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38, 60 & 82 GHz MMICs for High Capacity Communication Links

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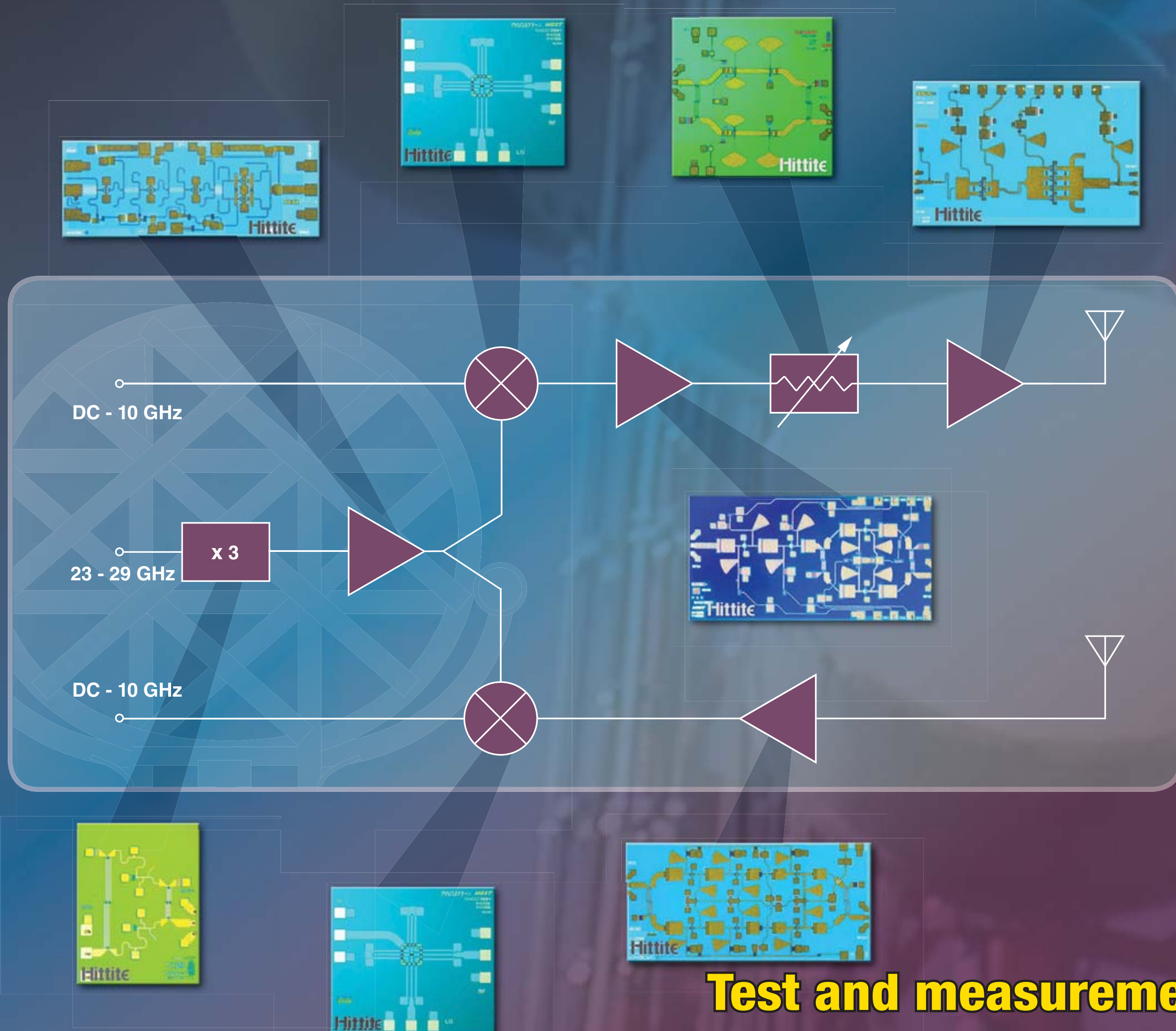

Test and measurement
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The European journal for the microwave and wireless design engineer

