Vol. 51 • No. 6

June 2008

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XTO-05	5-130 MHz	Ovenized Crystal	-95	-120	-140	-155	-160	-	100 MHz	11
PLD	30-130 MHz	P.L. Crystal	-95	-115	-140	-155	-155	-	100 MHz	13
PLD-1C	130-1000 MHz	P.L. Mult. Crystal	-80	-100	-120	-130	-135	-	560 MHz	13
BCO	.100-16.5 GHz	P.L. Single Loop	-65	-75	-80	-90	-115	-	16.35 GHz	13
VFS	1-14 GHz	Multiple Freq. Dual Loop	-60	-75	-110	-115	-115	-	12.5 GHz	13
DLCRO	.8-26 GHz	P.L. CRO Dual Loop	-60	-85	-110	-115	-115	-138	10 GHz	13
PLDRO	2-40 GHz	P.L. DRO Single/Dual	-60	-80	-110	-115	-120	-145	10 GHz	13
CP	.8-3.2 GHz	P.L. CRO Single Loop	-80	-110	-120	-130	-130	-140	2 GHz	13
CPM	4-15 GHz	P.L. Mult. Single Loop	-60	-90	-105	-110	-115	-130	12 GHz	13
ETCO	.1-24 GHz	Voltage Tuned CRO	-	-	-70	-100	-120	-130	2-4 GHz*	13

* Octave band.

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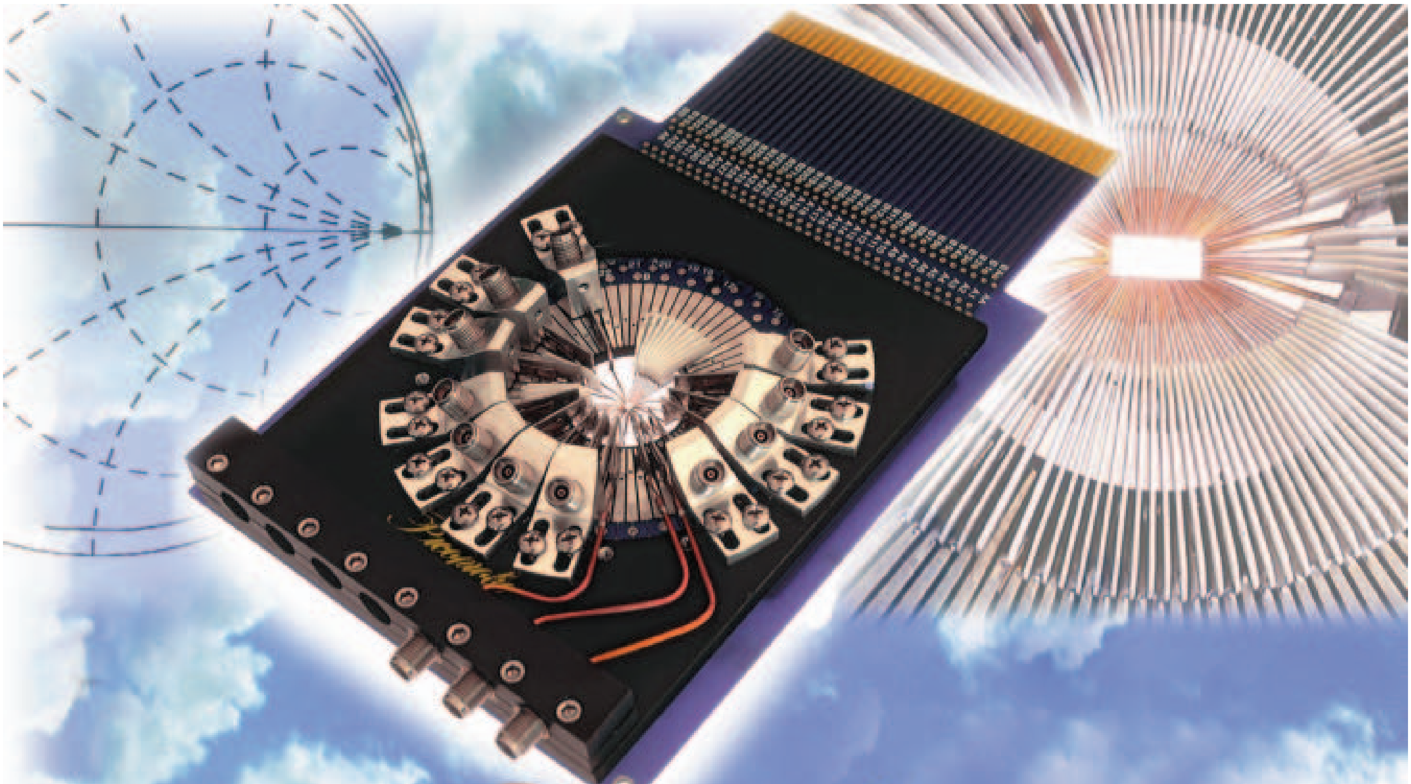

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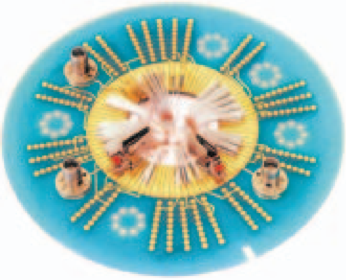

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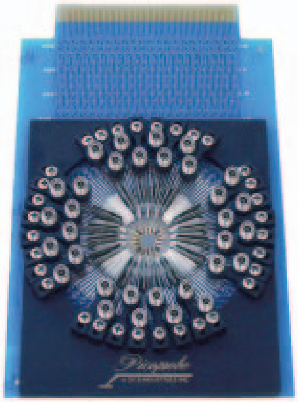

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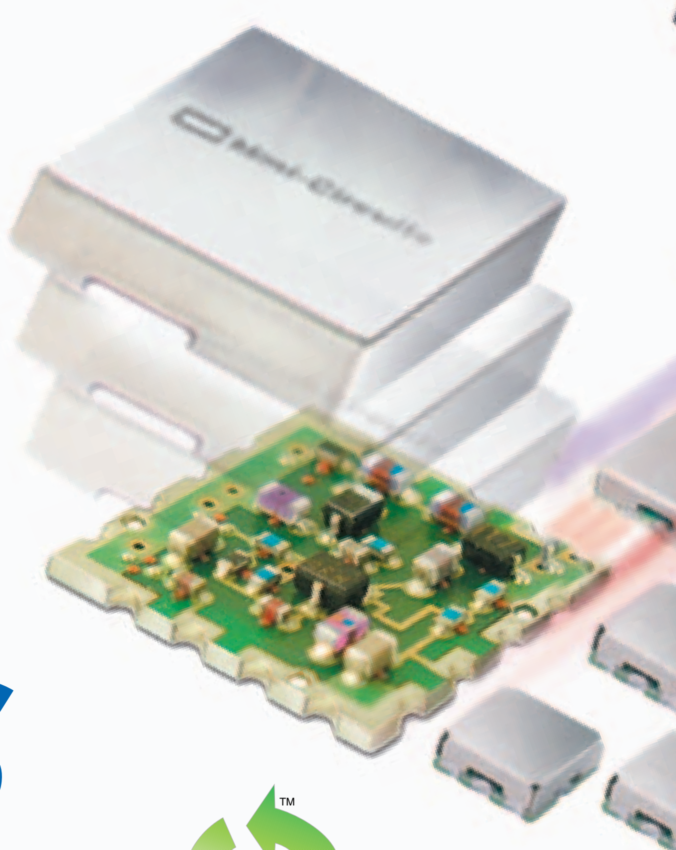

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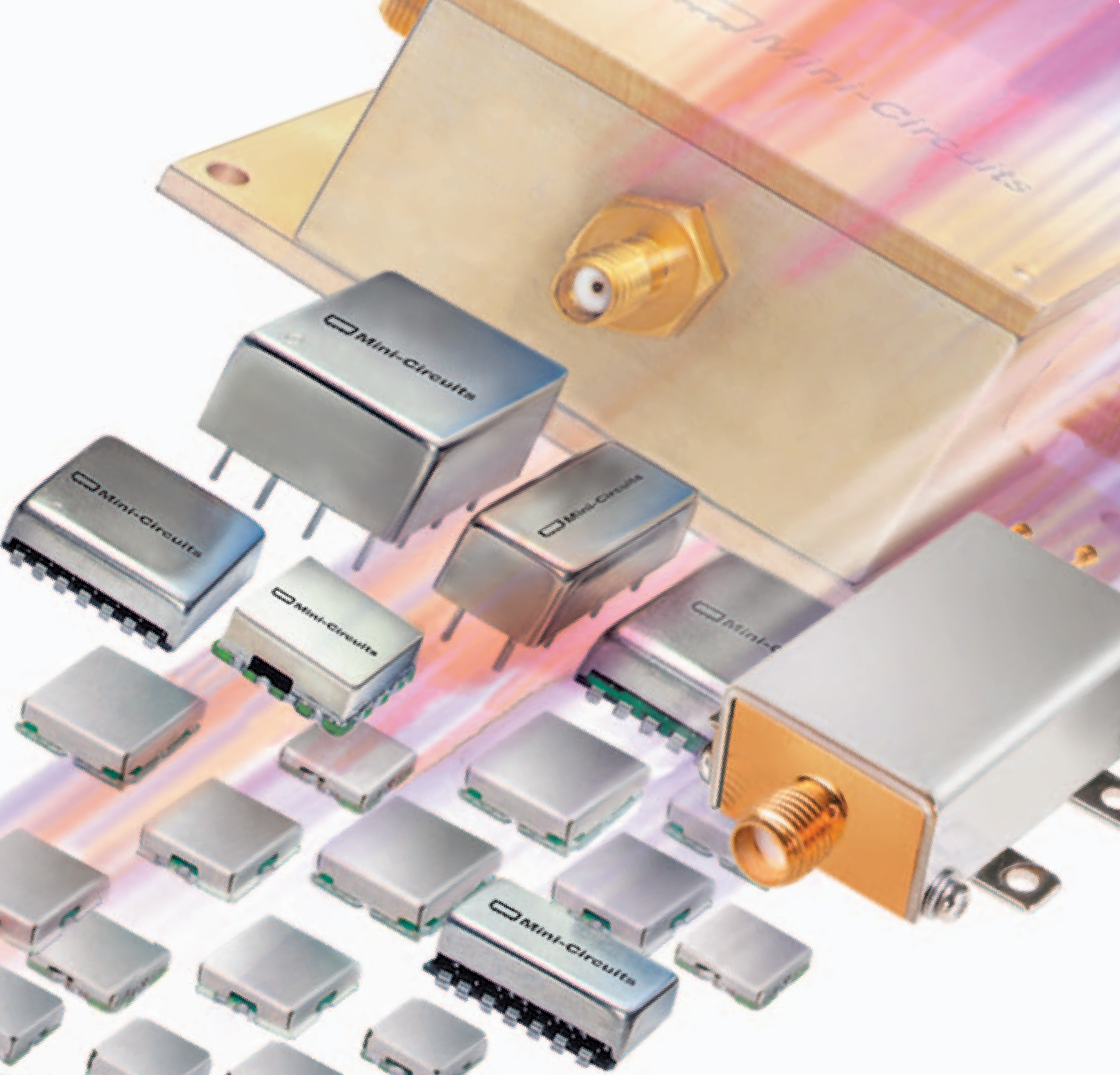

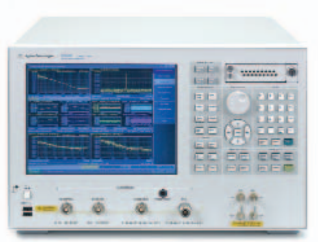

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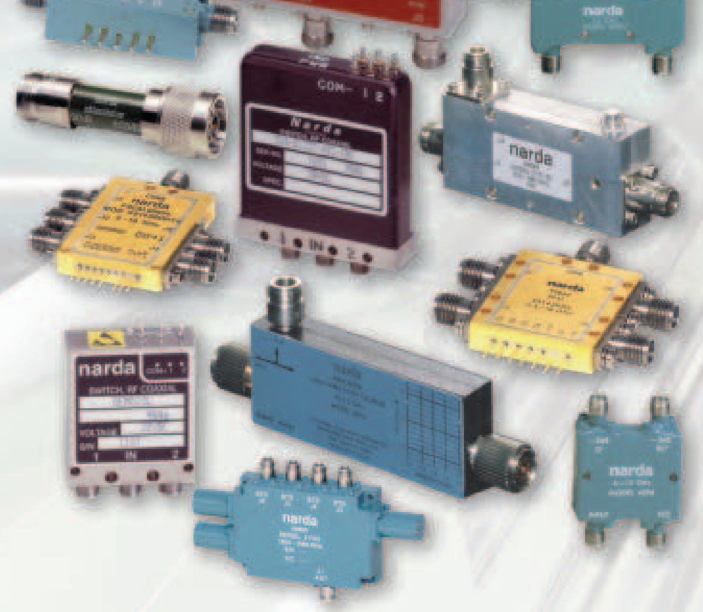

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COVER FEATURE: THEN AND NOW

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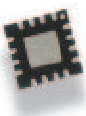

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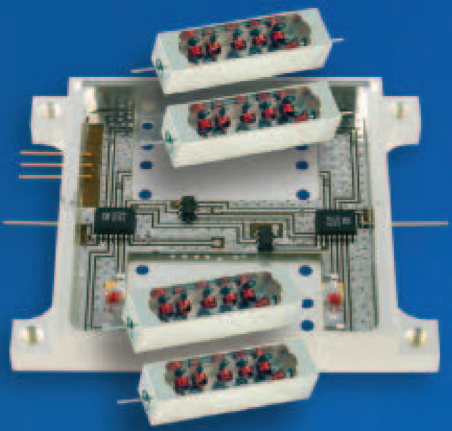

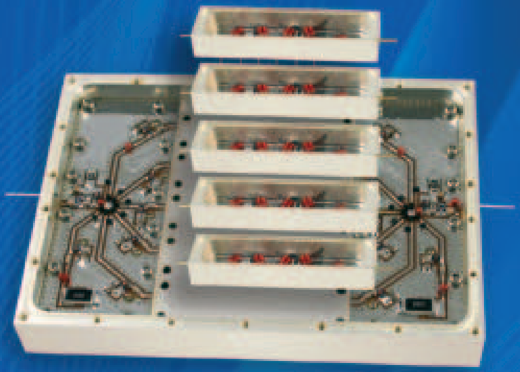

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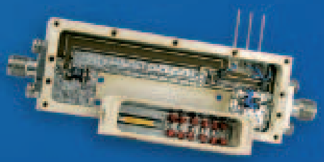

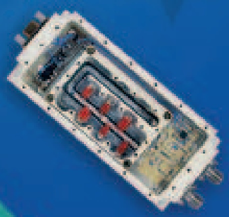

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June: For acoustic researchers, BAW filter tunability remains a sort of 'Holy Grail.' What would extending the tuning range mean to the industry? Join Robert Aigner, PhD, Director of R&D Acoustic Technologies, TriQuint, for an insightful discussion.

Event

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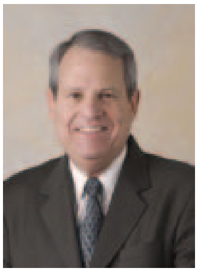
Executive Interview

In this month's executive interview, *MWJ* talks with **Robert Van Buskirk**, President of RFMD's Multi-Market Products Group (MPG). Robert shares his unique perspective from his senior management position about the technical and business focus of this group as well as the motivating factors behind RFMD's acquisition of Sirenza and Filtronic Compound Semiconductor, the logistics of merging these organizations and the outlook for multi-market RF/microwave semiconductor devices.



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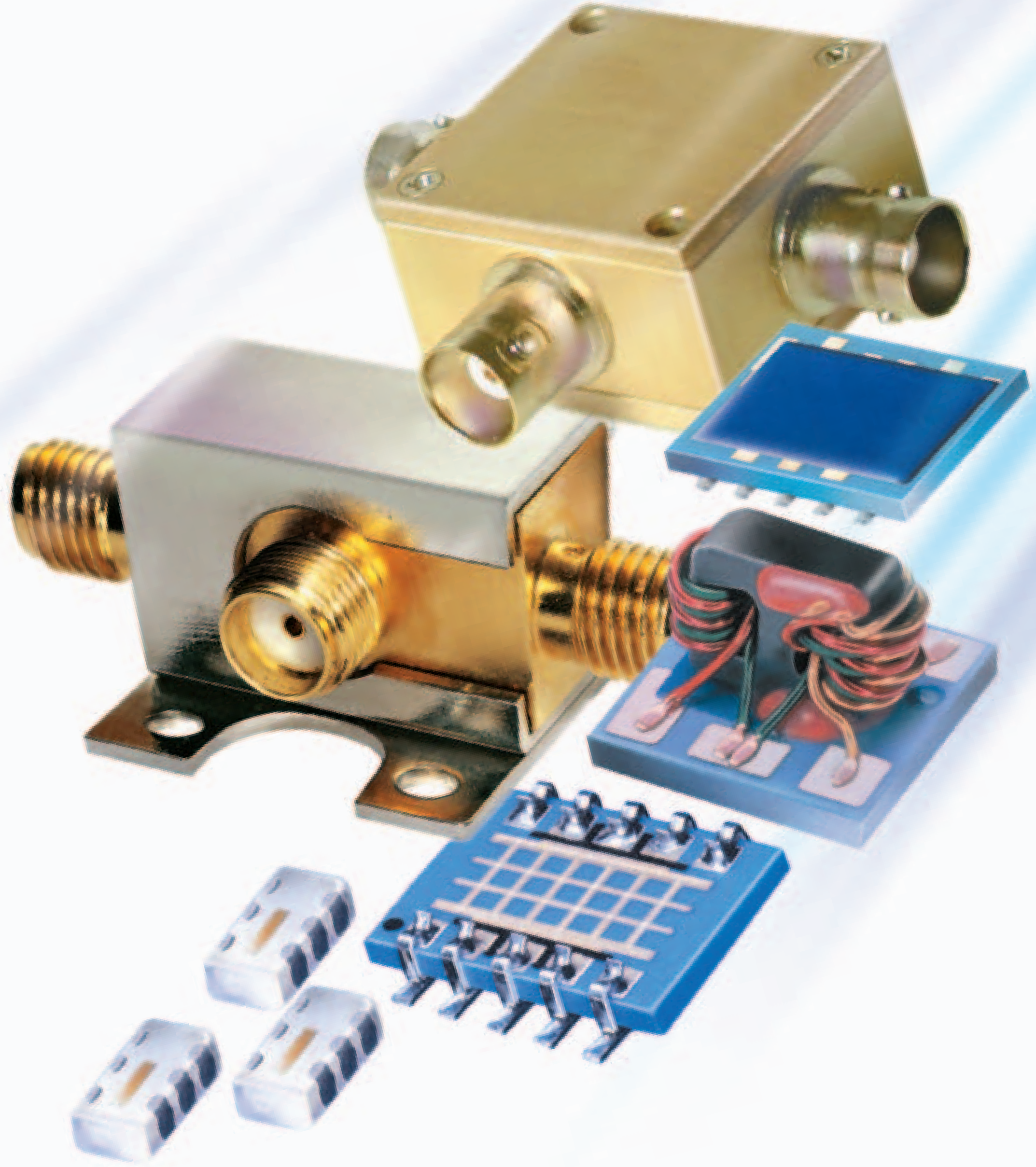

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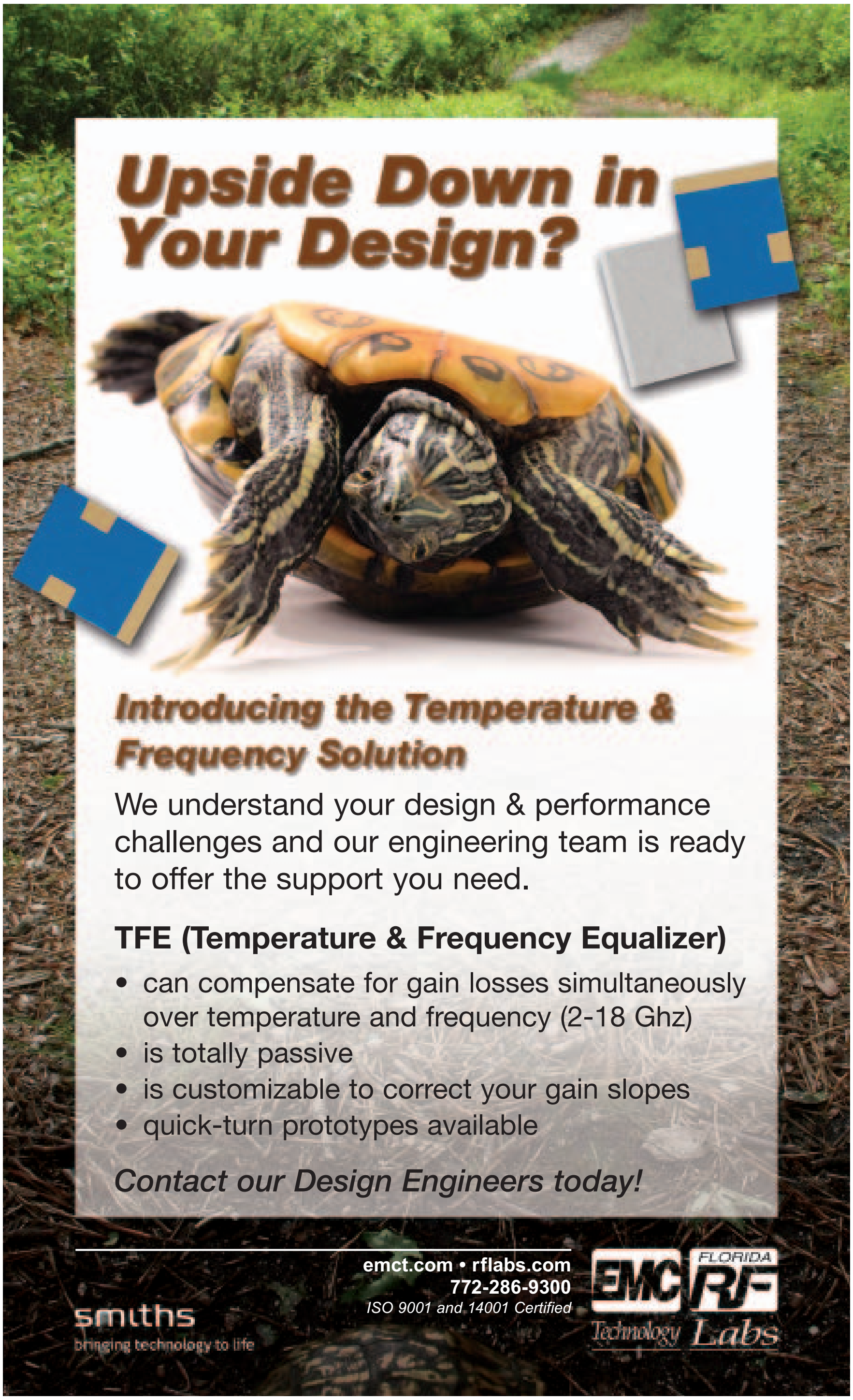

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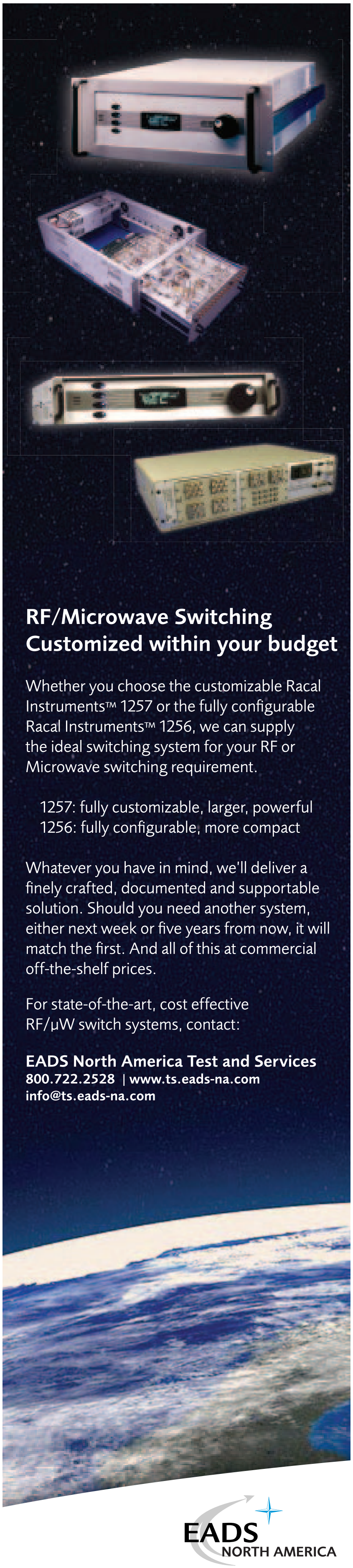

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■ **Site:** Archived on-line course.

■ **Dates:** Archived on-line for anytime viewing.

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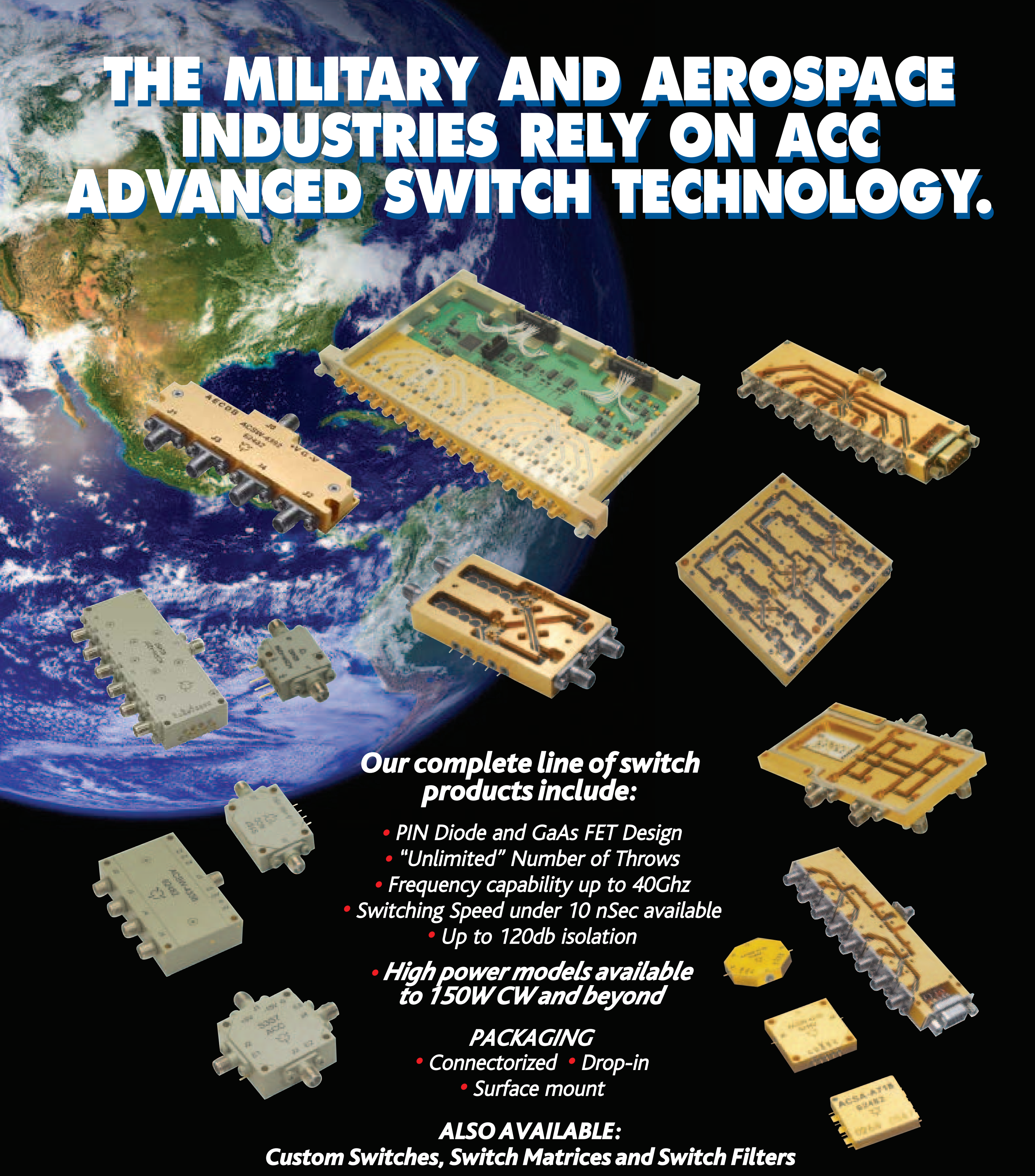

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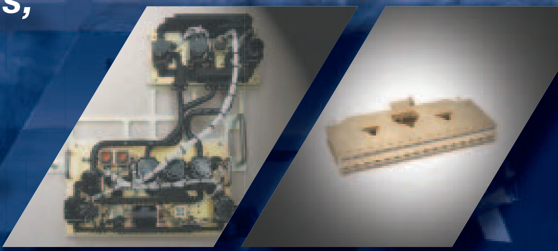

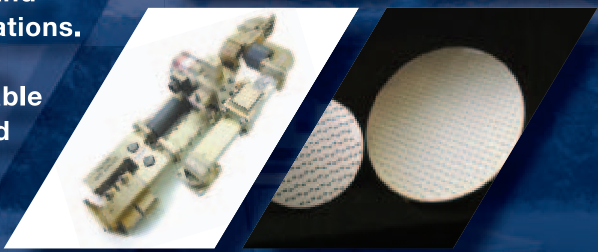

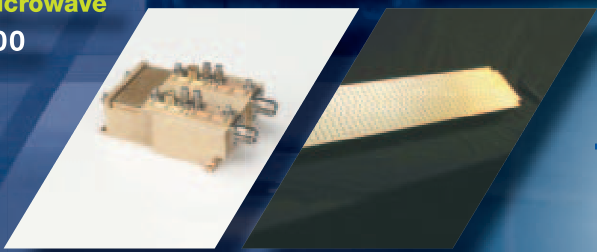

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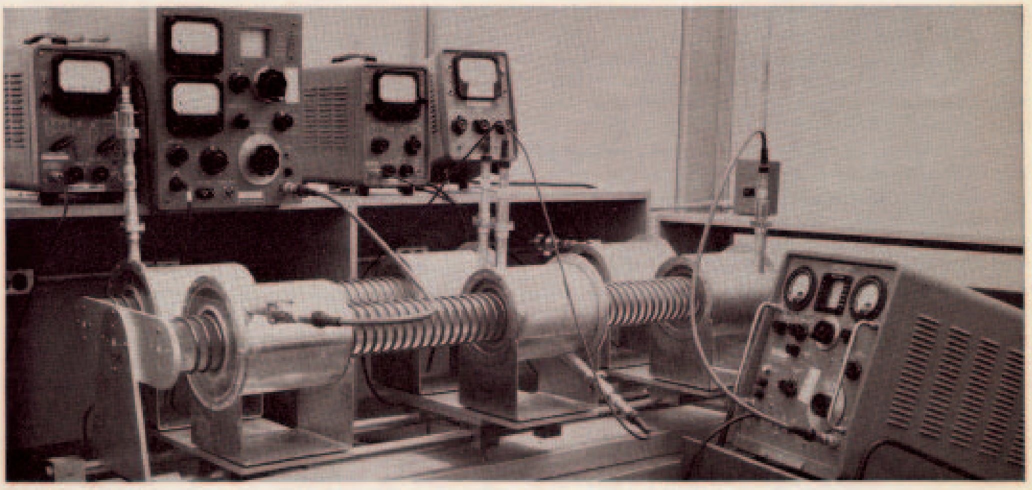
…is paper describes a device which can be used to change the path length between two terminals with a minimum of mechanical motion. It is essentially an electromechanical device using the principles of coupled helices and spatial beating phenomena. A most effective use can be made of this device in the VHF and UHF frequency regions where physically long line lengths become an intolerable mechanical burden. The phase shifter is analyzed according to transmission line theory. Exact dimensions and test results are given for a model which was built using this theory.



A HELICAL PHASE SHIFTER FOR V H F

By PAUL A. CRANDELL*
SYLVANIA ELECTRIC PRODUCTS, INC., WALTHAM, MASS.

FREDERICK J. DOMINICK**
SYLVANIA ELECTRIC PRODUCTS, INC., WALTHAM, MASS.

I. Introduction

An antenna beam scanner which uses the principle of phasing for beam steering a linear array has been designed. Essentially it is a slow wave helical structure with a coupled non-contacting outer helix. The directionally coupled outer helix can be varied mechanically along the axis of the inner helix to change the line length between two terminals. A series of single coupled helices can be used to program the phase to an array of elements and, in turn, to steer the beam of the array.

II. Theory of Coupled Helix

As shown in Figure 1, the phase shifting device operates on the principle of coupled helices. The energy incident on T_2 is electromagnetically transferred to the inner helix in the direction of T_1, thereby producing a non-contacting unity transmission device. With translational motion of the outer helix, this device becomes a phase shifter.

The electric design of the phase shifter was undertaken according to the theory proposed by Kompfner, et al,[1] which states that if the helices are contrawound and the phase velocities on each helix are equal, complete unidirectional power transfer takes place when the helices are coupled over some appropriate length.

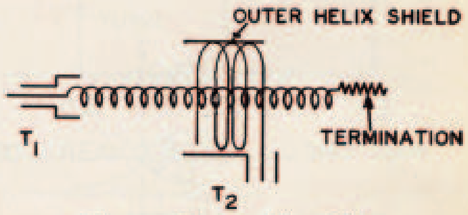


Figure 1 — Diagram of Phase Shifter

The properties of a concentric helix structure may be investigated by means of field theory; however, interesting properties can be deduced more simply by considering two transmission lines with uniformly distributed self and mu-

*Paul A. Crandell, formerly with Sylvania, now with National Company, Malden, Mass.
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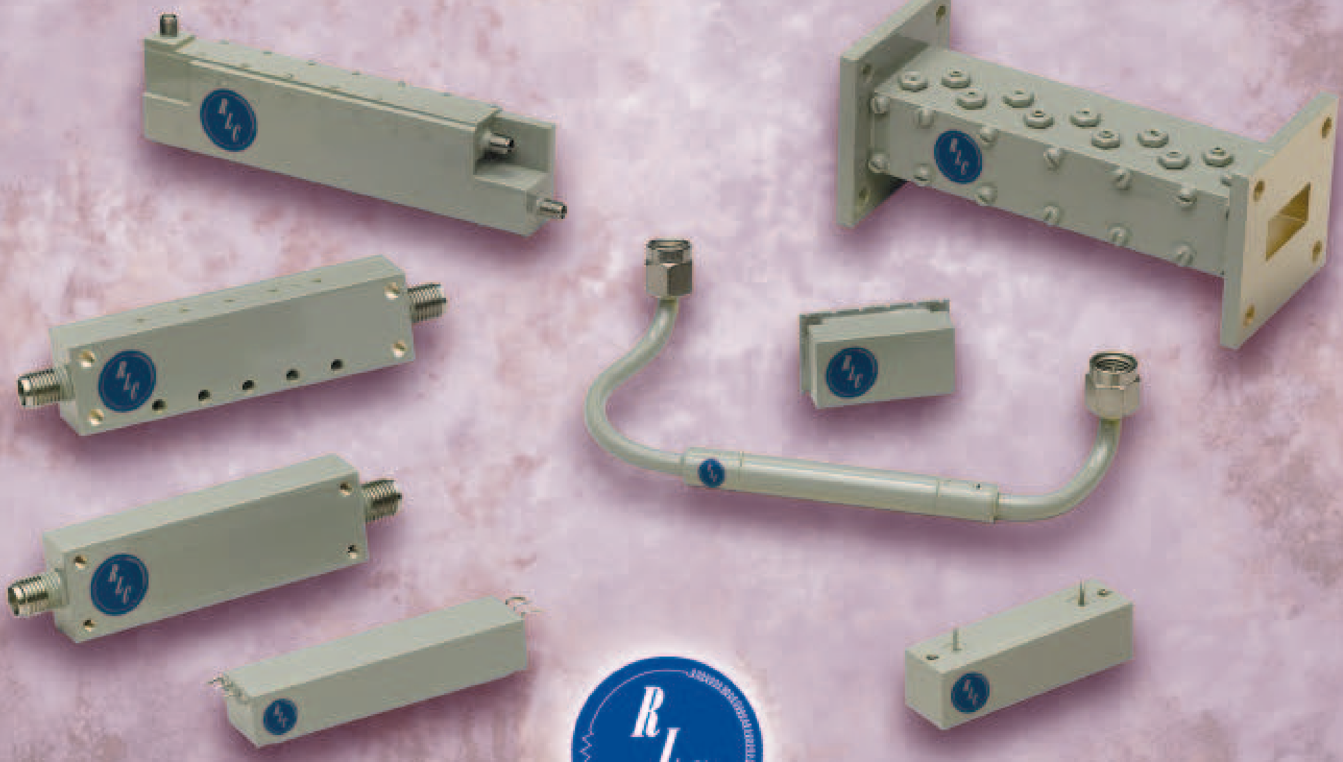

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tual susceptances and reactances. The use of field theory is inadvisable because of its mathematical complexity. If it were applied, the actual wire helix would have to be replaced by a helically conducting sheet of the same mean radius. Such a conducting sheet, or "sheath helix" as it is usually called, can conduct current only in the wire direction. The reason for replacing the wire helix by a sheath helix is that Maxwell's Equations cannot be solved in an appropriate coordinate system in which the surface of the wire is described by keeping one of the coordinates constant. For a detailed explanation of the solution of Maxwell's equations for a sheath helix, reference is made to a report written by S. Sensiper.[2]

In analyzing a concentric helix structure according to transmission line theory, the concentric helices can readily be compared to two transmission lines of series impedances jX_1 and jX_2, and shunt admittances jB_1 and jB_2, coupled by series mutual impedance jX_{12} and shunt mutual admittance jB_{12}. Applied to the case in which two transmission lines are coupled together, the transmission equations take the following form:

$$\frac{\partial I}{\partial z} = -jBV_1 - jB_{12}V_2$$

and

$$\frac{\partial V}{\partial z} = -jXI_1 - jX_{12}I_2,$$

where jX_{12} and jB_{12} are the series mutual impedance and shunt mutual admittance, respectively. Pierce[3] shows by suitable manipulations that if $X_1B_1 = X_2B_2$, there are two modes of transmission: a longitudinal mode in which

$$\frac{V_2}{V_1} = +1,$$

and a transverse mode in which

$$\frac{V_2}{V_1} = -1.$$

When these two modes are excited on the helix, the field distribution is such that the plane where the interfering currents are destructive on one sheath is the plane where they are constructive on the other sheath (see Figure 2). If the currents cancel completely on the inner helix, the condition for complete energy transfer is satisfied.

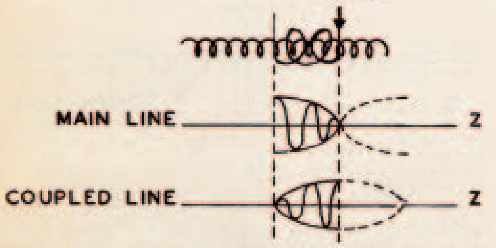


Figure 2 — Diagram of Instantaneous Current on Two Helices

III. Determination of Dimensions for the Phase Shifter

The important dimensions in designing a helical phase shifter are the pitch, the size of the wire, and the diameters of the helices. To obtain these dimensions for the VHF phase shifter described below, a delay factor of 14 was used as a starting point. This was not an arbitrary choice, but one based on considerations outlined by Stark.[4] This delay factor is the ratio of the velocity of light to that of the phase velocity on the helix, and is also equal to the ratio of the circumference to the pitch of the helix. In the model described here, the helix had a circumference of 10.84 inches; therefore, in keeping with the choice of 14 for delay factor, the pitch of the helix was 0.774 inch.

The next parameter considered was the wire diameter. Calculations by Peters, et al,[5] show that for least attenuation the ratio of the wire size diameter to the pitch should be equal to 0.33. On this basis, the wire diameter of the inner helix was established as 0.256 inch.

The theory of coupled helices[1] shows that the beat wavelength is stationary with respect to frequency, if the correct choice of geometrical parameters is made. To obtain stationary beat wavelength, the radius of the coupling (outer) helix should be approximately 1.5 times that of the inner helix. It is important to note that stationary beat wavelength also occurs when $\beta(a_2 - a_1) = 1$, where β is the uncoupled phase constant which is assumed to have the same value for both helices. Therefore, using the ratio of $a_2/a_1 = 1.5$, and $\beta_1 = \beta_2$ as a first approximation, it is possible to obtain the following dimensions:

Outer helix diameter = 5.15 inches (O.D.),
Circumference of outer helix $= \pi D = 16.2$ inches

$$\tau \text{ (pitch)} = \frac{\text{circumference}}{14} = 1.16 \text{ inches,}$$

and

Diameter of wire = (0.33) (1.16) = 0.383 inch.

Up to this point no account had been taken of the effects of the shield around the outer helix; therefore, the next step was to calculate the phase velocity of the shielded outer helix with the formulas developed by H. S. Kirchbaum:[6]

$$V_z \text{ (phase velocity)} = \frac{\tan \Psi}{\sqrt{u_o \varepsilon_2}} \sqrt{\frac{F_1}{F_2}}.$$

Also

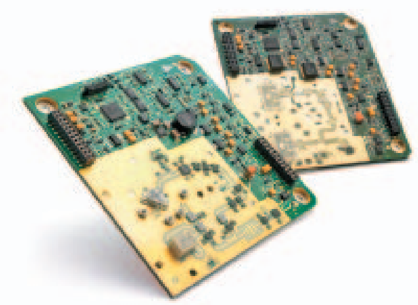
$$F_1 = \left\{ \log_e \frac{R_2}{R_1} - \frac{2\varepsilon_2}{\varepsilon_1 + \varepsilon_2} \sin \Psi \log_e \left[2 \sin \left(\frac{\pi r}{\tau \cos \Psi} \right) \right] \right\},$$

and

$$F_2 = \frac{1}{2}\left(1 - \frac{R_1{}^2}{R_2{}^2}\right) + \tan^2 \Psi \left\{ \log_e \frac{R_2}{R_1} - \frac{1}{\sin \Psi} \log_e \left[2 \sin \frac{\pi r}{\tau \cos \Psi} \right] \right\}$$

where

$\varepsilon_o = 8.85 \times 10^{-12}$ farads/meter,
$\varepsilon_1 = 2.6\varepsilon_o$, polystyrene for center conductor,
$\varepsilon_2 = 1\varepsilon_o$ air,
$R_2 = 3.250$ inches (This value is the radius of the shield covering the outer helix; it was chosen from impedance considerations.[6]),



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$R_1 = 2.200$ inches (measured from center of wire),

$$\Psi = \tan^{-1} \frac{\text{pitch}}{\text{circumference}} = 4.45°,$$

$\tau =$ pitch,

$$\frac{R_2}{R_1} = 1.46, \quad \frac{R_1^2}{R_2^2} = 0.483,$$

$$\frac{r \text{ (radius of wire)}}{R_1} = 0.0855, \quad \frac{R_1}{\tau \text{ (pitch)}} = 1.895.$$

Solving for V_p, a phase velocity equal to 0.179 times 10^8 meters per second was obtained. The delay factor was also calculated and found to be 16.8. As might be expected, the shield over the outer helix caused the phase velocity to decrease. The effects and necessary correction of this change in delay factor are analyzed below.

IV. Experimental Justification of Design Parameters

In order to measure the phase velocity of the outer helix experimentally, the outer helix was axially displaced along the inner helix, and the distance between minimums was measured. The outer helix had a measured velocity of 0.178 times 10^8 meters per second. This value for V_p agreed to within 0.56 percent of the calculated phase velocity, which was 0.179 times 10^8 meters per second.

To measure the phase velocity on the inner helix, a probe was axially displaced along the outside of the helix, one or two pitch diameters away from it. Because the mismatch was large, a piece of teledeltos, which is current-sensitive, was cut into the shape of an equilateral triangle, 8 inches by 8 inches by 8 inches, and wrapped around the outside of the helix to serve as a matched termination. The positions of minimums were then recorded and the phase velocity was calculated. The inner helix was designed to have a delay factor of 14, which would give a phase velocity of 0.214 times 10^8 meters per second; however, it was measured to have a delay factor of 15.5, or a phase velocity of 0.194 times 10^8 meters per second.

Figure 3 illustrates the experimental setup used to measure directivity. The power fed into arm A is substantially transferred to terminal C, and thereby makes the phase shifter a unity transmission device. The amount of power

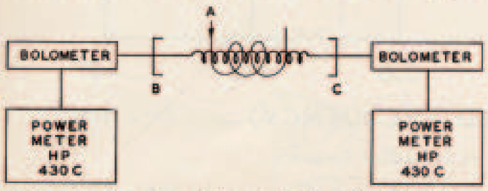

Figure 3 — Experimental Setup for Measuring Directivity

transferred depends on the length of the outer helix, which should be a quarter-beat wavelength.

Directivity measurements recorded for the dimensions of the helix showed that the maximum directivity that could be obtained was approximately 13 decibels with about 70 percent coupling. This meant that all of the power entering at arm A in Figure 3 was not being transferred, and that some power was being reflected back toward terminal B. It was mentioned previously that the two helices had to have approximately equal phase velocities in order to get maximum transfer of energy. When the values of the phase velocities on the inner and outer helices were checked, it was noted that they were not equal, but differed by approximately 8 percent. Therefore, adjustments had to be made to equalize the phase velocities on both helices. The phase velocity on the outer helix was adjusted to match that on the inner helix, which was kept constant. Since the pitch of the outer helix was the easiest dimension to vary, it was altered until approximately equal phase velocities were obtained. They occurred with a pitch of 0.875 inch on the outer helix and 0.774 inch on the inner helix.

The next step was to find the quarter-beat wavelength necessary for maximum power transfer. The equation for beat wavelength is given in Reference 1: beat wavelength is equal to (17.1) times $(a_2 - a_1)$, where a_2 and a_1 are the radii of the outer and inner helices, respectively. Substituting the values for a_2 and a_1 into this equation, the beat wavelength was recorded as 14.53 inches. With a pitch of 0.875 inch and a quarter beat wavelength of 3.63 inches, the number of turns was equal to 4.138. This meant that with these dimensions, maximum coupling and maximum directivity would be obtained.

The directivity of several outer helices with various numbers of turns was recorded. Maximum directivity and maximum coupling resulted when the number of turns equaled 4.187, which was in close agreement with the theoretical prediction. Using this value for the number of turns, the directivity was in the order of 40 db with 95 percent coupling (the other 5 percent was lost in attenuation and reflection). In order to get values of coupling this high, it was essential that the outer helix be well matched to the coaxial input. A larger percentage of coupling could be had at one position by changing the match at terminals B and C (see Figure 3); but, by introducing this mismatch, the output of B and C would vary as the outer helix was displaced axially. Therefore, to get a constant output level at terminals B and C, the VSWR along the inner helix between points A and B, and A and C, had to be less than 1.10.

By placing a 50-ohm load at the open end of the outer helix, the directivity may be increased by at least 10 db. This load absorbs the power which is not transferred and prevents it from reflecting back to terminal B (see Figure 3).

Table I records the results of tests conducted for an inner helix diameter of 3.44 inches, ¼ inch copper tubing, with a pitch of 0.774 inch, and for an outer helix diameter of 5.15 inches, ⅜ inch copper tubing, with pitches of 0.774, 0.835, 0.875, and 0.904 inch. (The diameter of

TABLE I

Directivity Versus Number of Turns

Number of turns	Directivity with outer helix pitch (decibels) 0.774 in.	0.835 in.	0.875 in.	0.904 in.
3.75				14.5
4.0				14.5
4.0625		19.6		
4.125	16.0	21.2	35.0	14.5
4.1875	17.0		50.0	16.5
4.25	16.3	26.6	38.5	12.5
4.5	12.5	15.7		

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the copper tubing for the outer helix is not the correct one for minimum attenuation with the pitch used; however, since the outer helix is only a short length of line, it was not practical to change this dimension to a non-standard tubing.) The coupling for all test cases was between 90 and 95 percent.

The relationship of directivity to normalized frequency was also measured, and is recorded in Figure 4. In each case the output terminals of the inner helix were matched to the input coax of the outer helix.

V. Conclusion

The single coupled helix can be extended to a finished device by mechanically ganging two outer helices through a coaxial line. By this means, all output terminals can be stationary. The path between output terminals can be varied by displacing the two coupled outer helices axially along the inner helices to which the output coaxial terminals are attached. Amplitude and phase variations versus displacement can be held to a minimum by correct matching of all coaxial to helix transitions.

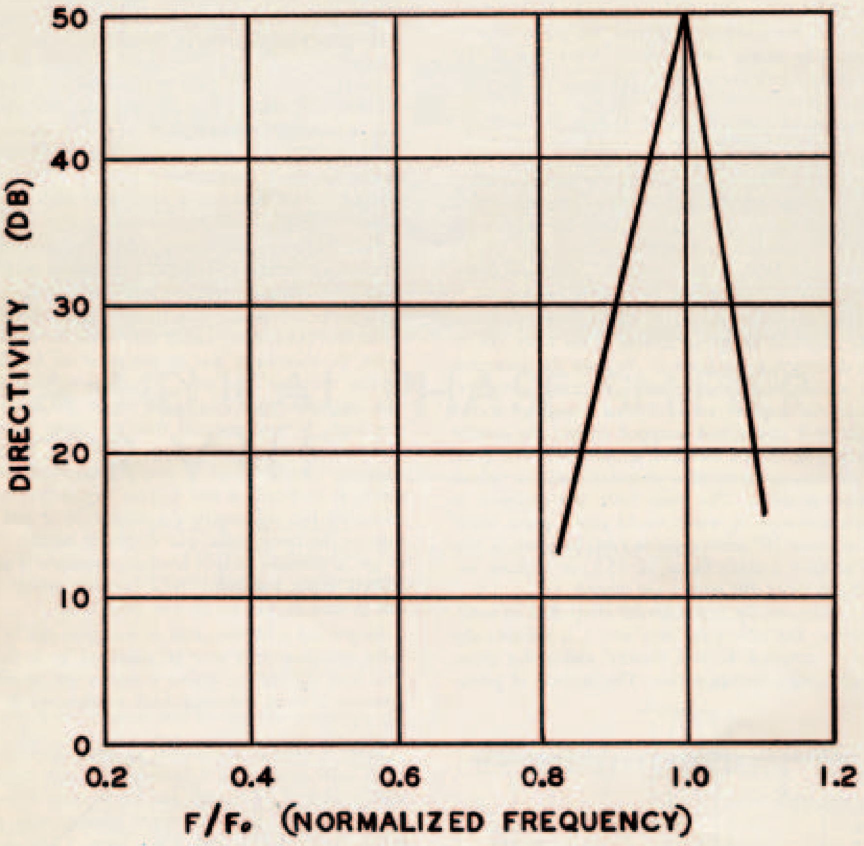

Figure 4 — Graph of Directivity vs. Normalized Frequency

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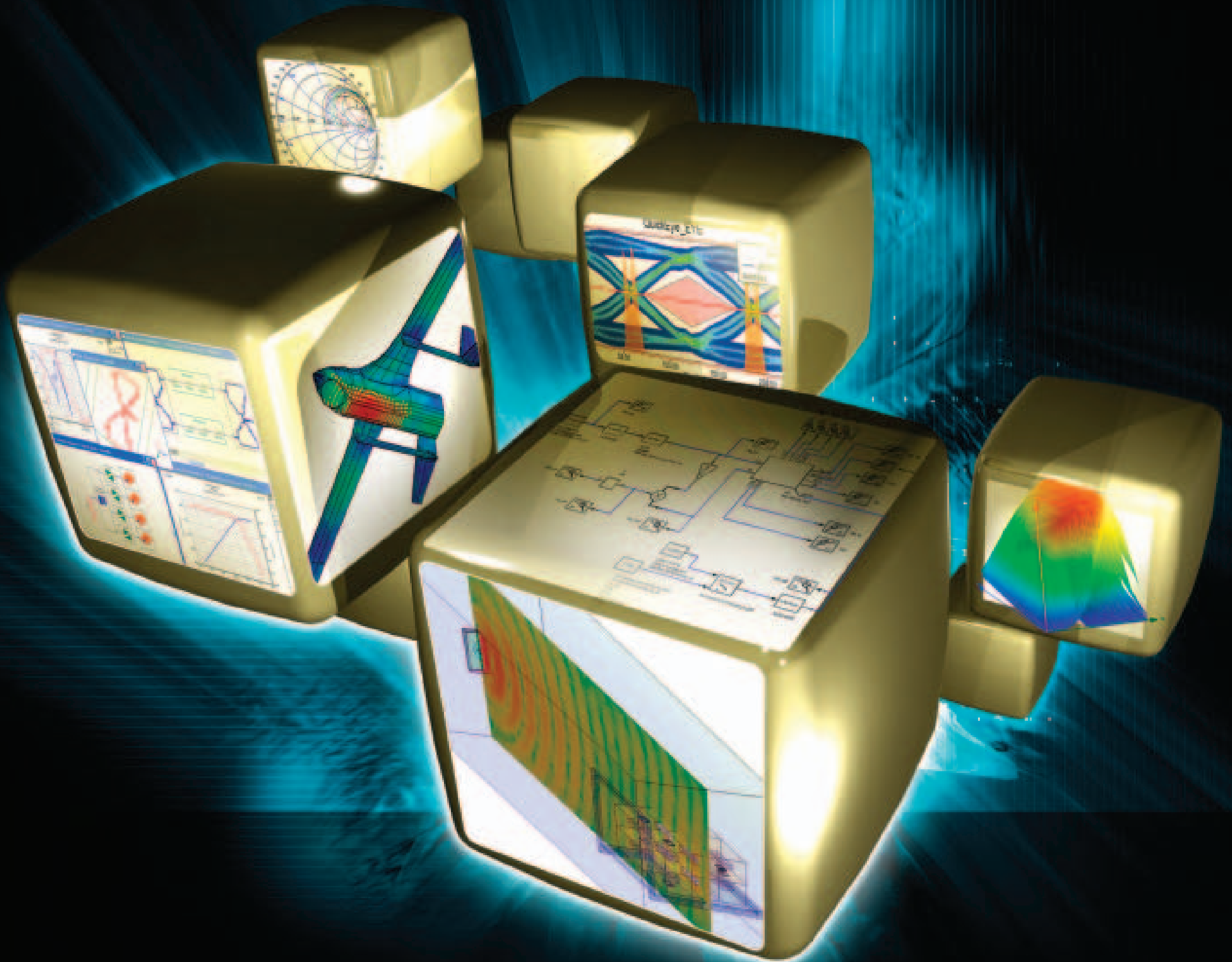
Acknowledgments

The authors wish to express gratitude to Mr. Louis Stark for his suggestions in connection with this study. The type of helical phase shifter described is an extension of a device originally developed by him at Lincoln Laboratory and Hughes Aircraft Company.



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A KU-BAND 4-BIT COMPACT OCTAVE BANDWIDTH GAAS MMIC PHASE SHIFTER

Editor's Note: *The editorial theme for June is semiconductors, MMICs and RFICs, so we are featuring several related technical articles and product features in this month's issue. In keeping with our Then and Now series that celebrates the* Microwave Journal's *50th anniversary, we have reprinted an article from 1958 titled "A Helical Phase Shifter for VHF" written by Paul A. Crandell and Frederick J. Cominick of Sylvania Electric. This article describes the theory and practice of constructing a phase shifter with coupled helical coils and is essentially an electromechanical device that can be used to steer the beam of an array. Then we "shift" forward to the Now article written by Inder Bahl and Mark Dayton of M/A-COM Tyco Electronics about "A Ku-band 4-bit Compact Octave Bandwidth GaAs MMIC Phase Shifter" that is only 2.6 mm² in size. This MMIC includes a 4-bit phase shifter along with digital drivers and achieves an RMS phase error of less than 4°, and an RMS amplitude error of less than 0.3 dB with an insertion loss of less than 6 dB over the operating band. The technology has come a long way from a large electromechanical phase shifter that occupies a table top to a compact MMIC phase shifter chip that takes a steady hand and fine tweezers to pick up.*

This article presents the design approach and test results of a X-/Ku-band 4-bit compact GaAs MMIC phase shifter developed for broadband applications. The phase shifter design is based on choosing an optimum topology for each bit, yielding compact size and low insertion loss. It also has on-chip integrated digital control. The MMIC phase shifter was fabricated employing GaAs-based high-performance 0.4 µm multi-function self-aligned gate (MSAG) MESFET technology with a multilevel plating process. A chip size of 2.6 mm² was achieved, the smallest size reported to date, and the MMIC phase shifter demonstrated state-of-the-art performance.

Several X-/Ku-band applications require multi-bit compact and low-cost phase shifters. For example, beam scanning in electronically-steered antennas is achieved by changing the phase of the RF signal fed to or received from each radiating element. For beam steering, programmable and digital bidirectional-phase shifters are required to adaptively adjust the transceiver phase in both transmit and receive modes. Generally, the digital bits in a multi-bit phase shifter have binary values, that is 4-bit

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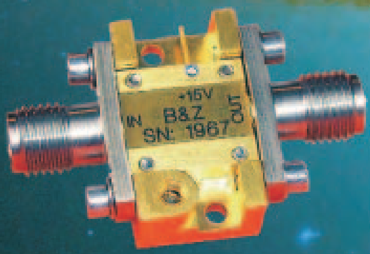

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and 5-bit phase shifters have 180°, 90°, 45°, 22.5° bits and 180°, 90°, 45°, 22.5°, 11.25° bits, respectively.

Most practical electronically-steered antennas for commercial applications, including satellite communication and WiMAX base stations, use 4-bit phase shifters as a compromise between cost, size, insertion loss and the incremental improvement in system performance when more phase bits are used. Large antennas rely on compact and low cost monolithic programmable multi-bit phase shifters based on FETs to achieve minimum size, weight, power consumption and cost.

During the past decade, there has been significant progress in programmable phase shifters. Many different technologies such as GaAs MESFET MMIC[1–3] and Si-based MMIC,[4–7] including MEMS,[4] SiGe p-i-n diode,[5] MOSFET[6] and CMOS[7] are being pursued to develop compact and low cost phase shifters. Progress in X-/Ku-band multi-bit MMIC phase shifters is summarized[3–7] in ***Table 1***. It may be noted from this table that, in comparison to GaAs-based MMIC phase shifters, the Si MMIC phase shifters have much higher insertion loss because of the lower resistivity of bulk silicon.

This article reports on the design and test results of a compact and low loss X-/Ku-band 4-bit GaAs MMIC phase shifter. The MMIC has on-chip integrated digital drivers for low cost applications.

PHASE SHIFTER DESIGN

Excellent multi-bit L- and S-band phase shifters for octave band applications have been developed using the GaAs MSAG MESFET process.[8,9] In order to meet current requirements and gain wider acceptance, MMIC phase shifters must have a small size and low insertion loss. These features can be accomplished with the MSAG process, using M/A-COM's Process 5C FETs with multi-level plating (MLP), high Q inductors[9–11] and a 5-mil thick GaAs substrate. The insertion loss can be further reduced using a suitable topology with fewer devices connected in series, while size is reduced by careful selection of topology, compacting components and MLP. The MLP process enables the incorporation of multi-layer microstrip lines and also provides flexibility in routing control bias lines in a compact way.

Digital phase shifters can have a number of topologies,[12–19] but the general principle is either the signal is switched between two separate networks, which have a fixed phase difference, or the phase shift of a single network is controlled by switching elements in or out. There are six main types of solid-state digitally controlled phase shifters, each with its own limitations. These are switched line (narrow band), reflection (poor match), loaded line (suitable only for small bits), switched low-pass/high-pass (high loss), switched network (suitable only for 180° bit) and embedded-FET type (suitable only for small phase bits). Generally, a different technique is optimum for each 'bit' and also depends on the bandwidth.

