

# Simplifying Radio Design For Millimeter Wave Point-to-Point and Satellite Earth Terminals

by TriQuint Semiconductor

## Introduction:

RF engineers are constantly searching for ways to simplify radio designs. Fewer components, smaller size, higher levels of circuit integration and standardization of assembly are all tools designers may employ to lower their design complexity and cost. Traditionally, higher RF frequency bands, C-Ka band, have been utilized for terrestrial network backhaul radio and satellite ground terminal applications. RF components for high frequency systems require advanced semiconductor processes to meet performance requirements.

For radio designs in the 6-40GHz frequency bands, multi-chip-modules (MCMs) have traditionally been used by radio OEMs to achieve the highest level of performance. For MCMs, multiple MMICs per module are required to realize the frequency generation, frequency conversion and amplification functions for both transmit and receive paths. Separate MMICs along with their associated passive bias/bypass components and wire-bond interconnects will generally provide the highest level of performance, but will also increase the size, complexity and cost of the radio module.

In recent years, MMIC suppliers have been working to reduce the number of ICs required for each module by integrating the frequency conversion and amplification functions into a single die. Although this integrated approach may simplify the module assembly, RF designers are faced with the possibility of lower system performance due to inherent non-optimal solutions that generic integrated functions provide. However, if integrated MMICs are designed for more specific customer applications, partitioned for maximum flexibility, and offered as both die and packaged versions, customers can choose between low-cost and performance options based on individual needs.

Advances in millimeter wave circuit design, modeling and device process technology are

