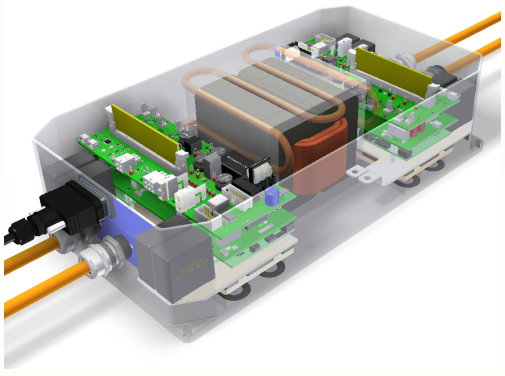
MAINSTREAM ENGINEERING CORPORATION

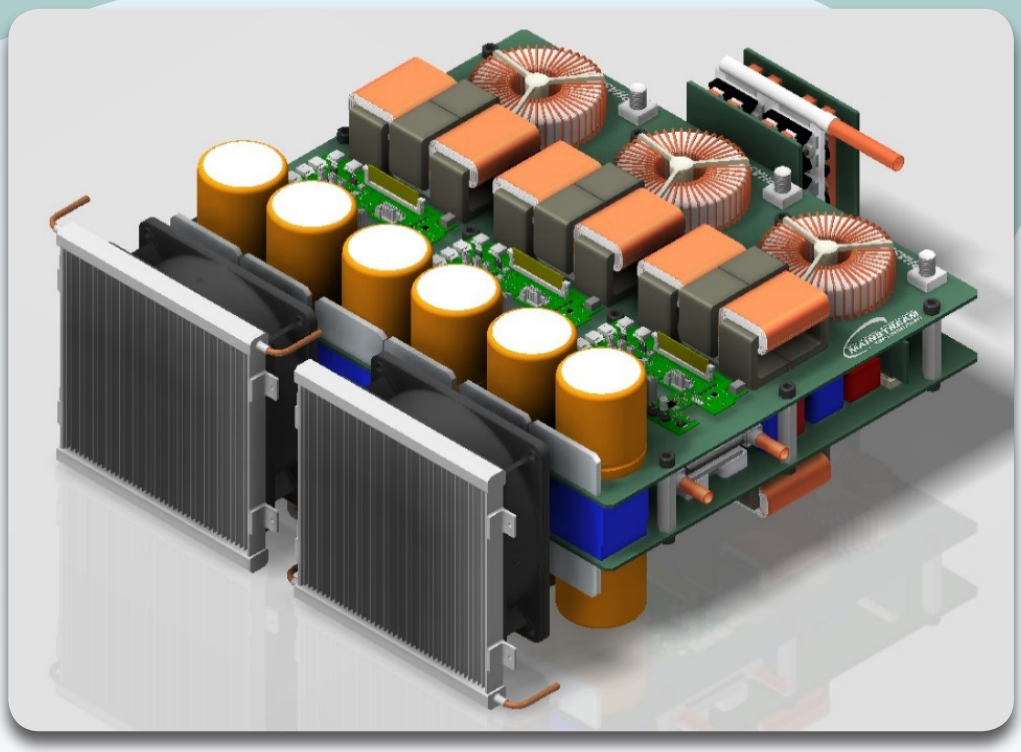
# Wide Bandgap Power Converters

Solutions Through Advanced Technology®
MAINSTREAM ENGINEERING

## Mainstream's Approach

Mainstream Engineering Corporation uses the latest wide bandgap (both GaN and SiC) devices to develop high-efficiency, size- and weight-optimized power converters for a wide range of demanding military and commercial applications. We specialize in low- to medium-power (1 kW to 500 kW) and low- to medium-voltage (24 V to 1700 V) systems. Mainstream develops and produces components and systems specifically for the rugged military environment where size, weight, and power (SWaP) are critical. We rely on our extensive history of developing thermal control and energy conversion systems to provide integrated power electronics that have tremendous SWaP advantages when compared to commercial and legacy military systems. All of Mainstream's power electronics are designed to satisfy requirements of MIL-STD-461, MIL-STD-1399, and MIL-STD-810.





## Benefits of Wide Bandgap Devices

Mainstream does not produce wide bandgap dies; we rely on device manufacturers to provide components that we integrate into our advanced system designs. Therefore, we are not biased toward a particular technology, and we understand the benefits of both GaN and SiC when it comes to developing custom solutions. We typically rely on GaN devices for low-voltage (<400 V) and low-temperature applications (<100°C) and SiC devices for high-voltage (>400 V) and/or high temperature (>100°C) applications, although each requires careful consideration of all the system requirements. As a result, we analyze the specific system benefits of each technology before proceeding with a design.