In general, the insertion loss of SPDT-based phase shifters is high because the switching devices are in series with the transmission path and the insertion loss increases with frequency. Multiple sections of series/shunt lumped elements results in smaller size and larger bandwidth at the cost of increased insertion loss due to the low Q of these elements as compared to distributed circuit elements such as microstrip. In order to further reduce the size, it has been shown that FET switches can be directly integrated into the filters, and the FET parasitic capacitances can be absorbed into the filter network.[12–15]

TABLE I
SUMMARY OF X-/KU-BAND MMIC PHASE SHIFTERS

Freq. Range (GHz)	No. of Bits	Insertion Loss (dB)	RMS Phase Error (°)	Chip Size (mm²)	Reference
9 to 15	5	14.5	12	4.3	7
11.7 to 12.7	4	11.1	8	3.1	6
13 to 15	5	8.2	7.5	3.9	3
10 to 16	4	5	4	2.6	this work

SWITCHING DEVICES

MESFETs or simply FETs are used as passive two-terminal switching devices, with the gate terminal acting as a port for the control signal only. The RF connections are made to the drain and the source terminals and the gate terminal looks into an open circuit for the RF signal. The RF impedance between the drain and the source terminals depends upon the DC control voltage at the gate terminal. For switching applications, low-impedance and high-impedance states are obtained either by making the gate voltage equal to zero or by using a gate voltage greater (numerically) than the pinch-off voltage, respectively. In most applications, the gate control voltage is approximately 1.5 to 2.0 times the pinch-off voltage (however, for a high power application the control voltage is much higher than the pinch-off voltage) and it is applied to the gate through a resistor which isolates the RF between the FET and the power supply. The resistor value depends upon the FET's gate periphery and the frequency of operation. For X- and Ku-band switches its value is approximately 3000 Ω-mm, that is, if the gate periphery is 1 mm, the resistor is approximately 3 kΩ.

FET switches are bi-directional, offer wide bandwidth performance and great design flexibility. As they are compatible with GaAs MMIC technology, they have small size, low cost and light weight. They offer:

- Virtually no DC-control power dissipation
- Nanosecond switching speed
- No DC blocking capacitors
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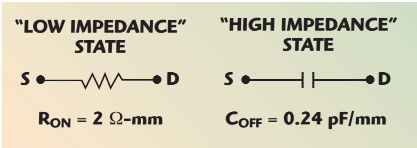
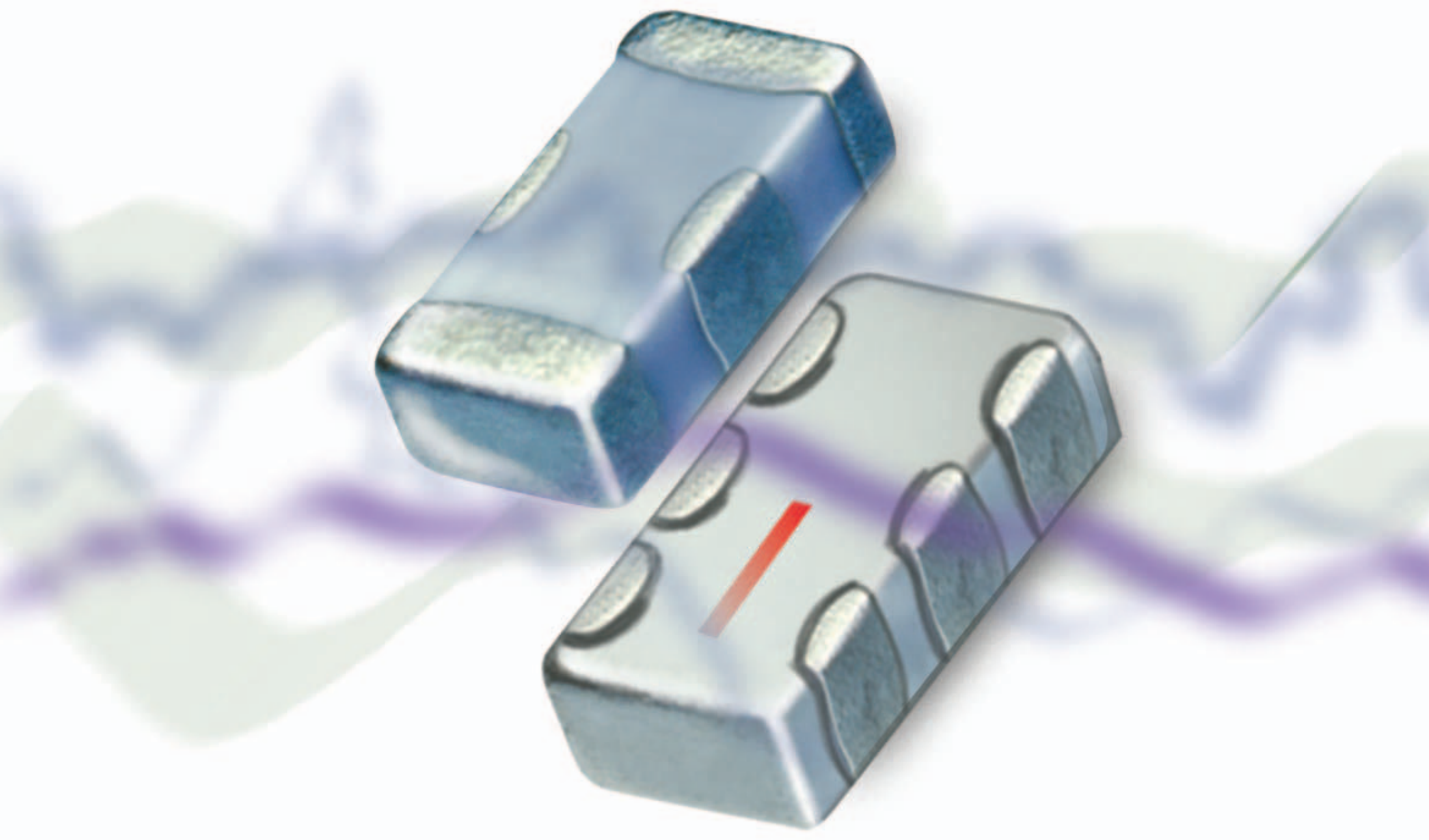
Switching FETs are modeled by two lumped element equivalent circuit models: one when the device is "ON" (low-impedance state) and the second when the device is "OFF" (high-impedance state). The model parameter extraction is generally based on statistical data with average and standard deviation values that



▲ *Fig. 1 Simplified on and off state equivalent circuits of a FET switch.*



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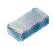

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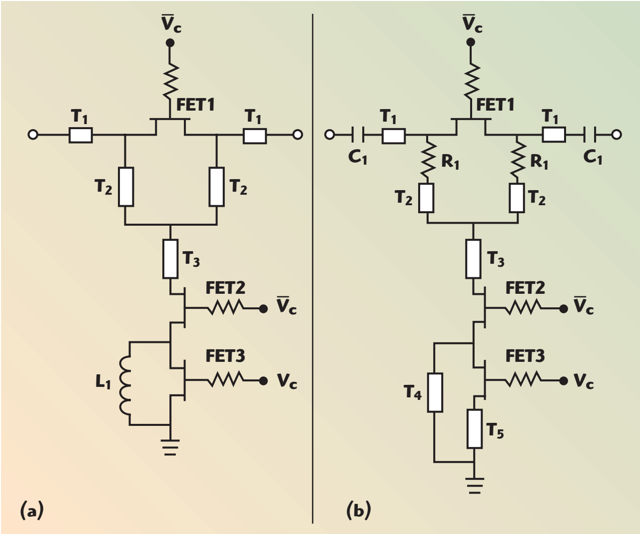


▲ *Fig. 2 Topology of a simplified, embedded-FET type phase shifter; (a) 22.5° bit and (b) 45° bit.*

will help in centering designs for high yield. A simplified equivalent circuit (EC) model for a MSAG 5C FET is shown in ***Figure 1***. The model element values shown are normalized to 1 mm of gate periphery.

CIRCUIT DESIGN

The X-/Ku-band 4-bit phase shifter was designed with 22.5°, 45°, 90° and 180° phase states. A suitable topology was selected for each bit to provide optimum performance and size. The topology was then optimized, employing the FET model shown with the FET periphery as a variable. Finally, the circuit was re-optimized using measured S-parameters data for FET sizes closest to standard FET cells, that is 50, 75, 100, 150, 200 µm, etc.

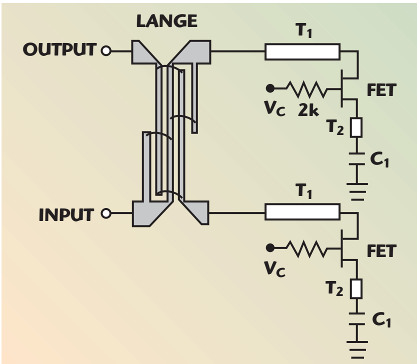
During the design of the compact and low-loss phase shifters, several trade-offs were considered, including:

- Insertion loss
- Insertion loss ripple
- RMS phase error
- VSWR
- Size

The topology used in the 22.5° bit is of the integrated or embedded-FET type, as shown in ***Figure 2***, where the FET's reactances become part of the phase shifting low-pass/high-pass filter networks. Here, for the reference state, FET1 and FET 2 are "ON" and FET3 is "OFF." This configuration has a lower insertion loss due to a single device in series. The configuration for the 45° bit is a modified version of the embedded-FET type topology. Resistor R1 is used to minimize the difference in insertion loss between the 'reference' and bit 'ON' states. This bit functions the same way as the 22.5° bit.

In order to achieve low insertion loss and a 90° flat phase response, a reflection-type phase shifter topology shown in ***Figure 3*** is used. For broadband applications a Lange coupler is usually used as a 90° hybrid. Signals from the coupled and direct ports are reflected with a magnitude of unity and the resultant signal appears at the output port. The 90° phase shift is achieved by switching in and out capacitor C_1. A major problem with this topology is not having a good match over a large bandwidth. In order to get a good match and a flat phase response, the Lange coupler was modified. The Lange coupler's conductors were placed on 3 µm thick polyimide atop the base GaAs. This configuration results in lower loss and better match than a Lange coupler on GaAs.

The 180° bit design is of the switched low-pass/high-pass filter phase shifter type shown in ***Figure 4***. This design employs SPDT switches to switch the signal between a high-pass and a low-pass filter. The filters have equal amplitude responses over the range of interest. The low-pass/high-pass phase shifter configuration is very suitable where an octave bandwidth and compact size are required.



▲ *Fig. 3 Topology used for the 90° phase shifter bit.*

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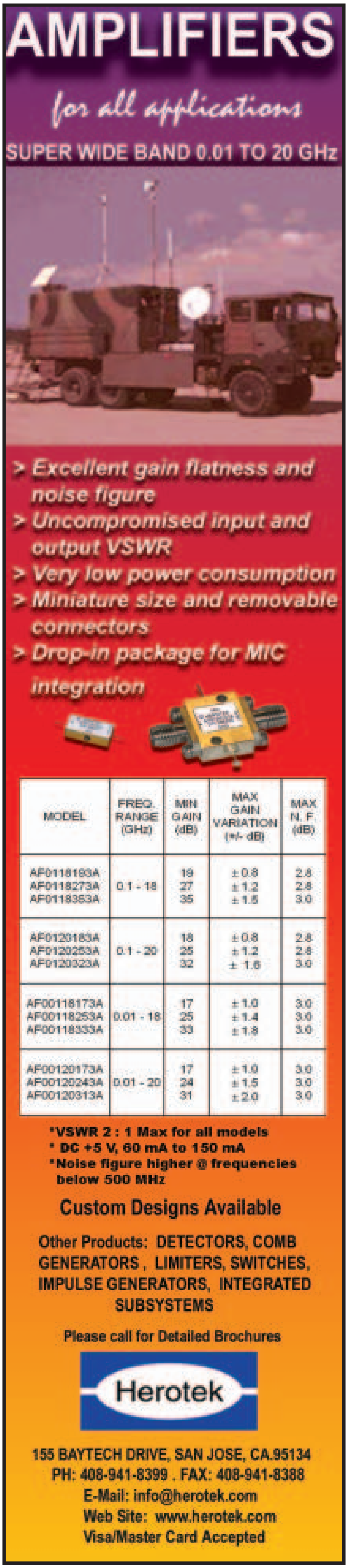
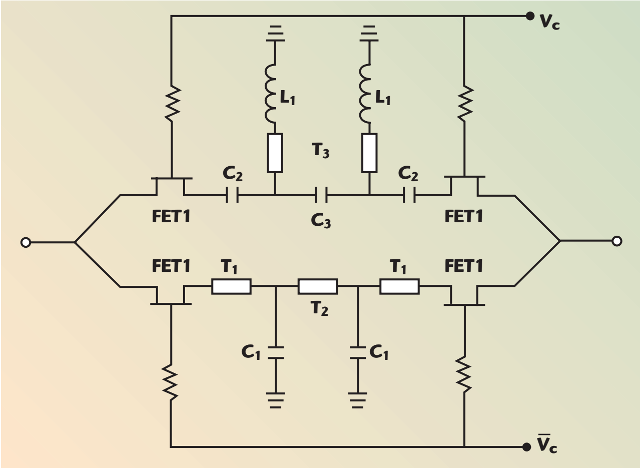


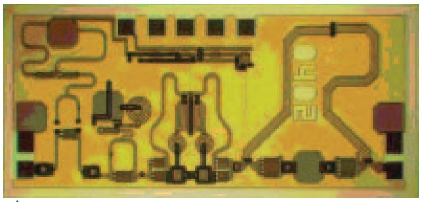


▲ *Fig. 4 Switched network 180° phase shifter bit.*

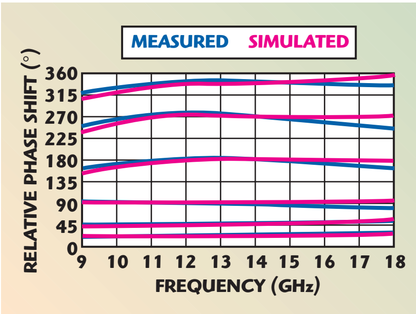
compatible with CMOS and TTL logic families and their treatments have been described by Bahl.[11] The power supply voltage VEE for the digital circuits is –5 V and the logic input voltage is 0 V for "low" and 5 V for "high." The logic inputs are converted to V_C and $\overline{V_C}$ to drive the switching FETs. The device control voltages are –4.8 and 0 V.

ON-CHIP INTEGRATED DIGITAL CONTROL

To obtain high-speed operation with low-power dissipation in the FET switches, the phase shifter ICs have integrated on-chip drivers. The primary objectives of the on-chip drivers include: (a) to be compatible with TTL logic levels; (b) minimum GaAs chip size; (c) achieve the same or better chip yield; and (d) to maintain overall lower cost. In these drivers, both depletion-mode and enhancement-mode transistors are used. The logic gate design is generally optimized by adjusting the sizes of the FETs and voltage shift diodes to achieve the correct voltage levels, low power consumption and high speed operation. The design of such drivers is accomplished by using the SPICE program. These drivers are



▲ *Fig. 5 Photograph of the X-/Ku-band 4-bit phase shifter.*



▲ *Fig. 6 Measured and simulated relative phase shift vs. frequency and phase state.*

CIRCUIT FABRICATION

The phase shifter circuit was fabricated using the ion-implanted planar refractory gate, multi-function self-aligned gate MESFET MMIC process.[8] This process features a full suite of active and passive components fabricated on 4" diameter GaAs wafers and is being used to develop low-cost, high-volume, high-performance and highly reliable multifunction monolithic ICs for commercial and military applications. Because of its versatility in integrating microwave and high-speed LSI functions on a single chip, the process has been named the multifunction self-aligned gate process. The MSAG process eliminates the need for a gate recess, the single most important yield and reproducibility limiting step. Each device type, which may include EFET, DFET, Schottky diode/limiter, low-noise FET, switching FET, power FET and n' implants, is optimized for its respective function. The phase shifter devices were fabricated using a process with three implants. The process includes Au/Ge/Ni metallization for ohmic contacts, 0.4 μm TiWN Schottky barrier gates, along with thin film and ion-implanted resistors. The 0.4 μm TiWN gates are covered by a 0.8 μm overlay after planarization. The MSAG TiWN gate is extremely robust (survives 900°C rapid thermal anneal temperature), which results in an MTTF of 100 years at a channel temperature of 150°C. A thickness of 2000 Å silicon nitride (ε_r = 6.8) is used for both MIM capacitors and passivation. The air bridges and bonding pads are 4.5 μm-thick plated gold.

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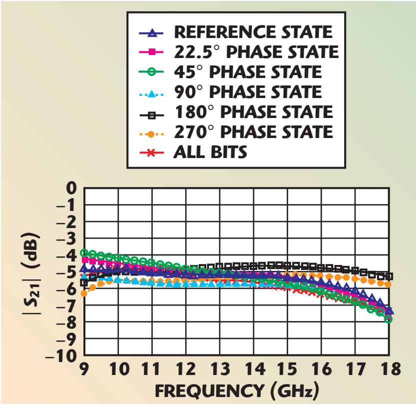
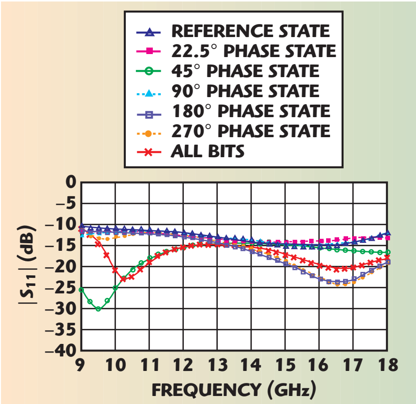
In the MLP MSAG process, three layers of polyimide ($\varepsilon_r = 3.2$) are used, including inter-level dielectric (3 µm thick), inductor crossover layer (7 µm thick) and scratch protection buffer layer (7 µm thick) for mechanical protection of the finished circuitry. The three metal layers are metal 1 (0.5 µm thick), first plated gold (4.5 µm thick) and second plated gold (4.5 µm thick). The multi-level plating (MLP) process allows the designer to reduce the overall chip size and lower the resistive loss in passive components. Low capacitance metallization crossovers are achieved by a polyimide inter-metal dielectric layer. The front side processing is completed by depositing a polyimide buffer layer. The buffer layer provides mechanical protection of the circuit structures during backside processing, dicing and subsequent assembly operations. Finally, the wafers are thinned to their final thickness, through-wafer vias are etched and the backside is metallized. The substrate thickness of the phase shifter chips is 125 µm. ***Figure 5*** shows a photograph of the X-/Ku-band phase shifter IC. The chip size is 2.4 × 1.1 mm (2.6 mm²).

TEST DATA AND DISCUSSIONS

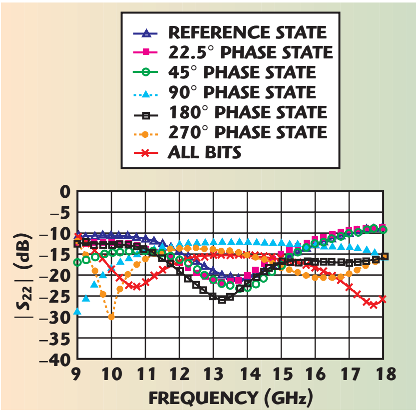
The typical performance of this X-/Ku-band phase shifter was deter-



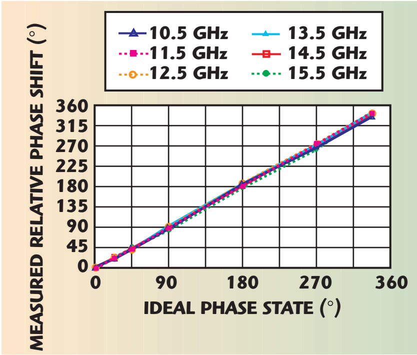
▲ *Fig. 7 Insertion loss vs. frequency and phase state.*



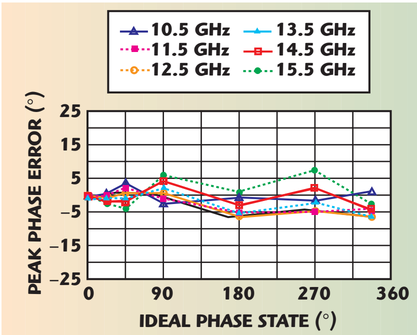
▲ *Fig. 8 Input return loss vs. frequency and phase state.*



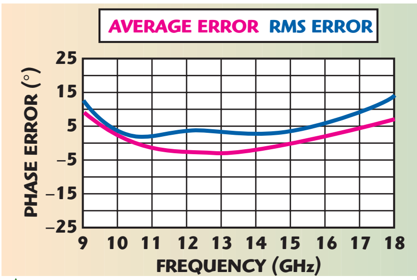
▲ *Fig. 9 Output return loss vs. frequency and phase state.*



▲ *Fig. 10 Relative phase response vs. commanded state and frequency.*



▲ *Fig. 11 Peak phase error vs. commanded state.*



▲ *Fig. 12 Statistical phase error vs. frequency.*

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P_{5dB}		**30**			**37**		dBm	
IP_3/IP_2	**40/50**			**46/60**			dBm	
Noise Figure		2.8	3.0		2.8	3.0	dB	
In/Out VSWR			1.5:1/2:1			1.5:1/2:1		
Maximum Input			+18			+18	dBm	
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mined using on-wafer measurements to develop the performance charts included in this article. ***Figure 6*** demonstrates the tight correlation between the simulated and measured phase shift versus frequency, particularly over the design band of 10.7 to 15.5 GHz. The phase states shown are reference state, or all phase bits off; all primary bits: 22.5, 45, 90 and 180° and two combination states: 270° and 337.5°, the all-phase-bits on state. This collection of phase states yields a concise representation of the IC performance without the overhead of measuring and analyzing every phase state combination. The insertion loss, input return loss, and output return loss versus frequency and phase state are shown in ***Figures 7, 8*** and ***9***, respectively. Over the design band, the insertion loss of the X-/Ku-band phase shifter is excellent at less than 6 dB. In addition, the gain variation with respect to phase state is also quite good at less than 1.5 dB, or an RMS amplitude error of less than 0.3 dB. The S_{11} and S_{22} magnitudes (input and output return loss) of this IC are less than –10 dB over all phase states. The phase performance metrics of the X-/Ku-band phase shifter are shown in ***Figures 10, 11*** and ***12***. The normalized phase shift of the device is shown as a function of frequency and commanded phase state. These figures demonstrate the high degree of phase accuracy across the entire design band. This behavior is borne out in further detail when the measured phase shift is compared against the ideal phase value. The worst case, or peak phase error, over the tested phase states and frequencies is –6.0° to 8.0°. Finally, the average phase error and the RMS error for this phase shifter are shown. The average error is between –2.5° and 1.0°. The RMS phase error is less than 4° across the operating band. Taken together, the peak, average, and RMS phase errors are indicative of a very good, mature phase shifter design. However, these results were achieved on a first iteration with minor tweaks. The performance outcome of this X-/Ku-band phase shifter is a strong validation of the topologies and methodologies employed in the execution of this design.

CONCLUSION

At these error levels, this phase shifter could be used in most phased-array applications without a look-up table. A look-up table is a mapping used to minimize the error between the actual phase shift and the commanded phase state. This fact results in a greatly simplified aperture calibration process and less overhead in terms of physical memory employed in the aperture beam steering processors. ■

ACKNOWLEDGMENT

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- Single DC supply or AC input
- Low phase-noise and pulsed applications

Options:

- Input Limiter
- Variable gain
- TTL RF/DC control
- Extended Temperature

Model Number	Frequency (GHz)	Gain (±dB, Max.)	Gain Flatness (±dB, Max.)	Noise Figure (dB, Max.)	VSWR In/Out (Max.)	Output Power (dBm, Min.)	DC Power @15V (mA, Nom.)
AMF-2B-00030300-150-32P	0.03-3	20	2.5	15	2:1/2.5:1	32	650*
AMF-4D-00100100-30-30P	0.1-1	44	1	3	2.2:1	30	850
AMF-3B-00500100-13-33P	0.5-1	43	1.5	1.3	2:1	33	1700
AMF-4D-00500200-25-33P	0.5-2	40	2	2.5	2:1/2.3:1	33	1400
AMF-4B-00800250-50-34P	0.8-2.5	40	3	5	2:1/2.3:1	34	2700
AMF-3B-01000200-35-30P	1-2	30	1	3.5	1.8:1	30	900
AMF-3B-01000200-20-33P	1-2	35	1	2	1.5:1	33	1200
AMF-5D-01000200-15-33P	1-2	50	1.5	1.5	2:1/2.3:1	33	1500
AMF-3D-01000400-45-30P	1-4	28	1.5	4.5	2:1/2.3:1	30	800
AMF-4D-01000400-35-30P	1-4	39	1.5	3.5	2:1/2.3:1	30	900
AMF-4D-01000800-85-30P	1-8	28	2	8.5	2.2:1	30	1100
AMF-3B-02000400-20-30P	2-4	35	1	2	2:1	30	950
AMF-4B-02000400-15-33P	2-4	50	1.5	1.5	2:1	33	1600
AMF-5B-02000600-70-33P	2-6	34	2	7	2:1	33	2200
AMF-4B-02000600-70-37P	2-6	35	2	7	2:1/2.8:1	37	4800
AMF-4B-02000800-80-36P	2-8	40	2.5	8	2:1/2.8:1	36	4800
AMF-3B-02001800-30-30P	2-18	35	2	3	2.2:1	30	2000
AMF-3B-02001800-60-32P	2-18	35	2.5	6	2:1/2.3:1	32	4500
AMF-3B-02002000-60-30P	2-20	40	2.5	6	2:1/2.5:1	30	4500
AMF-5B-04000800-60-30P	4-8	33	1.5	6	2:1	30	1400
AMF-4B-04000800-50-33P	4-8	36	1	5	2:1	33	1500
AMF-6B-06001800-80-33P	6-18	35	2.5	8	2.1:1/2.2:1	33	3500
AMF-2B-06001800-65-35P	6-18	45	3	6.5	2.1:1/2.2:1	35	6500
AMF-6B-06001800-120-40P	6-18	43	5	12	2:1/2.3:1	40	12,500

* Negative supply required.

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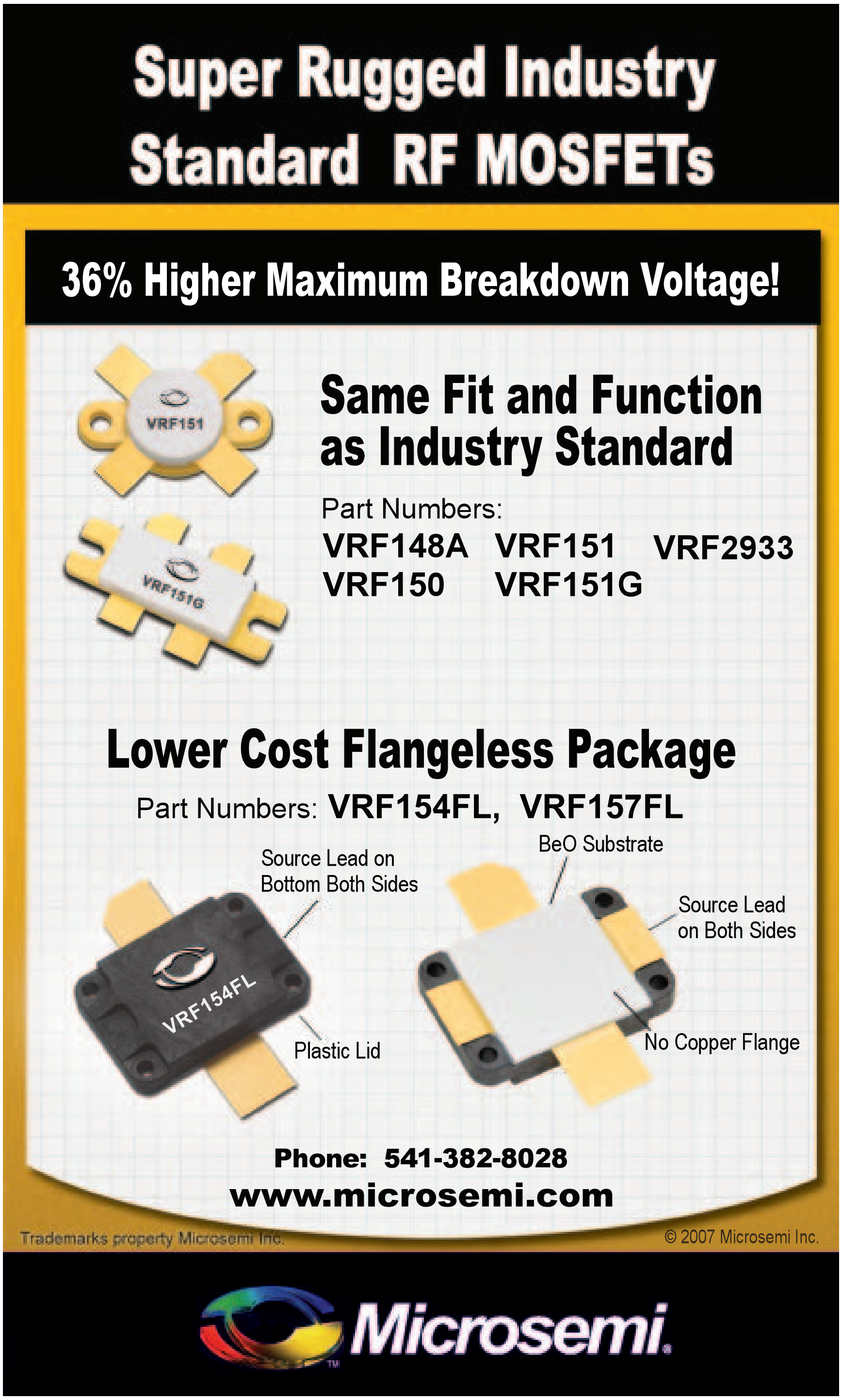

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Model	Frequency (GHz)	Gain (dB)	Flatness (dB) max	NF (dB) max	P1dB (dBm) min	VSWR (In/Out)	DC Current @ +12/+15VDC
Broadband Low Noise Amplifiers							
AML016L2802	0.1 – 6.0	28	±1.25	1.3*	+7	2.0:1	190
AML48L3001	4.0 – 8.0	30	±1.0	1.2	+10	1.8:1	150
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.

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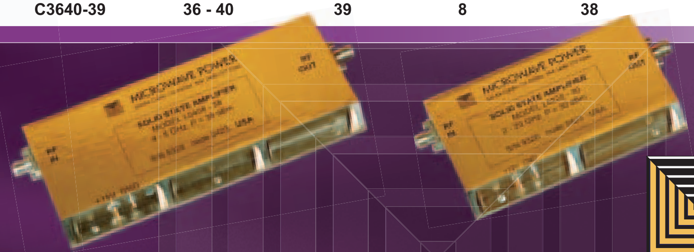
Model	Frequency (GHz)	Psat (dBm)	Psat (W)	P1dB (dBm)	Gain (dB)	DC Current(A) @ +12V or +15V
Broadband Microwave Power Amplifiers						
L0104-43	1 - 4	42.5	17.8	41.5	45	14
L0204-44	2 - 4	44	25	42.5	45	14
L0206-40	2 - 6	40	10	38.5	40	8.5
L0208-41	2 - 8	41	12	40	40	17
L0218-32	2 - 18	32	1.4	31	35	5
L0408-43	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



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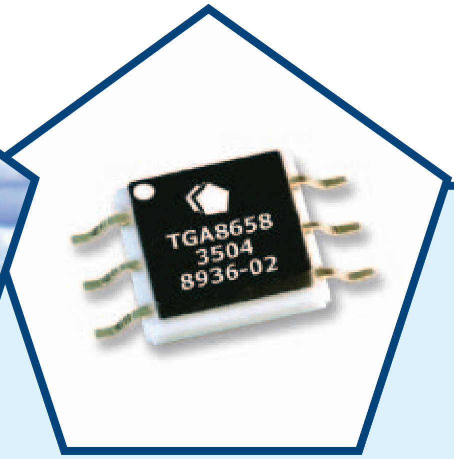

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mmWave Power Devices for PTP Radio and VSAT Ground Terminal Applications

Description	Frequency Range (GHz)	P1dB (Psat) / OIP3 (dBm)	Gain (dB)	NF / PAE (dB) (%)	Voltage / Current (V / mA)	Package Style	Part Number
HPA	7 - 8.5	(38) / –	21	– / 42	7 / 2000	Die	TGA2701
Driver Amp, SB	11 - 17	17 / –	23	6 / –	6 / 75	SM-06-12	TGA2507-SM
HPA	12 - 19	29 / –	25	–	5 - 7 / 435	SM-06-12	TGA2508-SM
2W HPA	12.5 - 16	(32) / 37	32	–	6 - 7 / 680	SM-01-24	TGA2503-SM
2W HPA	12.5 - 17	(33.5) / –	25	– / 25	7.5 / 650	SG-A1-6	TGA2510-EPU-SG
4W HPA	13 - 15	(36) / 41	25	–	7 / 1300	FL-A1-10	TGA8659-FL
6.5W HPA	13 - 16	(38) / –	24	–	8 / 2600	FL-A2-10	TGA2514-FL
2W HPA, PD	13 - 17	(34) / 38.5	26	– / 30	7.5 / 650	SG-A1-6	TGA2902-1-SCC-SG
2W HPA	13 - 17	(34) / 40	33	–	5 - 8 / 680	SG-A1-6	TGA8658-EPU-SG
1W HPA, PD	17 - 20	30 (32) / (42)	20	–	5 - 7 / 825	Die	*TGA4530**
Driver Amp	17 - 24	22 / –	19	4 / –	5 / 270	SM-09-16	TGA2521-SM
HPA, AGC, PD	17 - 24	(29) / 38	22	–	5 / 712	SM-010-20	TGA2522-SM
HPA	17 - 27	29 (31) / 37	22	–	7 / 760	Die	TGA4502-SCC
Gain Block & 2x/3x Multi	17 - 40	18 (22) / 24	22	7 / –	5 / 140	SM-A3-16	TGA4031-SM
HPA	25 - 31	35.5 (36) / –	22	–	6 / 2100	CP-A1-8	TGA4905-CP
MPA	25 - 35	25 / –	18	–	6 / 220	SM-A4-20	TGA4902-SM
7W HPA	26 - 31	(38.5) / –	22	–	6 / 4200	CP-A3-8	TGA4915-EPU-CP
2W HPA	27 - 31	32.5 (33) / –	22	–	6 / 840	CP-A2-8	TGA4513-CP
1W HPA	28 - 31	30 / –	19	– / 25	6 / 420	SM-A4-20	TGA4509-SM
4W HPA	28 - 31	36 (36.5) / –	22	– / 22	6 / 1600	Die	TGA4906
7W HPA	28 - 31	(38.5) / –	22	– / 20	6 / 3200	Die	TGA4916
Driver Amp	29 - 31	16 (17) / 22	15	–	6 / 60	SM-A4-20	TGA4510-SM
MPA	33 - 47	27 (27.5) / 36	18	–	6 / 400	Die	TGA4522
HPA	36 - 40	30 / –	14	–	6 - 7 / 500	Die	TGA1171-SCC

NOTES: * = New, SB = Self Biased, PD = Power Detector

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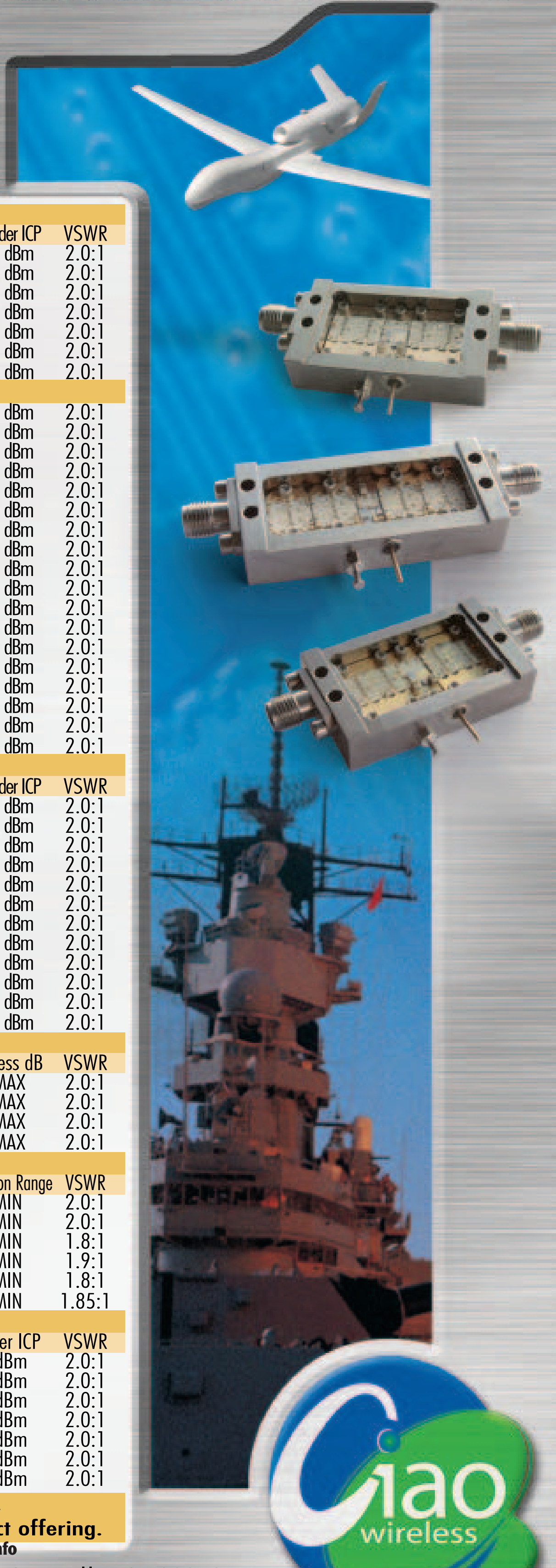

OCTAVE BAND LOW NOISE AMPLIFIERS

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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REMEC Defense and Space Products Support Test of AARGM Missile

REMEC Defense and Space (a subsidiary of Cobham Defense Electronic Systems) has received notice by ATK of another successful milestone test of the Advanced Anti Radiation Guided Missile (AARGM) at China Lake, CA. The missile was launched off-axis from low altitude from an F/A-18C hornet aircraft and was able to guide itself to a direct hit on a simulated enemy defense radar installation. The test, a joint effort between the US Navy, Alliant Techsystems and the Italian Air Force, was a critical milestone in the program and keeps the program on track for Low Rate Initial Production.

REMEC provides three integrated electronic assemblies to ATK for installation into the AARGM missile: the RF processor, an IF receiver and a WIA transmitter. REMEC has been a participant on the AARGM project since 2003 and is currently producing these assemblies under the SDD phase of the program. The current Navy/ATK schedule calls for low rate initial production to commence following completion of Milestone C, scheduled later this year. "REMEC is a critical supplier on the Government-industry AARGM development team," said Gordon Turner, ATK director of Strike Weapons. "The performance of REMEC's anti-radiation homing (ARH) receiver components was pivotal in the test missile ARH guidance to a direct hit on the target."

Following the successful test firing, Captain Larry Egbert, the Department of Defense program manager, Direct and Time Sensitive Strike Programs, stated: "The entire international AARGM team is pleased with the test results. I continue to be exceptionally proud of the achievements of our international, government-industry team. The successful test has shown the lethality against a real-world threat and demonstrates the viability of an affordable Destruction of Enemy Air Defenses (DEAD) capability for US, Italian and potentially other Allied Forces through the upgrade of legacy HARM weapons."

The test firing was a culmination of a successful series of laboratory integration and captive flights. It demonstrated the maturity of the AARGM integration with the F/A-18 aircraft and the continued progress of fielding a long-range, precision strike capability against a wide array of time-critical targets. The missile utilized GPS/INS navigation with enroute transition to ARH guidance on the air defense radar target. The test demonstrated how AARGM's digital ARH receiver can detect, identify, track, geographically locate and guide to lethal range on the target. With this test, AARGM has achieved nine successful live fires and numerous captive carry flights against a wide array of threats. When fielded in FY10, it will be the only extended range tactical supersonic multi-role strike weapon in the US and Italian inventories.

AARGM is a supersonic, air-launched tactical missile that will be integrated on the F/A-18C/D, F/A-18 E/F, EA-18C and Tornado IDS/ECR aircraft. The missile is being designed to be compatible with the F-35, EA-6B and US and Allied F-16 aircraft. Its advanced multisensory system, including a millimeter wave (MMW) terminal seeker, advanced digital anti-radiation homing (ARH) receiver and a GPS/INS, is capable of rapidly engaging traditional and advanced enemy air defense targets as well as non-radar time-sensitive strike targets. The AARGM MMW seeker can operate in concert with the ARH to counter RF shutdown tactics, or in a stand-alone mode to guide to non-emitting time sensitive targets. AARGM is a network-enabled weapon that directly receives tactical intelligence information via an embedded data link and transmits real-time weapon impact assessment (WIA) reports. AARGM, the successor to the US Navy AGM-88 HARM system, is a US and Italian international cooperative acquisition program with the US Navy as the executive agent.

GEO-1 Spacecraft Ready for Environmental Test Phase

Lockheed Martin announced that it has achieved a major integrated test milestone on the first Space-based Infrared System (SBIRS) geosynchronous orbit (GEO-1) spacecraft that enables the start of environmental testing in preparation for launch in 2009. The GEO-1 satellite, designed to provide new missile detection and surveillance capabilities for the nation, has completed a comprehensive baseline integrated system test (BIST) phase which began in early March to characterize the overall performance of the GEO-1 satellite and establish a performance baseline for entering environmental testing.

"I am proud of our entire team for completing this significant milestone ahead of schedule," said Col. Roger Teague, the US Air Force's SBIRS wing commander. "We continue to build confidence as we march towards the inaugural launch of this vitally important spacecraft." With the completion of BIST, the team will integrate the satellite's solar arrays, deployable light shade and thermal blankets and then prepare for acoustic and pyroshock testing where the integrated space vehicle will be subjected to the maximum sound and vibration levels expected during launch into orbit. "This comprehensive test confirms our readiness to enter the critical environmental test stage," said Jeff Smith, Lockheed Martin's SBIRS vice president and general manager. "Our team continues to make significant progress on this sophisticated satellite and we look forward to achieving mission success for our customer." SBRIS is designed to provide early warning of missile launches and simultaneously support other missions, including missile defense, technical intelligence and battlefield characterization. The SBRIS team is led by the Space-based Infrared System Wing at the US Air Force Space and Missile System Center, Los Angeles Air Force Base, CA. Lockheed Martin Space Systems Co., Sunnyvale, CA, is the SBIRS prime contractor, with Northrop Grumman Electronic Systems, Azusa, CA, as the payload integrator. Air Force Space Command operates the SBIRS system. Lockheed Martin's current contract includes two highly elliptical orbit (HEO) payloads and two GEO satellites, as well as ground-based assets to receive and process the infrared data. The Lockheed Martin team has delivered both HEO payloads and the first GEO satellite launch is scheduled for late 2009. The first HEO payload has completed initial on-orbit deployment and checkout and demonstrated that its performance meets or exceeds specifications. The program is in the early stages of adding additional GEO spacecrafts and HEO payloads to the planned constellation.

Raytheon Demonstrates Gallium Nitride Advantages in Radar Components

Raytheon Co. is developing transmit-receive modules based on the advanced semiconductor gallium nitride (GaN) for use in future radar upgrades.

"This transmit-receive module demonstration and parallel reliability testing show that GaN will soon be ready to take over where increased power and advanced capabilities are needed," said Mark Russell, vice president of engineering at Raytheon Integrated Defense Systems (IDS). The development is part of an on-going 42-month, $11.5 M Next Generation Transmit Receive Integrated Microwave Module (NGT) contract funded by the Missile Defense Agency's Advanced Technology Directorate. Raytheon is demonstrating that the transmit-receive modules using GaN-powered monolithic microwave integrated circuit amplifiers have a significant performance advantage in that they produce significantly higher radio frequency power with greater efficiency than current modules. The NGT program leverages GaN technology being developed under the Defense Advanced Research Projects Agency's Wide Bandgap Semiconductor program as well as company-funded efforts. Russell said that GaN technology significantly extends the warfighter's reach into the battlespace by increasing radar ranges, sensitivity and search capabilities. Alternatively, the technology enables reduction in the acquisition and lifecycle costs without sacrificing performance.

"The NGT program is important because it is the first significant government-funded contract to address the use of the more capable GaN semiconductors in a relevant environment," said Steve Bernstein, IDS's program manager on NGT. "This recent demonstration shows that GaN technology performs better in transmit-receive modules representative of those used in modern radars." ■

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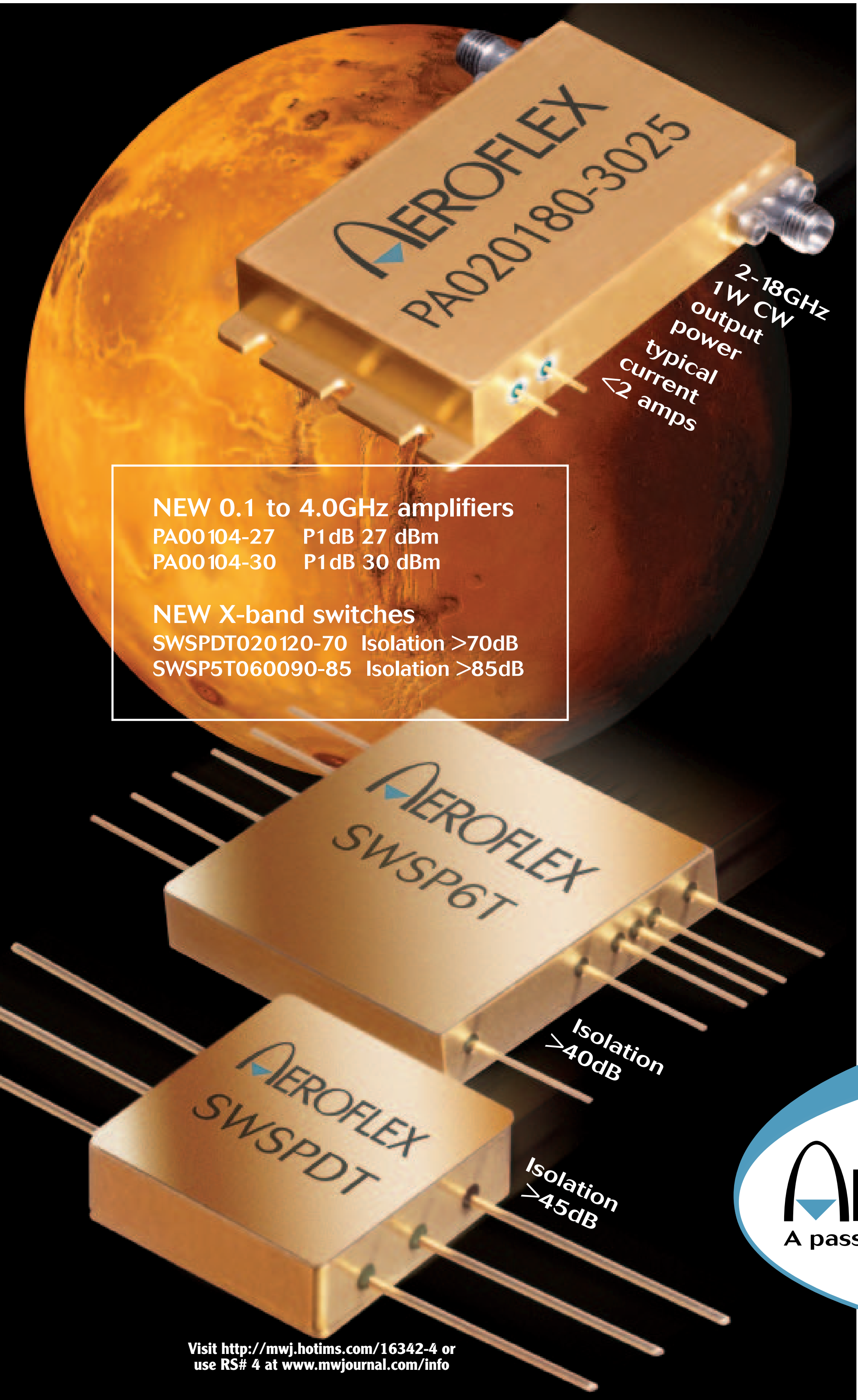

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World's Largest Radio Astronomy Project Begins

Scientists and engineers from around the world recently met in Australia to begin the preparatory phase for the biggest project ever undertaken in radio astronomy. The international Square Kilometre Array (SKA) will be 50 times more sensitive than any existing facility and will probe some of the biggest questions in the Universe.

The SKA was identified by the European Strategy Forum for Research Infrastructures (ESFRI) in its 2006 Roadmap for research infrastructures of pan-European relevance and the corresponding Preparatory Phase project, PrepSKA, will now pave the way for the SKA with a three-year programme. Its aim is to draw together international efforts from around the world to finalise a detailed, costed technical design, and to develop the governance and legal framework for the project. PrepSKA will also conduct additional studies of the short-listed sites being considered for the SKA, in Australia and South Africa.

PrepSKA is a €22 M programme, with €5.5 M from the European Union's Seventh Framework Programme (FP7) and further funding provided by the participating countries. It began in April 2008 and runs until 2011. The PrepSKA collaboration initially involves 24 organisations from 12 countries, including Australia, Canada, France, Germany, Italy, Portugal, Spain, South Africa, Sweden, the Netherlands, the UK and the US.

ESA and Astrium Sign Satellite Agreement

The European Space Agency and Astrium have signed a €195 M contract to provide the first Sentinel-2 earth observation satellite, devoted to monitoring the land environment, as part of the European Global Monitoring for Environment and Security (GMES) programme. As prime contractor, Astrium is responsible for the design, development and integration of the satellite, which will perform a high-end multi-spectral optical imaging mission.

GMES aims to deliver environment and security services and is being led by the European Commission. At the same time, it is the European contribution to the Global Earth Observation System of Systems (GEOSS). ESA is responsible for implementation of the GMES Space Component, a set of earth observation missions involving ESA, EU/ESA Member States and other partners. Central elements of the Space Component are the five families of Sentinel missions.

ESA carried out the Sentinel-2 definition phase over 2005/2006. The implementation phase started in October 2007 and the launch of the first Sentinel-2 satellite is planned for 2012. Sentinel-2 will deliver crucial data for information services to the EU and its Member States under GMES. The services fed by it cover areas such as climate change, sustainable development, environmental policies, European civil protection, common agricultural policy, development aid, humanitarian aid and the Common Foreign & Security Policy.

EPCOS Acquires RF-MEMS Business

EPCOS, a manufacturer of electronic components, modules and systems, has acquired the activities of NXP Semiconductors Netherlands B.V. in the area of Radio Frequency Micro-Electro-Mechanical Systems (RF-MEMS). Through the acquisition EPCOS continues its strategy of cooperative ventures and acquisitions aimed at extending its technology and product range, boosting its growth and entering new growth sectors. The new RF-MEMS business opens up additional market potential to the company in the potentially lucrative mobile communications market.

EPCOS is a world market leader in RF filters and with RF-MEMS, the company is extending its portfolio of RF products. To date these comprise both discrete filters and integrated modules, used for the transmit and receive circuits of mobile phones. With the RF-MEMS technology, the company expects to open up a new area of applications in the mobile phone market; RF-MEMS products are used between the transmit/receive unit and the antenna, and thus increase the company's share of value-added in this area. Moreover, MEMS technology also offers attractive growth opportunities outside the RF sector.

"By acquiring NXP's RF-MEMS activities, we are strengthening our competence in RF technology and are thus accelerating the transformation of our company from a manufacturer of discrete components to a systems provider," explained EPCOS president and CEO Gerhard Pegam. "By entering into the RF-MEMS business we are laying the foundation to benefit even more strongly from the growth dynamics of the mobile communications market in the future."

Wireless Industry Leaders Commit to LTE Framework

Alcatel-Lucent, Ericsson, NEC, NextWave Wireless, Nokia, Nokia Siemens Networks and Sony Ericsson have made a mutual commitment to a framework for establishing predictable and more transparent maximum aggregate costs for licensing intellectual property rights (IPR) that relate to 3GPP Long Term Evolution and Service Architecture Evolution standards (LTE/SAE). The companies invite all interested parties to join this initiative, which is intended to stimulate early adoption of mobile broadband technology across the communications and consumer electronic industries.

The framework is based on the prevalent industry principle of fair, reasonable and non-discriminatory (FRAND) licensing terms for essential patents. This means that the companies agree, subject to reciprocity, to reasonable, maximum aggregate royalty rates based on the value added by the technology in the end product and to flexible licensing arrangements according to the licensors' proportional share of all standard essential IPR for the relevant product category.

This framework balances the prevailing business conditions relevant for the successful widespread adoption of the LTE standard, which continues its progress toward definitive adoption by the industry in the applicable standards forums and organizations.

ST and NXP Merge Wireless Businesses

NXP and STMicroelectronics are to combine key wireless operations to form a joint venture company with strong relationships with all major handset manufacturers. The new organization will combine key design, sales and marketing, and back-end manufacturing assets from both companies into a streamlined worldwide joint venture that will rely on its parent companies and foundries for wafer fabrication services.

The new company will have the scale to meet customer needs in 2G, 2.5G, 3G, multimedia, connectivity and all future wireless technologies. It will be well positioned with all of the vital technologies for UMTS; for the emerging 3G Chinese standard; as well as other cellular, multimedia and connectivity capabilities, including WiFi, Bluetooth, GPS, FM Radio, USB and UWB. Thus, it will be able to effectively serve its global customers with complete wireless and mobile solutions across the spectrum of applications. The joint venture will also integrate the Silicon Laboratories' wireless and GloNav's GPS operations recently acquired by NXP.

In order to create a clear ownership structure, STMicroelectronics will take an 80 per cent stake in the joint venture. NXP will receive $1.55 B from ST, including a control premium, to be funded from outstanding cash (cash and cash equivalents balance for ST at year end 2007 were $3.5 B). The new organization is designed to be in a very healthy financial position, without debt, and able to grow its business with all of the leading cellular handset manufacturers.

The new company will be incorporated in the Netherlands and headquartered in Switzerland with approximately 9000 employees worldwide. It will operate its own assembly and test facilities in Calamba, Philippines and Muar, Malaysia. ■

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Markets for Microwave Modules in Military and Space-related Systems

Engalco has recently released an industry and markets report covering global military and space-related systems. "Microwaves Global Military and Space Systems" (MGMSS) provides "free world" market forecasts for microwave electronic module products sold into these segments.

The report separates products and applications into microwave (0.7 to 20 GHz) and millimeter-wave (above 20 GHz). While microwave products always take the lion's share of all markets, those for millimeter-wave products grow at a greater rate to reach over 38 percent of the global total by the end forecast year (2014).

Most types of amplifiers and oscillators are considered as well as mixers, ferrite components, RF electronic switches, frequency converters and frequency synthesizers. In all cases, the product formats are small modules rather than being rack-mounted units. End-user applications are segmented into "military" and "space systems." Markets for TRMs (as implemented in AESA radars) are also forecasted. Military markets always exceed those of space systems—although in some instances only by a fairly narrow margin. Microwave frequency synthesizers represent the category of product having the largest available market—typically in the hundreds of millions of dollar range. The next largest markets are those applying to TRMs (for AESA) and power amplifiers, respectively.

North America always remains the region (and within that region, the US) with the largest available markets; the US also contains by far the major manufacturing base. This report covers the "free world" markets and does not include military or space systems product trading between economies such as China, Iran or Russia. Markets in Europe and also the extensive region known as the "rest of the world" remain at levels substantially lower than North America for the entire forecast period.

In this report, data on average selling prices (ASP) and volume shipments are provided for nine product types—again with forecasts to 2014. A total of 21 companies, identified as being particularly influential within this industry sector are provided in some depth.

Researchers and publishers of many successful reports such as "MGDS2" in 2004 and AESAs in 2007, Engalco is a tech-sector consultancy, industry analysis, market forecasting and publishing concern. With strong experience in all relevant commercial and defense segments, the firm specializes mainly in the RF/microwave, wireless, fiber-optics, photonics and related electronic sectors. Since its inception in 1989, Engalco has been responsible for many published market reports and the completion of several private client projects in these sectors. The firm's mission is to continue providing a range of vital types of analysis, research and publishing services, in addition to customized consultancy based on its proven specialist capabilities. For further information, contact Engalco at +44 (0) 1262 424 249 (GMT) or e-mail: enquries@engalco-research.com.

Radio Proliferation Causing a Revolution in the Mobile Device Market

It was once easy to distinguish a cellphone: it had a phone number, was used for voice service and offered short message service (SMS) text messaging. Many cellphones also include third-generation (3G) network access to download rich media files and streamed content.

Wi-Fi networks, however, have become more prevalent, the addition of Wi-Fi radios permits hi-speed, low-cost internet access for additional applications on smartphones and other devices. Not only can Wi-Fi service be used for viewing Internet sites, the addition of an appropriate client application transforms a data-centric device into a voice device without using the cellular network.

The presence of multiple network access is a defining feature of the devices that are breaking out of their categories. Among the networks that are finding their way into personal and mobile devices are:

- Cellular in its various forms, including voice networks, as well as UMTS, HSPA and EV-DO data networks.
- Wi-Fi radios that can access business and personal networks, as well as public hotspots and metro-area Wi-Fi systems. Wi-Fi can be used for Internet access, voice over IP (VoIP) using an application such as Skype and for unlicensed mobile access (UMA) of cellular services over a Wi-Fi gateway.
- Broadcast receivers, such as FM radio and mobile video receivers for a variety of video broadcasting technologies, such as ISDBT, DVB-H and MediaFLO are finding their way into cellphones and other devices.
- WiMAX radios are expected to appear in a number of devices, starting with laptop-sized personal computers and eventually appearing in smaller devices.
- GPS provides location data for complex navigation applications, "place stamping" in addition to the traditional time and date stamps, or context for location-based applications, search and content.
- Local connectivity, such as Bluetooth, WiMedia, ZigBee and others, permits devices to send or receive content from other devices. For example, Nokia's N810 tablet device can access the cellular network using a Bluetooth connection to a cellphone.

Network connectivity is no longer the defining factor in differentiating portable devices. In-Stat expects more devices to connect via multiple networks, so users can be assured of finding access and selecting the preferred network, based on availability, cost, speed or other factors. There is more information about mobile devices and their network connections in "The Revolution in Mobile Devices," "Impact of Devices on the Mobile Broadband Universe," "UMDs—Are They for Real? A Worldwide Snapshot" and "Big Trends in Future Cellphones 2007–2012."

For Market Success, Driver Assistance Systems Must Really Help

Automated systems designed to help drivers avoid accidents are starting to become available on a wide range of vehicles. In these first generation systems, the assistance is mostly limited to flashing lights and audible/haptic signals. OEMs and suppliers are working hard to develop reliable technology that does not irritate drivers with constant alerts, but that does step in to warn if there is a real danger.

"Demonstrated robustness and reliability are critical before system developers take the next step of assuming some control over vehicle speed or direction," says ABI Research principal analyst David Alexander. "That stage has been reached with the latest adaptive cruise control systems that apply the brakes. Lane departure warning and blind spot detection sensors and algorithms still need to be proven in actual use."

Vehicle purchasers still need a lot of convincing of the value of this new technology. Unfortunately, for many people, safety is not as big a draw as convenience or comfort. As the technology develops and includes more features, the value equation will become more favorable. Sensor fusion is already starting to deliver additional benefits, and as advances in software and computing power continue, manufacturers will be able to offer more features for the same or lower prices as the first generation systems. "The bottom line is that drivers want to be helped by advanced technology rather than just nagged about what they might be doing wrong," says Alexander. "There are positive signs that progress is being made toward this goal, but the market is unlikely to take off until it is reached."

