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

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DPBU
RF Micro Devices Inc,
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
  - Swp Max 1.4e+009
  - Swp Min 9e+008
- **Load (5ohm chart)** 1.2GHz to 1.4GHz
  - Swp Max 1.4e+009
  - Swp Min 9e+008

red – input circuit, green - stability

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

Peak Output Power Vs. Frequency

Gain vs. Output Power Step Frequency

Peak Drain Eff, Peak PAE & Peak Idc vs. Frequency

Pulsed power measurements
Pulse width : 100usec
Duty cycle : 10%
Affects of Pulse Width & Duty Cycle

<table>
<thead>
<tr>
<th>1.2GHz to 1.4GHz</th>
<th>100usec 10% dc</th>
<th>1msec 10% dc</th>
<th>1msec 20% dc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Output Power</td>
<td>482W to 553W</td>
<td>400W to 500W</td>
<td>380W to 489W</td>
</tr>
<tr>
<td>Peak efficiency</td>
<td>59% to 74%</td>
<td>53% to 72%</td>
<td>53% to 72%</td>
</tr>
<tr>
<td>Gain @ peak power</td>
<td>12.4dB to 13.5dB</td>
<td>11.9dB to 13.1dB</td>
<td>11.7dB to 12.9dB</td>
</tr>
<tr>
<td>Linear gain</td>
<td>15.4dB to 15.8dB</td>
<td>15.1dB to 15.5dB</td>
<td>15.1dB to 15.4dB</td>
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</tbody>
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0.6dB to 0.7dB drop in power from 100usec pulse @ 10% duty cycle to 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

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