Microsemi - Agenda

- GaN Technology Advantages
- Microsemi GaN Power Transistor Offering
- Five Featured Products
- Microsemi GaN Amplifier Offering
- Summary
GaN and SiC Material Property Advantages for Pulsed Applications

GaN and SiC - higher power, higher frequency, longer pulses and duty cycle capabilities than Silicon:

<table>
<thead>
<tr>
<th>Material Property</th>
<th>Si</th>
<th>SiC</th>
<th>GaN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Band Gap (eV)</td>
<td>1.1</td>
<td>3.2</td>
<td>3.5</td>
</tr>
<tr>
<td>3 Times Silicon</td>
<td></td>
<td>3X</td>
<td></td>
</tr>
<tr>
<td>Critical Field (10^6 V/cm) Ten Times Silicon</td>
<td>0.3</td>
<td>3</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>10X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thermal Conductivity (Watt/cm^2-K) 3 Times Silicon</td>
<td>1.5</td>
<td>4.9</td>
<td>&gt;1.5</td>
</tr>
<tr>
<td></td>
<td>3X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Capability**
- High operating temperature.
- High voltage operation, higher power output and wider bandwidth.
- Higher Power Per part

**System Benefit**
- Increase reliability
- Reduce maintenance costs
- Extend system range with High power wide band amplifiers
- Reduce part size / eliminate cooling requirements

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S-Band 2.7 – 2.9GHz, 14 dB Gain, 300W Module

One GaN replaces three Si BJT transistors

Before

Driver x1

Output TR x2

Now

GaN Power
S-Band  2.7 – 2.9GHz, 14 dB Gain, 300W Module

GaN Power Advantages

- Higher Power
- Higher Gain
- Higher Efficiency
- Faster Rise time
- More rugged
- Simpler Assembly
- Smaller Size
Featured Product

I  Avionics Mode-S, IFF, Transponder
II Avionics Mode-S ELM
III Avionics Broad Band Data Link
IV Communication
V  Radar Air Traffic Control
For Avionics - Mode-S, IFF, Transponder

**MDS1400**

Freq – 1030 MHz  
Pout – 1400 W  
Efficiency – 50%  
Si BJT
### Avionics Bipolar Products

**TCAS**  
(1030MHz, 32us, 2%)  
- TCS1200  
- TCS800  
- TCS450  

**MODE-S**  
(1030MHz, 0.5/0.5, x128, 1%)  
- MDS1100  
- MDS800  
- MDS400  

**TRANSPONDER**  
(1090MHz, 10us, 1%)  
- TPR1000  
- TPR700  
- MS2206  

**DME**  
(1025-1150, 10us, 1%)  
- DME800  
- DME500  
- MS2554  
- SD1536-08  

**TACAN**  
(960-1215, 10us, 10%)  
- TAN500  
- TAN350  
- MS2267/TAN250A  
- TAN150  

**Mode-S ELM**  
(1030, 32/18 x42, 6%)  
- MDS500L  
- MDS280L  
- MDS140L  
- MDS60L
MDS1400 Power Curve

• New vs. Old - Transfer Curve
Avionics 1400W, 32us, 2%

- Capable of Delivering >1400W Pout

Boonton 4500B Pulse

Rise: --.s | Rise: --.s | OffTm: --.s
Peak: 1.469 kW | Peak: 173.4 W | Peak: 173.4 W
Width: 32.03 us | Width: 32.08 us | Pulse: 168.9 W

\[
\begin{align*}
169.9 \text{ Mk1} & \quad 835.086\% \quad 1.419 \text{ Mk2} \\
\text{W} & \quad \text{Ratio} & \quad \text{kW} \\
\end{align*}
\]
Featured Product II

For Avionics - Mode-S ELM

1011GN-700ELM
Avionics – 1030MHz, Mode-S ELM

32us (on) / 18 us (off), x 48, Period=24 ms

MDS500L – Si BJT

<table>
<thead>
<tr>
<th>Freq (MHz)</th>
<th>Pin (W)</th>
<th>Pout (W)</th>
<th>Gp (dB)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1030</td>
<td>60</td>
<td>525</td>
<td>9.4</td>
<td>57</td>
</tr>
</tbody>
</table>

1011GN-700 ELM – GaN

<table>
<thead>
<tr>
<th>Freq (MHz)</th>
<th>Pin (W)</th>
<th>Pout (W)</th>
<th>Gp (dB)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1030</td>
<td>5</td>
<td>720</td>
<td>21</td>
<td>72</td>
</tr>
</tbody>
</table>
Avionics – 1030MHz, Mode-S ELM

Typical RF Performance Data

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Pin (W)</th>
<th>Pout (W)</th>
<th>Id (A)</th>
<th>RL (dB)</th>
<th>Nd (%)</th>
<th>G (dB)</th>
<th>Trise (ns)</th>
<th>Tfall (ns)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1030</td>
<td>5</td>
<td>730</td>
<td>0.95</td>
<td>-15</td>
<td>75</td>
<td>21.6</td>
<td>25</td>
<td>20</td>
</tr>
</tbody>
</table>