ABI research's recent study, "Automotive Obstacle Detection Systems," offers an analysis of the global market trends, costs and technological evaluations of different approaches and strategies used by safety systems developers, and discusses existing product announcements and design wins. Systems and sensors forecasts for vehicles are provided globally, by region, through 2013. The study forms part of ABI Research's Emerging Technologies Research Services, which also includes other Research Reports, ABI Insights and analyst inquiry support. ■

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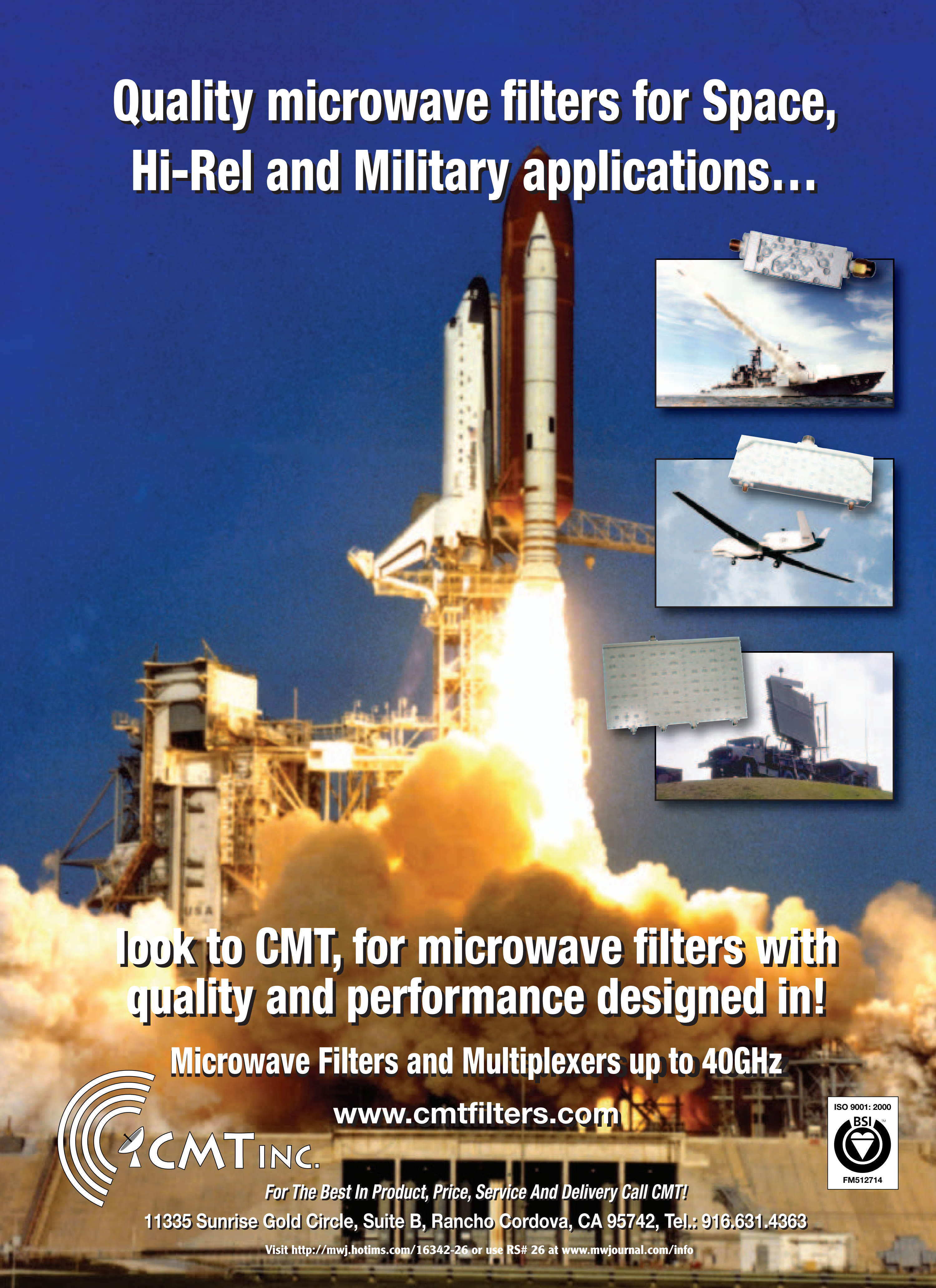
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INDUSTRY NEWS

■ **Tensolite**, of Carlisle Companies Inc., announced that it has signed a definitive agreement to acquire privately-owned **Carlyle Inc.**, a provider of sophisticated aerospace and network interconnection solutions. With annual sales of approximately $125 M, Carlyle is focused on manufacturing wire and cable harnesses, rack and panels, and cable assemblies for in-flight entertainment systems and specialty avionics applications. The company has facilities in Tukwila and Kent, WA. The business will operate within Carlisle's Tensolite Company division. The acquisition will strengthen Tensolite's core presence in specialty wire and cable and interconnect solutions for the aerospace industry. The purchase will also expand Tensolite's global reach and add to its capabilities in other specialty interconnect segments.

■ **Aeroflex** and **Innowireless** announced that they have entered into a technology partnership designed to accelerate the development of 3GPP LTE mobile devices for subscribers. The partnership will enable the two companies to combine their extensive engineering skills and resources to collaborate on the development of a new 3G LTE mobile test tool intended to enable handset designers and manufacturers accelerate the time-to-market of their 3G LTE products for subscribers. The new 3G LTE mobile test tool is expected to be available in Q4 2008 and will be marketed through Aeroflex's extensive worldwide sales and support channel.

■ **Orolia**, the French electronics technology group specializing in high-precision time and frequency generation, distribution and measurement, and **Rapco Electronics Ltd.**, a high-precision frequency standards, time code and distribution provider, have formed a strategic partnership to strengthen their competitive positions and provide tangible benefits to their customers and sales channel partners. In a multi-phased approach, Orolia Group companies Spectracom and SpectraTime will join the existing alliance between Pendulum Instruments (recently acquired by Orolia) and Rapco Electronics to cooperate on several fronts to leverage global distribution channels, operations and new product development efforts.

■ **TECOM Industries Inc.** announced that it has entered into a Cooperative Research and Development Agreement (CRADA) with the Naval Air Warfare Center Weapons Division (NAWCWD) in China Lake, CA, to develop and qualify the next generation instrumentation antenna for a Navy missile. The conformal, dual-band antenna provides GPS and S-band telemetry functionality, and is part of the next generation instrumentation package being developed to support future Air Force and Navy flight test and training requirements. Under the agreement, TECOM is working with NAWCWD engineers at Pt. Mugu to design, produce and qualify the antenna subsystem, consisting of a dual-band antenna with integrated low noise amplifier, filter and limiter. At the conclusion of the project the US government will have a fully qualified product ready for full-scale production. Completion is scheduled for Q3 2008.

■ **Technical Communities** announced a government services partnership agreement with **BreakingPoint Systems**, a provider of high performance application testing systems to network equipment manufacturers, service providers, US government agencies, military organizations and prime federal contractors. The agreement authorizes Technical Communities to provide government organizations with BreakingPoint products, service agreements and warranties including the BreakingPoint BPS-1000 and BPS-10k. With BreakingPoint products and services, government organizations can ensure the success of high performance computing and network security initiatives.

■ **ClearComm Technologies LLC** has announced its expansion into new facilities in Fruitland, MD. A larger, 35,000 square foot building is being utilized to produce ClearComm's commercial, military and wireless products. ClearComm is a manufacturer of filters, duplexers, diplexers and RF assemblies covering the frequency range of 10 MHz to 18 GHz. The new address is 28410 Crown Road, Fruitland, MD 21875. Phone number: (410) 860-0500, fax: (410) 860-9005, e-mail: sales@clearcommtech.com or visit www.clearcommtech.com.

■ **Advanced Switch Technology**, a designer and manufacturer of microwave switches, announced that after 16 years at its present location, the company will be moving to a newly built facility. The new plant will house its own shop with fully automated CNC machines, assembly lab and corporate offices, and it will allow a production increase of 30 to 50 percent. The new address is: 754 Fortune Crescent, Kingston, ON, Canada K7P 2T3. Phone number: (613) 384-3939, fax: (613) 384-5026 and e-mail: info@astswitch.com.

■ **AWR**® and **TriQuint Semiconductor Inc.**, an RF front-end product manufacturer and foundry services provider, announced Project JumpStart, a program designed to provide first-time AWR and TriQuint customers with a low cost introduction to the benefits of design and fabrication of gallium arsenide (GaAs) microwave monolithic integrated circuits (MMIC). Project JumpStart offers designers an affordable, low-risk means of bringing wireless design prototypes to market using AWR's electronic design automation (EDA) tools and TriQuint's pseudomorphic high electronic mobility transistor (PHEMT) foundry process.

■ **StratEdge**, a leader in the design and production of semiconductor packages for microwave, millimeter-wave and high speed digital devices, announced that it has been certified for ISO 9001:2000 at its new facility, which opened in November 2007. Since being ISO certified originally in 1998, StratEdge has consistently passed such audits and maintained its certification. Achieving certification indicates that StratEdge meets specific requirements for a quality management system.

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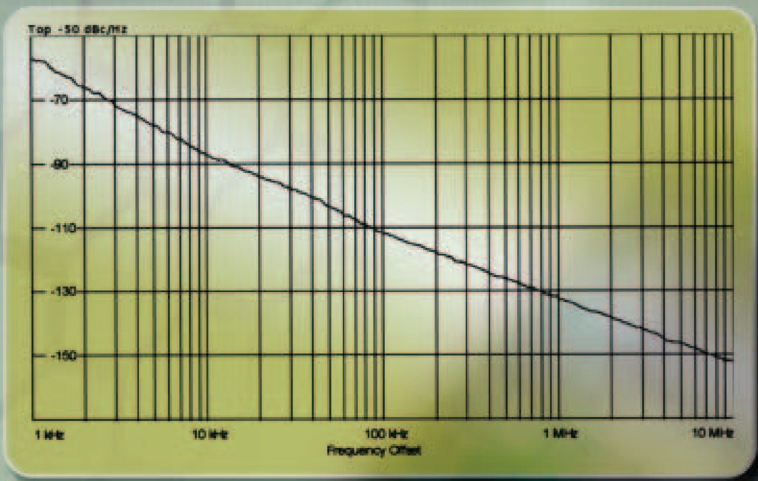

DCO & DXO
SERIES

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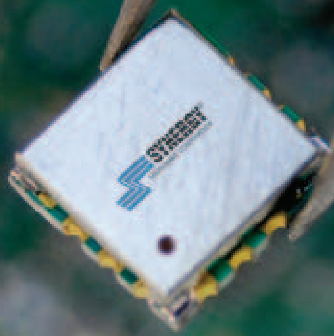

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■ Smiths Interconnect, part of the global technology company Smiths Group, announced that one of its businesses, **Sabritec**, has successfully passed qualification testing of its Size 16 ARINC 801 terminus for single- and multi-mode applications. Qualification test results show that Sabritec's ARINC 801 terminus maintains its low loss while being intermateable/interoperable with qualified termini and connectors.

■ **Jacket Micro Devices Inc.** (JMD) announced that laminate-based radio frequency system-in-package (RF SiP) products made with its patented Multi-Layer Organic (MLO) process have passed JEDEC reliability qualification testing. The MLO substrates, and modules assembled using them, are lead (Pb) free and RoHS-compliant.

■ **Times Microwave Systems** announced the availability of Mining, Safety and Health Administration (MSHA) approved RF cables. The LMR®-FR series of cables will now be marked with an additional MSHA qualification reference number, and can now be used in mining applications where MSHA approvals are required.

■ **Skyworks Solutions Inc.**, an innovator of high performance analog and mixed signal semiconductors enabling mobile connectivity, congratulates **Samsung** on recently winning two prominent FEMTO cell awards. Jang Young Shil, presented by the Maeil Business Newspaper and the Korea Industrial Technology Association (KOITA), operated by the Korean government, is granted based on technological importance, originality and economic value.

CONTRACTS

■ **e2v technologies**, the UK specialist developer and manufacturer of high technology components and subsystems, has been awarded a contract from the United States Department of Defense worth a total of $12 M. This win is a follow-on contract to that announced in February 2008, for the supply of defense electronic subsystems, which utilize the company's electronic tube technology.

■ **Elcom Technologies Inc.** announced a three-year extension to an existing agreement for the company's PLL controlled oscillator design that provides extremely low phase noise and excellent MTBF. The total value of the agreement exceeds $6 M and reflects Elcom's leadership in providing solutions for commercial test equipment companies.

■ **Endwave Corp.**, a provider of high frequency RF modules for telecommunications networks, defense electronics and homeland security systems, announced the receipt of a production contract from **Brijot Imaging Systems Inc.** Brijot, an industry leader in passive millimeter-wave imaging, has selected Endwave as the sole-source supplier of radiometer assemblies for use in its GEN 2 full body imaging system that employs passive millimeter-wave technology for concealed object detection and people screening. Under the terms of the contract, Endwave will produce complete radiometer assemblies operating over a millimeter-wave spectrum known as "W-band," which ranges from 75 to 100 GHz. Initial deliveries are projected to commence in the second quarter of 2008, while additional orders are expected to be released upon Brijot's acceptance of the first production units.

■ **Auriga Measurement Systems LLC** announced that over the past several months it has been awarded research and development contracts by the Army's CECOM and the Navy's SPAWAR and NAVAIR departments; this is the company's second win with NAVAIR. The ARMY Small Business Innovation Research (SBIR) award is for a high-powered multi-component switch for the Joint Tactical Radio System (JTRS), while the NAVAIR and SPAWAR projects focus on high efficiency and low noise power amplifiers, respectfully.

■ **Agilent Technologies Inc.** announced that **Universal Scientific Industrial Co. Ltd.** (USI) will use Agilent's WiMAX™ manufacturing networking test set for its Mobile WiMAX test needs. The company chose Agilent because of its ability to deliver fast measurement time for USI's Mobile WiMAX module test plan requirements. USI is a leader in the design and manufacturing services (DMS) industry that focuses on product development and capability enhancement.

■ **RF Industries Ltd.** announced that its RadioMobile division has received new orders from Dial-a-Cab for software and hardware valued at approximately $500,000 and scheduled for delivery over the next 10 months.

FINANCIAL NEWS

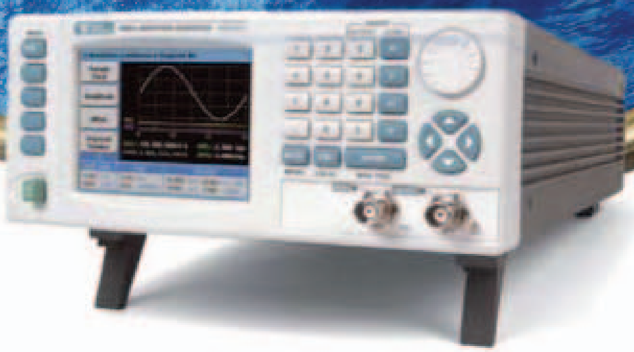
■ **Aperto® Networks**, a builder of advanced carrier-grade and cost-effective WiMAX base stations and subscriber units, announced that it has secured $20 M of new equity funding. The financing round was led by Quicksilver Ventures and included participation from several of the existing investors, including Gunn Allen Venture Partners, JK&B Capital, Canaan Partners, Alliance Ventures, Innovacom, JAFCO Ventures and Labrador Ventures.

■ **Merrimac Industries Inc.** reports sales of $5.4 M for the fourth quarter of 2007 ended December 29, 2007, compared to $5.2 M for the same period in 2006. Net income for the quarter was $1.1 M ($0.38 per share), compared to a net loss of $1.7 M ($0.55 per share) for the fourth quarter of last year.

PERSONNEL


▲ John Barr

■ After 37 years of service to HP and Agilent, **John Barr** has retired. Barr joined HP in 1971 after graduating from the Georgia Institute of Technology. He has held numerous roles in R&D including RF component designer, software engineer and then advanced through R&D management positions to R&D lab manager. Barr's career includes a long list of achievements, such as the development of the HP84000 RFIC tester and several network analyzers, such as the HP8510. He published 12 papers on RF mea-



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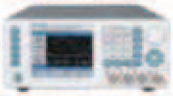

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surement techniques, received five patents, and maintained active membership in the IEEE before becoming an IEEE Fellow in 2002. He served as president of MTTS in 2002 as well as the general chair of IMS 2006. Barr joined Agilent EEsof in 2004 as the foundry program manager and most recently the RFIC product manager for RFDE and GoldenGate.


▲ Enrique Barrientos

■ **Enrique Barrientos** has been appointed CEO of the EADS Defence & Security Division in Spain. He takes responsibility for the activities of the division, reporting to the CEO of Military Air Systems, and for overarching Spanish activities, reporting to the CEO of EADS Defence & Security. Previously Barrientos was the chief of staff of the EADS Defence & Security Office in Munich, Germany, having been Head of Political Affairs EADS CASA. He was also vice president corporate development and held several other executive positions in different areas of the company. He is an aeronautical engineer and has a master's degree in business management and administration from the IESE Business School.

■ RF Micro Devices Inc. (RFMD®) announced that **William J. Pratt**, chief technical officer, and **Powell T. Seymour**, corporate vice president of strategic operations, have retired from RFMD after distinguished careers in the communications technology industry, including the co-founding of RFMD 17 years ago and active roles in the subsequent growth of RFMD. In 1991, Bill Pratt, Powell Seymour and Jerry D. Neal founded RFMD in Greensboro, NC. Pratt served as RFMD's chairman of the board from 1991 until August 2002 and continues to serve on RFMD's board of directors.

■ Renaissance Electronics (REC) announced a new addition to its team. **Michael Donaghey** joins the company as vice president of sales and marketing. Donaghey comes from Enterprise Rent-A-Car, where he held the position of vice president/general manager. He brings 17 years of sales management experience to REC. In his new position, Donaghey is responsible for directing overall business strategy for all of REC's product lines. The entire REC sales and marketing team now reports to Donaghey. He can be reached at (978) 772-7774 x14 or e-mail: mdonaghey@rec-usa.com.


▲ Steve Dudkiewicz

■ **Steve Dudkiewicz** has joined the Maury Microwave team as director of sales and marketing for Europe, Canada, Israel, India and Africa. Dudkiewicz comes to Maury from Focus Microwaves Inc., where he held the position of senior application and sales engineer. All inquiries can be sent to sdudkiewicz@maurymw.com.

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Tuning resolution:	1 kHz
Package size:	6.0″ x 6.0″ x 2.75″

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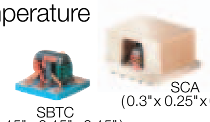

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SBTC-2-15-75+	500-1500	75 Ω	3.49
SBTC-2-10-5075+	50-1000	50/75 Ω	3.49
SBTC-2-10-7550+	5-1000	50/75 Ω	3.49
SCA-4-10+	5-1000	50 Ω	6.95
SCA-4-10-75+	10-1000	75 Ω	6.95
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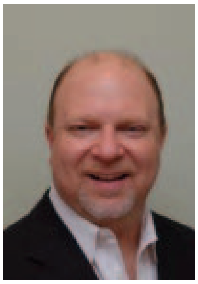
■ Park Electrochemical Corp. announced the appointment of **David R. Dahlquist** as director of marketing for the company. Dahlquist previously held the position of product director at Park Electrochemical Corp. He has previous experience with Photocircuits Corp. in the positions of director of technology-corporate and director of Quality and Engineering-PC-Asia.


▲ *Lee Goldstein*

■ Communication Infrastructure Corp.® announced that **Lee Goldstein** has joined the company as director of network engineering, a new division that will house the company's growing engineering services business. Based in Chicago, IL, Goldstein will help manage the design and implementation of wireless carrier infrastructure with the added focus of integrating cell sites and switching centers with the public telephone network. Goldstein most recently served as T-Mobile's director of network engineering and operations for the Central Region, where he managed a team of engineers in systems and transport design and implementation.

■ Radio Frequency Systems (RFS) announced the appointment of **Modeste Addra** to the position of product line manager Radio Link Networks. Most recently, Addra worked as chief technology officer for RFS. He will now turn his focus to the global growth of RFS radio link network solutions.


▲ *Suresh P. Ojha*

■ Phase Matrix has appointed **Suresh P. Ojha** to RF and microwave engineer, frequency synthesis group. Ojha is responsible for the microwave engineering activities for a new generation of fast switching frequency synthesizers. Ojha received his BS and MS degrees in electrical engineering with a specialization in RF and microwaves from UC Davis in 1993 and 1995, respectively. He has previously designed cellular base station power amplifiers and signal sources for Agilent Technologies and Gigatronics.

REP APPOINTMENT

■ **Kenet Inc.**, a fabless semiconductor company based in Woburn, MA, has appointed **Link Microtek** of Basingstoke as its UK representative. In addition to providing Kenet with sales and marketing coverage in the UK, Link Microtek will be working in partnership with **Globes Elektronik** in Germany and **Elexo** in France to establish a European inventory-sharing arrangement for the company's range of products.

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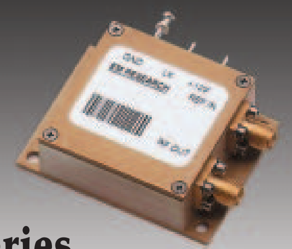
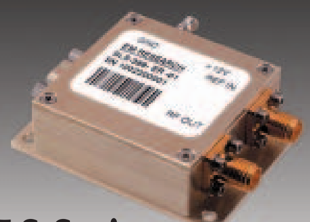

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Fixed Frequency Range: 5 to 420 MHz
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Frequency Range: 50 MHz to 12 GHz
Bandwidth: Fixed, up to 30%
Step Size: 10 KHz to 10 MHz
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Phase Noise (Fout = 12 GHz): < -85 dBc/Hz @ 10 KHz
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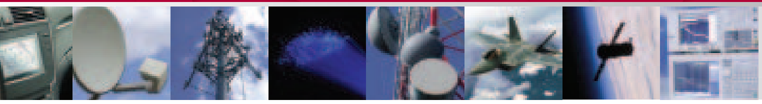

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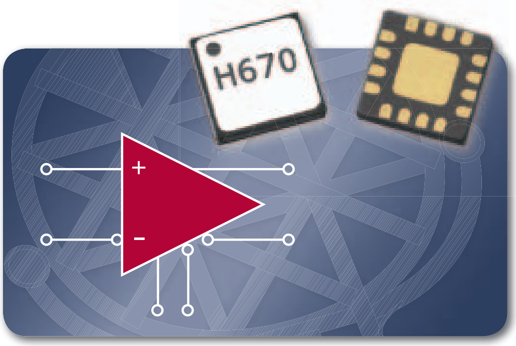

HIGH SPEED COMPARATORS

Input Clock Rate (GHz)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power Consumption	Vcc, Vee Power Supply (Vdc)	Package	Part Number
9.7	Latched Comparator-RSPECL	10	130	0.4	180 mW	+3.3, -3.0	LC3C	HMC674LC3C
9.7	Latched Comparator-RSCML	10	130	0.2	120 mW	+3.3, -3.0	LC3C	HMC675LC3C
9.7	Latched Comparator-RSECL	10	130	0.4	120 mW	+3.3, -3.0	LC3C	HMC676LC3C

High Speed Digital Logic

- ***Low Jitter: <1 ps Peak-to-Peak***
- ***Low Power Dissipation***
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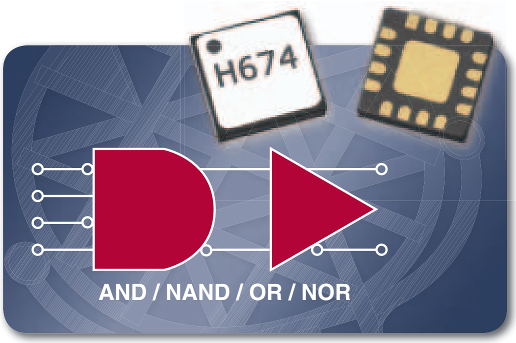

HIGH SPEED DIGITAL LOGIC

Data / Clock Rate (Gbps/GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vpp)	DC Power Consumption	Vee Power Supply (Vdc)	Package	Part Number
13	1:2 Fanout Buffer	22 / 20	<1	0.4 - 1.1	240 mW	-3.3	LC3C	HMC670LC3C
13	XOR / XNOR	22 / 20	<1	0.4 - 1.1	180 mW	-3.3	LC3C	HMC671LC3C
13	AND / NAND / OR / NOR	22 / 20	<1	0.4 - 1.1	180 mW	-3.3	LC3C	HMC672LC3C
13	D Flip-Flop	22 / 20	<1	0.4 - 1.1	210 mW	-3.3	LC3C	HMC673LC3C

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ADDITIVE (RESIDUAL) PHASE NOISE MEASUREMENT OF AMPLIFIERS, FREQUENCY DIVIDERS AND FREQUENCY MULTIPLIERS

Phase noise is becoming generally recognized (and accepted) as a critical performance parameter in higher performing test, radar and communication systems. However, additive phase noise is not typically measured on amplifiers, frequency dividers or frequency multipliers due to the perceived difficulty of the measurement and the prohibitive cost of available phase noise measurement systems.

Contrary to popular belief, accurate additive phase noise measurements are straightforward. Phase noise is typically considered an esoteric measurement, which many engineers and technicians would rather not have to make. This article removes the mystery from additive phase noise measurements and simplifies some of the techniques. Some knowledge of trigonometry is all that is really needed to understand additive phase noise measurements. This article demonstrates how to make valid residual phase noise measurements with a good synthesizer, low noise baseband amplifier and an audio card.

RESIDUAL OR ADDITIVE PHASE NOISE MEASUREMENT FUNDAMENTALS

Additive phase noise, also referred to as residual phase noise, is the self phase noise of a component that adds to an existing signal as the signal passes through it. It is additive linearly, not in decibels, which would be multiplicative. The term residual phase noise is used interchangeably with additive phase noise and is in reference to the original phase noise measurement of components. The measurement system inherently subtracts out the source noise in the test system, which leaves the phase noise of the DUT, or residual phase noise, as the remainder of what is being measured. Additive phase noise is a more apt description of the noise within the system being used, rather than reference to the measurement system.

JASON BREITBARTH AND JOE KOEBEL
Holzworth Instrumentation
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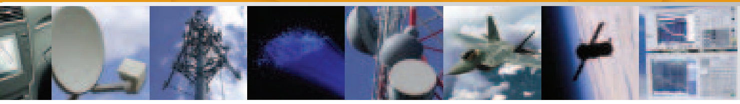

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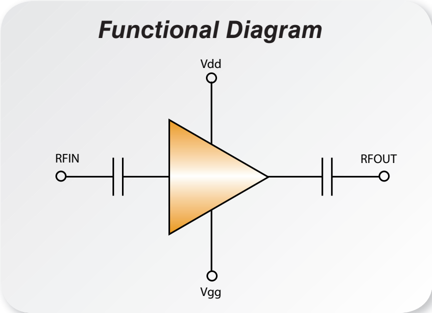
37 - 40 GHz



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	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	P1dB (dBm)	Bias Supply	VELOCIUM Part Number	HITTITE Part Number
NEW!	16 - 33	Medium Power Amp	17	33	24	+5V @ 400mA	APH596	HMC-APH596
NEW!	17 - 30	Medium Power Amp	20	31	22	+4.5V @ 400mA	APH196	HMC-APH196
NEW!	37 - 40	Medium Power Amp	20	35	26	+5V @ 640mA	APH510	HMC-APH510
NEW!	37 - 45	Medium Power Amp	21	32	23	+5V @ 475mA	APH403	HMC-APH403
NEW!	50 - 66	Medium Power Amp	24	25	17	+5V @ 220mA	ABH241	HMC-ABH241
NEW!	55 - 65	Medium Power Amp	13	25	16	+5V @ 80mA	ABH209	HMC-ABH209
NEW!	71 - 76	Medium Power Amp	24	-	17.5	+4V @ 160mA	AUH318	HMC-AUH318
NEW!	71 - 76	Medium Power Amp	13	-	20	+4V @ 240mA	APH633	HMC-APH633
NEW!	71 - 86	Medium Power Amp	16	-	15	+4V @ 130mA	AUH320	HMC-AUH320
NEW!	81 - 86	Medium Power Amp	22	-	17.5	+4V @ 160mA	AUH317	HMC-AUH317
NEW!	15 - 27	Power Amplifier, 1 Watt	17	37	29	+5V @ 1.44A	APH462	HMC-APH462
NEW!	18 - 20	Power Amplifier, 1 Watt	17.5	38.5	30	+5V @ 900mA	APH478	HMC-APH478
NEW!	21 - 24	Power Amplifier, 1 Watt	17	39	30.5	+5V @ 950mA	APH518	HMC-APH518
NEW!	24 - 26.5	Power Amplifier, 1 Watt	17	38	30	+5V @ 950mA	APH608	HMC-APH608
NEW!	27 - 31.5	Power Amplifier, 1 Watt	14	37	28	+5V @ 900mA	APH460	HMC-APH460
NEW!	37 - 40	Power Amplifier, 1 Watt	15	37	28	+5V @ 1.08A	APH473	HMC-APH473

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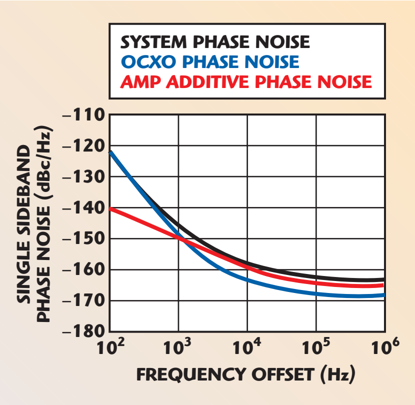
Why is additive phase noise important? Following are two examples, the first being the most obvious.

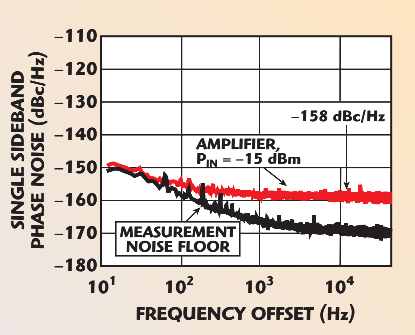
Example One

Consider a system that begins with a very low noise oven-controlled crystal oscillator (OCXO). A significant amount of work is done by the manufacturer to select appropriate internal components that add very little flicker noise to the signal. GaAs amplifiers tend to have a high flicker noise corner, a property on all amplifiers, than do silicon-based amplifiers. If a GaAs amplifier is used to amplify a very clean OCXO, it will likely degrade the phase noise in the 10 kHz region and possibly further out, depending on the signal-to-noise ratio of the amplifier operating under large signal. Equation 1 shows mathematically how the phase noise of the OCXO and amplifier, in dBc/Hz, add together

$$\mathcal{L}_{fm}\Big|_{system} = 10\log_{10}\left(\sqrt{10^{\frac{\mathcal{L}_{fm}|_{OCXO}}{10}} + 10^{\frac{\mathcal{L}_{fm}|_{AMP}}{10}}}\right) \quad (1)$$



▲ *Fig. 1 Graphical representation of the additive phase noise of an amplifier.*



▲ *Fig. 2 Measured additive phase noise of an amplifier with P_{in} = –15 dBm.*

Figure 1 is a graphical representation of Equation 1, where combining the noise of a good OCXO (in blue) and that of a marginal amplifier (in red) will cause degradations in the overall phase noise of the system (in black). At the point where the phase noises of the OCXO and amplifiers are equal and identical, at 1.5 kHz, the overall noise is exactly 3 dB higher.

Example 2

This example is less obvious. Most will agree that noise figure (besides gain and P_{-1dB}) is one of the most common specifications for an amplifier. This number does not fully represent the true added noise of an amplifier under anything but small-signal conditions and is an average for noise in carrier offset frequencies within a 4 MHz bandwidth. If one wants to measure the added noise of an amplifier when it is near compression, deep in compression, or when using a noisy power supply, the noise figure will not disclose any information that is useful under these scenarios. Additionally, the noise figure does not disclose any information about noise close to the carrier that may be important in some system. It can also be argued that additive phase noise measurements are indeed a good measurement for large-signal noise figure.

ADDITIVE PHASE NOISE RELATED TO NOISE FIGURE

Additive phase noise is directly related to noise figure under small-signal conditions. Under large-signal conditions, additive phase noise may aptly define large-signal noise figure. The traditional noise figure is an average of the additive phase noise under a very particular small-signal condition. Noise figure is defined as the degradation of the signal-to-noise ratio (SNR) at the input to the SNR at the output of a two-port device. A low noise amplifier may add less than 1 dB in a typical noise figure measurement and a standard gain block may exhibit over 5 dB. When taken out of small signal, but with an output power still near the P_{-1dB} point, other aspects of the amplifier start to become dominant and the noise figure measurement may no longer be valid. Flicker noise, shot noise and power supply noise may contribute a more significant amount of noise to the system than the noise figure may suggest. Some amplifiers exhibit marginally more noise in compression than at small signal, while others will demonstrate heavy degradations. Only an additive phase noise measurement can identify these sources of noise.

Noise figure and phase noise measurements (at relatively small signal) relate to each other in the following way: The measured additive phase noise, $\mathcal{L}_{fm}$ of an amplifier at some offset frequency (fm), is related to the noise figure by the thermal noise floor ($N_{thermal}$) and the amount of input power (P_{in}). This relationship has been presented by A. Hati, et al.[1]

The thermal noise floor of a 50 Ω system, denoted as $N_{thermal}$, at room temperature, is –174 dBm, which includes both amplitude and phase noise. Amplitude and phase noise each contribute to half the power of the thermal noise and are assumed to be uncorrelated, therefore leaving both the phase and amplitude of the thermal noise floor to be separately defined at –177 dBm. The value for $N_{thermal}$ is then –177 dBm.

The SNR of a signal is defined as $N_{thermal} - P_{in}$, where P_{in} is the signal power in dBm. The noise figure (NF) is the reduction of the signal-to-noise ratio of a two-port device. The measured phase noise is related to the thermal noise floor, input power and noise figure by the following relation:

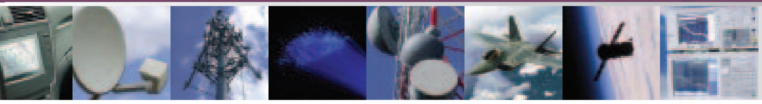
$$\mathcal{L}_{fm} = N_{thermal} - P_{in} + NF \quad (2)$$

where

$\mathcal{L}_{fm}$ = measured additive phase noise at frequency offset fm
$N_{thermal}$ = thermal noise floor (–177 dBm)
P_{in} = input power of the amplifier
NF = noise figure of the amplifier

This equation shows that the signal-to-noise ratio ($N_{thermal} - P_{in}$) is reduced by the noise figure resulting in the measured additive phase noise. This equation can be used to calculate the noise figure, given the measured additive phase noise and power input. The additive phase noise measurement can be used to calculate the noise figure of a device within the uncertainty of the measurement. More

Mixers to 90 GHz



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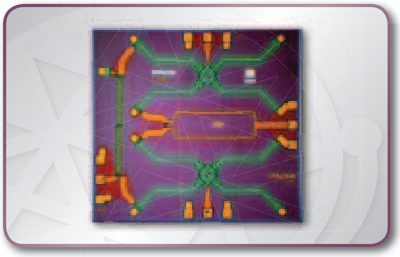
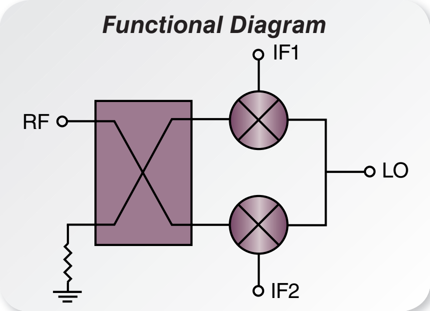
HMC-MDB172 GaAs MMIC I/Q Mixer, 19 - 33 GHz





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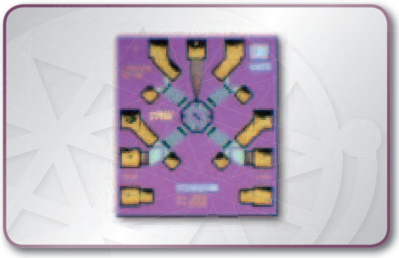
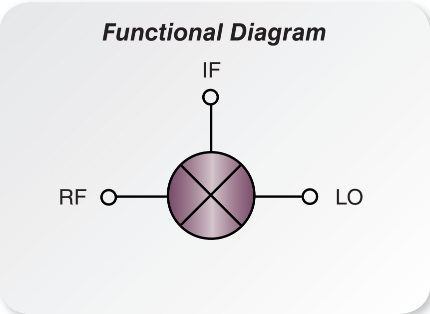
NEW!	19 - 33	I/Q Mixer / IRM	DC - 5	-8	25	17	MDB172	HMC-MDB172
NEW!	35 - 45	I/Q Mixer / IRM	DC - 5	-8	25	17	MDB171	HMC-MDB171
NEW!	55 - 64	I/Q Mixer / IRM	DC - 3	-9	30	16	MDB207	HMC-MDB207
NEW!	54 - 64	Sub-Harmonic I/Q Mixer / IRM	DC - 3	-12.5	30	7	MDB218	HMC-MDB218

HMC-MDB169 GaAs MMIC Fundamental Mixer, 54 - 64 GHz





- Upconversion & Downconversion
- High LO to RF Isolation: 30 dB
- Double-Balanced Topology
- Wide IF Bandwidth: DC - 5 GHz
- Compact Die Size: 1.0 x 0.9 mm

HITTITE - VELOCIUM DOUBLE-BALANCED MIXERS

	RF Freq. (GHz)	Function	IF Freq. (GHz)	Conversion Gain (dB)	LO / RF Isolation (dB)	Input IP3 (dBm)	VELOCIUM Part Number	HITTITE Part Number
NEW!	54 - 64	+13 LO, DBL-BAL	DC - 5	-8	30	13	MDB169	HMC-MDB169
NEW!	70 - 90	+14 LO, DBL-BAL	DC - 18	-12	-	-	MDB277	HMC-MDB277

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OIP3	38 – 40 dBm
P1dB	21 – 22 dBm
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RF_In Input Matching Circuit 1st Amp Attenuator 2nd Amp Output Matching Circuit RF_Out Vcc Serial Control Vcc

VGA Chain Analysis

	1st Amp	Attenuator	2nd Amp	VGA
Part Number	AP205A	6-bit digital Attenuator	AP205A	2AM0905S
Gain	13.5	-1.5	13.5	25.5
OIP3	40	55	40	40
P1dB	21	34	21	21

* 2AM family of VGA is designed by compounding from RFHIC' MMIC.

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UMTS Model	Modulated Avg.Pw. (W)	ACLR (Min) (dBc) ±5MHz	±10MHz	V / A
RFP-2140-33-28	2	-50	-52	28/1.5
RFP-2140-36-28	4	-50	-52	28/2.5
RFP-2140-39-28	8	-50	-52	28/3.5

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importantly, the additive phase noise measurement can give meaningful data on the true signal-to-noise ratio for an amplifier at large signal under real world conditions.

Figure 2 is an example of an additive phase noise measurement at a carrier of 100 MHz. The measured phase noise is –158 dBc/Hz at 10 kHz offset and the flicker corner of the device can be seen as the 10 dB per decade increase in noise, beginning at approximately 1 kHz. The input power of this amplifier was measured to be –15 dBm. Substituting the measured values for phase noise and input power into Equation 2, the noise figure is calculated to be 4 dB, exactly where this amplifier is specified to be.

HOW TO MAKE ADDITIVE PHASE NOISE MEASUREMENTS

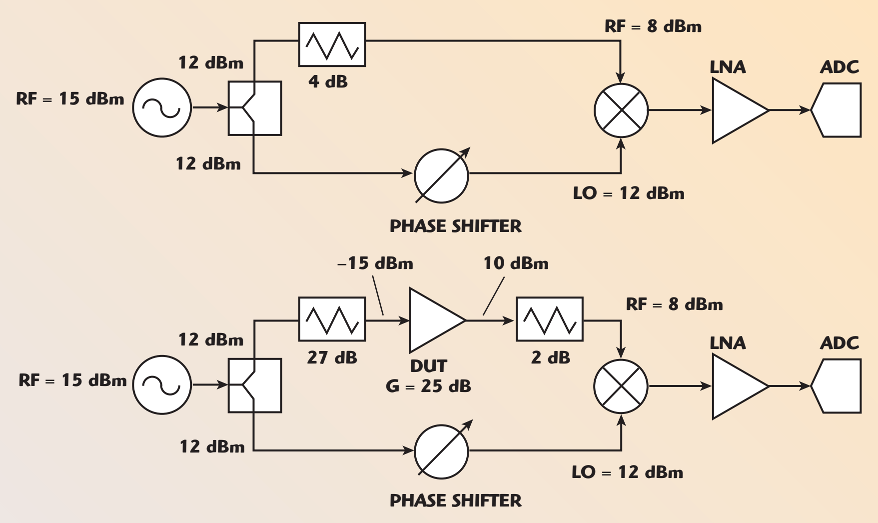
All additive phase noise measurements start from the same basic principle. A component is driven by a sinusoidal signal source, and then the noise contributed by the signal source is cancelled out, leaving the noise contributed by the DUT. When measuring phase noise, there are two categories for two-port devices: devices that do not change the frequency and devices that do.

AMPLIFIERS AND NON-FREQUENCY TRANSLATING DEVICES

Figure 3 shows the block diagram of the additive phase noise measurement set up used to measure the sample amplifier for both small-signal and large-signal noise figure. The top diagram is to measure the noise floor of the system under the same conditions as the DUT is being measured. The difference between measuring small signal and large signal is in setting the attenuators appropriately. The set-up begins with a very clean signal source, in this case, at 100 MHz.

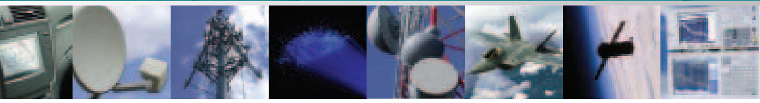
Using a high performance synthesizer, known to demonstrate ultra-low phase noise, is most beneficial for making these measurements accurately. The reason is that while the noise contributed by the source is theoretically cancelled, the phase detector has a finite ability to cancel noise, typically in the 30 to 60 dB range. If the measurement of a noise floor of –170 dBc/Hz is required, then a typical "low phase noise" synthesizer demonstrating a phase noise of approximately –100 dBc/Hz will not be sufficient. It is best to use a synthesizer having better than –120 dBc/Hz phase noise at the desired test frequency.

The synthesizer signal is split into two parts with a 3 dB power divider or a 6 dB resistive splitter. Selecting a 3 dB power divider that provides additional isolation between the two paths will considerably help with any mismatches. Each path must be of equal electrical length, except for the 90° phase shift required for the measurement. The phase detector is typically a double balanced mixer with the branches driving the LO and RF ports and the baseband analysis made at the DC coupled IF port. A mixer



▲ *Fig. 3 Block diagram of the additive phase noise measurement set-up.*

WIDEBAND SDLVA



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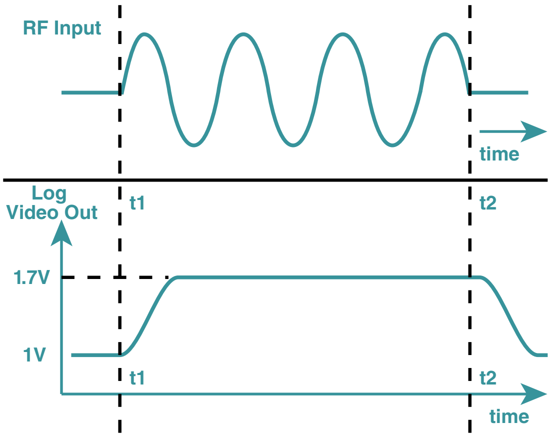

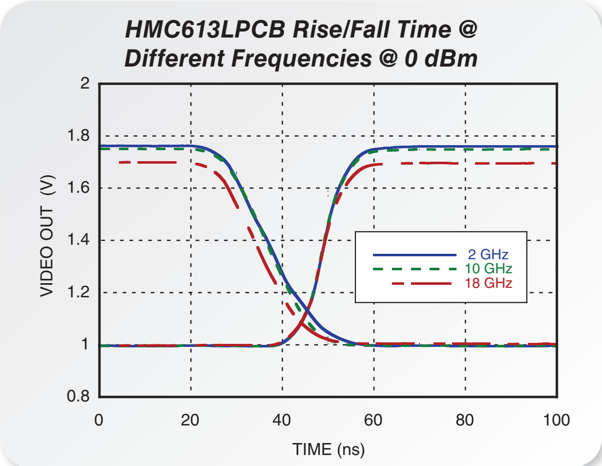

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	0.001 - 8.0	Log Detector	70 ± 3	-25	-61	+5V @ 113mA	LP4	**HMC602LP4E**
	0.001 - 10.0	Log Detector	70 ± 3	-25	-65	+5V @ 106mA	LP4	**HMC611LP4E**
NEW!	0.001 - 10.0	Log Detector	71 ±3	-25	-65	+5V @ 103mA	Chip	**HMC611**
	0.01 - 4.0	Log Detector	70 ± 3	19	-68	+3.3V @30mA	LP4	**HMC601LP4E**
	0.05 - 4.0	Log Detector	70 ± 3	19	-69	+3.3V @ 29mA	LP4	**HMC600LP4E**
	DC - 3.9	True RMS Detector	69 ± 1	37	-60	+5V @ 65mA	LP4	**HMC610LP4E**
NEW!	0.1 - 20	SDLVA	62	14	-57	+3.3V @ 83mA	LC4B	**HMC613LC4B**

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can often be used as a phase detector, but is not typically specified for this application by manufacturers, creating a significant amount of trial and error in locating an appropriate part. Not all mixers are created equal. In mixers, diode selection, port isolation and IF circuit topology all affect performance. It is best to drive the mixer under recommended power conditions, which is typically an LO drive of approximately 13 dBm (driving an LO from 10 to 16 dBm is typical for a mixer specified at 13 dBm). The RF port is driven at approximately 5 dB lower than the LO port. A higher power level at the RF port will provide more sensitivity in the measurements, but only up to a certain point. At higher RF drive levels, mixers can add additional shot noise, ultimately masking the measurement.

The test system branch, containing the amplifier (DUT), may be routed to either the LO or the RF port. The same is true for routing the phase shifter shown. In fact, they can be in the same branch if that is more convenient. However, both branches must remain as close to the same length in terms of time delay or the measurement will begin to degrade as it will not cancel the source noise as effectively. Attenuators are placed before and after components to set power levels appropriately for the measurement.

It is imperative that two measurements are always made. The first measurement is made with the amplifier in the system, and the second excluding the amplifier. Both measurements must be made with the exact same power levels at the mixer LO and RF ports (within 1 dB). This is necessary for two reasons: First, it identifies the measurement noise floor due to the set-up and exposes any potential problems. Second, it provides a degree of confidence in the measurement. For example, if the measured noise is only 2 dB above the measured noise floor, then the uncertainty in the phase noise measurement will be relatively high. However, if the measured phase noise is 10 dB above the measured noise floor, then the uncertainty is improved accordingly. The phase shifter is used to put the signals in quadrature (that is 90° apart). This condition is what allows the mixer to be used as a phase detector. The phase shift may be in either direction and need not be known—only that it's in quadrature. It is very easy to check for this condition with the use of a standard voltmeter. This is done by connecting a voltmeter to the output of the mixer (IF port). When the voltmeter reads zero, the system is in quadrature. What has effectively occurred is that the noise due to the amplifier has been down-converted, centering at 0 Hz, while the carrier noise due to the synthesizer has been cancelled out at baseband and pushed out to twice the synthesizer frequency. The proof is presented as follows:

The condition that is to be achieved is placing the two paths into quadrature (sine multiplied by cosine, at a frequency θ). Using the multiplicative trigonometric identity, this yields the following:

$$\sin(\theta)\cos(\theta) = \frac{1}{2}\sin(2\theta) \qquad (3)$$

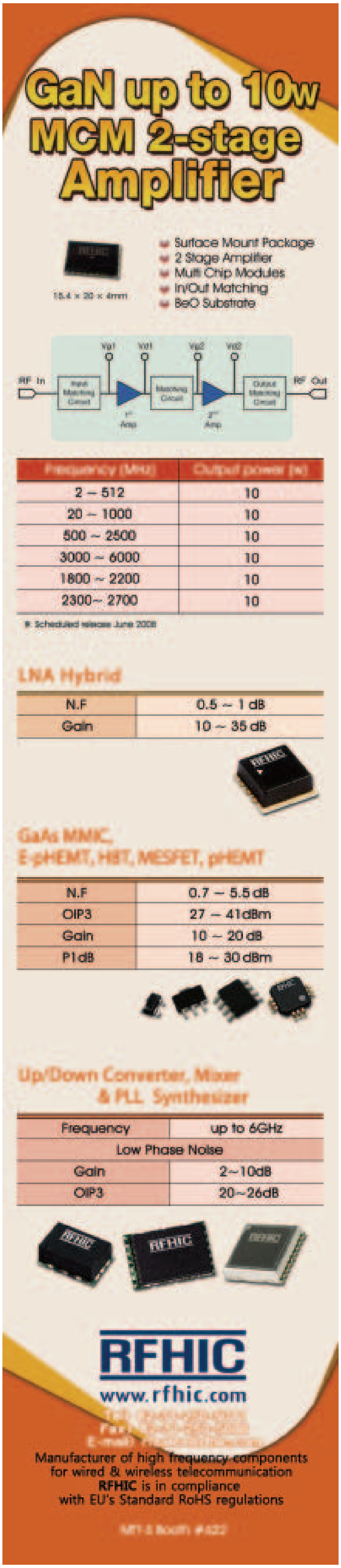
There is no DC component in the above equation, hence measuring 0 V DC. This would be the measurement with a system having an ideal synthesizer, an ideal mixer and no DUT. When the DUT is added to the test system with noise, designated as σ, then the identity is rewritten as

$$\sin(\theta)\cos(\theta+\sigma) = \frac{1}{2}\sin(\sigma) + \frac{1}{2}\sin(2\theta+\sigma) \qquad (4)$$

There are two notable terms: one at twice the synthesizer frequency, and one at baseband, or near DC proportional to the noise σ. If the signal is applied to a low pass filter, the high frequency portion is removed and the near DC portion remains. The remaining DC term can be rewritten using the small angle approximation since the phase noise deviation is very small with respect to one period.

$$\frac{1}{2}\sin(\sigma) \approx \frac{1}{2}\sigma \qquad (5)$$

The noise at the IF port of the mixer is first amplified by a low noise amplifier (LNA) and then sampled by an ADC or FFT analyzer. The actual value measured is designated as S_v, in units of V_{rms}/Hz. Noise is bandwidth dependent, so all measurements are normalized to 1 Hz. The measured



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value of S_v is proportional to the actual phase noise by a calibration constant, K_d. The ½ is dropped for convenience and is included as part of the calibration constant.

$$S_V = K_d \sigma \qquad (6)$$

The calibration constant (K_d) must be determined for each measurement and it should be noted that the measured phase noise and voltage noise are related by this constant. The phase noise (σ) is in terms of radians, and the measurement has a value of volts. The calibration constant units are in volts per radian in order to equate the two.

$$\frac{S_V\left[V_{rms}\right]}{\sigma\left[\text{rad}\right]} = K_d\left[\text{V/rad}\right] \qquad (7)$$

substituting

$$S_V = K_d \sigma \qquad (8)$$

or rewriting

$$\sigma = \frac{S_V}{K_d} \qquad (9)$$

The typical variable designation for phase noise is $S\sigma$.

$$S_\sigma = \frac{S_V}{K_d} \qquad (10)$$

The noise that has been down-converted to DC is a double sideband value, as it exists both above and below the carrier. The noise at DC is folded to positive only values and therefore the measured phase noise has twice the power than either sideband. In the literature, the sidebands have been shown to be equal and uncorrelated and the typical phase noise specified is in single sideband phase noise or L_{fm}, where f_m is the offset frequency.[2] This is related to $S\sigma$ as follows

$$\mathscr{L}_{fm} = \frac{S_\sigma}{\sqrt{2}} = \frac{S_V}{\sqrt{2}K_d} \qquad (11)$$

Here, it can be seen that the single sideband phase noise is related to the actual measured voltage at the IF port by a simple calibration constant K_d and the factor 2.

CALIBRATION

Calibration is relatively simple. The value of K_d is determined by the phase shifting one path by a known amount and measuring the corresponding voltage change at the mixer. This is done at DC and assumed to be valid at the carrier offset. Most mixers are flat to within a tenth or two of a dB in the DC to 1 MHz range. For example, if a 2° phase shift is introduced, or 0.035 radians, and a DC voltage change of 10 mV is measured, then the corresponding phase detector constant of 0.286 is calculated by dividing the volts by the radians. In terms of voltage, it can be converted into dB as

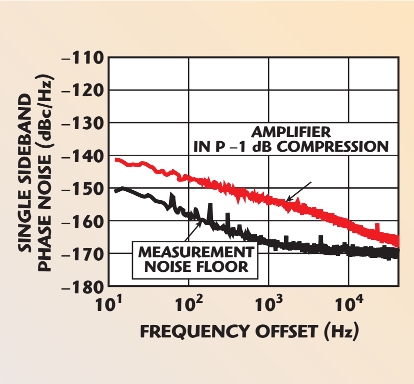
$$K_d\left(\text{dB}\right) = 20\log_{10}\left(\frac{\text{volts}}{\text{radian}}\right) =$$

$$20\log_{10}\left(0.286\right) = -10.9\ \text{dB} \qquad (12)$$

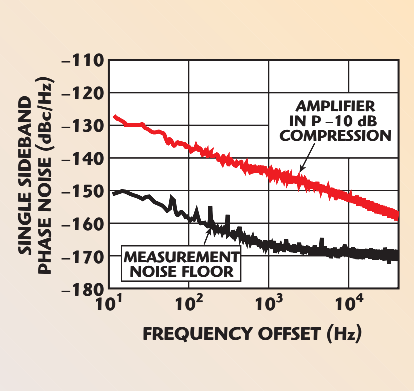
The voltage noise is usually specified in terms of dB and the phase noise relation to the measured voltage noise can be rewritten as

$$\mathscr{L}_{fm} = S_V - K_d - 3 \qquad (13)$$

If S_v is measured to be –165 dBV, using a phase detector constant (K_d) of –10.9 dB, then the resulting single sideband phase noise is –157.1 dB.



▲ *Fig. 4 Additive phase noise of the amplifier driven into 1 dB compression.*



▲ *Fig. 5 Phase noise of the amplifier driven into deep compression (–10 dB).*

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ZX60-2514M	0.5-2.5	16.4	4.8	+30.3	16.5	5.0	90	59.95
ZX60-2522M	0.5-2.5	23.5	3.0	+30.6	18.0	5.0	95	59.95
ZX60-3011	0.4-3.0	12.5	1.7	+31.0	21.0	12.0	120	139.95
ZX60-3018G	0.02-3.0	20.0	2.7	+25.0	11.8	12.0	45	49.95
ZX60-4016E	0.02-4.0	18.0	3.9	+30.0	16.5	12.0	75	49.95
ZX60-5916M	1.5-5.9	17.0	6.4	+28.3	14.4	5.0	96	59.95
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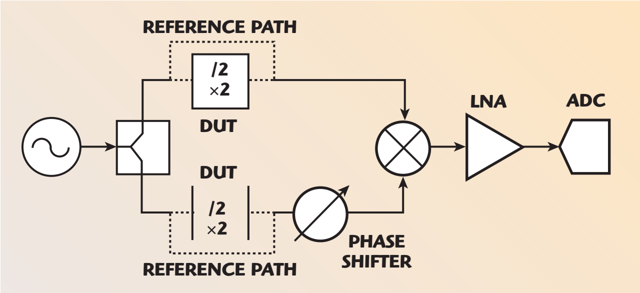


▲ *Fig. 6 Additive phase noise measurement set-up for frequency translating devices.*

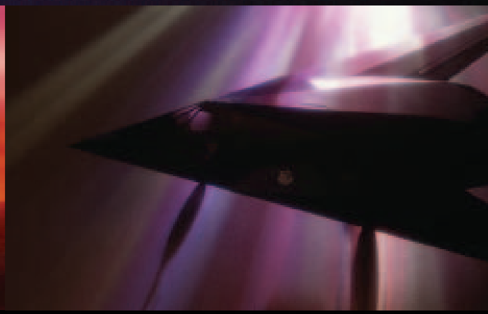
THE EFFECTS OF COMPRESSION ON THE LARGE-SIGNAL NOISE FIGURE

How a small-signal noise figure can be related to the additive phase noise when an amplifier is driven in a very linear region has been shown. What happens when an amplifier is driven into compression? ***Figure 4*** shows the same sample amplifier measured previously, but driven into 1 dB compression with an output of 19 dBm. The flicker corner has increased and the noise at offsets of less than 10 kHz has increased by approximately 10 dB. ***Figure 5*** shows the amplifier in deep compression and fully saturated at 20 dBm output. The flicker corner is beyond the audio card measurement bandwidth and the noise has been degraded by an additional 10 dB. This amplifier was powered by a battery pack and well bypassed, so that the measurement result is due strictly to the self noise of the amplifier. These figures show how the measurement of additive phase noise provides more effective information than using the small-signal noise figure.

Industry trends have been to improve amplifier efficiency, especially in high power amplifiers, which generally means operating in deep saturation. From these measurements, it can be concluded that the additive noise may be significant to the overall system performance. What has not been demonstrated are the effects of bias voltage noise on the overall phase noise when operating in deep compression. In deep compression, amplifiers go through a dramatic phase change as the drain voltage varies. This causes a large AM-PM conversion and any noise on the bias line will be heavily up-converted to the carrier frequency and measured as phase noise.[3]

ADDITIVE NOISE OR NOISE FIGURE OF FREQUENCY TRANSLATION DEVICES

Now consider an additive phase noise measurement for a frequency multiplier or a frequency divider. The only way to calculate the noise added by those devices is through an additive phase noise measurement. Virtually all frequency multipliers and dividers are driven in large signal for correct operation and the noise figure has absolutely no meaning in the traditional sense. These devices are used along the signal path and can degrade the overall signal-to-noise ratio of the system and it is important to know by exactly how much. This is especially true for active frequency multipliers



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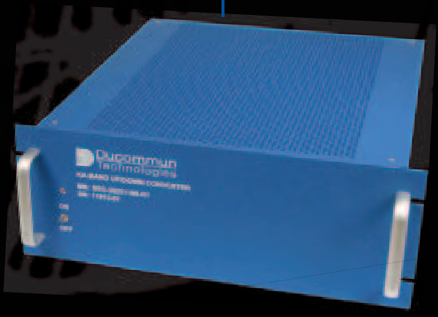

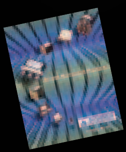

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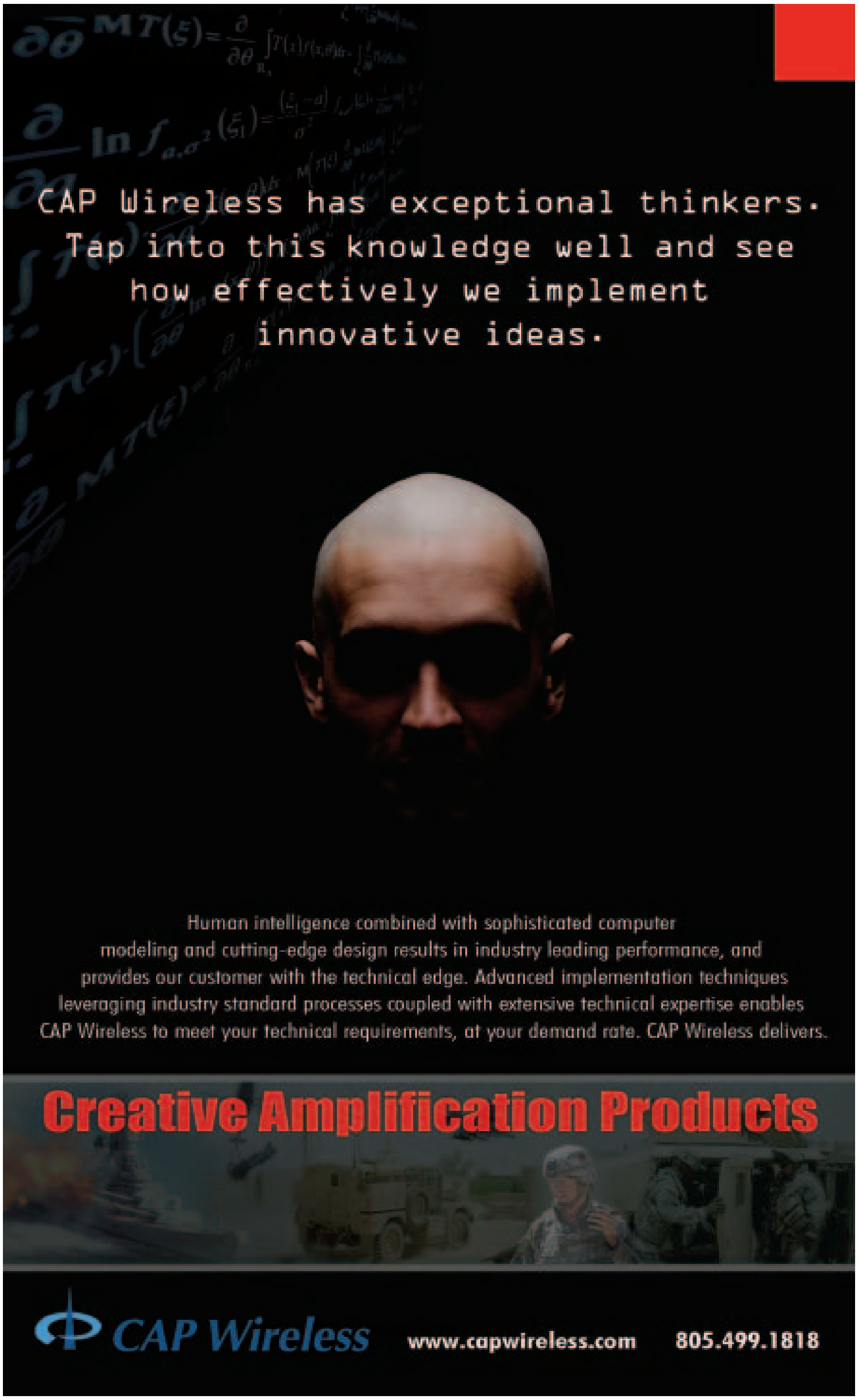
or dividers, which tend to be much noisier than their passive counterparts. ***Figure 6*** shows the measurement set-up used to measure the additive phase noise in frequency translating devices. The phase detector only works at a given frequency for both paths. Therefore, changes must be made identically to both paths in the measurement set-up, so that the phase detection frequency is identical for both the RF and LO ports. In this regard, frequency translation devices are always measured as a pair. The overall noise power measured is twice that of an individual device, assuming they exhibit identical noise amplitude and the noise is uncorrelated. If multiple devices are measured, then the individual contribution of any one device can be found.

