Low Side Chopper 600 V, 400 A, DIAP IGBT Power Module (Trench Field Stop IGBT)

Dual INT-A-PAK

PRIMARY CHARACTERISTICS	
IGBT Q1	
V_{CES}	600 V
I_C DC at 80 °C	375 A
$V_{CE(on)}$ (typical) at 400 A, 25 °C	1.67 V
CHOPPER DIODE D2	
V_{RRM}	600 V
I_F DC at 80 °C	278 A
V_{FM} (typical) at 400 A, 25 °C	1.61 V
t_{rr} at 400 A, 25 °C	141 ns
ANTIPARALLEL DIODE D1	
V_{RRM}	600 V
I_F DC at 80 °C	142 A
V_{FM} (typical) at 200 A, 25 °C	1.56 V
t_{rr} at 200 A, 25 °C	120 ns
Package	Dual INT-A-PAK
Circuit	Low side chopper

FEATURES

Pb-free
RoHS COMPLIANT

- Trench Field Stop IGBT technology
- 6 μs short circuit capability
- Low $V_{CE(on)}$
- Square RBSOA
- FRED Pt® antiparallel diode with ultrasoft reverse recovery characteristics
- Industry standard package
- Al_2O_3 DBC
- UL pending
- Designed for industrial level
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912

BENEFITS

- Increased operating efficiency
- Direct mounting on heatsink
- Very low junction to case thermal resistance

ABSOLUTE MAXIMUM RATINGS				
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MAX.**	**UNITS**
IGBT Q1				
Collector to emitter voltage	V_{CES}		600	V
Continuous collector current	I_C (1)	T_C = 25 °C	492	A
		T_C = 80 °C	375	
Pulsed collector current	I_{CM}	T_p = 6 ms, square pulse	850	
Clamped inductive load current	I_{LM}		693	
Gate to emitter voltage	V_{GE}		± 20	V
Maximum power dissipation	P_D	T_C = 25 °C	1363	W
		T_C = 80 °C	864	
DIODE D2				
Chopper diode continuous forward current	I_F	T_C = 25 °C	374	A
		T_C = 80 °C	278	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, T_J = 25 °C	1415	
Maximum power dissipation	P_D	T_C = 25 °C	652	W
		T_C = 80 °C	413	
DIODE D1				
Antiparallel diode continuous forward current	I_F	T_C = 25 °C	192	A
		T_C = 80 °C	142	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, T_J = 25 °C	725	
Maximum power dissipation	P_D	T_C = 25 °C	312	W
		T_C = 80 °C	198	
RMS isolation voltage	V_{ISOL}	Any terminal to case (V_{RMS} t = 1 s, T_J = 25 °C)	3500	V
Storage temperature range	T_{STG}		-40 to 150	°C
Operating junction temperature range	T_J		-40 to +175	°C

Note

(1) Maximum continuous collector current must be limited to 500 A to do not exceed the maximum temperature of terminals

ELECTRICAL SPECIFICATIONS (T_J = 25 °C unless otherwise specified)						
PARAMETER	**SYMBOL**	**TEST CONDITIONS**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
IGBT Q1						
Collector to emitter breakdown voltage	$V_{BR(CES)}$	V_{GE} = 0 V, I_C = 500 μA	600	-	-	V
Collector to emitter voltage	$V_{CE(on)}$	V_{GE} = 15 V, I_C = 300 A	-	1.48	-	
		V_{GE} = 15 V, I_C = 400 A	-	1.67	2.0	
		V_{GE} = 15 V, I_C = 300 A, T_J = 125 °C	-	1.64	-	
		V_{GE} = 15 V, I_C = 400 A, T_J = 125 °C	-	1.93	-	
Gate threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}$, I_C = 6.4 mA	4.6	5.9	7	
		$V_{CE} = V_{GE}$, I_C = 6.4 mA, T_J = 125 °C	-	4.6	-	
Temperature coefficient of threshold voltage	$\Delta V_{GE(th)}/\Delta T$	$V_{CE} = V_{GE}$, I_C = 6.4 mA, (25 °C to 125 °C)	-	-13	-	mV/°C
Forward transconductance	g_{fe}	V_{CE} = 20 V, I_C = 400 A	-	70	-	mS
Transfer characteristics	V_{GE}	V_{CE} = 20 V, I_C = 400 A	-	9.1	-	V
Collector to emitter leakage current	I_{CES}	V_{GE} = 0 V, V_{CE} = 600 V	-	0.2	20	μA
		V_{GE} = 0 V, V_{CE} = 600 V, T_J = 150 °C	-	1.6	-	mA
Gate to emitter leakage current	I_{GES}	V_{GE} = ± 20 V	-	-	± 1200	nA
DIODE D1						
Antiparallel diode forward voltage drop	V_{FM}	I_{FM} = 100 A	-	1.32	-	V
		I_{FM} = 200 A	-	1.56	1.82	
		I_{FM} = 100 A, T_J = 150 °C	-	1.1	-	
		I_{FM} = 200 A, T_J = 150 °C	-	1.42	-	
DIODE D2						
Blocking voltage	V_{RRM}	I_R = 500 μA	600	-	-	V
Leakage current	I_{RRM}	V_R = 600 V	-	0.2	15	μA
		V_R = 600 V, T_J = 150 °C	-	2.8	-	mA
Chopper diode forward voltage drop	V_{FM}	I_{FM} = 300 A	-	1.48	-	V
		I_{FM} = 400 A	-	1.61	1.92	
		I_{FM} = 300 A, T_J = 150 °C	-	1.34	-	
		I_{FM} = 400 A, T_J = 150 °C	-	1.51	-	

