



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



Dual INT-A-PAK

FEATURES

- Trench Field Stop IGBT technology
- 6 μ s short circuit capability
- Low $V_{CE(on)}$
- Square RBSOA
- FRED Pt[®] antiparallel diode with ultrasoft reverse recovery characteristics
- Industry standard package
- Al₂O₃ DBC
- UL pending
- Designed for industrial level
- Material categorization: for definitions of compliance please see www.vishay.com/doc?99912



RoHS
COMPLIANT

BENEFITS

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

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

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⁾	$T_C = 25\text{ °C}$	492	A
		$T_C = 80\text{ °C}$	375	
Pulsed collector current	I_{CM}	$T_p = 6\text{ ms, square pulse}$	850	
Clamped inductive load current	I_{LM}		693	
Gate to emitter voltage	V_{GE}		± 20	V
Maximum power dissipation	P_D	$T_C = 25\text{ °C}$	1363	W
		$T_C = 80\text{ °C}$	864	
DIODE D2				
Chopper diode continuous forward current	I_F	$T_C = 25\text{ °C}$	374	A
		$T_C = 80\text{ °C}$	278	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, $T_J = 25\text{ °C}$	1415	
Maximum power dissipation	P_D	$T_C = 25\text{ °C}$	652	W
		$T_C = 80\text{ °C}$	413	
DIODE D1				
Antiparallel diode continuous forward current	I_F	$T_C = 25\text{ °C}$	192	A
		$T_C = 80\text{ °C}$	142	
Single pulse forward current	I_{FSM}	10 ms sine or 6 ms rectangular pulse, $T_J = 25\text{ °C}$	725	
Maximum power dissipation	P_D	$T_C = 25\text{ °C}$	312	W
		$T_C = 80\text{ °C}$	198	
RMS isolation voltage	V_{ISOL}	Any terminal to case ($V_{RMS} t = 1\text{ s, } T_J = 25\text{ °C}$)	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 ($T_J = 25\text{ }^\circ\text{C}$ unless otherwise specified)						
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS
IGBT Q1						
Collector to emitter breakdown voltage	$V_{BR(CES)}$	$V_{GE} = 0\text{ V}, I_C = 500\text{ }\mu\text{A}$	600	-	-	V
Collector to emitter voltage	$V_{CE(on)}$	$V_{GE} = 15\text{ V}, I_C = 300\text{ A}$	-	1.48	-	
		$V_{GE} = 15\text{ V}, I_C = 400\text{ A}$	-	1.67	2.0	
		$V_{GE} = 15\text{ V}, I_C = 300\text{ A}, T_J = 125\text{ }^\circ\text{C}$	-	1.64	-	
		$V_{GE} = 15\text{ V}, I_C = 400\text{ A}, T_J = 125\text{ }^\circ\text{C}$	-	1.93	-	
Gate threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}, I_C = 6.4\text{ mA}$	4.6	5.9	7	
		$V_{CE} = V_{GE}, I_C = 6.4\text{ mA}, T_J = 125\text{ }^\circ\text{C}$	-	4.6	-	
Temperature coefficient of threshold voltage	$\Delta V_{GE(th)}/\Delta T$	$V_{CE} = V_{GE}, I_C = 6.4\text{ mA}, (25\text{ }^\circ\text{C to } 125\text{ }^\circ\text{C})$	-	-13	-	mV/°C
Forward transconductance	g_{fe}	$V_{CE} = 20\text{ V}, I_C = 400\text{ A}$	-	70	-	mS
Transfer characteristics	V_{GE}	$V_{CE} = 20\text{ V}, I_C = 400\text{ A}$	-	9.1	-	V
Collector to emitter leakage current	I_{CES}	$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}$	-	0.2	20	μA
		$V_{GE} = 0\text{ V}, V_{CE} = 600\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	1.6	-	mA
Gate to emitter leakage current	I_{GES}	$V_{GE} = \pm 20\text{ V}$	-	-	± 1200	nA
DIODE D1						
Antiparallel diode forward voltage drop	V_{FM}	$I_{FM} = 100\text{ A}$	-	1.32	-	V
		$I_{FM} = 200\text{ A}$	-	1.56	1.82	
		$I_{FM} = 100\text{ A}, T_J = 150\text{ }^\circ\text{C}$	-	1.1	-	
		$I_{FM} = 200\text{ A}, T_J = 150\text{ }^\circ\text{C}$	-	1.42	-	
DIODE D2						
Blocking voltage	V_{RRM}	$I_R = 500\text{ }\mu\text{A}$	600	-	-	V
Leakage current	I_{RRM}	$V_R = 600\text{ V}$	-	0.2	15	μA
		$V_R = 600\text{ V}, T_J = 150\text{ }^\circ\text{C}$	-	2.8	-	mA
Chopper diode forward voltage drop	V_{FM}	$I_{FM} = 300\text{ A}$	-	1.48	-	V
		$I_{FM} = 400\text{ A}$	-	1.61	1.92	
		$I_{FM} = 300\text{ A}, T_J = 150\text{ }^\circ\text{C}$	-	1.34	-	
		$I_{FM} = 400\text{ A}, T_J = 150\text{ }^\circ\text{C}$	-	1.51	-	

