IEEE Topical Symposium on Power Amplifiers for Wireless Communications:

A Compact L Band GaN based 500W Power Amplifier

Session 6: Base station, High Power Amplifiers

RFMD™

Matthew Poulton, David Aichele, Jason Martin

9/15/2009

DPBU
RF Micro Devices Inc,

IEEE

Outline

- Design Motivation
- Target Performance Specifications
- GaN Device Characteristics
- HPA Design Topology
- Design Simulation Results
- Application Solution
- Pulse RF Performance
- Affects of Pulse Width & Duty Cycle
- Summary

Motivation for compact high power L band PAs

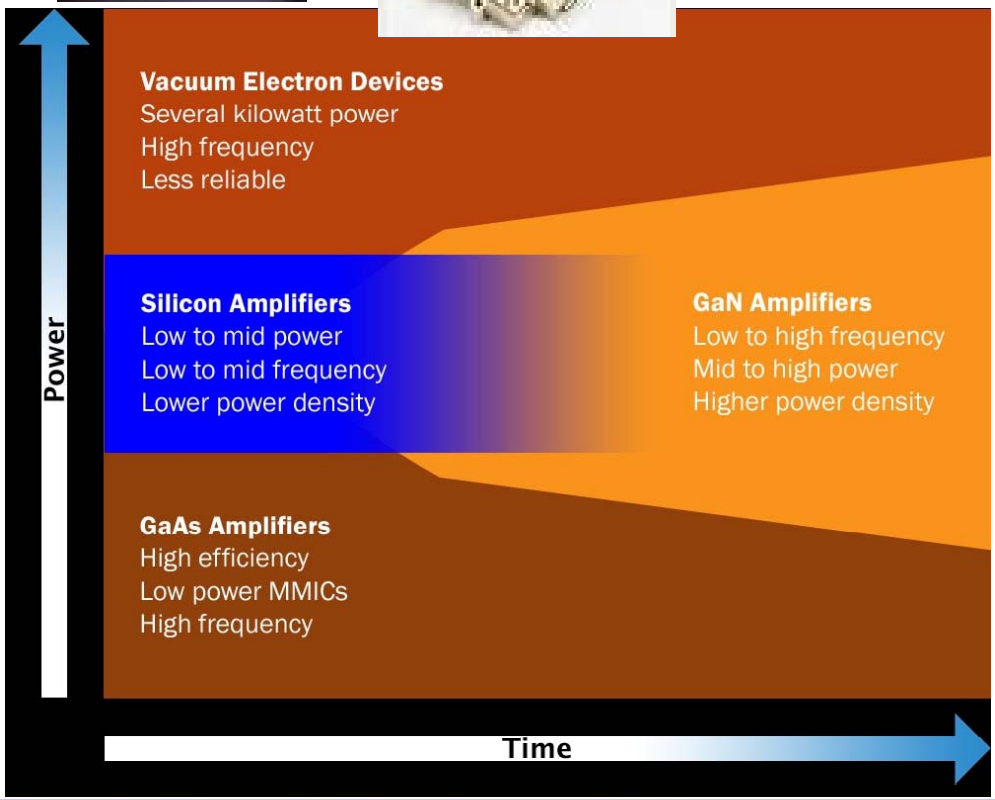
• High power amplifiers delivering hundreds of watts currently use VEDs, silicon or GaAs devices

•Typical applications combine many parts to deliver kilowatts of peak power in final application

• Phased array applications also require close proximity of tens or hundreds of high power devices

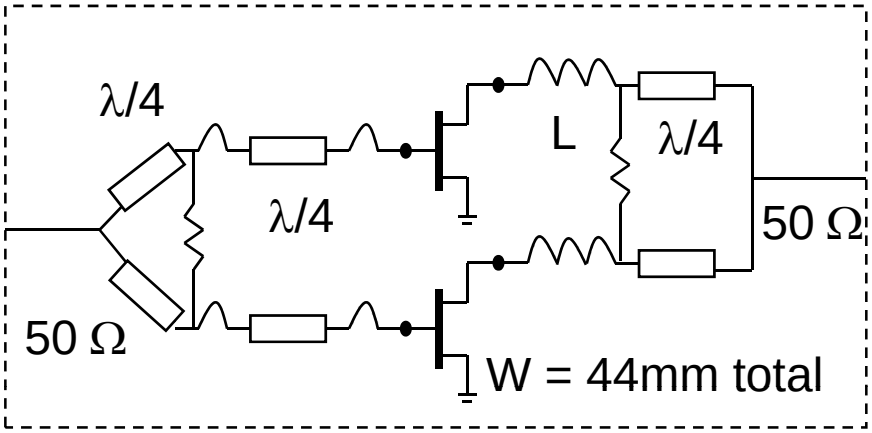
• Typical physical size of application circuit is significant typically 6inch by 6inch (15cm by 15cm)

