2SIXT0112T2A0
SCALE™-2 Family

Plug-and-Play Gate Driver for 1200 V and 1700 V Half-Bridge Power Modules via Electrical Interface

PRELIMINARY

Product Highlights

Highly Integrated, Compact Footprint
- Ready-to-use dual-channel gate driver solution optimized for XHP™2, HPnC and LV100 power modules
- 1 W output power per channel at maximum ambient temperature
- +15 / -8 A maximum gate current
- Isolated digital NTC readout signal
- Operation altitude up to 2000 m
- - 40 °C to 85 °C operating ambient temperature

Protection / Safety Features
- Short circuit protection ($V_{CE,SAT}$ monitoring)
- Undervoltage lock-out (UVLO) for primary and secondary sides

Comprehensive Safety Assurance
- 100% production tests include both transformer partial discharge and HIPOT testing
- Creepage on PCB and transformer material and clearance distances between primary and secondary sides meets IEC 61800-5-1 reinforced for two-level applications with 1700V power modules and basic isolation for three-level-applications with 1200 V power modules
- RoHS compliant

Application
- PV inverters

Description

The SCALE™-2 plug-and-play driver 2SIXT0112T2A0 is a compact dual-channel gate driver designed for the operation of XHP™2, HPnC and LV100 power modules in two and three-level PV application. The driver features an electrical interface, NTC read-out, and a built-in DC-DC power supply.

Figure 1. Board Photo of 2SIXT0112T2A0.

Pin Functional Description

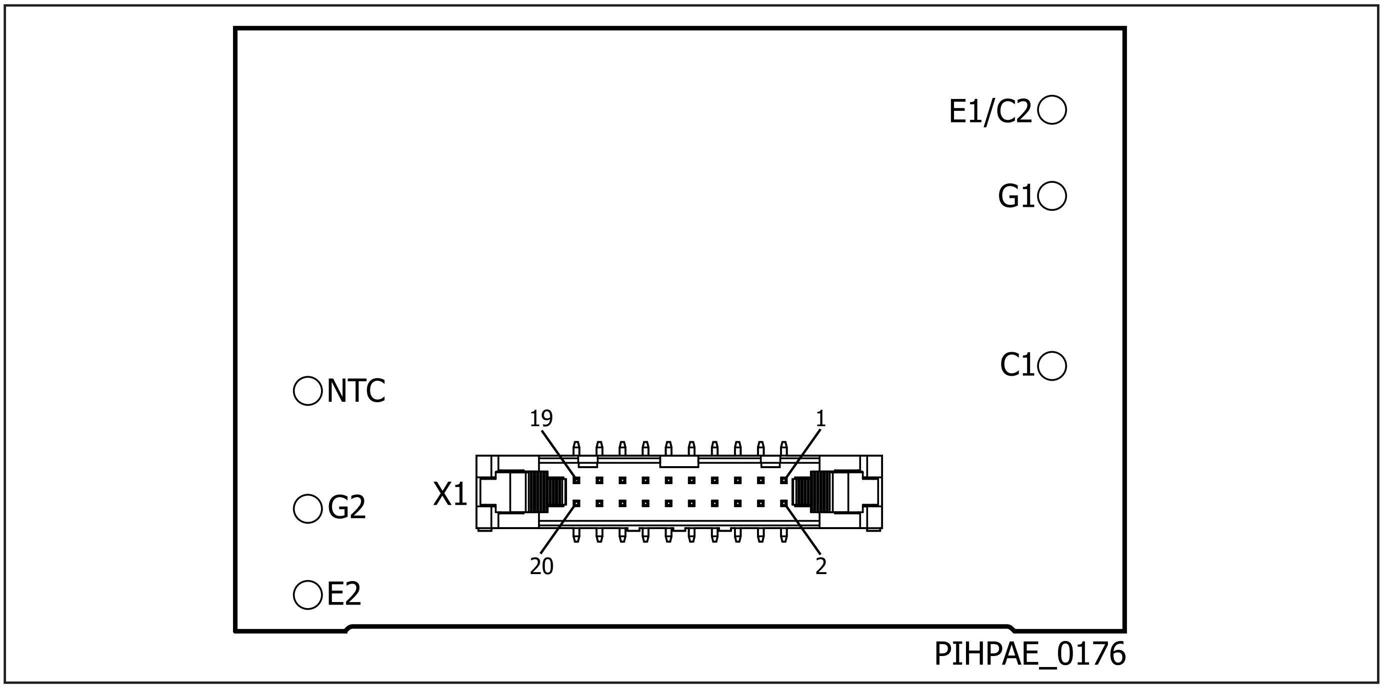

Figure 2. Pin Configuration.

