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

- 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

Pb-free
RoHS
COMPLIANT

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
		V_{GE} = 15 V, I_C = 400 A	-	1.67	2.0	V
		V_{GE} = 15 V, I_C = 300 A, T_J = 125 °C	-	1.64	-	V
		V_{GE} = 15 V, I_C = 400 A, T_J = 125 °C	-	1.93	-	V
Gate threshold voltage	$V_{GE(th)}$	V_{CE} = V_{GE}, I_C = 6.4 mA	4.6	5.9	7	V
		V_{CE} = V_{GE}, I_C = 6.4 mA, T_J = 125 °C	-	4.6	-	V
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	V
		I_{FM} = 100 A, T_J = 150 °C	-	1.1	-	V
		I_{FM} = 200 A, T_J = 150 °C	-	1.42	-	V
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	V
		I_{FM} = 300 A, T_J = 150 °C	-	1.34	-	V
		I_{FM} = 400 A, T_J = 150 °C	-	1.51	-	V

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	-	nC
Gate to collector charge (turn-on)	Q_{gc}			-	1240	-	nC
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	-	ns
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	-	ns
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	-	ns
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	-	ns

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

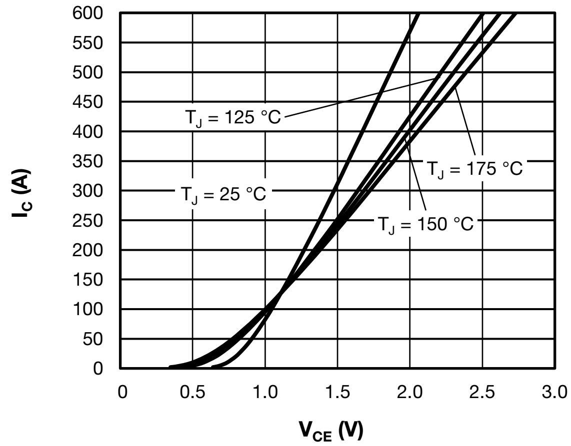


Fig. 1 - Typical IGBT Output Characteristics, $V_{GE} = 15$ V

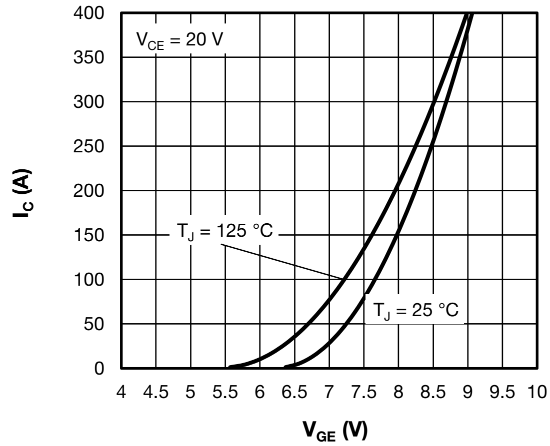


Fig. 4 - Typical IGBT Transfer Characteristics

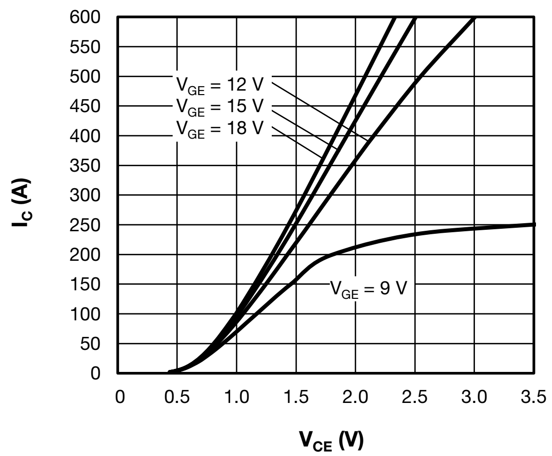


Fig. 2 - Typical IGBT Output Characteristics, $T_J = 125$ °C

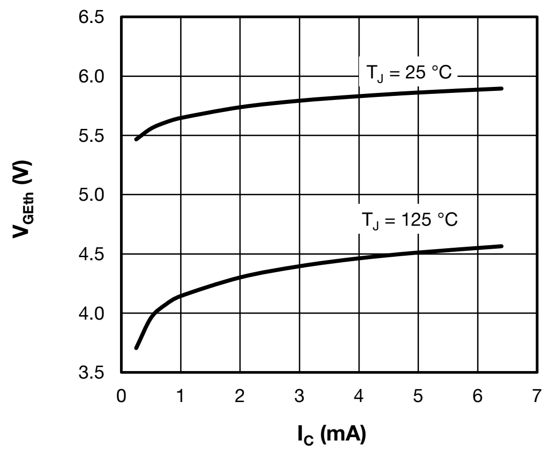


Fig. 5 - Typical IGBT Gate Threshold Voltage

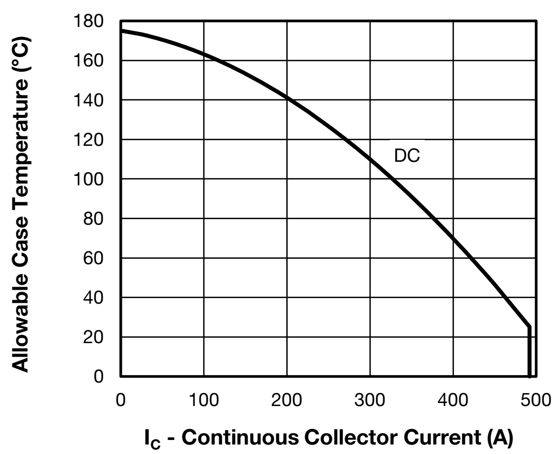


Fig. 3 - Maximum IGBT Continuous Collector Current vs. Case Temperature

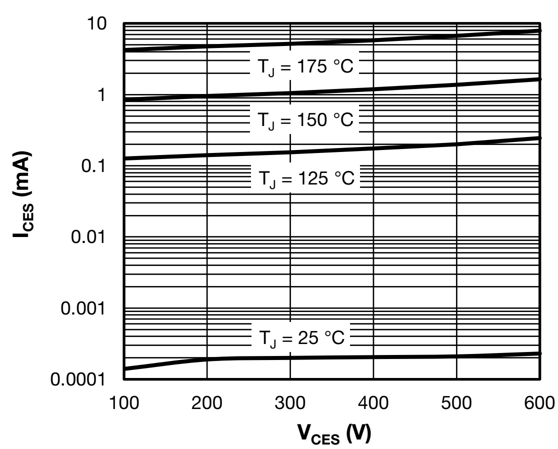


Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

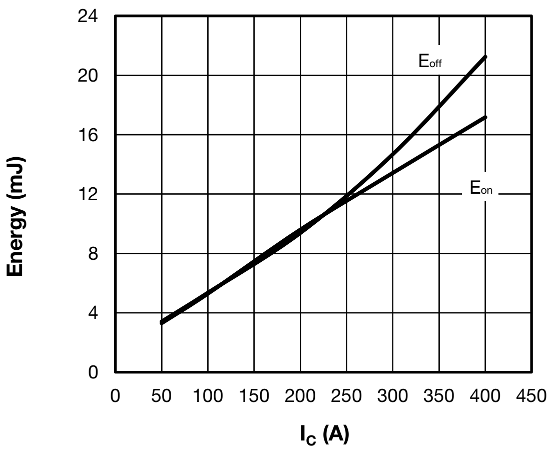


Fig. 7 - Typical IGBT Energy Loss vs. I_C with Freewheeling Diode
T_J = 125 °C, V_{CC} = 300 V, $R_{g(on)}$ = 6.8Ω, $R_{g(off)}$ = 1Ω
V_{GE} = +15 V/-15 V, L = 500 μH

