1SP0335D2S1R
SCALE™-2 Driver Family

Peripheral Plug-and-Play Gate Driver for Driving IGBT Modules up to 6500 V via Electrical Interface

Product Highlights

Highly Integrated, Compact Footprint

- Ready-to-use gate driver solution for power modules up to 6500 V blocking voltage
- Single-channel gate driver
- 35 A peak output gate current
- 1.6 W output power at maximum operating temperature
- Supports parallel connection of up to four power modules
- -40 °C to +85 °C operating ambient temperature range
- Optical status indicator

Protection / Safety Features

- Short-circuit protection
- Dynamic Advanced Active Clamping (DA^2C)
- Undervoltage lock-out (UVLO) protection
- Double-sided conformally coated (ELPEGUARD SL 1307 FLZ/2 from Lackwerke Peters)
- RoHS compliant

Applications

- Railway inverter
- Industrial drives
- Other industrial applications

Description

This datasheet describes the peripheral driver 1SP0335D2S1R of the main 1SP0335x2M1R gate driver family.

The Plug-and-Play 1SP0335D2S1R peripheral gate driver is a compact single-channel gate driver designed to drive a range of IGBT modules in parallel operation.

Power Integrations' Dynamic Advanced Active Clamping allows an extended DC-link voltage range to support the IGBT off-state for up to 60 seconds. This is ideal for railway and regenerating applications.

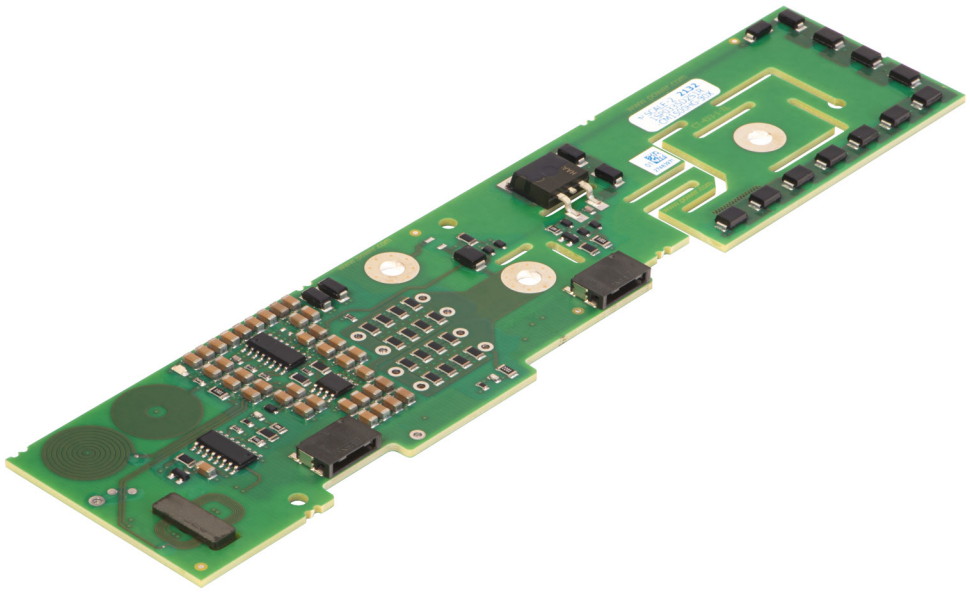

Figure 1. Product Photo of 1SP0335D2S1R.

