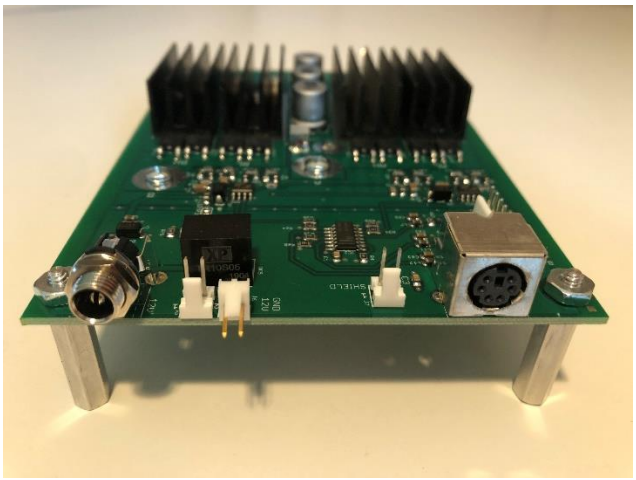
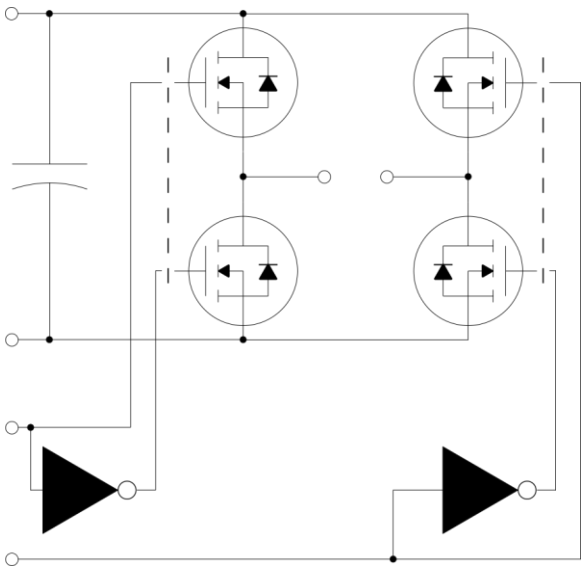
Description:
The SPI-DCI-35V-50A-BB-WF-1 is a MOSFET based H-Bridge assembly with a straight-forward interface and robust design, all on a compact, easily mounted PCB, allowing an engineer or hobbyist to conveniently and cost-effectively focus on developing the controls for his or her application rather than the power electronics. System features include:



- Effective active cooling
- Easy control and interfacing from typical microcontrollers
- Integrated dead-time insertion
- Integrated free-wheeling diodes
- Integrated 1320uF DC bus capacitor bank
- Direct control of the switch pairs in each phase
- Wide switching range up to 200kHz



The H-bridge can be used as a buck or boost converter, inverter, or rectifier enabling applications such as a brushed DC motor drive, single-phase AC motor drive, DC supply, LED drive, PWM rectifier, class D amplifier, or Tesla Coil drive, among countless other power conversion applications.

Absolute Maximum Ratings

Parameter		Max	Unit
DC Bus Voltage		50	V
Output Current		50	A
Junction Temperature		150	°C
Switching Frequency		200	kHz
Power	T_a 25°C	1500	W
Input Signal Level		5.5	V

Typical Operating Values, T_a = 25°C

General

Parameter		Min	Typ	Max	Unit
DC Bus Voltage		12	36	50	V
Continuous Output Current				45	A_{rms}
Heatsink Temperature				75	°C
Switching Frequency			20	200	kHz
DC Bus Capacitance		1060	1320	1580	µF
Input Signal Level		2.8	5	5.5	V