SWITCHING CHARACTERISTICS ($T_J = 25\text{ }^\circ\text{C}$ unless otherwise specified)							
PARAMETER	SYMBOL	TEST CONDITIONS	MIN.	TYP.	MAX.	UNITS	
IGBT Q1							
Total gate charge (turn-on)	Q_g	$I_C = 400\text{ A}, V_{CC} = 480\text{ V}, V_{GE} = 15\text{ V}$	-	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}	$R_{g(off)} = 1\text{ }\Omega$	$I_C = 300\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\text{ }\mu\text{H}, T_J = 25\text{ }^\circ\text{C}$	-	12.9	-	mJ
Turn-off delay time	$t_{d(off)}$			-	594	-	ns
Fall time	t_f			-	77	-	ns
Turn-on switching energy	E_{on}			-	12.8	-	mJ
Turn-on delay time	$t_{d(on)}$	$R_{g(on)} = 6.8\text{ }\Omega$	$I_C = 300\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\text{ }\mu\text{H}, T_J = 25\text{ }^\circ\text{C}$	-	337	-	ns
Rise time	t_r			-	197	-	ns
Turn-off switching energy	E_{off}	$R_{g(off)} = 1\text{ }\Omega$	$I_C = 300\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\text{ }\mu\text{H}, T_J = 125\text{ }^\circ\text{C}$	-	14.7	-	mJ
Turn-off delay time	$t_{d(off)}$			-	638	-	ns
Fall time	T_f			-	91	-	ns
Turn-on switching energy	E_{on}	$R_{g(on)} = 6.8\text{ }\Omega$	$I_C = 300\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\text{ }\mu\text{H}, T_J = 125\text{ }^\circ\text{C}$	-	13.4	-	mJ
Turn-on delay time	$t_{d(on)}$			-	339	-	ns
Rise time	t_r			-	204	-	ns



SWITCHING CHARACTERISTICS ($T_J = 25\text{ }^\circ\text{C}$ unless otherwise specified)								
PARAMETER	SYMBOL	TEST CONDITIONS		MIN.	TYP.	MAX.	UNITS	
Turn-off switching energy	E_{off}	$R_{g(off)} = 1\ \Omega$	$I_C = 400\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\ \mu\text{H}, T_J = 25\text{ }^\circ\text{C}$	-	19.3	-	mJ	
Turn-off delay time	$t_{d(off)}$			-	593	-	ns	
Fall time	t_f			-	82	-		
Turn-on switching energy	E_{on}	$R_{g(on)} = 6.8\ \Omega$		$I_C = 400\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\ \mu\text{H}, T_J = 25\text{ }^\circ\text{C}$	-	15.6	-	mJ
Turn-on delay time	$t_{d(on)}$				-	354	-	ns
Rise time	t_r				-	238	-	
Turn-off switching energy	E_{off}	$R_{g(off)} = 1\ \Omega$	$I_C = 400\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\ \mu\text{H}, T_J = 125\text{ }^\circ\text{C}$		-	21.2	-	mJ
Turn-off delay time	$t_{d(off)}$				-	631	-	ns
Fall time	T_f				-	92	-	
Turn-on switching energy	E_{on}	$R_{g(on)} = 6.8\ \Omega$		$I_C = 400\text{ A}, V_{CC} = 300\text{ V}, V_{GE} = \pm 15\text{ V}, L = 500\ \mu\text{H}, T_J = 125\text{ }^\circ\text{C}$	-	17.2	-	mJ
Turn-on delay time	$t_{d(on)}$				-	365	-	ns
Rise time	t_r				-	246	-	
Reverse bias safe operating area	RBSOA	$T_J = 175\text{ }^\circ\text{C}, I_C = 693\text{ A}, R_g = 10\ \Omega, V_{GE} = 15\text{ V to } 0\text{ V}, V_{CC} = 400\text{ V}, V_p = 600\text{ V}$			Fullsquare			
Short circuit safe operating area ⁽¹⁾⁽²⁾	SCSOA	$T_J = 150\text{ }^\circ\text{C}, V_{CC} = 360\text{ V}, V_{GE} = 15\text{ V}$			-	-	6	μs
DIODE D2								
Diode reverse recovery time	t_{rr}	$I_F = 400\text{ A}, V_{CC} = 400\text{ V}, T_J = 25\text{ }^\circ\text{C}, dl/dt = 1000\text{ A}/\mu\text{s},$	-	141	-	ns		
Diode peak reverse current	I_{rr}		-	41	-	A		
Diode recovery charge	Q_{rr}		-	3.2	-	μC		
Diode reverse recovery time	t_{rr}	$I_F = 400\text{ A}, V_{CC} = 400\text{ V}, T_J = 125\text{ }^\circ\text{C}, dl/dt = 1000\text{ A}/\mu\text{s},$	-	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}	$I_F = 200\text{ A}, V_R = 400\text{ V}, T_J = 25\text{ }^\circ\text{C}, dl/dt = 1000\text{ A}/\mu\text{s},$	-	120	-	ns		
Diode peak reverse current	I_{rr}		-	28	-	A		
Diode recovery charge	Q_{rr}		-	2.2	-	μC		
Diode reverse recovery time	t_{rr}	$I_F = 200\text{ A}, V_R = 400\text{ V}, T_J = 125\text{ }^\circ\text{C}, dl/dt = 1000\text{ A}/\mu\text{s},$	-	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	$^\circ\text{C}$	
Storage temperature range	T_{Stg}	-40	-	150		
Thermal resistance, junction to case per leg	Q1 IGBT	R_{thJC}	-	-	0.11	$^\circ\text{C}/\text{W}$
	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	