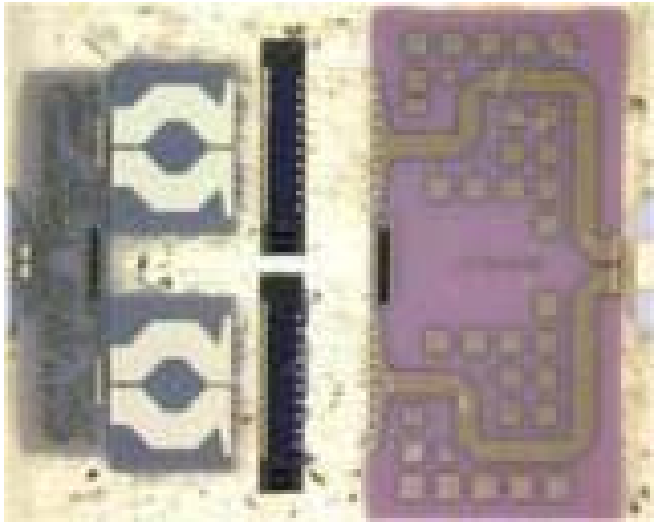
•Size reduction high power amplifier solution critical for kilowatt transmitters and phased array applications



HPA Design Topology

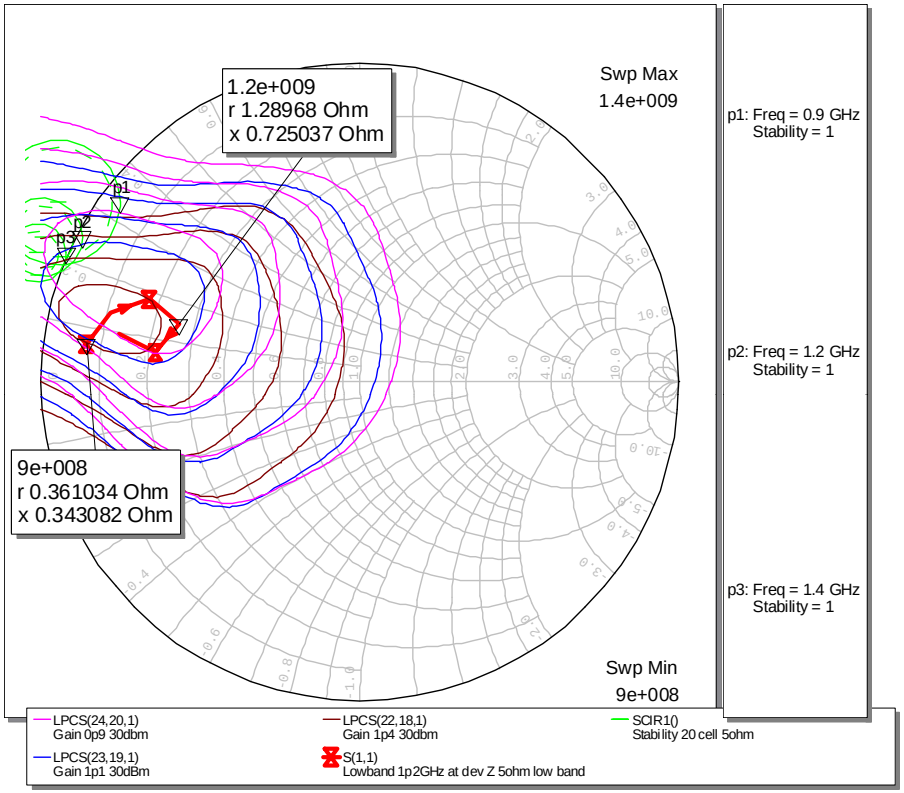
- Wilkinson combiners at input and output of devices, 50ohm impedance at the package leads
- Two stage quarter-wave impedance transformation for broader bandwidth
- High dielectric substrates for impedance transformation to present optimum load / source impedance to device
- Isolation resistors to prevent odd-mode oscillations
- Device for 500W HPA :
  2 x 22mm periphery (60 fingers)





