2SP0230T2x0
SCALE-2 Family

Gate Driver for Driving 62mm SiC-MOSFET and Si-IGBT modules up to 1700 V via Electrical Interface

Product Highlights

Highly Integrated, Compact Footprint

- Ready-to-use gate driver solution for 62 mm half-bridge SiC and IGBT power modules
- Dual channel gate driver
- Electrical interface
- The clearance and creepage distances are defined according to IEC60077-1 providing reinforced insulation up to 1700 V blocking voltage in 2-level applications and basic insulation for 3-level applications using modules up to 1200 V blocking voltage
- ±30 A peak output gate current
- 1.3 W output power per channel at maximum ambient temperature
- -40 °C to 85 °C operating ambient temperature

Protection / Safety Features

- Short-circuit protection
- Advanced Active Clamping (AAC)
- Undervoltage lock-out (UVLO) protection
- RoHS compliant

Applications

- Renewables
- EV charger
- Light rail and railway auxiliary converters
- Other industrial applications

Description

The Plug-and-Play 2SP0230T2x0 gate driver family is a compact double-channel gate driver designed for the operation of 62 mm half-bridge SiC and IGBT power modules up to 1700 V.

The drivers feature electrical interface with built-in DC/DC power supplies.

Power Integrations' Advanced Active Clamping allows to turn-off safely within an extended DC-link voltage range.

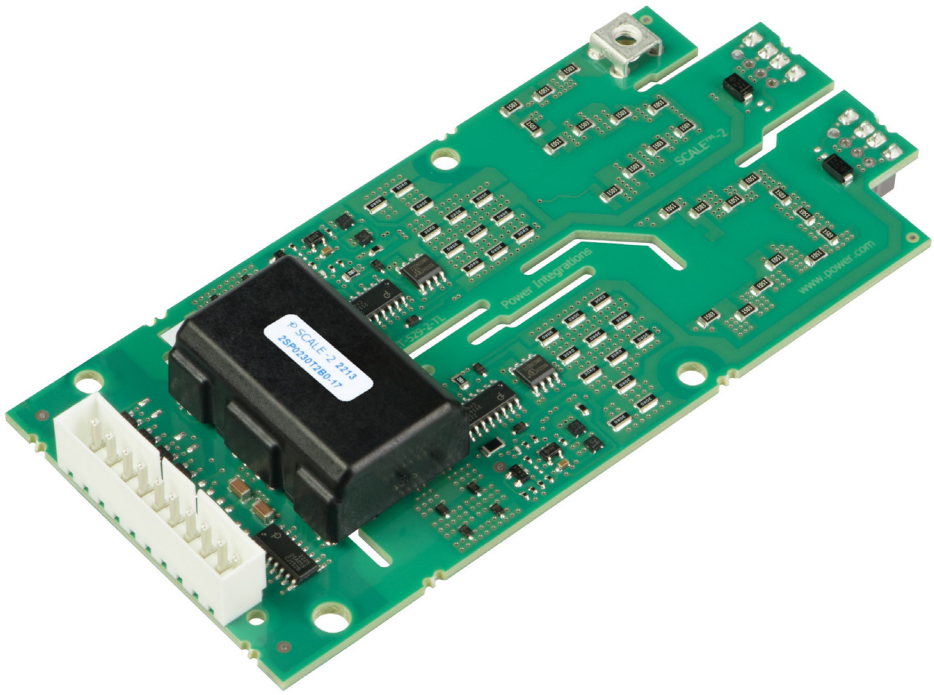

Figure 1. Board Photo of 2SP0230T2x0.