Pin Functional Description

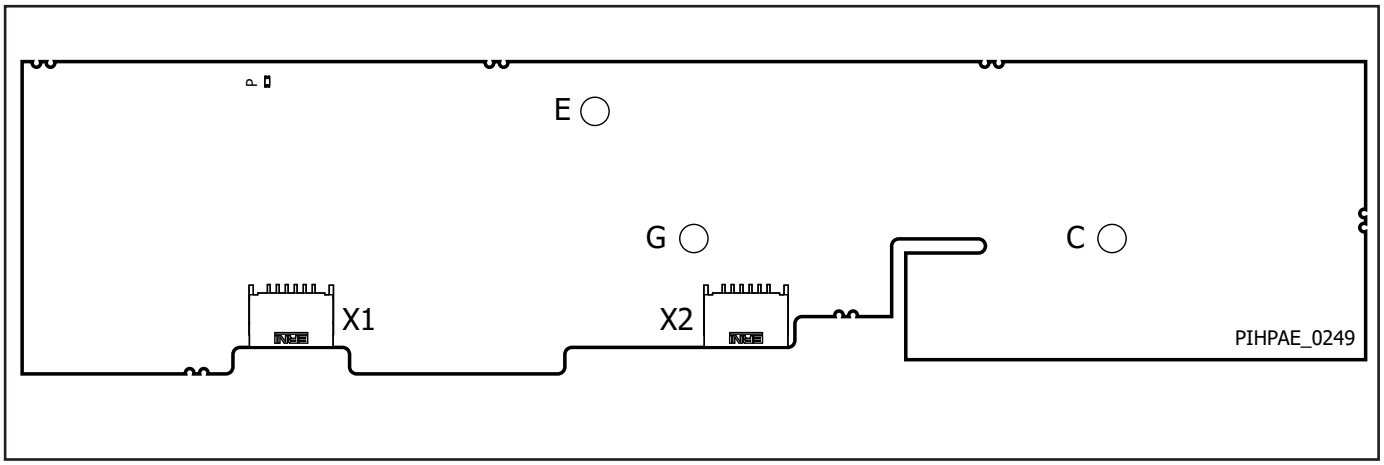

Figure 2. 1SP0335V2M1R Interfaces.

Connection to Main or to Another Peripheral Driver

Connector X1 and X2
MicroBridge interface to connect peripheral driver to main driver or another peripheral driver.
Part number: TE CONNECTIVITY 504275-E.

Connection to Semiconductor

Terminal G
Gate contact of IGBT.

Terminal E
Auxiliary emitter contact of IGBT.

Terminal C
Auxiliary collector contact of IGBT.

Optical Indicator P
Green LED for monitoring the status output. In the event of a fault the indicator is turned off.

Functional Description

The basic topology of the 1SP0335D2S1R driver is shown in Figure 3. This driver can be used together with main driver when parallel connection of IGBT modules is required. This driver can be connected to the main driver or another peripheral driver via X1/X2 paralleling interface. The X1 or X2 interfaces are identical.

The driver is equipped with the following features:

- Dynamic Advanced Active Clamping DA²C (overvoltage protection at turn-off)
- Gate monitoring
- Gate clamping to positive rail
- Power supply monitoring

The power supply as well as the input signal are provided by the main driver. No fiber optic connections are present on the peripheral driver. Moreover, no desaturation protection is implemented on the peripherals, as it is already implemented on the main driver.

Plug-and-play capability means that the drivers are ready to operate immediately after mounting. The user does not need to invest any effort in designing or adjusting the driver to match a specific application.

Description of X1/ X2
The paralleling interfaces X1/X2 are available on the gate driver. They allow up to three peripherals to be connected between each other or to the main driver.

Note that no galvanic isolation is implemented on the driver as it is implemented on the external DC-DC converter.

Screw Terminals
The main driver is mounted on top of the power module and fixed by screws.

Connection Cables for X1/X2
For recommended cables, please refer to datasheet RLC-IMS-61-050-0.

It is important to note that the paralleling cables are at high voltage (secondary-side potential). The user is responsible for applying sufficient isolation to all cables.

Power Supplies and Electrical Isolation
The power supply and electrical isolation are provided by the external DC-DC converter. The DC-DC converter needs a stabilized 15V supply voltage.

In addition, a signal insulation of 200 V_{PEAK} is provided on the peripheral drivers. This allows for dynamic voltage differences between parallel-connected drivers when switching operation is not symmetrical.

Signal isolation is realized via a planar transformer. Coreless common mode coils are placed in the supply conductors in order to limit the dynamic equalizing currents flowing to and from the main or between peripherals during asymmetric switching operation. It is recommended that the resulting equalizing current flowing is measured via the paralleling interface (see absolute maximum value).

Note that if required, the peak value as well as the RMS value of the equalizing current can be reduced by positioning a ferrite core around the paralleling cables.

Short-Circuit Detection
The main driver detects a short circuit and turns off the peripheral drivers synchronously. For more description, refer to the datasheet of the main driver.

Undervoltage Detection
The peripheral drivers are equipped with a local undervoltage monitoring circuit. In case of a supply undervoltage, the corresponding IGBT is driven immediately with a negative gate voltage to keep it in the offstate (the channel is blocked). Only the corresponding IGBT is switched off immediately, and not all paralleled IGBTs. However, all other parallel connected IGBTs will be turned off by the gate monitoring function implemented on all drivers after the given delay (see Gate monitoring).

