1SP0630S2M1R-CM1200HC-66X
SCALE™-2 Family

Main Gate Driver for 3300 V IGBT modules
Fiber-Optic I/O Interface

Product Highlights

Highly Integrated, Compact Footprint

- Ready-to-use gate driver solution for power modules up to 3300 V blocking voltage
- Single channel gate driver
- 30 A peak output gate current
- 1.6 W output power at maximum operating temperature
- Optimized for Mitsubishi's Half-Bridge Power Modules CM-1200HC-66X
- -40 °C to +85 °C operating ambient temperature
- Optical status indicator

Protection / Safety Features

- Undervoltage lock-out (UVLO) for the main gate driver
- Short circuit protection
- Dynamic Advanced Active Clamping (DA^2C)
- Applied double sided conformal coating (by using ELPEGUARD SL 1307 FLZ/2 from Lackwerke Peters)

Applications

- Railway inverter
- Industrial drives
- Other industrial applications

Description

The Plug-and-Play 1SP0630S2M1R-CM1200HC-66Xgate driver is a compact single-channel intelligent gate driver optimized for CM-1200HC-66X.

Power Integrations' Dynamic Advanced Active Clamping allows an extended DC-link voltage range in IGBT off-state for up to 60 s in railway and regenerating applications

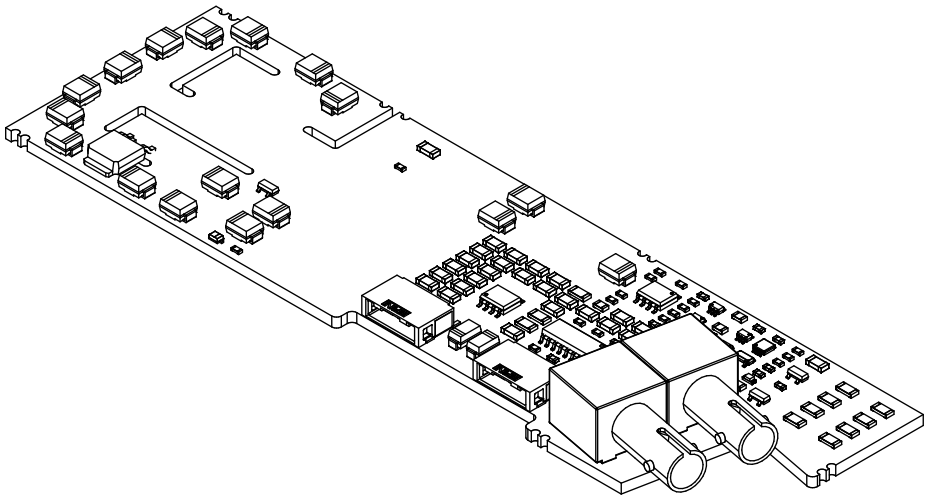

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Figure 1. 3D-Picture.