Pin Functional Description

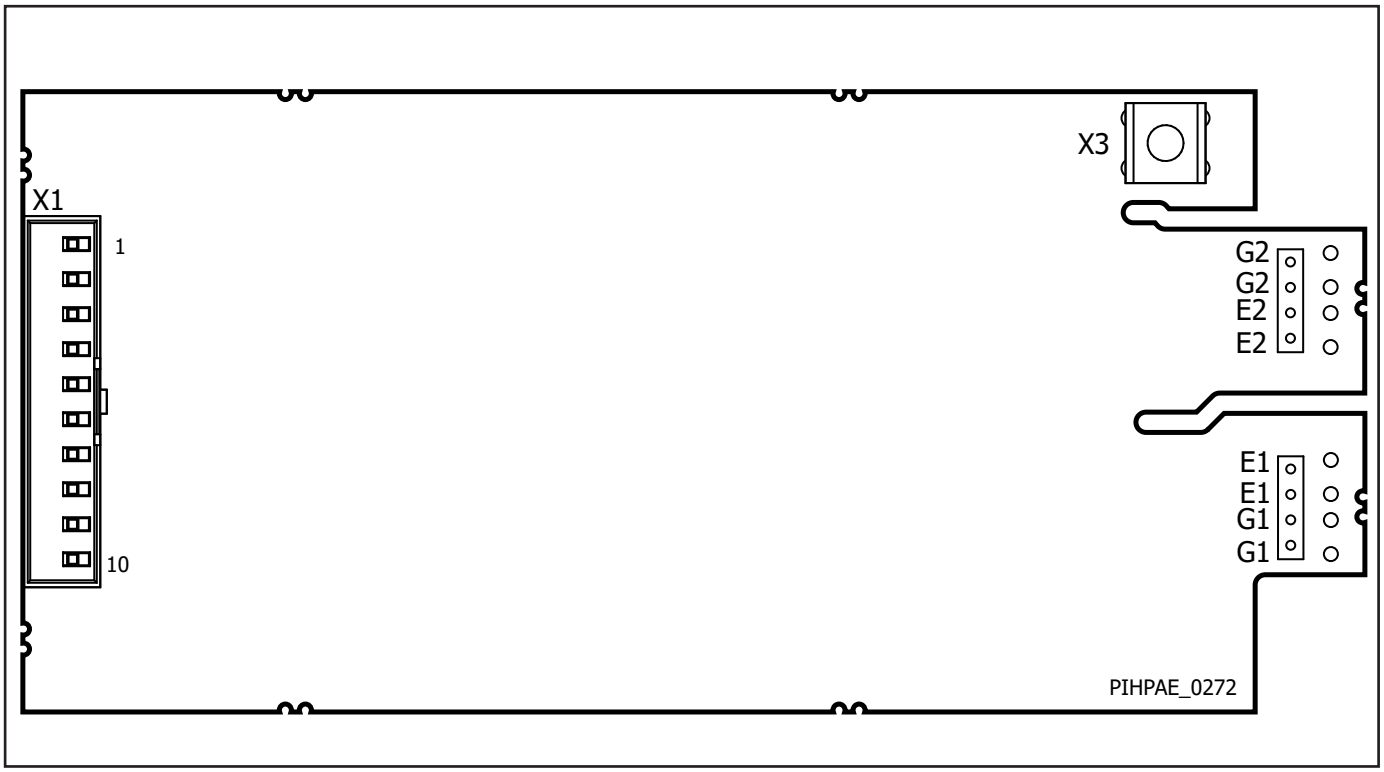

Figure 2. Pin Configuration.

Connector X1

To external power supply and signal interface (53258-1029 from Molex)

VCC (Pin 4)
This pin is the primary-side 15 V supply voltage connection for the primary-side electronic and the integrated DC/DC converter.

IN1 (Pin 6)
This pin is the command input for channel 1 (low-side switch).

SO1 (Pin 8)
This pin is the status output for channel 1 (low-side switch).

IN2 (Pin 1)
This pin is the command input for channel 2 (high-side switch).

SO2 (Pin 3)
This pin is the status output for channel 2 (high-side switch).

NC (Pins 9, 10)
These pins are electrically not connected.

GND (Pins 2, 5, 7)
These pins are the connection for the primary-side ground potential. All primary-side signals refer to these pins.

Connection To Semiconductor

Connector X3
This terminal (M4 screw terminal) is the connection to the collector of the high-side channel.

G1
Female FASTON Keystone 3557; Connection to the gate of the low-side channel. Parallel holes to the FASTON connection are available for optional connection of flexible PCB.

E1*
Female FASTON Keystone 3557; Connection to the emitter of the low-side channel. Parallel holes to the FASTON connection are available for optional connection of flexible PCB.

G2
Female FASTON Keystone 3557; Connection to the gate of the high-side channel. Parallel holes to the FASTON connection are available for optional connection of flexible PCB.

E2*
Female FASTON Keystone 3557; Connection to the emitter of the high-side channel. Parallel holes to the FASTON connection are available for optional connection of flexible PCB.

NOTE:
* 'Emitter' and 'Collector' are used to refer to both emitter/source and collector/drain in this datasheet.