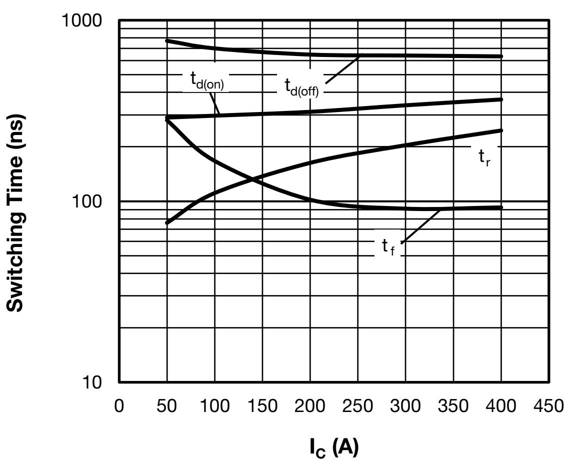


Fig. 8 - Typical Trench IGBT Switching Time vs. I_C
with Freewheeling Diode
T_J = 125 °C, V_{CC} = 300 V, $R_{g(on)}$ = 6.8 Ω, $R_{g(off)}$ = 1 Ω,
V_{GE} = +15 V/-15 V, L = 500 μH

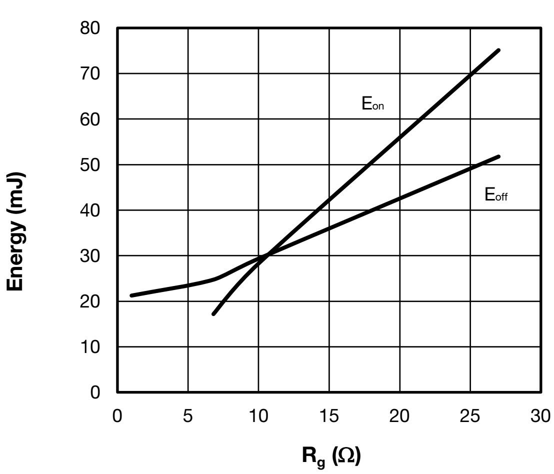


Fig. 9 - Typical Trench IGBT Energy Loss vs. R_g

with Freewheeling Diode
T_J = 125 °C, V_{CC} = 300 V, I_C = 400 A, V_{GE} = +15 V/-15 V, L = 500 μH