Pin Functional Description

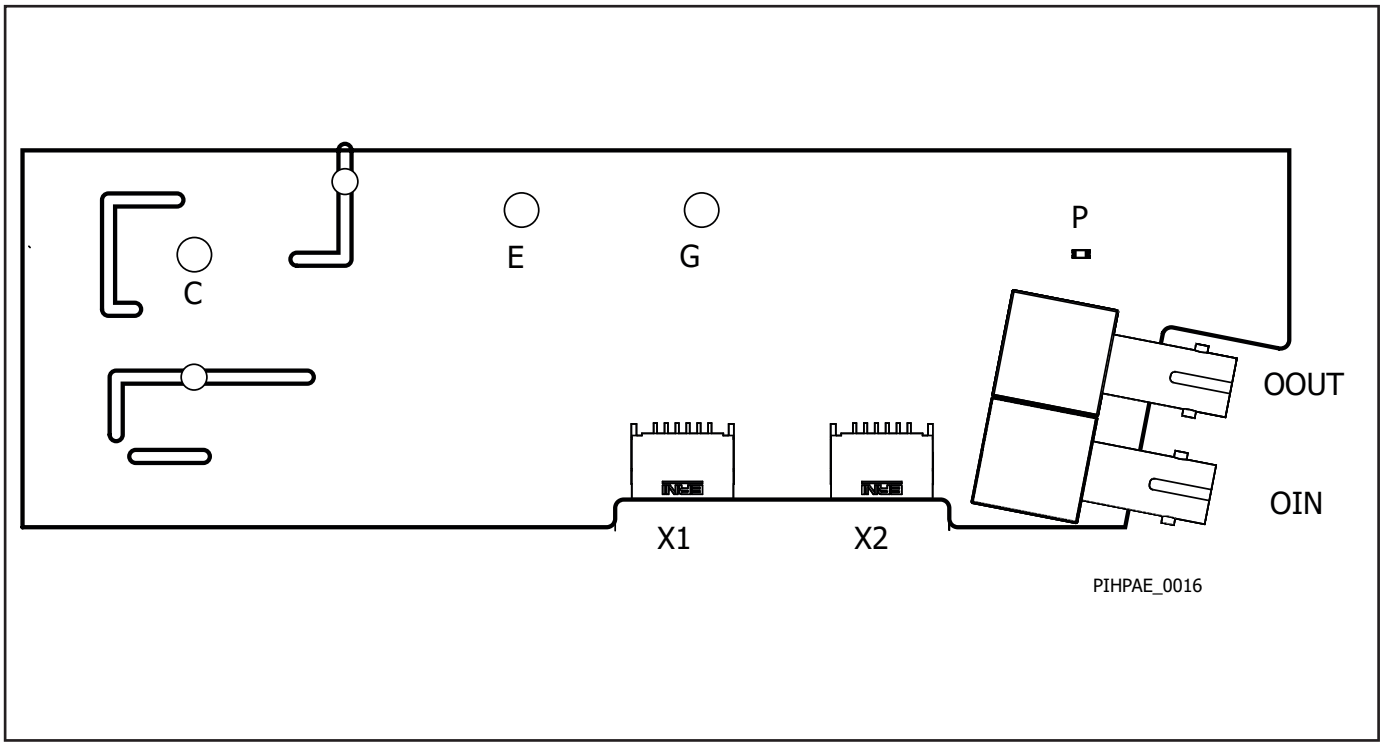

Figure 2. 1SP0630S2M1R-CM1200HC-66X interfaces.

Connection to DC-DC converter or to peripheral driver

Connector X1 and X2

ERNI interface to connect main driver to DC-DC Converter ISO6125R-33 or to peripheral driver.

Part number: Erni 504275, 6 pin, right angle.

VISO (Pin 1)

This pin provides secondary side positive supply voltage.

COM (Pin 2, 4)

This pin provides secondary side negative supply voltage.

Command signal (Pin 3)

This pin is the input for logic command signal.

NC (Pin 5)

This pin is not connected.

Gate Monitoring (Pin 6)

This pin is the output pin for gate monitoring.

Note: X1 and X2 are interchangeable.

Connection to Semiconductor

Terminal G

Gate contact of switch.

Terminal E

Auxiliary emitter contact of switch.

Terminal C

Auxiliary collector contact switch.

Fiber-Optic Interface

Main driver to external controller (fiber optic receivers and transmitters).

OIN (Receiver)

This fiber optic receiver is the command input.

Part number: Broadcom HFBR-2412Z

OOUT (Transmitter)

This fiber optic transmitter is the status output.

Part number: Broadcom HFBR-1412Z

Optical Indicator

P

Green optical for monitoring the status output. During fault state the indicator is turned off.

Functional Description

The basic topology of the 1SP0630S2M1R driver is shown in Figure 3. This main driver can be used as a standalone driver without a peripheral driver or with up to two peripheral drivers. One peripheral can be connected directly to the main driver. The X1 and X2 interfaces are fully identical.

The driver is equipped with the following features:

- Power supply monitoring
- Fiber-optic interface (drive input and fault feedback)
- Dynamic V_{CE} monitoring (short-circuit protection)
- Dynamic Advanced Active Clamping DA²C (overvoltage protection at turn-off)
- Gate monitoring

The power supply (isolated DC-DC converter ISO6125R-33) has not been integrated in the driver. It is a separate unit. All the components required for the optimal and safe driving of the relevant IGBT are included on the drive. Its plug-and-play capability means that it is ready to operate immediately after mounting. The user does not need to invest any effort in designing or adjusting the driver to a specific application.

Description of X1 and X2

The connector X1/X2 is used to connect main driver to DC-DC converter ISO6125R-33. In case of parallel operation with a peripheral driver one of these connectors is used to connect the main to peripheral driver. X1 and X2 are interchangeable.

The following signals are available on the interface X1 or X2:

- Supply voltage from the main to the peripheral
- Drive signal from the main to the peripheral. The drivers are configured so that all paralleled IGBT modules switch on and off synchronously.
- Gate-monitoring signal from the peripherals to the main.

It requires a set of cables to establish the electrical connection between the main driver and the first peripheral as well as between paralleled peripheral drivers. Note that there is no galvanic isolation for the power supply is implemented on the driver. Therefore, it is recommended to use an external DC-DC converter ISO6125R-33 for the power supply.

Connection cables for X1 and X2

For recommended cables, please read the datasheet RLC-IMS-61-050-0 and RLC-PSI-41-050-0.

It is important to note that the paralleling cables as well as the supply cables carry high potential. The user is fully responsible to apply sufficient isolation to the delivered cables.

Power Supplies and electrical isolation

The power supply and electrical isolation is provided by the external DC-DC converter. The DC-DC converter needs a stabilized +15V supply voltage.

Fiber Optic Receiver OIN

The input signal IN is received by a "ST fiber optic Link" receiver directly connected to the gate drive unit. OIN has a positive logic (here, light on implies turn-on) and is edge triggered. The gate driver signal is transferred from the OIN receiver to the gate with a propagation delay of $t_{P(LH)}$ for the turn-on and $t_{P(HL)}$ for the turn-off commands.

Fiber Optic Transmitter OOUT

During normal operation (i.e. the driver is supplied with power at nominal voltage, and there is no fault anywhere), the status feedback is given by a "light on" at the optical link. A malfunction is signaled by a "light off".

