PPEM-PrimePACK^{TM} Electrical Series

Overview

The AgileSwitch PPEM-PrimePack Electrical driver provides monitoring and fault reporting information to enable better control and analysis of an IGBT-based power system. The PPEM provides up to 20 Amps of peak current at an operating frequency up to 15 kHz. The driver includes isolated HI and LO Side DC/DC converters, an optional 2 pin MTA thermistor connector and provides up to 7 fault conditions that can be reported separately or as a single fault via the 20 pin control header. All AgileSwitch drivers use automotive temperature grade components and allow for modifying settings of gate resistors and active clamping.

Configurable Features

- 2-level turn-off time and voltage level
- Soft Shut Down (SSD) time and voltage level
- Desaturation time and voltage level
- Dead time
- Fault lockout settings
- Automatic Reset settings

Key Switch Driver Features

- Isolated Temperature Monitoring, PWM (Opt)
- Isolated High Voltage Monitoring, PWM (Opt)
- Master-Slave capability for parallel operation
- 2 X 5W output power
- RoHs and UL compliant
- Interface for 3.3V, 5V, or 15V Logic Levels
- Gate drive voltage +15V/-9V
- Peak gate current +20A/-15A
- Power supply under-voltage lockout (UVLO)
- Suitable for IGBTs up to 1700V

Applications

- Solar/PV Inverters
- Wind Turbines
- UPS
- HEV/EV
- Motor Drives
- High Speed Trains/Traction
- Induction Welding, Cutting and Heating
- Frequency Conversion
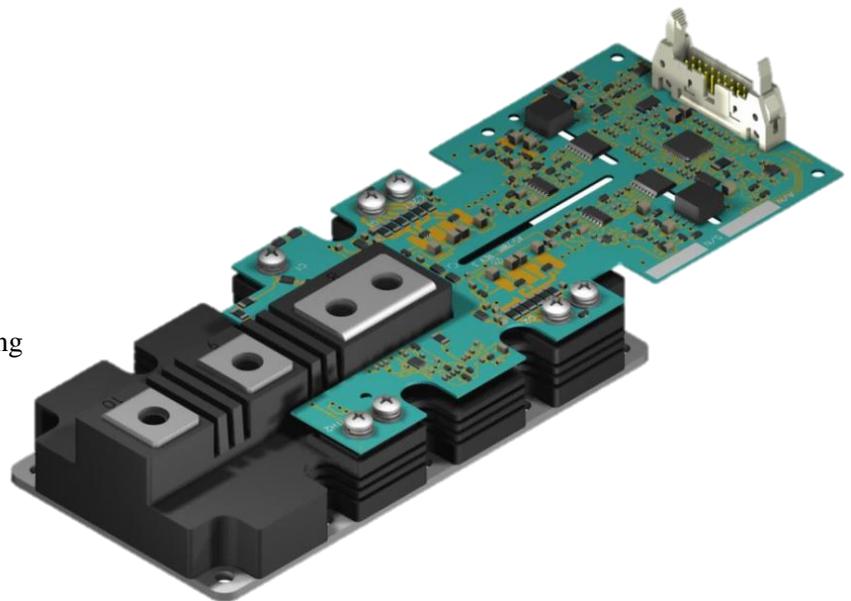
System Overview
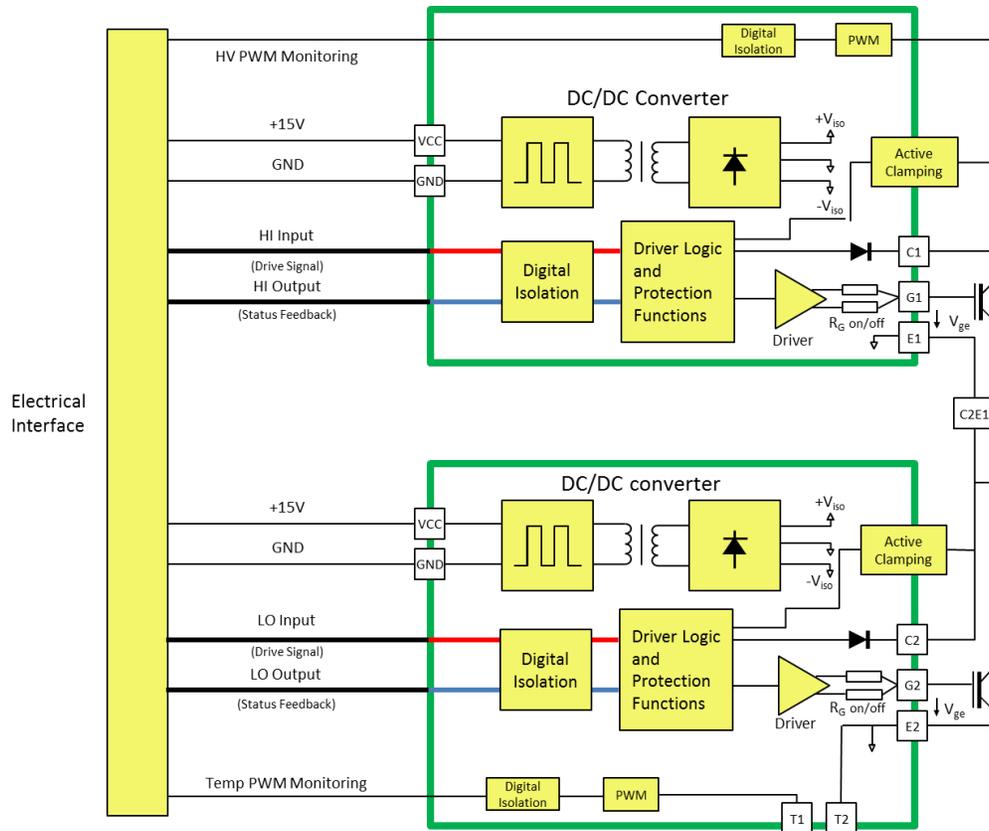
The basic topology of the driver is shown in Figure 1.