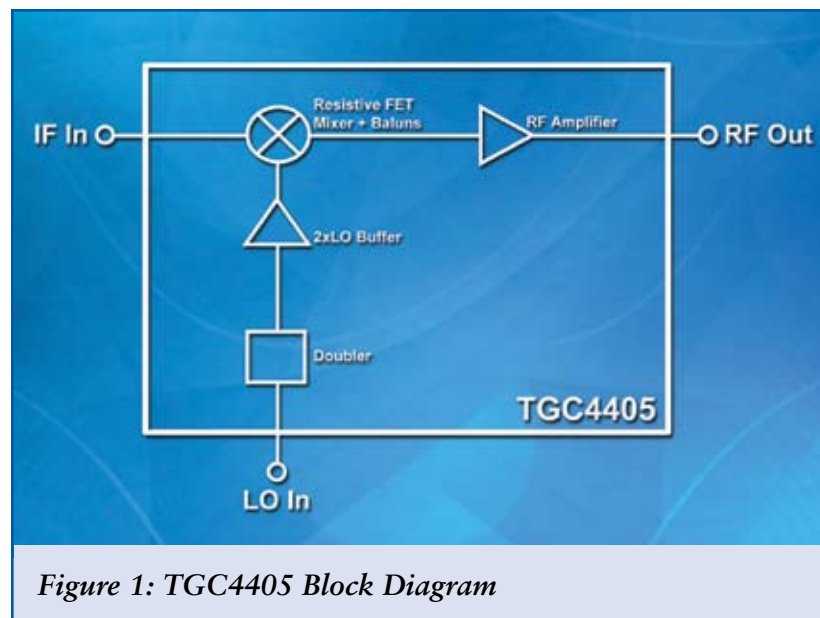


Figure 1: TGC4405 Block Diagram

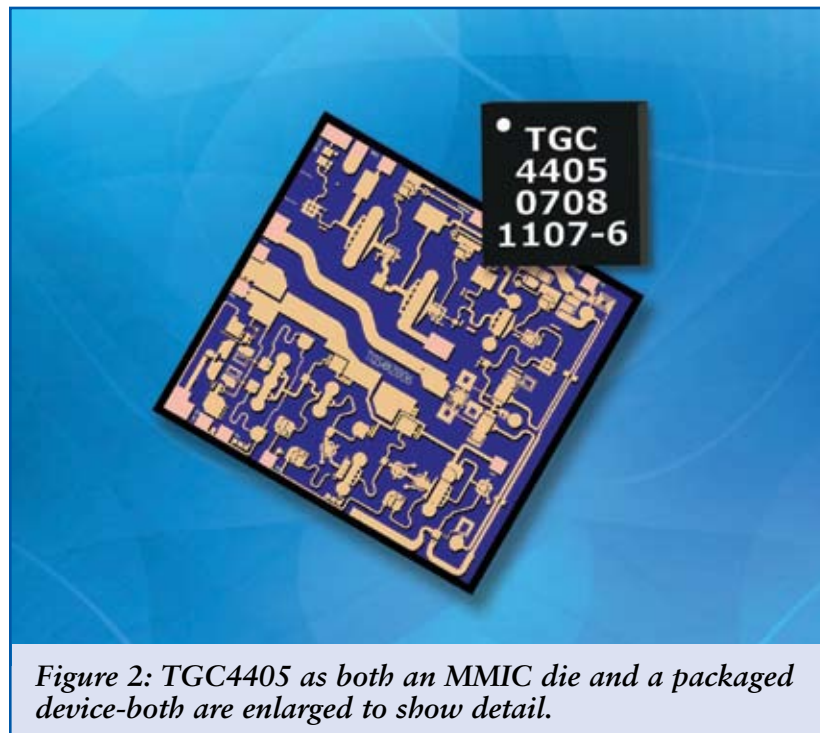


Figure 2: TGC4405 as both an MMIC die and a packaged device—both are enlarged to show detail.

now enabling integrated up-converters, downconverters and LO multipliers to become more available as standard off-the-shelf products for use by RF designers. Additionally, innovations in high frequency packaging and test capability have spawned a growing number of millimeter wave MMICs made available in packaged form. Although packaged MMICs may provide the radio OEM another degree of flexibility for module assembly, bare die may offer the highest performance solution. By offering designers both die-level and packaged options, plus multiple choices for selecting appropriate integration levels, TriQuint Semiconductor provides OEMs

greater overall flexibility to select the best solution for lowering costs and maximizing performance.

TriQuint Semiconductor's new integrated MMIC product lineup includes a fully integrated Ka-band upconverter, Ka-band frequency doubler with integrated buffer amplifier and a single balanced mixer. All products are offered as bare die and packaged versions to provide customers the greatest level of flexibility in optimizing system performance and assembly options.

An example of a new generation MMIC created from these developments is demonstrated in TriQuint's TGC4405 frequency upconverter that inte-

grates four components into a single MMIC. Customers can utilize the TGC4405 to simplify radio design through a reduction in cost, component count, size, and assembly complexity. These advantages are particularly appropriate for price competitive markets such as point-to-point radio and satellite earth stations. In legacy designs, a mixer, multiplier, LO amplifier and RF amplifier required 4 separate chips and may have utilized 2x - 4x the GaAs chip area in comparison with the TGC4405.

## Product Description:

Operating across the 17 to 27 GHz band, the TGC4405 is a single-balanced upconverter. This multi-function product features an integrated local oscillator frequency doubler and buffer amplifier, feeding a resistive FET mixer followed by an output RF amplifier. Figure 1 presents the key elements of this MMIC. All LO, RF and IF baluns are integrated onto the MMIC, allowing all RF ports to be single-ended with a 50-ohm impedance.

Port frequency ranges are as follows:

- LO: 8 to 13 GHz;
- RF: 17 to 27 GHz;
- IF: 500 to 3000 MHz.

The TGC4405 is created using TriQuint's 0.25µm Power pHEMT 3MI (3-metal interconnect) process that features three levels of interconnecting metal and thick passivation for environmental robustness. The 3MI process allows high density circuit design techniques resulting in a significant reduction in die size when compared with alternate technologies. Figure 2 displays this 2.07 x 1.93mm chip with 0.1mm thickness.

The inclusion of an RF output post amplifier allows the TGC4405 to exhibit a net conversion gain of 13 dB, which allows designers to insert filters or attenuation in the transmit upconversion chain without creating the need for additional gain stages. Figure 3 presents lower and upper sideband conversion gains as a function of

RF output frequency.

When operated with LO input levels of +2 to +5 dBm, the TGC4405 demonstrates an output third order intermodulation intercept level of +28 dBm (See Figure 4) and 30 dBc typical isolation between the fundamental and doubled local oscillator drive signal. Output RF port return loss is greater than 10 dB.