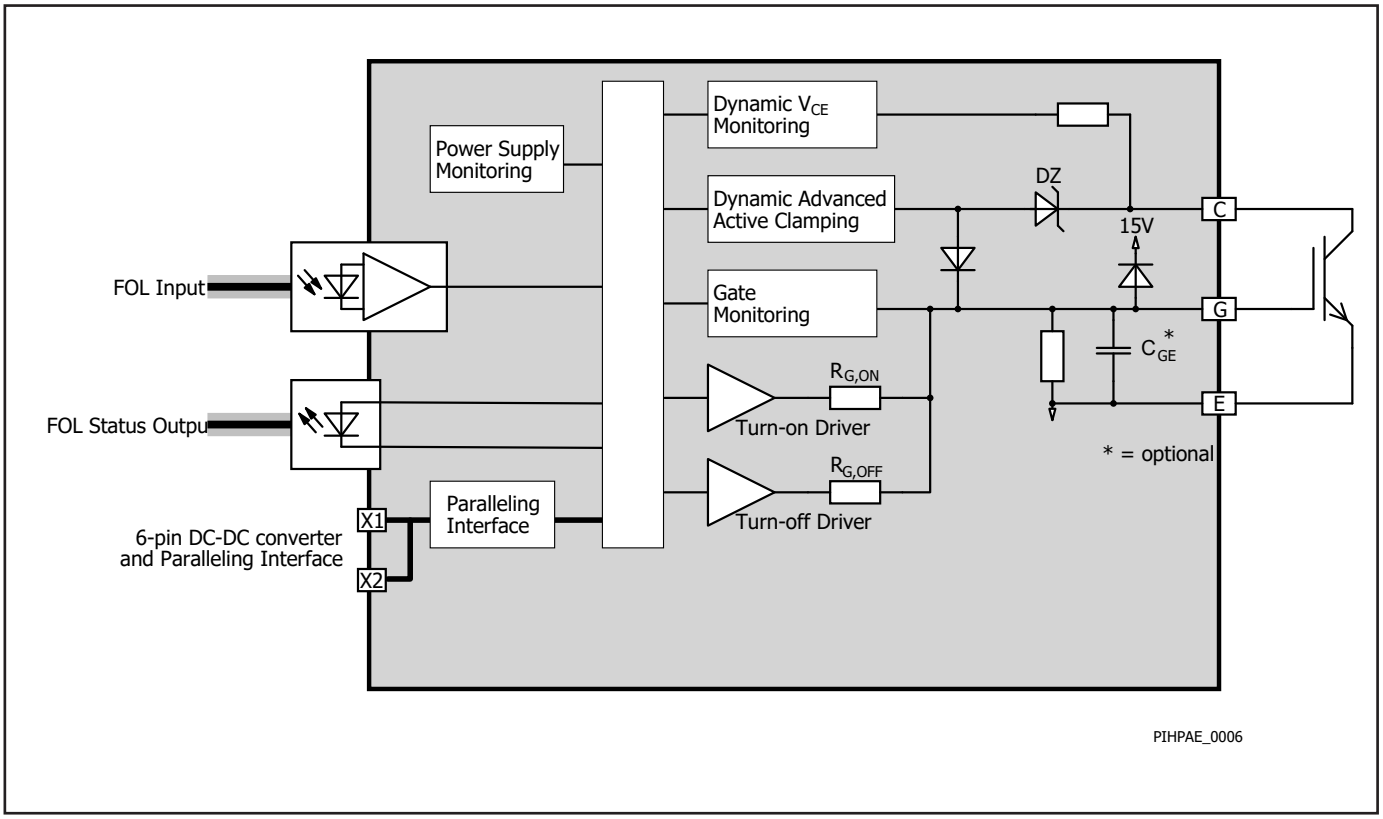

Figure 3. Functional Block Diagram.

Each edge of the control signal is acknowledged by the driver with a short pulse (the light is off for a period of t_{ACK}). This pulse can be observed by the host controller and it allows simple and continuous monitoring of all drivers and fiber-optic links of the system. Figure 5 shows the control and response signals of a gate driver in normal operation.

Short-Circuit detection

Figure 6 shows the response of the driver in the event of a short-circuit fault. The fault status is transferred to the status feedback terminal after the response time t_{res}. The light is then driven "off" during the delay to clear the fault state $t_{Fault,SC}$. The IGBT can be turned on again by applying a positive edge to the corresponding fiber-optic input after the fault status has disappeared.

Under Voltage detection

In case of under voltage fault on the main driver, the fault status remains active and the driver is locked as long as this under voltage remains.

Note: During power up, the status feedback will also show a fault condition until the supply under voltage disappears.

Gate monitoring fault

In the event of a gate monitoring fault, the fault status is transferred to the status feedback terminal after the filter delay $t_{d,Filter}$ (refer to the timing information) and remains active as long as the gate-monitoring fault is present.

If the driver goes from the "off state" to the "on state", and the gate-emitter voltage of one or more parallel connected drivers does not turn on, the driver response (V_{GE2} does not switch) is shown in Figure 7. The fault status is transferred to the status feedback terminal after the $t_{d,Filter}$. The driver shuts the IGBT off $t_{p(HL)}$ after $t_{d,Filter}$, and thus clears the fault condition.

Dynamic Advanced Active Clamping (DA²C)

Active clamping is a technique designed to partially turn on the IGBT in case the collector-emitter voltage exceeds a predefined threshold. The IGBT is then kept in linear operation. Basic active clamping topologies implement a single feedback path from the IGBT's collector through transient voltage suppressor (TVS) diodes to the IGBT gate. The gate driver contains Power Integrations' Dynamic Advanced Active Clamping (DA²C) based on this principle:

When active clamping is activated, the turn-off MOSFET of the gate driver is switched off in order to improve the effectiveness of the active clamping and to reduce the losses in the TVS diodes. This feature is called as Advanced Active Clamping.

