+11V @ 92mA	C-10 Module	HMC-C038
	0.01 - 20	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-10B Module	HMC-C036
	0.01 - 20	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-12 Module	HMC-C037

AMPLIFIERS (Continued)

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
2 - 20	Wideband PA	15	34	4	26	+12V @ 310mA	C-2 Module	HMC-C003
2 - 20	Wideband PA	14	30	4	24	+12V @ 310mA	C-2B Module	HMC-C023
2 - 20	Wideband PA	28	30	3	25	+12V @ 400mA	C-3B Module	HMC-C026
17 - 24	Wideband PA	22	33	3.5	24	+8V @ 250mA	C-10 Module	HMC-C020
21 - 31	Wideband PA	15	32	5	24	+8V @ 215mA	C-10 Module	HMC-C021
Connectorized Power Amplifier Modules - >10 Watts								
0.4 - 1.0	10 Watt PA	40	54	12	40	+12V @ 6.5A	C-7 Module	HMC-C012
0.8 - 2.0	10 Watt PA	43	56	12	40	+12V @ 6.5A	C-7 Module	HMC-C013

ATTENUATORS

Frequency (GHz)	Function	Loss (dB)	Atten. Range (dB)	Input IP3 (dBm)	Control Input (Vdc)	Package	Part Number
Attenuators - Analog							
0.45 - 2.2	Analog VVA, +V	1.9	0 to 48	20	0 to +3V	MS8	HMC473MS8E
1.5 - 2.3	Analog VVA, +V	3.3	0 to 40	15	0 to +2.5V	MS8	HMC210MS8E
DC - 8	Analog VVA	1.5	0 to 32	10	0 to -3V	MS8G	HMC346MS8GE
DC - 8	Analog VVA	2	0 to 30	10	0 to -3V	C8	HMC346C8
DC - 8	Analog VVA	2	0 to 30	10	0 to -3V	G8 Hermetic	HMC346G8
DC - 14	Analog VVA	2	0 to 30	10	0 to -3V	LP3	HMC346LP3E
DC - 18	Analog VVA	1.5	0 to 30	10	0 to -3V	LC3B	HMC346LC3B
DC - 20	Analog VVA	2.2	0 to 25	10	0 to -3V	Chip	HMC346
Attenuators - Digital							
DC - 5	1-Bit Digital	0.5	10	50	TTL/CMOS	LP3	HMC541LP3E
0.7 - 4.0	2-Bit Digital	0.5	2 to 6	52	0 / +3V	SOT26	HMC290E
0.7 - 4.0	2-Bit Digital	0.9	4 to 12	54	0 / +3V	SOT26	HMC291E
DC - 6	2-Bit Digital	0.5	2 to 6	50	TTL/CMOS	LP3	HMC467LP3E
0.75 - 2.0	3-Bit Digital	1.8	4 to 28	45	0 / +3V	MS8	HMC230MS8E
0.7 - 3.7	3-Bit Digital	1.3	2 to 14	51	0 / +3V	MS8	HMC288MS8E
DC - 6	3-Bit Digital	0.7	1 to 7	50	TTL/CMOS	LP3	HMC468LP3E
DC - 5.5	4-Bit Digital	0.8	1 to 15	48	TTL/CMOS	LP3	HMC540LP3E
0.7 - 2.7	5-Bit Digital	2.3	1 to 31	54	0 / +3V	QS16	HMC274QS16E
0.7 - 3.0	5-Bit Digital	1.3	0.5 to 15.5	48	0 / +3V	MS10	HMC603MS10E
0.7 - 3.0	5-Bit Digital	1.3	0.5 to 15.5	48	0 / +3V	QS16	HMC603QS16E
0.7 - 3.7	5-Bit Digital, Serial Control	2.1	1 to 31	48	Serial TTL/CMOS	LP4	HMC271LP4E
0.7 - 3.7	5-Bit Digital	2.1	1 to 31	48	0 / +3V	MS10G	HMC273MS10GE
0.7 - 3.8	5-Bit Digital, Serial Control	1.5	0.5 to 15.5	52	Serial TTL/CMOS	LP4	HMC305LP4E
0.7 - 3.8	5-Bit Digital	1.5	0.5 to 15.5	52	0 / +3V	MS10	HMC306MS10E
DC - 3	5-Bit Digital	2.0	1 to 31	44	0 / -5V	G16 Hermetic	HMC335G16
DC - 3	5-Bit Digital	1.3	1 to 31	45	TTL/CMOS	LP3	HMC470LP3E
DC - 4	5-Bit Digital	1.9	1 to 31	44	0 / -5V	QS16G	HMC307QS16GE
DC - 4	5-Bit Digital	0.7	0.25 to 7.75	50	TTL/CMOS	LP3	HMC539LP3E
DC - 3	6-Bit Digital	1.5	0.5 to 31.5	45	TTL/CMOS	LP4	HMC472LP4E
DC - 3	6-Bit Digital	3.0	0.5 to 31.5	32	0 / -5V	G16 Hermetic	HMC424G16
DC - 3	6-Bit Digital, Serial Control	1.2	0.5 to 31.5	45	Serial TTL/CMOS	LP4	HMC542LP4E
DC - 13	6-Bit Digital	4.0	0.5 to 31.5	32	0 / -5V	Chip	HMC424
DC - 13	6-Bit Digital	3.2	0.5 to 31.5	32	0 / -5V	LH5 Hermetic	HMC424LH5
DC - 13	6-Bit Digital	4.0	0.5 to 31.5	32	0 / -5V	LP3	HMC424LP3E
2.4 - 8.0	6-Bit Digital	3.5	0.5 to 31.5	40	0 / +5V	Chip	HMC425
2.4 - 8.0	6-Bit Digital	3.2	0.5 to 31.5	40	0 / +5V	LP3	HMC425LP3E

ATTENUATORS (Continued)

Frequency (GHz)	Function	Loss (dB)	Atten. Range (dB)	Input IP3 (dBm)	Control Input (Vdc)	Package	Part Number
Connectorized Attenuator Modules							
DC - 13	6-Bit Digital, Serial Control	3.6	0.5 to 31.5	32	Serial TTL/CMOS	C-6 Module	HMC-C018
DC - 13	6-Bit Digital	3.2	0.5 to 31.5	38	0 / +5V	C-6 Module	HMC-C025

DATA CONVERTERS

Input Freq. (GHz)	Function	Single Tone THD/SFDR (dB)	Max. Clock Rate (GS/s)	Output Noise (mV RMS)	Hold Mode Feed-through Rejection (dB)	Package	Part Number
DC - 4.5	Track-and-Hold Amplifier	-66/67	3.0	0.95	>60	LC4B	HMC660LC4B

FREQUENCY DIVIDERS (PRESCALERS) & PHASE / FREQUENCY DETECTORS

	Input Freq. (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
	DC - 8	Divide-by-2	-12 to +12	-6	-148	+3V @ 42mA	SOT26	HMC432E
	DC - 10	Divide-by-2	-15 to +10	0	-148	+5V @ 83mA	S8G	HMC361S8GE
	DC - 11	Divide-by-2	-15 to +10	0	-148	+5V @ 105mA	Chip	HMC361
	DC - 12.5	Divide-by-2	-15 to +10	2	-145	+5V @ 105mA	S8G	HMC364S8GE
	DC - 13	Divide-by-2	-15 to +10	1	-145	+5V @ 105mA	Chip	HMC364
	DC - 13	Divide-by-2	-15 to +10	5	-145	+5V @ 110mA	G8 Hermetic	HMC364G8
	DC - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 77mA	LP3	HMC492LP3E
	DC - 8	Divide-by-3	-12 to +12	-2	-148	+5V @ 67mA	MS8G	HMC437MS8GE
	DC - 4	Divide-by-4	-15 to +10	3.5	-146	+3V @ 13mA	MS8	HMC426MS8E
	DC - 8	Divide-by-4	-12 to +12	-3	-150	+3V @ 53mA	SOT26	HMC433E
	DC - 11	Divide-by-4	-15 to +10	-9	-149	+5V @ 68mA	Chip	HMC362
	DC - 12	Divide-by-4	-15 to +10	-9	-149	+5V @ 68mA	S8G	HMC362S8GE
	DC - 13	Divide-by-4	-15 to +10	2	-151	+5V @ 110mA	Chip	HMC365
	DC - 13	Divide-by-4	-15 to +10	7	-151	+5V @ 120mA	G8 Hermetic	HMC365G8
	DC - 13	Divide-by-4	-15 to +10	2	-151	+5V @ 110mA	S8G	HMC365S8GE
	DC - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 96mA	LP3	HMC493LP3E
	10 - 26	Divide-by-4	-15 to +10	-4	-150	+5V @ 96mA	LC3	HMC447LC3
	DC - 7	Divide-by-5	-12 to +12	-1	-150	+5V @ 80mA	MS8G	HMC438MS8GE
	DC - 8	Divide-by-8	-5 to +12	-2	-150	+3V @ 62mA	SOT26	HMC434E
	DC - 12	Divide-by-8	-15 to +10	-9	-153	+5V @ 70mA	Chip	HMC363
	DC - 12	Divide-by-8	-15 to +10	4	-153	+5V @ 90mA	G8 Hermetic	HMC363G8
	DC - 12	Divide-by-8	-15 to +10	-9	-153	+5V @ 70mA	S8G	HMC363S8GE
	DC - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 105mA	LP3	HMC494LP3E
	Connectorized Frequency Divider Modules							
	0.5 - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 75mA	C-1 Module	HMC-C005
	0.5 - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 93mA	C-1 Module	HMC-C006
NEW!	0.5 - 8	Divide-by-5	-15 to +10	-1	-55	+5V @ 80mA	C-1 Module	HMC-C039
	0.5 - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 98mA	C-1 Module	HMC-C007
NEW!	0.5 - 18	Divide-by-10	-15 to +10	-1	-155	+5V @ 152mA	C-1 Module	HMC-C040
	Phase / Frequency Detectors & Counters							
	DC - 2.2	5-bit Counter, ÷2 to 32	-15 to +10	4	-153	+5V @ 194mA	LP4	HMC394LP4E
	0.01 - 1.3	Phase Freq. Detector	-10 to +10	2 Vpk-pk	-153	+5V @ 96mA	QS16G	HMC439QS16GE
	0.01 - 2.8	PFD / Counter	-10 to +10	2 Vpk-pk	-153	+5V @ 250mA	QS16G	HMC440QS16GE

FREQUENCY MULTIPLIERS - ACTIVE

	Input Freq. (MHz)	Function	Output Freq. (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
	3000 - 4500	Active x2	6 - 9	0	17	-140	LP4	HMC575LP4E
NEW!	4000 - 10500	Active x2	8 - 21	5	17	-139	Chip	HMC561

FREQUENCY MULTIPLIERS - ACTIVE (Continued)

Input Freq. (MHz)	Function	Output Freq. (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
NEW! 4000 - 10500	Active x2	8 - 21	5	14	-139	LP3	HMC561LP3E
4000 - 11000	Active x2	8 - 22	5	12	-134	LC3B	HMC573LC3B
4500 - 8000	Active x2	9 - 16	2	15	-140	LP4	HMC368LP4E
4950 - 6350	Active x2	9.9 - 12.7	0	4	-142	LP3	HMC369LP3E
9000 - 14500	Active x2	18 - 29	3	17	-132	Chip	HMC576
9000 - 14500	Active x2	18 - 29	3	15	-132	LC3B	HMC576LC3B
9500 - 12500	Active x2	19 - 25	0	12	-135	Chip	HMC448
10000 - 12500	Active x2	20 - 25	0	11	-135	LC3B	HMC448LC3B
12000 - 16500	Active x2	24 - 33	3	17	-132	Chip	HMC578
12000 - 16500	Active x2	24 - 33	3	15	-132	LC3B	HMC578LC3B
13500 - 16500	Active x2	27 - 33	0	10	-132	Chip	HMC449
13500 - 15500	Active x2	27 - 31	0	10	-132	LC3B	HMC449LC3B
13500 - 15500	Active x2	27 - 31	5	20	-128	LC4B	HMC577LC4B
16000 - 23000	Active x2	32 - 46	3	13	-127	Chip	HMC579
2450 - 2800	Active x4	9.8 - 11.2	-15	3	-142	LP4	HMC443LP4E
3600 - 4100	Active x4	14.4 - 16.4	-15	0	-140	LP4	HMC370LP4E
1237.5 - 1400	Active x8	9.9 - 11.2	-15	6	-136	LP4	HMC444LP4E
618.75 - 687.5	Active x16	9.9 - 11	-15	7	-130	LP4	HMC445LP4E
Connectorized Frequency Multiplier Modules							
3000 - 5000	Active x2	6 - 10	3	17	-140	C-10 Module	HMC-C031
9000 - 14500	Active x2	18 - 29	3	16	-132	C-10 Module	HMC-C032
12000 - 16500	Active x2	24 - 33	3	17	-132	C-10 Module	HMC-C033
16000 - 23000	Active x2	32 - 46	3	13	-130	C-10 Module	HMC-C034

FREQUENCY MULTIPLIERS - PASSIVE

Input Freq. (GHz)	Function	Output Freq. (GHz)	Conv. Gain (dB)	1Fo / 4Fo Isolation (dBm)	Input Drive (dBm)	Package	Part Number
0.7 - 2.4	x2 Passive	1.4 - 4.8	-15	47 / 38	10 to 20	Chip	HMC156
0.7 - 2.4	x2 Passive	1.4 - 4.8	-15	47 / 38	10 to 20	C8	HMC156C8
0.85 - 2.0	x2 Passive	1.6 - 4.0	-15	45 / 40	10 to 20	MS8	HMC187MS8E
1.25 - 3.0	x2 Passive	2.5 - 6.0	-15	45 / 45	10 to 20	MS8	HMC188MS8E
1.3 - 4.0	x2 Passive	2.6 - 8.0	-15	45 / 40	10 to 20	Chip	HMC158
1.3 - 4.0	x2 Passive	2.6 - 8.0	-15	45 / 40	10 to 20	C8	HMC158C8
2 - 4	x2 Passive	4 - 8	-13	34 / 40	10 to 15	MS8	HMC189MS8E
4 - 8	x2 Passive	8 - 16	-20	45 / 38	10 to 15	Chip	HMC204
4 - 8	x2 Passive	8 - 16	-17	41 / 40	10 to 15	C8	HMC204C8
4 - 8	x2 Passive	8 - 16	-17	42 / 50	10 to 15	MS8G	HMC204MS8GE
6 - 12	x2 Passive	12 - 24	-17	32 / 32	10 to 15	Chip	HMC205
12 - 18	x2 Passive	24 - 36	-14	50 / 60	11 to 15	Chip	HMC331

I/Q MIXERS / IRMs & I/Q RECEIVERS

RF/LO Freq. (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	Input IP3 (dBm)	Package	Part Number
I/Q Mixers / IRMs							
1.7 - 4.5	I/Q Mixer / IRM	DC - 1.5	-8	-	23	LP5	HMC340LP5E
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	23	Chip	HMC525
4 - 8.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	23	LC4	HMC525LC4
5.9 - 12.0	I/Q Mixer / IRM	DC - 1.5	-8	30	18	Chip	HMC256
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7	40	22	Chip	HMC520
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7	40	23	LC4	HMC520LC4
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	40	28	Chip	HMC526
6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	40	28	LC4	HMC526LC4
8.5 - 13.5	I/Q Mixer / IRM	DC - 3.5	-7.5	40	24	Chip	HMC521

Selection Guide by Product

I/Q MIXERS / IRMs & I/Q RECEIVERS (Continued)