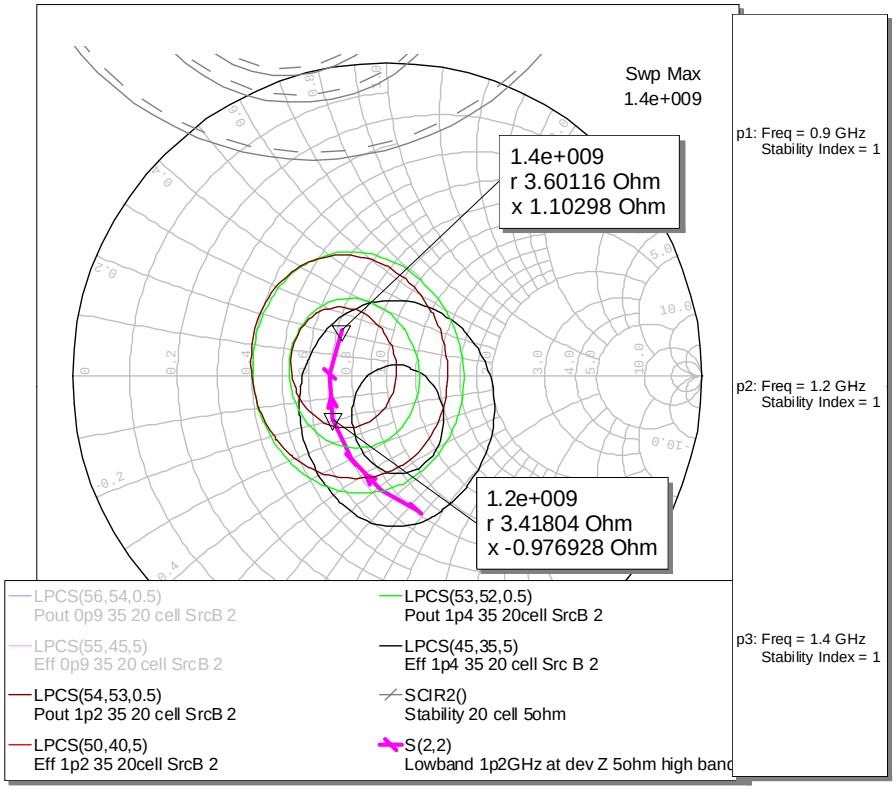
GaN Model Source Pull, Load Pull

Source (5ohm chart) 1.2GHz to 1.4GHz



red – input circuit, green - stability

Load (5ohm chart) 1.2GHz to 1.4GHz

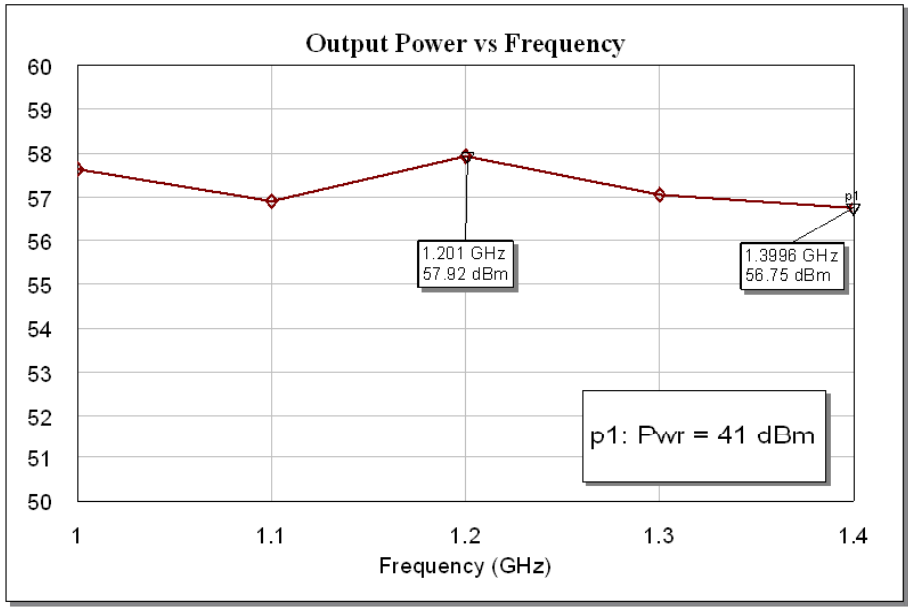


