

The Necessity of Developing Lighter, Smaller and More Efficient Power Modules for Small Sats

Jason Stange
Senior Space Systems Engineer, Packet Digital

PacketDigital

Who is Packet Digital?

Manufacturing facilities

25,000 sq. feet

80,000 sq. feet (coming soon)

Advanced automated machinery

Rapidly growing company



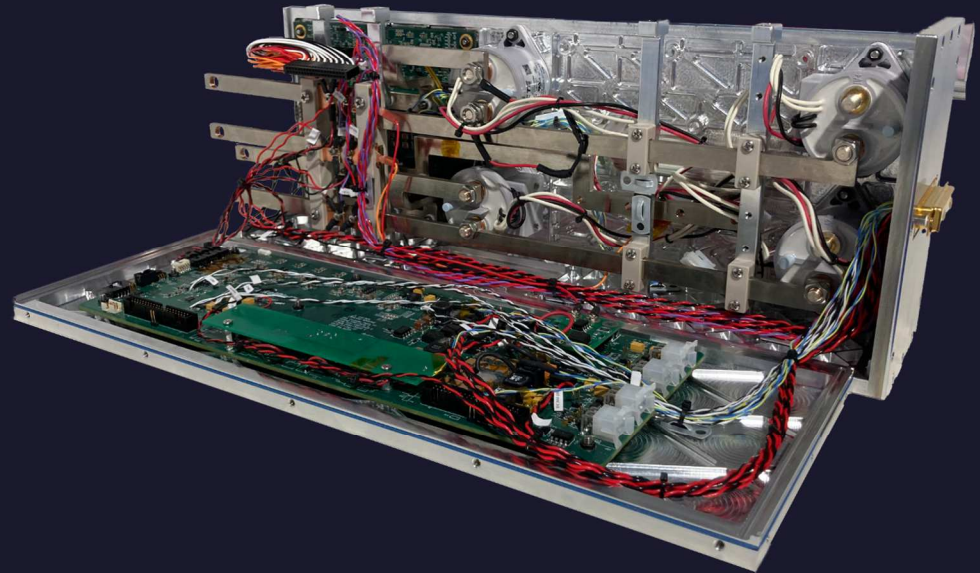


Addressing areas of need

Resource management

- Improving gravimetric and volumetric power densities
- Maximizing power conversion efficiency
- Reduce need for complex thermal management systems

Packet Digital's SmallSat Power Supply Unit (PSU) Solution



GaNFET Based Maximum Power Point Tracker (MPPT) Card



Packet Digital's GaN based MPPT hardware and embedded algorithms take precise power measurements and adjust settings quickly to maintain maximum power transfer from solar panels to the spacecraft bus.