Figure 1: Basic schematic of the PPEM-PrimePACK Electrical Series IGBT driver.

Absolute Maximum Ratings

Interaction of maximum ratings is dependent on operating conditions

Parameter	Description	Min	Max	Unit
Supply Voltage	VCC to GND	0	18	V
Peak Gate Current	Note 1	-15	+20	A
Input Logic Levels	To GND	-0.5	16	V
Output Power per Gate			5.0	W
Switching Frequency	Note 2		15	kHz
Isolation Voltage	Primary to Secondary VAC RMS 1 min		3750	V
Working Voltage	Primary to Secondary, Secondary to Secondary		1200/1700	V
Creepage Distance	Primary to Secondary Side	8		mm
dV/dt	Rate of change input to output		25	kV/µs
Operating Temperature		-40	+85 (+100 opt)	°C
Storage Temperature		-40	+90	°C

Electrical Characteristics

Conditions: V_{SUP} = +15.0 V, V_{IN_LOGIC} = 15V or 5V or 3.3V

Power Supply	Description	Min	Typ	Max	Unit
Supply Voltage	VCC to GND	14.5	15	16.5	V
Supply Current	Without Load - Note 3		120	150	mA
Average Supply Current	Note 3			650	mA
UVLO Level-HI and LO	Secondary Side low voltage detect fault level	10			V
V_{SOFT}*	2-level turn-off or Soft Shut Down Voltage, configurable	10.5	11.0	11.5	V

Logic Signal	Description	Min	Typ	Max	Unit
Input Impedance	HI and LO Side Input Level	4.7			kΩ
V_{IN} Low	Turn off threshold			0.9	V
V_{IN} High	Turn on threshold	2.5			V
Gate Output Voltage Low		-8	-9	-10	V
Gate Output Voltage High		+14	+15	+16	V
Fault Output Voltage				0.5	V
Fault Output Current	Note 4			15	mA
Switching Frequency	Note 2		5	15	kHz
HV & Temp Monitoring (Opt.)	High Voltage (HV) & Temp Monitoring Output	0		3.3	V
HV & Temp Monitoring (Opt.)	PWM Frequency	23	25	27	kHz
HV & Temp Monitoring (Opt.)	Output Impedance		1.0 1%		kΩ

IGBT Short Protection	Description	Min	Typ	Max	Unit
Desat Monitor Voltage*	Between Collector and Emitter of IGBT		9.0		V
T_{DSAT}*	Activation after IGBT Turn on		6.1		μs
Response Time after Fault			500		ns

Note 1: Input signal should not be activated until 20 ms after power is applied to allow on board DC-DC converter to stabilize.

Note 2: Actual maximum switching speed is a function of gate capacitance.

Note 3: Supply Current with load of 1.0 Ω and 100nF C_{INPUT} + 10,000nC dynamic gate charge at an operating frequency of 10 kHz.

Note 4: Fault lines are open collector and require a pull-up resistor.