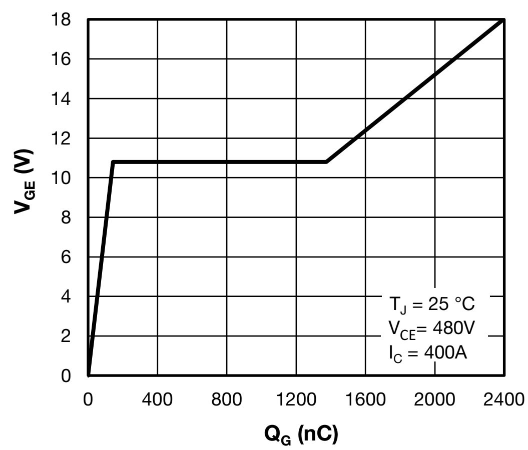


Fig. 10 - Typical Trench IGBT Gate Charge vs.
Gate to Emitter Voltage

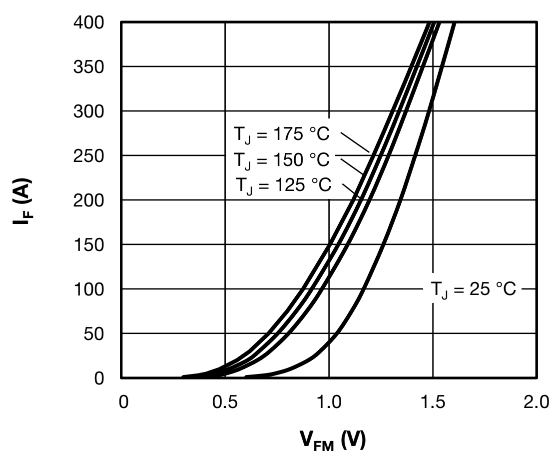


Fig. 11 - Typical D2 Diode Forward Characteristics

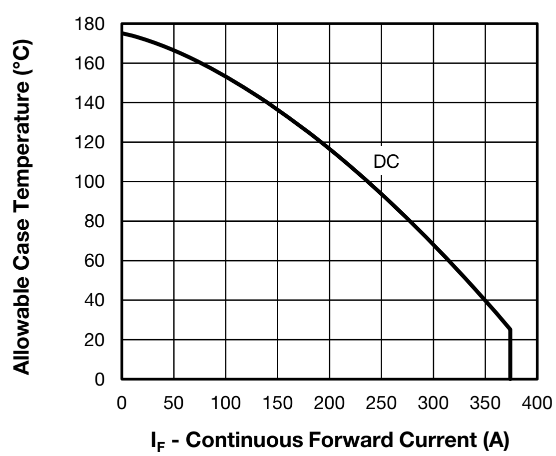


Fig. 12 - Maximum D2 Diode Continuous Forward Current vs. Case Temperature

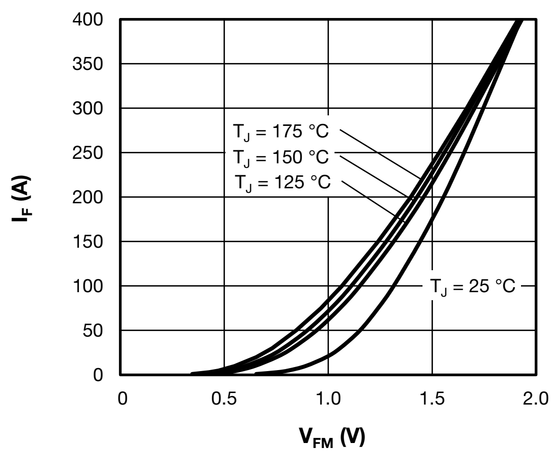


Fig. 13 - Typical D1 Diode Forward Characteristics

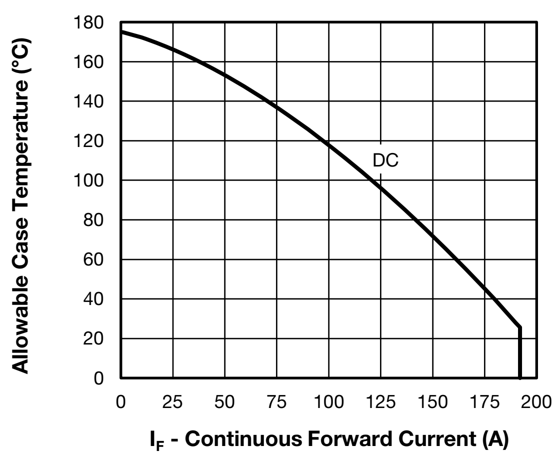


Fig. 14 - Maximum D1 Diode Continuous Forward Current vs. Case Temperature

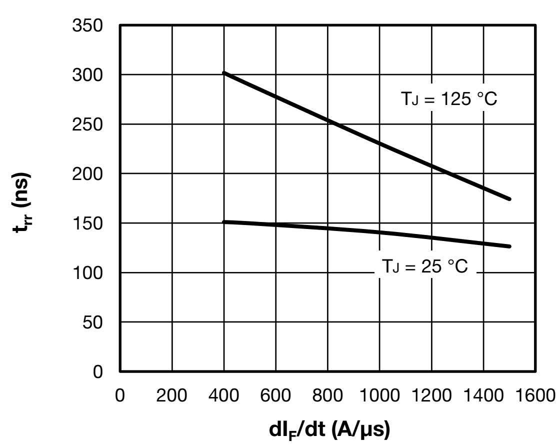


Fig. 15 - Typical Diode Reverse Recovery Time vs. dI_F/dt

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

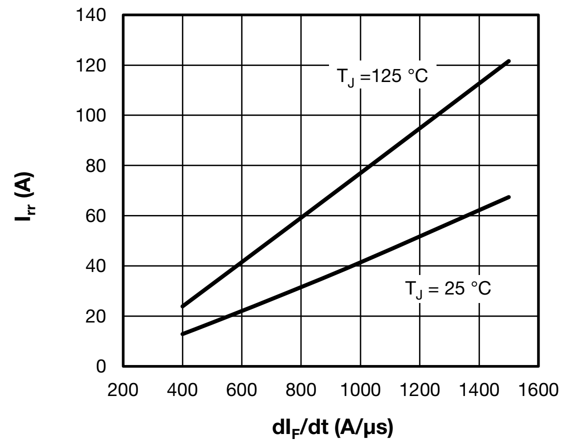


Fig. 16 - Typical Diode Reverse Recovery Current vs. dI_F/dt
I_F = 400 A, V_{CC} = 400 V