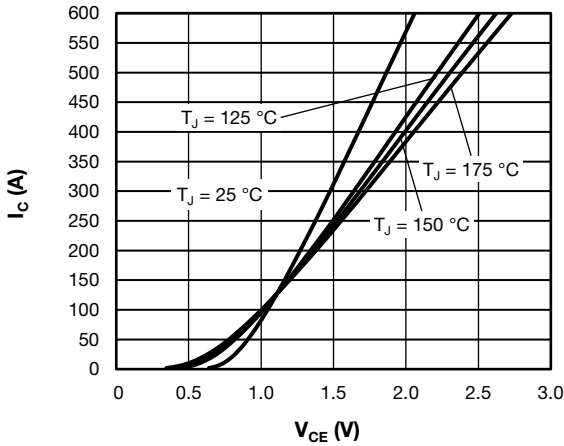


Fig. 1 - Typical IGBT Output Characteristics, $V_{GE} = 15\text{ V}$

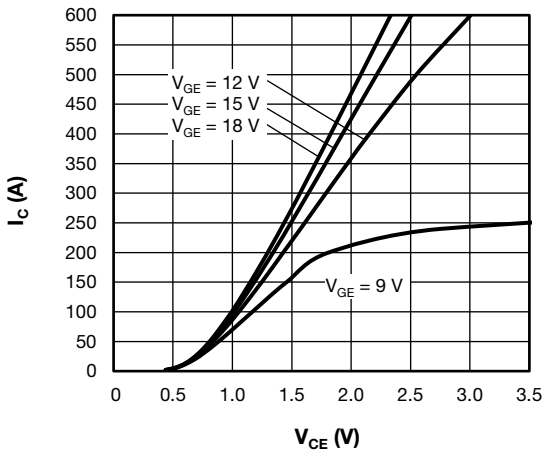


Fig. 2 - Typical IGBT Output Characteristics, $T_J = 125\text{ }^\circ\text{C}$

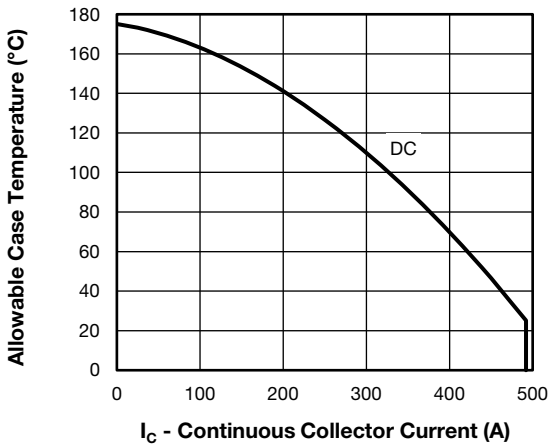


Fig. 3 - Maximum IGBT Continuous Collector Current vs. Case Temperature

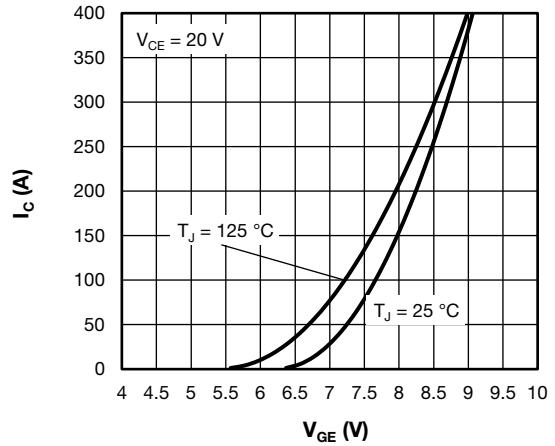


Fig. 4 - Typical IGBT Transfer Characteristics

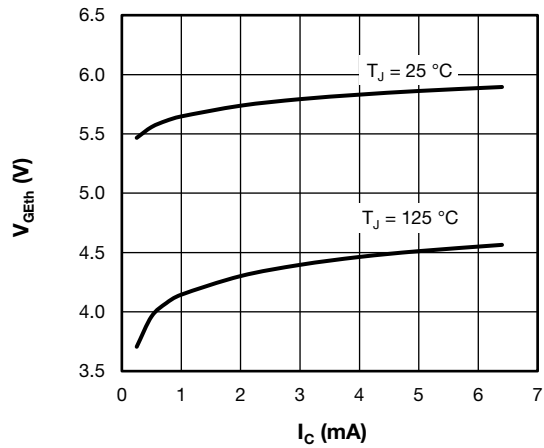


Fig. 5 - Typical IGBT Gate Threshold Voltage

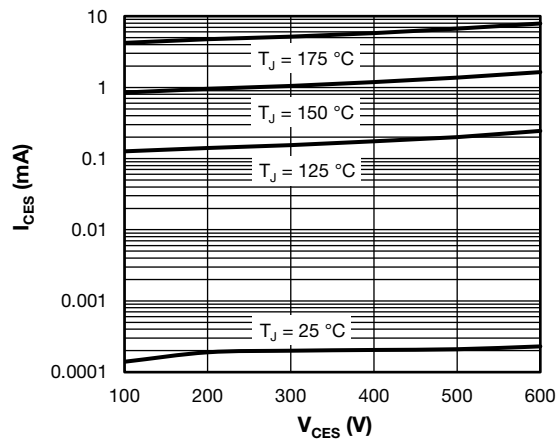


Fig. 6 - Typical IGBT Zero Gate Voltage Collector Current

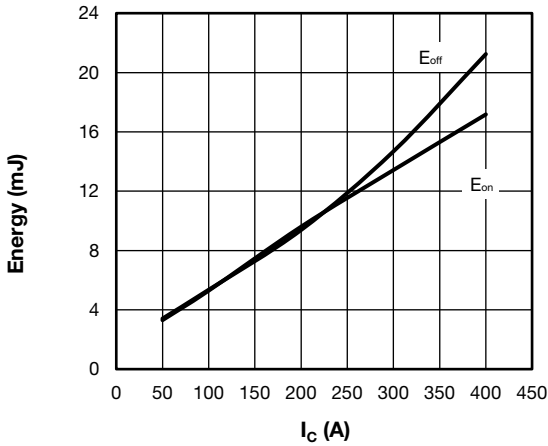


Fig. 7 - Typical IGBT Energy Loss vs. I_C with Freewheeling Diode
 $T_J = 125\text{ }^\circ\text{C}$, $V_{CC} = 300\text{ V}$, $R_{g(on)} = 6.8\ \Omega$, $R_{g(off)} = 1\ \Omega$
