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

transphorm

Highest Performance, Highest Reliability GaN

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

Strategic Partners

KKR, nexperia, Department of Defense, Microchip, Marelli, YASKAWA

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

transphorm

Key Success of Transphorm

- Best-in-class **R**eliability
- Simplicity of **D**esignability
- Ease of **D**riveability
- High volume **R**eproducibility 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

SuperGaN®

bel CORSAIR DELTA MAROTTA TDK YASKAWA

Field Data	
Installed Power	> 250 MW
Device Hours	> 13 billion ($13e^9$)
FIT*	< 0.5
Field Returns	2

***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

Your Success is Our Mission

MAROTTA®

Proprietary Disclaimers

MAROTTA CONTROLS PROPRIETARY INFORMATION

The information contained in this document is Marotta Controls Proprietary and is discussed in confidence. It remains the property of Marotta Controls, Inc. and shall not be used, disclosed to others or reported without the prior written consent of Marotta. If consent is given for reproduction in whole or in part, this notice and the notice set forth on each page of this document shall appear in any such reproduction, in whole or in part.

WARNING: INFORMATION SUBJECT TO U.S. EXPORT CONTROL LAWS

This document, which includes any attachments and exhibits hereto, may contain technical data or technology subject to the international traffic in arms regulations (ITAR, 22 C.F.R. Parts 120-130) or the export administration regulations (EAR, 15 C.F.R. Parts 730-774), which may not be exported out of the united states or released or disclosed to foreign persons inside or outside the united states, without first obtaining an export license, authorization, or other approval from the U.S. Government. Violations of the ITAR and the ear are subject to civil and criminal penalties. It is the receiver's responsibility to comply with all applicable U.S. Export control laws and regulations and include this notice with any reproduced portion of this document.

Company Overview

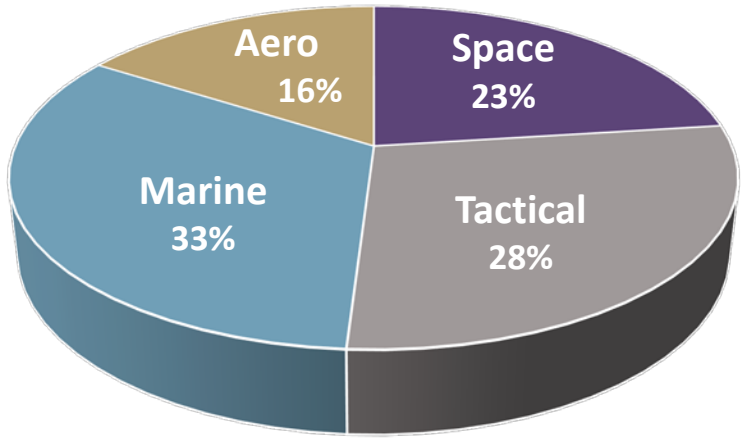
Our Company

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

2010	2021
150 Employees	**350 Employees**
115,000 ft^2 facility	**135,000 ft^2 facility**
100% Mechanical	**54% Mechanical 46% Electronics**
1,200 units shipped	**9,000+ units shipped**

Our Business

Innovative solutions provider for hard-to-solve technical challenges.



Advanced Control Systems for:

POWER	FLUID
ELECTRONICS	PRESSURE
FLOW	MOTION

Our Achievements

LOCKHEED MARTIN

Small Business Supplier of the Year

LOCKHEED MARTIN

Outstanding Small Business

NASA

Two-time recipient of the George M. Low Award

BOEING

Special Recognition for ISS Program Performance

NORTHROP GRUMMAN

Platinum Source Supplier

Power Electronics Capability Evolution

MAROTTA

Dual Channel Pump Controller

2004

Motor Pump Controller

2006

Pneumatic Compressor System ECUs

2007

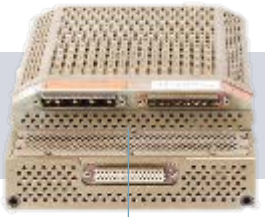
Aft Pneumatic Source Controller

2008

Launcher Compressor ECU

2010

Launcher Power Conversion

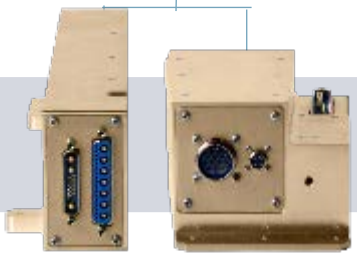


2012

Fin Actuator ECU

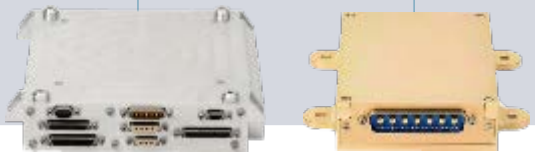
2013

2014



2015

2016



2017

2018

2019

2021

Missile Power Supplies

Power Distribution

1-STEP AC-DC Power Conversion

MAROTTA®

Product Overview: PDU 300

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**

MAROTTA®

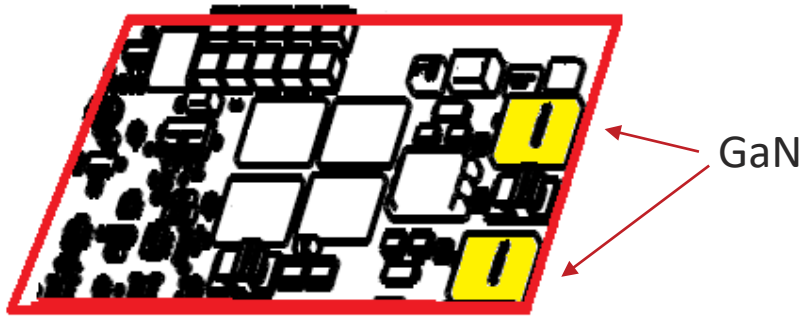
Design Decisions

- **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
    - 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