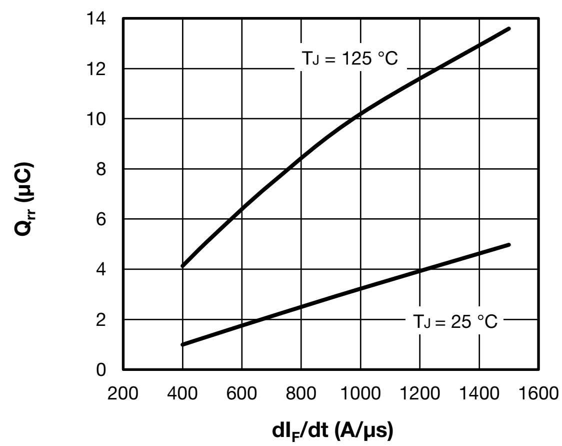


Fig. 17 - Typical Diode Reverse Recovery Charge vs. dI_F/dt
I_F = 400 A, V_{CC} = 400 V

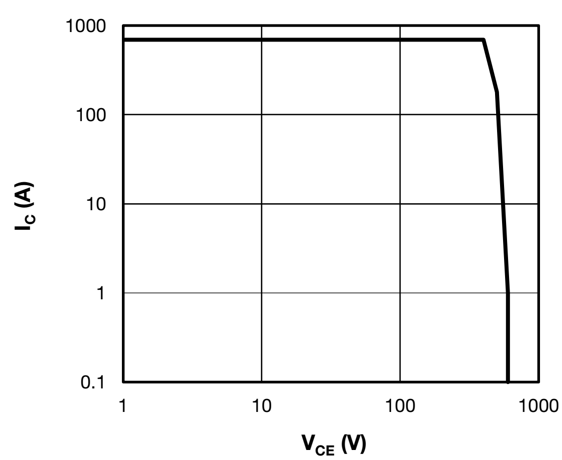


Fig. 18 - IGBT Reverse BIAS SOA
T_J = 175 °C, I_C= 693 A, R_g = 10 Ω, V_{GE} = +15 V / 0 V,