	RF/LO Freq. (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	Input IP3 (dBm)	Package	Part Number
	8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-7.5	35	28	Chip	HMC527
	8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-7.5	34	28	LC4	HMC527LC4
	8.5 - 13.6	I/Q Mixer / IRM	DC - 3.5	-7.5	38	24	LC4	HMC521LC4
	11 - 16	I/Q Mixer / IRM	DC - 3.5	-7.5	35	24	Chip	HMC522
	11 - 16	I/Q Mixer / IRM	DC - 3.5	-7.5	35	24	LC4	HMC522LC4
	11 - 16	I/Q Mixer / IRM	DC - 3.5	-8	35	27	Chip	HMC528
	11 - 16	I/Q Mixer / IRM	DC - 3.5	-8	35	26	LC4	HMC528LC4
	15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	25	25	LC4	HMC523LC4
	15 - 23.6	I/Q Mixer / IRM	DC - 3.5	-8	27	25	Chip	HMC523
	22 - 32	I/Q Mixer / IRM	DC - 3.5	-10	23	20	Chip	HMC524
	22 - 32	I/Q Mixer / IRM	DC - 4.5	-10	20	20	LC3B	HMC524LC3B
	31 - 38	I/Q Mixer / IRM	DC - 3.5	-10.5	17	21	Chip	HMC555
	36 - 41	I/Q Mixer / IRM	DC - 3.5	-11	18	23	Chip	HMC556
	26 - 33 RF	Sub-Harmonic I/Q Mixer / IRM	DC - 3	-11	22	16	Chip	HMC404
	Connectorized I/Q Mixer Modules							
	4 - 8.5	I/Q Mixer	DC - 3.5	-7.5	37	23	C-4 Module	HMC-C009
NEW!	6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	35	25	C-4 Module	HMC-C041
NEW!	8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-8	28	25	C-4 Module	HMC-C042
NEW!	11 - 16	I/Q Mixer / IRM	DC - 3.5	-9	30	28	C-4 Module	HMC-C043
NEW!	15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	30	25	C-4 Module	HMC-C044
	I/Q Receivers							
	7 - 9	I/Q Receiver	DC - 3.5	10	35	1	LC5	HMC567LC5
	9 - 12	I/Q Receiver	DC - 3.5	14	33	-1	LC5	HMC568LC5
	12 - 16	I/Q Receiver	DC - 3.5	14	32	-1	LC5	HMC569LC5
	17 - 21	I/Q Receiver	DC - 3.5	10	17	3	Chip	HMC570
	17 - 21	I/Q Receiver	DC - 3.5	10	18	2	LC5	HMC570LC5
	21 - 25	I/Q Receiver	DC - 3.5	11	24	5	Chip	HMC571
	21 - 25	I/Q Receiver	DC - 3.5	10	20	5	LC5	HMC571LC5
	24 - 28	I/Q Receiver	DC - 3.5	8	20	5	Chip	HMC572
	24 - 28	I/Q Receiver	DC - 3.5	8	20	5	LC5	HMC572LC5

MIXERS

RF Freq. (GHz)	Function	IF Freq. (GHz)	Conv. Gain (dB)	LO/RF Isol. (dB)	Input IP3 (dBm)	Package	Part Number
High IP3 Mixers							
0.45 - 0.5	High IP3, SGL-END	DC - 0.15	-9.5	20	32	MS8	HMC387MS8E
0.4 - 0.65	High IP3, 0 LO	DC - 0.25	-9	7	33	MS8G	HMC585MS8GE
0.6 - 1.2	High IP3, SGL-BAL	DC - 0.3	-7.5	22	27	MS8	HMC350MS8E
0.7 - 1.2	High IP3, DBL-BAL	DC - 0.3	-10	42	26	S8	HMC351S8E
0.7 - 1.4	High IP3, 0 LO	DC - 0.35	-9	20	35	MS8G	HMC483MS8GE
0.74 - 0.96	High IP3, SGL-END	DC - 0.25	-8.5	24	35	MS8	HMC399MS8E
0.8 - 1.2	High IP3, DBL-BAL, 0 LO	DC - 0.3	-8	27	27	LP4	HMC551LP4E
1.1 - 1.7	High IP3, DBL-BAL	DC - 0.7	-7	40	24	MS8	HMC296MS8E
1.3 - 2.5	High IP3, DBL-BAL	DC - 0.65	-9	30	25	MS8	HMC216MS8E
1.5 - 3.5	High IP3, DBL-BAL	DC - 1	-8	38	25	MS8	HMC316MS8E
1.6 - 3.0	High IP3, DBL-BAL, 0 LO	DC - 1	-8	30	25	LP4	HMC552LP4E
1.7 - 2.2	High IP3, SGL-END	DC - 0.3	-8.8	30	36	MS8	HMC400MS8E
1.7 - 2.2	High IP3, 0 LO	0.05 - 0.3	-9.2	8	35	MS8G	HMC485MS8GE
1.7 - 3.0	High IP3, SGL-BAL	DC - 0.8	-9	30	30	MS8	HMC304MS8E

MIXERS (Continued)

	RF Freq. (GHz)	Function	IF Freq. (GHz)	Conv. Gain (dB)	LO/RF Isol. (dB)	Input IP3 (dBm)	Package	Part Number
	1.7 - 4.0	High IP3, DBL-BAL, +4 LO	DC - 1.0	-8	32	25	LP4	HMC215LP4E
	1.8 - 2.2	High IP3, SGL-END	DC - 0.5	-8.5	25	31	MS8	HMC402MS8E
NEW!	2.3 - 4.0	High IP3, +4 LO	DC - 1.0	-10	15	35	LP4	HMC615LP4E
	2.4 - 4.0	High IP3, SGL-END	DC - 1	-10	30	34	MS8	HMC214MS8E
	9 - 15	High IP3, DBL-BAL	DC - 2.5	-7.5	40	24	MS8G	HMC410MS8GE
	Downconverter RFICs							
	0.7 - 1.0	Downconverter	0.05 - 0.25	12.5	25	15	QS16	HMC420QS16E
	0.8 - 0.96	Hi-IP3 Dual Downconverter	0.05 - 0.3	9	4	26	LP6	HMC581LP6E
	0.8 - 1.0	Hi-IP3 Downconverter	0.05 - 0.25	13.8	28	15	QS16G	HMC377QS16GE
NEW!	0.8 - 2.7	Hi-IP3 Wideband Downconverter	0.001 - 0.6	-1	48	26	LP4	HMC334LP4E
	1.4 - 2.3	Hi-IP3 Downconverter	0.05 - 0.3	9	33	19	QS16G	HMC421QS16E
	1.7 - 2.2	Hi-IP3 Downconverter	0.05 - 0.3	11	25	19	QS16G	HMC380QS16GE
	1.7 - 2.2	Hi-IP3 Dual Downconverter	50 - 300	9	10	27	LP6	HMC381LP6E
	0 to +7 dBm LO Double & Single Balanced Mixers							
	0.6 - 1.3	Low LO, DBL-BAL	DC - 0.4	-8	35	15	MS8	HMC423MS8E
	1.2 - 2.5	Low LO, DBL-BAL	DC - 1	-8	30	15	MS8	HMC422MS8E
	2 - 2.8	Low LO, SGL-BAL	DC - 1	-8	20	10	SOT26	HMC332E
	3 - 3.8	Low LO, SGL-BAL	DC - 1	-8.5	15	10	SOT26	HMC333E
	4 - 7	0 LO, DBL-BAL	DC - 2.5	-7	32	15	MS8G	HMC488MS8GE
	4.5 - 6.0	+7 LO, DBL-BAL	DC - 1.6	-7	28	13	MS8	HMC218MS8E
	+10 dBm LO Double & Single Balanced Mixers							
	0.7 - 2.0	+10 LO, DBL-BAL	DC - 0.3	-9	45	17	S8	HMC207S8E
	0.7 - 2.0	+10 LO, DBL-BAL	DC - 0.5	-9	24	17	MS8	HMC208MS8E
	1.5 - 4.5	+10 LO, DBL-BAL	DC - 1.5	-8.5	40	19	MS8	HMC213MS8E
	1.7 - 3.0	+10 LO, SGL-BAL	DC - 0.8	-9	30	21	MS8	HMC272MS8E
	1.7 - 3.5	+10 LO, SGL-BAL	DC - 0.9	-9	30	21	SOT26	HMC285E
	4.5 - 8.0	+10 LO, DBL-BAL	DC - 2	-8.2	35	16	C8	HMC168C8
	5 - 12	+10 LO, DBL-BAL	DC - 4	-7.5	25	17	MS8	HMC220MS8E
	7 - 10	+10 LO, DBL-BAL	DC - 2	-9	32	16	C8	HMC171C8
	+13 dBm LO Double & Single Balanced Mixers							
	0.7 - 1.2	+13 LO, SGL-BAL	DC - 0.3	-9	26	21	MS8	HMC277MS8E
	1.7 - 4.5	+13 LO, DBL-BAL	DC - 1	-8	30	20	MS8	HMC175MS8E
	2.5 - 4.0	+13 LO, DBL-BAL	DC - 2	-9	45	18	C8	HMC170C8
	4.5 - 9.0	+13 LO, DBL-BAL	DC - 2.5	-8.5	25	21	MS8	HMC219MS8E
	7 - 14	+13 LO, DBL-BAL	DC - 5	-7	48	22	Chip	HMC553
	7 - 14	+13 LO, DBL-BAL	DC - 5	-7	50	22	LC3B	HMC553LC3B
	9 - 15	+13 LO, DBL-BAL	DC - 2.5	-7.5	40 - 50	17	MS8G	HMC412MS8GE
	10 - 15	+13 LO, SGL-BAL	DC - 3	-9	27	16	MS8G	HMC411MS8GE
	11 - 20	+13 LO, DBL-BAL	DC - 6	-7	46	18	Chip	HMC554
	11 - 20	+13 LO, DBL-BAL	DC - 6	-7	46	18	LC3B	HMC554LC3B
	14 - 26	+13 LO, DBL-BAL	DC - 8	-7.5	39	20	Chip	HMC260
	14 - 26	+13 LO, DBL-BAL	DC - 8	-7.5	38	20	LC3B	HMC260LC3B
	16 - 30	+13 LO, DBL-BAL	DC - 8	-8	38	21	LC3B	HMC292LC3B
	17 - 31	+13 LO, DBL-BAL	DC - 6	-8	32	19	LM3C	HMC292LM3C
	20 - 30	+13 LO, DBL-BAL	DC - 8	-7.5	38	19	Chip	HMC292
	24 - 32	+13 LO, DBL-BAL	DC - 8	-10	38	18	LC3B	HMC329LC3B
	24 - 40	+13 LO, DBL-BAL	DC - 18	-8	35	21	Chip	HMC560
	24 - 40	+13 LO, DBL-BAL	DC - 17	-10	35	21	LM3	HMC560LM3

SELECTION GUIDE BY PRODUCT

MIXERS (Continued)

	RF Freq. (GHz)	Function	IF Freq. (GHz)	Conv. Gain (dB)	LO/RF Isol. (dB)	Input IP3 (dBm)	Package	Part Number
	25 - 40	+13 LO, DBL-BAL	DC - 8	-9.5	42	19	Chip	HMC329
	26 - 40	+13 LO, DBL-BAL	DC - 8	-8	37	19	LM3	HMC329LM3
	+15 to +20 dBm LO Double & Single Balanced Mixers							
	1.8 - 5.0	+15 LO, DBL-BAL	DC - 3	-7	42	18	Chip	HMC128
	1.8 - 5.0	+15 LO, DBL-BAL	DC - 2	-8	40	18	G8 Hermetic	HMC128G8
	4 - 8	+15 LO, DBL-BAL	DC - 3	-7	40	17	Chip	HMC129
	4 - 8	+15 LO, DBL-BAL	DC - 3	-7	30	17	G8 Hermetic	HMC129G8
	4 - 8	+15 LO, DBL-BAL	DC - 3	-7	40	17	LC4	HMC129LC4
	6 - 11	+15 LO, DBL-BAL	DC - 2	-7	40	17	Chip	HMC130
	6 - 15	+15 LO, DBL-BAL	DC - 2	-8.5	35	20	C8	HMC141C8 / 142C8
	6 - 18	+15 LO, DBL-BAL	DC - 6	-10	25	21	Chip	HMC141 / 142
	7 - 14	+15 LO, DBL-BAL	DC - 2	-10	35	20	LH5 Hermetic	HMC141LH5
	14 - 23	+15 LO, DBL-BAL	DC - 2	-10.5	38	18	Chip	HMC203
	5 - 20	+20 LO, DBL-BAL	DC - 3	-10	30	21	Chip	HMC143 / 144
	6 - 20	+20 LO, DBL-BAL	DC - 3	-10	30	21	LC4	HMC144LC4
NEW!	6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	24	LH5 Hermetic	HMC144LH5
	Sub-Harmonic Mixers							
	14 - 20 RF	Sub-Harmonic	DC - 3	-10	40	7	LM3	HMC258LM3
	14 - 21 RF	Sub-Harmonic	DC - 3	-10	40	7	Chip	HMC258
	17 - 25 RF	Sub-Harmonic	DC - 3	-9	25 - 30	10	Chip	HMC337
	20 - 30 RF	Sub-Harmonic	DC - 6	-10	40	13	Chip	HMC264
	21 - 31 RF	Sub-Harmonic	DC - 6	-9	40	13	LC3B	HMC264LC3B
	20 - 30 RF	Sub-Harmonic	DC - 4	-9	30	10	LM3	HMC264LM3
	20 - 31 RF	Sub-Harmonic	0.7 - 3.0	3	28	8	LM3	HMC265LM3
	20 - 32 RF	Sub-Harmonic	0.7 - 3.0	3	20 - 40	10	Chip	HMC265
	20 - 40 RF	Sub-Harmonic	1 - 3	-12	24	13	Chip	HMC266
NEW!	24 - 34 RF	Sub-Harmonic	DC - 3	-11	33	13	LC3B	HMC338LC3B
	26 - 33 RF	Sub-Harmonic	DC - 2.5	-9	33	11	Chip	HMC338
	33 - 42 RF	Sub-Harmonic	DC - 3	-10	37	10	Chip	HMC339
	Connectorized Mixer Modules							
	23 - 37	+13 LO, DBL-BAL	DC - 19	-9	35	19	C-11 Module	HMC-C035
	16 - 32	+13 LO, DBL-BAL	DC - 8	-8	28	19	C-11 Module	HMC-C014
	24 - 38	+13 LO, DBL-BAL	DC - 8	-8.5	35	20	C-11 Module	HMC-C015

DEMODULATORS - I/Q Demodulator

Input Freq. (GHz)	Function	IF Freq. (GHz)	Conv. Gain (dB)	Noise Figure (dB)	IIP3 / IIP2 (dBm)	Package	Part Number
0.1 - 4.0	I/Q Demodulator	DC - 0.25	-3.5	15	+25 / +60	LP4	HMC597LP4E

MODULATORS - Bi-Phase Modulator

Input Freq. (GHz)	Function	Loss (dB)	Amp/Phase Balance (dB/Deg)	Carrier Supr. (dBc)	Bias Control (mA)	Package	Part Number
1.8 - 5.2	Bi-Phase	8	0.2 / 2.5	30	+/- 5	Chip	HMC135
4 - 8	Bi-Phase	8	0.1 / 4.0	30	+/- 5	Chip	HMC136
6 - 11	Bi-Phase	9	0.25 / 10.0	20	+/- 5	Chip	HMC137

MODULATORS - Direct Quadrature Modulator

Input Freq. (GHz)	Function	OIP3 (dBm) / Carrier Supr. (dBc)	Modulation Bandwidth (MHz)	Output Noise Floor (dBc/Hz)	Bias Supply	Package	Part Number
0.1 - 4	Direct	23 / 42	DC - 700	-159	+5V @ 170mA	LP4	HMC497LP4E
0.25 - 3.8	Direct	14 / 38	DC - 250	-158	+3.3V @ 108mA	LP3	HMC495LP3E
4 - 7	Direct	17 / 34	DC - 250	-157	+3V @ 93mA	LP3	HMC496LP3E

MODULATORS - Vector Modulator

Frequency (GHz)	Function	Gain Range (dB)	Cont. Phase Control (deg)	IP3 / Noise Floor (Ratio)	Input IP3 @ Max. Gain (dBm)	Package	Part Number
1.8 - 2.2	Vector	-50 to -10	360	185	33	LP3	HMC500LP3E

PHASE SHIFTERS - Analog

Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd harmonic Pin = 10 dBm (dBc)	Control Voltage Range (Vdc)	Package	Part Number
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
Connectorized Phase Shifter Modules							
6 - 15	Analog	7	750° @ 6 GHz 450° @ 15 GHz	40	0V to +5V	C-1 Module	HMC-C010

PHASE SHIFTERS - Digital

	Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	IIP3 (dBm)	Control Input (Vdc)	Package	Part Number
NEW!	8 - 12	4-Bit Digital	5	22.5 to 360	40	0 / -3V	Chip	HMC543
NEW!	8 - 12	4-Bit Digital	6.5	22.5 to 360	37	0 / -3V	LC4B	HMC543LC4B

POWER DETECTORS

	Frequency (GHz)	Function	± 3 dB Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package	Part Number
NEW!	0.001 - 8.0	Log Detector	70	-25	-61	+5V @ 113mA	LP4	HMC602LP4E
NEW!	0.01 - 4.0	Log Detector	70	19	-68	+3.3V @ 30mA	LP4	HMC601LP4E
	0.05 - 4.0	Log Detector	70	19	-69	+3.3V @ 29mA	LP4	HMC600LP4E
NEW!	0.1 - 3.9	True RMS Detector	69*	37	-60	+5V @ 65 mA	LP4	HMC610LP4E