* Configurable parameter

Temperature and High Voltage PWM Monitoring: The AgileSwitch PPEM Driver provides two isolated 25 kHz, 3.3V PWM output signals that monitor the thermistor temperature and the DC Link Voltage (High Side collector to Low Side emitter) of the IGBT module. The PWM signals have an output impedance of 1 kΩ. When combined with an external low pass filter, these signals represent a real time, isolated voltage for both High Voltage and Thermistor Temperature. A Sallen-Key active low pass filter can be used with these outputs as shown below with a 2 kHz cut-off frequency. The cut-off frequency can be optimized for your application. For simplicity, a simple RC low pass filter with 100 Hz cut-off frequency can also be used.
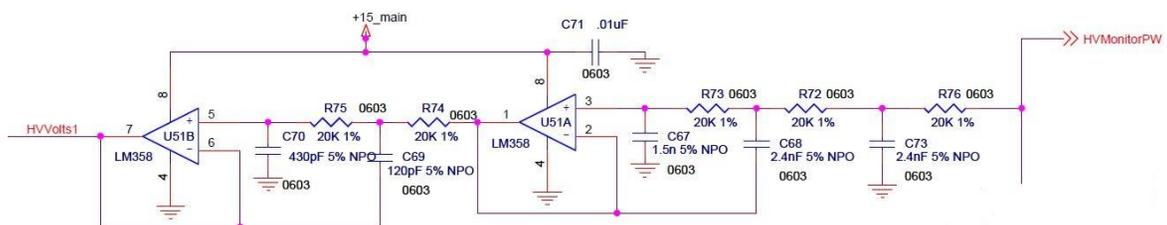

Figure 2: Example of external 2kHz low pass filter

Interconnects

Controller/Power to Driver Connectors

Connector	Type	Manufacturer Part Number
Mating Ribbon Cable	20 Pin	FCI 71600-120LF
Driver Board	20 Pin	FCI 71918-220LF

Master to Slave Driver Connectors (Optional – Please specify if required, otherwise not populated)

Connector	Type	Manufacturer Part Number
Driver Board	5 Pin	TE 5-103635-4
Cable Assembly	5 Pin	TE 104257-4
Driver Board	4 Pin	TE 5-103635-3
Cable Assembly	4 Pin	TE 104257-3

PINOUT

Pin No	Signal	Pin No	Signal
1	VCC – +15V Supply Voltage	2	GND
3	VCC – +15V Supply Voltage	4	GND
5	VCC – +15V Supply Voltage	6	GND
7	VCC – +15V Supply Voltage	8	GND
9	HI-F – HI-Fault	10	GND
11	HI-D – HI Drive In	12	GND
13	LO-F – LO-Fault	14	GND
15	LO-D – LO Drive In	16	GND
17	AL-F – All Fault (Low when HI-F or LO-F if low)	18	HV-P – Isolated High Voltage Monitoring
19	F-RS – Fault Reset (Auto Reset Optional)	20	TE-P - Isolated Temperature Monitoring