When measuring a single pair of devices, there are two unknowns (the phase noise of each device) and one known (the phase noise for the pair). Inherently, there is a 3 dB uncertainty in the measurement of two devices. The noise may be equal between both DUTs or entirely due to one.



The phase shift for calibration is determined for the phase comparison frequency and the input frequency is irrelevant. To that extent, the frequency multiplication or division may be of any ratio, provided both paths are identical. A notable complication with additive phase noise measurements of frequency translation devices is related to the drive power of the mixer or phase detector. A frequency doubler may output less than 0 dBm, not enough to drive the LO of the mixer, so an amplifier is required to provide gain to the signal prior of the mixer, which may add phase noise to the overall measurement. Careful selection of a proper amplifier and good characterization can reduce this effect to an extremely low level.

BASEBAND ANALYSIS AND PHASE DETECTORS

Voltage noise measured at the IF port of the mixer is very close to the thermal noise floor of the load impedance presented to the mixer. A 50 Ω resistor exhibits a noise of less than 1 nV/Hz. To that extent, an analog to digital converter (ADC) cannot measure down to the appropriate level and the signal must be amplified into the range of the ADC. The requited gain can vary from 20 to 60 dB or, in terms of voltage, 10x to 1000x, depending on the noise level to be amplified and the dynamic range of the ADC. Even the best FFT analyzers cannot measure down to this level without some external amplification. Most engineers seek data from 10 Hz to approximately 1 MHz, although 100 Hz to 100 kHz is often sufficient.

A good low noise amplifier exhibits a self noise near 1 nV/Hz, which is enough to degrade the noise due to even a 50 Ω resistor only marginally. Furthermore, it has a bandwidth that will extend to at least the highest desired measurement. A low cost way to do phase noise measurements to 40 kHz is to use a good LNA in conjunction with a high performance audio card as an FFT analyzer. Most high-end audio cards

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$$X = \frac{|y_1| - \left|\frac{y_2}{10}\right|}{\left[\frac{n - \tan(\pi / s)}{(4h - m)}\right]} + \frac{(p-1)^2}{(e^{\pi i} + |a|)}$$

- a = peak E plane sidelobe level of a typical pyramidal horn antenna (to nearest whole dB)
- h = cutoff frequency of TE_{10} mode in WR-90 waveguide (in GHz to nearest tenth)
- m = cascaded noise figure of an amplifier with NF = 1 dB and G = 10 dB followed by an amplifier with NF = 3.5 dB (in dB to nearest tenth)
- n = Z0 of air dielectric coax with D/d = 2.3 (to nearest Ohm)
- p = directivity of a uniformly illuminated 1 m^2 aperture at 3 GHz (in dBi to nearest tenth)
- s = mismatch loss of a 2:1 VSWR (in dB to nearest tenth)
- y_1 = insertion loss between two 15 dBi horn antennas spaced 100 m apart at 3 GHz (to nearest dB)
- y_2 = the peak spectral component of a 0 dBm signal pulsed 100 us PW, 1 ms PRI as measured with a spectrum analyzer with RBW of 300 Hz (to nearest dBm)

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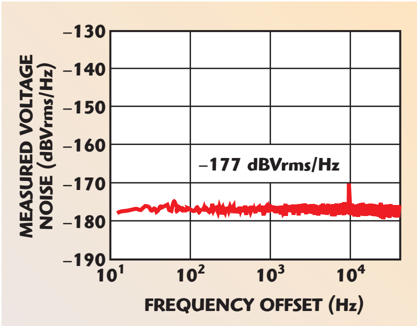
sample at up to 96 ksps with a bandwidth that extends from 20 Hz to 40 kHz and very often extend down to 10 Hz with only 1 to 2 dB of attenuation. All the measurements for this article were made using the LNA plus audio card method. A copy of the Matlab™ script used to perform these measurements can be made available upon request to the authors (support@holzworth.com). ***Figure 7*** shows the voltage noise floor of an audio card using a low noise amplifier that exhibits a 1 nV/Hz.

A note on frequency translation devices: typically, these devices contain high levels of harmonics, both sub harmonics and higher harmonics. Digital frequency dividers have a square wave output, causing very high third, fifth and higher harmonics. Analog frequency dividers may have strong sub harmonics and associated harmonics. If these harmonics are within 20 dB of the desired signal to be measured, it can affect the accuracy of the measurement. Under this scenario, it is advised that the desired frequency be filtered out so as to not adversely affect the measurement.

MIXERS AS PHASE DETECTORS

Not all mixers are created equal (as phase detectors), not even double balanced mixers. LO-RF and LO-IF isolation, conversion efficiency, IF bandwidth and IF circuitry, and even the type of diode used affect how a mixer operates as a phase detector. There are many variables and whenever a new mixer is selected as a phase detector, a series of measurements should be completed to determine noise floor, compression levels and a range of calibration constants. Having a well characterized mixer can give an early indication of a bad calibration or a poor test set-up, if the calibration constant is significantly different from the expected value.

A good phase detector will exhibit a noise floor of –170 dBc/Hz, even if driven by a nearly perfect synthesizer and will always exhibit some flicker noise. A final note that phase detectors demonstrate a limited signal-to-noise ratio when acting as phase detectors: first, the LO drive level must be sufficient to turn the diodes on. The RF signal is then multiplied by the LO and passed onto the IF port with some conversion efficiency. Assuming that the output voltage at the IF is approximately 424 mV_{rms} when sweeping the phase 360° (600 mV peak voltage), the LNA has a self noise of approximately 1 nV/Hz. If a 50 Ω resistor is used to terminate the mixer, then the overall noise will be



▲ *Fig. 7 Voltage noise floor of an audio card using a low noise amplifier.*

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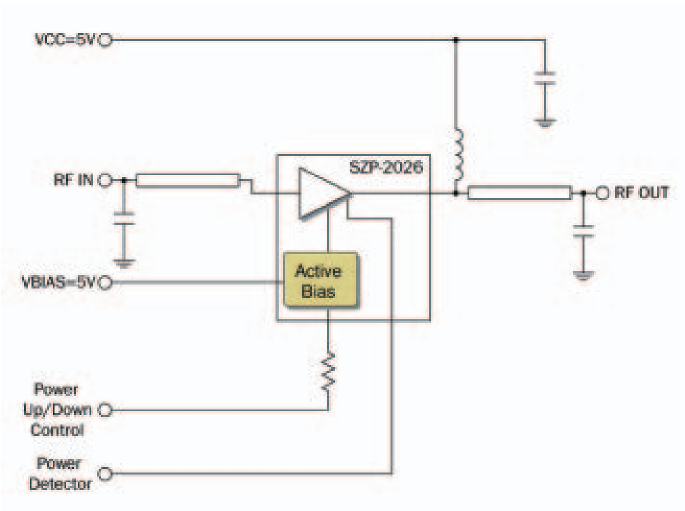

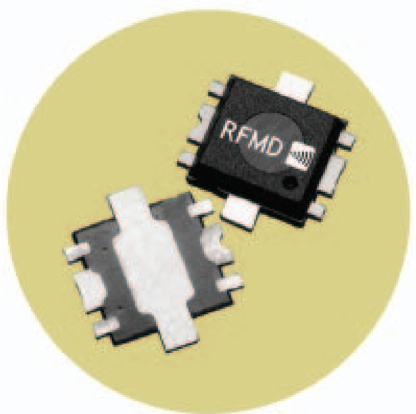

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Gain	12.8	12.0	9.0
Po	+27 dBm	+27 dBm	+25 dBm
Vcc	+6.0 Vdc	+6.0 Vdc	+5.0 Vdc
Icq	445 ma	385 ma	602 ma

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approximately 1.4 nV/Hz at the LNA. Taking the ratio of 1.4 nV/424 mV results in a –169.6 dBc/Hz noise floor. To improve the SNR of the measurement, a larger RF drive must be used, but at some point the mixer compresses and will no longer improve the SNR, actually hindering it by adding shot noise from the mixer and degrading the flicker noise corner.

Many manufacturer application notes indicate that using a high impedance to terminate the mixer (anywhere from 1 to 5 kΩ) instead of a standard 50 Ω will improve the sensitivity, but the phase detector constant will at most double. The mixer diodes exhibit a self noise of a few hundred ohms to 1 kΩ and the increase in voltage noise of the equivalent resistance at the IF port increases the noise floor. This will cancel any increase in the phase detector constant, which results in approximately the same SNR. Finally, when terminating a mixer with something other than 50 Ω, the isolation of the mixer may be degraded and the overall phase noise performance reduced.

CONCLUSION

This article has presented additive phase noise as an element inherent in all two-port devices. Simple and economical means to measure additive phase noise in amplifiers, multipliers and dividers have been shown. Once the effort has been made to apply the equations presented, the additive phase noise measurement can become an integral part of every R&D and manufacturing test line. ■

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Joe Koebel *received his BSEE from Michigan Technological University in 1994 with an emphasis on electromagnetics and communications theory. Past professional experience includes working for Hughes Space & Communications (now Boeing Satellite Systems) and Picosecond Pulse Labs. He is currently a cofounder and VP of sales & marketing for Holzworth Instrumentation.*

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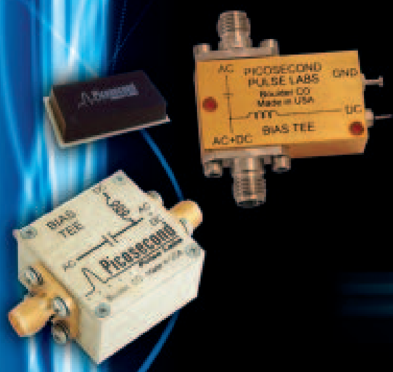

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5531	10 GHz	750 KHz	1.5 KV	20 mA
5541A	>26 GHz	80 kHz	50 V	100 mA
5542	50 GHz	10 kHz	16 V	100 mA
5542K	40 GHz	12 KHz	16 V	100 mA
5542LL	>40 GHz	12 kHz	16 V	100 mA
5545	20 GHz	65 kHz	50 V	500 mA
5546	7 GHz	3.5 KHz	50 V	500 mA
5547	15 GHz	5 kHz	50 V	500 mA
5550B	18 GHz	100 kHz*	50 V	500 mA*
5575A	12 GHz	10 kHz*	50 V	500 mA*
5580	15 GHz	10 kHz	50 V	2 Amp
5585	18 GHz	2 GHz	100 V	6 Amps
5586	5 GHz	1 GHz	100 V	8 Amps
5587	2 GHz	200 MHz	100 V	6 Amps
5589	2.8 GHz	300 MHz	100 V	7 Amps
SM100	13 GHz	14 kHz	16 V	500 mA
SM101	15 GHz	7 kHz*	16 V	500 mA

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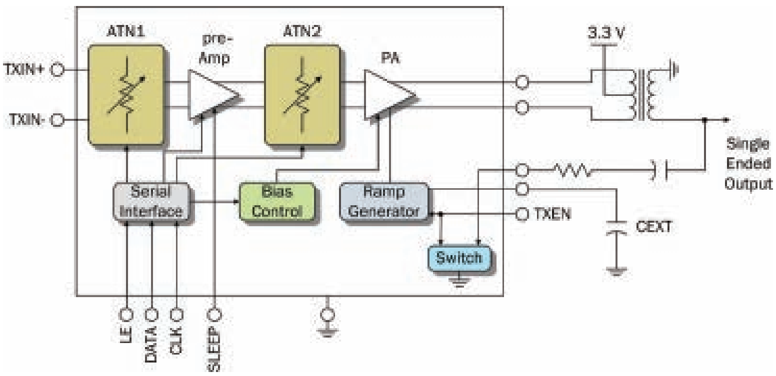

DESCRIPTION

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S518324 SPECIFICATIONS

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@ Gmax	@ Gmin	@ Gmax	@ Gmin		@ Gmax	@ Gmin	@ Tx disable		
140	70	31	-34.5	0.5	-35	-52	<-65	-65	-58

FEATURES

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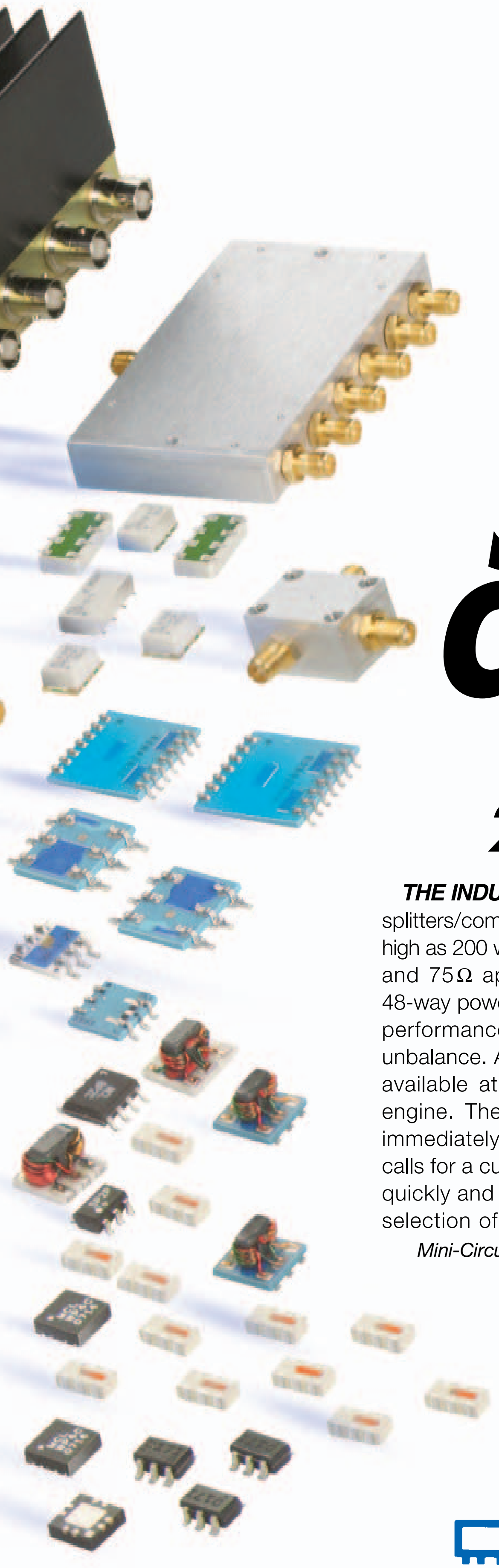

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A 3 TO 5 GHZ ULTRA-WIDEBAND LOW NOISE AMPLIFIER USING INGAP/INGAAS ENHANCEMENT-MODE PHEMT TECHNOLOGY

A 3 to 5 GHz ultra-wideband (UWB) resistive shunt-feedback low noise amplifier (LNA) was demonstrated by using a In0.5Ga0.5P/InGaAs enhancement-mode (E-mode) pseudomorphic high electron mobility transistor (PHEMT) for the first time. The resistive shunt-feedback achieves a wideband input matching with a small noise figure (NF) degradation, because the Q-factor of the narrow band LNA input terminal is reduced. In this article, a low NF for a InGaP/InGaAs E-mode PHEMT LNA can be demonstrated, because the $In_{0.5}Ga_{0.5}P$ Schottky layer design provides low DX-center related defects and low oxidization rate with moisture. The measured results show a 15 dB gain from 3 to 5 GHz, and the input/output return losses are both less than 10 dB. The minimum noise figure is 3.43 dB at 4.5 GHz and is less than 3.6 dB over the 3 to 5 GHz band. An input third-order intercept point (IIP3) of –8.5 dBm and an output third-order intercept point (OIP3) of 9.7 dBm were obtained, while consuming 21 mA from a 3 V DC supply.

UWB communication systems have recently attracted tremendous attention for industry, media and academic applications. The UWB system is a new wireless technology capable of transmitting data over a wide frequency range with low power consumption and high data rates.[1,2] In order to develop UWB communication ICs with reasonable cost for consumer electronics, the integration of transceiver and receiver sub-circuits dominated the total chip size and fabrication cost. Based on previous studies, the UWB low noise amplifier, switch, and power amplifier can be designed and integrated using sub-micron Si RFCMOS or SiGe BiCMOS technologies.[3,4] However, a low switch insertion loss and a small LNA noise figure in a UWB module were difficult to obtain in the Si RFCMOS or SiGe BiCMOS processes si-

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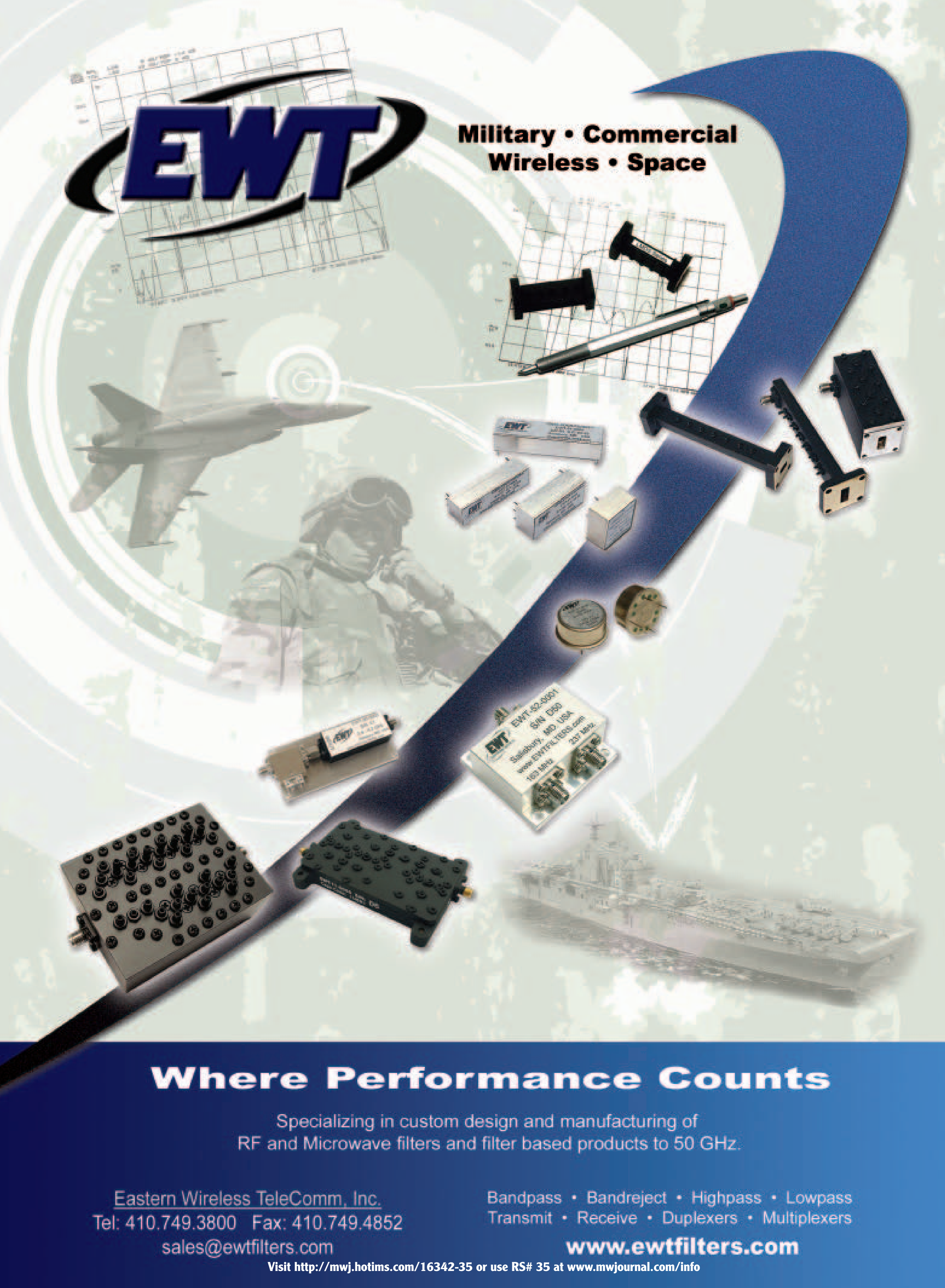

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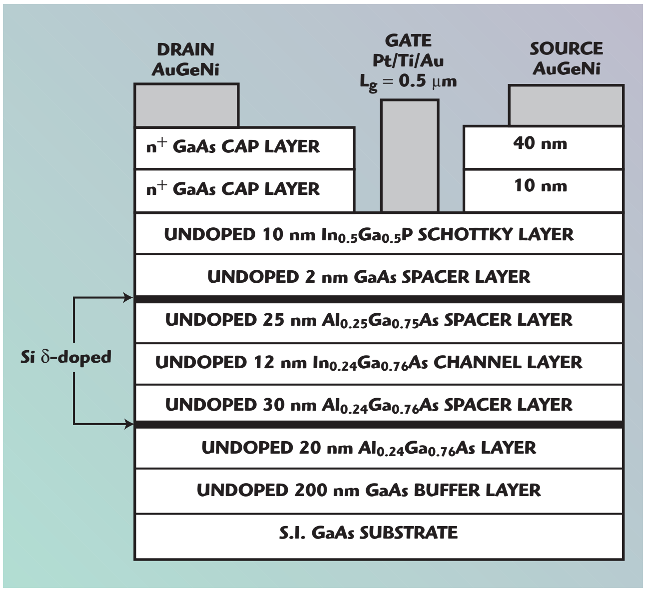
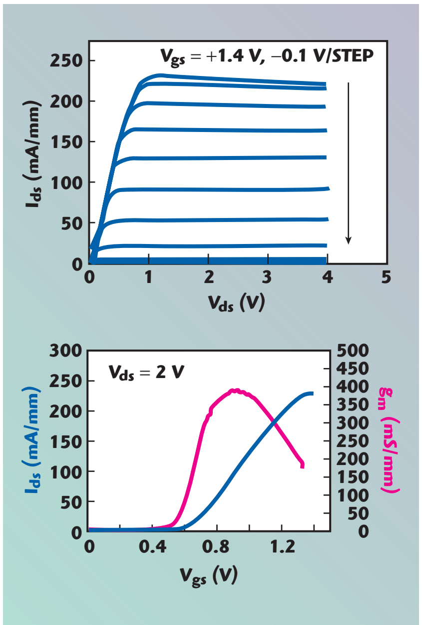
multaneously. Therefore, a low insertion loss and low harmonic InGaP/InGaAs PHEMT switch was proposed to meet the industry criteria for a wideband switch.[5] In this regard, an InGaP/InGaAs enhancement-mode PHEMT was first used and demonstrated on a UWB low noise amplifier. This process can easily be integrated with a depletion-mode InGaP/InGaAs PHEMT switch using an InGaP/InGaAs E/D-mode process.[6] In the PHEMT process, the InGaP/InGaAs E-mode PHEMT includes excellent etching selectivity between the InGaP and the GaAs, which increases the device manufacturability. The high-energy bandgap of the InGaP Schottky layer results in low microwave noise and reduces the Gunn oscillation effects.[7] In addition, InGaP does not form DX-centers and causes less deep-level defects, which has great potential to improve the reliability of the PHEMTs. This article describes the design and implementation of a MMIC for a 3 to 5 GHz UWB LNA using an InGaP E-mode PHEMT technology. The 3 to 5 GHz UWB LNA exhibits a 15 to 19 dB gain with 3.5 dB of average noise figure with 63 mW DC power consumption. The chip size is 1 mm^2.

DEVICE STRUCTURE, FABRICATION AND PERFORMANCE

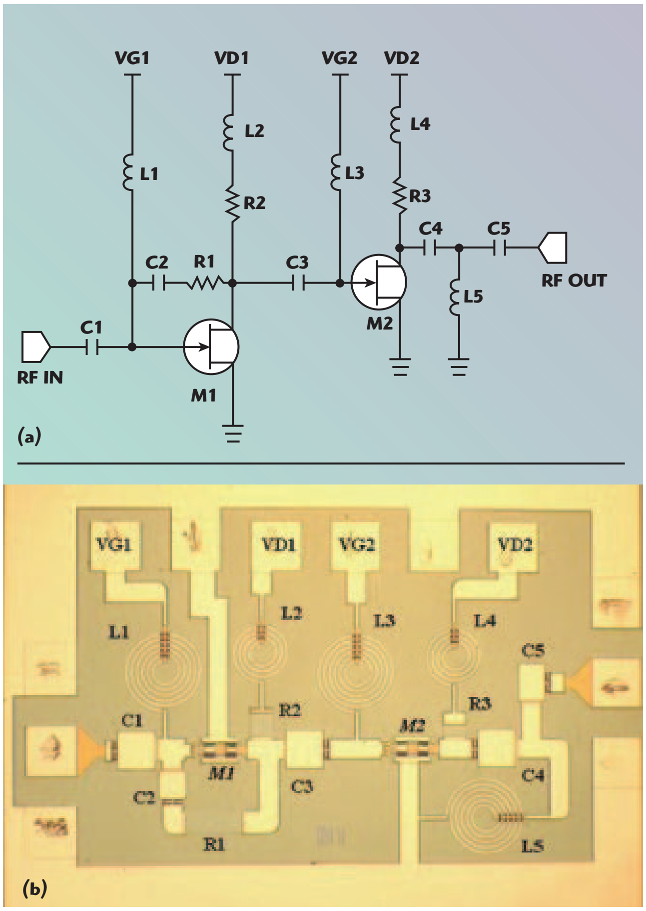
Figure 1 shows the epitaxial structure of the $In_{0.5}Ga_{0.5}P/In_{0.24}Ga_{0.76}As$ E-mode PHEMTs. Two Si planar δ-doping layers are placed on either side of the InGaAs undoped channel layer with an AlGaAs spacer layer for high transconductance consideration. An undoped 100 Å InGaP Schottky layer was grown on an intrinsic GaAs layer to form a Schottky barrier. Finally, two n^+–GaAs cap layers were grown to improve the ohmic contact resistivities. The designed structure demonstrated a sheet charge density of 2.2×10^{12} cm^{-2} together with a Hall mobility of 6120 cm^2/V-sec at 300 K after removing the n^+–GaAs cap layers. In the device fabrication, ohmic contacts of Au/Ge/Ni/Au metals were deposited by e-beam evaporation and patterned by a conventional lift-off process. An ion-implant isolation technology was applied for mesa isolation to avoid sidewall gate leakage current. After a highly-selective succinic acid gate recess process,[6] 0.5 µm long Pt/Ti/Au-gates (40 Å/500 Å/4000 Å) were deposited by a lift-off process. Prior to the deposition of the 1000 Å-thick SiN_x passivation layer, the wafer was subjected to an O_2 plasma treatment to clean it. Pt gate diffusion into the InGaP Schottky layer of the device was achieved during the SiNx deposition at 250°C. The typical drain-to-source current (I_{ds}) versus drain-to-source voltage (V_{ds}) and the transconductance (V_{gs}) characteristics of the fabricated InGaP/InGaAs E-mode PHEMT are shown in ***Figure 2***. As can be seen, the device can be operated with gate voltages up to 1.4 V, which



▲ *Fig. 1 Cross-sectional structure of the InGaP E-mode PHEMT.*



▲ *Fig. 2 I_{ds} and g_m vs. V_{gs} characteristics of the InGaP E-mode PHEMT.*



▲ *Fig. 3 Proposed schematic diagram (a) and die micro-photograph (b) of the InGaP E-mode PHEMT LNA for UWB applications.*

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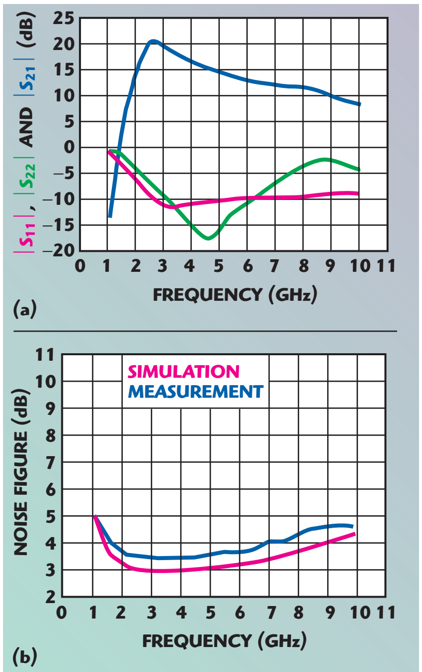
corresponds to a I_{ds} of 230 mA/mm when the drain voltage is 3 V, owing to the high Schottky barrier (0.86 eV) of metal-InGaP contact and large ΔE_c (0.4 eV) between the InGaP and InGaAs.[8] The drain-to-source leakage current at V_{ds} = 2 V and V_{gs} = 0 V is less than 0.2 μA/mm. A low drain-to-source steady-state leakage current is beneficial for suppressing the device power consumption and signal loss, particularly at low bias conditions. The V_{gs} dependence of transconductance (g_m) and I_{ds} at V_{ds} = 2 V are also shown. The threshold voltage (V_{th}) is 0.34 V (defined as I_{ds} = 1 mA/mm) and the maximum I_{ds} and g_m are 235 mA/mm and 390 mS/mm, respectively. Based on a previous study, the InGaP/InGaAs E-mode PHEMT demonstrated a 0.611 dB minimum noise figure at 3 to 5 GHz operation; this range is 1.2 to 1.8 dB for the AlGaAs/InGaAs devices.[9] Therefore, the InGaP/InGaAs E-mode PHEMT really offers a high potential for UWB LNA applications, owing to its low power consumption and small noise figure.

THE DESIGN OF THE RESISTIVE FEEDBACK UWB LNA

The proposed UWB LNA was fabricated using a WIN Semiconductor Enhancement/Depletion-mode PHEMT process, which has 0.5 μm gate length with a current-gain cut-off frequency (f_T) of 32 GHz and a power-gain cut-off frequency (f_{max}) of 85 GHz. ***Figure 3*** shows the proposed LNA topology and a microphotograph of the die of the InGaP E-mode PHEMT LNA. R1 was added as a shunt-feedback element to the conventional common-source topology. C2 is used for the AC coupling and two terminals DC isolation. For the small-signal equivalent circuit of the first stage, a Miller feedback resistance can be represented by R1 and the open loop voltage gain (A_V) of the first stage of LNA [$R_{1M} = R1/(1-A_V)$]. For this resistive shunt-feedback topology, the proper R_{1M} gathered the S_{11} values within the passband closer to the center of the Smith chart, resulting in wideband input matching. The feedback resistor also provided its conventional roles of flattening the gain over a wider bandwidth of frequencies with smaller noise figure degradation and stabilized the circuit.[10] Another benefit of a proper feedback resistor R1 is to control the Q-factor of the resonating narrowband LNA circuit, which is approximately given as

$$Q_{WB} \sim 1/\left[\frac{\left(\omega_0 L_g\right)^2 \omega_0 C_{gs}}{R_{fM}}\right] \qquad (1)$$

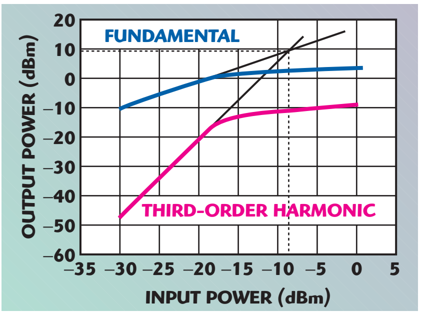


▲ *Fig. 4 Measured S-parameters (a) and noise figure (b) of the proposed LNA.*

R1 is 0.4 kΩ in this proposed LNA, which was realized by a mesa resistor (200 Ω/sq) to achieve a proper Q-factor for wideband matching consideration. The die size is 1 mm².

CIRCUIT MEASUREMENT RESULTS

The InGaP/InGaAs PHEMT LNA for UWB applications was measured using on-wafer testing. The transistor



▲ *Fig. 5 Measured output power at 3 GHz and third harmonic power (IM3) vs. input power.*

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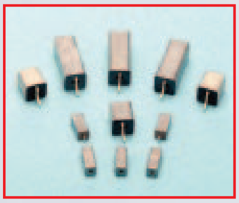

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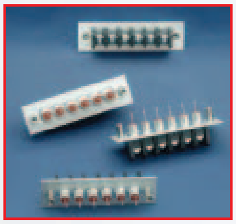

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TABLE I

COMPARISON OF PUBLISHED LNAs FOR UWB APPLICATIONS

Process	BW (GHz)	Gain (dB)	NF (dB)	IRL (dB)	Power (mW)	Topology	Ref.
0.5 µm InGaP E-mode PHEMT	3~5	15	< 3.6	< –10	63	resistive shunt-feedback	this work
0.18 µm CMOS	2.3~9.2	9.3	< 9.5	< –10	9	Chebyshev filter matched	2
0.18 µm CMOS	3~5	9.8	< 6	< –9	12.6	resistive shunt-feedback	10
0.18 µm CMOS	0.3~7	8.6	< 6.2	< –16	9	low-power distributed	12
0.35 µm SiGe BiCMOS	3.1~10.6	10	< 6.4	< –7	5.4	low-power distributed	13

gate dimensions of E-mode PHEMT (M1 and M2) are both 0.5 × 150 µm. As to the DC power consumption, the drain current of the input stage and the output stage are 7 and 14 mA, respectively. The gate biases for the two stages were adjusted to reach a compromise between noise figure and g_m characteristics. The gate bias voltage is +0.75 V and the drain bias voltage is 3 V for the input stage, and +0.85 V and 3 V for the output stage. By using an enhancement-mode design of the active devices, the negative bias circuit can be avoided, which is a major drawback of the conventional depletion-mode PHEMT related MMICs. The measured power gain, the input/output return loss and the noise figure are shown in ***Figure 4***. The measured input return loss (S_{11}) and output return loss (S_{22}) are both higher than 10.0 dB over the 3 to 5 GHz range. The flat and high S_{11} is obtained, due to the resistive feedback topology. The maximum power gain (S_{21}) is higher than 15 dB and the 3 dB bandwidth covers the 3 to 5 GHz range. The measured NF shows a minimum value of 3.4 dB at 4 GHz and stays at less than 3.6 dB up to 5 GHz, but rises up to 4 dB at 7.5 GHz.

Compared to the simulation results using the self-defined Angelov model,[11] the slight increase in NF over the 3 to 5 GHz range is caused by the lower power gain at these frequencies. The trend of NF between the simulation and measurements is similar. The third-order inter-modulation (IM3) product, obtained from the device output spectra versus the input power, is an important index of the device dynamic range. A two-tone evaluation was performed at frequencies of 3 and 3.001 GHz, as shown in ***Figure 5***. A third-order input intercept point (IIP3) of –8.5 dBm and a third-order output intercept point (OIP3) of 9.7 dBm were obtained. ***Table 1*** summarizes the comparison of recently published LNAs for UWB applications. It includes different topologies for broadband amplifiers. Although the power consumption of the proposed LNA is higher than for the other studies, the superior noise performance of this technology still offers a high potential for UWB LNA applications.

CONCLUSION

In this article, a low noise UWB LNA was demonstrated using InGaP/InGaAs E-mode PHEMT technology for the first time. With a resistive shunt-feedback topology, the proper R_{1M} concentrated the S_{11} values in the passband closer to the center of the Smith chart, resulting in a wideband input matching. The E-mode InGaP Schottky layer design not only provides a small microwave noise, but also permits the use of a positive biasing voltage supply compared to the traditional AlGaAs Schottky layer design, which uses a negative voltage supply. The proposed E-mode InGaP/InGaAs PHEMT LNA achieved a power gain of 15 dB with a total DC power con-

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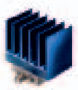

MODEL	FREQ. (GHz)	GAIN (dB)	POUT (dBm) @ 1 dB Comp.	NOISE FIG. (dB)	PRICE (1-9)
ZVA-183X+	0.7-18	26	+24	3.0	845.00
ZVA-213X+	0.8-21	26	+24	3.0	945.00
ZVA-183+	0.7-18	26	+24	3.0	895.00
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sumption of 63 mW. The measured noise figure was less than 3.6 dB from 3 to 5 GHz. Compared with the recently published broadband LNAs, the proposed E-mode InGaP/InGaAs PHEMT LNA provides a practical low noise and high gain solution for UWB applications. ■

ACKNOWLEDGMENT

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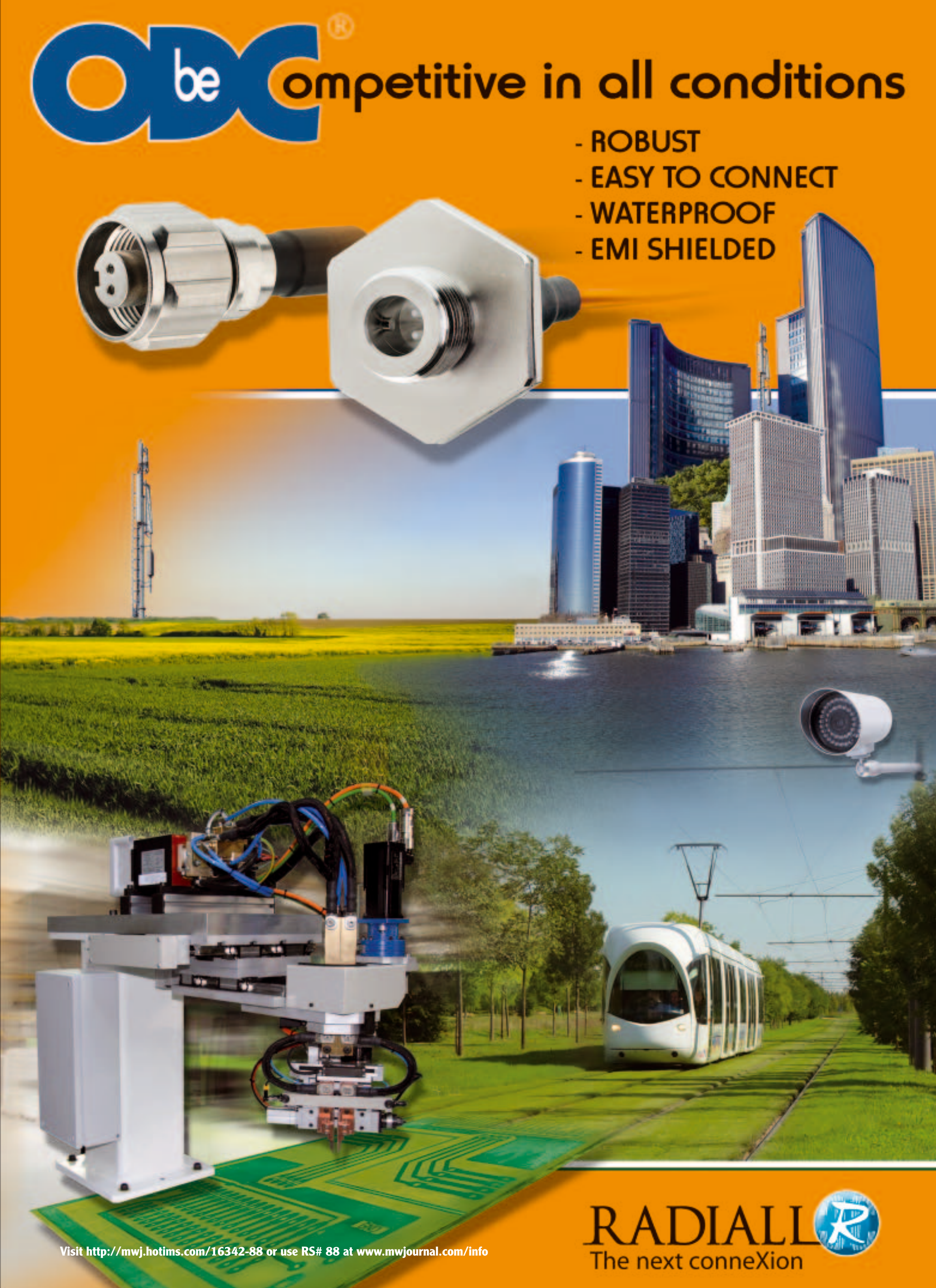

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APPLYING THE SLOW-WAVE EFFECT IN THE DESIGN OF A COMPACT ANTENNA

A novel method to design a compact antenna has been proposed. The shorting and feeding positions are located on both sides of the designed antenna, respectively; therefore, it is called a planar double inverted L antenna (PDILA). According to measured performance, the significance of the slow-wave effect was verified if the etching geometry on the radiator of the antenna was placed at the position of the larger current density. The more obvious slow-wave effect introduced the lower relative resonant frequency, and the antenna size could be reduced significantly by the application of the slow-wave property. Modifying the width and height of the antenna is an alternative way to reduce its size.

Recent developments in most consumer electronic products is toward miniaturization. The technology of integrated circuits is widely applied in the field of communication baseband modules and radio frequency modules to make communication products smaller in size. On the contrary, the technology of integrated circuits is difficult to use to design a compact antenna. Therefore, the design of compact antennas becomes a critical technique to reduce the size of communication products.

A Planar Inverted F Antenna (PIFA) is a major structure in compact antennas. There are detailed discussions in the literature.[1–3] The PIFA antenna is also usually used in the design of dual-band[4–6] and diversity antennas.[7] The outstanding feature of the antenna is its $\lambda/4$ resonant length. The advantage over monopole antennas and microstrip antennas is planar geometry and no dielectric loss, respectively. The design method of using a capacitive load to minimize the PIFA antenna has been discussed.[1]

The goal of this article is to use an alternative method to design the antenna that performs as well as a PIFA antenna. ***Figure 1*** shows the structure of the antenna. The feeding position is adjusted such that the total length of the radiator and ground forms the $\lambda/2$ length; the phase of the current on the radiator conductor will then be consistent. The length of the radiator on the antenna is $\lambda/4$, the same as the PIFA antenna. This article also discusses the influence of antenna height and width to the resonant frequency, and shows that the increasing width and height of

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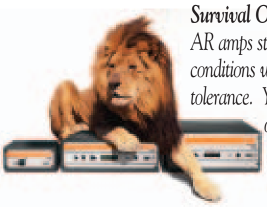

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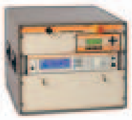

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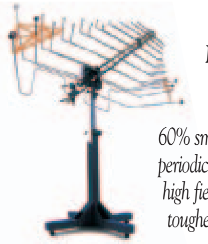

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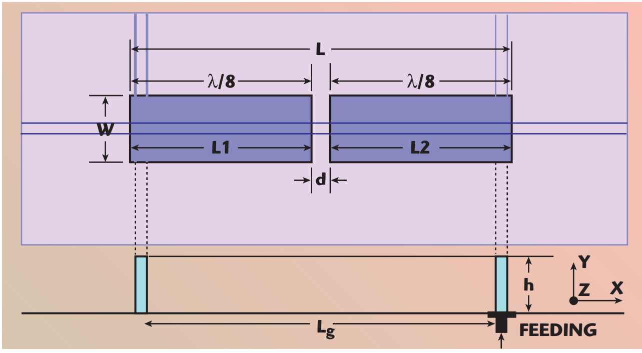
the antenna lowers its resonant frequency. In order to minimize the antenna size, the applicable geometry is etched on the radiator or ground that will induce the slow-wave effect on the antenna. ***Figure 2*** illustrates the structure of the etching geometry. The etching geometry increases the equivalent inductance and capacitance that will decrease phase velocity on the antenna to minimize antenna size.

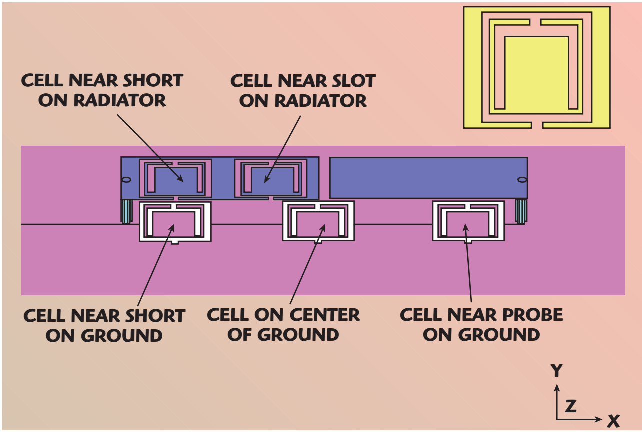
ANTENNA MODULE AND SLOW-WAVE EFFECT APPLICATION

Antenna Configuration

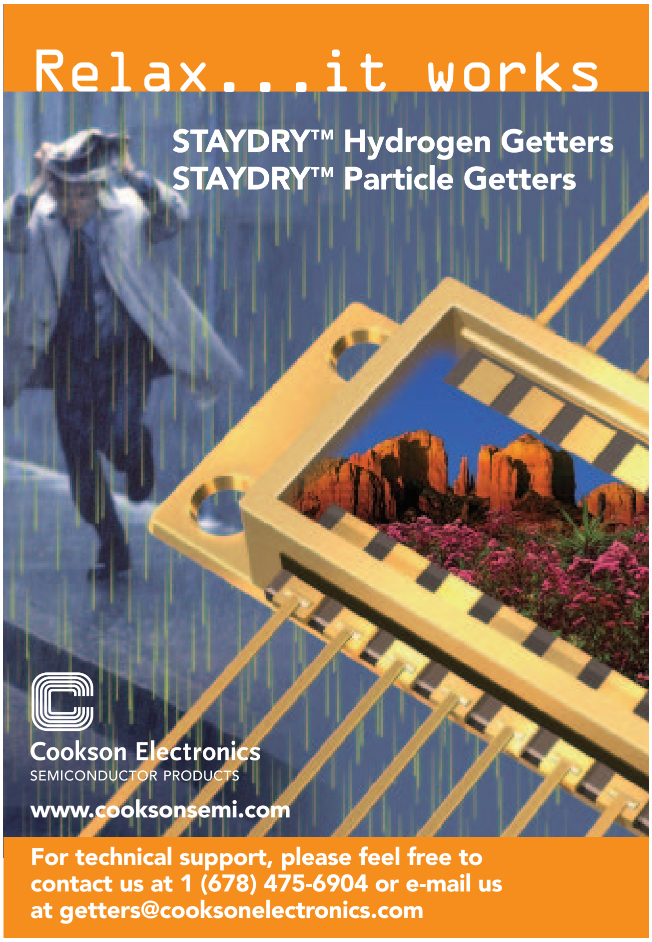
As shown in ***Figure 3***, the antenna transmission module is divided into two segments. One is the upper radiator composed of two conductors with one-eighth wavelength. The other is the lower ground with a quarter-wavelength. The feeding port uses the coaxial feed. The position of the feeding port can be placed on one of the two ends. If one side on the antenna is the feed position, the other side is the short to ground. ***Figure 4*** illustrates the equivalent transmission line model. The slot on the upper conductor and between the two upper conductors as well as ground are modeled as the equivalent capacitors C_1, C_2 and C_3, respectively. The short-pin end and the feeding port end are modeled as the radiation resistance $R_1/2$ in series with the equivalent inductor L_1 and radiation resistance $R_1/2$ in series with the equivalent inductor L_2, respectively. The radiation resistance and equivalent inductor are produced by the upper radiator, short pin and feeding port. The radiation resistance can transfer the energy to propagate in space when resonance occurs. In this antenna structure, the lower ground



▲ *Fig. 1 Structure of the novel planar double inverted L antenna (PDILA).*



▲ *Fig. 2 Etching structure and etching position.*



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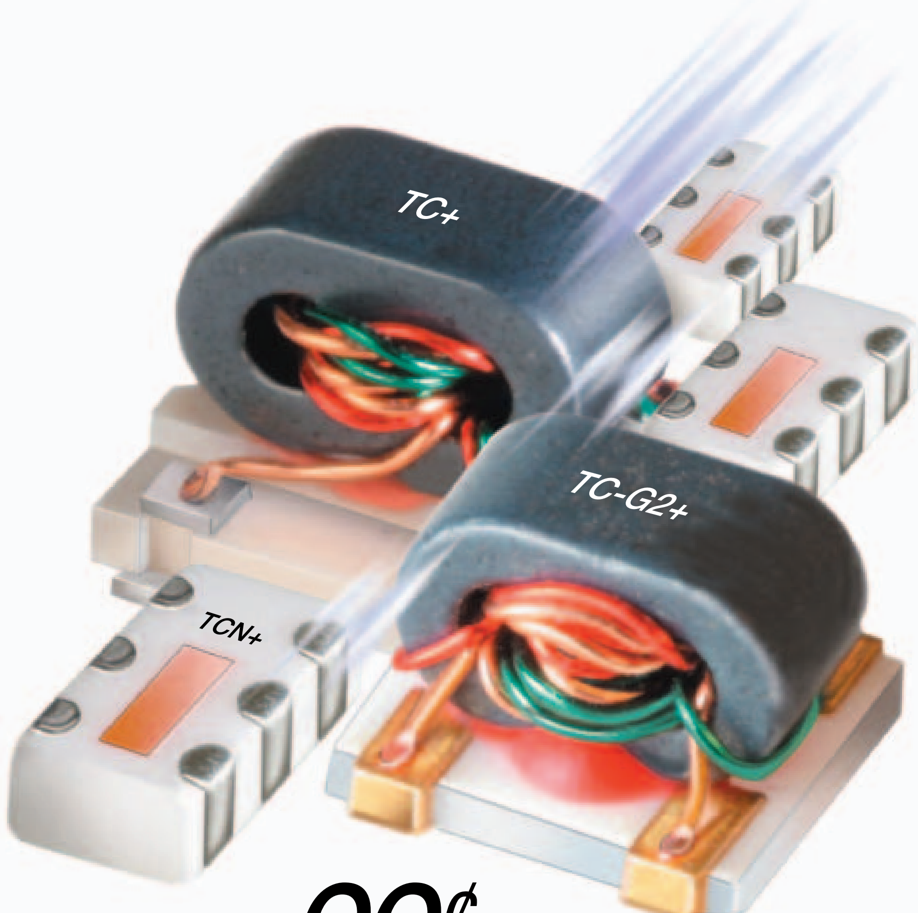

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provides the phase delay $\beta_2 \times \lambda/8$ and the radiator conductors provide the phase delay $\beta_1 \times \lambda/8$. When the length of each conductor on the upper radiator and ground plane is one-eighth wavelength and quarter-wavelength, respectively, the phase of current on the radiator is in phase to produce the resonant phenomenon. When the resonant frequency is at 2.1 GHz, L1 = L2 = 18.5 mm, Lg = 40 mm and h = 6 mm.

An Application of the Slow-wave Effect to Minimize Antenna Size

The purpose of slow wave is to slow down the propagation phase velocity. In this article, the antenna design increases the equivalent inductance and capacitance for antenna resonance. The relationship among phase velocity, capacitance and inductance is

$$v_p = 1/\sqrt{LC} \qquad (1)$$

where

v_p = phase velocity
L = equivalent inductance
C = equivalent capacitance

Increasing the inductance and capacitance can decrease phase velocity. The method of increasing inductance and capacitance is to etch applicable geometries on the antenna conductor, which is shown in Figure 4. The etched portion and thin conductor portion on the geometry increases the parallel capacitance effect as well as the series inductance effect, respectively. Therefore, it will decrease phase velocity to minimize the antenna size. The relationship of phase velocity and wavelength is

$$v_p = f\lambda \qquad (2)$$

where

f = resonant frequency
λ = resonant wavelength

At the same resonant frequency, decreasing phase velocity can reduce the resonant wavelength and antenna length.

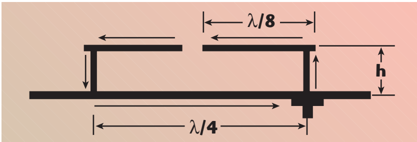

Fig. 3 Transmission module of the novel planar double inverted L antenna (PDILA).

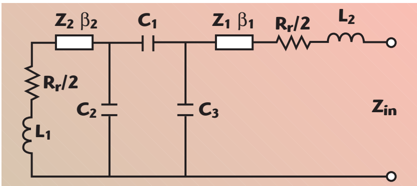

Fig. 4 Equivalent transmission line circuit of the novel PDILA.

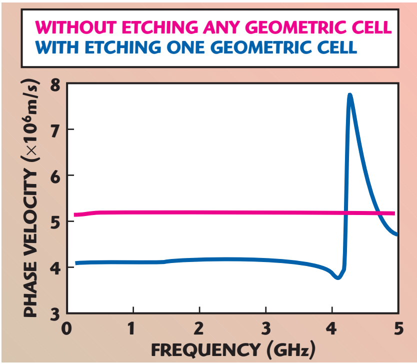

Fig. 5 Phase velocity with and without etching structure.

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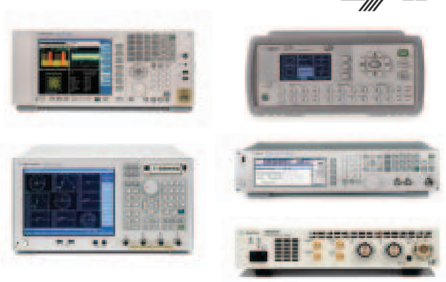

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RESULTS AND DISCUSSION

Influence of the Slow-wave Effect on the Antenna

Figure 5 shows how etching geometric figures on the conductor surface induces phase delay that will affect resonant frequency. There are two situations. The thin line shows the case without etching any geometric pattern on the conductor. The phase velocity is approximately 5.1 × 10^6 m/s and is almost independent of frequency. The blue line shows the case with etching the geometric pattern on the antenna. The geometric pattern is shown in Figure 2. The phase velocity is approximately 4.1 × 10^6 m/s under 4 GHz showing 20 percent reduction compared to the case without the etched structure on the conductor. The phase velocity rises above 4 GHz. At 4.2 to 4.7 GHz, the phase velocity is higher than without the etched geometric pattern. Hence, the etched geometry can only be used to design a compact antenna for less than 4 GHz.

Figure 6 shows the measured return loss using a HP8720C. The affect on resonant frequency by different etching positions with the same height, length and width of the antenna will now be discussed. The reference line is without an etched pattern on that antenna. The antenna size with h = 6 mm, W = 8 mm and L1 = L2 = 18.5 mm has a resonant frequency of about 2.1 GHz. The results shown in Figure 6 indicate that etching the geometry on the radiator provides the slow-wave effect more than etching the geometry on the ground, and etching the geometry on the near short provides more effect of the slow wave because the current distribution on the antenna conduc-

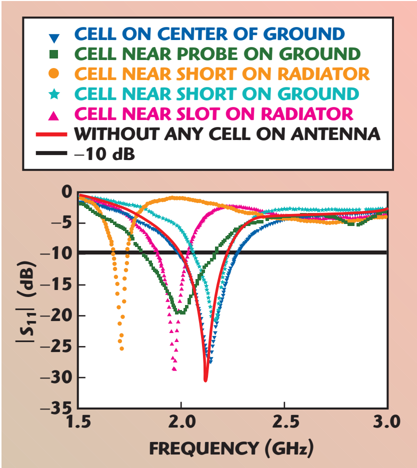

Fig. 6 Measured S_{11} return loss for the etched geometry on different positions of the antenna conductor.

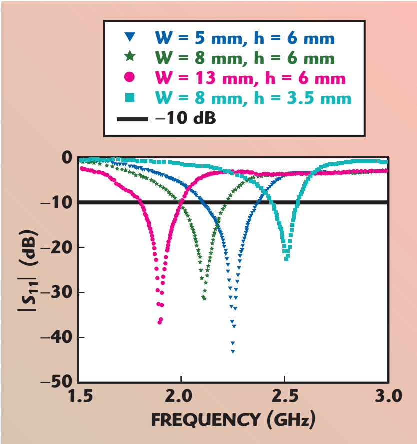

Fig. 7 Measured return loss for different widths and heights of the antenna.

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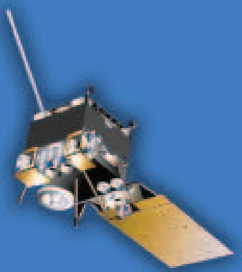

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tor is not uniform and near the short of the antenna provides larger current distribution; hence, the etching geometry near the short conductor of the antenna can obtain more of a slow-wave effect. Etching the geometric pattern on the ground cannot increase the effect of the slow wave because there is a larger area on the ground that causes a smaller current to flow to the antenna resonant route, thereby inducing a smaller equivalent capacitance and inductance.

The Influence of Antenna Size

Figure 7 illustrates how antenna size influences resonant frequency when the antenna size is set to h = 6 mm, L1 = L2 = 18.5 mm and different widths of W = 13 mm, 8 mm or 5 mm, respectively. Increasing the width of the antenna results in a lower resonant frequency. Increasing radiator width can increase the capacitance effect that decreases phase velocity. At the same radiator length, adjusting the width of the antenna will vary the resonant frequency. According to the results, the height of the antenna can affect resonant frequency. At the same antenna length, reducing antenna height can increase the antenna resonant frequency. According to the analysis, etching applicable geometries on the antenna or increasing width and height can achieve a lower resonant frequency because etching a geometric pattern on the antenna and increasing the width of the antenna can increase equivalent capacitance and inductance.

