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

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Outline

- WiMAX Power Amplifier requirements
- Wide Band Gap RF power devices
- Model based design of the WiMAX Power Amplifier
- Measurement Results
- Summary

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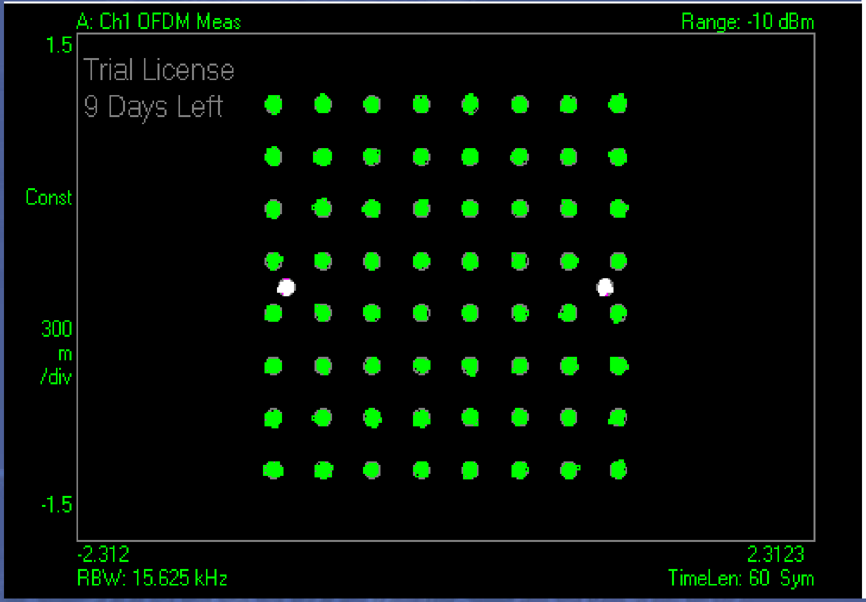
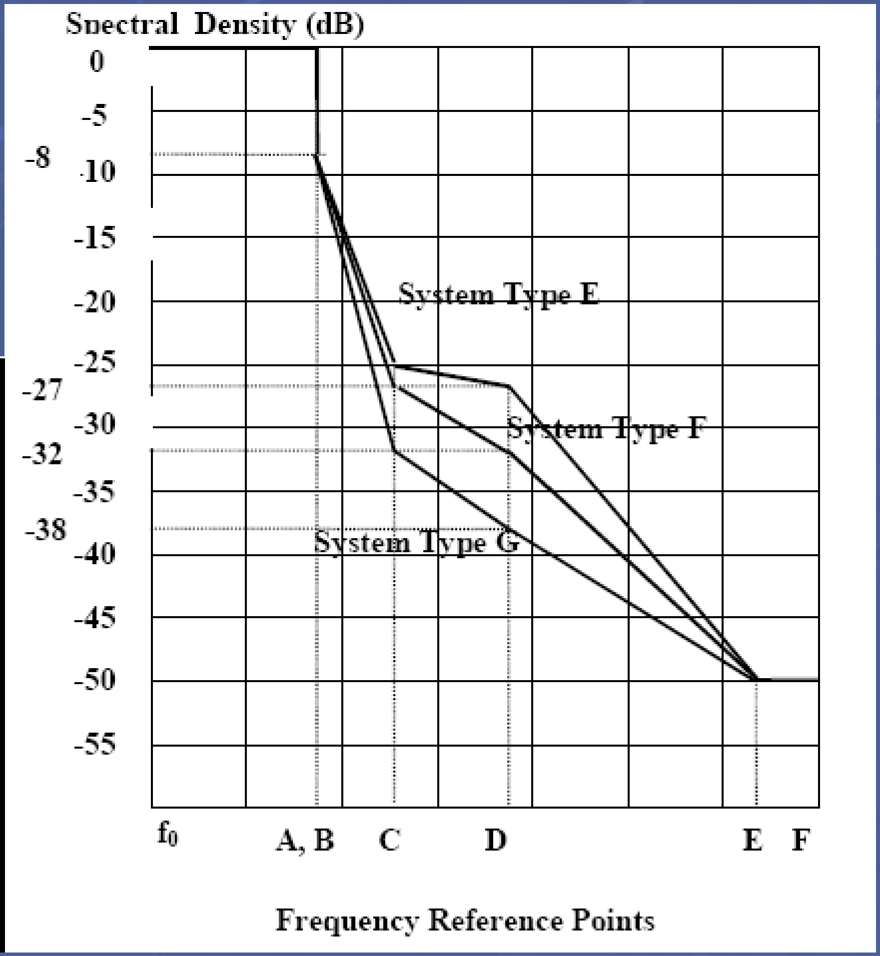
WiMAX Overview

- What is WiMAX ?
  - Next generation wireless network for data
- Frequency Allocations
  - 2.7GHz, 3.5GHz, 5.5GHz
- Signal Bandwidths
  - 1.25MHz to 20MHz per IEEE 802.16 2004
- Modulation
  - OFDM based with QPSK → 64QAM Bursting
- Power Levels
  - Subscriber units ~ 0.25W
  - Micro BTS up to 2W

WiMAX Tx Specifications

- ETSI EN 301 021 v 1.6.1, Para 5.3.3.1 For system type G
- IEEE802.16 2004
  - RCE < -31dB