MAROTTA

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**

MAROTTA®

Thermal Design

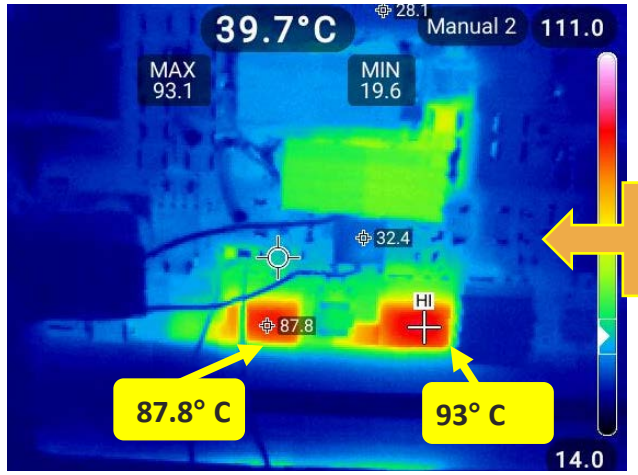
- The thermal design of the product presented as many challenges as the mechanical packaging, part layout and routing.
- Early engineering tests were successful with the following thermal results with Silicon MOSFETS
  - Initial power dissipation and efficiency measurements were **lower** than anticipated
  - 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

MAROTTA®

Si MOSFET

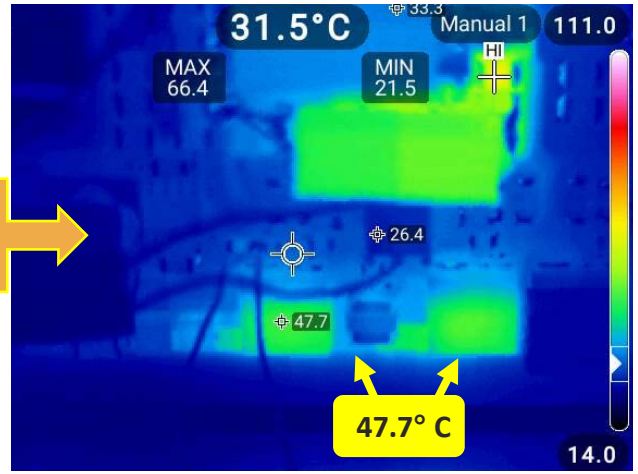


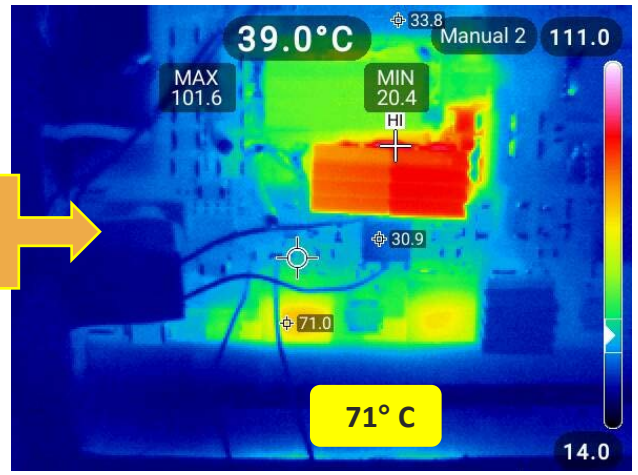
** With heatsink*

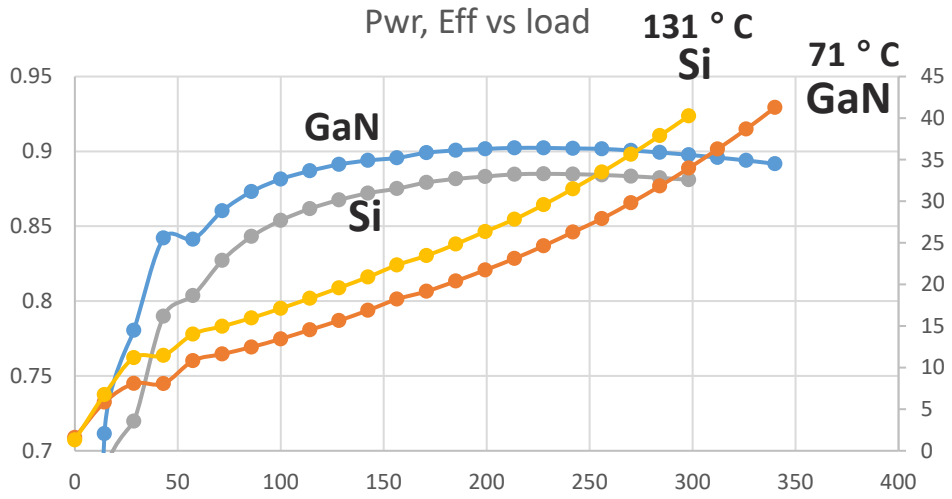
170W Load

340W Load

TPH3208







- Gan transistor operated to full load with **no heatsink 71C**
- MOSFET transistor would have exceeded 130C w/o heatsink
- For the same operating conditions **GaN was 40C 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

MAROTTA®

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

MAROTTA®

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

MAROTTA CONTROLS, INC.

78 Boonton Avenue

P.O. Box 427

Montville, NJ 07045

+1.973.334.7800

www.marotta.com

Quality Certifications

AS9100:D & ISO 9001:2015

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


transphorm
www.transphormusa.com