SWITCHING CHARACTERISTICS (T_J = 25 °C unless otherwise specified)							
PARAMETER	**SYMBOL**	**TEST CONDITIONS**		**MIN.**	**TYP.**	**MAX.**	**UNITS**
IGBT Q1							
Total gate charge (turn-on)	Q_g	I_C = 400 A, V_{CC} = 480 V, V_{GE} = 15 V		-	1970	-	nC
Gate to emitter charge (turn-on)	Q_{ge}			-	144	-	
Gate to collector charge (turn-on)	Q_{gc}			-	1240	-	
Turn-off switching energy	E_{off}	$R_{g\ (off)}$ = 1 Ω	I_C = 300 A, V_{CC} = 300 V, V_{GE} = ± 15 V, L = 500 μH, T_J = 25 °C	-	12.9	-	mJ
Turn-off delay time	$t_{d(off)}$			-	594	-	ns
Fall time	t_f			-	77	-	
Turn-on switching energy	E_{on}	$R_{g\ (on)}$ = 6.8 Ω		-	12.8	-	mJ
Turn-on delay time	$t_{d(on)}$			-	337	-	ns
Rise time	t_r			-	197	-	
Turn-off switching energy	E_{off}	$R_{g\ (off)}$ = 1 Ω	I_C = 300 A, V_{CC} = 300 V, V_{GE} = ± 15 V, L = 500 μH, T_J = 125 °C	-	14.7	-	mJ
Turn-off delay time	$t_{d(off)}$			-	638	-	ns
Fall time	T_f			-	91	-	
Turn-on switching energy	E_{on}	$R_{g\ (on)}$ = 6.8 Ω		-	13.4	-	mJ
Turn-on delay time	$t_{d(on)}$			-	339	-	ns
Rise time	t_r			-	204	-	

SWITCHING CHARACTERISTICS (T_J = 25 °C unless otherwise specified)							
PARAMETER	**SYMBOL**	**TEST CONDITIONS**		**MIN.**	**TYP.**	**MAX.**	**UNITS**
Turn-off switching energy	E_{off}	$R_{g\ (off)}$ = 1 Ω	I_C = 400 A, V_{CC} = 300 V, V_{GE} = ± 15 V, L = 500 µH, T_J = 25 °C	-	19.3	-	mJ
Turn-off delay time	$t_{d(off)}$			-	593	-	ns
Fall time	t_f			-	82	-	
Turn-on switching energy	E_{on}	$R_{g\ (on)}$ = 6.8 Ω		-	15.6	-	mJ
Turn-on delay time	$t_{d(on)}$			-	354	-	ns
Rise time	t_r			-	238	-	
Turn-off switching energy	E_{off}	$R_{g\ (off)}$ = 1 Ω	I_C = 400 A, V_{CC} = 300 V, V_{GE} = ± 15 V, L = 500 µH, T_J = 125 °C	-	21.2	-	mJ
Turn-off delay time	$t_{d(off)}$			-	631	-	ns
Fall time	T_f			-	92	-	
Turn-on switching energy	E_{on}	$R_{g\ (on)}$ = 6.8 Ω		-	17.2	-	mJ
Turn-on delay time	$t_{d(on)}$			-	365	-	ns
Rise time	t_r			-	246	-	
Reverse bias safe operating area	RBSOA	T_J = 175 °C, I_C = 693 A, R_g = 10 Ω, V_{GE} = 15 V to 0 V, V_{CC} = 400 V, V_p = 600 V		Fullsquare			
Short circuit safe operating area [(1)(2)]	SCSOA	T_J = 150 °C, V_{CC} = 360 V, V_{GE} = 15 V		-	-	6	µs
DIODE D2							
Diode reverse recovery time	t_{rr}	I_F = 400 A, V_{CC} = 400 V, T_J = 25 °C, dI/dt = 1000 A/µs,		-	141	-	ns
Diode peak reverse current	I_{rr}			-	41	-	A
Diode recovery charge	Q_{rr}			-	3.2	-	µC
Diode reverse recovery time	t_{rr}	I_F = 400 A, V_{CC} = 400 V, T_J = 125 °C, dI/dt = 1000 A/µs,		-	230	-	ns
Diode peak reverse current	I_{rr}			-	77	-	A
Diode recovery charge	Q_{rr}			-	10.2	-	µC
DIODE D1							
Diode reverse recovery time	t_{rr}	I_F = 200 A, V_R = 400 V, T_J = 25 °C, dI/dt = 1000 A/µs,		-	120	-	ns
Diode peak reverse current	I_{rr}			-	28	-	A
Diode recovery charge	Q_{rr}			-	2.2	-	µC
Diode reverse recovery time	t_{rr}	I_F = 200 A, V_R = 400 V, T_J = 125 °C, dI/dt = 1000 A/µs,		-	165	-	ns
Diode peak reverse current	I_{rr}			-	90	-	A
Diode recovery charge	Q_{rr}			-	9.1	-	µC

Notes

(1) Not subject to production test - verified by design / characterization

(2) Allowed number of short circuits: < 1000; time between short circuits: > 1 s

THERMAL AND MECHANICAL SPECIFICATIONS						
PARAMETER		**SYMBOL**	**MIN.**	**TYP.**	**MAX.**	**UNITS**
Operating junction temperature range		T_J	-40	-	175	°C
Storage temperature range		T_{Stg}	-40	-	150	
Thermal resistance, junction to case per leg	Q1 IGBT	R_{thJC}	-	-	0.11	°C/W
	D1 diode		-	-	0.48	
	D2 diode		-	-	0.23	
Thermal resistance, case to sink per module		R_{thCS}	-	0.05	-	
Mounting torque	Power terminal screw: M6		2.5	-	5.0	Nm
	Mounting screw: M6		3.0	-	5.0	
Weight			-	300	-	g

