GaN Devices Set Benchmarks for Power and Bandwidth

by TriQuint Semiconductor

Since gallium nitride (GaN) RF power devices made their appearance in effective counter-IED (C-IED) jammers in Iraq and Afghanistan, they have steadily increased in performance, reliability, efficiency, and frequency coverage. High-performance commercial applications are also implementing GaN in hybrid solutions that typically place the GaN-based device in the output stage of a design. Not surprisingly, GaN continues to be specified for a much wider range of defense and high-performance commercial applications ranging from terrestrial and satellite communications, to electronic warfare (EW) including countermeasures and radar. Three new GaN MMIC RF power amplifiers from TriQuint Semiconductor were designed for use in defense applications but are equally suited to any application requiring an optimum combination of RF output power, gain, efficiency, and broad bandwidth.

The new GaN MMICs include the TGA2572, TGA2573, and TGA2576 that operate from 14 to 16 GHz, 2 to 18 GHz, and 2.5 to 6 GHz respectively. The TGA2572 and TGA2573 represent an "ideal" combination of frequency coverage, gain, power-added efficiency (PAE), and RF power output in their class, and open new possibilities for the use of GaN in a variety of applications. Their unique capabilities are not matched by other commercially-available GaN devices. The TGA2576 delivers 40 W (46 dBm) of saturated (Psat) RF output power across a frequency range that includes key defense bands and related system applications.

All three devices, fabricated using TriQuint's proven 0.25 µm GaN-SiC process, are available as die-level products for easy incorporation into multi-chip modules and integrated assemblies. TriQuint offers two of the three devices as packaged products. The TGA2572-FL (Figure 1) places TriQuint's GaN die into an industry standard flange package for easier handling and superior heat mitigation. The TGA2572 is tailored to meet the requirements of satellite communications and point-to-point microwave radio systems operating at Ku-band. It delivers saturated power (Psat) of 20 W (43 dBm) with gain of 23 dB and PAE of 30%. The TGA2576-FL is also available using the same industry-standard package. The TGA2576 has gain of 25 dB and PAE greater than 30%, and is an excellent choice for counter-IED jammers and defense and commercial applications operating in the S- and C-bands.

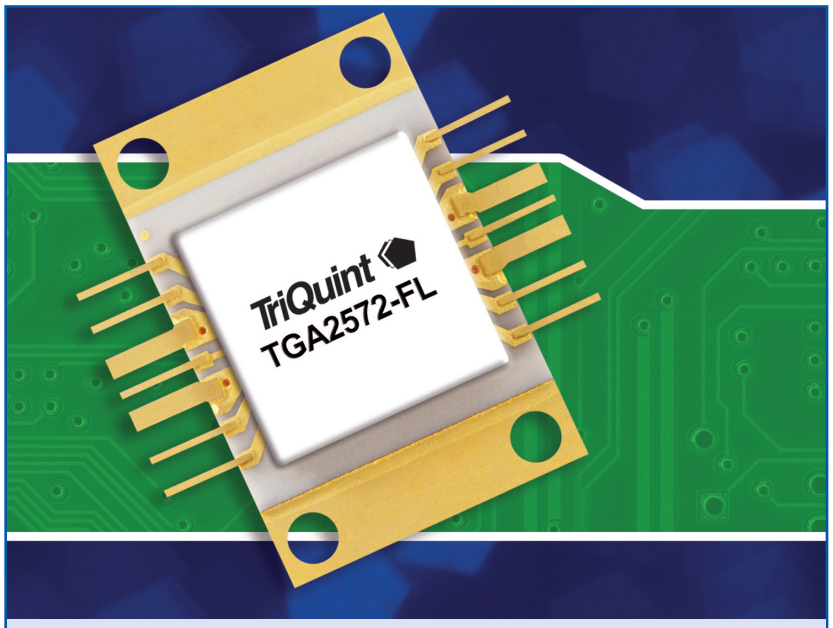

Figure 1: The TGA2572-FL places TriQuint's GaN die into an industry standard flange package for easier handling and superior heat mitigation.

