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RF AND MICROWAVE TECHNOLOGY FOR DESIGN ENGINEERS

Designing broadband WiMAX PA using GaN power transistors

In addition to investigating the performance and design benefits of using gallium nitride (GaN) power transistors in broadband WiMAX applications, this article also presents RF performance achieved with silicon substrate and plastic overmold packaging for these transistors.

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The broadband wireless technology WiMAX IEEE 802.16 has generated a significant amount of interest for delivering the latest in fixed and mobile services over large areas in a cost-effective manner. Currently, there are two licensed bands (2.3 GHz to 2.7 GHz and 3.3 GHz to 3.8 GHz) and one license exempt band (5.725 GHz to 5.85 GHz) available under the 802.16 standard. OEMs developing RF amplifiers for fixed and mobile WiMAX infrastructures require a transistor that is able to simultaneously deliver high power and broad bandwidth performance at the frequency bands described above. AlGaN/GaN HFET's ability to produce high output powers at high frequencies and over large bandwidths makes it the ideal technology to enable WiMAX solutions from the performance perspective. Delivering gallium nitride's (GaN) performance levels on low cost, reproducible, and readily available Si substrates, makes a compelling argument for the technology platform.

Nitronex has developed a family of products that target the 2.3 GHz to 2.7 GHz and 3.3 GHz to 3.8 GHz WiMAX applications. This lineup employs AlGaN/GaN HFETs grown by MOCVD on high resistivity 100 mm Si (111) substrates. The epitaxial structure consists of nucleation and transition layers, ~0.8 µm of GaN followed by ~180 Å of $Al_{.26}Ga_{.74}N$ and completed with a ~10 Å GaN capping layer. The layout of the device includes a gate length of 0.5µm and the use of a source field plate.

The NPT25015 and the NPT35015 address the OEMs requirements for 1 W to 2 W of linear power for the 2.3 GHz to 2.7 GHz and 3.3GHz to 3.8 GHz bands respectively. These devices incorporate transistors with 8 mm of gate periphery within a plastic overmold package. The use of plastic overmold packaging offers a reduction in packaging costs of greater than 10 times when compared to the use of ceramic air cavity packages. This cost savings is realized by leveraging Amkor Technologies low-cost plastic overmold power small outline package (PSOP).

The Amkor technology assembly process for the NPT25015 and the NPT35015 consists of attaching transistor die to a copper flange using a conductive epoxy die attach. The die's gate and drain pads are wire bonded to the package lead frame without additional internal matching components using one-mil diameter Au wires for each side. The wires and die are encapsulated in a plastic overmold,

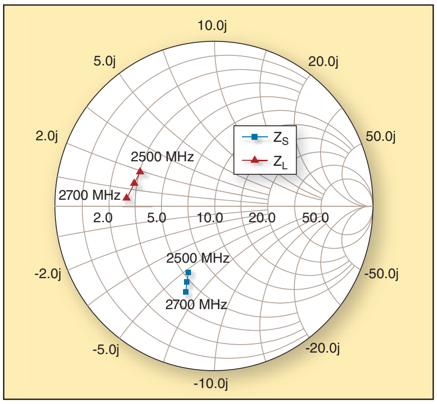

Figure 2. Optimum OFDM source and load impedance for the NPT25015 (VDD = 28 V, IDQ = 200 mA).

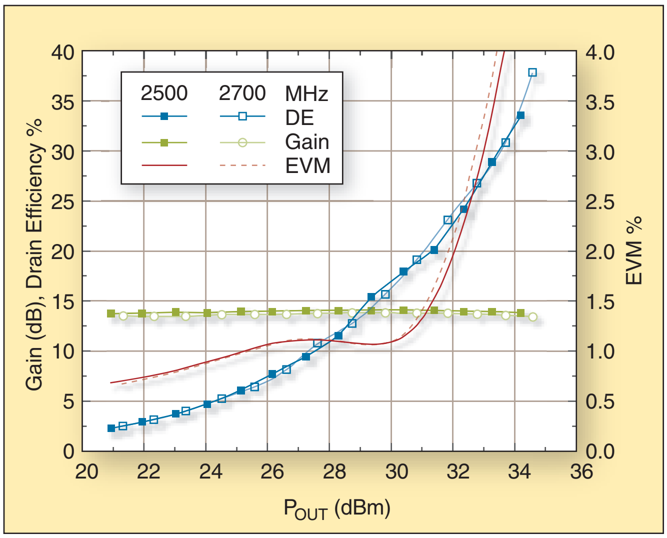

Figure 1. Typical OFDM performance of the NPT25015 in a load pull system at 2.5 GHz and 2.7 GHz (VDD = 28 V, IDQ = 200 mA).

