Leading the GaN Revolution

Marotta Controls Solves Complex Defense PSU Challenges with Transphorm’s GaN

APEC 2021

Philip Zuk
SVP of Technical Marketing and Business Development
**Company Overview**

*Transphorm is a Pioneer and Leading Provider of Gallium Nitride (GaN) Power Semiconductor Devices*

### At a Glance

- **OTCQB:** TGAN
- **Founded:** 2007; headquartered in Goleta, CA
- **Employees:** 87 (18 PhDs >300 years of GaN expertise)
- **Patents:** >1,000 patents
- **Full Production Capabilities:** high-volume wafer fab in Japan
- **World-wide** base with U.S., Japan strength
- **Total Revenue:** $11.4 million in 2020

### End Market Applications: Power Converters/Inverters

- Automotive EV and Charging
- Power Adapters / Compute / Crypto
- Data Center / Comm Infrastructure
- Broad Industrial

### Products

- Leader in high voltage (650V and above) GaN
- Comprehensive portfolio with multiple generations; > 12 billion operating hours and < 1 failure per billion hours in field
- First JEDEC and AEC-Q101 qualified 650V devices available in the market

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**Strategic Partners**

- KKR
- NXP
- Microchip
- Marelli
- Yaskawa
Key Success of Transphorm

• Best-in-class Reliability
• Simplicity of Designability
• Ease of Driveability
• High volume Reproducibility with silicon like yields
• Ability to develop relationships and partnerships amongst industry suppliers and customer
Offering Best-in-Class Field Reliability

Only GaN Supplier to Publish Early Life Failure Results

Field Data

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Installed Power</td>
<td>&gt; 250 MW</td>
</tr>
<tr>
<td>Device Hours</td>
<td>&gt; 13 billion (13e⁹)</td>
</tr>
<tr>
<td>FIT*</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Field Returns</td>
<td>2</td>
</tr>
</tbody>
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*Failure in time: failures per billion hours

Testimonials

“The Corsair AX1600i is the best PSU that money can buy today, period.” - tom's HARDWARE

“We initially selected Transphorm’s transistors for the reputable reliability and our experience has since exceeded our expectations,” - MAROTTA®

“Based largely on the power semiconductors’ proven quality and reliability as well as the team’s reputation for successful collaboration,” - TDK
Marotta Controls
Control Systems Solutions Provider
APEC 2021

Presented By:

Michael Germinario
Senior Technical Director

Michael Scruggs
Principal Engineer
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Company Overview

**Our Company**
- Established 1943 – 78 Years
- Small Business
- Privately owned
- 4X growth since 2010

**Our Business**

<table>
<thead>
<tr>
<th></th>
<th>Aero</th>
<th>Space</th>
<th>Marine</th>
<th>Tactical</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>16%</td>
<td>23%</td>
<td>33%</td>
<td>28%</td>
</tr>
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</table>

**Our Achievements**
- Innovative solutions provider for hard-to-solve technical challenges.
- Advanced Control Systems for:
  - POWER
  - ELECTRONICS
  - FLOW
  - FLUID
  - PRESSURE
  - MOTION

<table>
<thead>
<tr>
<th>Year</th>
<th>Employees</th>
<th>Facility Size</th>
<th>Mechanical</th>
<th>Units Shipped</th>
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<tbody>
<tr>
<td>2010</td>
<td>150</td>
<td>115,000 ft²</td>
<td>100%</td>
<td>1,200</td>
</tr>
<tr>
<td>2021</td>
<td>350</td>
<td>135,000 ft²</td>
<td>54%</td>
<td>9,000+</td>
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Special Recognition for ISS Program Performance
- Two-time recipient of the George M. Low Award
- Platinum Source Supplier

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Power Electronics Capability Evolution

- Dual Channel Pump Controller
- Motor Pump Controller
- Pneumatic Compressor System ECUs
- Aft Pneumatic Source Controller
- Launcher Compressor ECU
- Launcher Power Conversion
- Fin Actuator ECU

- Missile Power Supplies
- Power Distribution
- 1-STEP AC-DC Power Conversion

Featured Product: PDU300

The product we developed that utilizes Transphorm’s technology is one of our most sophisticated power conversion / distribution units that provides 18 different output voltages in a compact, lightweight package.