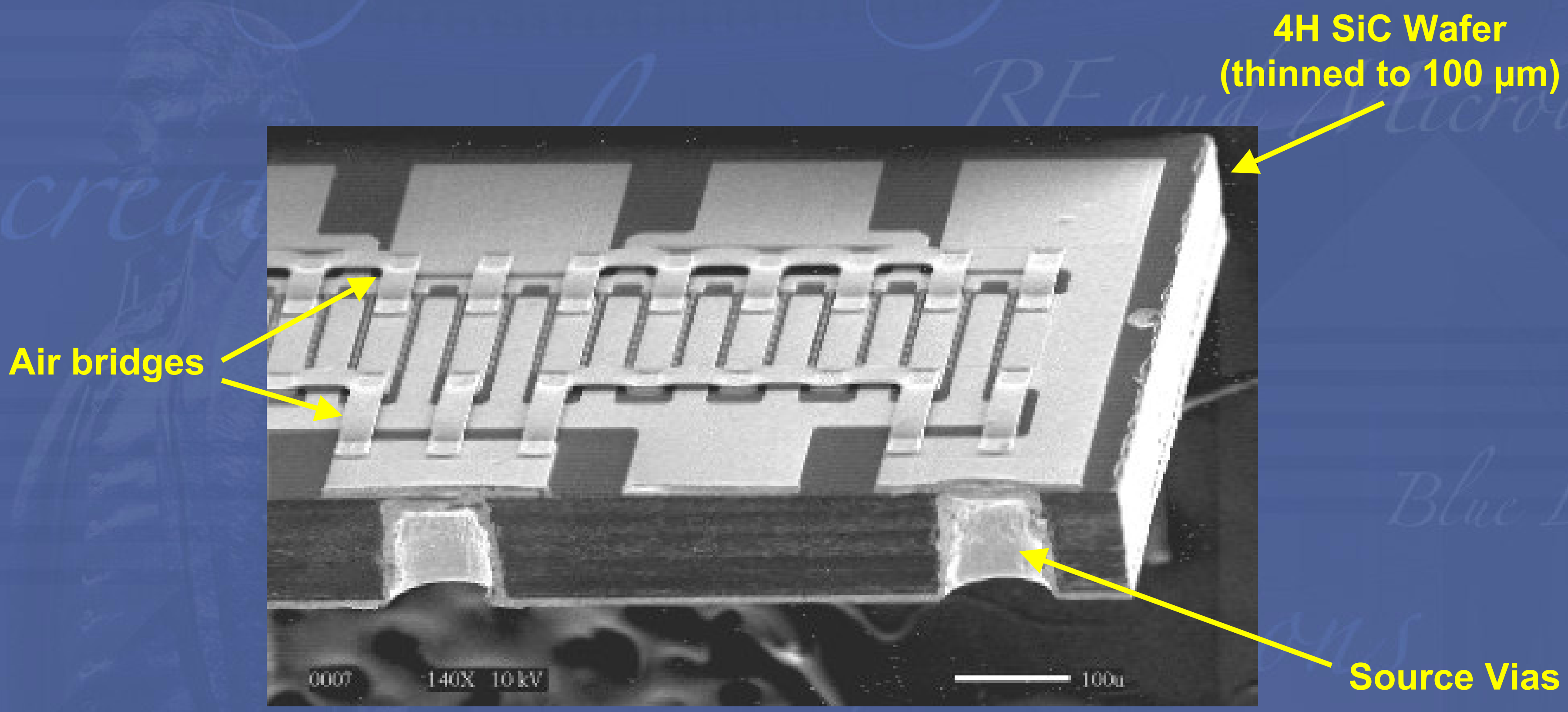




Advantages of WBG Transistors

- High Power Density
  - Smaller Devices
- High Voltage Operation
  - Higher Impedances
- Proven Long Term Reliability
  - $2x10^6$ MTTF @ 225°C
  - High Operating Temperatures
- Broad Band Performance
  - Low Output Capacitance per Peak Watt

SiC MESFETs



Experimental SiC MESFET (J. W. Palmour et al., Tech. Dig. IEDM, pp. 385-388, 2001, Cree)

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Design Goals

- Amplifier reference design using a new SiC MESFET based transistor
- Frequency band: 3.3 – 3.9GHz
- Drain Voltage: 48V
- Gain: 10dB
- Average Output Power: 1.5W
- Drain Efficiency: 17%
- RCE: < -31dB (EVM < 2.5%)
- Spectral Mask: > 2dB margin all points

- Efficiency and Linearity goals are specified at 1.5W

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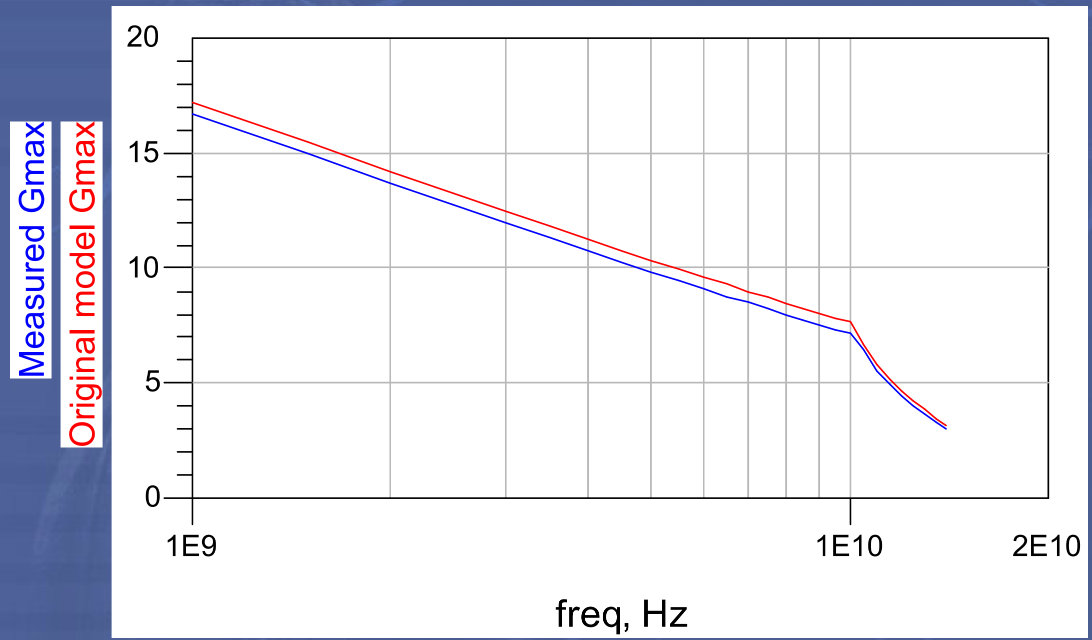
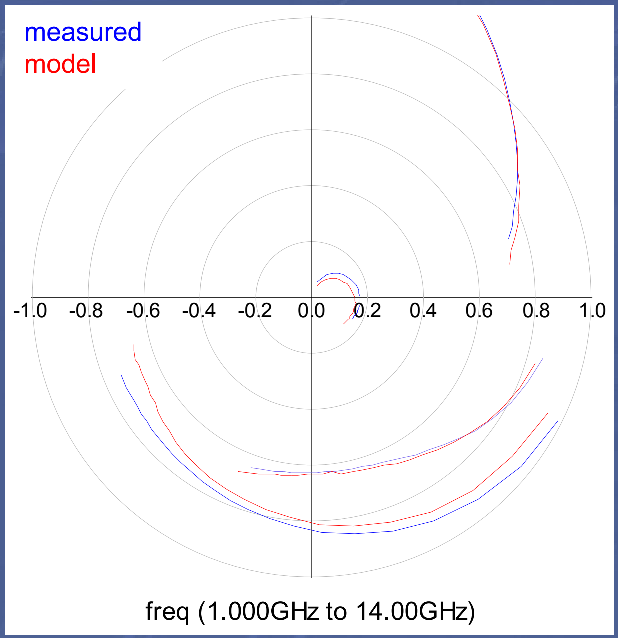
Model Based Design

- Design of transistor and evaluation circuit was performed using a large signal model
  - Pre-matching within the package included to peak high frequency gain
  - No output match necessary within the package due to intrinsic high output impedance
- Load pull verification of transistor model
- Measurement of s-parameters to validate the modeled package parasitics
- IM3 products were simulated to predict linearity to give faster circuit simulation