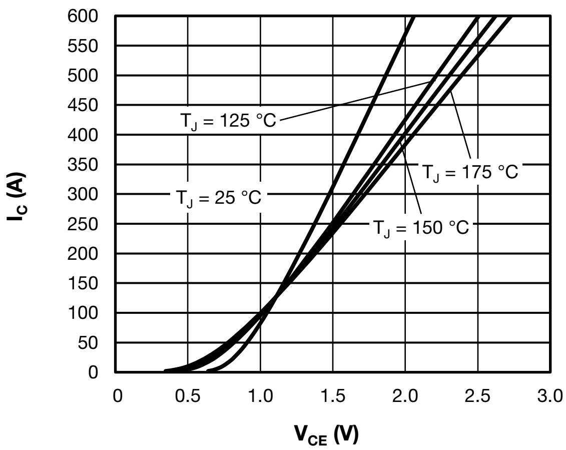


Fig. 1 - Typical IGBT Output Characteristics, V_{GE} = 15 V

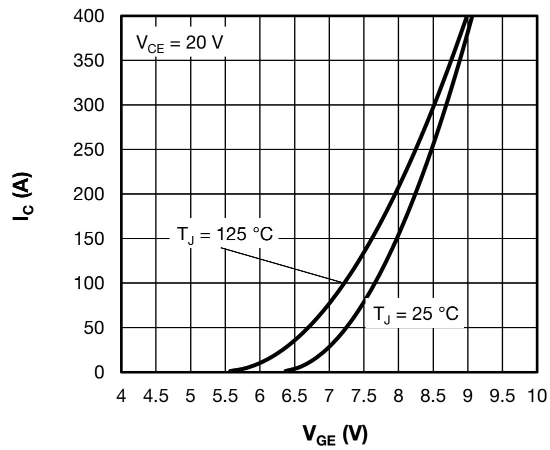


Fig. 4 - Typical IGBT Transfer Characteristics

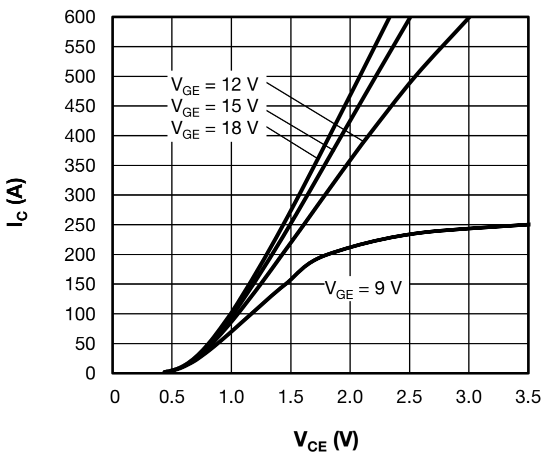


Fig. 2 - Typical IGBT Output Characteristics, T_J = 125 °C

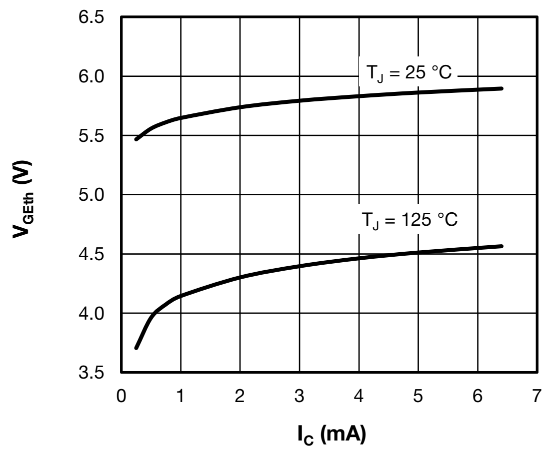


Fig. 5 - Typical IGBT Gate Threshold Voltage

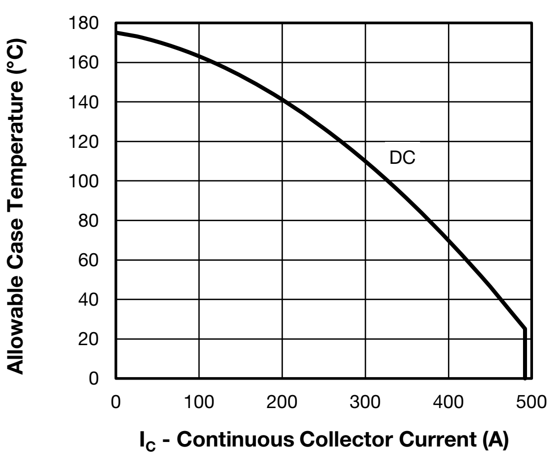


Fig. 3 - Maximum IGBT Continuous Collector Current vs. Case Temperature

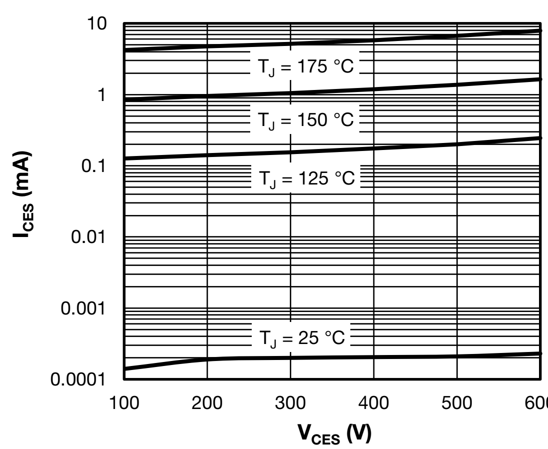


Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