Control Signal Ratings

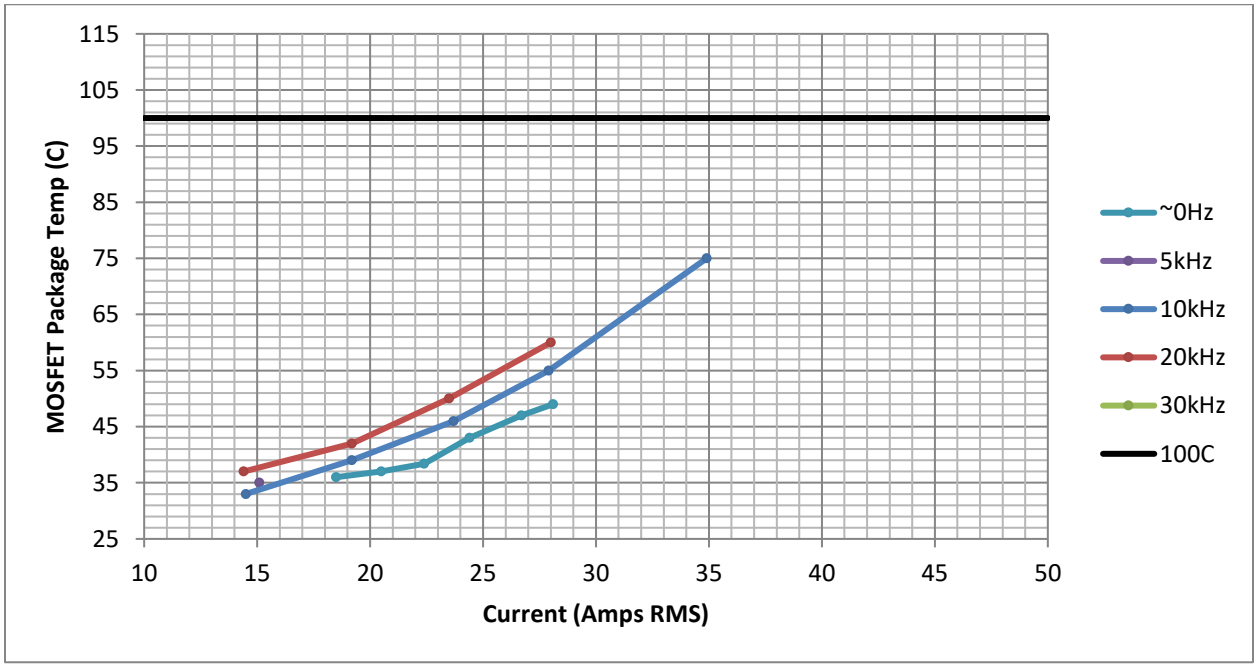
Parameter		Min	Typ	Max	Unit
Input Supply Voltage		8	12	13	V
Input Supply Current			0.01	0.25	A
Signal High Threshold		2.7	2.8	2.9	V
Signal Low Threshold		1.8	1.9	2.0	V
Signal Input Impedances		99	100	101	kΩ
Signal Input Filter Corners			1.25		MHz
Auxiliary Supply Voltage			5		V
Auxiliary Supply Current				500	mA
Fan Supply Voltage		5	12		V
Fan Supply Current			0.35	0.5	A

Switching Characteristics

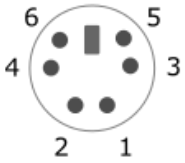
Parameter		Min	Typ	Max	Unit
Dead-Time		470	520	570	ns
Bootstrap Refresh Time				2.5	ms
Propagation Delay	Input to gate	150		600	ns
Rise Time		2000			ns
Fall Time		200			ns

Operation Curves Under Inductive Switching

MOSFET Package Temperature for Selected Switching Frequencies in kHz
Ambient Temperature 25°C, DC Bus 36V



Connections and Pinouts



The SPI-DCI-35V-50A-BB-WF-1 features a standard, shielded 6 pin miniDIN connector, and a polarized male header in parallel, to control the power switches. Additionally, a male header connected to the cable shield is provided as well as headers for the supply input. The H-bridge connections are made through labeled, plated through-holes and a connection is also provided for a thermistor to monitor the temperature of the AH MOSFETs.