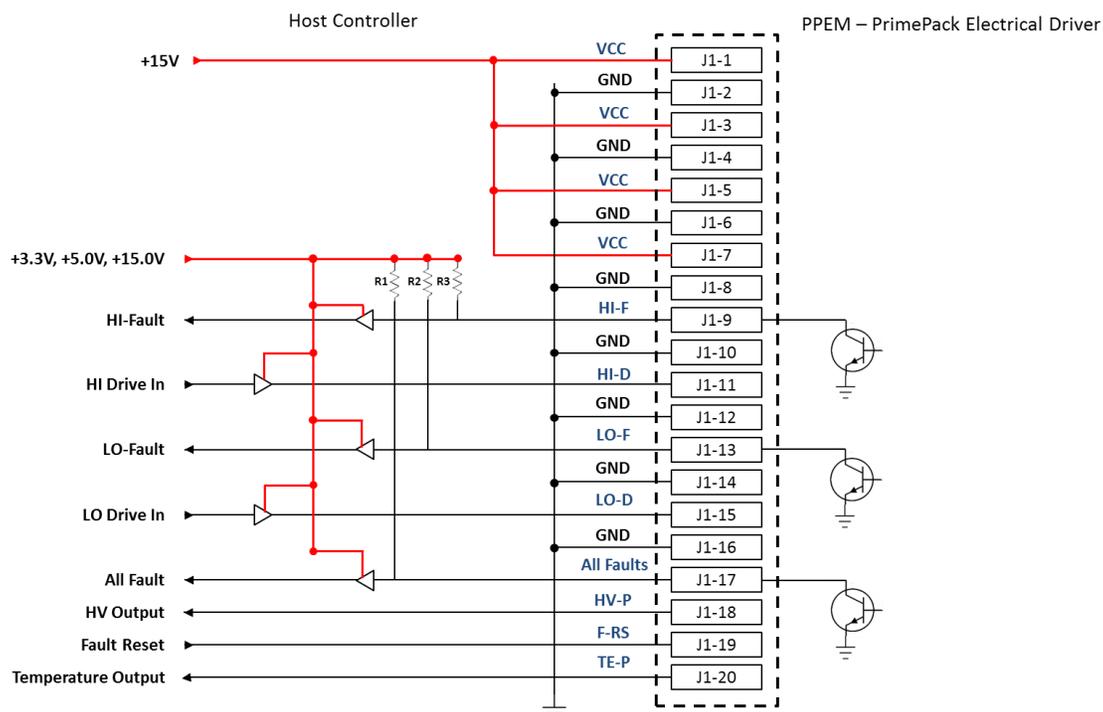## Recommended Interface Circuitry

Figure 3: PPEM-PrimePACK Electrical Series IGBT Driver Pin Connector
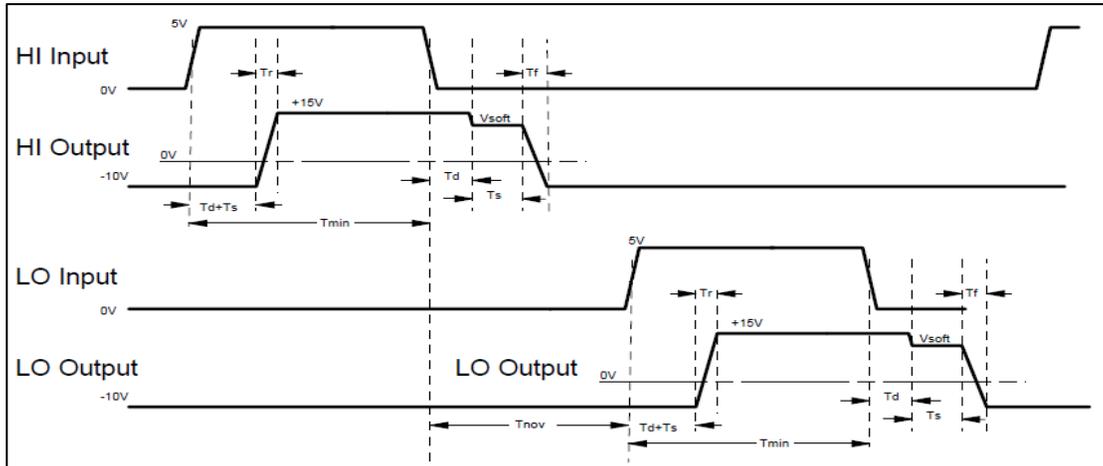
Timing Diagrams

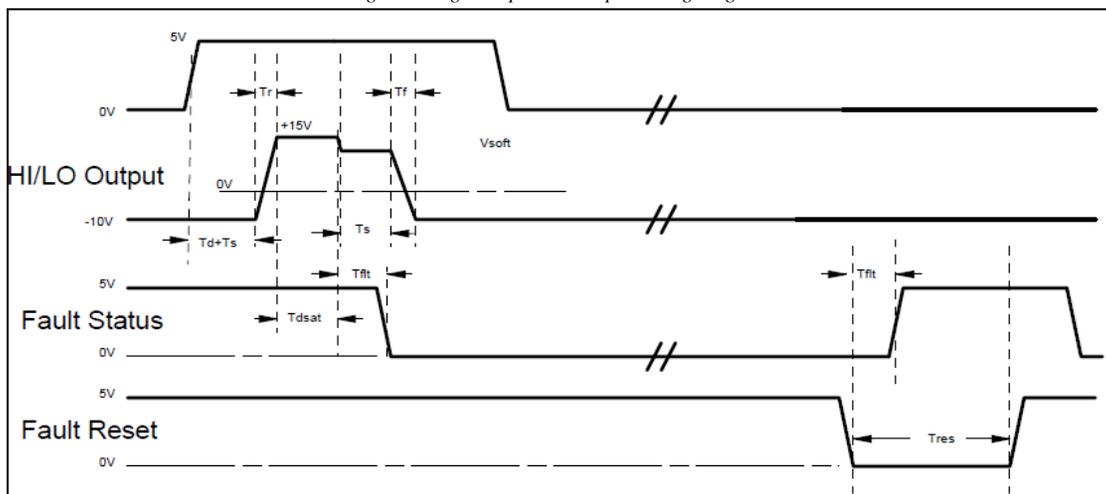*Figure 4: Signal input and output timing diagram.*

Figure 5: Signal desaturation and fault timing diagram.