Product lines combine to support transceiver designs from DC to 86 GHz

Hittite - Velocium MMIC products provide full coverage of commercial and military millimeterwave bands

By Mark T. Fallica, Hittite Microwave Corporation

In October of 2007, Hittite Microwave Corporation announced that the company had entered into a strategic agreement to license Northrop Grumman's Velocium line of MMIC (Monolithic Microwave Integrated Circuit) products, operating from DC to 86 GHz. Under the agreement, Northrop Grumman's Space Technology sector has licensed to Hittite a number of standard products and associated technology and establishes Hittite as the exclusive worldwide supplier of these products. This agreement expands Hittite's already extensive high frequency product line and enhances Hittite's foundry supply chain. The Hittite - Velocium MMIC products are used in automotive radar, long and short haul communications, fiber optics, test equipment, radar imaging, space, military, and other high performance electronic systems.

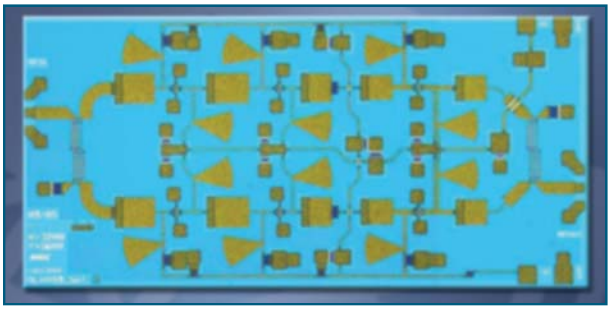
As consumers become familiar with the technology and associated benefits that wireless/3G and WiMAX/4G type networks afford, service providers simultaneously strive to increase backhaul/infrastructure capacity in order to stay ahead of demand. The widespread and growing use of bandwidth intensive applications such as IPTV, on-demand video distribution and file sharing can quickly over burden a service provider's available bandwidth. In regions where fiber is available, service providers may be able to quickly provision additional bandwidth, however, in many unwired regions of the world, millimeterwave radios are providing an attractive solution. Millimeterwave radio original equipment manufacturers (OEMs) are moving towards higher and higher frequencies, where the promise of less interference, along with huge swaths of available bandwidth, offer an enormous capacity advantage over the lower frequency bands, such as those where current 3G and 4G wireless systems operate. Various millimeterwave frequency bands from 38 to 86 GHz are available for use, with some bands providing as much as 7 GHz of available bandwidth. More bandwidth equates to more capacity, which makes these bands ideal for backhauling wired and wireless networks, among other high demand applications.

Designers working in the millimeterwave bands such as E band (60 – 86 GHz) and V band (50 – 75 GHz) face particular challenges. While discrete devices are available, producing millimeterwave radio transceivers based on traditional chip and wire approaches can be extremely challenging, and very much dependent on the skill level of the assembly personnel involved. The advantages of using pretested, Known Good Die (KGD) MMICs over their Microwave Integrated Circuit (MIC) and discrete hybrid counterparts include reduced parts count, quicker assembly, and more consistent performance; and the value of these advantages increases exponentially with the frequency of operation. Components used in today's millimeterwave transceivers must exhibit very high performance, and be robust enough to operate in harsh environments. While discrete solutions in small volume can possibly provide the fewest sacrifices in electrical performance, achieving consistent results in volume production at frequencies above 38 GHz, without the use of MMICs, can be frustrating.

Past and present Velocium customers are now being served by Hittite's world class and worldwide customer service and applications support groups. The addition of the Velocium product line brings the total Hittite product portfolio count to over 600 standard products which are available to design engineers working in virtually every wireless application. Hittite's goal is to provide a one-stop shop to designers working across the frequency spectrum by providing innovative, reliable products that are consistent and easy to implement.

The HMC-ALH509 Low Noise Amplifier is one example of the newly licensed products (Figure 1 and 2). The HMC-ALH509 is a

Figure 1: Photomicrograph of the HMC-ALH509, 71 to 86 GHz GaAs MMIC HEMT LNA.