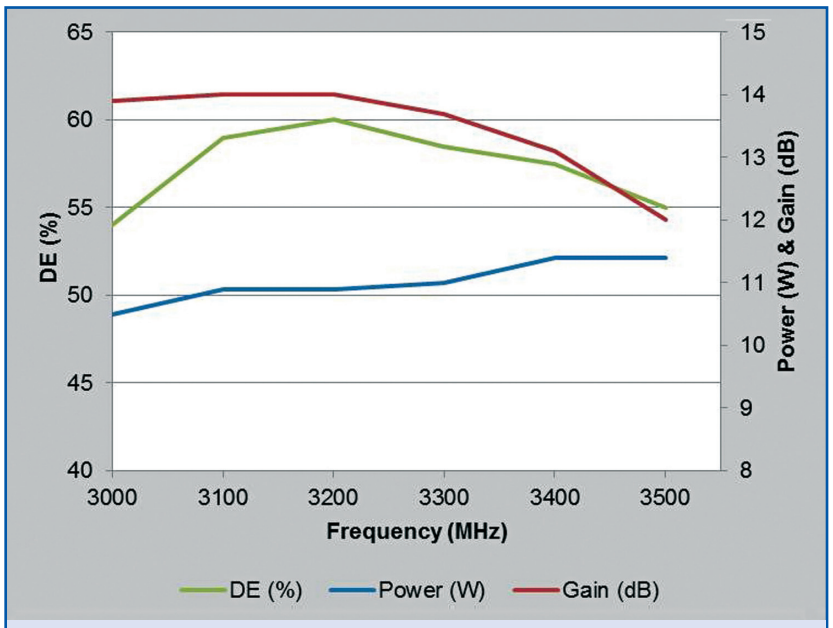

Figure 2: EVB performance of the T1G6000528-Q3, with a 200-ns pulse, 20% duty cycle signal. It shows drain efficiency of 53% at 3.5 GHz. The device offers more than 7 W output power across a wide bandwidth.

The TGA2573 produces 10 W (40 dBm) output power, 9 dB of gain and a PAE of 25%. Its ability to cover frequencies from S-band through Ku-band with flat frequency response and minimal gain variation makes it well suited for broadband applications such as EW, ECM, radar, and test equipment. All three devices are internally matched to 50 ohms and are tested on-wafer to ensure they meet or exceed their rated specifications.

To further extend these products' flexibility and enable the RF designer with more product solutions, TriQuint also offers the TGA2572-TS and the TGA2573-TS. These products combine the optimized performance of die-level devices while adding the convenience of coming pre-attached to economical thermal spreaders. These products are created using TriQuint's virtually void-free vacuum reflow process called Die-on-Tab (DoT). The DoT service is performed in-house by TriQuint, utilizing the same process controls and same performance standards as the company's MMIC manufacturing program.

In TriQuint's integrated assembly and test facilities, GaN die are placed on thermal spreaders using vacuum reflow to create a permanent bond between the die and either a copper-moly (CuMo) or copper tungsten (CuW) heat sink. X-ray and visual inspection are performed after assembly. The DoT process simplifies next-stage assembly and yield since DoT product solutions are 100% inspected by TriQuint before shipment. This ensures that the customer receives known good die and higher overall yields. In addition, the die-attach process helps reduce thermal mitigation requirements common to high-power GaN-based devices.

Expanding GaN Portfolio

TriQuint's portfolio of standard GaN devices includes HEMT RF power transistors with bandwidths as great as DC to 18 GHz, RF output power up to 100 W (50 dBm), and PAE greater than 55%. Packaged amplifier modules range in RF power output from 10 to 30 W and cover frequencies as high as 18 GHz with

Figure 3: The T1G4005528-FS delivers at least 55 W of P3dB output power with 50% PAE from DC to 3.5 GHz.