Functional Description

The 2SP0230T2x0 is a dual channel Plug-and-Play gate driver family for 62 mm SiC and IGBT power modules. It provides reinforced isolation for all primary-side signals in 2-level 1700 V application and basic insulation for 3-level 1200 V applications. Figure 3 shows the functional diagram of 2SP0230T2x0. This driver family has different variants with different voltage levels. The 2SP0230T2A0 is a -5 V regulated negative-rail driver, designed for SiC-MOSFET modules and it provides a non-regulated positive rail of ~15 V. The 2SP0230T2C0 is a 15 V regulated positive-rail driver, designed for Si-IGBT modules and it provides a non-regulated negative rail of ~ -10 V. As a plug-and-play gate driver, the 2SP0230T2x0 characteristics matches the requirements of the individual power module. The operation of channel 1 (low-side switch) and channel 2 (high-side switch) of the gate driver is independent of each other.

Power Supplies

The 2SP0230T2x0 provides a power supply input. Here a typical supply voltage level of 15 V is required. The input VCC supplies the primary-side electronic of the gate driver and the integrated DC/DC converter which generates the isolated voltage for the secondary-side gate driver channels. The positive rail of the gate driver channels has the voltage level V_{ISO} and the negative rail the voltage level V_{COM}. Both are referenced to the emitter potential at terminal E1 or E2 of the driven power semiconductor.

Under Voltage Monitoring

The supply voltages are closely monitored. In case of an under voltage condition (UVLO), a failure signal will be provided on the status output of the gate driver. If the UVLO is present on the primary-side supply V_{VCC}, both status output signals will be set to GND and all gate driver channels will be turned-off synchronously. In case of an UVLO on the secondary-side, the status signal of the respective channel will be set to GND and the corresponding power semiconductor will be turned off.

Signal Inputs (Primary-Side X1)

The input logic of IN1 and IN2 is designed to work with 15 V logic levels to provide a sufficient signal/noise ratio. Both inputs have positive logic and are edge-triggered.

Gate driver signals are transferred from the IN1 and IN2 pins to the corresponding gate with a propagation delay of $t_{P(LH)}$ for the turn-on and $t_{P(HL)}$ for the turn-off commands.

Status Outputs (Primary-Side X1)

The gate driver provides status feedback signals SO1 and SO2. The status feedback signal stays at V_{VCC} under no-fault conditions. In case of a fault, e.g. detected short-circuit of the driven power module or an under voltage lock-out (UVLO) condition on the secondary-side, the status feedback is set to GND potential for a duration of t_{BLK}. In case of a primary-side UVLO condition, both status feedback signals remain at GND during the UVLO and are extended by t_{BLK}. During this time no gate signals will be transmitted to the respective gate driver channel.

FASTON Connection

The gate driver is mounted on top of the power module and connected directly to the gate and emitter connectors of the power module through FASTON Keystone 3557 female connection. The driver has parallel holes to the FASTON to enable optional connection of external flexible PCB if it is needed.

Gate Voltage

The 2SP0230T2x0 provides an emitter controller which is able to generate the switching voltage levels $V_{GE,ON}$ and $V_{GE,OFF}$ which match the requirements of the SiC-MOSFET and the IGBT modules. The emitter controller is regulating the negative (turn-off) or the positive (turn-on) rail of the gate voltage depending on the driving requirements (typically the positive rail is regulated for IGBTs and the negative rail is regulated for SiC MOSFETs). Internal current sources are regulating actively the negative/positive gate-emitter voltage independently of actual load conditions within the maximum specified ratings.

The off-state gate-emitter voltage of the power semiconductor equals in steady state the negative supply voltage V_{COM}. The on-state gate-emitter voltage $V_{GE,ON}$ equals in steady state the voltage V_{ISO}. The non-regulated rail is load dependent. It has its highest absolute value under no load condition and is decreasing in absolute value with increasing load.