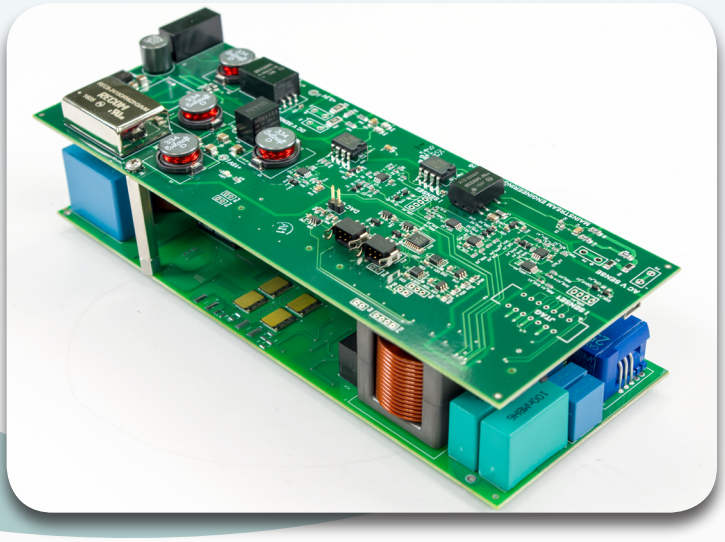
## Benefits of Thermal Integration

Mainstream has an extensive background in thermal control and will chose the appropriate thermal management technology based on system requirements. We have designed passive, natural convection or conduction systems where simplicity and reliability are paramount. We have also developed more advanced cooling solutions based on liquid cooling or two-phase cooling. We developed a 45 kW PM motor drive for a military high-speed compressor that uses two-phase R134a refrigerant as the coolant. This approach reduced the temperature rise through the VFDs coldplate to only a few degrees while also reducing the coldplate's thermal resistance by an order of magnitude over single-phase cooling options.

## Power Inverter

Inverters designed for low-cost commercial markets are often procured for critical military missions due to commercial availability. These inverters are large and inefficient and do not meet requirements for military grade electronics. Mainstream is developing 28 VDC to 120 VAC inverters using GaN devices that have a zero-percent de-rating at temperatures up to 71°C with natural convection cooling. In high-current (>50 A) and low-voltage (<50 V) applications, GaN devices have reduced losses when comparted to both Si and SiC-based devices.

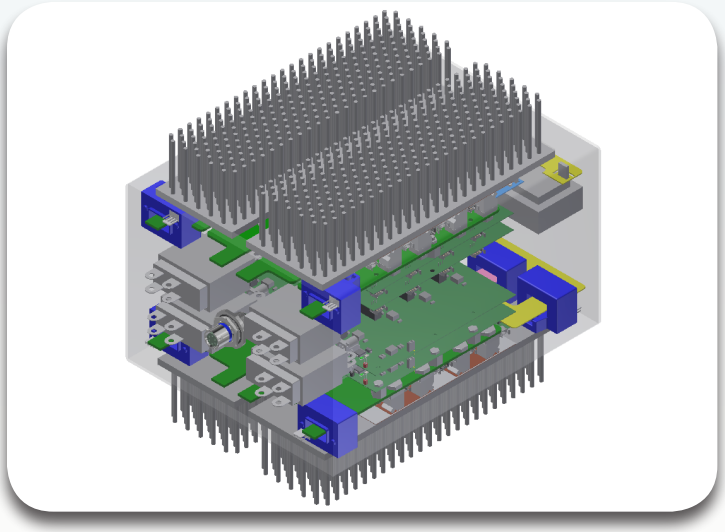
| 2.5 kW Power Inverter | |
|---|---|
| Power | 2.5 kW |
| Size | 12.5″ x 5.7″ x 2.6″ |
| Weight | 9.6 lbs |
| Efficiency | 94.6% |



## Battery Isolator Unit (BIU)

Whether for system redundancy, load isolation, or system stand-by, many applications use multiple battery banks for powering critical electronic loads. Often these battery banks are connected through battery-isolating diodes and a manual disconnect switch, which is heavy, inefficient and failure prone, and must be manually actuated. Mainstream is developing a more intelligent battery isolation using GaN-based devices, smart power electronics, and digital controls. Our first system interfaces with two military vehicle low-voltage (28 VDC) battery banks, allows bi-directional current flow independent of battery charge, has a zero-percent de-rating when bucking and boosting, and is cooled using only natural convection (smaller forced-convention systems are possible).

| 28 VDC BIU | |
|---|---|
| Power | 500 $A_{PK}$ |
| Size | 9.8″ x 8.1″ x 9.5″ |
| Weight | 28 lbs |
| Efficiency | >96% |



## Custom Power Modules

Thermal management and the level of integration with the power devices has a large impact on the size and weight of the entire power converter system. Commercial power modules have the lowest level of integration and provide for bolt-on thermal solutions, resulting in larger size systems. Mainstream is developing custom power modules using the latest GaN and SiC devices and integrating the thermal management at the baseplate and/or ceramic substrate layer. This has the potential to result in power densities of >5 MW/m$^3$ (kW/L) for power converters in the 200-400 kW range.

*Mainstream Engineering Corporation is a solutions-oriented research, development, and manufacturing business founded in 1986. Our engineering mission is to research and develop emerging technologies and to engineer these technologies into superior quality, military and private sector products that provide a technological advantage. Areas of expertise include thermal control, energy conversion, power electronics, turbomachinery, chemical technology, and materials science.*

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