MMIC Integration & Packaging for Defence & Automotive Radar: Size & Cost Reductions Create New Market Opportunities

October 9, 2013
Outline

- Overview
- Radar: commercial and defence
- Spatium™ power amplifiers
- AESA radar components
- RF packaging
- Summary
Synergistic Organization

**Mobile Devices**
Drives volume scale, lower costs & speed of innovation

**Network Infrastructure**
Drives high-performance product portfolio

**Defense**
Drives technology research & product solutions

TriQuint
Accelerating the Next Generation of RF

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Technology Integration Leader

- TriQuint is the only high-volume supplier integrating advanced, in-house active and passive technologies for the broad market.

**CUSTOMER BENEFITS**

- Minimize board space
- Saves engineering resources
- Maximize power efficiencies
- Reduced BOM
- Streamlined manufacturing
Basic Defense and Automotive Radar Block Diagrams

AESA Radar Basic Block Diagram

Pulse and Continuous Wave Radar Concepts

Varying complexity, trending towards more antenna ports for better resolution
Automotive Sensors / Radar

„The Sensitive Car of Tomorrow“

77 GHz Long Range Radar (LRR) (Lidar)
Long 1 to 120m

Infrared
Long 0 to 200m

Video
Medium 0 to 80m

24 GHz Short Range Radar (SRR)
Short 0.2 to 20m

Ultrasonic
Ultra short 0.2 to 1.5 (2.5) m

Illustration courtesy of Analog Devices
BLUE = RADAR Application
ORANGE = Ultrasonic

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Center Radar: Solid-State Power Amplifier, TWT Replacements
Center Feed Radars

TWTA Based Radar
**TriQuint Spatium™ Power Amplifier Technology**

- **Spatium™ power amplifiers**
  - TWTA upgrade / replacement
  - Electronic warfare
  - MilCom, data links
  - Radar
  - Test and measurement

- **Key Spatium™ PA features**
  - High efficiency
  - Compact form-factor
  - Low voltage operation
  - Graceful degradation
  - Short thermal path
  - High reliability / long life MTBF
  - No aging characteristics
  - Frequency scalable

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Solid state PA reliability with PAE equal to or greater than a TWTA
AESA Radar Components
Phased Array Radars

- Radar designers are very focused on size, weight and power (SWaP)
# GaN Packaged Transistors

<table>
<thead>
<tr>
<th>Part #</th>
<th>Frequency Range (GHz)</th>
<th>P_{sat} (W)</th>
<th>Gain (dB)</th>
<th>DE (%)</th>
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<td>DC-6</td>
<td>10W</td>
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* In Development

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Transmit / Receive RF Switch

- RF switch loss directly affects NF and PAE

- **High-power switch options**
  - Asymmetrical RF switches: high power transmit path, lower loss receive path
  - GaN T/R switches
    - High power handling capability (>100W) CW
    - Very low current (<6uA)
    - Low insertion loss (<0.7dB)
    - High RF power handling capability
## GaN Low-Noise Amplifier Products

<table>
<thead>
<tr>
<th>LNA</th>
<th>Frequency (GHz)</th>
<th>P1dB (dBm)</th>
<th>NF (dB)</th>
<th>SS Gain (dB)</th>
<th>TOI (dBm)</th>
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<th>Export</th>
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<td>TGA2612*</td>
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<td>GaN25</td>
<td>EAR99</td>
</tr>
</tbody>
</table>

* Plastic overmold package planned for Q4 2013

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Low noise figure with high input RF power survivability. Do you still need a limiter?
Tx / Rx Module on a Single MMIC
Transmit, receive and control functions on a single MMIC delivers SWaP advantages

- Transmit, receive and control functions on a single MMIC delivers SWaP advantages

GaAs or GaN SPDT

GaAs or GaN

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**RF Package Types**

- **TriQuint’s Cu-Flip™ process**
- **Surface mount packages**
  - Air cavity QFN
    - Ceramic or LCP
  - Over-molded QFN
  - Rogers laminate
- **High-power flange packages**
  - Cu-Moly based
  - Plastic over-molded
CuFlip™ TriQuint’s Cu-Bump Interconnect Technology

- **CuFlip™ advantages**
  - Low inductance connection
  - Reduces performance variability
  - Potential board and die size reduction

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Technology Advantage: BiHEMT and CuFlip™

BiHEMT
- Smaller, less complicated die
- Lower cost solution
- Provides path for higher integration

Conventional vs. BiHEMT + CuFlip™

Cu-Flip™
- More efficient PA
- Cooler operation due to lower thermal impedance (30-50%)
- Less manufacturing variation

Size reduction and performance increase with using enhanced process technology

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Summary

- Power amplifier advancements result in SWaP improvements for both center feed and AESA radar
- GaN RF switches and high-survivability LNAs improve performance and decrease size of the overall radar
- Packaging drives lower cost unit price and low cost assembly
Thank You!

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