TABLE I

MEASURED ANTENNA GAINS OF THE NOVEL PDILA WITH DIFFERENT WIDTH AND HEIGHT

Antenna Type (with etching cell on antenna)	Gain (dBi)	Antenna Size (mm)	Gain (dBi)
Cell near slot on radiator	2.93	W = 5, H = 6	2.9
Cell near short on radiator	2.1	W = 8, H = 6	3.41
Cell near probe on ground	2	W = 8, H = 6	3.41
Cell on center of ground	3	W = 13, H = 6	1.57
Cell near short on ground	2.37	W = 8, H = 3.5	2.6

Results for Antenna Pattern and Gain

Table 1 lists the gains of all of the antennas. The upper section is classified according to the position of the etched pattern on the radiator. The gains of the first two antennas in the upper section are 2.93 and 2.10 dBi, the former with the etched pattern near the slit on the radiator, the latter with the etched pattern near the short pin on the ground. The gains of the antennas from the third to the fifth graph on the upper section are 2, 3 and 2.37 dBi for the etched pattern on the ground close to the feed, the center on the ground and the ground near the short pin, respectively. The maximum gain of the antenna is found by etching on the center on the ground. The lower section is classified according to the different widths and heights. The gains of the antennas in the lower section are 2.9, 3.41, 1.57 and 2.6 dBi with the width of radiator 5, 8, 13 and 8 mm and height of radiator 6, 6, 6 and 3.5 mm, respectively. The maximum gain of the antenna is found with the width and height of the antenna at 8 and 6 mm, respectively. ***Figure 8*** plots the radiation patterns in sequence, the same as in Table 1. The asymmetry of the antenna radiation pattern is due

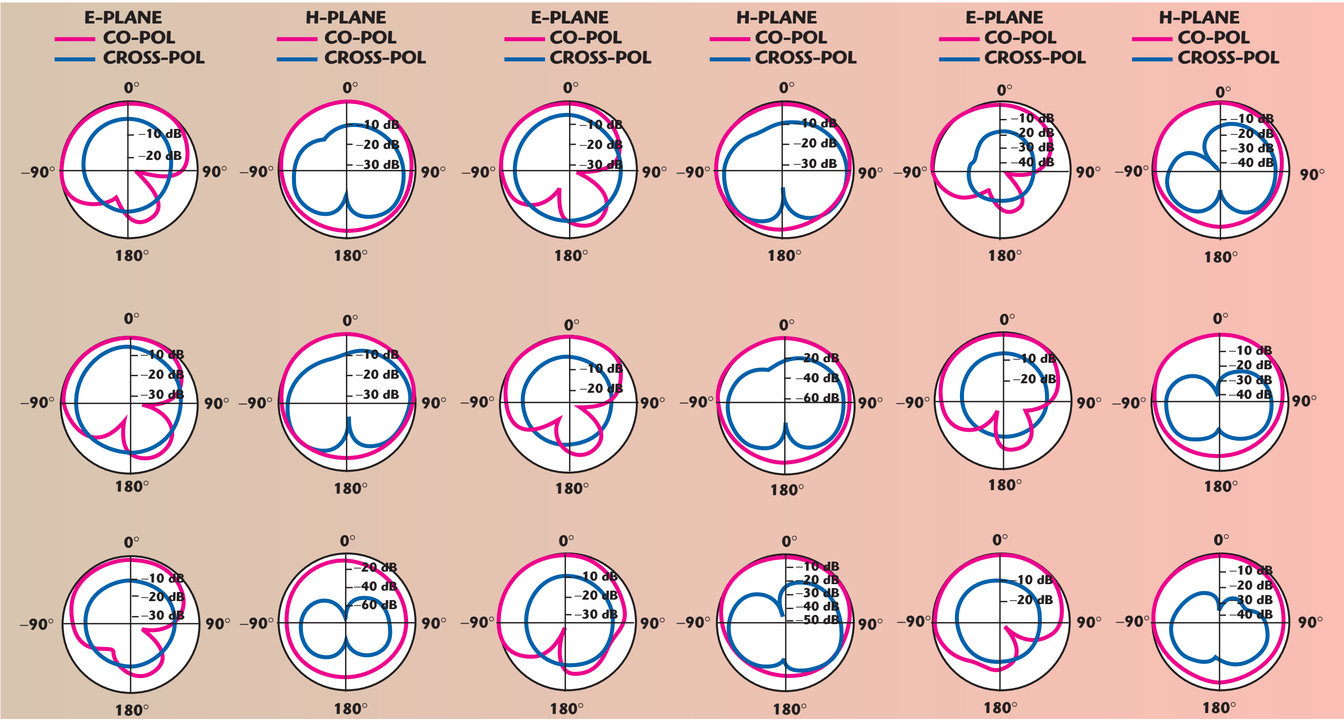

Fig. 8 Measured co-polarization (red) and cross-polarization (blue) radiation patterns of the novel PDILA antenna in the same sequence as in Table 1.

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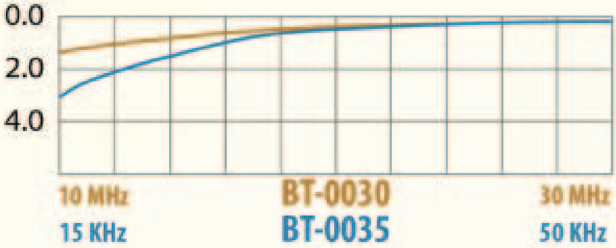

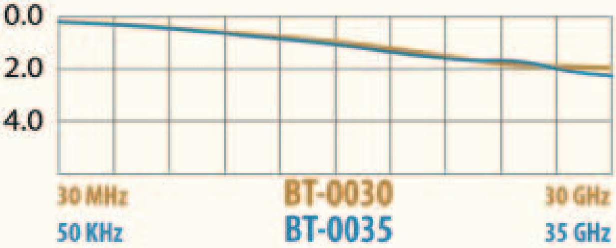

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to the single-end feed. Compared with the antenna without etching, the cross-polarization of the H-plane will increase by about 10 dB due to the etching structure on the antenna destroying the direction of the current on the conductor. Therefore, with the cross-polarization increased, the influence of the difference between co-polarization and cross-polarization of 10 dBi is not very large. As far as co-polarization is concerned, etching will not affect the magnitude of the radiation pattern. Changing the width and height of the antenna and etching structure could be used as methods to reduce the dimensions of the antenna.

CONCLUSION

A novel compact planar double inverted L antenna (PDILA) has been designed and fabricated; the length of the antenna is designed for a quarter-wavelength. The design for feeding, which is different from the conventional PIFA, is an innovative concept designed for a planar or concealed antenna. Due to no dielectric loss, this method can be used for higher frequency by modifying the width. If the applicable geometric structure is etched on the proper position of the antenna, the slow-wave effect can be measured. Moreover, etching in the position with the larger current density provides additional slow-wave effect. The effect of the slow wave will lower the resonant frequency, and hence reduce the length of the antenna. Putting the slow-wave structure on the antenna and increasing the width of the radiator are alternatives to reduce the antenna's dimensions. ■

ACKNOWLEDGMENT

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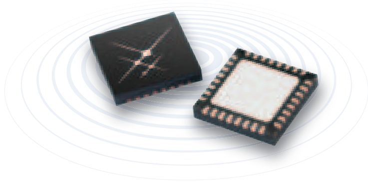

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SLICING THROUGH THE RADIO: AN INTEGRATED, CONFIGURABLE COMPONENTS APPROACH

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MWJ SPEAKS WITH ROBERT VAN BUSKIRK, PRESIDENT, RFMD'S MULTI-MARKET PRODUCTS GROUP.

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Highly integrated RF transceivers and system-on-chip (SOC) solutions are widely adopted in high-volume consumer products such as cellular handsets, WLAN routers and *Bluetooth*® headsets. However, the economics of semiconductor development do not support this high level of integration for low volume and custom-built radio designs. As such, these radios are designed using standard, off-the-shelf, RF components. Furthermore, many of these components were designed prior to the emergence of the latest radio standards, environmental directives and semiconductor technologies. Finding a balance between stringent performance targets and expectations for small, cost-effective and reliable solutions while using a catalogue of outdated components is very demanding. Couple in the call for lower power consumption and the ability to operate products from a single battery (Li-ion or polymer) and you have tremendous challenge to RF engineers as they tackle today's radio designs.

RFMD® recently introduced a line of integrated, configurable components to specifically address these very issues. In combining an RF synthesizer with wideband RF mixers, the RF205X line of components offers a solution by integrating common radio functions into a single device that can be operated from a single 3 V supply. Their uniquely configurable yet highly integrated design makes them the perfect choice for frequency band shifters, diversity receivers, satellite communications equipment, wireless repeaters, point-to-point radio links, instrumentation and test equipment, cognitive radios or simply as wideband low-noise signal sources. The block diagrams for the RF2051, RF2052 and RF2053 are shown in ***Figures 1a***, ***1b*** and ***1c***.

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WG Band	Waveguide Frequency Range (GHz)	Wavelength Range λo (mil)	Wavelength Range λo (mm)	Guide Wavelength Range ($\lambda g/\lambda o$)	Waveguide Impedance Range (Ω)	TE_{10} Cutoff Freq (GHz)	TE_{10} Cutoff λc (mil)	TE_{10} Cutoff λc (mm)	Internal Dimensions (mils)	Internal Dimensions (mm)
WR-28	26.5 - 40.0	445.4 - 295.1	11.313 - 7.495	1.650 - 1.177	621.9 - 443.6	21.1	560.0	14.22	280.0 x 140.0	7.112 x 3.556
WR-22	33.0 - 50.0	357.7 - 236.1	9.085 - 5.996	1.661 - 1.177	626.0 - 443.6	26.3	448.0	11.38	224.0 x 112.0	5.690 x 2.845
WR-19	40.0 - 60.0	295.1 - 196.7	7.495 - 4.997	1.613 - 1.173	608.3 - 442.4	31.4	376.0	9.55	188.0 x 94.0	4.775 x 2.388
WR-15	50.0 - 75.0	236.1 - 157.4	5.996 - 3.997	1.657 - 1.181	624.8 - 445.1	39.9	296.0	7.52	148.0 x 74.0	3.759 x 1.880
WR-12	60.0 - 90.0	196.7 - 131.1	4.997 - 3.331	1.690 - 1.186	637.2 - 447.1	48.4	244.0	6.20	122.0 x 61.0	3.099 x 1.549
WR-10	75.0 - 110.0	157.4 - 107.3	3.997 - 2.725	1.620 - 1.185	610.9 - 446.7	59.0	200.0	5.08	100.0 x 50.0	2.50 x 1.270
WR-08	90.0 - 140.0	131.1 - 84.3	3.331 - 2.141	1.746 - 1.177	658.1 - 443.6	73.8	160.0	4.06	80.0 x 40.0	2.032 x 1.016
WR-06	110.0 - 170.0	107.3 - 69.4	2.725 - 1.763	1.771 - 1.183	667.7 - 445.9	90.8	130.0	3.30	65.0 x 32.5	1.651 x 0.826
WR-05	140.0 - 220.0	84.3 - 53.6	2.141 - 1.363	1.777 - 1.176	669.7 - 443.3	115.7	102.0	2.59	51.0 x 25.5	1.295 x 0.648
WR-04	170.0 - 260.0	69.4 - 45.4	1.763 - 1.153	1.695 - 1.177	638.8 - 443.9	137.2	86.0	2.18	43.0 x 21.5	1.092 x 0.546
WR-03	220.0 - 325.0	53.6 - 36.3	1.363 - 0.922	1.627 - 1.183	613.5 - 445.9	173.6	68.0	1.73	34.0 x 17.0	0.864 x 0.432
WR-02.8	260.0 - 400.0	45.4 - 29.5	1.153 - 0.749	1.708 - 1.177	643.8 - 443.6	210.8	56.0	1.42	28.0 x 14.0	0.711 x 0.356
WR-02.2	325.0 - 500.0	36.3 - 23.6	0.922 - 0.600	1.771 - 1.185	667.7 - 446.7	268.2	44.0	1.12	22.0 x 11.0	0.559 x 0.279
WR-01.9	400.0 - 600.0	29.5 - 19.7	0.749 - 0.500	1.587 - 1.169	598.3 - 440.6	310.6	38.0	0.97	19.0 x 9.5	0.483 x 0.241
WR-01.5	500.0 - 750.0	23.6 - 15.7	0.600 - 0.400	1.620 - 1.175	610.9 - 442.8	393.4	30.0	0.76	15.0 x 7.5	0.381 x 0.191
WR-01.2	600.0 - 900.0	19.7 - 13.1	0.500 - 0.333	1.746 - 1.194	658.1 - 450.1	491.8	24.0	0.61	12.0 x 6.0	0.305 x 0.152
WR-01.0	750.0 - 1100.0	15.7 - 10.7	0.400 - 0.273	1.620 - 1.185	610.9 - 446.7	590.1	20.0	0.51	10.0 x 5.0	0.254 x 0.127

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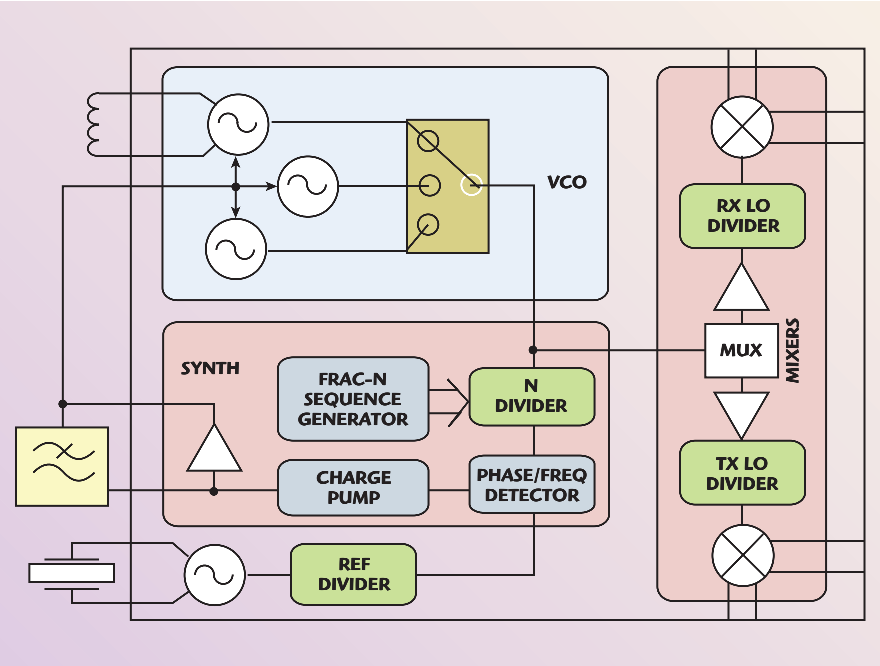
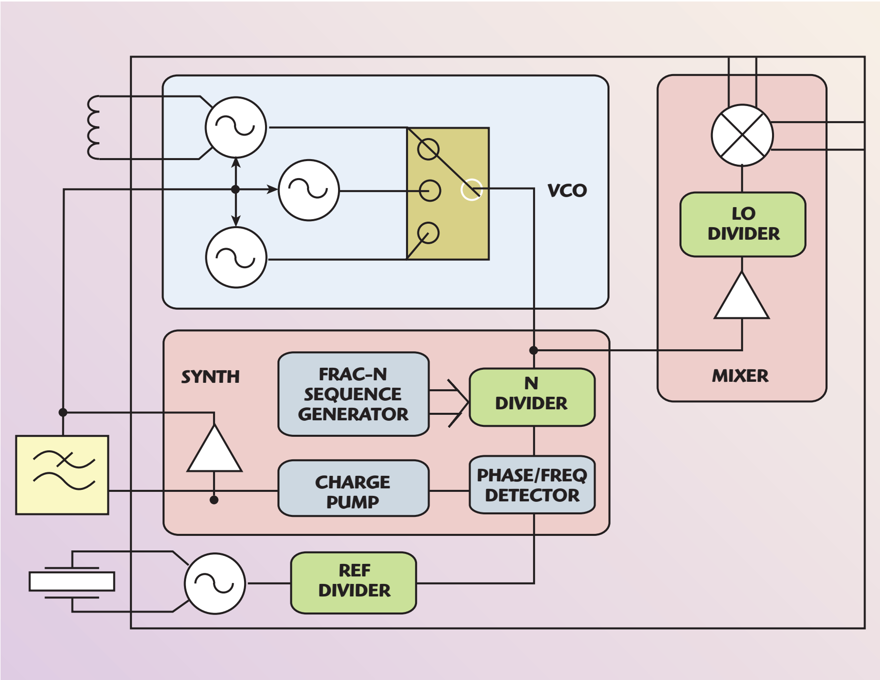
KEY FEATURES OF RF2051, RF2052 AND RF2053

The RF2051, RF2052 and RF2053 are designed for 2.7 to 3.6 V operation and are housed in a plastic 32-pin, 5 × 5 mm QFN package for optimum compatibility with portable, battery-powered devices. The RF synthesizer includes an integrated fractional-N phase-locked loop (PLL) with voltage-controlled oscillators (VCO) and dividers to produce a LO signal with a very fine frequency resolution down to 1.5 Hz. Additionally, the fractional-N synthesizer allows for a wide loop bandwidth to be used for digital/phase modulation to achieve fast PLL locking times and lower noise within the loop bandwidth. The LO generation blocks in the RF2051 and RF2052 have been designed to continuously cover the frequency range of 300 to 2400 MHz without component replacement.



▲ *Fig. 1a RF2051 block diagram.*



▲ *Fig. 1b RF2052 block diagram.*

The RF2053 allows designers to take advantage of an external VCO source, while exploiting the internal fractional-N PLL synthesizer and high linearity RF mixer. The integrated, high-linearity RF mixers are very broadband and operate from 50 to 2500 MHz as measured at the RF ports of the device. An external crystal or an external reference source of between 10 and 104 MHz is flexible enough to accommodate a variety of reference oscillator options. Highly configurable in nature, the RF2051, RF2052 and RF2053 utilize two separate hardware-selectable frequency registers to allow switching between two independent frequencies without re-programming (i.e. Rx/Tx, Rx1/Rx2 or Tx1/Tx2). The devices are also programmed using a true three-wire serial control interface and feature an automatic calibration algorithm to provide an accurate and stable LO signal. Last but not least, the bias currents can be programmed to optimize supply current/performance tradeoffs.

THE INTEGRATED CONFIGURABLE ADVANTAGE

Many benefits of this solution can be identified when compared with a discrete implementation of the same functionality:

Power consumption: The family of components is fabricated using circuit IP developed for RFMD's POLARIS® EGPRS transceivers. The stringent GSM handset performance and low power consumption requirements from 3 V supplies are well known. With RFMD's new RF205X line of components, the same current savings seen in transceiver-based solutions can be realized due to the integration of the RF interfaces such as those between the synthesizer LO output and the mixer, thus allowing optimization of impedances and parasitics, leading to this reduced power consumption. Furthermore, not all radio designs will have the same noise, linearity or supply current performance requirements, so the RF2051, RF2052 and RF2053 have been designed to allow power consumption in key circuit blocks such as the VCO, LO buffers and mixers to be programmed via the serial interface, thus minimizing current draw for a given application.

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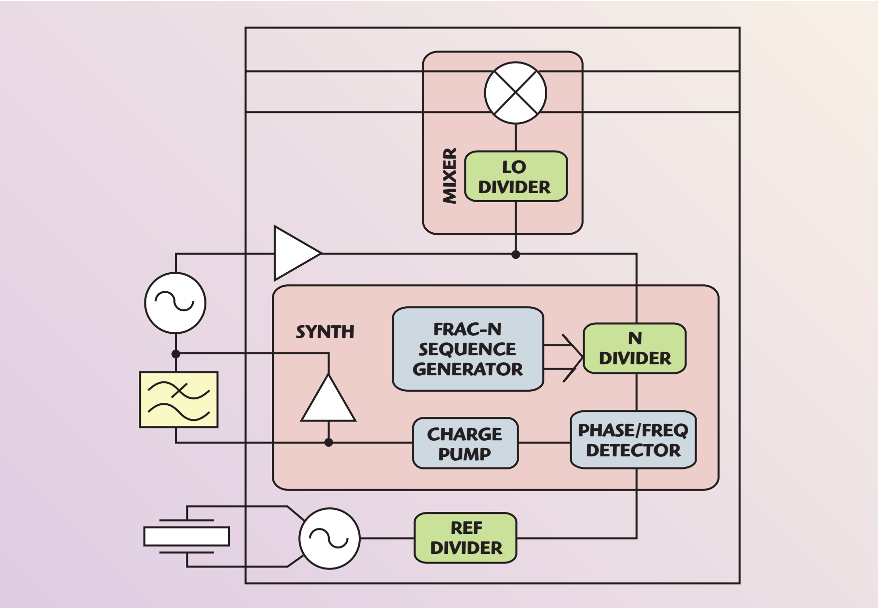
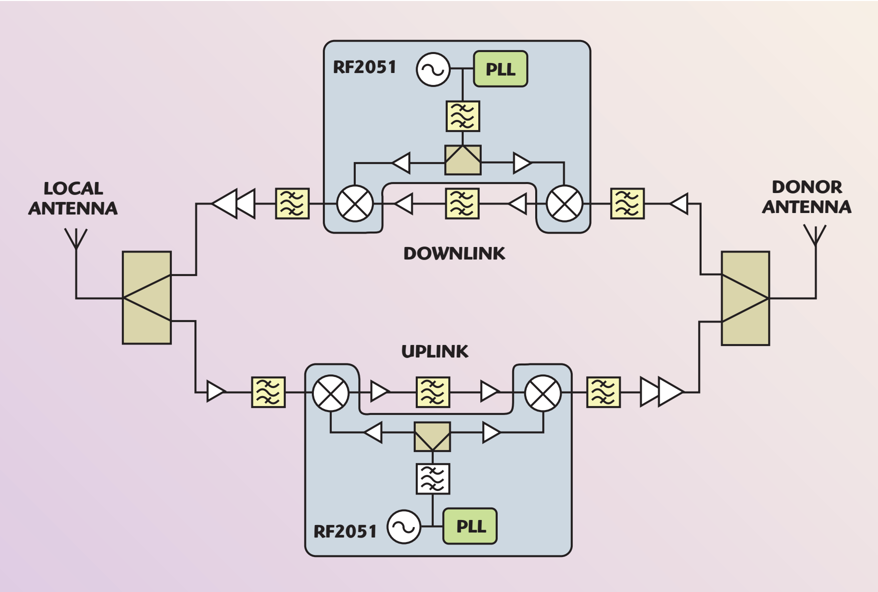
Solution size: The RF2051, RF2052 and RF2053 replace at least three to four single-function components—the synthesizer, the VCO and one or two mixers. Additional integrated functions that may otherwise have been required as discrete components include LO buffers and LO distribution. Integration of all of these functions, in addition to interconnect wiring, power supply decoupling, etc., leads to a significant reduction in solution size compared to a discrete component design.

Reduced development time: By integrating key interfaces between the VCO, the PLL and the mixers, the RF complexity of a radio solution is greatly reduced. Issues of RF pick-up and isolation related to these interfaces on a discrete component design may require many PCB spins to identify and correct. Moreover, because RFMD's components are configurable they can be used for most frequency bands and performance standards, and a high degree of design reuse or platform design can be employed, reducing time to market and maximizing lifetime revenue.

Final product yield: With RF2051, RF2052 and RF2053 the final electrical specifications for the complete functionality is guaranteed.

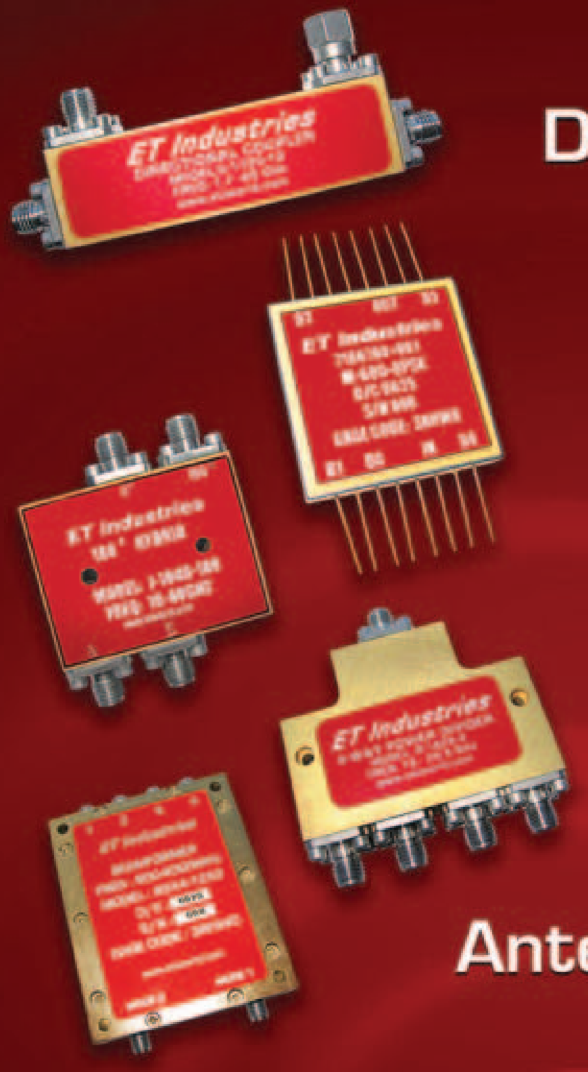


▲ *Fig. 1c RF2053 block diagram.*



▲ *Fig. 2 Example of a repeater application using the RF2051.*

10MHz to 65GHz COMPONENTS



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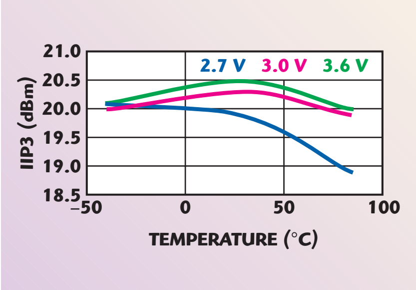
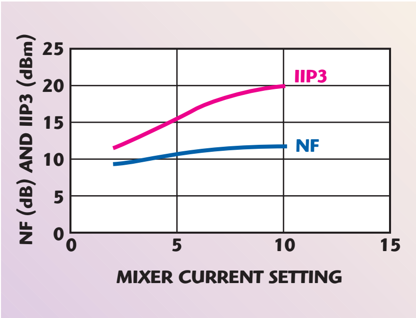
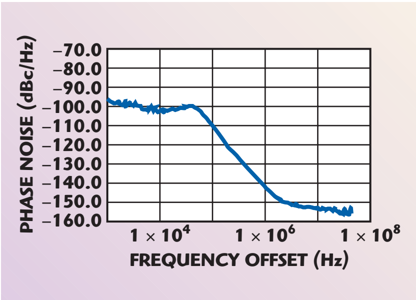
A discrete radio design requires that all performance permutations of the individual components and their effect on the overall system performance needs to be estimated. At best, this leads to a product that is over-designed in order to yield properly in the unlikely event that each of the individual component variations are at their worst-case limits. In the worst case, dramatic yield loss of the final product could result from unanticipated performance degradations when separately specified components are combined.



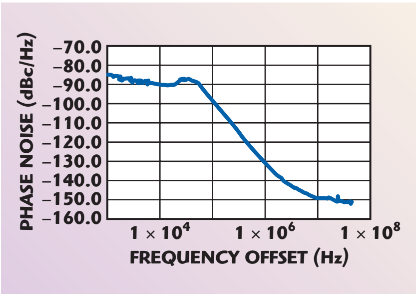
▲ *Fig. 3 IIP3 performance over temperature.*



▲ *Fig. 4 Noise figure and IIP3 vs. mixer current setting.*



▲ *Fig. 5 Phase noise at 500 MHz, 60 kHz LBW.*



▲ *Fig. 6 Phase noise at 2000 MHz, 60 kHz LBW.*

EXAMPLE OF THE "SLICE" APPLICATION

The following example exhibits a potential application for these integrated, configurable components as a frequency up and down conversion stage in a wireless repeater. In this application, both mixers are enabled concurrently and share the same LO frequency, which has been internally buffered to ensure isolation between the two paths. A significant reduction in solution complexity is achievable compared to a discrete component solution (see ***Figure 2***).

TYPICAL PERFORMANCE

Figure 3 shows the IIP3 performance over temperature for the RF205X family. ***Figure 4*** shows NF and IIP3 versus mixer current setting. ***Figures 5*** and ***6*** show the phase noise performance at 500 and 2000 MHz, respectively, with 60 kHz LBW.

CONCLUSION

RFMD has developed a new family of integrated, configurable components, utilizing advanced circuit design techniques on modern semiconductor processes that are broadly applicable to any number of radio designs and over a wide range of frequencies. A number of advantages over discrete component solutions can be identified, including lower power consumption, simpler supply voltage requirements, smaller board area, increased design confidence and a faster time to market. Because these components are broadly applicable, they are available "off-the-shelf" with short lead-times and can be ordered through the local sales channels and via the RFMD webstore. Furthermore, to assist in their implementation, an evaluation board is available with a USB programming interface and a software suite to allow control from a standard PC.

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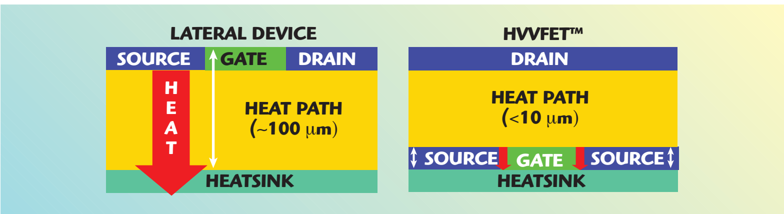
FIRST GENERATION HIGH VOLTAGE VERTICAL FET

Radio Frequency (RF) power amplifiers play a critical role in a broad range of wireless applications, including infrastructure for mobile devices and cell phones, broadcasting and medical equipment, satellite and military communications, emergency radios, and radar. Increasing demands on overall system performance, in turn, translates into added pressure on power amplifiers to deliver excellent efficiency (for low power consumption), linearity, and reliability at a reasonable size and cost.

As demand for cost-effective, high performance continues to mount, new and innovative techniques and materials must be introduced into the market. One such recent development is the vertical architecture being introduced with the HVVFET™ transistor from HVVi Semiconductor. The HVVFET (High Voltage Vertical Field Effect Transistor) is a discrete high power transistor for RF amplifier applications. Devices based on this new structure demonstrate excellent linearity, efficiency and high gain characteristics for high peak-to-average-ratio applications such as CDMA, WCDMA, TD-SCDMA and OFDM systems.

Fig. 1 Cross-sectional views of typical lateral transistor and new High Voltage Vertical FET.



HIGHER OPERATING VOLTAGE FROM A VERTICAL DEVICE

This vertical architecture is shown in ***Figure 1***. In contrast to lateral devices, the substrate of the HVVFET acts as the drain of the transistor. This results in a transistor capable of higher operating voltages. The HVVFET depletes vertically into the substrate as voltage is applied to the drain. This novel device architecture approaches planar breakdown in the vertical drain region, thereby standing off the maximum voltage with the minimum Rds_{on} (on resistance). In addition to improving device packing density, the architecture greatly lowers parasitic capacitance.

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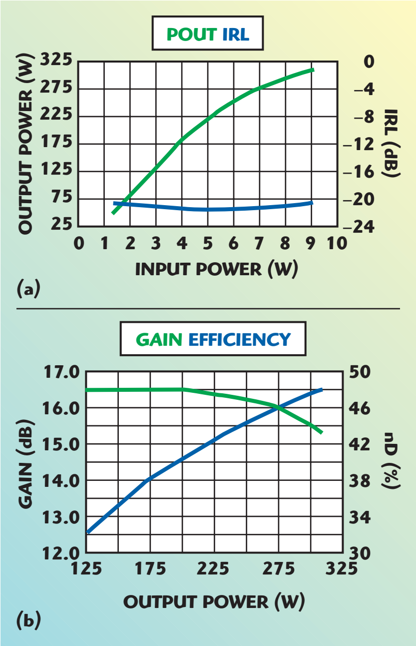
The HVVFET's unique structure provides performance characteristics that improve as the device migrates to even higher operating voltages. The company's product roadmap is to produce greater RF power through high voltage allowing the device to operate at a lower drain-source current. This results in a smaller die size and reduced parasitic capacitance per watt. Lower capacitance supports higher-frequency operation, and the lower current density leads to improved reliability.



▲ *Fig. 2 Typical device performance under Class AB operation and RF pulse conditions of 50 µs pulse width and 5% duty cycle with VDD = 48 V and IDQ = 100 mA. The device produces over (a) 300 W of output power with (b) 48% drain efficiency measured at 1060 MHz.*

EFFICIENT HEAT TRANSFER

Heat is often the limiting factor to improving power amplifier performance. The HVVFET vertical architecture actually allows the transistors to deliver higher power while generating less heat by more efficiently removing heat from the device. Additional thermal management is achieved via a new flip-chip package expressly designed for this product. By more efficiently dissipating heat from the die, these new devices can deliver more power with higher efficiency (see ***Figures 2a*** and ***2b***), better gain (thereby reducing the number of amplifier stages) and improved reliability.

SYSTEM BENEFITS

The first devices fabricated in the new HVVFET technology offer major advantages over devices built in competing technologies. In radar and avionics applications, HVVi's new product family doubles the output power and gain in the same package footprint while reducing power consumption by 30 percent. Moreover, by lowering thermal resistance and simplifying the design, this new approach offers significant advantages in terms of ruggedness and reliability. As an example, HVVi's initial transistors are specified to withstand a VSWR of 20:1 at all phase angles under full rated output power.

DEVICE RF PERFORMANCE

The HVVFET is currently being targeted for pulsed applications in the L-band avionics and radar markets and is available in three product families. The HVV1011-025 (30 W) and HVV1011-300 (300 W) target avionic applications such as IFF, TCAS, transponder/interrogator applications with a frequency range between 1030 and 1090 MHz (50 µsec pulse widths, 5% duty cycle). The HVV1012-050 (50 W) and HVV1012-100 (100 W) are ideal for DME avionic applications operating at 1025 to 1150 MHz and pulse widths of 10 µsec, 1% duty cycle. For ground-based radar applications, the company offers the HVV1214-025 (25 W), HVV1214-100 (100 W) and HVV-1214-200 (200 W). These devices are tuned to operate in the 1200 to 1400 MHz frequency band at pulse widths of 200 µsec and 10% duty cycle. See ***Table 1*** for performance data.

DEVICE PACKAGING AND SUPPORT

The devices come in several package types including a two-lead metal flanged HV400 package (see ***Figure 3a***) with a liquid crystal polymer lid as well as a surface-mount transistor package with a ceramic lid (see ***Figure 3b***). Both package styles are qualified for gross leak test—MIL-STD-750D, method 1071.6, test con-

TABLE I
PERFORMANCE SUMMARY OF THE HVV1011, HVV1012 AND HVV1214 PRODUCT FAMILIES

Part Number	Frequency (MHz)	VDD (V)	IDQ (mA)	Power (W)	Gain (dB)	Efficiency (%)	Package Type
L-BAND FAMILY OF AVIONICS RF POWER TRANSISTORS							
For IFF, TCAS, Transponder/Interrogator Applications (Pulse Width = 50 µs, Duty Cycle = 5%)							
HVV1011-025	1030 to 1090	48	15	30	18	49	SM200
HVV1011-300	1030 to 1090	48	100	300	15	48	HV400
For DME Applications (Pulse Width = 10 µs, Duty Cycle = 1%)							
HVV1012-050	1025 to 1150	48	25	50	20.5	49	HV400
HVV1012-100	1025 to 1150	48	50	100	19.5	48	HV400
L-BAND FAMILY OF RADAR RF POWER TRANSISTORS							
For Ground-based Radar Applications (Pulse Width = 200 µs, Duty Cycle = 10%)							
HVV1214-025	1200 to 1400	48	25	25	17.5	49	SM200
HVV1214-100	1200 to 1400	48	50	100	19.5	49	HV400
HVV1214-200	1200 to 1400	48	100	200	17	48	HV400

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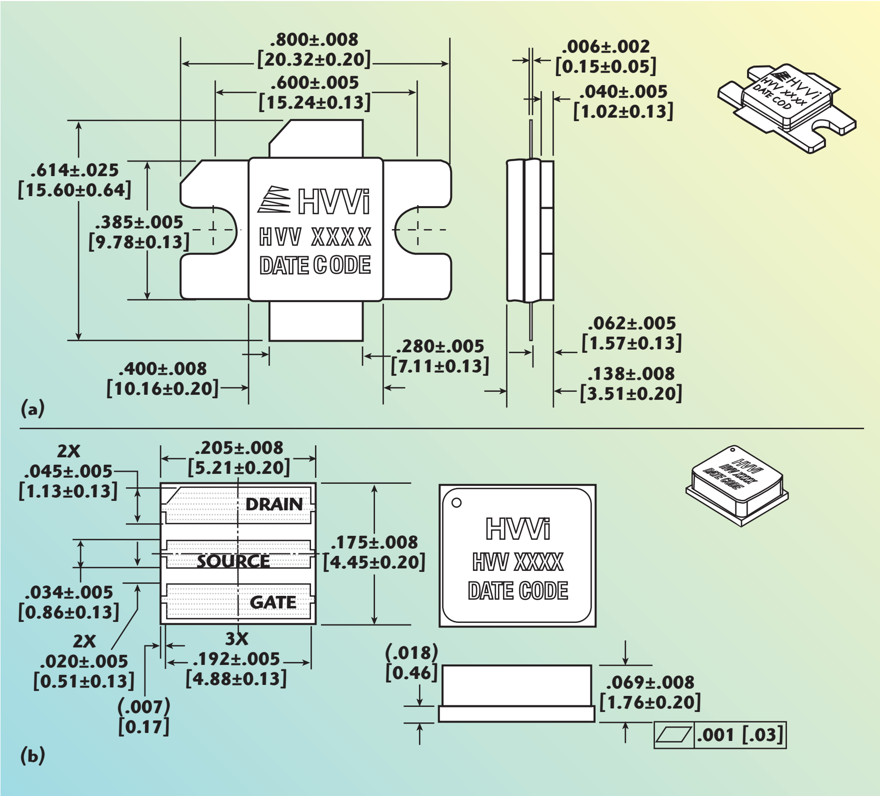

▲ *Fig. 3 Top, side and isometric views of HVVFET package styles: (a) HV400 package (b) surface-mount (SM200) package with bottom pattern view.*

dition C. The 100 W and high power packaged devices also have input and output internal pre-matching to improve performance and reduce external circuit complexity.

CONCLUSION

This new device, the first new silicon RF power transistor structure introduced in over a decade, allows large amounts of transistor periphery to be placed in a small region of silicon, maximizing device packing density and transistor reliability while constraining the geometry of the transistor cells. The new device offers performance that is ideal for RF and microwave pulsed applications such as avionics and radar. This patent-pending vertical architecture transistor is produced in mature, proven and highly cost-effective CMOS wafer process fabrication facilities. Evaluation kits are also available.

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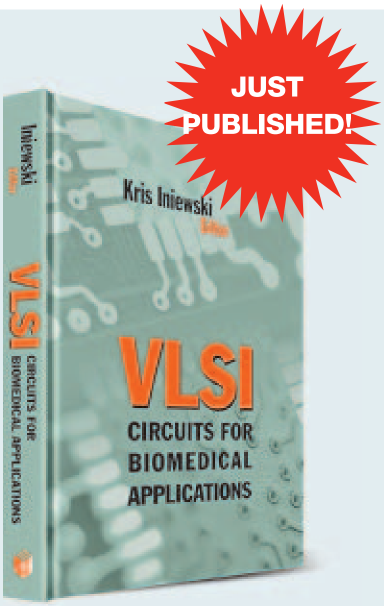

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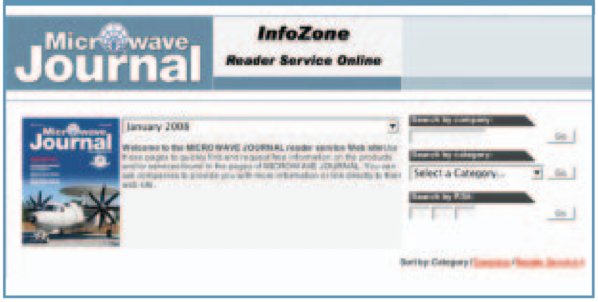

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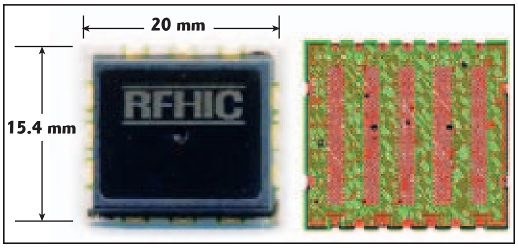
GaN Two-stage 10 W Hybrid Transmitter Power Amplifier Modules

The rapid development and mass production of integrated circuits (IC) have been key factors driving the evolution of miniature handsets. Now other fields such as UMTS, WiMAX, WiBro, base stations, repeaters and Customer Premises Equipment (CPE) are reaping the benefit of the integration of such modules. To satisfy this requirement, RFHIC has developed a new family—the 2WB series and 2GB series—of GaN two-stage 10 W hybrid transmitter power amplifier modules.

The utilization of a multi-chip hybrid module means that all the associated bias circuits and in/out matching circuits can be integrated within the highly conductive substrate. Also, GaN HEMT devices offer significant improvements that result in wide bandwidths, high voltage, high efficiency and high reliability, together with the provision of over 10 W of power.

Fig. 1 2GB ceramic board package.



Standard wideband plastic packages are not able to handle such output power. However, the multi-chip hybrid module can do so. By utilizing the multi-chip hybrid module, the company was able to make a cut-ration short circuit on the substrate.

CHARACTERISTICS

For this family of two-stage GaN HEMT devices, 15.4 × 20 × 0.635 mm beryllium oxide (BeO) substrates are used. Specifically for WCDMA, WiMAX and military applications, input/output matching circuits and bias circuits were integrated into hybrids with 20 to 40 dB gain at frequencies below 6 GHz, producing over 10 W (CW) of output power. ***Figure 1*** shows the 2 GB ceramic board.

The bias circuit supplies –1.3 V and 24 to 30 V to drain, and depending on the efficiency and output level, current can be controlled

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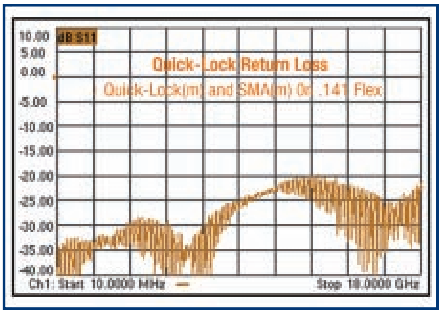

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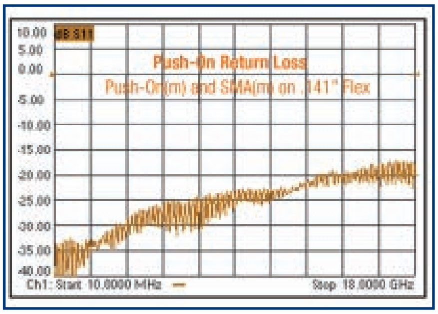

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	L72-486-610	2.0	1.0	25
	L72-486-915	3.0	1.5	25
	L72-486-1220	4.0	1.7	25
	L72-486-1830	6.0	3.0	25
SMAm to SMA Push-On™ m RTK Flex 405	L71-796-305	1.0	0.9	25
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	L71-796-610	2.0	1.5	25
	L71-796-915	3.0	2.3	25
	L71-796-1220	4.0	2.6	25
	L71-796-1830	6.0	4.5	25
SMAm-to SMA Quick-Lock™ m RTK Flex 402	L72-487-305	1.0	0.6	25
	L72-487-457	1.5	0.8	25
	L72-487-610	2.0	1.0	25
	L72-487-915	3.0	1.5	25
	L72-487-1220	4.0	1.7	25
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Note 1 – Insertion Loss in dB (Typ.) at mid-band
Note 2 – Return Loss in dB (Typ.) at mid-band.

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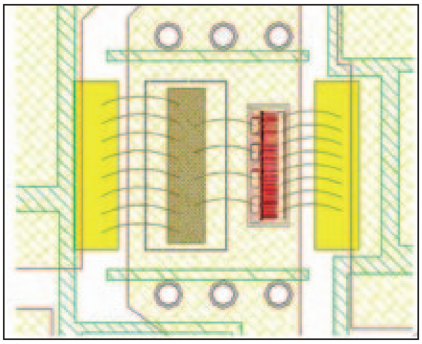
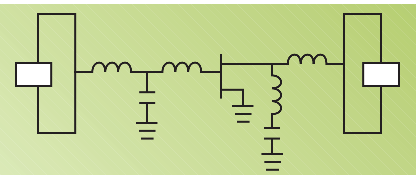
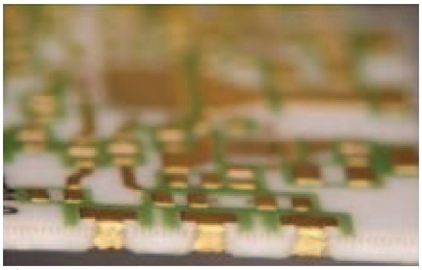


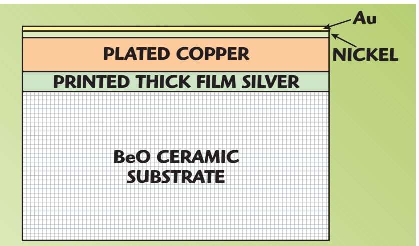
▲ *Fig. 2 Internal matching wire map on ceramic board.*



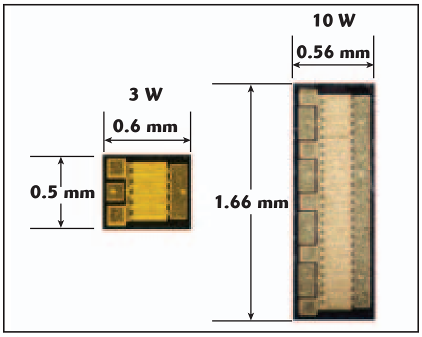
▲ *Fig. 3 Internal matching circuit.*



▲ *Fig. 4 Side view of ceramic board.*



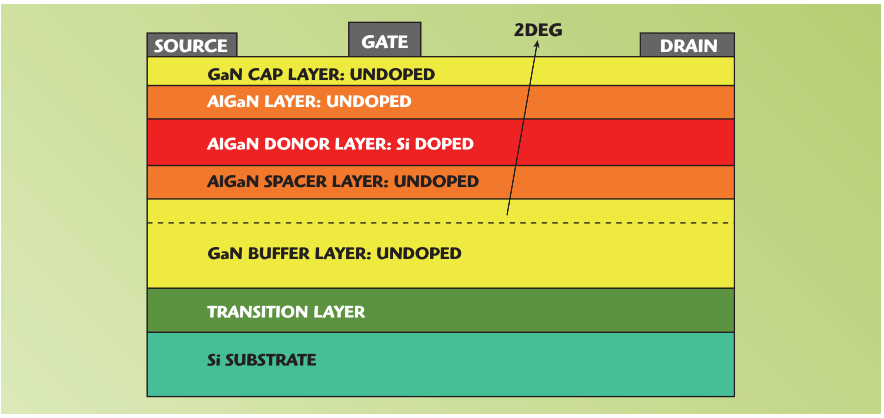
▲ *Fig. 5 Illustration of the ceramic board structure layers.*



▲ *Fig. 6 GaN HEMT amplifiers (courtesy of Nitronex).*

between 250 and 600 mA and used for Class AB or Class A adjustment.

The input/output matching can be varied to fit the specific application.



▲ *Fig. 7 GaN device structure (courtesy of Nitronex).*

The use of high-Q capacitors, feedback circuits and internal matching are some of the ways that the characteristics of the GaN device can be adjusted and matched to the application. ***Figure 2*** illustrates the internal matching wire map on the ceramic board, while ***Figure 3*** shows the internal matching circuit.

THE SUBSTRATE

The substrate uses 99.5 percent BeO, has a thermal conductivity of 285 W/mK, a coefficient of thermal expansion of 9.0, dielectric constant of 6.67 at 10 GHz (room temperature) and a dissipation factor of 0.0004 at 10 GHz (room temperature). 0.025-inch thick BeO substrates are used in order to reduce the thermal impedance and 30 units of the 10 W hybrid are arrayed in a 4.5 by 4.0 inch sheet. ***Figure 4*** shows the side section of the ceramic board.

The substrate, shown in ***Figure 5***, is thick film, which is plated with 15 µm copper, while high power and high frequency devices are achieved by plating with nickel and gold. For the GaN HEMT, the specification of the drive is a 3 W die with 10 fingers (gate length 0.5 µm and gate width 200 µm), while the second stage is a 10 W die with 40 fingers, as illustrated in ***Figure 6***. To reduce the price, GaN is used on silicon as the substrate. Also, the bandwidth, gain, P_{out} and current can be controlled through the matching process. ***Figure 7*** shows the GaN device structure.

This new family of GaN two-stage 10 W hybrid transmitter power amplifier modules has been specifically designed for a wide variety of applications such as wireless base stations, repeaters, CPE and broadband access power modules: DTV (50 to 860 MHz), TRS TETRA (130 to 960 MHz), cellular (815 to 894 MHz), GSM (880 to 1,880 MHz), PCS (1750 to 1990 MHz), UMTS (1880 to 2170 MHz), WiBro MMDS (2,300 to 2700 MHz), WiMAX WiFi (3300 to 3800 MHz), military radio (500 to 3,000 MHz, 2500 to 6000 MHz) and phased-array radar (2700 to 3300 MHz, 5800 to 6000 MHz).

The GaN HEMT chip on a BeO ceramic board has the advantages of being small in size, having a good heat-sink and no need for an external matching circuit. Also, its modularity brings simplification, enabling mass production and resulting in low manufacturing costs.

CONCLUSION

RFHIC has invested a great deal of time and effort into developing and researching the next generation of power transistors that utilize GaN HEMT devices. The 10 W miniature hybrid module offers an easily adjustable matching process to suit the specific application and is mass produced at low cost. The usage of a multi-chip hybrid module on top of a BeO ceramic board minimizes the external circuits, resulting in high power and high gain, and a digital predistortion technique improves the linearity and efficiency.

ACKNOWLEDGMENT

RFHIC would like to acknowledge the role and cooperation of Nitronex in the development of these new products.

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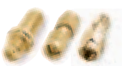

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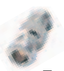

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XC0900B-30	0.8–1.0	355
XC1500A-20	1.0–2.0	150
1P510	1.7–2.0	20
1P520	1.7–2.0	25
XC1900E-10	1.7–2.0	175
XC1900A-05	1.7–2.0	200
XC1900A-10	1.7–2.0	175
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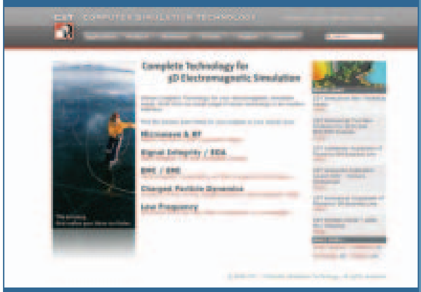

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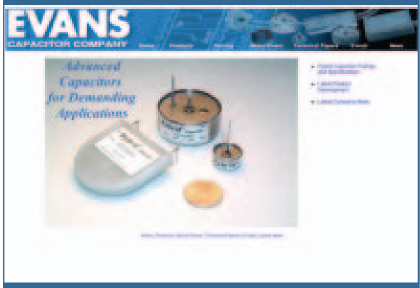

Advanced Capacitors

This web site shares technical information, white papers, specs and pricing for the company's energy-dense Hybrid® capacitors and Hybrid® capacitor banks. High performance aircraft, including the Joint Strike Fighter and the Apache helicopter, use Evans Hybrid capacitors for laser targeting, communications modules, controls, cockpit displays, phased-array radars and fire control systems. Evans tantalum, hermetic, Hybrid capacitors have over 4× the energy density of any military-style capacitor.

Evans Capacitor Co.,
72 Boyd Avenue,
East Providence, RI 02914

www.evanscap.com

ICs, Modules and Subsystems

Hittite's new web site contains new features including a crisp webpage design and a dynamic homepage featuring new products, markets, press releases and featured articles. Users will find information quickly with its new search feature button. Comprehensive individual product splash pages containing in-depth product information and technical content are located on one easy to navigate page. Users will find improved product support, Quality and Reliability pages as well.

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

www.hittite.com

Microwave Shop Front

As part of a corporate branding makeover, the web site offers a number of customer orientated features including comprehensive data sheets, product brochures and a specific log-in area designed to promote the company's wide range of standard and bespoke microwave components and services. As a shop front for the company's business, the site holds a considerable volume of relevant data-rich, technical information and the new layout enables pages to be uploaded and information to be downloaded quickly.

Labtech Microwave,
Broadaxe Business Park,
Presteigne, Powys, LD8 2UH, UK

www.labtechmicrowave.com

Components and Subsystems

Narda Microwave–East has completely redesigned its web site at www.nardamicrowave.com/east. The site is much easier to use and provides greater resources than its predecessor. The new site makes finding information about the company's products, as well as design and application information and customer support far easier and faster than ever before. All products and product families are more fully described, with detailed specifications and drawings that are easily accessible.

Narda Microwave–East,
435 Moreland Road,
Hauppauge, NY 11788

www.nardamicrowave.com

Marketing Communications

Strand Marketing provides integrated marketing communications for regional and international high-tech companies, ranging from RF/microwave to biotech. The new site offers the unique opportunity to browse the agency's extensive creative portfolio by toggling between a client- or a project-based tour. Choosing the client-based option, visitors can read and learn about the agency's current client-base, including specific company challenges and the corresponding, custom-fit marketing solutions.

Strand Marketing Inc.,
10 Railroad Street,
Newburyport, MA 01950

www.strandmarketing.com

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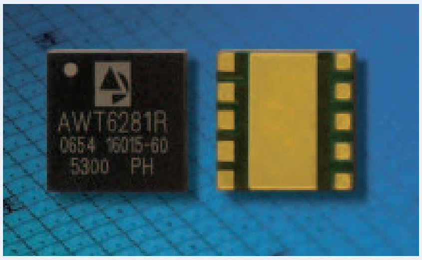
Linear Power Amplifier

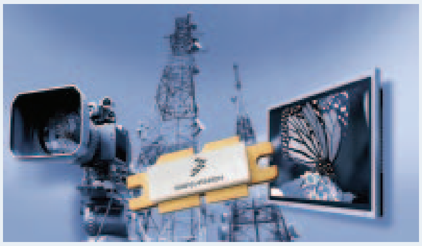


The AWT6281 HELP3™ WCDMA linear power amplifier (PA) is engineered specifically for use in advanced 3G handsets for EGSM (Band 8) UMTS wireless networks. The new power amplifier extends the operating time of 3G handsets and data cards, which is critical for successful operation using today's High Speed Packet Access (HSPA) networks. AWT6281 has been specified by leading chipset manufacturers for selected reference designs. The model AWT6281 provides full compliance with HSDPA and HSUPA requirements and reduces average current consumption by 75 percent compared to competing devices.

ANADIGICS Inc.,
Warren, NJ (908) 668-5000,
www.anadigics.com.

RS No. 216

450 W RF Power Transistor

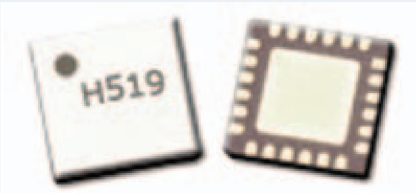


The model MRF6VP3450H is a 50 V laterally diffused MOS (LDMOS) RF power transistor designed to deliver 50 percent higher output power than competing UHF TV broadcast solutions. The MRF6VP3450H device offers the highest output power in its class for UHF applications while enabling system-level power reductions that can potentially save broadcasters thousands of dollars in operating costs. The MRF6VP3450H delivers more than 450 W peak power at P1dB with 50 percent efficiency throughout the UHF broadcast frequency band.

Freescale Semiconductor Inc.,
Austin, TX (800) 521-6274,
www.freescale.com.

RS No. 217

MMIC LNA



The HMC519LC4 GaAs PHEMT MMIC LNA is rated from 18 to 31 GHz, and delivers 14 dB gain, 3.5 dB noise figure and +24 dBm output IP3. The HMC519LC4 also exhibits consistent output power and excellent gain flatness, making it ideal for test and measurement equipment, and applications that require coverage of multiple microwave radio bands with a single MMIC. This compact, self-biased LNA provides up to +24 dBm output IP3 while consuming only 75 mA from a single +3 V supply. This MMIC LNA covers microwave radio, military EW, and test and measurement applications.

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

RS No. 218

Architecture for Silicon Power Transistor Design

Based on the world's first high frequency, high voltage vertical field effect transistor (HVVFET™), HVVi's new architecture delivers frequency bandwidth, voltage and power levels to radar and avionic applications that far exceed the capabilities of current bipolar and LDMOS technologies. This patent-pending technology allows HVVi to achieve performance levels comparable to non-silicon technologies at much more attractive cost levels. As part of its initial announcement, HVVi is also introducing its first three products based on this innovative new HVVFET architecture targeted at high power, pulsed RF applications in the L-band such as IFF, TCAS, TACAN and Mode-S, the three new devices leverage the inherent benefits of the HVVFET process to deliver high output power and high gain in an extremely compact package. All three transistors are designed to operate at 48 V.

HVVi Semiconductors Inc.,
Phoenix, AZ (480) 776-3800,
www.hvvi.com.

RS No. 219

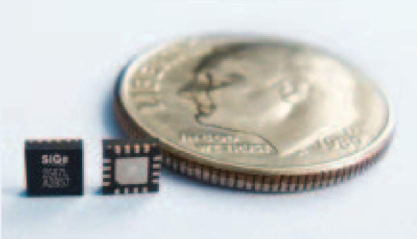
High Linearity Amplifier

The 5 GHz SZP-5026Z high linearity amplifier is designed specifically for use in WLAN and WiMAX consumer premises equipment (CPE), access point and base transceiver station (BTS) applications. The SZP-5026Z is a 2 W single-stage Class AB Indium Gallium Phosphide (InGaP) heterojunction bipolar transistor (HBT) amplifier optimized for use as either a final or driver stage in WiMAX equipment. The SZP-5026Z delivers world-class error vector magnitude (EVM) performance of 2.5 percent at 25.5 dBm output power. Some features include: 3 to 5 V supply operation and operating frequency range of 4.9 to 5.9 GHz.

RF Micro Devices,
Greensboro, NC (336) 664-1233,
www.rfmd.com.

RS No. 221

Power Amplifier

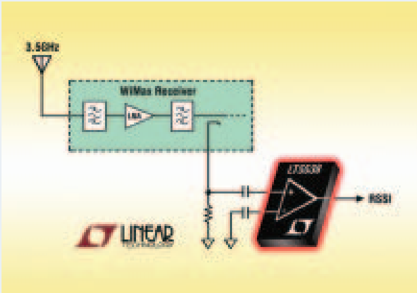


The model SE2587L is a power amplifier designed to optimize performance of Wi-Fi systems. The SE2587L is based on the company's high performance architecture, which delivers excellent linearity at industry leading transmit power levels of +19 dBm in 802.11g mode and +24 dBm in 802.11b mode. The high linearity optimizes transmission of greater data rates over longer distances, thereby allowing systems to support emerging wireless multimedia applications such as video distribution, video streaming and high-speed data. The SE2587L is the smallest of SiGe Semiconductor's discrete power amplifiers, packaged in a 3×3 mm QFN package.

SiGe Semiconductor Inc.,
Andover, MA (877) 602-7443,
www.sige.com.

RS No. 222

40 MHz to 3.8 GHz Log RF Power Detector



This monolithic broadband, high performance logarithmic RF power detector provides accurate RF power measurement over a wide frequency range covering the 800 to 900 MHz and the 1.7 to 2.2 GHz cellular bands, as well as the 2.6 and 3.5 GHz WiMAX bands. The LT5538 RF power detector provides a DC output voltage that is log-linearly proportional to its input power level. Within its measurement dynamic range, the detector exhibits best-in-class accuracy and linearity of ±0.8 dB over its rated operating temperature range of –40° to +85°C.

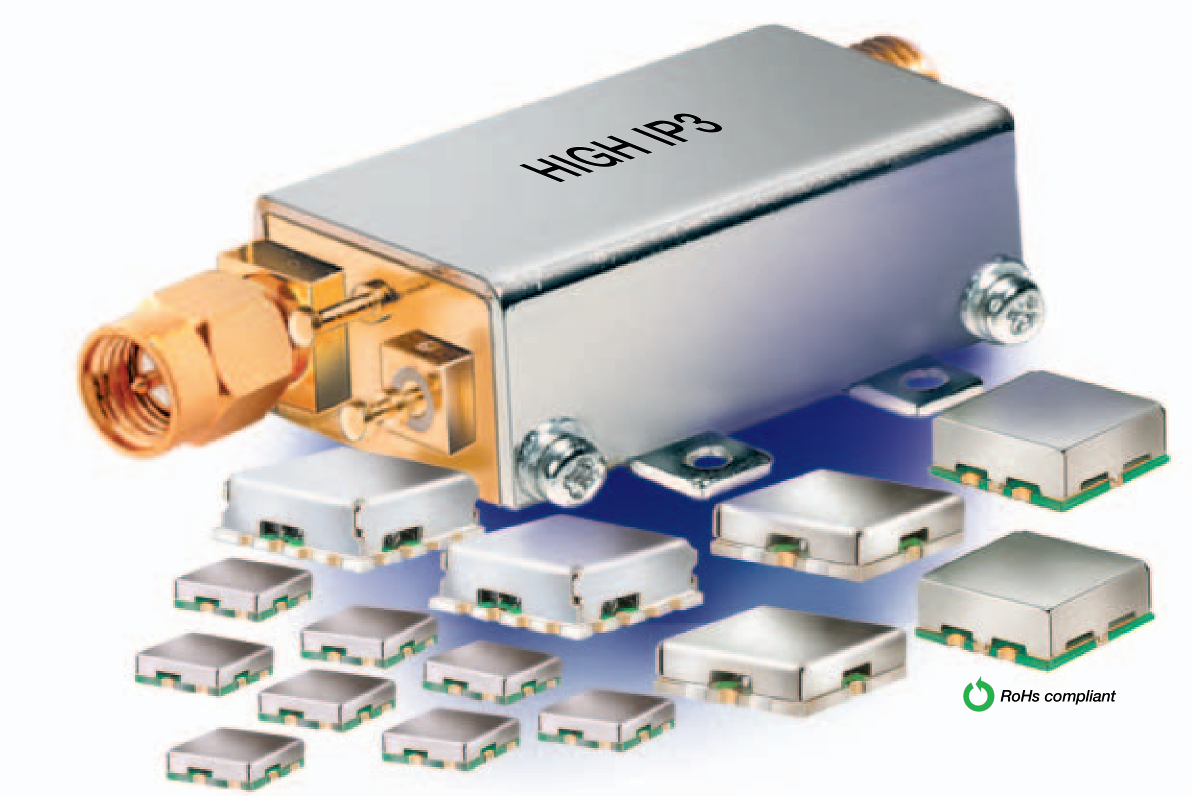
Linear Technology Corp.,
Milpitas, CA (408) 432-1900,
www.linear.com.