Additional TVS diodes have been added in series to the TVS diodes required to withstand the maximum DC-link voltage under switching operation. These TVS diodes are short-circuited during the IGBT on state as well as for about 15…20µs after the turn-off command to guarantee efficient active clamping. After this delay, these additional TVS diodes are activated and allow the DC-link voltage to be increased to a higher value during the IGBT off-state. This feature – together with Advanced Active Clamping – is called Dynamic Advanced Active Clamping (DA²C). Note that the time during which the voltage can be applied above the value for switching operation should be limited to short periods (<60s).

Optical Indicators for Main and Peripheral

To facilitate verification, the driver is equipped with a green status LED. The LED light up under normal operation. A turned-off LED means that the respective driver is not supplied with voltage, the supply voltage is too low or that the gate monitoring function has detected a fault. on. Moreover, in case of IGBT short-circuit, the LED on the main driver is switched off during the delay to clear the fault state (refer to timing information).

Dynamic behavior of IGBT

The dynamic behavior of IGBT modules depends on their type and

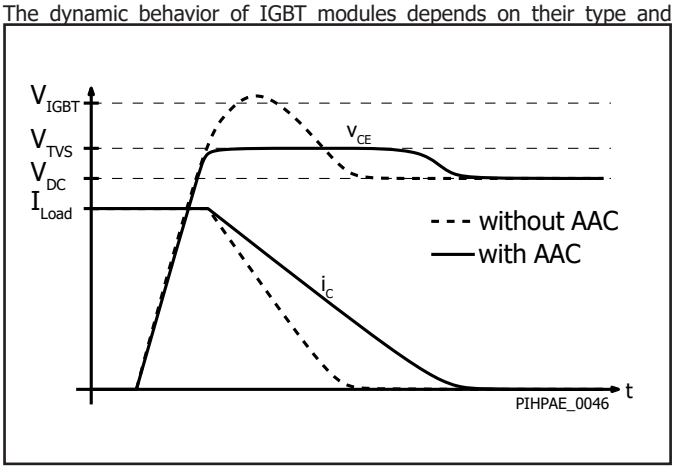

Figure 4. Dynamic Advanced Active Clamping.

manufacturer due to the specific behavior of the included IGBT and diode chips, the particular module construction and the distribution of the internal gate resistances and inductances. Note that different module types from the same manufacturer may also require a specific gate-driver adaptation.

Power Integrations therefore supplies specific versions of SCALE-2 plug-and-play drivers adapted to the particular IGBT module. These drivers must not be used with IGBT modules other than those for which they were specified.

Turn-on of the IGBT / commutation of diode current

When a driver input goes high (light on), the gate driver turns on the corresponding IGBT. The driver already includes the gate resistors, which are matched to the relevant IGBT module.

The driver is optimized to achieve minimum switching losses for the case of relatively low inductances within the power stack. It is recommended to check the commutation behavior within the final system assembly.

Turn-off of the IGBT

The IGBT is turned off when the corresponding input turns low (light off). The gate resistors are determined by Power Integrations and must not be altered.

Fast turn-off of the IGBT may cause over voltage, which increases with DC-link voltage or load current. The turn-off over voltage can be approximated by:

$$V_{tr} = L_S \times di_C/dt$$

where V_{tr} is the turn-off overvoltage, i_C the collector current and L_S the stray inductance.

Overvoltage limitation at turn-off is essential for high-power or high-voltage IGBTs. To solve this problem, SCALE-2 plug-and-play drivers provide a Dynamic Advanced Active Clamping function DA²C.