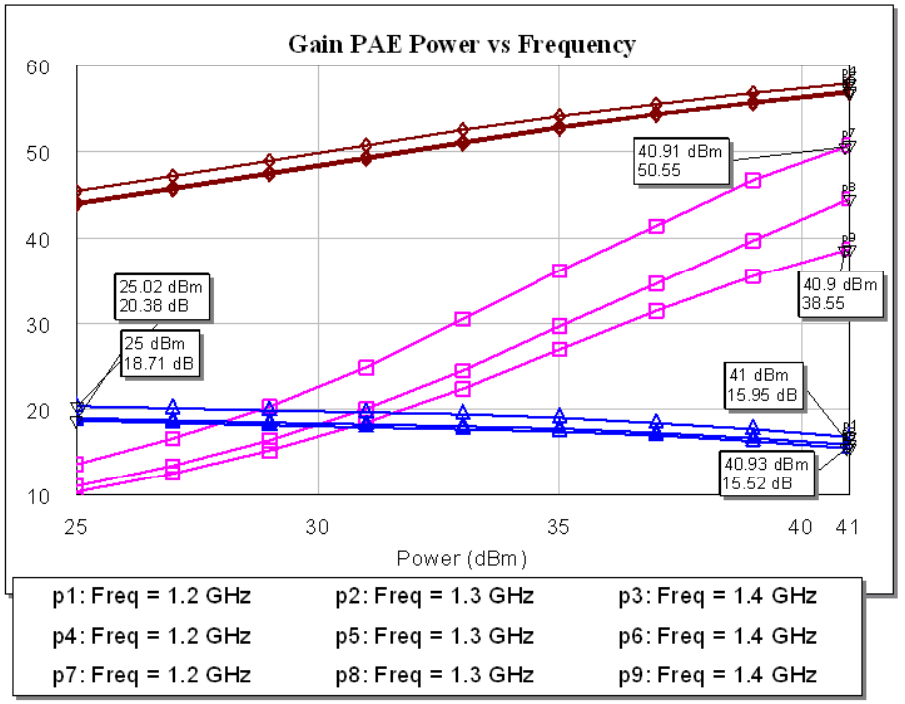
Pink – output circuit, grey - stability

- GaN Non Linear Model (NLM) used to generate source and load contours
- Source contours generated for Pin = +10dBm
- Load contours generated for Pin = +41dBm