 $V_{GE} = +15\text{ V}/-15\text{ V}$, $L = 500\ \mu\text{H}$

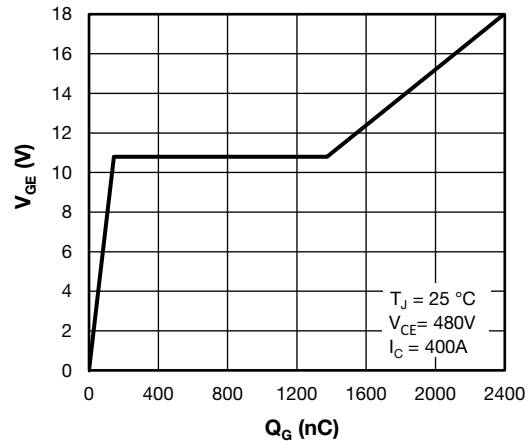


Fig. 10 - Typical Trench IGBT Gate Charge vs. Gate to Emitter Voltage

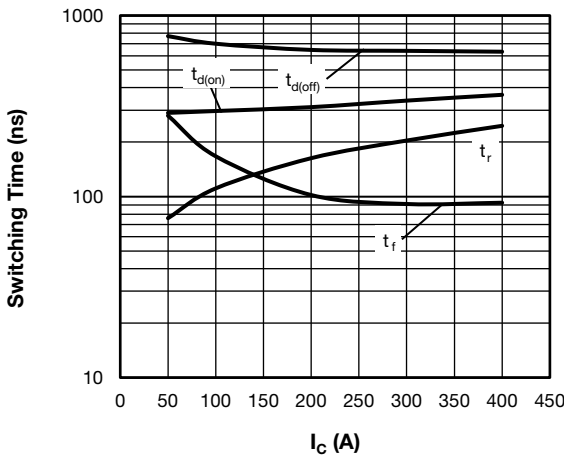


Fig. 8 - Typical Trench IGBT Switching Time vs. I_C with Freewheeling Diode
 $T_J = 125\text{ }^\circ\text{C}$, $V_{CC} = 300\text{ V}$, $R_{g(on)} = 6.8\ \Omega$, $R_{g(off)} = 1\ \Omega$,
 $V_{GE} = +15\text{ V}/-15\text{ V}$, $L = 500\ \mu\text{H}$

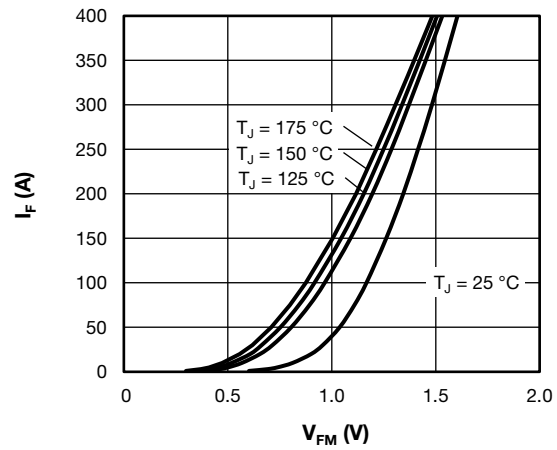


Fig. 11 - Typical D2 Diode Forward Characteristics

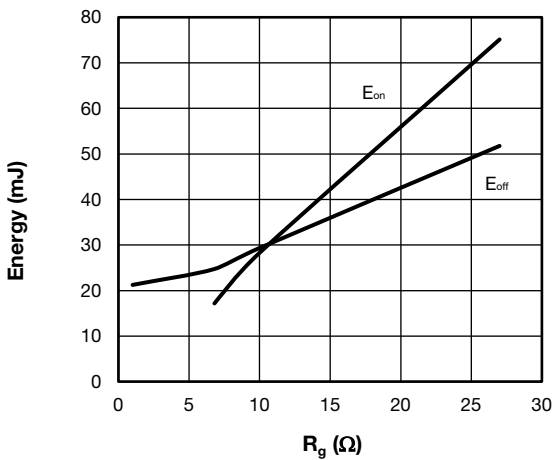


Fig. 9 - Typical Trench IGBT Energy Loss vs. R_g with Freewheeling Diode
 $T_J = 125\text{ }^\circ\text{C}$, $V_{CC} = 300\text{ V}$, $I_C = 400\text{ A}$, $V_{GE} = +15\text{ V}/-15\text{ V}$, $L = 500\ \mu\text{H}$