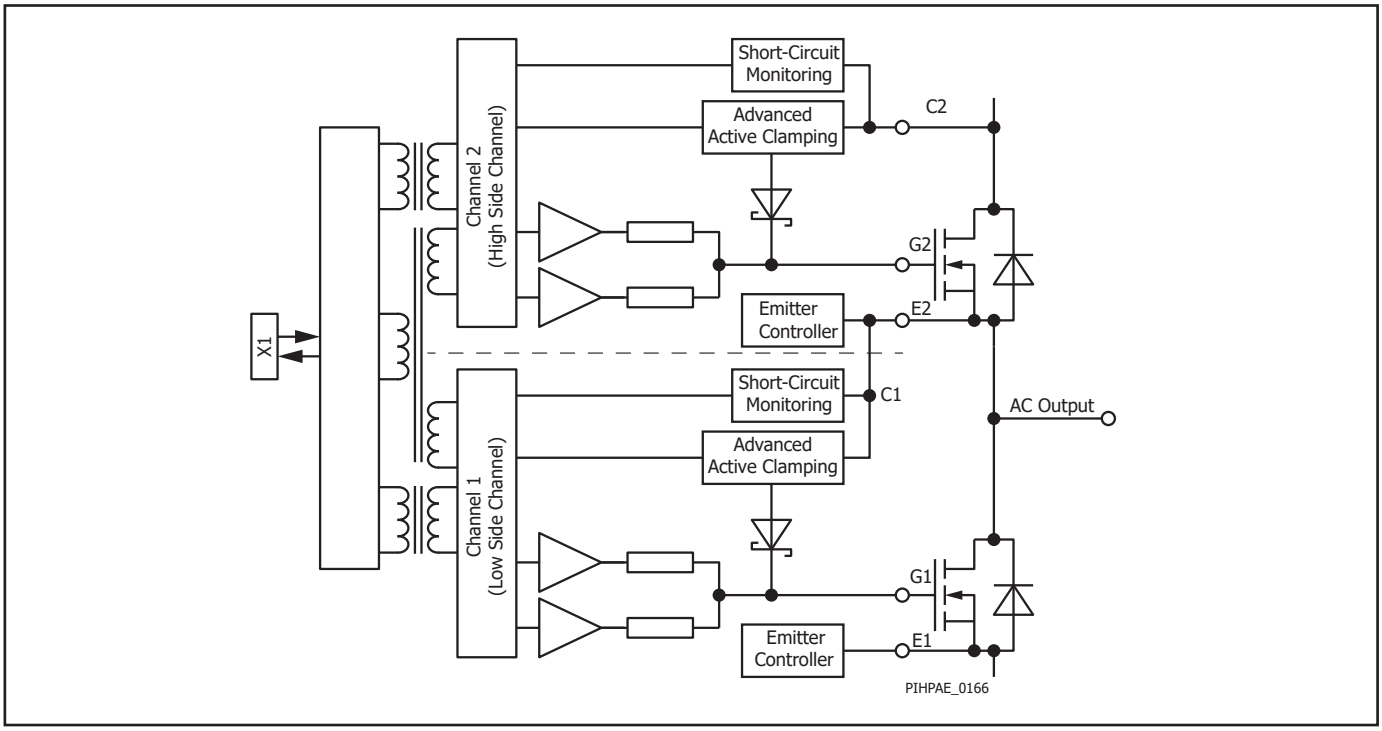

Figure 3. Functional Block Diagram of 2SP0230T2x0.

Short-Circuit Protection

The 2SP0230T2x0 gate driver uses the semiconductor's desaturation effect to detect short-circuits.

The desaturation is monitored by using a resistor sensing network. The collector-emitter voltage is checked after the response time t_{RES} at turn-on to detect a short circuit. If the voltage is higher than the programmed threshold voltage $V_{CE(SAT)}$, the driver detects a short-circuit condition. The monitored power semiconductor is switched off immediately and a fault signal is transmitted to the status output after a delay t_{SOx}.

The fault feedback is automatically reset after the blocking time t_{BLK}. The semiconductor is turned on again as soon as the next on-signal is applied to the respective inputs after the fault status has disappeared. It should be noted that the response time t_{RES} is dependent on the DC-link voltage. It remains constant over a wide range of high DC-link voltage and increases at lower DC-link voltages. An example waveform is shown in Figure 4.

Gate Clamping

In the event of a short-circuit condition the gate voltage is increased due to the high dv_{CE}/dt between the collector and emitter terminals of the driven power semiconductor. This dv_{CE}/dt is driving a current through the Miller-capacitance (capacitance between the gate and collector) and charges the gate capacitance, which eventually leads to a gate-emitter voltage larger than the nominal gate-emitter turn-on voltage. In consequence, the short-circuit current is increased due to the transconductance of the power semiconductor.

To ensure that the gate-emitter voltage stays close to the nominal turn-on voltage the gate driver features a gate-clamping circuitry. The gate clamping provides a voltage similar to V_{VISO} to the gate. As the effective short-circuit current is a function of the gate-emitter voltage the short-circuit current is limited. This is shown in Figure 4 where the gate-emitter voltage and in consequence the short-circuit current is kept at a flat plateau. As a result, the energy dissipated in the power semiconductor during the short-circuit event is reduced, leading to a junction temperature within the short-circuit safe operating area (SCSOA) limits and enabling a safe turn-off of the device.