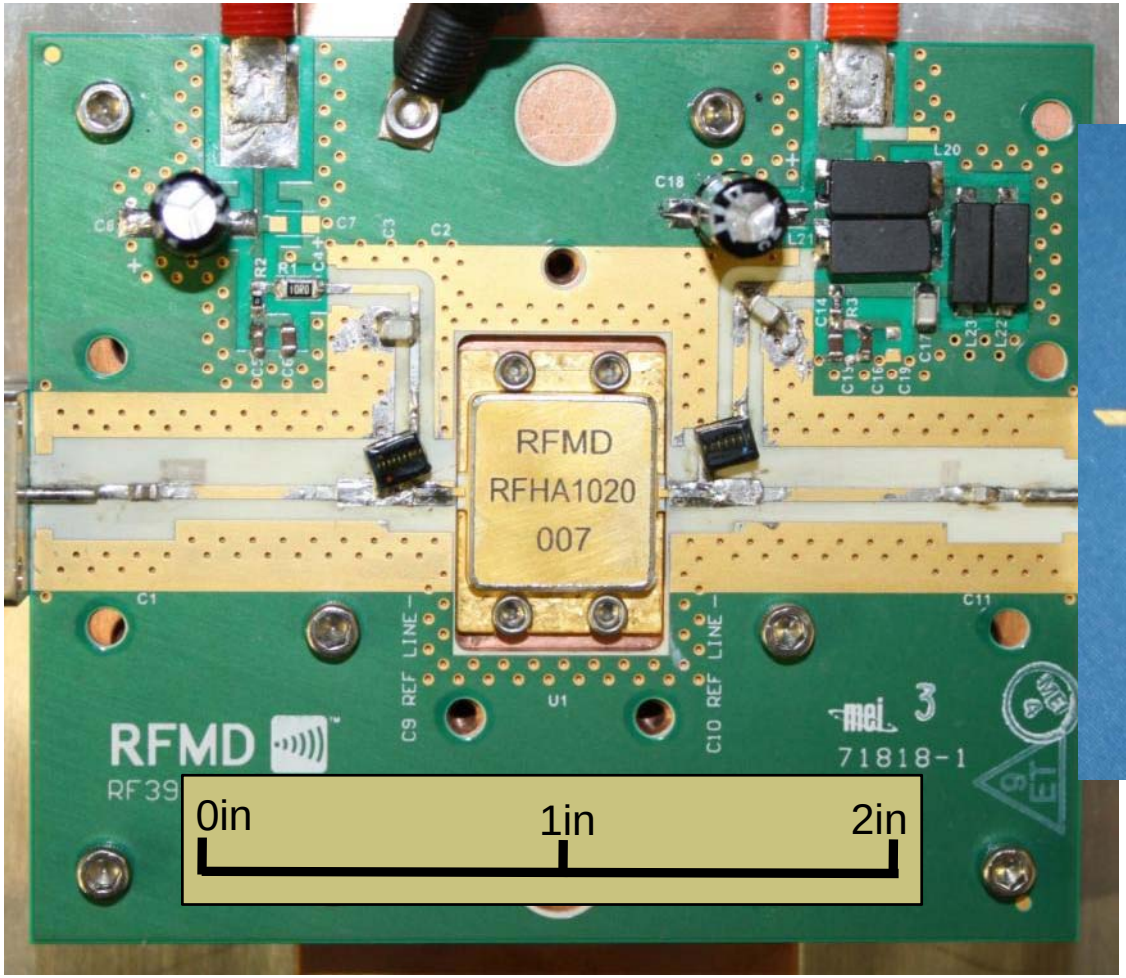
Design NLM Simulation

- EM simulation used to design splitter/combiner networks
- GaN Non Linear Model (NLM) used to estimate RF performance over frequency
- Ideal bias networks (lossless, broadband) used for simulation
- NLM provides isothermal results (short pulse)