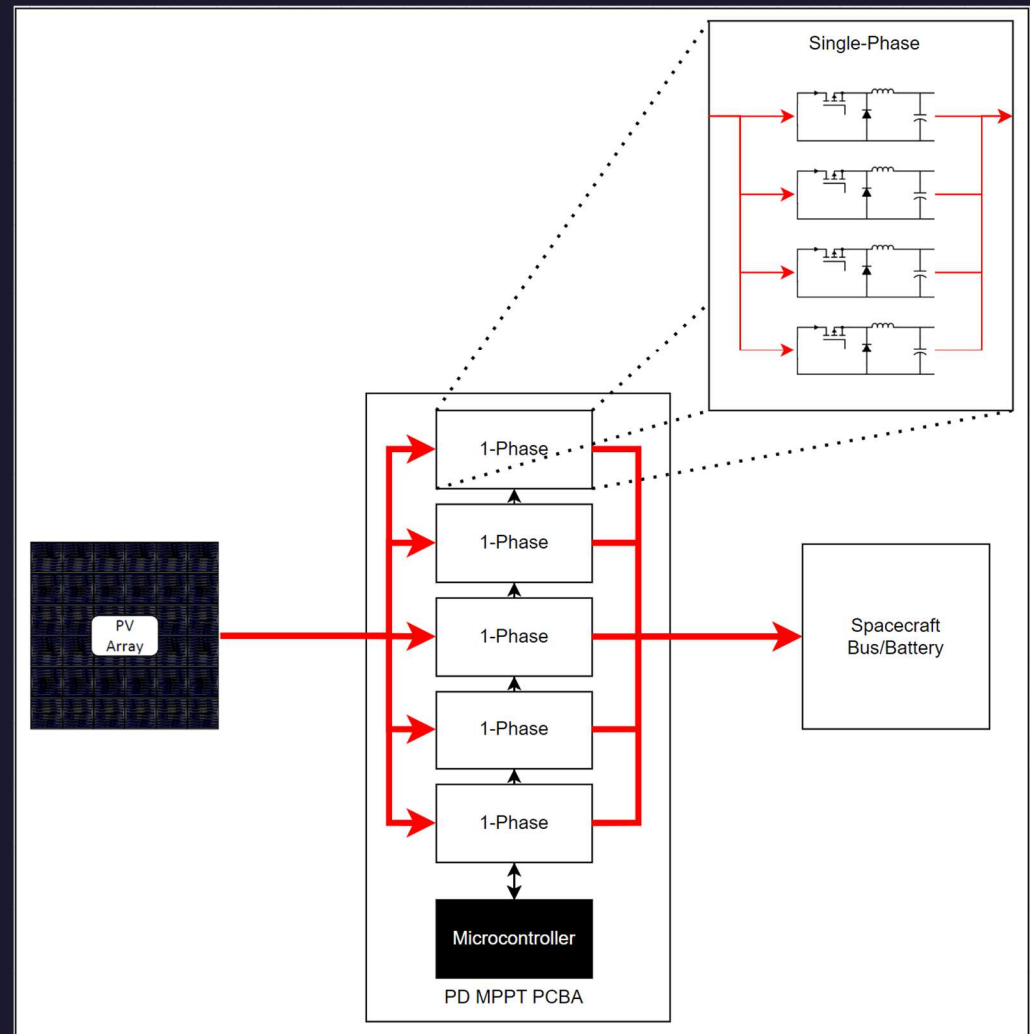
GaN Based MPPT High-Power System Architecture

Single Phase

- 4x GaN Buck-Converters
- 800W Max

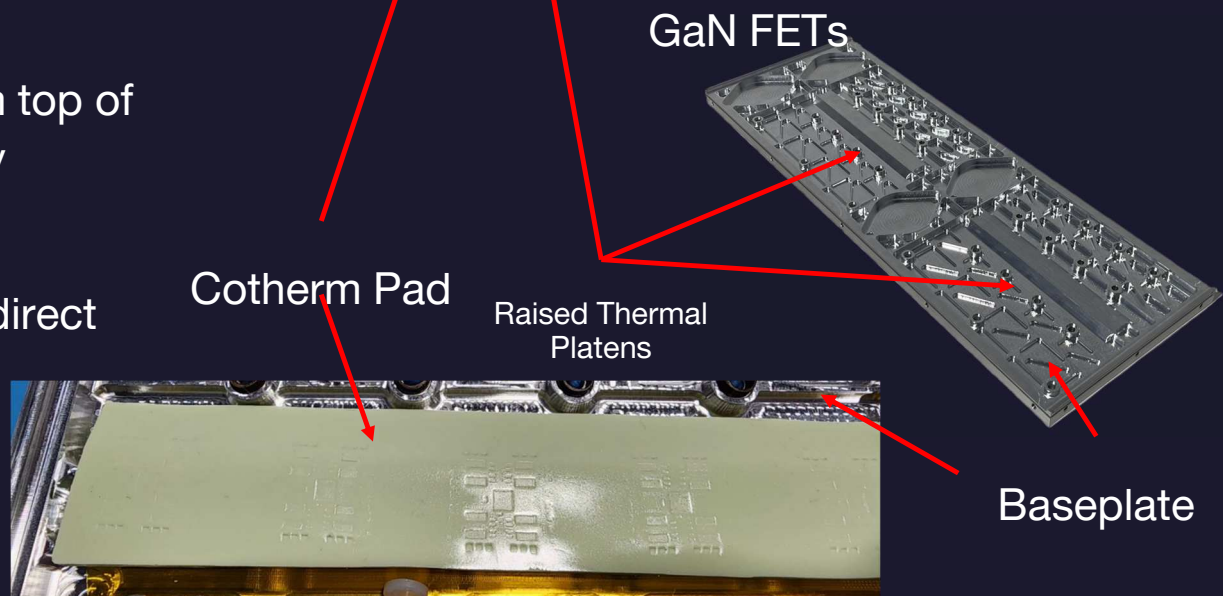
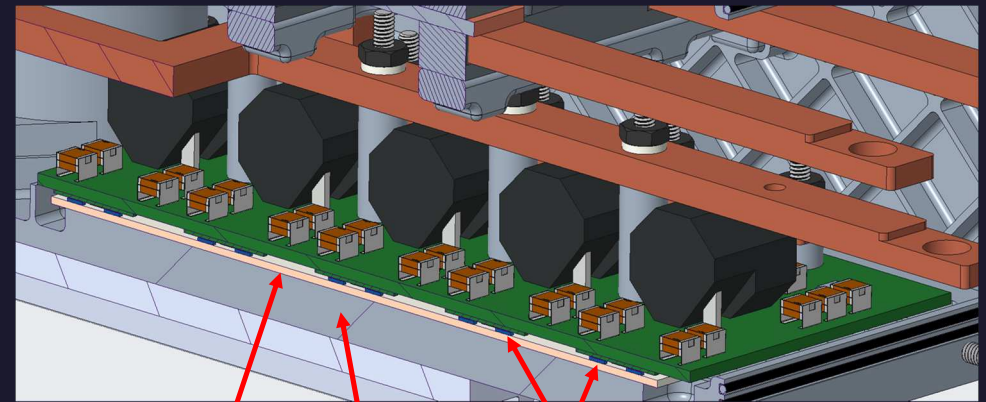
MPPT System

