2SMS0220D2xxC
SCALE-iFlex-Single Family

Module Adapted Gate Driver for Half-Bridge Power Modules in High-Voltage Package up to 3300 V

Product Highlights

Highly Integrated, Compact Footprint

- Ready-to-use gate driver solution optimized for power modules up to 3300 V blocking voltage
- Dual channel gate driver
- To be controlled by IMC
- Up to 3 W output power per channel
- ± 20 A maximum gate current
- Supply voltage to be provided by IMC
- Operation altitude up to 2000 m
- - 40 °C to 85 °C operating ambient temperature

Protection / Safety Features

- Short-circuit protection
- Overvoltage protection by Advanced Active Clamping (AAC)
- Undervoltage lock-out (UVLO)
- Applied double sided conformal coating

Full Safety and Regulatory Compliance

- Clearance and creepage distances between secondary and secondary-sides meet requirements for functional isolation according to IEC61800-5-1 and EN 50124-1
- RoHS compliant

Applications

- Wind and photovoltaic power
- Traction inverter
- Industrial drives
- Other industrial applications

Description

This datasheet describes the Module Adapted Gate Drivers (MAGs) of the SCALE-iFlex™-Single gate driver family which works conjointly with a central Isolated Master Control (IMCs). The 2SMS0220D2C0C is designed to work with 2SIS0400T2C0C-33, and the 2SMS0220D2D0C with 2SIS0400V2D0C-33.

The IMCs are designed for the operation of power modules with blocking voltage up to 3300 V, whereas the MAGs are available in different variants optimized for different power modules and chip technologies of different suppliers in the voltage classes up to 3300 V.

SCALE-iFlex-Single enables compact and easy control of the power modules providing high flexibility and system scalability with a minimum development effort. In addition, it allows compact mounting of adjacent modules due to the integrated isolation housing.

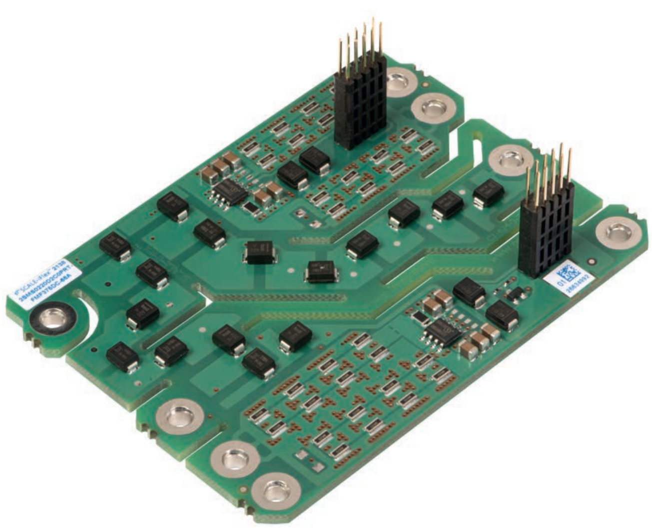

Figure 1. Board photo of 2SMS0220D2C0C.

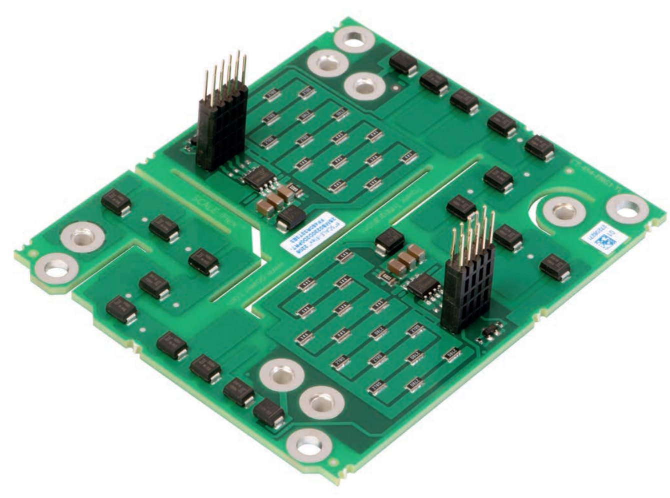

Figure 2. Board photo of 2SMS0220D2D0C.

This Product is Covered by Patents and/or Pending Patent Applications.