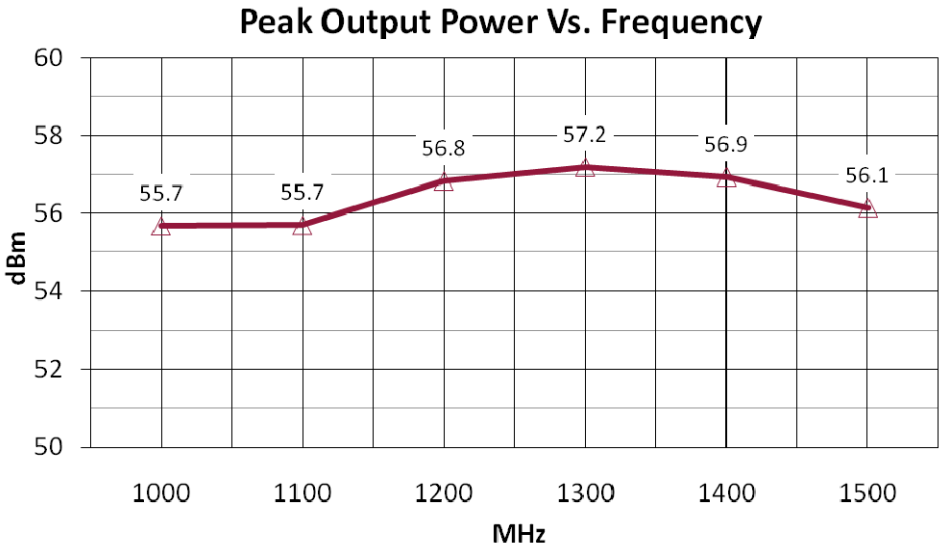


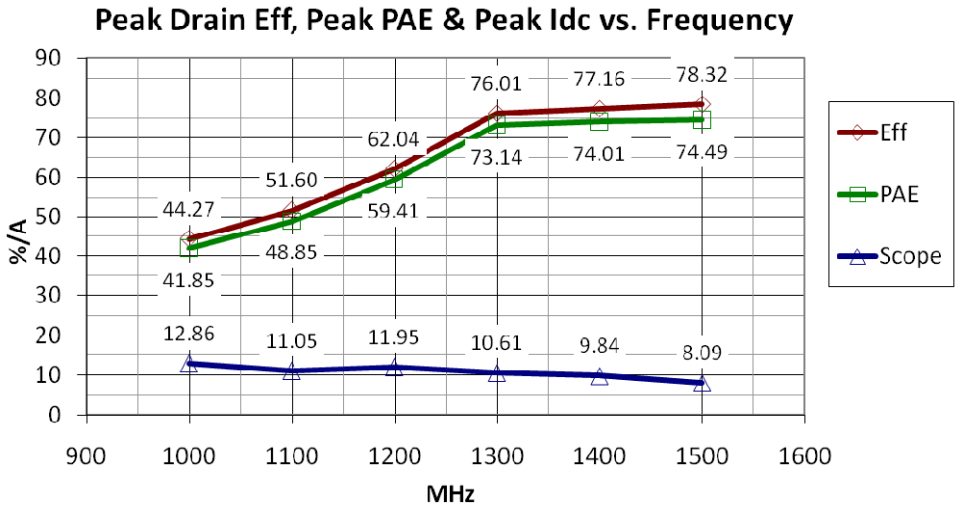
Compact L band GaN HPA

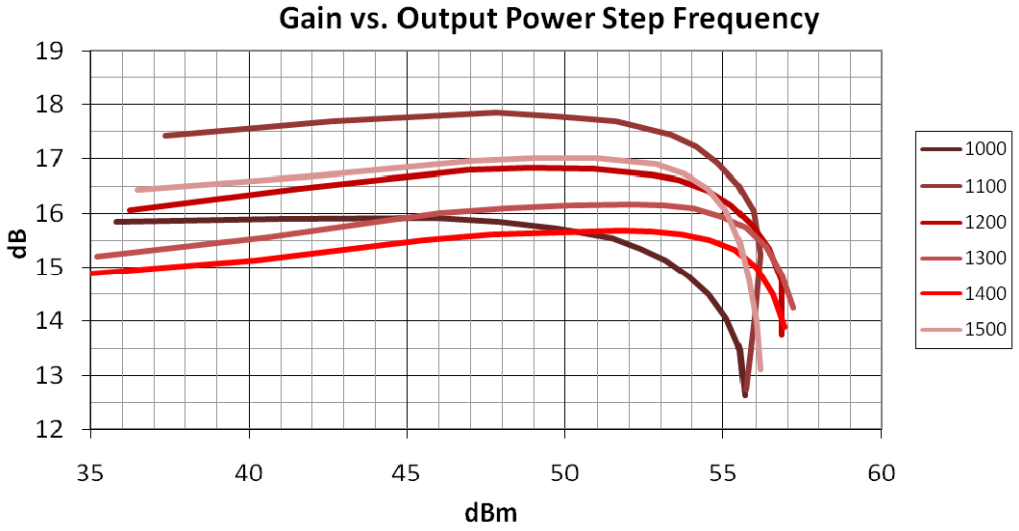


- **Very compact application circuit for L band 500W solution: 2” x 2”**

Pulsed RF Measurements







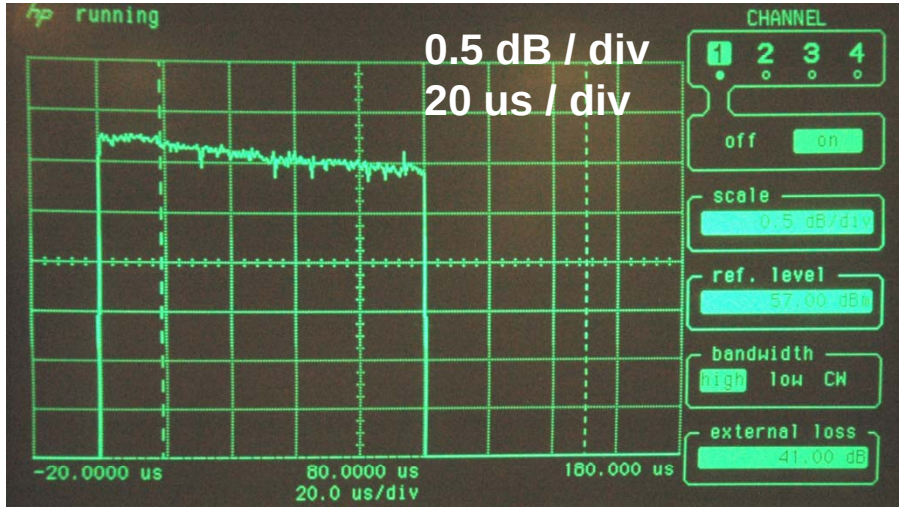
Pulsed power measurements
Pulse width : 100usec
Duty cycle : 10%

Affects of Pulse Width & Duty Cycle

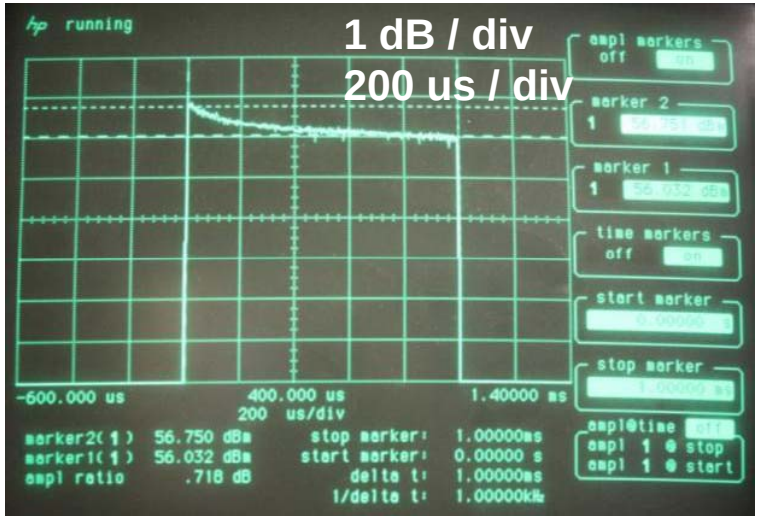
1.2GHz to 1.4GHz	100usec 10% dc	1msec 10% dc	1msec 20% dc
Peak Output Power	482W to 553W	400W to 500W	380W to 489W
Peak efficiency	59% to 74%	53% to 72%	53% to 72%
Gain @ peak power	12.4dB to 13.5dB	11.9dB to 13.1dB	11.7dB to 12.9dB
Linear gain	15.4dB to 15.8dB	15.1dB to 15.5dB	15.1dB to 15.4dB

0.6dB to 0.7dB drop in power from 100usec pulse @ 10% duty cycle to 1msec pulse @ 20% duty cycle

100usec pulse, 10% duty cycle



1msec pulse, 20% duty cycle



Compact GaN L Band 500W PA Summary

- Demonstrated a compact 500W L band power amplifier
- Design completed using non linear model results exclusively
- Package matched to 50ohm at the input and output lead
- Application real estate including bias networks and occupies a 2 inch by 2 inch area
- Optimized for 1.2GHz to 1.4GHz, but can operate with 31% bandwidth
- For long pulse widths and duty cycles 0.6dB to 0.7dB drop in peak power performance

1.2GHz to 1.4GHz (200MHz, 15% bw)

- Peak Pout **482W to 524W**
- Peak efficiency **59% to 76%**
- Gain at peak power **13.1dB to 13.9dB**
- Linear gain **14.9dB to 16.5dB**

1.1GHz to 1.5GHz (400MHz, 31% bw)

- Peak Pout **370W to 524W**
- Peak efficiency **49% to 74%**
- Gain at peak power **12.5dB to 14.2dB**
- Linear gain **14.9dB to 17.5dB**

Thank you

Acknowledgements
Dave Aichele, Jason Martin, Jay Martin, Bill Hurley, Frank Rogers, Brian Sousa