Connector X1

CNC TECH 3010-20-003-13-00 Eject Latch Header Assembly (or similar) at X1; Connection from 2SIXT0112T2A0 to superior controller.

VCC (Pins 1, 3, 5, 7)
This pin is the primary-side 15 V supply voltage connection for the primary-side electronic and the integrated DC/DC converter.

IN1 (Pin 15)
This pin is the command input for channel 1 (low-side switch).

SO1 (Pin 13)
This pin is the status output for channel 1 (low-side switch).

IN2 (Pin 11)
This pin is the command input for channel 2 (high-side switch).

SO2 (Pin 9)
This pin is the status output for channel 2 (high-side switch).

TPM (Pin 19)
This is the measurement output for the NTC temperature sensing.

GND (Pins 2, 4, 6, 8, 10 , 12, 14, 16, 18, 20)
These pins are the connection for the primary-side ground potential. All primary-side signals refer to these pins.

Connections to Power Module

2SIXT0112T2A0 gate driver is are directly mounted to power modules using screws.

G1
This is the screw connection to the gate of the high-side IGBT.

E1
This is the screw connection to the emitter of the high-side IGBT.

E1/C2
This is the screw connection to the emitter of the high-side IGBT and to the collector of the low-side IGBT.

G2
This is the screw connection to the gate of the low-side IGBT.

C2
This is the screw connection to the collector of the low-side IGBT.

NTC
This is the screw connection to the NTC of the IGBT module.

Functional Description

The 2SIXT0112T2A0 is a dual channel Plug-and-Play gate driver for 1200 V and 1700 V half-bridge power modules that use XHP[TM]2, HPnC and LV100 packages. The driver provides reinforced isolation between primary and secondary sides for 1700 V in 2-level application and basic isolation for 1200 V in 3-level applications. As plug-and-play gate driver, the 2SIXT0112T2A0 characteristics match the requirements of the individual power module.

Power Supplies (Primary-Side X1)

The 2SIXT0112T2A0 provides a power supply input. A typical supply voltage level of 15 V is required. The input VCC supplies the primary-side electronics 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_{VISO}, while the negative rail is at V_{COM}. Both are referenced to the emitter potential at terminal E1 or E2 of the driven power semiconductor.

Undervoltage Monitoring

The supply voltages are closely monitored. In the event of an under voltage condition (UVLO), a failure signal will be provided on the status output SO1/SO2 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(s) will be turned off after the delay $t_{PD(SOx)}$.

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 status feedback signals SO1 and SO2 remain at V_{VCC} under normal (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 the 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.

Short-Circuit Protection

The 2SIXT0112T2A0 gate driver variant uses the semiconductor's desaturation effect to detect short-circuits.

The desaturation is monitored on the driver 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 primary-side status.

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 but 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.

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.

NTC Temperature Measurement

The driver senses the NTC temperature of the attached power module. This signal can be accessed at TPM on X1 interface connector. The temperature signal at terminal TPM is a duty cycle based protocol with a repeatable pulse of F_{TPM}.

Note: The NTC temperature does not represent the junction temperature of any of the semiconductor dies within the power module. Instead, it is a good indication of the baseplate temperature of the power module.