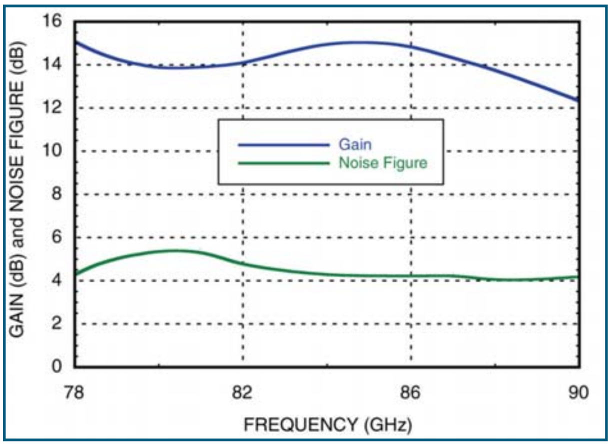
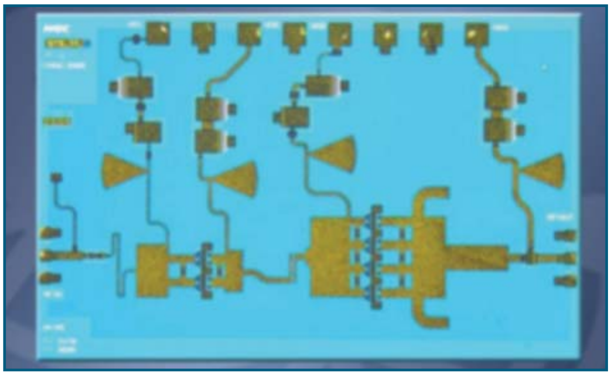


Figure 2: Gain and noise figure versus frequency for the HMC-ALH509, 71 to 86 GHz GaAs MMIC HEMT LNA.

Figure 3: Photomicrograph of the HMC-APH633, 71 to 76 GHz GaAs MMIC HEMT MPA.



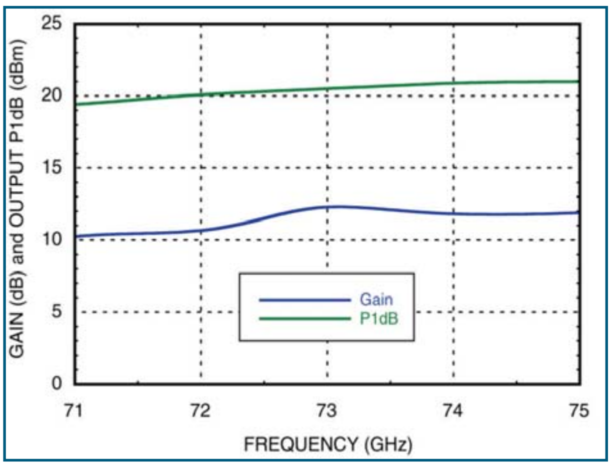


Figure 4: Gain and output P1dB versus frequency for the HMC-APH633, 71 to 76 GHz GaAs MMIC HEMT MPA.

three stage MMIC LNA which is fabricated in a GaAs HEMT process, and is specified for operation from 71 to 86 GHz. The HMC-ALH509 features 14 dB of small signal gain, 4.5 dB of noise figure and an output power of +7 dBm at 1dB compression. The HMC-ALH509 consumes only 50 mA from a +2 V supply and incorporates a balanced topology which enhances stability margin and provides excellent I/O return losses. The HMC-ALH509 requires only two off-chip bias decoupling capacitors, and no external matching components.

The HMC-APH633 is a two-stage GaAs MMIC Medium Power Amplifier which is also ideal for E-Band radio applications (Figure 3 and 4). The HMC-APH633 is fabricated in a GaAs HEMT process, and is specified for operation from 71 to 76 GHz. The HMC-APH633 delivers 13 dB of gain at midband, and a consistent +20 dBm output P1dB across the band. The HMC-APH633 requires no external matching components, and consumes only 240 mA from a +4 V supply.