*** ±1 dB Dynamic Range**

SWITCHES

	Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
	SPST & SPDT Switches							
	DC - 6	SPST, Failsafe	0.7	25	27	0 / +2.2 to +5V	SOT26	HMC550E
	DC - 6	SPST, Hi Isolation	1.4	52	27	0 / -5V	G7 Hermetic	HMC231G7
	DC - 2.5	SPDT, Reflective	0.4	36	29	0 / -5V	S8	HMC239S8E
	DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	HMC197E
	DC - 3	SPDT, Reflective	0.4	28	30	0 / +3V	SOT26	HMC221E
	DC - 3	SPDT, Reflective	0.4	27	30	0 / +3V	MS8	HMC190MS8E
	DC - 3	SPDT, Reflective	0.3	31	34	0 / +3 to +8V	SOT26	HMC545E
	DC - 4	SPDT, Reflective	0.5	28	29	0 / -5V or +5V / 0	Chip	HMC240
	DC - 2.5	SPDT, CATV	0.6	58	28	0 / +5V	LP3	HMC348LP3E
	DC - 3	SPDT, Hi Isolation	0.7	50	23	0 / +5V	MS8	HMC194MS8E
	DC - 3.5	SPDT, Hi Isolation	0.5	45	25	0 / +5V	MS8G	HMC284MS8GE
	DC - 4	SPDT, Hi Isolation	0.9	65	31	0 / +5V	LP4C	HMC349LP4CE
	DC - 4	SPDT, Hi Isolation	0.9	57	31	0 / +5V	MS8G	HMC349MS8GE
	DC - 4	SPDT, Hi Isolation	1.1	47	31	0 / +5V	MS8G	HMC435MS8GE
	DC - 6	SPDT, Hi Isolation	1.4	50	26	0 / -5V	G7 Hermetic	HMC232G7
	DC - 6	SPDT, Hi Isolation	1.4	43	26	0 / -5V	G8 Hermetic	HMC232G8
	DC - 6	SPDT, Hi Isolation	1.4	43	26	0 / -5V	G8 Hermetic	HMC233G8
	DC - 6	SPDT, Hi Isolation	1.6	42	25	0 / +5V	MS8G	HMC336MS8GE
NEW!	DC - 6	SPDT, Hi Isolation	1.4	46	27	0 / -5V	G7	HMC607G7
	DC - 8	SPDT, Hi Isolation	1.4	50	26	0 / -5V	C8	HMC232C8
	DC - 8	SPDT, Hi Isolation	1.5	45	26	0 / -5V	C8	HMC234C8
	DC - 8	SPDT, Hi Isolation	1.2	48	23	0 / -5V	MS8G	HMC270MS8GE
	DC - 8	SPDT, Hi Isolation	2.0	44	23	0 / -5V	C8	HMC347C8
	DC - 8	SPDT, Hi Isolation	2.2	35	23	0 / -5V	G8 Hermetic	HMC347G8

Selection Guide by Product

SWITCHES (Continued)

	Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
	DC - 12	SPDT, Hi Isolation	1.5	55	27	0 / -5V	LP4	HMC232LP4E
	DC - 15	SPDT, Hi Isolation	1.4	50	26	0 / -5V	Chip	HMC232
	DC - 15	SPDT, Hi Isolation	1.7	44	23	0 / -5V	LP3	HMC347LP3E
NEW!	DC - 15	SPDT, Hi Isolation	1.7	60	26	0 / -5V	Chip	HMC607
	DC - 20	SPDT, Hi Isolation	1.7	45	23	0 / -5V	Chip	HMC347
	DC - 20	SPDT, Hi Isolation	1.8	47	23	0 / -5V	LP3	HMC547LP3E
	0.2 - 2.2	SPDT, 10W, Failsafe	0.4	40	> 40	0 / +3 to +8V	MS8G	HMC546MS8GE
	0.2 - 2.7	SPDT, 10W, Failsafe	0.4	35	43	0 / +3 to +8V	LP2	HMC546LP2E
	0.824 - 0.894	SPDT, 10W, T/R	0.6	22	> 40	0 / +5V	SOT26	HMC446E
	DC - 2	SPDT T/R	0.6	20	35	0 / +3V	SOT26	HMC226E
	DC - 3	SPDT, 3W, T/R	0.3	30	37	0 / +3 to +10V	SOT26	HMC595E
	DC - 3	SPDT, 5W, T/R	0.3	30	39	0 / +3 to +10V	MS8	HMC574MS8E
	DC - 3	SPDT, 10W, T/R	0.5	30	> 40	0 / +3 to +10V	MS8G	HMC484MS8GE
	DC - 4	SPDT T/R	0.25	23	39	0 / +3 to +5V	SOT26	HMC544E
	DC - 6	SPDT T/R	0.5	27	37	0 / +3 to +5V	MS8G	HMC536MS8GE
	DC - 6	SPDT T/R	0.6	27	37	0 / +3 to +5V	LP2	HMC536LP2E
	5 - 6	SPDT T/R	1.2	31	33	TTL/CMOS	MS8	HMC224MS8E
	Multi-Throw Switches							
	DC - 3.5	SP3T	0.5	44	26	TTL/CMOS	QS16	HMC245QS16E
	DC - 2	SP4T	0.8	32	24	0 / -5V	S14	HMC182S14E
	DC - 3.5	SP4T	0.6	45	25	TTL/CMOS	QS16	HMC241QS16E
	DC - 4	SP4T	0.6	47	26	TTL/CMOS	LP3	HMC241LP3E
	DC - 4	SP4T	0.7	40	25	TTL/CMOS	G16 Hermetic	HMC244G16
	DC - 8	SP4T	1.8	42	21	0 / -5V	Chip	HMC344
NEW!	DC - 8	SP4T	2.0	45	26	0 / -5V	LC3	HMC344LC3
	DC - 8	SP4T	1.8	40	21	0 / -5V	LP3	HMC344LP3E
	DC - 8	SP4T	2.0	32	21	0 / 5V	LP3	HMC345LP3E
	DC - 12	SP4T	1.8	42	27	0 / -5V	LH5 Hermetic	HMC344LH5
	DC - 3	SP6T	0.8	41	24	TTL/CMOS	QS24	HMC252QS24E
	DC - 2	SP8T	1.3	30	20	0 / -5V	QS24	HMC183QS24E
	DC - 2.5	SP8T	1.1	36	23	TTL/CMOS	QS24	HMC253QS24E
	DC - 3.5	SP8T	1.2	36	24	TTL/CMOS	LC4	HMC253LC4
	DC - 8	SP8T	2.3	40	23	0 / 5V	LP4	HMC321LP4E
	DC - 10	SP8T	2	38	23	0 / -5V	Chip	HMC322
	DC - 8	SP8T	2.5	25	23	0 / -5V	LP4	HMC322LP4E
	Bypass, Diversity, Matrix & Transfer Switches							
	DC - 2.5	Bypass DPDT	0.3	25	23	0 / +5V	MS8	HMC199MS8E
	4.9 - 5.9	Diversity DPDT	1	23	30	0 / +3V	MS8G	HMC436MS8GE
	5 - 6	Diversity DPDT	1.2	20	30	0 / +5V	MS8G	HMC393MS8GE
	0.2 - 3.0	4x2 Matrix	6	44	26	0 / +5V	LP4	HMC276LP4E
NEW!	0.2 - 3.0	4x2 Matrix	6.5	43	22	0 / +3 to +5V	LP4	HMC596LP4E
	0.7 - 3.0	4x2 Matrix	5.8	33	26	0 / +5V	QS24	HMC276QS24E
	DC - 8.0	Transfer	1.2	42	26	0 / +5V	LP3	HMC427LP3E
	Connectorized Switch Modules							
	DC - 20	SPST, Hi Isolation	3	100	23	0 / +5V	C-9 Module	HMC-C019
	DC - 20	SPDT, Hi Isolation	2.0	40	23	0 / -5V	C-5 Module	HMC-C011

VARIABLE GAIN AMPLIFIERS

	Frequency (GHz)	Function	Gain Control Range (dB)	NF * (dB)	Input IP3 * (dBm)	P1dB (dBm)	Bias Supply	Package	Part Number
NEW!	DC - 6	Digital, 0.5 dB LSB	-11.5 to 20	5.2	13	20	+5V @ 87mA	LP5	HMC625LP5E

**** Max Gain State***

VOLTAGE CONTROLLED OSCILLATORS*

	Frequency (GHz)	Function	Output Power (dBm)	10kHz SSB Phase Noise (dBc/Hz)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
	2.05 - 2.25	VCO with Buffer	3.5	-89	-112	+3V @ 35mA	LP4	HMC384LP4E
	2.25 - 2.5	VCO with Buffer	4.5	-89	-115	+3V @ 35mA	LP4	HMC385LP4E
	2.6 - 2.8	VCO with Buffer	5	-88	-115	+3V @ 35mA	LP4	HMC386LP4E
	2.75 - 3.0	VCO with Buffer	4.5	-89	-114	+3V @ 37mA	LP4	HMC416LP4E
	3.15 - 3.4	VCO with Buffer	4.9	-88	-113	+3V @ 39mA	LP4	HMC388LP4E
	3.35 - 3.55	VCO with Buffer	4.7	-89	-112	+3V @ 41mA	LP4	HMC389LP4E
	3.55 - 3.9	VCO with Buffer	4.7	-87	-112	+3V @ 42mA	LP4	HMC390LP4E
	3.9 - 4.45	VCO with Buffer	5	-81	-106	+3V @ 30mA	LP4	HMC391LP4E
	4.45 - 5.0	VCO with Buffer	4	-79	-105	+3V @ 30mA	LP4	HMC429LP4E
	5.0 - 5.5	VCO with Buffer	2	-80	-103	+3V @ 27mA	LP4	HMC430LP4E
	5.5 - 6.1	VCO with Buffer	2	-80	-102	+3V @ 27mA	LP4	HMC431LP4E
	5.8 - 6.8	VCO with Buffer	10	-82	-105	+3V @ 100mA	MS8G	HMC358MS8GE
	6.1 - 6.72	VCO with Buffer	4.5	-73	-101	+3V @ 31mA	LP4	HMC466LP4E
	6.8 - 7.4	VCO with Buffer	11	-80	-106	+3V @ 80mA	LP4	HMC505LP4E
	7.1 - 7.9	VCO with Buffer	14	-80	-101	+3V @ 85mA	LP4	HMC532LP4E
	7.8 - 8.7	VCO with Buffer	14	-80	-103	+3V @ 77mA	LP4	HMC506LP4E
	13.2 -13.5	VCO with ÷8	-8	-83	-110	+5V @ 230mA	QS16G	HMC401QS16GE
	14.0 - 15.0	VCO with ÷8	6	-75	-110	+5V @ 260mA	QS16G	HMC398QS16GE
	23.8 - 24.8	VCO with ÷16	11	-70	-95	+5V @ 220mA	LP4	HMC533LP4E
	Wideband VCOs							
	4 - 8	Wideband VCO	5	-75	-100	+5V @ 55mA	LC4B	HMC586LC4B
	5 - 10	Wideband VCO	5	-65	-95	+5V @ 55mA	LC4B	HMC587LC4B
	8 - 12.5	Wideband VCO	5	-65	-93	+5V @ 55mA	LC4B	HMC588LC4B
	Connectorized VCO Modules							
NEW!	4 - 8	Wideband VCO	20	-75	-95	+12V @ 185mA	C-1 Module	HMC-C028
NEW!	5 - 10	Wideband VCO	20	-64	-93	+12V @ 195mA	C-1 Module	HMC-C029
NEW!	8 - 12.5	Wideband VCO	21	-59	-83	+12V @ 195mA	C-1 Module	HMC-C030

**** HMC VCOs integrate resonator, negative resistance generator and tuning varactor circuits on-chip. No external components are required.***

VOLTAGE CONTROLLED OSCILLATORS WITH Fo/2 OUTPUT

	Fo Frequency (GHz)	Fo/2 Frequency (GHz)	Function	Fo Output Power (dBm)	100KHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
	6.65 - 7.65	3.325 - 3.825	VCO with Fo/2	13	-115	+5V @ 230mA	LP5	HMC507LP5E
	7.3 - 8.2	3.65 - 4.1	VCO with Fo/2	15	-116	+5V @ 240mA	LP5	HMC508LP5E
	7.8 - 8.8	3.9 - 4.4	VCO with Fo/2	13	-115	+5V @ 250mA	LP5	HMC509LP5E
	9.05 - 10.15	4.525 - 5.075	VCO with Fo/2	13	-115	+5V @ 265mA	LP5	HMC511LP5E
	8.45 - 9.55	4.225 - 4.775	VCO with Fo/2 & ÷4	13	-113	+5V @ 315mA	LP5	HMC510LP5E
NEW!	9.5 - 10.8	4.75 - 5.4	VCO with Fo/2 & ÷4	11	-110	+5V @ 350mA	LP5	HMC530LP5E
NEW!	9.6 - 10.8	4.8 - 5.4	VCO with Fo/2 & ÷4	9	-111	+5V @ 330mA	LP5	HMC512LP5E
	10.43 - 11.46	5.215 - 5.73	VCO with Fo/2 & ÷4	7	-110	+3V @ 275mA	LP5	HMC513LP5E
	10.6 - 11.8	5.3 - 5.9	VCO with Fo/2 & ÷4	11	-110	+5V @ 350mA	LP5	HMC534LP4E
NEW!	11.1 - 12.4	5.55 - 6.2	VCO with Fo/2 & ÷4	9	-110	+5V @ 350mA	LP5	HMC582LP5E
	11.17 - 12.02	5.585 - 6.01	VCO with Fo/2 & ÷4	7	-110	+3V @ 275mA	LP5	HMC514LP5E
	11.5 - 12.5	5.75 - 6.25	VCO with Fo/2 & ÷4	10	-110	+5V @ 200mA	LP5	HMC515LP5E
	11.5 - 12.8	5.75 - 6.4	VCO with Fo/2 & ÷4	11	-110	+5V @ 350mA	LP5	HMC583LP5E

VOLTAGE CONTROLLED OSCILLATORS WITH Fo/2 OUTPUT (Continued)

Fo Frequency (GHz)	Fo/2 Frequency (GHz)	Function	Fo Output Power (dBm)	100KHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
12.4 - 13.4	6.2 - 6.7	VCO with Fo/2 & ÷4	8	-110	+5V @ 260mA	LP5	HMC529LP5E
12.5 - 13.9	6.25 - 6.95	VCO with Fo/2 & ÷4	10	-110	+5V @ 330mA	LP5	HMC584LP5E
13.6 - 14.9	6.8 - 7.45	VCO with Fo/2 & ÷4	7	-110	+5V @ 260mA	LP5	HMC531LP5E

PHASE LOCKED OSCILLATOR

Frequency (GHz)	Function	Output Power (dBm)	10kHz SSB Phase Noise (dBc/Hz)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
14.7 - 15.4	Phase Locked Oscillator	9	-110	-110	+5V @ 340mA +12V @ 28mA	LP4	HMC535LP4E

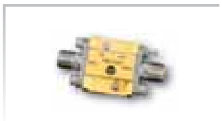
SYNTHESIZERS

Frequency (GHz)	Function	100kHz SSB Phase Noise (dBc/Hz)	Spurious (dBc)	Switching Speed (µs)	Part Number
0.01 - 8	Single Output Synthesized Signal Generator	-135	-75	10	HMC-T1000
0.01 - 8	Dual Output Synthesized Signal Generator	-135	-75	10	HMC-T1000A

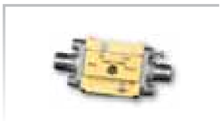
CONNECTORIZED MODULES

Robust, High Performance RF to Light Solutions

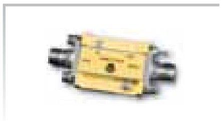
Our hermetic module product line is expanding with new wideband / power / low noise amplifiers, attenuators, mixers, phase shifters, prescalers, switches & VCOs. Utilizing our standard MMIC products, we take advantage of our design, manufacturing and quality knowledge base. Contact us to discuss your custom module requirements.