Pin Functional Description

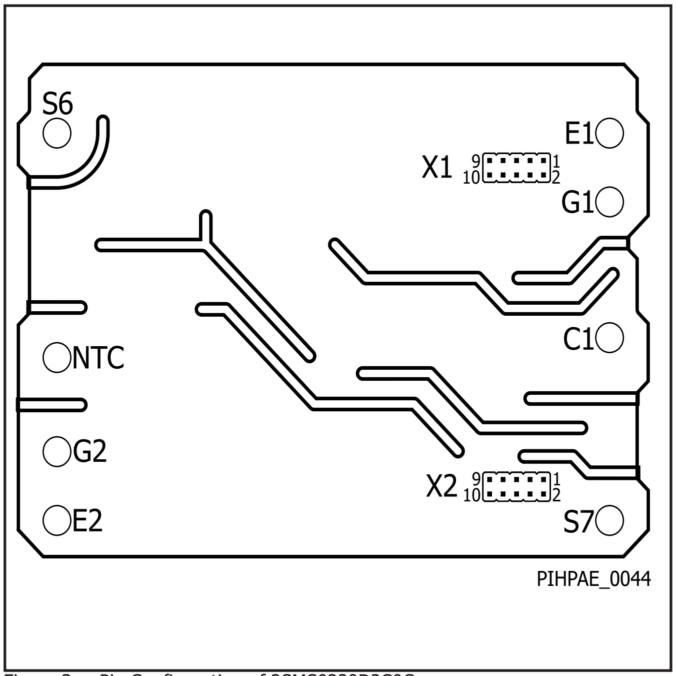

Figure 3. Pin Configuration of 2SMS0220D2C0C.

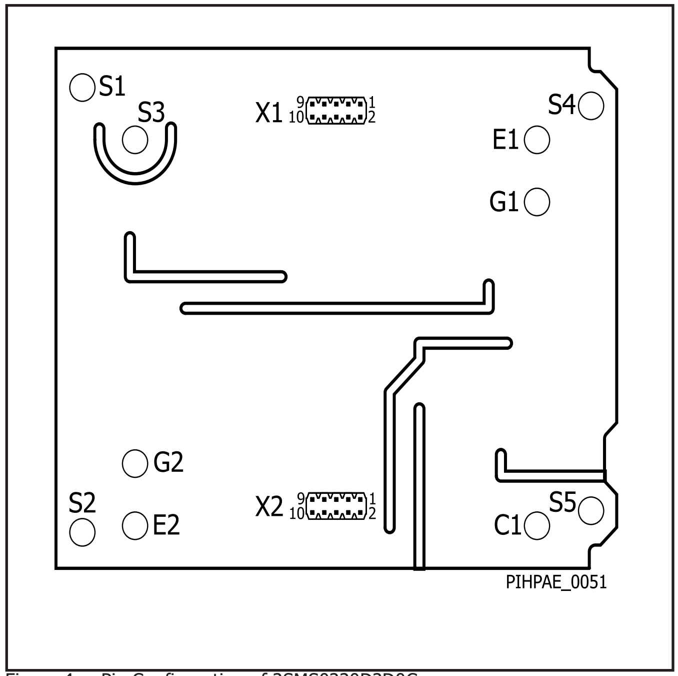

Figure 4. Pin Configuration of 2SMS0220D2D0C.

Connection To Semiconductor

Terminal G1
Gate contact of channel 1 switch.

Terminal E1
Auxiliary emitter contact of channel 1 switch.

Terminal C1
Auxiliary collector contact of channel 1 switch.

Terminal G2
Gate contact of channel 2 switch.

Terminal E2
Auxiliary emitter contact of channel 2 switch.

Screw Holes S1 to S5
Dome positions for fixation of the 2SMS0220D2D0C to the IMC housing and the IGBT module.

S3 is for fixation to IGBT module, and S1, S2, S4 and S5 are to the IMC housing.

Screw Holes S6, S7
Dome positions for fixation of the 2SMS0220D2C0C to the IMC housing.

Additionally, E1 and E2 in 2SMS0220D2C0C are also used for the mechanical connection to the IMC housing.

Connection To IMC

Connector X1
Pin-header connector to IMC for gate driver channel 1.

Connector X2
Pin-header connector to IMC for gate driver channel 2.

NTC
Contacts to module internal NTC.

Functional Description

The 2SMS0220D2xxC (MAGs) are dual-channel plug-and-play gate drivers for all XHP3, XHP2/LV100, HV100, and equivalent power module packages. The MAGs are fully mechanically and electrically adapted to the IGBT modules. They work in conjunction with the IMCs directly mounted on top of them.