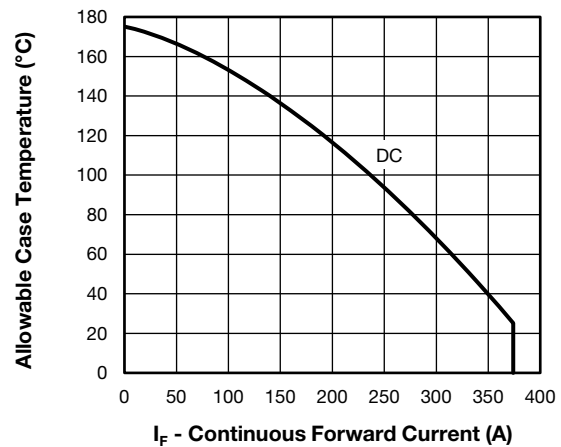


Fig. 12 - Maximum D2 Diode Continuous Forward Current vs. Case Temperature

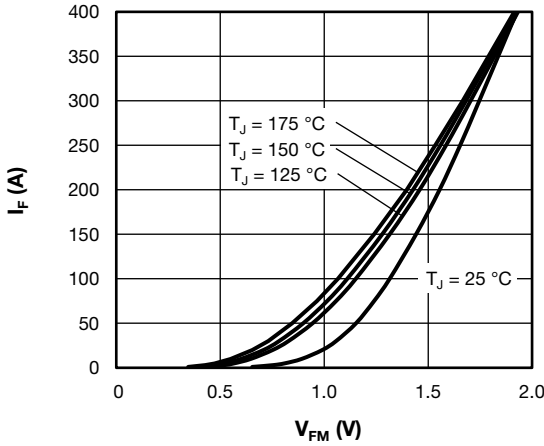


Fig. 13 - Typical D1 Diode Forward Characteristics

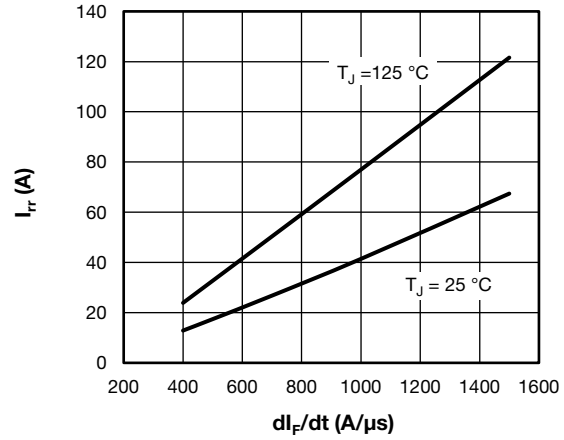


Fig. 16 - Typical Diode Reverse Recovery Current vs. di_F/dt
 $I_F = 400 \text{ A}, V_{CC} = 400 \text{ V}$

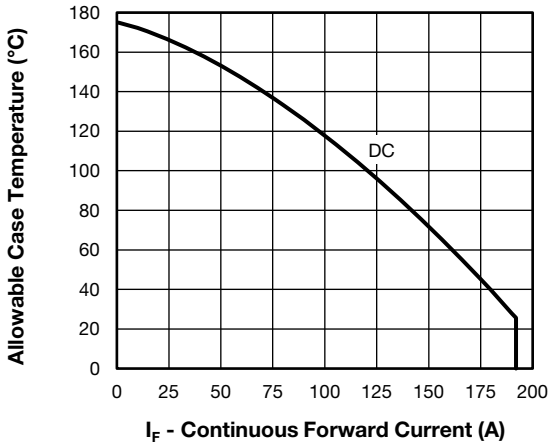


Fig. 14 - Maximum D1 Diode Continuous Forward Current vs. Case Temperature

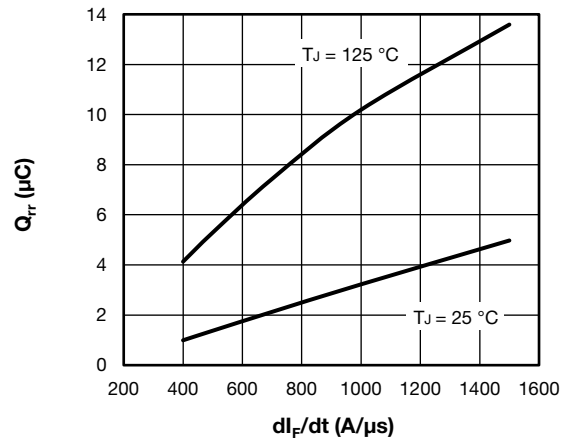


Fig. 17 - Typical Diode Reverse Recovery Charge vs. di_F/dt
 $I_F = 400 \text{ A}, V_{CC} = 400 \text{ V}$