As with all of the MMIC products in the Hittite – Velocium product line, all bond pads and the die mounting surfaces of the HMC-ALH509 LNA and the HMC-APH633 MPA are Ti/Au metallized, and feature fully passivated HEMT devices to ensure rugged and reliable operation. All of these die are compatible with conventional die attach methods, as well as thermocompression and thermosonic wire bonding, making them ideal for MCM and hybrid microcircuit applications.

One of the more popular millimeterwave bands spans 57 to 64 GHz, where there is 7 GHz of available bandwidth which straddles a peak in the atmospheric absorption of the electromagnetic waves. This portion of the spectrum is particularly attractive for secure communications in military applications, where the high atmospheric attenuation makes electronic eavesdropping very difficult. This high absorption property also affords dense frequency reuse in a wireless network situation, since adjacent radio links are less likely to interfere with each other. As a result of the high absorption rate, the FCC allows a generous amount of maximum output power to users in this band to enable sufficient transmission distances.

In contrast, the 71- 76 GHz and 81 – 86 GHz bands, which are designated as unlicensed FCC bands, are characterized by a relative null in the atmospheric absorption. This property allows longer distance radio links, and reduces the required emission levels. This same feature is also useful for other applications such as military and satellite communications, radio astronomy, radio navigation, and of course terrestrial point to point millimeterwave radios. While it can be less expensive to build communications systems at lower frequencies, the shorter wavelengths associated with the millimeter wave bands offers several system level advantages such as smaller antennas for a given beam width, and higher data capacity in a given percentage bandwidth.

While Millimeterwave Point-to-Point Radio architectures can vary widely depending on the application and the associated cost goals, the block diagram shown in Figure 5 is an example of how Hittite chip and SMT packaged components can be used to assemble 71 – 76 and 81 – 86 GHz transceivers. The example transceiver features QPSK modulation, double up conversion, double down conversion, one crystal reference, and only two standard VCOs.

As shown in the frequency generation section, the HMC583LP5E Voltage Controlled Oscillator (VCO) with RF/2 and divide-by-4 outputs, the HMC440QS16G Phase/ Frequency Detector, and the HMC432E Divide-by-2 Prescaler can be combined to quickly fabricate an LO source with +11 dBm output power, and very low SSB phase noise. The HMC440QS16GE Phase/Frequency Detector incorporates a 5 bit counter which can provide any divide ratio from 2 to 32. In the example shown, the counter is set to divide by 25, and the reference oscillator is cut for 63 MHz, such that the fundamental LO output frequency is locked at 12.6 GHz. Note that the RF/2 and the divide-by-4 outputs of the HMC583LP5E VCO help to reduce the number of parts needed to generate the LO signal at 12.6 GHz.