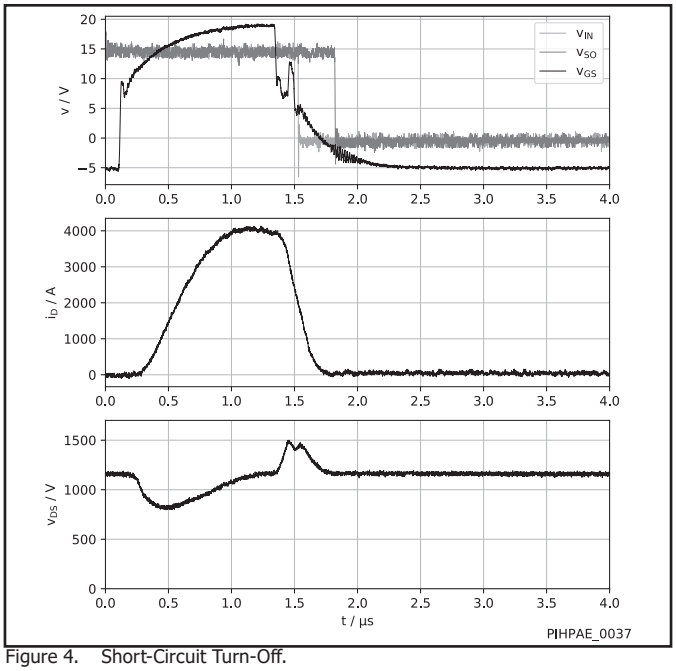

Figure 4. Short-Circuit Turn-Off.

Advanced Active Clamping (AAC)

Active clamping is a technique designed to partially turn on the SiC-MOSFET or IGBT modules in case the collector-emitter voltage exceeds a pre-defined threshold. The semiconductor is then kept in linear operation. Basic active clamping topologies implement a single feedback path from the module's collector through transient voltage suppressor (TVS) diodes to the module gate. The gate driver in 2SP0230T2x0 contains Power Integrations' Advanced Active Clamping (AAC) that operates as follows:

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 mainly integrated in the secondary-side ASIC of the gate driver. The principle of AAC is illustrated in Figure 5.

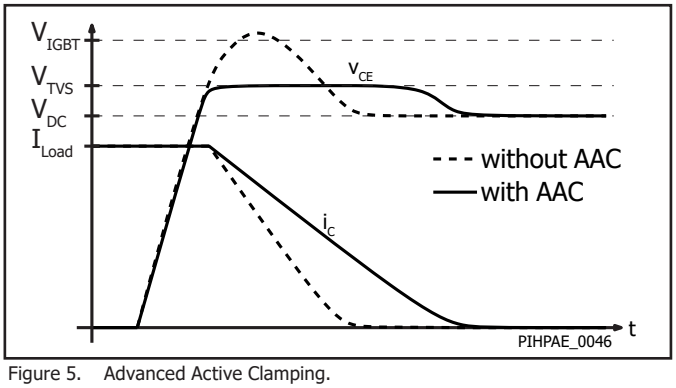

Figure 5. Advanced Active Clamping.

Absolute Maximum Ratings

Parameter	Symbol	Conditions T_A = -40 °C to 85 °C	Min	Max	Units
Absolute Maximum Ratings[1]					
Primary-Side Supply Voltage	V_{VCC}	VCC to GND	0	16	V
Primary-Side Supply Current	I_{VCC}	Average supply current at full load		410	mA
Logic Input Voltage (Command Signal)	V_{INx}	INx to GND	0	V_{VCC} + 0.5	V
Logic Output Voltage (Status Signal)	V_{SOx}	SOx to GND	0	V_{VCC} + 0.5	V
Status Output Current[2]	I_{SOx}	SOx to GND, fault condition, total current		20	mA
Gate Output Power Per Channel[3]	P_{Gx}			1.3	W
Switching Frequency[4]	f_{SW}			92	kHz
Operating Voltage Primary-Secondary Side	V_{OP}	Transient only		2060	V
		Permanently applied		1620	
Operating Voltage Secondary-Secondary Side	V_{CE}	1.7 kV driver versions, transient only		1700	V
		1.2 kV driver versions, transient only		1200	
DC-Link Voltage	$V_{DC(LINK)}$	Switching operation (1.7 kV driver versions)		1200	V
		Off state (1.7 kV driver versions)		1250	
		Switching operation (1.2 kV driver versions)		860	
		Off state (1.2 kV driver versions)		860	
Test Voltage Primary-Side to Secondary-Side	$V_{ISO(PS)}$	50 Hz, 60 s		6813	V_{RMS}
Test Voltage Secondary-Side to Secondary-Side[5]	$V_{ISO(SS)}$	50 Hz, 60 s		4050	V_{RMS}
Common-Mode Transient Immunity	|dv/dt|			50	kV/µs
Storage Temperature[6]	T_{ST}		-40	50	°C
Operating Ambient Temperature	T_A		-40	85	°C
Surface Temperature[7]	T			125	°C
Relative Humidity	H_R	No condensation		93	%
Altitude of Operation[8]	A_{OP}			2000	m