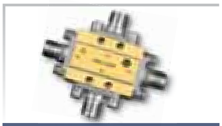
C-1 / C-1B
35.31 x 17.78 x 7.38 mm



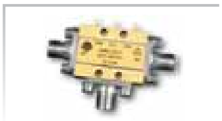
C-2 / C-2B
38.1 x 17.78 x 7.38 mm



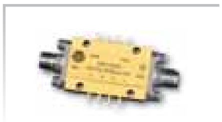
C-3 / C-3B
40.89 x 17.78 x 7.38 mm



C-4
41.66 x 36.32 x 8.50 mm

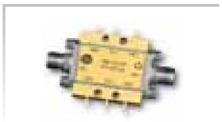


C-5
41.66 x 29.84 x 8.50 mm

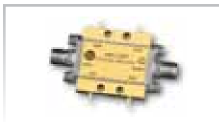


C-6
45.34 x 17.27 x 8.50 mm

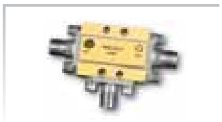
C-7
192.3 x 106.7 x 35.0 mm



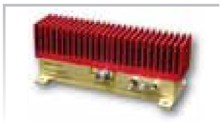
C-9
41.66 x 27.59 x 8.50 mm



C-10 / C-10B
41.66 x 27.59 x 8.50 mm



C-11
41.66 x 29.84 x 8.50 mm



C-12
107.6 x 43.0 x 43.0 mm

FEATURES:

- ♦ *Off-The-Shelf Availability*
- ♦ *Hermetically Sealed*
- ♦ *Internal DC Power Regulation*
- ♦ *Field Replaceable Connectors*
- ♦ *Military & Space Upscreening*
- ♦ *Customization Offered*

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
29 - 36	Low Noise	20	22	2.9	11	+3V @ 80mA	C-10 Module	HMC-C027
2 - 20	Wideband LNA	15	24	2.2	14	+12V @ 65mA	C-1 Module	HMC-C001
2 - 20	Wideband LNA	14	26	2	18	+12V @ 60mA	C-2 Module	HMC-C002
2 - 20	Wideband LNA	14	27	2	16	+8V @ 75mA	C-2B Module	HMC-C022
7 - 17	Wideband LNA	22	25	2.5	14	+8V @ 93mA	C-1 Module	HMC-C016
17 - 27	Wideband LNA	18	25	3	14	+8V @ 96mA	C-1B Module	HMC-C017
0.01 - 15	Wideband Driver	16	33	3	23	+12V @ 195mA	C-3 Module	HMC-C004
0.01 - 15	Wideband Driver	15	30	3	23	+12V @ 225mA	C-3B Module	HMC-C024
2 - 35	Wideband Driver	11	26	4	16	+11V @ 92mA	C-10 Module	HMC-C038
0.01 - 20	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-10B Module	HMC-C036
0.01 - 20	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-12 Module	HMC-C037
2 - 20	Wideband PA	15	34	4	26	+12V @ 310mA	C-2 Module	HMC-C003
2 - 20	Wideband PA	14	30	4	24	+12V @ 310mA	C-2B Module	HMC-C023
2 - 20	Wideband PA	28	30	3	25	+12V @ 400mA	C-3B Module	HMC-C026
17 - 24	Wideband PA	22	33	3.5	24	+8V @ 250mA	C-10 Module	HMC-C020
21 - 31	Wideband PA	15	32	5	24	+8V @ 215mA	C-10 Module	HMC-C021
Connectorized Power Amplifier Modules - >10 Watts								
0.4 - 1.0	10 Watt PA	40	54	12	40	+12V @ 6.5A	C-7 Module	HMC-C012
0.8 - 2.0	10 Watt PA	43	56	12	40	+12V @ 6.5A	C-7 Module	HMC-C013
1.8 - 2.2	15 Watt PA	42	53	6	42	+14V @ 6.5A	C-7 Module	HMC-C008

Connectorized Modules

Robust, High Performance RF to Light Solutions

ATTENUATORS

	Frequency (GHz)	Function	Loss (dB)	Atten. Range (dB)	Input IP3 (dBm)	Control Input (Vdc)	Package	Part Number
	DC - 13	6-Bit Digital, Serial Control	3.6	0.5 to 31.5	32	Serial TTL/CMOS	C-6 Module	HMC-C018
	DC - 13	6-Bit Digital	3.2	0.5 to 31.5	38	0 / +5V	C-6 Module	HMC-C025

FREQUENCY DIVIDERS (PRESCALERS) & PHASE / FREQUENCY DETECTORS

	Input Freq. (GHz)	Function	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
	DC - 18	Divide-by-2	-15 to +10	-4	-150	+5V @ 75mA	C-1 Module	HMC-C005
	DC - 18	Divide-by-4	-15 to +10	-4	-150	+5V @ 93mA	C-1 Module	HMC-C006
NEW!	0.5 - 8	Divide-by-5	-15 to +10	-1	-155	+5V @ 80 mA	C-1 Module	HMC-C039
	DC - 18	Divide-by-8	-15 to +10	-4	-150	+5V @ 98mA	C-1 Module	HMC-C007
NEW!	0.5 - 15	Divide-by-10	-15 to +10	-1	-155	+5V @ 152mA	C-1 Module	HMC-C040

FREQUENCY MULTIPLIERS - ACTIVE

	Input Freq. (MHz)	Function	Output Freq. (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
	3000 - 5000	Active x2	6 - 10	3	17	-140	C-10 Module	HMC-C031
	9000 - 14500	Active x2	18 - 29	3	16	-132	C-10 Module	HMC-C032
	12000 - 16500	Active x2	24 - 33	3	17	-132	C-10 Module	HMC-C033
	16000 - 23000	Active x2	32 - 46	3	13	-130	C-10 Module	HMC-C034

I/Q MIXERS

	RF/LO Freq. (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	Input IP3 (dBm)	Package	Part Number
	4 - 8.5	I/Q Mixer	DC - 3.5	-7.5	37	23	C-4 Module	HMC-C009
NEW!	6 - 10	I/Q Mixer / IRM	DC - 3.5	-7.5	35	25	C-4 Module	HMC-C041
NEW!	8.5 - 13.5	I/Q Mixer / IRM	DC - 2	-8	28	25	C-4 Module	HMC-C042
NEW!	11 - 16	I/Q Mixer / IRM	DC - 3.5	-9	30	28	C-4 Module	HMC-C043
NEW!	15 - 23	I/Q Mixer / IRM	DC - 3.5	-8	30	25	C-4 Module	HMC-C044

MIXERS

	RF Freq. (GHz)	Function	IF Freq. (GHz)	Conv. Gain (dB)	LO/RF Isol. (dB)	Input IP3 (dBm)	Package	Part Number
	23 - 37	+13 LO, DBL-BAL	DC - 13	-9	35	19	C-11 Module	HMC-C035
	16 - 32	+13 LO, DBL-BAL	DC - 8	-8	28	19	C-11 Module	HMC-C014
	24 - 38	+13 LO, DBL-BAL	DC - 8	-8.5	35	20	C-11 Module	HMC-C015

PHASE SHIFTERS - Analog

	Frequency (GHz)	Function	Insertion Loss (dB)	Phase Range (deg)	2nd harmonic Pin = 10 dBm (dBc)	Control Voltage Range (Vdc)	Package	Part Number
	6 - 15	Analog	7	750° @ 6 GHz 450° @ 15 GHz	40	0V to +5V	C-1 Module	HMC-C010

SWITCHES

	Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
	DC - 20	SPST, Hi Isolation	3	100	23	0 / +5V	C-9 Module	HMC-C019
	DC - 20	SPDT, Hi Isolation	2.0	40	23	0 / -5V	C-5 Module	HMC-C011

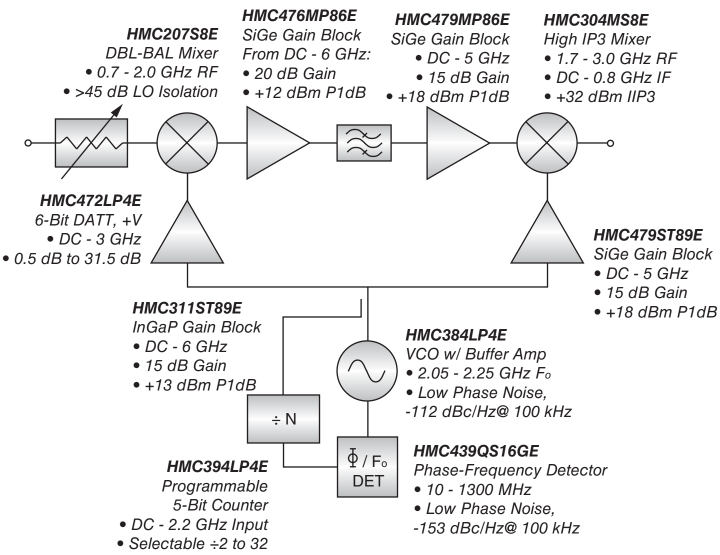
VOLTAGE CONTROLLED OSCILLATORS*

	Frequency (GHz)	Function	Output Power (dBm)	10kHz SSB Phase Noise (dBc/Hz)	100kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
NEW!	4 - 8	Wideband VCO	20	-75	-95	+12V @ 185mA	C-1 Module	HMC-C028
NEW!	5 - 10	Wideband VCO	20	-64	-93	+12V @ 195mA	C-1 Module	HMC-C029
NEW!	8 - 12.5	Wideband VCO	21	-59	-83	+12V @ 195mA	C-1 Module	HMC-C030

APPLICATION CIRCUITS

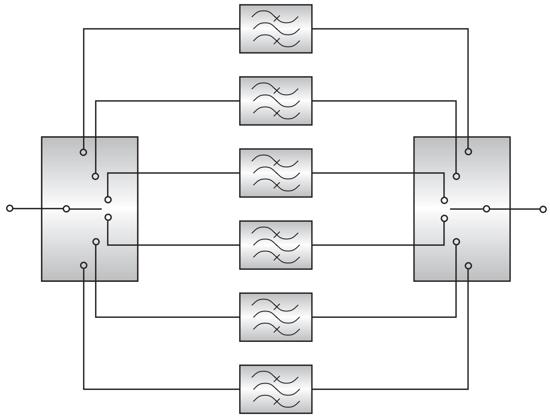
CABLE MODEM, CATV, DBS & VoIP SOLUTIONS, 5 - 2150 MHz

Cable Modem Termination System (CMTS)



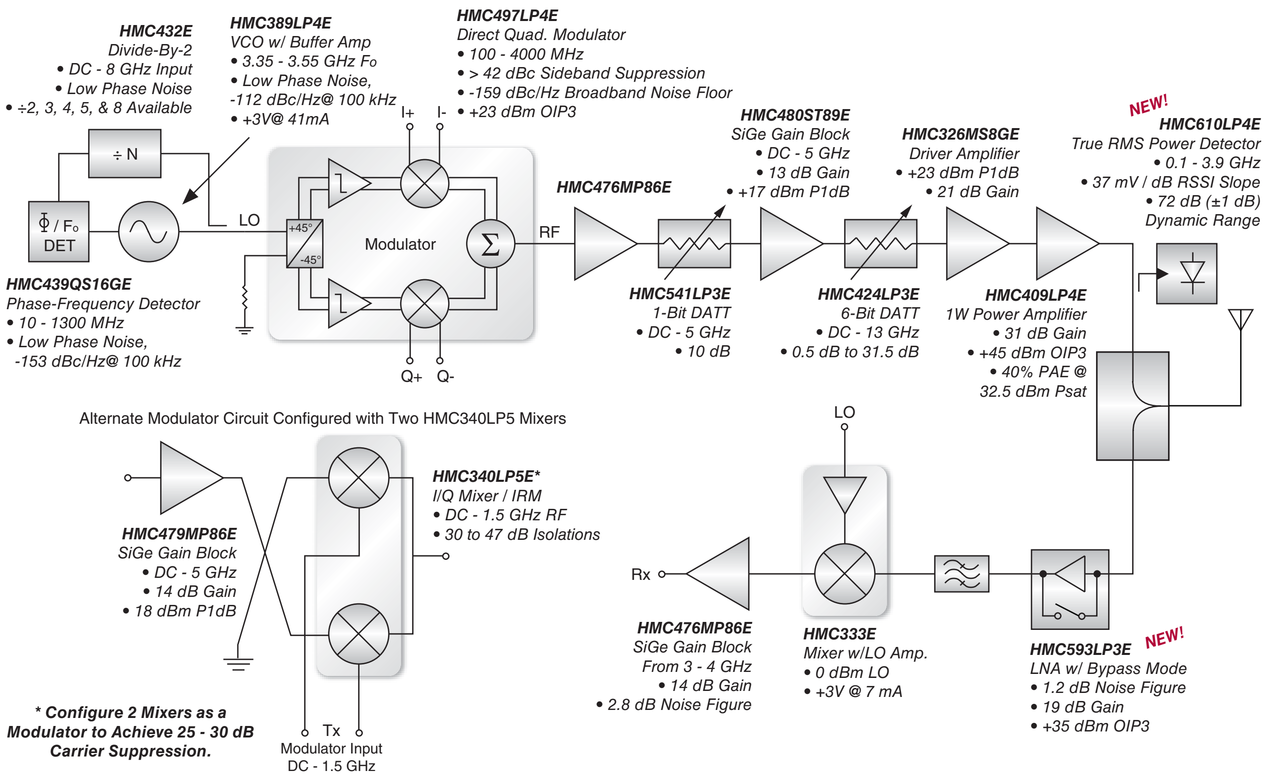
A Selection of SPNT Switches for CATV Filter & Signal Routing

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



Typical Broadband applications are illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

WiMAX & FIXED WIRELESS, 2 - 6 GHz

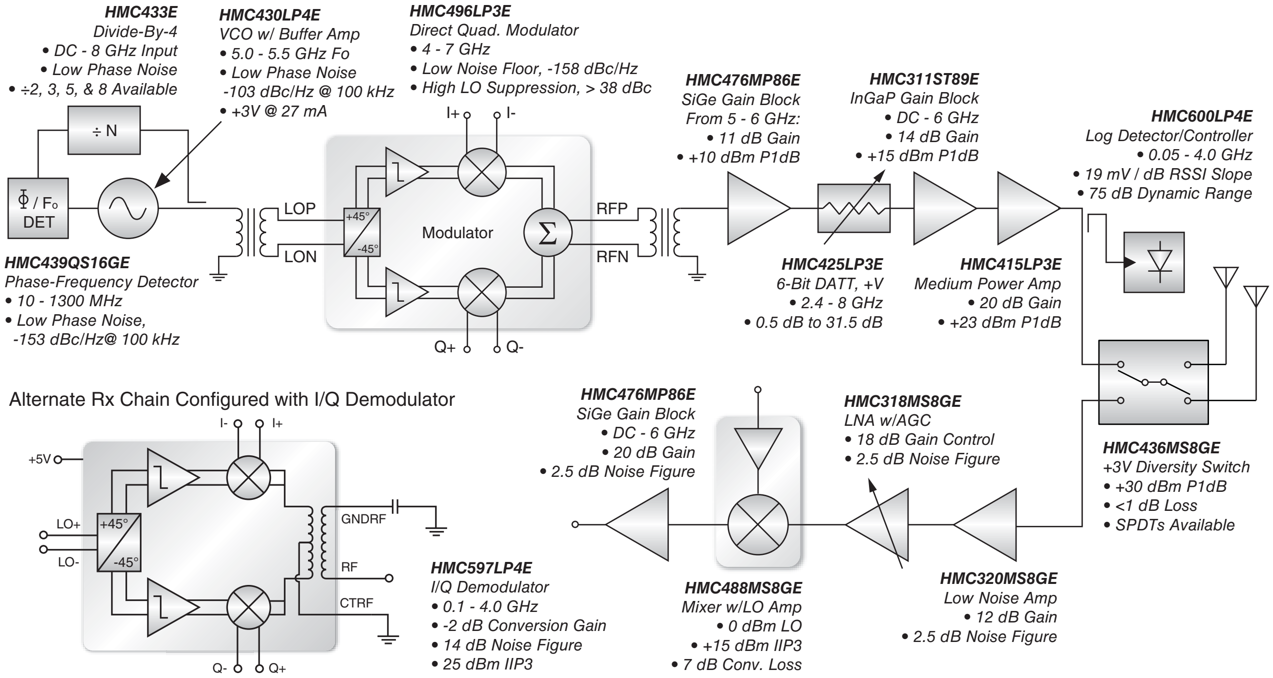


Typical WiMAX / FWA Transceiver is illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