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

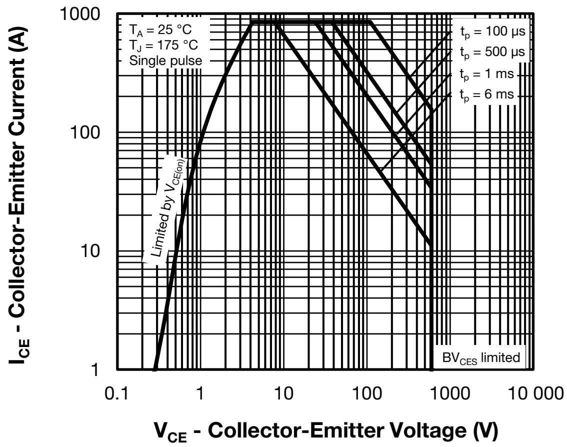


Fig. 19 - IGBT Safe Operating Area

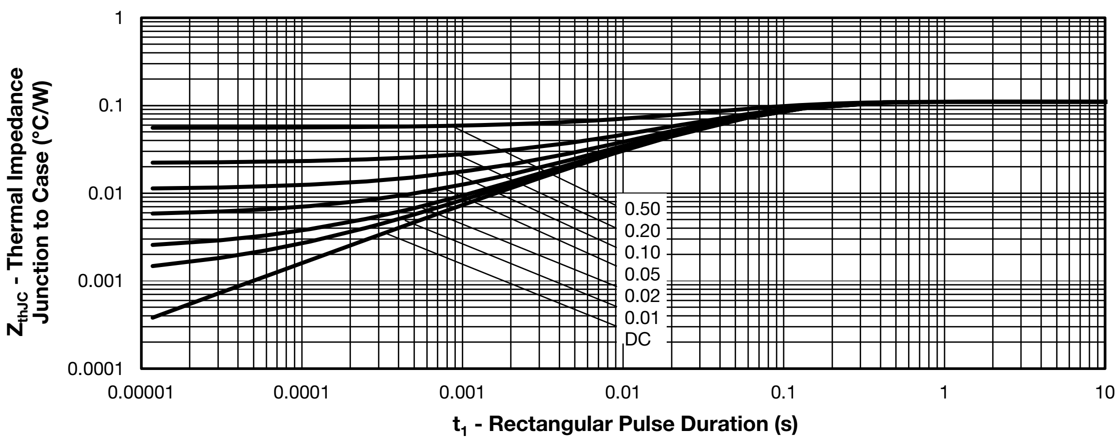


Fig. 20 - Maximum IGBT Thermal Impedance Z_{thJC} Characteristics

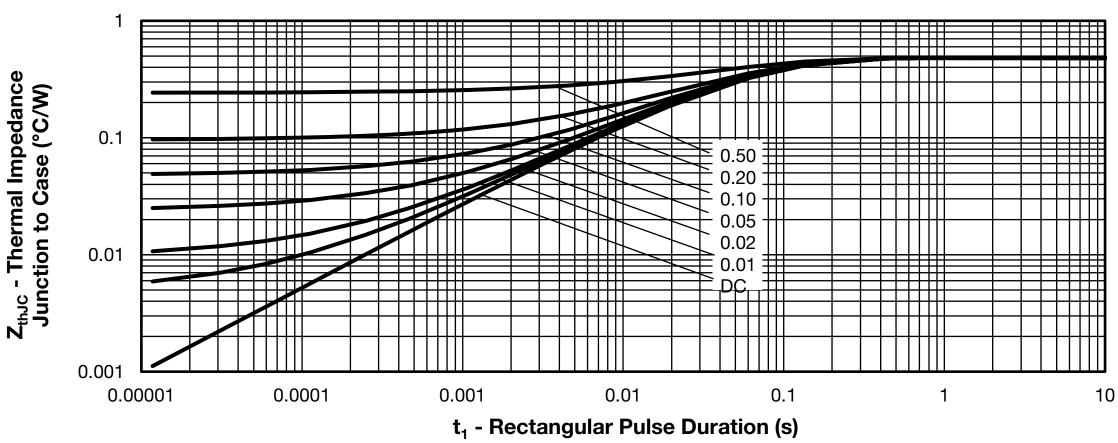


Fig. 21 - Maximum D1 Diode Thermal Impedance Z_{thJC} Characteristics

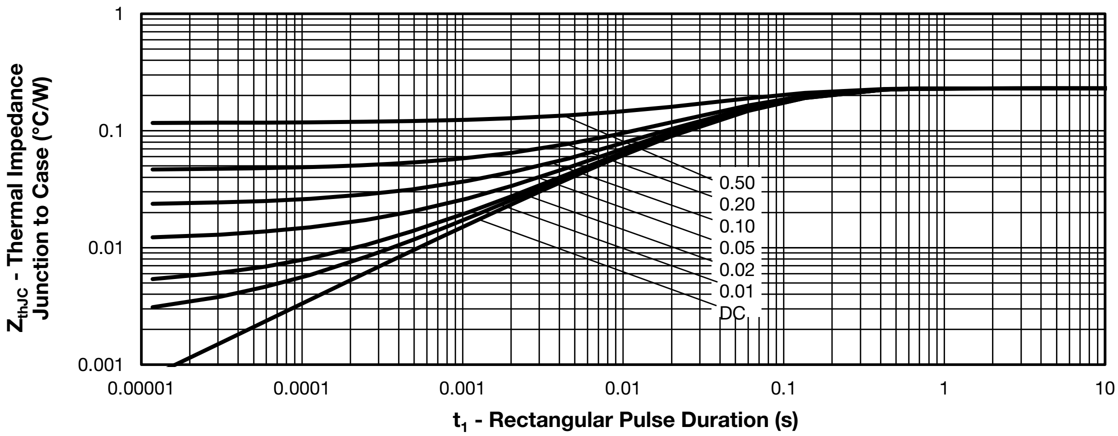


Fig. 22 - Maximum D2 Diode Thermal Impedance Z_{thJC} Characteristics

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)