RS No. 232

Constant Impedance

VVAs

10 to 3000 MHz



from $*3*95 *ea.qty.10-49*

Voltage Variable Attenuators (VVAs) deliver as high as 40 dB attenuation control over the 10 MHz through 3.0 GHz range. Offered in both 50 and 75 Ω models these surface-mount and coaxial low-cost VVAs require no external components and maintain a good impedance match over the entire frequency and attenuation range, typically 20 dB return loss at input and output ports. These high performance units offer insertion loss as low as 1.5 dB, typical IP3 performance as high as +56 dBm, and minimal phase variation low as 7°.

Mini-Circuits VVAs are enclosed in shielded surface-mount cases as small as 0.3" x 0.3" x 0.1". Coaxial models are available with unibody case with SMA connectors. Applications include automatic-level-control (ALC) circuits, gain and power level control, and leveling in feedforward amplifiers. Visit the Mini-Circuits website at www.minicircuits.com for comprehensive performance data, circuit layouts, environmental specifications and real-time price and availability.

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Visit http://mwj.hotims.com/16342-77 or use RS# 77 at www.mwjournal.com/info

COMPONENTS

Waveguide Switch

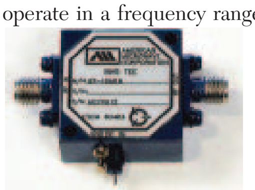
This double ridge WRD580 waveguide switch covers popular frequency bands including C-band, X-band and Ku-band. Available options for all AST switches are fully weatherized units, for outdoor use and miniature drive head.

Advanced Switch Technology,
Kingston, ON, Canada (613) 384-3939,
www.astswitch.com.

RS No. 223

Ultra-broadband Bias Tee

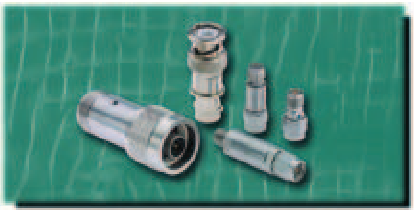
The model BT-10M18 is a bias tee designed to operate in a frequency range from 10 MHz to 20 GHz. The insertion loss is 1.5 dB maximum at 20 GHz, 20 dB of isolation from 10 to 300 MHz and 30 dB from 300 MHz to 20 GHz with a VSWR of 2.0 maximum.



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

RS No. 224

Fixed Attenuators



These low cost 1 W fixed attenuators are available in SMA (model 351-300-XXX), N (model 352-300-XXX), TNC (model 353-300-XXX) and BNC (model 354-300-XXX) connectors. Male to female configurations are standard; other configurations are available upon request. Attenuation values are 1 to 40 dB in 1 dB increments for all connector types listed. Delivery for up to 100 pieces is from stock to one week ARO.

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

RS No. 225

Hi-Q Capacitor Design Kits

Passive Plus has introduced 18 new Hi-Q Capacitor Design Kits that are available in two case sizes: 0.055" × 0.055" (1005) and 0.110" × 0.110" (1011). 1005 kits: DKD1005P01 contains 16 values ranging from 0.1 pF thru 2.0 pF; DKD1005P02 contains 16 values ranging from 1.0 pF thru 10 pF; and DKD1005P03 contains 16 values ranging from 10 pF thru 100 pF. 1011 kits: DKD1011P01 contains 16 values ranging from 1 pF thru 10 pF; DKD1011P02 contains 16 values ranging from 10 pF thru 100 pF; and DKD1011P03 contains 16 values ranging from 100 pF thru 1000 pF. Above six kits are also available in non-magnetic and NPO versions. Passive Plus Inc. is offering one FREE for calendar 2008.

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

RS No. 253

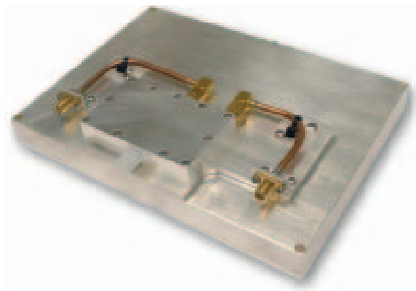
2.4 GHz Diplexer

ClearComm Technologies' family of point-to-point and wireless band products includes its newly released 2.4 GHz diplexers. These units feature a combline cavity structure allowing high performance within a compact package. The diplexers are designed for low combining loss and high port-to-port isolation. The diplexers are frequency scalable from 2.2 to 2.6 GHz covering the wireless local loop and WCS bands.

ClearComm Technologies LLC,
Fruitland, MD (410) 860-0500,
www.clearcommtech.com.

RS No. 226

UHF Receive Multicoupler



These UHF receive multicouplers offer a nominal gain of 35 dB while maintaining a low noise figure of 2 dB maximum. Input voltages range from +20 to +28 VDC with a maximum current of 100 mA. The 1 dB compression point is rated for > +8 dBm. Standard connectors are SMA, but most connector types are available. This unit is also available with optional +15 VDC input voltage. Single output configuration is also available.

Eastern Wireless TeleComm Inc.,
Salisbury, MD (410) 749-3800,
www.ewtfilters.com.

RS No. 227

PIN Diode Switch Module

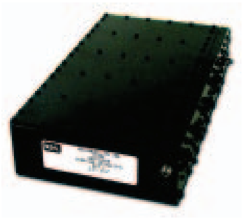
The SW0425-8 is a 1P8T wideband switch module with low loss and high resolution. It operates in the 380 MHz to 2.5 GHz frequency range and has a maximum insertion loss of < 1 dB below 1 GHz and < 2 dB above 1 GHz. The isolation comes in a range of > 40 dB for the IN-OUT operation and 35 dB for the OUT-OUT operation. The module allows a maximum input power of +27 dBm. The switch module weighs 120 g and measures 80 × 100 mm. It comes with MCX (f) connectors and operates in a temperature range of 0° to 70°C.

Eubus GmbH,
Munich, Germany +49 (0) 89 540 32 733,
www.eubus.net.

RS No. 228

UHF Notch Filter

The model 5NSP-445.25/X20-O/O is a notch filter optimized for steep skirts, and for low-loss. By exploiting mixed technologies, such as TEM resonators, suspended-substrate strip-lines and lumped components, the filter exhibits the best trade-offs of performance-to-volume ratio. There are several applications for this filter, ranging from rejecting signals at around 445 MHz from a nearby Tx antenna, to eliminating an unwanted harmonic from a transmitter, while the rest of the spectrum remains unaffected. In either case, the band-reject filter serves as a "quick fix" to everyday field solutions. This feature is enabled, due to the broadband matching of the device, from DC to 1000 MHz, by simply connecting the filter in line with the antenna.

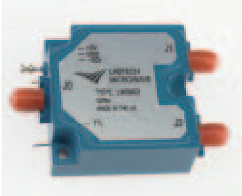


K&L Microwave,
Salisbury, MD (410) 749-2424,
www.klmicrowave.com.

RS No. 229

High Power Switch

Designed for harsh environments, the LMS902 Single Pole Double Throw (SPDT) narrowband switch operates in the 1 to 1.1 GHz microwave range and has a power handling capacity of 500 W peak. The design provides less than 0.8 dB insertion loss, more than 45 dB of isolation and a switching speed of less than 1 µs. The LMS902 is a high power switch aimed at the Identification Friend and Foe (IFF) market. Typical of this application, the RF power is not applied during switching.



Labtech Microwave,
Presteigne, Powys, UK
+44 (0)1544 260903,
www.labtechmicrowave.com.

RS No. 230

Surface-mount Combline Filter

Lark has engineered a new family of surface-mount combline filters from 5 to 15 GHz, with

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ARC TECHNOLOGIES, INC.

ARC Technologies, Inc., 11 Chestnut St., Amesbury, MA 01913 USA
Tel: (978) 388-2993 • Fax: (978) 388-6866 • Email: sales@arc-tech.com

Visit http://mwj.hotims.com/16342-15 or use RS# 15 at www.mwjournal.com/info

a 3 to 20 percent bandwidth and exceptionally low insertion loss of 0.5 to 1.5 dB combined with return loss of 14 dB minimum/17 dB typical and a package size of 0.75" to 2.25"L × 0.5"W × 0.5"H. These filters meet military environmental specifications.

Lark Engineering Co.,
San Juan Capistrano, CA (949) 240-1233,
www.larkengineering.com.

RS No. 231

Ceramic Filter

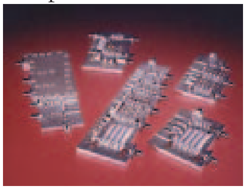
The model DR-1575/50 is a ceramic filter that covers the GPS L1 frequency of 1575.42 MHz. The filter exhibits less than 3.5 dB of insertion loss across the passband of 1550 to 1600 MHz, while providing greater than 50 dB of rejection at 1475 and 1675 MHz. The unit measures approximately 1" × 0.45" × 0.25" and is available from stock.

Lorch Commercial and Wireless,
Salisbury, MD (800) 780-2169,
www.lorch.com.

RS No. 233

Wideband Multiplexers

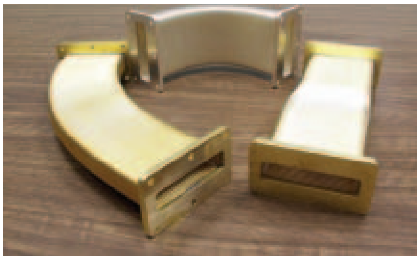
This low profile contiguous channel wideband multiplexer series is available over the 0.5 to 40 GHz range and offers a number of features. Compact and lightweight, all models are 0.400" thin, yet product performance is not compromised. Any combination of 12 standard crossover frequencies from 1 to 34 GHz may be selected to achieve broadband multiplexing as required. With this design flexibility multiplexing is easily achieved for the most popular EW bands from 0.5 to 40 GHz. Band edge rejection options are available and all units may be adapted for custom configurations.



Microphase Corp.,
Norwalk, CT (203) 866-8000,
www.microphase.com.

RS No. 234

Flexible Waveguide



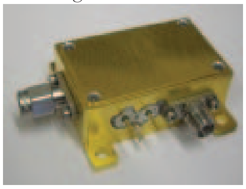
This space-qualified WR284 ½ height is a true seamless flexible waveguide as it is manufactured from a seamless brass alloy #435 tube that has a wall thickness of 0.007 with a convolution height of 0.110 inches. This waveguide is pressure tight and can be purchased preformed into E and H plane bends, as shown in the picture. It can be used in combination with existing WR284 ½ height rigid waveguide to fabricate flex-rigid blended assemblies allowing for some deflection, and deployment of hardware in waveguide runs. Microtech has developed this WR284 ½ height seamless brass waveguide in continuous lengths of up to 24 inches. This waveguide is extremely flexible and can be supplied with a vinyl jacket.

Microtech Inc.,
Cheshire, CT (203) 272-3234,
www.microtech-inc.com.

RS No. 235

Filter Detector

The model RFFD-618-730049 is a filter detector designed to measure signals from 6 to 18 GHz while rejecting the harmonics of these signals in the band from 20 to 26.5 GHz. A suspended substrate filter is used to give low roll off at 18 GHz. The unit also includes slope compensation that ensures the response increases from 6 to 18 GHz thereby ensuring that maximum sensitivity occurs at 18 GHz. The detector uses Schottky diodes for high reliability and wide temperature range. An additional Schottky diode is included for use in a DC balance circuit. Size: 1" × 1.6" × 0.6".



Planar Monolithics Industries,
Frederick, MD (301) 662-4700,
www.planarmonolithics.com.

RS No. 236

High Power Directional Couplers

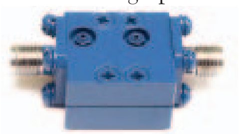
Pulsar Microwave Corp. introduces a new series of 0.5 to 8 GHz three-, four- and eight-way power dividers. All three models have 18 dB isolation and the insertion losses for the three-, four- and eight-way power dividers are 1.5, 1.8 and 2.6 dB, respectively.

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

RS No. 237

18 to 40 GHz High Pass Filter

Reactel part number 7HS-18G/40G-K11 is a broadband high pass filter passing 18 to 40 GHz. This small unit features low loss and in excess of 30 dB rejection from DC to 16 GHz. The company manufactures many different varieties of filters; contact Reactel directly with your specific needs.



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

RS No. 238

Miniature Ultra-flat Schottky Detectors

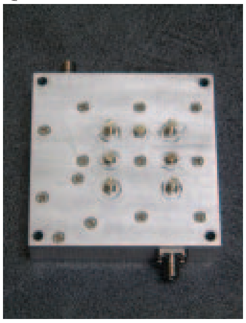
These miniature ultra-flat detectors utilize a zero-bias Schottky design. The microwave power is coupled directly to the extremely small components reducing package parasitics and transition mismatches. This design results in a low VSWR and a flat, smooth output over a wide bandwidth. Options available include negative or positive output, a choice of three output connectors and operation to 26.5 or 40 GHz.

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

RS No. 239

3.5 GHz WiMAX TDD Filter

These 2.3 to 3.8 GHz TDD filters offer a high Q structure that enables the achievement of high rejection and low passband insertion loss. The filters feature a new low cost technology less than $65.00 at 1k and $45.00 at 10k. The TDD filter operates in a frequency range from 2300 to 2700 MHz and 3300 to 3800 MHz and offers a cross coupled design – > 20 dB improved rejection. The filters are lightweight and compact in size: 73 × 73 × 27 mm. Other features include high stability over the temperature range of –40° to 85°C and easy installation saves money and time.

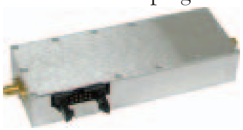


Trackcom Systems International Inc.,
Quebec, Canada (514) 336-4529,
www.trackcom-sys.ca.

RS No. 240

Programmable Attenuator

The model SPA-53095-1S-5V-TTL-R is a wideband solid-state programmable attenuator that features a dynamic range of 95 dB in 1 dB steps over a wide frequency range of 400 to 3000 MHz. Attenuation accuracy is ±0.4 dB or 2.5 percent over the entire range. VSWR is 1.5 maximum and insertion loss is 5.5 dB maximum. Switching speed is < 100 ns and the operating temperature range is 0 to +70°C. The control protocol is TTL and via a 10-pin connector. The RF connectors are SMA female. Delivery: stock to six weeks.



Trilithic Inc.,
Indianapolis, IN (317) 895-3600,
www.trilithic.com.

RS No. 241

Ultra WIDE BANDWIDTH VCOs

Features:

- Ultra Wide Bandwidth
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- Exceptional Phase Noise
- Very Low Post Thermal Drift
- Small Size Surface Mount
- Lead Free - RoHS Compliant
- Patent Pending REL-PRO® Technology

RoHS COMPLIANT

DCMO & DCFOSeries

Model	Frequency (MHz)	Tuning Voltage* (VDC)	DC Bias VDC @ I (Max)	Minimum Output Power (dBm)	Typical Phase Noise @ 10 kHz (dBc/Hz)
DCMO514-5	50 - 140	0.5 - 24	+5 @ 30 mA	+3.5	-110
DCMO616-5	65 - 160	0.5 - 24	+5 @ 35 mA	+3	-108
DCMO1027	100 - 270	0 - 24	+5 to 12 @ 35 mA	+2.5	-112
DCMO1129	110 - 290	0.5 - 24	+5 to +12 @ 35 mA	+2.5	-105
DCMO1545	150 - 450	0.5 - 24	+5 to 12 @ 35 mA	+4	-108
DCMO1857	180 - 570	0.5 - 24	+5 to 12 @ 30 mA	+3	-108
DCMO2260-5	220 - 600	0.5 - 24	+5 @ 35 mA	+2	-108
DCMO2476	240 - 760	0.5 - 24	+5 to 12 @ 35 mA	+4	-108
DCMO3288-5	320 - 880	0.5 - 24	+5 @ 35 mA	+3	-109
DCFO35105-5	350 - 1050	0 - 25	+5 @ 40 mA	+7	-112
DCMO40110-5	400 - 1100	0.5 - 24	+5 @ 42 mA	+5	-103
DCMO40110-8	400 - 1100	0.5 - 24	+8 @ 45 mA	+5	-104
DCMO50120-5	500 - 1200	0.5 - 24	+5 @ 40 mA	+6	-118
DCMO50120-12	500 - 1200	0.5 - 24	+12 @ 35 mA	+6	-103
DCMO60170-5	600 - 1700	0 - 25	+5 @ 35 mA	+3	-99
DCMO80210-5	800 - 2100	0.5 - 24	+5 @ 35 mA	+5	-96
DCMO80210-10	800 - 2100	0.5 - 24	+10 @ 35 mA	+6	-100
DCMO90220-5	900 - 2200	0.5 - 24	+5 @ 35 mA	+4	-98
DCMO90220-12	900 - 2200	0.5 - 25	+12 @ 35 mA	+6	-99
DCMO100230-12	1000 - 2300	0.5 - 24	+12 @ 35 mA	+3	-101
DCMO100230-5	1000 - 2300	0.5 - 24	+5 @ 35 mA	+3	-98
DCMO110250-5	1100 - 2500	0.5 - 28	+5 @ 35 mA	+6	-100
DCMO135270-8	1350 - 2700	0.5 - 20	+8 @ 35 mA	+4	-93
DCMO150318-5	1500 - 3200	0.5 - 20	+5 @ 30 mA	+7	-93
DCMO150320-5	1500 - 3200	0.5 - 18	+5 @ 60 mA	0	-92
DCMO172332-5	1720 - 3320	0.5 - 24	+5 @ 30 mA	+4	-94
DCMO190410-5	1900 - 4100	0.5 - 16	+5 @ 50 mA	+2	-90
DCMO250512-5	2500 - 5125	0.5 - 24	+5 @ 50 mA	-2	-78

* Guaranteed sub bands with lower tuning voltages. See specification sheet for details.

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SYNERGY® MICROWAVE CORPORATION

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

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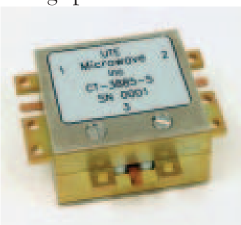
Drop-in Circulator

The model CT-3885-S is designed to operate at 2.5 kW peak and 250 W average power in the 3 GHz radar bands. Bandwidth is up to 12 percent.



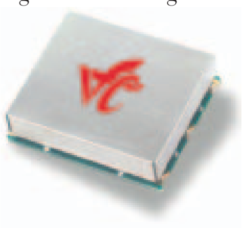
Typical specs are 20 dB isolation, 0.3 dB insertion loss and 1.25 maximum VSWR. The 1⅝ × 1⅝ × ⅞ package provides for optimum RF grounding and heat transfer. Other stripline interface high power units are available from VHF thru C-band.

UTE Microwave Inc.,
Asbury Park, NJ (732) 922-1009,
www.utemicrowave.com.

RS No. 242

Free-run Mode Jitter Attenuators

The VFJA402 and VFJA430 jitter attenuators are integrated clock/PLL timing solutions designed for 1G/10G/100G synchronous Ethernet applications.



The VFJA402 provides two LVPECL outputs from 10 to 200 MHz. The VFJA430 has two LVCMOS outputs from 10 to 200 MHz. Two select inputs [S1,S0] allow the user to select 1 of 3 preset input frequencies from 8 kHz to 200 MHz or free-run mode for both jitter attenuators. The VFJA402 and VFJA430 offer ultra-low output jitter (0.20 ps RMS 12 kHz to 20 MHz). The devices operate from a +3.3 V DC power supply and typically consume 150 mW. Both are available in a 19.5 × 15.5 mm surface-mount package and are RoHS 6/6 compliant.

Valpey Fisher Corp.,
Hopkinton, MA (508) 435-6831, www.valpeyfisher.com.

RS No. 243

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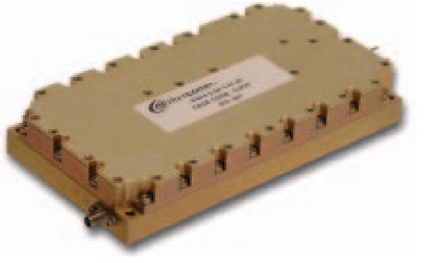
AMPLIFIERS

GaN RF Amplifier

The model SSPA 0.020-1.000-20 is a high power, broadband, Gallium Nitride (GaN) RF amplifier that operates from 20 to 1000 MHz.



The bandwidth of this amplifier can be extended to 1200 MHz+ with similar performance. This PA is ideal for broadband military platforms as well as commercial applications because it is robust and offers high power over a multi-octave bandwidth with excellent power-added efficiency. This amplifier was designed for broadband jamming and communication system platforms. This amplifier operates with a base plate temperature of 85°C with no degradation in the MTBF for the GaN devices inside. It is packaged in a modular housing that is approximately 3.4" (w) × 6.4" (l) × 1.06" (h).

Aethercomm Inc.,
San Marcos, CA (760) 598-4340, www.aethercomm.com.

RS No. 244

High Power Amplifier

The BBM3K5KHM (SKU #1119) is a high power amplifier suitable for broadband mobile jamming and band specific high power linear applications in the P/L/S frequency bands of 500 to 2500 MHz, with 50 W of output power.

This compact module utilizes high power advanced GaN devices that provide excellent power density, high efficiency, wide dynamic range and low distortions. Features include: solid-state linear design, instantaneous ultra-broadband, small and lightweight, suitable for all modulation standards and built-in control, monitoring and protection circuits.

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

RS No. 245

Rugged Wideband Amplifiers

Operating from 0.8 to 21 GHz, this amplifier delivers 19 to 25 dBm output power with an excellent VSWR of 1.3 over the entire band.

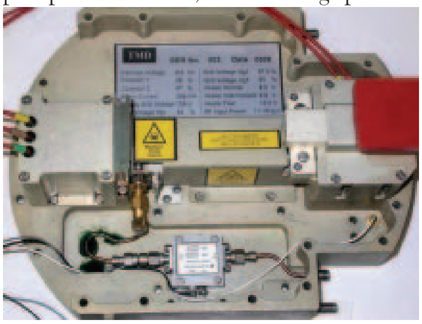
This rugged amplifier can withstand accidental open/short at output while delivering full output power corresponding to 1 dB compression point. This feature also enables it to operate reliably when interfaced with loads that have poor VSWR. The amplifier is unconditionally stable and operates over –55° to 85°C base plate temperatures making it suitable for many commercial applications. It is housed in a hermetic case, which makes it ideal for use in harsh environments such as military.

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

RS No. 246

Ku-band TWT

The high power, fast warm, PT6789 Ku-band travelling wave tube has a peak power of 1000 W, with an average power of 400 W continuous or 600 W for short periods.



It operates at the top of the Ku radar band, at a high duty of up to 33 percent, and at very high pulse repetition frequency. The TWT is also equipped to work in a harsh environment.

TMD Technologies Ltd.,
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RS No. 247

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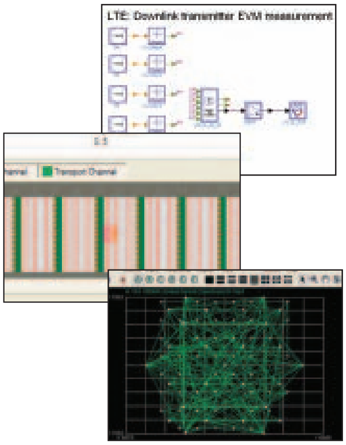

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ANTENNA

TETRA Radio Antenna Coupler

Claimed to be the first antenna coupler for TETRA frequencies, the 4914 enables TETRA mobile phones to be tested without having to use type-specific RF adapters. The shuttle provided with the unit holds the radio terminal, ensuring that the radio is positioned accurately and thus providing high precision measurements with good repeatability. The 4914 antenna coupler complements the 2303 Stabilock, a dedicated TETRA mobile station tester for service in the field of professional mobile radio. The coupler can also be used for mobile phone systems operating in the 400 MHz range, such as CDMA-450.

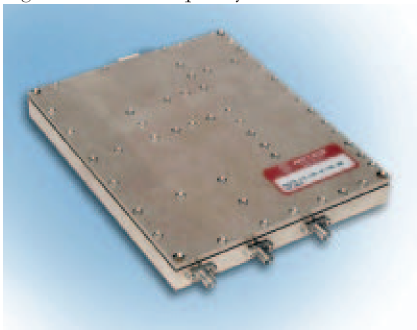
Willtek Communications GmbH,
Ismaning, Germany +49 (0) 99641 200, www.willtek.com.

RS No. 248

SOURCES

Low Phase Noise Synthesizers

The LFTS series of low phase noise synthesizers offers state-of-the-art high resolution frequency sources for INTELSAT applications. The LFTS series comes with standard 100 Hz step sizes, and provides an additional output that may be used as the second conversion LO for dual conversion up and downconverters. This field proven design consumes less power, which contributes to a very high MTBF and increased reliability.



MITEQ Inc.,
Hauppauge, NY (631) 436-7400, www.miteq.com.

RS No. 249

Voltage-controlled Oscillator

This MD series of economical voltage-controlled oscillators offers low phase noise in the industry standard one half inch square package. Model MD102MST operates in a frequency range from 1260 to 1285 MHz and is rated –111 dBc at 10 kHz offset. Many other catalog models are available and custom designs can be supplied with no NRE.

Modco Inc.,
Sparks, NV (775) 331-2442,
www.modcoinc.com.

RS No. 250

Mini Voltage-controlled Oscillators

The DCO and DXO micro series of miniature voltage-controlled oscillators (VCO) is designed for C-band and X-band applications. These VCOs are based on Synergy's proprietary patented technology and patents pending, which enhances bandwidth, reduces phase noise and improves immunity to phase hits. Several models are available with starting frequency at approximately 4 to 10 GHz, in tuning bandwidths of approximately 1000 MHz, and tuning voltages ranging from 0 to a maximum of 24 V DC. Phase noise for 8 to 9 GHz is typically better

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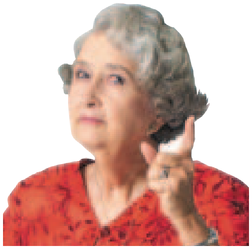

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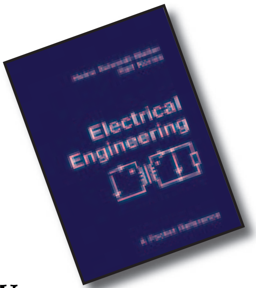

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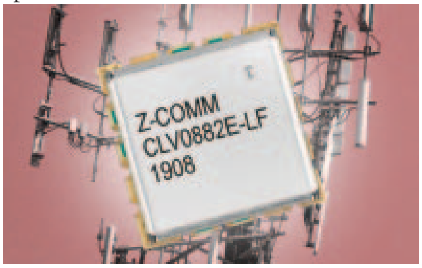
than 85 dBm at 10 kHz. These new series of VCOs are packaged in a tiny VCO surface-mount package measuring 0.3" × 0.3" × 0.1", RoHS compliant and can be delivered in tape and reel for automatic assembly processes.

Synergy Microwave Corp.,
Paterson, NJ (973) 881-8800, www.synergymwave.com.
RS No. 251

UHF-band Oscillator

The model CLV0882E-LF is a lead-free, RoHS compliant oscillator that operates in the UHF-band (822 to 943 MHz) and features ultra-low typical phase noise performance of –114 dBc/Hz at 10 kHz offset. The unique design covers the bandwidth between 1 to 9 V with a typical tuning sensitivity of 30 MHz/V. It is designed to operate at 5 V DC supply while drawing 22 mA (typical) over the extended operating temperature range of –40° to 85°C. CLV0882E-LF is ideally suited for UHF band applications that require low phase noise performance and linear tuning. Size: 0.50" × 0.50" × 0.22". Delivery: stock to four weeks.

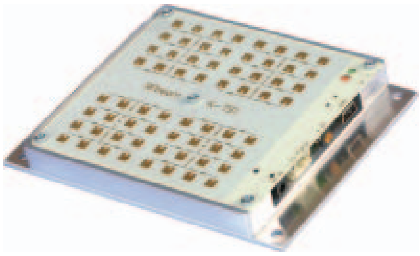


Z-Communications Inc.,
San Diego, CA (858) 621-2700, www.zcomm.com.
RS No. 252

TEST EQUIPMENT

Radar Module Test System

K-TS1 is a fully integrated radar module test system for K-band transmitters, receivers and transceivers. It consists of a digitally controlled synthesizer and transmitter, a selective receiver with power indicator and a synthetic Doppler target simulator. Its 'all-in-one' design simplifies geometrical adjustment of the unit under test because it only has to be targeted once for all tests. Streaming or single shot operation modes provide high flexibility and high performance measurement results can be obtained in just a few keystrokes.



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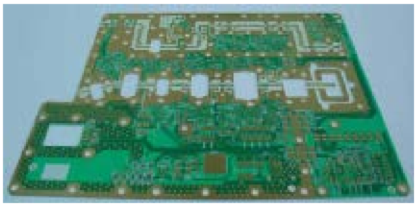

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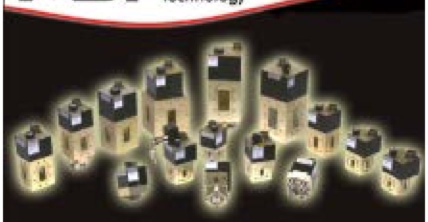
RS 114

AST Advanced Switch Technology



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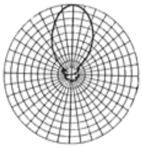

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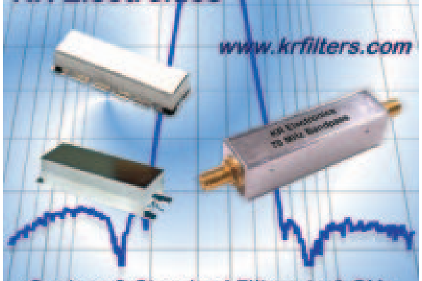

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RS 54

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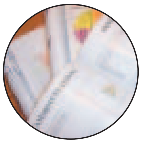
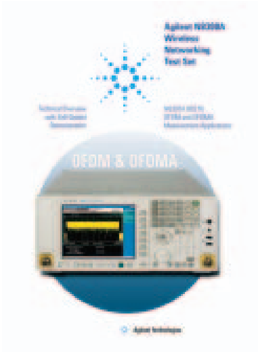


DEMONSTRATION GUIDE



A new technical overview with a self-guided demonstration is now available for WiMAX test developers and application engineers. The guide shows how the Agilent N8300A wireless networking test set can be used with the Agilent N6301A 802.16 OFDM and OFDMA measurement applications and the Agilent N7615B Signal Studio software to expedite transmitter and receiver test development, lower costs and shorten time to market.

Agilent Technologies Inc.,
Santa Clara, CA (800) 829-4444,
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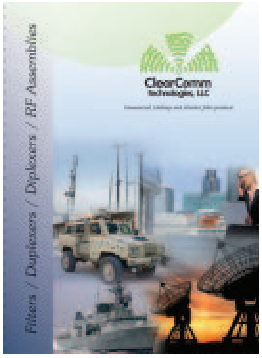
RS No. 200

PRODUCT CATALOG



ClearComm Technologies LLC, a designer and manufacturer of RF and microwave filter products for the military, commercial and wireless markets, has released a new product catalog featuring a complete line of cavity and discrete element filters covering the frequency range of 1 MHz to 20 GHz. The catalog features information about ClearComm including contact information and customer service. Quality, engineering and environmental commitments are described.

ClearComm Technologies LLC,
Fruitland, MD (410) 860-0500,
www.clearcommtech.com.

RS No. 201

GUIDE TO OFDM/A, MIMO, WLAN AND WIMAX

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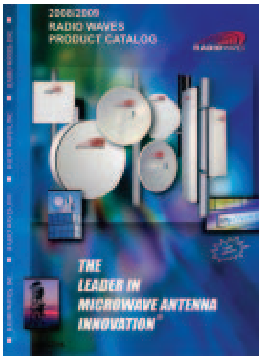
PRODUCT CATALOG

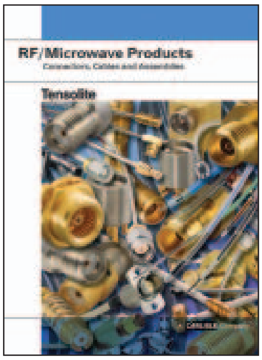


This 2008/2009 catalog includes new products such as Radio Waves' complete family of WiMAX antennas, new sector, Xcelarator™ panel and omni antennas for 4.9 GHz public safety networks, new high performance parabolic antennas for the 4.9 and 5 GHz bands, and new high frequency licensed band antennas. For a free copy please contact Radio Waves at sales@radiowavesinc.com.

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

RS No. 203

RF/MICROWAVE PRODUCTS



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Tensolite Co.,
St. Augustine, FL (800) 458-9960,
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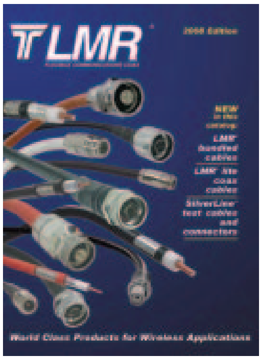

The 13th edition of the *LMR® Wireless Products Catalog* includes the entire range of LMR cables, including LMR-DB, LMR-FR, LMR-Ultraflex, LMR-LLPL and LMR-75 as well as TCOM® (low PIM cable), FBT® low loss, high power cables, and T-RAD™ leaky feeder cables. Also included in this latest edition are LMR-lite, LMR Bundled Cable, SilverLine and TuffGrip test cables.

Times Microwave Systems,
Wallingford, CT (203) 949-8400,
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RS No. 205

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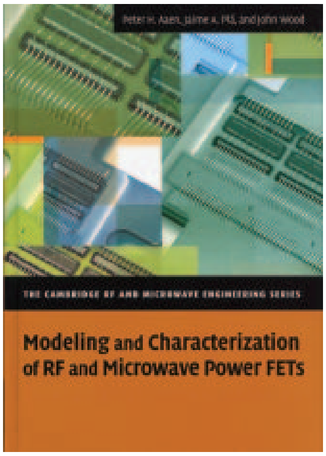

P.H. Aaen, J.A. Plá and J. Wood
377 pages; $99 • Cambridge University Press
ISBN: 978-0-521-87066-5

This book is about the modeling of RF power transistors, in particular field effect transistors or FETs. Characterization and measurement techniques, analysis and synthesis methods are described, as well as the model implementation in the simulator and validation techniques that are needed to produce a transistor model that can be used with confidence by the circuit designer.

The book starts by reviewing some of the historical developments in both applications and device technology that have resulted in transistor devices capable of delivering tens to hundred of watts at RF and microwave frequencies. The basics of FET operation are also reviewed, although the detailed physical principles are left to semiconductor device texts. Accurate measurements form the foundation of the model. Descriptions of how calibration and fixturing are used to ensure that repeatable and accurate measurements of the high power amplifier transistor are offered. The analysis and construction of the compact model are then described. The transistor is partitioned into passive and active components and the modeling of these elements is addressed in detail. The active transistor can then be accessed by de-embedding the package elements. A large-signal model of the FET can be constructed from DC and RF measurements. A number of techniques for measuring the static and dynamic thermal properties are described. Considerations on how the model can be constructed in the circuit simulator are given, using function approximations or data fitting techniques and how the model can be verified to work correctly. The model predictions are then compared with high power RF measurements, such as load-pull and large-signal network analyzers to validate the model accuracy and provide the circuit designers with confidence in its use.

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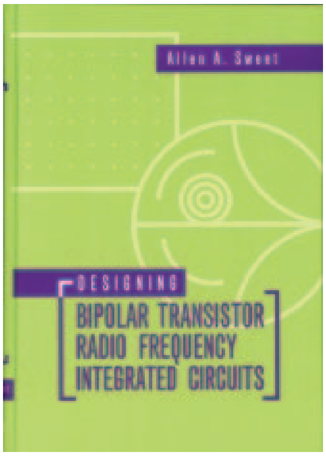
Designing Bipolar Transistor Radio Frequency Integrated Circuits



Allen A. Sweet
334 pages; $119, £66 • Artech House
ISBN: 978-1-59693-128-2

This practical resource offers engineers an in-depth and up-to-date understanding of bipolar transistor RFIC design. Unlike most books on the market that focus on GaAs MESFET or silicon CMOS process technology, this unique volume is dedicated exclusively to RFIC designs based on bipolar technology. Until now, critical GaAs HBT and SiGe HBT technologies have been largely neglected in reference books. This book fills this gap, providing a detailed treatment of this increasingly important topic. It is dedicated to equipping the circuit designer with all the necessary tools to be successful at RF/microwave RFIC designs, using HBT bipolar devices. Applications for RFICs, along with typical chip architectures for fulfilling the needs of these applications, are discussed in Chapters 2 and 3. Both InGaP/GaAs HBT and SiGe HBT technologies are presented in Chapters 4 and 5, in order to provide the process knowledge the designer needs to achieve their goals. Several design techniques for passive circuits are presented in Chapter 6. Amplifier design concepts are discussed, including specific approaches to the design of low-noise amplifiers (LNA), power amplifiers (PA) and wideband gain blocks, in Chapters 7 to 10. Following the amplifier design material, Chapter 11 covers mixer design and Chapter 12 concentrates on frequency multiplier design. The design of VCOs is covered in Chapter 13. Throughout Chapter 13, numerous VCO design examples are presented. Phase noise concepts are discussed in detail and examples of low-phase-noise designs are given. All designs are simulated using the Agilent Advanced Design System (ADS®) simulation tool set. The final two Chapters, 14 and 15, disclose, in a general way, the considerations that the designer must keep in mind when approaching the circuit layout, as well as economic considerations and how they affect many design decisions.

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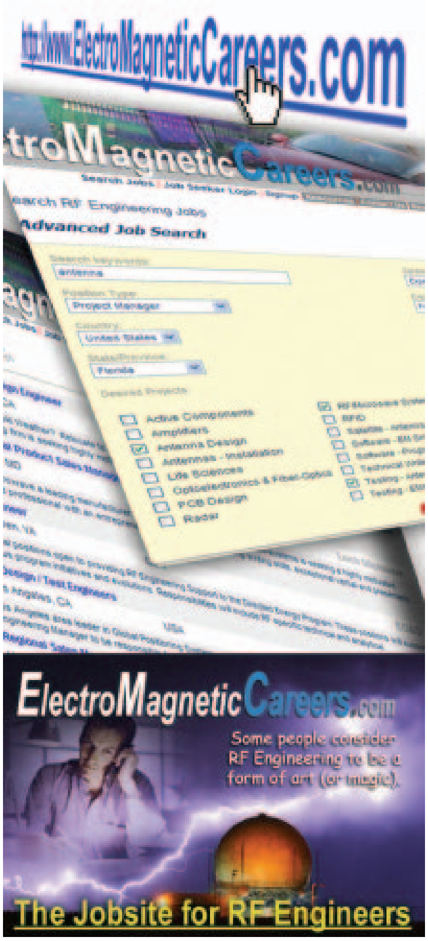

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Career Corner

About Job Market and Marketing RF/Microwave Engineering Part I

This article suggests ways in which information obtained from the job market can be used to complement or affirm other market research and lead generation efforts.

***Macro Level:* Job Market as a Sensor of the Industry and Its Markets**

Job markets are interrelated with their respective industries. Demand for technology expertise in B2B technology market segments reflects business and technology trends. The job market can therefore be used as a resource for business information, supporting strategy, marketing and sales.

***Industry Trends:* Applications and Technologies**

Variations in demand for engineering expertise identified with a technology or application are resulted from different causes, all of which are important indications of the marketplace. A growing number of companies engaging in a spreading technology, a technology approaching the end of its life cycle, or regional economy effects are only a few examples of related scenarios. Scanning online job postings for WiFi or RFID engineers, for example, you will find a perfect match to global trends in those industry sectors. On the other hand, try to fish for low-frequency, high power RF engineer and see what you will come up with.

***Market Trends:* Geography**

One can actually map-out worldwide technology and manufacturing centers by scanning international job boards for postings requiring matching engineering skills.

Observing international markets, we expect to find correlation between the job market and the business potential in that country. Regional shifts in demand typically relate to local factors and therefore present an opportunity or challenge needing attention. Attention to the specific engineering expertise in demand will indicate the state of an industry/technology sector in that region.

Scanning through international job boards, for example, brings up all those offshore destinations and regions currently experiencing industrial growth (e.g. India, China and Eastern Europe).

***Micro Level:* Job Postings as a Resource for Business Data**

A company's hiring activity reflects its ongoing business and where it is heading. Expansion in manufacturing, engineering or R&D activities result in job vacancies, most of which are posted online. Publicized job vacancies as well as engineer resumes can be used to explore business opportunities and prospects.

Identifying Prospects

Wouldn't you expect that companies hiring engineers matching the professional profile of your clients also need your product or service? Monitoring online job postings specifying requirements typical to your client engineers' roles and expertise will reveal untapped accounts (companies, potential customers).

"What is the Competition Engaged With?"

Observing competitors' recruiting ads gains insight into their technology and business activity. Occasionally this will confirm what is already known, but at times it might also expose strategy and unpublicized activities.

Conclusion

The concept described above is not a breakthrough. It is simple logic derived from observing related employment information posted online. *The breakthrough is in the availability of this data online for practical use.* Unlike earlier days, this approach can be exercised using internet research tools or services.

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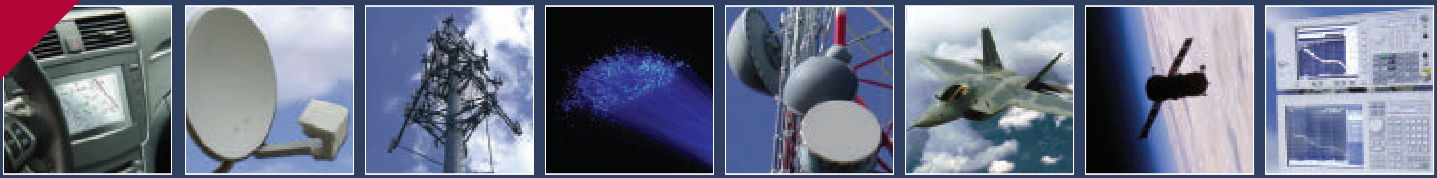

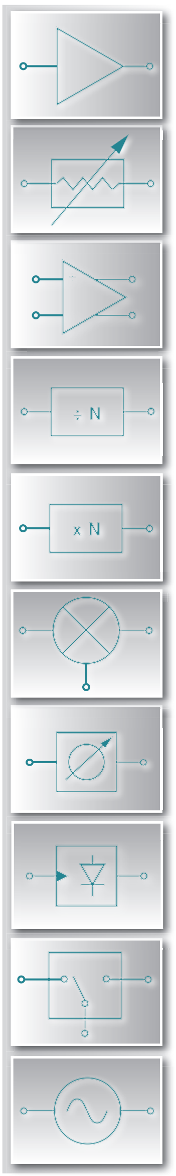

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MICROWAVE CORPORATION

June 2008

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
Low Noise Amplifiers								
DC - 20	Low Noise	14	29.5	2.5	17	+8V @ 75mA	LC5	HMC460LC5
0.175 - 0.66	Low Noise	24	37	0.5	19	+5V @ 90mA	LP3	HMC616LP3E
0.55 - 1.2	Low Noise	16	37	0.5	21	+5V @ 88mA	LP3	HMC617LP3E
1.7 - 2.2	Low Noise	19	36	0.75	20	+5V @ 117mA	LP3	HMC618LP3E
2.3 - 2.7	Low Noise	19	29	0.8	16	+5V @ 60mA	LP2	HMC667LP2E
4.8 - 6.0	Low Noise w/ Bypass	15	26	1.5	14	+5V @ 42mA	LP3	HMC604LP3E
18 - 31	Low Noise	15	23	3.5	11	+3V @ 75mA	LC4	HMC519LC4
Linear & Power Amplifiers								
0.05 - 3.0	High IP3	13	38	2.7	22	+5V @ 105mA	ST89	HMC639ST89E
0.2 - 4.0	High IP3	13	40	2.2	22	+5V @ 155mA	ST89	HMC636ST89E
27 - 32	Power Amplifier, 1 Watt	18.5	37	-	30	+5V @ 800mA	Chip	HMC693
Wideband (Distributed) Amplifiers								
DC - 6	Wideband PA	14	41	5	29.5	+12V @ 400mA	Chip	HMC637
DC - 15	Wideband PA	19	35	2.5	27.5	+8V @ 300mA	LC5	HMC659LC5
5 - 17	Wideband Driver	31	30	8	23	+5V @ 180mA	Chip	HMC633
5.5 - 17	Wideband Driver	30	30	8	23	+5V @ 180mA	LC4	HMC633LC4
5 - 20	Wideband Driver	22	31	7.5	23	+5V @ 180mA	Chip	HMC634
5 - 20	Wideband Driver	21	29	7.5	22	+5V @ 180mA	LC4	HMC634LC4
18 - 40	Wideband Driver	19.5	29	8	23	+5V @ 280mA	Chip	HMC635

AMPLIFIERS - *Transimpedance*

Operating Freq. (GHz)	Function	Transimpedance (kΩ)	Input Overload (mApp)	Bandwidth (GHz)	Deterministic Jitter (ps)	Noise (pA/√Hz)	Package	Part Number
1 - 10	10.7 Gbps Transimpedance	1.25	3	7.5	<20	11	Chip	HMC690

ATTENUATORS - *Analog & Digital*

Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	Part Number
DC - 6	4-Bit Digital Serial & Parallel Control	2.5	3 to 45	50	0 / +5V	LP4	HMC629LP4E
Connectorized Attenuator Modules							
DC - 20	Analog VVA	5.5	35	10	-5	C-10 Module	HMC-C053

FREQUENCY MULTIPLIERS - *Active*

Input Freq. (GHz)	Function	Output Freq. (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
11 - 23	Active x2	22 - 46	5	15	-	Chip	HMC598

DATA CONVERTERS - *High Speed Comparators*

Input Clock Rate (GHz)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power Consumption (mW)	Vcc, Vee Power Supply (Vdc)	Package	Part Number
9.7	Latched Comparator-RSPECL	10	130	0.4	180	+3.3, -3.0	LC3C	HMC674LC3C
9.7	Latched Comparator-RSCML	10	130	0.2	120	+3.3, -3.0	LC3C	HMC675LC3C
9.7	Latched Comparator-RSECL	10	130	0.4	120	+3.3, -3.0	LC3C	HMC676LC3C

HIGH SPEED DIGITAL LOGIC

Data / Clock Rate (Gbps/GHz)	Function	Rise / Fall (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vpp)	DC Power Consumption	Vee Power Supply (Vdc)	Package	Part Number
13	1:2 Fanout Buffer	22 / 20	<1	0.4 - 1.1	240	-3.3	LC3C	HMC670LC3C
13	XOR / XNOR	22 / 20	<1	0.4 - 1.1	180	-3.3	LC3C	HMC671LC3C
13	AND / NAND / OR / NOR	22 / 20	<1	0.4 - 1.1	180	-3.3	LC3C	HMC672LC3C
13	D-Flip-Flop	22 / 20	<1	0.4 - 1.1	210	-3.3	LC3C	HMC673LC3C

INTERFACE - *Drivers*

Bit Rate (mbps)	Function	Input	Output Voltage (V)	Output Current (mA)	Bias Supply	Package	Part Number
10	6-Bit Switch Driver / Controller	TTL/CMOS	-5 / +2.2	1	+5V @ 1.5mA	LP5	HMC677LP5E

MIXERS - *High IP3 Double Balanced and Downconverter Mixers*

RF Freq. (GHz)	Function	IF Freq. (GHz)	Conversion Gain (dB)	LO/RF Isol. (dB)	IIP3 (dBm)	Package	Part Number
0.7 - 1.0	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7	23	32	LP4	HMC684LP4E
0.7 - 1.1	High IP3, DBL-BAL, 0 LO	DC - 0.5	-7.5	24	34	LP4	HMC686LP4E

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MIXERS - *High IP3 Double Balanced and Downconverter Mixers*

RF Freq. (GHz)	Function	IF Freq. (GHz)	Conversion Gain (dB)	LO/RF Isol. (dB)	IIP3 (dBm)	Package	Part Number
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	30	35	LP4	HMC685LP4E
1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	31	34	LP4	HMC687LP4E
2.2 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	25	31	LP4	HMC688LP4E
2.2 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	26	31	LP4	HMC689LP4E
3.3 - 3.9	High IP3, DBL-BAL, 0 LO	DC - 0.6	-8.5	28	30	LP4	HMC666LP4E
4 - 12	High IP3, DBL-BAL	DC - 5	-7.7	45	29	Chip	HMC663
4 - 12	High IP3, DBL-BAL	DC - 5	-7.7	45	29	LC3	HMC663LC3
0.7 - 1.0	High IP3, Dual Downconverter	0.06 - 0.5	7.5	16	23	LP6C	HMC683LP6CE
0.7 - 1.2	Hi-IP3 Downconverter w/ RF Amplifier	0.05 - 1.0	28	32	2	LP4	HMC621LP4E
1.7 - 2.2	High IP3, Dual Downconverter	0.06 - 0.4	6	25	25	LP6C	HMC682LP6CE
1.7 - 2.4	Hi-IP3 Downconverter w/ RF Amplifier	0.05 - 1.0	29	30	6	LP4	HMC623LP4E
0.7 - 1.2	+3 LO, DBL-BAL	0.25 - 0.55	10	36	22	LP4	HMC665LP4E
1.8 - 3.9	+3 LO, DBL-BAL	0.2 - 0.55	9	33	23	LP4	HMC622LP4E
11 - 20	+13 LO, DBL-BAL	DC - 6	-7	43	18	C-11 Module	HMC-C051

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
0.4 - 4.0	Direct	22 / 48	DC - 700	-162	+5V @ 160 mA	LP4	HMC697LP4E

PASSIVES - *Fixed Attenuators*

Frequency (GHz)	Function	Attenuation Accuracy (dB)	Nominal Attenuation (dB)	Max Input Power (dBm)	Chip Size	Package	Part Number
DC - 25	Passive	±1.5	10	+25	N/A	LP2	HMC656LP2E
DC - 25	Passive	±2	15	+25	N/A	LP2	HMC657LP2E
DC - 25	Passive	±2	20	+25	N/A	LP2	HMC658LP2E

PLLs - *Fractional Synthesizers*

Frequency (GHz)	Function	Max. PFD Freq. Resolution (MHz) @ 3.3V +85°C	Max. Reference Freq. (MHz)	Figure of Merit @ 6 GHz (Frac / INT) (dBc/Hz)	Min. Freq. Resolution (Hz) @ 50 MHz PFD	Total Current Consumption (mA)	Package	Part Number
0.001 - 8.0	Fractional Synthesizer	100	200	-221 / -226	3	95	LP4	HMC700LP4E

POWER DETECTORS - *Log Detector / Controller, RMS Detector and SDLVA*

Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package	Part Number
50 Hz - 3 GHz	Log Detector / Controller	74 ±3	+19	-66	+3.3V @ 29mA	LP4	HMC612LP4E
0.001 - 10	Log Detector / Controller	73 ±3	-25	-65	+5V @ 103mA	Chip	HMC611
0.1 - 3.9	True RMS Detector w/ IPWR	71 ±1	37	-58	+5V @ 75mA	LP4	HMC614LP4E
0.1 - 20	SDLVA *	62	14	-57	+3.3V @ 83mA	LC4B	HMC613LC4B
1 - 20	SDLVA *	59	14	-67	+12V @ 86mA	C-10 Module	HMC-C052

* Successive Detection Log Video Amplifier

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
DC - 3	SDPT T/R	0.5	25	39	TTL/CMOS	MS8	HMC174MS8E
DC - 18	SP4T	2.1	42	24	0 / -5V	Chip	HMC641

SYNTHESIZERS

Frequency (GHz)	Function	Frequency Resolution (MHz)	1 GHz Max Power Output (dBm)	100 kHz SSB Phase Noise (dBc/Hz) @ 1 GHz	100 kHz SSB Phase Noise (dBc/Hz) @ 4 GHz	Spurious @ 1 GHz (dBC)	Switching Speed @100 MHz Steps	Part Number
0.7 - 8.0	Signal Generator	1	+17	-78 **@ 1 GHz**	-83 **@ 4 GHz**	-48	200	HMC-T2000

VARIABLE GAIN AMPLIFIERS - *Analog & Digital*

Frequency (GHz)	Function	Gain Control Range (dB)	NF * (dB)	OIP3 * (dBm)	P1dB (dBm)	Bias Supply	Package	Part Number
0.4 - 3.0	Analog	-25 to 20	5	40	23	+5V @ 265mA	LP5	HMC640LP5E
7 - 16	Analog	20	5.5	28	24	+5V @ 170mA	Chip	HMC694
0.03 - 0.4	5-Bit Digital w/ Differential Outputs	-4 to +19	4.8	40	25	+5V @ 240mA	LP4	HMC680LP4E
0.05 - 0.8	5-Bit Digital	-8 to 15	5	35	18	+5V @ 65mA	LP4	HMC628LP4E
DC - 1.0	6-Bit Digital, Serial Control	8.5 to 40	4	36	20	+5V @ 176mA	LP5	HMC681LP5E

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INTRODUCING THE JUNE 2008 SELECTION GUIDE!

Hittite Microwave Corporation is pleased to introduce our June 2008 Product Selection Guide summarizing over 625 products including 63 new products not included in Hittite's 2008 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, Fiber Optic, Military and Space. Full specifications for each product is available at www.hittite.com or a CD-ROM may be ordered.