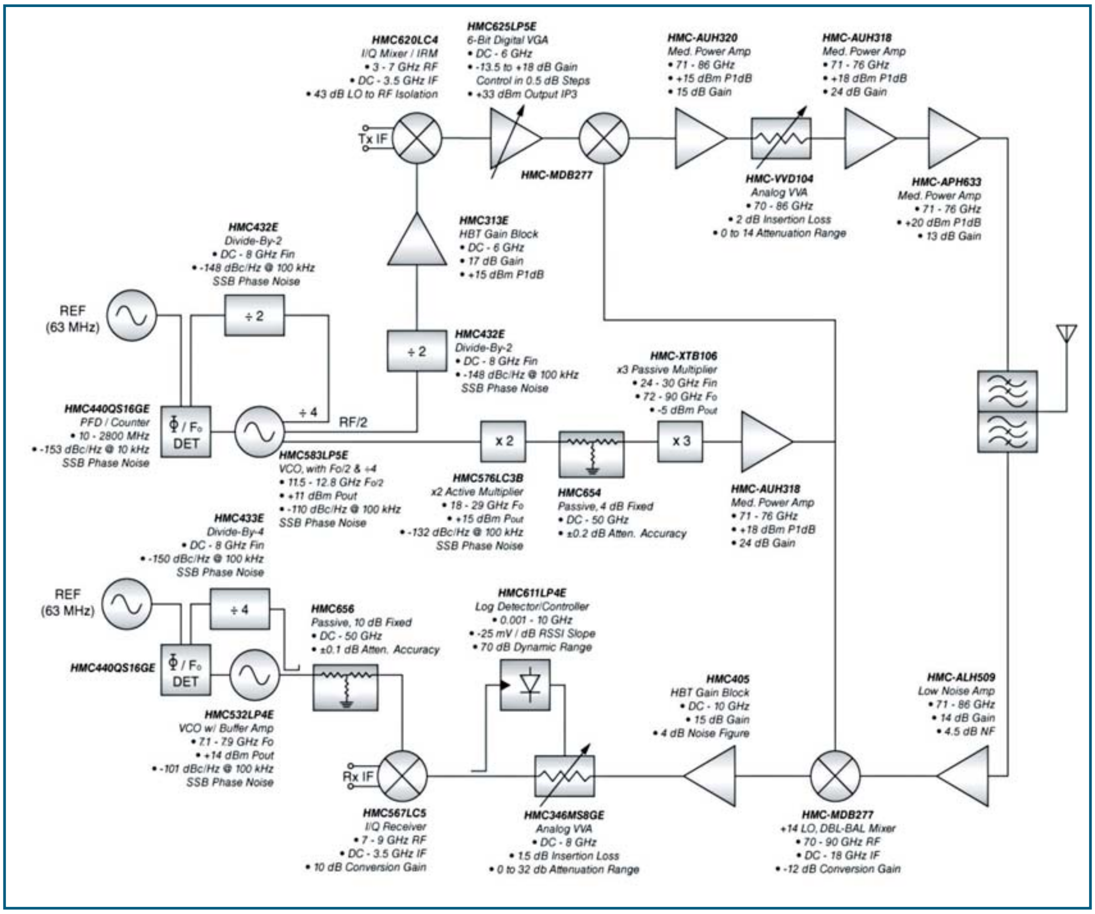
The RF/2 output of the HMC583LP5E is divided by 2 in the HMC432E divider, and then amplified in the HMC313E HBT Gain Block. The LO signal at +15 dBm is used to drive the LO port of the HMC620LC4 I/Q Mixer IRM in the transmit path. This mixer is ideal for use as a QPSK modulator, accepting baseband data at its I and Q ports, and upconverting to 3.15 GHz.

A cascade of multiplication is used to generate the E-Band LO frequency which is required for the final upconversion. The fundamental output of the HMC583LP5E VCO is multiplied in the HMC576LC3B X2 Active Multiplier, and further multiplied in the HMC-XTB106 X3 Passive Multiplier for a total multiplication factor 6. The HMC-AUH318 Medium Power Amplifier is used to boost the 75.6 GHz LO signal. The HMC-MDB277 Double Balanced Mixer is used as the final upconverter in the transmit section while a cascade of amplifiers is used to generate the Tx output with approximately +20 dBm output P1dB. The HMC625LP5E Digital Variable Gain Amplifier, and the HMC-VVD104 Voltage Variable Attenuator are used in the transmit chain to provide IF and RF gain control, respectively.

The HMC-MDB277 is also used as the first downconverter in the Rx chain, and is preceded by the HMC-ALH509 Low Noise Amplifier. In the example shown, the Rx chain operates at 83.16 GHz, where the HMC-ALH509 exhibits 4.5 dB noise figure and 14 dB gain, and makes an ideal low noise stage. After downconversion in the HMC-

MDB277, the IF band is then amplified in the HMC405 Gain Block. For applications where IF power control is desired, the VSET output of the HMC611LP4E Logarithmic Detector/Controller can be conditioned to drive the control input of the HMC346MS8GE Voltage Variable Attenuator, to construct a closed loop power control circuit.

Figure 5: A complete E-band transceiver based on Hittite-Velocium components.