SiC MESFET Small Signal Die Model





- 1mm test FET
- CW measurements @ 25°C
- Small-signal parameters at 25% I_{DSS} compare well with model

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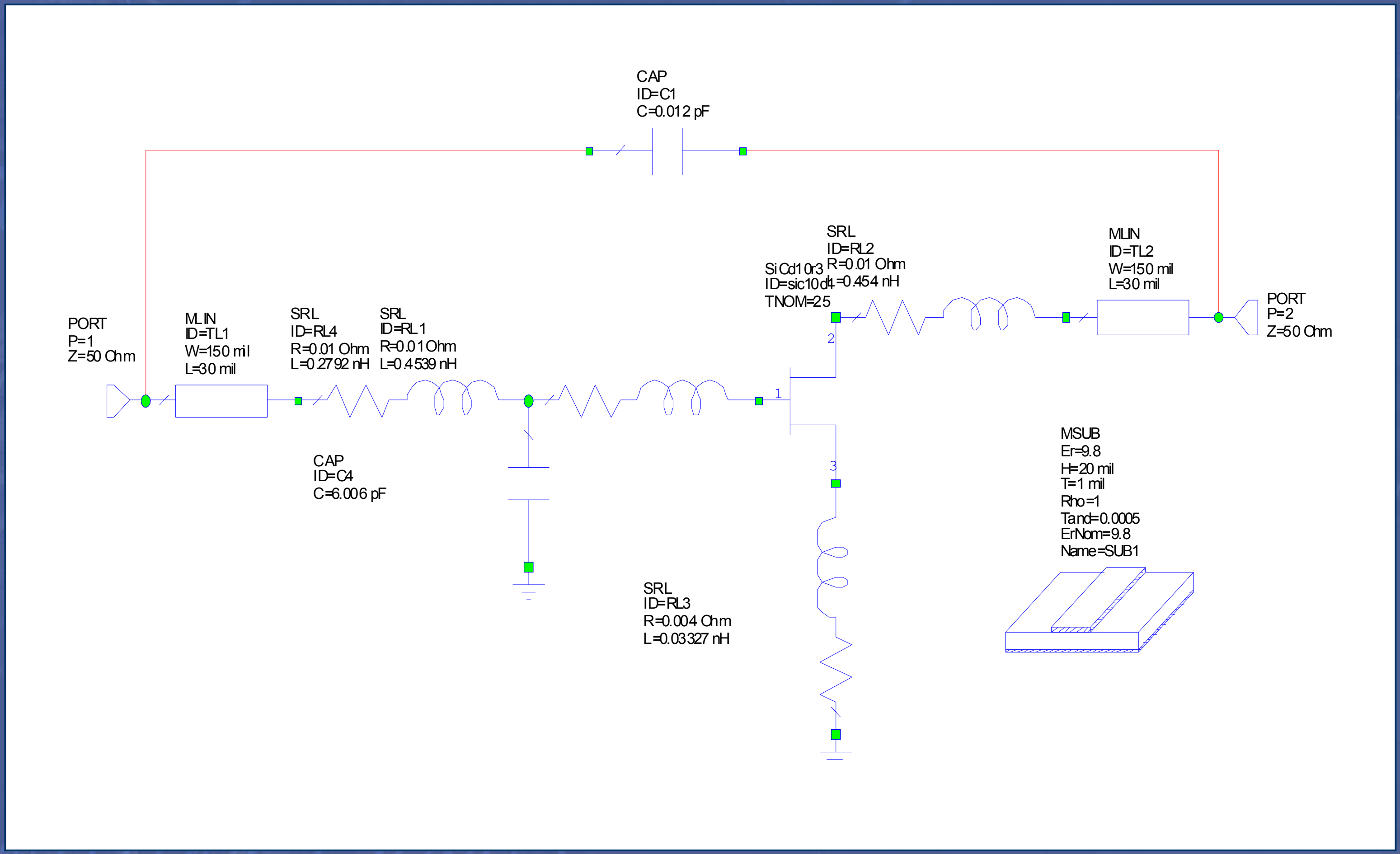
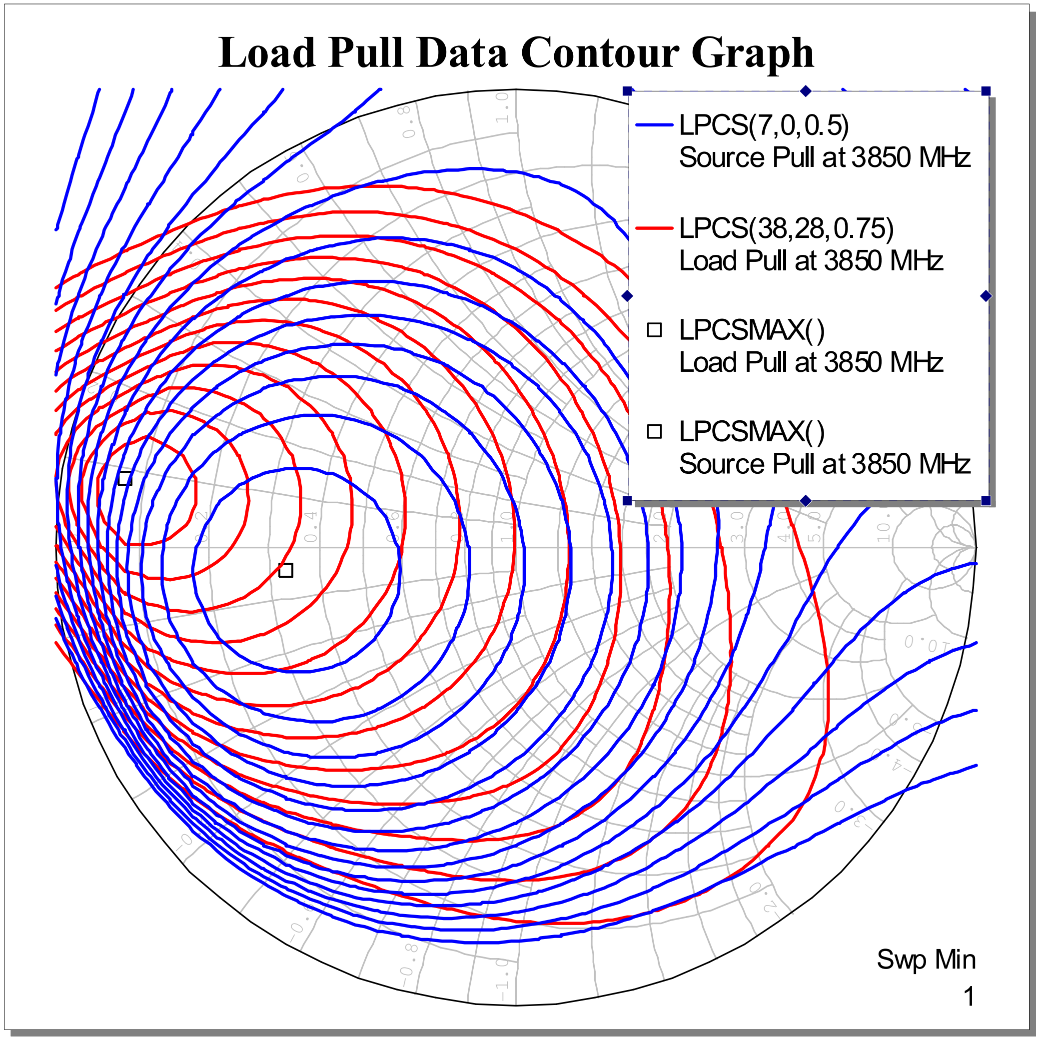
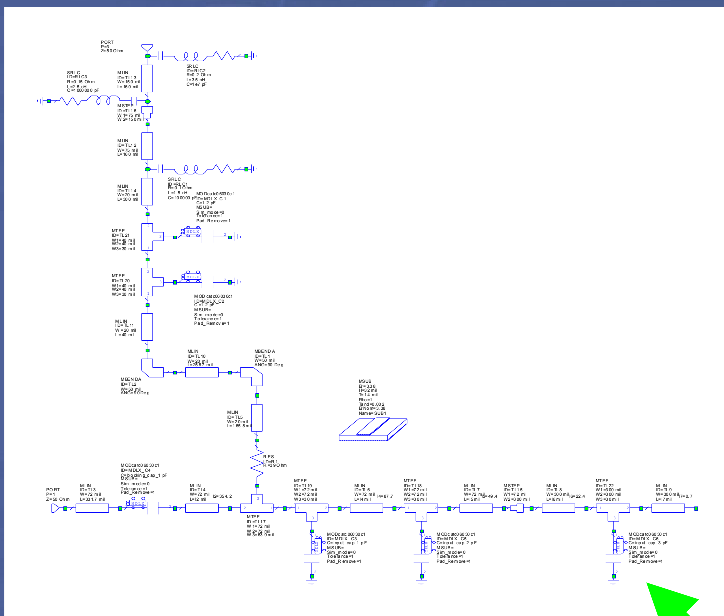
Transistor Model