Application Circuits

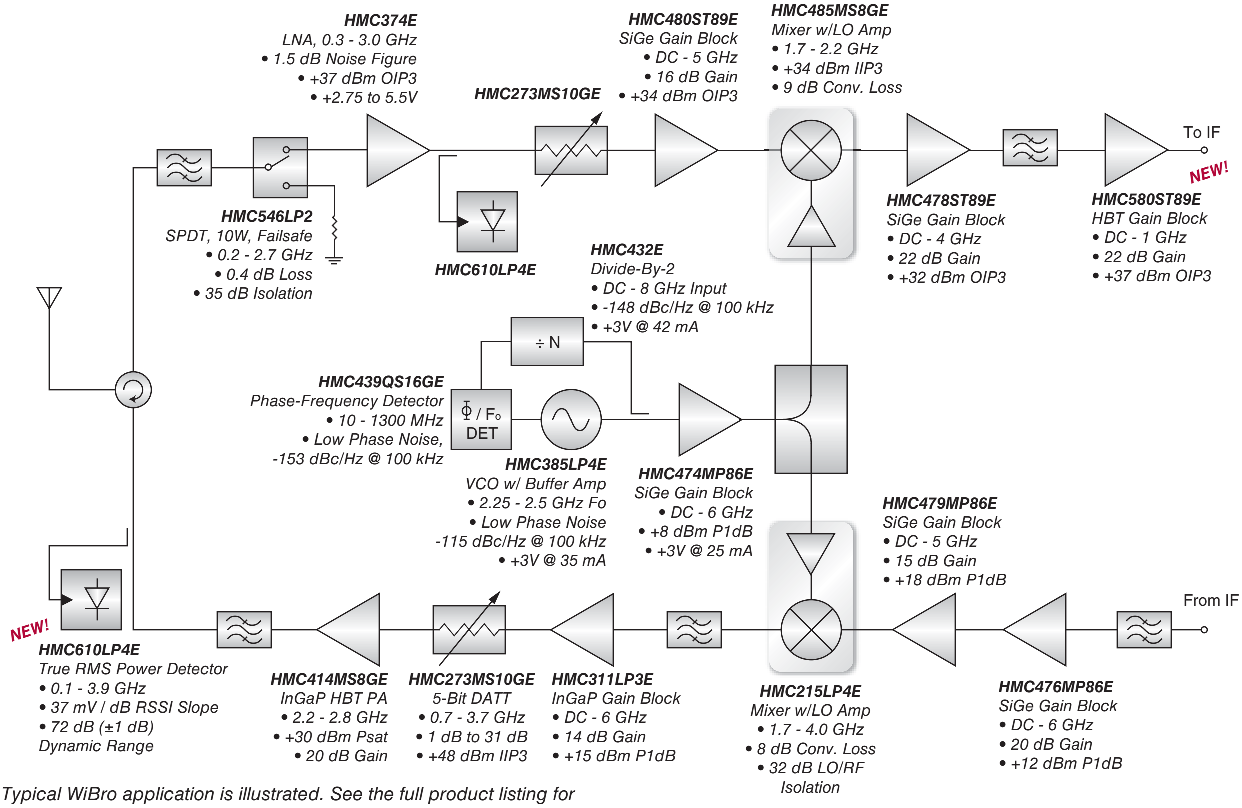
Broadband, DC - 11 GHz

WirelessLAN, UWB, UNII & ISM Solutions, 2.4, 4.9, 5.4, 5.8 & 3 - 11 GHz



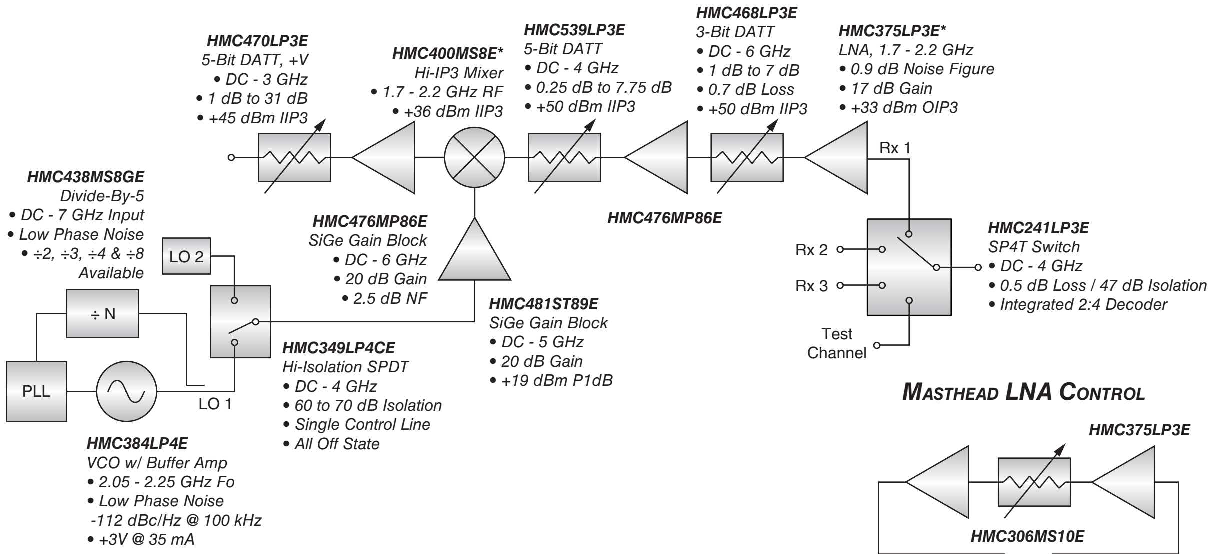
Typical 4.9 - 5.9 GHz Wi-Fi Access Point application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

WiBro "Wireless Broadband", 1.82 - 1.87, 2.3 - 2.5 & 3.48 - 3.52 GHz

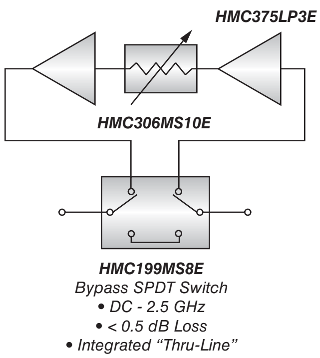


Typical WiBro application is illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

BTS RECEIVER SOLUTIONS FEATURING HIGH IP3 MIXER



MASTHEAD LNA CONTROL



*** For 700 - 1000 MHz Systems Use:**

HMC399MS8E
Hi-IP3 Mixer
• 700 - 1000 MHz RF
• +35 dBm IIP3

HMC376LP3E
LNA, 700 - 1000 MHz
• 0.7 dB Noise Figure
• 14 dB Gain
• +36 dBm OIP3

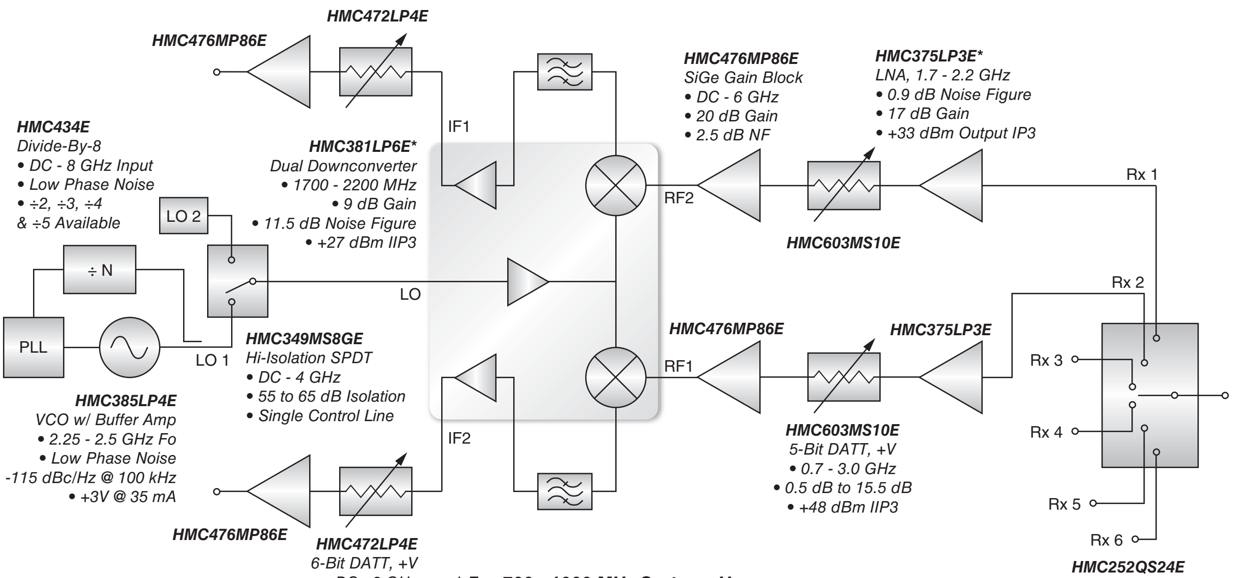
*** For 380 - 500 MHz Systems Use:**

HMC387MS8E
Hi-IP3 Mixer
• 450 - 500 MHz RF
• +32 dBm IIP3

HMC356LP3E
LNA, 350 - 550 MHz
• 1 dB Noise Figure
• 17 dB Gain
• +35 dBm OIP3

Ask About Our Custom VCO Capabilities!

BTS RECEIVER SOLUTIONS FEATURING DUAL RFIC DOWNCONVERTER



*** For 700 - 1000 MHz Systems Use:**

HMC372LP3E
LNA
• 700 - 1000 MHz
• 0.9 dB Noise Figure
• 15 dB Gain
• +35 dBm IIP3

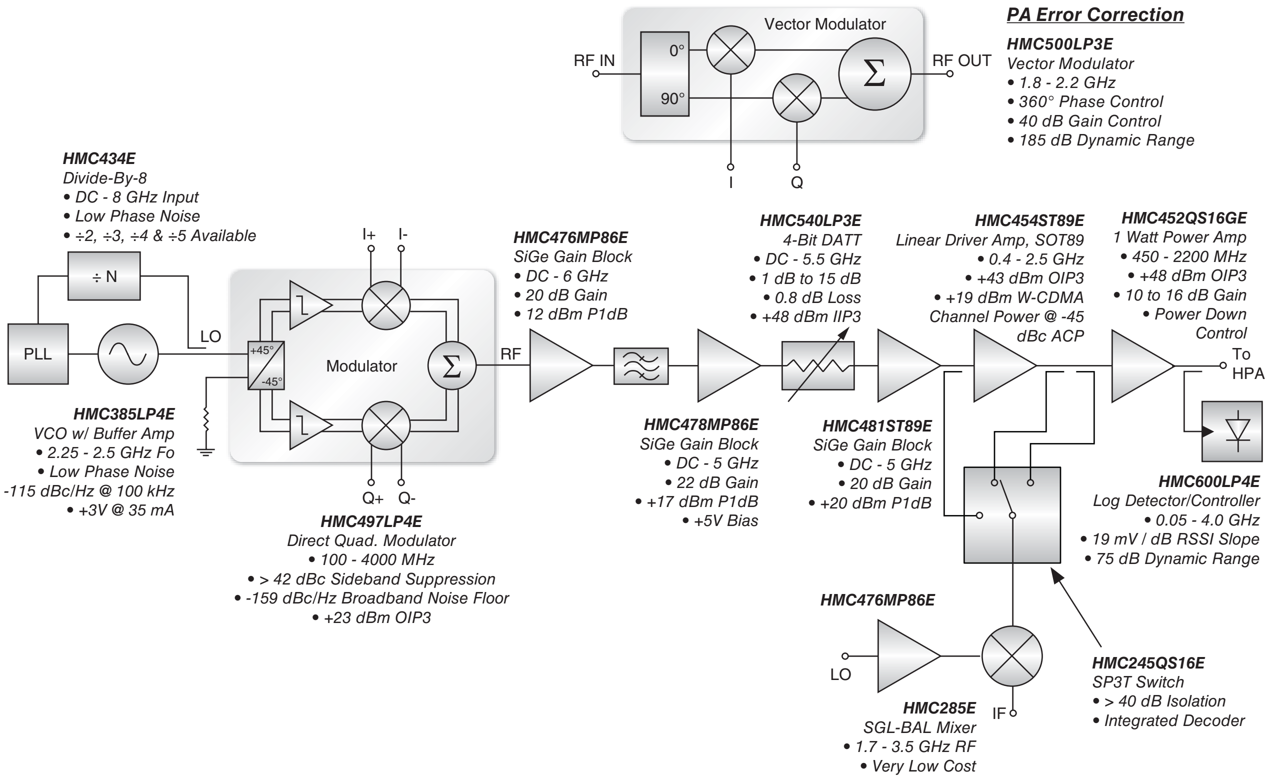
HMC373LP3E
LNA w/ Bypass Mode
• 700 - 1000 MHz
• 0.9 dB Noise Figure
• 14 dB Gain
• < 2 dB Bypass IL

HMC581LP6E
Dual Downconverter
• 800 - 960 MHz
• 9 dB Gain
• 13 dB Noise Figure
• +26 dBm IIP3

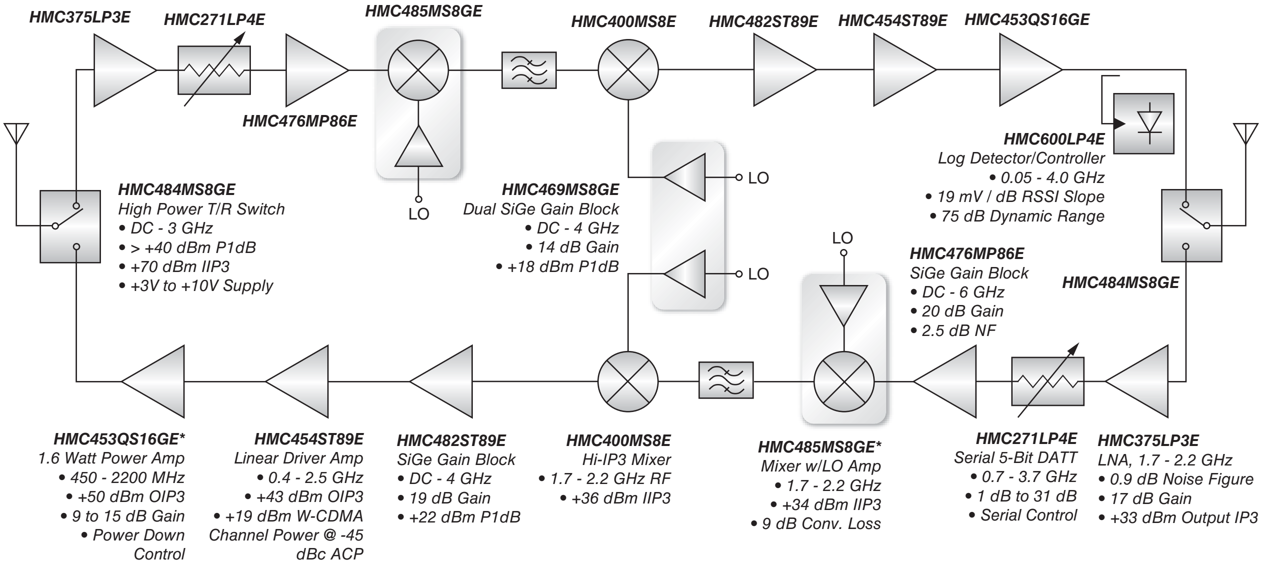
Typical Cellular/PCS/3G applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