Recommended Operating Conditions

Parameter	Symbol	Conditions T_A = -40 °C to 85 °C	Min	Typ	Max	Units
Power Supply						
Primary-Side Supply Voltage	V_{VCC}	VCC to GND	14.5	15	15.5	V

Characteristics

Parameter	Symbol	Conditions V_{VCC} = 15 V , T_A = 25 °C		Min	Typ	Max	Units
Power Supply							
Supply Current	I_{VCC}	2SP0230T2A0, without load			59		mA
		2SP0230T2A0, f_{SW} = 50 kHz, P_{Gx} = $P_{Gx,max}$, 50% duty cycle			281		
Power Supply Monitoring Threshold (Primary-Side)	$UVLO_{VCC}$	Referenced to GND	Clear fault (resume operation)	11.6	12.6	13.6	V
			Set fault (suspend operation)	11.0	12.0	13.0	
			Hysteresis	0.35			
Power Supply Monitoring Threshold (Secondary-Side)[9]	$UVLO_{VISO}$	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		
Output Voltage (Secondary-Side)	V_{VISO}	2SP0230T2A0, without load			25.3		V
		2SP0230T2A0, f_{SW} = 92 kHz, P_{Gx} = $P_{G,max}$, 50 % duty cycle			24.9		
Coupling Capacitance	C_{IO}	Primary-side to secondary-side, total per channel			19		pF
Gate Ouput							
Gate Turn-On Voltage	$V_{GE(ON)}$	2SP0230T2A0, without load, referenced to respective terminal Ex			20.3		V
		2SP0230T2A0, P_{Gx} = $P_{G,max}$, referenced to respective terminal Ex			19.9		
		2SP0230T2C0, without load, referenced to respective terminal Ex			15		
		2SP0230T2C0, P_{Gx} = $P_{G,max}$, referenced to respective terminal Ex			15		
Gate Turn-Off Voltage	$V_{GE(OFF)}$	2SP0230T2A0, without load, referenced to respective terminal Ex			-5		V
		2SP0230T2A0, P_{Gx} = $P_{G,max}$, referenced to respective terminal Ex			-5		
		2SP0230T2C0, without load, referenced to respective terminal Ex			-10.3		
		2SP0230T2C0, P_{Gx} = $P_{G,max}$, referenced to respective terminal Ex			-9.9		

Characteristics (cont.)

Parameter	Symbol	Conditions V_{VCC} = 15 V, T_A = 25 °C		Min	Typ	Max	Units
Logic Inputs and Status Outputs							
Input Impedance	R_{INx}	INx to GND		7.6	7.8	8	kΩ
Turn-On Threshold	$V_{TH-ON(INx)}$	INx to GND			10.2		V
Turn-Off Threshold	$V_{TH-OFF(INx)}$	INx to GND			5.1		V
Status Output Pull-Up Resistor to VCC	R_{SOx}	A pull-up resistor connects SOx to VCC			4.7		kΩ
Short Circuit Protection							
Static V_{CE}-Monitoring Threshold	$V_{CE(SAT)}$	2SP0230T2A0, 1.7 kV driver versions			53		V
		2SP0230T2A0, 1.2 kV driver versions			TBD		
		2SP0230T2C0, 1.7 kV driver versions			44		
		2SP0230T2C0, 1.2 kV driver versions			44		
Response Time (10% V_{GE} to 90% V_{GE})	t_{RES}	1.7 kV driver versions	2SP0230T2A0, DC-link voltage = 1200 V		1.8		µs
			2SP0230T2C0, DC-link voltage = 1200 V		TBD		
		1.2 kV driver versions	2SP0230T2A0, DC-link voltage = 860 V		TBD		
			2SP0230T2C0, DC-link voltage = 860 V		6.3		

Characteristics (cont.)