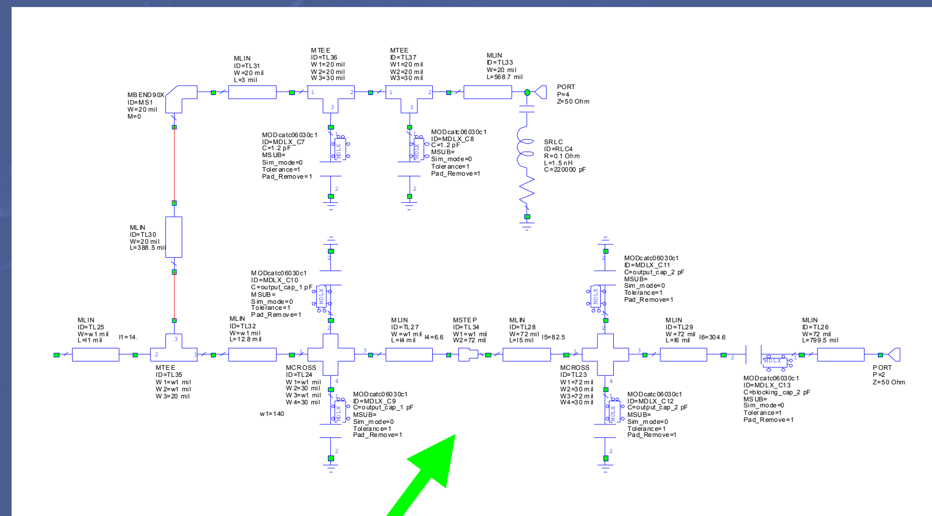


Simulated Source and Load-Pull Data



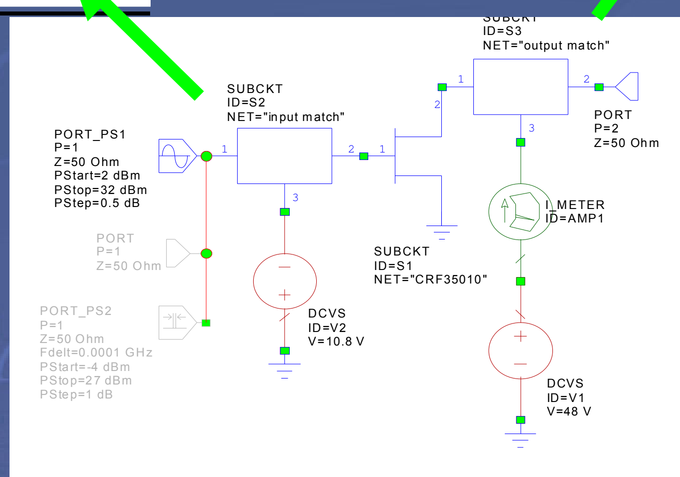
Circuit Model



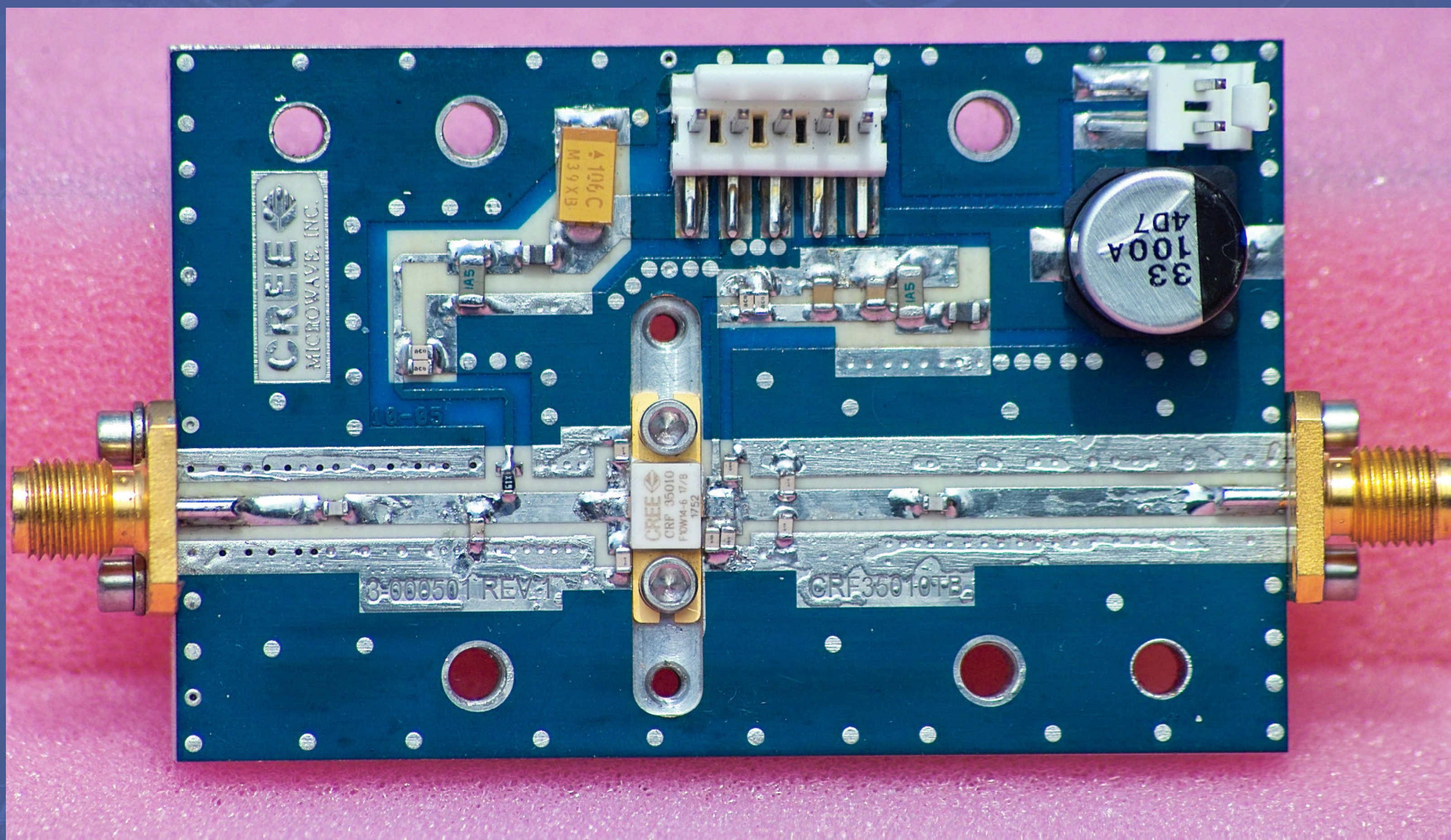


Input Match

Output Match



CRF35010 Evaluation Test Board



Measured Results

- The CRF35010 was characterized using the following tests