The TGC4405 and other members of the MFC product family are designed for similar market segments, but with different subsets of the frequency conversion components. The TGC4402 provides the IF-to-RF frequency upconversion function without the LO frequency doubler or the output amplifier; the TGC4403 is a stand alone millimeter wave frequency doubler with integrated buffer amplifier. Multiple band designs are possible using the TGC4405 with alternate input frequencies and filters for increased flexibility. Various options of the frequency conversion components allow customers maximum flexibility to determine the level of integration that is optimum for specific applications. For example: the TGC4403 might be used in a system that benefits from integration of the LO doubler circuit paired with a higher performance single circuit mixer. Completing the range of options, TriQuint offers surface mount packaged versions of these products (TGC4402-SM, TGC4403-SM

and TGC4405-SM) that provide similar performance to their die counterparts, but in convenient 4x4mm footprints.

#### Conclusions:

Multi-function circuits are enabling the next generation of cost-effective high performance products. Simplified radio design solutions utilizing integrated MMIC functions can reduce module complexity, improve time-to-market for new platforms and produce cost savings for radio OEMs. By offering designers both die-level and packaged options, plus multiple choices for selecting the appropriate level of integration, TriQuint Semiconductor provides OEMs the greatest overall flexibility to select the best solution for lowest cost and maximum performance.

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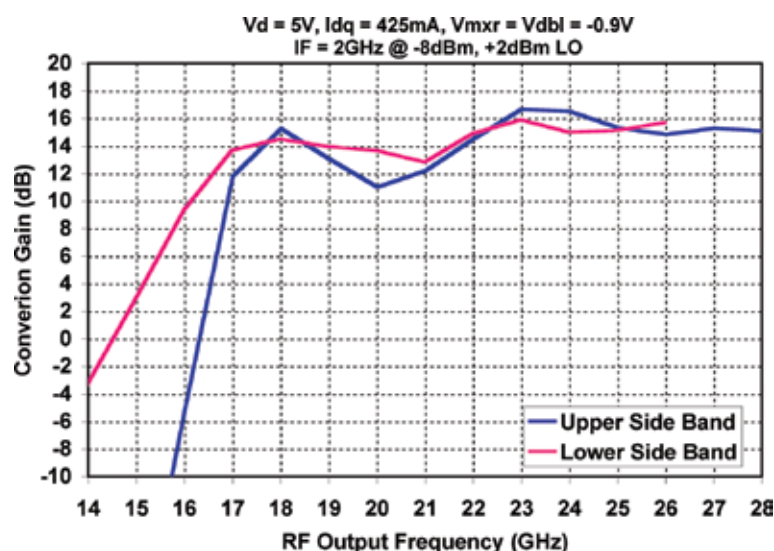


Figure 3: Conversion Gain vs. Frequency

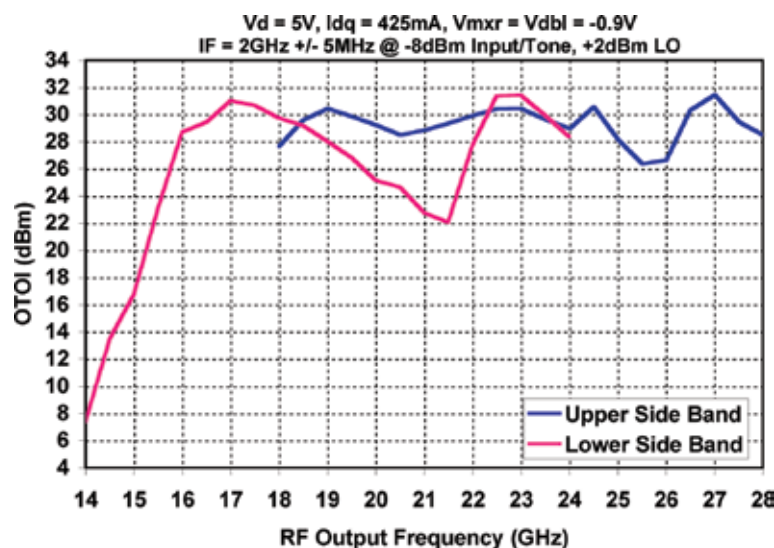


Figure 4. Output Third Order Intermodulation Intercept