Timing Characteristics						
Turn-On Delay	$t_{P(LH)}$	50% INx to 10% VGE		97		ns
Turn-Off Delay	$t_{P(LH)}$	50% INx to 90% VGE		78		ns
Transmission Delay of Fault State	t_{SOX}	After secondary-side fault detection		300		ns
Blocking Time	t_{BLK}	After secondary-side fault detection		24		ms
Electrical Isolation						
Test Voltage[10]	$V_{ISO(PS)}$	Primary-side to secondary-side	6813			V_{RMS}
	$V_{ISO(SS)}$	Secondary-side to secondary-side	4050			V_{RMS}
Partial Discharge Extinction Voltage[11]	$P_{D(PS)}$	Primary-side to secondary-side	2201			V_{RMS}
	$P_{D(SS)}$	Secondary-side to secondary-side	1442			V_{RMS}
Creepage Distance[12]	CPG_{P-S}	Primary-side to secondary-side	12			mm
	CPG_{S-S}	Secondary-side to secondary-side	6			mm
Clearance Distance	CLR_{P-S}	Primary-side to secondary-side	10.5			mm
	CLR_{S-S}	Secondary-side to secondary-side	5.6			mm
Mounting						
Mounting Holes	D_{HOLE}	Diameter of screw hole S1 – S4		4		mm
Bending	I_{BEND}	According to IPC			0.75	%

NOTES:
1. Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device.
2. The status output current must be limited by external pull-up resistors located on the host board.
3. Actually achievable maximum power depends on several parameters and may be lower than the given value. It has to be validated in the final system. It is mainly limited by the maximum allowed surface temperature.
4. This limit applies to the whole product family. The actual achievable switching frequency may be lower for specific gate driver variants and has to be validated in final system as it is additionally limited by maximum gate output power in conjunction with the maximum allowed surface temperature.
5. This value applies to the transformer. The test voltage cannot be applied to the product itself due to the active clamping and desaturation protection circuits.
6. The storage temperature inside the original package 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 actual operating conditions, must be limited to the given value to ensure long-term reliability of the product.
8. Operation above this level requires a voltage derating to ensure long-term reliability of the product.
9. Those values refer to a driver internal emitter reference which is not connected to the external emitter except for driver versions where the positive rail is controled to 15 V.
10. The transformer of every production sample has undergone 100% testing at the given value for 1s.
11. Partial discharge measurement is performed on each transformer.
12. The PCB material features a CTI value of 600.