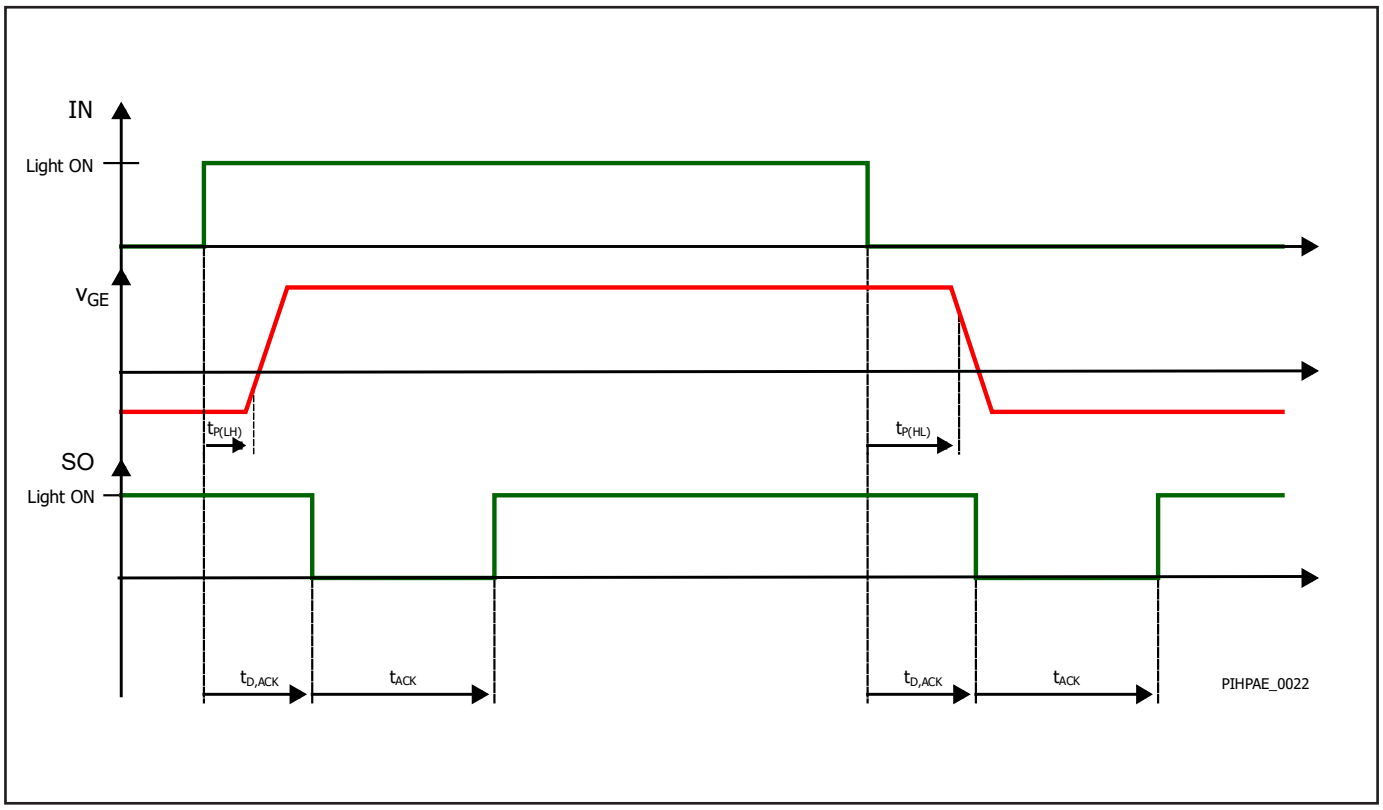

Figure 5. Fiber Optic Feedback of the driver in normal operation mode.

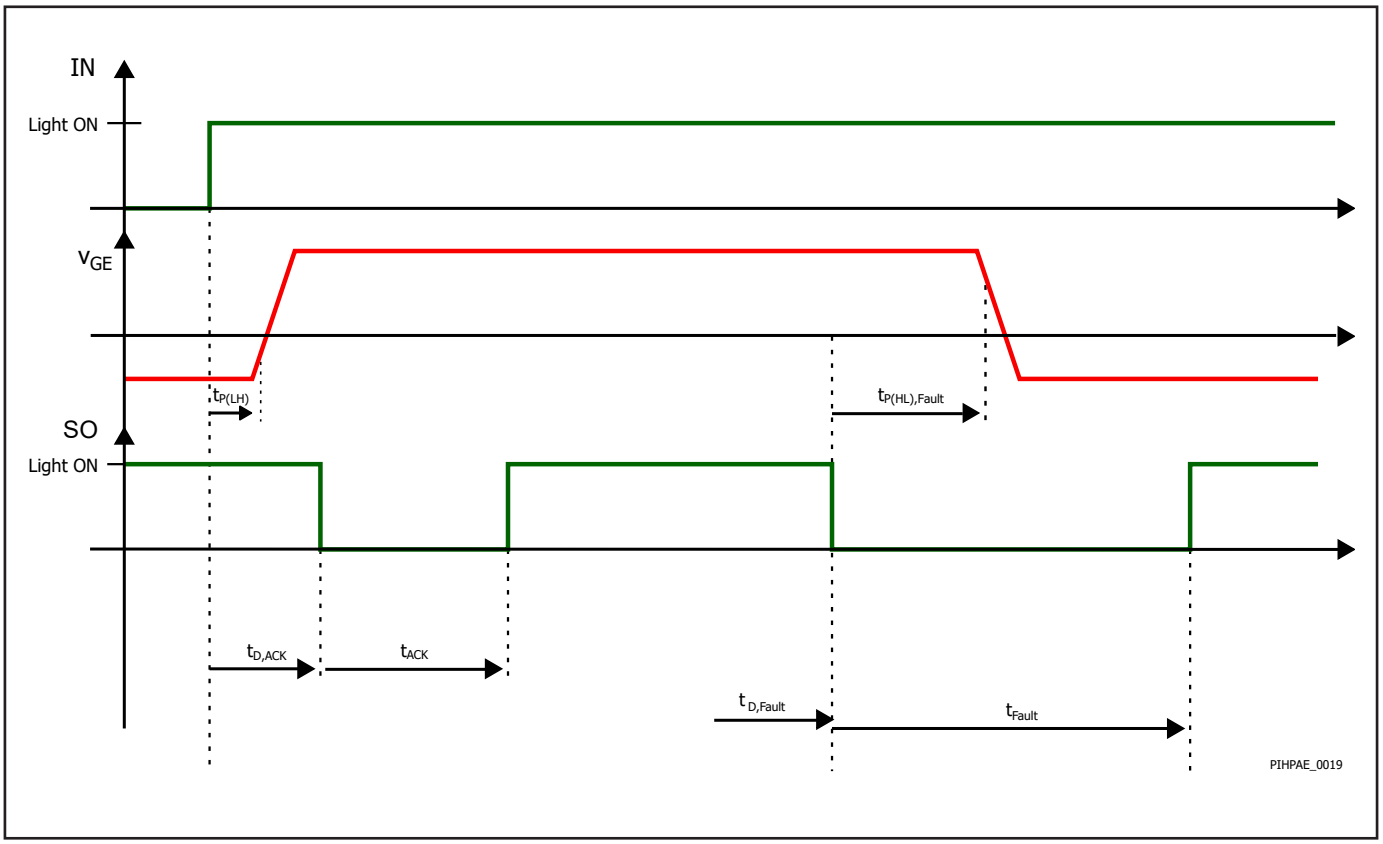

Figure 6. Fiber Optic Feedback of the driver in fault operation mode.

