A high linearity, high efficiency WiMAX power amplifier using SiC MESFETs

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Abstract

This paper describes the results of a broadband, high linearity, high efficiency power amplifier for WiMAX basestation applications in the 3.3 – 3.9 GHz band. Using SiC MESFETs, a single-stage power amplifier has been designed that provides a significant increase in performance, providing 17% drain efficiency, 1.5% EVM, and 3dB margin to spectral mask at 1.5W average output power under a WiMAX compliant signal, compared with realizations using other transistor technologies.

Introduction

The CRF35010 is a discrete transistor that includes input pre-matching in a very small outline package. This device has a 1dB compression point of 12 Watts with a peak power capability of 20 Watts over the entire 3.3 – 3.9 GHz WiMAX band. This transistor operates over the complete WiMAX band without any need for re-tuning.

Silicon Carbide is an excellent semiconductor technology for broadband, high power applications. The wide bandgap results in a high breakdown voltage process. The CRF35010 operates at 48 volts (drain-to-source) providing a load line with high output impedance, thus making broadband matching easier compared to GaAs MESFET. The outstanding thermal capabilities of silicon carbide enable the device to run at elevated temperatures with excellent reliability. Mean time to failure (MTTF) of $2x10^6$ hours has been proven at a junction temperature of 225ºC.

Design and Results

The CRF35010 was designed using Cree's internally developed large signal models. The pre-match was included to improve the gain performance of the device at the high frequency end of the band. It also improves the input impedance of the transistor. The test board was designed to transform the device impedances, nominally Z_s=20 Ohm and Z_L=5 Ohm to a system impedance of 50 Ohm. A photograph of the CRF35010 based amplifier is show in Figure 1.

Figure 2 shows the small signal performance of the CRF35010 in its associated test board. The gain is greater than 9dB from 3.3 GHz to 3.9 GHz and the input return loss is better than 5dB across the band. The effect of the internal pre-matching capacitor can clearly be seen with the strong resonance in S11 at about 3.8 GHz.

The spectral mask for WiMAX is defined by ETSI specification EN301 021. A diagram of the mask is shown in Figure 3. The majority of testing has been performed using 3.5 MHz wide signals that have 64QAM bursts. The amplifier has also been measured with wider signals with no apparent degradation in the performance. The performance of the amplifier at 1.5 Watts average is show in Figure 4.

Figures 5 and 6 show the performance of the amplifier in terms of the ETSI "D" offset and the relative constellation error (RCE) over a wide dynamic range (RCE being a decibel representation of the RMS error vector magnitude (EVM)). The amplifier is specification compliant up to an average RF output power of 2 Watts.

Conclusions

This paper has shown state-of-the-art performance for a WiMAX power amplifier utilizing Cree's SiC MESFET devices. This new device at least doubles the efficiency when compared to existing GaAs FET's for the same average output power. Developments of higher power transistors and modules for operation in the same frequency band as well as the 2.5 to 2.9 GHz and 4.9 to 5.9 GHz bands are in progress.

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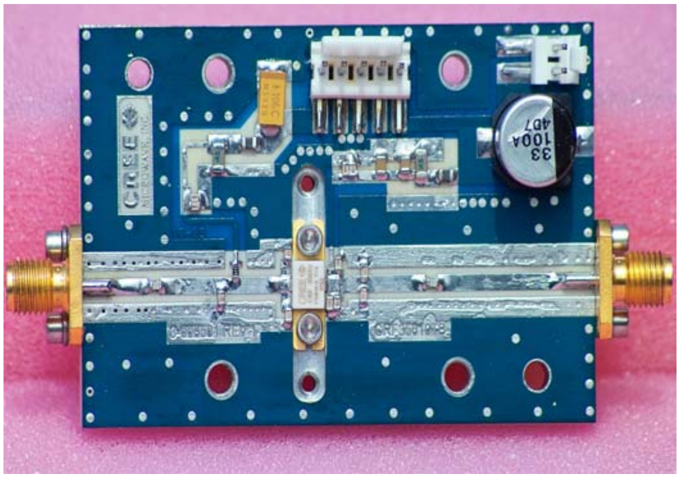