Timing Diagram Values

Conditions: V_{SUP} = +15.0 V, Temp = 0 ℃ to 85 ℃

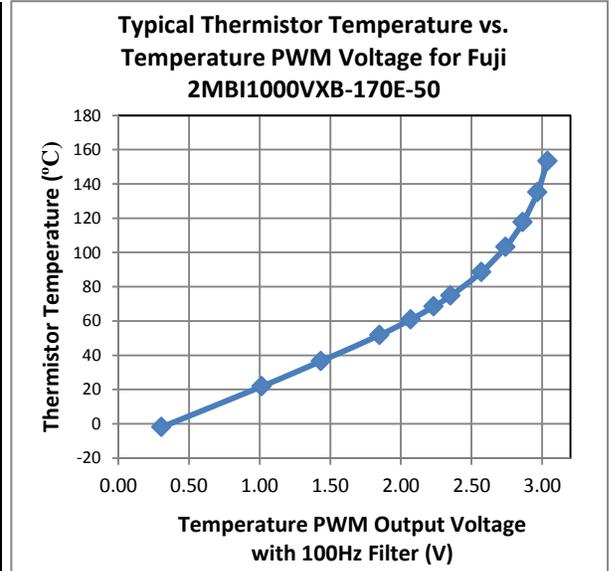| Description	Symbol	Min	Typ	Max	Units	Notes
Minimum Pulse Width	T_{MIN}	1000			ns	
Delay Time	T_D			250	ns	
Rise Time	T_R		100	200	ns	Measured from 10% to 90% points on edge, Measurement Point 1
Fall Time	T_F		150	250	ns	Measured from 10% to 90% points on edge, Measurement Point 2
Soft Turn Off Time	T_S	750	850	950	ns	Configurable
Desaturation Time	T_{DSAT}	5800	6100	6400	ns	Configurable
Fault Time Delay	T_{FLT}	250	300	500	ns	
Dead Time	T_{NOV}		3000		ns	Recommended Time between Inputs, configurable
Reset Timing	T_{RES}	500			ns	
Automatic Reset (Optional)			5		ms	Standard setting of 5 ms, configurable from 100µs to 10 ms
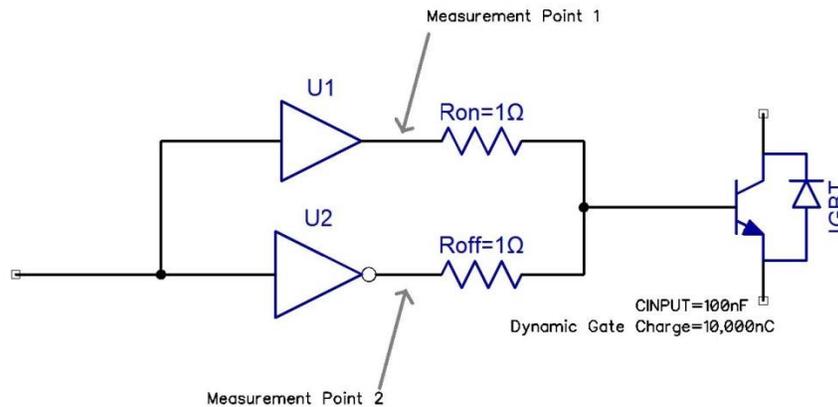
Figure 6: Measurement points for rise and fall time. C_{INPUT} and Dynamic gate charge are from Fuji 2MBI1000VXB-170E-50 IGBT.

The following Table and Charts describe the Temperature Monitor Output Voltage vs. Thermistor Resistance and Thermistor Temperature.