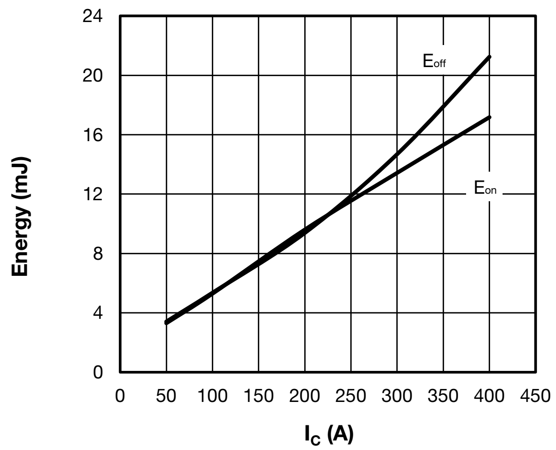


Fig. 7 - Typical IGBT Energy Loss vs. I_C with Freewheeling Diode
T_J = 125 °C, V_{CC} = 300 V, $R_{g(on)}$ = 6.8Ω, $R_{g(off)}$ = 1Ω
V_{GE} = +15 V/-15 V, L = 500 μH

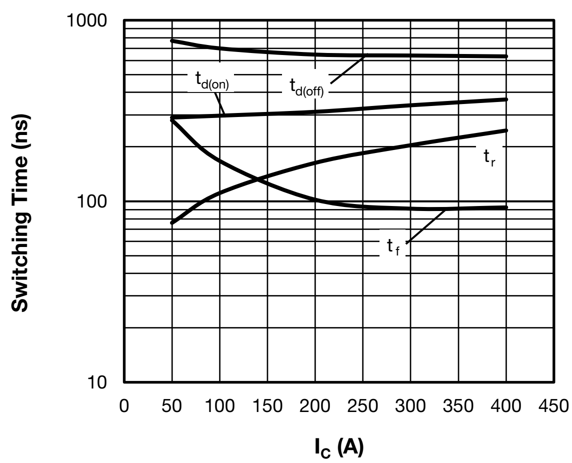


Fig. 8 - Typical Trench IGBT Switching Time vs. I_C
with Freewheeling Diode
T_J = 125 °C, V_{CC} = 300 V, $R_{g(on)}$ = 6.8 Ω, $R_{g(off)}$ = 1 Ω,
V_{GE} = +15 V/-15 V, L = 500 μH

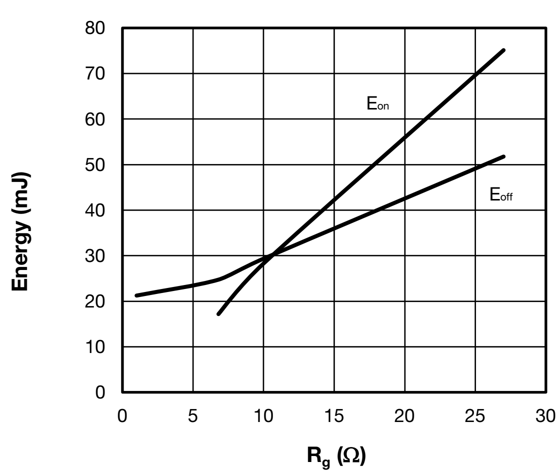


Fig. 9 - Typical Trench IGBT Energy Loss vs. R_g
with Freewheeling Diode
T_J = 125 °C, V_{CC} = 300 V, I_C = 400 A, V_{GE} = +15 V/-15 V, L = 500 μH