  - Small Signal s-parameters
  - CW Gain, Power and Efficiency
  - WiMAX linearity
    - Spectral Mask
    - RCE
- All power measurements were made vs. frequency and over the required 15dB dynamic range

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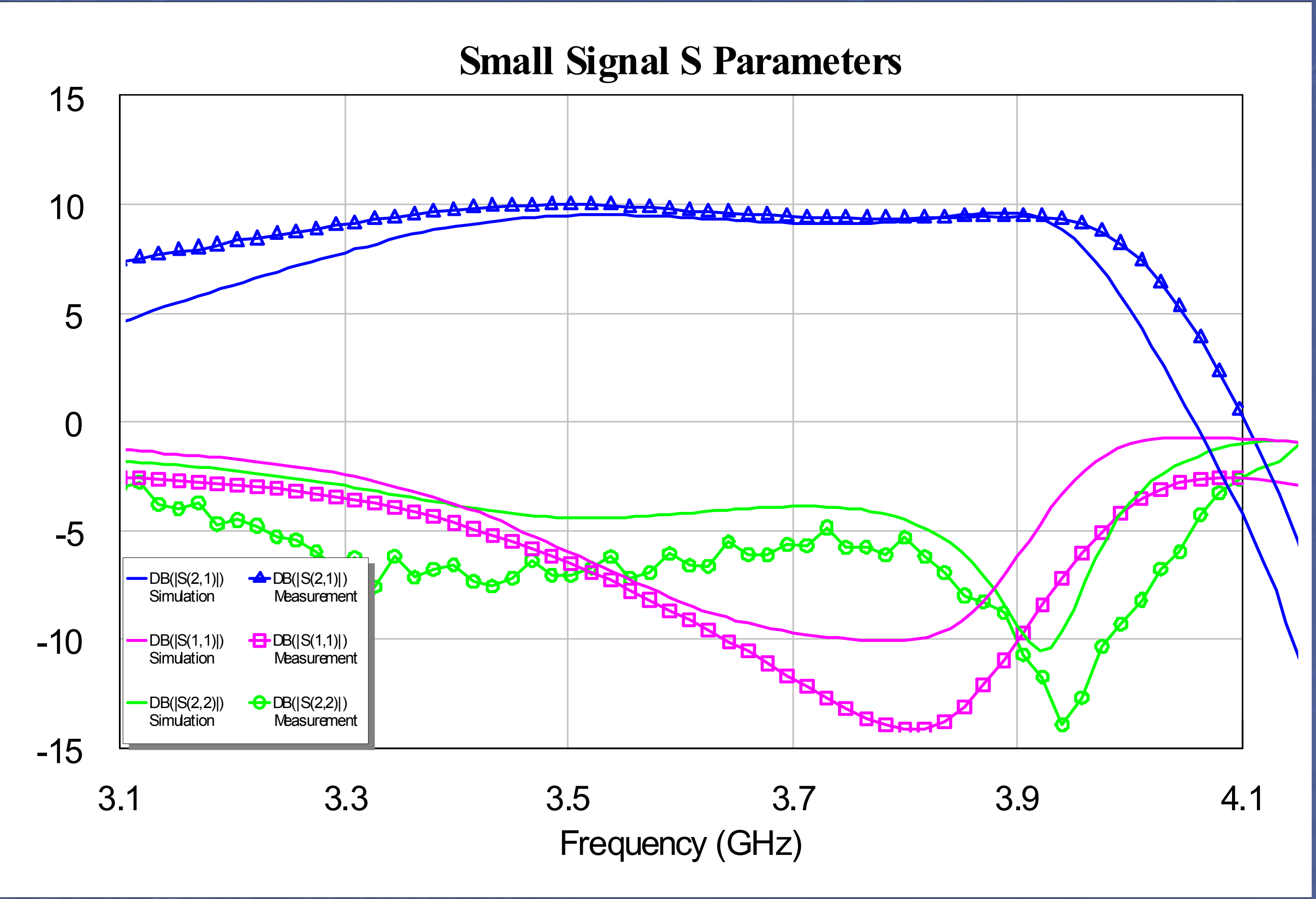
Small Signal S-Parameters