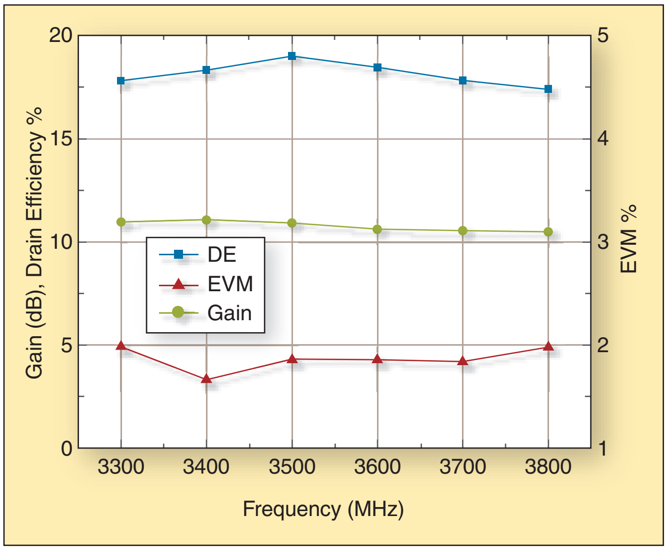

Figure 3. Typical NPT35015 OFDM performance in a load pull system at Pout = 32 dBm (VDD = 28 V, IDQ = 200 mA).

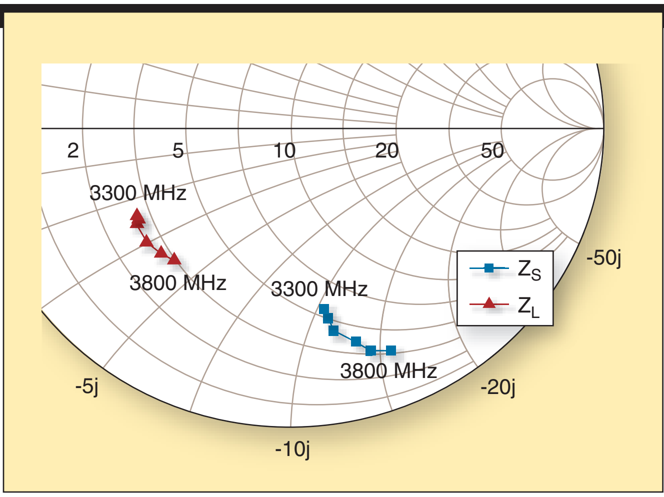

Figure 4. Optimum OFDM source and load impedances for the NPT35015 (VDD = 28 V, IDQ = 200 mA).

which has a higher dielectric constant than air resulting in slightly larger parasitics than an air cavity package. However, this does not significantly impact the RF performance of the device.

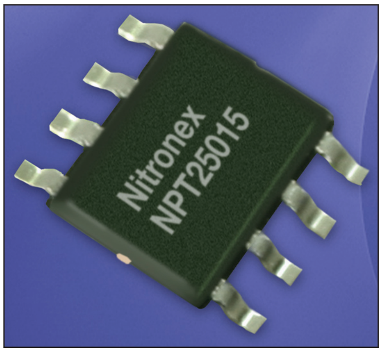

Figure 5. NPT25015 is housed in a low-cost plastic overmold package.

RF characterization of the devices was performed in a Focus Microwave load pull system. The packaged devices were tested using a 50 Ω test fixture under a single carrier orthogonal frequency-division multiplexing (OFDM) waveform (64 QAM 3/4, 20 ms frame rate, 3.5 MHz channel bandwidth) producing a peak to average ratio of 10.3 dB at 0.01% probability on CCDF. The devices were biased with a drain voltage of 28 V and a drain current of 200 mA.

Figure 1 shows the OFDM performance of a typical NPT25015 at 2.5 GHz and 2.7 GHz. At an output power of 32 dBm the devices typically produce 14 dB of gain, 23.5% of drain efficiency and an EVM of 2%. The source and load impedances, presented in a 10 Ω Smith Chart in Figure 2, are well behaved across the 200 MHz band.

The typical OFDM performance at an output power of 32 dBm across the 3.3 GHz to 3.8 GHz band for the NPT35015 is depicted in Figure 3. The devices are capable of delivering ≥11 dB of gain, ≥17% of drain efficiency and ≤ 2% of EVM across the entire band. The source and load impedances across the 500 MHz band are presented in a 10 Ω Smith Chart shown in Figure 4. Similar to the NPT25015, these impedances are well behaved across the operating band allowing for the realization of broadband designs.