- High Power >700W
- High Efficiency >70%
- High Gain >20 dB
- Mode-S ELM pulse
- Small Size – Single Ended
- GaN Technology
Featured Product III

For Broad Band Avionics – Data Link

| 0912GN-250 | 960-1215MHz, 128us, 10% |
| 0912GN-500  | 17 dB Power Gain, 250W / 500W Power |
|             | TACAN, JTIDS, DME, TCAS, Mode-S |
For Broad Band Communication

1020GN-60CW
Sneak Preview – L-Band Transistor

Broad Band, 1-2GHz, 60W CW

<table>
<thead>
<tr>
<th>Freq(GHz)</th>
<th>Pin(W)</th>
<th>Pout(W)</th>
<th>Gp(db)</th>
<th>Id(A)</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.5</td>
<td>73</td>
<td>13.1</td>
<td>3.69</td>
<td>41%</td>
</tr>
<tr>
<td>1.2</td>
<td>3.5</td>
<td>61</td>
<td>12.4</td>
<td>2.82</td>
<td>45%</td>
</tr>
<tr>
<td>1.5</td>
<td>3.5</td>
<td>58</td>
<td>12.2</td>
<td>2.27</td>
<td>53%</td>
</tr>
<tr>
<td>1.8</td>
<td>3.5</td>
<td>67</td>
<td>12.8</td>
<td>2.96</td>
<td>47%</td>
</tr>
<tr>
<td>2</td>
<td>3.5</td>
<td>56</td>
<td>12.0</td>
<td>2.56</td>
<td>46%</td>
</tr>
</tbody>
</table>
Featured Product V

For Radar – Air Traffic Control

2729GN-400

2729GN-500
## 2729GN-400

**Single S-Band Transistor => 400W**

<table>
<thead>
<tr>
<th>Freq (GHz)</th>
<th>Pin (W)</th>
<th>Pout (W)</th>
<th>Gp (dB)</th>
<th>Effi(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7</td>
<td>28.2</td>
<td>415</td>
<td>11.7</td>
<td>50</td>
</tr>
<tr>
<td>2.8</td>
<td>28.2</td>
<td>418</td>
<td>11.7</td>
<td>55</td>
</tr>
<tr>
<td>2.9</td>
<td>28.2</td>
<td>422</td>
<td>11.8</td>
<td>57</td>
</tr>
</tbody>
</table>

Model 2729GN-400:

Vdd= 65V, Idq=750mA_pk, 100uS @ 10%

![Graph showing performance](chart.png)
# 2729GN-500

## Single S-Band Transistor => 500W

<table>
<thead>
<tr>
<th>Freq (GHz)</th>
<th>Pin (W)</th>
<th>Pout (W)</th>
<th>Gp (dB)</th>
<th>Effi (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7</td>
<td>31.6</td>
<td>531</td>
<td>12.3</td>
<td>50</td>
</tr>
<tr>
<td>2.8</td>
<td>31.6</td>
<td>520</td>
<td>12.2</td>
<td>52</td>
</tr>
<tr>
<td>2.9</td>
<td>31.6</td>
<td>528</td>
<td>12.2</td>
<td>56</td>
</tr>
</tbody>
</table>

**Model 2729GN-500**

Vdd = 65V, Idq = 800mA_peak, 100µs @ 10%
Featured Product VI

For Radar – Air Traffic Control

2729GN-1000P
1214-800P L-Band Pallet

- 1.2 – 1.4 GHz, 330us, 10%, +50V, 800W
S-Band GaN Amplifier

1KW Amplifier with 6” x 6” x 1”
S-Band GaN 1000W Pallet

- 2.7 – 2.9 GHz, 100us, 5%, 1000W, 3” x 3” x.25”

Model 2729GN-1000
Vdd = 65V, Idq = 2A_pk, 100us 5%

![Graph showing Pout (W) vs Pin (W) for different frequencies (2.7GHz, 2.8GHz, 2.9GHz).](image)
S-Band  Power of Excellence!

![Graph showing power output for various components: Si-170, Si-300P, GaN-300, GaN-400, GaN-500, and GaN-1000P. Each component is represented by a bar, with the y-axis showing power in watts (W).]
The GaN Revolution Has Officially Begun!
High Power GaN Amplifier
GaN Product Offering

- **High Power Amp**
  - Connectorized High Gain High Power

- **Multi TR Module**
  - High Gain Driver, isolator included

- **Paired TR Pallet**
  - Ease of Use, 50 ohm Plug-N-Play

- **Transistor**
  - Platform Transistor
High Power GaN Amplifiers

Gallium Nitride (GaN)

- Employs latest semiconductor technologies
- Multi-octave amplifiers and application specific narrow band amplifiers currently cover frequencies to 18 GHz.
- High Efficiency and High Power Density achieved
- Catalog designs offer power levels up to 100 Watts; custom designs for non-catalog frequency bands are available.
# GaN Amplifier Offering