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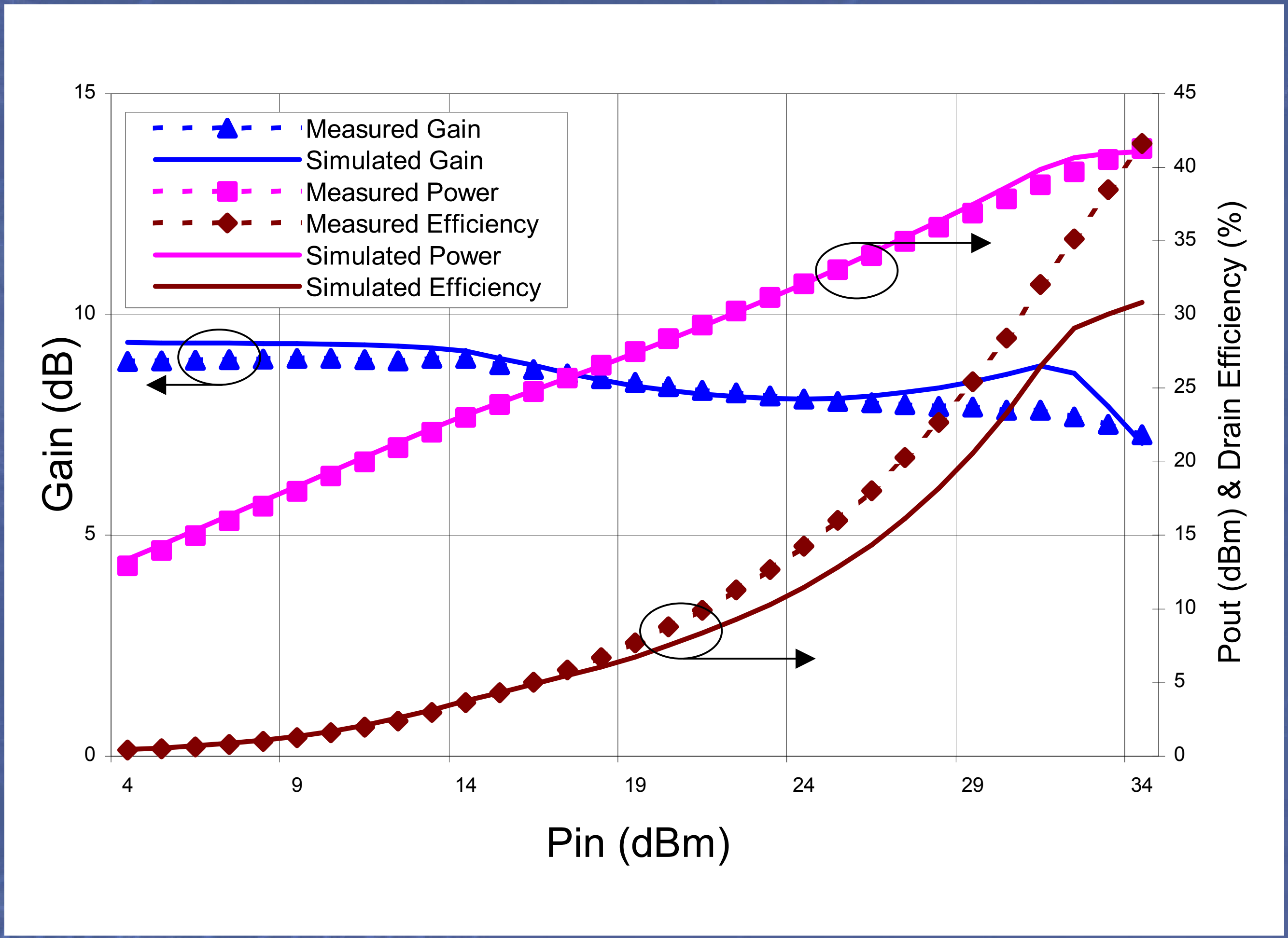
CW Power, Gain and Efficiency