Connector Terminals (X1 and X2)
The MAG has one connector terminal per channel.

The MAG needs to be connected to the secondary-side of the IMC. The IMC and MAG have to be mounted in a piggyback as depicted in Figure 5, i.e. direct connection to the pin header. The channel assignment is mechanically determined. Channel 1 from the IMC is connected to channel 1 of the MAG (X1). Accordingly, channel 2 of the IMC is with channel 2 of the MAG (X2).

Screw Terminals S1 to S7
The MAG is mounted on top of the power module and fixed by screws to the IMC housing and the IGBT module.

For 2SMS0220D2D0C, S3 is a hole fixation to the IGBT module, and S1, S2, S4 and S5 are the hole fixation to the IMC housing. For 2SMS0220D2D0C, in addition to S6 and S7, E1 and E2 are used for the mechanical connection to the IMC housing.

Gate Voltage
SCALE-iFlex-Single possesses a voltage regulator for the positive (turn-on) rail of the gate voltage. Internal current sources are regulating actively the positive gate-emitter voltage independently of actual load conditions within the maximum specified ratings. Therefore, the on-state gate-emitter voltage of the power semi-conductor equals in steady state the positive supply voltage V_{VISO}.

The off-state gate-emitter voltage $V_{GE(OFF)}$ equals in steady-state the voltage V_{COM}. This voltage is load-dependent. It has its lowest value under no-load conditions and is increasing slightly (i.e. getting less negative) with increasing load.

In the event of an under-voltage lock-out condition, the gate driver changes positive rail control towards controlling the negative rail V_{COM}. By this, potential parasitic turn-on events of the power semiconductor are avoided.

Power Supply
The isolated voltages for the gate driver channels of the MAG are generated by the integrated DC/DC converter of the IMC. The positive rail of the gate driver channels has the voltage level V_{VISO} and the negative rail has the voltage level V_{COM}. Both are referenced to the emitter potential at terminal E1 or E2 of the driven power semiconductor.

Short-Circuit Protection
The SCALE-iFlex-Single gate driver uses the semiconductor's desaturation effect to detect short-circuits.

The desaturation is monitored on each MAG 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 semi-conductor is switched off immediately and a fault signal is transmitted to the IMC.

It should be noted that the response time t_{RES} is dependent on the DC-link voltage. It remains constant between about 50% to 100% of the maximum DC-link voltage and increases at lower DC-link voltages. Please refer to the relevant data sheet section.

Note: The desaturation function is for short-circuit detection only and cannot provide over-current protection.However, over-current detection has a lower time priority and can be easily provided by the application.