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		280	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
Temperature Output Voltage (NTC Measurement)	V_{TPM}	V_{TPM} to GND		V_{VCC} + 0.5	V
Status Output Current[2]	I_{SOx}	SOx to GND, fault condition, total current	0	20	mA
Temperature Measurement Output Current	I_{TPM}	TPM to GND, total current	0	100	mA
Gate Output Power Per Channel[3]	P_{Gx}			1	W
Switching Frequency	f_{SW}			25	kHz
Operating Voltage Primary-Side to Secondary-Side	$V_{OP(P-S)}$	Transient only		2050	V
		Permanently applied		1600	
Operating Voltage Secondary-Side to Secondary-Side	$V_{OP(S-S)}$	Transient only		1700	V
		Switching operation		1200	V
Test Voltage Primary-Side to Secondary-Side	$V_{ISO(PS)}$	50 Hz, 60 s		6813	V_{RMS}
Test Voltage Secondary-Side to Secondary-Side[4]	$V_{ISO(SS)}$	50 Hz, 60 s		4050	V_{RMS}
Common-Mode Transient Immunity	|dv/dt|			50	kV/µs
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	20	95	%
Altitude of Operation[7]	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}	Without load			70		mA
		$P_{Gx} = P_{Gx,max}$ f_{SW} = 3.5 kHz, 50 % duty cycle			230		mA
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)	$UVLO_{VISOx}$	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			
	$UVLO_{COMx}$		Clear fault (resume operation)		-5.15		V
			Set fault (suspend operation)		-4.85		
			Hysteresis		0.3		
Output Voltage (Secondary-Side)	V_{VISOx}	Without load			25.3		V
		Referenced to V_{COMx}, $P_{Gx} = P_{Gx,max}$, f_{SW} = 3.5 kHz, 50% duty cycle			24.8		
Coupling Capacitance	C_{IO}	Primary-side to secondary-side, total per channel			TBD		pF
Logic Inputs and Status Outputs							
Input Impedance	R_{INx}	INx to GND			4.5		kΩ
Turn-On Threshold	$V_{TH-ON(INx)}$	INx to GND			10.4		V
Turn-Off Threshold	$V_{TH-OFF(INx)}$	INx to GND			4.8		V
Timing Characteristics							
Turn-On Delay	$t_{P(LH)}$	50% INx to 10% of $V_{GE(ON)}$			100		ns
Turn-Off Delay	$t_{P(HL)}$	50% INx to 90% of $V_{GE(ON)}$			100		ns
Transmission Delay of Fault State	t_{SOx}	After secondary-side fault detection			400		ns
Blocking Time	t_{BLK}	After secondary-side fault detection			20		ms
TPM Output							
Signal Repetion Frequency	F_{TPM}				1		Hz
TPM Measurement Tolerance		At 25 °C excluding NTC tolerance			3.5		K
Signal Characteristics		5 % ≤ D_{TPM} ≤ 95 %		R_{NTC} = (A1+ (A2 · D_{TPM})) / (A3+(A4 · D_{TPM})) where A1 = TBD, A2 = TBD, A3 = TBD and A4 = TBD			

Characteristics (cont.)

Parameter	Symbol	Conditions T_A = 25 °C	Min	Typ	Max	Units
Short Circuit Protection						
Static V_{CE}-Monitoring Threshold	$V_{CE(SAT)}$	1.7 kV driver version		59		V
Response Time (10% V_{GE} to 90% V_{GE})	t_{RES}	1.7 kV driver version DC-link voltage = 1200 V		8		µs
Turn-off Delay after Short-Circuit Detection	$t_{PD(SOx)}$			100		ns
Gate Output						
Turn-On Gate Voltage	$V_{GE(ON)}$			15		V
Turn-Off Gate Voltage	$V_{GE(OFF)}$	Without load		-10.3		V
		P_{Gx} = $P_{Gx,,max}$, f_{SW} = 3.5 kHz, 50% duty cycle		-9.8		
Electrical Isolation						
Test Voltage[8]	$V_{ISO(PS)}$	Primary-side to secondary-side	6813			V_{RMS}
	$V_{ISO(SS)}$	Secondary-side to secondary-side	4050			V_{RMS}
Partial Discharge Extinction Voltage[9]	$P_{D(PS)}$	Primary-side to secondary-side	2201			V_{RMS}
	$P_{D(SS)}$	Secondary-side to secondary-side	1442			V_{RMS}
Creepage Distance	CPG_{P-S}	Primary-side to secondary-side, on PCB	16			mm
	CPG_{S-S}	Secondary-side to secondary-side, on PCB	6.4			mm
Clearance Distance	CLR_{P-S}	Primary-side to secondary-side	12.2			mm
	CLR_{S-S}	Secondary-side to secondary-side	6.4			mm
Mounting						
Mounting Holes	D_{HOLE}	Diameter of screw hole S1 - S4		3.2		mm
Mounting Torque[10]	M	Screw M3				Nm
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 value applies to the transformer for 2SIXT0112T2A0. The test voltage cannot be applied to the product itself due to the desaturation protection circuits.
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 long-term reliability of the product.
8. The transformer of every production sample has undergone 100% testing at the given value for 1s.
9. Partial discharge measurement is performed on each transformer.
10. Refer to data sheet of the IGBT module.