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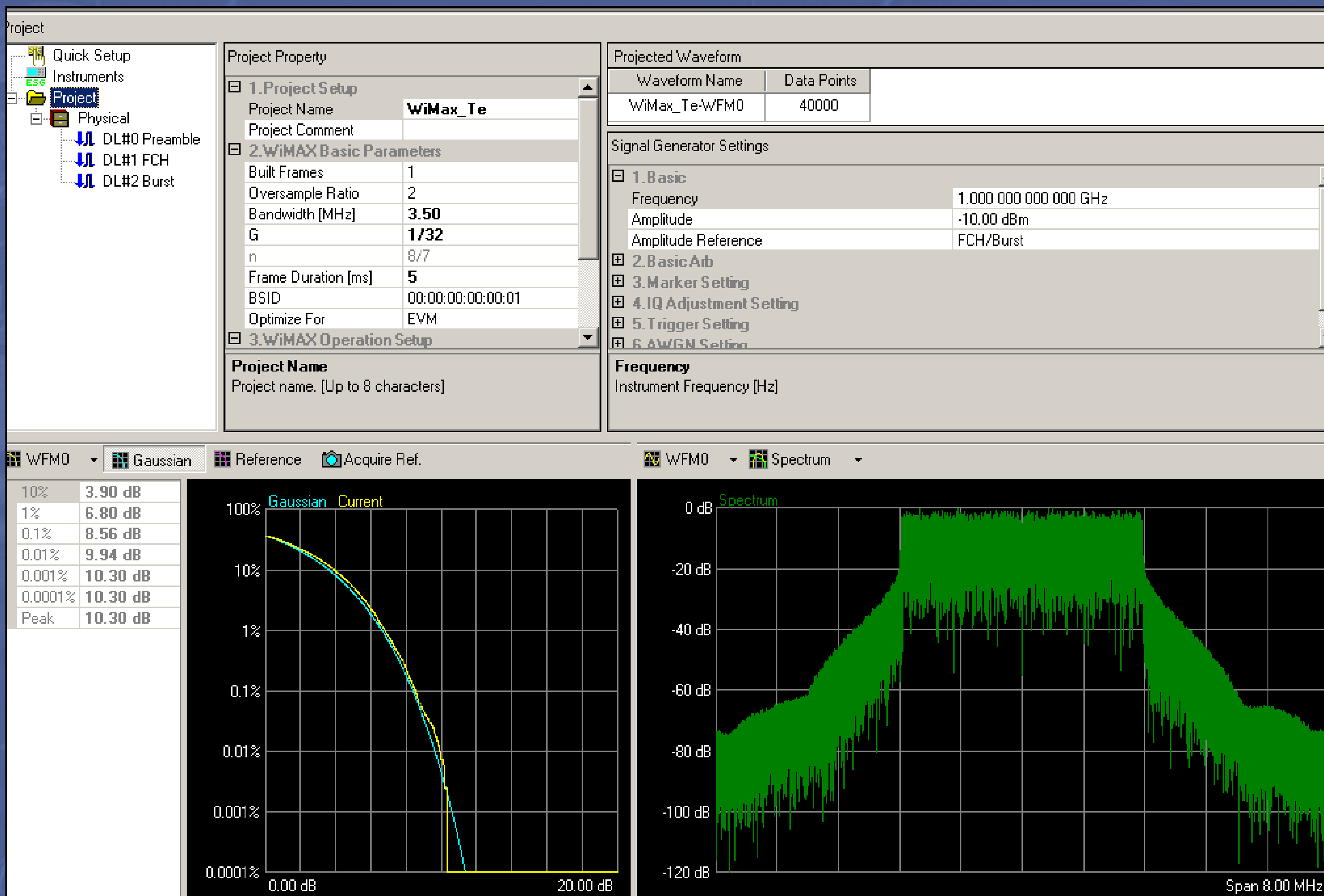
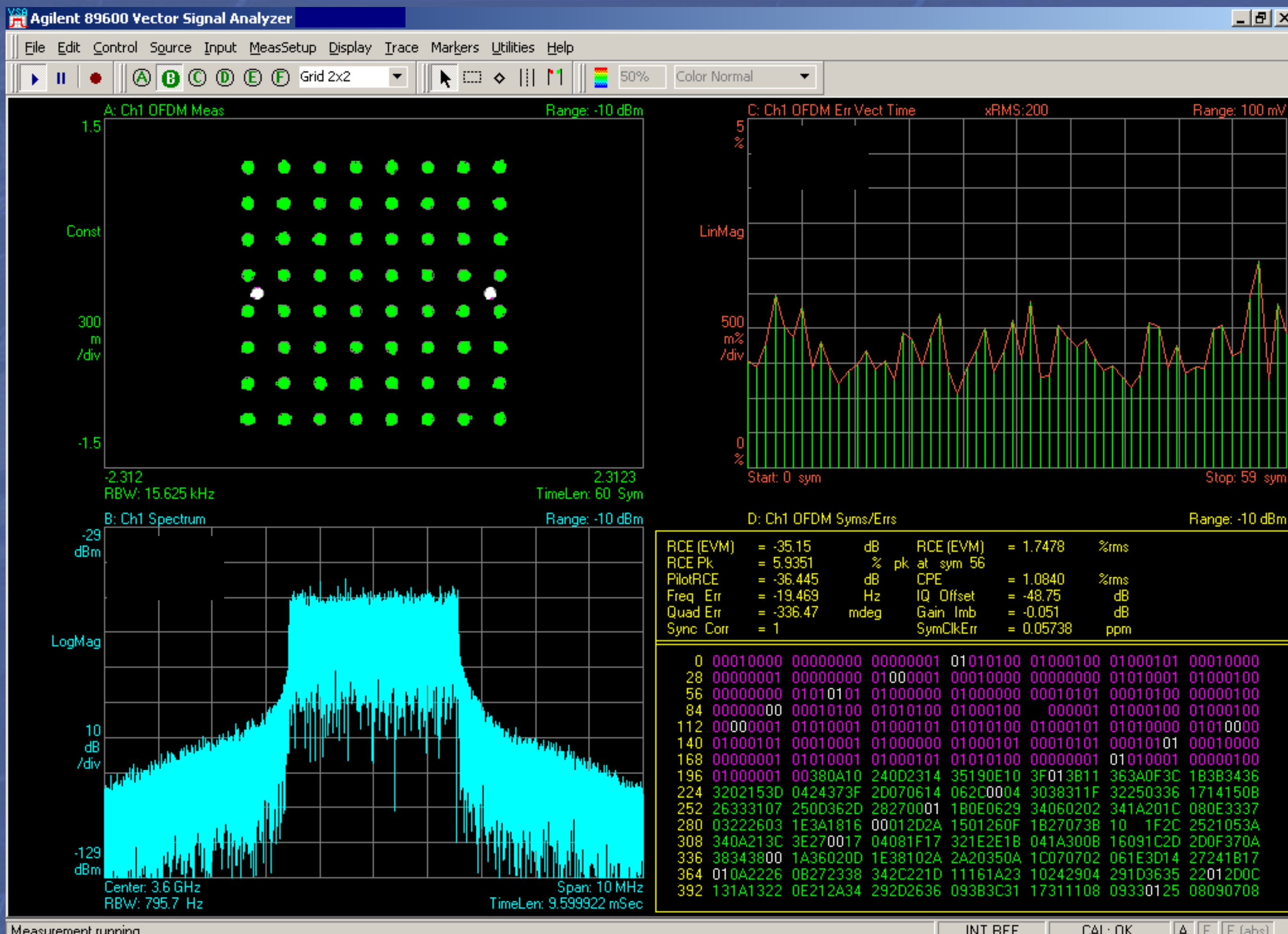
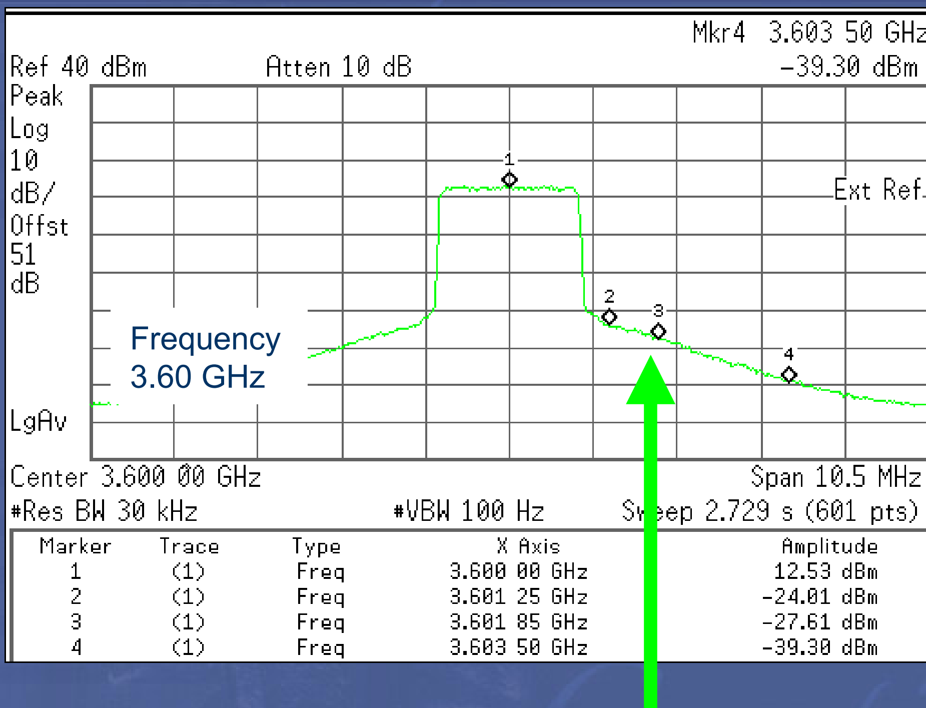
WiMAX – Signal Generation