To address the need for higher power in output stage power amplifiers in the 3.3 GHz to 3.8 GHz band, Nitronex has developed the NPT35050. These devices use a 36 mm periphery transistor with a two-stage input match, no output match and biased at a rain voltage of 28 V and a drain current of 750 mA to achieve ≥ 6 W of linear power. Unlike the NPT25015 and NPT35015, the NPT35050 is packaged in a thermally enhanced ceramic air cavity package with a eutectic die attach process. The thermally enhanced package is constructed with a copper/copper molybdenum alloy/copper (CPC)-based flange rather than the typical copper tungsten (CuW)-based flange. The thermal conductivity of CPC based flange is ~1.4 times higher than its CuW counterpart. The thermal

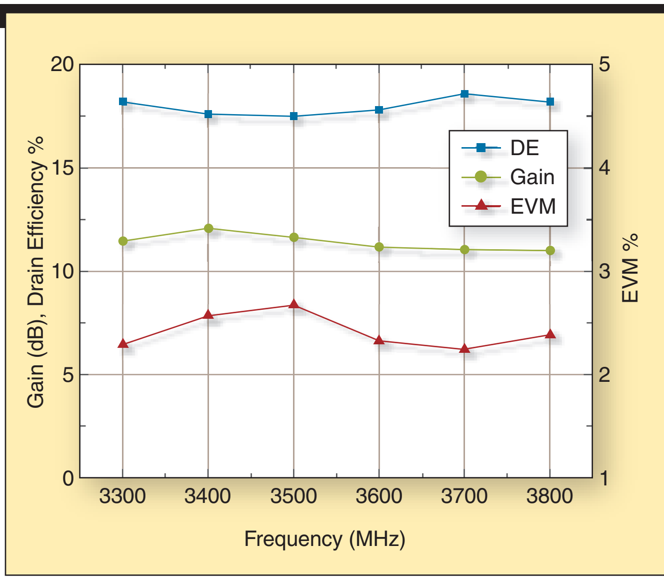

Figure 6. Typical NPT35050 OFDM performance in a load pull system at Pout = 38 dBm (VDD = 28 V, IDQ = 750 mA).

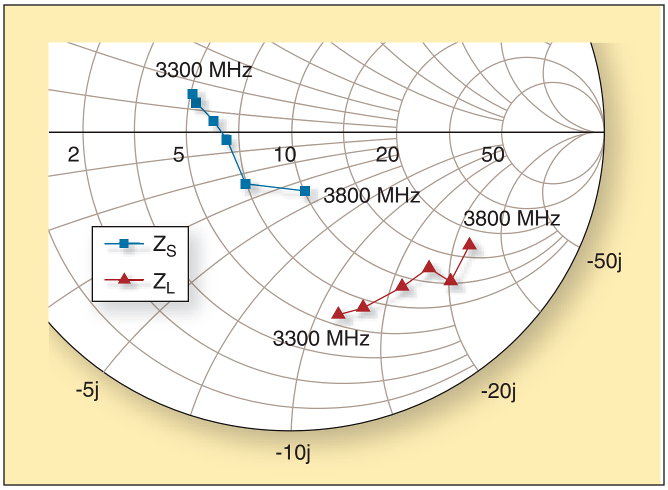

Figure 7. Optimum OFDM source and load impedances for the NTP35050 (VDD = 28 V, IDQ = 750 mA).

advantage that this process delivers is necessary when operating at the higher power levels. The typical OFDM performance at an output power of 38 dBm across the 3.3 GHz to 3.8 GHz band for the NPT35050 is depicted in Figure 6. The devices are capable of delivering ≥11 dB of gain, ≥17% of drain efficiency and ≤2.5% of EVM across the entire band. Figure 7 shows the OFDM source and load impedances across the 500 MHz band in a 10 Ω Smith Chart.

Nitronex has developed a demonstration board for the NPT35050 tuned for the 3.4 GHz to 3.6 GHz band resulting in excellent OFDM performance. The performance in the demonstration board across the band is virtually identical to the data achieved in the load pull system.

GaN HFETs make them the ideal solution to achieve the technical goals related to producing infrastructure for the WiMAX application. The use of Si as the substrate for the GaN structures offers a number of advantages, such as cost, scalability, reproducibility and ease of processing, when compared to other substrates typically used for GaN. Furthermore, combining GaN's performance with low-cost plastic overmold package delivers a powerful, cost effective solution for WiMAX applications. RFD

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