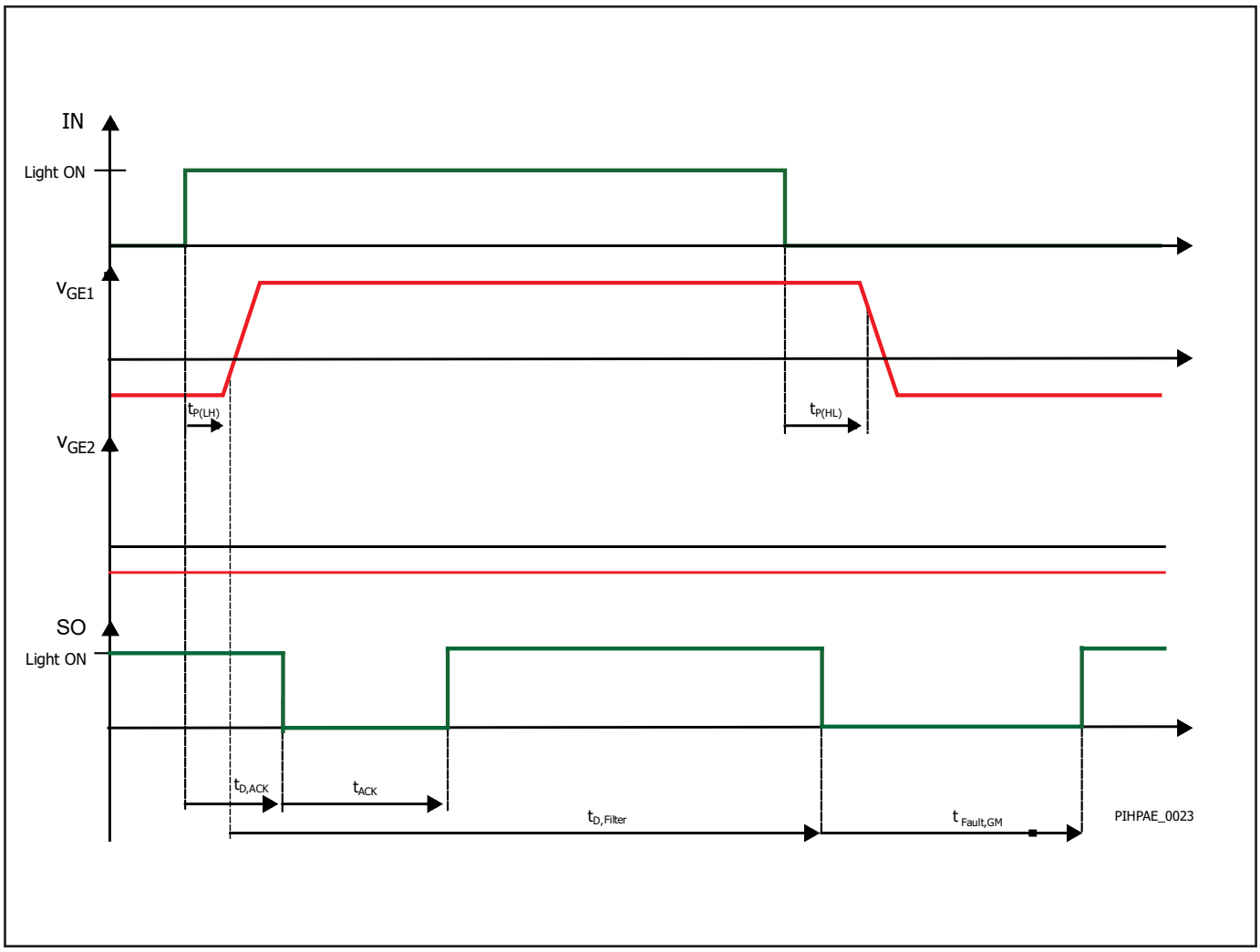

Figure 7. Fiber Optic Feedback of the driver in gate monitoring fault operation mode

Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min	Max	Units
Absolute Maximum Ratings[1]					
Supply voltage	V_{DC}	VDC to GND		30	V
Average supply current	I_{DC}	Main driver only		160	mA
Switching frequency[2]	f_{SW}	T_a < = 70 °C		10	kHz
Gate output power	P_G	T_a < = 85 °C		1.6	W
		T_a < = 70 °C		2.2	
Gate peak output current	I_G	Limited by the gate resistors		30	A
DC-link voltage	$V_{DC\text{-}Link}$	Switching operation[3]		2200	V_{DC}
		Off State[4]		2700	
Operating voltage	V_{CE}			3300	V_{peak}
Common-mode transient immunity	|dv/dt|	Between parallel connected drivers		50	kV/µs
Interface current (main driver to peripheral driver)[5]	$I_{Interface}$	RMS value		4	A_{RMS}
		Peak value		20	A_{Peak}
Storage temperature[6]	T_{st}		-40	50	°C
Operating ambient temperature	T_A		-40	85	°C
Component surface temperature[7]	T			125	°C
Relative humidity	H_r	No condensation		93	%
Altitude of operation[8]	A_{op}			2000	m