- Avionic application; unpressurized assembly
- Conduction cooled baseplate temp -55C to +85C
- Combination of vibration / shock environments
- Size: LESS THAN 32 CU IN
- Weigh: ~1.6Lbs

- Input power 270V aircraft power derived from 115VAC 3PH 400Hz power
- Transients up to 400VDC 100ms
- Ride through power drop-outs for bus transfers (0.2 msec min)
- Total power processing 1.2Kw into multiple outputs (>15) with time dependent power profile
Power Distribution Design

Design Decisions

• DC-DC Brick vs Custom Design Considerations
  ▪ Form Factor - sky-lining with other components
  ▪ Power derating with high temperature – full power at max temp profile
    o Thermal shutdown not allowed
  ▪ Ease of customization: soft start, turn on time, current limiting
  ▪ Voltage operating range – energy storage tradeoffs

• Solution Decision: Custom DC-DC converter
  ▪ Take advantage of volume and area – trading circuits and form factor
  ▪ Full power operation with no thermal shutdown
  ▪ Extended operating voltage range to minimize energy storage

Marotta design is comparable to 1/8 brick size
1/8 brick size
2.3” x 0.9” x .465” max

Converter power side
Magnetics on opposite surface
Sky-lined with other circuits to maximize volume
Power Distribution Design

Packaging

Size – Cross Section
The optimum architecture resulted in fitting four 270V to 28V 300W converters in 19 cu in with additional layout sky-lining and I/O constraints to accommodate the large number of low voltage output circuitry, energy storage

- Converter volume ~4.75 cu in
- Max spacing between circuit cards .515 in
- Hot components near transfer surface
- Cooling paths through PWB copper augmented by thermal pads to heat transfer surfaces
- PWB Routing top to bottom to minimize trace lengths and loop areas and to optimize volume

Design features
- Simple hard switched topology with minimum parts count and drive circuitry

Part selection
- Planar xfmr design – low profile >300KHz operation
- SiC output diodes PQFN pkg
- Transistor PQFN pkg
The thermal design of the product presented as many challenges as the mechanical packaging, part layout and routing.

Early engineering tests were successful with the following thermal results with Silicon MOSFETS:

- Initial power dissipation and efficiency measurements were lower than anticipated.
- Transistor temperatures would be at or exceed the maximum limit under worst case operating conditions.
- Dynamic load conditions indicated more margin on transformer saturation was beneficial:
  - Higher switching frequency would be necessary to prevent increasing transformer size.
  - Higher switching frequency would incur higher losses.

GaN was considered to help solve the thermal design and maintain present transformer size.
Power Transistor Selection – TPH3208 vs. Si MOSFET

- Gan transistor operated to full load with **no heatsink 71°C**
- MOSFET transistor would have exceeded 130°C w/o heatsink
- For the same operating conditions **GaN was 40°C cooler**
- Converter Power dissipation was 6.4W less with GaN
- **2% improvement in converter efficiency (pk eff of 90.2% was obtained)**

**SIGNIFICANT THERMAL IMPROVEMENT WITH GaN**
Design Updates

Final Design Improvements

- **Power Improvements with GaN**
  - Exceeded converter dissipation & efficiency targets
  - Power reduction of 6.4W/converter
  - Saved 25.6W dissipation
  - Higher switching frequency operation
  - Max temperatures well within part ratings under all operating environments

- **Drive Improvements with GaN Cascode**
  - Direct substitution with existing design – no change in drive circuitry required
  - Reduction in drive voltage to regulator control circuits
  - Power reduction 0.6W per converter
  - Reduced local hotspots
  - Circuit simplification
Design Updates

Summary

1. The use of GaN enabled a quick solution to the converter design solving challenging thermal problems in a very dense mechanical package.

2. Ease of use, low losses permitted the design to operate with margin over temperature, and reduce risk of magnetics saturation by increasing the switching frequency.

3. The use of the GaN proved very successful in this project and is in production.
Your Success is Our Mission

Contact Us

Your Success is Our Mission

Quality Certifications

ASQR-01
Boeing Approved Processor D1-4426
BQMS D6-82479 Addendum 2 (AS9006) – Boeing
General Dynamics Electric Boat 2678
Huntington Ingalls, Newport News 2678
HSM-10 – Hamilton Sundstrand
IPC-A-610
IPC-J-STD-001ES
JSF SEAL Level 2
J-STD 001
MIL-Q-9858A, MIL-I-45208
MSJ4000 – Mitsubishi Heavy Industries
NASA 8739.4
NASA 8739.1A
Navy Level 1 – Pressure Boundary / Subsafe
QPS-102 – Bell Helicopter

MAROTTA CONTROLS, INC.
78 Boonton Avenue
P.O. Box 427
Montville, NJ 07045
+1.973.334.7800
www.marotta.com