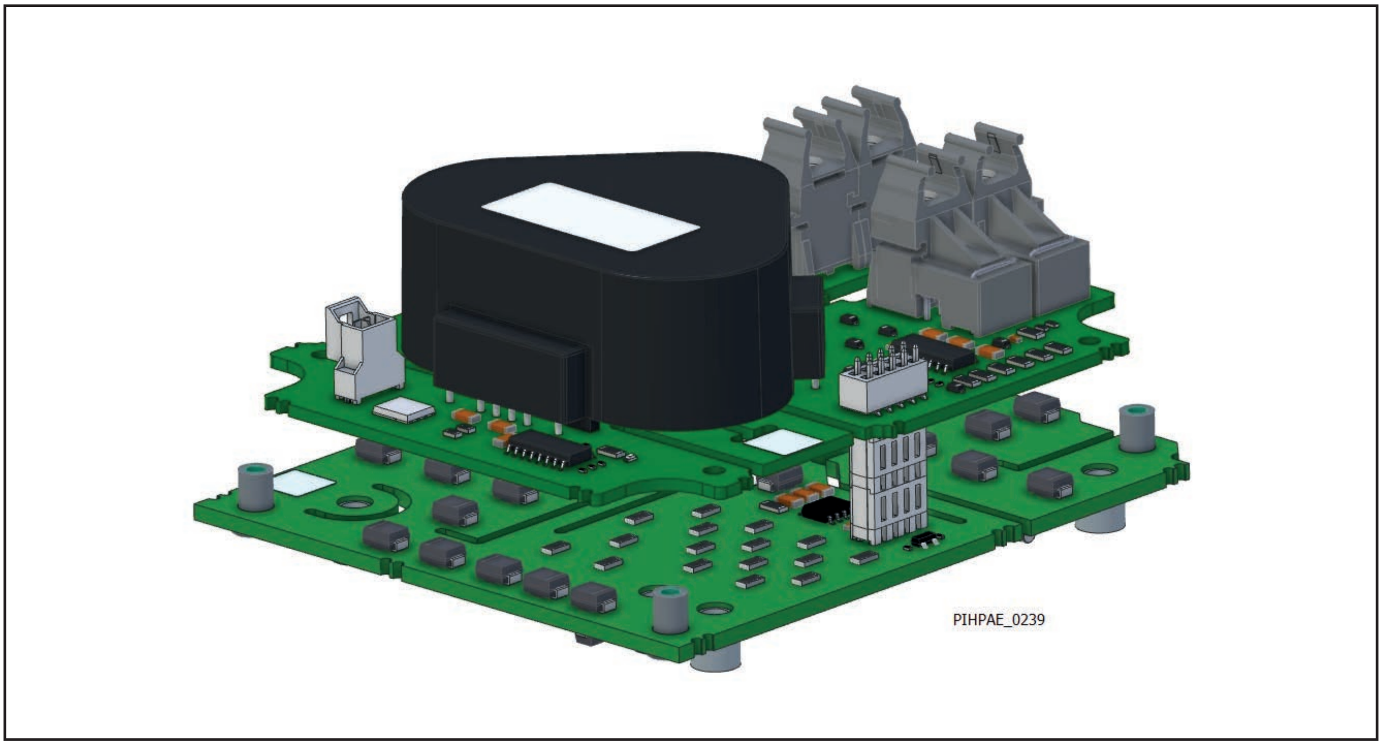

Figure 5. Assembly (Actual product may differ from illustration.).

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 drives 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 each MAG features gate-clamping circuitry. The gate clamping provides a voltage similar to V_{VISO} to the gate, i.e. 15 V. As the effective short-circuit current is a function of the gate-emitter voltage the short-circuit current is limited. As consequence, 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.

Advanced Active Clamping (AAC)

Active clamping is a technique designed to partially turn on the power semiconductor in case the collector-emitter voltage exceeds a predefined threshold. The power semiconductor is then kept in linear operation. Figure 6 illustrates the general behavior of active clamping and its voltage thresholds.

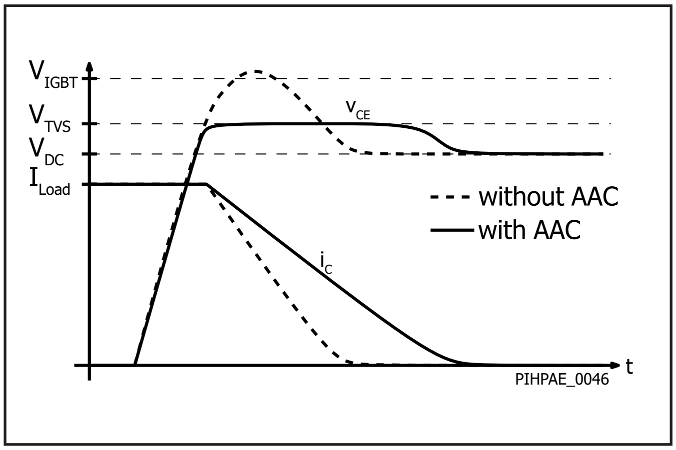

Figure 6. Advanced Active Clamping.

Basic active clamping topologies implement a single feedback path from the power semiconductor collector through transient voltage suppressor (TVS) diodes to the power semiconductor gate. The gate driver contains Power Integrations' Advanced Active Clamping (AAC) 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 mainly integrated in the secondary-side ASIC of the gate driver.

It should be noted that AAC should not be activated during regular operation to avoid excessive heating of the transient voltage suppressor diodes.

Mounting Instruction

The PCB of the IMC is pre-mounted to the housing. The 2SMS0220D2D0C has to be mounted first on the power module. Round spacer (e.g. 05.54.053 from ETTINGER or 963050174 from WE WÜRTH ELEKTRONIK) need to be placed on the terminal screws of the MAG. The IMC with the housing 2SIS0400V2D0C-33 is fixed over the MAG through the spacers with 16 mm M3 screws (S1, S2, S3 and S4 of IMC).