Cellular Infrastructure, 380 - 2200 MHz

BTS Transmitter Solutions



CDMA / GSM Repeater Solutions



*** High Gain Option:**

HMC457QS16GE
1 Watt Power Amp
• 1.7 - 2.2 GHz
• +46 dBm OIP3
• 26 dB Gain

*** For 700 - 1000 MHz Systems Use:**

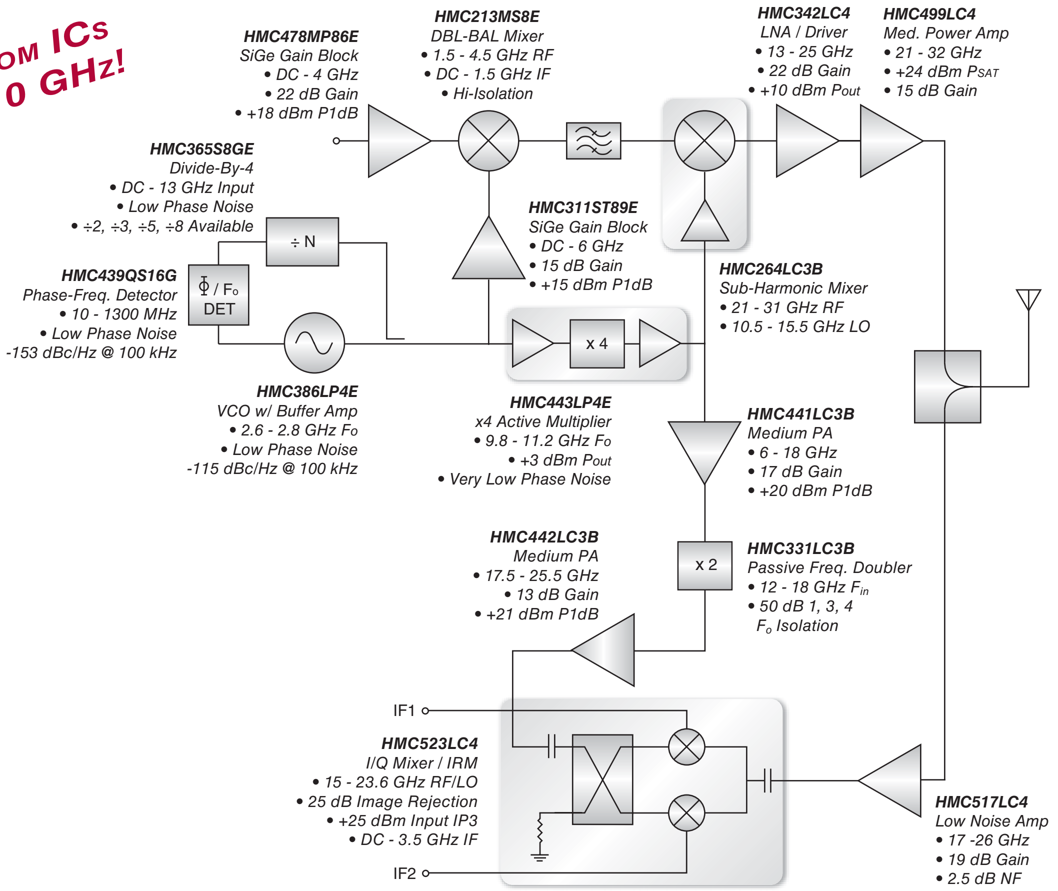
HMC483MS8GE
Mixer w/LO Amp
• 0.7 - 1.4 GHz
• +35 dBm IIP3

Typical Cellular/PCS/3G applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

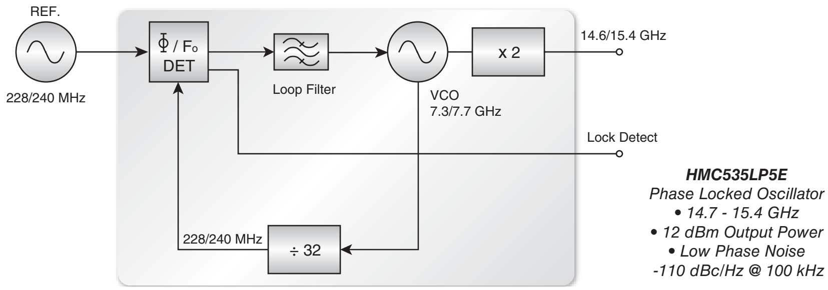
Microwave & mmWave Communications, Test & Measurement & Sensors, 2 - 60 GHz

Double Upconversion & Direct Downconversion

Custom ICs to 110 GHz!



15 GHz Integrated PLO



* Products Available in Die, SMT or Connectorized Package Form to 60 GHz!

C-4	LC3 / LC3B	LC4 / LC4B	LC5	LM1 / LM3
41.66 x 36.32 x 8.50 mm	3.0 x 3.0 x 1.0 mm	4.0 x 4.0 x 1.0 / 1.2 mm	5.0 x 5.0 x 1.0 mm	5.1 x 5.1 x 1.1 mm

Typical Microwave / Millimeterwave transceiver application is illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

Selection Guide by Market

* A selection of components, see the full product listing starting on page 5.

BROADBAND, DC - 11 GHz – CATV, DBS, VoIP, WiMAX, WiBro & WLAN

Function	0.005 - 2.15 GHz CATV & DBS	1.8 - 2.7 GHz WiMAX / WiBro	3.3 - 3.9 GHz WiMAX / WiBro	4.9 - 5.9 GHz WiMAX / Fixed
Low Noise Amplifier	HMC548LP3E HMC549MS8GE	HMC286E HMC287MS8GE HMC605LP3E	HMC491LP3E HMC593LP3E	HMC318MS8GE HMC320MS8GE
Driver Amplifier	HMC454ST89E HMC475ST89E HMC589ST89E	HMC308E HMC475ST89E HMC589ST89E	HMC326MS8GE HMC327MS8GE HMC475ST89E	HMC406MS8GE HMC407MS8GE HM415LP3E
Linear & Power Amplifier	HMC453QS16GE	HMC454ST89E	HMC409LP4E	HMC408LP3E
Attenuator: Analog	HMC473MS8E	HMC346MS8GE	HMC346MS8GE	HMC346MS8GE
Attenuator: Digital	HMC467LP3E HMC468LP3E HMC541LP3E HMC542LP4E	HMC305LP4E HMC467LP3E HMC540LP3E HMC542LP4E	HMC271LP4E HMC424LP3E HMC467LP3E HMC539LP3E	HMC424LP3E HMC425LP3E HMC467LP3E HMC468LP3E
Mixer	HMC207S8E HMC208MS8E HMC216MS8E HMC400MS8E HMC483MS8GE	HMC215LP4E HMC285E HMC316MS8E HMC334LP4E HMC552LP4E	HMC214MS8E HMC215LP4E HMC333E HMC340LP5E HMC615LP4E	HMC220MS8E HMC218MS8E HMC219MS8E HMC488MS8GE HMC525LC5
Demodulator	HMC597LP4E	HMC597LP4E	HMC597LP4E	
Modulator	HMC495LP3E HMC497LP4E	HMC495LP3E HMC497LP4E	HMC495LP3E HMC497LP4E	HMC496LP3E
Power Detector	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E
Switch: SPST & SPNT	HMC253QS24E HMC536MS8GE HMC536LP2E HMC544E HMC550E	HMC241LP3E HMC484MS8GE HMC536LP2E HMC536MS8GE HMC546LP2E HMC550E	HMC241LP3E HMC349MS8GE HMC536LP2E HMC536MS8GE HMC544E HMC550E	HMC224MS8E HMC321LP4 HMC536LP2E HMC536MS8GE HMC550E
Switch: Bypass, Diversity, Matrix & Transfer	HMC276LP4E HMC427LP3E HMC596LP4E	HMC276LP4E HMC427LP3E HMC596LP4E	HMC427LP3E	HMC436MS8GE HMC427LP3E
VCO	HMC384LP4E	HMC384LP4E HMC385LP4E	HMC388LP4E HMC389LP4E	HMC430LP4E HMC431LP4E
VGA	HMC625LP5E	HMC625LP5E	HMC625LP5E	HMC625LP5E

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

Function	400 MHz	800 / 900 MHz	1800 / 1900 MHz	2100 / 2200 MHz
Low Noise Amplifier	HMC356LP3E HMC374E	HMC372LP3E HMC376LP3E	HMC375LP3E HMC382LP3E	HMC375LP3E HMC382LP3E
Driver Amplifier	HMC454ST89E HMC475ST89E HMC478ST89E HMC580ST89E	HMC308E HMC454ST89E HMC475ST89E HMC589ST89E	HMC308E HMC454ST89E HMC475ST89E HMC589ST89E	HMC308E HMC454ST89E HMC475ST89E HMC589ST89E
Linear & Power Amplifier	HMC452ST89E HMC453ST89E	HMC450QS16GE HMC452ST89E HMC453ST89E	HMC452ST89E HMC453ST89E HMC457QS16GE	HMC452ST89E HMC453ST89E HMC455LP3E
Attenuator: Analog	HMC473MS8E	HMC473MS8E	HMC210MS8E	HMC210MS8E
Attenuator: Digital	HMC539LP3E HMC540LP3E HMC541LP3E HMC472LP4E HMC542LP4E	HMC539LP3E HMC540LP3E HMC541LP3E HMC467LP3E HMC542LP4E	HMC539LP3E HMC540LP3E HMC541LP3E HMC468LP3E HMC542LP4	HMC305LP4E HMC539LP3E HMC540LP3E HMC541LP3E HMC542LP4E
Frequency Divider & Detector	HMC394LP4E HMC434E HMC439QS16GE	HMC394LP4E HMC434E HMC439QS16GE	HMC394LP4E HMC434E HMC439QS16GE	HMC394LP4E HMC434E HMC439QS16GE
Mixer	HMC387MS8E HMC585MS8GE	HMC277MS8E HMC334LP4E HMC399MS8E HMC423MS8E HMC483MS8GE HMC551LP4E HMC581LP6E	HMC215LP4E HMC334LP4E HMC381LP6E HMC400MS8E HMC485MS8GE HMC552LP4E	HMC215LP4E HMC334LP4E HMC400MS8E HMC421QS16GE HMC422MS8E HMC615LP4
Demodulator	HMC597LP4E	HMC597LP4E	HMC597LP4E	HMC597LP4E

* A selection of components, see the full product listing starting on page 5.

CELLULAR INFRASTRUCTURE, 380 - 2200 MHz – GSM, GPRS, CDMA, WCDMA & UMTS (Cont.)

Function	400 MHz	800 / 900 MHz	1800 / 1900 MHz	2100 / 2200 MHz
Modulator	HMC495LP3E HMC497LP4E	HMC495LP3E HMC497LP4E	HMC495LP3E HMC497LP4E	HMC495LP3E HMC497LP4E
Power Detector	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E
Switch: SPST & SPNT	HMC321LP4E HMC349MS8GE HMC546MS8GE HMC550E	HMC349MS8GE HMC546MS8GE HMC550E HMC574MS8E	HMC349MS8GE HMC545E HMC546MS8GE HMC550E	HMC349MS8GE HMC484MS8GE HMC546LP2E HMC550E
Switch: Bypass, Diversity, Matrix & Transfer	HMC199MS8E	HMC199MS8E	HMC199MS8E	HMC199MS8E
VGA	HMC625LP5E	HMC625LP5E	HMC625LP5E	HMC625LP5E

FIBER OPTICS *

Function	OC-1	OC-3	OC-12	OC-48	OC-192	OC-384	OC-768
Broadband Gain Blocks	HMC396 HMC405 HMC474MP86E HMC475ST89E	HMC396 HMC405 HMC474MP86E HMC475ST89E	HMC396 HMC405 HMC474MP86E HMC475ST89E	HMC396 HMC405 HMC474MP86E HMC475ST89E	HMC405		
Wideband (Distributed) Amplifiers	HMC459 HMC460 HMC465 HMC465LP5E HMC559	HMC459 HMC460 HMC465 HMC465LP5E HMC559	HMC459 HMC460 HMC465 HMC465LP5E HMC559	HMC459 HMC460 HMC465 HMC465LP5E HMC559	HMC459 HMC460 HMC465 HMC465LP5E HMC559		
Connectorized Amplifier Modules	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037	HMC-C004 HMC-C036 HMC-C037		
Attenuators: Analog	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346G8 HMC346LP3E HMC346MS8GE	HMC346 HMC346LP3		
Attenuators: Digital	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E	HMC424 HMC424LH5 HMC424LP3E		
Connectorized Attenuator Modules	HMC-C018 HMC-C025	HMC-C018 HMC-C025	HMC-C018 HMC-C025	HMC-C018 HMC-C025	HMC-C025		
Frequency Dividers & Detectors	HMC394LP4E HMC439QS16GE HMC440QS16GE HMC492LP3E HMC493LP3E HMC494LP3E	HMC394LP4E HMC439QS16GE HMC440QS16GE HMC492LP3E HMC493LP3E HMC494LP3E	HMC394LP4E HMC439QS16GE HMC440QS16GE HMC492LP3E HMC493LP3E HMC494LP3E	HMC440QS16GE HMC492LP3E HMC493LP3E			
Connectorized Freq. Divider Modules	HMC-C040	HMC-C006 HMC-C007 HMC-C039 HMC-C040	HMC-C005 HMC-C006 HMC-C007 HMC-C039 HMC-C040	HMC-C005 HMC-C006			
Frequency Multipliers: Active					HMC448LC3B HMC576 HMC576LC3B HMC561LP3E	HMC576 HMC576LC3B HMC579 HMC561LP3E	HMC579
Connectorized Freq. Multiplier Modules					HMC-C032 HMC-C033 HMC-C034		
Connectorized Mixer Modules	HMC-C035	HMC-C035	HMC-C035	HMC-C035			
Phase Shifters: Analog				HMC247 HMC538LP4E	HMC247 HMC538LP4E		
Phase Shifters: Digital					HMC543LC4B		
Connectorized Phase Shifter Modules					HMC-C010		

Selection Guide by Market

** A selection of components, see the full product listing starting on page 5.*

FIBER OPTICS * (Continued)

Function	OC-1	OC-3	OC-12	OC-48	OC-192	OC-384	OC-768
Switches: SPDT	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E		
Switches: Multi-Throw	HMC253LC4 HMC344LC3	HMC253LC4 HMC344LC3	HMC253LC4 HMC344LC3	HMC253LC4 HMC344LC3			
Switches: Transfer	HMC427LP3E	HMC427LP3E	HMC427LP3E	HMC427LP3E			
Connectorized Switch Modules	HMC-C011 HMC-C019	HMC-C011 HMC-C019	HMC-C011 HMC-C019	HMC-C011 HMC-C019	HMC-C011 HMC-C019		

MICROWAVE & MILLIMETERWAVE RADIO *

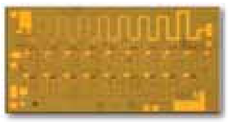
Function	7 / 8 GHz	11 GHz	13 GHz	15 GHz	18 GHz	23 GHz	26 / 28 GHz	32 / 38 GHz
Low Noise Amplifier	HMC392LH5 HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC565 HMC565LC5	HMC516LC5 HMC565 HMC565LC5	HMC517LC4 HMC565 HMC565LC5	HMC341LC3B HMC517LC4	HMC341LC3B HMC517LC4 HMC518	HMC263 HMC566
Driver Amplifier	HMC441LP3E HMC451LC3 HMC516LC5	HMC441LP3E HMC451LC3 HMC516LC5	HMC441LC3B HMC451LC3 HMC490LP5E	HMC441LC3B HMC451LC3 HMC490LP5E	HMC383LC4 HMC442LC3B HMC498LC4	HMC383LC4 HMC442LC3B HMC498LC4	HMC383LC4 HMC283LM1 HMC499LC4	HMC283LM1 HMC300LM1 HMC383LC4
Power Amplifier	HMC486LP5E HMC590 HMC590LP5E HMC591 HMC591LP5E	HMC487LP5E HMC592	HMC489LP5E HMC592	HMC489LP5E	HMC498LC4	HMC498LC4	HMC499LC4	HMC283LM1
Wideband (Distributed) Amplifiers	HMC463LH250 HMC606 HMC606LC5	HMC463LH250 HMC606 HMC606LC5	HMC463LH250 HMC606 HMC606LC5	HMC463LH250 HMC606 HMC606LC5	HMC463LH250 HMC606 HMC606LC5			
Attenuator: Analog	HMC346LP3E	HMC346LP3E	HMC346LP3E	HMC346LC3B	HMC346LC3B			
Divide-by-2	HMC361S8GE	HMC364S8GE	HMC492LP3E	HMC492LP3E	HMC492LP3E			
Divide-by-4	HMC362S8GE	HMC365S8GE	HMC493LP3E	HMC493LP3E	HMC447LC3	HMC447LC3	HMC447LC3	
Divide-by-8	HMC363S8GE	HMC363S8GE	HMC494LP3E	HMC494LP3E				
Multiplier: Active X2	HMC368LP4E HMC575LP4E HMC561LP3E	HMC368LP4E HMC573LC3B HMC561LP3E	HMC368LP4E HMC573LC3B HMC561LP3E	HMC368LP4E HMC573LC3B HMC561LP3E	HMC448LC3B HMC576 HMC576LC3B	HMC448LC3B HMC576 HMC576LC3B	HMC448LC3B HMC577LC4B HMC578 HMC578LC3B	HMC449LC3B HMC578LC3B HMC579
Multiplier: Active X4		HMC443LP4E	HMC370LP4E	HMC370LP4E				
Multiplier: Passive X2	HMC189MS8E	HMC189MS8E	HMC204MS8GE	HMC204MS8GE	HMC204MS8GE	HMC205	HMC331	HMC331
I/Q Receiver	HMC567LC5	HMC568LC5	HMC569LC5	HMC570 HMC570LC5	HMC571 HMC571LC5	HMC572 HMC572LC5	HMC572 HMC572LC5	
I/Q Mixer / IRM	HMC520LC4 HMC525LC4	HMC521LC4 HMC527LC4	HMC521LC4 HMC527LC4	HMC522LC4 HMC528LC4	HMC523 HMC523LC4	HMC523 HMC523LC4 HMC524	HMC524 HMC524LC3B	HMC404 HMC555 HMC556
Mixer: Fundamental	HMC129LC4 HMC144LC4 HMC219MS8E HMC220MS8E HMC553 HMC553LC3B	HMC144LC4 HMC411MS8GE HMC412MS8GE HMC553 HMC553LC3B	HMC144LC4 HMC411MS8GE HMC412MS8GE HMC553 HMC553LC3B	HMC144LC4 HMC260LC3B HMC412MS8GE HMC554 HMC554LC3B	HMC144LC4 HMC260LC3B HMC292LC3B HMC554 HMC554LC3B	HMC260LC3B HMC292LC3B	HMC292LC3B HMC329LC3B HMC560 HMC560LM3	HMC294 HMC329LM3 HMC560 HMC560LM3
Mixer: Sub-Harmonic				HMC258LM3	HMC258LM3 HMC337	HMC264LC3B HMC338LC3B	HMC264LC3B HMC265LM3 HMC338LC3B	HMC338 HMC339
Switch	HMC547LP3E HMC607	HMC547LP3E HMC607	HMC547LP3E HMC607	HMC547LP3E HMC607	HMC547LP3E			
VCO & PLO: **Requires X2 or X4	HMC466LP4E HMC505LP4E HMC506LP4E HMC532LP4E HMC586LC4B HMC587LC4B	HMC513LP4E HMC515LP5E HMC534LP4E HMC582LP5E HMC588LC4B	HMC513LP4E HMC529LP4E HMC584LP5E	HMC529LP4E HMC531LP5E HMC535LP5E	HMC429LP4E**	HMC431LP4E**	HMC515LP5E** HMC531LP5E**	HMC505LP4E HMC506LP4E

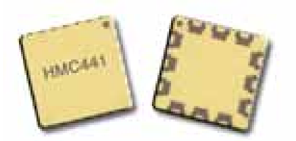
High Reliability Solutions for Land, Sea, Air & Space

MILITARY & SPACE

Military Level & Hi-Rel Commercial / Industrial Components & Assemblies

Hittite Microwave performs Class B screening on standard & custom product die and packaged die including SMT plastic encapsulated devices for COTS applications.