- 5x Phases
- Digitally controlled
- Helps spread thermal load



Thermal Design

- Problem: Small GaN package size does not allow for good thermal conduction to PCBA for thermal relief.
- Solution: Create a thermal path from top of GaN device directly to power supply baseplate.
- Largest expected thermal load has direct path to spacecraft chassis.



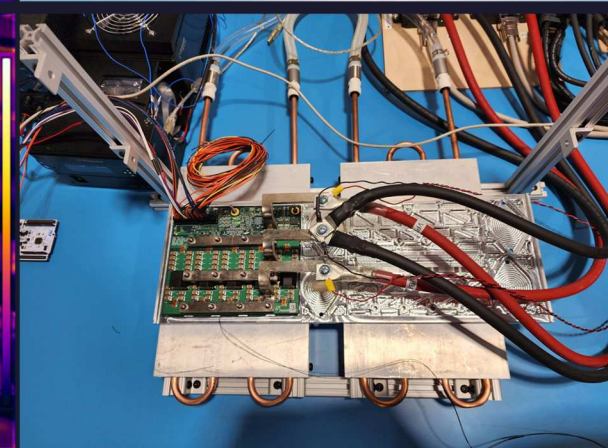
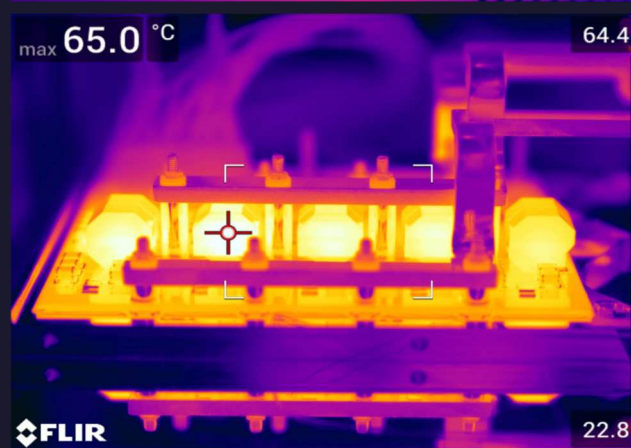
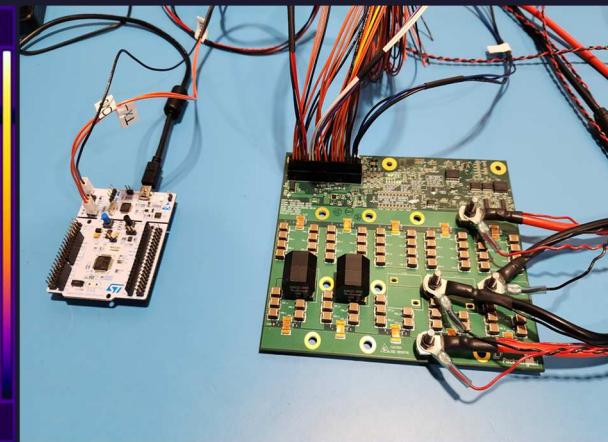
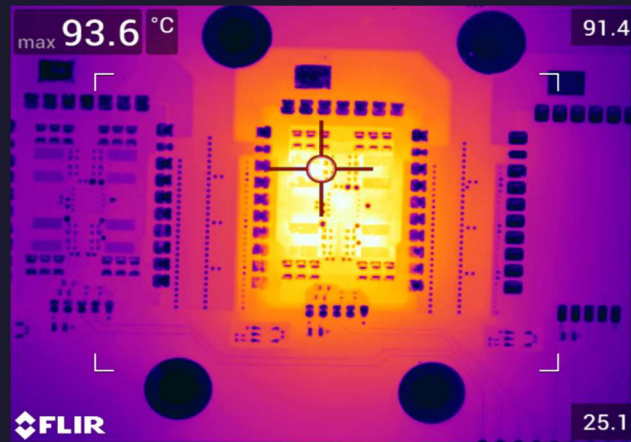
MPPT Thermal Performance