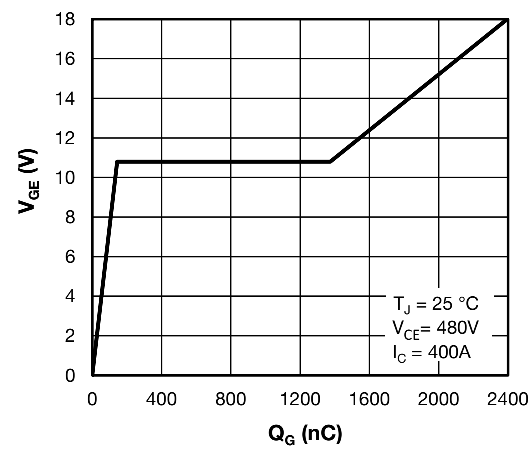


Fig. 10 - Typical Trench IGBT Gate Charge vs.
Gate to Emitter Voltage

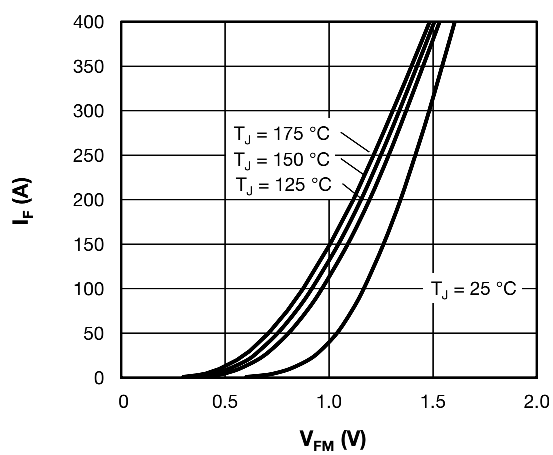


Fig. 11 - Typical D2 Diode Forward Characteristics

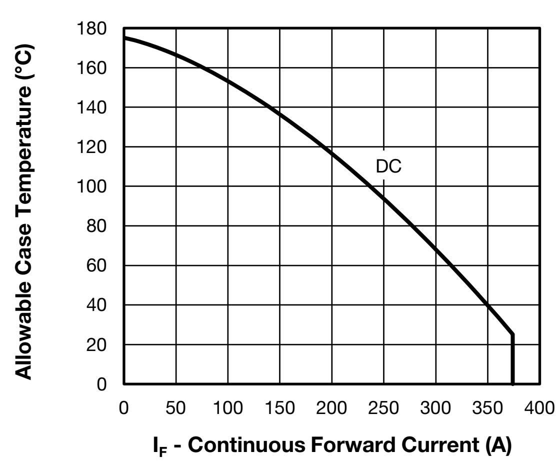


Fig. 12 - Maximum D2 Diode Continuous Forward Current vs. Case Temperature

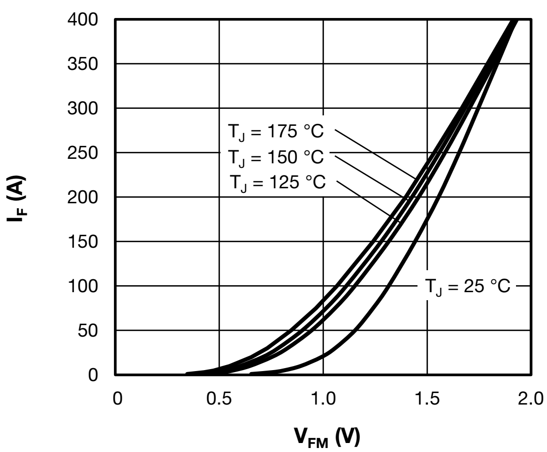


Fig. 13 - Typical D1 Diode Forward Characteristics

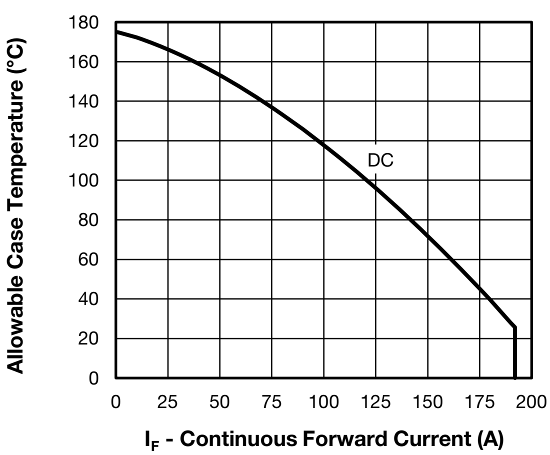


Fig. 14 - Maximum D1 Diode Continuous Forward Current vs. Case Temperature

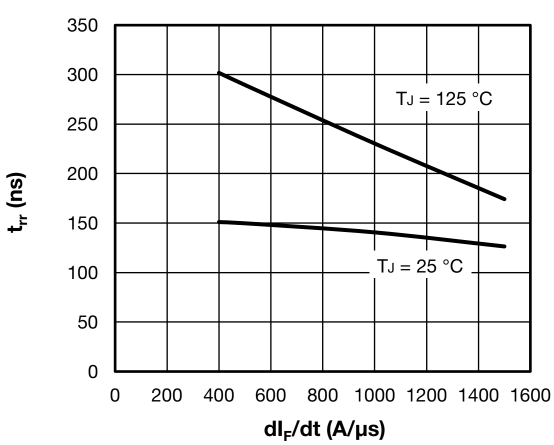


Fig. 15 - Typical Diode Reverse Recovery Time vs. dI_F/dt

I_F = 400 A, V_{CC} = 400 V

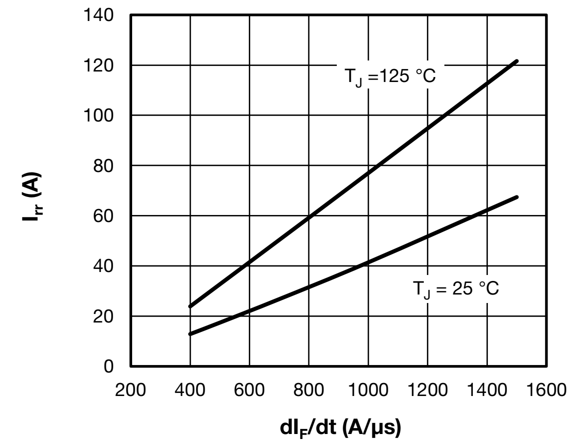


Fig. 16 - Typical Diode Reverse Recovery Current vs. dI_F/dt
I_F = 400 A, V_{CC} = 400 V

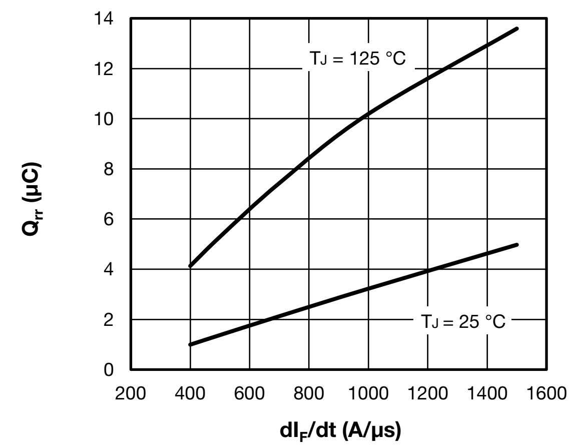


Fig. 17 - Typical Diode Reverse Recovery Charge vs. dI_F/dt
I_F = 400 A, V_{CC} = 400 V