Connectors

Description		Connector	Specification
Control Signals		miniDIN	6 Pin, Female
Control Supply		Barrel Jack	ID 2.5mm, OD 5.5mm
DC+, DC-, A, B		Screw Hole	#6-32

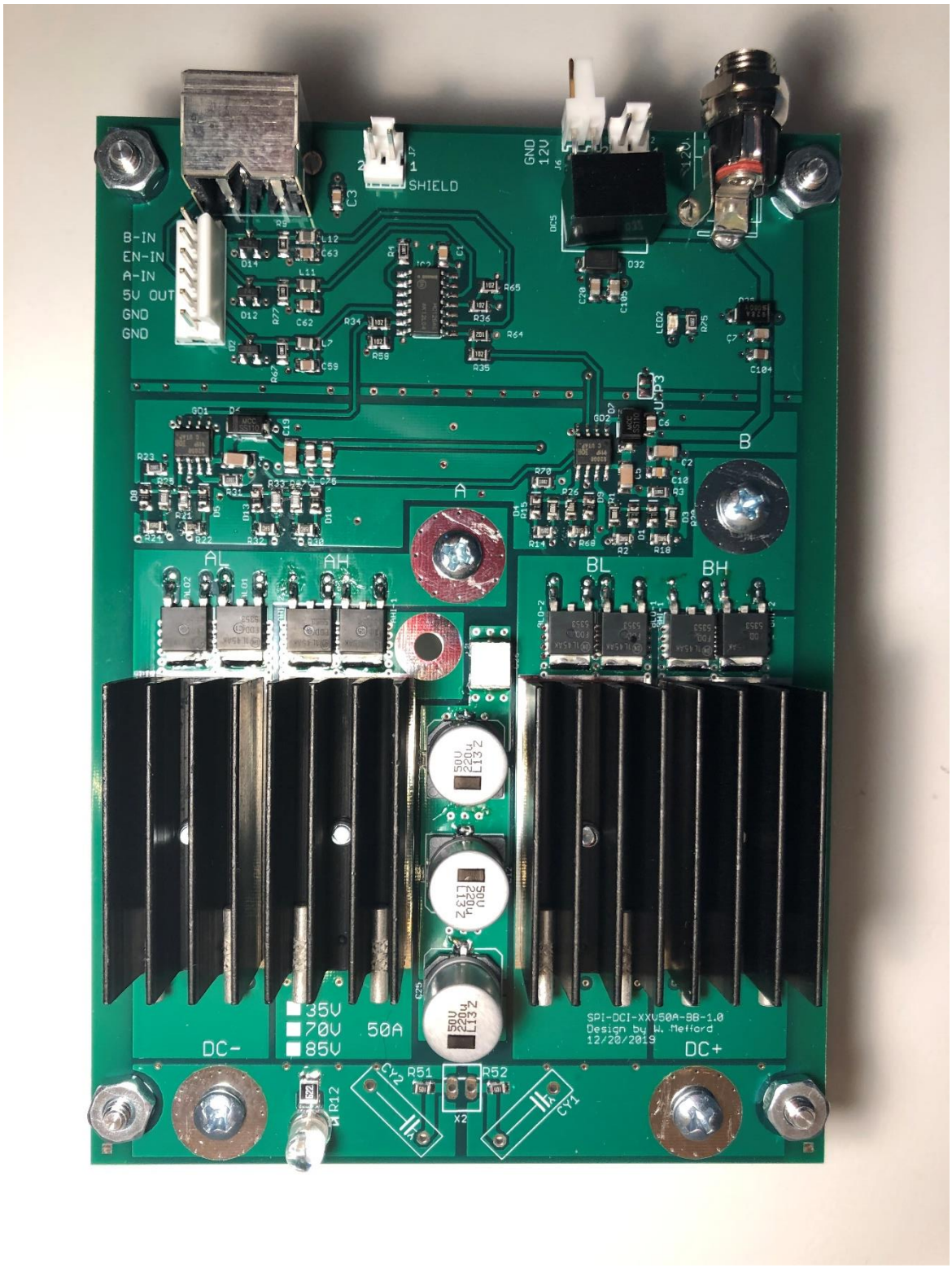