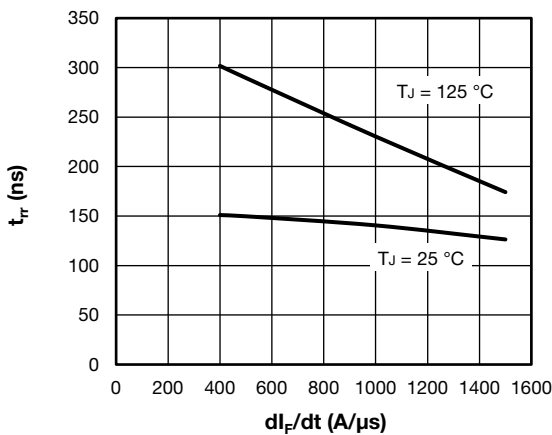


Fig. 15 - Typical Diode Reverse Recovery Time vs. di_F/dt
 $I_F = 400 \text{ A}, V_{CC} = 400 \text{ V}$

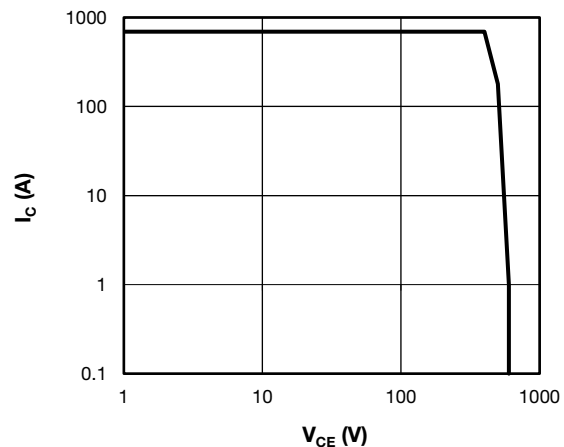


Fig. 18 - IGBT Reverse BIAS SOA
 $T_J = 175 \text{ °C}, I_C = 693 \text{ A}, R_g = 10 \text{ } \Omega, V_{GE} = +15 \text{ V} / 0 \text{ V},$
 $V_{CC} = 400 \text{ V}, V_p = 600 \text{ V}$