AMPLIFIERS

	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
	Low Noise Amplifiers								
NEW!	DC - 20	Low Noise	14	29.5	2.5	17	+8V @ 75mA	LC5	HMC460LC5
	0.04 - 0.96	Low Noise, Dual Output	5	27	3.5	12	+5V @ 120mA	MS8G	HMC549MS8GE
NEW!	0.175 - 0.66	Low Noise	24	37	0.5	19	+5V @ 90mA	LP3	HMC616LP3E
	0.3 - 3.0	Low Noise, High IP3	15	37	1.5	22	+5V @ 90mA	SOT26	HMC374E
	0.35 - 0.55	Low Noise	17	38	1	21	+5V @ 104mA	LP3	HMC356LP3E
NEW!	0.55 - 1.2	Low Noise	16	37	0.5	21	+5V @ 88mA	LP5	HMC617LP3E
	0.7 - 1.0	Low Noise	15	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 - 12	Low Noise	17	28	1.5	19	+5V @ 55mA	Chip	HMC-ALH444
	1.2 - 3.0	Low Noise	26	21	1.3	11.5	+5V @ 21mA	LP3	HMC548LP3E
	1.7 - 2.2	Low Noise	17	34	0.9	18	+5V @ 136mA	LP3	HMC375LP3E
	1.7 - 2.2	Low Noise	17	30	1	16	+5V @ 67mA	LP3	HMC382LP3E
NEW!	1.7 - 2.2	Low Noise	19	36	0.75	20	+5V @ 117mA	LP3	HMC618LP3E
	2 - 4	Low Noise	10	36	2.6	21	+6V @ 100mA	Chip	HMC594
	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	36.5	3.5	21.5	+6V @ 170mA	LC4	HMC609LC4
	2 - 22	Low Noise	16	-	1.7	14	+4V @ 45mA	Chip	HMC-ALH482
	2.3 - 2.5	Low Noise	19	12	1.7	6	+3V @ 8.5mA	SOT26	HMC286E
	2.3 - 2.5	Low Noise	21	7	2.5	3	+3V @ 9mA	MS8	HMC287MS8E
NEW!	2.3 - 2.7	Low Noise	19	29	0.8	16	+5V @ 60mA	LP2	HMC667LP2E
	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
	3.3 - 3.8	Low Noise w/ Bypass	19	29	1.2	16	+5V @ 40mA	LP3	HMC593LP3E
	3.4 - 3.8	Low Noise w/ Bypass	16	18	2	7	+3V @ 9mA	LP3	HMC491LP3E
	3.5 - 7.0	Low Noise	15.5	28	2.4	16	+5V @ 50mA	Chip	HMC392
	3.5 - 7.0	Low Noise	16	30	2.5	16	+5V @ 55mA	LC4	HMC392LC4
	3.5 - 7.0	Low Noise	15	28	3	16	+5V @ 65mA	LH5	HMC392LH5
NEW!	4.8 - 6.0	Low Noise w/ Bypass	15	26	1.5	14	+5V @ 42mA	LP3	HMC604LP3E
	5 - 6	Low Noise	9	13	2.5	2	+3V @ 6mA	MS8G	HMC318MS8GE
	5 - 6	Low Noise	12	10	2.5	9	+3V @ 25mA	MS8G	HMC320MS8GE
	5 - 20	Low Noise	13	26	2.2	16	+5V @ 30mA	Chip	HMC-ALH435
	6 - 20	Low Noise	22	20	2.3	10	+3V @ 53mA	Chip	HMC565
	6 - 20	Low Noise	21	20	2.5	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

SELECTION GUIDE BY PRODUCT

AMPLIFIERS

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
9 - 18	Low Noise	20	25	2	14	+3V @ 65mA	LC5	HMC516LC5
12 - 16	Medium Power LNA	23	34	2.5	25	+5V @ 200mA	LP5	HMC490LP5E
12 - 17	Medium Power LNA	27	35	2	26	+5V @ 200mA	Chip	HMC490
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
14 - 27	Low Noise	18	-	2.5	14	+4V @ 90mA	Chip	HMC-ALH216
14 - 27	Low Noise	20	-	2	14	+4V @ 90mA	Chip	HMC-ALH476
17 - 26	Low Noise	19	23	2.2	11	+3V @ 65mA	Chip	HMC517
17 - 26	Low Noise	19	23	2.5	13	+3V @ 67mA	LC4	HMC517LC4
18 - 32	Low Noise	15	23	2.8	12	+3V @ 65mA	Chip	HMC519
NEW! 18 - 31	Low Noise	15	23	3.5	11	+3V @ 75mA	LC4	HMC519LC4
18 - 40	Low Noise	10	-	3.9	12	+5V @ 45mA	Chip	HMC-ALH445
20 - 32	Low Noise	15	23	3	12	+3V @ 65mA	Chip	HMC518
21 - 29	Low Noise	13	19	2.5	8	+3V @ 35mA	LC3B	HMC341LC3B
22 - 26.5	Low Noise	25	-	3	12	+2.5V @ 52mA	Chip	HMC-ALH311
24 - 30	Low Noise	13	16	2.5	6	+3V @ 30mA	Chip	HMC341
24 - 32	Low Noise	21	-	2	7	+5V @ 68mA	Chip	HMC-ALH364
24 - 36	Low Noise	23	17	2	8	+3V @ 58mA	Chip	HMC263
24 - 40	Low Noise	12	-	3.5	13	+4V @ 45mA	Chip	HMC-ALH244
24 - 40	Low Noise	22	-	2	11	+5V @ 66mA	Chip	HMC-ALH369
24 - 40	Low Noise	11.5	-	4	15	+4V @ 60mA	Chip	HMC-ALH140
27 - 33	Low Noise	20	-	3	12	+2.5V @ 52mA	Chip	HMC-ALH313
29 - 36	Low Noise	20	23.5	2.8	12	+3V @ 80mA	Chip	HMC566
35 - 45	Low Noise	16	-	2	6	+4V @ 87mA	Chip	HMC-ALH376
37 - 42	Low Noise	22	-	3.5	12	+2.5V @ 52mA	Chip	HMC-ALH310
57 - 65	Low Noise	21	-	4	12	+2.5V @ 64mA	Chip	HMC-ALH382
71 - 86	Low Noise	14	-	4.5	7	+2.4V @ 30mA	Chip	HMC-ALH459
71 - 86	Low Noise	14	-	5	7	+2V @ 50mA	Chip	HMC-ALH509
***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	15	20	3	8	+3V @ 25mA	SC70	HMC474SC70E
DC - 6	SiGe Gain Block	20	25	2.5	12	+5V @ 35mA	MP86	HMC476MP86E
DC - 6	SiGe Gain Block	19	24	2.5	12	+5V @ 35mA	SC70	HMC476SC70E
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	32	4.5	15	+5V @ 56mA	LP3	HMC311LP3E
DC - 8	HBT Gain Block	15	30	5	15	+5V @ 54mA	SC70	HMC311SC70E
DC - 6	HBT Gain Block	16	31.5	4.5	15.5	+5V @ 54mA	ST89	HMC311ST89E
DC - 4	SiGe Gain Block	22	32	2	18	+5V @ 62mA	MP86	HMC478MP86E
DC - 4	SiGe Gain Block	24	31	2.5	16	+5V @ 62mA	SC70	HMC478SC70E
DC - 4	SiGe Gain Block	22	33	3	18	+5V @ 62mA	ST89	HMC478ST89E
DC - 5	SiGe Gain Block	15	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
DC - 4	HBT Gain Block	21	33	4	21	+5V @ 82mA	ST89	HMC589ST89E

AMPLIFIERS

	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
	DC - 1	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
	17.5 - 41	Driver	21	27	-	20	+5V @ 295mA	Chip	HMC-AUH256
	Linear & Power Amplifiers								
NEW!	0.05 - 3.0	High IP3 Amp	13	38	2.7	22	+5V @ 105mA	ST89	HMC639ST89E
NEW!	0.2 - 4.0	High IP3 Amp	13	40	2.2	22	+5V @ 155mA	ST89	HMC636ST89E
	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 Amplifier	26	40	8	26	+4V @ 310mA	QS16G	HMC450QS16GE
	1.6 - 2.2	Medium Power Amplifier	22	40	5.5	27	+3.6V @ 270mA	QS16G	HMC413QS16GE
	4.9 - 5.9	Medium Power Amplifier	20	32	6	23	+3V @ 285mA	LP3	HMC415LP3E
	5 - 6	Medium Power Amplifier	18	38	6	26	+5V @ 300mA	MS8G	HMC406MS8GE
	5 - 7	Medium Power Amplifier	15	40	5.5	25	+5V @ 230mA	MS8G	HMC407MS8GE
	5 - 20	Medium Power Amplifier	22	30	6.5	20	+5V @ 127mA	Chip	HMC451
	5 - 20	Medium Power Amplifier	19	30	7	19	+5V @ 114mA	LC3	HMC451LC3
	6 - 18	Medium Power Amplifier	15.5	32	4.5	20	+5V @ 95mA	Chip	HMC441
	6 - 18	Medium Power Amplifier	17	32	4.5	20	+5V @ 95mA	LC3B	HMC441LC3B
	6.5 - 13.5	Medium Power Amplifier	14	29	4.5	18	+5V @ 95mA	LP3	HMC441LP3E
	7 - 15.5	Medium Power Amplifier	15	32	4.8	20	+5V @ 95mA	LH5 Hermetic	HMC441LH5
	7 - 15.5	Medium Power Amplifier	15	30	4.5	19	+5V @ 90mA	LM1	HMC441LM1
	9.5 - 11.5	Medium Power Amplifier	32	33	5.5	27	+5V @ 310mA	Chip	HMC608
	9.5 - 11.5	Medium Power Amplifier	29.5	33	6	27	+5V @ 310mA	LC4	HMC608LC4
	12 - 30	Medium Power Amplifier	16	25	7	16	+5V @ 101mA	Chip	HMC383
	12 - 30	Medium Power Amplifier	15	25	7.5	16.5	+5V @ 100mA	LC4	HMC383LC4
	16 - 33	Medium Power Amplifier	17	33	-	24	+5V @ 400mA	Chip	HMC-APH596
	17 - 24	Medium Power Amplifier	24	34	4	25	+5V @ 250mA	Chip	HMC498
	17 - 24	Medium Power Amplifier	22	36	4	25	+5V @ 250mA	LC4	HMC498LC4
	17 - 30	Medium Power Amplifier	20	31	-	22	+4.5V @ 400mA	Chip	HMC-APH196
	17 - 40	Medium Power Amplifier	21	26	10	18	+3.5V @ 300mA	Chip	HMC283
	17 - 40	Medium Power Amplifier	20	27	10	18	+3.5V @ 300mA	LM1	HMC283LM1
	17.5 - 24	Medium Power Amplifier	14	28	6.5	21.5	+5V @ 85mA	LM1	HMC442LM1
	17.5 - 25.5	Medium Power Amplifier	13	27	8	22	+5V @ 84mA	LC3B	HMC442LC3B
	17.5 - 25.5	Medium Power Amplifier	15	28	5.5	22	+5V @ 85mA	Chip	HMC442
	21 - 32	Medium Power Amplifier	16	33	5	24	+5V @ 200mA	Chip	HMC499
	21 - 32	Medium Power Amplifier	17	34	5	23	+5V @ 200mA	LC4	HMC499LC4
	37 - 40	Medium Power Amplifier	20	35	-	26	+5V @ 640mA	Chip	HMC-APH510
	37 - 45	Medium Power Amplifier	21	32	-	23	+5V @ 475mA	Chip	HMC-APH403
	50 - 66	Medium Power Amplifier	24	25	-	17	+5V @ 220mA	Chip	HMC-ABH241
	55 - 65	Medium Power Amplifier	13	25	-	16	+5V @ 80mA	Chip	HMC-ABH209
	71 - 76	Medium Power Amplifier	24	-	-	17.5	+4V @ 130mA	Chip	HMC-AUH318
	71 - 76	Medium Power Amplifier	12	-	-	-	+4V @ 240mA	Chip	HMC-APH633
	71 - 86	Medium Power Amplifier	15	-	-	15	+4V @ 130mA	Chip	HMC-AUH320
	81 - 86	Medium Power Amplifier	22	-	-	17.5	+4V @ 160mA	Chip	HMC-AUH317
	0.4 - 2.2	Power Amplifier, 1 Watt	21	49	6.5	30	+5V @ 510mA	ST89	HMC452ST89E

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Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
0.4 - 2.2	Power Amplifier, 1.6 Watt	20.5	49	6.5	32	+5V @ 725mA	ST89	HMC453ST89E
0.45 - 2.2	Power Amplifier, 1 Watt	22.5	48	7	30	+5V @ 485mA	QS16G	HMC452QS16GE
0.45 - 2.2	Power Amplifier, 1.6 Watt	21.5	51	6.5	33	+5V @ 725mA	QS16G	HMC453QS16GE
1.7 - 2.2	Power Amplifier, 1 Watt	27	46	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
6 - 9.5	Power Amplifier, 1 Watt	21	40	-	30.5	+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	-	31.5	+7V @ 820mA	Chip	HMC590
6 - 10	Power Amplifier, 2 Watt	23	43	-	33.5	+7V @ 1340mA	Chip	HMC591
7 - 9	Power Amplifier, 2 Watt	26	40	6.5	33.5	+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
10 - 13	Power Amplifier, 1 Watt	19	38	-	31	+7V @ 750mA	Chip	HMC592
12 - 16	Power Amplifier, 1 Watt	13	34	9	31	+7V @ 1.3A	LP5	HMC489LP5E
15 - 27	Power Amplifier, 1 Watt	17	37	-	29	+5V @ 1.44A	Chip	HMC-APH462
18 - 20	Power Amplifier, 1 Watt	17.5	38.5	-	30	+5V @ 900mA	Chip	HMC-APH478
21 - 24	Power Amplifier, 1 Watt	17	39	-	30.5	+5V @ 950mA	Chip	HMC-APH518
24 - 26.5	Power Amplifier, 1 Watt	17	38	-	30	+5V @ 950mA	Chip	HMC-APH608
27 - 31.5	Power Amplifier, 1 Watt	14	37	-	28	+5V @ 900mA	Chip	HMC-APH460
NEW! 27 - 32	Power Amplifier, 1 Watt	18.5	37	-	30	+5V @ 800mA	Chip	HMC693
37 - 40	Power Amplifier, 1 Watt	15	37	-	28	+5V @ 1.08A	Chip	HMC-APH473

Wideband (Distributed) Amplifiers

Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
DC - 20	Wideband LNA	14	28	2.5	16	+8V @ 60mA	Chip	HMC460
2 - 20	Wideband LNA	15.5	26.5	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	19	+5V @ 60mA	Chip	HMC463
2 - 20	Wideband LNA w/AGC	13	26	3	18	+5V @ 60mA	LP5	HMC463LP5E
2 - 20	Wideband LNA w/AGC	14	28	2.5	18	+5V @ 60mA	LH250	HMC463LH250
2 - 20	Wideband LNA	10	-	3.5	10	+2V @ 55mA	Chip	HMC-ALH102
2 - 18	Wideband, Low Phase Noise	14	27	4.5	15	+5V @ 64mA	Chip	HMC606
2 - 18	Wideband, Low Phase Noise	13.5	27	7	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	12.5	27	3	18	+8V @ 80mA	Chip	HMC562
NEW! 5 - 17	Wideband Driver	31	30	8	23	+5V @ 180mA	Chip	HMC633
NEW! 5.5 - 17	Wideband Driver	30	30	8	23	+5V @ 180mA	LC4	HMC633LC4
NEW! 5 - 20	Wideband Driver	22	31	7.5	23	+5V @ 180mA	Chip	HMC634
NEW! 5 - 20	Wideband Driver	21	29	7.5	22	+5V @ 180mA	LC4	HMC634LC4
NEW! 18 - 40	Wideband Driver	19.5	29	8	23	+5V @ 280mA	Chip	HMC635
NEW! DC - 6	Wideband PA	14	45	-	30	+12V @ 400mA	Chip	HMC637
DC - 10	Wideband PA	12	41	6	28.5	+12V @ 300mA	Chip	HMC619
DC - 10	Wideband PA	12	41	6	28	+12V @ 300mA	LP5	HMC619LP5E
DC - 15	Wideband PA	19	35	2	26.5	+8V @ 300mA	Chip	HMC659

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	Frequency (GHz)	Function	Gain (dB)	OIP3 (dBm)	NF (dB)	P1dB (dBm)	Bias Supply	Package	Part Number
NEW!	DC - 15	Wideband PA	19	35	2.5	27.5	+8V @ 300mA	LC5	HMC659LC5
	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								
	1.8 - 4.2	Low Noise	26	26	0.7	15.5	+12V @ 112mA	C-10 Module	HMC-C045
	5 - 9	Low Noise	24	25	1.4	15	+12V @ 105mA	C-10 Module	HMC-C048
	29 - 36	Low Noise	20	22	2.9	11	+3V @ 80mA	C-10 Module	HMC-C027
	2 - 18	Wideband LNA	14	27	4.5	15	+12V @ 60mA	C-1 Module	HMC-C050
	2 - 20	Wideband LNA	15	25	2.5	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	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 - 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	12	29	3	18	+11V @ 92mA	C-10 Module	HMC-C038
	0.01 - 15	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-10B Module	HMC-C036
	0.01 - 15	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	15	34	4	26	+12V @ 310mA	C-2B Module	HMC-C023
	2 - 20	Wideband PA	31	33	3	26	+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

AMPLIFIERS - *Microwave & Optical Drivers*

Frequency (GHz)	Function	Gain (dB)	Group Variation Delay (pS)	Additive Jitter (pS)	P1dB (dBm)	Output Voltage Level (V-p-p)	Package	Part Number
DC - 35	Wideband Driver	15	±10	-	21	8	AUH249	HMC-AUH249
DC - 43	Wideband Driver	14	±10	0.4	16.5	8	AUH232	HMC-AUH232
0.5 - 65	Wideband Driver	10	-	-	-	2.5	AUH312	HMC-AUH312

AMPLIFIERS - *Transimpedance*

	Operating Frequency (GHz)	Function	Transimpedance (kΩ)	Input Overload (mApp)	Bandwidth (GHz)	Deterministic Jitter (ps)	Noise (pA/√ Hz)	Package	Part Number
NEW!	1 - 10	10.7 Gbps Transimpedance	1.25	3	7.5	<20	11	Chip	HMC690

ATTENUATORS

Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (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

ATTENUATORS

	Frequency (GHz)	Function	Insertion Loss (dB)	Attenuation Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	Part Number
	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
	17 - 27	Analog VVA	1.5	0 to 22	17	-4 / +4	Chip	HMC-VVD102
	36 - 50	Analog VVA	1.5	0 to 22	17	0 / +4	Chip	HMC-VVD106
	70 - 86	Analog VVA	2	0 to 14	-	-5 / +5	Chip	HMC-VVD104
	Attenuators - Digital							
	DC - 5	1-Bit Digital	1	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	50	TTL/CMOS	LP3	HMC540LP3E
NEW!	DC - 6	4-Bit Digital Serial & Parallel Control	2.5	3 to 45	50	0 / +5V	LP4	HMC629LP4E
	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 - 3.8	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 - 3.8	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 - 6	6-Bit Digital Serial & Parallel Control	1.8	31.5	55	0 / +5V	LP4	HMC624LP4E
	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
	Connectorized Attenuator Modules							
NEW!	DC - 20	Analog VVA	5.5	35	10	-5	C-10 Module	HMC-C053
	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 Frequency (GHz)	Function	Single Tone THD/SFDR (dB)	Maximum 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

DATA CONVERTERS - High Speed Comparators

	Input Clock Rate (GHz)	Function	Deterministic Jitter (ps)	Propagation Delay (ps)	Output Voltage Swing (Vdc)	DC Power Consumption (mW)	Vcc, Vee Power Supply (Vdc)	Package	Part Number
NEW!	9.7	Latched Comparator-RSPECL	10	130	0.4	180	+3.3, -3.0	LC3C	HMC674LC3C
NEW!	9.7	Latched Comparator-RSCML	10	130	0.2	120	+3.3, -3.0	LC3C	HMC675LC3C
NEW!	9.7	Latched Comparator-RSECL	10	130	0.4	120	+3.3, -3.0	LC3C	HMC676LC3C

FREQUENCY DIVIDERS (PRESCALERS) & PHASE / FREQUENCY DETECTORS

Input Frequency (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	3	-148	+5V @ 83mA	S8G	HMC361S8GE
DC - 11	Divide-by-2	-15 to +10	3	-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	-153	+5V @ 69mA	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	-6	-149	+5V @ 68mA	Chip	HMC362
DC - 12	Divide-by-4	-15 to +10	-6	-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	-153	+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
0.5 - 8	Divide-by-5	-15 to +10	-1	-155	+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
0.5 - 17	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 Frequency (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
3 - 4	Active x2	6 - 9	0	17	-140	LP4	HMC575LP4E
4.0 - 10.5	Active x2	8 - 21	5	17	-139	Chip	HMC561
4.0 - 10.5	Active x2	8 - 21	5	14	-139	LP3	HMC561LP3E
4 - 11	Active x2	8 - 22	5	12	-134	LC3B	HMC573LC3B
4.5 - 8.0	Active x2	9 - 16	2	15	-140	LP4	HMC368LP4E

FREQUENCY MULTIPLIERS - *Active*

	Input Frequency (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
	4.95 - 6.35	Active x2	9.9 - 12.7	0	4	-142	LP3	HMC369LP3E
	9.0 - 14.5	Active x2	18 - 29	3	17	-132	Chip	HMC576
	9.0 - 14.5	Active x2	18 - 29	3	15	-132	LC3B	HMC576LC3B
	9.5 - 12.5	Active x2	19 - 25	0	11	-135	Chip	HMC448
	10.0 - 12.5	Active x2	20 - 25	0	11	-135	LC3B	HMC448LC3B
NEW!	11 - 23	Active x2	22 - 46	5	15	-	Chip	HMC598
	12.0 - 16.5	Active x2	24 - 33	3	17	-132	Chip	HMC578
	12.0 - 16.5	Active x2	24 - 33	3	15	-132	LC3B	HMC578LC3B
	13.5 - 15.5	Active x2	27 - 31	0	9	-132	LC3B	HMC449LC3B
	13.5 - 15.5	Active x2	27 - 31	5	20	-128	LC4B	HMC577LC4B
	13.5 - 16.5	Active x2	27 - 33	0	10	-132	Chip	HMC449
	16 - 23	Active x2	32 - 46	3	13	-127	Chip	HMC579
	2.45 - 2.8	Active x4	9.8 - 11.2	-15	3	-142	LP4	HMC443LP4E
	3.6 - 4.1	Active x4	14.4 - 16.4	-15	0	-140	LP4	HMC370LP4E
	14 - 16	Active x4	56 - 64	2	-6	-	Chip	HMC-XDH158
	1.2375 - 1.4	Active x8	9.9 - 11.2	-15	6	-136	LP4	HMC444LP4E
	0.61875 - 0.6875	Active x16	9.9 - 11	-15	7	-130	LP4	HMC445LP4E

Connectorized Frequency Multiplier Modules

Input Frequency (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
3 - 5	Active x2	6 - 10	3	17	-140	C-10 Module	HMC-C031
9.0 - 14.5	Active x2	18 - 29	3	16	-132	C-10 Module	HMC-C032
12.0 - 16.5	Active x2	24 - 33	3	17	-132	C-10 Module	HMC-C033
16 - 23	Active x2	32 - 46	3	13	-130	C-10 Module	HMC-C034

FREQUENCY MULTIPLIERS - *Passive*

Input Frequency (GHz)	Function	Output Frequency (GHz)	Conversion 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	1.7 - 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
10 - 15	x2 Passive	20 - 30	13	30	+13	Chip	HMC-XDB112
12 - 18	x2 Passive	24 - 36	-14	50 / 60	11 to 15	Chip	HMC331
24 - 30	x3 Passive	72 - 90	19	-	+13	Chip	HMC-XTB106

HIGH SPEED DIGITAL LOGIC - *New Product Line!*

	Data / Clock Rate (Gbps / GHz)	Function	Rise / Fall Time (ps)	Deterministic Jitter (ps)	Differential Output Voltage Swing (Vpp)	DC Power Consumption (mW)	Vee Power Supply (Vdc)	Package	Part Number
NEW!	13	1:2 Fanout Buffer	22 / 20	<1	0.4 - 1.1	240	-3.3	LC3C	HMC670LC3C
NEW!	13	XOR / XNOR	22 / 20	<1	0.4 - 1.1	180	-3.3	LC3C	HMC671LC3C
NEW!	13	AND / NAND / OR / NOR	22 / 20	<1	0.4 - 1.1	180	-3.3	LC3C	HMC672LC3C
NEW!	13	D Flip-Flop	22 / 20	<1	0.4 - 1.1	210	-3.3	LC3C	HMC673LC3C

SELECTION GUIDE BY PRODUCT

INTERFACE - Drivers

	Bit Rate (mbps)	Function	Input	Output Voltage (V)	Output Current (mA)	Bias Supply	Package	Part Number
NEW!	10	6-Bit Switch Driver / Controller	TTL/CMOS	-5 / +2.2	1	+5V @ 1.5mA	LP5	HMC677LP5E

I/Q MIXERS / IRMs & I/Q RECEIVERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	IIP3 (dBm)	Package	Part Number
I/Q Mixers / IRMs							
1.7 - 4.5	I/Q Mixer / IRM	DC - 1.5	-8	-	23	LP5	HMC340LP5E
3 - 7	I/Q Mixer / IRM	DC - 3.5	-7.5	33	23	Chip	HMC620
3 - 7	I/Q Mixer / IRM	DC - 3.5	-7.5	32	22	LC4	HMC620LC4
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
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
19 - 33	I/Q Mixer / IRM	DC - 5	-8	25	17	Chip	HMC-MDB172
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
35 - 45	I/Q Mixer / IRM	DC - 5	-8	25	17	Chip	HMC-MDB171
36 - 41	I/Q Mixer / IRM	DC - 3.5	-11	18	23	Chip	HMC556
55 - 64	I/Q Mixer / IRM	DC - 3	-9	30	16	Chip	HMC-MDB207
26 - 33 RF	Sub-Harmonic I/Q Mixer / IRM	DC - 3	-11	22	16	Chip	HMC404
54 - 64	Sub-Harmonic I/Q Mixer / IRM	DC - 3	-12.5	30	7	Chip	HMC-MDB218
Connectorized I/Q Mixer Modules							
4 - 8.5	I/Q Mixer	DC - 3.5	-7.5	35	23	C-4 Module	HMC-C009
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
20 - 31	I/Q Mixer / IRM	DC - 4.5	-10	24	22.5	C-4B	HMC-C046
30 - 38	I/Q Mixer / IRM	DC - 3.5	-10.5	15	19	C-4B	HMC-C047
I/Q Receivers							
7 - 9	I/Q Receiver	DC - 3.5	10	35	1.5	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	-0.5	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

I/Q MIXERS / IRMs & I/Q RECEIVERS

RF / LO Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Image Rejection (dB)	IIP3 (dBm)	Package	Part Number
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	18	5	LC5	HMC572LC5

MIXERS

	RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isol. (dB)	IIP3 (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 - 1.0	High IP3, SGL-END	DC - 0.25	-8.5	24	35	MS8	HMC399MS8E
NEW!	0.7 - 1.0	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7	23	32	LP4	HMC684LP4E
NEW!	0.7 - 1.1	High IP3, DBL-BAL, 0 LO	DC - 0.5	-7.5	24	34	LP4	HMC686LP4E
	0.7 - 1.2	High IP3, DBL-BAL	DC - 0.3	-9	42	25	S8	HMC351S8E
	0.7 - 1.4	High IP3, 0 LO	DC - 0.35	-9	20	33	MS8G	HMC483MS8GE
	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	9	35	MS8G	HMC485MS8GE
NEW!	1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	30	35	LP4	HMC685LP4E
NEW!	1.7 - 2.2	High IP3, DBL-BAL, 0 LO	DC - 0.5	-8	31	34	LP4	HMC687LP4E
	1.7 - 3.0	High IP3, SGL-BAL	DC - 0.8	-9	30	30	MS8	HMC304MS8E
	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!	2.2 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	25	31	LP4	HMC688LP4E
NEW!	2.2 - 2.7	High IP3, DBL-BAL, 0 LO	DC - 0.45	-7.5	26	31	LP4	HMC689LP4E
	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
NEW!	3.3 - 3.9	High IP3, DBL-BAL, 0 LO	DC - 0.6	-8.5	28	30	LP4	HMC666LP4E
NEW!	4 - 12	High IP3, DBL-BAL	DC - 5	-7.7	45	29	Chip	HMC663
NEW!	4 - 12	High IP3, DBL-BAL	DC - 5	-7.7	45	29	LC3	HMC633LC3
	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
NEW!	0.7 - 1.0	High IP3, Dual Downconverter	0.06 - 0.5	7.5	16	23	LP6C	HMC683LP6CE
NEW!	0.7 - 1.2	Hi-IP3 Downconverter w/RF Amplifier	0.05 - 1.0	28	32	2	LP4	HMC621LP4E
	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
	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
NEW!	1.7 - 2.2	Hi-IP3, Dual Downconverter	0.06 - 0.4	6	25	25	LP6C	HMC682LP6CE
NEW!	1.7 - 2.4	Hi-IP3 Downconverter w/RF Amplifier	0.05 - 1.0	29	30	6	LP4	HMC623LP4E
	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

MIXERS

	RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isol. (dB)	IIP3 (dBm)	Package	Part Number
NEW!	0.7 - 1.2	+3 LO, DBL-BAL	0.25 - 0.55	10	36	22	LP4	HMC665LP4E
NEW!	1.8 - 3.9	+3 LO, DBL-BAL	0.2 - 0.55	9	33	23	LP4	HMC622LP4E
	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	30	18	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	40	21	LC3B	HMC292LC3B
	17 - 31	+13 LO, DBL-BAL	DC - 6	-8	32	19	LM3C	HMC292LM3C
	18 - 32	+13 LO, DBL-BAL	DC - 8	-7.5	38	19	Chip	HMC292
	24 - 32	+13 LO, DBL-BAL	DC - 8	-10	38	19	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
	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
	54 - 64	+13 LO, DBL-BAL	DC - 5	-8	30	13	Chip	HMC-MDB169
+15 to +20 dBm LO Double & Single Balanced Mixers								
	2.5 - 7	+15 LO, DBL-BAL	DC - 3	-7	48	22	Chip	HMC557
	2.5 - 7	+15 LO, DBL-BAL	DC - 3	-7	48	22	LC4	HMC557LC4
	70 - 90	+14 LO, DBL-BAL	DC - 18	-12	-	-	Chip	HMC-MDB277
	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	-10	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	-8	30	18	G8 Hermetic	HMC129G8
	4 - 8	+15 LO, DBL-BAL	DC - 3	-7	40	17	LC4	HMC129LC4
	5.5 - 14	+15 LO, DBL-BAL	DC - 6	-7	45	24	Chip	HMC558
	5.5 - 14	+15 LO, DBL-BAL	DC - 6	-7	45	24	LC3B	HMC558LC3B

MIXERS

RF Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	LO / RF Isol. (dB)	IIP3 (dBm)	Package	Part Number
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	25	Chip	HMC143 / 144
6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	23	LC4	HMC144LC4
6 - 20	+20 LO, DBL-BAL	DC - 3	-10	35	24	LH5 Hermetic	HMC144LH5
Sub-Harmonic Mixers							
14 - 20	Sub-Harmonic	DC - 3	-10	40	7	LM3	HMC258LM3
14 - 21	Sub-Harmonic	DC - 3	-10	40	7	Chip	HMC258
14.5 - 19.5	Sub-Harmonic	DC - 3.5	-10	45	5	LC3B	HMC258LC3B
17 - 25	Sub-Harmonic	DC - 3	-9	25 - 30	10	Chip	HMC337
20 - 30	Sub-Harmonic	DC - 6	-10	40	13	Chip	HMC264
21 - 31	Sub-Harmonic	DC - 6	-9	40	13	LC3B	HMC264LC3B
20 - 30	Sub-Harmonic	DC - 4	-9	30	10	LM3	HMC264LM3
20 - 31	Sub-Harmonic	0.7 - 3.0	3	28	8	LM3	HMC265LM3
20 - 32	Sub-Harmonic	0.7 - 3.0	3	20 - 40	10	Chip	HMC265
20 - 40	Sub-Harmonic	1 - 3	-12	24	13	Chip	HMC266
24 - 34	Sub-Harmonic	DC - 3	-11	33	13	LC3B	HMC338LC3B
26 - 33	Sub-Harmonic	DC - 2.5	-9	33	11	Chip	HMC338
33 - 42	Sub-Harmonic	DC - 3	-10	37	10	Chip	HMC339
Connectorized Mixer Modules							
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	35	19	C-11 Module	HMC-C014
24 - 38	+13 LO, DBL-BAL	DC - 8	-8.5	35	20	C-11 Module	HMC-C015
NEW! 11 - 20	+13 LO, DBL-BAL	DC - 6	-7	43	18	C-11 Module	HMC-C051

DEMODULATORS - *I/Q Demodulator*

Input Frequency (GHz)	Function	IF Frequency (GHz)	Conversion Gain (dB)	Noise Figure (dB)	IIP3 / IIP2 (dBm)	Package	Part Number
0.1 - 4.0	I/Q Demodulator	DC - 0.6	-3.5	15	+25 / +60	LP4	HMC597LP4E

MODULATORS - *Bi-Phase Modulator*

Input Frequency (GHz)	Function	Loss (dB)	Amp / Phase Balance (dB/Deg)	Carrier Supression (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 Frequency (GHz)	Function	OIP3 (dBm) / Carrier Supression (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
NEW! 0.4 - 4.0	Direct	22 / 48	DC - 700	-162	+5V @ 160mA	LP4	HMC697LP4E
4 - 7	Direct	17 / 34	DC - 250	-157	+3V @ 93mA	LP3	HMC496LP3E

SELECTION GUIDE BY PRODUCT

MODULATORS - *Vector Modulators*

Frequency (GHz)	Function	Gain Range (dB)	Continuous Phase Control (deg)	IP3 / Noise Floor (Ratio)	IIP3 @ Max. Gain (dBm)	Package	Part Number
0.7 - 1.0	Vector	-50 to -10	360	186.5	34	LP3	HMC630LP3E
1.8 - 2.7	Vector	-50 to -10	360	186	35	LP3	HMC631LP3E
1.8 - 2.2	Vector	-50 to -10	360	185	33	LP3	HMC500LP3E

PASSIVES - *Fixed Attenuators - New Product Line!*

	Frequency (GHz)	Function	Attenuation Accuracy (dB)	Nominal Attenuation (dB)	Maximum Input Power (dBm)	Chip Size	Package	Part Number
	DC - 50	Thru Line	±0.2	0.15	-	17 x 18	Chip	HMC650
	DC - 50	Thru Line	±0.3	0.15	-	23 x 18	Chip	HMC651
	DC - 50	Passive	±0.2	2	27	17 x 18	Chip	HMC652
	DC - 50	Passive	±0.2	3	26	17 x 18	Chip	HMC653
	DC - 50	Passive	±0.2	4	25	17 x 18	Chip	HMC654
	DC - 50	Passive	±0.2	6	26	17 x 18	Chip	HMC655
	DC - 50	Passive	±0.1	10	25	17 x 18	Chip	HMC656
NEW!	DC - 25	Passive	±1.5	10	25	N/A	LP2	HMC656LP2E
	DC - 50	Passive	±0.4	15	25	17 x 18	Chip	HMC657
NEW!	DC - 25	Passive	±2	15	25	N/A	LP2	HMC657LP2E
	DC - 50	Passive	±0.5	20	25	23 x 18	Chip	HMC658
NEW!	DC - 25	Passive	±2	20	25	N/A	LP2	HMC658LP2E

PLLs - *Fractional Synthesizers - New Product Line!*

	Frequency (GHz)	Function	Maximum PFD Freq. Resolution (MHz) @ 3.3V +85°C	Max. Reference Freq. (MHz)	Figure of Merit @ 6 GHz (Frac / INT) (dBc/Hz)	Min. Freq. Resolution (Hz) @ 50 MHz PFD	Total Current Consumption (mA)	Package	Part Number
NEW!	0.001 - 8.0	Fractional Synthesizer	100	200	-221 / -226	3	95	LP4	HMC700LP4E

POWER DETECTORS

	Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package	Part Number
NEW!	50 Hz - 3.0	Log Detector/Controller	74 ±3	19	-66	+3.3V @ 29mA	LP4	HMC612LP4E
	0.001 - 8.0	Log Detector/Controller	70 ±3	-25	-61	+5V @ 113mA	LP4	HMC602LP4E
NEW!	0.001 - 10.0	Log Detector/Controller	73 ±3	-25	-65	+5V @ 103mA	Chip	HMC611
	0.001 - 10.0	Log Detector/Controller	70 ±3	-25	-65	+5V @ 106mA	LP4	HMC611LP4E
	0.01 - 4.0	Log Detector/Controller	70 ±3	19	-68	+3.3V @ 30mA	LP4	HMC601LP4E
	0.05 - 4.0	Log Detector/Controller	70 ±3	19	-69	+3.3V @ 29mA	LP4	HMC600LP4E
	DC - 3.9	True RMS Detector	69 ±1	37	-60	+5V @ 65 mA	LP4	HMC610LP4E
NEW!	0.1 - 3.9	True RMS Detector w/ IPWR	71 ±1	37	-58	+5V @ 75mA	LP4	HMC614LP4E
NEW!	0.1 - 20	SDLVA *	62	14	-57	+3.3V @ 83mA	LC4B	HMC613LC4B
Connectorized Power Detector Modules								
NEW!	1 - 20	SDLVA *	59	14	-67	+12V @ 86mA	C-10 Module	HMC-C052

* Successive Detection Log Video Amplifier

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	27	30	0 / +3V	MS8	HMC190MS8E

SWITCHES

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
DC - 3	SPDT, Hi Isolation	0.7	50	23	0 / +5V	MS8	HMC194MS8E
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	0.3	31	34	0 / +3 to +8V	SOT26	HMC545E
DC - 3.5	SPDT, Hi Isolation	0.5	45	25	0 / +5V	MS8G	HMC284MS8GE
DC - 4	SPDT, Reflective	0.5	28	29	0 / -5V or +5V / 0	Chip	HMC240
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
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
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	1.6	44	23	0 / -5V	LP3	HMC347LP3E
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
55 - 86	SPDT, Reflective	2	30	-	-5 / +5	Chip	HMC-SDD112
0.1 - 2.1	SPDT, 40W, Failsafe	0.4	22	46	0 / +3V to +8V	LP2	HMC646LP2E
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 - 2.5	SPDT, CATV	0.6	58	28	0 / +5V	LP3	HMC348LP3E
NEW! DC - 3	SPDT T/R	0.5	25	39	TTL/CMOS	MS8	HMC174MS8E
DC - 3	SPDT, 10W, T/R	0.5	30	> 40	0 / +3 to +10V	MS8G	HMC484MS8GE
DC - 3	SPDT, 5W, T/R	0.3	30	39	0 / +3 to +10V	MS8	HMC574MS8E
DC - 3	SPDT, 3W, T/R	0.3	30	37	0 / +3 to +10V	SOT26	HMC595E
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

Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
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	0.5	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
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	2.2	32	21	0 / 5V	LP3	HMC345LP3E

Selection Guide by Product

SWITCHES

	Frequency (GHz)	Function	Insertion Loss (dB)	Isolation (dB)	Input P1dB (dBm)	Control Input (Vdc)	Package	Part Number
	DC - 12	SP4T	1.8	42	27	0 / -5V	LH5 Hermetic	HMC344LH5
NEW!	DC - 18	SP4T	2.1	42	24	0 / -5V	Chip	HMC641
	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
	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

SYNTHESIZERS

Frequency (GHz)	Function	100 kHz 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

SYNTHESIZERS - *Precise RF Signal Generation for ATE & Lab Environments*

	Frequency (GHz)	Function	Frequency Resolution (MHz)	1 GHz Max Power Output (dBm)	100kHz SSB Phase Noise (dBc/Hz) @ 1 GHz	100kHz SSB Phase Noise (dBc/Hz) @ 4 GHz	Spurious @ 1 GHz (dBc)	Switching Speed @ 100 MHz Steps (µs)	Part Number
NEW!	0.7 - 8.0	Signal Generator	1	+17	-78	-83	-48	<200	HMC-T2000

VARIABLE GAIN AMPLIFIERS - *Digital*

	Frequency (GHz)	Function	Gain Control Range (dB)	NF * (dB)	OIP3 * (dBm)	P1dB (dBm)	Bias Supply	Package	Part Number
NEW!	0.4 - 3.0	Analog	-25 to 20	5	40	23	+5V @ 265mA	LP5	HMC640LP5E
NEW!	7 - 16	Analog	20	5.5	28	24	+5V @ 170mA	Chip	HMC694
NEW!	0.03 - 0.4	5-Bit Digital w/ Differential Outputs	-4 to +19	4.8	40	25	+5V @ 240mA	LP4	HMC680LP4E
NEW!	0.05 - 0.8	5-Bit Digital	-8 to 15	5	35	18	+5V @ 65mA	LP4	HMC628LP4E
	DC - 1	6-Bit Digital, Serial & Parallel Control	-11.5 to 20	4.3	36	20	+5V @ 90mA	LP5	HMC627LP5E
	DC - 1	6-Bit Digital, Parallel Control	8.5 to 40	4	36	20	+5V @ 176mA	LP5	HMC626LP5E
NEW!	DC - 1	6-Bit Digital, Serial Control	8.5 to 40	4	36	20	+5V @ 176mA	LP5	HMC681LP5E
	DC - 6	6-Bit Digital, Serial & Parallel Control	-13.5 to 18	6	33	19	+5V @ 88mA	LP5	HMC625LP5E

**** Maximum Gain State***

VOLTAGE CONTROLLED OSCILLATORS*

Frequency (GHz)	Function	Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz 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	12	-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							
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

** 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)	100 kHz 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	-116	+5V @ 315mA	LP5	HMC510LP5E
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
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	HMC534LP5E
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

VOLTAGE CONTROLLED OSCILLATORS WITH Fo/2 OUTPUT

Fo Frequency (GHz)	Fo/2 Frequency (GHz)	Function	Fo Output Power (dBm)	100 kHz SSB Phase Noise (dBc/Hz)	Bias Supply	Package	Part Number
11.5 - 12.8	5.75 - 6.4	VCO with Fo/2 & ÷4	11	-110	+5V @ 350mA	LP5	HMC583LP5E
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
14.25 - 15.65	7.125 - 7.825	VCO with Fo/2 & ÷4	9	-107	+5V @ 350mA	LP5	HMC632LP5E

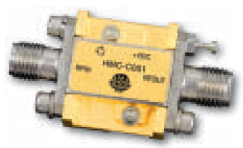
PHASE LOCKED OSCILLATOR

Frequency (GHz)	Function	Output Power (dBm)	10 kHz SSB Phase Noise (dBc/Hz)	100 kHz 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

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.



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
1.8 - 4.2	Low Noise	26	26	0.7	15.5	+8V @ 112mA	C-10 Module	HMC-C045
5 - 9	Low Noise	24	25	1.4	15	+12V @ 105mA	C-10 Module	HMC-C048
29 - 36	Low Noise	20	22	2.9	11	+3V @ 80mA	C-10 Module	HMC-C027
2 - 20	Wideband LNA	15	25	2.5	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	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	12	29	3	18	+11V @ 92mA	C-10 Module	HMC-C038
0.05 - 15	Wideband PA, 1/2 Watt	12	36	4	28	+11V @ 360mA	C-10B Module	HMC-C036
0.05 - 15	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	15	34	4	26	+12V @ 310mA	C-2B Module	HMC-C023
2 - 20	Wideband PA	31	33	3	26	+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

ATTENUATORS

	Frequency (GHz)	Function	Loss (dB)	Atten. Range (dB)	IIP3 (dBm)	Control Input (Vdc)	Package	Part Number
NEW!	DC - 20	Analog VVA	5.5	35	10	-5	C-10 Module	HMC-C053
	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
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
0.5 - 17	Divide-by-10	-15 to +10	-1	-155	+5V @ 152mA	C-1 Module	HMC-C040

Robust, High Performance RF to Light Solutions

FREQUENCY MULTIPLIERS - *Active*

Input Freq. (GHz)	Function	Output Frequency (GHz)	Input Power (dBm)	Output Power (dBm)	100kHz SSB Phase Noise (dBc/Hz)	Package	Part Number
3 - 5	Active x2	6 - 10	3	17	-140	C-10 Module	HMC-C031
9.0 - 14.5	Active x2	18 - 29	3	16	-132	C-10 Module	HMC-C032
12.0 - 16.5	Active x2	24 - 33	3	17	-132	C-10 Module	HMC-C033
16 - 23	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)	IIP3 (dBm)	Package	Part Number
4 - 8.5	I/Q Mixer	DC - 3.5	-7.5	35	23	C-4 Module	HMC-C009
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
20 - 31	I/Q Mixer / IRM	DC - 4.5	-10	24	22.5	C-4B Module	HMC-C046
30 - 38	I/Q Mixer / IRM	DC - 3.5	-10.5	15	19	C-4B Module	HMC-C047

MIXERS

	RF Freq. (GHz)	Function	IF Frequency (GHz)	Conv. Gain (dB)	LO/RF Isol. (dB)	IIP3 (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	35	19	C-11 Module	HMC-C014
	24 - 38	+13 LO, DBL-BAL	DC - 8	-8.5	35	20	C-11 Module	HMC-C015
NEW!	11 - 20	+13 LO, DBL-BAL	DC - 6	-7	43	18	C-11 Module	HMC-C051

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

POWER DETECTORS

	Frequency (GHz)	Function	Dynamic Range (dB)	RSSI Slope (mV / dB)	RF Threshold Level (dBm)	Bias Supply	Package	Part Number
NEW!	1 - 20	SDLVA *	59	14	-67	+12V @ 86mA	C-10 Module	HMC-C052

* Successive Detection Log Video Amplifier

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
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

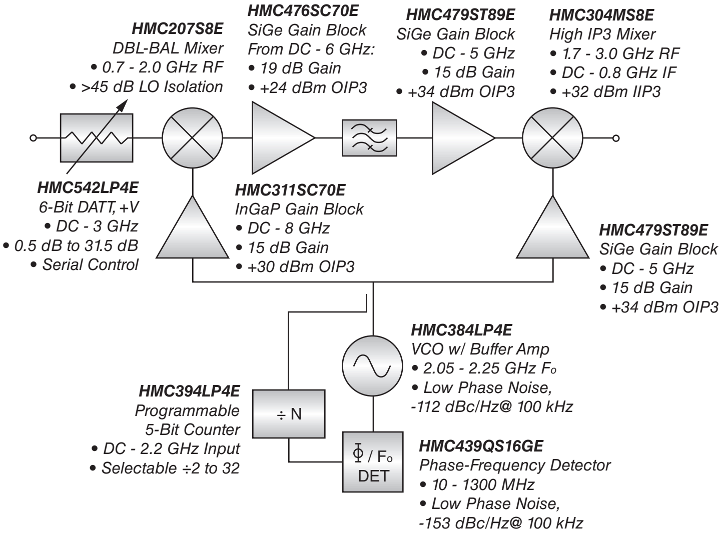
BROADBAND

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 HMC636ST89E HMC639ST89E	HMC476SC70E HMC491LP3E HMC593LP3E HMC636ST89E HMC639ST89E	HMC318MS8GE HMC320MS8GE HMC476SC70E HMC604LP3E
Driver Amplifier & Gain Block	HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E	HMC308E HMC311SC70E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E	HMC311SC70E HMC326MS8GE HMC327MS8GE HMC474SC70E HMC475ST89E HMC476SC70E	HMC311SC70E HMC406MS8GE HMC407MS8GE HM415LP3E HMC474SC70E HMC476SC70E
Linear & Power Amplifier	HMC453QS16GE HMC636ST89E	HMC454ST89E HMC636ST89E	HMC409LP4E HMC636ST89E	HMC408LP3E
Attenuator: Analog	HMC473MS8E	HMC346MS8GE	HMC346MS8GE	HMC346MS8GE
Attenuator: Digital	HMC467LP3E HMC468LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC305LP4E HMC540LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424LP3E HMC467LP3E HMC539LP3E HMC624LP4E HMC629LP4E	HMC425LP3E HMC467LP3E HMC468LP3E HMC624LP4E HMC629LP4E
Mixer	HMC207S8E HMC208MS8E HMC216MS8E HMC400MS8E HMC483MS8GE	HMC215LP4E HMC285E HMC316MS8E HMC334LP4E HMC552LP4E HMC557 HMC557LC4 HMC622LP4E HMC688LP4E HMC689LP4E	HMC214MS8E HMC215LP4E HMC333E HMC340LP5E HMC557 HMC557LC4 HMC615LP4E HMC622LP4E HMC666LP4E	HMC220MS8E HMC218MS8E HMC219MS8E HMC488MS8GE HMC525LC5 HMC557 HMC557LC4
Demodulator	HMC597LP4E	HMC597LP4E HMC631LP3E	HMC597LP4E	
Modulator	HMC495LP3E HMC497LP4E HMC696LP4E	HMC495LP3E HMC497LP4E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC697LP4E	HMC496LP3E
Phase Shifter: Digital		HMC647 HMC647LP6E	HMC648 HMC648LP6E HMC649 HMC649LP6E	HMC649 HMC649LP6E HMC638LP5E
PLL	HMC700LP4E	HMC700LP4E	HMC700LP4E	HMC700LP4E
Power Detector	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E HMC612LP4E HMC614LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E HMC612LP4E HMC614LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E HMC614LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E
Switch: SPST & SPNT	HMC253QS24E HMC536MS8GE HMC536LP2E HMC544E HMC550E HMC646LP2E	HMC241LP3E HMC484MS8GE HMC536MS8GE HMC546LP2E HMC550E	HMC241LP3E HMC349MS8GE 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 HMC626LP5E HMC627LP5E HMC628LP4E	HMC625LP5E HMC640LP5E HMC680LP4E HMC681LP5E	HMC625LP5E HMC680LP4E HMC681LP5E	HMC625LP5E HMC680LP4E HMC681LP5E

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

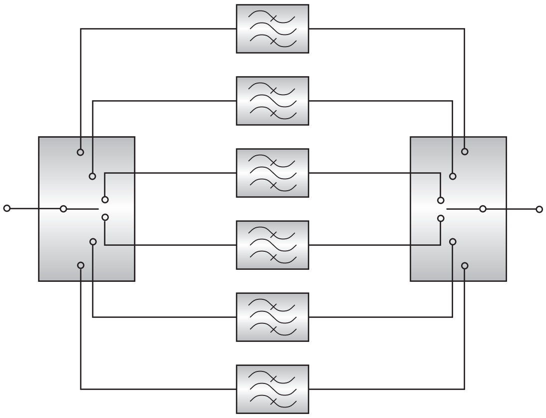
Cable Modem Termination System (CMTS)



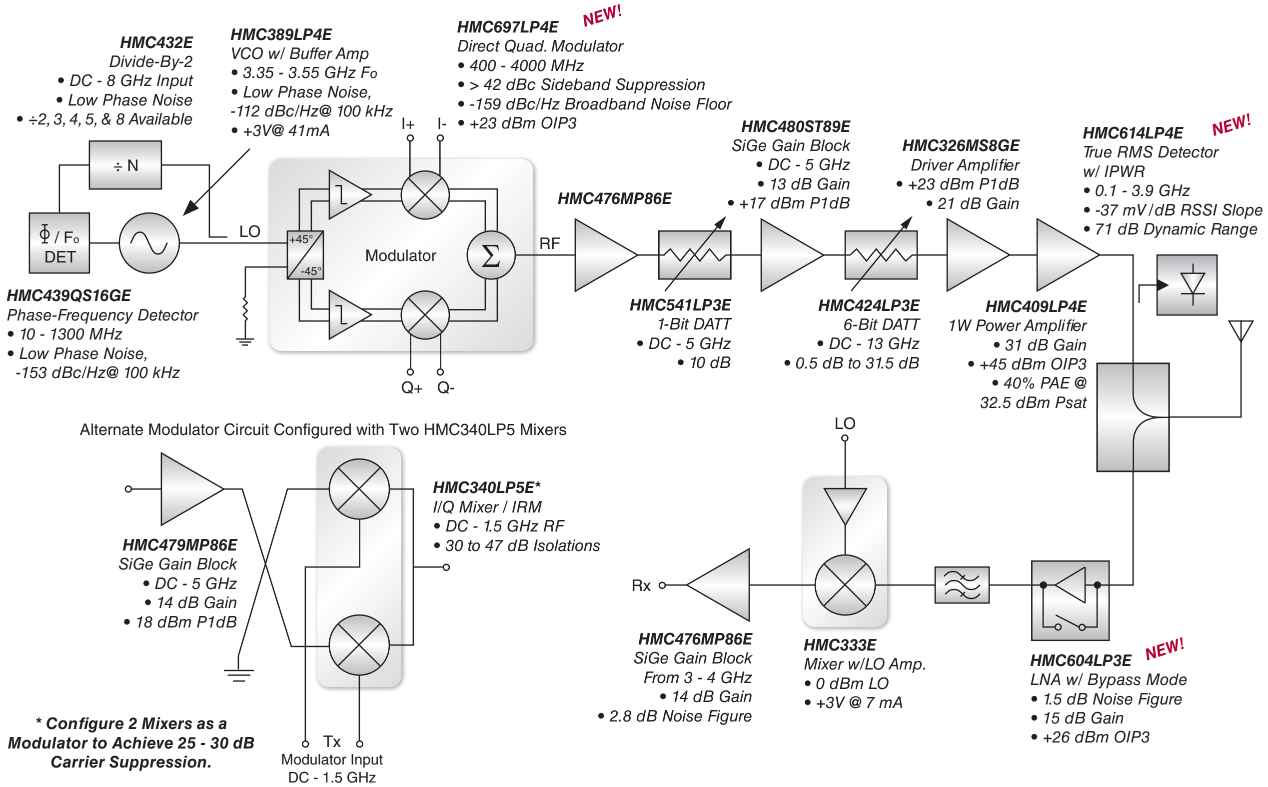
Typical Broadband applications are illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

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

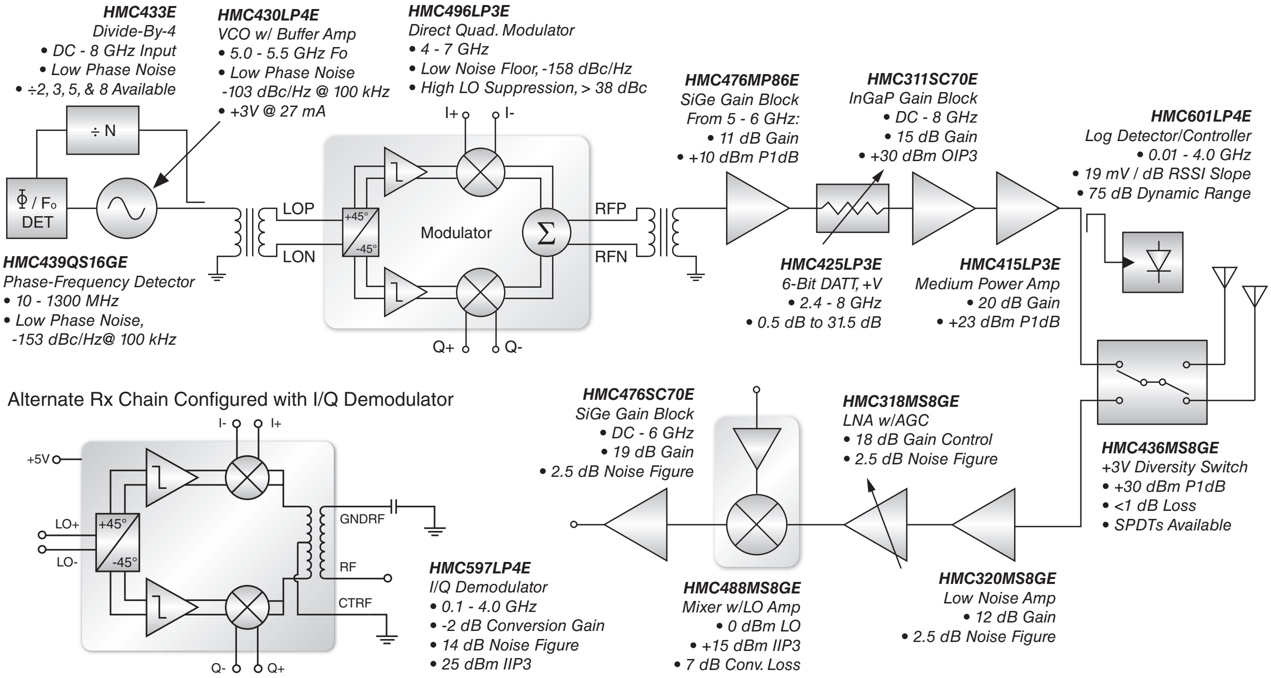


WIMAX & FIXED WIRELESS, 2 - 6 GHz



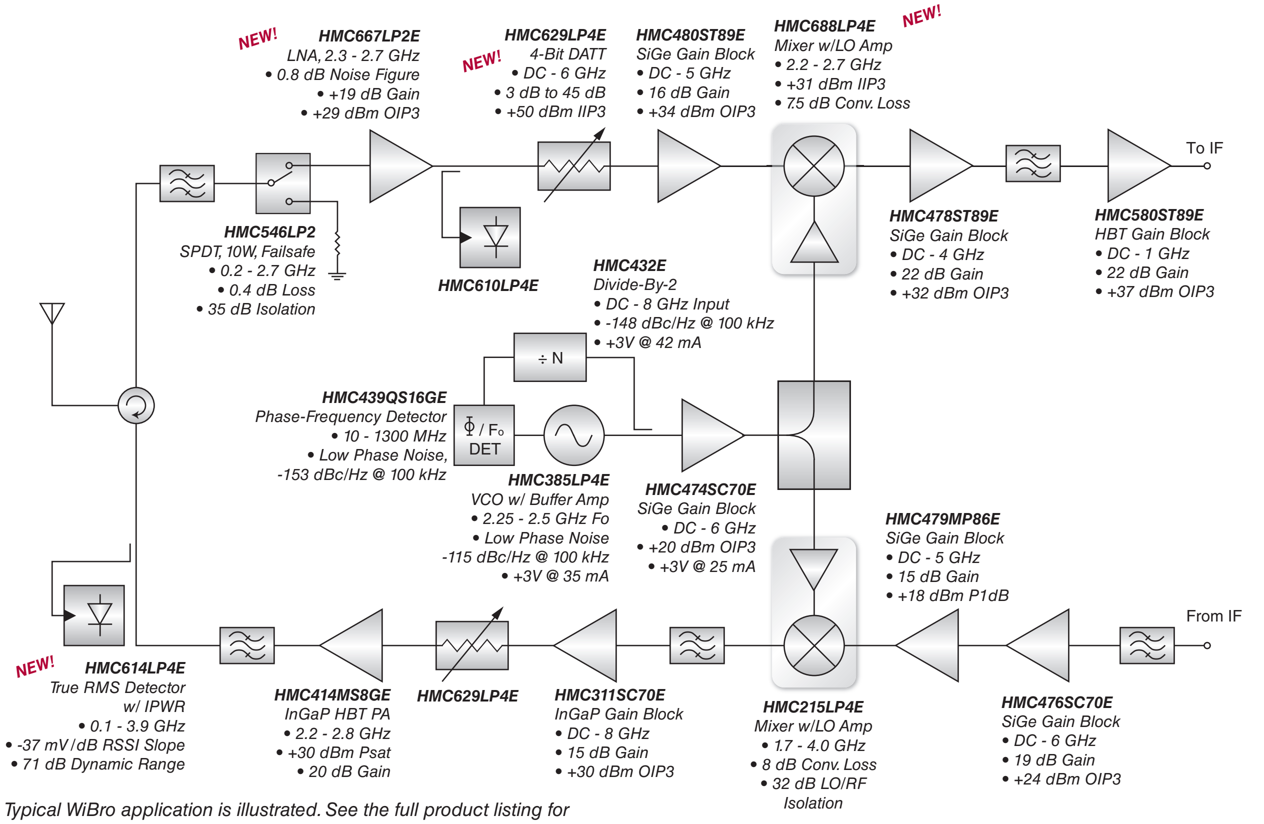
Typical WiMAX / FWA Transceiver is illustrated. See the full product listing for alternatives to the select HMC products shown in each functional block.

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.

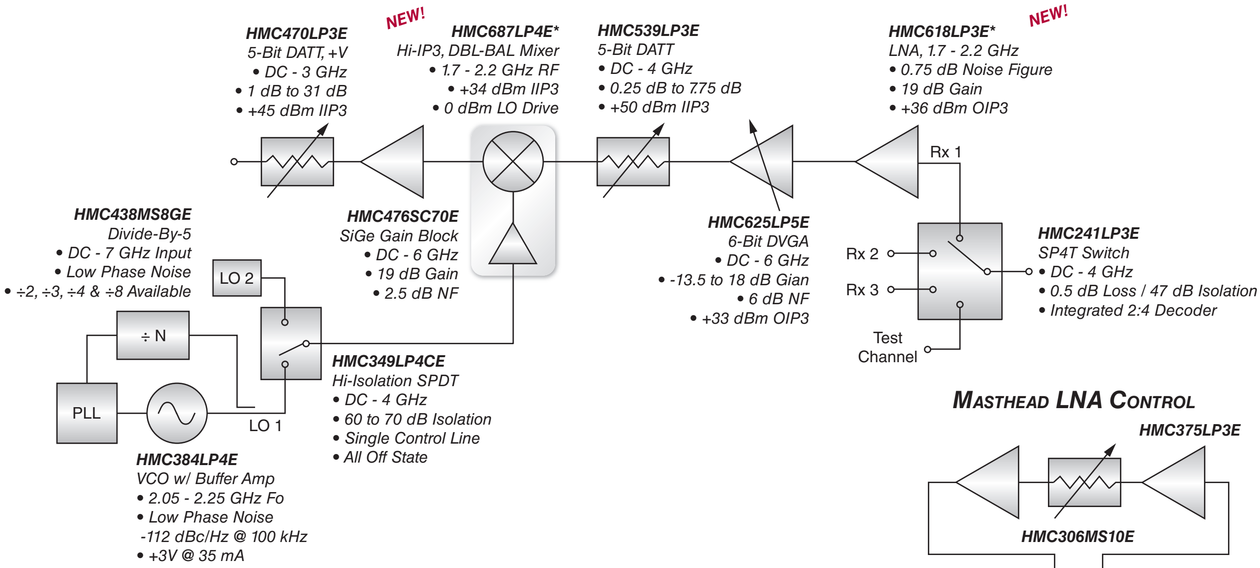
* *A selection of components, see the full product listing starting on page 5.*

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

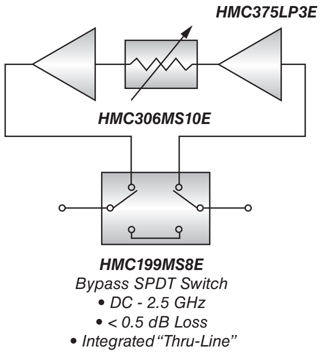
Function	400 MHz	700 / 800 / 900 MHz	1800 / 1900 MHz	2100 / 2200 MHz
Low Noise Amplifier	HMC356LP3E HMC374E HMC616LP3E HMC636ST89E	HMC372LP3E HMC376LP3E HMC617LP3E HMC636ST89E	HMC375LP3E HMC382LP3E HMC618LP3E HMC636ST89E	HMC375LP3E HMC382LP3E HMC618LP3E HMC636ST89E
Driver Amplifier & Gain Block	HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC478ST89E HMC580ST89E	HMC308E HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E	HMC308E HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E	HMC308E HMC311SC70E HMC454ST89E HMC474SC70E HMC475ST89E HMC476SC70E HMC589ST89E
Linear & Power Amplifier	HMC452ST89E HMC453ST89E HMC454ST89E HMC636ST89E	HMC450QS16GE HMC452ST89E HMC453ST89E HMC454ST89E HMC636ST89E	HMC452ST89E HMC453ST89E HMC454ST89E HMC457QS16GE HMC636ST89E	HMC452ST89E HMC453ST89E HMC454ST89E HMC455LP3E HMC636ST89E
Attenuator: Analog	HMC473MS8E	HMC473MS8E	HMC210MS8E	HMC210MS8E
Attenuator: Digital	HMC540LP3E HMC541LP3E HMC472LP4E HMC542LP4E HMC624LP4E HMC629LP4E	HMC540LP3E HMC541LP3E HMC467LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC539LP3E HMC541LP3E HMC468LP3E HMC542LP4 HMC624LP4E HMC629LP4E	HMC305LP4E HMC539LP3E HMC541LP3E HMC542LP4E HMC624LP4E HMC629LP4E
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 HMC621LP4E HMC665LP4E HMC683LP6E HMC684LP4E HMC686LP4E	HMC215LP4E HMC334LP4E HMC381LP6E HMC400MS8E HMC485MS8GE HMC552LP4E HMC622LP4E HMC623LP4E HMC682LP6E HMC685LP4E HMC687LP4E	HMC215LP4E HMC334LP4E HMC400MS8E HMC421QS16GE HMC422MS8E HMC615LP4 HMC622LP4E HMC688LP4E HMC689LP4E
Demodulator	HMC597LP4E	HMC597LP4E	HMC597LP4E	HMC597LP4E
Modulator: Direct Quadrature & Vector	HMC495LP3E HMC497LP4E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC630LP3E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC631LP3E HMC696LP4E HMC697LP4E	HMC495LP3E HMC497LP4E HMC631LP3E HMC696LP4E HMC697LP4E
Power Detector	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E HMC611LP4E HMC612LP4E HMC614LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E HMC611LP4E HMC612LP4E HMC614LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E HMC611LP4E HMC612LP4E HMC614LP4E	HMC600LP4E HMC601LP4E HMC602LP4E HMC610LP4E HMC611LP4E HMC612LP4E HMC614LP4E
Switch: SPST & SPNT	HMC349MS8GE HMC546MS8GE HMC550E HMC646LP2E	HMC546MS8GE HMC550E HMC574MS8E HMC646LP2E	HMC545E HMC546MS8GE HMC550E HMC646LP2E	HMC484MS8GE HMC546LP2E HMC550E HMC646LP2E
Switch: Bypass, Diversity, Matrix & Transfer	HMC199MS8E HMC596LP4E	HMC199MS8E HMC596LP4E	HMC199MS8E HMC596LP4E	HMC199MS8E HMC596LP4E
VGA	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC640LP5E HMC680LP4E HMC681LP5E	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC640LP5E HMC680LP4E HMC681LP5E	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC640LP5E HMC680LP4E HMC681LP5E	HMC625LP5E HMC626LP5E HMC627LP5E HMC628LP4E HMC640LP5E HMC680LP4E HMC681LP5E

CELLULAR INFRASTRUCTURE

BTS Receiver Solutions Featuring High IP3 Mixer



Masthead LNA Control



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

HMC686LP4E NEW!
Hi-IP3, DBL-BAL Mixer
- 0.7 - 1.1 GHz RF
- +34 dBm IIP3
- 0 dBm LO Drive

HMC617LP3E NEW!
LNA, 550 - 1200 MHz
- 0.5 dB Noise Figure
- 16 dB Gain
- +37 dBm OIP3

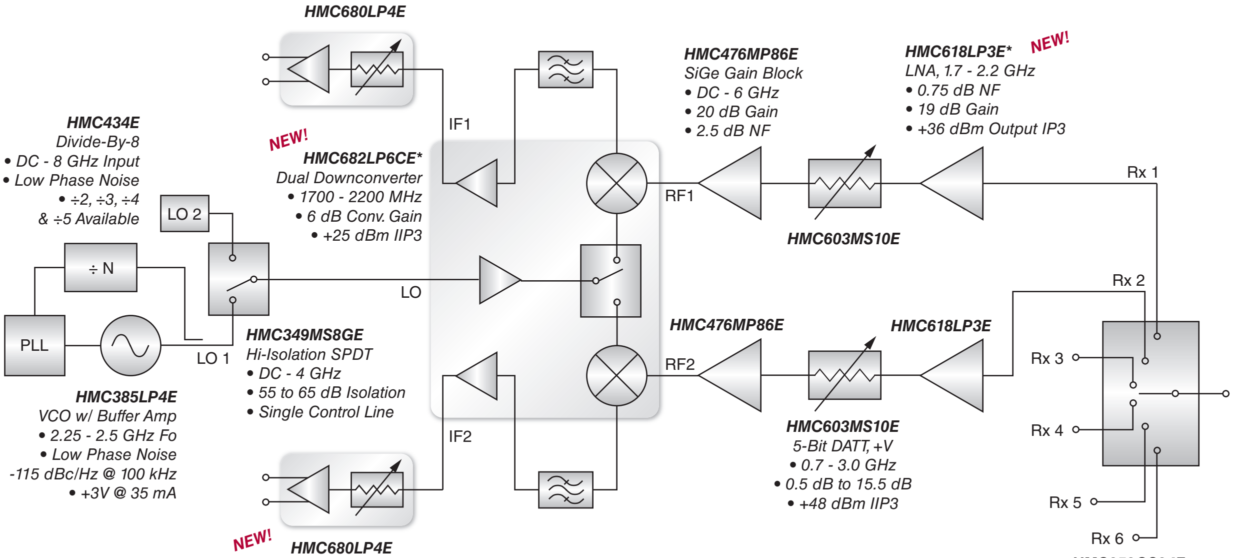
*** For 380 - 500 MHz Systems Use:**

HMC585MS8GE
Hi-IP3 Mixer w/ LO Amp
- 400 - 650 MHz RF
- +33 dBm IIP3
- 0 dBm LO Drive

HMC616LP3E NEW!
LNA, 175 - 660 MHz
- 0.5 dB Noise Figure
- 17 dB Gain
- +35 dBm OIP3

Ask About Our Custom VCO Capabilities!