miniDIN, 6 Pin

Pin Number		Signal Name
1		B In
2		+5V Out
3		A In
4		Ground
5		Enable In
6		NC

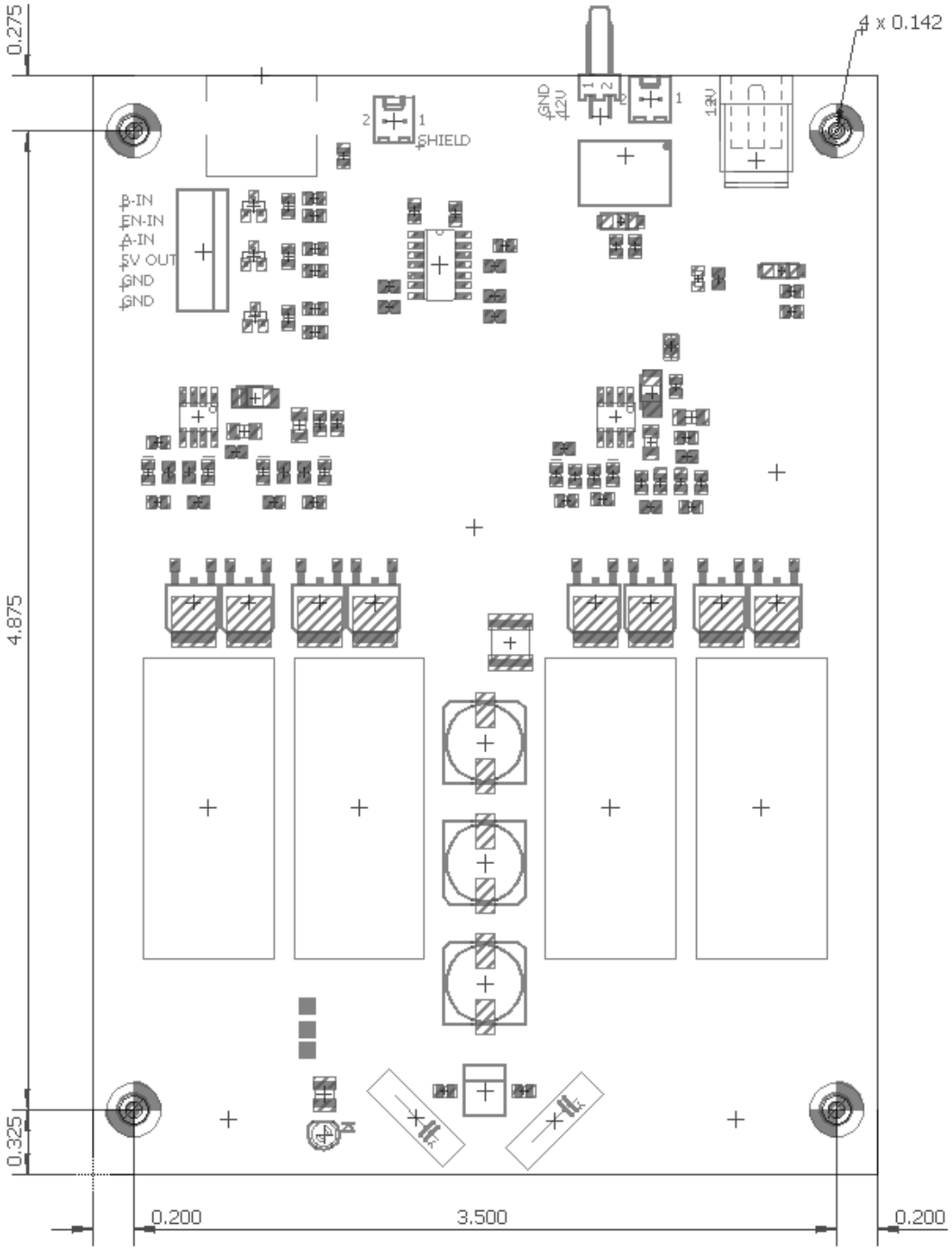
Below are recommended parts for interfacing with the module.