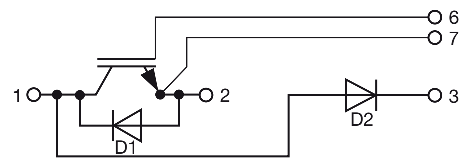
6 - Package indicator (H = Dual INT-A-PAK)

7 - Voltage rating (060 = 600 V)

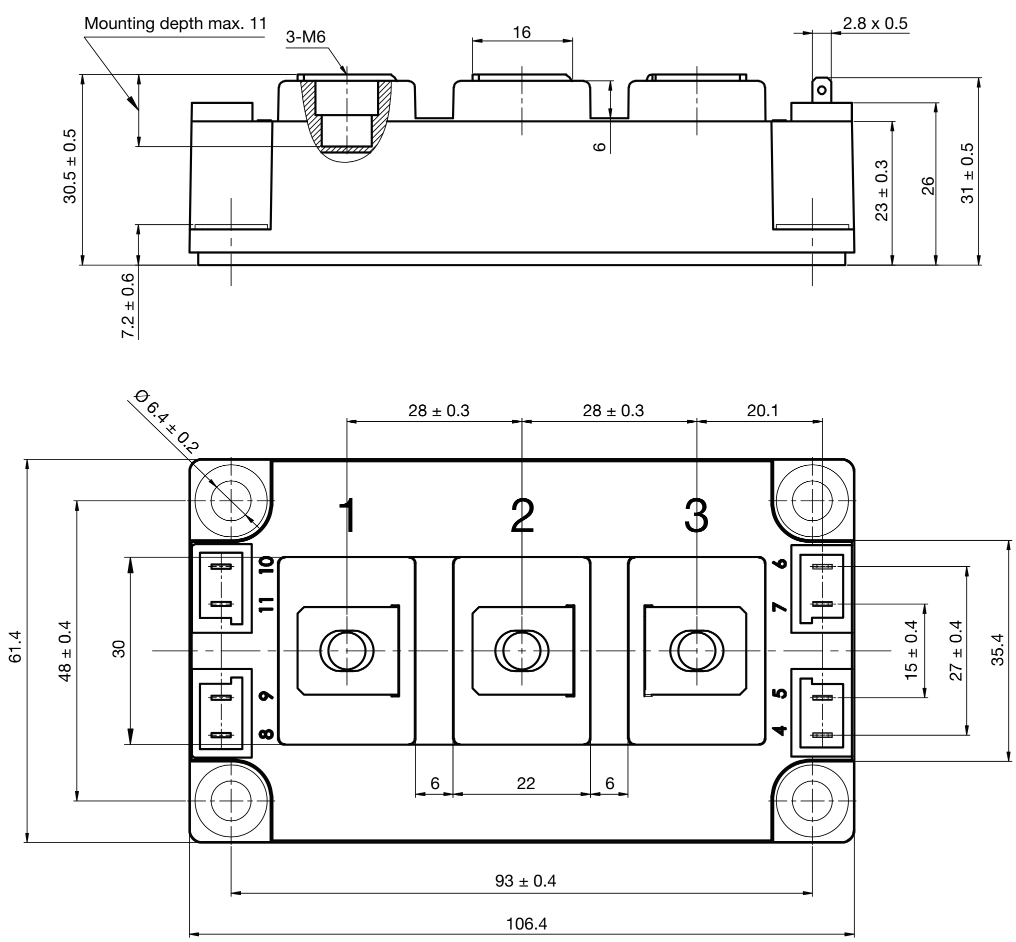
8 - N = none

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