Gate Monitoring Fault
The gate voltage of the peripheral driver is monitored on the mains. For more description, refer to the datasheet of the main driver.

Dynamic Advanced Active Clamping (DA²C)
The peripheral driver is equipped with DA2C. For more description, see datasheet of the main driver.

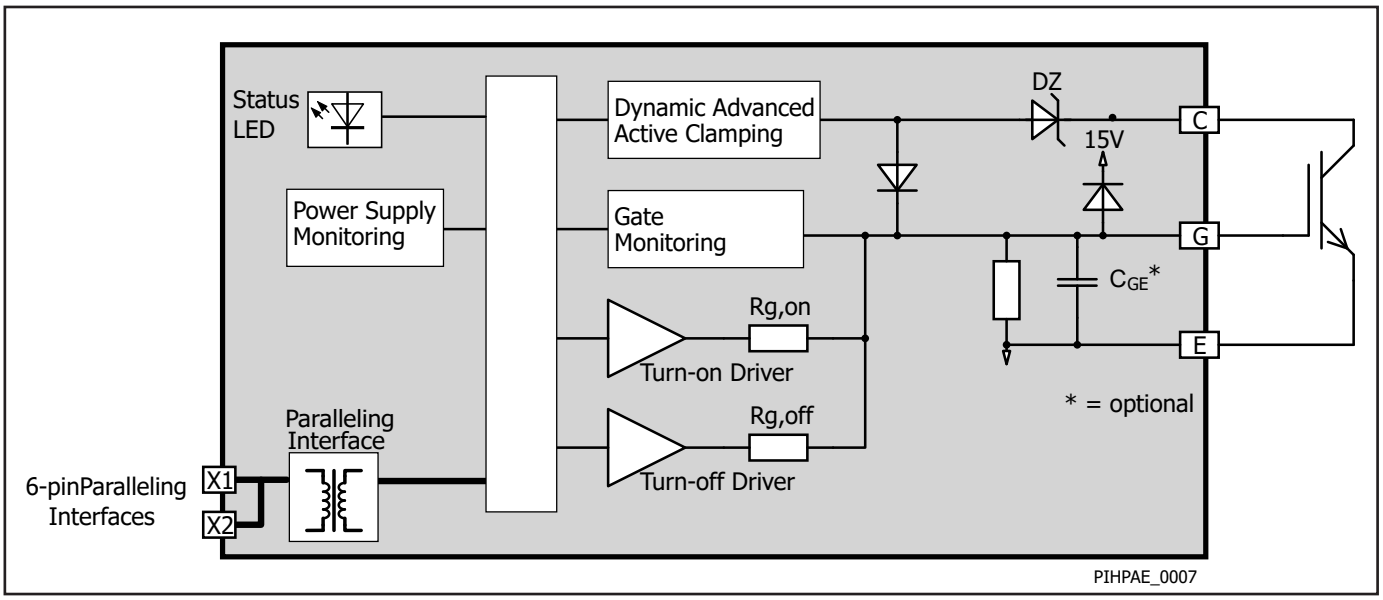

Figure 3. Functional Block Diagram.

Optical Indicators
To facilitate verification, the driver is equipped with a green status LED. The LED lights up under normal operation. A turned-off LED indicates that the driver is not supplied with voltage or the local supply voltage is too low.

Dynamic Behavior of IGBT
Due to the different behavior of the included IGBT and diode chips, the dynamic behavior of the IGBT module depends on their type and manufacturer. Module construction and the distribution of the internal gate resistances and inductances also play a role in determining dynamic response. 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 each type of 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
The driver includes the gate resistors, matched to the appropriate IGBT module. The driver is optimized to achieve minimum switching losses when paired with relatively low inductances within the power stack. It is therefore recommended to check the commutation behavior of the system assembly.

Turn-Off of the IGBT
The gate resistance is already optimized and should not be altered. Fast turn-off of the IGBT may cause overvoltage, which increases with DC-link voltage or load current. The turn-off overvoltage is approximately:

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

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

Limiting overvoltage at turn-off is essential for high-power or high-voltage IGBTs. To ensure this, SCALE-2 plug-and-play drivers provide a Dynamic Advanced Active Clamping function DA^{2}C.

3-Level and Multilevel Topologies
1SP0335D2S1R drivers can be used in 3-level or multilevel topologies, please refer to application note AN-0901.