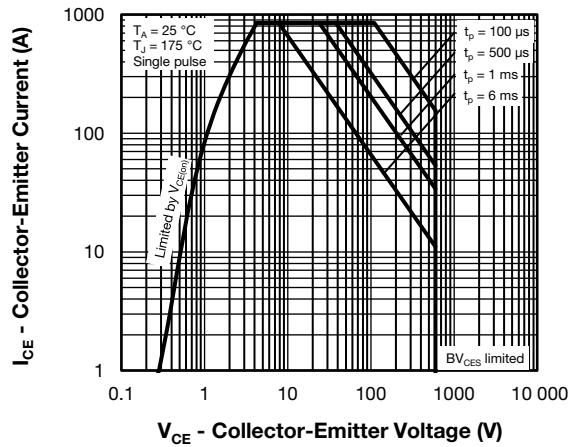


Fig. 19 - IGBT Safe Operating Area

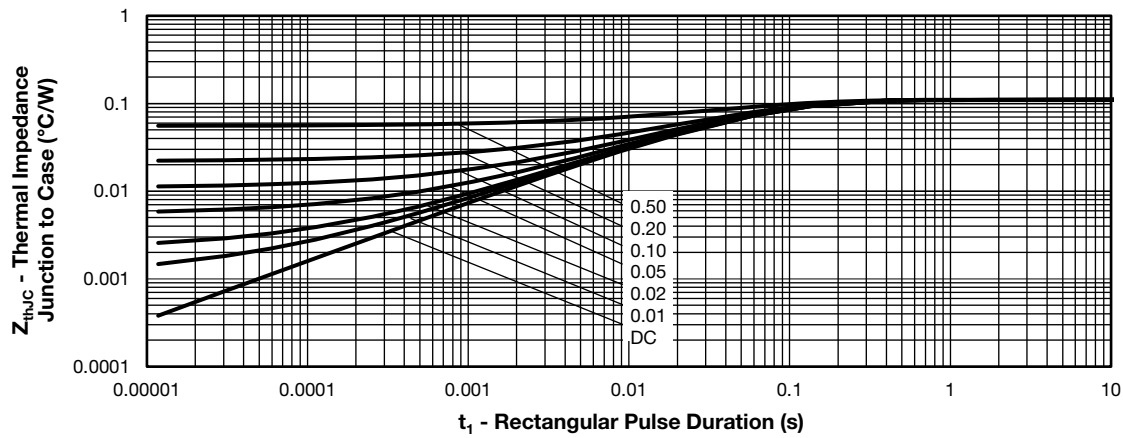


Fig. 20 - Maximum IGBT Thermal Impedance Z_{thJC} Characteristics

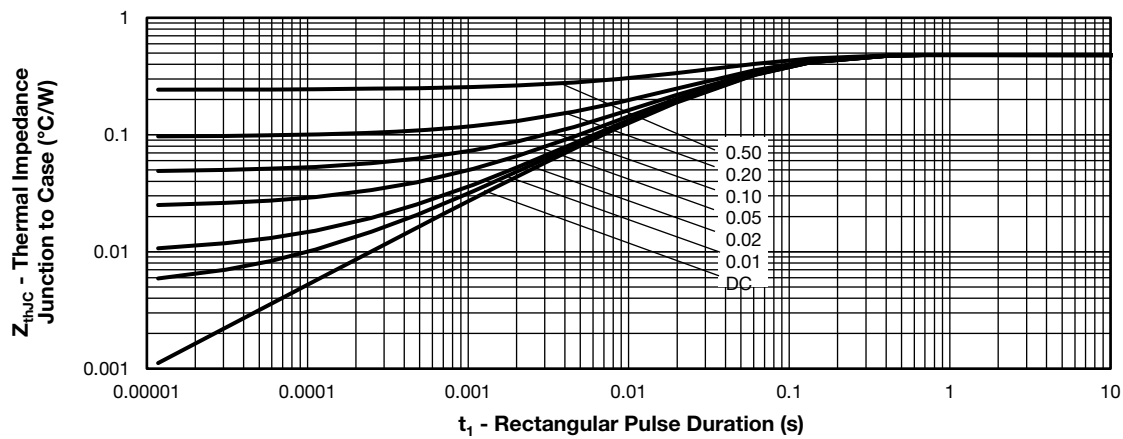


Fig. 21 - Maximum D1 Diode Thermal Impedance Z_{thJC} Characteristics

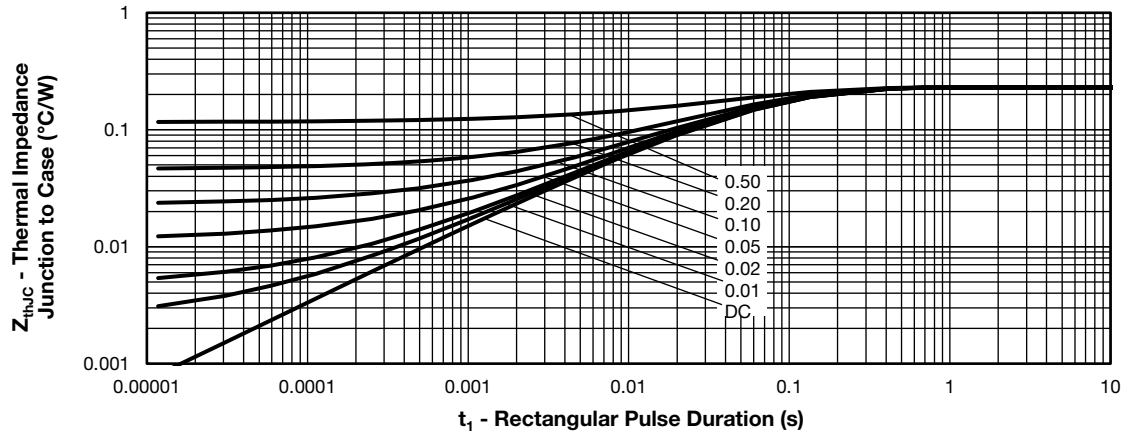


Fig. 22 - Maximum D2 Diode Thermal Impedance Z_{thJC} Characteristics

ORDERING INFORMATION TABLE

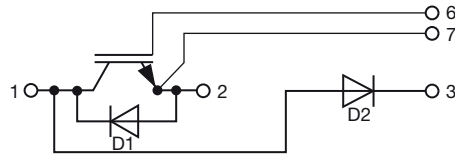
Device code	VS-	G	T	400	L	H	060	N
	①	②	③	④	⑤	⑥	⑦	⑧

- 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

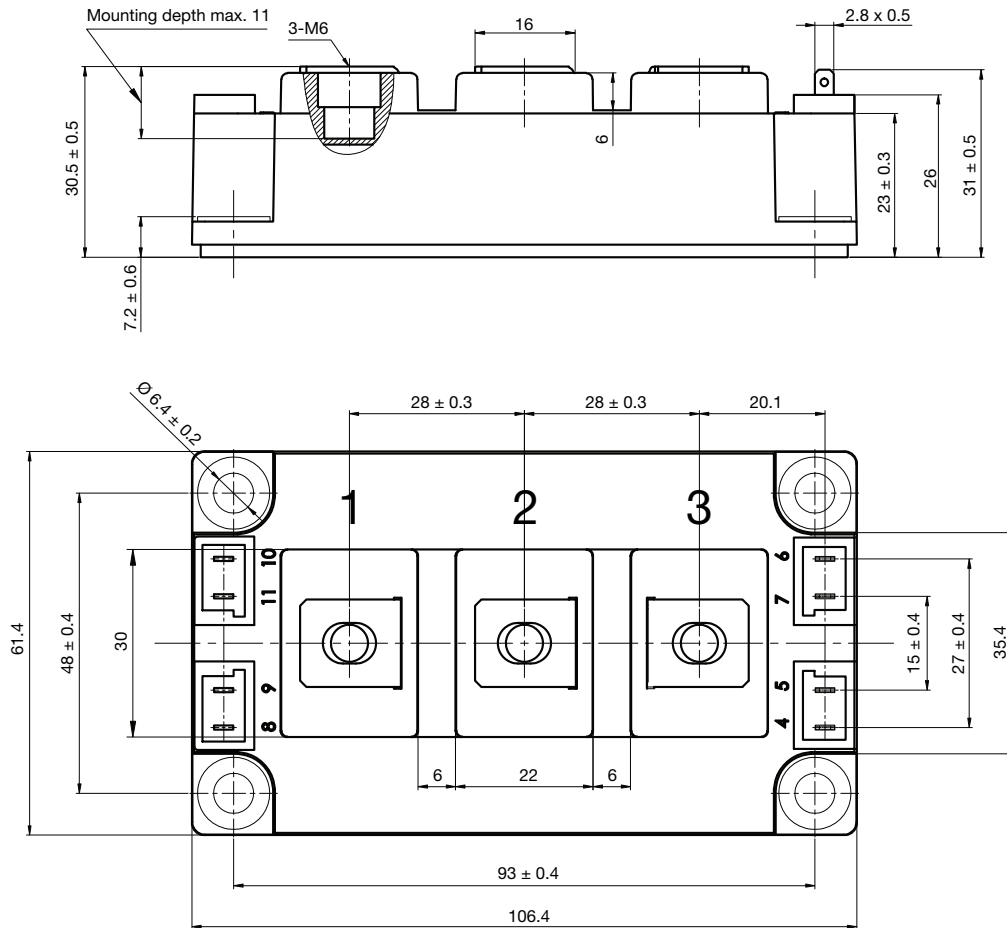
LINKS TO RELATED DOCUMENTS	
Dimensions	www.vishay.com/doc?95525
Application Note	www.vishay.com/doc?95553