For the 2SMS0220D2C0C, four jack-screws (e.g. 94518233 from WE WÜRTH ELEKTRONIK) need to be placed on terminal screws E1, E2, S6 and S7. The IMC with the housing 2SIS0400T2C0C-33 is fixed over the MAG through the jack-screws with 12 mm M3 screws (S1, S2, S3 and S4 of IMC).

To avoid mechanical stress of the IMC during and after the mounting process, any bending or warping force imposed to the IMC must not lead to a vaulting or twisting of the housing of 0.75 % per axis.

Conformal Coating

The electronic components in the gate drivers 2SMS0220D2xxC are protected by a layer of acrylic conformal coating on both sides of the PCB with a typical thickness of 50 µm using ELPEGUARD SL 1307 FLZ/2 from Lackwerke Peters. This coating layer increases product reliability when exposed to contaminated environments.

Note: Standing water (e.g. condensate water) on top of the coating layer must be prevented. This water will diffuse through the layer over time. If allowed to remain, it will eventually form a thin film between the PCB surface and coating layer, which will cause leakage currents to increase. Such currents will interfere with the performance of the gate driver.

Absolute Maximum Ratings

Parameter	Symbol	Conditions T_A = -40 °C to 85 °C	Min	Max	Units
Absolute Maximum Ratings[1]					
Output Power Per Channel[2]	P_{Gx}			3	W
Switching Frequency[3]	f_{SW}			25	kHz
DC-link Voltage[4]	$V_{DC\text{-}Link}$	3.3 kV driver versions (Limited to 60 s)		2500	V
		3.3 kV driver versions (Permanently applied)		2200	
		1.7 kV driver versions (Limited to 60 s)		1250	
		1.7 kV driver versions (Permanently applied)		1200	
Operating Voltage	V_{CE}	With 3.3 kV versions		3300	V
		With 1.7 kV versions		1700	
Storage Temperature[5]	T_{ST}		-40	50	°C
Operating Ambient Temperature	T_A		-40	85	°C
Surface Temperature[6]	T			125	°C
Relative Humidity	H_R	No condensation		93	%
Altitude of Operation[7]	A_{OP}			2000	m

NOTES:
1. Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device.
2. 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.
3. 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 the final system as it is additionally limited by the maximum gate output power in conjunction with the maximum allowed surface temperature.
4. High-Pot test voltage between both secondary sides is not possible due to the presence of transient voltage suppressors needed for the active clamping functionality.
5. 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.
6. 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.
7. Operation above this level requires a voltage derating to ensure proper isolation coordination.

Parameter	Symbol	Conditions T_A = 25 °C		Min	Typ	Max	Units
Electrical Characteristics							
Gate Turn-On Voltage	$V_{GE(on)}$	IMC supplied with 15 V, referenced to the corresponding emitter			15		V
Gate Turn-Off Voltage[8]	$V_{GE(off)}$	Referenced to the corresponding emitter			15 - VISO		V
Static V_{CE}-Monitoring Threshold	$V_{CE(SAT)}$	3.3 kV driver versions			113		V
		1.7 kV driver versions			46		V
Response Time	t_{RES}	10% to 90% of V_{GE} (with 3.3 kV)	DC-link voltage = 1000 V		9		µs
			DC-link voltage = 1500 V		7.1		
			DC-link voltage = 2200 V		7		
		10% to 90% of V_{GE} (with 1.7 kV)	DC-link voltage = 600 V		5.7		µs
			DC-link voltage = 800 V		5.2		
			DC-link voltage = 1200 V		5.2		
Delay to Power Semi-conductor Turn-Off After Short-Circuit Detection	$t_{pd,SC}$				0.15		µs
Creepage Distance	CPG_{S-S}	Secondary-side to secondary-side		22			mm
Clearance Distance	CLR_{S-S}	Secondary-side to secondary-side		8			mm
Mounting Holes	d_{hole}	Diameter of screw holes			4.3		mm
Screw Header/Washer Diameter	d_{M3}	Terminals G1, E1, C1, G2, E2, S1 to S7				8.0	mm
Terminal Connection Torque[9]	M_{MAG}	Screw M3					Nm
Bending	I_{bend}	According to IPC				0.75	%

NOTES:
8. The gate turn-off voltage is determined by the VISO voltage. Refer to the corresponding IMC data sheet for the corresponding values.
9. Refer to data sheet of the IGBT module.