Parallel Connection of Main and Peripheral Drivers
If parallel connection up to four IGBT modules is required, one main and up to three peripheral drivers are used. The electrical isolation is provided by the external DC-DC converter ISO5125R-xx. The electrical isolation of signals is realized on the main driver (via the fiber optic interface for the input signal and the status feedback). The power supply for the peripheral drivers as well as input signal and gate monitoring feedback are transmitted between the peripheral and the main driver via the interface bus connected to the paralleling interfaces X1 and/or X2 respectively. X1 and X2 are identical and interchangeable on the main driver and on the peripheral driver. The paralleling interface connections X1 and X2 ensure that all paralleled drivers switch on and off synchronously.
For more information about the paralleling of this diver family and recommendations about optimizing the mechanical layout of the converter set-up, please refer to the AN-2201.

Conformal Coating
The electronic components in the gate driver 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	Min	Max	Units
Absolute Maximum Ratings[1]					
Supply Voltage	$V_{VISO-COM}$	VISO to COM		30	V
Switching Frequency[2]	f_{SW}			10	kHz
Gate Output Power	P_G	$T_a \leq 85$ °C		1.6	W
		$T_a \leq 70$ °C		2.2	
DC-Link Voltage	$V_{DC-LINK}$	Switching operation[3] (4.5 kV driver versions)		3000	V_{DC}
		Off State[4] (4.5 kV driver versions)		3550	
		Switching operation[3] (6.5 kV driver versions)		4400	
		Off State[4] (6.5 kV driver versions)		5200	
Operating Voltage	V_{CE}	4.5 kV driver versions		4500	V_{PEAK}
		6.5 kV driver versions		6500	
Emitter to Emitter Voltage	V_{E1-E2}	Between parallel connected drivers		200	V_{PEAK}
Common-Mode Transient Immunity	|dv/dt|	Between parallel connected drivers		50	kV/µs
Interface Current (Main or Peripheral 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_{SURF}			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 to COM	23.5	25	26.5	V

Characteristics

Parameter	Symbol	Conditions $V_{ISO-COM}$ = 25 V, T_A = 25 °C		Min	Typ	Max	Units
Power Supply							
Supply Current	I_{VISO}	Peripheral driver only, without load			20		mA
		Peripheral driver only, 1.6 W, f_{SW} = 1.55 kHz, 50% duty cycle			87		
Power Supply Monitoring Threshold (Secondary-Side)	$UVLO_{VISO}$	Referenced to E	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		
Mounting[9]							
Mounting Torque	M_{MAIN}	Screw M4, as per IGBT data sheet					Nm
Bending	I_{BEND}	According to IPC				0.75	%
Gate Output							
Turn-On Gate Output Voltage	$V_{GE(ON)}$				15		V
Turn-Off Gate Output Voltage	$V_{GE(OFF)}$				-10		V

NOTES:

1. Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device.
2. 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.
3. This limit is due to active clamping.
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 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 to ensure long-term reliability of the product.
8. Operation above this level requires a voltage derating to ensure proper isolation coordination.
9. Refer to the data sheet of the IGBT module.