Recommended Operating Condition

Parameter	Symbol	Conditions T_A = -40 °C to 85 °C	Min	Typ	Max	Units
Power Supply						
Supply voltage	$V_{VISO-COM}$	VISO-COM to GND	23.5	25	26.5	V

Characteristics

Parameter	Symbol	Conditions T_A = +25 °C, $V_{VISO-COM}$ = 25 V		Min	Typ	Max	Units
Power Supply							
Supply current	I_{VISO}	Main driver only, without load			44		mA
		1.6 W, fsw=1.63 kHz, 50% duty cycle			118		
Power supply monitoring threshold (secondary side)	$UVLO_{VISO}$	Referenced to respective terminal E1 or E2	Clear fault (resume operation)	11.6	12.6	13.6	V
			Set fault (suspend operation)	11.0	12.0	13.0	
			Hysteresis	0.35			
	$UVLO_{COM}$		Clear fault (resume operation)		-5.15		V
			Set fault (suspend operation)		-4.85		
			Hysteresis		0.3		
Timing Characteristics							
Turn-on delay	$t_{p(LH)}$	IN-Light ON to 10% of $V_{GE(on)}$, no load attached, 1m FO cable to external control			180		ns
Turn-off delay	$t_{p(HL)}$	IN-Light OFF to 90% of $V_{GE(off)}$, no load attached, 1m FO cable to external control			180		ns
Duration acknowledge pulse	t_{ACK}	Length of Acknowledge SO-Light OFF		400	700	1050	ns
Delay of acknowledgment pulse	$t_{D,ACK}$	IN-Light ON/OFF to SO-Light OFF, 1m FO cable to external control			250		ns
Propagation delay of fault state condition	$t_{D,Fault}$	IN-Light ON/OFF to SO-Light OFF			100		ns
Gate monitoring[9]							
Turn-on threshold	$V_{GE,on,min}$	G_{mean} to E, set fault			12.9		V
Turn-off threshold	$V_{GE,off,min}$	G_{mean} to E, set fault			-7.6		V
Duration of fault state gate monitoring condition	$t_{Fault,GM}$	Length of fault pulse			1		µs
Filter delay	$t_{D,Filter}$	Turn-on			32		µs
		Turn-off			32		

Parameter	Symbol	Conditions T_A = +25 °C		Min	Typ	Max	Units
Short-circuit protection							
Static V_{CE}-monitoring threshold	$V_{CE(stat)}$				170		V
Response time	t_{res}	10% to 90% of V_{GE}	DC-link voltage = 2200 V		5.8		µs
			DC-link voltage = 1500 V		5.8		
			DC-link voltage = 1100 V		5.9		
			DC-link voltage = 800 V		7.7		
Delay to power semi-conductor turn-off after short-circuit detection	$t_{pd,SO}$				0.3		µs
Duration of fault state short circuit condition	$t_{Fault,SC}$	Length of fault pulse Under UVLO condition the fault signal is present as long under voltage is present			9		µs
Mounting							
Mounting torque	M_{Main}	Screw M4 As per IGBT datasheet		1		2	Nm
Bending	I_{bend}	According to IPC				0.75	%
Gate Output							
Turn-on gate resistor	$R_{G(on)}$	The gate resistors are determined to optimally match the power device characteristics			2.25		Ω
Turn-off gate resistor	$R_{G(off)}$				18.75		Ω
Auxiliary gate capacitor	C_{GE}				N.A.		nF

NOTES:

1. Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device.
2. Actually achievable maximum switching frequency has to be validated in final system as it is limited by maximum gate output power in conjunction with maximum allowed surface temperature
3. This limit is due to active clamping in the gate driver.
4. Due to the Dynamic Active Advanced Clamping Function (DA2C) implemented on the driver, the DC link voltage can be increased in the off state condition (e.g. after emergency shutdown). This value is only valid when the IGBTs are in the off state (not switching). The time during which the voltage can be applied should be limited to short periods (< 60 seconds).
5. Dynamic voltages between auxiliary emitters of parallel connected drivers at turn on and turn off lead to unequal currents over the interface. The peak and RMS values of the resulting current must be limited to the given value.
6. The storage temperature inside the original package or in case the coating material of coated products may touch external parts must be limited to the given value. Otherwise, it is limited to 85°C
7. The component surface temperature, which may strongly vary depending on the operating condition, must be limited to the given value for coated driver versions to ensure long-term reliability of the coating material.
8. Operation above this level requires a voltage derating to ensure proper isolation coordination.
9. The mean value $V_{GE,mean}$ of all gate voltages (main and all peripheral) is filtered and compared to the given values at turn-on and turn-off. If the specified values are exceeded ($V_{GE,mean}<V_{GE,on,min}$ at turn-on resp. $V_{GE,mean}>V_{GE,off,max}$ at turn-off) after the given filter delay, the driver turns off all parallel-connected IGBTs and a fault is transmitted to the status output