Product Dimensions of 2SMS0220D2C0C

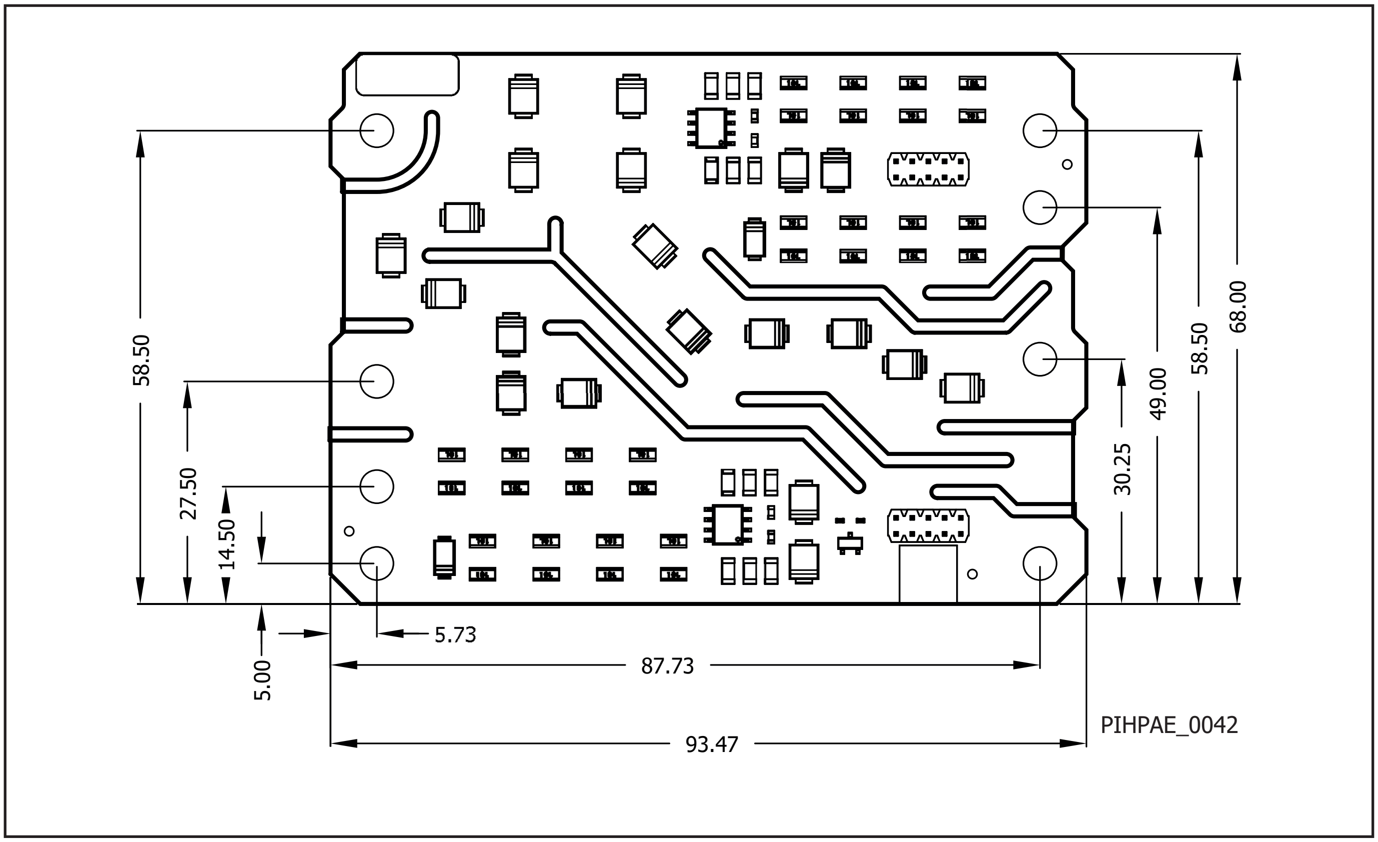

Figure 7. Side View of 2SMS0220D2C0C.