Recommended Interfacing Parts

Description		Manufacturer	Part Number
miniDIN Connector		TE Connectivity	5749180-1
Control Supply, 12V		CUI	SWI12-12-N-P6
Thermistor, 10k		TDK	B57703M0103A017


B-IN
EN-IN
A-IN
5V OUT
GND
GND
SHIELD
GND
12V
A
B
AL
AH
BL
BH
35V
70V
85V
50A
DC-
DC+
SPI-DCI-XXV50A-BB-1.0
Design by W. Mefford
12/20/2019

Dimensions and Mounting



All dimensions in inches

Application Information

1. Architecture

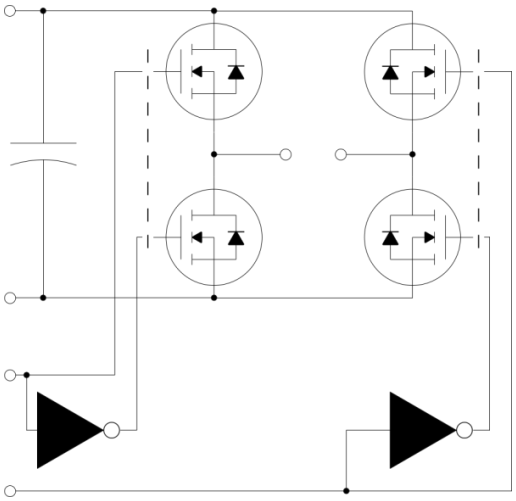
The SPI-DCI-35V-50A-BB-WF-1 is broadly split into two sections: the power section that includes the H-bridge and the control section that allows for easy interfacing with the switches in the H-bridge.

The H-bridge is a conventional topology composed of four power switches, but each of these ideal switches is constructed by paralleling two MOSFETs, giving a total of eight switching devices. Each MOSFET also has an integrated free-wheeling diode (the body diode), though this is typically activated only on the order of microseconds during switching events since the input logic forces a switch in each phase to be on as long as the system is enabled.

The MOSFETs are driven by two dual gate-drive circuits, each powered either by the 12V DC power supply or from a boot-strap circuit. The boot-strap circuits impose a maximum refresh time for the lower switches of roughly 2.5ms to allow the high side boot-strap capacitors to maintain charge. Without refreshing the boot-strap circuit, a high-side transistor in the on state will gradually loose charge and turn off unexpectedly, tri-stating the leg.

The DC bus is supported by six electrolytic capacitors totaling 1320µF which is suitable to control the ripple of many loads, but also mitigates spikes on the DC bus due to switching. Additional capacitance may need to be added externally for certain loads or sources to reduce DC bus ripple and capacitor heating. The DC bus also features a red LED to alert the user to the presence of a voltage as well as slowly discharge the capacitor bank. This results in an effective resistance of roughly 6.2kΩ across the DC bus.

The low-power section interfaces with the gate drivers through filters and buffers to make interfacing simple. An external 12V supply (provided) is required to operate the low-power section, though it is regulated down to 5V to power the low-voltage section and provide an auxiliary supply to the user. The logic inputs accept both 5V and 3.3V signals and have 100kΩ input impedances.



2. H-Bridge Control

The SPI-DCI-35V-50A-BB-WF-1 has three digital control inputs: Phase A, Phase B, and ENABLE. Each input has a 100kΩ resistor to ground followed by an LC filter and a CMOS buffer.