CIRCUIT CONFIGURATION

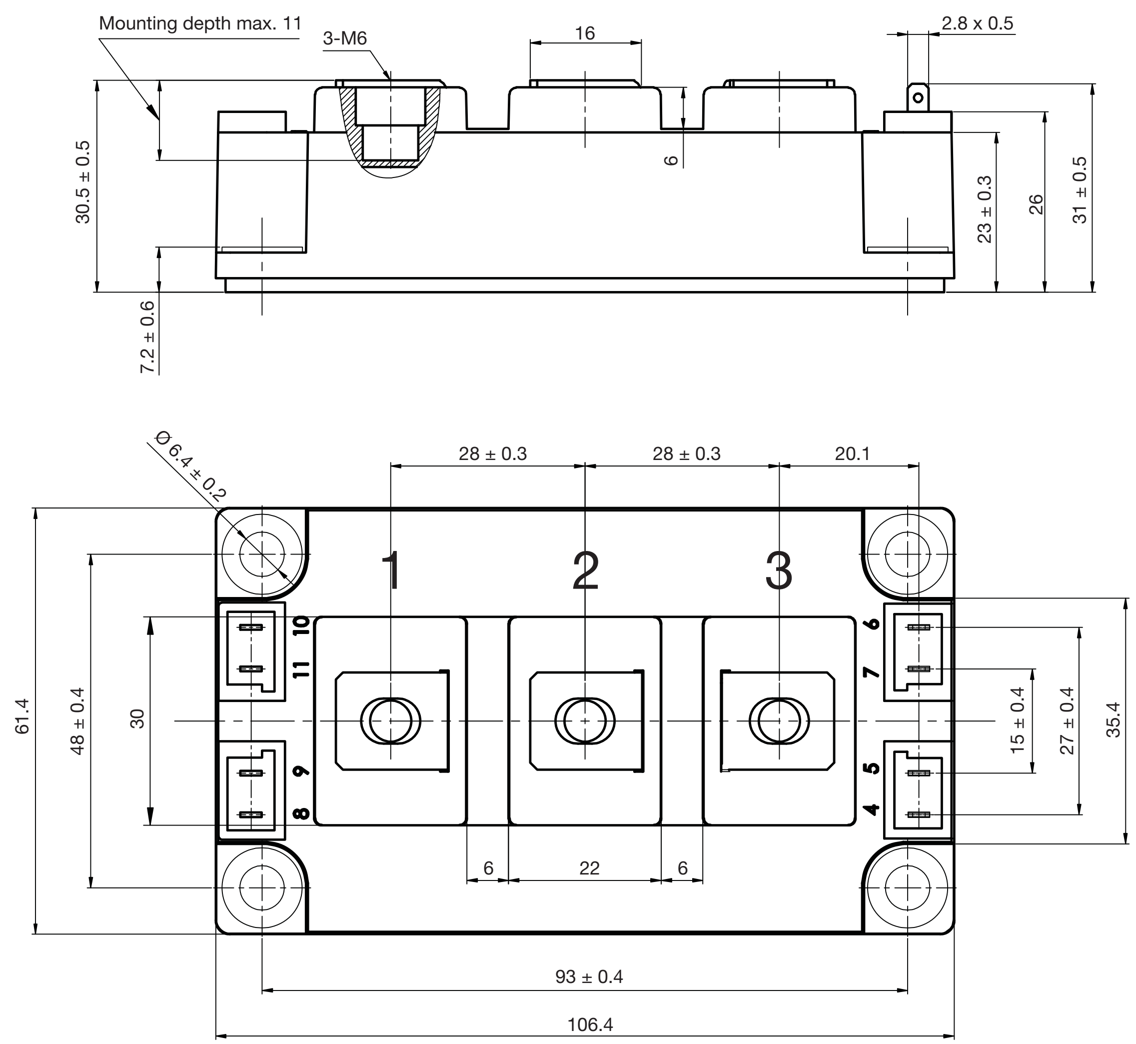


DIMENSIONS in millimeters



Double INT-A-PAK

DIMENSIONS in millimeters (inches)



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