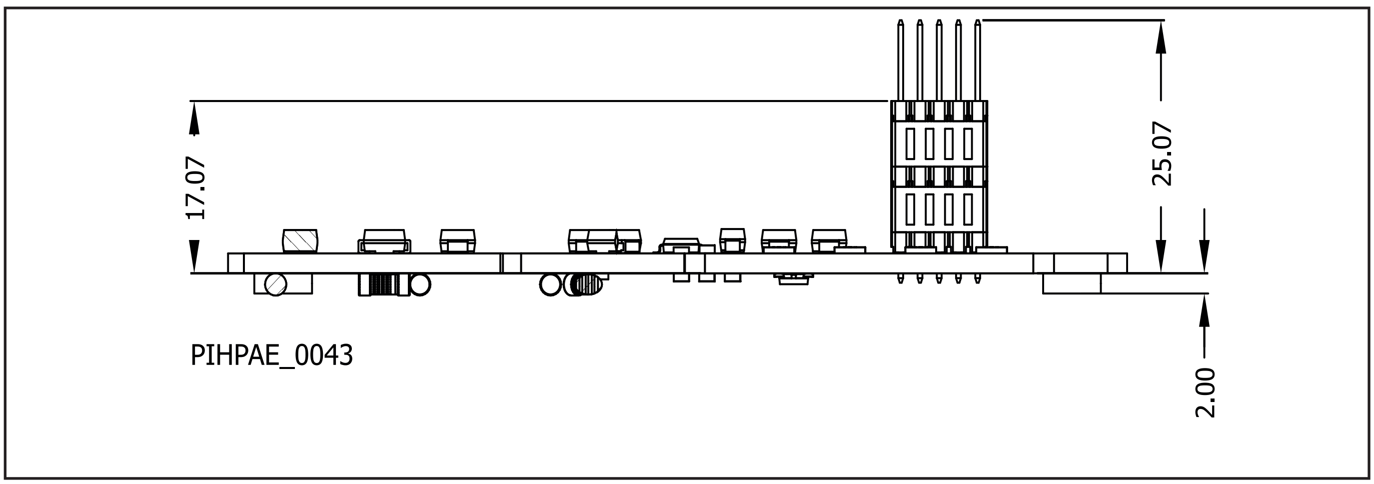

Figure 8. Top View of 2SMS0220D2C0C.