Single Channel Open Air (Top):

- Ambient: 25° C
- Power: 500W
- Max Temp (GaN FET): 93.6° C

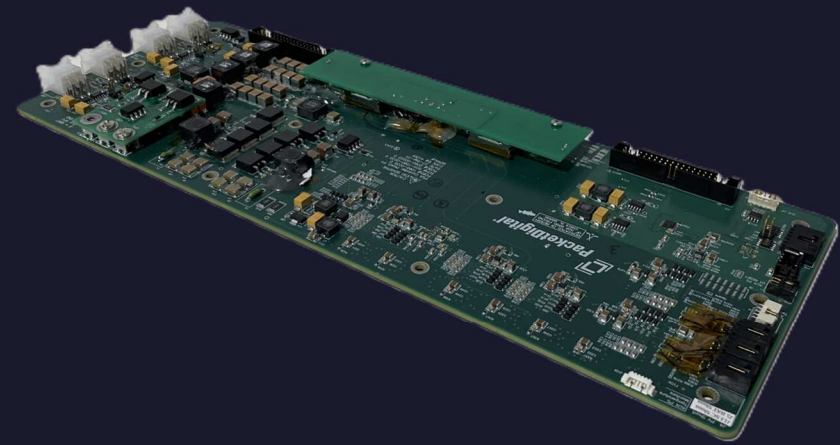
Full Card Liquid Cooled (Bottom):

- Ambient: 25° C
- Power: 3100W
- Max Temp (Inductor): 65.0° C



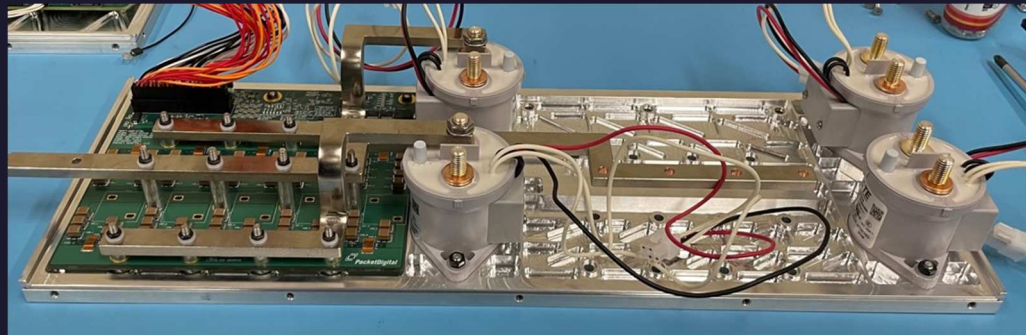
Local Power Management & Distribution (PMAD) Card

Packet Digital's PMAD independently monitors Power Supply Unit (PSU) housekeeping telemetry, provides local housekeeping voltages to each of the MPPT's, manages contactor operations, and handles unit communications with the spacecraft computer.