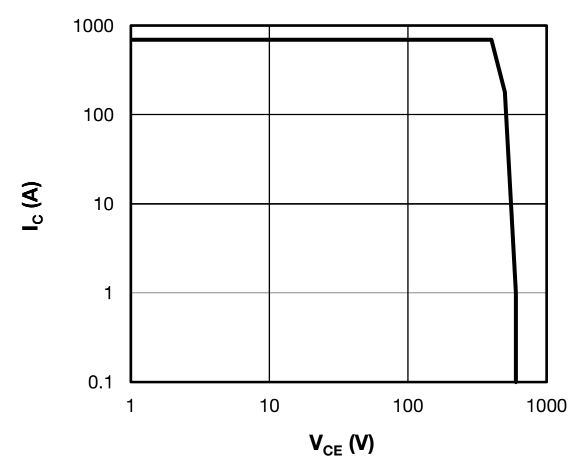


Fig. 18 - IGBT Reverse BIAS SOA
T_J = 175 °C, I_C= 693 A, R_g = 10 Ω, V_{GE} = +15 V / 0 V,

V_{CC} = 400 V, V_p = 600 V

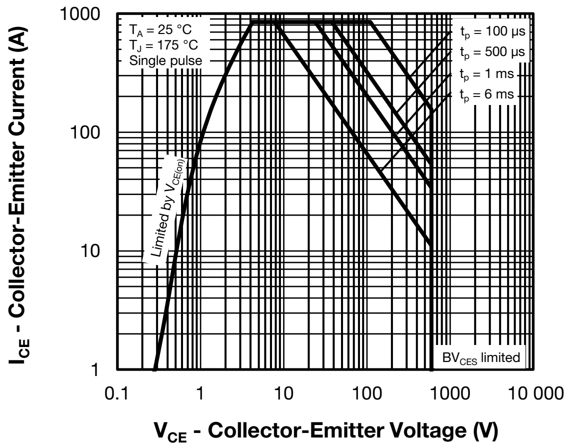


Fig. 19 - IGBT Safe Operating Area

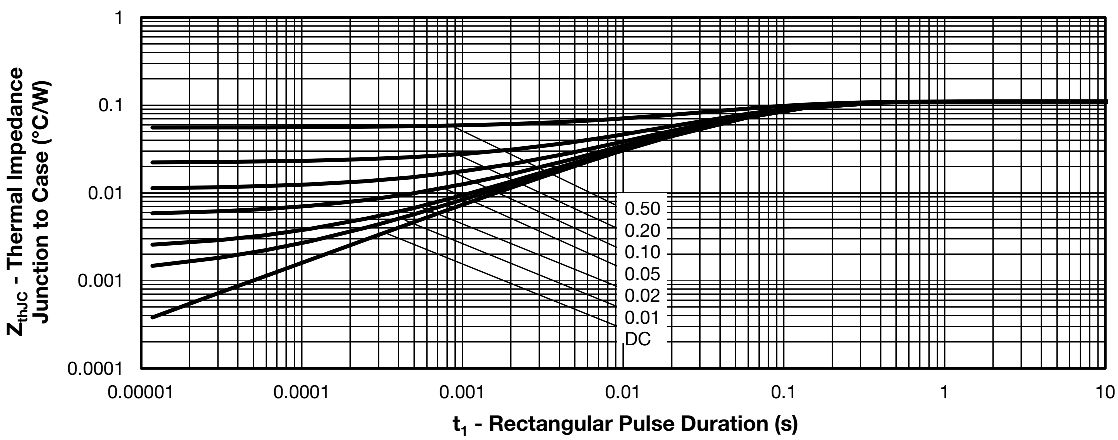


Fig. 20 - Maximum IGBT Thermal Impedance Z_{thJC} Characteristics

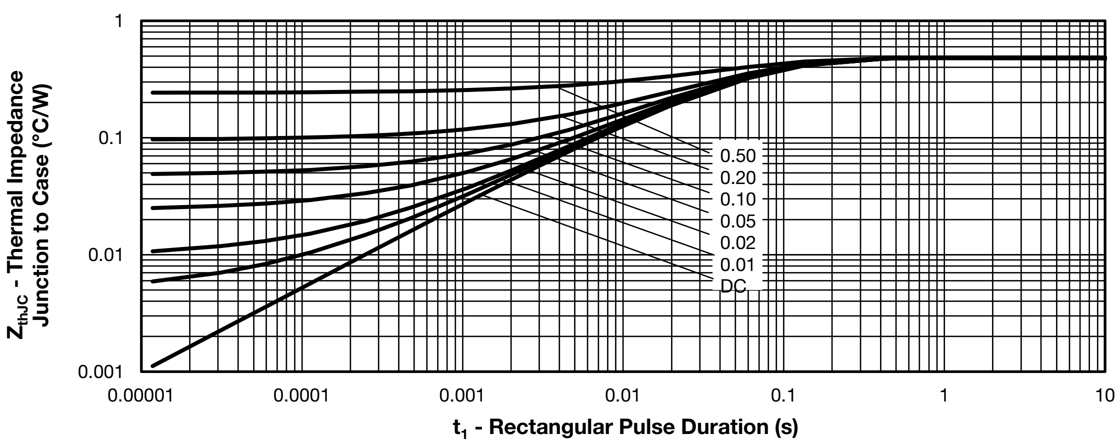


Fig. 21 - Maximum D1 Diode Thermal Impedance Z_{thJC} Characteristics

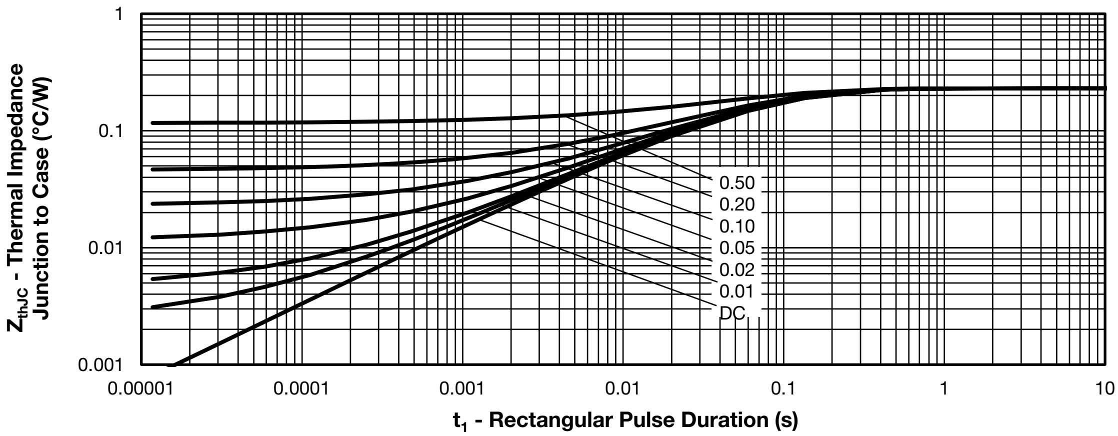


Fig. 22 - Maximum D2 Diode Thermal Impedance Z_{thJC} Characteristics