Product Dimensions of 2SMS0220D2D0C

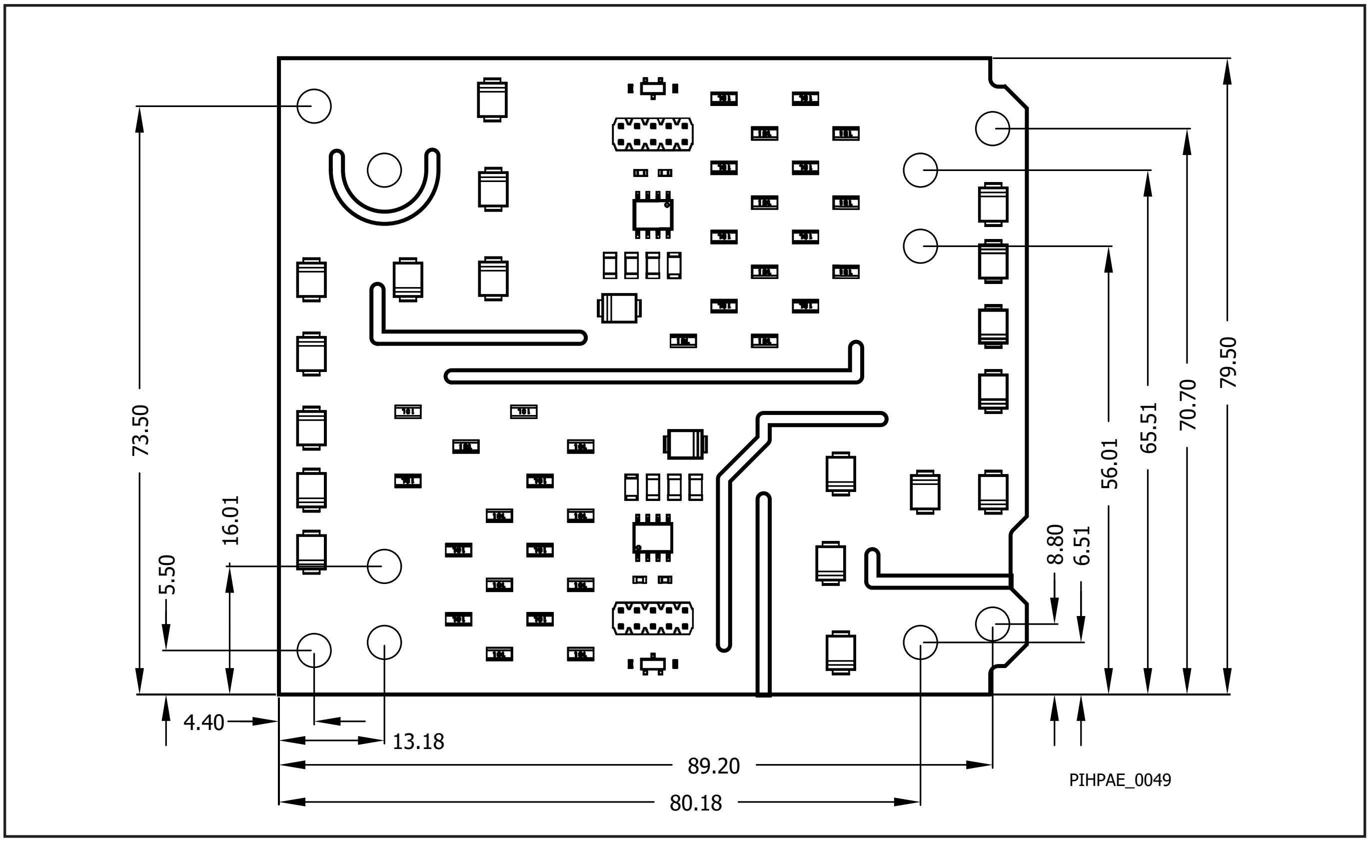

Figure 9. Top View of 2SMS0220D2D0C.

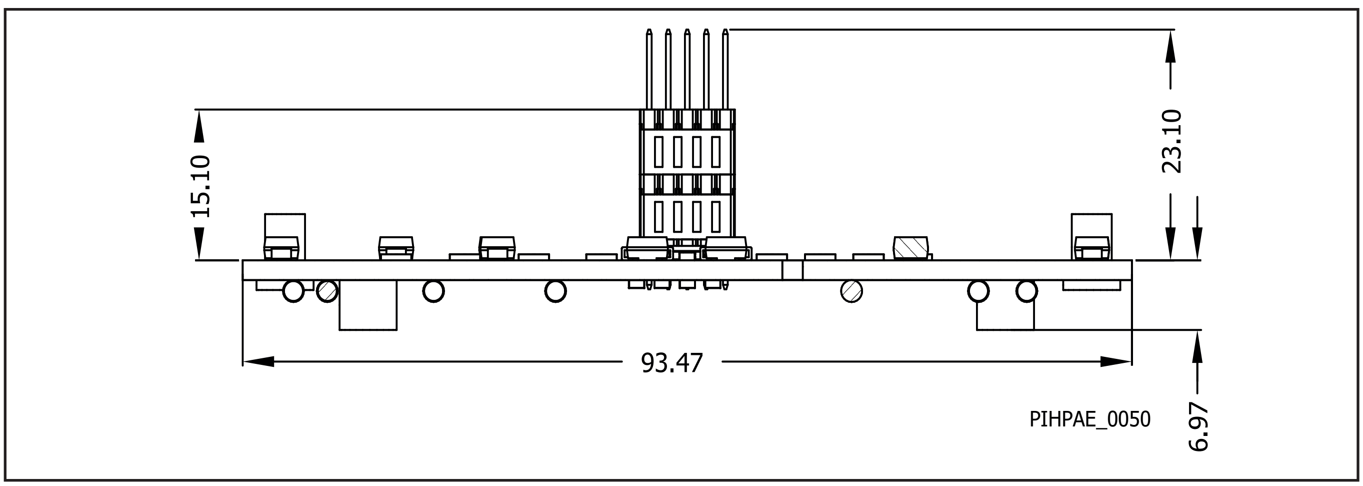

Figure 10. Side View of 2SMS0220D2D0C.

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.

Product details

Part Number	Power Module	Voltage Class	Current Class	Package	IGBT Supplier	$R_{G(ON)}$	$R_{G(OFF)}$	C_{GE}
2SMS0220D2C0C-CM600DA-66X	CM600DA-66X	3300 V	600 A	LV100	Mitsubishi	2.25 Ω	53.75 Ω	33 nF
2SMS0220D2C0C-CM1200DA-34X	CM1200DA-34X	1700 V	1200 A	LV100	Mitsubishi	1.14 Ω	7.0 Ω	33 nF
2SMS0220D2D0C-FF450R33T3E3	FF450R33T3E3	3300 V	450 A	XHP™3	Infineon	0.7 Ω	3.375 Ω	Not Assembled

Revision	Notes	Date
A	Final Datasheet.	11/22

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