Product Dimensions

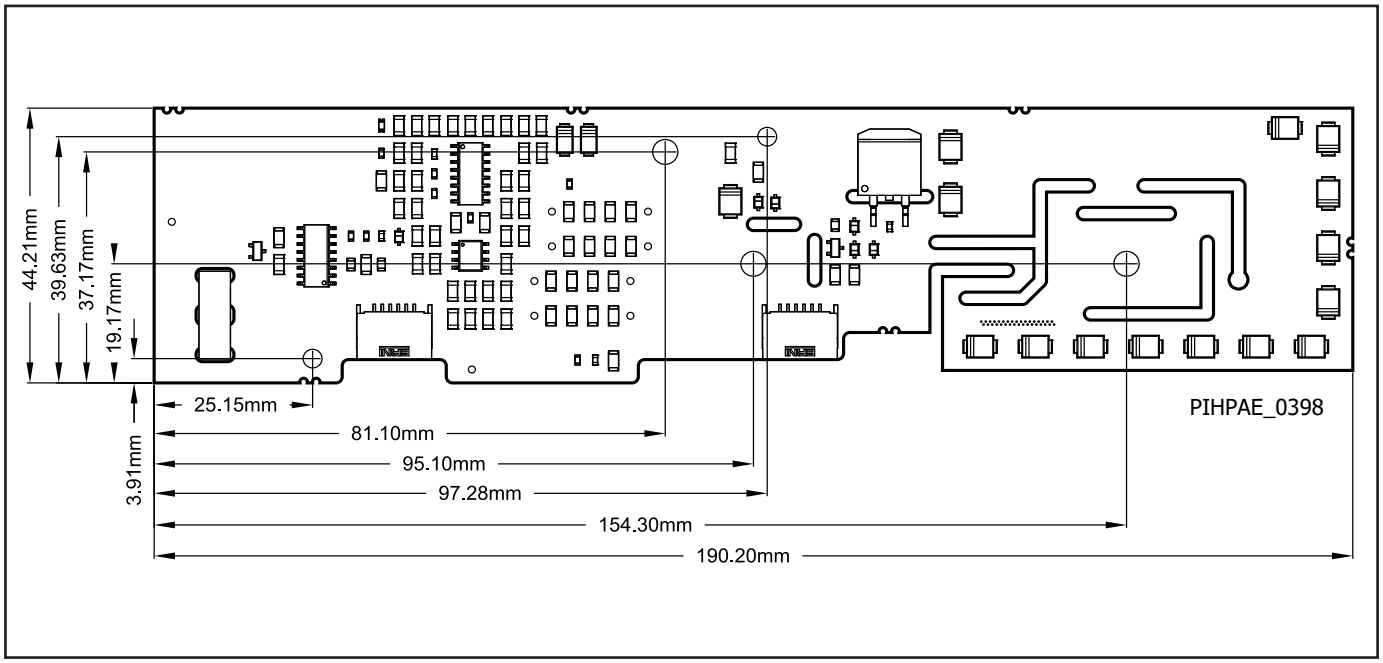

Figure 4. Top View.

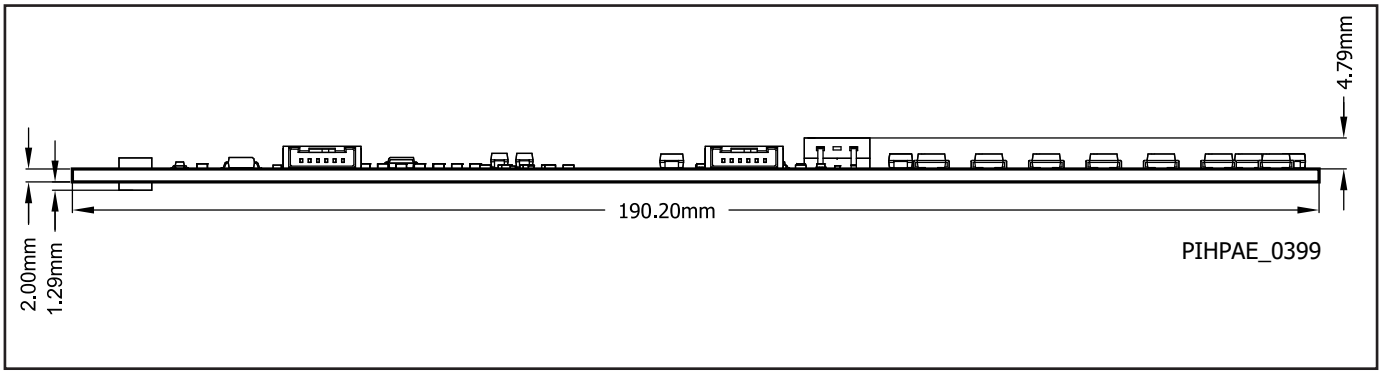

Figure 5. Side View.

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}
1SP0335D2S1R-CM900HG-130X	CM900HG-130X	6500 V	900 A	IHM	Mitsubishi	4.5 Ω	30 Ω	Not Assembled
1SP0335D2S1R-CM600HG-130X	CM600HG-130X	6500 V	600 A	IHM	Mitsubishi	6.375 Ω	45 Ω	Not Assembled
1SP0335D2S1R-CM1500HG-90X	CM1500HG-90X	4500 V	1500 A	IHM	Mitsubishi	2.5 Ω	30 Ω	Not Assembled
1SP0335D2S1R-MBN1500FH45F-H	MBN1500FH45F-H	4500 V	1500 A	IHV	Hitachi	3.375 Ω	3.375 Ω	Not Assembled

Revision	Notes	Date
A	Final Datasheet.	12/23

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