Thermistor Resistance vs. Temperature PWM Voltage

$R^2 = 1$

Thermistor Resistance (Ω) vs. Temperature PWM Output Voltage with 100Hz Filter (V)
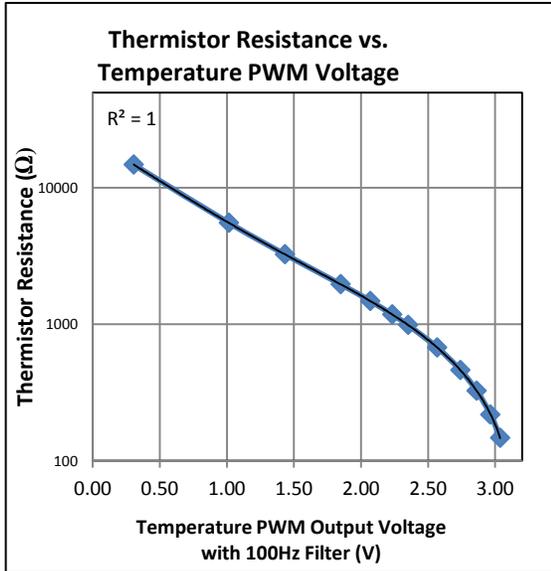
PWM Output Voltage (V)	Thermistor Temp (°C)
3.04	153
2.97	135
2.86	118
2.74	103
2.57	89
2.35	75
2.23	68
2.07	61
1.85	52
1.43	37
1.02	22
0.31	-2

Typical Thermistor Temperature vs. Temperature PWM Voltage for Fuji 2MBI1000VXB-170E-50

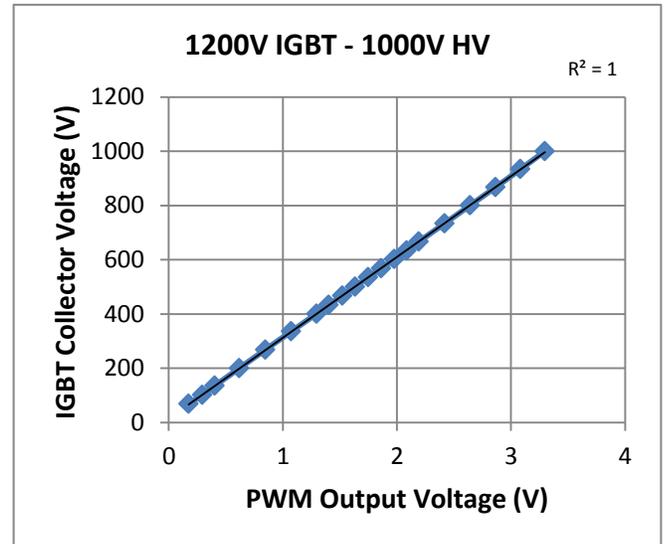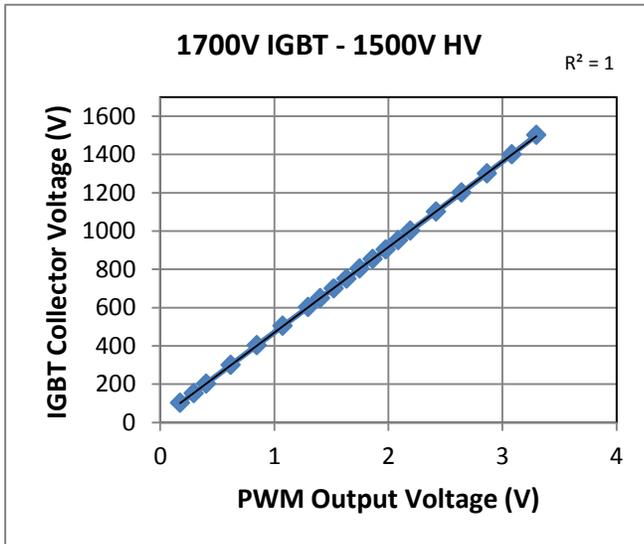Thermistor Temperature (°C) vs. Temperature PWM Output Voltage with 100Hz Filter (V)

Equation for slope above:
$y = -113.4x^5 + 1463.8x^4 - 7699.7x^3 + 21103x^2 - 31882x + 22778$

Data for this graph is in the table to the left.

The following graphs describe the DC Link (HI Side IGBT Collector to LO Side IGBT Emitter) Monitor Output Voltage. The range of the PWM Voltage Monitor is 1% accurate from 150V to 1450V when set for a 1700V IGBT and 1% accurate from 100V to 950V when set for a 1200V IGBT.

1700V IGBT - 1500V HV

$R^2 = 1$

IGBT Collector Voltage (V) vs. PWM Output Voltage (V)

1200V IGBT - 1000V HV

$R^2 = 1$

IGBT Collector Voltage (V) vs. PWM Output Voltage (V)

Generic Sample Factory Settings

1. The dead time is set at 3.0 µs, and in most applications this amount of "off" time between the HI-Side and LO-Side IGBTs switching is sufficient to prevent shoot-through from occurring. It is important to determine this requirement for each specific application. If your application requires a change to dead time, please contact AgileSwitch.