ORDERING INFORMATION TABLE

Device code	VS-	G	T	400	L	H	060	N
	1	2	3	4	5	6	7	8

1 - Vishay Semiconductors product

2 - Insulated gate bipolar transistor (IGBT)

3 - T = Trench Field Stop IGBT technology

4 - Current rating (400 = 400 A)

5 - Circuit configuration (L = low side chopper)

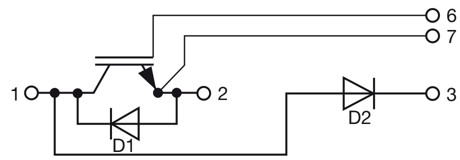
6 - Package indicator (H = Dual INT-A-PAK)

7 - Voltage rating (060 = 600 V)

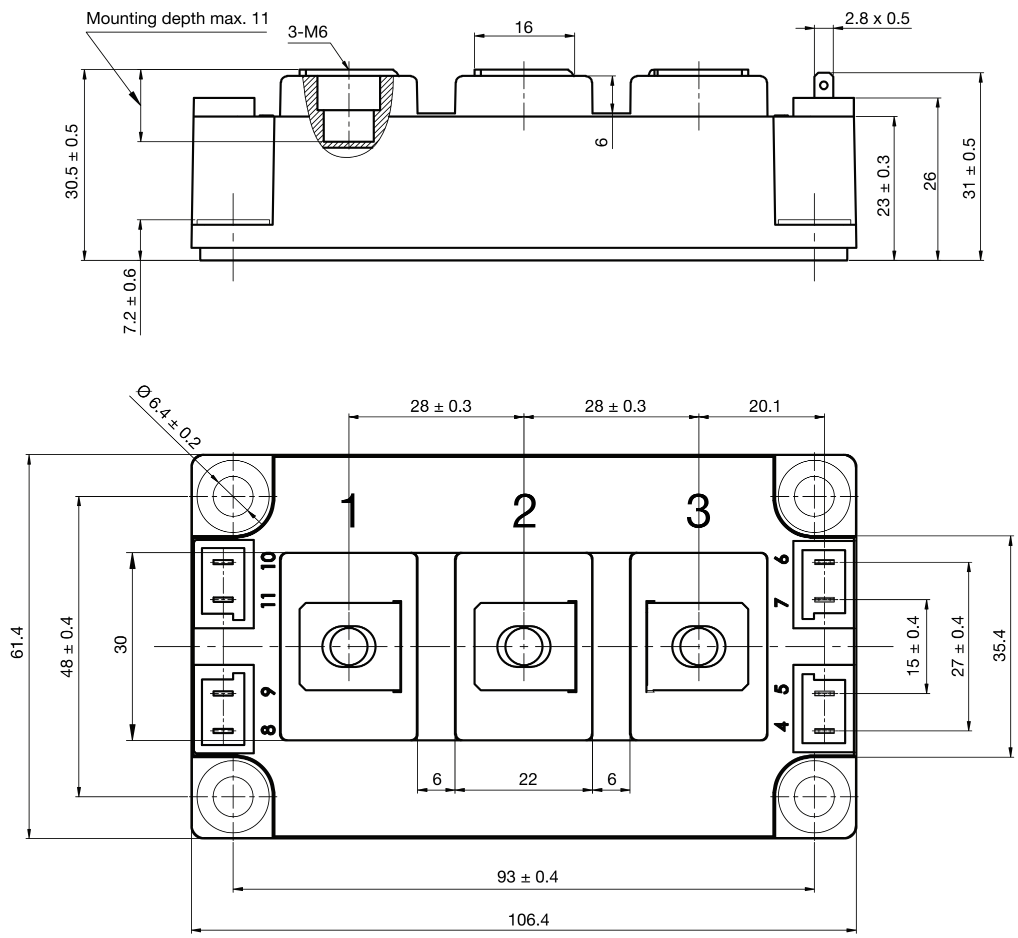
8 - N = none

LINKS TO RELATED DOCUMENTS	
Dimensions	www.vishay.com/doc?95525
Application Note	www.vishay.com/doc?95553