Function	26 / 28 GHz	32 / 38 GHz	39 - 43 GHz	44 - 66 GHz	71 - 86 GHz
Low Noise Amplifier	HMC341LC3B HMC517LC4 HMC518 HMC519	HMC263 HMC566	HMC-ALH244 HMC-ALH310 HMC-ALH369 HMC-ALH376	HMC-ALH382	HMC-ALH459 HMC-ALH509
Driver & Power Amplifier	HMC283LM1 HMC499LC4 HMC-APH196 HMC-APH460 HMC-APH462 HMC-APH608 HMC-APH596	HMC283LM1 HMC300LM1 HMC383LC4 HMC-APH403 HMC-APH473 HMC-APH510 HMC-APH596	HMC283 HMC-ALH310 HMC-ALH376 HMC-APH403 HMC-APH473 HMC-APH510 HMC-AUH256	HMC-ABH209 HMC-ABH241 HMC-ABH403	HMC-AUH317 HMC-AUH318 HMC-AUH320 HMC-APH577 HMC-APH633
Wideband (Distributed) Amplifier	HMC562 HMC-AUH312	HMC562 HMC-AUH312	HMC-AUH232 HMC-AUH312	HMC-AUH312	
Attenuator: Voltage Variable	HMC-VVD102	HMC-VVD106	HMC-VVD106	HMC-VVD106	HMC-VVD104
Attenuator: Passive	HMC650 - HMC658	HMC650 - HMC658	HMC650 - HMC658	HMC650 - HMC658	
Frequency Divider	HMC447LC3				
Frequency Multiplier	HMC449LC3B HMC577LC4B HMC578LC3B	HMC449LC3B HMC578LC3B HMC579	HMC331 HMC579	HMC-XDH158	HMC-XTB106
Mixer: I/Q & Receiver	HMC524 HMC524LC3B HMC572LC5	HMC404 HMC555 HMC556	HMC-MDB171 HMC-MDB172	HMC-MDB171 HMC-MDB207	
Mixer: Fundamental	HMC292LC3B HMC329LC3B HMC560LM3	HMC294 HMC329LM3 HMC560LM3	HMC329 HMC560 HMC560LM3	HMC-MDB169	HMC-MDB277
Mixer: Sub-Harmonic	HMC264LC3B HMC265LM3 HMC338LC3B	HMC266 HMC338LC3B HMC339	HMC266 HMC339	HMC-MDB218	
Switch				HMC-SDD112	HMC-SDD112
VCO & PLO: (Multiplication Required)	HMC401QS16GE HMC515LP5E HMC584LP5E	HMC505LP4E HMC532LP4E HMC587LC4B	HMC506LP4E HMC530LP5E HMC588LC4B	HMC401QS16GE HMC583LP5E HMC632LP5E	HMC398QS16GE HMC531LP5E HMC582LP5E

Table 1: A selection of Hittite chip and SMT transceiver components for microwave and millimeterwave applications.

Finally the HMC567LC5 I/Q Receiver is used to demodulate the QPSK signal, and uses a dedicated synthesizer which is based on the HMC532LP5E VCO, HMC433E Divide-by-4, and the HMC440QS16GE Phase/Frequency Detector.

It should be noted that all of the die and SMT components used in the example transceiver are RoHS compliant. The designer can fabricate most of the radio with SMT components, and reserve only a small section for bare MMIC assembly. This partitioning should enable a modularized approach where the sub-25 GHz section of the radio can be assembled and tested, before being mated with the millimeterwave section. This approach also facilitates the manufacture of a significant portion of the radio by either an in-house SMT line, or by multiple, competing CM (contract manufacturer) locations.

All of the products shown on the example block diagram are available from stock to support all of the major RF sections of a typical radio including the transmit, receive, LO generation and LO distribution sections of the transceiver.

Hittite is well known for its broad portfolio of die and SMT packaged components for the Microwave and Millimeterwave markets. Table 1 provides a selection of Hittite's MMIC based Amplifiers, Control Products, Mixers, Frequency Multipliers and Dividers, Switches and VCOs. This table illustrates the breadth and depth of products which Hittite offers to the radio designer. Each of these products are available as in-stock, off-the-shelf products. The table lists over 90 products available for millimeterwave applications from 38 to 86 GHz, with hundreds more products available which operate at IF and RF frequencies. In total, designers can choose from more than 600 standard products offered by Hittite including data converters, modulators and demodulators, phase shifters, switches, and synthesizers. Data sheets and supporting information for all of Hittite's products are available online at www.hittite.com.