CIRCUIT CONFIGURATION



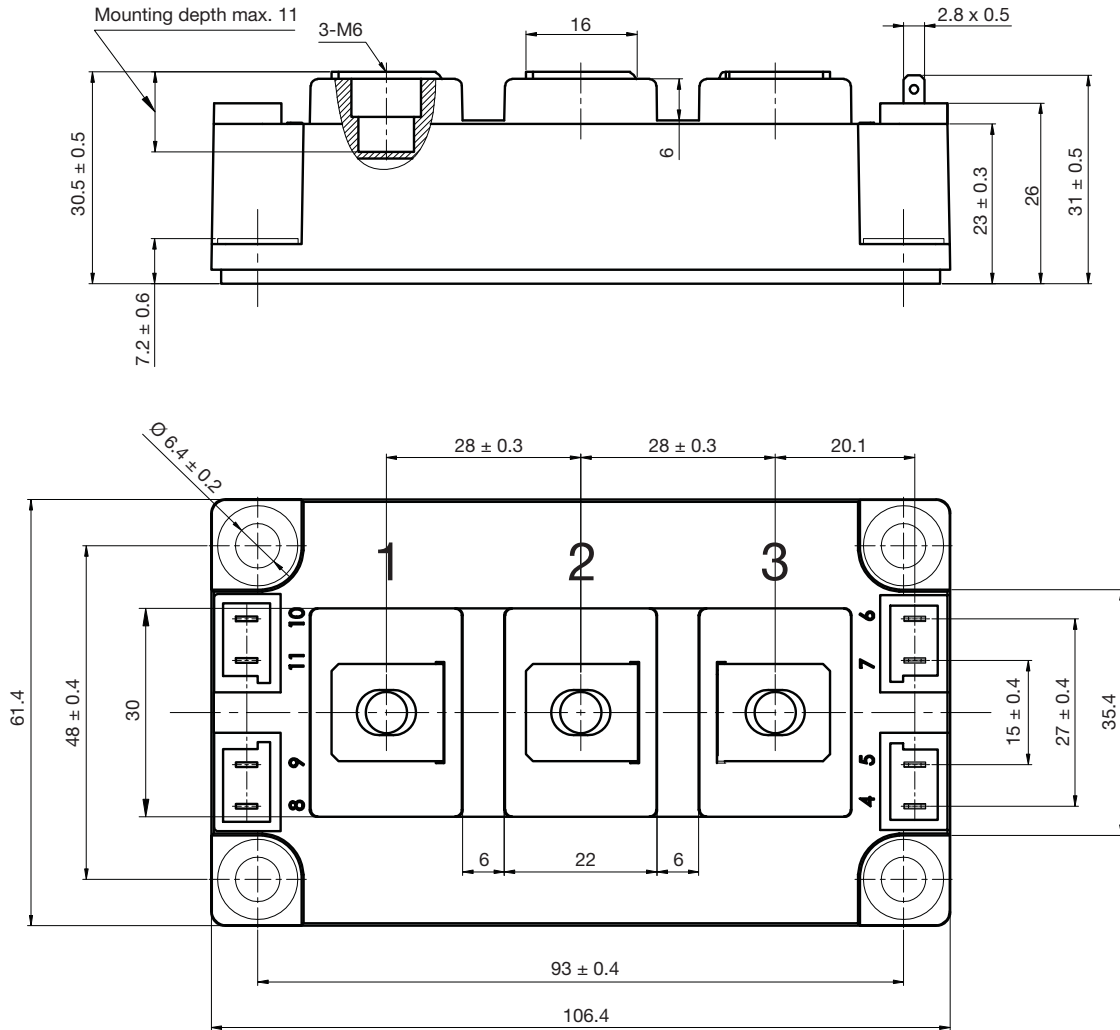
DIMENSIONS in millimeters





Double INT-A-PAK

DIMENSIONS in millimeters (inches)





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