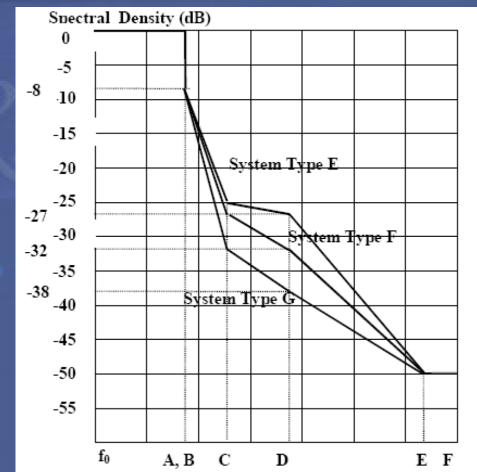


WiMAX – Demodulated Signal

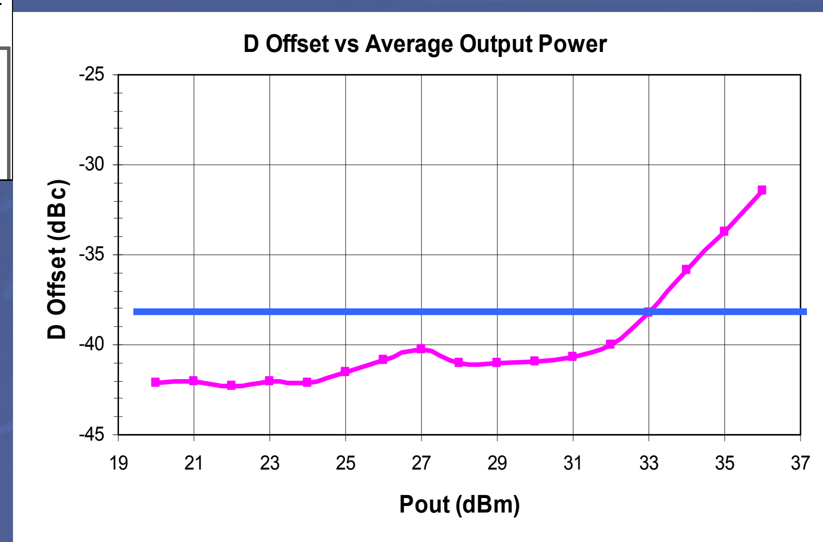


WiMAX – Spectral Mask

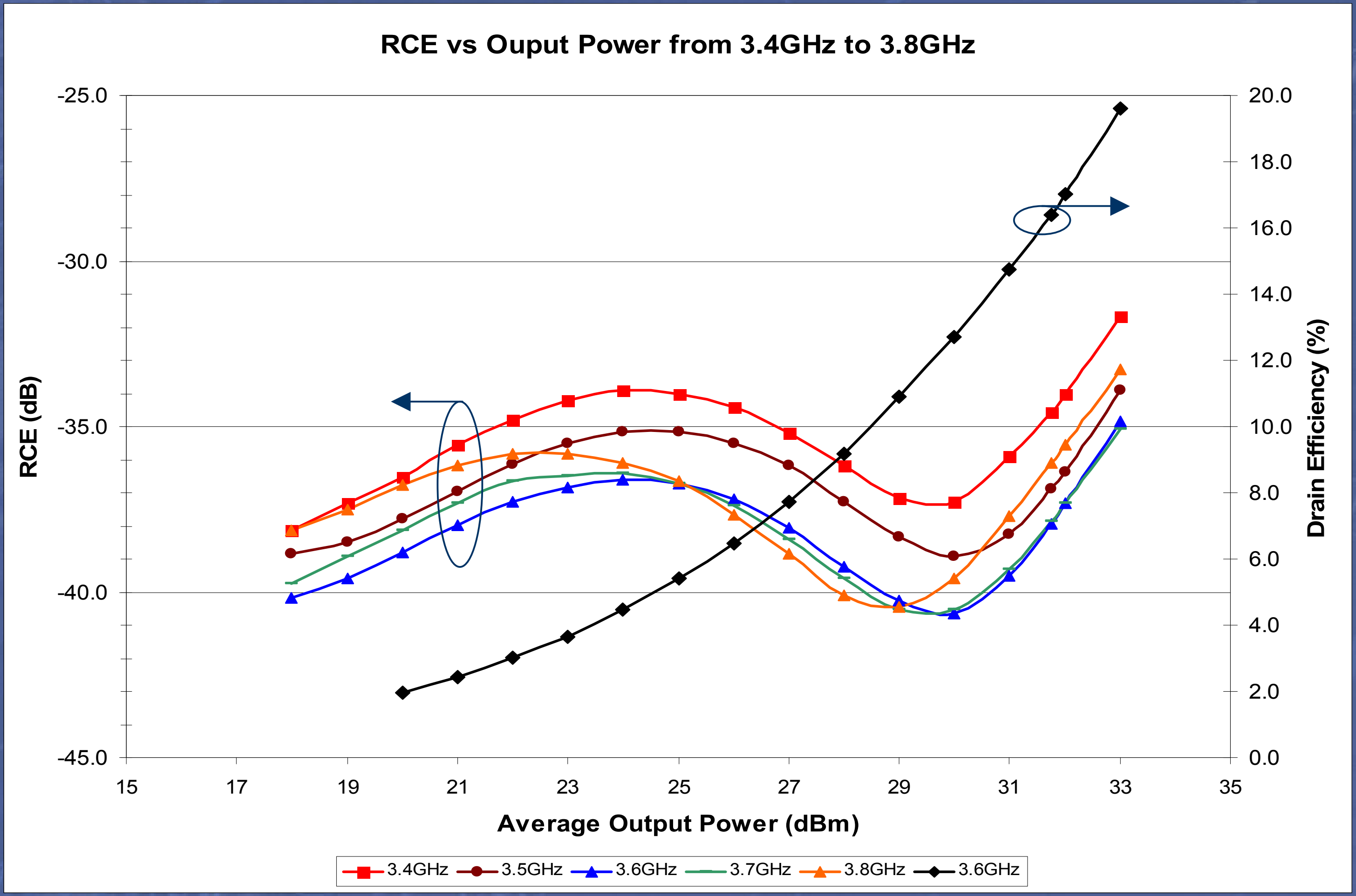




D Offset is as defined in ETSI EN 301 021 v 1.6.1, Para 5.3.3.1 for type G system



WiMAX – RCE and Efficiency



Summary

- Introduced the new WiMAX system
- Showed advantages of using wide band gap semiconductors
- Compared measured and modeled data
- Met most design goals with first pass success

Acknowledgements

We would like to thank all the people involved in the manufacture of the CRF35010 transistors and the associated reference design circuits at Cree Microwave in Sunnyvale and Durham

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