Figure 1. CRF35010 and test board

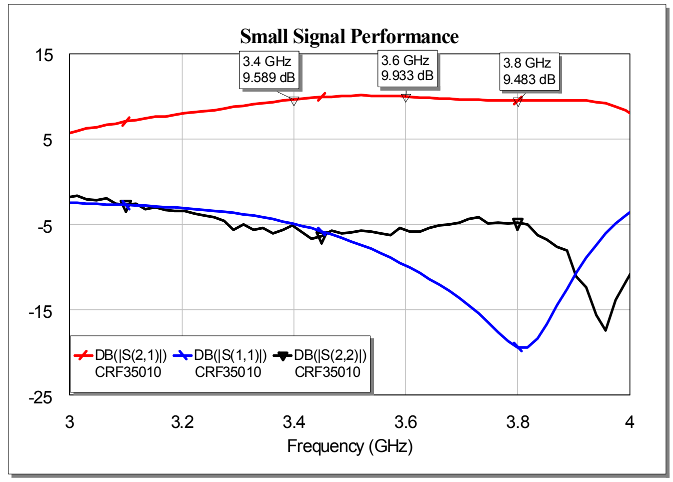

Figure 2. Small signal s-parameters of CRF35010 in test board

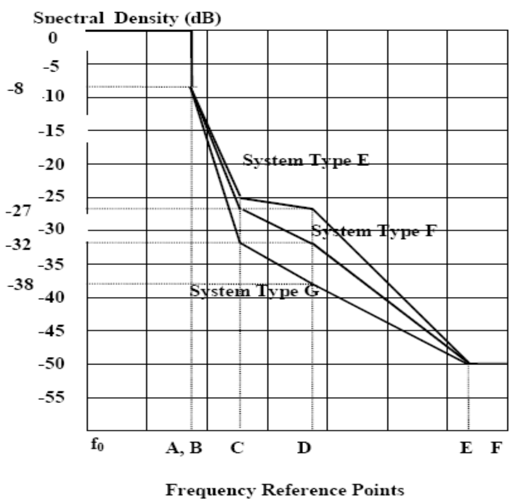

Figure 3. WiMAX Spectral Emission Mask

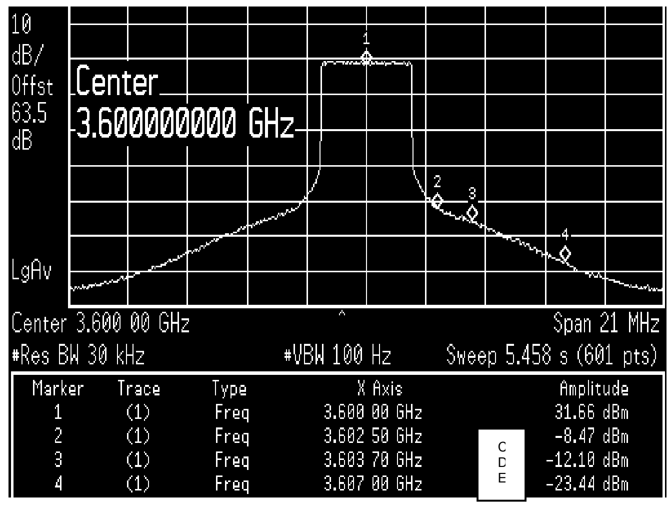

Figure 4. Spectral plot of CRF35010 at 1.5W Average, 3.6GHz

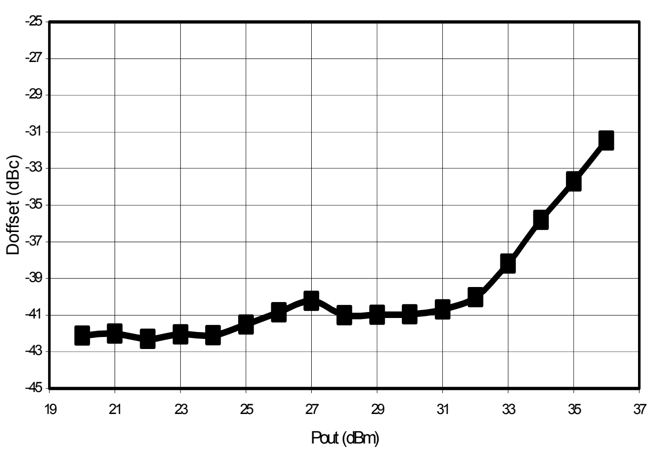

Figure 5. WiMAX Relative Offset Power vs Average Output Power for CRF35010 at 3.6GHz

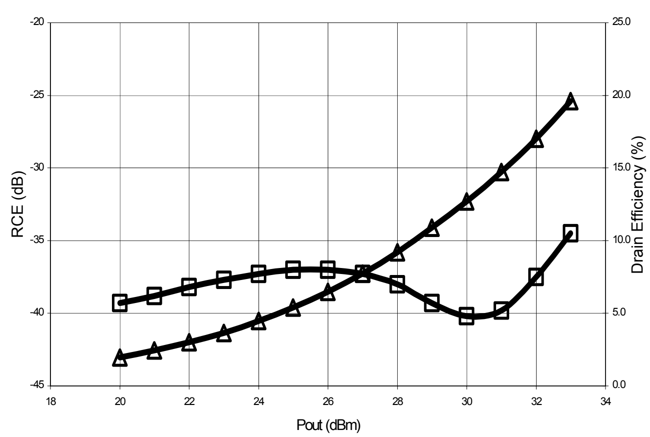

Figure 6. RCE and Drain Efficiency vs Average Ouptut Power for CRF35010 at 3.6GHz

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