The two switches constituting a phase are controlled with one signal and dead-time is automatically inserted for the user in the gate drivers. Essentially, the two-phase controls behave as extensions of the controlling device: when the control signal is high, the phase terminal is connected to DC+, when the signal is low, the phase terminal is connected to DC-.

The ENABLE signal is logically "ANDed" with the two phase controls so that when high, the two control signals control the MOSFETs as described above, and when low, all of the MOSFETs are off, regardless of the phase controls' states. Setting the ENABLE signal to low, or disabling the inverter, can also be thought of as "tri-stating" the H-bridge. It should be noted that if the load is inductive and carrying a current, the free-wheeling diodes will continue to conduct in an uncontrolled fashion despite the H-bridge being disabled, passing energy to the DC bus.

ENABLE	Phase A/B In	Terminal A/B
Low	Low	Tri-State
Low	High	Tri-State
High	Low	Low
High	High	High

3. Heat and Cooling

The SPI-DCI-35V-50A-BB-WF-1 is an actively air-cooled system, dramatically improving its performance over its passively cooled cousin. A hole for mounting a thermistor to monitor the temperature of the AH MOSFETs is provided. It should be noted anything electrically connected to this terminal will be at DC+.

In general, the cooler the environment, the more effective the heat sinks will be. To estimate the temperature of the MOSFETs (measured at the package), refer to the previously provided graph of collected data. If the ambient temperature is known, the operating curves can be estimated by adding the difference between the ambient temperature and 25°C, effectively shifting all of the curves up or down.

4. Paralleling Phases

For applications where only a half-bridge or one phase-leg is required, it will likely be advantageous to parallel the two phases available in the H-bridge, reducing losses. To parallel the two, simply run a cable from one phase output to the other and route the same control signal as A Phase to the B phase control input. They must have identical control signals to avoid a shoot-through condition from occurring.

5. DC Bus Capacitor Bank

The DC Bus has integrated into it a 1320µF electrolytic capacitor bank rated at 50V, the same as the MOSFETs. For many applications, this will be a sufficiently sized capacitance, but often ripple voltage or ripple current caused by either the source (e.g. passive rectifier) or load will require additional capacitance. Additionally, many loads can store a great deal of energy that can be transferred to the DC bus periodically or while halting the load. The voltage rise due to this energy transfer could exceed the

maximum voltage of the DC bus, destroying the MOSFETs, which will undoubtedly protect the capacitors. Externally adding capacitance to the DC bus is a relatively simple task so long as one knows how to appropriately size a capacitor bank, the only precaution being that the conductors between the two should be as low impedance (short) as possible.

Another important design feature—or lack thereof—to keep in mind is that there is no capacitor charging circuit. The bus voltage will need to be ramped in some fashion if a DC source is connected to it. Abruptly connecting a voltage to the capacitor bank will cause an in-rush current that could destroy or damage the capacitors, destroy or damage the voltage source, or at the very least, trigger safety measures "upstream".

6. Grounding

Both the control and power portions of the PCB share the same reference. On the power side, this is referred to as DC- and on the control side this is referred to as Gnd, though both are connected by thick traces that cut across a conductive barrier intended to separate the sides. Additionally, the shield of the control cable is connected through a trace to Gnd and a two-pin header is provided to easily connect to the cable's shield. Effectively, this interconnectedness makes the entire system referenced to the negative DC bus, which could require special care. For example, if a conventional passive rectifier is used to provide DC power to the inverter, the negative rail will not be at ground potential unless an isolation transformer is used and a connection to ground deliberately made. The absence of either of these conditions will either lead to a floating DC bus, or a short across the rectifier, potentially destroying the diode and the high current taking an unexpected path through the controller.

Incomplete Items:
Picture with fans
Operating temperatures
Description of 12V connectors