2. The default gate resistors for the driver are 1.5 Ω (R_{gON}) and 2.3 Ω (R_{gOFF}). This is a safe value for all supported IGBTs. For optimum performance, these resistors may be changed from 3.0 Ω up to 10.0 Ω.

3. Desaturation (T_{DSAT}) monitoring is set for 6.1 µs. This can be adjusted from 1 through 9 µs. The voltage level can be configured to any whole number value between 3V and 13V. The default setting is 9V. If the voltage across the IGBT is greater than the set voltage level, a desaturation fault is detected and the IGBT is turned off and a fault signal is output. Please contact AgileSwitch to change the desaturation monitor time and voltage.

4. All faults are reset by the controller by pulling pin 19 low. Pin 19 must be high for normal operation. It is recommended to use a 4.7kΩ pull-up resistor. If the Auto Reset option is selected, pin 19 can be a no connection (NC).

5. The NTC temperature is monitored through an isolated PWM voltage available on pin 20 of the 20 pin driver board connector. It can be connected to an optional two pin connector on request.

6. The IGBT High Side Collector voltage is monitored through an optional, isolated PWM voltage on pin 18 of the 20 pin driver board connector.

7. If Auto Reset is not selected, the Fault Reset signal, pin 19, must go low to clear all fault signals. Since the fault signals are latched, the state of the latches cannot be guaranteed on power up and it is recommended that the Fault Reset signal be pulled low for at least 500 ns at start up after the power supplies have stabilized.

Generic Sample Factory Settings – Fault and Monitoring Conditions

AgileSwitch drivers are designed to provide safe, secure and efficient operation of the IGBT, as well as to provide unparalleled information on the condition of the overall system.

Generic samples are set at the factory to perform certain actions (e.g. turn off the HI side or LO side of the IGBT) and to report that a fault occurred based on IGBT performance parameters that occur outside of default ranges. Certain parameters are configurable. Please contact AgileSwitch for details.

All Faults: Any fault condition activates the All Faults line. Based on this occurrence, the controller can interrogate the HI/LO Fault lines, for the appropriate Fault Condition Code. Gate driver can support internal pull-up resistors to 3.3V for HI, LO and All Faults at customer's request.

Lockout: The generic sample driver is configured to enable a lockout (requiring a reset from the controller). This can be changed to either report the fault without turning off the IGBT or automatically reset after 5 ms.

Fault Condition/Action	Generic Sample Default Trigger Values	Action on IGBT if Active	Output to Controller (if active)	Lockout
UVLO – HI	See Electrical Characteristics	Turn Off HI & LO Side	HI Fault	Yes[1]
UVLO - LO	See Electrical Characteristics	Turn Off HI &LO Side	LO Fault	Yes[1]
Desat - HI	See Electrical Characteristics	Turn Off HI & LO Side	HI Fault	Yes[1]
Desat – LO	See Electrical Characteristics	Turn Off HI & LO Side	LO Fault	Yes[1]
Active Clamping – HI	Optional – values if active: 950V[1] (1200V IGBT) 1350V[1] (1700V IGBT)	Active Clamping Occurs	None	No
Active Clamping – LO	Optional – values if active: 950V[1] (1200V IGBT) 1350V[1] (1700V IGBT)	Active Clamping Occurs	None	No
Cross Latch/Shoot Through	Attempt to turn on both IGBTs simultaneously	Does not allow turn on of inactive IGBT until active is off for 3.0 µs[1] If Both IGBTs are on, turn off HI & LO Side	HI & LO Faults	Yes[1]

1 Configurable parameter

Important Precautions

Caution: Handling devices with high voltages involves risk to life. It is imperative to comply with all respective precautions and safety regulations.

When installing the ribbon cable, please make sure that power is turned off. Multi-signal values are sent along this ribbon cable, thus hot swapping may cause damage to the IC components on the board.

AgileSwitch assumes that the gate drive board has been mounted on the IGBT prior to start-up testing. It is recommended that the user checks that the IGBT modules are operating inside the Specified Operating Area (SOA) as specified by the IGBT manufacturer including short circuit testing under very low load conditions.