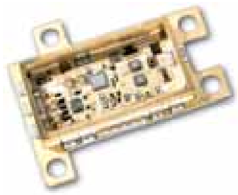


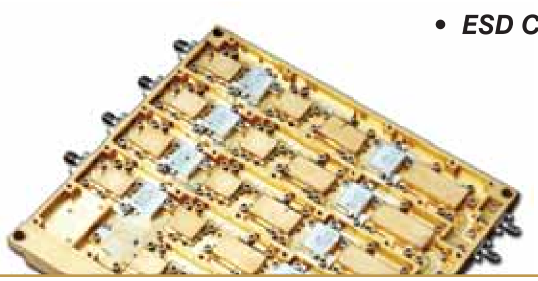


We design, produce and screen highly integrated MIC sub-assemblies for major defense OEMs.

Class B Screening MIL-PRF-38534 / 38535

- *VI to Method 2010B & 2017B*
- *Bond Pull & Die Shear Test*
- *Solderability Test*
- *High Temp Burn-In Test*
- *Vibration Stress Test*
- *Temp Cycle Stress Test*
- *Constant Acceleration Stress Test*
- *Fine & Gross Hermeticity Test*
- *Serialized Test Data*
- *ESD Characterization*





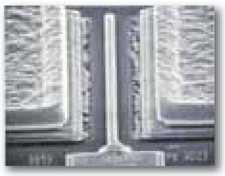
Space Level Component & Module Qualification

Class S Screening & Qualification MIL-PRF-38534 / 38535

- *VI to Methods*
  2010A & 2017S
- *Temp Cycle Stress Test*
- *High Temp Burn-In & Life Test*
- *Wafer Lot Acceptance Test*
  Bond Pull & Die Shear Test
  SEM Inspection
  Metal & Glass Thicknesses
- *Serialized Test Data*
- *Qualification Report*

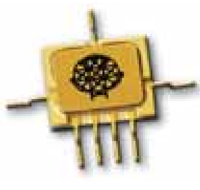
Hittite Microwave offers Class S screening on standard & custom product die and select hermetic packaged devices.

We are qualified by major spacecraft OEMs worldwide, shipping tens of thousands of S-Level components which are currently operational on dozens of commercial, scientific & military spacecraft.



FET Channel SEM

Serialized Die
in GEL-PAK



Hermetic
SMT Package

Hermetic Modules

Contact Us Today With Your High Reliability Mixed-Signal RF, Microwave & Millimeterwave Requirements!

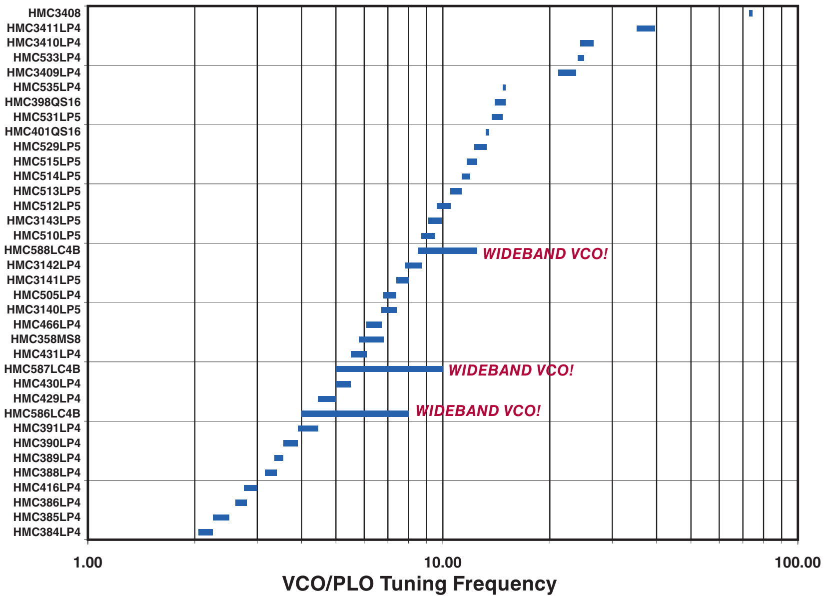
Frequency Generation

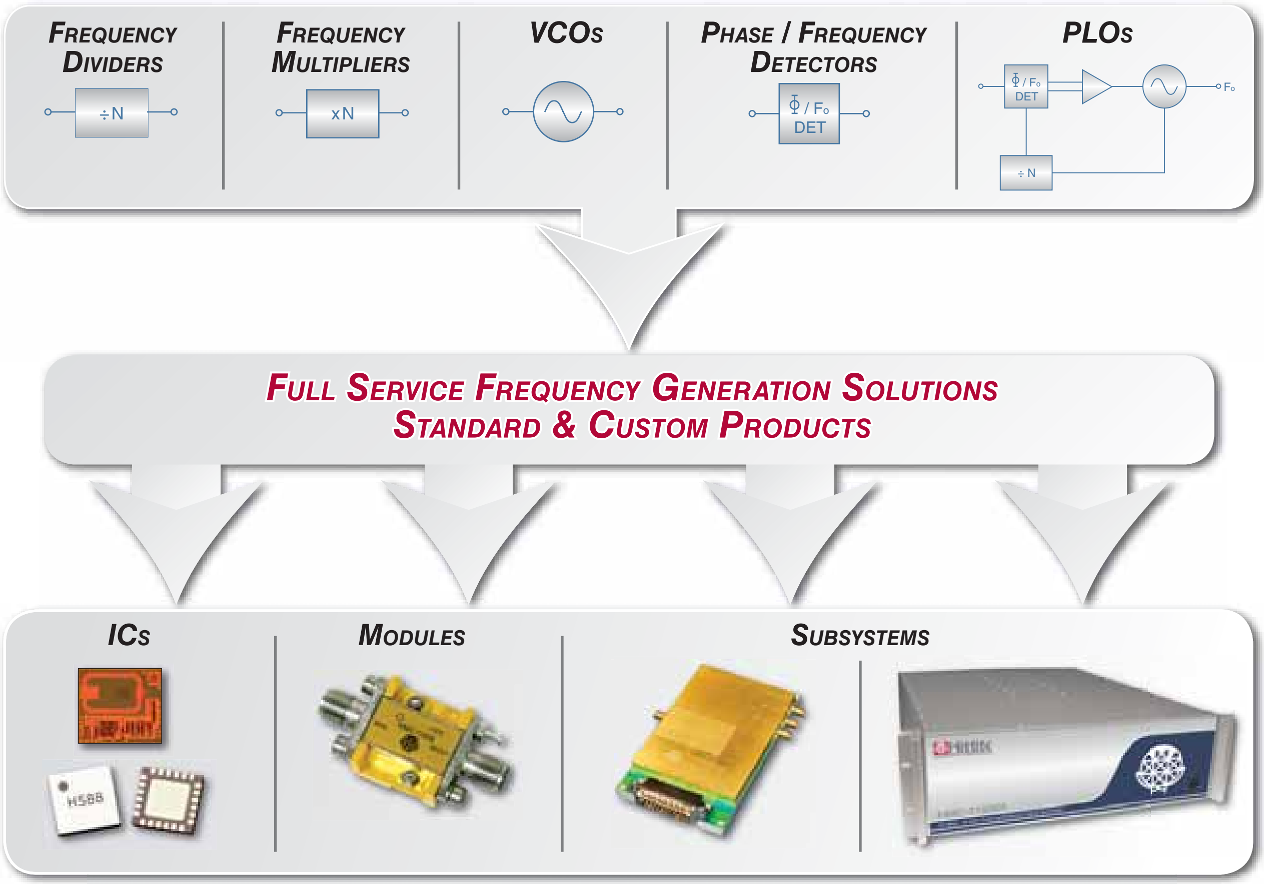
IC, Module & Subsystem Solutions to 80 GHz

VCOs, PLOs, PLLs, Dividers, Detectors, Multipliers & Synthesizers

Hittite Microwave offers standard and custom Frequency Generation products from DC to 80 GHz. Our MMIC VCOs integrate a resonator, negative resistance circuit & tuning varactor and/or dividers and buffer amplifiers. The accuracy & repeatability of MMIC wafer processing eliminates all tuning at our factory and yours.

A Sampling of MMIC VCOs & PLOs





HMC-T1000A DUAL SYNTHESIZED SIGNAL GENERATOR, 10 MHz TO 8 GHz

- *Two Independently Controllable / Programmable Synthesizers*
- *-135 dBc/Hz SSB Phase Noise @ 100 kHz Offset @ 8 GHz*
- *-75 dBc Spurious*
- *10 µSec Switching Speed*
- *Standard Rack Mountable 17” 3U Chassis*
- *Ideal for ATE, Test & Measurement, and Communications*

Two Synthesizers Per Unit

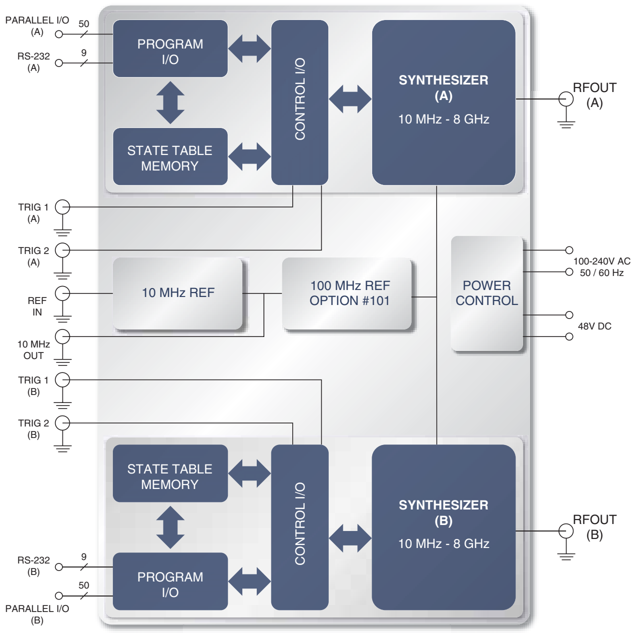
Introducing a new Synthesized Microwave Signal Generator from Hittite that delivers “best in class” ultra low phase noise performance coupled with fast 10 microsecond switching in a standard 17” 3U chassis. The HMC-T1000A integrates two, independently controllable / programmable, 10 MHz to 8 GHz synthesizers that provide high output power of up to +15 dBm each and excellent spectral purity of -75 dBc.

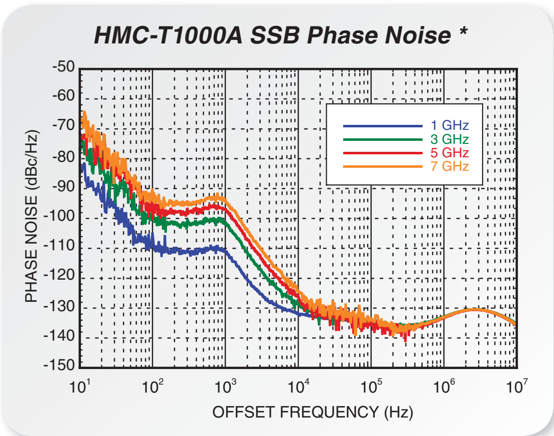
Innovative MMICs = Revolutionary Synthesizer

Based upon 20+ years of Hittite proprietary MMIC technology, packaging expertise and our unique synthesizer architecture, the HMC-T1000A achieves SSB phase noise performance of -135 dBc/Hz at 100 kHz offset that is 10 dB better than any microwave synthesizer in the same class. Our core MMIC technology delivers fast frequency switching while maintaining revolutionary phase noise performance.

Programmable & Flexible For All Applications

Both BCD-parallel and RS-232 interfaces enable independent control of each of the synthesizers. Power supply inputs include 100V to 240V 50/60 Hz AC or 48V DC. The HMC-T1000A is a flexible solution for all production test, R&D and communications applications. Hittite offers customization of the HMC-T1000A for specific electrical and environmental requirements.





SYNTHESIZER PERFORMANCE

Frequency	Range	10 MHz to 8 GHz				
	Resolution	0.001 Hz				
	Switching Speed	10 µSec				
Step Sweep	Operational Modes	Fully Programmable via State Table				
	Number of States	65,536 Maximum				
Output	General	2 Independently Controllable / Programmable RF Outputs				
	Power (dBm)	10 MHz to 3 GHz	+15 dBm			
		3 GHz to 8 GHz	+10 dBm			
Spectral Purity	Spurious	-75 dBc				
	Enhanced SSB Phase Noise (dBc/Hz) *	Offset From Carrier				
		100 Hz	1 kHz	10 kHz	100 kHz	1 MHz
	10 MHz to 1 GHz	-110	-112	-132	-135	-133
	>1 GHz to 3 GHz	-100	-102	-129	-135	-133
	>3 GHz to 5 GHz	-97	-97	-126	-135	-133
	>5 GHz to 7 GHz	-94	-95	-125	-135	-133
	8 GHz	-92	-94	-125	-135	-133

** Utilizing Option #101, 100 MHz REF*

Designer's Kits

Evaluation Boards & ICs Reduce Design Cycle Time

5 Designer Kits Available to Choose From!

- ***Gain Blocks DC - 6 GHz, HMC-DK001***
- ***Linear Driver Amplifiers 0.4 - 2.5 GHz, HMC-DK002***
- ***High IP3 Mixers 0.45 - 4.0 GHz, HMC-DK003***
- ***Digital Attenuators DC - 6 GHz, HMC-DK004***
- ***SPDT Switches DC - 12 GHz, HMC-DK005***

Design engineers can now order pre-packaged MMIC Designer Kits which enable them to quickly assess which Hittite product is the best choice for their application. The end result is a design that goes to layout more quickly and with fewer subsequent changes.

Each Hittite Designer's Kit contains an assembled & tested connectorized evaluation board, 5 to 10 ICs of each part and the latest Hittite CD-ROM catalog.