Product Dimensions

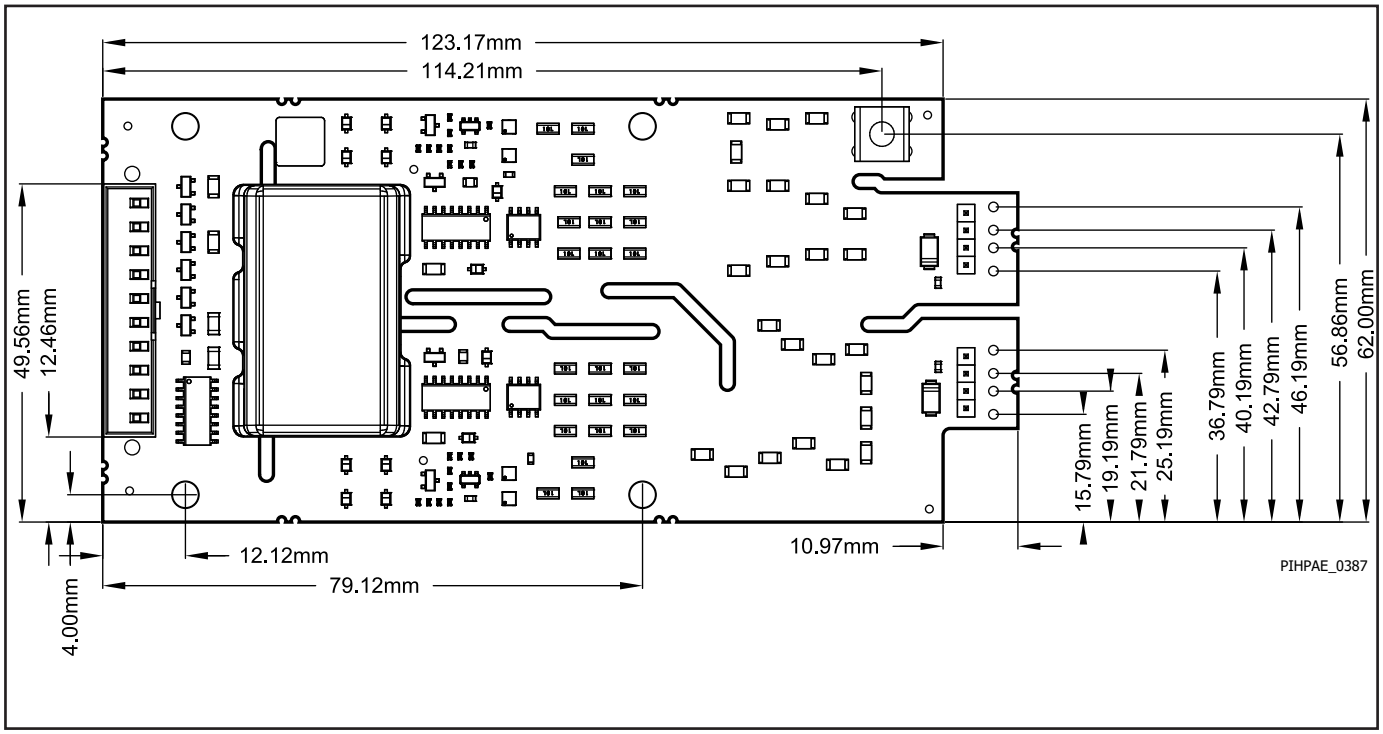

Figure 6. Top View.

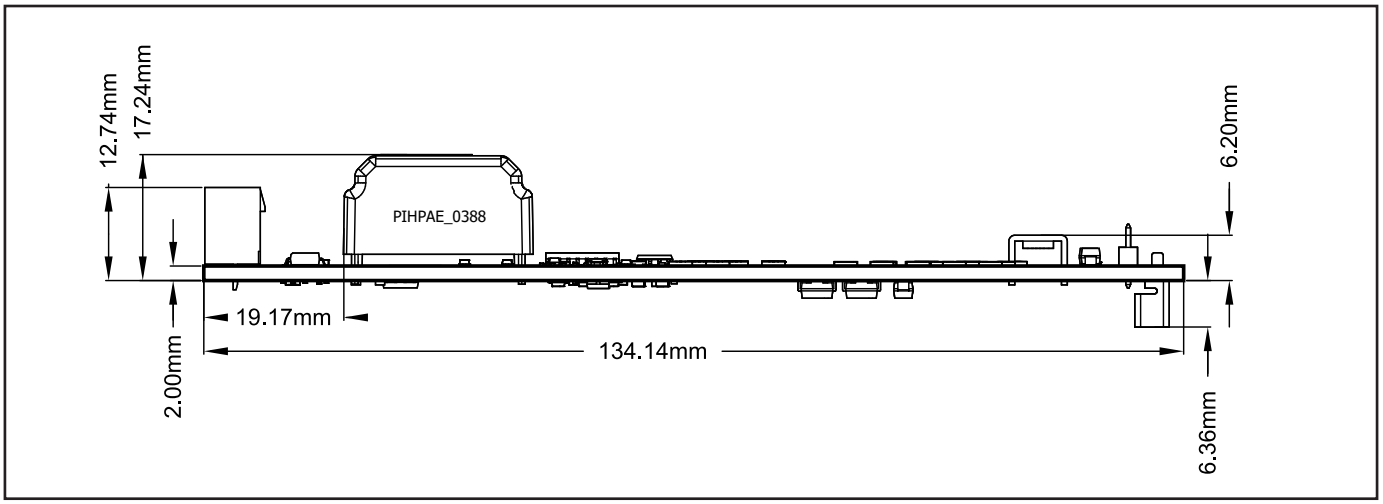

Figure 7. Side View.

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 to 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.

Product Details

Part Number	Power Module	Voltage Class	Current Class	Package	IGBT Supplier	$R_{G(ON)}$	$R_{G(OFF)}$	C_{GE}
2SP0230T2A0-CAS300M17BM2	CAS300M17BM2	1700 V	325 A	62 mm	Wolfspeed	5.0 Ω	5.0 Ω	N.A.
2SP0230T2C0-CM450DY-24T	CM450DY-24T	1200 V	450 A	62 mm	Mitsubish Electric	1.13 Ω	1.52 Ω	N.A.
2SP0230T2C0-2MBI300XHA120-50	2MBI300XHA120-50	1200 V	300 A	62 mm	Fuji Electric	1.83 Ω	3.0 Ω	N.A.
2SP0230T2C0-FF200R12KS4	FF200R12KS4	1200 V	200 A	62 mm	Infineon	5.0 Ω	6.5 Ω	N.A.

Revision	Notes	Date
A	Final Datasheet.	11/23

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