Recommended Start-Up Testing

1. Connect the Driver through the 20 pin control header to your drive electronics and supply the driver with +15V.
2. Send the fault reset pin, pin 19, a low signal. Return pin 19 to a high condition. (If Auto Reset is selected, you may ignore this step.)
3. Check the gate voltage:
   a. For the off-state, the nominal gate voltage should be -8V to -10V.
   b. For the on state, it is +14V to +16V.
   c. Check that the supply current of the driver is within spec with inactive trigger signals and then at the desired switching frequency.
4. The system is now ready for application testing under load conditions.
5. Check the Thermal Conditions to verify that the system is operating within specified temperature range.
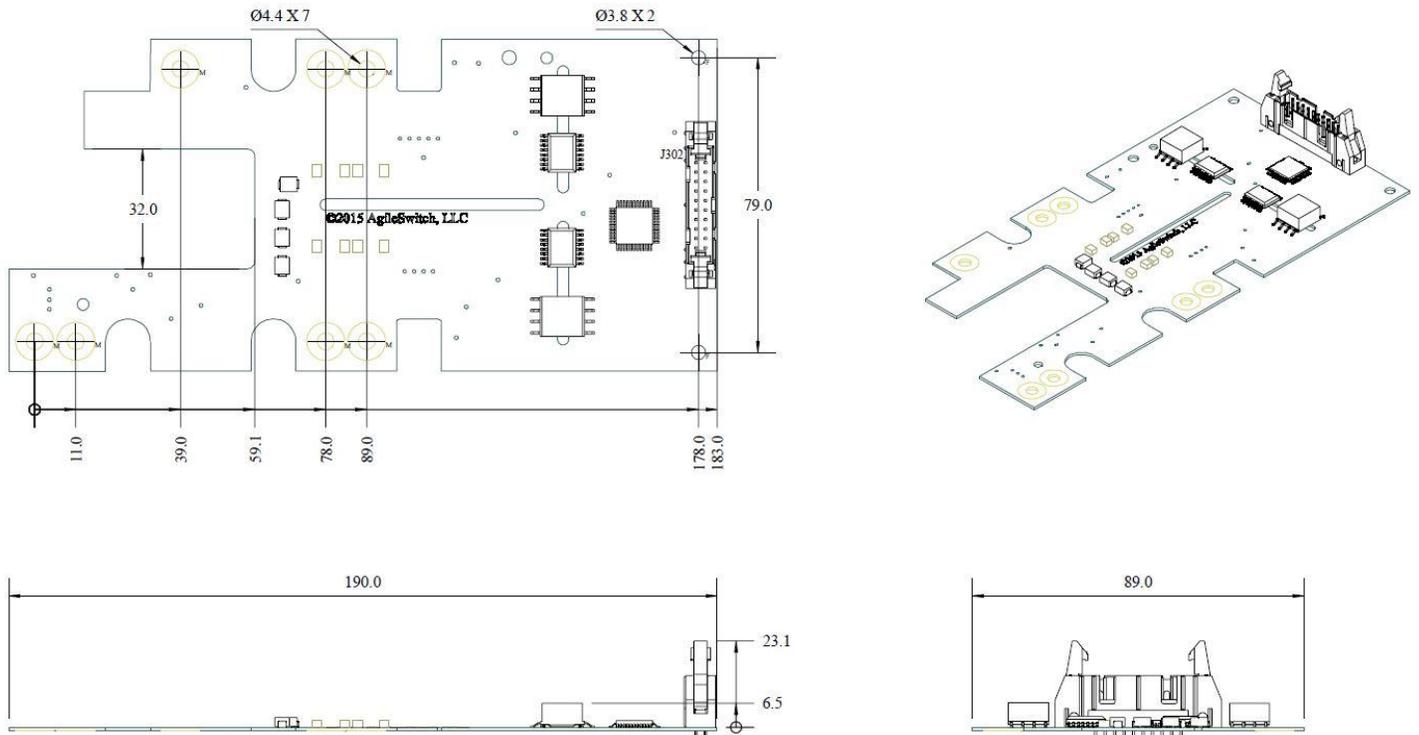
Mechanical Dimensions

Figure 7: Dimensions of the PPEM-PrimePACK Electrical Series IGBT driver (+/- 0.1mm)

Dimensions are in mm.

Download the full drawing and model for additional details. Not all components are shown.
PPEM Drawing
PPEM .STEP Model

Revisions

Prepared By	Approved By	Version	Date	Description
A. Fender	A. Charpentier	12	5/13/2015	PCB Rev 4

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Patent Notices

Offering	Issued U.S. Patent Numbers
AgileStack^{TM} Power Stack	8,984,197

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