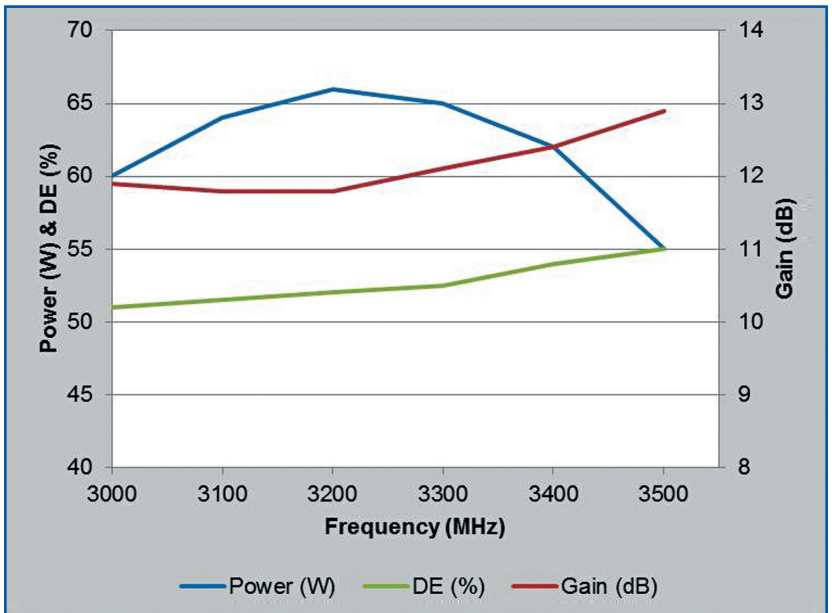

Figure 4: EVB performance of the T1G4005528-FS with a 100-us pulse, 20% duty cycle signal. Drain efficiency is greater than 50%. The device provides best-in-class linear gain greater than 15 dB and more than 55 W compressed output power at 3.5 GHz.

gain greater than 25 dB and PAE greater than 40%.

Other recent additions to the company's GaN devices include the T1G6001528-Q3 and T1G4005528-FS. The T1G6001528-Q3 delivers more than 18 W of RF output power at P3dB, PAE greater than 50% from DC to 6 GHz, and 10 dB of gain at 6 GHz, making it well-suited for both narrowband applications such as communications systems as well as very broadband applications such as test equipment, electronic warfare and radar. The T1G6000528-Q3 is a broadband, 7-W device with greater than 50% efficiency from 20 MHz to 6 GHz, and more than 9 dB of gain at 6 GHz. EVB performance of the T1G6000528-Q3 is shown in Figure 2. Typical applications all types of communications systems, jammers, radar, base stations, and test equipment.

Finally, the T1G4005528-FS (Figure 3) delivers at least 55 W of P3dB output power with 50% PAE from DC to 3.5 GHz. Gain is greater than 14 dB at 3.3 GHz. EVB performance of the T1G4005528-FS is shown in Figure 4. Both devices leave matching to the designer who can create simple external matching networks that optimize the devices for maximum power, gain, and efficiency. They are mounted in earless ceramic packages and operate from 28 VDC. Detailed specifications for all these devices are shown in Table 1.

GaN Product and Foundry Innovation

TriQuint's GaN development activities began in 1999, when the technology was comparatively embryonic. The company has been a key participant in government-sponsored programs focused on speeding GaN technology development. They include a $17.5-million multi-year contract originating in Title III of the Defense Production Act and administered by the U.S. Air Force Research Laboratory (AFRL). The goal of the program is to develop greater yield, and enhanced manufacturing capabilities as well as time-to-market. A now-completed program with the AFRL also developed GaN modules/integrated assemblies for an Unmanned Aerial Vehicle (UAV) program designed to increase the range and overall mission capabilities of the UAV fleet.

In collaboration with several industry and university partners, TriQuint is leading

Table 1: Key GaN Device Specifications

Model	Type	Frequency Range (GHz)	RF output (W)	Gain	Efficiency (%)
TGA2572	MMIC	14 to 16	20	23	30
TGA2572-FL	Flange	14 to 16	20	23	30
TGA2572-TS	Die	14 to 16	20	23	30
TGA2573	MMIC	2 to 18	10	9	25
TGA2573-TS	Die	2 to 18	10	9	25
TGA2576	MMIC	2.5 to 6	30	25	>30
TGA2576-FL	Flange	2.5 to 6	30	25	>30
T1G4005528-FS	Package	DC to 3.5	55	15	>50
T1G6000528-Q3	Package	20 MHz to 6	7	9	>50
T1G6001528-Q3	Package	DC to 6	18	15	>50

Phase II of the DARPA Nitride Electronic NeXt-Generation Technology (NEXT) program, which is seeking highly advanced mixed signal (RF and digital) circuits up to 500 GHz. In December 2011 TriQuint was chosen to lead DARPA's Microscale Power Conversion (MPC) program that will develop very high power, ultra-fast GaN switches that will be paired with new RF power amplifiers for advanced transceiver systems. TriQuint's new switch will be designed to handle up to 500 V (DC-DC) with a target slew rate of 500V/ns.

The Department of Defense has certified TriQuint's foundry services as a Category 1A 'Trusted Foundry' for GaN and gallium arsenide (GaAs) integrated circuits. The program requires that accredited foundries meet stringent product control and secure handling standards in all stages of circuit fabrication. TriQuint is currently fabricating GaN devices on 100-mm wafers, the current state of the art in GaN process technology, and has expanded its product line to include GaN switches with operating frequency ranges up to 18 GHz, very low insertion loss, and power-handling ability up to 40 W. More information is available at www.triquint.com/defense or by e-mail at info-defense@tqs.com.

TRIQUINT SEMICONDUCTOR