<table>
<thead>
<tr>
<th>Model Number</th>
<th>Frequency (GHz)</th>
<th>Gain (dBmin)</th>
<th>Psat (dBm min)</th>
<th>Psat (Watts typ)</th>
<th>DC Power</th>
<th>PAE</th>
<th>ECCN</th>
</tr>
</thead>
<tbody>
<tr>
<td>AML056P4511</td>
<td>0.5 - 6.0</td>
<td>45</td>
<td>39</td>
<td>10</td>
<td>28V/1.3A</td>
<td>25%</td>
<td>EAR99</td>
</tr>
<tr>
<td>AML056P4512</td>
<td>0.5 - 6.0</td>
<td>45</td>
<td>43</td>
<td>25</td>
<td>40V/2.7A</td>
<td>23%</td>
<td>EAR99</td>
</tr>
<tr>
<td>AML26P4012</td>
<td>2.0 - 6.0</td>
<td>45</td>
<td>43</td>
<td>25</td>
<td>28V/3.0A</td>
<td>30%</td>
<td>EAR99</td>
</tr>
<tr>
<td>AML26P4013</td>
<td>2.0 - 6.0</td>
<td>50</td>
<td>46</td>
<td>50</td>
<td>28V/6.0A</td>
<td>30%</td>
<td>EAR99</td>
</tr>
<tr>
<td>AML59P4512</td>
<td>5.5 - 9.0</td>
<td>45</td>
<td>45</td>
<td>40</td>
<td>28V/4.0A</td>
<td>35%</td>
<td>3A001.b.4.b</td>
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<tr>
<td>AML59P4513</td>
<td>5.5 - 9.0</td>
<td>45</td>
<td>48</td>
<td>80</td>
<td>28V/8.0A</td>
<td>35%</td>
<td>3A001.b.4.b</td>
</tr>
<tr>
<td>AML811P5011</td>
<td>7.8 - 11.0</td>
<td>45</td>
<td>43</td>
<td>25</td>
<td>28V/2.8A</td>
<td>30%</td>
<td>3A001.b.4.b</td>
</tr>
<tr>
<td>AML811P5012</td>
<td>7.8 - 11.0</td>
<td>50</td>
<td>46</td>
<td>50</td>
<td>28V/5.5A</td>
<td>30%</td>
<td>3A001.b.4.b</td>
</tr>
<tr>
<td>AML811P5013</td>
<td>7.8 - 11.0</td>
<td>50</td>
<td>48</td>
<td>80</td>
<td>28V/11.5A</td>
<td>25%</td>
<td>3A001.b.4.b</td>
</tr>
<tr>
<td>AML1416P4511</td>
<td>14.0 - 16.0</td>
<td>45</td>
<td>42</td>
<td>20</td>
<td>30V/3.2A</td>
<td>20%</td>
<td>ITAR</td>
</tr>
<tr>
<td>AML1416P4512</td>
<td>14.0 - 16.0</td>
<td>45</td>
<td>45</td>
<td>40</td>
<td>30V/6.2A</td>
<td>20%</td>
<td>ITAR</td>
</tr>
<tr>
<td>AML618P4014</td>
<td>6.0 - 18.0</td>
<td>40</td>
<td>39</td>
<td>10</td>
<td>32V/2.8A</td>
<td>12%</td>
<td>ITAR</td>
</tr>
<tr>
<td>AML618P4015</td>
<td>6.0 - 18.0</td>
<td>40</td>
<td>42</td>
<td>20</td>
<td>32V/4.9A</td>
<td>12%</td>
<td>ITAR</td>
</tr>
<tr>
<td>AML218P4012</td>
<td>2.0 - 18.0</td>
<td>35</td>
<td>37</td>
<td>6</td>
<td>32V/1.5A</td>
<td>13%</td>
<td>ITAR</td>
</tr>
<tr>
<td>AML218P4011</td>
<td>2.0 - 18.0</td>
<td>40</td>
<td>39</td>
<td>10</td>
<td>32V/2.5A</td>
<td>12%</td>
<td>ITAR</td>
</tr>
</tbody>
</table>
GaN Amplifier Product Offering

Catalog GaN amplifiers feature internal TTL Control for DC On/Off
  Duty Cycle up to 100%
  Switching Speed: 50% TTL – 90% / 10%
  Turn-On: 250 ns nom
  Turn-Off: 500 ns nom
  DC Consumption typically reduced by 90%

Faster Switching Available

Measured data on 2-18 GHz 10 Watt PA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turn-On Time</td>
<td>163.5 ns</td>
</tr>
<tr>
<td>Rise Time</td>
<td>30.5 ns</td>
</tr>
<tr>
<td>Turn-Off Time</td>
<td>389 ns</td>
</tr>
<tr>
<td>Fall Time</td>
<td>90 ns</td>
</tr>
</tbody>
</table>
GaN

2-18 GHz 8-10 Watts PA

Pout vs Frequency

P5dB (dBm)

Freq(GHz)

P5dB_32V

P5dB_35V

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Thank You – Questions?