IN STOCK DESIGNER KITS

Kit Contents	Gain Blocks DC - 6 GHz HMC-DK001 *	Linear Driver Amps 0.4 - 2.5 GHz HMC-DK002 **	Hi-IP3 Mixers 0.45 - 4.0 GHz HMC-DK003 **	Digital Attenuators DC - 6 GHz HMC-DK004 **	SPDT Switches DC - 12 GHz HMC-DK005 **
ICs	HMC474MP86E HMC476MP86E HMC313E HMC311ST89E HMC478MP86E HMC478ST89E HMC479MP86E HMC479ST89E HMC481ST89E HMC480ST89E HMC481MP86E HMC482ST89E	HMC454ST89E HMC450QS16GE HMC413QS16GE HMC452ST89E HMC453ST89E HMC457QS16GE	HMC387MS8E HMC483MS8GE HMC399MS8E HMC316MS8E HMC400MS8E HMC485MS8GE HMC402MS8E HMC214MS8E HMC478ST89E HMC481ST89E HMC480ST89E	HMC291E HMC468LP3E HMC274QS16E HMC271LP4E HMC273MS10GE HMC305LP4E HMC306MS10E HMC470LP3E HMC472LP4E	HMC221E HMC284MS8GE HMC349MS8GE HMC232LP4E HMC226E HMC595E HMC574MS8E HMC484MS8GE HMC536MS8GE
Eval Boards	104217 – HMC313E 110161 – HMC478ST89E 107490 – HMC481MP86E	107749 – HMC454ST89E 108349 – HMC450QS16GE 105000 – HMC413QS16GE 108712 – HMC452ST89E 108718 – HMC453ST89E 106043 – HMC457QS16GE	110161 – HMC478ST89E 105188 – HMC485MS8GE 106334 – HMC399MS8E 101830 – HMC400MS8E	103372 – HMC291E 107302 – HMC468LP3E 104976 – HMC274QS16E 108782 – HMC271LP4E 103393 – HMC273MS10GE 108782 – HMC305MS10E 103393 – HMC306MS10E 107006 – HMC470LP3E 107010 – HMC472LP4E	101675 – HMC221E 107662 – HMC349MS8GE 107723 – HMC232LP4E 104124 – HMC574MS8E 104124 – HMC484MS8GE 105143 – HMC536MS8GE

** 10 each IC and 1 each Eval Board per kit as listed.*
*** 5 each IC and 1 each Eval Board per kit as listed.*

GAIN BLOCKS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Gain Blocks	Mini-Circuits	Gali-1, Gali-19, Gali-2, Gali-21, Gali-29	HMC311ST89E	
Gain Blocks	Mini-Circuits	VAM-3, VAM-6, VAM-7, VNA-21		HMC313E
Gain Blocks	Mini-Circuits	LEE-49, LEE-59		HMC396
Gain Blocks	Mini-Circuits	LEE-39		HMC397
Gain Blocks	Mini-Circuits	LEE-19, LEE-29		HMC405
Gain Blocks	Mini-Circuits	MAR-1SM, MAR-2SM, MAR-6SM, MAR-7SM	HMC474MP86E	
Gain Blocks	Mini-Circuits	ERA-1, ERA-1SM, ERA-2, ERA-21SM, ERA-2SM, ERA-3, ERA-3SM, ERA-8SM, MAR-3SM, RAM-1, RAM-2, RAM-3, RAM-4, RAM-6, RAM-7, RAM-8	HMC476MP86E	
Gain Blocks	Mini-Circuits	MNA-3, MNA-5, VNA-23 , VNA-28		HMC476MP86E
Gain Blocks	Mini-Circuits	Gali-S66	HMC476ST89E	
Gain Blocks	Mini-Circuits	ERA-33SM, MAR-4SM, MAR-8ASM, MAR-8SM	HMC478MP86E	
Gain Blocks	Mini-Circuits	MNA-7		HMC478MP86E
Gain Blocks	Mini-Circuits	Gali-3, Gali-33, Gali-39, Gali-4F, Gali-51F, Gali-52, Gali-55, Gali-5F, Gali-6F	HMC478ST89E	
Gain Blocks	Mini-Circuits	ERA-4SM, ERA-4XSM, ERA-5, ERA-6, ERA-6SM, MAV-11SM, MAV-11BSM, MAV-11A	HMC479MP86E	
Gain Blocks	Mini-Circuits	MNA-2 , MNA-4, VNA-22		HMC479MP86E
Gain Blocks	Mini-Circuits	Gali-4, Gali-49, Gali-6	HMC479ST89E	
Gain Blocks	Mini-Circuits	Gali-5, Gali-51, Gali-59	HMC480ST89E	
Gain Blocks	Mini-Circuits	ERA-4, ERA-50SM, ERA-51SM, ERA-5SM, ERA-5XSM	HMC481MP86E	
Gain Blocks	Mini-Circuits	MNA-6, VNA-25		HMC481MP86E
Gain Blocks	Mini-Circuits	Gali-74	HMC482ST89E	
Gain Blocks	Sirenza	SGA-4163, SGA-4263		HMC311ST89E
Gain Blocks	Sirenza	NGA-586, NGA-589, NGA-686, NGA-689		HMC313E
Gain Blocks	Sirenza	SGA-0163, SGA-0363, SGA-1163, SGA-1263, SGA-2163, SGB-2233, SGA-2263, SGA-2363, SGA-2463, SGB-4333		HMC474MP86E
Gain Blocks	Sirenza	SGA-2186, SGA-2286, SGA-2386, SGA-2486	HMC474MP86E	
Gain Blocks	Sirenza	SGA-3263, SGA-3363, SGA-3463, SGA-3563, SGB-2433, SGB-4533		HMC476MP86E
Gain Blocks	Sirenza	NGA-386 , SGA-3286, SGA-3386, SGA-3486, SGA-3586	HMC476MP86E	
Gain Blocks	Sirenza	SGA-4186, SGA-4286, SGA-4386, SGA-4486, SGA-5386, SGA-5486, SGA-5586	HMC478MP86E	
Gain Blocks	Sirenza	SGB-6433, SGB-6533		HMC478MP86E
Gain Blocks	Sirenza	SGA-4363, SGA-4463, SGA-4563		HMC478ST89E
Gain Blocks	Sirenza	SGA-4586, SGA-5389, SGA-5489, SGA-5589	HMC478ST89E	
Gain Blocks	Sirenza	SGA-5263		HMC479ST89E
Gain Blocks	Sirenza	SGA-5286	HMC479MP86E	
Gain Blocks	Sirenza	SGA-5289	HMC479ST89E	
Gain Blocks	Sirenza	NGA-489 , SGA-6289, SGA-6389, SGA-6489, SGA-6589, SGA-7489	HMC580ST89E	
Gain Blocks	Sirenza	SGA-6386, SGA-6286, SGA-6486, SGA-6586	HMC481MP86E	
Gain Blocks	Sirenza	NGA-186, NGA-286, NGA-486		HMC480ST89E
Gain Blocks	Sirenza	SGA-7489	HMC482ST89E	
Gain Blocks	WJ	AH1	HMC454ST89E	
Gain Blocks	WJ	ECG004B, ECG006F	HMC311ST89E	HMC311LP3E
Gain Blocks	WJ	AG102, AG103	HMC580ST89E	
Gain Blocks	WJ	AG302-63, AG303-63, ECG004F		HMC313E
Gain Blocks	WJ	AG201-63, AG202-63, AG203-63		HMC474MP86E
Gain Blocks	WJ	AG201-86, AG202-86, AG203-86	HMC474MP86E	
Gain Blocks	WJ	AG302-86, AG303-86, ECG001C, ECG004C	HMC476MP86E	
Gain Blocks	WJ	ECG001F, ACG001B		HMC476MP86E
Gain Blocks	WJ	AG503-86, ECG002C, ECG006C	HMC478MP86E	
Gain Blocks	WJ	ECG002F		HMC478MP86E
Gain Blocks	WJ	ECG006B, ECG002B, SCG002B, AG503-89	HMC478ST89E	
Gain Blocks	WJ	AG402-86, ECG040C, AG602-86, EC1119C	HMC479MP86E	
Gain Blocks	WJ	AG402-89, ECG040B, AG602-89, EC1119B	HMC479ST89E	
Gain Blocks	WJ	AG603-89, AG604-89, ECG050B, EC1019B	HMC480ST89E	
Gain Blocks	WJ	AG403-86, ECG005C, ECG055C, AG603-86, AG604-86, ECG050C, EC1019C, EC1078C	HMC481MP86E	
Gain Blocks	WJ	AG403-89, ECG005B, ECG055B	HMC481ST89E	
Gain Blocks	WJ	EC1078B, ECG003, ECG008	HMC482ST89E	

Hittite Microwave Offers Performance & Price Competitive Components

ATTENUATORS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Digital Attenuators	Skyworks	AA100-59LF	HMC230MS8E	
Digital Attenuators	Skyworks	AA101-80	HMC274QS16E	
Digital Attenuators	Skyworks	AA106-86	HMC603MS10E	
Digital Attenuators	Skyworks	SKY12322-86	HMC306MS10E	
Digital Attenuators	Skyworks	SKY12324-73	HMC291E	
Digital Attenuators	M/A-COM	MAATSS0002	HMC274QS16E	
Digital Attenuators	M/A-COM	MAATSS0001	HMC603QS16E	
Digital Attenuators	M/A-COM	MAATSS0017	HMC603QS16E	
Digital Attenuators	M/A-COM	MAATSS0012	HMC306MS10E	

POWER DETECTORS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Log Detectors	Analog Devices	AD8313		HMC600LP4E HMC601LP4E
Log Detectors	Analog Devices	AD8318		HMC602LP4E
True RMS Detectors	Analog Devices	AD8362		HMC610LP4E
Log Detectors	Maxim	MAX2015		HMC600LP4E HMC601LP4E
Log Detectors	Linear Technology	LT5534		HMC600LP4E HMC601LP4E

SWITCHES

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Switches	Skyworks	AS204-80	HMC241QS16E	
Switches	Skyworks	AS196-307	HMC349LP4CE	
Switches	Skyworks	AS193-73	HMC226E	
Switches	Skyworks	AS169-73	HMC545E	
Switches	Skyworks	AS186-302	HMC435MS8GE	
Switches	M/A-COM	SW-239	HMC239S8E	
Switches	M/A-COM	SW-395		HMC226E

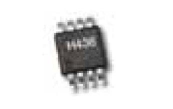
Available SMT & Module Packages

Plastic SMT

E 
MP86 "Micro-P" 5.21 x 5.08 x 1.57 mm

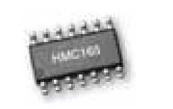
E 
SOT26 2.8 x 2.9 x 1.2 mm

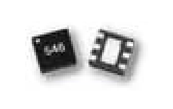
E 
ST89 4.50 x 4.14 x 1.54 mm

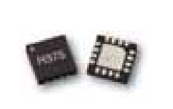
E 
MS8 / MS8G 4.9 x 3.0 x 1.0 mm

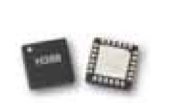
E 
MS10 / MS10G 4.9 x 3.0 x 1.0 mm

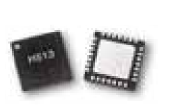
E 
S8 / S8G 6.0 x 4.9 x 1.6 mm

E 
S14 6.0 x 8.7 x 1.6 mm

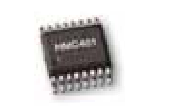
E 
LP2 "DFN" 2.0 x 2.0 x 1.0 mm

E 
LP3 "QFN" 3.0 x 3.0 x 1.0 mm

E 
LP4 / LP4C "QFN" 4.0 x 4.0 x 1.0 mm

E 
LP5 "QFN" 5.0 x 5.0 x 1.0 mm

E 
LP6 "QFN" 6.0 x 6.0 x 1.0 mm

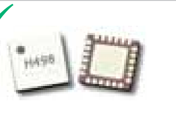
E 
QS16 / QS16G 6.0 x 4.9 x 1.5 mm

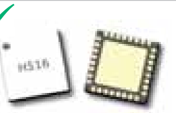
E 

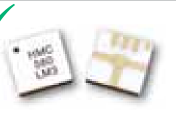
QS24 6.0 x 8.7 x 1.6 mm

Ceramic SMT

✓ 
LC3 / LC3B 3.0 x 3.0 x 1.0 mm

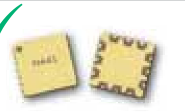
✓ 
LC4 / LC4B 4.0 x 4.0 x 1.0 / 1.2 mm

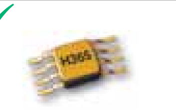
✓ 
LC5 5.0 x 5.0 x 1.0 mm

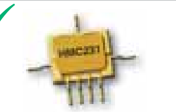
✓ 
LM1 / LM3 5.1 x 5.1 x 1.1 mm

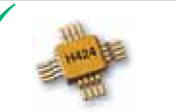
✓ 
C8 7.4 x 5.1 x 2.4 mm

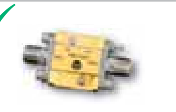
Hermetic Ceramic SMT & Connectorized Modules

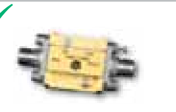
✓ 
LH5 Hermetic 5.0 x 5.0 x 1.0 mm

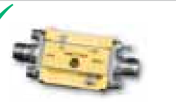
✓ 
G8 Hermetic 10.2 x 4.6 x 1.8 mm

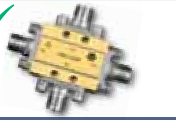
✓ 
G7 Hermetic 16.1 x 17.3 x 1.7 mm

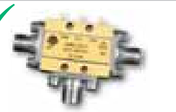
✓ 
G16 Hermetic 10.4 x 10.4 x 1.7 mm

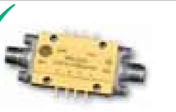
✓ 
C-1 / C-1B 35.31 x 17.78 x 7.38 mm

✓ 
C-2 / C-2B 38.1 x 17.78 x 7.38 mm

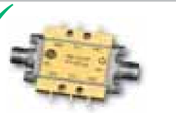
✓ 
C-3 / C-3B 40.89 x 17.78 x 7.38 mm

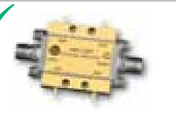
✓ 
C-4 41.66 x 36.32 x 8.50 mm

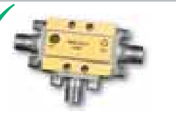
✓ 
C-5 41.66 x 29.84 x 8.50 mm

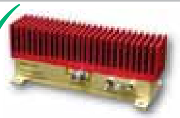
✓ 
C-6 45.34 x 17.27 x 8.50 mm

✓ 
C-7 192.3 x 106.7 x 35.0 mm

✓ 
C-9 41.66 x 27.59 x 8.50 mm

✓ 
C-10 / C-10B 41.66 x 27.59 x 8.50 mm

✓ 
C-11 41.66 x 29.84 x 8.50 mm

✓ 
C-12 107.6 x 43.0 x 43.0 mm

E ✓ =RoHS Compliant.

HMC "Green" Component Program

Hittite Microwave meets the Restriction of Hazardous Substances (RoHS) European Union directive and has eliminated halogen compounds, antimony compounds and lead (Pb) from our products. HMC plastic package types are now qualified for both RoHS and JEDEC MSL1 (260 deg. C peak temperature) and their related products have been released to production. The lead plating is 100% matte tin (Sn) over copper alloy and is compatible with standard SnPb solder as well as higher temperature "Pb free" solders. RoHS Compliant "E" products are form, fit & functional replacements for their related, released non-RoHS HMC product. Products such as all bare die (chips) and ceramic based packages have always been RoHS Compliant, are released, are available from stock and do not require a "E" part number suffix designator.

Hittite offers RoHS Compliant RFIC & MMIC standard catalog products and will continue to offer the original non-RoHS versions of our plastic packaged products. Please contact earthfriendly@hittite.com for details on our RoHS Compliant products or see the RoHS Compliant Components link on our web site.

Hittite MICROWAVE CORPORATION

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Hittite Microwave Corporation is Committed to:

- *Being a supplier of products of the highest quality.*
- *Advancing state-of-the-art technology to support our products.*
- *Enhancing our competitive position with superior products.*

Hittite's Quality Policy Recognizes Responsibilities for Every Individual to:

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- *Create an environment where highest standards are maintained.*
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Data Sheets

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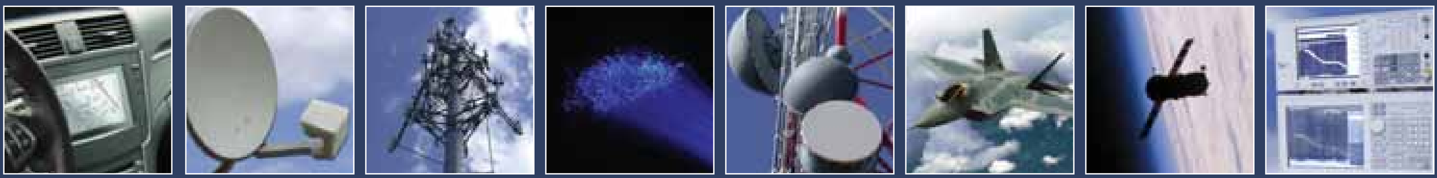

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