CIRCUIT CONFIGURATION

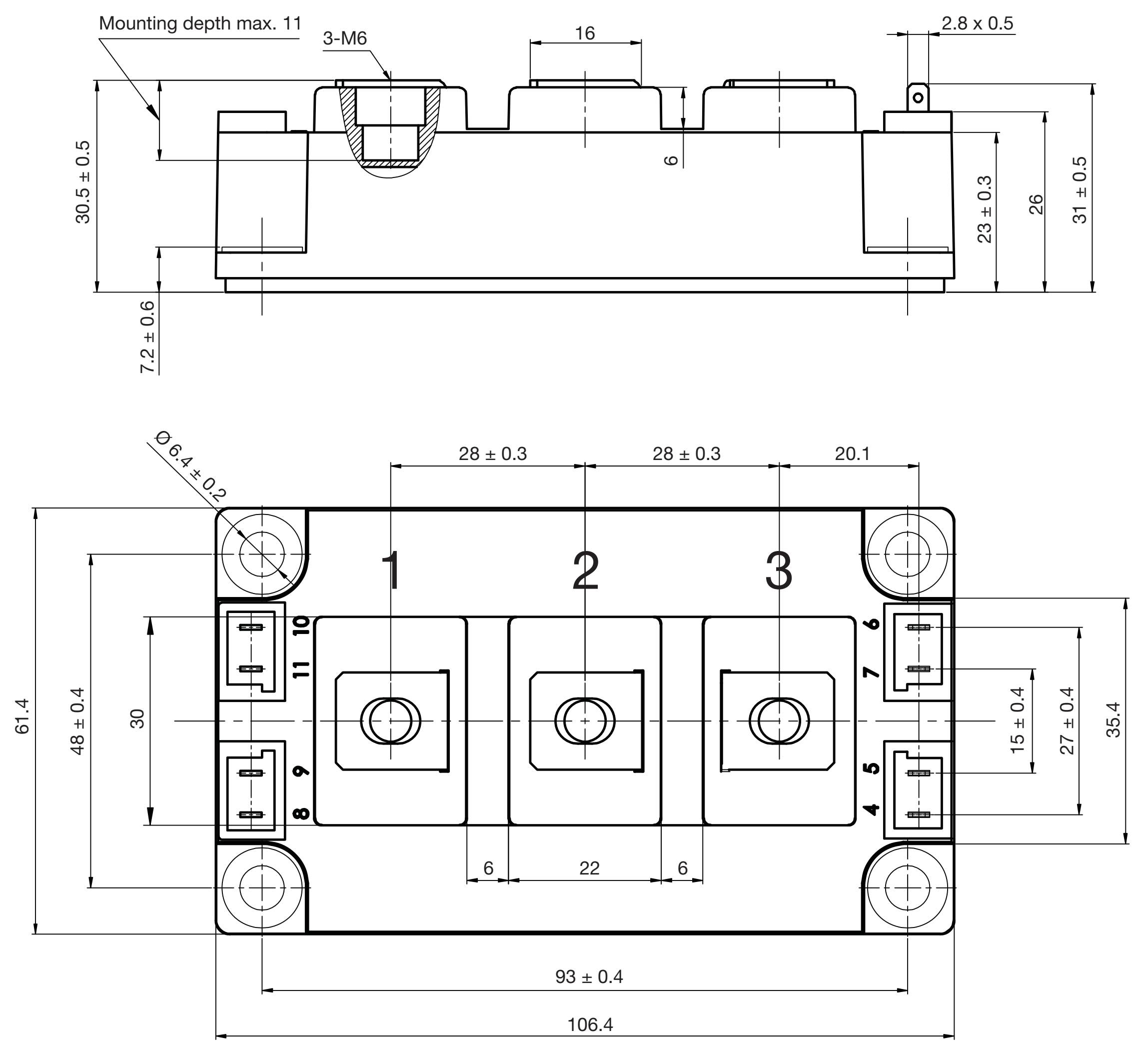


DIMENSIONS in millimeters



Double INT-A-PAK

DIMENSIONS in millimeters (inches)



Disclaimer

ALL PRODUCT, PRODUCT SPECIFICATIONS AND DATA ARE SUBJECT TO CHANGE WITHOUT NOTICE TO IMPROVE RELIABILITY, FUNCTION OR DESIGN OR OTHERWISE.

Vishay Intertechnology, Inc., its affiliates, agents, and employees, and all persons acting on its or their behalf (collectively, "Vishay"), disclaim any and all liability for any errors, inaccuracies or incompleteness contained in any datasheet or in any other disclosure relating to any product.

Vishay makes no warranty, representation or guarantee regarding the suitability of the products for any particular purpose or the continuing production of any product. To the maximum extent permitted by applicable law, Vishay disclaims (i) any and all liability arising out of the application or use of any product, (ii) any and all liability, including without limitation special, consequential or incidental damages, and (iii) any and all implied warranties, including warranties of fitness for particular purpose, non-infringement and merchantability.

Statements regarding the suitability of products for certain types of applications are based on Vishay's knowledge of typical requirements that are often placed on Vishay products in generic applications. Such statements are not binding statements about the suitability of products for a particular application. It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application. Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time. All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts. Product specifications do not expand or otherwise modify Vishay's terms and conditions of purchase, including but not limited to the warranty expressed therein.

Hyperlinks included in this datasheet may direct users to third-party websites. These links are provided as a convenience and for informational purposes only. Inclusion of these hyperlinks does not constitute an endorsement or an approval by Vishay of any of the products, services or opinions of the corporation, organization or individual associated with the third-party website. Vishay disclaims any and all liability and bears no responsibility for the accuracy, legality or content of the third-party website or for that of subsequent links.

Vishay products are not designed for use in life-saving or life-sustaining applications or any application in which the failure of the Vishay product could result in personal injury or death unless specifically qualified in writing by Vishay. Customers using or selling Vishay products not expressly indicated for use in such applications do so at their own risk. Please contact authorized Vishay personnel to obtain written terms and conditions regarding products designed for such applications.

No license, express or implied, by estoppel or otherwise, to any intellectual property rights is granted by this document or by any conduct of Vishay. Product names and markings noted herein may be trademarks of their respective owners.