BTS Receiver Solutions Featuring Dual RFIC Downconverter



NEW! **HMC680LP4E**
5-Bit DVGA w/ Differential Outputs
- 30 - 400 MHz
- -4 to +19 dB Gain
- +40 dBm OIP3

HMC252QS24E
SP6T Switch
- DC - 3.0 GHz
- 0.8 dB Loss
- 41 dB Isolation
- Integrated 3:6 Decoder

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

HMC617LP3E NEW!
LNA
- 550 - 1200 MHz
- 0.5 dB Noise Figure
- 16 dB Gain
- +37 dBm IIP3

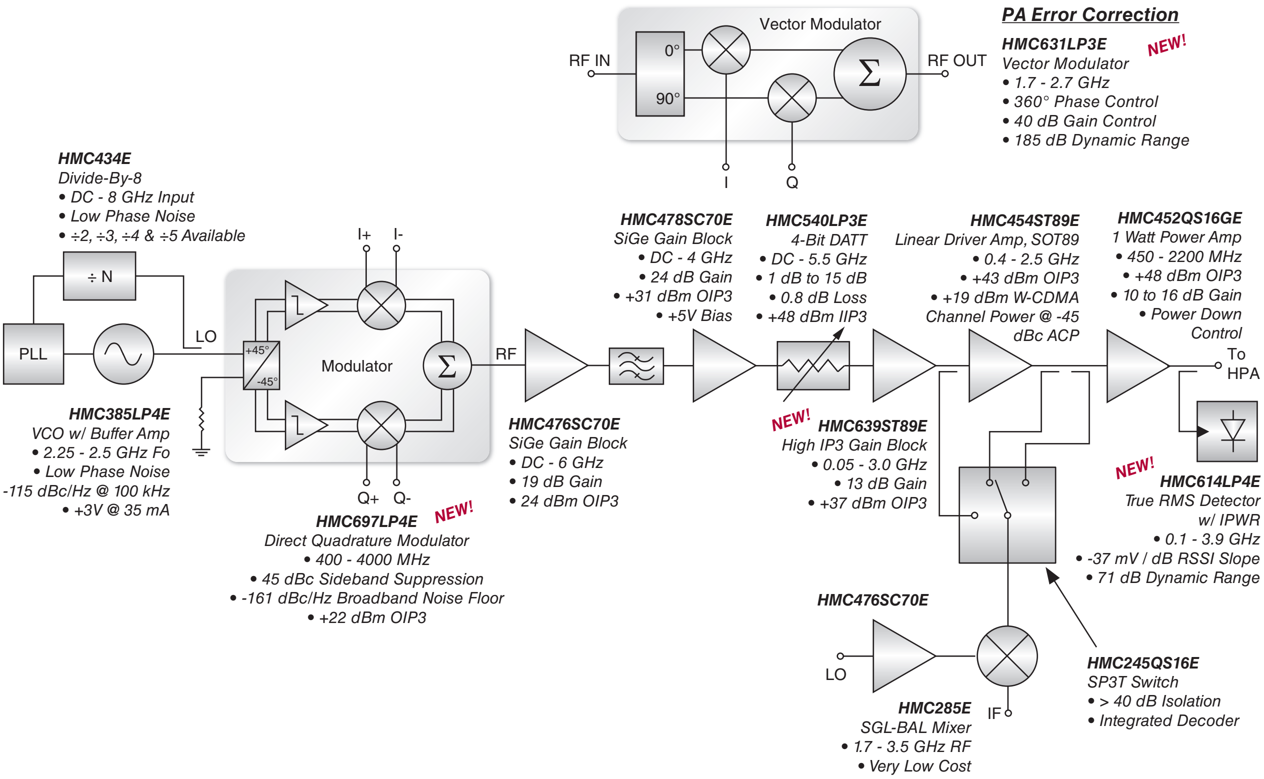
HMC373LP3E
LNA w/ Bypass Mode
- 700 - 1000 MHz
- 0.9 dB Noise Figure
- 14 dB Gain
- < 2 dB Bypass IL

HMC683LP6CE NEW!
Dual Downconverter
- 700 - 1000 MHz
- 7.5 dB Conv. Gain
- +23 dBm IIP3

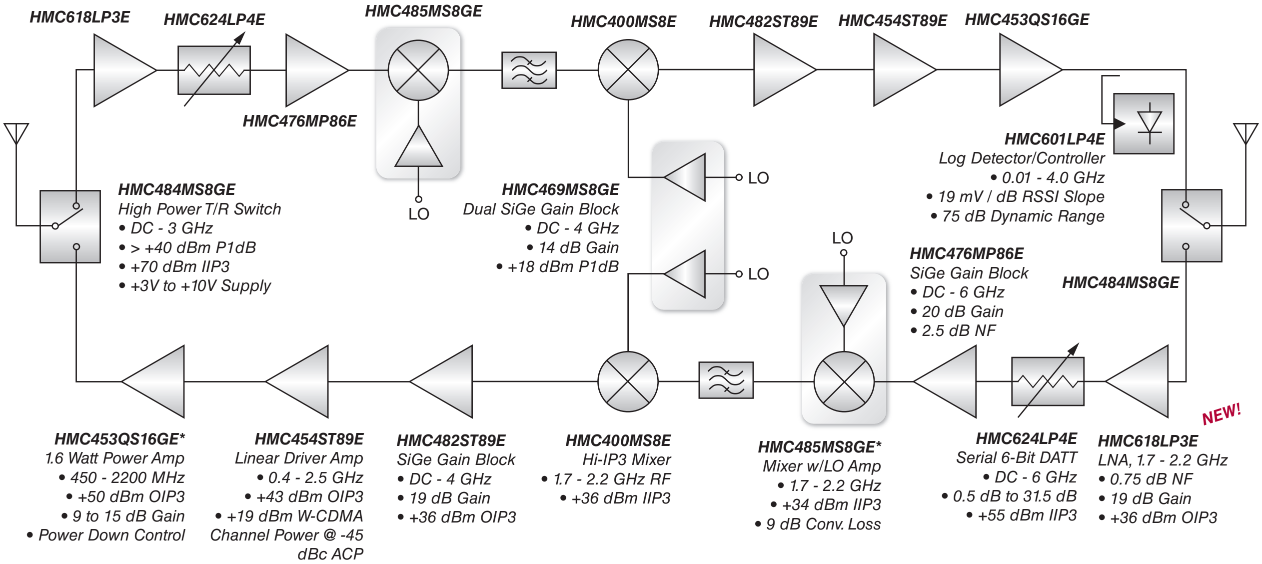
Typical Cellular/PCS/3G applications are illustrated.
See the full product listing for alternatives to the select HMC products shown in each functional block.

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 & MILLIMETERWAVE RADIO, 7 to 23 GHz *

Function	7 / 8 GHz	11 GHz	13 GHz	15 GHz	18 GHz	23 GHz
Low Noise Amplifier	HMC392LC4 HMC392LH5 HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC564 HMC564LC4 HMC565 HMC565LC5	HMC516LC5 HMC565 HMC565LC5	HMC516LC5 HMC565 HMC565LC5	HMC517LC4 HMC519 HMC519LC4 HMC565 HMC565LC5	HMC341LC3B HMC517LC4 HMC519 HMC519LC4
Driver Amplifier	HMC441LP3E HMC451LC3 HMC516LC5	HMC441LP3E HMC451LC3 HMC516LC5	HMC441LC3B HMC451LC3 HMC490LP5E	HMC441LC3B HMC451LC3 HMC490LP5E	HMC383LC4 HMC442LC3B HMC498LC4	HMC383LC4 HMC442LC3B HMC498LC4
Power Amplifier	HMC486LP5E HMC590 HMC590LP5E HMC591 HMC591LP5E	HMC487LP5E HMC592 HMC608 HMC608LC4	HMC489LP5E HMC592	HMC489LP5E HMC-APH462	HMC498LC4 HMC-APH196 HMC-APH462 HMC-APH478 HMC-APH596	HMC498LC4 HMC-APH196 HMC-APH462 HMC-APH518 HMC-APH596
Wideband (Distributed) Amplifiers	HMC463LH250 HMC606 HMC606LC5 HMC619 HMC619LP5E HMC633 HMC633LC4 HMC634 HMC634LC4 HMC659 HMC-ALH102 HMC-ALH435 HMC-ALH444 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC633 HMC633LC4 HMC634 HMC634LC4 HMC-ALH102 HMC-ALH435 HMC-ALH444 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC633 HMC633LC4 HMC634 HMC634LC4 HMC-ALH102 HMC-ALH435 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC633 HMC633LC4 HMC634 HMC634LC4 HMC-ALH102 HMC-ALH216 HMC-ALH435 HMC-ALH476 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC463LH250 HMC606 HMC606LC5 HMC634 HMC634LC4 HMC659 HMC-ALH102 HMC-ALH216 HMC-ALH435 HMC-ALH445 HMC-ALH476 HMC-ALH482 HMC-AUH232 HMC-AUH249 HMc-AUH256 HMC-AUH312	HMC635 HMC-ALH216 HMC-ALH311 HMC-ALH445 HMC-ALH476 HMC-AUH232 HMC-AUH249 HMC-AUH256 HMC-AUH312
Attenuator: Analog	HMC346LP3E	HMC346LP3E	HMC346LP3E	HMC346LC3B	HMC346LC3B HMC-VVD102	HMC-VVD102
Divide-by-2	HMC361S8GE	HMC364S8GE	HMC492LP3E	HMC492LP3E	HMC492LP3E	
Divide-by-4	HMC362S8GE	HMC365S8GE	HMC493LP3E	HMC493LP3E	HMC447LC3	HMC447LC3
Divide-by-8	HMC363S8GE	HMC363S8GE	HMC494LP3E	HMC494LP3E		
Multiplier: Active X2	HMC368LP4E HMC575LP4E HMC561LP3E	HMC368LP4E HMC573LC3B HMC561LP3E HMC-XDB112	HMC368LP4E HMC573LC3B HMC561LP3E HMC-XDB112	HMC368LP4E HMC573LC3B HMC561LP3E HMC-XDB112	HMC448LC3B HMC576 HMC576LC3B	HMC448LC3B HMC576 HMC576LC3B
Multiplier: Active X4		HMC443LP4E	HMC370LP4E	HMC370LP4E HMC-XDH158		
Multiplier: Passive X2	HMC189MS8E	HMC189MS8E	HMC204MS8GE	HMC204MS8GE	HMC204MS8GE	HMC205
I/Q Receiver	HMC567LC5	HMC568LC5	HMC569LC5	HMC570 HMC570LC5	HMC571 HMC571LC5	HMC572 HMC572LC5
I/Q Mixer / IRM	HMC520LC4 HMC525LC4 HMC620 HMC620LC4	HMC521LC4 HMC527LC4	HMC521LC4 HMC527LC4	HMC522LC4 HMC528LC4	HMC523 HMC523LC4	HMC523 HMC523LC4 HMC524 HMC-MDB172
Mixer: Fundamental	HMC129LC4 HMC144LC4 HMC219MS8E HMC220MS8E HMC553 HMC553LC3B HMC558 HMC558LC3B	HMC144LC4 HMC411MS8GE HMC412MS8GE HMC553 HMC553LC3B HMC558 HMC558LC3B HMC-C051	HMC144LC4 HMC411MS8GE HMC412MS8GE HMC553 HMC553LC3B HMC558 HMC558LC3B HMC-C051	HMC144LC4 HMC260LC3B HMC412MS8GE HMC554 HMC554LC3B HMC558 HMC558LC3B HMC-C051	HMC144LC4 HMC260LC3B HMC292LC3B HMC554 HMC554LC3B HMC-C051	HMC260LC3B HMC292LC3B
Mixer: Sub-Harmonic				HMC258LM3	HMC258LC3B HMC258LM3 HMC337	HMC264LC3B HMC338LC3B
Switch	HMC547LP3E HMC641	HMC607 HMC641	HMC547LP3E HMC641	HMC607 HMC641	HMC547LP3E HMC641	

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

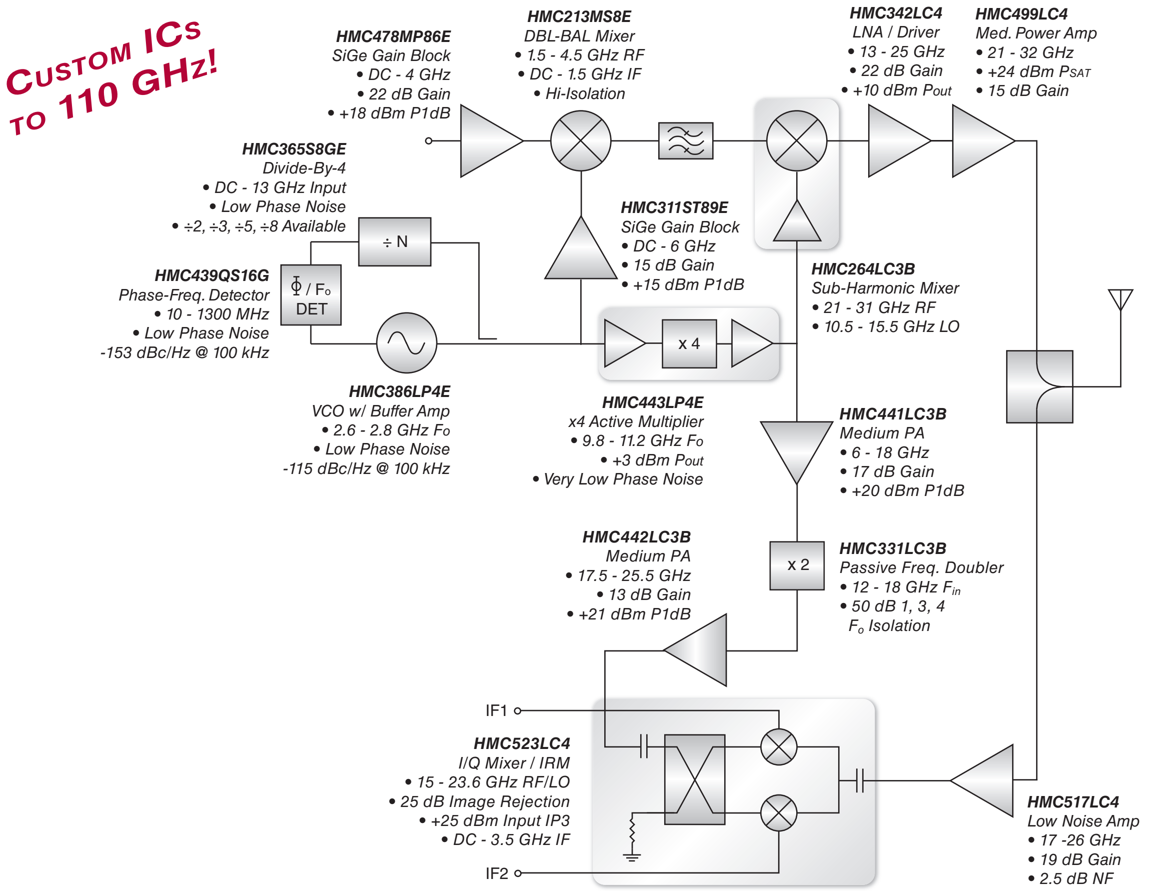
MICROWAVE & MILLIMETERWAVE RADIO, 7 to 23 GHz *

Function	7 / 8 GHz	11 GHz	13 GHz	15 GHz	18 GHz	23 GHz
VCO & PLO: ****Requires X2 or X4**	HMC466LP4E HMC505LP4E HMC506LP4E HMC532LP4E HMC586LC4B HMC587LC4B	HMC513LP4E HMC515LP5E HMC534LP4E HMC582LP5E HMC588LC4B	HMC513LP4E HMC529LP4E HMC584LP5E	HMC529LP4E HMC531LP5E HMC535LP5E HMC632LP5E	HMC429LP4E**	HMC431LP4E**

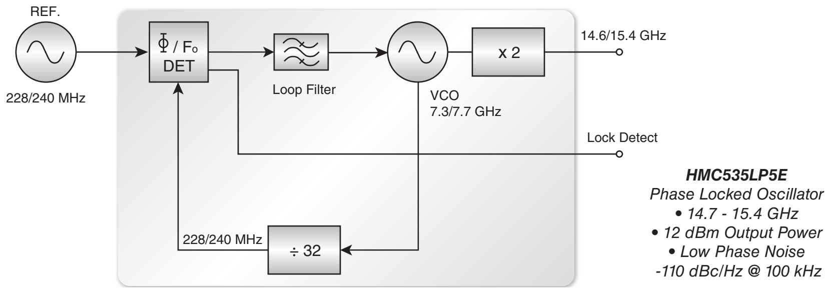
MICROWAVE & MILLIMETERWAVE RADIO, 26 to 86 GHz *

Function	26 / 28 GHz	32 / 38 GHz	32 - 43 GHz	44 - 66 GHz	71 - 86 GHz
Low Noise Amplifier	HMC341LC3B HMC517LC4 HMC519LC4	HMC263 HMC566		HMC-ALH382	HMC-ALH459 HMC-ALH509
Driver Amplifier	HMC383LC4 HMC283LM1 HMC499LC4	HMC283LM1 HMC300LM1 HMC383LC4	HMC-APH403 HMC-APH473 HMC-APH510	HMC-ABH209 HMC-ABH241 HMC-ABH403	HMC-AUH317 HMC-AUH318 HMC-AUH320
Power Amplifier	HMC499LC4 HMC-APH196 HMC-APH460 HMC-APH462 HMC-APH596 HMC-APH608	HMC283LM1 HMC-APH403 HMC-APH473 HMC-APH510 HMC-APH596	HMC-APH403 HMC-APH473 HMC-APH510 HMC-AUH256	HMC-ABH209 HMC-ABH241 HMC-ABH403	HMC-AUH317 HMC-AUH318 HMC-AUH320
Wideband **(Distributed)** **Amplifiers**	HMC-ALH140 HMC-ALH216 HMC-ALH244 HMC-ALH311 HMC-ALH313 HMC-ALH364 HMC-ALH369 HMC-ALH445 HMC-ALH476 HMC-AUH232 HMC-AUH249 HMC-AUH256 HMC-AUH312	HMC635 HMC-ALH140 HMC-ALH244 HMC-ALH310 HMC-ALH313 HMC-ALH364 HMC-ALH369 HMC-ALH376 HMC-ALH445 HMC-AUH249 HMC-AUH256	HMC-ALH140 HMC-ALH244 HMC-ALH310 HMC-ALH313 HMC-ALH364 HMC-ALH369 HMC-ALH376 HMC-ALH445 HMC-AUH232 HMC-AUH249 HMC-AUH256 HMC-AUH312	HMC-ALH376 HMC-AUH312	
Attenuator: Analog	HMC-VVD102	HMC-VVD106	HMC-VVD106	HMC-VVD106	HMC-VVD104
Divide-by-4	HMC447LC3				
Multiplier: Active X2	HMC448LC3B HMC577LC4B HMC578LC3B HMC598	HMC449LC3B HMC578LC3B HMC579 HMC598	HMC598	HMC598	
Multiplier: Active X4					
Multiplier: Passive X2	HMC331	HMC331			
I/Q Receiver	HMC572 HMC572LC5				
I/Q Mixer / IRM	HMC524 HMC524LC3B HMC-MDB172	HMC404 HMC555 HMC556	HMC-MDB171 HMC-MDB172	HMC-MDB171 HMC-MDB207	
Mixer: **Fundamental**	HMC292LC3B HMC329LC3B HMC557 HMC557LC4 HMC560 HMC560LM3	HMC294 HMC329LM3 HMC560 HMC560LM3		HMC-MDB169	
Mixer: **Sub-Harmonic**	HMC264LC3B HMC265LM3 HMC338LC3B	HMC338 HMC339		HMC-MDB218	
Switch				HMC-SDD112	HMC-SDD112
VCO & PLO: ****Requires X2 or X4** **Switch**	HMC515LP5E** HMC531LP5E**	HMC505LP4E HMC506LP4E		 HMC-SDD112	 HMC-SDD112
VCO & PLO: ****Requires X2 or X4**	HMC515LP5E** HMC531LP5E**	HMC505LP4E HMC506LP4E			

DOUBLE UPCONVERSION & DIRECT DOWNCONVERSION



15 GHz INTEGRATED PLO



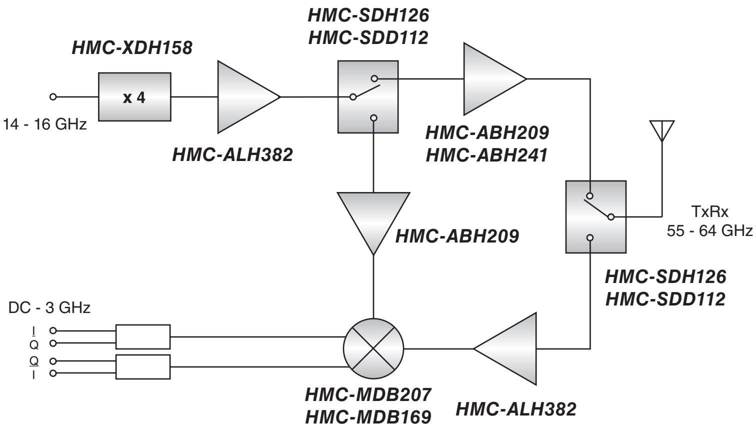
PRODUCTS AVAILABLE IN DIE, SMT OR CONNECTORIZED PACKAGE FORM TO 86 GHz!

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

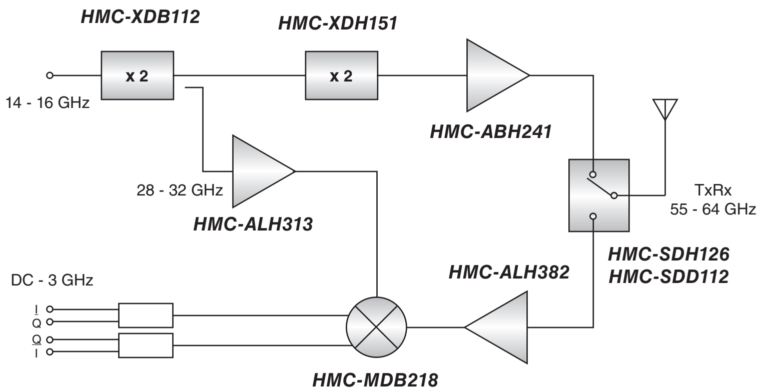
60 GHz TxRx Chipset

Features:

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



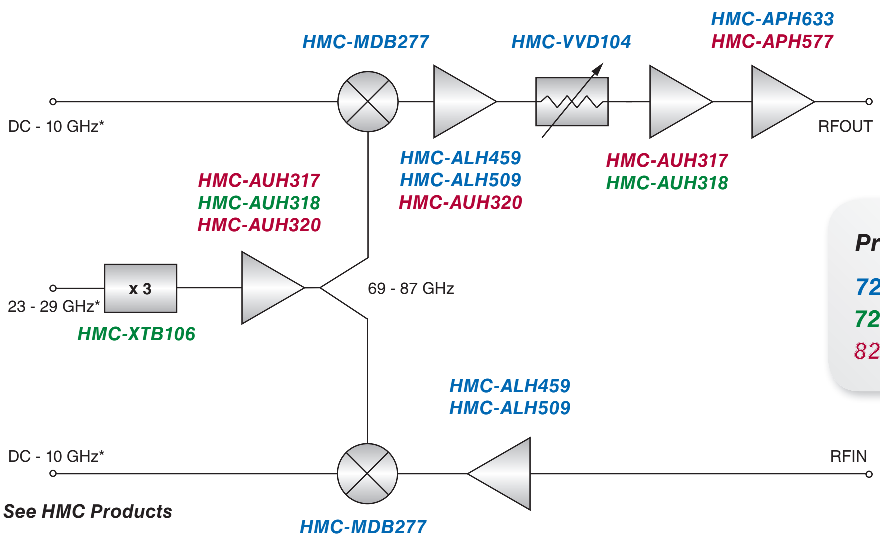
Sub-Harmonic Option for 60 GHz Chipset



Applications:

- Short Haul High Capacity Links
- Picocell Mobile Phone Links
- Network Backbone & Branch Links
- HDTV Wireless Component Links

72 & 82 GHz TxRx Chipset for High Capacity Communication Links



* See HMC Products

Product Key

72 & 82 GHz
72 GHz Only
82 GHz Only

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

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

FIBER OPTICS *

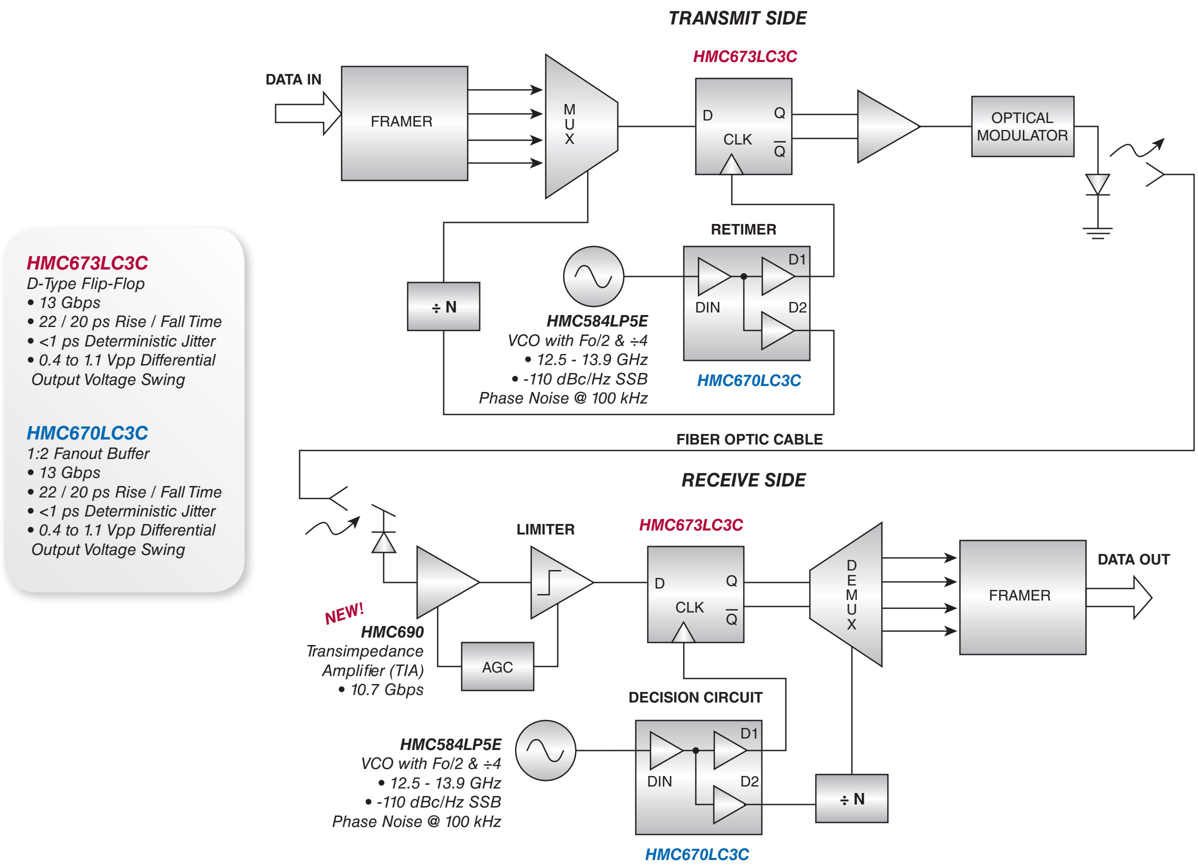
Function	31 Mbps	OC-3	OC-12	OC-48	OC-192	OC-768
Broadband Gain Blocks	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC311SC70E HMC396 HMC405 HMC474MP86E HMC474SC70E HMC475ST89E HMC476SC70E HMC478SC70E	HMC405	
Transimpedance Amplifier					HMC690	
Wideband (Distributed) Amplifiers	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC459 HMC460 HMC465 HMC465LP5E HMC559 HMC-AUH232 HMC-AUH249 HMC-AUH312	HMC-AUH312
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	HMC-VVD104 HMC-VVD106
Attenuators: Digital	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E HMC542LP4E HMC624LP4E HMC629LP4E	HMC424 HMC424LH5 HMC424LP3E	
Attenuators: Passive	HMC650 HMC651 HMC652 HMC653 HMC654 HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 HMC651 HMC652 HMC653 HMC654 HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 HMC651 HMC652 HMC653 HMC654 HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 HMC651 HMC652 HMC653 HMC654 HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 HMC651 HMC652 HMC653 HMC654 HMC655 HMC656LP2E HMC657LP2E HMC658LP2E	HMC650 HMC651 HMC652 HMC653 HMC654 HMC655 HMC656 HMC657 HMC658
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 HMC598 HMC-XDB112 HMC-XDH158	HMC579 HMC598
Connectorized Freq. Multiplier Modules					HMC-C032 HMC-C033 HMC-C034	
High Speed Comparators	HMC674LC3C HMC675LC3C HMC676LC3C	HMC674LC3C HMC675LC3C HMC676LC3C	HMC674LC3C HMC675LC3C HMC676LC3C	HMC674LC3C HMC675LC3C HMC676LC3C	HMC674LC3C HMC675LC3C HMC676LC3C	

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

FIBER OPTICS *

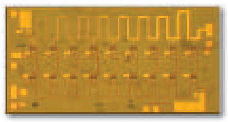
Function	31 Mbps	OC-3	OC-12	OC-48	OC-192	OC-768
High Speed Digital Logic: **1:2 Fanout Buffer** **XOR / XNOR** **AND / NAND / OR / NOR** **D-Flip-Flop**	HMC670LC3C HMC671LC3C HMC672LC3C HMC673LC3C	HMC670LC3C HMC671LC3C HMC672LC3C HMC673LC3C	HMC670LC3C HMC671LC3C HMC672LC3C HMC673LC3C	HMC670LC3C HMC671LC3C HMC672LC3C HMC673LC3C	HMC670LC3C HMC671LC3C HMC672LC3C HMC673LC3C	
Connectorized Mixer Modules	HMC-C035	HMC-C035	HMC-C035	HMC-C035		
Phase Shifters: Analog				HMC247 HMC538LP4E	HMC247 HMC538LP4E	
Phase Shifters: Digital				HMC647 HMC647LP6E HMC648 HMC648LP6E	HMC642 HMC642LC5 HMC643 HMC643LC5 HMC644 HMC644LC5	
Connectorized Phase Shifter Modules					HMC-C010	
Switches: SPDT	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E HMC646LP2E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E HMC646LP2E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E HMC646LP2E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC232 HMC232LP4E HMC347 HMC347LP3E HMC547LP3E	HMC-SDD112
Switches: Multi-Throw	HMC253LC4 HMC344LC3 HMC641	HMC253LC4 HMC344LC3 HMC641	HMC253LC4 HMC344LC3 HMC641	HMC253LC4 HMC344LC3 HMC641	HMC641	
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	

TYPICAL SERIAL FIBER OPTIC DATA TRANSMISSION SYSTEM



MILITARY LEVEL & HI-REL COMMERCIAL / INDUSTRIAL COMPONENTS & ASSEMBLIES

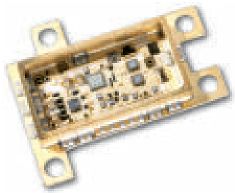
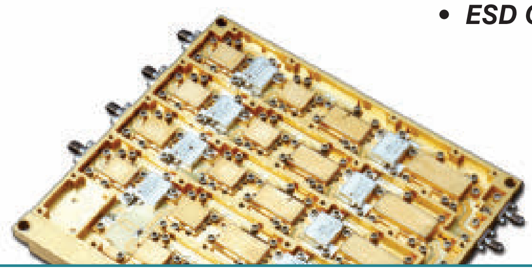
Hittite Microwave performs Class B screening on standard & custom product die and packaged die including SMT plastic encapsulated devices for COTS applications.




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

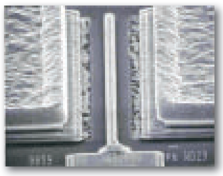
SPACE LEVEL COMPONENT & MODULE QUALIFICATION

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

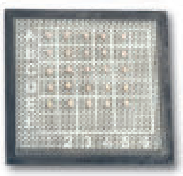
- *VI to Methods*
  2010A & 2017K
- *Temp Cycle Stress Test*
- *High Temp Burn-In & Life Test*
- *Wafer Lot Acceptance Test*
  Bond Pull & Die Shear Test
  SEM Inspection
  Metal & Glass Thicknesses
- *Serialized Test Data*
- *Qualification Report*

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

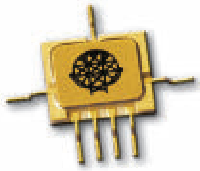
We are qualified by major spacecraft OEMs worldwide, shipping tens of thousands of S-Level components which are currently operational on dozens of commercial, scientific & military spacecraft.



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!

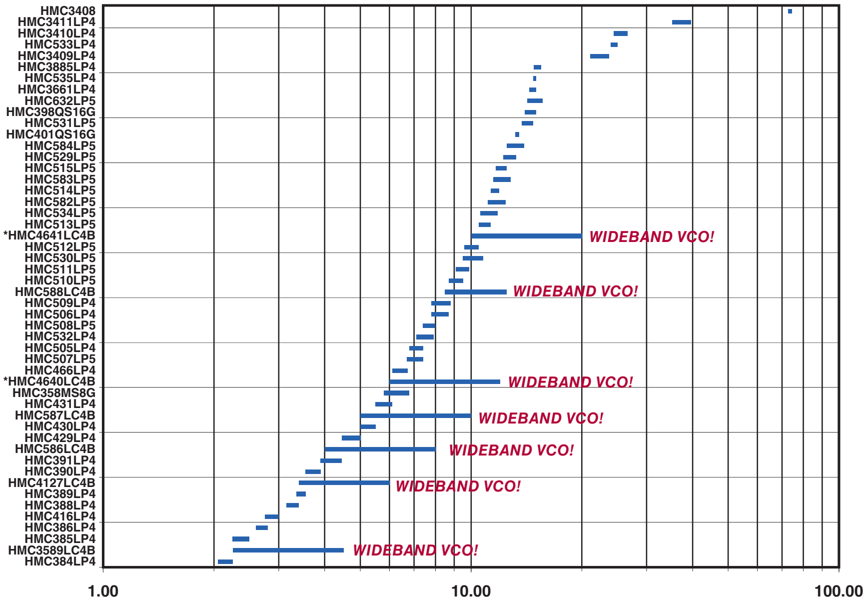
FREQUENCY GENERATION

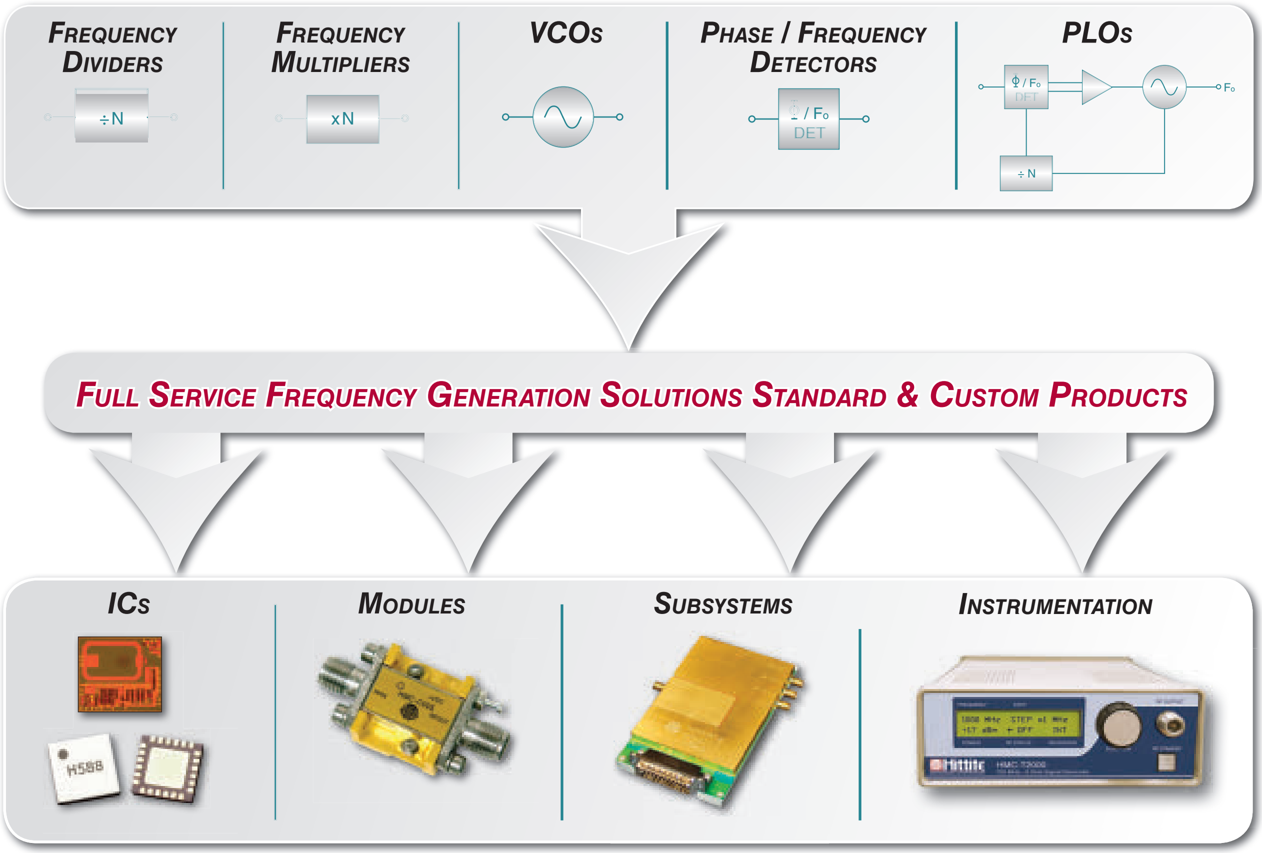
IC, Module & Subsystem Solutions to 80 GHz

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





PRECISE RF SIGNAL GENERATION FOR ATE & LAB ENVIRONMENTS!

NEW!

HMC-T2000 Synthesized Signal Generator, 700 MHz to 8 GHz

The HMC-T2000 is an easy to implement test equipment solution designed to fulfill your signal generation needs. Built on a foundation of high quality and market leading Hittite MMICs, the HMC-T2000 provides the highest output power, lowest harmonic levels and broadest frequency range amongst signal generators of its size and cost.

This compact and lightweight signal generator also features a USB interface and innovative control software ensuring carefree integration within various test environments while improving overall productivity and equipment utilization.

Applications

- ♦ *ATE*
- ♦ *Test & Measurement*
- ♦ *R&D Laboratories*

Performance

- ♦ *High Output Power: +17 dBm*
- ♦ *Wide Frequency Range: 700 MHz to 8 GHz*
- ♦ *Excellent Harmonic Rejection: < -40 dBc*
- ♦ *Phase Continuity Capability; Integer Mode Architecture*

Advantages

- ♦ *Versatile: Higher Drive Simplifies Test Set-ups*
- ♦ *Efficient: Fast Frequency Switching, 200 μs*
- ♦ *Accurate: Incorporates Hittite MMICs*
- ♦ *Flexible: Manual or Software Control via USB*

SYNTHESIZED SIGNAL GENERATION

Frequency (GHz)	Function	Frequency Resolution (MHz)	1 GHz Max Power Output (dBm)	100 kHz SSB Phase Noise (dBc/Hz) @ 1 GHz	100 kHz SSB Phase Noise (dBc/Hz) @ 4 GHz	Spurious @ 1 GHz (dBc)	Switching Speed @ 100 MHz Steps (μs)	Part Number
0.7 - 8.0	Signal Generator	1	+17	-78	-83	-48	200	**HMC-T2000**

Contact Us for Your Test & Measurement Product Requirements

Designer's Kits

Evaluation Boards & ICs Reduce Design Cycle Time

6 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***
- ***NEW!*** ♦ ***Passive Attenuator Chips DC - 50 GHz, HMC-DK006***

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.

Designer's Kit	Kit Contents			
	ICs		Eval Boards	
Gain Blocks **DC - 6 GHz** **HMC-DK001***	HMC474MP86E HMC476MP86E HMC313E HMC311ST89E HMC478MP86E HMC478ST89E	HMC479MP86E HMC479ST89E HMC481ST89E HMC480ST89E HMC481MP86E HMC482ST89E	104217 – HMC313E 110161 – HMC478ST89E 107490 – HMC481MP86E	
Linear Driver Amps **0.4 - 2.5 GHz** **HMC-DK002****	HMC454ST89E HMC450QS16GE HMC413QS16GE	HMC452ST89E HMC453ST89E HMC457QS16GE	107749 – HMC454ST89E 108349 – HMC450QS16GE 105000 – HMC413QS16GE	108712 – HMC452ST89E 108718 – HMC453ST89E 106043 – HMC457QS16GE
Hi-IP3 Mixers **0.45 - 4.0 GHz** **HMC-DK003****	HMC387MS8E HMC483MS8GE HMC399MS8E HMC316MS8E HMC400MS8E HMC485MS8GE	HMC402MS8E HMC214MS8E HMC478ST89E HMC481ST89E HMC480ST89E	110161 – HMC478ST89E 105188 – HMC485MS8GE	106334 – HMC399MS8E 101830 – HMC400MS8E
Digital Attenuators **DC - 6 GHz** **HMC-DK004****	HMC291E HMC468LP3E HMC274QS16E HMC271LP4E HMC273MS10GE	HMC305LP4E HMC306MS10E HMC470LP3E HMC472LP4E	103372 – HMC291E 107302 – HMC468LP3E 104976 – HMC274QS16E 108782 – HMC271LP4E 103393 – HMC273MS10GE	108782 – HMC305MS10E 103393 – HMC306MS10E 107006 – HMC470LP3E 107010 – HMC472LP4E
SPDT Switches **DC - 12 GHz** **HMC-DK005****	HMC221E HMC284MS8GE HMC349MS8GE HMC232LP4E HMC226E	HMC595E HMC574MS8E HMC484MS8GE HMC536MS8GE	101675 – HMC221E 107662 – HMC349MS8GE 107723 – HMC232LP4E	104124 – HMC574MS8E 104124 – HMC484MS8GE 105143 – HMC536MS8GE
Passive Attenuators **DC - 50 GHz** **HMC-DK006**	HMC650 HMC651 HMC652 HMC653 HMC654	HMC655 HMC656 HMC657 HMC658		

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 / RFMD	SGA-4163, SGA-4263		HMC311ST89E
Gain Blocks	Sirenza / RFMD	NGA-586, NGA-589, NGA-686, NGA-689		HMC313E
Gain Blocks	Sirenza / RFMD	SGA-0163, SGA-0363, SGA-1163, SGA-1263, SGA-2163, SGB-2233, SGA-2263, SGA-2363, SGA-2463, SGB-4333		HMC474MP86E
Gain Blocks	Sirenza / RFMD	SGA-2186, SGA-2286, SGA-2386, SGA-2486	HMC474MP86E	
Gain Blocks	Sirenza / RFMD	SGA-3263, SGA-3363, SGA-3463, SGA-3563, SGB-2433, SGB-4533		HMC476MP86E
Gain Blocks	Sirenza / RFMD	NGA-386 , SGA-3286, SGA-3386, SGA-3486, SGA-3586	HMC476MP86E	
Gain Blocks	Sirenza / RFMD	SGA-4186, SGA-4286, SGA-4386, SGA-4486, SGA-5386, SGA-5486, SGA-5586	HMC478MP86E	
Gain Blocks	Sirenza / RFMD	SGB-6433, SGB-6533		HMC478MP86E
Gain Blocks	Sirenza / RFMD	SGA-4363, SGA-4463, SGA-4563		HMC478ST89E
Gain Blocks	Sirenza / RFMD	SGA-4586, SGA-5389, SGA-5489, SGA-5589	HMC478ST89E	
Gain Blocks	Sirenza / RFMD	SGA-5263		HMC479ST89E
Gain Blocks	Sirenza / RFMD	SGA-5286	HMC479MP86E	
Gain Blocks	Sirenza / RFMD	SGA-5289	HMC479ST89E	
Gain Blocks	Sirenza / RFMD	NGA-489 , SGA-6289, SGA-6389, SGA-6489, SGA-6589, SGA-7489	HMC580ST89E	
Gain Blocks	Sirenza / RFMD	SGA-6386, SGA-6286, SGA-6486, SGA-6586	HMC481MP86E	
Gain Blocks	Sirenza / RFMD	NGA-186, NGA-286, NGA-486		HMC480ST89E
Gain Blocks	Sirenza / RFMD	SGA-7489	HMC482ST89E	
Gain Blocks	WJ / Triquint	AH1	HMC636ST89E	
Gain Blocks	WJ / Triquint	AM-1	HMC639ST89E	
Gain Blocks	WJ / Triquint	ECG004B, ECG006F	HMC311ST89E	HMC311LP3E
Gain Blocks	WJ / Triquint	AG102, AG103	HMC580ST89E	
Gain Blocks	WJ / Triquint	AG302-63, AG303-63, ECG004F		HMC313E
Gain Blocks	WJ / Triquint	AG201-63, AG202-63, AG203-63		HMC474MP86E
Gain Blocks	WJ / Triquint	AG201-86, AG202-86, AG203-86	HMC474MP86E	
Gain Blocks	WJ / Triquint	AG302-86, AG303-86, ECG001C, ECG004C	HMC476MP86E	
Gain Blocks	WJ / Triquint	ECG001F, ACG001B		HMC476MP86E
Gain Blocks	WJ / Triquint	AG503-86, ECG002C, ECG006C	HMC478MP86E	
Gain Blocks	WJ / Triquint	ECG002F		HMC478MP86E
Gain Blocks	WJ / Triquint	ECG006B, ECG002B, SCG002B, AG503-89	HMC478ST89E	
Gain Blocks	WJ / Triquint	AG402-86, ECG040C, AG602-86, EC1119C	HMC479MP86E	
Gain Blocks	WJ / Triquint	AG402-89, ECG040B, AG602-89, EC1119B	HMC479ST89E	
Gain Blocks	WJ / Triquint	AG603-89, AG604-89, ECG050B, EC1019B	HMC480ST89E	
Gain Blocks	WJ / Triquint	AG403-86, ECG005C, ECG055C, AG603-86, AG604-86, ECG050C, EC1019C, EC1078C	HMC481MP86E	
Gain Blocks	WJ / Triquint	AG403-89, ECG005B, ECG055B	HMC481ST89E	
Gain Blocks	WJ / Triquint	EC1078B, ECG003, ECG008	HMC482ST89E	

Competitor Cross-Reference

Hittite Microwave Offers Performance & Price Competitive Components

ATTENUATORS

Product	Competitor	Competitor P/N	Hittite P/N Package & Performance	Hittite P/N Performance
Digital Attenuators	Skyworks	AA100-59LF	HMC230MS8E	
Digital Attenuators	Skyworks	AA101-80	HMC274QS16E	
Digital Attenuators	Skyworks	AA106-86	HMC603MS10E	
Digital Attenuators	Skyworks	SKY12322-86	HMC306MS10E	
Digital Attenuators	Skyworks	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
Log Detectors	Linear Technology	LT5538		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

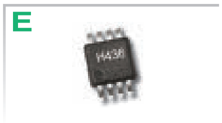
Available Plastic, Ceramic, Hermetic SMT & Connectorized Module Packages

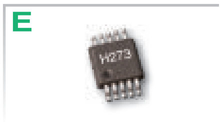

MP86 "Micro-P"
5.21 x 5.08 x 1.57 mm

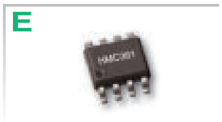

SC70
2.15 x 2.1 x 0.9 mm

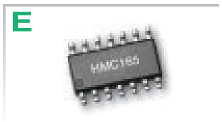

SOT26
2.8 x 2.9 x 1.2 mm

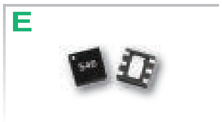

ST89
4.50 x 4.14 x 1.54 mm

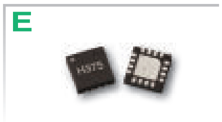

MS8 / MS8G
4.9 x 3.0 x 1.0 mm

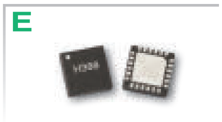

MS10 / MS10G
4.9 x 3.0 x 1.0 mm

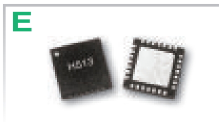

S8 / S8G
6.0 x 4.9 x 1.6 mm


S14
6.0 x 8.7 x 1.6 mm

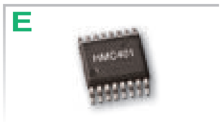

LP2 "DFN"
2.0 x 2.0 x 1.0 mm

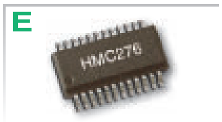

LP3 "QFN"
3.0 x 3.0 x 1.0 mm


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

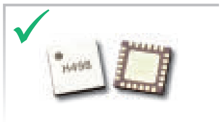

LP5 "QFN"
5.0 x 5.0 x 1.0 mm

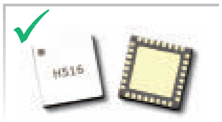

LP6 / LP6C "QFN"
6.0 x 6.0 x 1.0 mm


QS16 / QS16G
6.0 x 4.9 x 1.5 mm


QS24
6.0 x 8.7 x 1.6 mm


LC3 / LC3B / LC3C
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

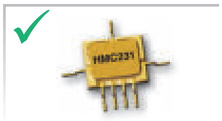

LM1 / LM3
5.1 x 5.1 x 1.1 mm

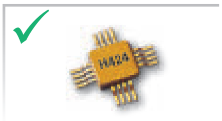

C8
7.4 x 5.1 x 2.4 mm

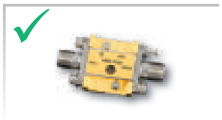

LH250 Hermetic
6.35 x 6.35 x 1.27 mm

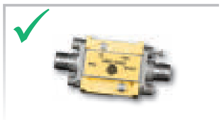

LH5 Hermetic
5.0 x 5.0 x 1.0 mm

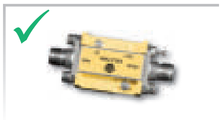

G8 Hermetic
10.2 x 4.6 x 1.8 mm

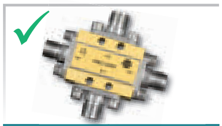

G7 Hermetic
16.1 x 17.3 x 1.7 mm

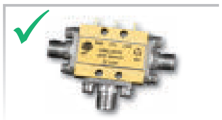

G16 Hermetic
10.4 x 10.4 x 1.7 mm

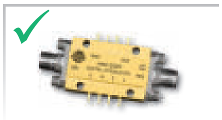

C-1 / C-1B
35.31 x 17.78 x 7.38 mm


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

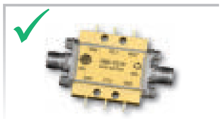

C-3 / C-3B
40.89 x 17.78 x 7.38 mm

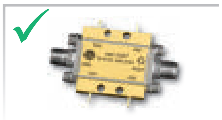

C-4
41.66 x 36.32 x 8.50 mm

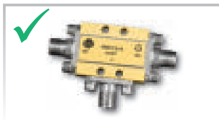

C-5
41.66 x 29.84 x 8.50 mm

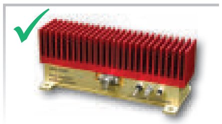

C-6
45.34 x 17.27 x 8.50 mm


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.

Customer Support

How to Buy:

Hittite Microwave Corporation offers many convenient ways to order products and/or receive pricing and delivery information. Our order entry/MRP system assures customer sample requests and orders will be entered quickly, tracked easily, and completed accurately on-time.

Direct Sales

- **HMC Field Sales Offices:**
  You may contact our corporate or field sales offices listed on the back cover for assistance in purchasing Hittite products.
- **Purchase On-line: www.hittite.com**
  With Hittite Microwave's E-Commerce capability customers can enjoy the convenience of on-line ordering via a secure shopping cart interface. Products can be purchased using either a MasterCard, Visa, American Express or JBC card. Orders are confirmed within one business day with delivery information. Orders ship within 2 business days of confirmation, based on availability.
- **Purchase Orders via HMC Corporate Sales:**
  You may contact Hittite Microwave directly at (978) 250-3343. Purchase orders can be faxed to (978) 250-3373 or sent via email to sales@hittite.com. There is a minimum purchase order charge of $500.00 (U.S. Dollars).

Worldwide Network of Sales Representatives

You may purchase our products through our network of manufacturer representatives. European customers may also purchase products in Euros directly from Hittite Microwave Deutschland GmbH.

Our Quality Policy:

Hittite Microwave Corporation is Committed to:

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

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

- *Take the initiative to promote quality.*
- *Create an environment where highest standards are maintained.*
- *Participate in continuous improvement practices*

Quality & Product Support:

The Quality & Product Support Section of Our Web Site Includes:

- *Quality Assurance - Product manufacturing, qualification & screening flows.*
- *Product Reliability*
- *Qualification Test Reports*

Product Application Support

- *Application Engineering Support*
- *Application Notes*
- *Mixer Spur Chart Calculator & PLL Phase Noise Calculator*
- *Package & Layout Drawings - Product outline, PCB land pattern and tape & reel drawings.*
- *Parametric Product Search- Match desired performance parameters to HMC products.*
- *Product Cross Reference - Thousands of ICs cross-referenced to HMC products.*
- *Published Papers*
- *S-Parameter Files*

Data Sheets

- *Complete product data sheets in PDF format can be found on our web site.*

What We Do

Hittite Microwave Corporation is an innovative designer and manufacturer of analog and mixed-signal ICs, modules, subsystems and instrumentation for RF, microwave and millimeterwave applications covering DC to 110 GHz. Our RFIC/MMIC products are developed using state-of-the-art GaAs, GaN, InGaP/GaAs, InP, SOI, SiGe, CMOS and BiCMOS semi-conductor processes utilizing MESFET, HEMT, pHEMT, mHEMT, HBT and PIN devices. Our broad product portfolio includes:

Amplifiers	*Passives*
Attenuators	*Phase Shifters*
Data Converters	*PLLs*
Freq. Dividers & Detectors	*Power Detectors*
Freq. Multipliers	*Sensors*
High Speed Digital Logic	*Switches*
Interface	*Synthesizers*
Mixers	*VGAs*
Mods. & Demodulators	*VCOs & PLOs*

We also design and supply highly integrated custom ICs, modules, subsystems and instrumentation that combine multiple functions for specific requirements. We select the most appropriate semiconductor and package technologies, uniquely balancing digital and analog integration techniques.

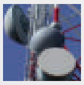
Our custom and standard products support a wide range of wireless / wired communications and radar applications for the following markets:

Automotive
Telematics & Sensors

Broadband
CATV, DBS, WiMAX, WLAN,
Fixed Wireless & UWB

Cellular Infrastructure
GSM, GPRS, CDMA, WCDMA,
UMTS & TD-SCDMA

Fiber Optic
OC-48 to OC-768



Microwave & mmWave Communications
Backhaul Radio Links
Multi-Pt Radios & VSAT

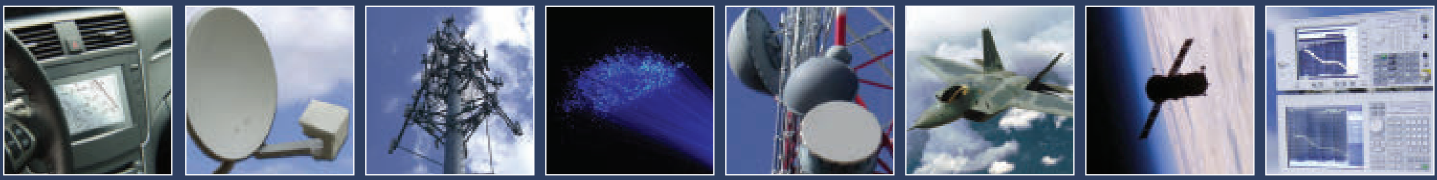
Military
C^3I, ECM & EW

Space
Payload Electronics

Test & Measurement
Commercial / Industrial
Sensors & Test Equipment

Every component is backed by Hittite Microwave's commitment to total quality. HMC is ISO 9001:2000, AS9100 B and ISO/TS 16949:2002 certified. Every Hittite employee and subcontractor is responsible for maintaining the highest level of quality. We are constantly working towards improvement of our procedures and processes, thus providing our customers with products that meet or exceed all requirements, are delivered on-time and function reliably throughout their useful life.

Connecting Our World Through Integrated Solutions



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