Reliability and EMC Qualification Items

Test Item	Test Methods and Conditions
Environmental Tests[1]	
Dry heat	IEC 60068-2-2, 85 °C, 96 h, DUT operated
Cold	IEC 60068-2-1, -40 °C, 96 h, DUT operated
Thermal cycling	IEC 60068-2-14, -40 °C and 85 °C, ramp: 5 °C/min, dwell: 30 min, DUT operated, 10 cycles
Endurance Tests[1]	
High temperature operating lifetime	IEC 60068-2-2, 85 °C, test duration 1000 h, DUT operated
Damp heat	IEC 60068-2-78, 85 °C, 85% R.H., 56d, DUT operated
Thermal cycling	IEC 60068-2-14, -40 °C, 125 °C (5 K/min, 200 cycles, DUT unpowered)
EMC Tests[1]	
Electrostatic discharge	IEC 61000-4-2, ±2 kV charge voltage, Class A, 10 pulses each, contact and air discharge.
Fast Transient/Burst Immunity	IEC 61000-4-4, 5 kHz, Power ports: ±2kV, 5kHz, 300ms, Signal/control ports: ±1kV, 5kHz, 300ms, duration per test: 60s
Conducted noise immunity	IEC 61000-4-6, frequency range 0.15 – 80 MHz, 3 V_{RMS}, log 1%
Mechanical Tests[1]	
Mechanical vibrations (sinusoidal)	IEC 60068-2-6, frequency range 200 - 500 Hz (± 3.3 mm displacement, 15 m/s², 1 sweep cycles)
Mechanical shock	IEC 61373, Class 1B, acceleration 30 m/S², duration 30 ms, vertical and transversal, half sine, ±100 shocks per axis