Product Dimensions

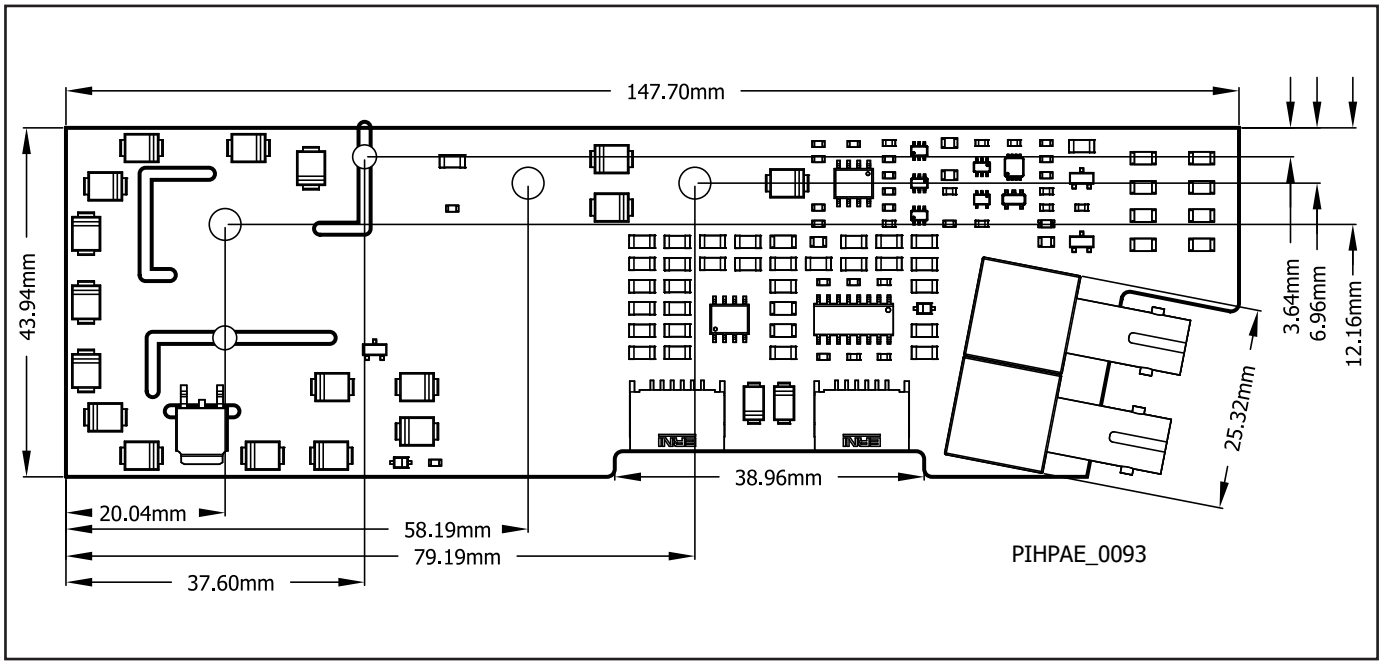

Figure 8. Top View.

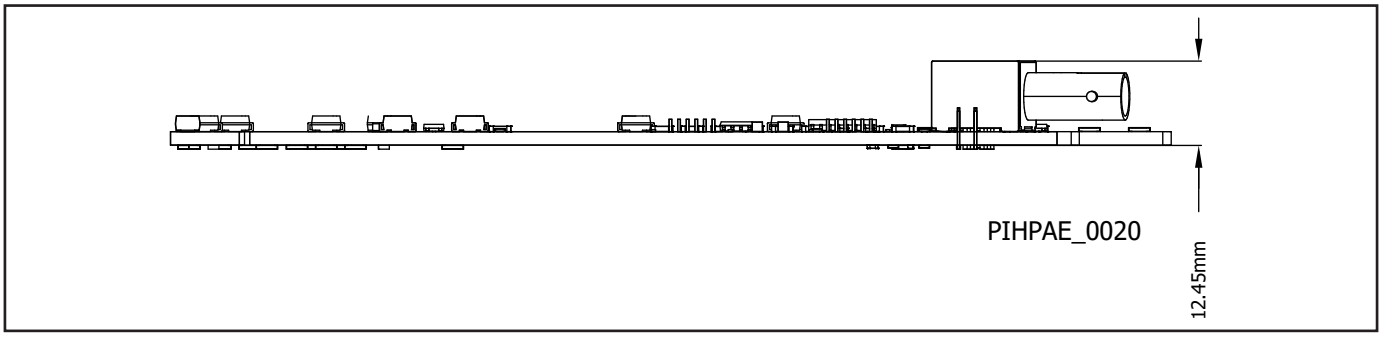

Figure 9. Side View.

Transportation and Storage Conditions

For transportation and storage conditions refer to Power Integrations' Application Note AN-1501.

RoHS Statement

We hereby confirm that the product supplied does not contain any of the restricted substances according Article 4 of the RoHS Directive 2011/65/EU in excess of the maximum concentration values tolerated by weight in any of their homogeneous materials.

Additionally, the product complies with RoHS Directive 2015/863/EU (known as RoHS 3) from 31 March 2015, which amends Annex II of Directive 2011/65/EU.

Notes

Revision	Notes	Date
A	Final Datasheet	05/21

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