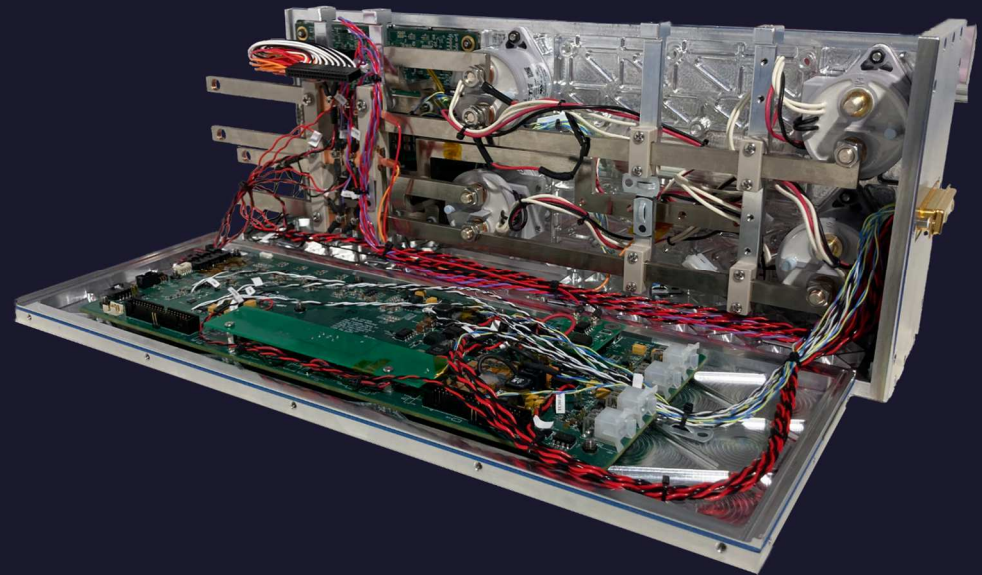
System Safety & Redundancy

- Input/output power contactors for converter isolation from spacecraft systems
- Hardware safety trips
 - Voltage, current & thermal
- Independent watchdogs for hard reset of microcontrollers
- N+1 Redundancy of converter hardware



3kW SmallSat PSU

- Power: 3kW Nominal, 4kW Peak
- 98% Peak Conversion Efficiency
- Power Density: 394 W/kg – 0.459 W/cm³
- N+1 Redundancy
- System Safety Features
 - Overvoltage
 - Overcurrent
 - Thermal
- Radiation Environment Protections
 - Single-Event Upset (SEU)
 - Single-Event Latch-Up (SEL)



MPPT SmallSat Use Cases

- Low Earth Orbit (LEO) missions, spacecraft batteries require constant recharging due to repeated solar array eclipse during orbit cycle.
- Allows for smaller Photovoltaic (PV) Array sizes to be considered in mission trades based on Worst Case and End-of-Life (EOL) mission power requirements.
- On orbit spacecraft attitude control or altitude maneuvers that utilize electric propulsion.

Future Plans

- Vacuum testing of improved design.
- Explore scalability of MPPT design architecture.
- Actively seeking opportunities for spaceflight heritage.

Conclusion

- Packet Digital, 20+ years innovating power systems
- Developed a GaNFET based MPPT for use in Smallsats
 - Power: 4kW Max
 - Efficiency: 98% Max
 - N+1 Redundancy
- Plan to develop scalable solution in the near future





Innovative Power Solutions

Thank you!

Jason Stange
Senior Space Systems Engineer, Packet Digital