NOTES:
1. Qualification is ongoing

Product Dimensions

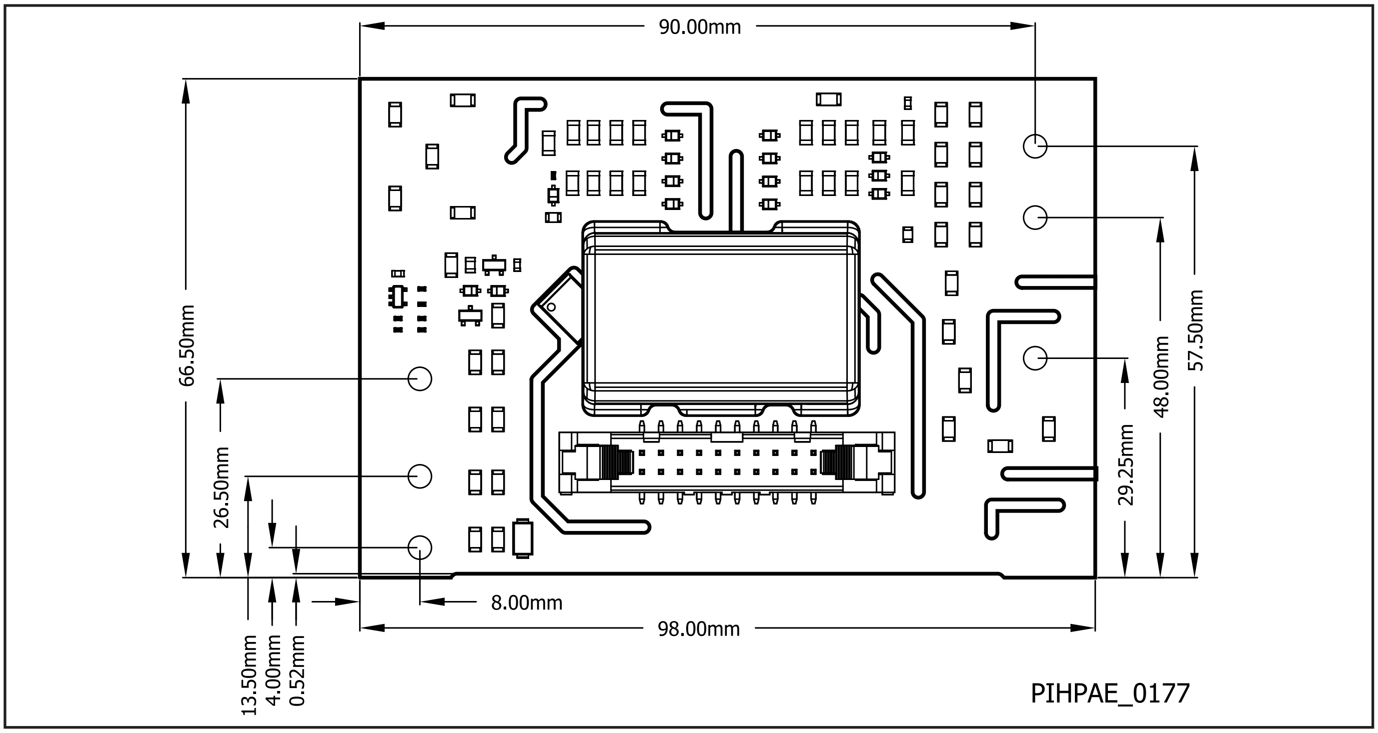

Figure 3. Top View

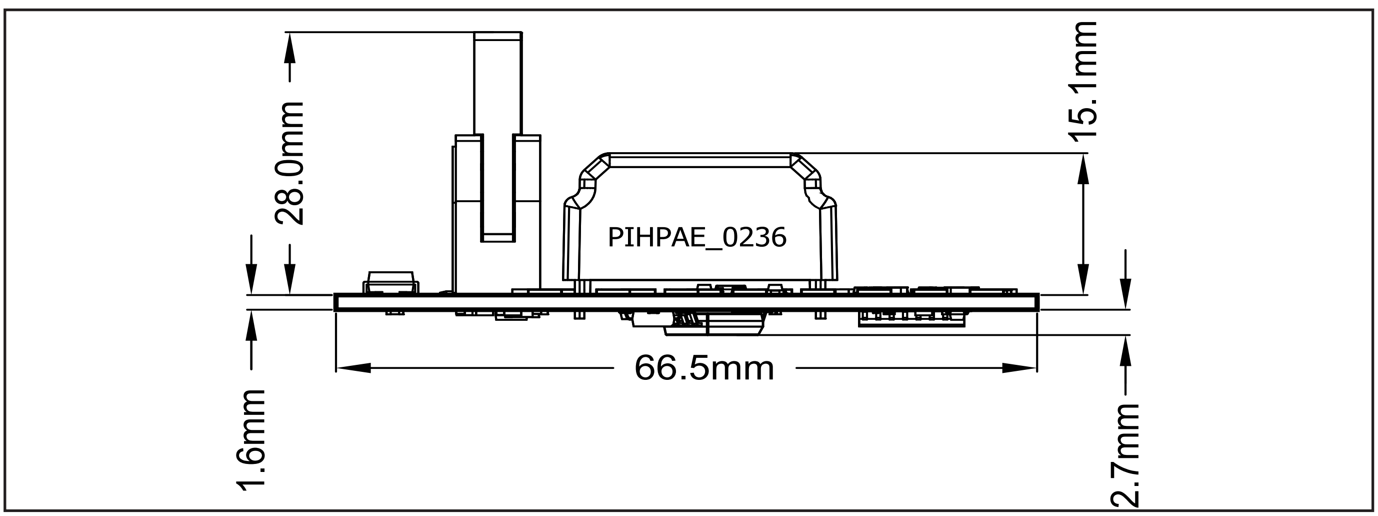

Figure 4. Side View.

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 described in 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}
2SIXT0112T2A0-FF1800XTR17T2P5	FF1800XTR17T2P5	1700 V	1800 A	XHP2	Infineon	TBD	TBD	TBD
2SIXT0112T2A0-CM1200DW-34T	CM1200DW-34T	1700 V	1200 A	LV100	Mitsubishi	TBD	TBD	TBD

Revision	Notes	Date
A	Preliminary Datasheet.	05/24

For the latest updates, visit our website: www.power.com

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